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FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT: FARGO-MOORHEAD METROPOLITAN AREA FLOOD RISK MANAGEMENT, JULY 2011

COMMUNICATION

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Final Feasibility Report and Environmental Impact Statement

Fargo-Moorhead Metropolitan Area Flood Risk Management

Volume 3
Appendices B-I

July 2011

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Appendix B
Hydraulics

Fargo-Moorhead Metropolitan Area Flood Risk Management

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USACE-MVP-0000087955

Appendix B

Hydraulics

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B.1.0 GENERAL

This appendix presents a summary of the Phase 4 hydraulic analyses of existing conditions and proposed diversion alternatives for the Red River of the North (RRN) in the vicinity of Fargo and Moorhead. The previous screenings of flood mitigation alternatives presented in the Phase 2 and 3 versions of this appendix are not repeated. All elevations referred to in this appendix are in NAVD 1988 unless otherwise noted

Most of the pertinent hydraulic information has been developed by a team of consulting engineering firms led by Moore Engineering, Incorporated. This work was performed under an in-kind services contract through the local sponsors and is documented in the report, *Red River Diversion, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 4, February 28, 2011.* **The consultant's report is provided as Attachment 5 of this Feasibility Study. The General Report and Appendices B, C, and F of Attachment 5 cover most of the hydraulic aspects of this study. Instead of repeating that information here, the reader is referred to Attachment 5 for most of the hydraulic information.** This appendix will simply provide a brief summary regarding the status of hydraulic studies and the status of District Quality Control (DQC) and Agency Technical Review (ATR) efforts.

B.2.0 STATUS OF HYDRAULIC STUDIES

B.2.1. WORK COMPLETED

After the downstream impacts of the project developed in Phase 3 were analyzed, it was determined that they were not fully definable and another approach was needed. Phase 4 focuses on developing a Locally Preferred Plan (LPP) that has all impacts fully defined. Following the consideration of multiple options, the USACE and local project sponsors decided to pursue an option that included raising the water levels, or staging, upstream of the FM Metro area. While this would impact homes and properties on the upstream side of the project, this option allows the impacts to be fully defined and there are fewer structures affected by shifting the impacts upstream and the mitigation measures are also less costly for the upstream staging option. In addition to utilizing the existing topography, much of which is already inundated by flooding, this concept also includes a constructed storage area that provides some control on the storage and subsequent release of the water to help with the timing and the impacts at peak flood stage.

In order to develop a design that incorporates the benefits of the upstream storage and staging, the design for this phase required the use of unsteady state modeling techniques. Up until this point, unsteady flow models had only been used to analyze the impacts of the project designs that had been developed with steady state methods, which are simpler and less time intensive to use. The Phase 4 effort involved extensive upgrades to the existing unsteady state existing conditions models followed by full project design utilizing these models to analyze the benefits of upstream storage and staging. This phase involved only the redesign of the Locally Preferred Plan (LPP), which is the North Dakota East Diversion. The design for the Federally Comparable Plan (FCP) completed in Phase 3 is adequate since the project impacts have been fully defined and upstream staging is not required to fully define these impacts. Therefore, no updates were completed for the FCP as part of Phase 4. The background information on the FCP design and other information on the alternatives on the Minnesota side of the Red River can be found in the reports published for Phase 3 and earlier phases of this study. However, the FCP design was analyzed with the updated models developed for Phase 4 to evaluate the downstream impacts.

The hydraulic analysis spans approximately 325 miles of the Red River of the North from near Abercrombie, North Dakota through Fargo, North Dakota and Moorhead, Minnesota to the downstream end at Drayton, North Dakota. The communities of Fargo and Moorhead are located approximately 453 river miles above the mouth of the Red River of the North at Lake Winnipeg, Manitoba. The river model geometry is highlighted in Figure B-1 (taken from Attachment 5). It includes the Red River of the North main stem and several tributaries.

When it was found that downstream impacts could not be fully defined (zero impact location) within the original study extents, the model was first extended to River Mile 316 near Thompson, North Dakota (Phase 3), and then to River Mile 198 at Drayton (Phase 4). It has also been extended upstream on the Red River of the North to near Abercrombie, North Dakota at approximately River Mile 524. The model was also extended farther upstream on the Sheyenne and Maple Rivers to better define the breakouts and flow distribution on the western side of the project.

B.2.1.1. Existing Condition Modeling

The Existing Conditions HEC-RAS unsteady flow model was developed with sufficient detail to be used as a baseline for project feasibility design as well as benefit and impact analysis. It was calibrated based on the 2009 spring flood and the calibration was verified using the 2006, 1997, and 2010 historic spring flood events. Stage and discharge hydrographs and high water mark data were used in the calibration effort.

The temporary flood protection measures, present during the historic flood events and necessary for calibration, were removed to produce the geometry for the unprotected condition. The impacts of the project were determined by comparing the with-project models to the existing condition models without emergency measures in place. This allows for the determination of the full benefits of the project by comparing it to the

damages that would be incurred if nothing was done to protect the communities. All impacts presented reference the "without emergency protection" condition for both existing and with-project conditions.

A more complete summary of the Existing Condition modeling effort is available in Attachment 5, General Report, Section 3.2. The reader is referred to Attachment 5, Appendix B to understand the details of the Existing Condition hydraulic study.

B.2.1.2. Flood Events Modeled

The 10-percent, 2-percent, 1-percent, and 0.2-percent annual chance synthetic flood events were developed as the primary means to evaluate Existing Conditions, to assist with project feasibility design, and to analyze potential impacts from flood mitigation alternatives (LPP and FCP) being considered as part of this project.

In addition to the synthetic flood events, four larger recent historic flood events in Fargo-Moorhead (1997, 2006, 2009 and 2010) were also simulated. These model runs are not intended for project feasibility design or for flood damage reduction evaluation. However, they provide two very tangible benefits. First, they offer the possibility to better communicate the project impacts to all stakeholders and the general public because they can relate to how the project would change the conditions that were experienced during the recent larger flood events. The second benefit of having conducted these model runs is that they allow estimation of project upstream staging/storage and downstream impacts without having to assume that the magnitude and timing of tributary flows affect the magnitude and timing of flooding downstream; this is better captured with looking at four historic events versus the synthetic event analysis.

A more complete summary of the synthetic and historic flood model development is available in Attachment 5, General Report, Sections 3.2 and 3.3.

B.2.1.3. Locally Preferred Plan (LPP)

Most simply, the LPP involves a diversion and the temporary staging of water upstream to both reduce flood damages for the Fargo-Moorhead metro area and reduce downstream stage impacts. Downstream stage impacts are reduced to 0.0 between Oslo and Drayton. The LPP provides flood damage reduction up to the 0.2-percent chance flood event for nearly 200,000 people and 80 square miles of infrastructure. The major features of the LPP are shown in Figures B-2 and B-3 (taken from Attachment 5). Figure B-3 is included since Figure B-2 doesn't show the extent of temporary staging area upstream of the control structures south of Fargo-Moorhead. Seven river systems (Red River of the North, Wild Rice River, Wolverton Creek, Sheyenne River, Maple River, Lower Rush River, Rush River) and a number of drains are directly affected by the project. The diversion is approximately 36 miles long while the channel length of the Red River of the North cutoff by the diversion is 60.7 miles.

Low flows for the Sheyenne River and the Maple River will cross the diversion via aqueducts while the Rush River, Lower Rush River, Drain 14, and a number of other smaller ditches will be captured by the diversion. High flows on the Sheyenne River and Maple River will pass into the diversion via spillway weirs adjacent to the aqueducts. The Maple River Aqueduct and the Sheyenne River Aqueduct are designed for fish passage. Fish passage structures are provided at five locations (Outlet Drop Structure, Rush River Drop Structure, Lower Rush River Drop Structure, Wild Rice River Control Structure, Red River of the North Control Structure) to assist fish passage while the project is in operation.

Three control structures (Red River of the North, Wild Rice River, Wolverton Creek) and the Diversion Inlet Structure control the amount and timing of diversion flow and staged water. The area of water staging includes an area of more controlled storage, named Storage Area 1, which assists with reducing stage impacts downstream of the project. The maximum staged water elevation is 922.9 and occurs for the 1.0-percent chance flood event. The maximum staged water elevation causes the maximum diverted flow of approximately 19,000 cfs. The staged water elevation is slightly lower for the 0.2-percent chance flood event due to fewer challenges in reducing downstream stage impacts. For floods larger than the 0.2-percent chance event that would cause higher staging elevations, flow will be allowed to exit the staging area to the west over a weir at elevation 922.9 along Cass County Highway 17. This means that water will diverted into the Sheyenne River basin for extremely large flood events. Except for the weir at elevation 922.9 along Cass County Highway 17, the staged water, both upstream of the diversion and in Storage Area 1, will be contained by levees with 5 feet of freeboard above the 922.9 elevation. Attachment 5, Appendix F indicates the levees have a top elevation of 927.0, but these levees will actually have to be at elevation 927.9. Cost contingencies have been set to cover the additional cost of this additional levee height.

For the case of high flow conditions on the Sheyenne River while peak flooding is occurring on the Red and Wild Rice Rivers, the capacity of the proposed diversion channel is such that flooding along the Sheyenne River will be no worse than it is under existing conditions. Breakout flows from the Sheyenne River that cross Cass County Highway 17 and enter the Wild Rice River basin under existing conditions will be directed to the diversion channel via a new ditch. The exact location and design and location of this ditch have yet to be determined, but it is known that the ditch can be designed to function without inducing additional flooding. Other smaller ditches may also be required to prevent drainage issues along the proposed tie-back levees.

Summary stage and flow information for the LPP is provided as Tables B-1 and B-2 (taken from Attachment 5). It is important to note that the degree of staging needed to reduce downstream stage impacts for the historic event simulations is in-line with the required staging identified for the synthetic events. This supports the timing used for the synthetic event simulations and the final staging elevations for the synthetic flood events.

The operational scheme developed for the primary flood control structures at this feasibility level has been based on synthetic and historical floods for peak flows on the

Red River of the North with coincidental events on its tributaries as well as on synthetic floods for peak flows on the ND tributaries (directly affected by the LPP diversion channel) with coincidental events on the Red River of the North. These events provide a sample of flood events with a variety of hydrograph shapes and peak flows. However, it is recognized that a more complete evaluation (possibly including stochastic modeling) would be needed to develop the detailed operational plan of the flood control structures during final design. Furthermore, it is important to acknowledge that, following the example of the Manitoba Floodway and other similar large flood control projects, the operational plan developed during final design will be subject to further refinements and modifications after the project has been in place during actual flood events.

The project goal is to not cause any additional flooding along the Sheyenne River, Maple River, Lower Rush River, Rush River, and local drains adjacent to the LPP diversion. For many areas flooding will be reduced since the design water surface profile in the LPP diversion will be lower than it is in the existing Horace to West Fargo and West Fargo diversions, but to preserve existing floodplains the inlets to the diversion will not be designed to reduce flooding for the 1-percent chance and less frequent peak flows from the Sheyenne/Drain 14/Maple/Rush and local drainage areas (for these events the goal is to maintain the existing condition). The design presented does not completely meet the goals stated above. The current design does have areas where flooding is worse than the existing condition. Resolving the issue of increased flood stages will be relatively easy in some areas and more of a challenge in others. Cost contingencies have been raised to address these issues.

A more complete summary of the LPP is available in Attachment 5, General Report, Section 3.3. The reader is referred to Attachment 5, Appendices C and F to understand the details of the LPP hydraulic study.

B.2.1.4. Federally Comparable Plan (FCP)

The FCP diversion alternative for the Phase 4 feasibility study is the same as the one presented in the Phase 3 report. The main features consist of a control structure on the Red River of the North, the diversion channel, and the outlet structure for the diversion channel. The FCP diversion channel starts approximately one mile north of the confluence of the Red River of the North and Wild Rice River, extends north around the Cities of Moorhead and Dilworth and ultimately re-enters the Red River of the North near its confluence with the Sheyenne River. The alignment is approximately 25 miles long. In addition to the main diversion channel, this alignment requires additional channels upstream of the Red River control structure to prevent stage increases upstream of the project along the Red River of the North and Wild Rice River. A supplementary extension channel parallels the Red River of the North upstream of the entrance to the diversion channel to allow for additional capacity to offset blockage of the breakouts to Cass County Drains 27 and 53. This secondary FCP extension channel is approximately 3 miles long and has a 50 foot bottom width. A second, shorter channel, the Wild Rice Breakout Channel, was added near the intersection of I-29 and Cass County Highway 16. This channel, which is less than one mile long and crosses under I-29, will convey water

across I-29 that would have naturally broken out to Cass County Drain 27 and has a 50 foot bottom width. Additionally, the FCP includes 20 roadway bridges and 4 railroad bridges that cross the diversion channel.

Similar to the LPP, Phase 4 includes the modeling of Existing Conditions and With-Project (FCP) for the historic 1997, 2006, 2009, and 2010 spring floods to determine the downstream impacts. These impacts are related to the loss of floodplain storage and changes to timing as a result of the flows conveyed through the diversion channel. For the FCP downstream impact analysis, the emergency protection measures that were in place during these historic event calibrations/verifications were not included. The FCP diversion channel from the Phase 3 design was incorporated into the Phase 4 HEC-RAS unsteady flow model. The With-Project water surface profiles were then compared to the Existing Conditions water surface profile to quantify the project impacts.

Phase 4 also includes the modeling of Existing Conditions and With-Project (FCP) for four synthetic events (0.2-, 1-, 2-, and 10-percent chance design floods) to determine the downstream impacts. These impacts are related to the loss of floodplain storage and changes to timing as a result of the diversion channel. The FCP diversion channel from the Phase 3 design was incorporated into the Phase 4 HEC-RAS unsteady flow model. The With-Project water surface profiles were then compared to the Existing Conditions water surface profile to quantify the project impacts.

Summary stage and flow information for the FCP is provided as Tables B-3 and B-4 (taken from Attachment 5). There is no upstream staging and the downstream impacts gradually attenuate downstream.

A more complete summary of the LPP is available in Attachment 5, General Report, Section 3.4. The reader is referred to Attachment 5, Appendices C and F to understand the details of the FCP hydraulic study.

B.2.2. ADDITIONAL STUDY INFORMATION

Ice analyses of existing conditions and the diversion alternatives are being performed by the Ice Engineering Group at the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL). The ice analyses consist of three phases: 1) A review and analysis of historical ice and hydro-met data combined with an ice monitoring program, 2) An assessment of impacts to the ice regime in the vicinity of FM as a result of the diversion project, and 3) Analyses of the ice interaction with the RNN diversion and tributary crossing structures. These three phases involve reviewing historic ice data including ice thickness measurements and photos, simulating ice-affected water surface profiles with HEC-RAS, and using the state-of-the-art two-dimensional ice-hydraulic model DynaRICE to assess overall project performance with the expected ice conditions. Preliminary information from the ice study is included in Attachment 5, Appendix F, Exhibit J and a draft ice study report is provided as Attachment 1 to this appendix. The preliminary information has been used in updating costs associated with ice management (see Appendix L for cost information).

An assessment of project impacts to the Richland County drains is provided as Attachment 2 to this appendix.

Geomorphic studies are being conducted but these efforts have been delayed due to a longer-than-expected testing schedule, early snow conditions, and high water and in the Fargo-Moorhead area. Preliminary geomorphic information is included as Attachment 5, Appendix F, Exhibit I. Since that that Exhibit I was prepared additional sediment transport data has been collected during the spring 2011 high flows by the USGS and made available in a preliminary nature. The sediment data collected in 2011 was compared to the data collected during the spring 2010 high flow period. A comparison of the 2010 to 2011 sediment transport data and the conclusion that the additional data does support the conclusions of the Feasibility Study on the potential impact of the proposed project on sediment transport and geomorphology in the studied rivers. A memorandum discussing the 2011 sediment transport data is provided as Attachment 3 to this appendix.

Questions regarding whether the LPP would increase the duration of flooding downstream of the proposed diversion were raised during the public comment review period. A discussion of existing conditions vs. LPP hydrographs at three locations downstream of the proposed diversion (Hendrum, Halstad, and Grand Forks) is provided as Attachment 4 to this appendix.

The wind setup and wave height analysis for the LPP staging area is provided as Attachment 5. A minimum of 3 feet of freeboard is recommended.

B.3.0 QUALITY ASSURANCE / QUALITY CONTROL

B.3.1. CONTRACTOR QA/QC

The contractor conducted a series of internal QA/QC reviews that involved both reviewers on the project design team and reviewers independent of the design team. The comments and responses developed during the review of the existing conditions models are documented in Attachment 5, Appendix B (Section B6.0 and Exhibit H). The comments and responses for the with-project models are documented in Attachment 5, Appendix C (Section 2.15 and Exhibit 5). The contractor QA/QC reviews were extensive and must be read to fully understand the complete QA/QC effort.

B.3.2. DISTRICT QUALITY CONTROL (DQC) AND AGENCY TECHNICAL REVIEW (ATR)

The draft hydrology report and draft unsteady HEC-RAS models were sent out for District Quality Control (DQC) and Agency Technical Review (ATR) in late August 2010. The reviews were conducted by independent Corps' reviewers. Vicksburg District (MVK) performed the DQC and Omaha District (NWO) performed the ATR. The comments and responses are provided in the following table.

Table B-1

Summary HEC-RAS Unsteady Flow Model Results for Design Floods - Locally Preferred Plan

North Dakota Diversion (LPP) - [illegible] (No Protection)							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	804.12	168,364	804.23	171,002	0.11	2,638
Minimum Impact Location	1410241	812.15	152,872	812.19	156,165	0.04	3,294
Oslo Gage	1416287	813.88	152,851	813.93	156,084	0.05	3,232
Grand Forks Gage	1558518	836.36	146,225	836.58	149,112	0.22	2,887
Maximum Impact Location	1561353	838.53	102,444	838.80	102,054	0.27	-390
Thompson Gage	1667877	850.69	112,422	850.64	111,394	-0.05	-1,027
Halstad Gage	1981580	871.54	101,754	871.32	92,746	-0.22	-9,007
Fargo Gage (13th Ave S, 12th Ave S)	2388223	905.8 (43.06*)	61,717	902.77 (40.03*)	29,865	-3.03	-31,852
US Diversion**	2531315	915.94	28,577	922.44	27,846	6.50	-731
Hickson Gage**	2563754	919.69	35,636	922.54	32,491	2.85	-3,145
Abercrombie**	2764835	940.90	44,308	940.91	44,308	0.01	0

North Dakota Diversion (LPP) - [illegible] (No Protection)							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	801.73	119,255	801.81	120,751	0.08	1,496
Minimum Impact Location	1410241	811.47	113,625	811.51	115,682	0.04	2,057
Oslo Gage	1416287	813.01	113,556	813.07	115,628	0.06	2,071
Grand Forks Gage	1558518	832.97	107,980	833.21	110,497	0.24	2,517
Maximum Impact Location	1573768	835.27	80,735	835.56	80,686	0.29	-49
Thompson Gage	1667877	847.35	82,926	847.39	82,608	0.04	-317
Halstad Gage	1981580	869.09	71,581	869.03	70,992	-0.06	-589
Fargo Gage (13th Ave S, 12th Ave S)	2388223	903.86 (41.12*)	34,875	893.54 (30.8*)	11,718	-10.32	-23,157
US Diversion**	2531315	914.65	21,458	922.88	11,024	8.23	-10,434
Hickson Gage**	2563754	917.52	21,730	922.90	18,655	5.38	-3,075
Abercrombie**	2764835	935.62	23,000	935.73	23,000	0.11	0

North Dakota Diversion (LPP) - [illegible] (No Protection)							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	800.72	100,869	800.80	102,165	0.08	1,296
Minimum Impact Location	1410241	811.12	97,700	811.15	98,889	0.03	1,189
Oslo Gage	1416287	812.53	97,643	812.57	98,857	0.04	1,215
Grand Forks Gage	1558518	831.13	91,118	831.31	92,619	0.18	1,501
Maximum Impact Location	1602184	836.27	69,861	836.65	70,584	0.38	723
Thompson Gage	1667877	844.83	69,367	845.07	70,104	0.24	737
Halstad Gage	1981580	867.99	59,416	867.99	59,542	0.00	126
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.6 (39.86*)	29,167	892.72 (29.98*)	10,603	-9.88	-18,565
US Diversion**	2531315	913.76	18,435	920.86	10,477	7.10	-7,959
Hickson Gage**	2563754	916.34	18,898	920.92	18,428	4.58	-470
Abercrombie**	2764835	934.48	20,726	934.62	20,726	0.14	0

North Dakota Diversion (LPP) - [illegible] (No Protection)							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	798.53	62,917	798.54	63,042	0.01	125
Minimum Impact Location	1327581	803.44	57,657	803.45	58,094	0.01	437
Oslo Gage	1416287	810.51	59,092	810.55	59,629	0.04	537
Grand Forks Gage	1558518	825.98	56,662	826.09	57,169	0.11	507
Maximum Impact Location	1561283	826.49	43,551	826.61	43,504	0.12	-47
Thompson Gage	1667877	837.58	42,815	837.62	42,843	0.04	28
Halstad Gage	1981580	864.55	34,653	864.43	34,160	-0.12	-493
Fargo Gage (13th Ave S, 12th Ave S)	2388223	897.33 (34.59*)	17,024	891.86 (29.12*)	10,156	-5.47	-6,868
US Diversion**	2531315	908.06	10,333	916.29	8,861	8.23	-1,472
Hickson Gage**	2563754	910.21	10,428	916.80	10,077	6.59	-351
Abercrombie**	2764835	929.05	11,278	929.16	11,278	0.11	0

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

** Discharge does not include flow conveyed in the floodplain outside the main conveyance channel of the Red River

Table B-2

Summary HEC-RAS Unsteady Flow Model Results for Historic Floods - Locally Preferred Plan

North Dakota Diversion (LPP) - [illegible] Event (No Protection)

Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	801.95	123,404	801.94	123,251	-0.01	-153
Oslo Gage	1416287	813.29	124,661	813.30	124,735	0.01	74
Minimum Impact Location	1555329	833.59	119,246	833.60	119,281	0.01	35
Grand Forks Gage	1558518	834.04	119,103	834.05	119,142	0.01	39
Thompson Gage	1667877	847.29	78,351	847.43	79,439	0.14	1,088
Maximum Impact Location (Nielsville)	1829877	860.86	71,728	861.11	72,925	0.25	1,197
Halstad Gage	1981580	868.65	64,821	868.78	66,780	0.13	1,959
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.42 (39.68*)	27,574	893.11 (30.37*)	9,968	-9.31	-17,606
US Diversion**	2531315	911.89	13,686	921.60	9,530	9.71	-4,156
Hickson Gage**	2563754	913.85	13,729	921.63	13,235	7.78	-494
Abercrombie**	2764835	931.08	13,995	931.36	13,995	0.28	0

North Dakota Diversion (LPP) - [illegible] Event (No Protection)

Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	799.44	78,252	799.46	78,666	0.02	414
Oslo Gage	1416287	811.58	74,550	811.61	75,093	0.03	543
Minimum Impact Location	1443147	813.86	75,635	813.88	76,312	0.02	677
Grand Forks Gage	1558518	828.63	72,782	828.72	73,387	0.09	605
Thompson Gage	1667877	840.63	52,499	840.84	53,273	0.21	775
Maximum Impact Location	1749702	848.33	52,262	848.59	53,030	0.26	768
Halstad Gage	1981580	866.64	43,060	866.70	43,552	0.06	492
Fargo Gage (13th Ave S, 12th Ave S)	2388223	899.57 (36.83*)	21,028	891.96 (29.22*)	10,109	-7.61	-10,919
US Diversion**	2531315	910.60	14,053	918.72	9,530	8.12	-4,523
Hickson Gage**	2563754	913.11	14,313	918.90	14,362	5.79	49
Abercrombie**	2764835	931.58	15,027	931.74	15,027	0.16	0

North Dakota Diversion (LPP) - [illegible] Event (No Protection)

Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	799.85	85,308	799.84	85,166	-0.01	-143
Minimum Impact Location	1345544	805.87	91,028	805.88	90,929	0.01	-99
Oslo Gage	1416287	812.02	85,672	812.04	84,367	0.02	-1,304
Grand Forks Gage	1558518	829.33	77,165	829.39	77,550	0.06	385
Maximum Impact Location	1561353	830.20	63,468	830.28	63,506	0.08	38
Thompson Gage	1667877	843.05	61,510	843.07	61,577	0.02	67
Halstad Gage	1981580	867.60	55,176	867.56	54,910	-0.04	-266
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.66 (39.92*)	29,234	893.46 (30.72*)	11,561	-9.20	-17,674
US Diversion**	2531315	914.24	23,639	921.62	10,897	7.38	-12,742
Hickson Gage**	2563754	917.76	24,393	921.64	24,562	3.88	170
Abercrombie**	2764835	937.51	28,176	937.59	28,176	0.08	0

North Dakota Diversion (LPP) - [illegible] Event (No Protection)

Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	798.71	65,928	798.72	66,106	0.01	177
Minimum Impact Location	1327581	803.80	66,011	803.81	65,808	0.01	-203
Oslo Gage	1416287	811.09	67,101	811.07	66,850	-0.02	-251
Grand Forks Gage	1558518	827.23	63,406	827.19	63,172	-0.04	-235
Thompson Gage	1667877	840.28	52,023	840.44	52,694	0.16	672
Halstad Gage	1981580	866.55	42,389	866.70	43,585	0.15	1,196
Maximum Impact Location (Hendrum)	2038409	870.62	38,264	870.86	39,350	0.24	1,085
Fargo Gage (13th Ave S, 12th Ave S)	2388223	899.77 (37.03*)	21,481	892.38 (29.64*)	10,291	-7.39	-11,190
US Diversion**	2531315	910.17	12,352	918.90	8,623	8.73	-3,729
Hickson Gage**	2563754	912.23	12,677	918.98	12,686	6.75	8
Abercrombie**	2764835	930.57	13,236	930.74	13,236	0.17	0

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

** Discharge does not include flow conveyed in the floodplain outside the main conveyance channel of the Red River

Table B-3

Summary HEC-RAS Unsteady Flow Model Results for Design Floods - Federally Comparable Plan

Minnesota Diversion (FCP) - [illegible] Event (No Protection)							
Location	Station	Existing No Protection		MN Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	804.12	168,364	804.27	170,409	0.15	2,045
Oslo Gage	1416287	813.88	152,851	813.95	157,374	0.07	4,523
Minimum Impact Location	1416400	814.23	152,852	814.29	157,375	0.06	4,522
Grand Forks Gage	1558518	836.36	146,225	836.72	150,748	0.36	4,523
Maximum Impact Location	1580152	839.75	102,174	840.20	104,725	0.45	2,551
Thompson Gage	1667877	850.69	112,422	850.93	115,330	0.24	2,908
Halstad Gage	1981580	871.54	101,754	871.72	104,334	0.18	2,580
Fargo Gage (13th Ave S, 12th Ave S)	2388223	905.8 (43.06*)	61,717	902.83 (40.09*)	30,044	-2.97	-31,673
US Diversion**	2470898	910.99	32,153	910.81	34,471	-0.18	2,319
Hickson Gage**	2563754	919.69	35,636	919.67	35,565	-0.02	-71
Abercrombie**	2764835	940.90	44,308	940.90	44,308	0.00	0

Minnesota Diversion (FCP) - [illegible] Event (No Protection)							
Location	Station	Existing No Protection		MN Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	801.73	119,255	801.92	122,945	0.19	3,690
Minimum Impact Location	1408098	811.34	113,281	811.39	116,227	0.05	2,946
Oslo Gage	1416287	813.01	113,556	813.09	116,500	0.08	2,944
Grand Forks Gage	1558518	832.97	107,980	833.35	112,047	0.38	4,067
Thompson Gage	1667877	847.35	82,926	848.11	88,519	0.76	5,593
Maximum Impact Location	1813905	860.78	75,611	862.01	81,907	1.23	6,296
Halstad Gage	1981580	869.09	71,581	869.68	80,624	0.59	9,043
Fargo Gage (13th Ave S, 12th Ave S)	2388223	903.86 (41.12*)	34,875	894.91 (32.17*)	11,756	-8.95	-23,119
US Diversion**	2470898	910.13	29,330	910.71	22,794	0.58	-6,536
Hickson Gage**	2563754	917.52	21,730	917.51	21,734	-0.01	3
Abercrombie**	2764835	935.62	23,000	935.62	23,000	0.00	0

Minnesota Diversion (FCP) - [illegible] Event (No Protection)							
Location	Station	Existing No Protection		MN Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	800.72	100,869	800.83	102,845	0.11	1,976
Oslo Gage	1416287	812.53	97,643	812.56	98,491	0.03	848
Minimum Impact Location	1448026	814.89	84,147	814.91	85,013	0.02	867
Grand Forks Gage	1558518	831.13	91,118	831.26	92,141	0.13	1,023
Thompson Gage	1667877	844.83	69,367	845.61	73,330	0.78	3,963
Maximum Impact Location	1829650	858.51	63,541	859.52	67,966	1.01	4,425
Halstad Gage	1981580	867.99	59,416	868.47	65,150	0.48	5,735
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.6 (39.86*)	29,167	894.02 (31.28*)	10,878	-8.58	-18,289
US Diversion**	2470898	909.54	27,658	909.4	27,987	-0.14	329
Hickson Gage**	2563754	916.34	18,898	916.37	18,925	0.03	27
Abercrombie**	2764835	934.48	20,726	934.49	20,726	0.01	0

Minnesota Diversion (FCP) - [illegible] Event (No Protection)							
Location	Station	Existing No Protection		MN Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	798.53	62,917	798.57	63,651	0.04	734
Minimum Impact Location	1410241	809.75	58,880	809.78	59,596	0.03	717
Oslo Gage	1416287	810.51	59,092	810.56	59,699	0.05	607
Grand Forks Gage	1558518	825.98	56,662	826.10	57,258	0.12	596
Thompson Gage	1667877	837.58	42,815	837.82	43,590	0.24	775
Halstad Gage	1981580	864.55	34,653	864.88	35,715	0.33	1,063
Maximum Impact Location	2236491	883.37	29,991	883.82	32,040	0.45	2,048
Fargo Gage (13th Ave S, 12th Ave S)	2388223	897.33 (34.59*)	17,024	892.66 (29.92*)	9,933	-4.67	-7,091
US Diversion**	2470898	904.54	16,759	904.71	17,329	0.17	570
Hickson Gage**	2563754	910.21	10,428	910.27	10,459	0.06	31
Abercrombie**	2764835	929.05	11,278	929.05	11,278	0.00	0

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

** Discharge does not include flow conveyed in the floodplain outside the main conveyance channel of the Red River

Table B-4

Summary HEC-RAS Unsteady Flow Model Results for Historic Floods - Federally Comparable Plan

Minnesota Diversion (FCP) - [illegible] Event (No Protection)							
Location	Station	Existing No Protection		MN Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	801.95	123,404	802.05	125,375	0.10	1,971
Oslo Gage	1416287	813.29	124,661	813.34	126,501	0.05	1,840
Minimum Impact Location	1425253	814.37	107,206	814.40	108,227	0.03	1,021
Grand Forks Gage	1558518	834.04	119,103	834.21	120,893	0.17	1,790
Thompson Gage	1667877	847.29	78,351	847.66	81,143	0.37	2,792
Maximum Impact Location	1813905	859.97	71,913	860.6	74,743	0.63	2,830
Halstad Gage	1981580	868.65	64,821	868.92	68,476	0.27	3,655
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.42 (39.68*)	27,574	894.1 (31.36*)	9,978	-8.32	-17,596
US Diversion**	2470898	908.85	23,779	908.94	25,235	0.09	1456
Hickson Gage**	2563754	913.85	13,729	914.00	13,738	0.15	10
Abercrombie**	2764835	931.08	13,995	931.08	13,995	0.00	0

Minnesota Diversion (FCP) - [illegible] Event (No Protection)							
Location	Station	Existing No Protection		MN Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	799.44	78,252	799.47	78,770	0.03	518
Oslo Gage	1416287	811.58	74,550	811.60	74,929	0.02	379
Minimum Impact Location	1448026	814.15	67,113	814.16	67,444	0.01	331
Grand Forks Gage	1558518	828.63	72,782	828.69	73,160	0.06	378
Thompson Gage	1667877	840.63	52,499	840.84	53,450	0.21	951
Halstad Gage	1981580	866.64	43,060	866.86	44,955	0.22	1,895
Maximum Impact Location	2058853	871.99	36,500	872.36	38,554	0.37	2,054
Fargo Gage (13th Ave S, 12th Ave S)	2388223	899.57 (36.83*)	21,028	893.15 (30.41*)	10,078	-6.42	-10,950
US Diversion**	2470898	906.81	20,782	906.53	20,782	-0.28	0.00
Hickson Gage**	2563754	913.11	14,313	913.15	14,352	0.04	39
Abercrombie**	2764835	931.58	15,027	931.58	15,027	0.00	0

Minnesota Diversion (FCP) - [illegible] Event (No Protection)							
Location	Station	Existing No Protection		MN Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	799.85	85,308	799.98	87,702	0.13	2,393
Minimum Impact Location	1410241	810.81	83,759	810.89	87,295	0.08	3,536
Oslo Gage	1416287	812.02	85,672	812.16	87,316	0.14	1,645
Grand Forks Gage	1558518	829.33	77,165	829.83	80,831	0.50	3,666
Thompson Gage	1667877	843.05	61,510	843.97	65,379	0.92	3,869
Maximum Impact Location	1789494	853.76	58,180	854.88	62,266	1.12	4,086
Halstad Gage	1981580	867.6	55,176	868.02	60,798	0.42	5,622
Fargo Gage (13th Ave S, 12th Ave S)	2388223	902.66 (39.92*)	29,234	894.03 (31.29*)	11,964	-8.63	-17,270
US Diversion**	2470898	909.61	28,395	909.47	27,912	-0.14	-483
Hickson Gage**	2563754	917.76	24,393	917.75	24,407	-0.01	14
Abercrombie**	2764835	937.51	28,176	937.51	28,176	0.00	0

Minnesota Diversion (FCP) - [illegible] Event (No Protection)							
Location	Station	Existing No Protection		MN Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	798.71	65,928	798.76	66,687	0.05	759
Oslo Gage	1416287	811.09	67,101	811.11	67,463	0.02	363
Minimum Impact Location	1467237	815.28	66,433	815.30	66,870	0.02	437
Grand Forks Gage	1558518	827.23	63,406	827.29	63,783	0.06	377
Thompson Gage	1667877	840.28	52,023	840.55	53,139	0.27	1,116
Maximum Impact Location	1829650	853.73	49,914	854.1	51,122	0.37	1,208
Halstad Gage	1981580	866.55	42,389	866.76	43,888	0.21	1,499
Fargo Gage (13th Ave S, 12th Ave S)	2388223	899.77 (37.03*)	21,481	893.37 (30.63*)	10,231	-6.40	-11,250
US Diversion**	2470898	906.89	20,427	906.8	21,469	-0.09	1043
Hickson Gage**	2563754	912.23	12,677	912.42	12,697	0.19	20
Abercrombie**	2764835	930.57	13,236	930.57	13,236	0.00	0

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

**Discharge does not include flow conveyed in the floodplain outside the main conveyance channel of the Red River

FARGO MOORHEAD METRO FEASIBILITY STUDY

UNSTEADY FLOW MODELING

DISTRICT QUALITY CONTROL (DQC) AND AGENCY TECHNICAL REVIEW (ATR) COMMENTS

Reviewer	District	Review Type	#	Date of Comment	Comments	Initial Response	Final Response
Malcolm Dove	MVK	DQC	1	31-Aug-2010	The downstream water level increases that are related to storage area routing can be refined with a sensitivity analysis and possibly with a modified diversion routing approach. RAS model testing is under way, and Mr. Malcolm Dove at CEMVK-ED-H is POC for this information.	Storage connection and lateral structure weir coefficients were adjusted as part of a Sensitivity Analysis. The impacts on the model results are small as outlined in the attached sensitivity analysis results.	The sensitivity analyses are documented in Attachment 5, Appendix B (Section B3.5.3, Exhibit F, and Exhibit G).
Mike Alexander	MVK	DQC	2	31-Aug-2010	A LIDAR data set is available for the study drainage basin that may allow a quick 2-dimensional flow routing model that uses the overbank bathymetry instead of a storage area concept. Two-dimensional modeling development, time and cost, and solution quality assessments are also being prepared at MVK. POC for this effort is Mr. Mike Alexander at CEMVK-ED-HH.	No Response.	Due to the importance of detailed road and culvert information and considering the extent of the model, it was decided that a 2-D model is not practical at this time.
Aaron Buesing	MVP	DQC	3	31-Aug-2010	Consider going through all HTab parameter settings. By making sure the curves don't go too much higher than the highest expected energy elevation and using a higher number of points (up to 100), the increment can be reduced. This might improve storage accounting. Reducing the increment of hydraulic property curves could help model stability, if that's been an issue, but it also could hurt.	H-tab - cross sections, bridge, culvert, inline structures, Storage Area Connections have been adjusted. Elevations were set based on 0.2-percent chance event +5 feet. Increments were set at the maximum (100).	No further reponse.
Aaron Buesing	MVP	DQC	4	31-Aug-2010	SA Conn:BufSC26: A value of 10000, which I think is meant to be the Max Flow (Recommended), has been entered as the Tail water maximum elevation (optional).	This has been revised.	No further reponse.
Aaron Buesing	MVP	DQC	5	31-Aug-2010	Pan through all of the Hydraulic Property Tables plots (cross-sections, internal boundaries, storage area connections) to see if anything else looks strange. That's how the SA Conn:BufSC26 issue was discovered. Do #3 above first so you limit these plots to the real range of interest - right now you'll find some strange looking plots, but the elevations where the curves are strange are well above the 500-yr maximum water surface elevation.	Response to Comment # 3 was completed, and additional QC was performed.	No further reponse.
Aaron Buesing	MVP	DQC	6	31-Aug-2010	The flooded outlines suggest that additional sections between Georgetown and Shelly should be added as storage areas to the HEC-RAS model. It also may make sense to convert the outer portion of a few cross-sections in this area to storage areas.	The 1-percent chance event ND Diversion and 0.2-percent chance event Existing Conditions flood outlines were mapped to identify the floodplain extent. Storage areas were added, where necessary, to ensure the model encompasses the full floodplain.	No further reponse.
Aaron Buesing	MVP	DQC	7	31-Aug-2010	The possibility of water being moved too fast through connected storage areas was discussed internally and Mark Jensen (HEC) was also consulted. Water moving too fast certainly could be an issue for inundated storage areas where flow can go out as fast as it can come in (level pool routing would govern, which would move water too fast). However, the timing of water going into and out of storage should be good. If the modeler does a good job deciding what should be modeled in the cross-section data and what should be modeled as a storage area, the model will probably will do a good job on timing, but obviously that isn't always easy to do - sensitivity analyses are good. Mark Jensen suggested lowering storage area connection weir coefficients as a means to slow the movement of the flood wave through storage areas, thereby performing a sensitivity analysis. HEC is working on implementing 2d diffusion wave routing for storage areas in HEC-RAS, but this is still a few months away. HEC will be asked to see if there's any possibility of making this model a test case for the 2d diffusion wave routing effort. As seen from MVK's comments, storage routing is an issue being investigated by both MVP and MVK.	Storage Area Connection weir coefficients and Lateral Structure weir coefficients have been analyzed for Existing Conditions and ND Diversion for the 1-percent chance flood with coefficients = 1.5, 2.0, 2.6 and 3.0 depending on the location. The impacts on the model results were minimal as outlined in the attached sensitivity analysis.	The sensitivity analyses are documented in Attachment 5, Appendix B (Section B3.5.3, Exhibit F, and Exhibit G). The HEC-RAS 2-D diffusive wave functionality is not far enough along to be used for this study.
Aaron Buesing	MVP	DQC	8	2-Sep-2010	There are sections along the ND diversion, outside the area of protection, that are modeled as storage areas for existing conditions but are not modeled for the ND diversion alternative.	Storage areas were added west of the ND Diversion alignment. This allows hydrology to be inserted in the same location for existing conditions and with project conditions. A weir will need to be developed to convey water into the diversion and it is anticipated that existing conditions flood elevations will be maintained.	No further reponse.
Aaron Buesing	MVP	DQC	9	2-Sep-2010	There are sections modeled as storage areas along the ND diversion, outside the area of protection, that are not connected to the diversion via a lateral weirs. Allowing water into these section from the diversion may increase available storage and possibly slow down the progression of the hydrograph.	Original assumptions didn't include any water to breakout of the diversion once it was in. As noted in the response to comment 8, the need for additional storage areas for both existing and with-project conditions has been reviewed and additional storage areas have been added to the model for both conditions. Storage areas have been added along the diversion near the Rush River as well as between the Sheyenne River and Maple River.	No further reponse.
Malcolm Dove	MVK	DQC	10	7-Sep-2010	Model, General: If the existing model geometry had been structured such that the flowlines from the existing model could be plotted against the ND-Diversion and the MN-Diversion output, it would have been more obvious where the effects of increased flows as well as hydrograph timing were occurring.	Dummy reaches would need to be incorporated into the existing conditions model as well as each of the diversion models to allow common reach names. This would likely cause additional model instability. It is not anticipated that this would be done. It would however, be advantageous to view all of profiles simultaneously.	No further reponse.

FARGO MOORHEAD METRO FEASIBILITY STUDY

UNSTEADY FLOW MODELING

DISTRICT QUALITY CONTROL (DQC) AND AGENCY TECHNICAL REVIEW (ATR) COMMENTS

Reviewer	District	Review Type	#	Date of Comment	Comments	Initial Response	Final Response
Malcolm Dove	MVK	DQC	11	7-Sep-2010	Model, Diversion Channels: It is noted that the ND and MN Diversion channels have n-values of 0.030 which is relatively smooth for an earth lined channel. Normally the roughness coefficient for a newly constructed channel increases with age and a plan should be designed on what will be expected in the future. It is good to look at other aged cut channels that have deteriorated and use n-values similar to those channels. The Sheyenne Diversion (Existing condition) has assigned n-values of 0.040, which would probably be in the range of the ND-Diversion channel or the MN-Diversion channel after it has aged.	A sensitivity analysis was performed using n-values of 0.035 and 0.040. The impact on the model results was minimal as noted in the attached sensitivity analysis. Based on a review of similar projects, such as the Winnipeg Diversion, an n-value of 0.030 seems appropriate.	The sensitivity analyses are documented in Attachment 5, Appendix B, Exhibit F.
Malcolm Dove	MVK	DQC	12	7-Sep-2010	Hydrology, General: Timing of the flood hydrographs in a plan of this type can result in misleading stage increases. Sensitivity analysis is important in determining the final answer concerning how flood flow attenuates within a river reach.	Sensitivity of hydrograph timing such as the Elm River was completed during calibration and model development. It is an issue and we saw localized diversion impact differences. More information is needed on the timing and pattern of the significantly large drainage area of the Elm River. Gaging data from the USGS during the spring 2010 flood event has provided some guidance on timing. Additional sensitivity of tributary timing/contributions from the Sheyenne/Maple/Buffalo River watersheds was performed as part of a sensitivity analysis. The impact on the model results was small as noted in the attached sensitivity analysis results	The sensitivity analyses are documented in Attachment 5, Appendix B, Exhibit F.
Malcolm Dove	MVK	DQC	13	7-Sep-2010	Hydrology, Maple River: It is noted that the flow file for Maple River at the upper end (Sta 36989) uses a file from the MAPLE RIVER/MOUTH/FLOW /BALANCED HYDROGRAPHS.dss file for the 100year frequency plan. It is not clear if this flow was computed for the total stream above the mouth or above Sta 36989. This should be clarified.	There is a minor drainage area between the mouth and upper end of the model. It was assumed it would be negligible. This would be better defined with detailed hydrology review of Sheyenne/Maple Rivers and the expansion of the model geometry along the Lower Sheyenne and Maple Rivers which is ongoing (see response to Comment 8). See also the response to Comment 12.	The HEC-RAS was updated based on the revised hydrologic information found in Appendix A, which includes local flow for the reach in question.
Malcolm Dove	MVK	DQC	14	7-Sep-2010	Hydrology, Maple River: Under the existing condition 100-year plan, there is an additional flow that was entered at Sta. 7823 that comes from the flow hydrograph of the Sheyenne River above the mouth of the Maple River. It is noted that this hydrograph (Existing condition) is reduced to 0.525 of the Sheyenne River and produces a peak inflow of 7500cfs. Then in the ND-Div plan, the Sheyenne River hydrograph is increased to 1.05 and entered uniform from Sta. (33749 to 29611) and produces a peak inflow of 16080 cfs on 1 April. This results in the following changes (The peak time of the hydrograph is changed from 3April-1200hrs at Sta. 36989 to 2April-at the junction of the ND Diversion). This should be reconsidered due to the increase in inflow and the fact that the peak stage in the reach is over a foot higher for the ND Diversion plan than the Existing Condition plan. This would result in more flooding along the Maple River.	Existing Conditions Upper end of Maple River RS 36989 = 12,500 cfs. This is the same for both plans. Upper end of Sheyenne River - RS 232811 = 4,600 cfs. This is the same for both plans. The Sheyenne River Channel only allows 4,600 cfs to be contained in the channel upstream of Horace (near Sheyenne and Sheyenne Diversion). Everything else breaks out of channel. The breakout flows are approximately 15,000 cfs and they re-enter the system near the Maple/Sheyenne confluence. This comes down to a level of detail in the model. Upstream of the Maple/Sheyenne confluence everything floods out on large events. Instead of placing the entire hydrograph on the Maple River, we placed half of it along the Maple and half of it along the Sheyenne at nearly the same location. When the ND Diversion becomes active, it wouldn't seem appropriate to place the inflow on both the Maple and the Sheyenne. Therefore the entire hydrograph was placed on the Maple River. This creates issues with containing the large hydrograph. For the purposes of the model, the hydrograph was to be inserted, a set amount sent downstream on the Maple, and the remaining hydrograph was to be sent down the diversion. Additional storage areas could be placed west of the diversion, but if this attenuates the peak on existing conditions, we would have to increase the inflow hydrographs to maintain our Red River calibration hydrograph downstream of the Buffalo River. Breakout Flows - Existing Conditions Maple River RS 7823 - Multiplier Ratio = 0.525 Sheyenne River RS 108266 -	The entire Sheyenne/Maple drainage system from their confluence upstream to where they enter Glacial Lake Agassiz has been added to the unsteady HEC-RAS model. Therefore all breakout flows out of the Sheyenne and Maple Rivers are routed downstream through storage areas and intervening ditches. Also the coincident flow hydrology has been updated. The hydrology is documented in Appendix A. The updated HEC-RAS model and results are documented in Attachment 5, Appendices B, C, and F.

FARGO MOORHEAD METRO FEASIBILITY STUDY

UNSTEADY FLOW MODELING

DISTRICT QUALITY CONTROL (DQC) AND AGENCY TECHNICAL REVIEW (ATR) COMMENTS

Reviewer	District	Review Type	#	Date of Comment	Comments	Initial Response	Final Response
Malcolm Dove	MVK	DQC	15	8-Sep-2010	I have read and understand the response to comment #14, however after our conference call this morning (Aaron Buesing, Mike Alexander and myself) I feel I need to address Greg's comments in more detail. Normally when flow (15000cfs) as stated breaks out of banks and goes into storage it rarely comes back into the stream as a peak flow of 15000cfs. It has to come back overbank when the channel water elevation has receeded to allow it or it re-enters downstream through a side channel when the difference in water surface in the main channel and tributary allow it. It is noted that under the existing condition scenario there is an approximate 50-50 split in the 15000 cfs between Maple River and Sheyenne River, however, under the ND Diversion plan the total peak flow of 15000cfs is entered into the Maple River between station 33749 to 29811. The reality of this much flow entering back into the river when the water surface elevation is already above top bank and spread out over an approximate mile wide cross-section needs to be re-analyzed. Forcing the flow into the channel results in a total flow of about 29000cfs being pushed into the diversion in a relatively narrow opening. It is understood that this project is on a short schedule, however the study should keep this area in mind on how this overbank flow will be handled in the future detailed studies.	Agreed. The hydrology is being refined and more geometry is being developed (PIE Model) to route the hydrographs and breakout flows through the Sheyenne and Maple reaches. As discussed in previous conference calls, if the flows are attenuated through storage/routing, which I also believe they should be, then additional water needs to be added for all scenarios to re-build the hydrograph to match on the Red River downstream of the Buffalo River. Sensitivity analysis was performed as outlined in the response to comment 12 and additional model geometry is being added along the lower Sheyenne and Maple Rivers as outlined in the response to comment 8. Additional refinement will need to be done as part of final design.	The entire Sheyenne/Maple drainage system from their confluence upstream to where they enter Glacial Lake Agassiz has been added to the unsteady HEC-RAS model. Therefore all breakout flows out of the Sheyenne and Maple Rivers are routed downstream through storage areas and intervening ditches. Also the coincident flow hydrology has been updated. The hydrology is documented in Appendix A. The updated HEC-RAS model and results are documented in Attachment 5, Appendices B, C, and F.
Roger Kay	NWO	ATR	16	8-Sep-2010	"2009 Model" Folder RAS: I am curious as to why the model (2009 FP) was calibrated to discharge, rather than stage at measured gage locations (at least it seems to be, as results are presented showing the match in discharge, rather than stage)? The measurements of stage are nearly always more accurate than measurements and estimations of discharge, which is why the HEC-RAS Users Manual suggests calibrating an unsteady model to stage, rather than discharge. A quick comparison of actual discharge to measured discharge at the downstream model boundary seems to show too high of a peak discharge compared to measured (~10,000 cfs), although total volume matches within ~3%. This may indicate that the model is too smooth, leading to flows reaching downstream portions of the model too soon, which may lead to increased stages for the design conditions (although this may be at least partially tied to the use of a rating curve for the downstream boundary condition – see comment below).	The model was calibrated to both stage and discharge. The 2009 discharge at Halstad was 67,300 cfs. The discharge at Thompson was 61,100 cfs. This includes adding the Marsh River, Goose River, Sandhill River, and local ungagged drainage areas. We couldn't get the model to reflect this discharge reduction. When the model was extended downstream to Drayton, ND, the 2009 calibration includes an "S" curve to reflect real discharge reduction upstream of Thompson. The Thompson gage hydrograph matches Grand Forks with reasonable local inflows.	The calibration effort involved stage and discharge calibration. The calibration effort is described in Attachment 5, Appendix B (Section B5.0 and Exhibits A - D).
Roger Kay	NWO	ATR	17	8-Sep-2010	"2009 Model" Folder RAS: Using a rating curve for the downstream boundary condition on an unsteady HEC-RAS model is probably more appropriate if there is a control structure at the downstream boundary (such as a weir or gated structure). Using the rating curve prevents the "looped" rating curve from being duplicated, and this effect propagates some distance upstream. Please be certain to ascertain how far up from the downstream boundary that results should not be used to determine differences between with- and with-out project conditions profiles. A better solution would be to extend the model far enough downstream of the area of interest, such that the boundary condition assumed has no impact on computed profiles for the area of interest. This may end up an iterative process.	Subsequent to the July 30, 2010 submittal, the model has been extended farther downstream to near Drayton, ND. The impact on the model results at Thompson as a result of this extension was small.	Stage impacts are essentially the same for at least the downstream-most 67 river miles of the HEC-RAS model (stage impacts vary from 0.04 to 0.08 feet along that reach). Based on this, we feel it is safe to assume that the rating curve boundary condition is affecting stage impact results at the boundary by no more than a few hundreths of a foot. This effect is on the order of the HEC-RAS calculation tolerances and is therefore considered negligible. The absolute stage values at the boundary may be off by a greater degree, but the concern are stage impacts, not absolute values.
Roger Kay	NWO	ATR	18	8-Sep-2010	"2009 Model" Folder RAS: Need to keep bank stations at bank stations – e.g. x-sec 1939454 has "n" value of 0.04 from Sta. 19332.06 to 19569.7, but bank stations from Sta. 19306.08 to 19637.6; the "n"-value between Sta. 19306.08 and 19332.06 and between 19569.7 and 19637.6 is 0.1, which seems to be too high for this channel. A cursory review of this location in Google Earth shows a channel that is about 230 feet wide, bank to bank, not 330 feet. A previous comment addressed cross-sections where the bank stations were being placed incorrectly, as it does impact the calculations in RAS. A review of other cross-sections shows this to be an issue at a large number of cross-sections. Please ensure that all cross-sections use an appropriate station for the bank stations and that the "n"-value for the channel itself does not contain areas of high "n"-values.	During calibration and after the first round of comments, the bank stations were evaluated and the n values were verified for the model reach to Halstad, MN. Model extension from Halstad to Thompson and from Thompson to Drayton utilized existing USACE model geometry that was incorporated with little revision to the geometry. See also the response to comment 19. Additional review and detail will be added to the model reach downstream from Halstad as part of the future modeling work that is planned.	Bank stations and Manning's n values were re-evaluated and adjusted where deemed appropriate. The revised models are documented in Attachment 5, Appendices B, C, and F. The study contractors have completed an extensive independent QA/QC effort that is documented in Attachment 5, Appendix C (Sections C2.15 and Exhibit 5).

FARGO MOORHEAD METRO FEASIBILITY STUDY

UNSTEADY FLOW MODELING

DISTRICT QUALITY CONTROL (DQC) AND AGENCY TECHNICAL REVIEW (ATR) COMMENTS

Reviewer	District	Review Type	#	Date of Comment	Comments	Initial Response	Final Response
Roger Kay	NWO	ATR	19	8-Sep-2010	"2009 Model" Folder RAS: Remember that a cross-section is supposed to be representative of the floodplain and channel from a point midway between the upstream and downstream cross-section. Again, going to x-sec 1939454 as an example – the area adjacent to the channel has an "n"-value of 0.1, which appears to be representing an area of trees. These areas are 73 feet wide at the left bank and 83 feet wide at the right bank. These distances seem reasonable for the actual location of the cross-section. However, this seems to be about the minimum width for trees adjacent to the channel within the reach this cross-section should be representing; the maximum width of tree coverage on either bank is several times greater. The same appears true for a majority of the cross-sections, at least in the lower portion of the model, as they seem to be located at areas where trees do not extend very far from the channel. Whether this cross-section arrangement was by design or chance, it will have an impact on the model and how it replicates measured water surfaces, but more importantly, may be making the model too smooth, and thereby not attenuating flows quite as much as they should. I would suggest that you carefully determine an average width of tree area next to the	The original model development was downstream to Halstad. Model geometry, calibration, and synthetic event calibration for 10, 50, 100, and 500 year events from Halstad to Thompson occurred in a very short time frame less than 2 weeks. It was understood that the downstream reaches would have less detail and less review prior to using. The reaches from Thompson to Drayton (not included in this review) were obtained from the USACE from previous studies. Additional review and detail will be added to the model reach downstream from Halstad as part of the future modeling work that is planned.	Bank stations and Manning's n values were re-evaluated and adjusted where deemed appropriate. The revised models are documented in Attachment 5, Appendices B, C, and F. The study contractors have completed an extensive independent QA/QC effort that is documented in Attachment 5, Appendix C (Sections C2.15 and Exhibit 5).
Roger Kay	NWO	ATR	20	8-Sep-2010	"2009 Model" Folder RAS: In the 2009 calibration model, there are a number of storage areas that have water surface elevations rising/falling that do not appear to be connected to the change in stage on riverine reaches; rather, they appear to be due to improperly set initial conditions. It doesn't appear that any of these would have a significant impact on the final solution, but all initial conditions should be double-checked.	Some rivers or storage areas needed higher flows or starting WSEs to provide stable initial starting conditions. It is anticipated that this goes away prior to the event hydrograph and does not create any impact on the results. They will be revised if time permits.	Starting water surface elevations for the storage areas were reviewed and set to minimize unrealistic water surface elevations at the beginning of the simulation. For model stability some initial water surface elevations are still set somewhat high, but this does not have a significant impact of the model results.
Roger Kay	NWO	ATR	21	8-Sep-2010	"2009 Model" Folder RAS: Some cross-sections appear to be incorrectly described with "n"-values. For instance, from x-sec 2129130 to 2129181, there is only one or two "n"-values for the entire section, with the channel being far rougher than the x-secs upstream or downstream.	This is an error and has been changed.	No further reponse.
Roger Kay	NWO	ATR	22	8-Sep-2010	"2009 Model" Folder RAS: The elevations of some bank stations seem excessively high compared to nearby cross-sections; e.g. x-sec 1986219 has bank elevations more than 20 feet higher than nearby cross-sections. Please verify that the banks are being defined in the proper location at each cross-section.	All cross sections in the primary model (downstream to Halstad) were reviewed at one time. Cross Section 1986219 has been changed as it was missed originally.	Bank stations and Manning's n values were re-evaluated and adjusted where deemed appropriate. The revised models are documented in Attachment 5, Appendices B, C, and F. The study contractors have completed an extensive independent QA/QC effort that is documented in Attachment 5, Appendix C (Sections C2.15 and Exhibit 5).
Roger Kay	NWO	ATR	23	8-Sep-2010	"2009 Model" Folder RAS: The MN Diversion and ND Diversion plans were delivered without up-to-date results. After correcting some missing DSS links in the unsteady flow files, neither plan ran to completion – the ND Diversion plan went unstable after 4½ hours simulation time, while the MN Diversion plan ran to the end of simulation, but hung up on the post-processing. It is unfortunate that the models supplied do not run to completion, as that lowers my confidence in their use in modeling design flows. Please ensure that the most recent model results are sent for review, and that all plans run without bombing out.	We ran into this during model calibration and runs. However, all of the models did have a successful run through completion. HEC was contacted about the post processing error and stated that there was a bug in the programming and the model went into an unrecoverable loop. They also stated that it wouldn't be fixed until the next version which is a long ways out.	No further reponse.

FARGO MOORHEAD METRO FEASIBILITY STUDY

UNSTEADY FLOW MODELING

DISTRICT QUALITY CONTROL (DQC) AND AGENCY TECHNICAL REVIEW (ATR) COMMENTS

Reviewer	District	Review Type	#	Date of Comment	Comments	Initial Response	Final Response
Roger Kay	NWO	ATR	24	8-Sep-2010	"10yr Model" folder (and other "X-yr Model" folders): Be sure to check for model instabilities – view animated profiles for various reaches. For instance, on the "MN DIV SHORT DNS" reach, the water surface inexplicably rises in the lower portion of the model at time step 23Mar2006 2400 hrs, then quickly lowers. Further upstream, in the lower portion of the "MN DIV SHORT EXT" reach, there is a large drop in water surface for much of the duration of the simulation, and a large drop in water surface at near maximum profiles. Also be sure to use the general profile plots and animate them for various variables to troubleshoot problem areas – for instance, on the same reach as above, the top widths show rapid expansion and contraction, which indicates that some encroachments may be necessary along the diversion reach. There are a great number of areas that I would suggest investigating for making model changes, but given the quick turn-around on this review, I was not able to "play around" with the model to see what those changes may do. Please verify that results make sense throughout the course of the simulation, not just the maximum water surface, as this can have an impact on movement of water through the system, and may lead to under- or over-stating the downstream impacts of the project.	This is a result of the short timeline of the project. The diversion geometry was created with the steady state model. Several iterations of model geometries have been received as the design parameters and hydrology have changed. The turn around time on inserting the geometry and re-running the unsteady flows (10, 50, 100, 500 year events) was a week to two weeks on average. Results were required in such a short time, we had enough time to get the model to run and verify that the discharges seemed reasonable. "the water surface inexplicably rises in the lower portion of the model" This issue presents itself and then goes away one interval later. Profiles were reviewed and used for diagnosis. This is very isolated and does not seem to be an issue. Further upstream, in the lower portion of the "MN DIV SHORT EXT" reach, there is a large drop in water surface for much of the duration of the simulation, and a large drop in water surface at near maximum profiles. This Channel Extension comment is not applicable. The channel extension was in the geometry from the beginning of the project, but as shown in the model results discharges 190 cfs. It was identified that the channel extension was not needed anymore for capacity and with the given timeline was easier to leave it in with minimal flows to provide model stability than completely remove it. Final adjustments can be made to the model with final design once a single plan is selected.	The study contractors have completed an extensive independent QA/QC effort that is documented in Attachment 5, Appendix C (Sections C2.15 and Exhibit 5).
Roger Kay	NWO	ATR	25	8-Sep-2010	"10yr Model" folder (and other "X-yr Model" folders): Be sure to check inflow and outflow volumes at all boundary conditions to be sure the same volume is passing out of the model as coming into the model. A quick check of the downstream boundary condition shows 2.4% more volume of flow for the MN diversion, compared to the existing conditions, while the ND diversion only has 0.2% more flow volume (10-yr). For the 100-yr condition, the MN diversion shows 1.3% more flow volume and the ND diversion 0.8% more flow volume than the existing condition. Since balanced hydrographs are being used, I would have expected the flow volumes to be closer, especially for the two diversion alternatives, unless the simulation is leaving considerably more flow in storage areas for the various plans (although a spot check of various storage areas did not reveal any with significant storage at the end of simulation) or there are differing amounts of storage at simulation start.	The volumes at the downstream end have continuously been checked throughout modeling. One thing to consider is that the diversion reaches need water in them in order to remain stable, therefore just placing the diversion geometries in the model require additional volume to be added to the system. With that being said 1-2% additional volume has been assumed to be acceptable. We did also check to verify if any water is remaining in the system.	No further reponse.
Roger Kay	NWO	ATR	26	8-Sep-2010	"10yr Model" folder (and other "X-yr Model" folders): There is no channel ice for any of the design conditions. Please be sure to include ice impacts on assessing with- and with-out project conditions (as discussed previously).	This will be addressed during final design.	Ice studies have not been completed, but a preliminary ice assessment is provided at Attachment 5, Appendix F, Exhibit J. Retaining ice upstream of the structures appears feasible due to the low velocities. The impact of having less flow through the area of protection has yet to be determined.
Roger Kay	NWO	ATR	27	8-Sep-2010	"10yr Model" folder (and other "X-yr Model" folders): Be sure to double-check initial conditions for all storage areas – a spot-check of various storage areas shows multiple storage areas that experience a foot or more of change in water surface in the first 12 hours of simulation. This may have an impact on total volume passed out of the model and water surfaces in the first few days of simulation. As an example, refer to X-Sec 82415 on Wild Rice ND and SA WRSA 300 – note how flows in the river do not correspond with the input hydrograph for this reach for several days (noted in 10- and 100-yr models, did not check other models for this, but likely present as well).	This can be reviewed further. Again, it comes down to a level of detail and time constraint to review all of the initial conditions that don't present issues during the event hydrograph. It does not seem to impact the results and will be addressed with final design.	Starting water surface elevations for the storage areas were reviewed and set to minimize unrealistic water surface elevations at the beginning of the simulation. For model stability some initial water surface elevations are still set somewhat high, but this does not have a significant impact of the model results.
Roger Kay	NWO	ATR	28	8-Sep-2010	"10yr Model" folder (and other "X-yr Model" folders): What differences in the 3 geometries (Existing, MN Diversion, ND Diversion) exist between the 10-, 50-, 100-, and 500-yr models? I did a spot-check of various cross-sections, storage areas and structures, and nothing jumped out at me, but it was not possible to compare everything. If there are no differences in geometry, then the different flow events should be in one project to make comparisons easier between flow events. If there are differences, please list them, and why they are necessary.	Very minimal changes. The 50-year and 100-year are identical. The 10-year required additional tweaking where tributaries are connected to "ease" the transitions, especially on the diversions where the diversion channel is well above the Red River channel. The 500-year geometry required storage areas WRSA348 and WRSA349 to be removed and simplified. The geometries will be combined.	The final feasibility study models have identical geometries for the 10-, 50-, 100-, and 500-yr models.

FARGO MOORHEAD METRO FEASIBILITY STUDY

UNSTEADY FLOW MODELING

DISTRICT QUALITY CONTROL (DQC) AND AGENCY TECHNICAL REVIEW (ATR) COMMENTS

Reviewer	District	Review Type	#	Date of Comment	Comments	Initial Response	Final Response
Roger Kay	NWO	ATR	29	8-Sep-2010	"10yr Model" folder (and other "X-yr Model" folders): Model should be extended further downstream, given the magnitude of differences at the current downstream boundary, to verify that increases in water surface do not negatively impact existing flood protection projects that are currently certified against the 100-yr flood. Additionally, the downstream boundary condition should not use a rating curve, but rather a normal depth condition, and be sufficiently downstream of the area of concern so that profiles are not impacted by the assnmption for downstream boundary condition.	Subsequent to the July 30, 2010 submittal, the model has been extended farther downstream to near Drayton, ND. The impact on the model results at Thompson as a result of this extension was small.	No further reponse.
Roger Kay	NWO	ATR	30	8-Sep-2010	General Comment: The model geometry is quite extensive. Due to the extensive nature of the model, it was not possible to review all aspects of the model in the time allotted. There may be substantial issues with the model not presented in these comments.	Agreed. Due to the extensive nature of the model and the given time constraints, it was and is not possible to review every detail of the model. The internal review during calibration and model development has identified issues and trends within the model that have been identified for significance and dealt with in determining how they may affect the downstream impacts. With the given time allowed for the project, it is not anticipated that the review comments will have significant impacts on the results.	The study contractors have completed an extensive independent QA/QC effort that is documented in Attachment 5, Appendix C (Sections C2.15 and Exhibit 5).
Roger Kay	NWO	ATR	31	8-Sep-2010	General Comment: For model review, it would be preferable to maintain directory structure, so that the reviewer can rerun various plans without having to reconnect various DSS files that are in different locations than originally run.	All dss files were available. The next submittal will include all .dss files combined into one.	The directory structure now allows for the model to be transferred and run without loss of DSS file connections.
Roger Kay	NWO	ATR	32	8-Sep-2010	General Comment: The invert profiles for the diversion plans are exceptionally flat – on the magnitude of ½- to 1-foot per mile. While this is not overly flat for a naturally occurring stream, it seems extremely flat for a constructed channel, at least as far as maintaining positive grade throughout the entire reach during construction. This could lead to maintenance issues, as low spots will likely retain local runoff and develop more "wetland"-type vegetation. Additionally, I see no mention of a sediment analysis to assess the long-term diversion channel morphology. While the geometries presented are not overly optimistic for constructed conditions (i.e. assumption seem reasonable for roughness, geometry, etc), I think long-term performance of the project needs a closer look, so as to evaluate project performance over the life of the project. This may show an increased need for O&M over that assumed, which may impact project BCR.	Will likely be evaluated with final design. Not a hydraulic issue	A report on sediment transport and geomorphology is included as Attachment 5, Appendix F, Exhibit I. Based on the study effort to date, significant sedimentation in the diversion channel is not expected. The final geomorphology study is expected to be complete in late 2011.
Roger Kay	NWO	ATR	33	8-Sep-2010	General Comment: Timing of tributary flows has the potential for a major impact on the difference between with- and with-out diversion project water surface profiles downstream of the diversion. How much work was put into assessing the sensitivity of the model to the tributary flow timing? It may be wise to assess project performance assuming a "worst-case" and "best-case" scenario for timing of the balanced hydrographs, based on the historic record, if this has not already been done.	The tributary hydrographs have been reviewed especially locations downstream of the diversion reaches (Elm River). The timing has shown to have an impact on downstream results. Additional hydrology support would be required for this task. Or a sensitivity could be applied by shifting local inflows around. One thing to keep in mind is... If the Elm River is shifted a day earlier or later, something else must be justified to be shifted to fill the remaining portion of the balanced hydrograph just downstream at Halstad. Additional sensitivity analysis was performed as outlined under the response to Comment 12 and the model response to the changes was small.	The sensitivity analyses are documented in Attachment 5, Appendix B, Exhibit F. The entire Sheyenne/Maple drainage system from their confluence upstream to where they enter Glacial Lake Agassiz has been added to the unsteady HEC-RAS model. Therefore all breakout flows out of the Sheyenne and Maple Rivers are routed downstream through storage areas and intervening ditches. Also the coincident flow hydrology has been updated. The hydrology is documented in Appendix A. The updated HEC-RAS model and results are documented in Attachment 5, Appendices B, C, and F.
Roger Kay	NWO	ATR	34	8-Sep-2010	General Comment: Some comments presented here (e.g. #18) are similar to comments made previously, but do not appear to have been completely addressed throughout the model. Also, there are several issues raised in comments above that lead me to think the model may be passing flows downstream a little too quickly, thereby overstating the with-project impacts on computed water surface. However, there are also some issues that may be causing the model to understate impacts – it is impossible to evaluate without making extensive (and careful) changes. Even though this project has been on a fast-track schedule, it is important to address modeling issues (and in a consistent manner), as they may have substantial impact on the final answer. It has been my experience that a good answer that is late is almost always preferable to a bad answer that is on time.	We agree with this comment. Additional sensitivity analysis is being performed, mainly, 1. Weir coefficients for storage connections and lateral structures. 2. Need for additional storage areas downstream from diversion outlet. 3. Need for storage areas/connections along the ND Diversion Channel. 4. Diversion Channel Roughness Coefficients. 5. Timing of hydrographs for tributaries including the Sheyenne/Maple/Buffalo/Elm River and local inflows. The results fo the sensitivity analysis that have been performed to date are attached. Overall, the sensitivity analysis shows the impact of these changes on the downstream impacts is small. The work related to the storage area/connectsions and flow distribution along the lower Sheyenne and Maple Rivers is ongoing.	The sensitivity analyses are documented in Attachment 5, Appendix B (Section B3.5.3, Exhibit F, and Exhibit G).

FARGO MOORHEAD METRO FEASIBILITY STUDY							
UNSTEADY FLOW MODELING							
DISTRICT QUALITY CONTROL (DQC) AND AGENCY TECHNICAL REVIEW (ATR) COMMENTS							
Reviewer	District	Review Type	#	Date of Comment	Comments	Initial Response	Final Response
Roger Kay	NWO	ATR	35	8-Sep-2010	General Comment: In spite of what some of my comments may suggest, I think overall the work done to date with the HEC-RAS modeling has been tremendous given the time constraints, as this is a highly complex model. I will be very interested in seeing what the final model shows for results.	-	No further reponse.

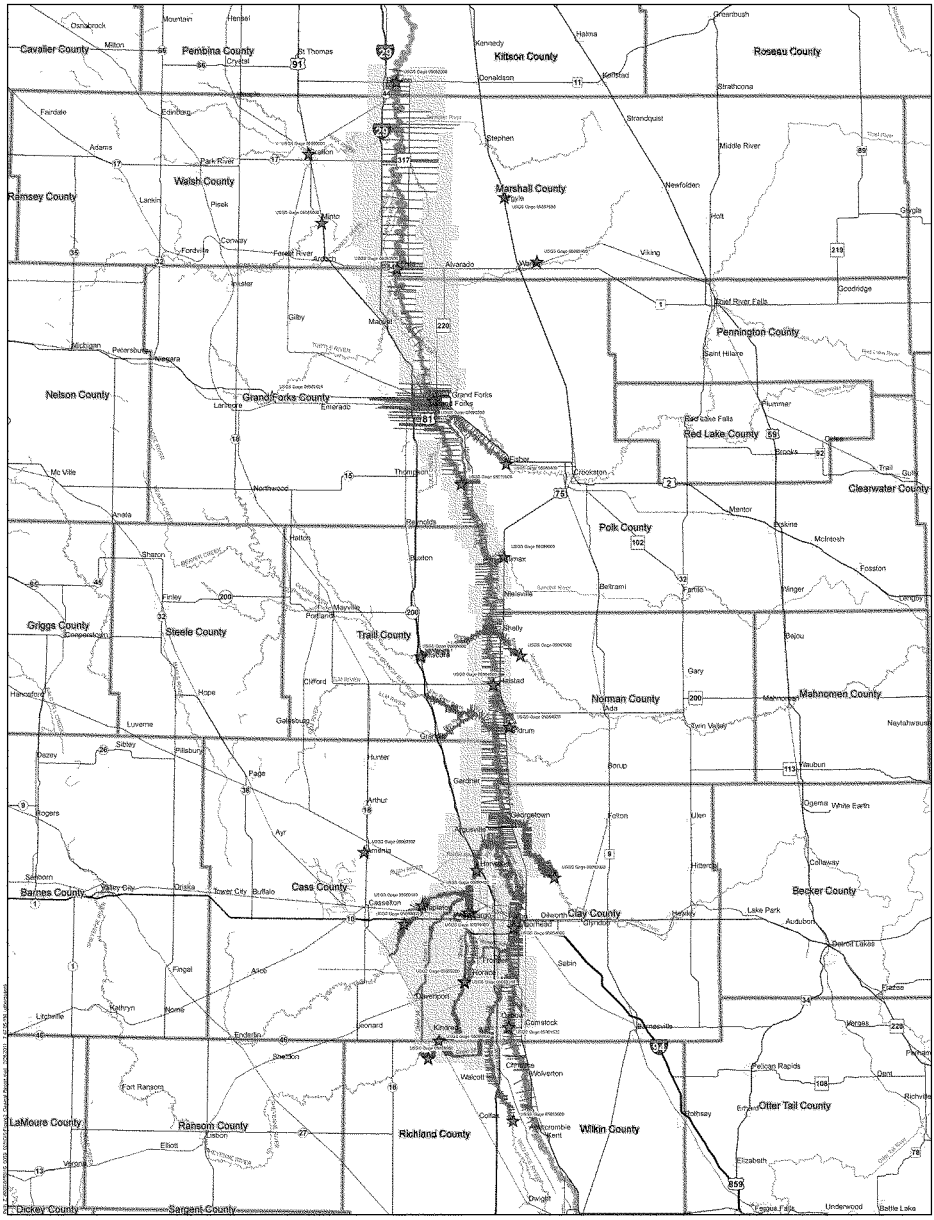
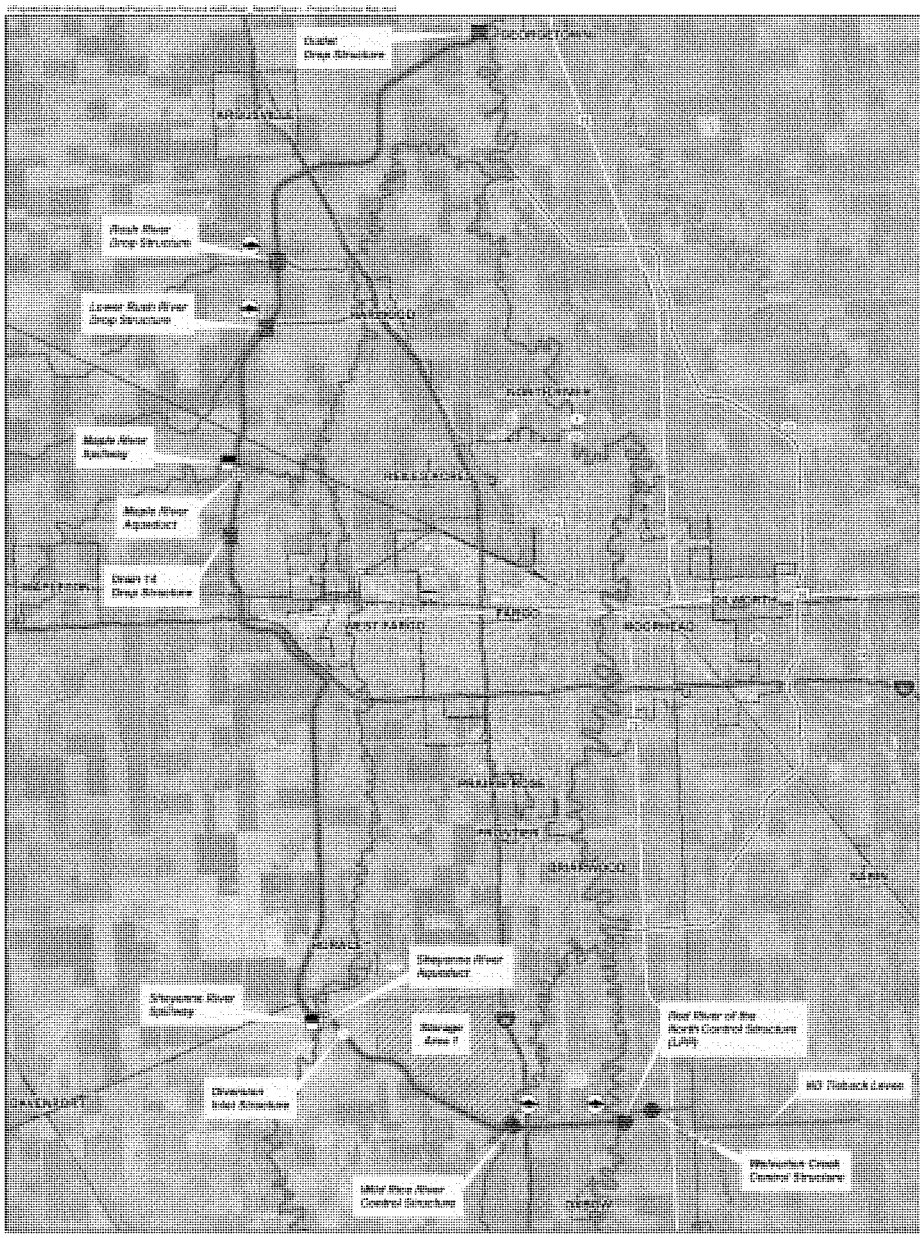


Figure B-1

Unsteady HEC-RAS Modeling
Study Area Map

- USGS Gages
- Existing Conditions Model Cross Sections
- Existing Conditions Model Reaches
- Existing Conditions Model Storage Areas
- Model Cross Sections
- City Boundaries
- Counties

0 3 6 12 18
Miles



Hydraulic Structures

- Weir
- Aqueduct
- Control Structure
- Drop Structure
- Spillway
- Fish Passageway

- ND Tieback Levee
- North Dakota Diversion Locally Preferred Plan (LPP)
- Minnesota Diversion Federally Comparable Plan (FCP)
- Channel Reclamation Reaches
- Storage Area 1

Figure B-2

PROJECT OVERVIEW

Fargo - Moorhead Area

0 0.5 1 2 3 4 Miles

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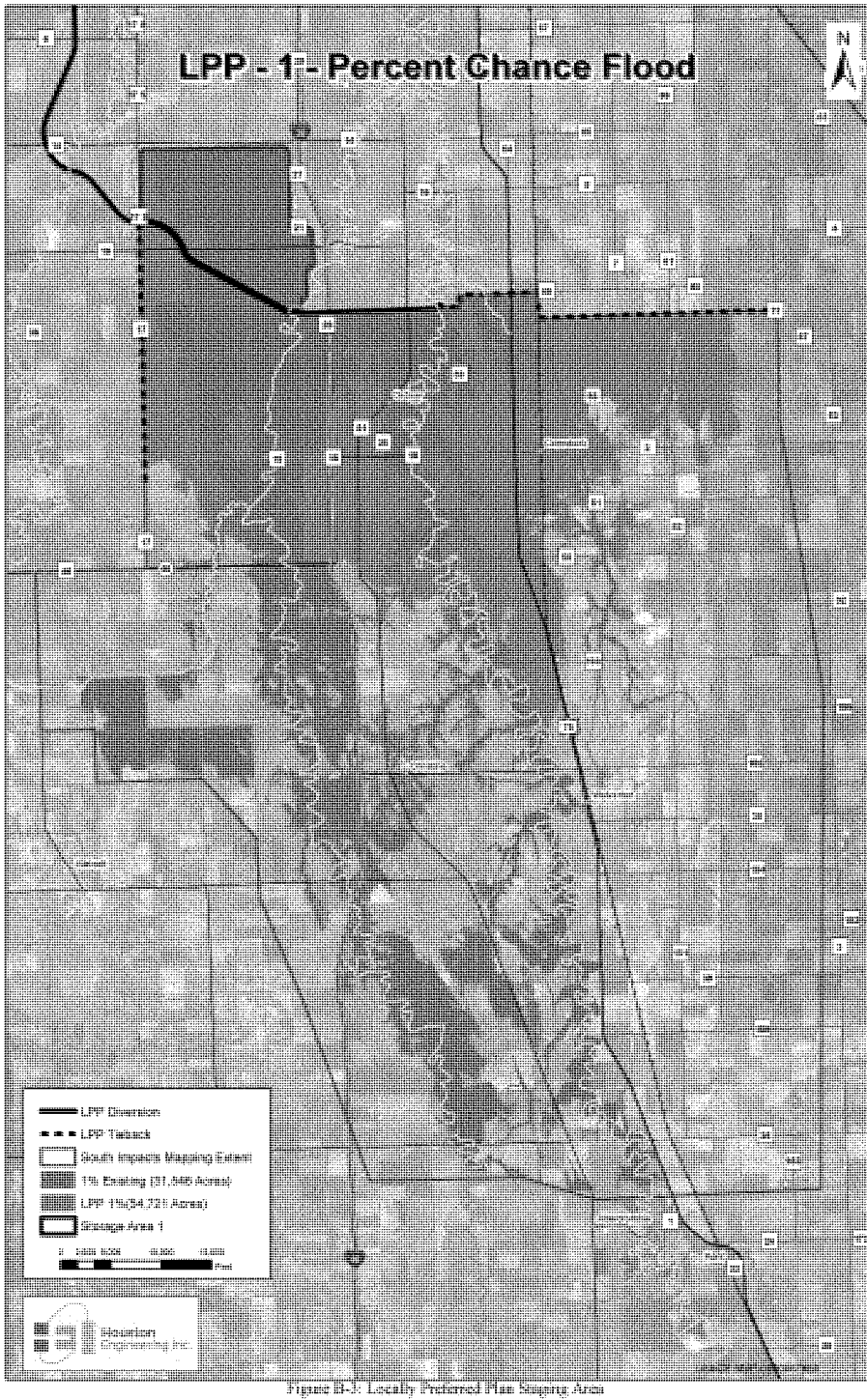

Figure B-3: Locally Preferred Plan Mapping Area

Attachment 1

Ice Analysis for
Red River of the North Diversion Project
Fargo ND, Moorhead, MN

DRAFT REPORT

Ice Analysis for Red River of the North Diversion Project Fargo ND, Moorhead, MN

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HEC-RAS results added by Aaron Buesing, St. Paul District

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1. Introduction

The all-time peak stage on the Red River of the North (RRN) at Fargo, ND occurred on March 28, 2009, causing major flooding in the Fargo and Moorhead (F/M) area (Fig. 1). In terms of river discharge, this event had a return interval of about 100 years. The RRN also experienced major flooding in the early spring of 1997 with the greatest damages occurring farther downstream at Grand Forks. Though discharge was the predominant factor, ice and ice jams played a role in both these events. To mitigate future flooding, plans are being developed for diversion channels to bypass a large portion of RRN flood flows around Fargo and Moorhead. The alternatives being evaluated call for a gated structure located on the RRN about 27 river miles (RM) south of Fargo that would divert as much as two-thirds of the 100-year flow into bypass canals around the cities on the North Dakota side (Fig. 2). The canal would cross and intercept flow from five tributaries to re-enter the RRN about 34 RM north of Fargo. It is estimated that 10-20 years will be required to build the project at an estimated cost of about $1.4 billion. Construction will take place from downstream to upstream, intercepting the downstream tributaries first and building the upstream crossing and diversion structures later on. This will allow time to monitor ice conditions and refine ice aspects of the design of the more complex upstream structures.

This report describes the first phase of ice analyses and field observations being done in support of project design. A main objective is to identify and design for possible ice problems at the RRN diversion and tributary crossing structures. A second objective is to anticipate possible changes to the ice regime on the RRN in the Fargo-Moorhead (F-M) area. A concern is that the project may change nature of ice breakup on the mainstem RRN. Under existing conditions the spring rise is long and gradual allowing most of the RRN ice to melt by the time of peak stage. With the diversion in operation, the peak at Fargo, though lower, may occur before the ice has melted. This change could lead to breakup ice jamming and possible flooding at lower discharges than before.

1.1. Approach

The ice study consists of three phases: 1.) a review and analysis of historical ice and hydro-met data combined with an ice monitoring program, 2.) an assessment of impacts to the ice regime in the vicinity of F-M as a result of the diversion project and 3.) analyses of ice interaction with the RNN diversion and tributary crossing structures. This interim report describes the results of the first phase.

Historical information and hydro-meteorological data related to spring flooding and ice processes on the RRN in the project area were compiled and reviewed. Performance of similar flood control projects was also reviewed. Satellite imagery and aerial photos were compiled and incorporated in the above analysis of historical and hydro-met information. A model was developed to calculated ice growth and decay for the period of record, and it was validated with observed data. Ice conditions were monitored at key locations on the ground and from the air during the winter of 2011.

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Looking beyond this phase of the study, possible changes to the RRN ice regime in the vicinity of Fargo-Moorhead as a result of the diversion will be assessed. The HEC-RAS model will be used to simulate ice-affected water surface profiles in this section of river during the spring breakup period using inputs from the historical and hydro-met analyses and the ice monitoring program. HEC-RAS simulation results will be used to assess the potential for ice jam flooding on this section of the RRN under with-project conditions.

2. Initial Investigations and Ice Monitoring

The initial ice investigations included a review of historical spring flood information analysis of hydro-meteorological data. The performance of similar flood control projects under ice conditions was reviewed and a model developed to calculated RRN ice growth and decay for the last several decades. Ice conditions were monitored from the ground, by aircraft and the use of satellite imagery.

2.1. Historical Spring Floods on the RRN

General Ice Processes on the RRN

The RRN in the vicinity of Fargo and Moorhead is low gradient meandering river with low water velocities during the ice formation period favoring the growth of sheet ice that often exceeds 2 ft in thickness by late winter. Ice-out on the RRN is typically gradual without dynamic ice runs. While water levels may rise well above the top of bank elevation, the ice cover typically melts in place, often confined within bends or held within the channel by natural levees or trees along the banks. An important question in this study is the timing of ice-out with respect to the timing of peak discharge and stage. Other important questions relate to how and where the ice moves or accumulates during the breakup period.

Winter period flood problems on the RNN appear to be increasing with time as shown in the time series of annual peak discharges (Fig. 3). Of the 8 highest peak discharges, 6 occurred in the last 14 years and 5 of those 6 occurred between Dec. 1 and April 15 when there was a strong likelihood of ice on the river. Fig. 4 compares hydrographs for the six most recent large spring floods at Fargo showing that the timing of peak stage falls within a 4 week time frame and the rise from base flow to peak typically takes about 1-1/2 weeks. Fig. 5 shows the probability distribution of annual of peak discharges at Fargo showing the majority of the largest floods to have occurred during the ice season. In addition to the Fargo-Moorhead area which experienced a flood or record on March 28, 2009, ice-related flooding has occurred at a number of other locations along the RRN including Oslo, Drayton and Pembina, and Grand Forks. Damages at Grand Forks there have been greatly reduced by flood control works built since the 1997 flood of record. In 1997, flooding was widespread along the RRN at locations such as Wahpeton, Tyler, Breckenridge, Hickson, Fargo, Drayton, Grand Forks and Emerson. Table 1 lists the 8 most severe flood events in terms of peak discharge at Fargo since 1897, 7 of which occurred between Dec. 1 and April 15.

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Table 1. Historic RNN Floods at Fargo-Moorhead.

Year	Day	Peak Stage (ft)	Peak Discharge (cfs)	Recurrence Interval for Discharge (years)
2009	3/28	40.84	29,500	112
1997	4/17	39.57	28,000	56
2011	4/9	38.74	25,700	37
1969	4/15	37.34	25,300	28
1897	4/7	39.10	25,000	22
2010	3/21	36.99	21,200	19
2001	4/14	36.69	20,300	16
2006	4/5	37.13	19,900	14

Plots of discharge, stage, air temperature and AFDD for the years 1958-2011 can be found in Appendix A (available upon request). A discussion of these hydro-meteorological data appears in Section 2.2.

The CRREL Ice Jam Database (IJDB) reports less severe ice related flooding along the RRN in 1989, 1969, 1961, 1960, 1959, 1957, 1955, 1954, 1952, 1948, 1946, and 1945, though many of these are ice-affected gage reports with no mention of damages. One IJDB report of interest is a "large ice obstruction" at Hickson, ND on April 9, 1997 which is about 2 RM upstream of the proposed diversion .

Below is a discussion of historic flood imagery and the timing of ice-out on the RNN in the vicinity of Fargo and Moorhead for the recent floods of 1997, 2001, 2006, 2009, 2010 and 2011. These observations are later compared to the 2011 field observations and also used to validate the ice growth model described in Section 2.4. The 27 photographs referenced in this section appear in Appendix B.

For these six floods, the more confined, faster flowing section of the RRN within the F-M metropolitan area had melted out before the time of peak stage. Upstream and downstream of the cities, remnants of sheet ice remained within tree-lined channels of the RRN and tributaries including the general locations of the inlet and outlet of the proposed ND-side diversion canal. Ice jams were documented upstream of the RRN bridges in the F/M metropolitan area but these accumulations caused little stage rise and melted rapidly in the presence of the high flows. More serious ice jams have been reported at bridges and culverts along the tributaries particularly the Sheyenne R. and the canal crossings within the West Fargo Diversion Project.

1997 Flood

The 1997 flood peaked late in Fargo on 4/17 at 39.57 ft (Figs.4 and 8). Satellite images at this time (Figs B1-B3) show remnants of the ice cover in some of the sharper bends above and below F/M, but the river is mostly ice free through the metropolitan area. The images show residual ice within the original channel near the start and end of the

proposed ND-side diversion canal. Fig. B4 shows no remaining ice no ice within the F/M Metropolitan area at the time of the 4/17/1997 peak. The ground was mostly free of snow cover at this time making it difficult to distinguish fields from flooded areas. USGS discharge measurements at Fargo indicate the presence of an ice cover at the gage on 25 March and intermittent shore ice until 4/11. The last ice-affected gage reading at Fargo was on 4/2/1997.

2001 Flood
Flood stages peaked in Fargo on 4/14 at 36.65 ft. Aerial photos at about this time show no evidence of an ice cover or ice floes in the F-M area (Fig. B5 and B6). USGS discharge measurements at Halstad, Fargo and Hickson reported ice-free conditions sometime before 4/10, 4/3 and 4/9, respectively. The last ice affected gage reading at Fargo occurred on 3/10/01. This information suggests that ice had released of melted prior to the peak of the flood.

2006 Flood
The 2006 flood peaked at Fargo on 4/5 at 36.82 ft. Aerial Photos taken near the peak, show no remaining ice cover in the bends of the Red River in the Fargo area (Fig. B7 and B8). Figs.B9-B11 show the progressive melting of an ice accumulation upstream of the 12th Ave. Bridge in Fargo between 4/1 and 4/4/2006. USGS measurements at the Fargo Gage documented the presence of ice on 3/28 and ice-free conditions starting on 4/1/2006.

2009 Flood
The flood of record peaked at the Fargo Gage on 3/28/2009 at 40.65 ft. Figs. B12 and B13 are satellite images near the time of peak. As in the other cases, the river was ice free through most the F-M metropolitan area by the time of peak. Upstream and downstream of the city shine lines of ice are visible within flooded bends at the start and end of the proposed ND diversion canal, at the Wild Rice confluence and north of F-M. An aerial photo of the confluence of the RRN and Wild Rice River shows considerable ice remaining within in the flooded river channels (Fig. B14). Fig. B15 shows the RRN downstream of the Wild Rice into Fargo to be mostly clear of ice by the time of peak. The 2009 flood differs from others in that the ground was snow covered giving much of the flooded areas a gray slushy appearance.

Fig. B16 shows ice accumulated upstream of the 12th Ave. N. Bridge in Fargo on 3/24. Fig. B17 shows open water on the RRN in Moorhead on 3/25 and Figs.B18 and B19 show open river conditions in downtown F/M and upstream at 14th Ave. N in Fargo respectively. By 3/27 no ice remained behind the major area bridges (Fig. B20).

USGS measurements at Fargo indicated an ice cover on 3/21 March, and an ice free condition by 3/24/2009. Both the Halstad and Hickson Gages retained their ice longer, until 3/28 and 4/1 respectively.

2010 Flood
The 2010 flood peaked early at 36.99 ft on 3/21. An image just prior to the peak show ice free channels in parts of Fargo (Fig. B21). A series of image from 13-15 Mar (Figs.B22-24) show the gradual melt-out of ice on a section of the RRN just north of the downtown area , suggesting that much of the RNN in the Fargo area melted out prior to the 3/21 peak. The record of images from the Fargo USGS Gage Web camera show breakup occurring gradually between 3/13 and 3/15 (see FargoGage2010Breakup.pdf). Fig. B25 shows large ice floes still passing through the 1st Ave. Bridge in Moorhead on 3/20. Fig. B26 shows ice in lodged bends or moving as large floes south of F-M in the vicinity of the start of the proposed diversion canal. Farther north and into Fargo, the river appears ice free (Fig. B27). USGS discharge measurements indicate ice on the RRN downstream at the Hickson Gage on 3/20, but this ice was reported to have cleared by 3/23. The RRN was noted to be ice covered at the Fargo Gage on 3/17 March, but clear by 3/19.

2011 Flood
The 2011 flood peaked in Fargo at 38. 74 ft on 4/9. As with the other floods described above, the RRN channel through the F/M metropolitan area was ice free at this time. The USGS reported an ice-free condition at the Fargo Gage in 3/16. The record of images from the Fargo USGS Gage Web camera show breakup in the section of river upstream of the F-M bridges occurring later, between 4/4 and 4/5 (see FargoGage2011Breakup.pdf). Although sections of the channel had opened up through the cities by the end of March, cold weather persisted and much of the river in the project area upstream and downstream retained a nearly complete ice cover until about 4/1 when temperatures moderated. Some ice jams occurred at bridges along the West Fargo Diversion canal and were broken using large excavators. The 2011 ice-out is described in more detail in Section 2.5 which reports on field monitoring efforts.

2.2. Analysis of Hydro-Meteorological Data

Daily average discharge, stage, air temperature, and net accumulated freezing degree days (AFDD) plotted for 1958-2011period of record for the following locations shown in Table 2.

Table 2. Hydro-Meteorological Data; RRN and Tributaries near Fargo-Moorhead.

Parameter	*Location*
Daily Average Discharge and Stage USGS Gauging Stations	RRN Gage @ Kindred, ND
	RRN @ Fargo, ND
	RRN @ Halstad, ND
	Wild Rice R. @ Mantador, ND
	Sheyenne R. at Kindred, ND
	Maple River at Mapleton, ND
Daily Average Air Temperature	Hector Int. Airport, Fargo, ND
Accumulated Freezing Degree Days	

Plots of these data for the December-April period for the years of 1958-2011 appear in Appendix A (available upon request). Plots of the three largest floods; 2009, 2011 and 1997 are shown in Figs.6, 7, and 8 respectively. Hydro-met data were analyzed to identify ice characteristics associated with major spring floods. For each year of record back to 1958, Table 3 lists the day of peak stage, daily average discharge and accumulated freezing degree day for the day of peak ($AFDD_{peak}$). $AFDD_{peak}$ is typically preceded by winter maximum AFDD ($AFDD_{max}$) which is also listed. Maximum ice thickness $t_{i\,max}$ was calculated from $AFDD_{max}$.

(1)

US Army (2005) C is a coefficient typically ranging from 0.3 to 0.6 inches. A C value of 0.59 was used based on field-measured ice thickness data. An important parameter in this study is the condition of the ice cover by the time of peak stage. Equation 1 is a good predictor of thermal ice growth ice on slow moving rivers such as the RRN but is poorly suited for estimating ice melting, hence the need for the more sophisticated ice melting model which is presented in Section 2.4. As a rough indicator of ice conditions at the time of peak stage, the time intervals between $AFDD_{max}$ and $AFDD_{peak}$ are listed, as well as the corresponding decrease in AFDD.

The photo analysis in Section 2.1 indicate that ice-out along the RRN though the F-M metropolitan area typically occurs before the time of peak while upstream and downstream ice covers tend to stay in place longer. The last day of reported ice at the Fargo Gage is listed in Table 3 for the 1990-2011 period with the number of days between ice-out to peak stage. Table 4 compares these parameters for the 6 largest floods with average values for the entire 1958-2011 period showing discharge to be the most important factor. For the flood years, the average day of peak stage is 7 days later than the long-term average date and the average discharge 16,400 cfs higher. Average $AFDD_{peak}$, $AFDD_{max}$ are slightly greater for flood years with calculated ice thickness 1.7 inches higher. This suggests that ice is a minor player in the maximum flood levels experienced on the RRN in the F-M area. The decrease in AFDD for the flood years is nearly the same as the average; 76 compared to 74, but the period of warming is on average 6 days longer. Similarly, the time interval between the ice-out at Fargo and peak stage is much greater for the flood years; 14 days compared to the long term average of 1 day.

Table 4. Hydro-Meteorological Data for Major Floods vs. Long Term Averages

Year of Flood	Day of Peak Stage	Peak Stage (ft)	Peak Discharge (cfs)	AFDD Day of Peak Discharge	AFDD max (F)	Day of AFDD max	Max Ice Thickness (in)	AFDD max to Peak Stage (days)	Δ AFDD Max to Peak	Day of Ice Out at Fargo	Ice-Out to Peak Stage (days)
2009	28-Mar	40.65	29,500	2508	2533	14-Mar	30	14	-25	24-Mar	4
1997	17-Apr	39.57	27,630	2968	2988	12-Apr	32	5	-20	2-Apr	15
2011	9-Apr	38.74	25,700	2450	2600	1-Apr	30	8	-150	16-Mar	24
2010	21-Mar	36.99	21,200	1924	1981	5-Mar	26	16	-57	19-Mar	2
2006	5-Apr	36.82	19,400	1444	1536	25-Mar	23	11	-92	1-Apr	4
2001	14-Apr	36.65	20,200	2638	2750	27-Mar	31	18	-112	10-Mar	35
Flood Yrs.	5-Apr	38.24	23,938	2322	2398	24-Mar	29	12	-76	22-Mar	14
All Years	29-Mar	26.25	7,550	2,062	2,137	21-Mar	27	6	-74	26-Mar	1
Difference	7	12.0	16388	260	261	3	1.7	6	-2	-4	13

2.3. Performance of Similar Flood Control Projects Under Ice Conditions

A 29-mile long floodway was built on the Red River at Winnipeg, Manitoba following the devastating flood of May 1950. From its completion in 1969 to 2006, the project has saved the city an estimated $10 billion in damages. Much of the information below is from Andres (2005). The Red River in the vicinity of Winnipeg experiences is about double in size and discharge and experiences more dynamic ice runs and ice jams than the RRN in the vicinity of F-M. Due to a much larger drainage area, the spring flood period is more drawn out at Winnipeg, lasting up to one month. Breakup on the Red River at Winnipeg precedes the flood peak by a longer interval than on the RRN near F-M. The breakup can be a thermal or melt-in-place event typically when breakup discharge is below about 42,000 cfs or, for larger flows, a dynamic downstream progressing event with jams consolidating and increasing is size towards the Red River confluence with Lake Winnipeg.

Typically Red River ice cover upstream of Winnipeg is well deteriorated or gone by the start of the diversion into the floodway. This occurs at an open water discharge of about 42,000 cfs (35,000 with ice on the river). For the flow range potentially affected by ice conditions gates on the Red River below the Floodway inlet are lowered in small increments to maintain "natural condition" river stages upstream of the diversion. This lack of upstream stage fluctuation would tend to maintain an intact ice cover allowing it to melt in place rather than be drawn into the Floodway. At capacity, the Winnipeg Floodway can convey 56,000 cfs about 40% of the upstream river flow of 140,000 cfs.

Efforts are made to prevent ice from entering the Floodway with this year's breakup being an example. On April 7, 2011 several major ice jams had formed on the Red River at Winnipeg and downstream. CBC News reported that on that day the Floodway was "not operational" stating the "officials do not like to activate the gates when there is still ice on the river because of concern that the ice could clog up the floodway and create

jams or cause structural damage to the bridge supports". Most of the ice jams on the Red River at Winnipeg had reportedly released by April 8.

The Floodway was activated on April 9. Videos from the Web show some ice pieces and debris passing over the inlet weir into the Floodway but this minor amount of ice appears to not have been a problem. Based on the Winnipeg experience, it appears that the proposed F-M diversion project can be operated to avoid ice problems.

2.4 Ice Growth and Decay Model

2.4.1. Background

Ice growth, decay and breakup were calculated by the unified degree-day method (UDDM) presented by Shen and Yapa (1985). This method improved upon the traditional modified Stefan degree day method which is only strictly valid for ice formation:

$$t_i = C\sqrt{NetAFDD} \qquad (2.2.4.1)$$

where C is a coefficient ranging from 0.3 to 0.6 (US Army, 2005) and AFDD is a summation of daily average degrees of frost. AFDD on day n are calculated by

$$AFDD = \sum_{1}^{n}(32 - T_a) \qquad (2.2.4.2)$$

where T_a is the daily average air temperature in °F. The AFDD curve is then shifted up to a start value of zero on the date where it takes on consistently positive values, yielding the Net AFDD curve.

The unified degree-day method separates the phases of ice growth, deterioration and break-up. For break-up and deterioration, the following equation is used:

$$h = \left(h_o^{\,2} + \alpha S\right)^{1/2} - \beta t^{\theta} \qquad (2.2.4.3)$$

Where h_o is the initial ice cover thickness, α, β and θ are coefficients, and S is the AFDD since the ice cover formed. The final term represent heat flux from the water to the ice cover, which is only substantial when water temperatures are significantly higher than freezing, which is not the case on the Red River, so it will be neglected. The α coefficient differs between the formation and decay phase such that:

$$\alpha = \begin{cases} \alpha_o & for T_a^{\,2} \geq T_B \; growth \\ \alpha_o - m(T_a^{\,2} - T_B) & for T_a^{\,2} < T_B \; decay \end{cases} \qquad (2.2.4.4)$$

T_a^2 is the average freezing degree-day for the two preceding days and T_B is a value which represents the change to the decay condition such that when T_a^2 decreases to T_B decay begins. During the decay period, once h is smaller than $h_{\max} - \Delta h_r$ ice thickness is no longer allowed to increase in equation (2.2.4.3). Once α reaches a lower limit of α_1, the breakup period begins. Ice thickness during the breakup period is evaluated as:

$$h_{j+1} = h_j - b \qquad (2.2.4.5)$$

where j is the day and b represents the loss of ice thickness to breakup.

In summary, to use the unified degree-day method for estimating ice thickness on the Red River of the North, the following parameters must be calibrated: α_o, α_1, m, T_B, Δh_r, and b.

2.4.2. Calibration

Hydro-meteorological data was used to calibrate and evaluate the ice thickness according to the unified degree-day method. At the USGS gage in Fargo, flow was recorded since 1901, water temperatures since 1998 and stage since 2000. Air temperature minima and maxima were recorded since 1948.

Ice measurements taken at the Fargo gage by the Corps in 2001-2003 and again in 2011 by Andy Tuthill of CRREL (Table 5).

Table 5. Ice Field Measurements and evaluated growth coefficients

Date	Measured thickness (in)	AFDD (deg F-day)	C	α_o
2/22/2001	27.72	2133	0.57	0.36
2/28/2002	12	693	0.38	0.21
2/27/2003	26.88	1684	0.63	0.43
1/10/2011	19	1001	0.56	0.37
		average*	0.59	0.39

** assuming 2002 data was an outlier*

The coefficient C, from the Stefan equation was evaluated for each of the measurement dates. An average of $C = 0.59$ was determined, assuming the 2002 measurement was an outlier.

To determine the growth coefficient α_o for the unified degree-day method, the freezeup date and initial freezeup ice thickness had to be determined. Using USGS records, the

first date during which the flow was estimated due to ice effects at the Fargo gage was assumed to be the freezeup date (Table 6). For years without USGS records, the freezeup date was assumed to occur on the day of the average AFDD = 159 of the known data.

Table 6. Estimated Freezeup dates at the Fargo Gage

Water Year	Date	AFDD (deg F-day)
2010	5-Dec	63
2009	21-Nov	71
2008	26-Nov	22
2007	28-Nov	11
2006	2-Dec	164
2005	30-Nov	57
2004	19-Nov	77
2003	30-Nov	114
2002	29-Dec	321
2001	25-Nov	205
2000	13-Dec	45
1999	11-Dec	85
1998	15-Nov	78
1995	5-Jan	536
1994	25-Nov	104
1993	21-Dec	440
1992	22-Nov	173
1991	19-Dec	175
1990	3-Dec	270
	average	159

The ice thickness at freeze-up was estimated using the method from Pariset et al. (1966):

$$V = \sqrt{2g\frac{\rho - \rho_i}{\rho}h}\frac{h}{H} \qquad (2.2.4.6)$$

where ρ and ρ_i are the densities of water and ice, respectively, g is the acceleration due to gravity, the velocity $V=Q/BH$, Q is the flowrate, H is the depth, and B is the river width. The river width was assumed to be about 150 feet wide, as recorded during the ice measurements listed above. The formation thickness, h_o, was evaluated from Equation (2.2.4.6) for all the years during which stage measurements were available. For years when stage measurements were not recorded, the average of the evaluated h_o was assumed. Equation (2.2.4.3) was used to evaluate α_o for the years of the field measurements (Table 7). α_o =0.39 was calibrated from the average of α_o evaluated from the field thickness measurements, assuming the 2002 measurement was an outlier.

To calibrate the remaining parameters, α_1, m, T_B, Δh_r, and b, ice out date was required. Two methods to indicate ice out date were used. First, the date when the water temperature rose above freezing was proposed. Second, information on ice conditions was gleaned from USGS field reports, which indicated whether the river was ice covered during discharge measurements. These data, however, only describe conditions at the gage and provide a window for ice out because measurements were irregular (NWIS, 2011). The years 2006, 2009 and 2010 were used as calibration years because USGS measurements provided a small window which also matched the rise above freezing temperatures. The following table lists the parameters which were found to provide the best match for the data. Figs.1-3 show the water years used for calibration. It can be seen from these data that ice out occurs quickly after the maximum ice thickness and peak AFDD. This results in a small period of deterioration before the lower limit α_1 is reached and the breakup phase begin.

Table 7: Calibrated parameters

C	0.59	
α_o	0.39	
α_1	0.32	
m	0.04	
T_B	-1.1	°F
Δh_r	2	in
b	3	in

2.4.3. Conclusions

Table 8 details the peak stages, peak AFDD and ice thickness for each year of record. Results show that the peak AFDD and maximum ice thickness occurred within a period of 15 days before to 40 days after the time of peak stage. On average peak stage occurred 10 days after the time of calculated maximum ice thickness, with a median of 11.5 days. The Δ AFDD ranges from -431 to -15 °F-day, with an average of Δ AFDD= -88. The small difference in days and Δ AFDD between AFDD peak and stage peak indicates again that the ice deterioration period is very short on the Red River of the North at Fargo.

Table 9 shows the ice out dates by the three criteria: water temperature rise above freezing, first USGS observation of open water and the results of the unified-degree day method. By the unified degree-day method, for period of record, 38 ice-outs occurred before the peak stage, while 28 occurred after. For the known flood years of 2001, 2009 and 2010, the UDDM predicted ice-out at Fargo before the time of peak stage in agreement with observations presented in Section 2.2. For the flood of 1997 the UDDM, predicted ice-out in Fargo to occur after the peak stage. This error could have resulted from the fact that the UDDM models only the affects of thermal growth and decay due to ambient temperature and does not capture the effect of the warm inflow from tributaries. Also, all calibration was based on the ice-out date at the Fargo gage, which does not represent the entire study area. The observations presented in Section 2.2 suggest that

residual ice covers can persist until the time of peak flow on sections of the RRN upstream and downstream of metropolitan F-M. The UDDM results do agree with the observations that, for many years, particularly ones with floods, ice-out occurs before or during the peak stage event. With more calibration the UDDM model could be used to model ice growth and decay at key locations such as the start and end of the diversion canal and tributary crossing structures. Appendix C (available upon request) contains plots of the ice growth and decay for each year of the period of record.

2.5. Field Monitoring of Ice Conditions 2011

CRREL made two trips to the F/M area during the 2011 winter to observe ice conditions and gather ice-related information. The first visit took place from January 11-13 under mid-winter conditions and the second on April 6-9 during the ramp up to Fargo's 3rd largest flood in history. The objective of the midwinter visit was to document ice formation processes, visit locations important to the proposed project and measure ice thickness at key locations. The winter visit also provided a low water inspection of RRN and tributary sites for signs of past ice action such as tree scarring and abrasion as well as ice damage to banks and structures. The spring visit took place during the rise to peak stage which occurred on April 9th . The extent and condition of the melting ice cover was documented as well as any evidence of ice movement or ice jamming.

Important locations included the section of RRN through Fargo-Moorhead and the sections of river upstream and downstream of the metropolitan area in the vicinity of the proposed diversion structure and canal outlet. Tributaries were inspected in vicinity of proposed diversions and canal crossings during the midwinter and breakup periods. Mid-winter ice thickness measured at the above-mentioned sites and used to calibrate the ice thickness model. The breakup period field observations relied on aerial reconnaissance as widespread flooding prevented access to many sites by car or foot. In addition to observing breakup period ice extent and condition, ice melting processes were documented along with ice transport and ice jamming locations. A series of captioned photos documenting the mid-winter and breakup period ice observations are included in Appendix D.

2.5.1. Mid-Winter Period

Sites visited during the Jan. 10-11 period are listed in Table 10 and shown on Fig. 8.

Table 10. Sites Visited and Measured ice Thickness, Jan. 10-11, 2011

Sites	*Ice Thickness (in)*
RRN vicinity of proposed diversion	12-19
RRN County Rd. (CR) 16 Bridge	
RRN Metropolitan Fargo-Moorhead	
Wild Rice R. canal crossing site	19
Sheyenne R. CR 16 Bridge (0.5 mi u/s of canal crossing site)	13.5-18
Sheyenne R. CR 10 Bridge	
Maple R. 168th Ave. (0.5 mi. d/s of canal crossing site)	

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Sheyenne R. 32nd St. W	
Sheyenne R. CR 32 Bridge	
RRN vicinity of proposed canal outlet	18-21

The winter of 2010-2011 was relatively cold and snowy with over 1000 AFDD by the end of the first week in January and a snow depth of about 2 ft. These conditions produced an ice cover thickness of about 19 on slower moving portions the RRN and tributaries with about 12 in of ice on faster flowing sections. In the steeper section of the RRN through the F/M metropolitan area, open leads persisted (D13and D14).

January 10-11, 2010

In the vicinity of the proposed diversion, the banks were tiered with a low bank height of about 8 ft above base flow stage and high bank height in the15-20 ft range (D1). Abraded bark and minor scarring was seen on some trees near the between freezeup level and the top of high bank height (D2). There was no sign of significant tree scarring such as one sees on river with dynamic ice runs. Abrasion lines were seen on large trees near the proposed diversion location, 5-8 ft above the high bank level, probably the result of ice or debris movement across meanders during major floods (D3). The solid sheet ice and lack of tree scar evidence ice movement was also seen downstream of the diversion area from the CR 16 RRN Bridge crossing (D4).

The Wild Rice River in the vicinity of the proposed canal crossing and diversion was lined by 10-15-ft high banks confined within tree covered natural levees (D5 and D6). The sheet ice cover here was 19 in-thick.

The Sheyenne R. 0.5 mi upstream of the proposed canal crossing CR 16 Bridge had 10-ft high banks lined with dense tree growth (D7). Other than minor abrasion of tree bark, no evidence of dynamic ice action was found (D8). Measured ice thickness was between 14 to 20 inches.

The Sheyenne R. downstream of West Fargo was similar in appearance (D10). Under the deep snow cover, the baseflow channel of the Maple River near the proposed canal crossing location was difficult to distinguish within the treed river corridor (D9).

Approaching its confluence with the RRN, the Sheyenne R. channel was wider than upstream with lower banks and less dense tree cover (D11).

The RRN channel near proposed canal outlet was about 150 ft wide with 8-ft-high lower banks and higher banks about 20 ft above the base flow elevation. Here the sheet ice cover was 18-21-in-thick (D12).

2.5.2. Breakup Period

Significant melting of the ice cover occurred during the course of the April 6-9, 2011 field visit. The last two weeks of March 2011 had been unseasonably cold, putting off the

start of the rise until the early of April. The ice in the vicinity of the Fargo Gage had released on April 4-5, leading to nearly ice-free conditions on the RRN in the FM metropolitan area by April 6 (D17 and D18). A series of web camera images from the Fargo Gage for the 2011 ice-out period can be seen in the attached FargoGage2011Breakup.pdf. A similar collection of images for 2010 shows the ice release occurring in phases on March 14-16 (FargoGage2010Breakup.pdf). In both cases, the ice in the vicinity of the gage the upstream sheet ice cover fractured into large floes that drifted downstream uneventfully without jamming or shoving.

April 6, 2011
Upstream of F-M, the RRN ice cover was for the most part intact in the vicinity of the proposed diversion structure on the evening of April 6 (D15). Similarly decayed sheet ice remained in the series of bends on the RRN in the vicinity of the Wild Rice R. confluence (D16).

April 7, 2011
A mid-day recon flight on April 7 found similar conditions on the RRN near the proposed diversion (D21-23) and the Wild Rice confluence (D20) on April 7 as on the previous evening. Some of the bends closer to F-M contained accumulations of ice floes (D19) but had negligible backwater effect.

The Wild Rice R. and surrounding land were completely flooded in the vicinity of the proposed diversion canal with trees providing the only clue as to the location of the river banks. (D24 and D39).

The Sheyenne R. was bankfull and covered in decayed sheet ice in the vicinity of CR 16 and the proposed canal crossing 0.5 mi upstream (D25, 26,40 and 41). Several miles upstream, broken floes had accumulated at the CR 14 Bridge (D42) and currents were fast enough downstream of the bridge to tilt floes on edge (D43).

Downstream, flow being diverted from the ice covered Sheyenne R. into the West Fargo Flood Control Project had caused floes to accumulate at the CR 17 Bridge, with no blockage or backwater effect (D28, D45-46). Along the West Fargo Diversion Canal minor accumulations of floes could be seen upstream of the railroad bridge near I-94 and the 13th Ave Bridge (D29, 30, 31, 47). The previous day, an ice blockage at the railroad bridge had created 3 ft of backwater and large excavators were used to break the jam and help the floes through the narrow openings. Reportedly ice blockages at bridges along the Sheyenne West Fargo Diversion Canal were a greater problem in 2010 when the earlier more rapid rise to peak resulted in the movement of thicker stronger ice floes.

Northward towards Harwood the Sheyenne R. was mostly ice free (D32 and 34). The Maple R. and surrounding fields in the vicinity of the proposed canal crossing was completely flooded and discernable only by traces of remaining sheet ice and trees lining the banks (D33).

The Sheyenne in the vicinity of its confluence with the Rush River held linear remnants of its sheet ice cover while the Rush maintained a decayed sheet ice cover on its channelized downstream portion (D35).

The RRN was mostly clear of ice from F-M upstream beyond Georgetown with some areas of drifting ice floes (D36). In the vicinity of the proposed canal outlet, the RRN was out of bank flooding adjacent fields (D37).

April 8, 2011
By the afternoon of April 8th, much of the residual ice covers seen the previous two days had disappeared. On the RRN in the vicinity of the Wild Rice confluence and the proposed diversion, most of the ice was gone (D50-52).

The Sheyenne from CR 16 to the West Fargo diversion was also clear of ice except for isolated minor jams at bridges and bends (D53-56).

2.6. Field Possible Changes to the Red River of the North Ice Regime in the Vicinity of Fargo Moorhead as a result of the Diversion Project

Possible changes to the RRN ice regime in the vicinity of Fargo-Moorhead as a result of the diversion project were assessed. The HEC-RAS model was then used to simulate with project water surface profiles in this section of river during the spring breakup period with inputs derived from the historical and preceding historical review, ice observations and hydro-met analyses. The potential for ice jamming for the with-diversion case was compared to existing ice-hydraulic conditions during recent spring floods in the F-M metropolitan area.

2.6.1. HEC-RAS Modeling of Ice and Hydraulic Conditions in the Vicinity of Fargo-Moorhead.

Inputs
Inputs to the HEC-RAS modeling of potential ice jams relied on a number of assumptions on breakup period ice conditions, ice sources reaches ice transport and ice jam locations. Also important was the range of river discharge at which the ice cover could be expected to remain intact, melt away, or transport downstream of form jams.

Under current plans it is expected that the mainstem RRN will convey about 10-11 Kcfs through the city during a 100-yr. flood event while the remainder passes through the diversion canal. During a 500 yr flood event, as much as 25 Kcfs may pass down the mainstem RRN through the F-M metropolitan area.

Ice hydraulic characteristics of recent floods were reviewed to determine the range of discharges above which ice is no longer a factor in the F-M area. The USGS daily discharge records indicate the dates that the Fargo gage is no longer ice-affected as far back as 1990. This transition to open water conditions would mean that no ice jams

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would exist downstream at the Main Ave., NP Railroad and Center Ave. Bridges to increase stage at the gage.

At the time of the USGS reported ice-free date, any remaining sheet ice on the upstream sections of the RRN would be melted or lodged in bends, otherwise this ice would release and accumulate at the downtown bridges, particularly the NP RR Bridge whose piers are closely-spaced. It is safe to assume that once the USGS declares the stage record as no longer ice affected, that the potential for ice jams in the F-M metropolitan area is past for that year.

The photo record that some ice accumulated at the 12 Ave Bridge on 4/1/2006, the USGS ice-out date. In the photos, this 2006 ice accumulation did not appear to be causing a significant stage rise and was mostly melted by the next day. In a discussion with the Fargo City engineers on 1/11/11, Mark Bittner said that the 2010 flood came early, cresting on 3/21. Though there was concern about ice jams in the city, he said that nearly all the ice was gone by 3/18 and the releasing floes passed through the bridges without significant jams. Mr. Bittner said that during the 2010 ice-out, some citizens reported a backup on the RRN at the 12 Ave. Bridge prompting a level survey by the City that found only a small difference in upstream and downstream stages.

For the 1990-2011 period, daily average discharges on the USGS-reported days of ice-out average 10,400 cfs. The highest ice-out day flow of 15,360 cfs, occurred on 3/19/2010, the earliest of the recent flood events. This is not surprising since one would expect thicker and more competent ice early on in the breakup season.

Based on these observations, 10,000 cfs represents a maximum upper limit flow for the HEC-RAS modeling of potential ice jams in the F-M metropolitan area. At flows approaching the 15 Kcfs level, the ice volume remaining in the system would be unlikely to cause significant jams.

The existing conditions 2006 flood hydrograph was used as the future conditions through the cities flow for the 100 yr flood event. In this instance the predicted maximum flow through town will be on the order of 11-12 Kcfs, very similar to 2006 conditions.

Two ice sets of ice conditions were simulated for 10,000 cfs through the protected area using HEC-RAS. The first case assumed an initial 1.0 ft-thick ice cover with a Mannings n of 0.012 at all locations along the mainstem RRN the inlet and outlet of the diversion canal. It was assumed that during the rise to 10,000 cfs the ice cover has thinned from its initial 2.5 ft thickness down to about 1.0 ft. The HEC-RAS model run indicates stages through town would be about 1.0 ft higher at 10,000 cfs with this ice cover. Ice cover would deteriorate more with higher flows through town. With 15,000 cfs allowed through the protected area, ice should be essentially gone.

The second case assumes a minor ice jam between the 12 Avenue Bridge and the upstream railroad bridge for the 10,000 cfs flow-through-town condition. Open water conditions are assumed to exist from there up to the Wild Rice Confluence. Maximum

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upstream stage impacts are about 1.0 ft. A jam is not expected when the flow through town is 15,000 cfs or greater.

2.6.2. Comparison of Ice Jam Potential in the F-M Metropolitan Area with and without-Diversion

For the 100 year event with the diversion project operating RRN flow through the cities will reach a maximum of about 10 Kcfs. Review of recent flood events indicates that by the time the discharge at the Fargo Gage reaches 10 Kcfs, much of the ice in this section of river has melted and open water conditions prevail. Based on this analysis of historical data, it is expected that the potential for ice jamming with and without project will be quite similar. One would still expect minor ice jams at the 12th Ave. Bridge as they occur under existing conditions. At through-town flows associated with greater than 100 year events (up to 25 Kcfs) one would expect open water conditions to prevail and ice to be no factor.

3. Response to ATR Comments and Questions

3.1. What happens to flows in the diversion channel and protected area if we have a large snowmelt flood event, augmented by rainfall, followed by extreme cold (like in 2009), wherein more ice is produced in the diversion channel and protected area? If the flood peak is already in the system, how much might newly formed ice impact the project stages?

It is unlikely that sufficient ice would be formed on the canal to cause any problems. Taking 2009 as an example, the AFDD curve increased by about 50 during the last week in March. Assuming quiescent and water close to the freezing water temperatures (≤33 °F), this would result in a maximum of about 3-4 inches of ice growth. With the high discharges and water velocities (on the order of 2-3 ft/s) one would not expect much ice growth on the canals or the natural channels during a week-long period with daily average air temperatures on the order of 20°F or above.

3.2. How will an earlier peak downstream of the project affect ice and damages caused by ice? The unsteady RAS modeling shows the peak being 1 to 2 days earlier with the project.

An earlier peak downstream of the project may accelerate the melting and release of any remaining ice in the section of the RRN downstream of the canal outlet. The lower with-diversion flows in the bypassed reach of the RRN plus a possible backwater effect from canal outflow will reduce water velocities in the F-M section of the RRN. This may prolong the ice-out period in the F-M section. It is unlikely that these changes to the flow regime in the vicinity of F-M will increases the tendency for ice jamming since water velocities will be lower.

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3.3. Is it valid to use the Manning Equation for flow in the aqueduct with an ice cover; since the hydraulic radius is changed and the ice occupies a portion of the cross sectional flow area?

Yes, as long as flow is uniform (water surface slope = channel bed slope. etc) and the channel is wide enough that the ice cover can be considered floating (usually the case).

The hydraulic radius (flow area / wetted perimeter) needs to be calculated for the ice cover case (about half the under ice depth for a wide rectangular channel).

A composite Manning n_c that factors flow resistance for both the bed and the ice underside should be used in the Manning Equation. n_c can be calculated from Eq. 12 in White (1999).

http://www.crrel.usace.army.mil/library/crrelreports/CR99_11.pdf

The ice routines within HEC-RAS are useful for this type of calculation particularly where flow conditions are gradually-varied rather than uniform.

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Table 3. Hydro-meteorological data for the Red River of the North at Fargo, ND, 1958-2011. Recent flood years are highlighted.

Year	Day of Peak Stage	Peak Stage (ft)	Peak Discharge (cfs)	AFDD Day of Peak	AFDD max (F)	Day of AFDD max	Max Ice Thickness (in)	AFDD max to Peak Stage (days)	Δ AFDD Max to Peak	Day of Ice Out at Fargo	Ice-Out to Peak Stage (days)
2011	9-Apr	38.74	25700	2450	2600	1-Apr	30	8	-150	16-Mar	24
2010	21-Mar	36.99	21200	2027	2103	12-Mar	27	9	-76	19-Mar	2
2009	28-Mar	40.65	29500	1634	1650	5-Mar	24	23	-16	24-Mar	4
2008	23-Mar	16.2	967	2376	2400	14-Mar	29	9	-24	13-Apr	-21
2007	27-Mar	22.09	6484	2387	2387	28-Mar	29	-1	0	26-Mar	1
2006	5-Apr	36.82	19400	1444	1520	17-Mar	23	19	-76	1-Apr	4
2005	1-Apr	18.52	3908	1350	1280	25-Mar	21	7	70	3-Apr	-2
2004	26-Mar	16.18	1379	1900	1995	25-Mar	26	1	-95	1-Apr	-6
2003	27-Mar	15.76	1708	2000	2150	12-Mar	27	15	-150	27-Mar	0
2002	1-Apr	15.88	1793	1373	1450	8-Apr	22	-7	-77	23-Mar	9
2001	14-Apr	36.65	20200	2627	2750	1-Apr	31	13	-123	10-Mar	35
2000	11-Mar		3484	1151	1250	17-Mar	21	-6	-99	11-Mar	0
1999	22-Mar	20.81	4900	1150	1256	27-Feb	21	23	-106	27-Mar	-5
1998	2-Mar		8029	1240	1450	14-Mar	22	-12	-210	16-Mar	-14
1997	17-Apr	39.57	27630	2968	3000	16-Mar	32	32	-32	2-Apr	15
1996	15-Apr	28.75	9,940	2967	2988	12-Apr	32	3	-21		
1995	22-Mar		5484	2769	2987	12-Apr	32	-21	-218	7-Apr	-16
1994	22-Mar		10466	2470	2500	27-Mar	30	-5	-30	1-Apr	-10
1993	5-Apr	28.27	10100	2259	2400	21-Mar	29	15	-141	1-Apr	4
1992	11-Mar		1697	1297	1344	23-Mar	22	-12	-47	11-Mar	0
1991	3-Apr		1092	1672	1750	26-Feb	25	36	-78	3-Apr	0

1990	21-Mar		602	1609	1750	15-Mar	25	6	-141	1-Apr	-11
1989	9-Apr	35.39	18900	2452	2500	27-Mar	30	13	-48		
1988	11-Mar	15.1	981	1833	1950	25-Mar	26	-14	-117		
1987	10-Mar		1930	1155	1220	21-Mar	21	-11	-65		
1986	3-Apr	27.19	18600	2452	2620	13-Mar	30	21	-168		
1985	23-Mar		2380	2062	2200	20-Mar	28	3	-138		
1984	1-Apr	28.27	9450	2261	2151	9-Mar	27	23	110		
1983	8-Mar		765	1279	1450	20-Mar	22	-12	-171		
1982	4-Apr	25.07	5800	2893	2900	23-Mar	32	12	-7		
1981	25-Mar		350	1444	1550	8-Apr	23	-14	-106		
1980	5-Apr	20.74	4730	2139	2250	6-Mar	28	30	-111		
1979	19-Apr	34.93	17200	3357	3500	24-Mar	35	26	-143		
1978	2-Apr	34.41	17000	3021	3150	10-Apr	33	-8	-129		
1977	31-Mar		329	2363	2510	18-Mar	30	13	-147		
1976	30-Mar	18.7	3000	1816	1900	7-Mar	26	23	-84		
1975	21-Apr		8380	1922	1867	21-Mar	25	31	55		
1974	14-Apr	20.25	4040	2460	2510	5-Apr	30	9	-50		
1973	15-Mar	16.14	1830	1962	1950	7-Apr	26	-23	12		
1972	25-Mar	25.3	7080	2442	2510	28-Feb	30	25	-68		
1971	21-Mar		1430	2293	2350	13-Mar	29	8	-57		
1970	12-Apr		1770	2329	2301	16-Mar	28	27	28		
1969	15-Apr	37.34	23900	2457	2418	3-Apr	29	12	39		
1968	19-Mar		510	1790	1800	2-Apr	25	-14	-10		
1967	31-Mar		4230	2280	2450	14-Mar	29	17	-170		
1966	22-Mar	30.16	10600	2383	2402	21-Mar	29	1	-19		
1965	15-Apr	30.5	11300	2029	2180	8-Mar	28	38	-151		
1964	19-Apr	16.22	2330	1575	1800	5-Apr	25	14	-225		
1963	1-Apr		1290	1926	1808	31-Mar	25	1	118		

1962	19-Apr		6400	2402	2500	23-Mar	30	27	-98		
1961	8-Mar		508	1800	1800	15-Apr	25	-38	0		
1960	8-Apr	12.48	3700	2182	2250	27-Feb	28	40	-68		
1959	7-Apr		696	2103	2220	24-Mar	28	14	-117		
1958	11-Mar		654	1349	1450	21-Mar	22	-101			
Averages	29-Mar	26.3	7550	2062	2137	21-Mar	27	6	-74	26-Mar	1

Year of Flood	Day of Peak Stage	Peak Stage (ft)	Peak Discharge (cfs)	AFDD Day of Peak Discharge	AFDD max (F)	Day of AFDD max	Max Ice Thickness (in)	AFDD max to Peak Stage (days)	Δ AFDD Max to Peak	Day of Ice Out at Fargo	Ice-Out to Peak Stage (days)
2009	28-Mar	40.65	29,500	1634	1650	5-Mar	24	23	-16	24-Mar	4
1997	17-Apr	39.57	27,630	2968	3000	16-Mar	32	32	-32	2-Apr	15
2011	9-Apr	38.74	25,700	2450	2600	1-Apr	30	8	-150	16-Mar	24
1969	15-Apr	37.34	23,900	2457	2418	3-Apr	29	12	39		
2010	21-Mar	36.99	21,200	2027	2103	12-Mar	27	9	-76	19-Mar	2
2006	5-Apr	36.82	19,400	1444	1520	17-Mar	23	19	-76	1-Apr	4
2001	14-Apr	36.65	20,200	2627	2750	1-Apr	31	13	-123	10-Mar	35
Averages: Flood Yrs.	6-Apr	38.11	23,933	2230	2292	21-Mar	28	17	-62	22-Mar	14
1958-2011	29-Mar	26.25	7,550	2,062	2,137	21-Mar	27	6	-74	26-Mar	1

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Table 8: Peak Stage, Maximum AFDD, Ice Thickness (h), and Differences for Period of Record

	Peak Stage				Maximum AFDD for Winter				Maximum Ice Thickness	$AFDD_{max}$ to Peak Stage	
Water Year	Day	Stage (ft)	Q (cfs)	AFDD °F-day	Day of $AFDD_{max}$ (°F)	$AFDD_{max}$ (°F)	h (AFDD) (in)	h (unified AFDD) (in)	h_{max} (unified AFDD) (in)	(days)	Δ AFDD (°F)
2010	21-Mar	36.95	21100	1924	5-Mar	1981	26	27	27	16	-57
2009	28-Mar	40.65	29100	2508	14-Mar	2533	30	31	31	14	-25
2008	23-Mar	15.26	968	2373	28-Mar	2388	29	30	30	-5	-15
2007	6-Apr	25.63	8770	1459	20-Mar	1570	23	24	24	17	-111
2006	5-Apr	37.04	19800	1444	25-Mar	1536	23	23	23	11	-92
2005	1-Apr	18.61	3990	1692	21-Mar	1782	25	26	26	11	-90
2004	26-Mar	16.18	1320	1910	22-Mar	1940	26	27	27	4	-30
2003	22-Apr	15.86	1780	1720	13-Mar	2151	27	28	28	40	-431
2002	1-Apr	15.93	1940	1375	5-Apr	1417	22	21	21	-4	-41
2001	14-Apr	36.65	20200	2638	27-Mar	2750	31	31	31	18	-112
2000	11-Mar	*	3580	1156	22-Feb	1257	21	22	22	17	-100
1999	22-Mar	20.81	4800	1539	14-Mar	1581	23	24		8	-43
1998	2-Mar	*	8210	1188	16-Mar	1410	22	23	25	-14	-223
1997	17-Apr	39.57	27800	2968	12-Apr	2988	32	33	33	5	-20
1996	17-Apr	39.54	9340	2843	7-Apr	2922	32	33	33	10	-79
1995	22-Mar	*	10500	1664	11-Mar	1773	25	22	22	11	-108
1994	22-Mar	*	3000	2464	17-Mar	2507	30	30	30	5	-43
1993	5-Apr	28.27	9900	2260	23-Mar	2344	29	27	27	13	-84
1992	11-Mar	*	1760	1297	25-Feb	1343	22	21	21	14	-46
1991	3-Apr	*	1250	1662	9-Mar	1807	25	25	25	25	-144
1990	21-Mar	*	610	1608	6-Mar	1660	24	23	23	15	-52

Peak Stage	Peak Stage				Maximum AFDD for Winter				Maximum Ice Thickness	$AFDD_{max}$ to Peak Stage	
Water Year	Day	Stage (ft)	Q (cfs)	AFDD °F-day	Day of $AFDD_{max}$ (°F)	$AFDD_{max}$ (°F)	h (AFDD) (in)	h (unified AFDD) (in)	h_{max} (unified AFDD) (in)	(days)	Δ AFDD (°F)
1989	9-Apr	35.39	18600	2453	24-Mar	2489	29	30	30	16	-35
1988	11-Mar	15.1	924	1829	21-Mar	1925	26	26	26	-10	-97
1987	10-Mar	*	1930	1155	13-Mar	1180	20	20	20	-3	-25
1986	3-Apr	27.19	8420	2453	20-Mar	2619	30	31	31	14	-166
1985	23-Mar	*	2380	2069	8-Mar	2153	27	28	28	15	-84
1984	1-Apr	28.27	9450	2261	20-Mar	2320	28	29	29	12	-59
1983	8-Mar	*	765	1279	23-Mar	1381	22	22	22	-15	-102
1982	4-Apr	25.07	5800	2879	8-Apr	2909	32	33	33	-4	-30
1981	25-Mar	*	350	1444	10-Mar	1545	23	23	23	15	-100
1980	5-Apr	20.74	4730	2161	25-Mar	2231	28	28	28	11	-70
1979	19-Apr	34.93	17200	3357	9-Apr	3448	35	36	36	10	-91
1978	2-Apr	34.41	16800	3022	25-Mar	3068	33	33	33	8	-45
1977	31-Mar	*	329	2364	7-Mar	2499	29	30	30	24	-135
1976	30-Mar	18.7	3000	1817	21-Mar	1895	26	20	26	9	-78
1975	21-Apr	*	8380	1923	5-Apr	2019	27	27	27	16	-96
1974	14-Apr	20.25	4040	2460	4-Apr	2526	30	30	30	10	-66
1973	15-Mar	16.14	1830	1889	28-Feb	1948	26	26	26	15	-59
1972	25-Mar	25.3	6420	2442	13-Mar	2501	30	30	30	12	-59
1971	21-Mar	*	1430	2293	24-Mar	2330	28	29	29	-3	-37
1970	12-Apr	*	1770	2330	3-Apr	2418	29	29	29	9	-88

	Peak Stage				Maximum AFDD for Winter				Maximum Ice Thickness	$AFDD_{max}$ to Peak Stage	
Water Year	Day	Stage (ft)	Q (cfs)	AFDD °F-day	Day of $AFDD_{max}$ (°F)	$AFDD_{max}$ (°F)	h (AFDD) (in)	h (unified AFDD) (in)	h_{max} (unified AFDD) (in)	(days)	Δ AFDD (°F)
1969	15-Apr	37.34	23900	2458	2-Apr	2626	30	31	31	13	-169
1968	19-Mar	*	510	1790	3-Mar	1856	25	26	26	16	-66
1967	31-Mar	*	4230	2280	21-Mar	2402	29	29		10	-122
1966	22-Mar	30.16	10600	2383	8-Mar	2450	29	30	30	14	-67
1965	15-Apr	30.5	11300	3112	31-Mar	3210	33	34	34	15	-98
1964	19-Apr	16.22	2280	1564	31-Mar	1809	25	25	25	19	-245
1963	1-Apr	*	1290	1927	21-Mar	2078	27	27	27	11	-151
1962	19-Apr	*	6400	2402	24-Mar	2468	29	30	30	26	-66
1961	8-Mar	*	508	1795	27-Feb	1814	25	25	25	9	-19
1960	8-Apr	12.48	3700	2183	25-Mar	2220	28	28	32	14	-37
1959	7-Apr	*	696	2106	21-Mar	2303	28	29	29	17	-197
1958	11-Mar	*	654	1342	21-Mar	1413	22	22	22	-10	-71
1957	27-Mar	*	1580	2055	19-Mar	2126	27	28	28	8	-72
1956	16-Apr	12.54	3810	2910	31-Mar	2968	32	33	33	16	-58
1955	4-Apr	11.12	2600	2094	28-Mar	2203	28	28	28	7	-109
1954	28-Mar	*	1060	1812	3-Apr	1907	26	26	26	-6	-95
1953	26-Mar	*	1790	1569	16-Mar	1613	24	24	24	10	-44
1952	16-Apr	28.79	16200	2608	28-Mar	2711	31	31	31	19	-103
1951	11-Apr	20.73	7990	2812	24-Mar	2897	32	32	32	18	-85
1950	7-Apr	20.88	7680	2851	13-Apr	2894	32	32	32	-6	-43
1949	4-Apr	*	1780	2559	23-Mar	2605	30	31	33	12	-46

** when peak stage could not be identified from USGS records, the date of peak stage was assumed to occur on the same day as the peak flow*

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Table 9: Ice-out Dates by Several Methods: Water Temperature Rise, Fargo Gage Observed as Clear, and Unified AFDD Method

	Water Temp Rises Above Freezing		Fargo Gage observed as clear of ice		Unified AFDD method, ti=0		Water Temp Rise to Peak Stage		Unified AFDD Method to Peak Stage	
Water Year	Day	AFDD °F-day	Day	AFDD °F-day	Day	°F-day	Days	Δ AFDD °F-day	Days	Δ AFDD °F-day
2010	19-Mar	1925.2	19-Mar	1925	19-Mar	1925	2	55	2	55
2009	24-Mar	2468.8	24-Mar	2484	24-Mar	2469	4	64	4	64
2008	26-Feb	2095.9	23-Apr	2131	8-Apr	2316	25	292	-16	72
2007	27-Mar	1461.8	28-Mar	1447	30-Mar	1426	10	108	7	145
2006	4-Apr	1464.8	2-Apr	1479	4-Apr	1465	1	72	1	72
2005	2-Apr	1680	15-Apr	1395	31-Mar	1702	-1	102	1	80
2004	30-Mar	1875.6	1-Apr	1859	1-Apr	1859	-4	65	-6	81
2003	4-Apr	1969	7-Apr	1969	20-Mar	2080	18	182	33	71
2002	11-Apr	1376.1	27-Mar	1391	14-Apr	1308	-10	40	-13	109
2001	3-Apr	2734.6	3-Apr	2735	10-Apr	2682	11	16	4	68
2000	9-Mar	1131.6	15-Mar	1180	3-Mar	1190	2	125	8	67
1999	25-Mar	1538.7	28-Mar	1504	24-Mar	1539	-3	43	-2	43
1998			25-Mar	1389	31-Mar	1326			-29	85
1997	11-Apr	2985.8	3-Apr	2915	25-Apr	2827	6	2	-8	161
1996					18-Apr	2823			-1	99
1995			2-Feb	1621	17-Mar	1708			5	65
1994					28-Mar	2489			-6	18
1993			5-Apr	2260	3-Apr	2273			2	72
1992			18-Mar	1317	6-Mar	1280			5	63
1991			2-Apr	1687	19-Mar	1770			15	37
1990			28-Mar	1652	17-Mar	1591			4	69

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	Water Temp rises above freezing		Fargo Gage observed as clear of ice		Unified AFDD method, ti=0		Water Temp Rise to Peak Stage		Unified AFDD Method to Peak Stage	
Water Year	Day	AFDD °F-day	Day	AFDD °F-day	Day	°F-day	Days	Δ AFDD °F-day	Days	Δ AFDD °F-day
1989			5-Apr	2451	5-Apr	2451			4	37
1988			7-Apr	1790	30-Mar	1899			-19	27
1987			31-Mar	1125	24-Mar	1101			-14	80
1986			2-Apr	2467	1-Apr	2478			2	140
1985			3-Apr	2008	21-Mar	2094			2	59
1984			30-Mar	2273	3-Apr	2241			-2	79
1983					8-Apr	1333			-31	48
1982					21-Apr	2769			-17	140
1981					19-Mar	1497			6	47
1980					8-Apr	2114			-3	117
1979					23-Apr	3295			-4	153
1978					5-Apr	3011			-3	57
1977					17-Mar	2429			14	70
1976					28-Mar	1837			2	58
1975					16-Apr	1963			5	56
1974					19-Apr	2396			-5	130
1973					19-Mar	1891			-4	57
1972					23-Mar	2443			2	58
1971					5-Apr	2303			-15	27
1970					15-Apr	2306			-3	113
1969					14-Apr	2481			1	146
1968					14-Mar	1851			5	5

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	Water Temp rises above freezing		Fargo Gage observed as clear of ice		Unified AFDD method, ti=0		Water Temp Rise to Peak Stage		Unified AFDD Method to Peak Stage	
Water Year	Day	AFDD °F-day	Day	AFDD °F-day	Day	°F-day	Days	Δ AFDD °F-day	Days	Δ AFDD °F-day
1967					1-Apr	2286			-1	116
1966					21-Mar	2387			1	63
1965					19-Apr	3084			-4	126
1964					9-Apr	1756			10	53
1963					30-Mar	1977			2	101
1962					5-Apr	2449			14	20
1961					10-Mar	1799			-2	14
1960					14-Apr	2113			-6	107
1959					31-Mar	2213			7	90
1958					30-Mar	1339			-19	74
1957					27-Mar	2055			0	72
1956					13-Apr	2924			3	44
1955					3-Apr	2109			1	95
1954					13-Apr	1765			-16	141
1953					26-Mar	1569			0	44
1952					11-Apr	2674			5	37
1951					8-Apr	2829			3	69
1950					25-Apr	2767			-18	128
1949					12-Apr	2451			-8	155

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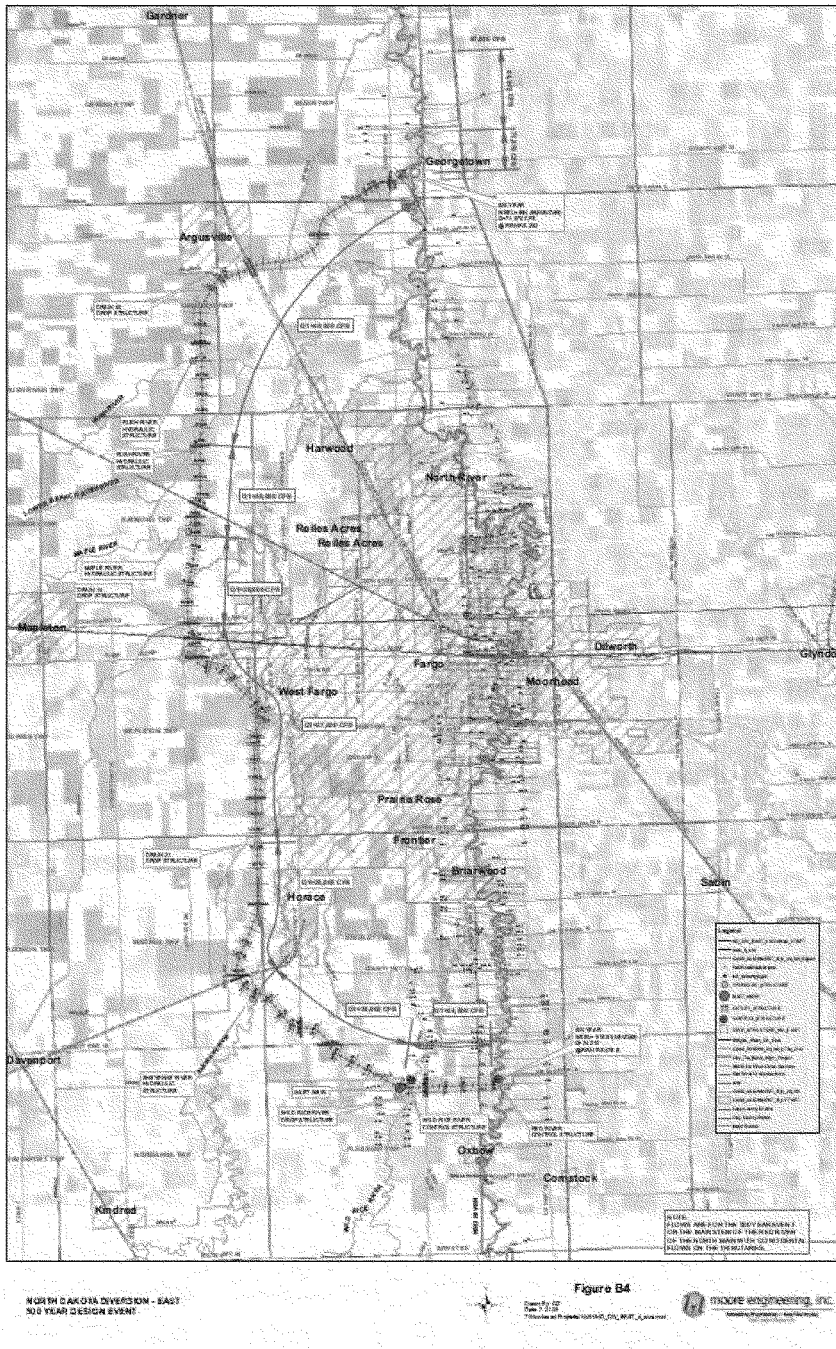

Fig. 1. Map of project area showing the North Dakota side diversion alternative.

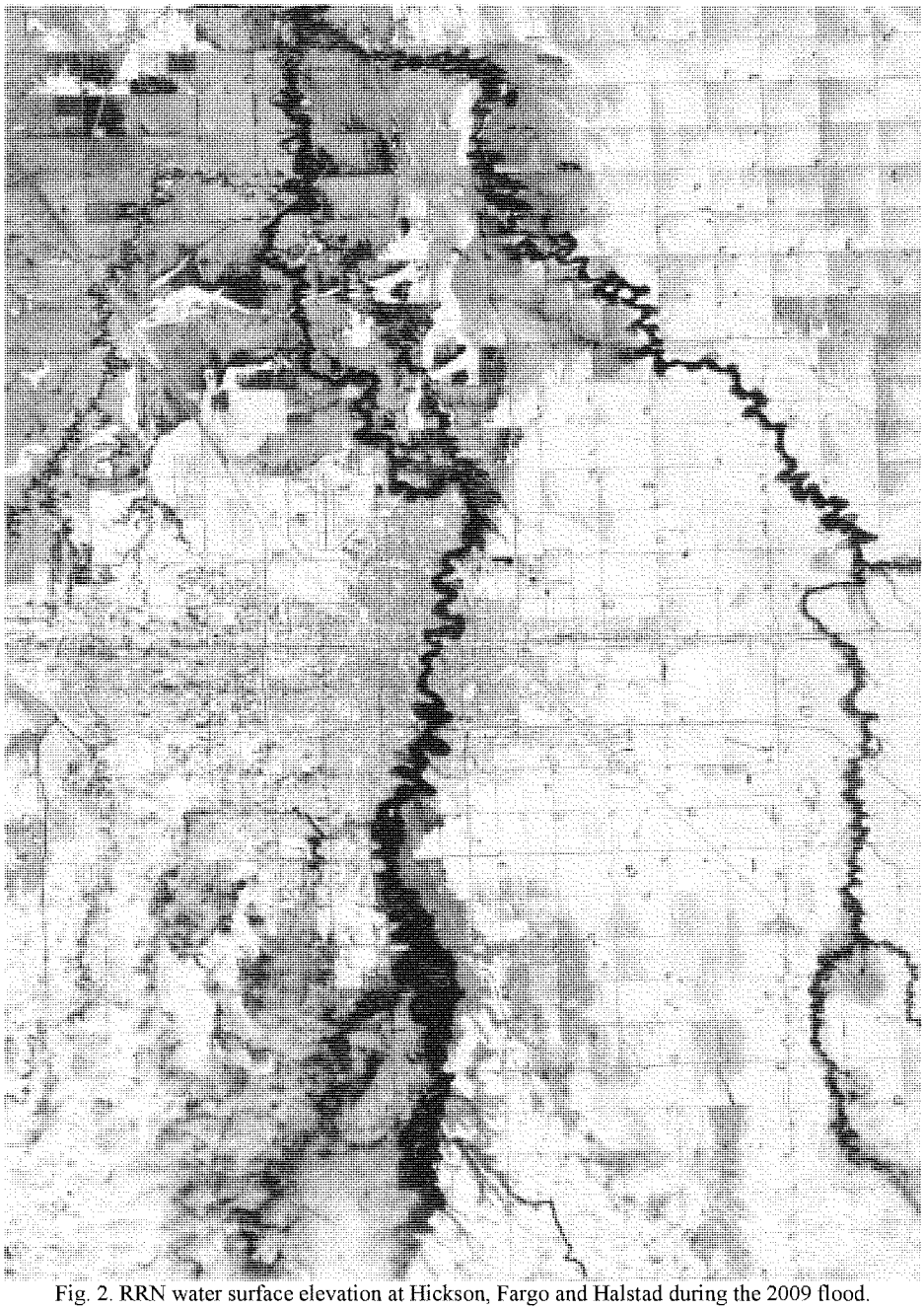

Fig. 2. RRN water surface elevation at Hickson, Fargo and Halstad during the 2009 flood.

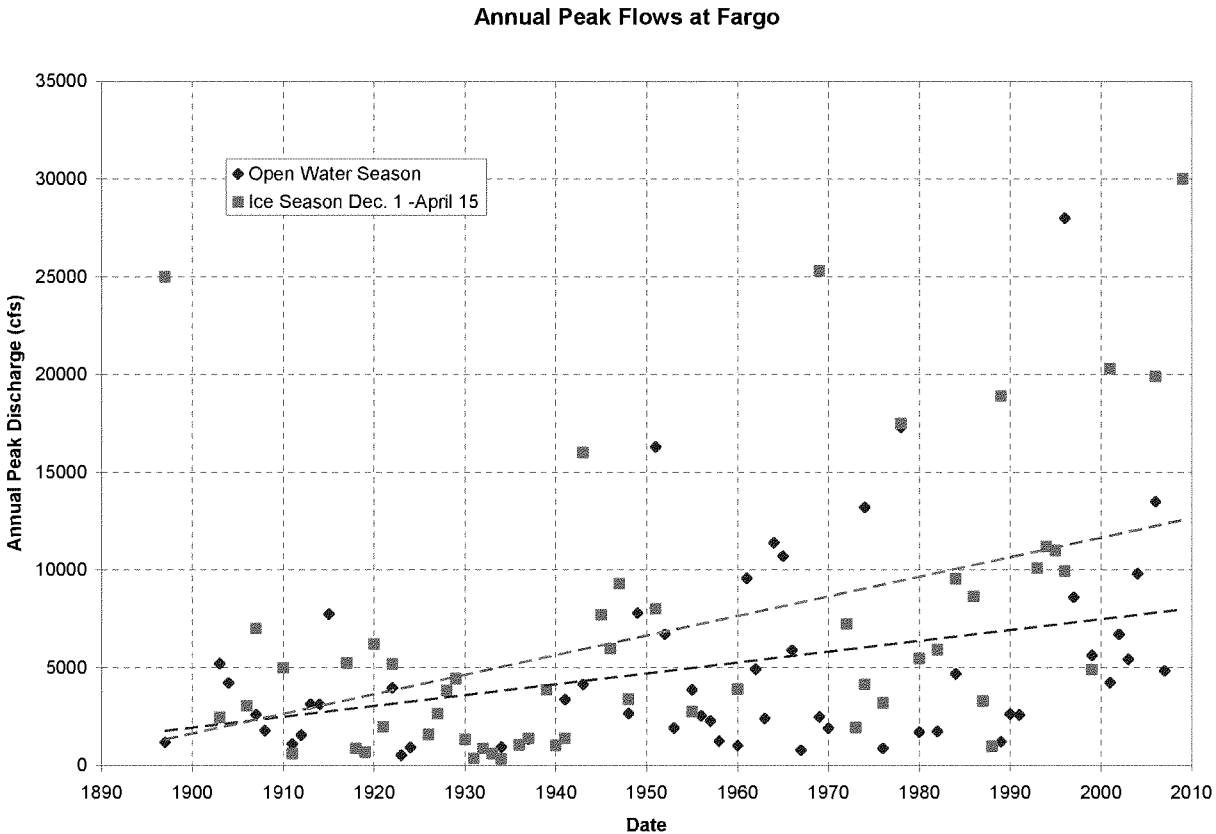

Fig. 3. Annual peak discharges at Fargo.

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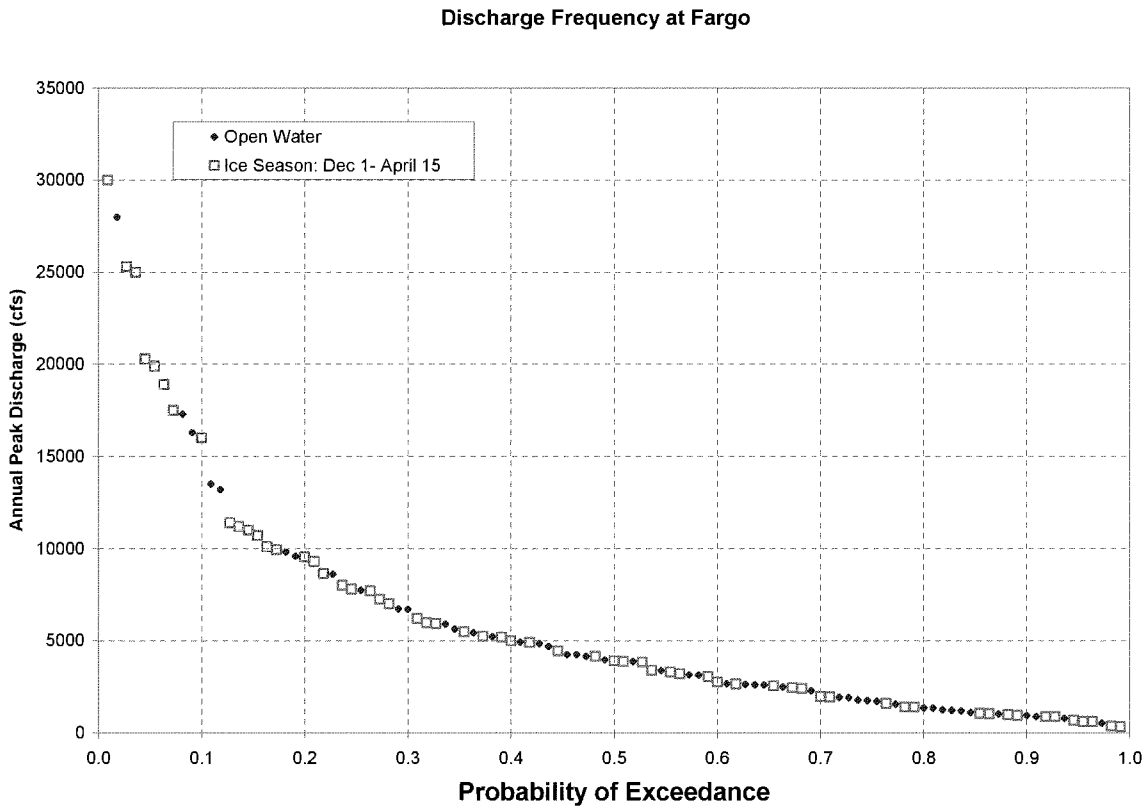

Figure 4. Probability distribution of peak discharges at Fargo.

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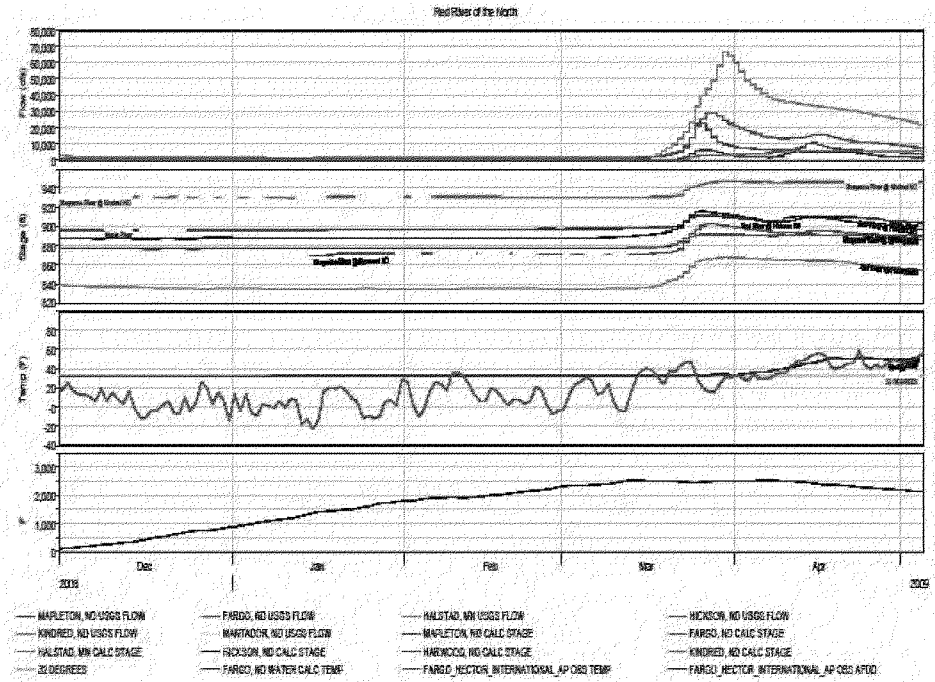

Figure 5. Daily average air temperature and AFDD, and discharge stage and stage for RRN and tributaries in the Fargo-Moorhead area, 2009 Flood

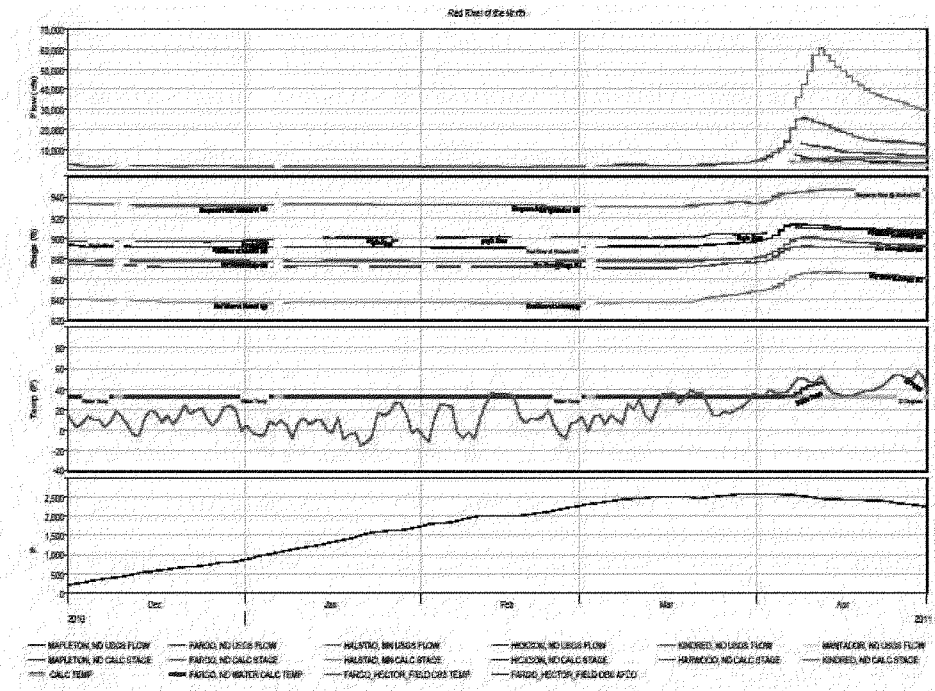

Figure 6. Daily average air temperature and AFDD, and discharge stage and stage for RRN and tributaries in the Fargo-Moorhead area, 2011 flood.

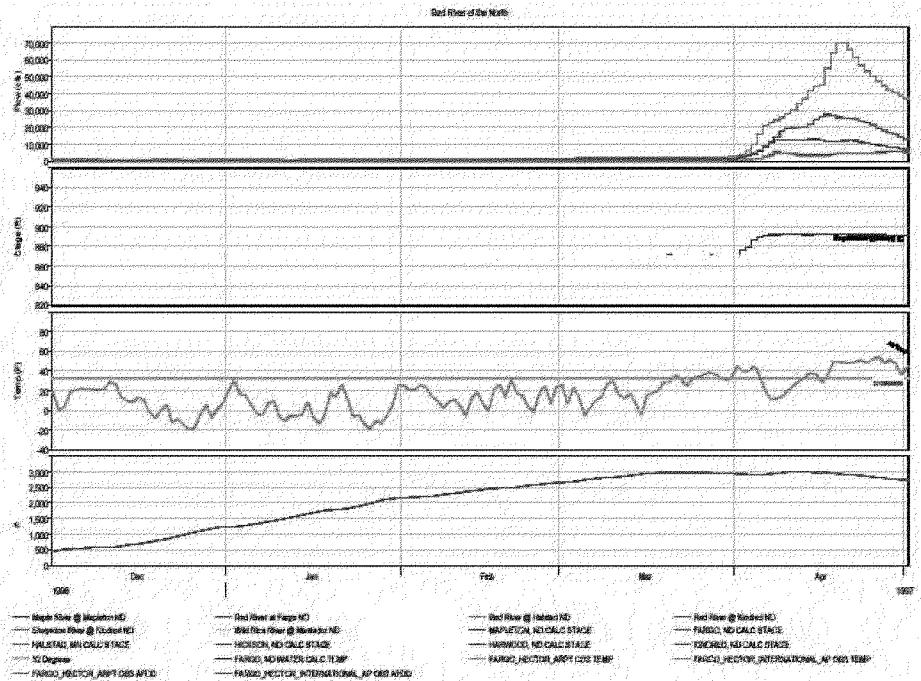

Figure 7. Daily average air temperature and AFDD, and discharge stage and stage for RRN and tributaries in the Fargo-Moorhead area; 1997 flood.

Appendix B

Images 1997, 2001, 2006, 2009, and 2010 Floods
Red River of the North, Fargo-Moorhead Area

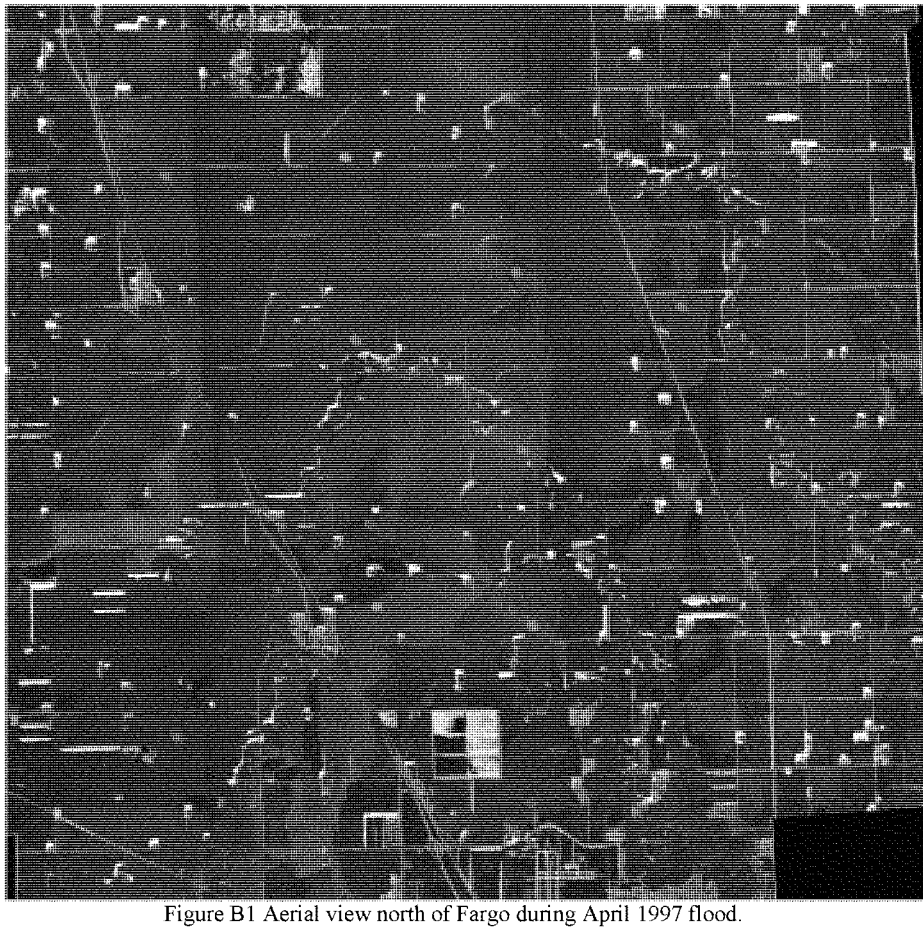

Figure B1 Aerial view north of Fargo during April 1997 flood.

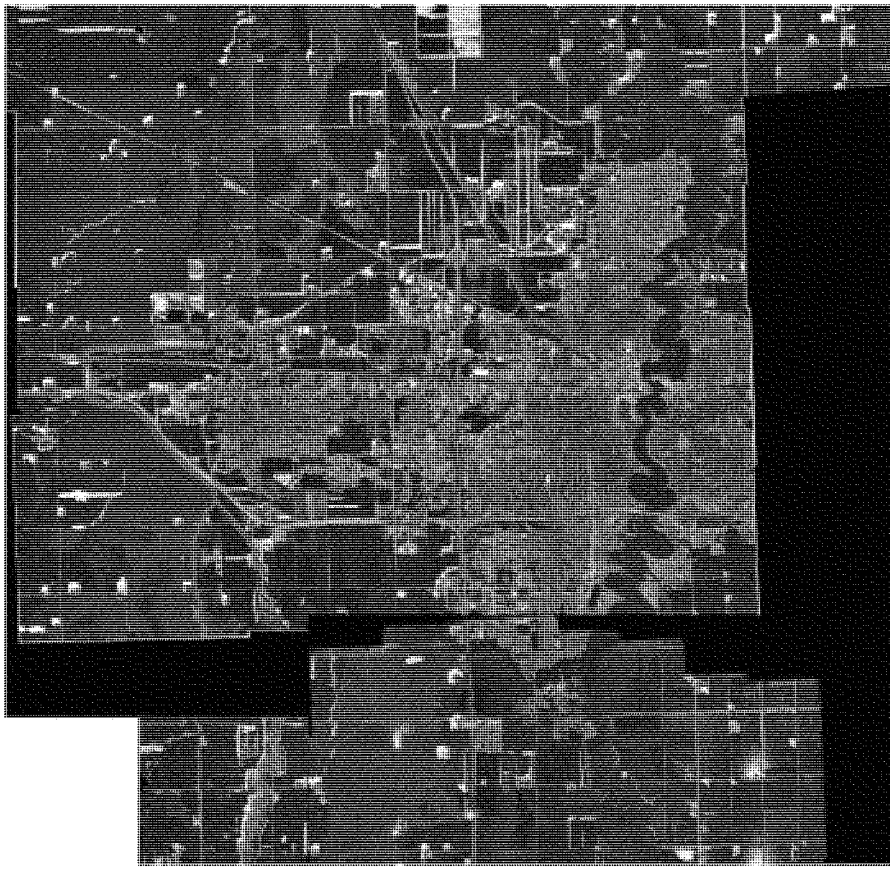

Figure B2. Aerial view of Fargo and surrounds during April 1997 flood.

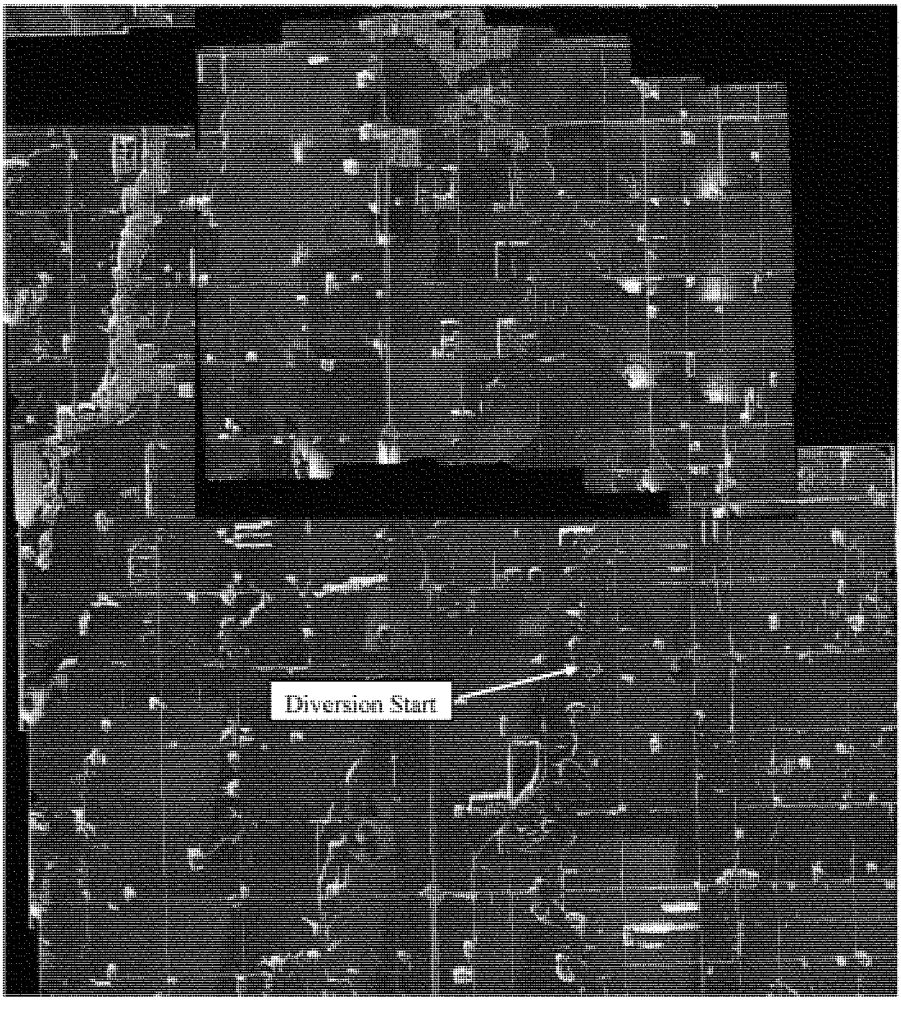

Fig. B3. Aerial view south of Fargo during April 1997 flood.

Figure B4. View of Fargo during the 1997 flood looking north. (Photo Courtesy of City of Fargo, ND)

Figure B5. View looking upstream of Fargo and Moorhead during the April 2001 flood (Photos Courtesy of North Dakota State University)

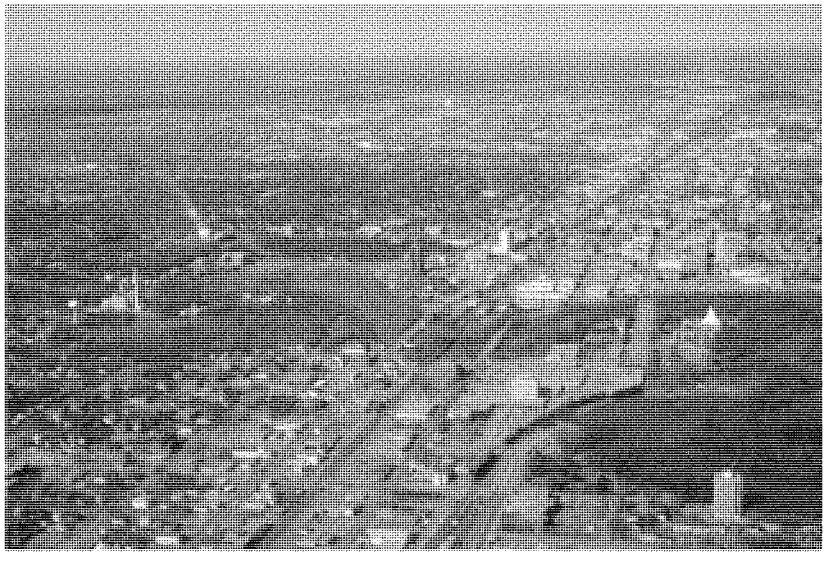

Figure B6. View looking west of Fargo and Moorhead during the April 2001 flood (Photos Courtesy of North Dakota State University)

Figure B7. View of 2006 RRN flood looking north toward F/M.

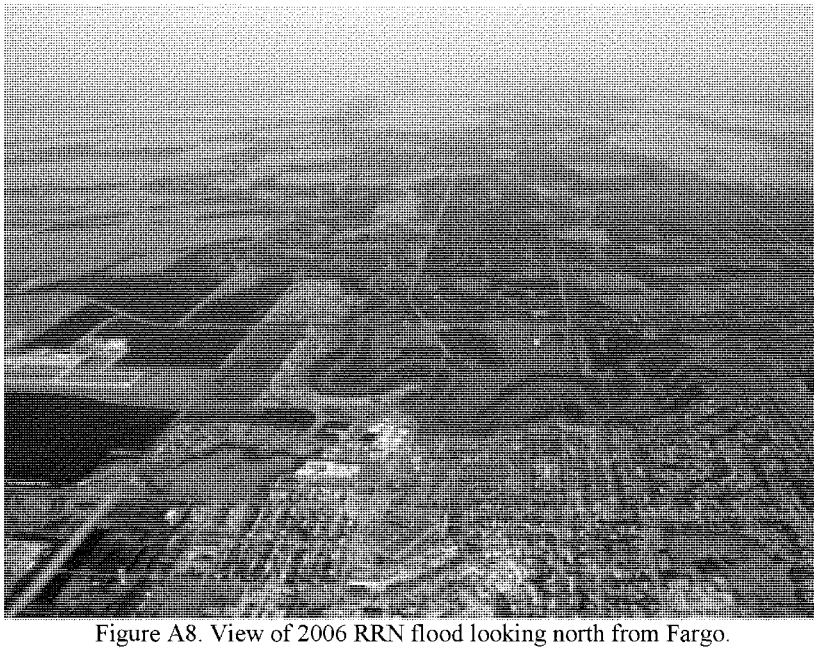

Figure A8. View of 2006 RRN flood looking north from Fargo.

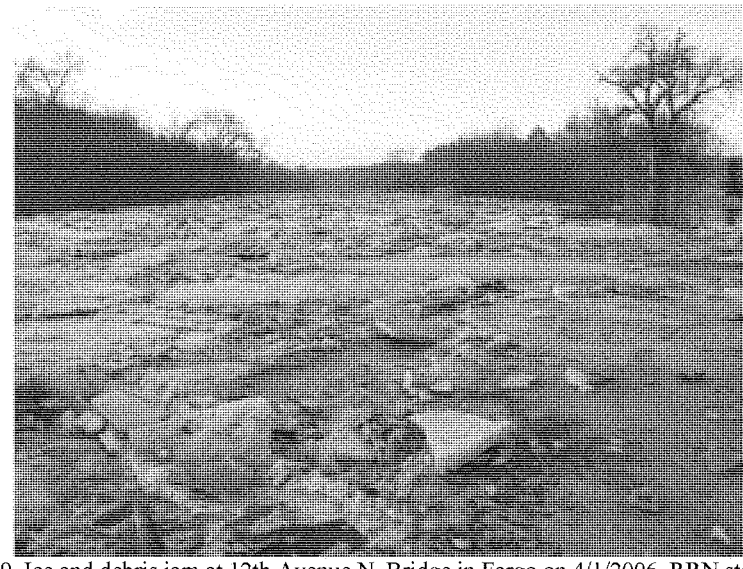

Figure B9. Ice and debris jam at 12th Avenue N. Bridge in Fargo on 4/1/2006. RRN stage at Fargo was 27.5 ft. (Photo Courtesy of North Dakota State University)

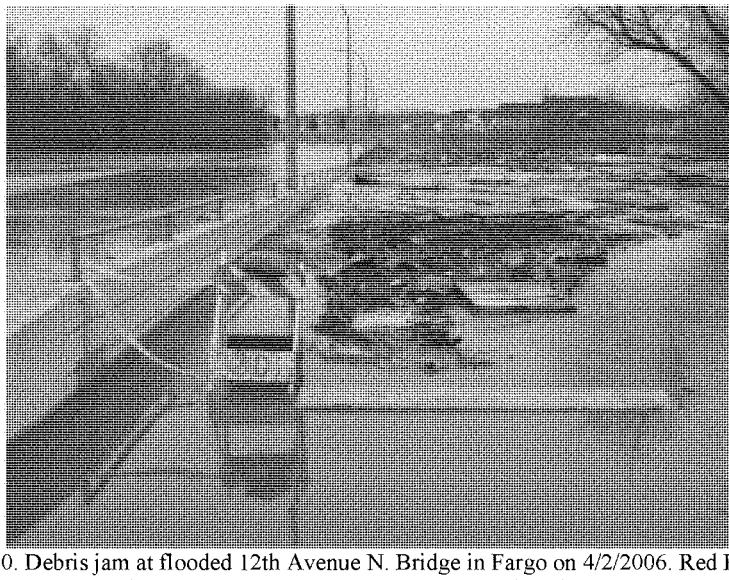

Figure B10. Debris jam at flooded 12th Avenue N. Bridge in Fargo on 4/2/2006. Red River stage at Fargo was 31.9 ft. (Photo Courtesy of North Dakota State University)

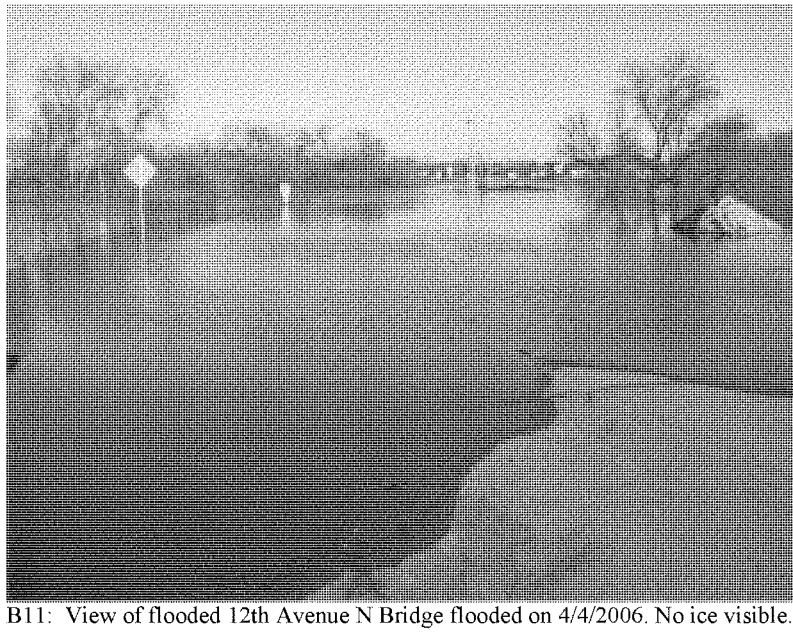

Figure B11: View of flooded 12th Avenue N Bridge flooded on 4/4/2006. No ice visible. RRN stage at Fargo was 37.1 ft. (Photo Courtesy of North Dakota State University)

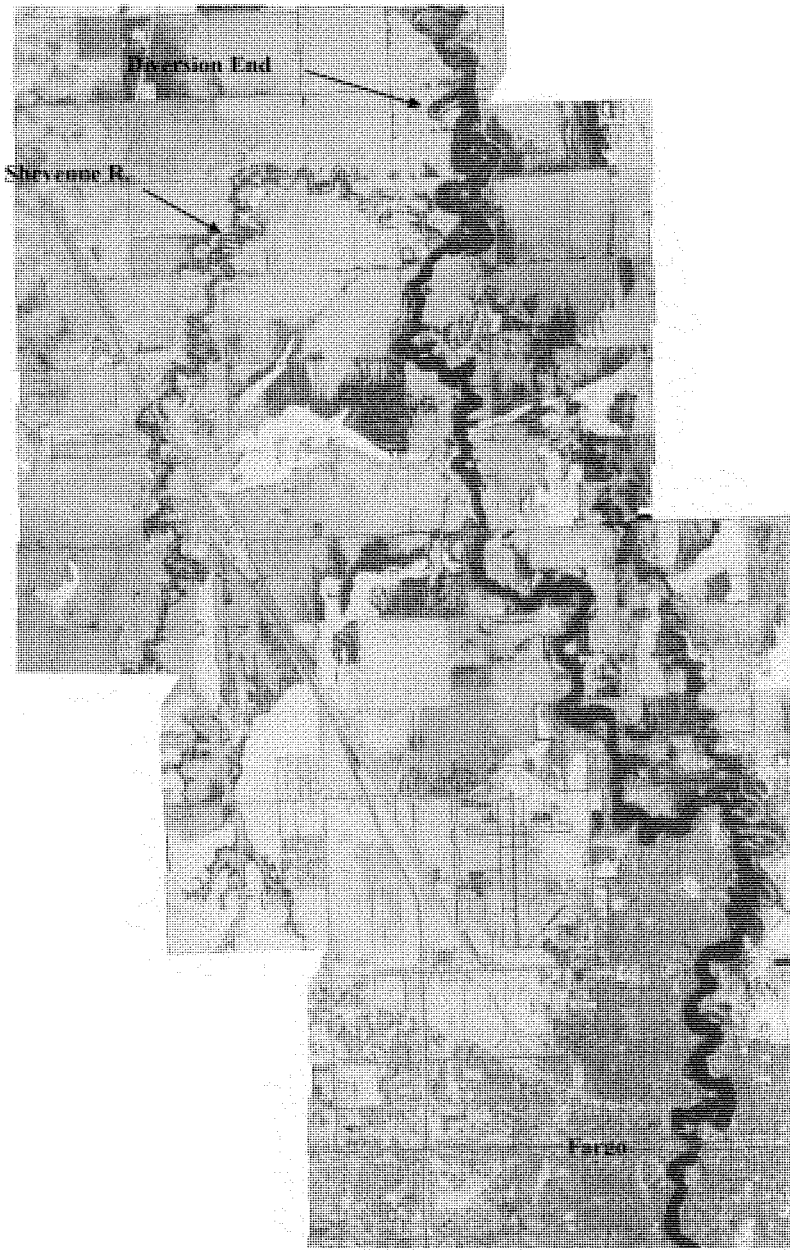

Figure BA12. Aerial view of the March 2009 flood. Fargo and north.

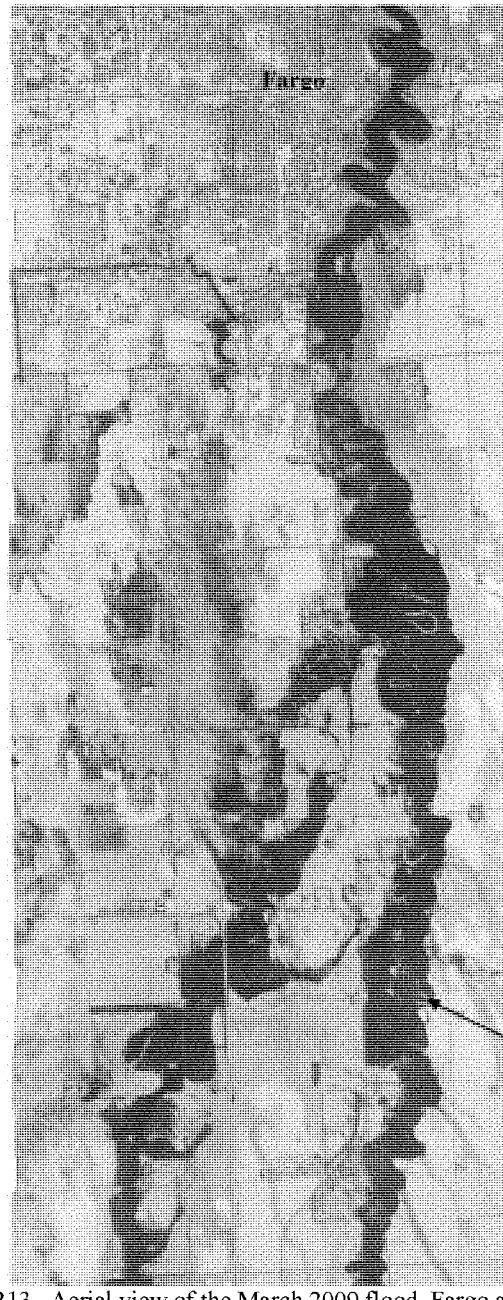

Figure B13. Aerial view of the March 2009 flood. Fargo and south.

Figure B14. March 2009. View looking south at confluence of RRN (left) and Wild Rice River (right). (Photo Courtesy City of Fargo, ND)

Figure B15. March 2009. View looking of RRN and Fargo-Moorhead. (Photo Courtesy City of Fargo, ND)

Figure B16. Ice and debris jam at 12th Avenue N. Bridge in Fargo on 3/24/2009, RRN stage at Fargo: 32.4 ft. (Photo Courtesy of North Dakota State University).

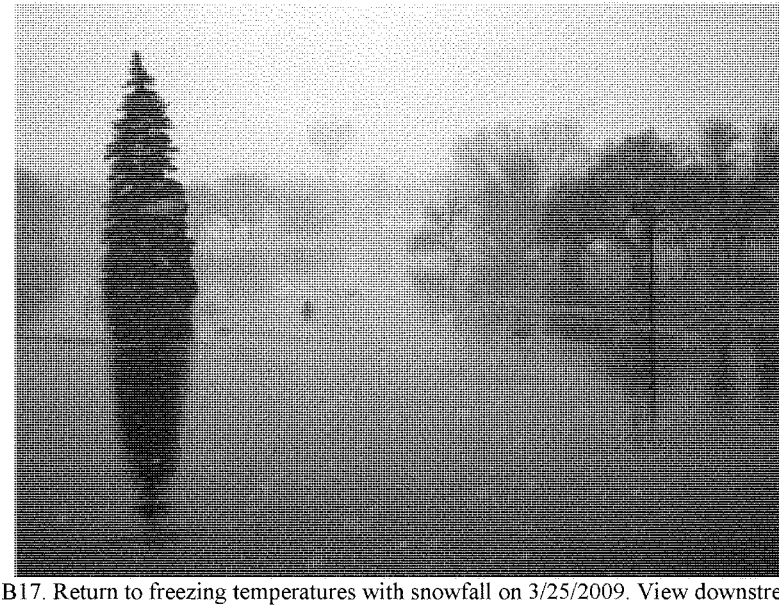

Figure B17. Return to freezing temperatures with snowfall on 3/25/2009. View downstream from the Main Ave. Bridge in Moorhead. RRN stage at Fargo: 36.6 ft. (Photo Courtesy of North Dakota State University)

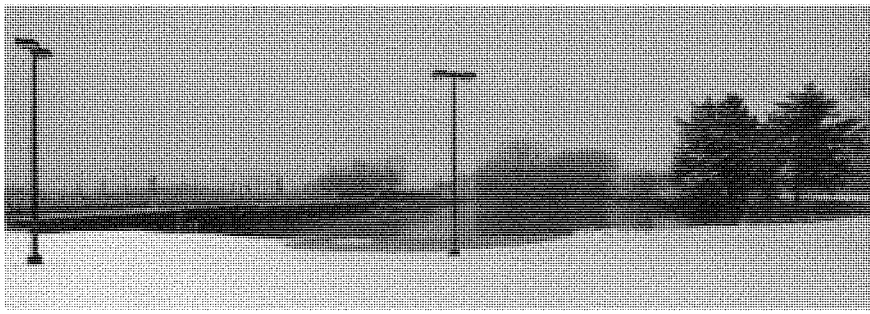

Figure B18. View of Center Ave. and BNSF Railroad Bridges across RRN toward Fargo on 3/25/2009. RRN stage at Fargo: 36.6 ft. (Photo Courtesy of North Dakota State University)

Figure B19. Temporary dike along RRN at Elm St. and 14th Ave. N. in Fargo on 3/26/2009. . RRN stage at Fargo): 39.6 ft (Photo Courtesy of North Dakota State University)

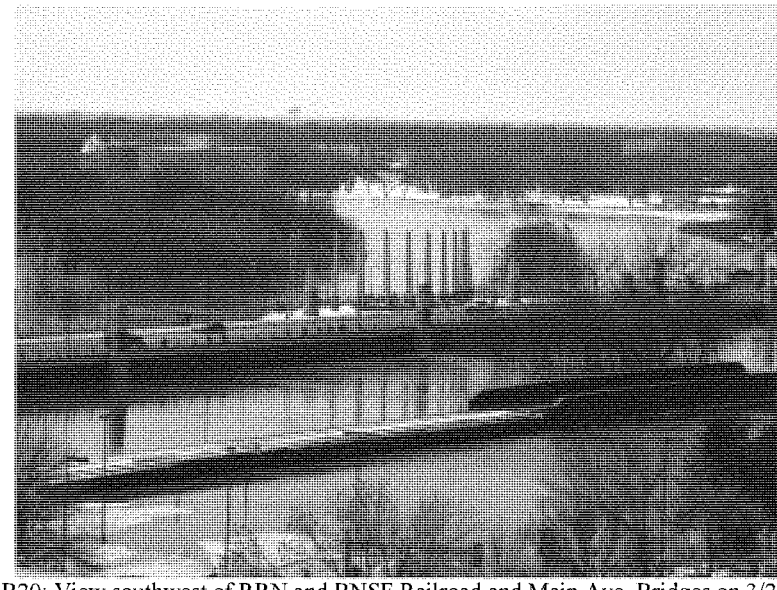

Figure B20: View southwest of RRN and BNSF Railroad and Main Ave. Bridges on 3/27/2009. RRN stage at Fargo close to peak at 40.7 ft. (Photo Courtesy of North Dakota State University)

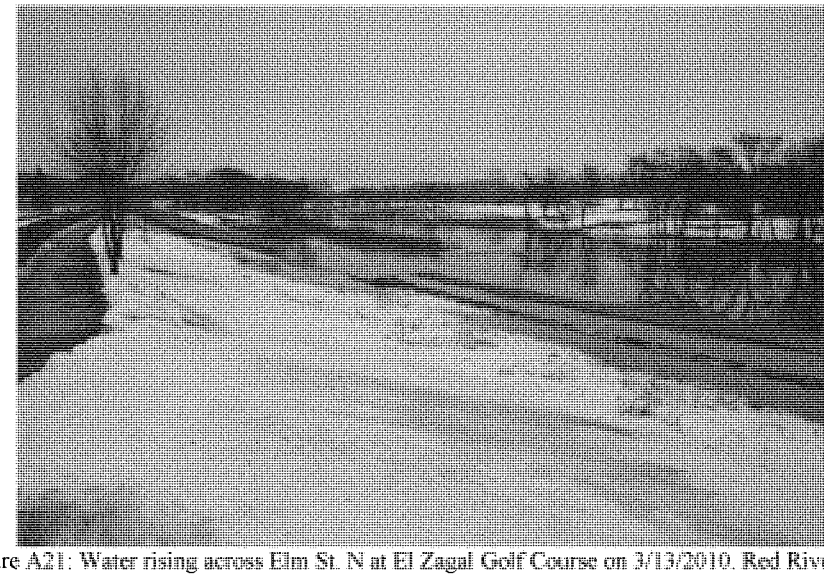

Figure A21: Water rising across Elm St. N at El Zagal Golf Course on 3/13/2010. Red River stage at Fargo: 18.7 ft. (Photo Courtesy of North Dakota State University)

Figure B22. View of RRN looking downstream towards downtown Fargo on 3/13/2010. RRN stage at Fargo: 18.7 ft. (Photo Courtesy of North Dakota State University)

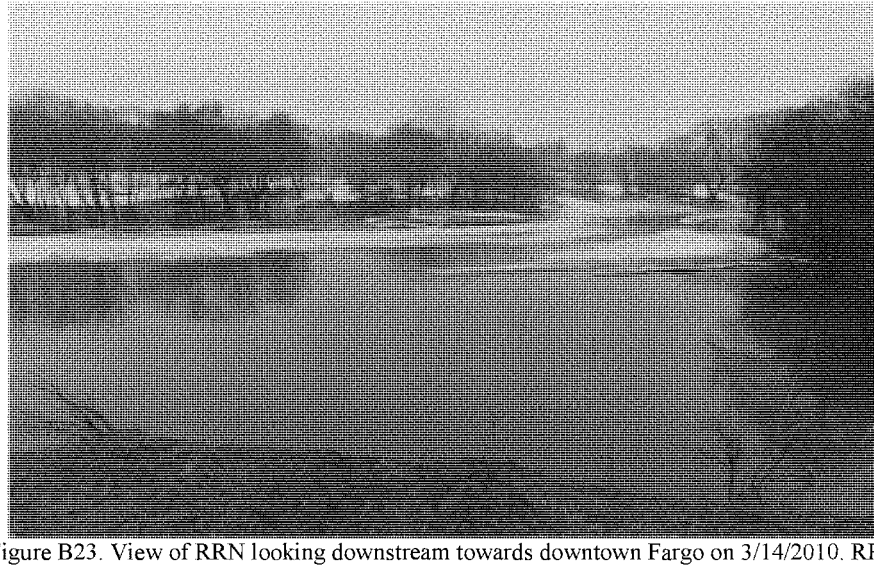

Figure B23. View of RRN looking downstream towards downtown Fargo on 3/14/2010. RRN stage at Fargo: 22.5 ft. (Photo Courtesy of North Dakota State University)

Figure B24. View of RRN looking downstream towards downtown Fargo on 3/15/2010. RRN stage at Fargo: 25.0 ft. (Photo Courtesy of North Dakota State University)

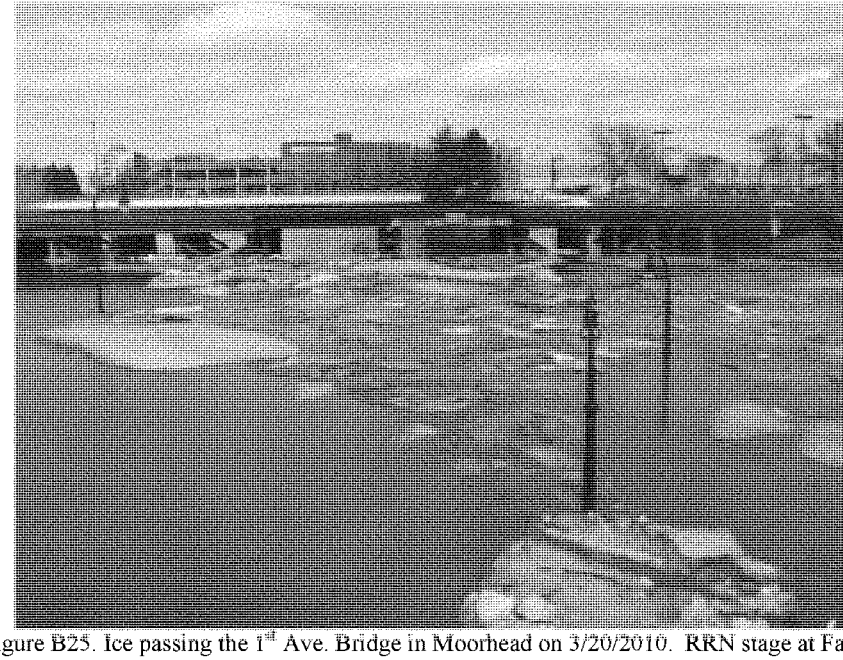

Figure B25. Ice passing the 1st Ave. Bridge in Moorhead on 3/20/2010. RRN stage at Fargo: 36.6 ft. (Photo Courtesy of North Dakota State University)

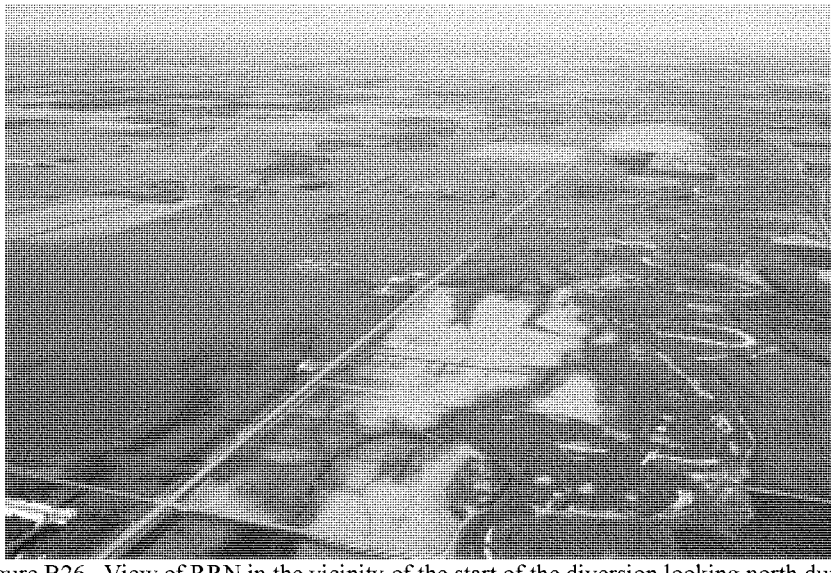

Figure B26. View of RRN in the vicinity of the start of the diversion looking north during March 2010 flood. (Photo Courtesy City of Fargo, ND)

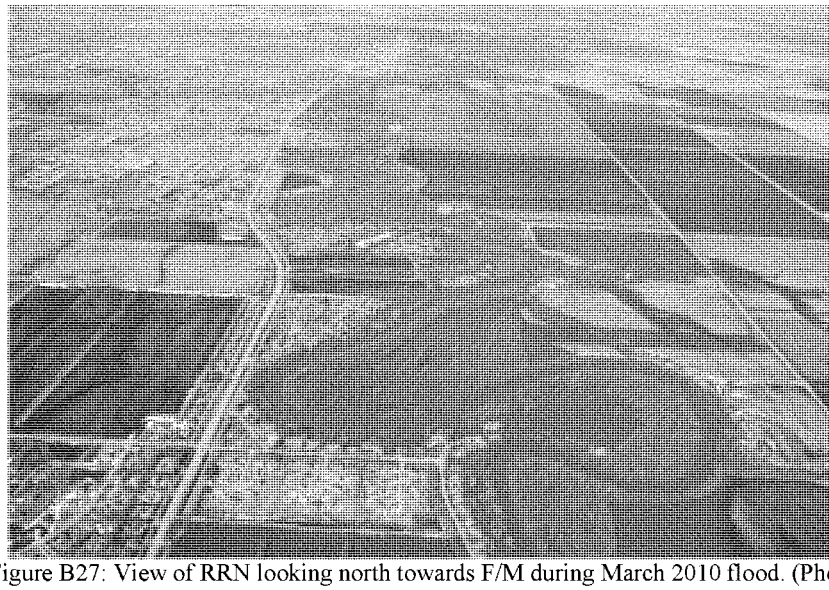

Figure B27: View of RRN looking north towards F/M during March 2010 flood. (Photo Courtesy City of Fargo, ND)

Appendix D

Photo Log of Ice Conditions During Field Visits to RRN Fargo-Moorhead

January 10-12, 2011
April 6-9, 1011

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D3. RRN near diversion. Minor ice tree abrasion at 2009 peak flood levels.
D4. RRN looking downstream from CR 16 Bridge 1-10-11.
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D6. Wild Rice River near diversion 1-10-11. Sheet ice cover 19-in-thick
D7. Sheyenne R. CR 16 upstream of crossing 1-11-11. Sheet ice 14-18-in-thick,
D8. Sheyenne R. CR 16 upstream of crossing 1-11-11.
D9. Maple R. near crossing. 1-1-11.
D10. Sheyenne River south of Harwood at 32nd Ave. 1-1-11.
D11. Sheyenne River near RRN confluence 1-1-11. Tiered banks, wider channel.
D12. RRN near proposed canal outlet 1-11-11. sheet ice18-21-in-thick
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D16. RRN looking west at Wild Rice R confluence, showing decayed sheet ice 4-6-11.
D17. Small accumulation of floes on RRN at Gooseberry Mound Park in Moorhead 4-6-11.
D18. RRN Gooseberry Mound Parlkto F/M Bridges river nearly free of ice 4-7-11.
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D20. Remaining ice cover in bends near RRN-Wild Rice Confluence on 4-7-11.
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D22. RRN in vicinity of proposed diversion looking upstream on 4-7-11.
D23. Decayed sheet ice on RRN near diversion on 4-7-11
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D25. Sheyenne R. looking NW at CR 16 and proposed canal crossing 4-7-11.
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D27. Sheyenne River diversion into W. Fargo FC system near Horace 4-7-11.
D28. Sheyenne River diversion into W. Fargo canal system at CR 17 near 1-94 4-7-11.
D29. Looking west at remaining ice accumulations in W. Fargo diversion canal on 4-7-11.
D30. Minor ice accumulations at RR Bridge in W. Fargo diversion canal on 4-7-11.
D31. Canal branch reentering Sheyenne R in W. Fargo 4-7-11.
D32. Sheyenne River nearly ice-free south of Harwood at 32nd St. 4-7-11.
D33. Residual ice in Maple R. Canal crossing area 4-7-11.
D34. Accumulation of floes on Sheyenne R south of Harwood CR 17. 4-7-11.
D35. Remaining ice in vicinity of Rush R. Sheyenne confluence 4-7-11.
D36. Drifting ice on RRN near Georgetown 4-7-11.
D37. RRN in vicinity of outlet of proposed diversion canal 4-7-11.
D38. RRN ice-free at downtown Fargo-Moorhead on 4-7-11.
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D40. Decayed sheet ice on Sheyenne R. upstream of CR 16 4-7-11.
D41. Remaining ice cover on Sheyenne R. downstream of CR 16 4-7-11.
D42. Ice accumulation on Sheyenne R. upstream of CR 14 4-7-11.
D43. Fast currents and shoved ice floes, Sheyenne R. downstream of CR 14 4-7-11.
D44. Melting sheet ice on Sheyenne R upstream of 52nd Ave. W. 4-7-11.

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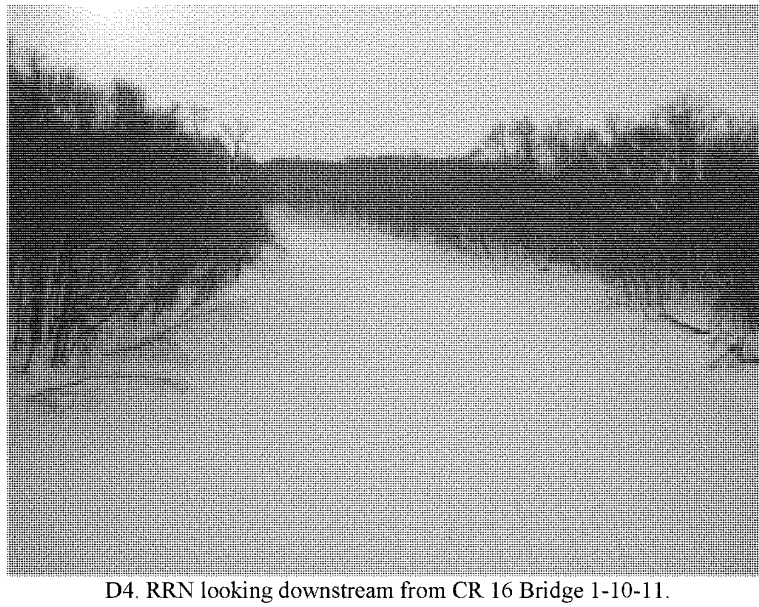
D45. Decayed sheet ice on Sheyenne R upstream CR 17 Br. 4-7-11.
D46. Sheyenne diversion into W. Fargo FC Project at CR 17 Br. 4-7-11.
D47. Accumulated floes upstream of 13th Ave Bridge W. Fargo Diversion 4-7-11.
D48. Residual sheet ice on Sheyenne R. upstream of 12th Ave. NW 4-7-11.
D49. Ice-free RRN looking upstream from Veterans Br. Moorhead, 4-7-11.
D50. Remnants of sheet ice cover on Wild Rice R. near confluence with RRN 4-8-11.
D51. RRN ice nearly melted on at proposed diversion location 4-8-11.
D52. View from proposed diversion westward towards Wild Rice R. 4-8-11.
D53. Accumulated floes at Sheyenne R.diversion CR 17 Br.4-8-11.
D54. Minor ice jam on Sheyenne R. upstream of upstream 17th Ave. SE 4-8-11.
D55. Decayed floes in bend along CR 8 4-8-11.
D56. Remaining ice at diversion of Sheyenne at CR 17 Br.4-8-11.

USACE-MVP-0000087955

D1. RRN near diversion. 12-19 in thick sheet ice cover, tiered banks, no evidence of significant past ice action 1-10-11.

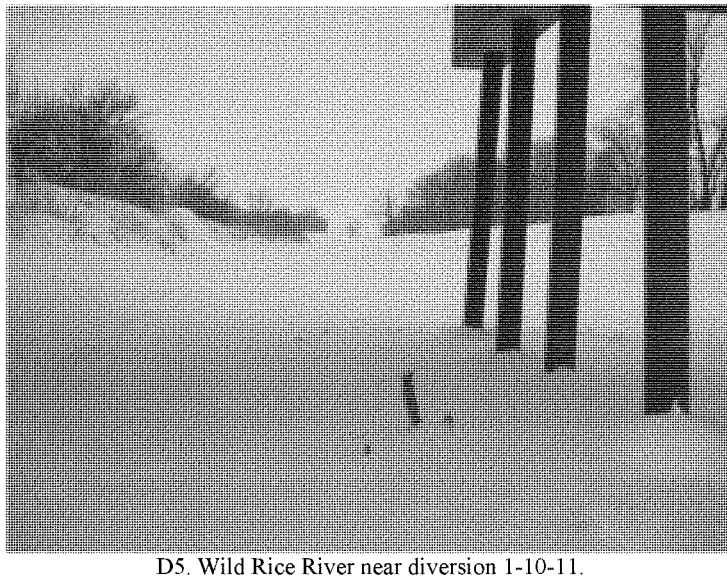
D2. RRN near diversion, minor ice tree scarring at base flow and intermediate flood levels. 1-10-11.

D3. RRN near diversion. Minor ice tree abrasion at 2009 peak flood levels.

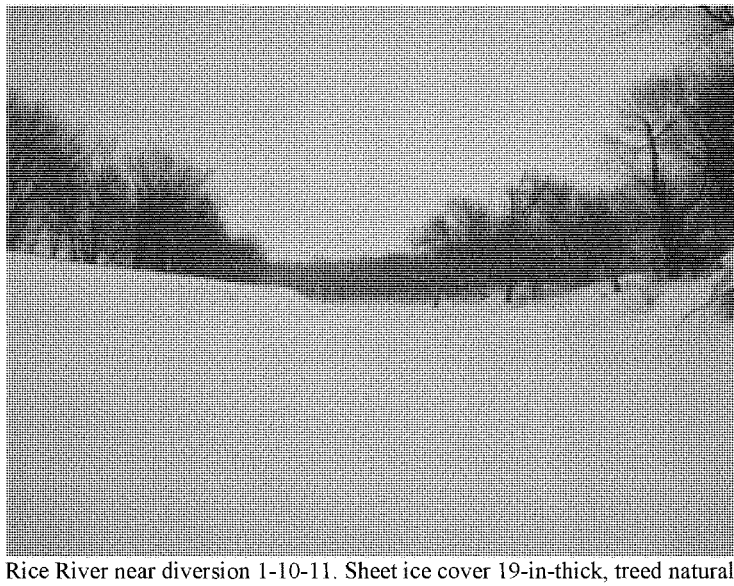


D4. RRN looking downstream from CR 16 Bridge 1-10-11.

USACE-MVP-0000087955



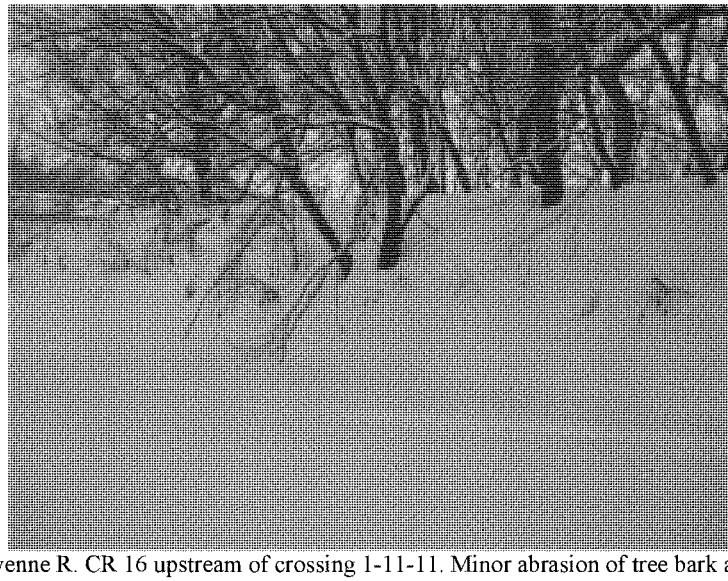
D5. Wild Rice River near diversion 1-10-11.



D6. Wild Rice River near diversion 1-10-11. Sheet ice cover 19-in-thick, treed natural levees, no evidence of significant ice action in the past.

USACE-MVP-0000087955

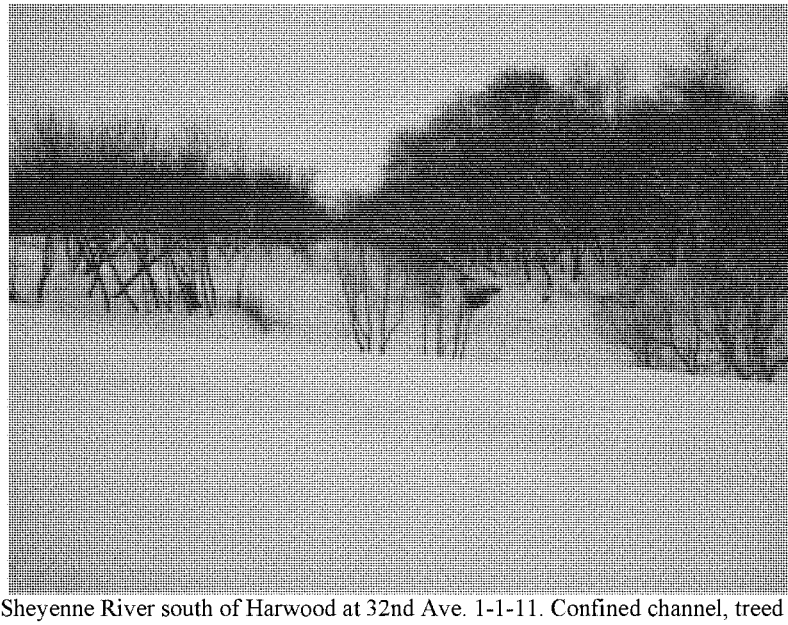
D7. Sheyenne R. CR 16 upstream of crossing 1-11-11. Sheet ice 14-18-in-thick, treed natural levees. Little sign of significant ice movement in past.



D8. Sheyenne R. CR 16 upstream of crossing 1-11-11. Minor abrasion of tree bark at bankfull height.

USACE-MVP-0000087955

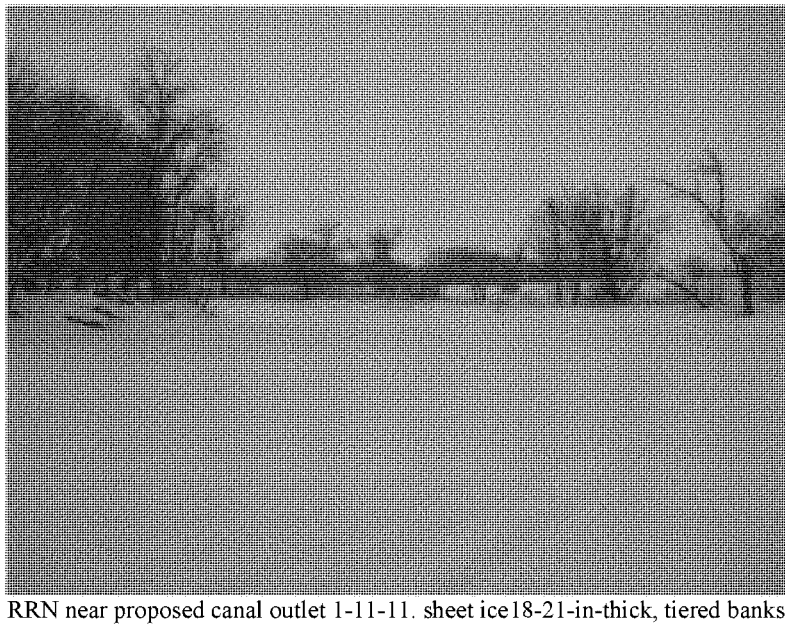
D9. Maple R. near crossing. 1-1-11.



D10. Sheyenne River south of Harwood at 32nd Ave. 1-1-11. Confined channel, treed natural levees.

USACE-MVP-0000087955

D11. Sheyenne River near RRN confluence 1-1-11. Tiered banks, wider channel.



D12. RRN near proposed canal outlet 1-11-11. sheet ice18-21-in-thick, tiered banks, wide channel.

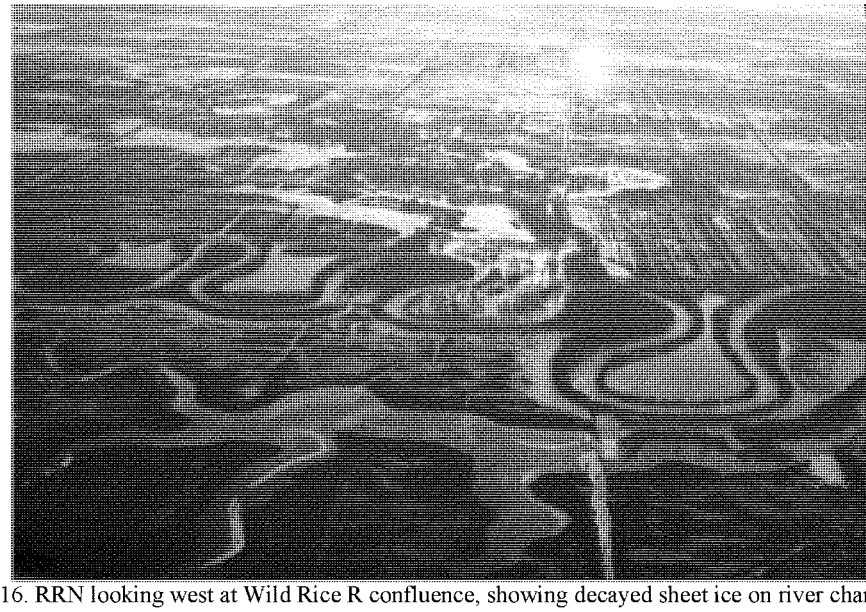
USACE-MVP-0000087955

D13. RRN downstream of Constitution Br. F/M on 1-12-11. Open leads, faster flow.

D14. RRN from Veterans Br. F/M on 1-12-11, looking upstream towards gage.

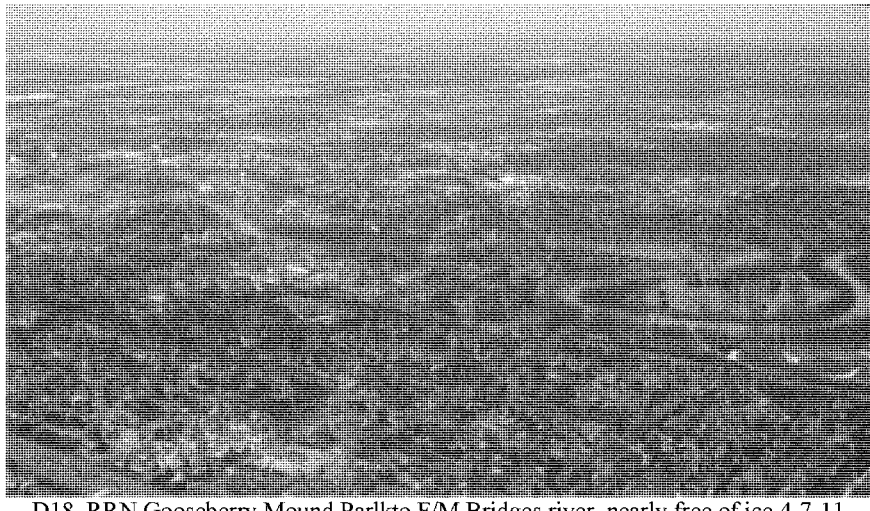
USACE-MVP-0000087955

D15. RRN near diversion 4-6-11 showing decayed sheet ice on river channel.



D16. RRN looking west at Wild Rice R confluence, showing decayed sheet ice on river channel 4-6-11.

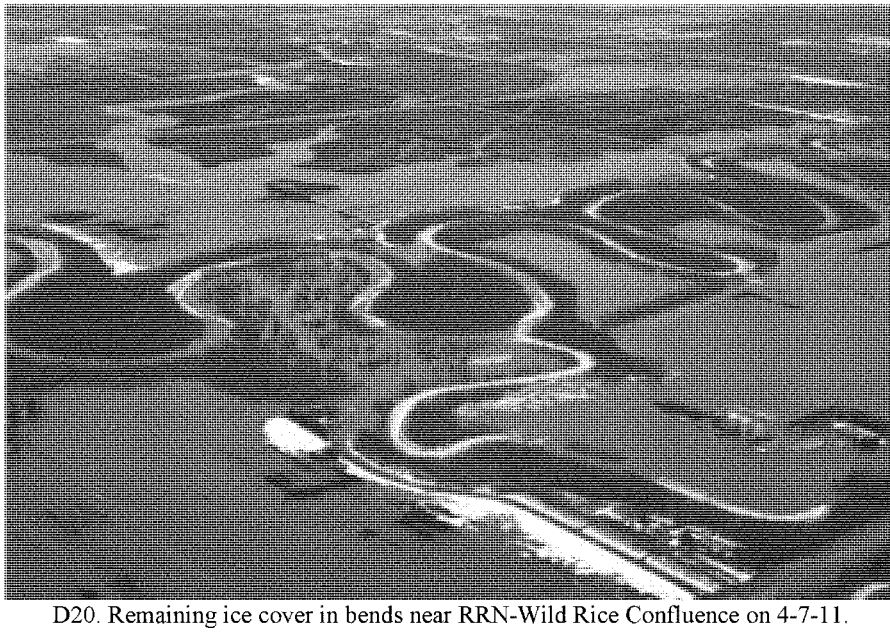
D17. Small accumulation of floes on RRN at Gooseberry Mound Park in Moorhead 4-6-11.



D18. RRN Gooseberry Mound Parlkto F/M Bridges river nearly free of ice 4-7-11.

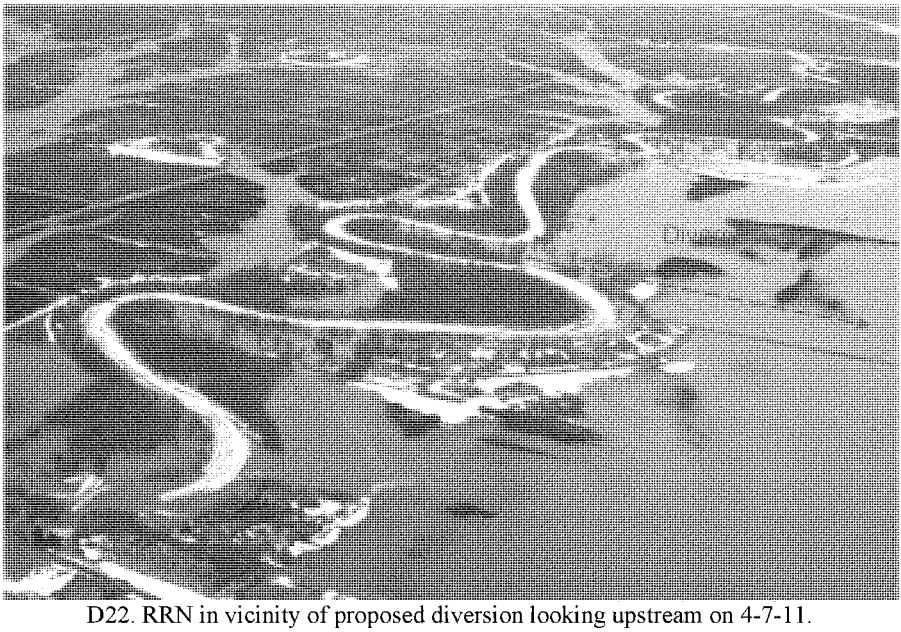
USACE-MVP-0000087955

D19. Residual ice on RRN downstream of US Rt. 81 Bridge on 4-7-11.

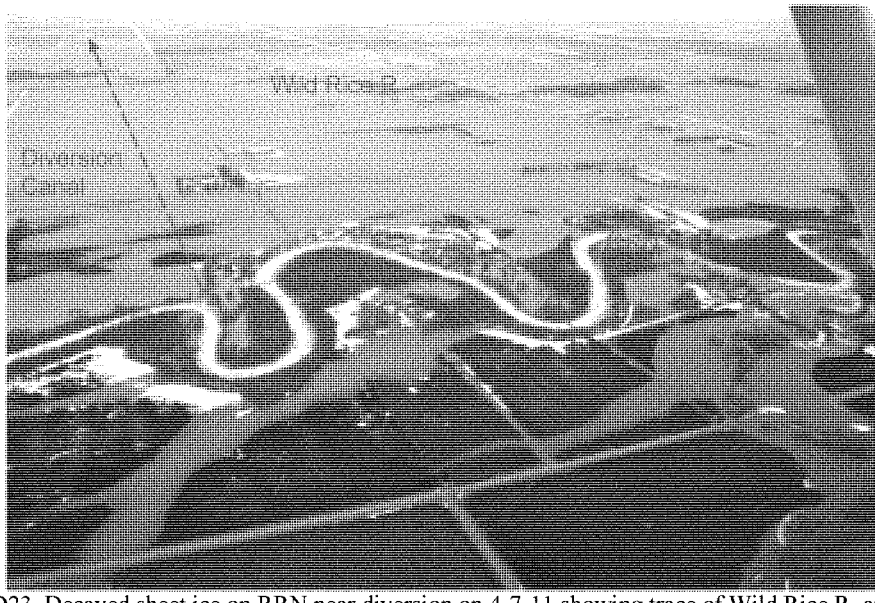


D20. Remaining ice cover in bends near RRN-Wild Rice Confluence on 4-7-11.

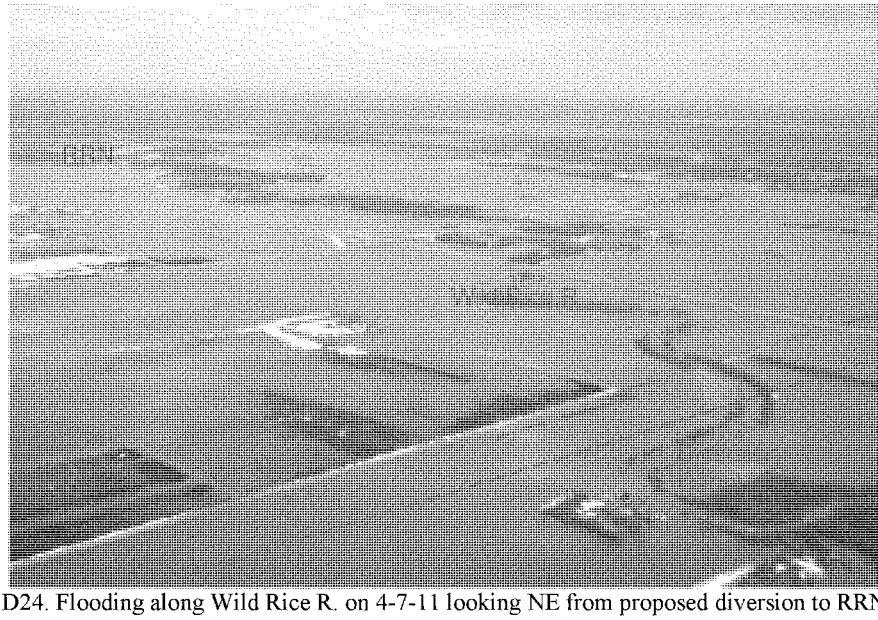
D21. RRN in vicinity of proposed diversion, looking downstream on 4-7-11.



D22. RRN in vicinity of proposed diversion looking upstream on 4-7-11.



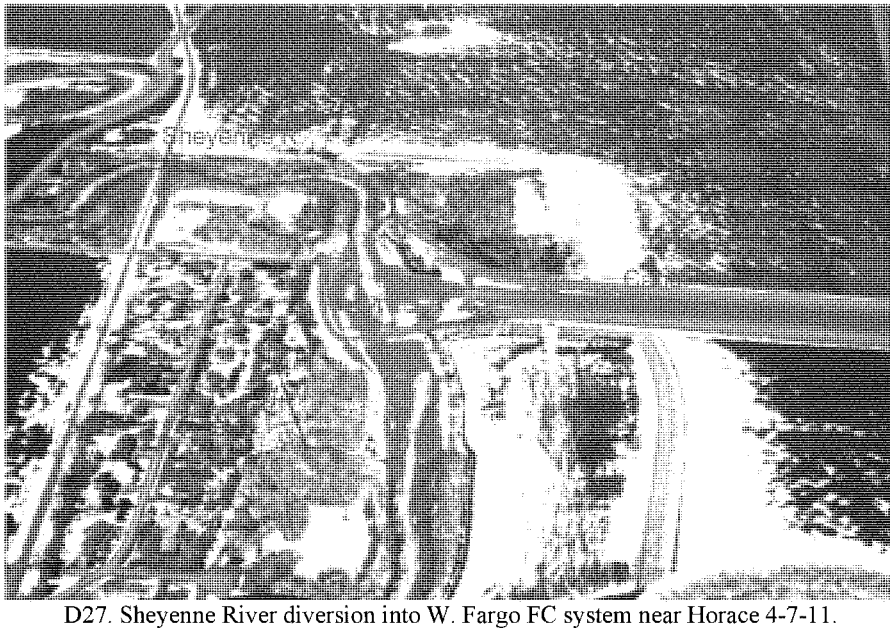
D23. Decayed sheet ice on RRN near diversion on 4-7-11 showing trace of Wild Rice R and flooded areas to the west.



D24. Flooding along Wild Rice R. on 4-7-11 looking NE from proposed diversion to RRN.

D25. Sheyenne R. looking NW at CR 16 and proposed canal crossing 4-7-11.

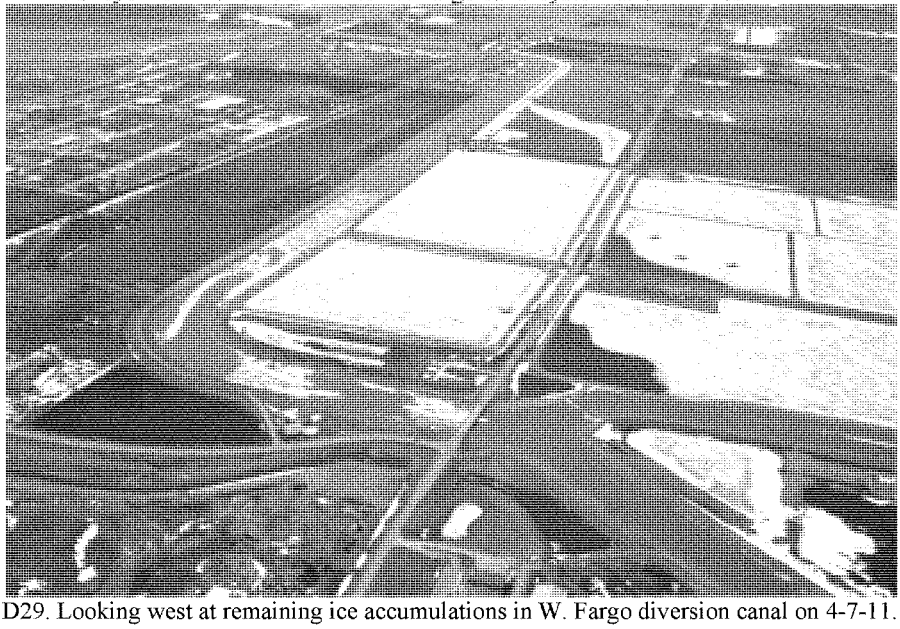
D26. Residual ice on Sheyenne R. in vicinity of proposed canal 4-7-11.



D27. Sheyenne River diversion into W. Fargo FC system near Horace 4-7-11.

USACE-MVP-0000087955

D28. Sheyenne River diversion into W. Fargo canal system at CR 17 near I-94 4-7-11.



D29. Looking west at remaining ice accumulations in W. Fargo diversion canal on 4-7-11.

D30. Minor ice accumulations at RR Bridge in W. Fargo diversion canal on 4-7-11.

D31. Minor ice accumulation in canal branch reentering Sheyenne R in W. Fargo 4-7-11.

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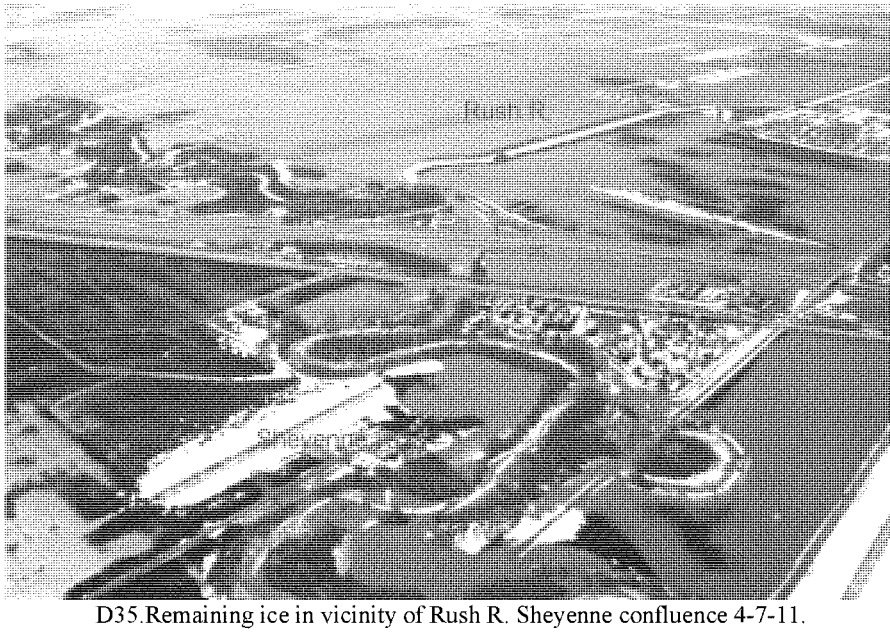
D32. Sheyenne River nearly ice-free south of Harwood at 32nd St. 4-7-11.

D33. Residual ice in Maple R. Canal crossing area 4-7-11.

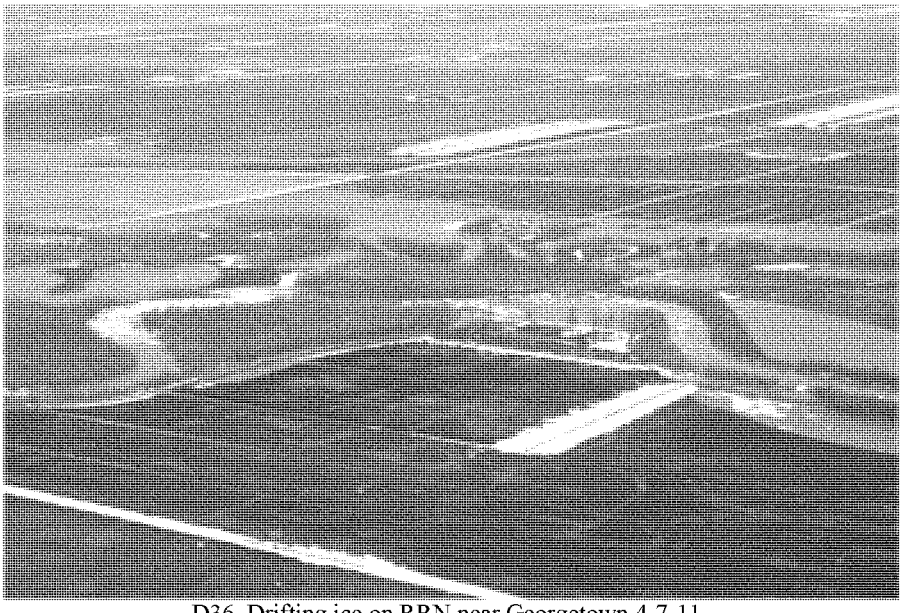
USACE-MVP-0000087955

D34.Accumulation of floes on Sheyenne R south of Harwood CR 17. 4-7-11.

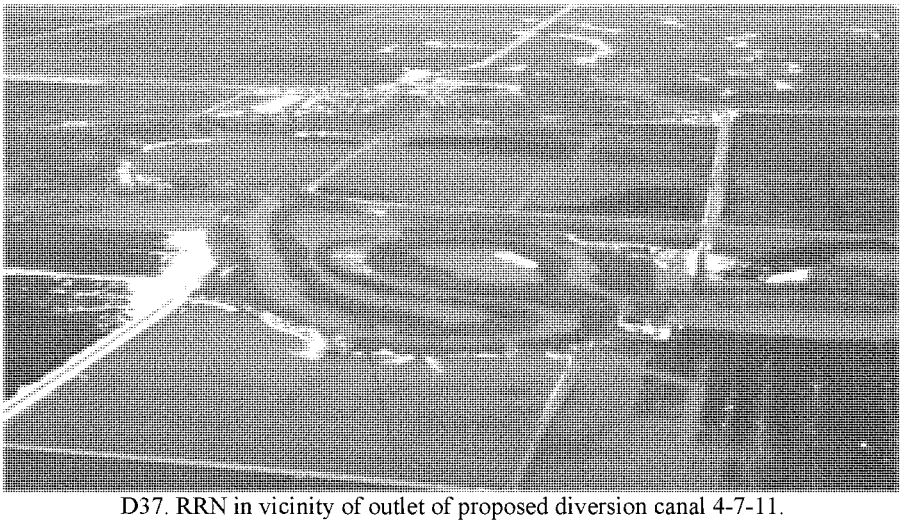


D35.Remaining ice in vicinity of Rush R. Sheyenne confluence 4-7-11.

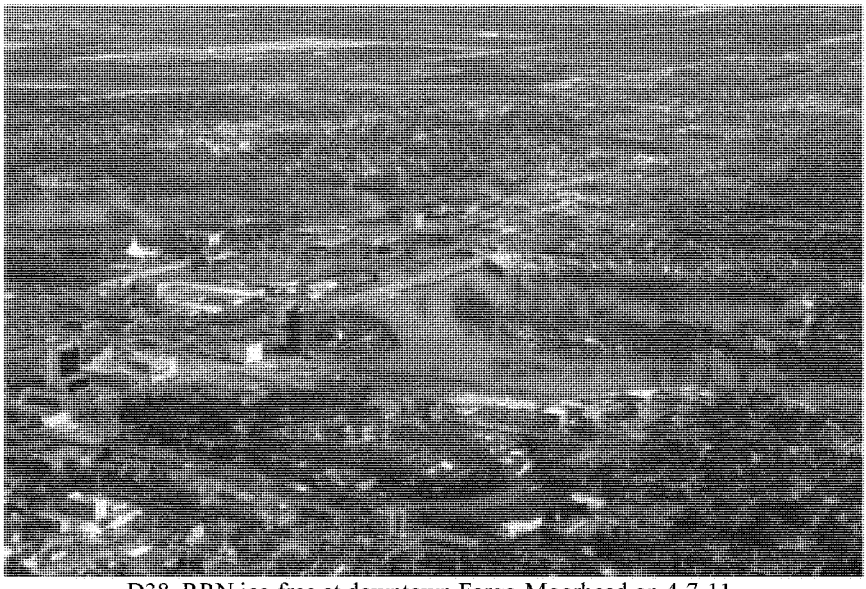
USACE-MVP-0000087955



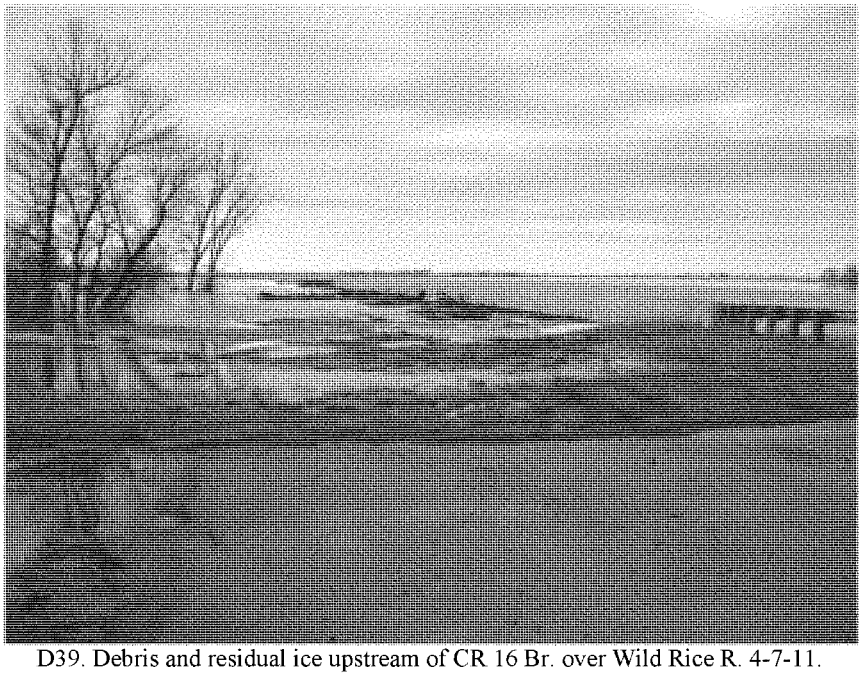
D36. Drifting ice on RRN near Georgetown 4-7-11.



D37. RRN in vicinity of outlet of proposed diversion canal 4-7-11.



D38. RRN ice-free at downtown Fargo-Moorhead on 4-7-11.



D39. Debris and residual ice upstream of CR 16 Br. over Wild Rice R. 4-7-11.

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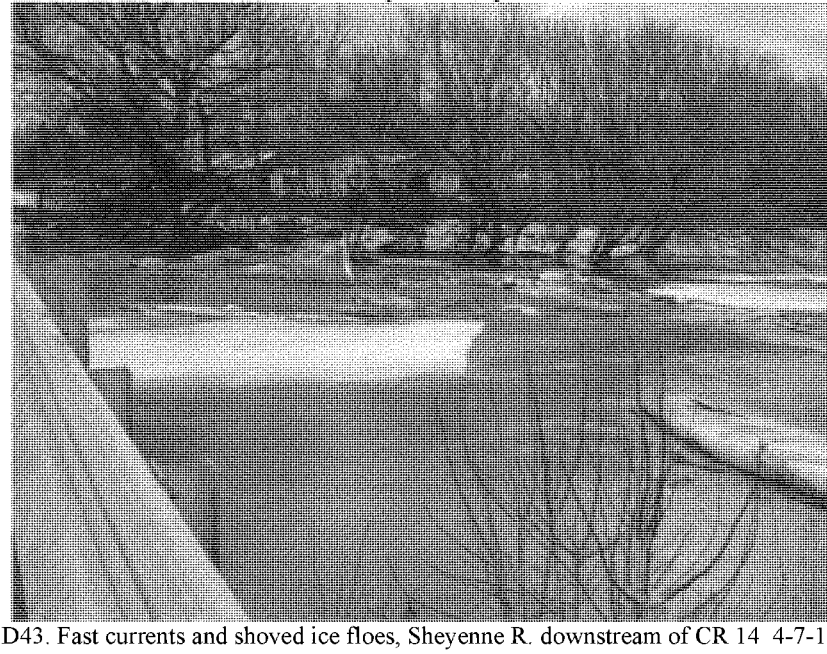
D40. Decayed sheet ice on Sheyenne R. upstream of CR 16 4-7-11.

D41. Remaining ice cover on Sheyenne R. downstream of CR 16 4-7-11.

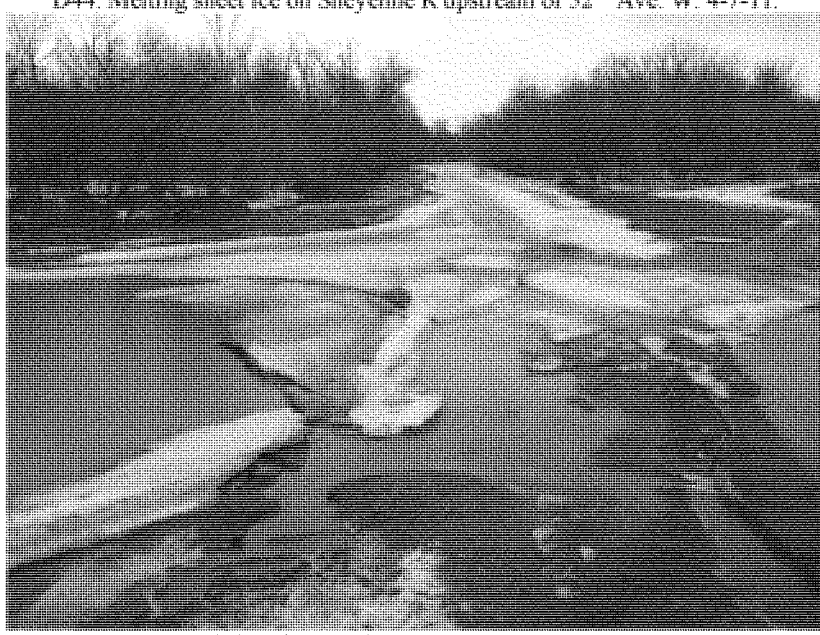
USACE-MVP-0000087955

D42. Ice accumulation on Sheyenne R. upstream of CR 14 4-7-11.



D43. Fast currents and shoved ice floes, Sheyenne R. downstream of CR 14 4-7-11.

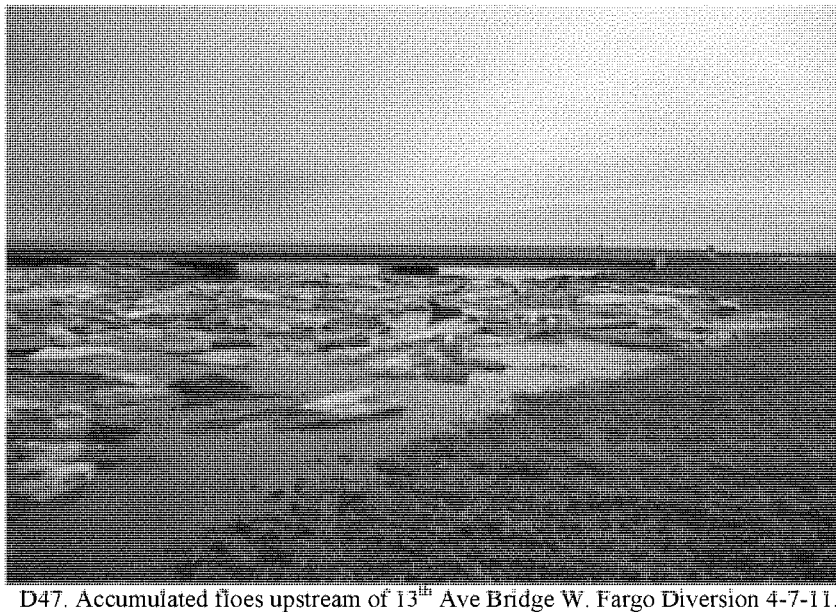
D44. Melting sheet ice on Sheyenne R upstream of 52nd Ave. W. 4-7-11.



D45. Decayed sheet ice on Sheyenne R upstream CR 17 Br. 4-7-11.

USACE-MVP-0000087955

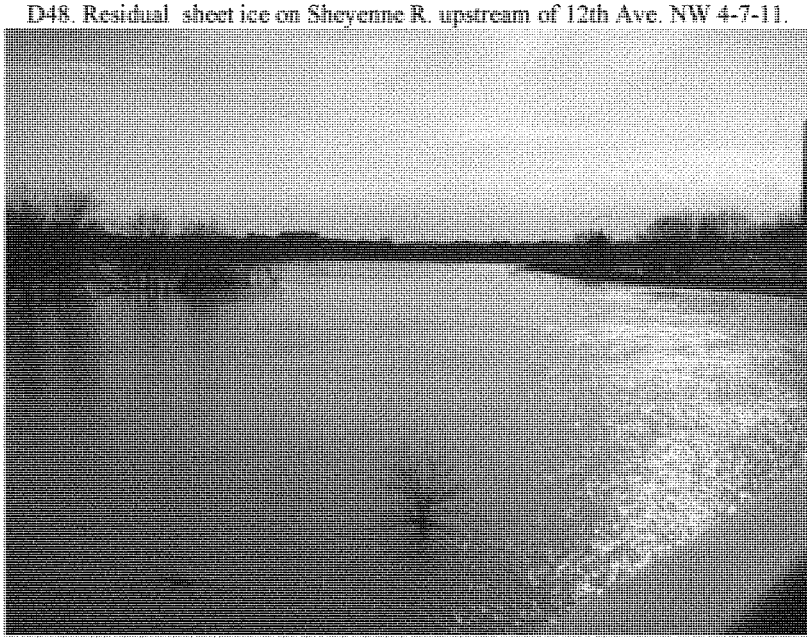
D46. Floes and sheet ice at Sheyenne diversion into W. Fargo FC Project at CR 17 Br. 4-7-11.



D47. Accumulated floes upstream of 13th Ave Bridge W. Fargo Diversion 4-7-11.

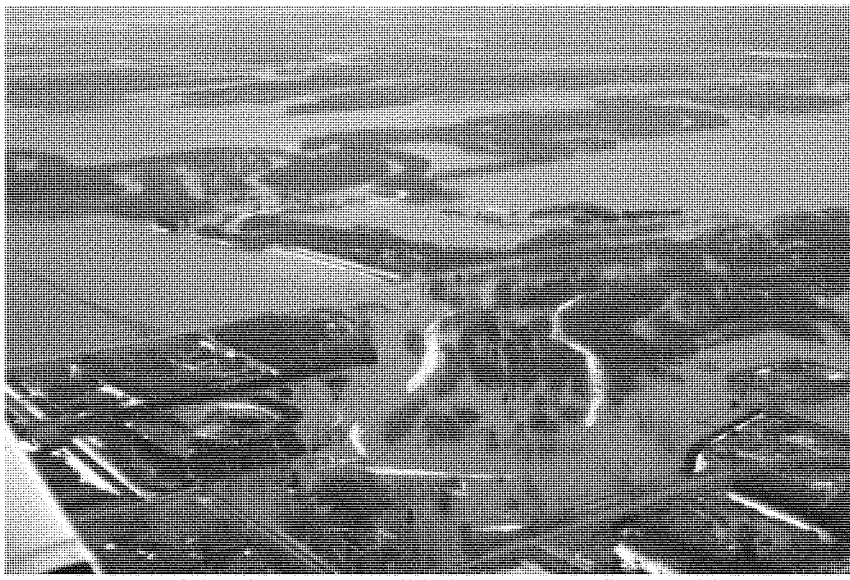
USACE-MVP-0000087955

D48. Residual sheet ice on Sheyenne R. upstream of 12th Ave. NW 4-7-11.

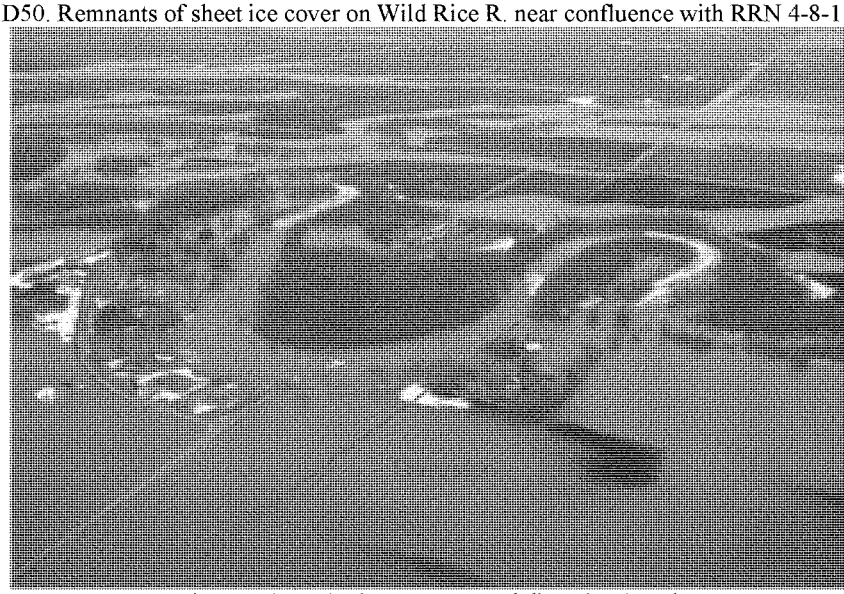


D49. Ice-free RRN looking upstream from Veterans Br. Moorhead, 4-7-11.

USACE-MVP-0000087955



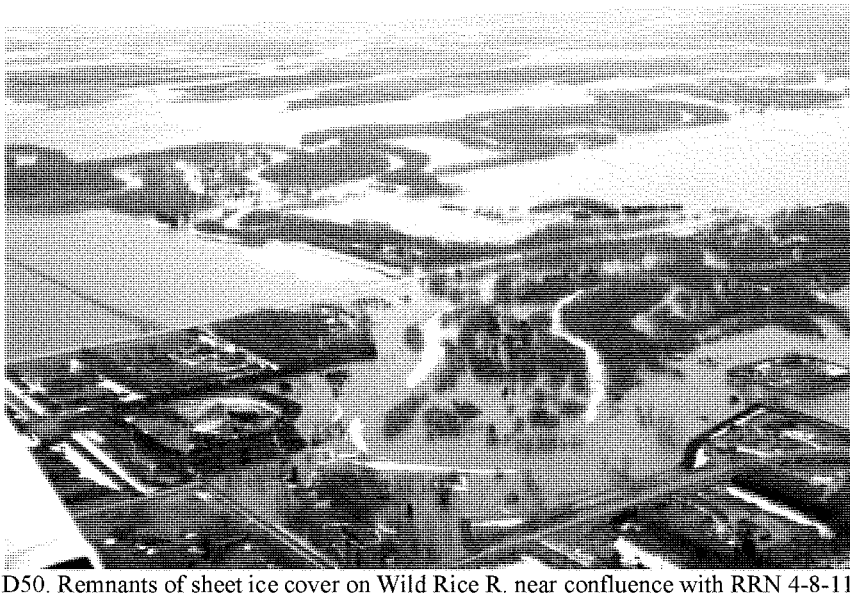
D50. Remnants of sheet ice cover on Wild Rice R. near confluence with RRN 4-8-11.



D51. RRN ice nearly melted on at proposed diversion location 4-8-11.

USACE-MVP-0000087955

D52. View from proposed diversion westward towards Wild Rice R. 4-8-11.

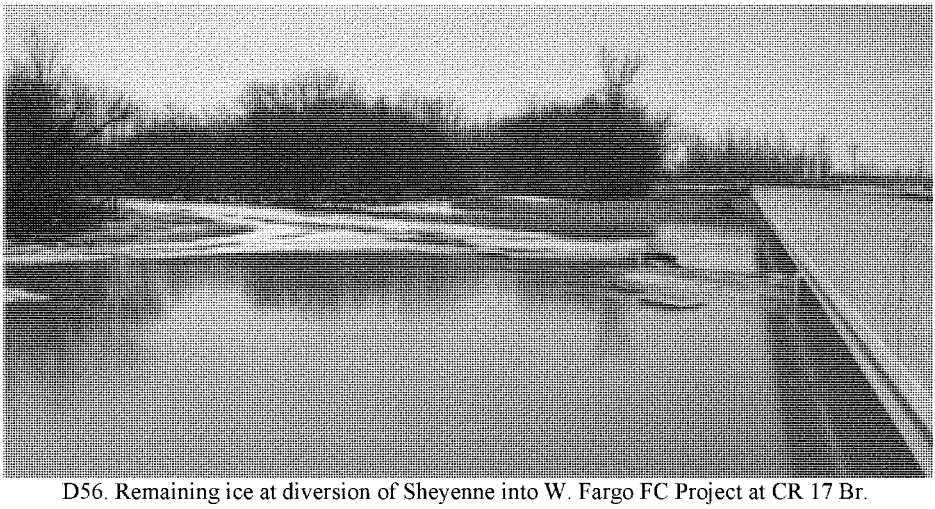


D50. Remnants of sheet ice cover on Wild Rice R. near confluence with RRN 4-8-11.

D51. RRN ice nearly melted on at proposed diversion location 4-8-11.

USACE-MVP-0000087955

D55. Decayed floes in bend along CR 8 4-8-11.



D56. Remaining ice at diversion of Sheyenne into W. Fargo FC Project at CR 17 Br. 4-8-11.

Attachment 2

Response to Richland County Drain Comment

MEMO

HoustonEngineering Inc.

To: U.S. Army Corps of Engineers – St. Paul District
City of Fargo, North Dakota
City of Moorhead, Minnesota

Date: July 5, 2011

From: Gregg Thielman, P.E., CFM
Houston Engineering, Inc.

Subject: FM Metro Flood Risk Management Project - Richland County Drain Impact Assessment

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Introduction:

On June 13, 2011, the Richland County Water Resource District (WRD) submitted comments on the proposed Fargo Moorhead Metro Flood Risk Management Project diversion alternatives as part of the comment period for the Supplemental Draft Environmental Impact Study. Specifically, the WRD requested the following information for the 100-year (1-percent chance) and 500-year (0.2-percent chance) flood events compared to existing conditions:

A. Analysis of impacts to the legal drains in the northern end of Richland County.

B. Analysis of impacts, which include stage increases, changes in flow, velocities, and drainage patterns on the Wild Rice, Sheyenne, and Red Rivers within Richland County.

C. Analysis of impacts on all other natural drainage systems in Richland County.

Response:

Our initial response to these questions is as follows:

A. Richland County Legal Drain Impacts:

Figures 1 and 2 highlight existing legal drains in Richland County within the staging area for the Locally Preferred Plan (LPP) diversion alternative (North Dakota Diversion). These include Richland County Drains 2, 5, 17, 19, 27, 37, 48, 57, and 64. The impact to these drains as a result of the LPP diversion alternative will be increased stages when the upstream staging area is being utilized. The staging impacts on the drains will be less than 1 foot for the 1-percent and 0.2-percent chance flood events as shown in Figures 1 and 2. These figures show the depth difference in feet between the LPP diversion alternative and existing conditions for the 1-percent chance and 0.2-percent chance flood event based on the unsteady HEC-RAS model results as presented in the April, 2011 technical appendices. Given the small impact of the staging area, we believe the impacts on the Richland County legal drains will be minor. In addition, runoff from the local drains will typically occur prior to peak flows on the Red River and Wild Rice River which will further reduce impacts.

For the Federally Comparable Plan (FCP) diversion alternative, there will be no impacts to legal drains in Richland County since the diversion will be operated so that existing conditions are matched upstream from the diversion inlet.

B. Wild Rice, Sheyenne, and Red River Impacts:

Similar to the legal drain impacts, the impacts to the Wild Rice and Red River for the LPP diversion alternative will be increased stages when the upstream staging area is being utilized. Peak stage impacts for the LPP are summarized in the following table:

River	Model Location	Location Description	Existing Conditions		LPP		Difference	
			1-percent chance	0.2-percent chance	1-percent chance	0.2-percent chance	1-percent chance	0.2-percent chance
			Elevation	Elevation	Elevation	Elevation	(ft)	(ft)
Red	2582884	Cass/Richland County Line	919.1	922.2	923.1	923.4	4.0	1.1
Red	2655411	Christine, ND (Upstream HWY 30)	925.2	929.9	926.2	930.0	1.0	0.0
Red	2764835	Abercrombie, ND	935.6	940.9	935.7	940.9	0.1	0.0
Wild Rice	109200	Upstream of HWY 46	923.5	925.3	923.8	925.3	0.3	0.0
Wild Rice	169892	Upstream of I-29	931.5	934.0	931.5	933.9	0.0	0.0
Wild Rice	225847	Abercrombie, ND	937.9	940.7	937.9	940.7	0.0	0.0

*Elevations Reference NAVD88

Table 1 – Wild Rice and Red River stage impacts for LPP diversion alternative.

The peak stage increases for the Wild Rice and Red Rivers occur at the Cass/Richland County line and diminish as you proceed upstream. Stages on the Sheyenne River in Richland County will not be impacted for the LPP diversion alternative.

There will be no impact on discharge for the Wild Rice and Red Rivers as a result of the LPP diversion alternative and any impact on velocity will be small. There will likely be

some reduction in velocity during the staging of water for those areas that are impacted by higher stage. Breakout flows from the Sheyenne River into the Wild Rice River will still occur similar to existing conditions.

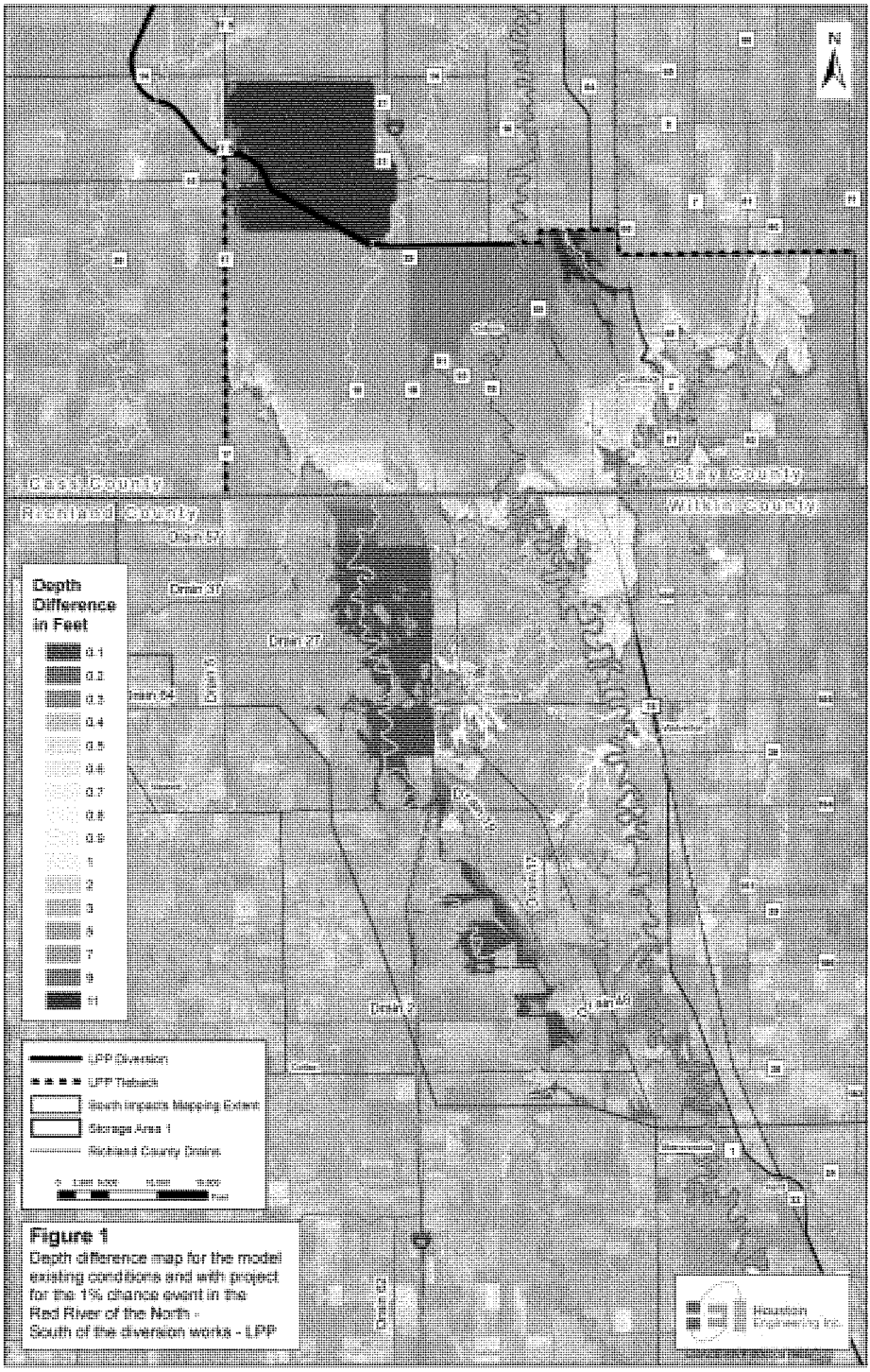
For the Federally Comparable Plan (FCP) diversion alternative, there will be no impacts to the Wild Rice, Sheyenne, or Red River in Richland County since the diversion will be operated so that existing conditions are matched upstream from the diversion inlet.

C. Other Natural Drainage System Impacts:

Impacts to other natural drainage systems in Richland County will also be related to increased stages when the upstream staging area is being utilized for the LPP diversion alternative as highlighted in Figures 1 and 2. No impacts will occur for the FCP diversion alternative since the diversion will be operated so that existing conditions are matched upstream from the diversion inlet.

Figures:

Figure 1 – Richland County Drain Impacts – LPP 1% chance flood event.
Figure 2 – Richland County Drain Impacts – LPP 0.2% chance flood event.


Cass County
Richland County
Drain 57
Drain 37
Drain 27
Drain 54
Drain 17
Drain 18
Drain 19
Drain 20
Drain 21
Drain 22
Drain 23
Drain 24
Drain 25
Drain 26
Drain 28
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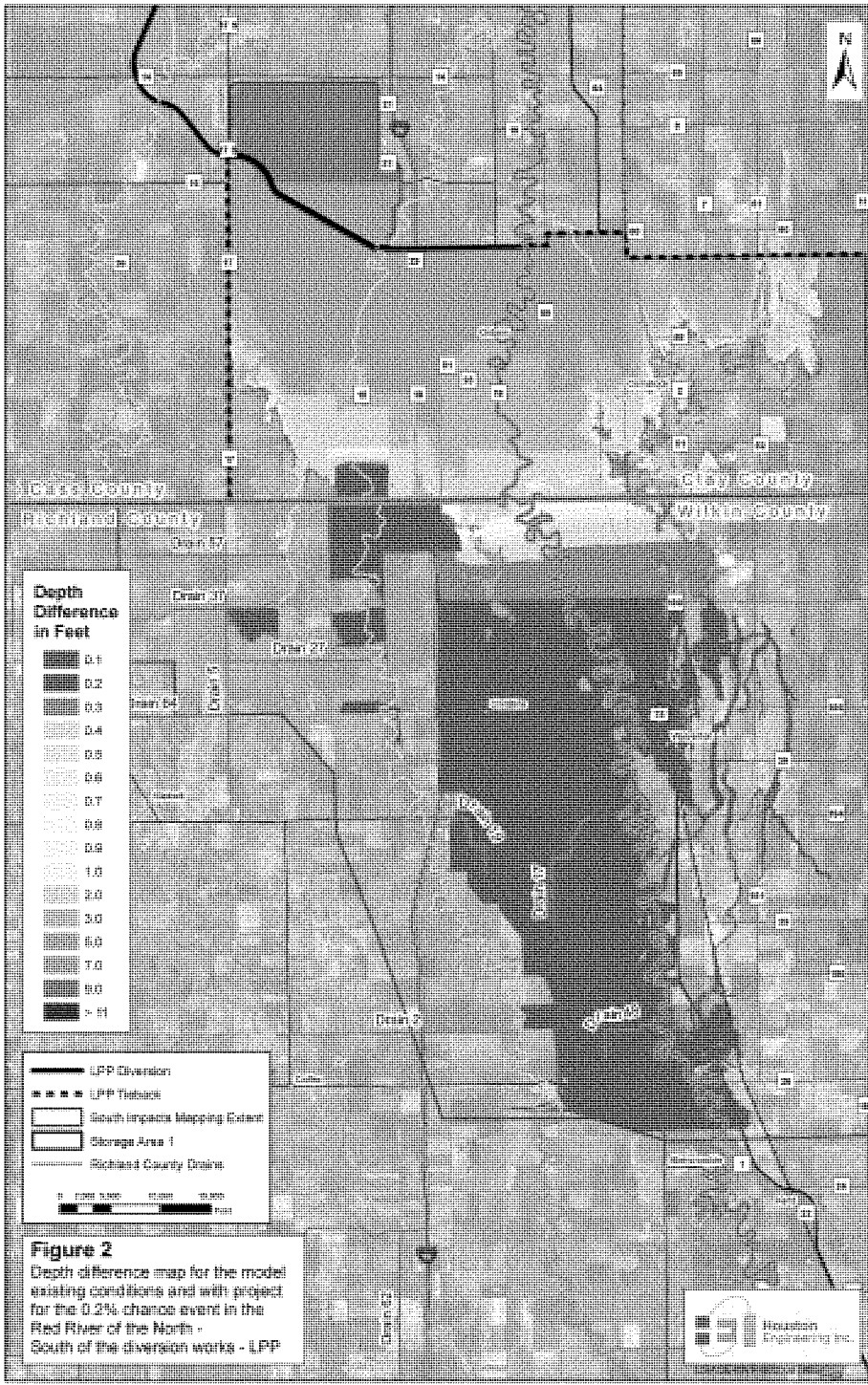

Figure 2
Depth difference map for the model existing conditions and with project for the 0.2% chance event in the Red River of the North - South of the diversion works - LPP

Attachment 3

2011 Sediment Transport Data from USGS

resourceful. naturally.
engineering and environmental consultants
BARR

Technical Memorandum

To: Michelle Schneider – USACE
From: Peter Hinck and Miguel Wong
Subject: 2011 Sediment Transport Data from USGS
Date: July 8, 2011
Project: 34091004.00 420 400
c: Jon Sobiech, Elliott Stefanik and Aaron Buesing – USACE

The USGS collected sediment data on the Red River of the North (RRN) and its tributaries in and around the cities of Fargo and Moorhead during the spring flood of 2010. This data was summarized in the USGS Scientific Investigations Report 2011-5064 titled "Sediment Concentrations, Load, and Particle Size Distributions in the Red River of the North and Selected Tributaries near Fargo, North Dakota during the 2010 Spring High-Flow Event" (Blanchard et al., 2010). The relevance of this information for the feasibility of the proposed diversion of the RRN and its tributaries was discussed in detail in Exhibit I of Appendix F of the *Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 4* (Version 2 of Exhibit I dated March 9, 2011).

Subsequent to the publication of the Feasibility Study, Phase 4 report, the USGS provided information pertaining to collected sediment data on the RRN and its tributaries during the spring flood of 2011. These new data are currently available in preliminary form from the USGS and will be summarized in a forthcoming USGS report. The purpose of this memorandum is to assess whether these new (preliminary) data alter any of the conclusions presented in the Feasibility Study, Phase 4 report. The sediment sampling in 2011 included additional sites beyond those sampled in 2010, but only sites that were sampled during both flood events are discussed in this memorandum.

Sampling Period Comparison

Sediment data were collected in 2011 between April 4 and May 17 (44 days) at the locations shown in Table 2, with between 16 and 19 sampling events at each site. This represents a significantly longer period of record and more sampling events than in 2010, when measurements were taken 8 to 12 times over a period of 20 days. In both years the majority of the sediment data were collected on the receding

limb of the flood hydrograph, and this collection extended over a much longer period in 2011. Figure 1 shows the measured flows at the sampling location on the RRN near Fargo for both the 2010 and 2011 events. Figure 2 shows the measured total sediment transport at the same location for both events. Note from these figures that the peak flow at this location in 2011 was 23,400 cfs compared to 21,100 cfs in 2010. Also note that the shape of the receding limb of the hydrograph in 2011 is similar to that in 2010, but the flows are approximately 3,000-4,000 cfs larger in 2011.

Sediment Loading Comparison

Total sediment loading for the period of concurrent measurements is shown in Table 1 for 2010 and in Table 2 for 2011. The differences in total sediment loading (suspended sediment load, bedload, and total sediment load) for the two events are affected by the differences in the length of the monitoring period discussed above. Because the extended monitoring period in 2011 included more sampling events on the receding limb of the hydrograph, the total load shown in Table 2 is more influenced by sediment transport conditions during the receding limb of the hydrograph, hence the daily average sediment loads over the period of measurement are smaller in 2011.

At the locations studied here, the peak sediment loading shown for 2011 in Table 2 is neither consistently greater nor less than that shown for 2010 in Table 1. The RRN could be considered the exception to this general, somewhat simplified assessment. The peak flow in the RRN was greater in 2011 than 2010 (see Figure 1) and the peak sediment load for both sites in the RRN was greater in 2011 than 2010. However, sediment loads in 2010 are similar or greater than those in 2010 for most of the receding limb of the hydrograph even though flows in 2010 were smaller than in 2011. These measurements would suggest that an improved characterization of sediment transport conditions should be based on an evaluation of river morphodynamics over the entire flood hydrograph that complements the attempt to develop unique relationships between instantaneous flows and sediment transport rates. For the RRN in particular, further analysis is recommended to examine the effect that differences between the two flood events (beyond simply the peak flow value) may have had on the quantity of sediment transport and its channel morphology.

Despite some differences in sediment loading between the two events, it is clear from the data presented in Table 1 and Table 2 that the broad characteristics of the RRN and its tributaries are consistent. The vast majority of the sediment load in this system is transported as suspended sediment, with bedload

representing generally less than 1% of the total sediment in transport. Sediment loading in the Sheyenne River is proportionally greater than in the other rivers, driven by the higher observed loading from suspended sediment in the Sheyenne River.

Figure 3 shows the observed suspended sediment concentrations at the locations monitored in 2010 and 2011. The range of observed concentrations is broadly similar between the two flood events for all sites, although the bulk of the data (central 50%) shows lower concentrations at most sites in 2011 compared to 2010. As indicated above, this may be due to the fact that the longer measurement period in 2011 included more observations on the receding limb of the hydrograph. As in 2010, the suspended sediment concentrations in the Sheyenne River, both upstream and downstream of the existing Horace/West Fargo diversion, were significantly greater than for the other rivers.

Sediment Balance Comparison

The data collected in both 2010 and 2011 on the RRN and Wild Rice River (WRR) are sufficient to perform a simple flow and sediment balance for the portion of the RRN upstream of the confluence with the Sheyenne River. In the absence of other data, the assumption for this simplified analysis is that no significant additional flow or sediment enters the WRR or RRN between the upstream monitoring locations (WRR near St. Benedict and RRN near Christine) and the downstream location (RRN near Fargo).

As shown in Figure 4 and Figure 5, the flow and sediment balances for both events are reasonably close, given the necessary simplifying assumptions indicated above. For both years, the total flow measured in Fargo was slightly higher than the total flow measured at the upstream RRN and WRR locations (5-9% difference). For both years, the total sediment load measured in Fargo was slightly less than the total load measured at the upstream RRN and WRR locations (1-3% difference).

The sediment balance result for 2011 would demonstrate that, as expected based on the comparable analysis based on the 2010 sediment transport data, the sediment load in the RRN through the cities of Fargo and Moorhead is neither increasing nor decreasing. More importantly, it would imply that the RRN does not appear to be gaining sediment (via erosion) or losing sediment (via aggradation) over this reach. This corroborates the description of the RRN as a stable riverine system, with sediment loading from fine suspended material that is primarily washed through the system.

A similar sediment balance can be performed for the Sheyenne River system at the Horace/West Fargo Diversion. Because there was not a monitoring location on the diversion channel itself, the flow and sediment balance must be assumed to close. The flow and sediment load on the Horace/West Fargo Diversion can then be calculated. The calculated balances for 2010 and 2011 are shown in Figure 6and Figure 7, respectively.

In 2010, both the flow and sediment load in the Sheyenne River downstream of the Horace/West Fargo Diversion were approximately 47-48% of the flow and sediment load in the Sheyenne River upstream of the existing diversion. In other words, the existing diversion did not affect the proportion of sediment with respect to flows (or sediment concentration) in the Sheyenne River. In 2011, a greater portion of the upstream flow (48%) than of the upstream sediment (41%) was measured in the Sheyenne River downstream of the existing diversion, and the suspended sediment concentrations in 2011 were slightly lower downstream than upstream Sheyenne River. This change from 2010 to 2011 is not large enough to indicate a significant difference in the fluvial system, and may be related to the differences in timing between the two flood events (the peak flow conditions persisted much longer on the Sheyenne in 2011 than they did in 2010). More interestingly, the measurements in 2011 would suggest that the existing diversion could be more efficient in diverting (out of the Sheyenne River natural system) sediments than water, and this is possible because of the fine nature of the sediments mobilized by the Sheyenne River primarily in suspension (over 99.5% in both years).

Sediment Gradation Comparison

Figure 8 through Figure 31 present the measured gradations of both the bed sediment and the bedload material as well as the fraction of suspended sediment that is finer than sand at each location in both 2010 and 2011. In general, the preliminary data from 2011 shows similar behavior as that observed in 2010 for all locations. Minor differences include:

- Several measurements of coarser bed material in the WRR in 2011 (Figure 9), consisting of coarse sand to fine gravel;
- Measurements of coarser suspended material in the upstream Sheyenne River in 2011 (see note on Figure 13), with as much as 43% of the suspended material being sand or larger particles;

- A wider range of measured fines content in the suspended material in the downstream Sheyenne River in 2011 (see note on Figure 17), with 10-30% of the suspended material being sand or larger particles;
- A wider range of bedload gradations in the Maple River in 2011 (compare Figure 22 and Figure 23);
- Slightly finer bed material in the RRN near Fargo in 2011 (compare Figure 28 and Figure 29), and a slightly larger amount of measured coarse suspended material (see note on Figure 29).

It should be noted that none of these differences indicates a significant shift in the fluvial system or invalidates the conclusions of the Feasibility Study, Phase 4 report. The differences appear to be the result of natural variability in complex riverine systems.

Conclusions

The preliminary sediment transport data for the 2011 high-flow event support the conclusions of the Feasibility Study, Phase 4 report with regards to the potential impact of the proposed project on sediment transport and geomorphology in the studied rivers. Because the RRN and its tributaries are dominated by the transport of fine suspended material, the diversion of a fraction of the river flow is expected to divert an approximately proportional fraction of the total sediment load transported as suspended sediment. This suspended sediment, being fine-grained with very slow settling velocities, can be expected to move through the diversion system and return to the RRN downstream of Fargo and Moorhead.

The Horace/West Fargo Diversion of the Sheyenne River provides an example of the potential impacts that can be expected from the proposed diversion. As discussed in the Feasibility Study, Phase 4 report, the Sheyenne River system has coarser bed material and more coarse suspended sediment than the other affected rivers, meaning that the impacts of diversion on sediment transport would be expected to be the most significant. However, even the somewhat coarser suspended sediment in the Sheyenne River is passed into the protected area and to the diversion channel in approximate proportion to the flow. The slight differences in flow and sediment transport observed in the Sheyenne system in 2011 warrant further analysis but do not indicate a significant difference in the behavior of the fluvial system.

The potential project impacts to the geomorphology of the RRN and its tributaries from the discussed changes in the sediment transport regime are expected to be negligible. The RRN is a stable riverine

system, neither aggrading nor degrading, with sediment transport primarily in suspension. These characteristics are not expected to change significantly following implementation of the proposed diversion works.

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Figure 1 – Comparison of 2010 and 2011 Sampling Period Flows for the RRN near Fargo

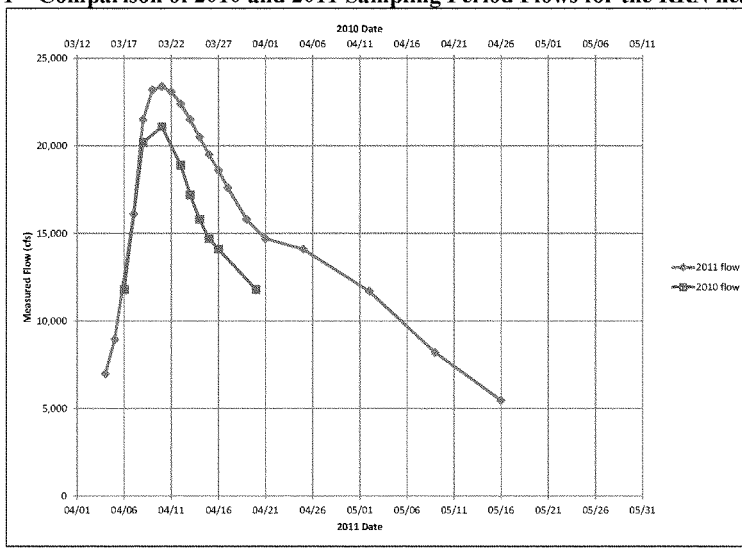

Figure 2 – Comparison of 2010 and 2011 Sampling Period Loads for the RRN near Fargo

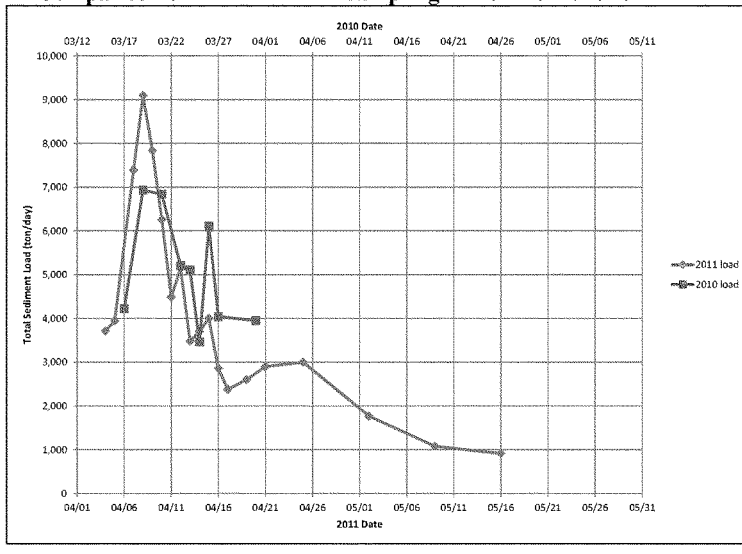

Table 1 – Observed Sediment Loading (*2010*)

Site Name	Time Period[1]	Total Flow (million ft^3)	Total Sus. Sed. Load (tons)	Total Bedload (tons)[2]	Total Sed. Load (tons)	Peak Sed. Load (tons/day)
Wild Rice River near St. Benedict	March 18, 2010 - March 31, 2010	8,780	43,260	31.8 (0.07%)	43,300	4,020
Sheyenne River above Sheyenne River Diversion near Horace	March 24, 2010 - April 7, 2010	5,340	119,590	40.7 (0.03%)	119,630	14,600
Sheyenne River at Horace	March 24, 2010 - April 7, 2010	2,580	56,370	9.3 (0.01%)	56,380	5,250
Maple River below Mapleton	March 19, 2010 - April 6, 2010	4,660	31,520	70.9 (0.2%)	31,600	4,840
Red River of the North near Christine	March 18, 2010 - March 31, 2010	10,030	30,780	171 (0.6%)	30,950	3,950
Red River of the North near Fargo	March 18, 2010 - March 31, 2010	19,810	72,080	27.6 (0.04%)	72,110	6,930

Table 2 – Observed Sediment Loading (*2011*)

Site Name	Time Period[1]	Total Flow (million ft^3)	Total Sus. Sed. Load (tons)	Total Bedload (tons)[2]	Total Sed. Load (tons)	Peak Sed. Load (tons/day)
Wild Rice River near St. Benedict	April 6, 2011 - May 16, 2011	17,960	67,610	195 (0.3%)	67,800	3,570
Sheyenne River above Sheyenne River Diversion near Horace	April 9, 2011 - May 16, 2011	14,730	175,130	84.0 (0.05%)	175,220	13,210
Sheyenne River at Horace	April 9, 2011 - May 16, 2011	7,060	72,450	220 (0.3%)	72,670	6,280
Maple River below Mapleton	April 7, 2011 - May 16, 2011	11,900	47,220	104 (0.2%)	47,320	3,650
Red River of the North near Christine	April 6, 2011 - May 16, 2011	26,710	49,700	756 (1.5%)	50,450	4,370
Red River of the North near Fargo	April 6, 2011 - May 16, 2011	48,650	117,460	91.7 (0.08%)	117,550	9,090

[1] Time period shown does not represent the complete monitoring period for all sites. The periods shown represent concurrent data on the WRR and RRN (March 18 to March 31, 2010 and April 6 to May 16, 2011) and on the Sheyenne River above and below the Sheyenne River Diversion (March 24 to April 7, 2010 and April 9 to May 16, 2011).
[2] Percentage values represent bedload as a fraction of total sediment load for the time periods shown.

Figure 3 – Comparison of 2010 and 2011 Suspended Sediment Concentration Data

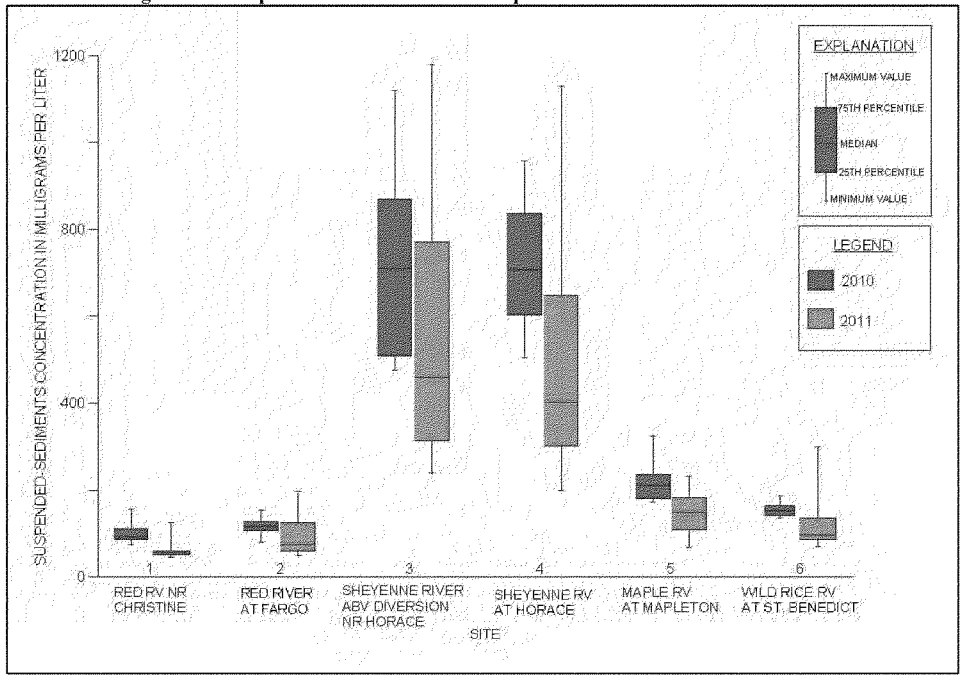

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Figure 4 – Flow and Sediment Balance (*2010*) – Red River of the North

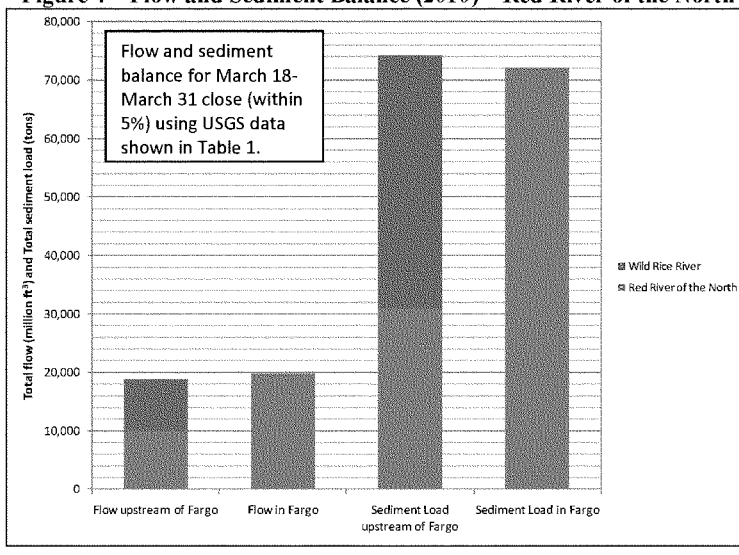

Figure 5 – Flow and Sediment Balance (*2011*) – Red River of the North

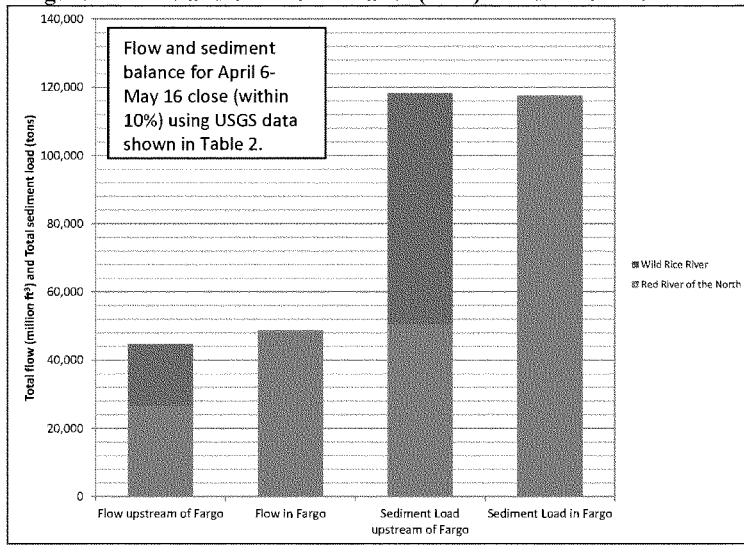

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Figure 6 – Flow and Sediment Balance (*2010*) – Sheyenne River

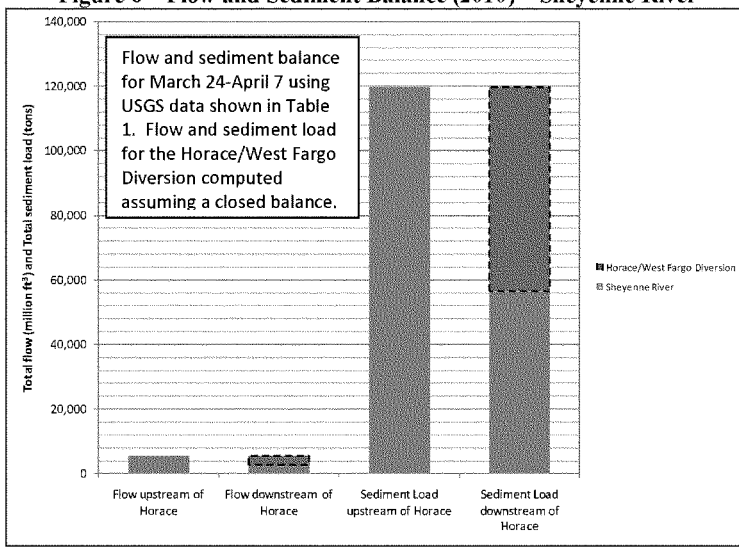

Figure 7 – Flow and Sediment Balance (*2011*) – Sheyenne River

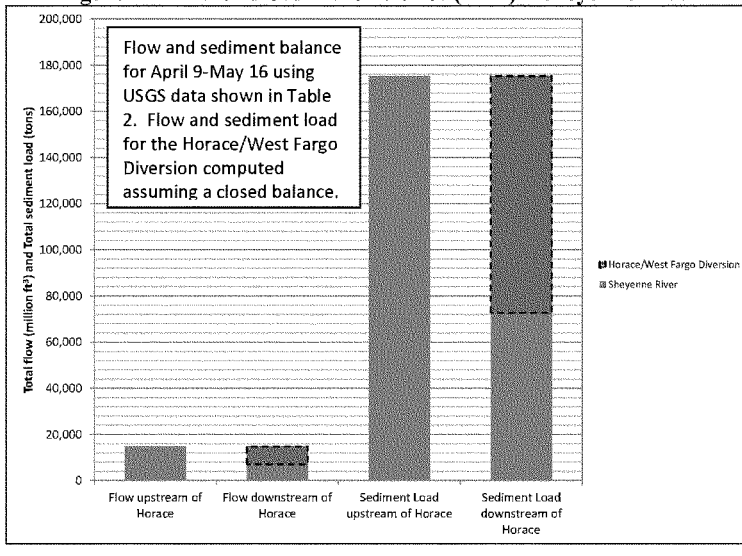

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Figure 8 – Bed Sediment Gradation (*2010*) – Wild Rice River near St. Benedict

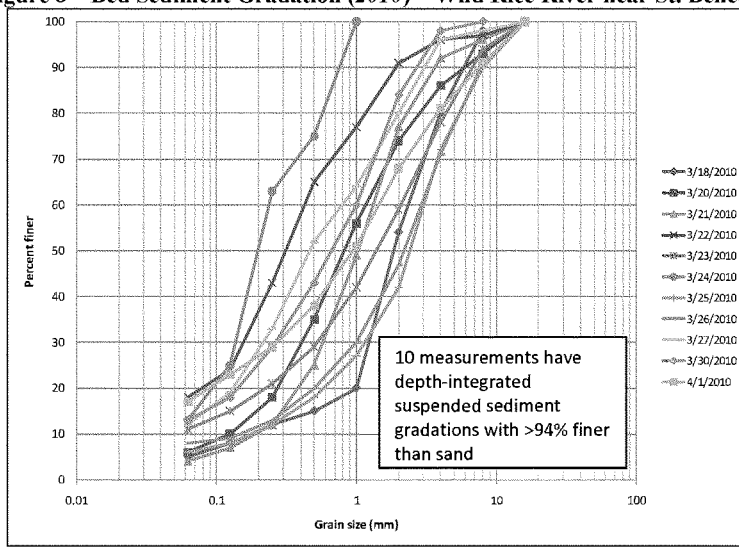

Figure 9 – Bed Sediment Gradation (*2011*) – Wild Rice River near St. Benedict

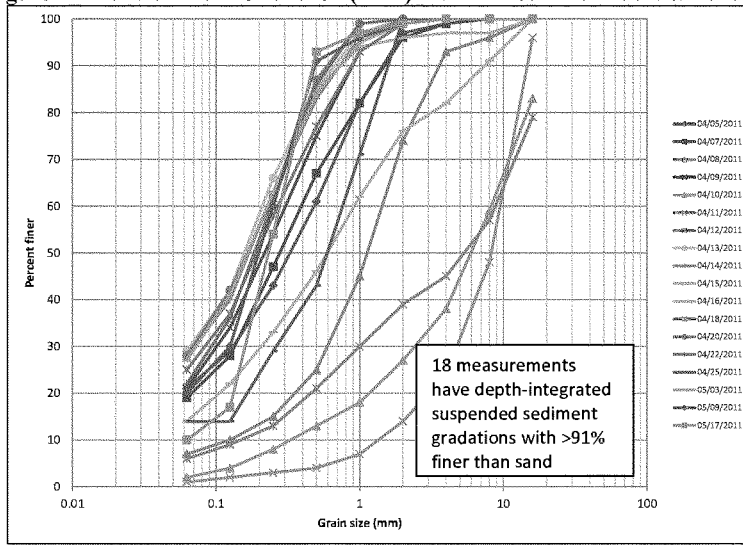

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Figure 10 – Bedload Gradation (*2010*) – Wild Rice River near St. Benedict

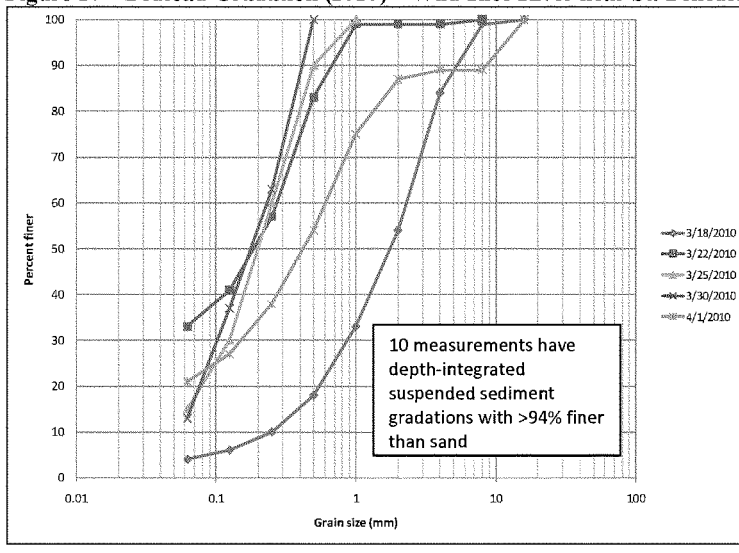

Figure 11 – Bedload Gradation (*2011*) – Wild Rice River near St. Benedict

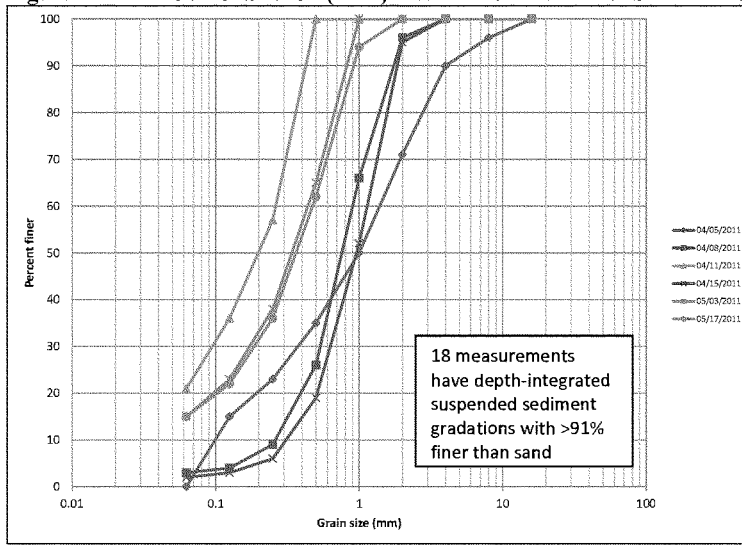

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Figure 12 – Bed Sediment Gradation (*2010*) – Sheyenne River abv. Diversion near Horace

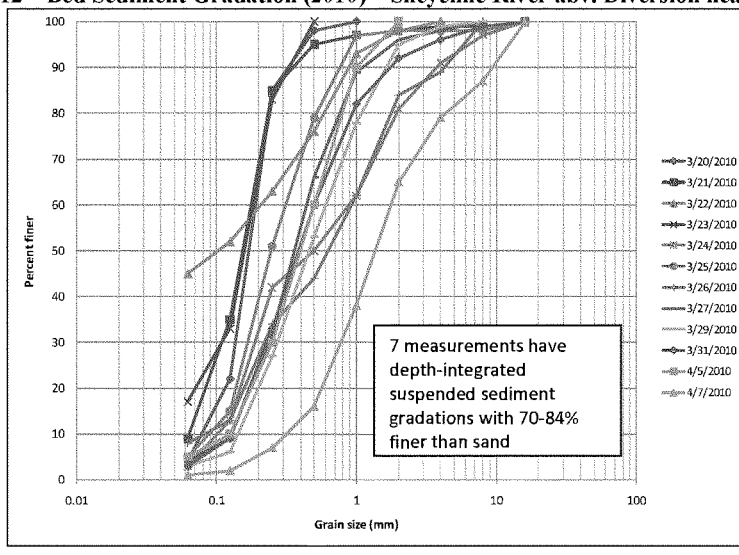

Figure 13 – Bed Sediment Gradation (*2011*) – Sheyenne River abv. Diversion near Horace

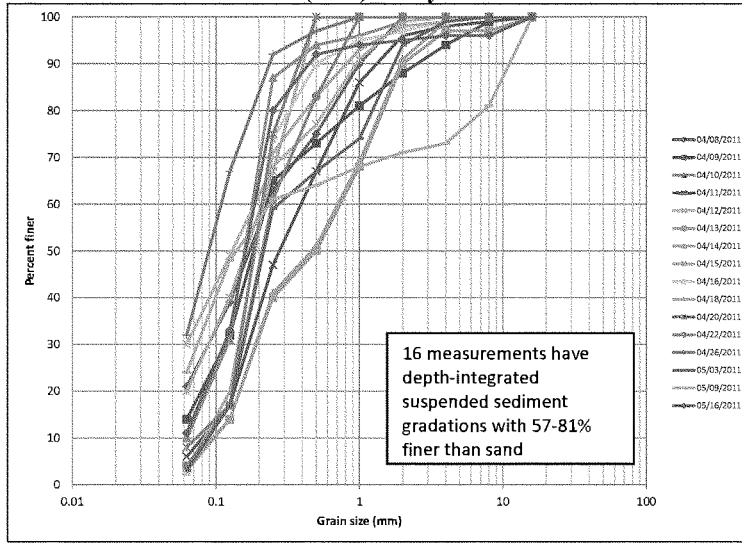

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Figure 14 – Bedload Gradation (*2010*) – Sheyenne River abv. Diversion near Horace

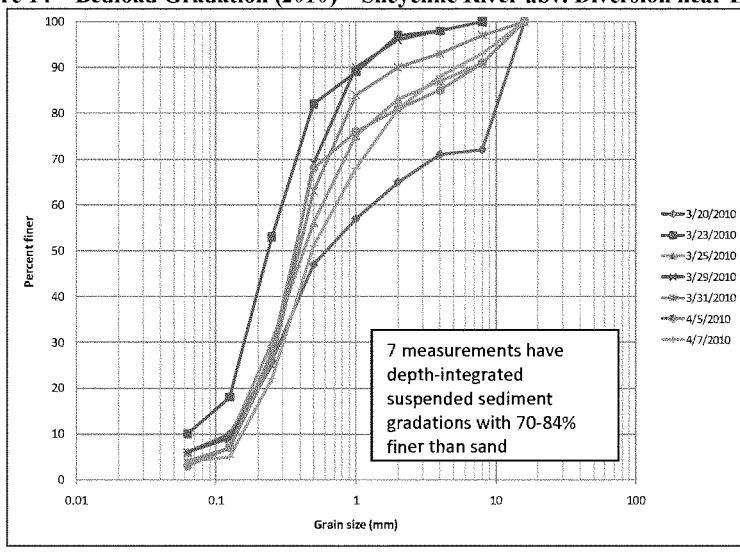

Figure 15 – Bedload Gradation (*2011*) – Sheyenne River abv. Diversion near Horace

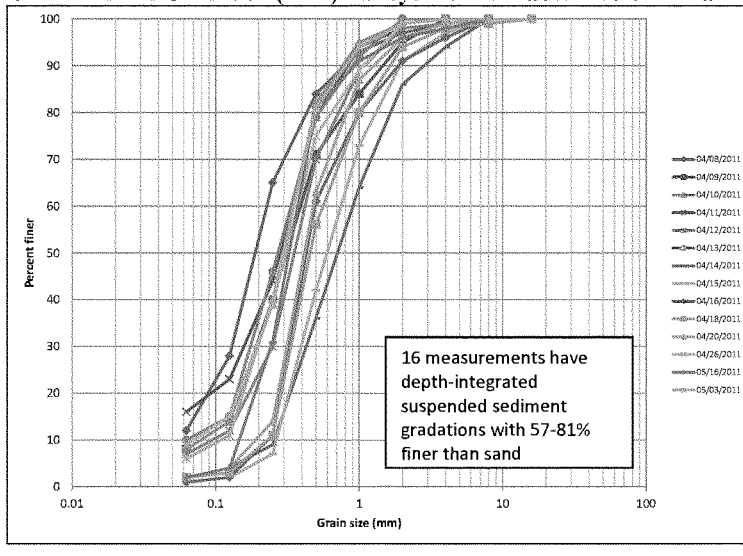

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Figure 16 – Bed Sediment Gradation (*2010*) – Sheyenne River at Horace

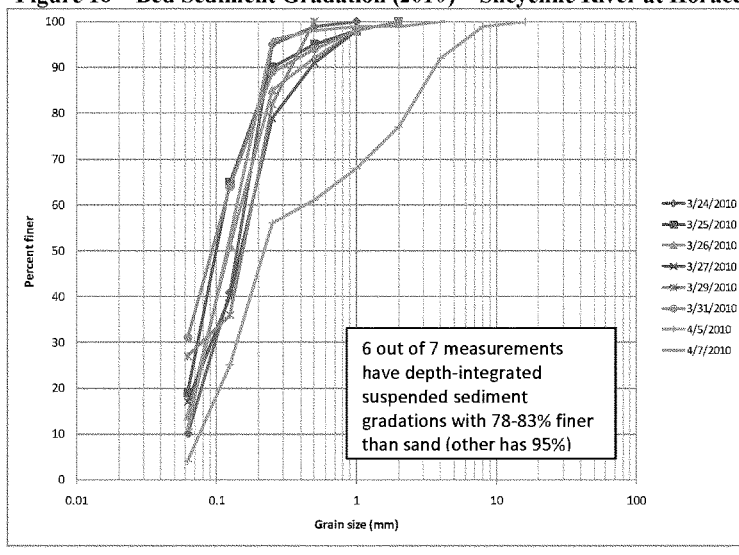

Figure 17 – Bed Sediment Gradation (*2011*) – Sheyenne River at Horace

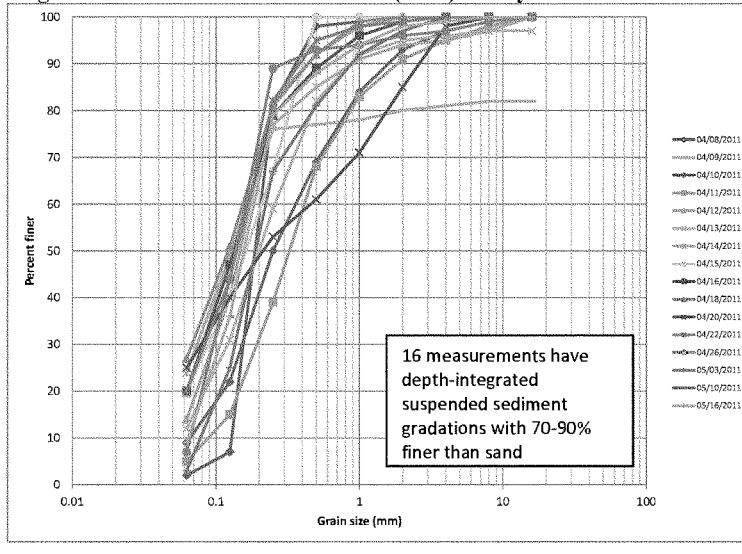

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Figure 18 – Bedload Gradation (*2010*) – Sheyenne River at Horace

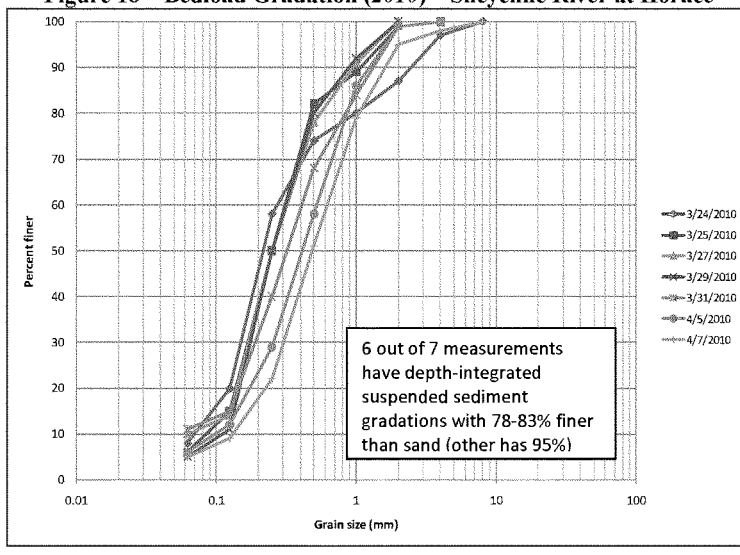

Figure 19 – Bedload Gradation (*2011*) – Sheyenne River at Horace

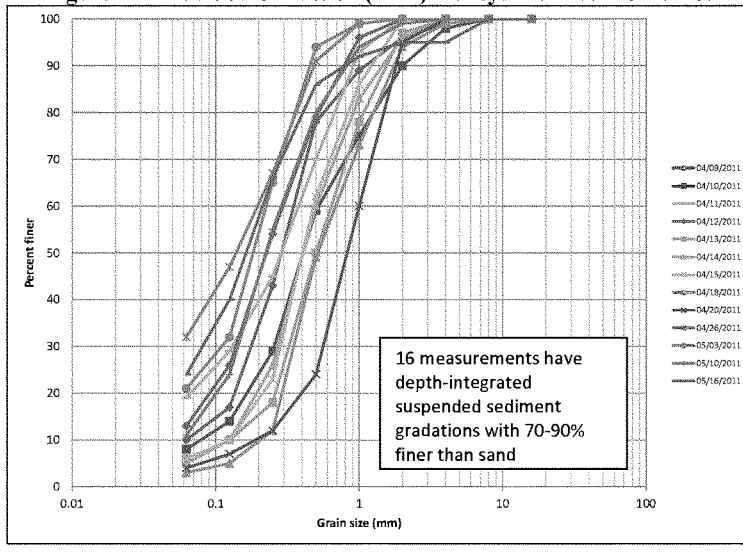

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Figure 20 – Bed Sediment Gradation (*2010*) – Maple River below Mapleton

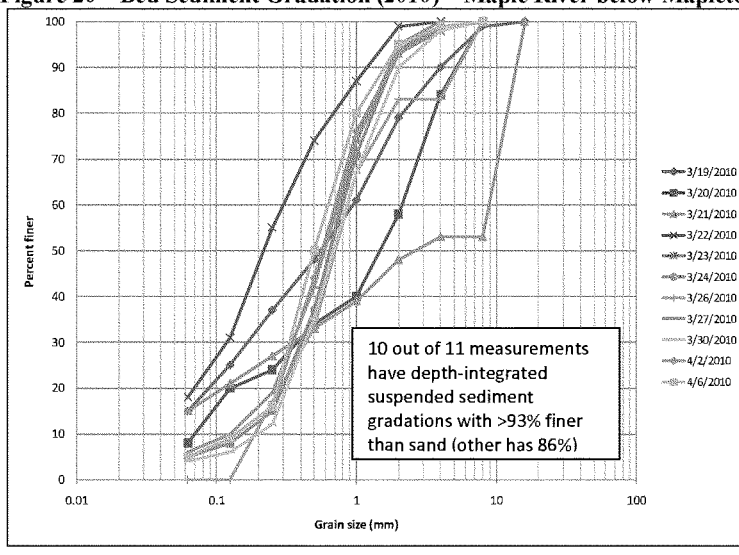

Figure 21 – Bed Sediment Gradation (*2011*) – Maple River below Mapleton

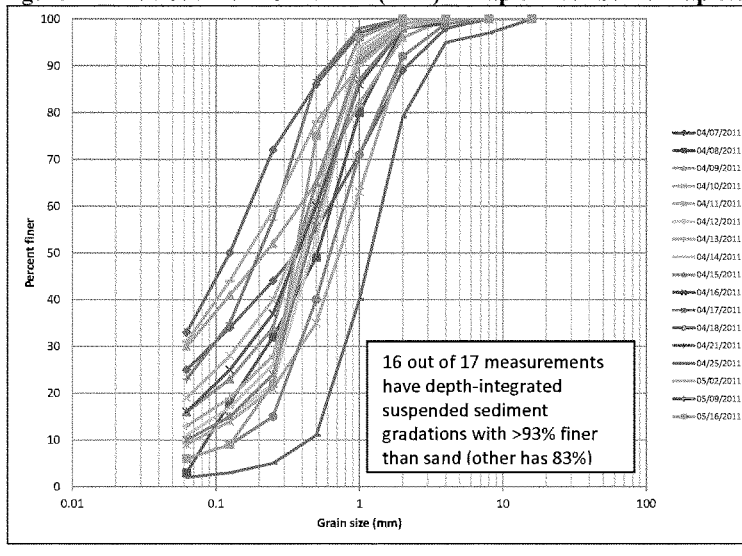

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Figure 22 – Bedload Gradation (*2010*) – Maple River below Mapleton

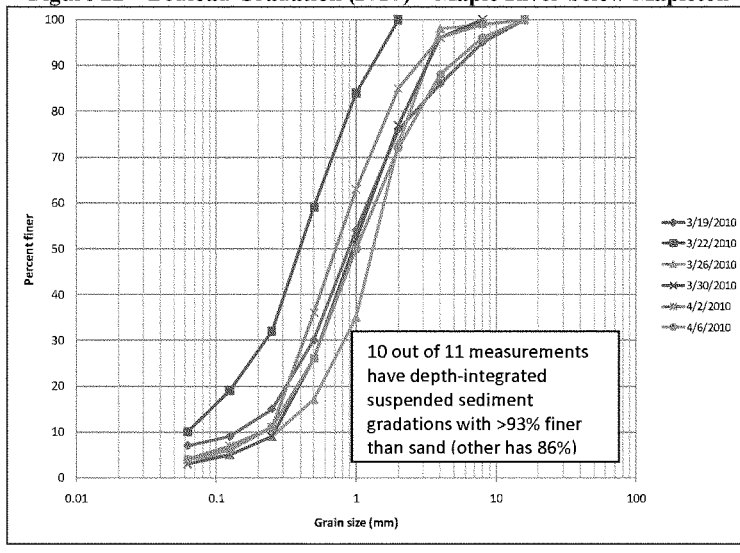

Figure 23 – Bedload Gradation (*2011*) – Maple River below Mapleton

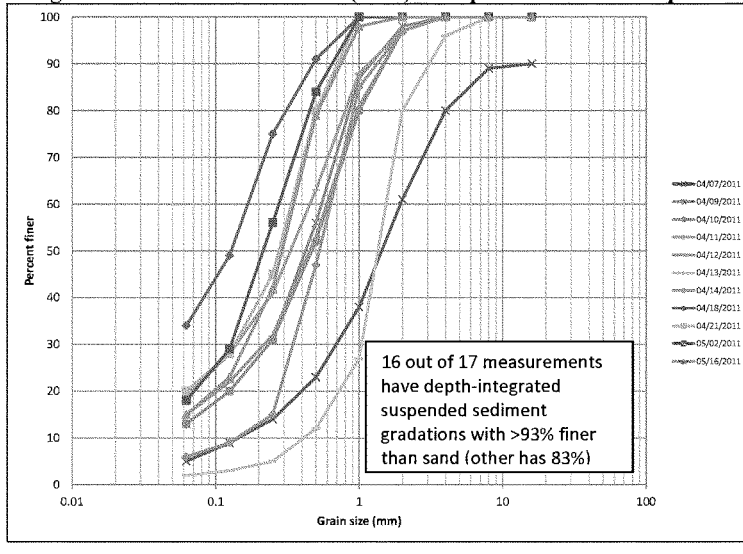

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Figure 24 – Bed Sediment Gradation (*2010*) – Red River of the North near Christine

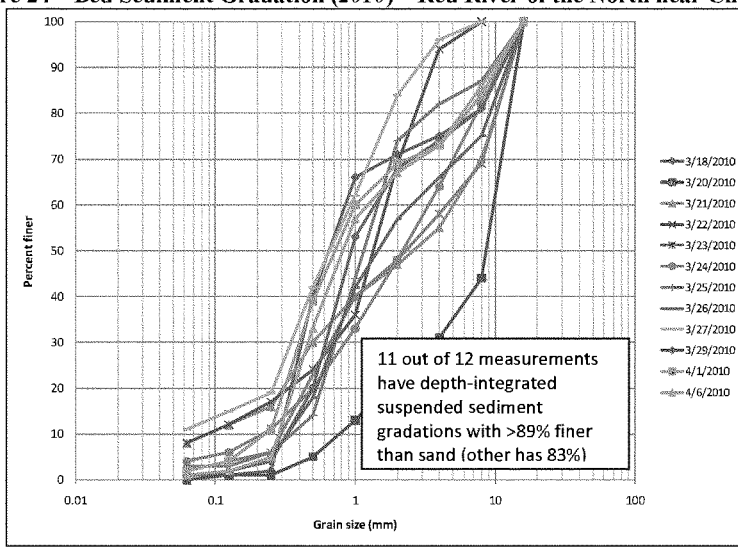

Figure 25 – Bed Sediment Gradation (*2011*) – Red River of the North near Christine

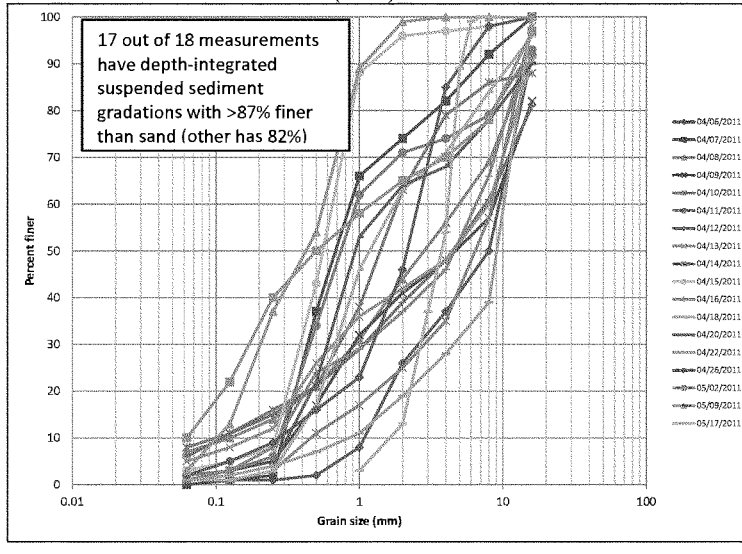

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Figure 26 – Bedload Gradation (*2010*) – Red River of the North near Christine

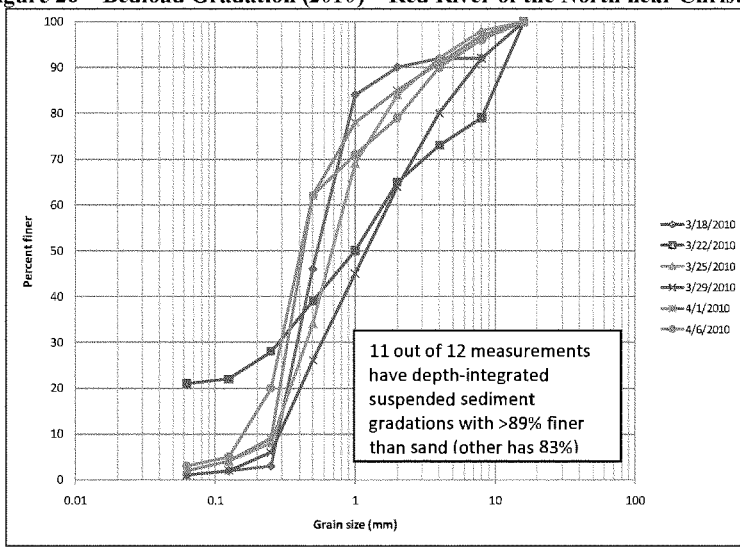

Figure 27 – Bedload Gradation (*2011*) – Red River of the North near Christine

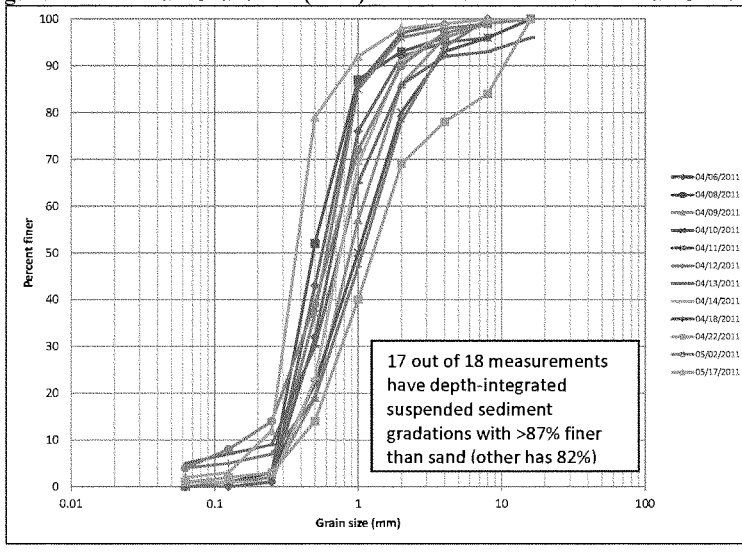

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Figure 28 – Bed Sediment Gradation (*2010*) – Red River of the North at Fargo

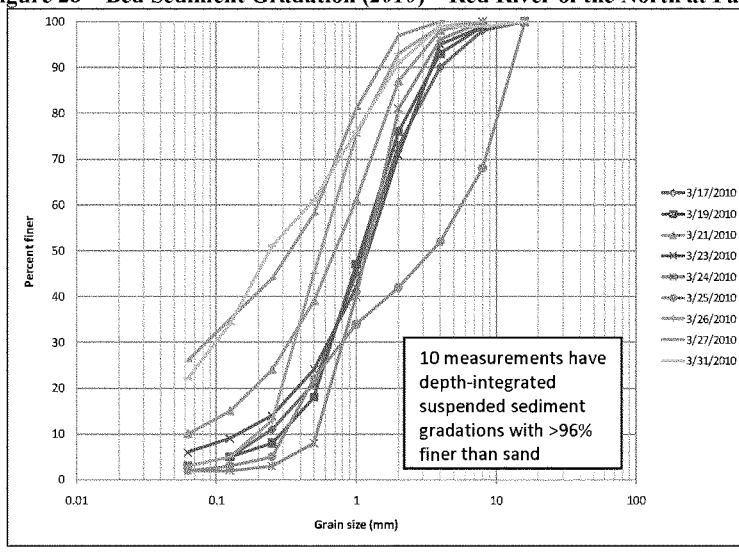

Figure 29 – Bed Sediment Gradation (*2011*) – Red River of the North at Fargo

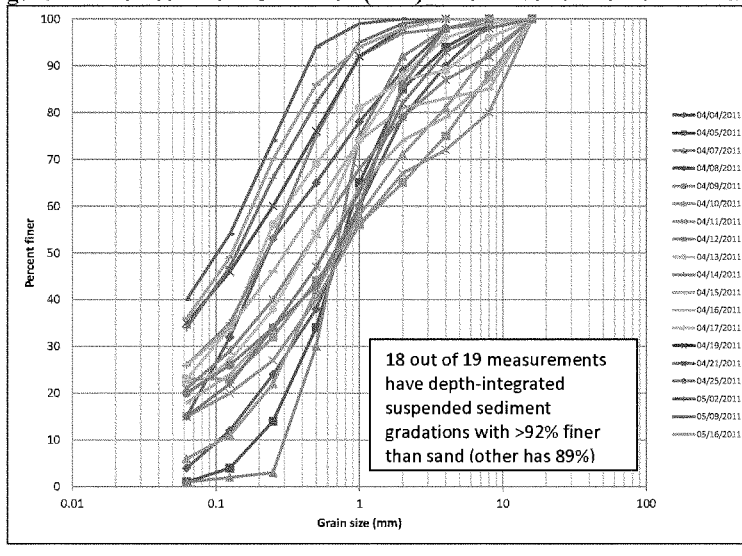

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Figure 30 – Bedload Gradation (*2010*) – Red River of the North at Fargo

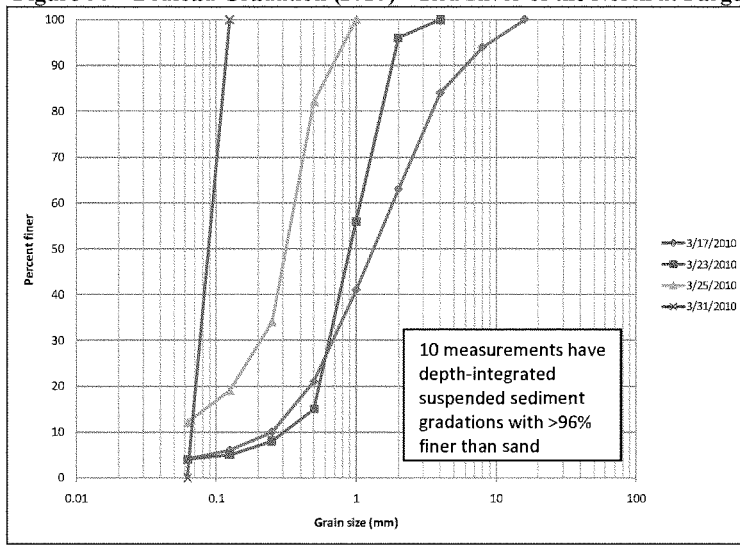
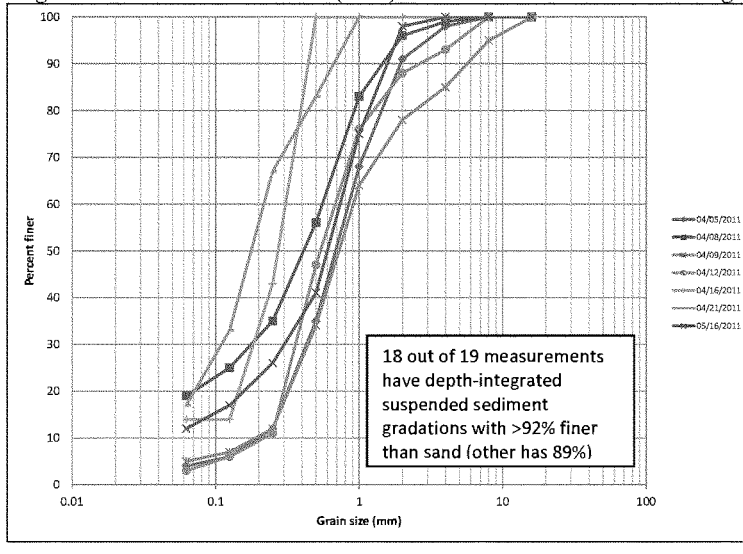


Figure 31 – Bedload Gradation (*2011*) – Red River of the North at Fargo

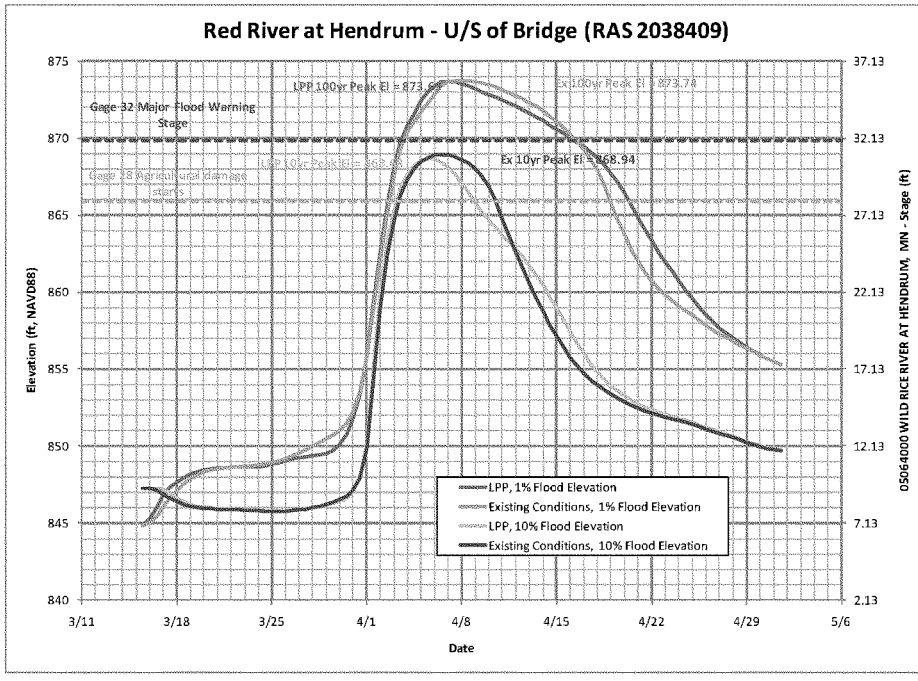


Attachment 4

LPP Hydrographs Downstream of Project

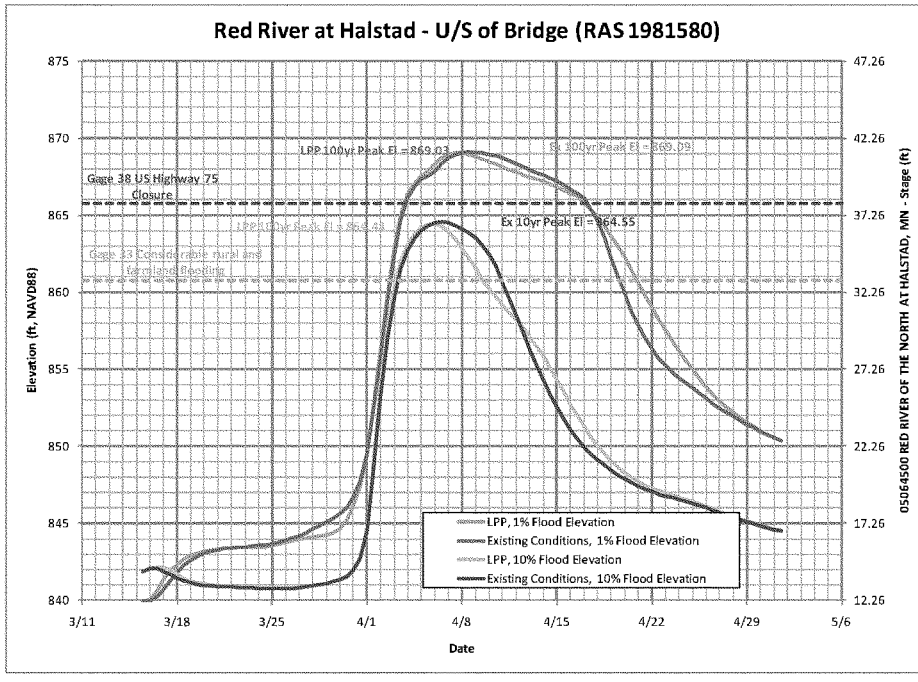
Flood Hydrograph Information Downstream of the LPP Project

1. Hendrum



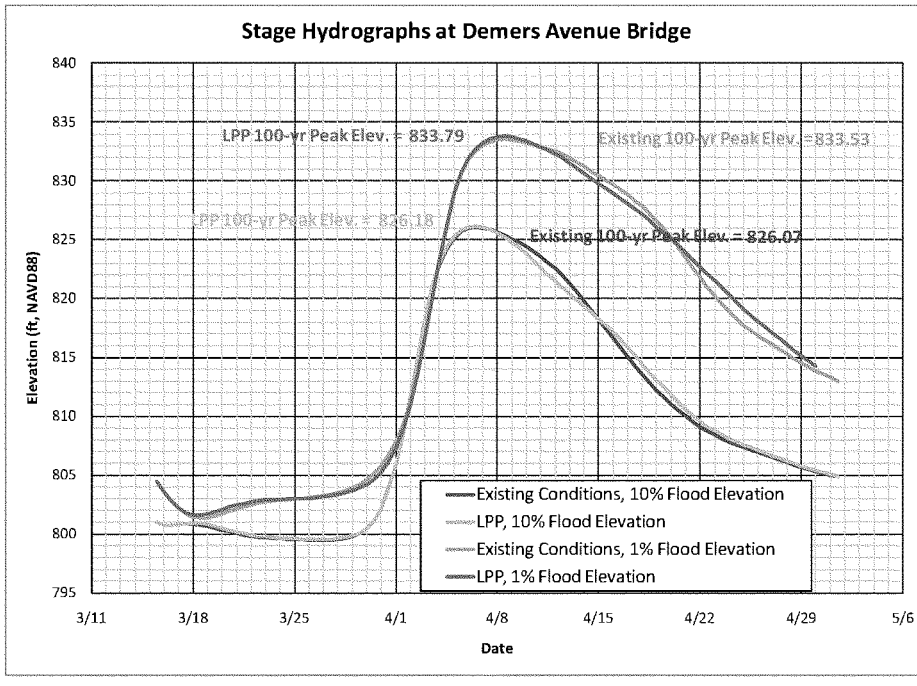
LPP 1% flood and 10% flood peak stages are slightly lower than they are for existing conditions. The duration of major flood stage for the 1% flood is no longer than it is for existing conditions, and the duration of the highest 2 to 3 feet of flooding is slightly less than for existing conditions. There is a slightly longer duration of flooding on lower land near the river for the 1% flood, but the duration of flooding on this lower land is somewhat less for the 10% flood.

2. Halstad



As is the case at Hendrum, the LPP 1% flood and 10% flood peak stages are slightly lower than they are for existing conditions. For the 1% flood, the duration of the highest stages is approximately the same as it is for existing conditions, and the duration is slightly shorter for lower land near the river. The duration of flooding on lower land near the river is shorter for the 10% flood.

3. Grand Forks



Stage hydrographs at the Demers Avenue bridge in Grand Forks for the 10% and 1% chance flood events show that the peak elevation is slightly higher with the LPP, but the duration of stages above elevation 819 for the 10% flood and above 825 for the 1% flood are somewhat less. While the hydrology and hydraulics used for this feasibility study are different from what was used for the Grand Forks' current DFIRM, they are sufficient to conclude that at Grand Forks the LPP will increase peak stages on the order of 0.1 to 0.3 ft for moderate and major floods and but will slightly reduce the duration of the highest stages. The higher stage might be a negative impact for any particular flood, but the shorter duration may be a benefit for any particular flood. The higher stage does not significantly reduce the level of flood risk reduction provided by the Grand Forks / East Grand Forks project and FEMA has stated that Flood Insurance Study updates will not be required for Polk County, MN and Grand Forks County, ND with the LPP.

Attachment 5

LPP Staging Area Wind/Wave Analysis

LPP Staging Area Wind/Wave Analysis

I. Wind Data

Data was collected from the NOAA National Climatic Data Center online resource in the form of Daily Surface Data. The weather station used for this study was the WBAN 14914 - Fargo Hector International Airport in Fargo, Cass County, ND. A wide range of wind data was available including the Fastest 5-second Wind Direction and Speed (F5SC), the Fastest 2-minute Wind Direction and Speed (F2MN), the Resultant Wind Direction and Speed (RDIR, RWND), as well as many others. The preferred method for obtaining a wave generating wind speed, as described in the Shore Protection Manual, is by converting the Fastest Mile Wind Direction and Speed (FSMI) to a longer duration. In the absence of available Fastest Mile Wind Direction and Speed for this location, the Fastest 2-minute Wind Direction and Speed was used instead. This data was collected for the past 10 years (2001-2010) and sorted by month and direction.

The current alignment of the diversion and tieback levees at the upstream staging area, oriented generally East to West, gives a South wind as the perpendicular wind speed. Waves perpendicular to the structure give higher overtopping rates than waves that hit the structure with an angle of incidence. In addition, the predominant wind direction (averaged over this 10 year period) is a SSW wind. For these reasons, wind speeds with directions between 135° and 225° from North were analyzed and summarized in the following table.

Summary of 322859 14914 FARGO HECTOR INTL AP Fastest 2-min Wind Speeds for South Winds (135 - 225 degrees) from 2001 through 2010 (in miles/hour)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min	9	9	8	10	10	8	9	8	10	9	8	9
Max	35	33	38	47	51	36	32	33	30	32	35	36
Avg	19	20	22	23	25	22	20	21	20	20	20	20

Average Max Monthly	37	mph
Average Max Mar-Aug	40	mph
Highest Max Monthly	51	mph

To account for a duration-averaged wind speed, the maximum 2-minute south wind over the 10 year period (51 mph) was taken to convert to a 1-hour wind speed. Using Figure 3-13 in the SPM, a 51 mph 2-minute wind converts to a 41.8 mph 1-hour wind. This wind speed compares closely with the average maximum Spring-Summer wind speed of 40 mph. A 1-hour design wind speed of 42 mph was chosen for calculations.

II. Fetch Delineation

Fetch delineation is a critical value for both wind setup calculations and for wave height development. In general, the staging area depths will be shallow, in the 5-15 ft depth range. This lower average depth for the staging area will tend to produce higher wind setup, or the tilting of the water surface in an enclosed basin caused by wind shear stress (EM 1110-2-1414 3-5). The simplified

estimate for wind setup gives an inversely proportional relationship between setup and average depth.

$$S = U^2F / 1400d$$

where

S = setup relative to the SWL (ft)
U = wind speed (mph)
F = fetch (miles)
d = average water depth over fetch (ft)

This equation yields values for wind setup of 0.75 ft to 1.25 ft for fetches ranging from 3-4 miles and average depths from 5-10 feet

III. Wave Development

Shallow depths have the opposite effect on wave development. Extreme wave heights in coastal engineering applications are often limited by shallow-water depths. Depending on local water depth and wave climate, the distribution of significant waves can be expected to be limited to 0.6 times the water depth (EM 1110-2-1100 II-8-25). Submerged roadways along the fetch profile create this limiting effect on wave development. Wave development profiles were generated for various fetches to see if the roadways caused a significant limiting effect on wave development. The limiting effect was found to be minor, and water depth actually increases closer to the structure, so depth-limiting of waves was ignored.

With depth-limiting ignored, the assumption for simplified wave prediction is that the waves are fetch-limited rather than duration limited. Fetch-limited waves assume the wind blows in essentially a constant direction for sufficient time to achieve steady-state waves. The time required for waves crossing an average fetch length of 3.5 miles with winds of 40-50 mph is greater than one hour (CEM Eq. II-2-35). Conservatively, the 1-hour wind speed of 42 mph will be used for wave development. Using various unique single wind-fetches, a range of wave heights and wave periods were developed using the equations found in the CEM Chapter II, Part 2. The wave heights range from 2.4 ft to 2.9 ft and wave periods range from 2.5 seconds to 2.9 seconds. These values, calculated from equations found in the CEM, are slightly more conservative than those calculated using the Automated Coastal Engineering System (ACES) software.

IV. Required Freeboard from Overtopping and Wind Setup

Using the overtopping formula developed by van der Meer and Janssen (CEM Eq. VI-5-42) with a grass levee slope of 1V:4H and an allowable overtopping value of 0.1 cfs/ft, overtopping freeboard is less than 2 ft for all the selected wind fetches. The average ultimate freeboard (overtopping freeboard plus wind setup) is 2.50 ft with a maximum ultimate freeboard of 2.75 ft. ***It is recommended that a minimum value of 3 feet of freeboard be considered in the design of all levees in the vicinity of the staging area.***

Appendix C
Economics

Fargo-Moorhead Metropolitan Area Flood Risk Management

Final Feasibility Report and Environmental Impact Statement

July 2011

US Army Corps of Engineers ®

Prepared by:
U.S. Army Corps of Engineers
St. Paul District
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Appendix C

Economics Appendix

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1- Fargo-Moorhead Nonresidential and Residential Structure Inventory and Surveys
2- Transportation Analysis

List of Acronyms and Abbreviations

AAD	Average Annual Damage
ACS	American Community Survey
AEP	Annual Exceedance Probability
BEA	Bureau of Economic Analysis
CES	Current Employment Statistic
cfs	Cubic feet per second
CGE	Computable General Equilibrium
CNP	Conditional Non-exceedance Probability
DDF	Depth-Damage Function
EAB	Expected Annual Benefit
EAD	Expected Annual Damage
EEAB	Equivalent Expected Annual Benefit
EEAD	Equivalent Expected Annual Damage
FCP	Federally Comparable Plan
FEMA	Federal Emergency Management Agency
FFE	Finished Floor Elevation
FTE	Full-Time Employee
GFMEDC	Greater Fargo Moorhead Economic Development Corporation
GDP	Gross Domestic Product
I-O	Input-Output
kcfs	kilo cubic feet per second
LPP	Locally Preferred Plan
LPT3	Log-Pearson Type III (analytical flow-frequency curve)
MSA	Metropolitan Statistical Area
NED	National Economic Development
P&G	Principles and Guidelines
RED	Regional Economic Development
USACE	United States Army Corps of Engineers
$/sf	Dollar per square foot

1.0 Introduction

This appendix documents the National Economic Development and Regional Economic Development analyses conducted for the Fargo-Moorhead Metro Area Feasibility Study. The analysis follows the framework and methodology as directed by the Corps' Planning Guidance Notebook (ER 1105-2-100) dated 22 April 2000 and any updated guidance since then. Alternative plans evaluated for flood risk management include diversions, levees/floodwalls, and nonstructural measures. These alternatives and others are discussed in detail in Appendix O of the main report.

An interest rate of 4-1/8 percent is used for discounting and present value calculations, except where otherwise noted. Costs and benefits are expressed in October 2011 price levels, except where otherwise noted. A 50-year planning period is assumed starting in the base year of 2019.

This analysis incorporates risk and uncertainty as directed by ER 1105-2-101, Risk-Based Analysis for Evaluation of Hydrology/Hydraulics, Geotechnical Stability, and Economics in Flood Damage Reduction Studies (1 March 1996) and EM 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies (August 1996). Uncertainty is inherent in all economic related input variables used in a typical flood damage analysis whether they may be LiDAR-originated ground elevations; first floor elevations determined by "windshield survey"; valuation of structures; generic depth-damage functions; content values based on content-structure value ratios; or assignment of occupancy type to structures for purposes of depth-damage calculations. Key hydrologic and hydraulic inputs such as frequency-discharge and stage-discharge relationships also possess their own elements of uncertainty. Attempts are made to address uncertainty by characterizing input variables in probabilistic terms rather than deterministic terms. Input data will typically be expressed as mean or median values with ranges determined by associated measures of variability.

In the context of planning for a flood risk management project, risk is typically associated with the residual threat of flooding and consists not only of the probability of its occurrence but also the consequences which can be expressed in both economic terms (i.e. flood damage) and in terms of public safety (threat of injury or loss of life). There is risk associated with the future without-project condition and the potential for flood-fight failure including related consequences. And there is risk associated with any with-project condition such as the potential for levees being overtopped or diversion capacities being exceeded, again all with related consequences. In addition to benefit-cost ratios and identification of a NED plan, results of this analysis will include descriptions of the residual risk associated with the various alternatives.

The Other Social Effects Account is considered in Appendix D.

2.0 Background

The Fargo-Moorhead Metropolitan area has a relatively high risk of flooding. The highest river stages have usually occurred as a result of spring snowmelt, but summer rainfall events have also led to significant flood damages. The Red River of the North (Red River or RNN) has exceeded

the National Weather Service flood stage of 18 feet in 48 of the last 109 years, and every year from 1993 through 2011. The residents of Fargo-Moorhead have been successful at preventing significant damages during past flood events by constructing emergency levees along large portions of the Red River. Constructing the emergency levees takes significant financial and human resources, causes business and traffic disruptions, and is taxing to the social fabric of the communities. Although the emergency levees have been successful in the past, there is a high risk of a catastrophic failure which would result in significant damages to the area.
Because of the flood risk, permanent measures are being evaluated to reduce potential flood damages.

A number of flood risk management alternatives have been considered as part of the Fargo Moorhead study. The alternatives were evaluated and screened based on the 4 accounts (National Economic Development, Regional Economic Development, Other Social Effects, and Environmental Quality) as well as other screening criteria discussed in Appendix O.

River levels of the RRN are often expressed in terms of stage above the zero elevation datum at the USGS gage in Fargo. The gage, located near river mile 453.0, has a zero datum elevation of 862.74 (1988 North American Vertical Datum). A river elevation of 897.74 at the gage, therefore, would be referred to as a stage of 35 feet (i.e., 897.74 minus 862.74). This allows for a common point of flood elevation reference throughout the local area.

2.1 Study Area

The geographic scope of the economic analysis encompasses the Fargo-Moorhead Metropolitan region, located within the area from approximately 12 miles west to 5 miles east of the Red River and from approximately 300 river miles north of Fargo near Emerson Manitoba to approximately 30 miles South of Fargo near Abercrombie ND. This area includes the Red River and the downstream portions of the Buffalo River, Wild Rice River (North Dakota), Sheyenne River, Maple River, Rush River, and other contributing streams that enter the Red River in the study area (Figure C-1). In North Dakota the study area includes a portion of Cass County and the cities of Fargo, West Fargo, Hickson, Oxbow, Wild Rice, Frontier, Briarwood, Prairie Rose, Horace, Reiles Acres, and Harwood. In Minnesota the study area includes a portion of Clay County and the cities of Moorhead, Dilworth, Oakport, Rustad, Kragnes and Georgetown.

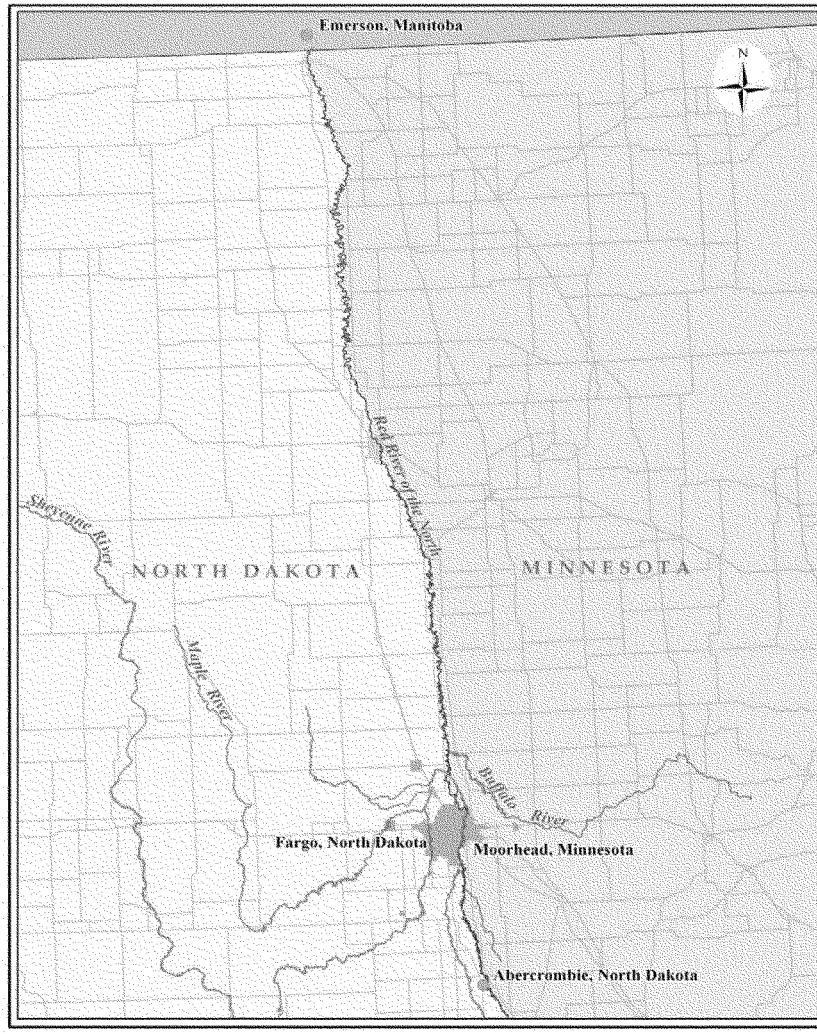


Figure C-1: Study Area

2.2 Fargo-Moorhead Regional Economy

The Fargo-Moorhead Metropolitan Statistical Area (MSA) straddles the North Dakota and Minnesota border on either side of the Red River. Fargo-Moorhead's business environment continues to grow and is ranked as follows, according to the Greater Fargo-Moorhead Economic Development Corporation (GFMEDC) Web site (2009):

- *#5 in Forbes ranking of the Top College Towns for Jobs in May 2009.*
- *#7 in Forbes Best Places for Business and Careers in March 2009. This is the sixth consecutive year that Fargo has made the top ten for small metropolitan areas. The index ranks cities according to cost of doing business, educational attainment of the population, income growth, projected job growth and net migration.*
- *#1 city in North Dakota for entrepreneurial start ups, according to Business Week.*
- *#8 in MSN and CareerBuilder.com's October 2008 list of the 25 Best Markets to Find a Job.*

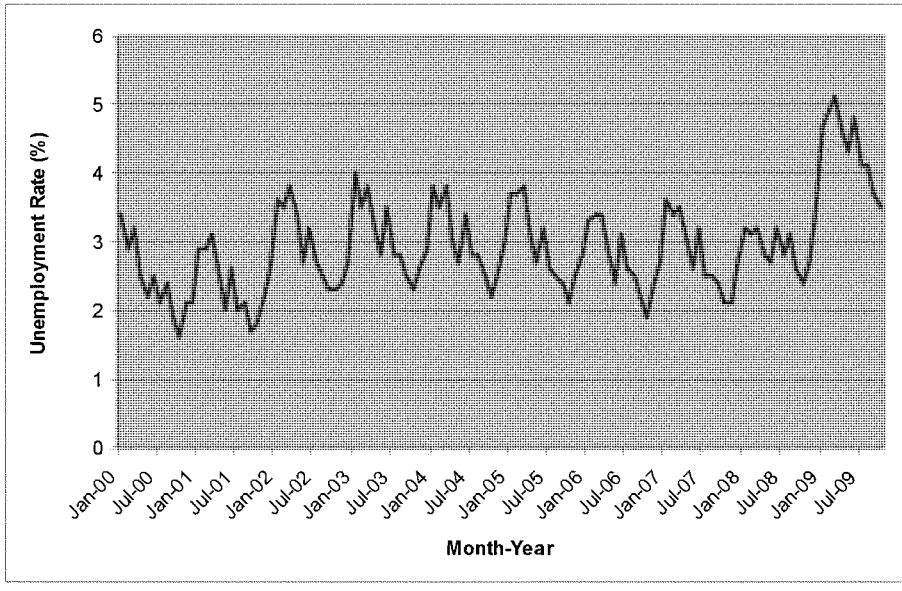
With one of the lowest unemployment rates in the nation, Fargo-Moorhead has consistently experienced gains in income and employment that exceed the national average. Data for the years 2004 through 2008 are shown in Table C-1. According to Moody's Economy.com, the Fargo-Moorhead economy continues to rank among the highest in vitality for U.S. metropolitan areas (GFMEDC 2009).

Table C-1 Fargo-Moorhead Economic Indicators

	2004	2005	2006	2007	2008
Gross Metro Product ($ billions)	6.7	7	7.2	7.6	8.1
Change over previous year (%)	3.5	4.8	2.1	5.8	6.4
Total Employment	109,600	112,700	115,600	118,700	121,800
Change over previous year (%)	3	2.8	2.6	2.7	2.6
Unemployment Rate	3	3	2.7	2.8	2.9
Personal Income Growth	6.5	6.1	6.5	7.3	9.5

Source: Moody's Economy.com, Oct. 2009 as cited in GFMEDC (2009)

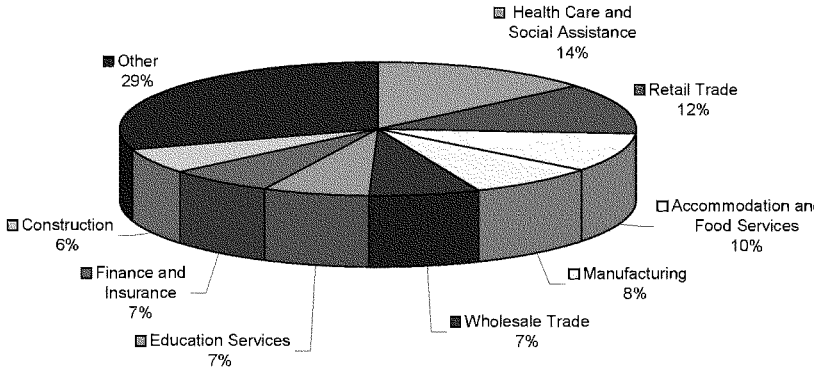
The Fargo-Moorhead metro area has one of the lowest unemployment rates in the Nation. In October 2009, the unemployment rate in the metro area was 3.7, and the national unemployment average during March 2009 was 8.6 percent (U.S. Bureau of Labor and Statistics, 2009). As recently as December 2010, the State unemployment average in North Dakota was 3.8 percent and in Minnesota it was 6.9 percent, compared to the national average of 9.4 percent (U.S. Bureau of Labor and Statistics, 2010). Figure C-2 displays unemployment trends for the Fargo-Moorhead MSA from the years 2000 to 2009.



Source: Job Service North Dakota, Labor Market Information Center, LAUS Unit, Jan. 2010

Figure C-2: Monthly Unemployment Data for Fargo-Moorhead MSA

Historically, the economy in Fargo-Moorhead has been dependent upon agriculture; however, that has changed substantially in recent decades. Now, the economy is based on retail trade, healthcare, technology, higher education and manufacturing. Major employers in the Fargo-Moorhead MSA are in the healthcare and education industries. Among the companies with the largest number of full-time employees (FTEs), the top five are in one of these two industries. MeritCare Health Systems is the largest employer with 3,691 FTEs (GFMEDC 2010). North Dakota State University is the second-largest with 2,401 FTEs. Notable mentions in other industries, such as back office operations, are the US Bank Service Center with 952 FTEs, and in the technology industry, Microsoft with 948 FTEs. Figure C-3 shows the percentage employed by each major industry.



Source: Greater Fargo Moorhead Economic Development Corporation (January 2010)

Figure C-3: Percentage Employed by Major Industry in Fargo-Moorhead MSA (2nd quarter 2009)

2.3 Population Size and Composition

According to the 2008 ACS, the population of the Fargo-Moorhead metropolitan area is estimated to be 194,839 persons. Based on the 2000 census, the total population in the 12-county study area is estimated to be 349,314 persons. In the metro area, the gender ratio is 1 to 1 (50 percent male and 50 percent female) and the median age is 31.6 years. Nationally, the population is 51 percent female and the median age is 36.7 years. Persons under 18 years old represent 23 percent of the population, which is lower than the national percentage of 25 percent. The percentage of residents over the age of 65 years (10 percent) is also lower in the metro area than the national percentage of 13 percent. The communities downstream of the metro area have lower percentages of persons under 5 years old, but higher concentrations of persons over 65 years old. It can generally be said of the downstream communities that, on average, they have a slightly higher percentage of older persons than is found in the metro area.

With the exception of Clay County, MN, and Grand Forks and Cass Counties, ND, the counties in the study area experienced a decline in population between 2000 and 2009. The decreases ranged from as little as 1.9 percent to as much as 17.1 percent. Over the past 50 years, the communities downstream of the Fargo-Moorhead metro area have seen population losses between 10 and 35 percent. The population of nearly every city and township between Fargo-Moorhead and Thompson, ND has decreased, with the exception of Oakport and Kragnes Townships, which are located immediately downstream of the metro area.

2.4 Income and Poverty

The median household income of the Fargo-Moorhead metropolitan area was somewhat lower ($47,636) than for the United States as a whole ($52,175). The poverty rate of individuals (12 percent) mirrored closely the national rate (13 percent). However, the child poverty rate was lower than the national rate: 11 percent of children less than 18 years of age lived in poverty in the Fargo-Moorhead metropolitan area, compared to 18 percent nationally. The poverty rate among families (7 percent) was slightly lower than the national rate of 10 percent; the poverty rate among female-headed households (31 percent) was very close to the national rate (29 percent of families that had a female-headed household and no husband present). Whereas 27 percent of households received Social Security nationally, 20 percent of Fargo-Moorhead metropolitan area households did.

2.5 Journey to Work

For commutes to work in Fargo-Moorhead metropolitan area, the proportion of workers who drove alone was somewhat higher than in the United States as a whole (82 percent versus 76 percent nationally), and the proportion who carpooled (9 percent) or used public transportation (1 percent) were somewhat lower. Notably, an estimated 7.1 percent of occupied households had no vehicle available (ACS pooled data from 2006–2008).

The mean travel time to work in all 12 counties in the study area was less than 25 minutes and, with the exception of Marshall and Norman Counties, MN, commute times were less than 20 minutes (U.S. Census Bureau, 2000).

2.6 Previous Flood Events

Local communities overwhelmingly believe there is a need for a flood risk management project.[1] The Red River has exceeded the 18 foot flood stage in 48 of the past 109 years and every year from 1993 through 2011. During each of these years, the cities constructed emergency levees to some extent to hold flood waters back and prevent damages. In recent history, the two flooding events that have had the greatest physical and emotional effect on the communities of Fargo and Moorhead are the 1997 and 2009 flood fights.

2.6.1 2009 Flood Event

The Red River flood of 2009, which affected large parts of both North Dakota and Minnesota, brought record flood levels to the Fargo-Moorhead area. At one point, the Red River was predicted to reach a level near 43 feet at Fargo. It actually crested at 40.82 feet at 12:15 a.m. on March 28, 2009. A severe cold snap on March 31 prevented an expected second crest, slowing the anticipated snow melt and allowing the river to retreat. Without the storm, many believed the flood walls and flood levees in and around Fargo and Moorhead would have been overtopped, which would have led to catastrophic damages within both cities.

The President declared a major disaster for most of the State of North Dakota on March 24, 2009 (FEMA 2009a). In addition, an emergency declaration was made for counties in the northwest of

[1] In 2009, 90% of Fargo residents voted in favor of a 1% increase in sales tax to contribute to the cost of permanent flood control (pers. comm. Brian Walters CEO GFMEDC).

Minnesota that directly border North Dakota and the Red River. The major disaster and emergency declarations enabled the Federal Emergency Management Agency (FEMA) and other Federal agencies to make Federal funding available to State and eligible local governments, and certain private nonprofits, for response and recovery.

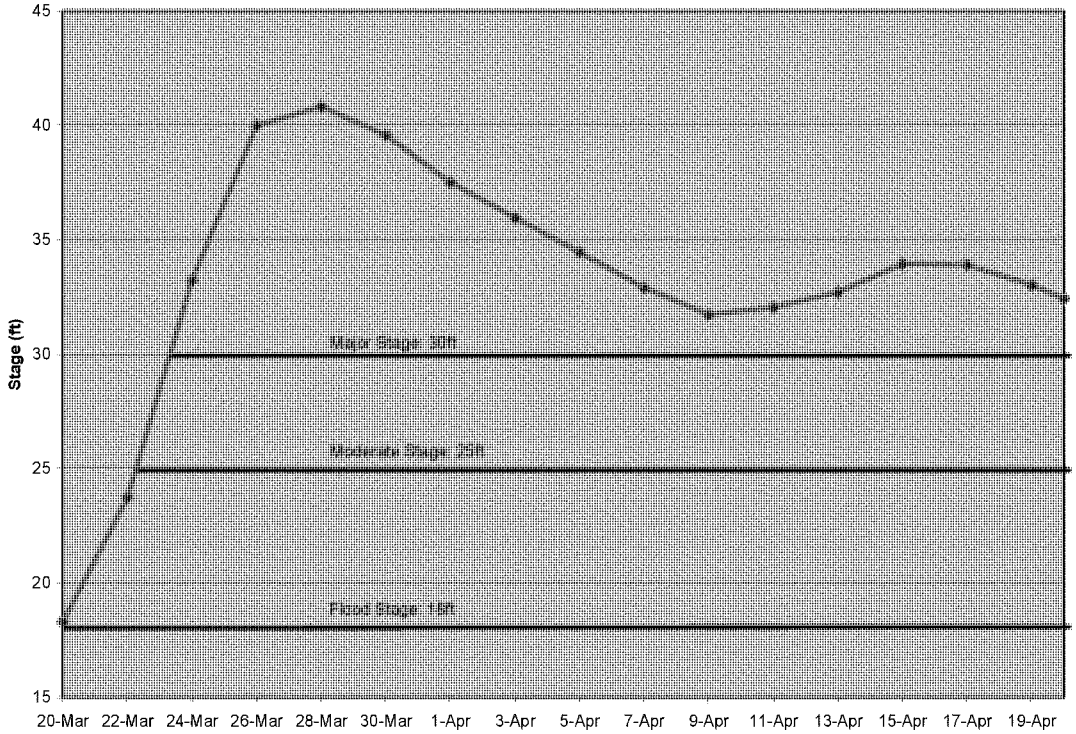
The Mayor of Fargo requested that all businesses not critical to the flood fight remain closed for a week starting on March 25, 2009 to ensure the transport route was kept clear for trucks carrying essential sand for sandbags. The closing of businesses made greater human resources available to assist in the flood fight by filling sandbags and building levees to reduce damages to the city. In addition, local universities were closed for 2 weeks to allow students to help with the flood fight.
Characteristics of the 2009 flood fight in the Fargo-Moorhead area include:

- Flood crested at 40.82 feet (refer to Figure C-4)
- Approximately 3.5 million sandbags were filled and placed (Walaker 2009)
- 100,000 people volunteered to assist with the flood fight (Forum of Fargo-Moorhead 2009)
- Over $150 million in disaster aid for North Dakota (2009 dollars; FEMA 2009b)
- Non-critical businesses were requested to remain closed for the week from March 25 to April 2 (Refer to Figure C-5)

2.6.2 1997 Flood Event

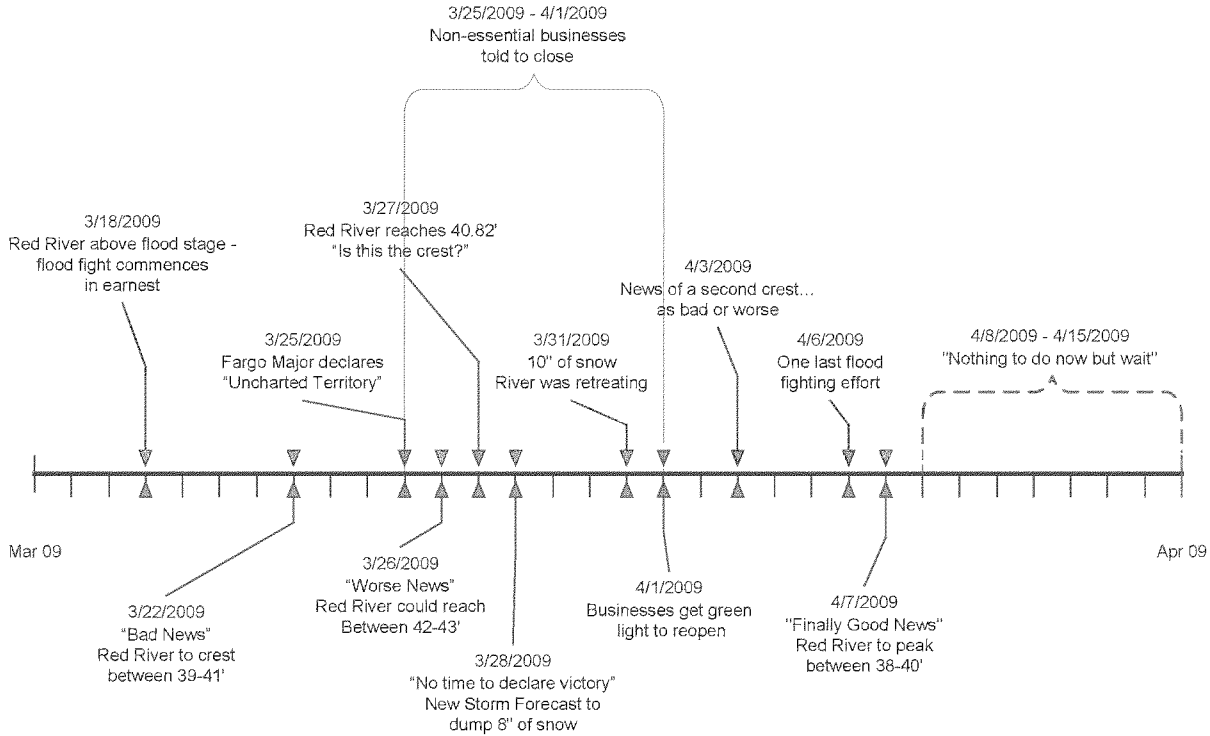
The Red River Flood of 1997 was a major flood that occurred in April and May 1997, along the Red River in North Dakota, Minnesota and southern Manitoba. Flooding was experienced throughout the Red River Valley, affecting the cities of Fargo and Winnipeg, but the greatest impacts were felt in Grand Forks and East Grand Forks, where floodwaters spread over 3 miles (5 kilometers) inland, inundating the twin communities.
Characteristics of the 1997 flood fight in the Fargo-Moorhead area include:

- Flood crest at 39.64 feet
- Total damages for the Red River region were $3.5 billion (1997 dollars; Shelby 2004)
- 3 million sandbags were filled and placed (Walaker 2009)
- Major flood impacts were in Grand Forks and East Grand Forks



Source: The Forum of Fargo-Moorhead (2009)

Figure C-4: The Red River at Fargo-Moorhead 2009



Source: Developed from the Forum of Fargo-Moorhead (2009)

Figure C-5: 2009 Flood Timeline

3.0 National Economic Development Account

3.1 Analysis Goals, Framework, and Terminology

3.1.1 Goals

A number of flood risk management measures were considered to address the flooding problem in the study area. These measures and combinations thereof were developed into alternative plans. Each plan was evaluated on the basis of National Economic Development (NED) benefits and NED costs. This account identifies the net benefits and benefit-cost ratio of each plan considered. The plan with the highest net benefits (NED benefits minus NED costs) is identified as the NED plan.

Two additional goals of this analysis are to identify the without-project equivalent expected annual damage (section 3.7) and project performance for each alternative (section 3.9).

3.1.2 Framework

Benefits and costs are determined using the "with project" versus "without project" framework. With- and without project conditions are forecasted based on an inventory of existing conditions that include hydrologic, hydraulic and economic conditions for the entire study area. Special consideration is given to foreseeable hydrologic, hydraulic and economic changes (with- and without-project) over the period of analysis.

The base year for this study is 2019. The base year is the point in time at which all benefits and costs are compared. All benefits and costs incurred prior to the base year are compounded to present worth. All benefits and costs incurred after the base year are discounted to present worth. The present worth of each benefit and cost stream is then converted into annual equivalent terms. The annual equivalents of each benefit and cost stream serves as the basis for comparing each alternative and identifying the federal plan. The current discount rate (4-1/8%) is used in discounting, compounding and annual equivalence, except where otherwise noted, as determined by EGM, 11-01, 'Federal Interest Rates for Corps of Engineers Projects for Fiscal Year 2011.'

Benefits and costs were evaluated with uncertainty in each hydrologic, hydraulic and economic variable. Where appropriate, flood risk management benefits were evaluated using a certified program (HEC-FDA 1.2.4) intended for such use.

3.1.3 Terminology

Average Annual Damage (AAD) and Benefit (AAB)

When evaluating flood damages, it is useful to relate the amount of damage to the water surface elevation in the river. In turn, each water surface elevation is related to certain amount flow, and

each flow is related to a frequency probability of exceedance. Therefore, each level of damage can be associated with a frequency, resulting in a damage-frequency curve. Average annual damage (AAD) is defined as the area under the damage-frequency curve.

Typically, AAD does not incorporate uncertainty in flows, water surface elevations, or damages, however the term is often confused with expected annual damages For the purposes of this report, AAD will represent the deterministic area under the damage-frequency curve (with no uncertainty).

AAD represents the average amount of damage that would occur in **any given year**, if **that year** were repeated infinitely many times over. The average value is based on the frequency of recurrence for each flood event. No other probabilistic variables are factored into the calculation of AAD.

AAD can vary by year, depending on changes in hydraulic, hydrologic, and economic conditions.

Average annual benefit (AAB) for any alternative is the difference between AAD without the alternative in place and AAD with the alternative in place.

Expected Annual Damage (EAD) and Benefit (EAB)

Expected annual damage (EAD) takes into account uncertainties in stage-damage, stage-flow, and flow-frequency relationships. EAD is the mean value of AAD, given the uncertainty associated with each damage, stage, and flow relationship. AAD and EAD are often confused, due to the similarity in the terms "average" and "expected." For the purposes of this report, expected annual damages refers to the probabilistic definition offered above. EAD is computed using HEC-FDA version 1.2.4, which utilizes the Monte Carlo method for evaluating mean values.

Expected annual damage represents the mean amount of damage that would occur in **any given year**, if **that year** were repeated infinitely many times over. The mean value is based on the frequency of recurrence for each flood event, as well as the uncertainties in stage-damage, stage-flow, and flow-frequency relationships.

EAD can vary by year, depending on changes in hydraulic, hydrologic, and economic conditions.

Expect annual benefit (EAB) for any alternative is the difference between EAD without the alternative in place and EAD with the alternative in place.

Equivalent Expected Annual Damage (EEAD) and Benefit (EEAB)

Throughout the period of analysis, EAD can vary if there are changes in hydraulic, hydrologic, or economic conditions. If each year is taken in sequence from the beginning of the period of analysis to the end, the result is a series or "stream" of EAD values. Equivalent Expected Annual Damage (EEAD) is the equivalent annual value of the EAD stream. It is computed by

amortizing the net present value of the EAD stream. Equivalent values are not necessarily probabilistic values, and depend only on the discount rate, the number of years in the period of analysis, and the stream of values. The only uncertainties accounted for in EEAD are those already accounted for in EAD.

EEAD values do not vary by year, and serve as a means of comparing benefits and costs in a consistent manner. Equivalent Expected annual benefit (EEAB) for any alternative is the difference between EEAD without the alternative in place and EEAD with the alternative in place. The EEAB represents the benefit that the alternative yields each year. Based on time value of money, the EEAB value is "equivalent" to the benefit stream yielded by the project. From an investment perspective, someone earning an annuity equal to the EEAB value for the life of the project would be no better and no worse off if he or she earned the benefit stream instead.

3.2 Alternatives

Alternatives formulation has been performed in an iterative process through four phases of the study. A number of flood risk management measures were considered throughout the study. These measures are discussed in Appendix O of the main report. Results from Phases one and two are presented in Appendix O but not in this Appendix. The following alternatives were carried forward for detailed modeling of economic benefits as part of Phases III and IV.

3.2.1 No action

The no action alternative would entail that no federal action take place.

3.2.2 Diversion Alternatives

Diversions on the North Dakota and Minnesota side were carried forward for evaluation. A number of sizes were considered ranging from 10,000 cfs to 45,000 cfs capacity channels.

3.2.3 Non-Structural Alternatives

Non-structural measures are discussed and evaluated in Appendix P of the Main Report. The non-structural measures carried forward are incremental, meaning they would be considered in addition to diversions. The non-structural analysis found feasible non-structural measures with Minnesota diversions. There were no feasible non-structural measures with North Dakota diversions.

3.2.4 Recreation Alternatives

Each diversion alternative creates opportunities to develop recreation features. Recreation plans are formulated and evaluated in Appendix M of the Main Report. The recreation features carried forward are incremental, meaning they would be considered in addition to diversions.

3.2.5 Final Array of Alternatives

The following is a list of the final alternatives evaluated for NED benefits.

Minnesota Short Alignment 10,000 cfs (Phase II)
Minnesota Short Alignment 15,000 cfs (Phase II)
Minnesota Short Alignment 20,000 cfs (Phase III)
Minnesota Short Alignment 25,000 cfs (Phase III)
Minnesota Short Alignment 30,000 cfs (Phase III)
Minnesota Short Alignment 35,000 cfs (Phase III and IV)
Minnesota Short Alignment 40,000 cfs (Phase III)
Minnesota Short Alignment 45,000 cfs (Phase III)
North Dakota East Alignment 35,000 cfs (Phase III and IV)
North Dakota East Alignment 20,000 cfs with Upstream Staging (Phase IV)
Non-Structural Alternatives (as increment)
Recreation Alternatives (as increment)

Three of these plans were carried forward to Phase IV. The selection of these plans is discussed in Chapter 3 of the Main Report. These plans are discussed below. Exhibit J contains maps of these plans. The other diversions from Phase III generally follow the same alignments.

North Dakota East Alignment 35,000 cfs (ND35K)

The ND35K would divert floodwaters through North Dakota along a 36-mile-long diversion channel. The diversion channel would start approximately 4 miles south (upstream) of the confluence of the Red and Wild Rice Rivers and extend west and north around the cities of Horace, Fargo, West Fargo, and Harwood, ND. The diversion capacity for this alternative is 35,000 cubic feet per second (cfs). The ND35K induces downstream stage increases greater than 2-feet in some areas during certain flood events.

North Dakota East Alignment 20,000 cfs with Upstream Staging (ND w/Staging, also LPP - Locally Preferred Plan)

The LPP would follow the same alignment as the ND35K. The diversion capacity for this alternative is approximately 20,000 cfs. A storage cell would be placed at the southern end of the project area. The control structure at the inlet and the tie-back levees would be designed to stage water upstream and in the storage cell. The LPP would increase stages upstream by more than 8-feet for a 1-percent chance event. The LPP would require buying out and relocating between 800 and 1,200 structures upstream, between 200 and 400 of which are households.

Minnesota Short Alignment 35,000 cfs (MN35K, also FCP - Federally Comparable Plan)

The FCP would divert floodwaters through Minnesota along a 25-mile-long diversion channel. The diversion channel would start at the confluence of the Red and Wild Rice Rivers and extend east and north, ending near the confluence of the Red and Sheyenne Rivers. The diversion capacity for this alternative is 35,000 cubic feet per second. The FCP induces downstream stage increases greater than 1-foot in some areas during certain flood events.

Reach Delineation

Table C-2 describes the how the study area is divided in general along the Red River. Exhibit I includes maps with the layout of each damage reach and their configuration in HEC-FDA 2.4.1.

Table C-2 Study Area Delineation by River Mile

Metro - Downstream - Upstream		
Sub-Area	Dnstrm River Mile	Upstrm River Mile
Downstream from Metro to Thompson	316	433
Fargo-Moorhead Metro	433	478
Upstream from Metro to Abercrombie	478	525

3.3 Period of Analysis

The period of analysis for this study is 50 years (per ER 1105-2-100). The base year of the period of analysis is the first year that benefits accrue from any of the alternatives considered. The Minnesota diversion alternatives are expected to be completed in 2019, earlier than other alternatives. All benefits and costs are compounded or discounted to the base year. Existing conditions serve as the basis for determining conditions in future years. When referring to existing conditions, the conditions at the present time are intended. Future conditions can refer to any year or series of years in the future. Future without-project conditions are the conditions that would occur if no federal action were taken. Future with-project conditions refer to conditions that would occur if any number of the alternatives considered were implemented.

The analysis years for evaluation of EAD and EEAD are 2019 (base year), 2044, and 2069. Existing hydrologic conditions were identified and it was determined that the flow-frequency curve is likely to shift throughout the period of analysis. The years 2044 and 2069 were chosen to evaluate changes in hydrologic conditions (the HEC-FDA models have analysis years one year prior to those stated above, however this does not change the equivalent values).

Costs of alternatives can be accrued as early as 8.5 years prior to the base year. All costs prior to base year are compounded appropriately.

3.4 Existing and Future Hydrologic and Hydraulic Conditions

3.4.1 Flow-Frequency Curves

The Corps Hydraulic Engineering Center (HEC) recommended the use of discharge-frequency in analyzing flood risk in the Fargo-Moorhead study area. This approach yields more accurate

representation of uncertainties, particularly for the extreme infrequent events. This approach was utilized in the economic analysis for the Red River of the North (RRN) within the metro area.

RRN discharges were determined using the Log Pearson's III analytical approach. Statistics include a mean (M), standard deviation (S), skew (G) and an equivalent record length. These statistics define the flow- frequency relationship for the economic analysis (statistics vary by analysis year), as well as the uncertainty about the flow-frequency curve. The diversion alternatives will not impact the frequency curve. Therefore, the frequency curve statistics are the same for both with- and without-project conditions (though varying by analysis year)

3.4.2 Transform-Flow Curves

For existing and future without project conditions, a transform-flow relationship was used to convert unregulated flows to regulated flows to account for upstream storage in the floodplain, and at Orwell and Lake Traverse Dams. Table C-3 displays the transform-flow relationship for existing conditions at the Fargo gage.

Any of the diversion alternatives considered primarily impact discharges in the main river channel by diverting high flows around the metro area. For the RRN, the changes in discharges are modeled by adjusting outflows in the transform-flow relationship downward. Transform-flow relationships were analyzed for each analysis year and each diversion alternative. The transform-flow relationships serve as the basis for computing diversion flood risk management benefits in each analysis year.

Table C-3 Transform-Flow Relationship

Unregulated to Regulated		
Exceedance Probability	Inflow Discharge	Outflow Discharge
0.99	554	440
0.9	1,814	1,450
0.75	3,428	2,800
0.5	6,655	5,600
0.2	14,322	12,150
0.1	20,808	17,000
0.05	27,960	22,000
0.02	38,445	29,300
0.01	47,153	34,700
0.005	56,524	46,200
0.002	69,914	61,700
0.001	80,791	74,000
0.0005	92,299	86,000
0.0001	120,572	120,572

3.4.3 Stage-Flow Curves and Water Surface Profiles

Two hydraulic models were used for economic analysis (see appendix B for more information). A steady flow model was developed in Phase II and III and used in the economic analysis for the RRN in the metro area. An unsteady flow model was developed in Phase III and IV and used in the economic analysis for tributaries and the RRN outside the metro area. Both models use Phase III hydrology with the "wet" period flows. These flows were developed at the recommendation of the Expert Opinion Elicitation Panel (EOE) discussed in Appendix A of the Main Report. The steady flow model also uses the flows from the future analysis years (2044 and 2069). The 50%, 20%, 10%, 5%, 2%, 1%, .5%, and .2% event flows were run with the steady state model for each analysis year. The 10%, 2%, 1%, and .2% event flows were run with the unsteady state model.

Water surface profiles (WSP's) were obtain from the hydraulic models. WSP's show the flood elevation for each flood event at each cross section in the hydraulic model. WSP's are primarily used in this analysis to estimate the stage-damage functions for each reach. The 8 profiles from the steady state model were used for the RRN in the metro area. The 10%, 2%, 1%, and .2% event profiles from the unsteady model were used to interpolate the 50%, 20%, 5%, and .5%, event profiles. These 8 WSP's were used in the economic analysis along tributaries and the RRN outside the metro area.

Stage-flow curves (rating curves) are required wherever a flow-frequency curve is used in HEC-FDA. Rating curves were used for each reach index location on the RRN in the metro area. The WSP's were used to develop the rating curves up to the .2% event. For events larger than the .2%, stages were obtained by plotting the stage-discharge curve and extrapolating.

Rating curves and hydraulic conditions will likely remain constant throughout the period of analysis, although impacts from sedimentation have not been fully analyzed in a Sedimentation Impact Analysis. Some of the flood risk management measures would alter certain rating curves. Diversion channels can increase or decrease stages in the rating curve through the metro area by surcharging or reducing the water surface where the diversion re-enters the natural channel. This "backwater effect" occurs near the downstream end of the diversion channel and gradually diminishes upstream on the natural channel. The smaller the diversion capacity, the less affect there will be in the rating curves. With-project conditions were evaluated to reflect the changes in such rating curves, where appropriate. A normal distribution was assumed for each rating curve with varying standard deviations for each elevation.

All modeling in the Metro area reaches is based on the steady state hydraulic model, which routes flows through river cross sections to approximate water surface elevations. The unsteady model is utilizes storage cells as well as cross sections to simulate elevations. The steady and unsteady models use the same flows; however the unsteady model puts some of the flow in storage cells. The addition of storage cells makes the stages lower in the unsteady model than in the steady state model. For the purposes of economic modeling, there are two key differences between the steady state model and the unsteady model:

1. Storage cells take flows from cross sections and show lower stages through town. This tends to lower expected annual damage estimates and benefits.
2. Storage cells allow flows to damage areas that were not damaged in steady model. This tends to increase expected annual damage estimates and benefits.

The risks to plan evaluation from using the steady flow model are discussed in section 3.10.4.

The unsteady model was used to assess economic benefits and impacts for all reaches upstream and downstream of the metro, and for all tributaries.

3.4.4 Elevation-Frequency Curves

For reaches on tributaries and on the RRN outside the metro area, elevation frequency curves were used for the economic analysis. Elevation–frequency curves for each reach index location were obtained from WSP's. HEC-FDA automatically computed standard deviations for these curves based on a normal distribution.

A large part of Cass County falls within the storage cell areas of the unsteady flow model. The Sheyenne River storage area is located on the north side of the study area and west of Interstate Highway 29. This area is affected by combined RRN and Sheyenne River flows. For purposes of hydraulic analysis, this area has been divided into cells with boundaries consisting of the grid-

like road network. Each individual cell is treated like a separate point along a water surface profile with a related frequency-stage relationship that is applied to the structures within the cell. Elevation-frequency curves were used for this area,

Between Horace and the Sheyenne River storage areas the Sheyenne River poses the greatest flood threat. A ridge of higher ground runs generally north-south that serves as a natural divide between the Sheyenne River and RRN flood plains. Elevation-frequency curves are used in the economic analysis in this area of Cass County. This area is at reduced risk from flooding up to the median 1% flood profile by the Corps' Horace-to-West Fargo diversion project (Exhibit I displays the areas with flood risk management features and some additional geographic features).

The Minnesota diversions have no flood risk benefits on the Sheyenne, Maple and Rush Rivers. However, the North Dakota diversions benefit reaches along these tributaries.

3.5 Without-Project Conditions

3.5.1 Existing / Emergency Flood Risk Management Measures

3.5.1.1 Existing Levees

When evaluating future with- and without project conditions, consideration must be given to the existing levee/floodwall projects in place as well as emergency measures performed by the cities during flood events. One Corps levee, in place since the 1960's, reduces flood risk for neighborhoods south of downtown (Downtown South reach from river miles 452.0 – 452.7). The city of Fargo has added to this levee extending its line further south and reducing flood risk for additional neighborhoods (Near South reach from river miles 452.7 – 453.0). Another Corps project, currently under construction, reduces flood risk for the Ridgewood neighborhood on the north side of Fargo. Several other levee segments, some of which were constructed during past flood events, also provide moderate to significant levels of localized flood risk management. These levees can be raised and/or extended with additional earth fill or with sandbags as flood emergency efforts dictate. A geotechnical analysis has been performed for these in-place projects to determine the level of flood risk reduction credit to assign to them. However, they would be susceptible to flanking at their edges when floodwaters reach the local ground elevation. These temporary levees require additional fill and/or sandbags during a flood fight to extend the line of protection. The "weak link" therefore, in the line of protection may not be the levees themselves but rather the segments placed as part of the emergency operations to extend or close a line of protection. No credit for reducing flood risk is given to these emergency segments. For reaches with these types of levees, a zero-damage elevation has been estimated that reflects the local ground elevation rather than a probable failure elevation on the levee. The table below shows the existing levels of flood risk management for sub-reaches within the Fargo North reach prior to emergency actions.

Table C-4 Beginning Damage- Fargo North

Approximate zero-damage elevations in Fargo North Sub-reaches

Subreach Number	Subreach	Dnstrm Limit	Upstrm Limit	Index	Zero-Damage Elevation
1	Fargo North End	438	447.3	442.7	895
2	Ridgewood	447.3	448.2	447.8	898.0 (TOL)
3	Near North	448.2	450.9	449.5	894.5
4	Downtown North	450.9	451.7	451.3	892.6
5	Downtown South	451.7	452.6	452.4	902.2 (TOL)
6	Near South	452.6	453	452.7	904.0 (TOL)
7	Lindenwood	453	455.3	454.2	900.6

Note: Corps projects (levees/floodwalls) in Subreaches 2 and 5; city project (levee) in Subreach 6; TOL = top of levee

A geotechnical failure analysis was included for the Near South levee (displayed in Exhibit I).

3.5.1.2 West Fargo

West Fargo is a larger city (2006 population of 20,681) within the study area. The Sheyenne River, a tributary of the Red River of the North, runs through town. A diversion/levee project constructed by the Corps of Engineers in the 1980's provides flood risk management from Sheyenne River flooding. However, flooding from a large RRN event can threaten the town from the east. Exhibit I displays the areas that are at a reduced risk of flooding through West Fargo.

West Fargo is divided into two reaches. The downtown reach is at reduced risk from Sheyenne River flooding by the Corps' diversion/levee project which is built to the median .2% flood profile or greater. This area is referenced to the RRN water surface profiles and includes a frequency-discharge relationship. The second reach, which extends from highway I-94 to the city's southern limit, is referenced to Sheyenne River water surface profiles which are expressed only in terms of frequency and elevation.

3.5.1.3 Other Local Flood Risk Management Features

Other local flood risk management projects, either in place or proposed and included as part of the future without-project condition include: the Horace to West Fargo diversion of the Sheyenne River (Corps-built project); Oakport (levee currently under construction, and property buyouts); and South Acres subdivision (levee). In addition to these structural projects, Fargo, with assistance from FEMA, has been actively acquiring flood prone properties and will continue to do so in the future. Properties currently planned for future buyout have been identified and removed from the structure inventory for damage/benefit evaluation purposes.

3.5.1.4 Geographic Features

A topographic ridge that generally runs North-South through the study area and separates the east part of Fargo from the west part and the City of West Fargo is of particular interest regarding lateral east-west flood flows from the Red River. This ridge acts as a natural flood barrier and provides a relative level of flood risk management to the west from Red River flooding. It also divides the floodplains of the Red and Sheyenne Rivers. Exhibit I displays the ridge alignment. Beginning damage elevations for structures on the west side of the ridge were adjusted as appropriate to account for the natural flood barrier.

3.5.2 Sewer backup flooding

A unique characteristic of flooding in the Fargo-Moorhead area is the potential for basement damage from backup of sanitary sewer lines. Homes not directly contacted by flood waters can incur basement damage via sewer lines originating from homes that are directly flooded. City officials contend that this is a major source of concern, and occurrences during past flooding and heavy rainfall/runoff events confirm this assertion. This phenomenon allows areas with a seemingly adequate level of topographic relief to incur indirect basement damage due to direct flooding of lower homes within the same sanitary sewer basin. A sanitary sewer basin is a subarea of the city in which all structures within the basin are connected to the same localized sewer system and whose drainage and flows to the sewage treatment plant are controlled by the same pump station. The zero-damage elevation for a particular basin is assumed to be the ground elevation of the lowest structure (plus 1 – 2 feet) in the basin. The basement of this lowest structure is assumed to be the entry point for flood waters into the local sewer basin which spread to other connected basements. Beginning damage elevations (HEC-FDA input data), typically set at a structure's ground elevation, are adjusted downward to the lower zero-damage elevation for the sanitary sewer basin.

3.5.3 Structure inventory

3.5.3.1 Metro Area

Structure data for the analysis of economic flood damages was obtained from Cass and Clay Counties and the cities of Fargo and Moorhead. Data was provided for all property parcels and included parcel ID numbers, structure values and structure types. In addition, field data was collected to confirm property types and locations and supplement data obtained from the cities and counties. Structures are categorized into the general categories of residential, apartment, commercial (includes industrial), public and agricultural.[2] Within each general category, structures are classified further and assigned a label referred to in the HEC-FDA data base as an occupancy name (Occ_Name). Each Occ_Name has its own depth-damage function which serves as the means for estimating damage by flood depth for the individual structure. See Table C-5 for structure count by category by area.

[2] Physical damage to agricultural structures was considered in this analysis, however no loss of agricultural production is considered.

Table C-5 HEC-FDA Structure Inventory Summary

Damage Reach	Apartment	Commercial	Public	Residential	Total
Fargo	1004	4503	393	21505	27405
West Fargo	113	842	11	7300	8266
Stanley Twp		24	2	513	539
Horace		35	6	634	675
Frontier		2		80	82
Prairie Rose				21	21
Briarwood				28	28
Pleasant Twp		15		27	42
North River				24	24
Reiles Acres				128	128
Harwood		9		243	258
Harwood Twp				99	99
Raymond Twp		1		16	17
Reed Twp		15		409	424
North Dakota subtotal	1117	5345	404	28805	35671
Moorhead & Greater Clay Co.	640	950	134	9148	10872
Total	1757	6396	552	40175	48880

3.5.3.2 Upstream and Downstream Areas

Field surveys were conducted for nearly all structures upstream and downstream of the Fargo Moorhead Metro. Information collected included structure type, condition, quality, foundation height, photographs, and other information for valuation of structures. Supplementary information was gained from Google maps street view or aerial imagery where needed. The upstream end of the inventory extends to Abercrombie, ND (but does not include it). The downstream end of the inventory extends to the Canadian border; however it is truncated at Thomson, ND at the downstream limit of the hydraulic model for the ND35K alternative.

3.5.3.3 Structure elevations

Structure elevation data is also required as input for the HEC-FDA model. In the spring of 2008, LiDAR digital elevation data was collected for the entire study area as part of the Red River Basin Mapping Initiative. The cities of Fargo and Moorhead provided shapefiles with building footprints for each structure within the city. Shapefiles with parcel footprints were available for the rest of the study area. Using GIS techniques, elevations were assigned to each building or parcel footprint based on the 2008 LiDAR. For structures with a building footprint, the lowest-adjacent-grade (LAG) was directly approximated. For structures with parcel footprints, either the mean or maximum parcel elevation was used to approximate the LAG.

First floor elevations were estimated based on a sample of structures surveyed for the height of the first floor above known ground elevations (foundation height). For West Fargo and nearly all of Cass County, each structure was surveyed (windshield) to estimate a foundation height. Approximately 970 structures in Fargo and Moorhead were surveyed (transit) by a local engineering firm (Houston) to collect first floor elevations. Houston measured the ground and first floor elevations at the front door of each sampled structure. An average difference between the surveyed first floor elevation and the LAG (LiDAR) was calculated for each occupancy type (one story, church, commercial, etc.). The resulting average foundation heights were applied to each structure in Fargo and Moorhead according to its occupancy type. URS Group Inc. submitted a report (attached) of the field work done as part of this study effort.

Beginning damage elevations for all non-residential structures and residential structures not on a sewer basin were assumed to be the LAG, unless there was a geographic feature or levee providing flood risk management to the structure. In such cases the beginning damage elevation was set at the top of the feature or levee. For residential structures on sewer basins, beginning damage elevations were assigned as described in section 3.5.2.

Due to the size of the study area and number of structures therein, it was not possible to obtain a direct estimate of uncertainty in structure elevations. The 2008 Red River Basin LiDAR has a margin of error of 1 ft (it supports 2 ft contours). Therefore, a standard deviation of ½ ft was used for the uncertainty in first floor elevations (using a normal distribution, the 95% confidence limit is two standard deviations on either side of the median value, which yields the 1 ft margin of error in the LiDAR).[3]

3.5.3.4 Structure values

Residential structure values were obtained from the respective assessors' offices (Fargo, Moorhead, Cass County and Clay County). Field data was collected and depreciated replacement values (DRV) were determined for a sample of structures (approximately 3,200 in the Metro and 90 upstream and downstream) throughout the study area using the Marshall-Swift cost estimating package.

[3] Note, section 4.0 of the URS report estimates the difference between surveyed ground elevations and ground elevations provided by USACE. However, due to the fact that the surveyed elevations were taken at the front of each structure, and the estimates by USACE are base on the LAG, the two estimates cannot be directly compared, nor can the surveyed elevations be used to approximate the uncertainty associated with LiDAR elevations.

For the Metro area the DRV's were compared with the sampled structures' assessed values in order to derive a factor for converting the values for all structures to a DRV basis. To convert assessed values to DRV's for Fargo and Cass County residential structures, a factor of 1.28 is applied and for Moorhead and Clay County, a factor of 1.3 is applied. All non-residential structures (commercial, industrial, public) were inventoried for the purpose of identifying damageable properties and for assigning depreciated replacement values. The inventory included field surveys to collect data on structure characteristics as input for the Marshall & Swift value estimation process. Since all structures were surveyed and assigned a value from the M&S estimator, no factor was necessary for application to non-surveyed structures as was done for the residential structures.

For the upstream area, structures were classified into like categories (e.g. two-story with basement, good condition, etc.) and assigned values based on a dollar-per-square-foot basis obtained from the sampled structures.

For all structures, it is assumed that structure value is a normally distributed random variable with a 5% standard deviation.

3.5.3.5 Damage categories

Flood damage to buildings includes the standard categories of structure and contents. Each building is labeled with a code, referred to in HEC-FDA as an occupancy name (Occ_Name), that links it to structure and content depth-damage functions specific for that type of property.

For commercial and public structures, separate depth-percent damage functions (DDF's) recently developed by IWR are applied to structure and content values to estimate damage by flood depth (Source – Solicitation of Expert Opinion Depth-Damage Function Calculations for the Benefit-Cost Analysis Tool (Draft Report), October 2008). The associated standard deviations are also used to address the uncertainty inherent with these functions. Content values are determined by applying unique content-to-structure value ratios (CSVR's) to the structure values themselves. To supplement the standard DDF's, field interviews were conducted for 33 of the larger and more unique commercial/industrial and public properties. The interviews were used to develop unique DDF's for contents of these properties while their structural damage was estimated using the standard DDF's for structures.

An estimation of uncertainty in the depth-damage relationship was obtained for each of the 33 interviewed structures. Damage was either normally or triangularly distributed at each depth. The standard deviation or high and low bounds were included in the DDF input in HEC-FDA.

Residential damage is estimated using the generic DDF's for structure and content damage provided in Economic Guidance Memorandum 04-01. Structure and content damages are both expressed as a percentage of structure value. The content damage functions are based on a content-to-structure value ratio of 100%. In addition to mean percent damage values by depth, EGM 04-01 also provides standard deviations which HEC-FDA uses to address uncertainty.

Residential structures are divided into seven types (i.e., Occ_Names) which include: one-story with and without basement; two or more stories with and without basement; split level with and without basement; and bi-level, among others.

3.5.3.6 Other Damage

In addition to structure and content damage, flood victims incur other costs. In an effort to quantify these other costs, a post-flood survey was conducted at Grand Forks and East Grand Forks (GF/EGF) after the flood of April 1997. This survey found that flood victims incur significant costs besides damage to their residential property and its contents. These include expenditures for travel, lodging and meals while evacuated from their homes; flood-related medical costs; vehicle damage; costs related to vandalism, looting and theft; cleanup costs including unpaid labor; and any other costs caused by flooding and not included as typical structural or content damage. Table C-6 summarizes the results of the post-flood survey and categories of other costs incurred by residents from the GF/EGF flood of 1997.

Table C-6 Other Flood Damage

	Other Flood Damage per Residence		
	Grand Forks		
	100-Yr	100 - 500-Yr	East Grand Forks
Category	Floodplain	Floodplain	500-yr floodplain
Vehicle	$4,227	$493	$1,531
Travel	2,442	557	1,849
Meals	1,155	607	391
Cleanup supplies	1,029	665	432
Unpaid labor	2,643	1,377	1,834
Moving, storage	144	5	37
Vandalism, etc	126	7	25
Medical	125	78	732
Other	645	41	789
Total	12,536	3,829	7,620

A regression equation was developed from the GF/EGF survey data relating damage to depth of flooding. The parameters have been updated using the consumer price index for urban consumers. The equation, which represents an average relationship for all residential structures, is as follows:

Other Damage = ($1,636 x Depth) - $7,254

Based on this equation, other damage starts when water depth in the basement reaches 4.5 feet. For residential structures without basements, other damages are assumed to begin at a flood elevation within one foot of the first floor of the structure. It is within this range that evacuation is assumed to commence and related costs start accruing. To apply this equation in the FDA model a depth-percent damage relationship was developed. Percent damage refers to damage expressed as a percent of other value. Each residential structure was assigned an arbitrary other value of $100,000. The regression equation was evaluated for a range of depths. For each depth, the resulting dollar figures were converted to percentages of $100,000. This percent-depth damage function was entered into FDA. The depth-percent damage relationship is displayed below. Apartments are assigned the same other damage relationship as residential structures.

Table C-7 Other Depth-Percent Damage

Depth (feet above basement floor)	Damage as % of other value ($100,000)
-4	0
-3	0.90%
-2	2.60%
-1	4.20%
0	5.80%
1	7.50%
2	9.10%
3	10.70%
4	12.40%
5	14.00%
6	15.70%
7	17.30%

Other damage is assumed to be a normally distributed variable with a standard deviation of 10%.

3.6 Existing and Future Economic Conditions

As discussed in section 3.4, flood risk and comparison of alternatives was evaluated for three analysis years: 2018, 2043 and 2068. The analysis years were selected based on anticipated changes in hydrologic conditions. At present, the Red River Basin is in a "wet" period, meaning that each level of flow is associated with a relatively high frequency. In future years each level of flow is expected to become less frequent. It was necessary to evaluate economic conditions for each of the analysis years.

The city of Fargo will continue to develop to the North and South. City ordinance requires all new development in the floodplain to be flood proofed to an elevation 2 ft above the Federal Emergency Management Agency (FEMA) 1% flood event profile. Future development was analyzed based on the Fargo Growth Plan (2007). The city will grow approximately 266 acres each year; approximately 52% of new development will be residential, while 48% will be commercial. The new structures were placed geographically as described in the Fargo Growth Plan. Based on these assumptions flood risk was calculated for the appropriate number of additional structures in each analysis year.

Based on discussions with the City of Fargo and Cass County, a large flood risk management structure would reduce the need for flood-proofing of new development. For the diversion alternatives, new development was on average assumed to be built 2 ft. lower than under without-project conditions (this varied by location). Flood proof cost savings benefits are discussed in section 3.7.6.

3.7 Damages and Benefits

3.7.1 Damage to Existing and Future Development

Most of the flood risk in the study area is comprised of damage to homes, businesses, and other buildings in the floodplain. Damages to existing and future development were calculated from the structure inventory (see section 3.5) using HEC-FDA. Stage-damage relationships for buildings in the study area were developed for with- and without-project conditions (for each reach and each damage category). Stage damage relationships for with-project conditions include future development at a lower elevation than under without-project conditions. In all other respects stage-damage relationships are the same under with- and without-project conditions (except where easements are needed for an alternative). Stage-damage curves for existing conditions (2011) are presented in Exhibit G.

EAD, for each alternative (except the ND w/staging) and analysis year was computed using HEC-FDA based on frequency, rating, and damage curves. The benefits for the North Dakota East Alignment 35,000 cfs plan (ND35k), as with the Minnesota plans, were modeled using the Phase III steady model. The North Dakota East Alignment 20,000 cfs with Upstream Staging (ND w/Staging) was developed in Phase IV; however, the stages approximately match those of the ND35k. Therefore, benefits for the ND w/Staging alternative are approximated using the results of the ND35k plan. This is discussed in more detail in section 3.10.5.

For Minnesota diversion, feasible non-structural measures were found in areas of Cass County (see Appendix P of the Main Report). These measures are in reaches not benefited by Minnesota diversions, particularly reaches along the tributaries. For this reason it was not necessary to adjust the structure inventory or stage-damage curves in HEC-FDA for the analysis of Minnesota diversions.

EEAD for each alternative was computed using standard present value and annualizing formulas - using the appropriate discount rate and period of analysis. The benefit of each alternative is the difference between without project EEAD and with project EEAD. This difference is the equivalent expected annual benefit EEAB.

EAD for existing conditions (2011) and each analysis year without project is presented in Table C-8. For the metro area, EAD increases until the base year (due to development), then decreases (due to changing hydrology). It is assumed that the change in EAD can be interpolated linearly between the analysis years. The linear interpolation serves as the basis for computing EEAD. EEAD for each alternative is presented in Table C-9. Table C-10 shows EEAB for each alternative.

EAD in the metro area for existing conditions is estimated at $177,743,000. Note that this is expected annual damage with existing and proposed projects in place but prior to additional emergency actions. Metro area EEAD is $183,792,000. A summary of existing conditions expected annual damage by reach and category is presented in exhibit H. Equivalent expected annual damage computations are displayed in Exhibit L.

In order to isolate the effects of future development versus hydrologic changes, damages were calculated using existing economic conditions for each analysis year (holding hydrology input constant in each year). Results of this analysis are presented in Exhibit L. Future growth accounts for 14% of EEAD (no damage occurs below the FEMA 1% flood elevation).

EAD and EEAD are presented in greater detail (by reach and by category) in Exhibit L.

Table C-8 EAD without Project Conditions - Development – ($1,000's)

Year	Metro Area	Upstream	Downstream
2011	$177,743	$693	$763
2019	$186,442	$693	$763
2044	$173,916	$693	$763
2069	$157,486	$693	$763

Table C-9 EEAD by Alternative – Development ($1,000's)

Plan	Metro Area	Upstream	Downstream
Without Project	$183,792	$693	$763
ND w/Staging**	$30,997	$183	$646
ND-E-35k	$30,997	$729	$879
MN-S-45k	$21,873	*	*
MN-S-40k	$24,894	*	*
MN-S-35k	$28,957	$729	$879
MN-S-30k	$35,667	*	*
MN-S-25k	$41,369	*	*
MN-S-20k	$55,092	*	*

*Not analyzed
**The operating plan for this alternative is not firm. The benefits shown downstream will likely not . likely occur with the final operating plan. Some adverse impacts may occur.

Table C-10 EEAB by Alternative – Development ($1,000's)

Plan	Metro Area	Upstream	Downstream
Without Project	$0	$0	$0
ND w/Staging**	$152,795	$509	$0
ND-E-35k***	$152,795	($36)	($116)
MN-S-45k	$161,919	*	*
MN-S-40k	$158,898	*	*
MN-S-35k***	$154,835	($36)	($116)
MN-S-30k	$148,125	*	*
MN-S-25k	$142,423	*	*
MN-S-20k	$128,700	*	*

*Not analyzed
**Benefits downstream adjusted. Some adverse impacts may occur
***Benefits are shown as negative. These are opportunity costs of the alternative and have been add to the cost side

3.7.2 Emergency costs

The cities of Fargo and Moorhead incur significant costs in flood fight efforts. A large part of these costs are for construction of earthen and sandbag levees (labor, equipment, materials, etc.). During large flood events, the cities build as many as 46 miles of emergency dikes and levees through town in an effort to retain flood waters. When flood waters recede, these levees must all be removed. Additional costs are incurred for emergency and other public services (police, medical, public works, National Guard, etc.) related to the flood fight. Businesses, residents, federal agencies, local and state governments, as well as humanitarian organizations such as the Red Cross, Salvation Army, and local churches all contribute to the flood fight, rescue and clean-up efforts.

The method used to quantify these costs was based on historical flood data collected through interviews with key agencies. Interviews were conducted with FEMA, the North Dakota National Guard, the ND Department of Human Services, the Red Cross, the Salvation Army, as well as the cities of Fargo and Moorhead. The data collected is based on six major floods: Fargo 1989, Grand Forks 1997, Fargo 1997, Fargo 2001, Fargo 2006 and Fargo 2009. Whenever possible, cost reports were obtained from the agencies involved in each flood event. In the absence of cost reports, estimates were obtained from individuals who were considered experts on the given flood event (e.g. the regional director of the Red Cross). For some costs, such as the number of volunteer hours contributed to flood fighting, data was not readily available. These costs were not included in the final emergency cost estimates. However, based on sensitivity analysis the missing costs do not amount to more than 3% of the emergency cost estimates.

The 1997 Grand Forks event was approximately a .5 % chance event. In order to account for the size difference between Fargo and Grand Forks, the emergency cost estimate for this event was increased. Emergency costs were multiplied by a factor equal to the population of Fargo and Moorhead, divided by the population of Grand Forks and East Grand Forks (population factor).

The 2001 and 2006 Fargo events were similar events. The cost estimates for these two events were averaged to estimate damages a stage of 37.88. The 1997 and 2009 Fargo events were likewise averaged to obtain an estimate of damage at a stage of 39.61.

The Fargo 1989 flood crested at a stage of 35.36. Construction of large scale emergency measures begin at a stage of 35 ft. Table C-11 displays the resulting stage-damage curve for Fargo-Moorhead emergency costs. All costs have been brought to present (2009) dollars. A standard deviation of 10% was used to account for uncertainty in the valuation of emergency costs.

Table C-11 Emergency Cost Stage-Damage Function ($1,000's)

Stage ft. (Gage)	Stage ft.	Damage	St.
31	893.74	$0	$0
35.36	898.1	$940	$94
37.88	900.62	$2,050	$205
39.61	902.35	$64,000	$6,400
42.19	904.93	$262,740	$26,274

The stage-damage curve for emergency costs was manually entered into HEC-FDA. Expected annual emergency costs were computed for each analysis year. The existing conditions (2011) expected annual damage is $7,739,000.

Emergency costs were analyzed for the Fargo Moorhead Metro only. Historically, flood fights and emergency costs have not been as significant for the impacted areas upstream or downstream, which are mostly rural, as they are for the Metro, which is a large urban area. Grand Forks North Dakota and East Grand Forks Minnesota are in the downstream affected area; however a large flood risk management project is in place in that community. Therefore, emergency costs for rural areas and for Grand Forks/ East Grand Forks are not expected be large enough to alter the results of the NED analysis.

EAD, EAB, and EEAD for the Emergency category are displayed in Tables C-15 though C-17.

3.7.3 Sewer and Infrastructure Damage

The cities of Fargo and Moorhead incur damages to sewer systems, roads and other infrastructure during major flood stages. The cities of Fargo and Moorhead provided records of sewer and road repairs that occurred due to past floods. These figures were indexed to current dollars (2010) and related to the stage associated with the historic flood. The following stage-damage curve was produced based on historical flood damage to sewer and infrastructure.

Table C-12 Sewer and Infrastructure Damages ($1,000's)

Stage ft. (Gage)	Elevation at RM 452.7	Damage (1,000)	St. Dev.(1,000)
30	892.74	$0	$0
37.13	899.87	$343	$34
39.72	902.46	$3,691	$369
40.82	903.56	$6,638	$664

This stage damage function was manually entered into HEC-FDA. Expected annual sewer and infrastructure damages were computed for each analysis year. The existing conditions expected annual damage is $291,000.

Sewer and infrastructure damages were analyzed for the Fargo-Moorhead Metro area only. These damages are expected to be relatively small in the downstream and upstream affected areas (which are mostly rural). As mentioned above, Grand Forks and East Grand Forks have a flood risk management project, and sewer and infrastructure damages are not expected to be high for those communities. Therefore, sewer and infrastructure damages outside the metro are expected to be small enough that they will not affect the NED analysis.

EAD, EAB, and EEAD for the Sewer & Infrastructure category are displayed in Tables C-15 though C-17.

3.7.4 Transportation costs

A stage-damage function was produced for transportation damages. See attachment 2-Transportation Analysis- for details of this calculation. Table C-13 displays the resulting stage damage function. The stage damage function was manually entered into HEC-FDA. Expected annual transportation damage for transportation costs was computed for each analysis year. The existing conditions expected annual damage is $4,029,000.

Table C-13 Transportation Stage-Damage Function ($1,000's)

Stage ft. (Gage)	Stage ft. (elevation at RM 452.7)	Damage (1,000)	St. Dev.(1,000)
20.26	882.87	$0	
28.53	891.15	$0	
32.52	895.14	$1,125	$113
35.1	897.71	$1,442	$144
37.87	900.48	$3,934	$393
39.61	902.21	$82,958	$8,296
42.19	904.77	$85,962	$8,596
44.02	906.59	$90,275	$9,028

Transportation costs were only analyzed for the metro area. Transportation costs outside the metro and induced transportation costs due to project construction were not quantified. This is a source of uncertainty in the NED analysis. These costs are not expected to be larger than the costs for without project conditions for the Metro area; however no sensitivity analysis has been conducted to verify this claim. Based on professional judgment, it is unlikely that the inclusion of these costs would alter the results of the NED analysis.

EAD, EAB, and EEAD for the Transportation category are displayed in Tables C-15 though C-17.

3.7.5 Flood proofing Cost Savings Benefits

Currently, new development in the floodplain in Fargo and Cass County requires flood proofing to reduce the threat of flood damage in the future and meet FEMA regulations. Savings of the cost to flood proof new construction is a benefit of a flood risk management project that can reduce the footprint of the floodplain. The area benefited is that area removed from the 100-year floodplain by the project that would have been developed in the future with flood proofing measures implemented.

Urban development in the study area has been expanding and will continue to expand over the course of the planning period. Fargo's population has grown from 47,000 in 1960 to over 93,000 in 2006, an average growth rate of over 2 percent per year (straight-line growth). To accommodate this growth, Fargo development has increased in recent years at an average rate of 266 acres per year. The Fargo Planning Department has projected urban growth for the next 50 years. They use this figure of 266 acres for projecting future development demand (Source: Growth Plan 2007 – City of Fargo, North Dakota). Growth is projected to occur within two development "tiers". Tier 1, an area adjacent to the present Fargo city limits, is sized to accommodate 25 years of growth at approximately 266 acres per year. Tier 2 is comprised of areas further away from the existing city and is expected to accommodate growth 25-50 years in the future. For years 25 through 50, at is assumed that development will continue at the rate of 266 acres per year. Each tier has a spatial component on both the north and south sides of town. In both Tier 1 and Tier 2 most future growth will occur within the 100-year flood plain and, without a flood risk management project, require flood proofing. In addition, within the city limits of Fargo itself, some acreage within the 100-year floodplain is also available for future development. Growth is expected at the same rate of 266 acres per year regardless of the need for flood proofing or not. Much of the area available for future growth is within the 100-year floodplain and future development with a diversion project in place would benefit from the saving of flood proofing costs in those areas removed from the floodplain.

Flood proofing measures include raising the grade of developable land with fill, waterproofing basement foundations, and building ring dikes around developable parcels. In addition to the direct construction cost is the opportunity cost of reduced revenue in the form of lost lot sales (estimated at up to $40,000 per acre) as flood proofed land is less intensively developed from a structural standpoint than non-flood proofed land. The type of flood risk reduction provided would vary by land use. Commercial, industrial, and public/institutional land uses would most likely elevate because of the high cost of their facilities and the ability to pay for higher land costs. Cost for this measure ranges from $55,000 to $70,000, by either elevating the entire site or acquiring additional properties for fill to elevate their buildings and facilities. For instance, a new Wal-Mart in south Fargo elevated the entire site, building and parking lot. These types of land use would use approximately 42% of the projected developable land area.

Residential and park land uses would more likely ring dike because the cost would be lower and these land uses seek lower cost land to make the housing feasible. Additional cost to develop in this manner is estimated at $35,000 per acre. Costs can range higher, however, for the more expensive residential development projects that, like commercial projects, involve the placement of fill to raise the grade of their lots and adjacent ancillary uses. These land uses are estimated to use approximately 58% of the projected developable land area. The percentage estimates are based on current and projected land use in the Fargo Growth Plan. Exhibit N presents the calculation of the flood proofing cost savings benefit per acre of development on a weighted average basis. This benefit is expected for each of the diversion alternatives since each will reduce the flood plain footprint sufficiently to accommodate future demand for flood-free developable land.

Table C-14 Flood proofing Cost Savings Benefit per Acre

Type	Percent Land use	Cost per acre	Wtd average
Comm/ind/public	42%	$62,500	$26,250
Residential	58%	$35,000	$20,300
Wtd average cost / acre			$46,550

Source: Fargo Department of Planning

The savings per acre is applied to the average acres per year developed on land converted from floodplain to non-floodplain by a diversion project. Floodplain maps for without and with-project conditions were used to estimate the amount of land formerly in the floodplain that would realize the flood proofing cost savings benefit. At the rate of 266 acres per year, the future demand for developable land over the 50-year planning period is 13,300 acres. Growth is assumed at the same rate for the interim period between 2010 and the base year of 2018. Development in the floodplain within this period would require flood proofing and incur the related costs. This land (266 acres/year x 8 years = 2,128 acres) would not be expected to realize the cost savings benefit. Land within Tier 1 and the Fargo city limits would be projected to be developed before Tier 2 land regardless of its location relative to the floodplain. This is in keeping with the city's planning goal to grow in an orderly and efficient manner. There are approximately 20,000 acres within Tiers 1 and 2 and in Fargo available for future development to the year 2068 so supply exceeds demand for the foreseeable future. Of this land, approximately 14,000 acres is within the present 100-year floodplain. As expected, the larger the diversion project, the larger the area removed from the 100-year floodplain and the larger the expected annual flood proofing cost savings. Exhibit L displays the acres by plan opened up to development free of flood proofing requirements, land outside of the floodplain used to meet growth demand, and residual acreage that may still require flood proofing to meet demand. Annual benefits are also estimated by applying the weighted average flood proofing cost per acre to the average annual acres benefited by plan. Average annual benefits range from $5.4 million for the MN Short 20k cfs diversion to $10.4 million for the ND 35k cfs diversion.

3.7.6 Flood Insurance Administration Cost Savings Benefits

A project that eliminates the threat of flooding from a 100-year flood event in the flood plain also eliminates the requirement for flood insurance for properties in the flood plain. A benefit can be claimed for saving the cost of administering the flood insurance policies as structures are no longer subject to flooding from a 100-year event. Per Economic Memorandum #06-04 dated April 6, 2006, the annual administration cost for flood insurance policies is $192. Currently there are 5,082 flood insurance policies in effect in the study area (Source: FEMA Region VIII office). This includes the cities of Fargo and Moorhead and the counties of Cass and Clay. Total administration costs associated with these policies amounts to $975,700. This is the benefit to a flood risk management project for eliminating the 100-year flood plain and the requirement to purchase flood insurance. This benefit applies to each of the diversion alternatives.

3.7.7 Non-Structural Benefits

Appendix P of the Main report contains the evaluation of non-structural measures. The incremental EEAB for non-structural measures are present in Table C-16

Table C-15 Non-Structural EEAB ($1,000's)

Plan	EEAB
Without Project	0
ND w/Staging	0
ND-E-35k	0
MN-S-45k	414
MN-S-40k	414
MN-S-35k	414
MN-S-30k	414
MN-S-25k	414

3.7.8 Recreation Benefits

Recreation features were formulated for each diversion alignment in Appendix M of the Main Report. The annual benefits for recreation plans from Appendix M are $4,806,000 with North Dakota diversions and $5,004,000 for Minnesota diversions.

3.7.9 Damage and Benefit Summary

Table C-16 though Table C-20 summarize the EAD, EEAD, EEAB, and other benefits discussed in the previous sections.

Table C-16 EAD without Project Conditions – Emergency Etc. ($1,000's)

	Metro Area		
Year	Emergency	Sewer&Infra	Traffic
2011	$7,739	$291	$4,029
2019	$7,739	$291	$4,029
2044	$6,311	$237	$3,290
2069	$5,239	$197	$2,728

Table C-17 EEAD by Alternative - Emergency Etc. ($1,000's)

	Metro Area		
Plan	Emergency	Sewer&Infra	Traffic
Without Project	$7,063	$266	$3,679
ND w/Staging	$648	$22	$333
ND-E-35k	$648	$22	$333
MN-S-45k	$369	$16	$242
MN-S-40k	$489	$20	$297
MN-S-35k	$646	$25	$372
MN-S-30k	$916	$34	$483
MN-S-25k	$1,111	$41	$579
MN-S-20k	$1,607	$62	$839

Table C-18 EEAB by Alternative – Emergency Etc. ($1,000's)

	Metro Area		
Plan	Emergency	Sewer&Infra	Traffic
Without Project	$0	$0	$0
ND w/Staging	$6,415	$244	$3,346
ND-E-35k	$6,415	$244	$3,346
MN-S-45k	$6,694	$250	$3,437
MN-S-40k	$6,574	$246	$3,382
MN-S-35k	$6,417	$241	$3,307
MN-S-30k	$6,147	$232	$3,196
MN-S-25k	$5,952	$225	$3,100
MN-S-20k	$5,456	$204	$2,840

Table C-19 EEAD Summary ($1,000's)

Category	Without	NDw/Staging	ND-E-35k	MN-S-45k	MN-S-40k	MN-S-35k	MN-S-30k	MN-S-25k	MN-S-20k
EEAD Development Metro	$183,792	$30,997	$30,997	$21,873	$24,894	$28,957	$35,667	$41,369	$55,092
EEAD Emergency	$7,063	$648	$648	$369	$489	$646	$916	$1,111	$1,607
EEAD Sewer&Infra	$266	$22	$22	$16	$20	$25	$34	$41	$62
EEAD Transportation	$3,679	$333	$333	$242	$297	$372	$483	$579	$839
Sub-Total Metro EEAD	$194,800	$32,000	$32,000	$22,500	$25,700	$30,000	$37,100	$43,100	$57,600
EEAD Development Upstream	$693	$183	$729	*	*	$729	*	*	*
EEAD Development Downstream	$763	$646	$879	*	*	$879	*	*	*
Sub-Total Outside Metro EEAD	$1,456	$829	$1,608	$0	$0	$1,608	$0	$0	$0
Total Study Area EEAD	$196,256	$32,829	$33,608	$22,500	$25,700	$31,608	$37,100	$43,100	$57,600

**Not Analyzed

Table C-20 EEAB Summary ($1,000's)

Category	NDw/Staging	ND-E-35k	MN-S-45k	MN-S-40k	MN-S-35k	MN-S-30k	MN-S-25k	MN-S-20k
EEAB Development Metro	$162,800	$162,800	$172,300	$169,100	$164,800	$157,700	$151,700	$137,200
EEAB Emergency	$6,415	$6,415	$6,694	$6,574	$6,417	$6,147	$5,952	$5,456
EEAB Sewer&Infra	$244	$244	$250	$246	$241	$232	$225	$204
EEAB Transportation	$3,346	$3,346	$3,437	$3,382	$3,307	$3,196	$3,100	$2,840
Sub-Total Metro EEAB	$172,805	$172,805	$182,681	$179,302	$174,765	$167,275	$160,977	$145,700
EEAB Development Upstream	$509	$0	$0	$0	$0	$0	$0	$0
EEAB Development Upstream	$0	*	**	**	*	**	**	**
Total FRM EEAB	$173,314	$172,805	$182,681	$179,302	$174,765	$167,275	$160,977	$145,700
EEAB Non Structural	$0	0	$414	$414	$414	$414	$414	$430
Flood Insurance Admin. Benefit	$958	$958	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000
Flood Proof Benefits	$9,993	$9,993	$6,240	$6,240	$6,240	$6,240	$6,240	$6,240
Total Alternative Benefits	$183,756	$183,756	$190,335	$186,956	$182,419	$174,929	$168,631	$153,370
Recreation Annual Benefit	$4,806	$4,806	$5,004	$5,004	$5,004	$5,004	$5,004	$5,004

*Factored in on cost side
**Not Analyzed

3.8 NED Costs

NED costs include the implementation costs of alternatives (including costs for mitigation of adverse impacts), opportunity costs of the investment (interest during construction), economic costs of unmitigated adverse impacts, and operation, maintenance, repairs, rehabilitations, and replacements (OMRR&R) of project features.

All costs and benefits must be compared on an annual basis, from a consistent point in time. Just as all benefits are compounded or discounted to the base year (2019) and annualized, so are all economic costs.

Screening of alternatives took place in both Phase III and Phase IV. Costs from both phases are present in this section. The costs from Phase III were developed in FY 2010, while costs from Phase IV were developed on FY 2011. The FY 2010 discount rate (4-3/8%) is used for Phase III and the FY 2011 discount rate (4-1/8%) is used for Phase IV. Similarly, price levels from 2010 and 2011 are used for Phase III and IV, respectively.

3.8.1 Installation and OMRR&R Costs

The cost estimates from appendix L for the Phase III and IV alternatives are presented tables C-19 and C-20.

Table C-21 Phase III Diversion Cost Estimates ($1,000's)

Plan	Installation Costs	Annual OMRR&R
ND-E-35k	$1,237,355	$3,318
MN-S-35k	$1,066,597	$2,375
MN-S-30k	$990,099	$2,217
MN-S-25k	$929,562	$2,057
MN-S-20k	$856,101	$1,883

Table C-22 Phase IV Diversion Cost Estimates ($1,000's)

Plan	Installation Costs	Annual OMRR&R
ND w/Staging	$1,745,033	$3,501
ND-E-35k	$1,484,913	$3,436
MN-S-35k	$1,205,207	$3,508

Detailed cost estimates were not developed for the MN-S-45k and MN-S-40k plans. In lieu of cost estimates for a Minnesota 40K CFS and Minnesota 45K CFS diversion, it was assumed that marginal costs were constant with respect to diversion capacity (KCFS). The

following regression equation was calculated based on cost estimates for the Minnesota 20K CFS through 35K CFS diversion:

Annual Charges ($1,000) = (KCFS x 860.01) + 35,900.8
R-squared = 0.99367

The projected annual charges for the 40K and 45K diversions are presented in Table C-23.

Table C-23 Projected Annual Charges ($1,000's)

Plan	Annual Installation & OMRR&R Costs
MN-S-40k	$70,301
MN-S-45k	$74,601

3.8.2 Opportunity Costs of Investment

Outlays made during the construction of alternatives are made with no immediate return on investment. Those outlays could have otherwise been invested elsewhere and begin returns on investment immediately. The forgone return on investment is an opportunity cost of the alternative. The returns on investment are forgone at a rate equal to the discount rate (this represents the annual return on investment earned by investing in other water resource projects). Similarly, outlays made after the base year are discounted to reflect the benefit of not forgoing a return on investment. Alternatively, applying discounting and compounding principles is equivalent to taking the present worth (at the base year) of all outlays.

In both Phases III and IV, it was estimated that a North Dakota diversion would take 8.5 years to construct and a Minnesota diversion would take 7.5 years. It was assumed that the diversion first costs would be distributed equally through each year of construction. These outlays are compounded annually to the base year. Tables C-20 and C-21 display the present worth of installation costs for each alternative in Phases III and IV. The difference between the present worth and installation costs is interest during construction (IDC). Exhibit K shows the computational steps to determine IDC for Phases III and IV.

Table C-24 Phase III Interest during Construction ($1,000's)

Plan	Installation Costs	IDC	Present Worth
ND-E-35k	$1,237,355	$224,548	$1,461,904
MN-S-35k	$1,066,597	$219,368	$1,285,965
MN-S-30k	$990,099	$203,635	$1,193,733
MN-S-25k	$929,562	$191,184	$1,120,745
MN-S-20k	$856,101	$176,075	$1,032,176
Rec ND	$34,753	$760	$35,513
Rec MN	$34,242	$2,280	$36,522

Table 25 Phase IV Interest during Construction ($1,000's)

Plan	Installation Costs	IDC	Present Worth
ND w/Staging	$1,745,033	$296,914	$2,041,947
ND-E-35k	$1,484,913	$252,655	$1,737,568
MN-S-35k	$1,205,207	$232,404	$1,437,611
Rec NDwStagin	$36,315	$791	$37,106
Rec ND35k	$38,835	$801	$39,636
Rec MN	$31,494	$2,015	$33,509

3.8.3 Economic Costs for Unmitigated Adverse Impacts

Diversion alternatives have a large footprint and greatly affect flood behavior. As a result, a number of economic, social, and environmental impacts occur, some adverse. Costs for mitigation of environmental impacts are included in the installation costs. These mitigation measures are discussed in section 5.5 of the Main Report. Economic and social impacts are mitigated to some extent, where takings are required, or where property is needed for project features (such as the staging area for the ND w/Staging alternative). These mitigation costs are included in the installation costs as well. For the most part, economic and social impacts are not mitigated with the diversion alternatives. Social impacts are discussed in Appendix D and in section 5.2.3 of the Main Report (consideration is also given to Environmental Justice issues in accordance with Executive Order 12898). The costs of unmitigated economic impacts were analyzed and to some extent quantified. The impacts that have been quantified are the induced flood risk impacts. Other economic impacts are discussed in Appendix D and in section 5.2.3 of the Main Report.

Induced flood damage was analyzed using HEC-FDA. There are induced damages upstream and downstream for Minnesota and North Dakota diversion. These damages were not fully analyzed in Phase III. Phase IV has included a preliminary identification of induced damages.

Table C-26 Phase IV Induced Damage ($1,000's)

Plan	Upstream	Downstream	Total
ND w/Staging*	-	-	-
ND-E-35k	$36	$116	$153
MN-S-35k	$36	$116	$153

*Some adverse impacts may occur.

3.8.4 NED Cost Summary

Table C-27 and Table C-28 display the NED costs discussed in the previous sections.

Table C-27 Phase III NED Costs ($1,000's)

	ND35K	MN45K	MN40K	MN35K	MN-S-30k	MN-S-25k	MN-S-20k
Total Diversion First Cost	$1,237,355	*	*	$1,066,597	$990,099	$929,562	$856,101
Present Worth of Investment	$1,461,904	*	*	$1,285,965	$1,193,733	$1,120,176	$1,032,176
Annual Diversion Investment Cost	$72,477	*	*	$63,754	$59,182	$55,535	$51,172
Annual Diversion O&M Cost	$3,318	*	*	$2,375	$2,217	$2,057	$1,883
Induced Damages	**	**	**	**	**	**	**
Annual Diversion Charges	$75,795	$74,601	$70,301	$66,129	$61,399	$57,592	$53,055
Total Recreation First Cost	$34,753	$34,242	$34,242	$34,242	$34,242	$34,242	$34,242
Present Worth of Investment	$35,513	$36,522	$36,522	$36,522	$36,522	$36,522	$36,522
Annual Recreation Investment Cost	$1,761	$1,811	$1,811	$1,811	$1,811	$1,811	$1,811
Annual Recreation O&M Cost	$47	$47	$47	$47	$47	$47	$47
Annual Recreation Charges	$1,808	$1,858	$1,858	$1,858	$1,858	$1,858	$1,858

Table C-28 Phase IV NED Costs ($1,000's)

	ND w/Staging	ND35K	MN35K
Total Diversion First Cost	$1,745,033	$1,484,913	$1,205,207
Present Worth of Investment	$2,041,947	$1,737,568	$1,437,611
Annual Diversion Investment Cost	$97,097	$82,623	$68,360
Annual Diversion O&M Cost	$3,501	$3,436	$3,508
Induced Damages	-	153	153
Annual Diversion Charges	$100,598	$86,212	$72,021
Total Recreation First Cost	$36,315	$38,835	$31,494
Present Worth of Investment	$37,106	$39,636	$33,509
Annual Recreation Investment Cost	$1,764	$1,885	$1,593
Annual Recreation O&M Cost	$130	$130	$40
Annual Recreation Charges	$1,894	$2,015	$1,634

3.8.5 NED Results, Net Benefits and Benefit-Cost Ratios

Table C-29 and Table C-30 display the comparison of benefits and costs for Phase III and Phase IV alternatives. The MN40K plan was identified in Phase III as the NED plan (the plan that reasonably maximizes net benefits). As discussed in Chapter 3 of the Main Report, the local study sponsors requested that the Corps recommend the ND35K as the Locally Preferred Plan (LPP). Since the ND35K had fewer benefits and more costs than the NED plan, the MN35K was selected for the basis of the federal cost share, making it the Federally Comparable Plan (FCP).

At the end of Phase III, the upstream and downstream impacts of the diversion alternatives had yet to be fully defined. Impacts were further defined, and the concept of staging measures was introduced in Phase IV. The analysis in Phase IV is based only on the ND w/Staging, the ND35K, and the MN35K. In Phase IV, the local study sponsor indicated that the preferred plan was the ND w/Staging. The St Paul District maintains that the Phase III identification of the NED plan was still valid in Phase IV, and that the current NED plan is the MN40K. The ND w/Staging is referred to as the LPP. The MN35K remains the FCP. For further discussion of the identification of the NED, LPP and FCP see Chapter 3 of the Main Report.

The project performance analysis is discussed in section 3.9 of this appendix. A sensitivity analysis of the economic analysis based on emergency flood-fights is discussed in section 3.10.1 of this appendix. Other risks and uncertainties in the economic analysis are discussed section 3.10 of this appendix.

Table C-29 Phase III Net Benefits and Benefit-Cost Ratios ($1,000's)

	ND-E-35k	MN-S-45k	MN-S-40k	MN-S-35k	MN-S-30k	MN-S-25k	MN-S-20k
Total Alternative Benefits	$183,756	$190,335	$186,956	$182,419	$174,929	$168,631	$153,370
Annual Diversion Charges	$75,795	$74,601	$70,301	$66,129	$61,399	$57,592	$53,055
Net Benefit	$107,961	$115,734	$116,655	$116,290	$113,530	$111,039	$100,315
Benefit-Cost Ratio	2.42	2.55	2.66	2.76	2.85	2.93	2.89
Recreation Annual Benefit	$4,806	$5,004	$5,004	$5,004	$5,004	$5,004	$5,004
Annual Recreation Charges	$1,808	$1,858	$1,858	$1,858	$1,858	$1,858	$1,858
Net Benefit	$2,998	$3,146	$3,146	$3,146	$3,146	$3,146	$3,146
Benefit-Cost Ratio	2.66	2.69	2.69	2.69	2.69	2.69	2.69

Table C-30 Phase IV Net Benefits and Benefit-Cost Ratios ($1,000's)

	ND w/Staging	ND35K	MN35K
Total Alternative Benefits	$174,817	$173,777	$172,454
Annual Diversion Charges	$100,598	$86,212	$72,021
Net Benefit	$74,219	$87,565	$100,433
Benefit-Cost Ratio	1.74	2.02	2.39
Recreation Annual Benefit	$5,130	$5,130	$5,355
Annual Recreation Charges	$1,894	$2,015	$1,634
Net Benefit	$3,236	$3,115	$3,721
Benefit-Cost Ratio	2.71	2.55	3.28

3.9 Project Performance, Risk and Uncertainty

Given the uncertainty associated with the various hydraulic, hydrologic, and economic relationships used in the flood damage analysis, there is likewise some uncertainty regarding a project's ability to provide the mean level of flood damage reduction. The estimated benefits of each alternative are therefore presented as a distribution, rather than deterministic values. Benefit-cost ratios are presented in section 3.8.5 based on mean (also termed expected) benefits. The distributions associated with those benefits are presented in exhibit M.

This analysis provides three measures of project performance:

1 Annual exceedance probabilities
2 Long Term Risk
3 Conditional non-exceedance probabilities

Before discussing the three measures of project performance it is necessary to define the term "target stage," which is the water surface elevation where significant damages occur. Depending on the reach in question, the elevation where significant damages occur is defined either as:

1 The elevation where damages amount to 5% of the damage occurring at the 1% flood elevation, or
2 The top of levee elevation (if the reach has a levee), or
3 Other elevation relevant to study.

The three measures of project performance are discussed below:

Annual Exceedance Probabilities
This is the probability in a given year that the water surface elevation will exceed the target stage. This can also be interpreted as the probability that significant damages (defined subjectively) will occur in a given year.

Long Term Risk
This is the probability that the water surface elevation will exceed the target stage at least once in a given time period (presented for 10, 30, and 50 years). This can also be interpreted as the probability of incurring significant damages within the given period of time.

Conditional Non-Exceedance Probabilities
This is the probability that a given flood event (say the 1% flood) will not exceed the target stage. The need to define flood events (such as the 1%) using a distribution arises from uncertainties in the flow-frequency and stage-flow relationships.

The project performance measures for each Phase IV alternative (including the No-Action alternative) are presented in Exhibit M for each reach in the study area. These measures are based on the "wet" hydrology from existing conditions. Since hydrologic flows decrease throughout the period of analysis, the performance measures will overstate risk. Particularly long-term risk will be overstated. The other measures will be accurate for earlier years in the period of analysis. The project performance measures at the Fargo gage (near river mile 453) are presented in Table C-31 using the stages of 892.74 and 903.56 (gage stage of 30 and 40.82) as the target stage. These stages are important in that the gage stage of 30 is widely consider the major damage stage in the metro, and the gage stage of 40.82 is the stage of the flood of record (2009).

Below is an interpretation of the project performance analysis from Table C-31. These interpretations are intended only for the gage location, and do not apply to other reaches. For project performance at all other reaches, see Exhibit M.

Annual Exceedance Probabilities
The expected annual frequency of the 2009 gage elevation was 2.36%. With any of the three projects in place the expected annual frequency of the 2009 water surface elevation is approximately .2%.

Long Term Risk
Under existing conditions, there is a 21.22% chance the 2009 flood water surface elevation would be exceeded in a given 10 year period. With any of the three plans in place there would be approximately a 2% chance of the 2009 water surface elevation being exceeded at least once in a ten year period.

Under existing conditions, there is a 69.65% chance the 2009 water surface elevation would be exceeded in a 50 period. With any of the three plans in place there would be between a 9% and 10% chance of the 2009 water surface elevation being exceeded in a 50 year period.

Conditional Non-Exceedance Probabilities
Under existing conditions, given that a 1% event occurs, there is a 14.65% chance that the water surface elevation will not exceed the 2009 stage.

With any of the three plans in place, given that a 1% event occurs, there is approximately a 99% chance that the water surface elevation will not exceed the 2009 stage.

Under existing conditions, given that a .2% event occurs, there is a .22% chance that the water surface elevation will not exceed the 2009 stage.

With any of the three plans in place, given that a .2% event occurs, there is between a 55% and 57% chance that the water surface elevation will not exceed the 2009 stage.

Table C-31 Project Performance at Fargo Gage

Without Project - ND w/Staging - ND35k - MN35k

Plan	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
		Median	Expected	10	30	50	10%	4%	2%	1%	0.40%	0.20%
30ft (major flood stage)												
Existing Conditions	892.74	22.56%	22.98%	92.65%	99.85%	100.00%	0.36%	0.00%	0.00%	0.00%	0.00%	0.00%
ND w/Staging	892.74	1.61%	5.66%	44.13%	76.67%	94.56%	79.95%	67.09%	49.39%	24.27%	4.20%	0.66%
ND35k	892.74	1.61%	5.66%	44.13%	76.67%	94.56%	79.95%	67.09%	49.39%	24.27%	4.20%	0.66%
MN35k	892.74	7.97%	11.15%	69.32%	94.79%	99.73%	53.66%	25.72%	11.83%	4.13%	0.53%	0.07%
40.82 (2009 stage)												
Existing Conditions	903.56	2.09%	2.36%	21.22%	44.91%	69.65%	99.96%	87.88%	47.17%	14.65%	1.67%	0.22%
ND w/Staging	903.56	0.16%	0.21%	2.04%	5.02%	9.78%	99.99%	100.00%	99.96%	98.60%	82.97%	55.25%
ND35k	903.56	0.16%	0.21%	2.04%	5.02%	9.78%	99.99%	100.00%	99.96%	98.60%	82.97%	55.25%
MN35k	903.56	0.15%	0.20%	1.94%	4.79%	9.35%	100.00%	100.00%	99.96%	98.75%	84.08%	57.04%

3.10 Risks and Uncertainties

A number of assumptions are made in the economic analysis of flood risk management studies. Resource and time constraints, sophistication of models, and technology limitations often limit the extent of analysis possible for such studies. The economic analysis for this study is likewise based on a number of assumptions, some of which are more significant than others. Significance should be determined by the level of uncertainty in the assumptions and how sensitive the results of the analysis are to that uncertainty.

The primary economic analyses to identify the NED plan were completed in Phase III of the study. In Phase IV, the study team continued to refine the hydrologic and hydraulic models solely to determine the upstream and downstream impacts of the diversion plans. In coordination with the Corps vertical team, no efforts were made to revisit the determination of the NED plan. The Phase III analyses adequately serve the required purpose of "reasonably maximizing" the NED benefits.

The following assumptions are sources of uncertainty for the NED analysis presented in this appendix (in no particular order).

3.10.1 Emergency Measures Sensitivity

The cities of Fargo and Moorhead have had success in fighting high flows on the Red River of the North in every major flood from 1997 to 2011. A number of variables have contributed to the success of the flood fight. These include warning time to prepare emergency measures, accuracy (relative) of crest predictions, adequate resources and volunteer labor, and timing of spring warm-up. Lastly the structural integrity of earthen levees, sandbags, and other flood barriers has been sound enough to avoid significant damages. Emergency measures, however, are not 100% effective, despite the fact that Fargo and Moorhead have always had success in the past. For the purposes of plan formulation and evaluation, it is assumed that the flood fight will always fail in the future. Under this scenario, expected annual damage and project benefits would be higher than if any degree of reliability were credited to the flood fight. As a reality check, a sensitivity analysis was conducted to determine the level of flood fight reliability that would make the NED plan, FCP, and LPP, and ND35k plan not feasible. EEAB for each plan was evaluated with emergency levees in place. There is a general consensus that the cities of Fargo and Moorhead would be unable to flood fight an event larger than the 2009 flood. Therefore, the 2009 flood elevations were used to determine the maximum height of emergency levees for this analysis. Table C-32 presents the results of this analysis. With full credit to emergency measures, all plans are still feasible.

Table C-32 Flood Fight Sensitivity EEAB ($1,000's)

Plan	EEAB no Credit	EEAB Full Credit	EEAB needed for BCR >1
ND w/Staging	$174,817	$157,432	$100,932
ND-E-35k	$173,777	$156,392	$86,259
MN-S-40k*	$186,956	$170,044	$70,301
MN-S-35k	$172,454	$155,132	$72,021

Cost are from Phase III - normally would be higher than MN35k costs

3.10.2 Difference in Frequency Curves

This issue is mentioned in section 3.4. The analysis of EAD and EEAD for metro area reaches on the RRN utilizes a Log-Pearson Type III (LPT3) flow-frequency curve. This approach better defines the uncertainty in the flow-frequency curve. The result is a non-centric distribution of flows, which tends to result in higher EAD than if another form of frequency analysis were used. The analysis of EAD for reaches along the tributaries and the RRN outside the metro utilizes an elevation-frequency curve, which results in a centric distribution of elevations. This approach does not define uncertainty about the elevations as well as the LPT3 curve. A comparison of the two approaches for the same reach showed that the theoretic maximum flood elevation for the .2% event was 1-2 ft higher with a LPT3 approach than with an elevation-frequency approach. The practical implication of this is that EAD and EEAD (and therefore EAB, EEAB, and induced damages) will look understated in elevation-frequency reaches when compared to LPT3 reaches. The potential risk is that EEAB on the tributary reaches in the metro will be understated for North Dakota diversion, and that induced risk upstream and downstream of the metro is understated for all diversions. This has the potential to impact the comparison of alternatives. The vertical team is confident that this issue would not significantly affect the identification of an NED plan and a selected plan.

3.10.3 Flow-Frequency used for with-project Analysis

The analysis of EEAD and project performance for without-project conditions uses LPT3 curves and elevation curves, each with a high degree of uncertainty in flows and elevations. The analysis if with-project conditions EEAD and project performance employs the same degree of uncertainty in flows and elevations.

Each diversion alternative has gated control structures at their upstream end, which allows for greater control of flows through the metro (and less uncertainty in flows and elevations). Control structures would reduce the variability in flow-frequency for the metro area; but that variability would be transferred upstream or downstream (excess flows

would either be stored or pass down the diversion channel). The LPP has additional storage capacity, which would likely augment these effects. This would not impact the without project EEAD, but would tend to overstate EEAD with-project in the metro and understate EEAD in downstream reaches. The project performance for with-project conditions would likewise overstate risk in the metro area and understate it upstream or downstream. This has the potential to impact the comparison of alternatives. The vertical team is confident that this issue would not significantly affect the identification of an NED plan and a selected plan.

3.10.4 Use of Steady Flow Hydraulic Model for Metro Area

This issue is mentioned in section 3.4.3. Two hydraulic models were developed in Phases III and IV, a steady state flow model and an unsteady state flow model. The unsteady flow model utilizes river cross sections for in channel flows as well as storage cells for breakout flows. The steady state flow model uses river cross sections but not storage cells. This model uses the same hydrology as the unsteady state flow model. The steady flow model is used for evaluation of EEAD and EEAB in the metro area along the RRN. Since the steady flow model contains all flows within the river cross sections, while the unsteady flow model allows flows into storage cells, the flow-elevations tend to be higher in the steady flow model at each cross section relative to the unsteady model. Using the steady flow model tends to overstate EEAD in river cross section and understate it in storage cells. Overall, the steady flow model likely overstates EEAD and EEAB. This has the potential to impact the comparison of alternatives. The vertical team is confident that this issue would not significantly affect the identification of an NED plan and a selected plan.

3.10.5 ND35K EEAB to Estimate LPP EEAB

The North Dakota with Staging alternative was developed in Phase IV and selected as the Locally Preferred Plan. Concurrently, all hydraulic modeling was done using an unsteady state model. The economic analysis for the Metro area was not revisited in Phase IV, since implementing the unsteady flow model would have required significant time and resources, and the NED analysis, completed in Phase III, was unlikely to change substantially. As a result, the revised LPP was developed in order to match the water surface elevations of the ND35K plan. This made the level of benefits provided by each plan comparable and warranted using the ND35K benefits as a proxy for the LPP benefits (as mentioned in section 3.7.1). There are uncertainties in this approach that require consideration. The LPP functions differently than the ND35K plan, in that the LPP provides benefits from the diversion channel as well as staging and storage features. This leads to a different operating plan with potentially less stage uncertainty in the protected area and more stage uncertainty downstream and upstream. It is possible that additional economic modeling would result in different EEAB for the LPP. It is unlikely that this would impact identification of the LPP.

3.10.6 Use of Project Performance Metrics from Analysis Year 2019

All project performance metrics are given from the "wet" period hydrology (the analysis year 2019). As a result long term flood risk tends to be overstated. Annual exceedance and conditional-non exceedance probabilities are accurate for the base year, but tend to

over state risk for later years. Consideration was given to averaging the performance metrics of all 3 analysis years, however it was concluded that the averaged metrics would be no easier to interpret than the base year metrics. The metrics displayed in this report are presented with the caveat that they are valid only for the base year, and are overstated for later years.

3.10.7 Use of Single Analysis Year for Upstream and Downstream

The upstream and downstream flood risk analysis utilized "wet" period hydrology from the base year. A truer analysis would incorporate future year hydrology to account for the non-stationarity of flow-frequency in the RRN. The use of base year hydrology tends to overstate EEAD and induced damage, since the flow-frequency curve tends to shift down over time. It is unlikely that this would have an appreciable effect on the damage estimates.

4.0 Regional Economic Development Account

NOTE: This analysis has not been updated for the Phase IV alternatives. The FY 10 discount rate of 4-3/8% is used for discounting, compounding, and annualization. Dollar figures are presented in FY 10 price levels.

4.1 Introduction

4.1.1 Project Overview

This report discusses effects on the regional economy of the proposed Fargo-Moorhead Flood Diversion Project. It provides the Regional Economic Development (RED) account as outlined in the United States Army Corps of Engineers (USACE) *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (a.k.a. Principles and Guidelines or P&G).

The positive effects of the project on the region's income are equal to the sum of the National Economic Development (NED) benefits that accrue to the region, plus transfer of income from outside the region. Income transfers to the region as a result of the project include income from implementation outlays, transfers of basic economic activity, and indirect and induced effects. In each case, income transfers refer to new income within the region rather than to increases in total expenditures. Similarly local costs and cost shares within the region are captured in determining the net regional economic impact. Indirect and induced impacts are the effects of the injection of money into the local economy. These effects are not the expenditures themselves, but the additional economic activity stimulated by the expenditures. For example, a direct expenditure may include the salaries paid to construction crews working on the project. An example of indirect expenditures would be the hotel expenses of construction crews staying in the region during construction. An example of an induced expenditure would be the changes in spending patterns by local businesses or individuals whose income is increased as a result of direct expenditures. Indirect and induced impacts are estimated using multipliers obtained from the regional Input-Output model discussed in section 4.2.3.

Although a number of flood risk management alternatives are being considered in the NED analysis, the RED analysis undertaken for this report only considers the most economically attractive With-Project alternatives within North Dakota (North Dakota East Diversion 35k cfs) and within Minnesota (Minnesota Short 35k cfs and Minnesota Short 20k cfs). These three alternatives are compared to the project baseline (Without-Project conditions) of continued flooding and flood fighting throughout the Fargo-Moorhead study region.

4.1.2 GFMEDC Business Survey

Following the successful flood fight in Fargo-Moorhead in 2009, the Greater Fargo Moorhead Economic Development Corporation (GFMEDC) completed a flood protection questionnaire with major local businesses to gage local reaction. Businesses were asked how their companies would be affected had the region been devastated with severe flooding. The results of the survey revealed anxiety among local business owners, and demonstrated that companies would leave the region in the event of a failed flood fight. In some cases, the loss of business to the Fargo-Moorhead MSA would be significant to the U.S. economy in that businesses are increasingly moving their operations overseas.
The national impact of a hypothetical manufacturing industry leaving the Fargo-Moorhead MSA is explored in Section 4.3.4.

4.2 Approach and Assumptions

4.2.1 Approach

The approach for this study was to assess the regional economic impacts associated with three aspects of the With-Project alternatives being considered:

- Construction costs (Section 4.3.1)
- Avoided flood damages (including avoided losses in business activity, avoided direct losses in regional product, and losses in indirect/induced regional product) (Section 4.3.2)
- Avoided loss in business confidence (without a permanent solution, the Fargo-Moorhead study region experiences reduced economic growth) (Section 4.3.3)

Furthermore, the study investigated the regional and national effects of a hypothetical local business relocating internationally if the Fargo/Moorhead Flood Diversion project did not proceed. For more information see Section 4.3.4.
The indirect/induced output and employment and tax impacts associated with the Fargo-Moorhead Flood Diversion project were estimated by DataSource as discussed below.
All costs and benefits are presented as annual equivalent values. Annual equivalent values are calculated over 50 years unless stated otherwise.

4.2.2 Period of Analysis

The regional costs and benefits associated with the Fargo/Moorhead Flood Diversion project alternatives occur at different times. The regional economic analysis has been undertaken relative to the base year which is the year construction is finalized. For this reason, construction costs are appreciated (Minnesota alternatives – 6 years, North Dakota - 8 years) by adding interest during construction to the base cost estimate. Likewise, costs associated with loss of business confidence, which is assumed for the Without-Project alternative, will occur with construction costs prior to the base year. Therefore these costs are also appreciated to the base year.

4.2.3 Regional Economic Impact Analysis

Various approaches have historically been used to assess the effect a change in production or expenditure will have on a region's economy. The most common approach has arguably been the use of input-output (I-O) models. The use of I-O models in economic impact analyses has increased dramatically with the advent of ready-made regional models. Ready-made models reduce both the time and cost of using I-O models for economic input assessment. In the United States, the three most widely used ready-made models are the IMPLAN[4] model initially produced by the U.S. Department of Agriculture Forest Service, the REMI model produced by Regional Economic Models Inc., and the RIMS II model developed by the U.S. Department of Commerce Bureau of Economic Analysis (BEA).

An I-O model uses a matrix representation of a region's economy to predict the effect of changes in one industry on others and by consumers, government, and foreign suppliers on the economy. It is a static, linear model of all purchases and sales between sectors of an economy. While I-O models are useful in providing ball-park estimates of very short-run responses to changes in production/expenditures, their key limitations are linearity, absence of behavioral considerations, absence of markets and prices, and lack of formal constraints (Rose 2006).

The limitations of I-O models are also the key advantages of Computable General Equilibrium (CGE) modeling. A CGE model is a non-linear model of individual behavioral response to price signals, subject to labor, capital, and natural resources constraints (Shoven and Whalley 1992 cited in Rose 2006). These advantages come with increased modeling complexity, much greater data needs, and time resources for operation. Therefore, while the use of CGE modeling is increasing, resource and data constraints make its use impractical at the regional level.

For this project, RIMS II regional multipliers are used to assess the regional economic impacts associated with the Fargo-Moorhead Flood Diversion Project. BEA's RIMS II multipliers provide a cost-effective way to estimate the economic impacts of changes in a regional economy, but like all economic impact models, RIMS II estimates of impacts are approximate order-of-magnitude estimates. However, empirical research has shown that RIMS II yields multipliers that are not substantially different in magnitude from those generated by regional I-O models based on relatively expensive surveys. The difference between RIMS II and survey-based multipliers is often only between 5 and 10 percent (BEA 2009).

In 2002, the GFMEDC obtained RIMS II multipliers for the local region and then adjusted the multipliers to reflect local conditions. The adjusted multipliers were then independently reviewed by Dr. Larry Leistritz at North Dakota State University, who concluded that if anything, their use would potentially underestimate regional economic impacts.

4.2.4 Assumptions

4.2.4.1 Economic Assumptions

Three types of regional economic multipliers were used to assess RED impacts: an output multiplier, an employment multiplier, and an earnings multiplier.

An output multiplier was used to estimate the indirect and induced output or revenues created and supported in businesses in the area. An employment multiplier was used to estimate the number of indirect and induced jobs created and supported in the State. An earnings multiplier

[4] The current IMPLAN I-O database and model is maintained and sold by MIG Inc. (Minnesota IMPLAN Group)

was used to estimate the amount of salaries to be paid to workers in these new indirect and induced jobs.
The multipliers show the estimated indirect and induced revenues of other companies in the area for every dollar of direct revenues generated by companies working on the project. An employment multiplier shows the number of indirect and induced jobs created for every direct job at the facility and the amount of salaries paid to these workers for every dollar paid to a direct worker on the project. The indirect and induced multipliers shown in Table C-33 were used in this analysis.

Table C-33 Indirect and Induced Multipliers used in the Analysis

	Construction	Operations	Avoided Flood Damages	Loss of business confidence
Output multiplier	0.4009	0.3790	0.3291	N/A
Employment multiplier	0.3363	0.1975	10.44*	10.44*
Earnings multiplier	0.3157	0.3089	0.3646	0.3646

Source: DataSource

*The number of jobs created in the regional economy from an additional $1 million of output.

4.2.4.2 Construction and Operations and Maintenance Costs

This section outlines the assumptions used to determine the RED impact associated with construction costs and annual operations and maintenance costs. The three With-Project options assessed are the North Dakota East 35k cfs, Minnesota Short 35k cfs and Minnesota Short 20k cfs channel diversion alternatives (Table C-34).

Table C-34 RED Project Costs for ND East 35k cfs, MN Short 35k cfs and MN Short 20k cfs ($1,000's)

	North Dakota East 35k cfs	Minnesota 35k cfs	Minnesota 20k cfs
Length of project, in years	8	6	6
Total construction costs	$1,294,707	$1,142,545	$870,513
Scheduled construction costs per year	$161,838	$190,424	$145,085
Total labor costs	$517,883	$457,018	$348,205
Construction labor costs per year	$64,735	$76,170	$58,034
Estimated construction salaries per year (about $20 an hour)	$41.6	$41.6	$41.6
Annual Operation & Maintenance Costs	$3,011	$2,861	$2,187

Source: USACE and Impact DataSource estimates

It is assumed that total construction costs would be injected into the local economy producing indirect and induced economic output.

4.2.4.3 Avoided Flood Damages

This section outlines the assumptions used to determine the RED impacts associated with avoided flood damages. Data on the expected annual benefits (avoided flood damages) for the North Dakota East 35k cfs Minnesota Short 35k cfs and Minnesota Short 20k cfs alternatives are shown in Table C-35, Table C-36 RED MN35 and Table C-37 respectively.

Table C-35 RED ND35 Expected Annual Benefit ($1,000's) – North Dakota East Diversion 35k cfs

Damage Classification	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Other	Total
Agricultural	$203	$1	$3	$17	$25	---	$249
Apartment	$2,243	$1,877	$230	$495	$0	---	$4,845
College	$788	$3	$0	$19	$0	---	$811
Commercial	$16,300	$6,733	$1,512	$384	$99	---	$25,028
Public	$1,324	$1,376	$19	$81	$142	---	$2,942
Residential	$7,994	$10,764	$3,568	$3,102	$3,830	---	$29,258
Emergency	---	---	---	---	---	$4,223	$4,223
						Total	$67,355

Source: USACE February 2010

Table C-36 RED MN35 Expected Annual Benefit ($1,000's) – Minnesota Short Diversion 35k cfs

Damage Classification	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Other	Total
Agricultural	$204	$1	$3	$10	$8	---	$225
Apartment	$2,247	$1,887	$202	$497	$0	---	$4,832
College	$792	$3	$0	$20	$0	---	$814
Commercial	$16,326	$6,769	$1,528	$380	$66	---	$25,069
Public	$1,326	$1,379	$19	$80	$86	---	$2,890
Residential	$7,978	$10,655	$2,483	$3,068	$1,549	---	$25,733
Emergency	---	---	---	---	---	$4,232	$4,232
						Total	$63,795

Source: USACE February 2010

Table C-37 RED MN20 Expected Annual Benefit ($1,000's) – Minnesota Short Diversion 20k cfs

Damage Classification	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$170	$1	$2	$9	$7	---	$189
Apartment	$1,897	$1,603	$169	$426	$0	---	$4,095
College	$665	$2	$0	$17	$0	---	$684
Commercial	$13,748	$5,737	$1,278	$323	$57	---	$21,144
Public	$1,134	$1,197	$16	$67	$77	---	$2,490
Residential	$6,779	$9,150	$2,080	$2,614	$1,375	---	$21,997
Emergency	---	---	---	---	---	$3,792	$3,792
						Total	$54,390

Source: USACE February 2010

The data in Table C-35, Table C-36, and Table C-37 are expected annual benefits that were calculated by subtracting residual damages (with flood diversion) from the estimate of annual damages under Without-Project conditions. For more information on Without-Project damages and residual damages, refer to Exhibit A.

To assess the full RED impacts associated with these expected annual benefits (NED benefits), the contribution of structural, contents, and other damages to total damages had to be considered. The split between structural, contents, and other damages is also summarized in Exhibit A. Depreciated structural values were used to calculate NED benefits. However, it is appropriate to estimate regional impacts using total building replacement values which reflect the market cost to replace damaged property. For example, it is not practical to replace 75% of a flood damaged structure, but rather replace it completely which will mean the structure will be in better condition than when it was damaged. Therefore depreciated structural values were increased by the assumed depreciation values shown in Table C-38.

Table C-38 Assumed Structural Depreciation Values

	Fargo North	Fargo South	West Fargo	Moorhead	Cass County
Agricultural	12%	4%	9%	N/A	8%
Apartment	9%	4%	12%	11%	8%
College	13%	4%	N/A	13%	9%
Commercial	10%	4%	12%	10%	9%
Public	11%	3%	6%	10%	7%
Residential	16%	15%	16%	16%	16%

Source: URS (2009), Marshall and Swift (2009a, 2009b)

Assumptions were also made for the proportion of affected properties with flood insurance and/or access to FEMA Public Assistance in the event of a declared disaster (Table C-39).

Table C-39 Assumed Flood Insurance and/or Access to Public Assistance

Damage Classification	Proportion	Notes
Agricultural	5%	Estimated by the authors
Apartment	20%	Based on FEMA flood insurance policies for the study region
College	50%	Assumed 50% publicly owned with access to Public Assistance
Commercial	10%	Estimated by consultants
Public	100%	Access to Public Assistance
Residential	20%	Based on FEMA flood insurance policies for the study region (Ashford 2009)

Where properties have access to flood insurance and/or Public Assistance, 20 percent of costs were assumed to be provided locally, with the remainder funded from outside the region. Using these assumptions and the damages shown in Exhibit A, the weighted average of 85 percent of damages are estimated to be paid for from within the Fargo-Moorhead region.
While flood damages result in a direct loss of gross domestic product for the region, some industries, for example the construction industry, would benefit. In the aftermath of a flood event, contractors would be required to rebuild homes, as would companies replacing damaged building contents and providers of temporary accommodation (although some businesses would be affected by flood damages themselves and be unable to meet demand). The following assumptions were made to reflect the short-term effect a flood would have in stimulating the local economy, and are based on considerations of the ability of the local economy to meet demand – both under normal circumstances and after a flood.

Structural Damages

- One-third of building contractors are from within the local region
- Indirect/induced effects are captured for all structural damages (both local and other contractors)

Contents Damages

- 75 percent of damaged contents are replaced locally
- Indirect/induced effects are captured for 75 percent of contents damages

Other Damages

- 100 percent of other damages are incurred locally

4.2.4.4 Avoided Loss of Business Income

An assessment was made of the avoided loss of business income for non-residential structures associated with reduced flooding. HEC-FDA Structure Detail Out files for Without-Project conditions were combined with additional data collected during a structure inventory performed

in the Fargo-Moorhead area in 2009.[5] The structure inventory data provided additional details about each nonresidential structure including the type of business as assigned by a Marshall and Swift occupancy code, and total square footage. The Marshall and Swift Occupancy Codes are provided as Exhibit B.

The HEC-FDA output files provided data on the depth of flooding in each structure for eight flood frequencies (2-, 5-, 10-, 20-, 50-, 100-, 200-, and 500-year flood events). Existing levees were accounted for. The depth of flooding for each flood event was used to determine the days of business interruption using a depth-damage function (DDF) provided by FEMA. The DDF relates depth of flooding to structural damage and subsequently, business interruption or days of "loss of function." The DDF used is shown in Table C-40.

Table C-40 Depth-Damage Function: Depth of Flooding versus Business Interruption

Depth of Flooding Relative to Structure FFE* (feet)	Business Interruption (days)
-2	0
-1	0
0	0
1	45
2	90
3	135
4	180
5	225
6	270
7	315
8	360
9	405
10+	450

Source: FEMA BCA Tool (v4.5.5)[6]
**FFE is the 1st finished floor elevation. All flood depths are relative to the elevation of the FFE.*

Based on assigned Marshall and Swift occupancy codes, each non-residential structure was assigned one of five classifications for average annual business income, which in turn were assigned a dollar per square foot amount. The rating for each Marshall and Swift occupancy code is provided in Exhibit B. Financial metrics, including income, costs, profit, and rent, are often expressed per square foot, to provide a comparable metric that is not affected by a building's footprint. Furthermore, companies such as BizMiner produce a "retail sales per square foot" report for almost 150,000 commercial businesses. In assessing loss of business income for the Fargo-Moorhead region, data on sales per square foot was obtained for select

[5] Complete details of the structure inventory are described in the URS report, "Final Project Report: Fargo-Moorhead Nonresidential and Residential Structure Inventory and Nonresidential Surveys", previously provided to the St. Paul District.
[6] The FEMA BCA Tool Kit, Version 4.5.5 for the Hazard Mitigation Assistance program can be obtained from http://www.bchelpline.com/

businesses in North Dakota from the 2002 U.S Economic Census.[7] Inflated to 2008 dollars, sales ranged from $550 to $250 per square foot.
The assumed annual business income per square foot that was developed based on census data and other publicly available sales data is shown in Table C-41 for each income category.

Table C-41 Assumed Annual Business Income by Income Category

Category	Definition	Annual Income ($/sf)
N	Negligible	$0.00
VL	Very Low	$50.00
L	Low	$150.00
M	Moderate	$400.00
H	High	$650.00

Source: U.S. Census 2002

The average daily income was multiplied by the days of business interruption for each flood event to calculate the loss of business income. The resulting frequency damage curve was then integrated to calculate the annual loss of business income for all flood frequencies (Table C-42)

Table C-42 Estimated Annual Loss of Business Income by Building Classification ($1,000's)

	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Total
Agricultural	$0	$0	$0	$0	$0	**$0**
Apartment	$0	$0	$0	$0	$0	**$0**
College	$0	$0	$0	$0	$0	**$0**
Commercial	$52,893	$7,439	$3,026	$516	$334	**$64,207**
Public	$1,576	$0	$9	$0	$16	**$1,602**
Residential	$0	$0	$0	$0	$0	**$0**
Total	$54,468	$7,439	$3,036	$516	$350	**$65,810**

The total estimated annual loss of business income is equal to $65.8 million. In Section 4.3, the indirect output, employment, and state/local tax implications for this loss of income are calculated. The loss of business income after mitigation is assumed to be negligible with all three With-Project alternatives. Therefore, the estimated annual loss of business income shown in Table C-42 is also the expected annual benefit for all three With-Project alternatives.

4.2.4.5 Loss of Business Confidence

This section outlines the assumptions used to determine the RED impact for a loss of business confidence resulting from frequent flooding in the Fargo-Moorhead MSA. The completion of a

[7] U.S. Census, Sector 44: Retail Trade: Subject Series - Misc Subjects: Floor Space by Selected Kind of Business for the United States and States: 2002.

flood diversion project in the Fargo-Moorhead MSA would provide a level of certainty for businesses and encourage general economic growth in the region. By looking at the difference between projected growth with and without the flood diversion project, the loss of business confidence in the region can be determined.
The loss of business confidence is calculated by analyzing the difference in the fiscal impacts associated with the gross domestic product for the Fargo MSA under two scenarios:

- Without flood diversion project
- With flood diversion project

A conservative and a moderate growth rate in regional output for the regional economy is assumed under each of these scenarios. The growth rates do not reflect actual flooding, but rather the perceived risk of flooding under the Without- and With-Project scenarios.

Although the NED analysis assumes that the same level of development would occur with or without a project, in reality some additional demand for new commercial structures would occur. The RED analysis is sensitive to changes in business activity; however it is difficult to predict how changes in business activity will affect demand for new buildings. While additional business activity would occur if a flood risk management project were completed, that activity may or may not occur in the floodplain, and may or may not significantly impact development. Therefore, it is a critical assumption for the RED analysis that the level of economic activity would be affected by a project; however it is not an important factor in the analysis of flood damage reduction for the NED account.

Without-Project Alternative

If no flood diversion project is completed in the region, businesses may leave the Fargo-Moorhead area, be reluctant to expand, or refuse to locate in the area due to concerns over potential flood damages. Additionally, individuals will be reluctant to remain or move to the Fargo-Moorhead area, further dampening economic growth in the region.
The analysis projects two levels of growth for the Without-Project alternative (Table C-43).

- *Conservative Case: 1.29 percent MSA GDP growth*

For the conservative case, the growth rate for the Without-Project alternative is assumed is equal to the first quartile annual average growth rate from 2001–2008 for all MSAs in the United States.

- *Moderate Case: 2.18 percent MSA GDP growth*

For the moderate case, the growth rate for the Without-Project alternative is assumed is equal to the median annual average growth rate from 2001–2008 for all MSAs in the United States.

With-Project Alternative

If the flood diversion project is completed in the region, businesses would be more confident and more likely to remain and expand in the area. The recent economic growth in the region may be spurred on further as other firms choose to locate in the Fargo-Moorhead area.

- *Conservative Case: 3.09 percent MSA GDP growth*

For the conservative case, the growth rate for the With-Project alternative is assumed is equal to the third quartile annual average growth rate from 2001–2008 for all MSAs in the United States.

- *Moderate Case: 4.11 percent MSA GDP growth*

For the moderate case, when the growth rate for the With-Project alternative is assumed is equal to the annual average growth rate from 2001–2008 for the Fargo MSA. This growth rate is in the 89th percentile for all MSAs during this period. Recently, the Fargo MSA has seen even greater growth. The annual average growth rate for the Fargo MSA from 2006–2008 is 5.1 percent. In the absence of other factors, the Fargo MSA would not be expected to maintain such a high growth rate going forward.

Table C-43 Fargo MSA Assumed Real Growth Rates

	Without-Project		**With-Project**	
	Conservative	Moderate	Conservative	Moderate
	Case 1	*Case 2*	*Case 3*	*Case 4*
Annual Growth Rate	1.29%	2.18%	3.09%	4.11%

4.3 RED Impacts

4.3.1 Construction and Operations and Maintenance

4.3.1.1 Economic Output/Increase in Gross Regional Product during Construction

The project would provide the following direct and indirect and induced economic output/increases in gross regional product during construction (Table C-44).

Table C-44 Economic Output/Increase in Gross Regional Product during Construction ($1,000's)

	North Dakota East 35k cfs			Minnesota 35k cfs			Minnesota 20k cfs		
	Direct Const. Output	Indirect and Induced Output	Total Economic Output	Direct Const. Output	Indirect and Induced Output	Total Economic Output	Direct Const. Output	Indirect and Induced Output	Total Economic Output
Year 1	$161,838	$64,881	$226,719	$190,424	$76,341	$266,765	$145,086	$58,165	$203,250
Year 2	$161,838	$64,881	$226,719	$190,424	$76,341	$266,765	$145,086	$58,165	$203,250
Year 3	$161,838	$64,881	$226,719	$190,424	$76,341	$266,765	$145,086	$58,165	$203,250
Year 4	$161,838	$64,881	$226,719	$190,424	$76,341	$266,765	$145,086	$58,165	$203,250
Year 5	$161,838	$64,881	$226,719	$190,424	$76,341	$266,765	$145,086	$58,165	$203,250
Year 6	$161,838	$64,881	$226,719	$190,424	$76,341	$266,765	$145,086	$58,165	$203,250
Year 7	$161,838	$64,881	$226,719						
Year 8	$161,838	$64,881	$226,719						
Total	**$1,294,707**	**$519,048**	**$1,813,755**	**$1,142,545**	**$458,046**	**$1,600,591**	**$870,513**	**$348,989**	**$1,219,502**
An. Eqv.	**$64,188**	**$25,733**	**$89,921**	**$56,644**	**$22,709**	**$79,353**	**$43,158**	**$17,302**	**$60,459**

Source: DataSource

** Annual equivalent values were calculated using a discount rate of 0.04375 over 50 years.*

The direct cost impact to the Fargo-Moorhead region is the estimated 20 percent of construction costs that would be met locally. This is Fargo-Moorhead's anticipated contribution to the non-Federal share of project costs (Federal/Non-Federal cost share rate of 65/35). However, the regional benefit associated with construction is the indirect and induced economic output that would be produced for an assumed 100 percent of the construction cost. The net RED benefits associated with construction are shown in Table C-45.

Table C-45 Regional Benefits and Costs during Construction ($1,000's)

	North Dakota East 35k cfs			Minnesota 35k cfs			Minnesota 20k cfs		
	Direct Regional Cost	Indirect and Induced Benefit	Total Economic Benefit	Direct Regional Cost	Indirect and Induced Benefit	Total Economic Benefit	Direct Regional Cost	Indirect and Induced Benefit	Total Economic Benefit
Year 1	$32,368	$64,881	$32,513	$38,085	$76,341	$38,256	$29,017	$58,165	$29,148
Year 2	$32,368	$64,881	$32,513	$38,085	$76,341	$38,256	$29,017	$58,165	$29,148
Year 3	$32,368	$64,881	$32,513	$38,085	$76,341	$38,256	$29,017	$58,165	$29,148
Year 4	$32,368	$64,881	$32,513	$38,085	$76,341	$38,256	$29,017	$58,165	$29,148
Year 5	$32,368	$64,881	$32,513	$38,085	$76,341	$38,256	$29,017	$58,165	$29,148
Year 6	$32,368	$64,881	$32,513	$38,085	$76,341	$38,256	$29,017	$58,165	$29,148
Year 7	$32,368	$64,881	$32,513						
Year 8	$32,368	$64,881	$32,513						
Total	$258,941	$519,048	$260,107	$228,509	$458,046	$229,537	$174,103	$348,989	$174,886
AnEqv*	$12,838	$25,733	$12,895	$11,329	$22,709	$11,380	$8,632	$17,302	$8,670

Source: DataSource

**Annual equivalent values were calculated using a discount rate of 0.04375 over 50 years.*

Given the assumed labor costs and that the annual average salary for workers is $41,600, the project would result in 1,556, 1,831 and 1,395 jobs annually for the North Dakota East 35k cfs Minnesota Short 35k cfs and Minnesota Short 20k cfs alternatives, respectively. Indirect and induced employment would add an additional 523, 613 and 469 jobs for the North Dakota East 35k cfs Minnesota Short 35k cfs and Minnesota Short 20k cfs alternatives, respectively. During construction, the project would generate the tax revenues shown in Table C-46 for the States and local taxing districts. The assumptions used to develop these estimates are provided in Exhibit C.

Table C-46 Annual Equivalent State and Local Tax Revenues during Construction ($1000)

	North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
States of North Dakota and Minnesota	$3,420	$3,018	$2,300
Local taxing districts	$695	$640	$488
Total	$4,115	$3,659	$2,788

Source: DataSource

**Annual equivalent values were calculated using a discount rate of 0.04375 over 50 years.*

4.3.1.2 Economic Output/Increase in Gross Regional Product from Operations and Maintenance

The project would provide the following direct, indirect and induced economic output/increase in gross regional product associated with operations and maintenance:

Table C-47 Annual Economic Output for Operations and Maintenance ($1,000's)

	Direct Operations Output	Indirect and Induced Output	Total Output
North Dakota East 35k cfs	$3,011	$1,141	$4,152
Minnesota Short 35k cfs	$2,861	$1,084	$3,945
Minnesota Short 20k cfs	$2,187	$829	$3,016

Source: DataSource

The direct cost impact to the Fargo-Moorhead region is the 100 percent of operations and maintenance costs that would be met locally. However, the regional benefit associated with operations and maintenance is the indirect and induced economic output that would be produced. The net RED benefit/cost associated with operations and maintenance is shown in Table C-48.

Table C-48 Regional Benefits and Costs during Operations and Maintenance ($1,000's)

	Direct Operations Output **(Cost)**	Indirect and Induced Output **(Benefit)**	Total Output **Net Benefit**
North Dakota East 35k cfs	$3,011	$1,141	($1,870)
Minnesota Short 35k cfs	$2,861	$1,084	($1,777)
Minnesota Short 20k cfs	$2,187	$829	($1,358)

Source: DataSource

Assuming that 30 percent of these costs are for salaries and the annual average salary for workers is $41,600, the project would result in 22, 21 and 16 direct jobs for the North Dakota East 35k, Minnesota Short 35k cfs and Minnesota Short 20k cfs alternatives, respectively. Indirect and induced employment will add an additional 4.4, 4.1, and 3.2 jobs for the North Dakota East 35k, Minnesota Short 35k cfs and Minnesota Short 20k cfs alternatives, respectively.
Operations and maintenance would generate the following total revenues for the States and local taxing districts (Table C-49). The assumptions used to develop these estimates for tax revenues are provided in Exhibit D.

Table C-49 Annual State and Local Tax Revenues due to Operations and Maintenance ($1,000's)

	North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
States of North Dakota and Minnesota	$74	$71	$54
Local taxing districts	$16	$15	$11
Total	**$90**	**$86**	**$65**

Source: DataSource

4.3.2 Avoided Flood Damages

The avoided flood damages presented in this section are the regional impacts associated with NED impacts and loss of business income. The assumptions behind these damages are outlined in Sections 4.2.4.3 and 4.2.4.4, respectively.

4.3.2.1 Regional Impacts Associated with NED Impacts

As described in Section 4.2.4.3 and shown in Exhibit A, the total estimated annual NED impacts are $77.0 million for Without Project conditions, and $9.7 million, $13.3 and $22.7 million for the North Dakota East 35k cfs, Minnesota Short 35k cfs and Minnesota Short 20k cfs alternatives, respectively.
These total NED damages were adjusted to increase depreciated structural damages to full replacement values and to reflect local expenditures only. Local expenditures were estimated at 85% of total annual flood damages. The resulting damages are shown in Table C-50.

Table C-50 Annual Flood Damages ($1,000's)

		With-Project		
	Without-Project Conditions	North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
Structural Damages*	$28,662	$3,723	$5,389	$8,874
Content Damages	$29,827	$3,868	$5,024	$8,772
Other Damages	$3,188	$417	$629	$1,020
Total	**$61,676**	**$8,007**	**$11,042**	**$18,666**

** Due to depreciation, structural damages were increased to reflect the full cost for building replacement.*

The annual flood damages would spur construction and indirect effects associated with repairing and replacing damaged structures and contents (Table C-51). The effect of reconstruction would be an increase in economic output. The construction industry would directly benefit from the need to increase damaged building infrastructure. Only 33 percent of construction is assumed to be undertaken by local firms.

Table C-51 Increase in Output in the Fargo-Moorhead Region Due to Reconstruction ($1,000's)

		With-Project		
	Without-Project Conditions	North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
Direct Output from Repair of Flood Damage				
Structural	$11,240	$1,460	$2,113	$3,480
(33% of structural flood damages)				
Indirect and Induced Output from Repair of Flood Damage				
Structural	$11,097	$1,441	$2,087	$3,436
(100% of indirect output calculated from annual structural flood damages)				
Contents	$8,661	$1,123	$1,459	$2,547
(75% of indirect output calculated from annual contents flood damages)				
Other Damage	$1,234	$161	$244	$395
(100% of indirect output calculated from annual other flood damages)				
Total Indirect and Induced Output	$20,993	$2,726	$3,789	$6,378
Total increase in Output in the region	$32,233	$4,186	$5,902	$9,858

Source: DataSource

The output increase can be translated into an increase in employment and earnings as shown in Table C-52.

Table C-52 Increase in Employment and Earnings in the Fargo-Moorhead Region Due to Reconstruction ($1,000's)

		With-Project		
	Without-Project Conditions	North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
Increase in output in region	$32,233	$4,186	$5,902	$9,858
Increase in employment in region	337	44	62	103
Increase in earnings in region	$11,752	$1,526	$2,152	$3,594

Source: DataSource

The implication of this loss of business income on State and local taxes was assessed. The results, which incorporate sales tax, personal income tax, corporate income tax, and other miscellaneous tax revenue, are shown in Table C-53. The assumptions used to develop these estimates for tax revenues are provided in Exhibit E.

Table C-53 Total Increase in State and Local Tax Revenue in the Fargo-Moorhead Region due to Reconstruction ($1,000's)

		With-Project		
	Without-Project Conditions	North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
Increase in States Tax Revenue	$903	$94	$132	$221
Increase in Local Tax Revenue	$219	$28	$40	$67
Total Increase in States and Local Tax Revenue	**$1,122**	**$122**	**$172**	**$288**

Source: DataSource

4.3.2.2 Regional Impacts Associated with Loss of Business Income

As described in Section 4.2.4.4, the annual loss of business income due to flooding under Without-Project conditions is estimated to be $69.6 million (Table C-54). The USACE estimates that both diversion alternatives would have negligible residual risk of loss of business income. This loss of business income is a direct reduction in output for the region. Because business disruptions caused by a flood ripple through the economy, an output multiplier was applied to determine the total loss in output.

Table C-54 Reduction in Output in the Fargo-Moorhead Region due to Loss of Business Income ($1,000's)

		With-Project		
	Without-Project Conditions	North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
Direct Loss of Business Income	$65,810	$0	$0	$0
Indirect Loss of Business Income	$21,658	$0	$0	$0
Total reduction in output in the region	$87,468	$0	$0	$0

Source: DataSource

The total reduction in output in the Fargo-Moorhead region is estimated to be $87.5 million annually. This total reduction in output can be translated into an annual reduction in 913 jobs. The implication of this loss of business income on State and local taxes was assessed. The results, which incorporate sales tax, personal income tax, corporate income tax, and other miscellaneous tax revenue, are shown in Table C-55. The assumptions used to develop these estimates for tax revenues are provided in Exhibit E.

Table C-55 Total Reduction in Tax Revenue in the Fargo-Moorhead Region due to Loss of Business Income ($1,000's)

		With- Project		
	Without-Project Conditions	North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
Reduction in States Tax Revenue	$2,449	$0	$0	$0
Reduction in Local Tax Revenue	$595	$0	$0	$0
Total Reduction in States and Local Tax Revenue	$3,044	$0	$0	$0

Source: DataSource

4.3.2.3 Summary of Avoided Losses

The benefit of having a diversion in place is the change in net business losses (losses avoided) (Table C-56). Net business losses are the difference between the following benefits and costs of flooding:

- Costs
  - Local expenditures to repair damages caused by the flood
  - Loss of business income
  - Reduction in State and local tax revenue due to the loss of business income
- Benefits
  - Increase in output due to increased damage caused by the flood
  - Additional State and local tax revenue due to additional output resulting from rebuilding efforts

Table C-56 Avoided Losses in the Fargo-Moorhead Region due to the Flood Diversion Project ($1,000's)

		With-Project		
	Without-Project Conditions	North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
Costs, State & Local Direct/Indirect impacts				
Damage Expenditure	$61,676	$8,007	$11,042	$18,666
Loss of Business Income	$87,468	$0	$0	$0
Benefits, State & Local Direct/Indirect/induced impacts				
Increase in Output	$32,233	$4,186	$5,902	$9,858
Net Loss	$116,912	$3,821	$5,139	$8,808

The net change in annual employment is calculated as the reduction in employment due to loss of business income less the increase in employment associated with construction (Table C-57).

Table C-57 Avoided Loss in Employment in the Fargo-Moorhead Region due to the Flood Diversion Project

		With-Project		
	Without-Project Conditions	North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
Reduction in employment (loss of business income)	913	0	0	0
Increase in employment (reconstruction)	337	44	62	103
Net Loss in Employment	**576**	**-44**	**-62**	**-103**

Source: DataSource

The net impact of loss of business income and flood damages on State and local taxes is shown in Table C-58. The results incorporate sales tax, personal income tax, corporate income tax, and other miscellaneous tax revenue impacts.

Table C-58 Net Change in Tax Revenue in the Fargo-Moorhead region due to the Flood Diversion Project ($1,000's)

		With-Project		
	Without-Project Conditions	North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
Reduction in States Tax Revenue	$1,547	-$94	-$132	-$221
Reduction in Local Tax Revenue	$376	-$28	-$40	-$67
Total Reduction in States and Local Tax Revenues	$1,923	-$122	-$172	-$288

Source: DataSource

4.3.3 Loss of Business Confidence

Figure C-6 below illustrates the Fargo MSA GDP growth over the next 20 years under the scenarios outlined in Section 4.2.4.5 above.

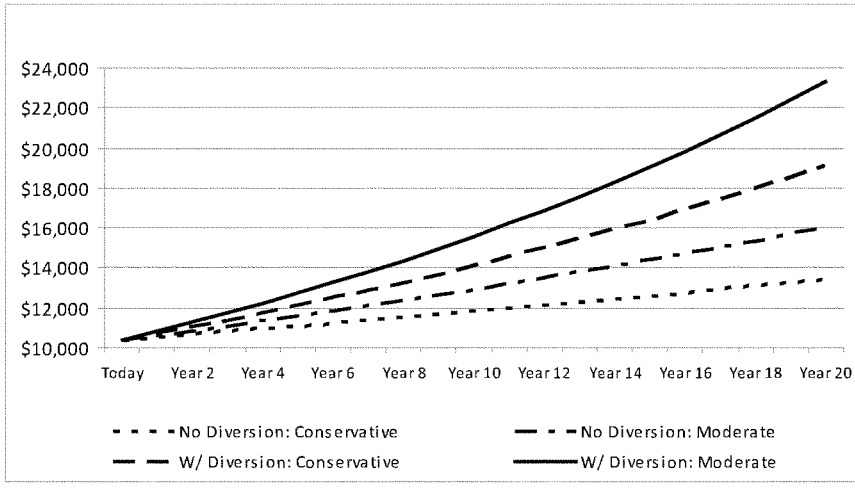


Figure C-6: Projected Real GDP (in Millions 2008 dollars)

Figure C-7 depicts the growth in tax revenues for the States and local taxing districts that result under the four scenarios.

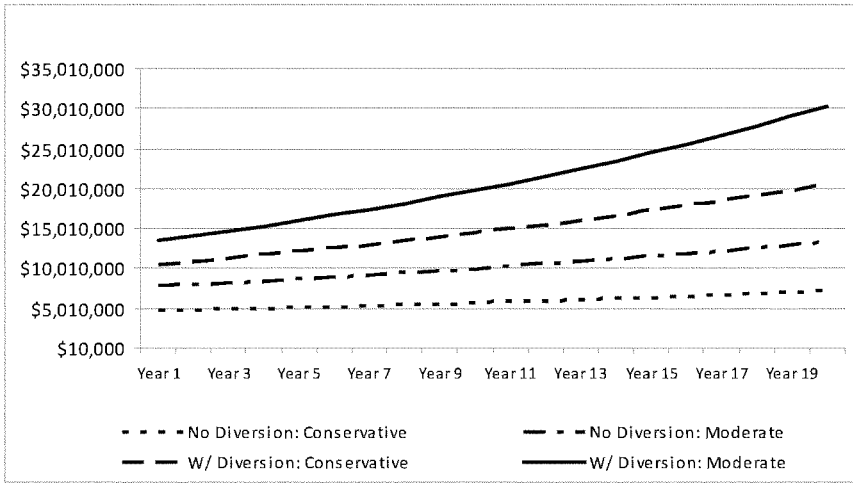


Figure C-7: Growth in Tax Revenues for State and Local Taxing Districts

4.3.3.1 Summary of Projected Economic Growth for Fargo MSA: Without-Project

The additional output in the region that results from general economic growth can be translated into additional employment and earnings in the area. Table C-59 summarizes economic output, employment, and earnings for the two Without-Project cases. In calculating the annual equivalent change in output, employment and earnings, years 1 to 8 were appreciated to the base year (year 9) and then combined with depreciated values from years 9 to 20.

Table C-59 Fargo MSA Economy: Without-Project ($1,000's)

	Conservative Growth *Case 1*			Moderate Growth *Case 2*		
	Additional Output (MSA GDP)	Additional Employment*	Additional Earnings*	Additional Output (MSA GDP)	Additional Employment*	Additional Earnings*
Year 1	$134,236	1,402	$48,943	$226,849	2,250	$82,710
Year 2	$135,968	1,410	$49,574	$231,794	2,272	$84,513
Year 3	$137,722	1,418	$50,214	$236,847	2,294	$86,355
Year 4	$139,498	1,426	$50,862	$242,010	2,316	$88,238
Year 5	$141,298	1,434	$51,518	$247,286	2,338	$90,161
Year 6	$143,121	1,442	$52,182	$252,677	2,360	$92,127
Year 7	$144,967	1,450	$52,855	$258,185	2,383	$94,135
Year 8	$146,837	1,458	$53,537	$263,814	2,406	$96,187
Year 9	$148,731	1,467	$54,228	$269,565	2,429	$98,284
Year 10	$150,650	1,475	$54,927	$275,442	2,452	$100,427
Year 11	$152,593	1,483	$55,636	$281,446	2,476	$102,616
Year 12	$154,562	1,492	$56,354	$287,582	2,499	$104,853
Year 13	$156,556	1,500	$57,081	$293,851	2,523	$107,139
Year 14	$158,575	1,509	$57,817	$300,257	2,547	$109,475
Year 15	$160,621	1,517	$58,563	$306,803	2,572	$111,861
Year 16	$162,693	1,526	$59,318	$313,491	2,597	$114,300
Year 17	$164,791	1,534	$60,084	$320,325	2,621	$116,792
Year 18	$166,917	1,543	$60,859	$327,308	2,647	$119,338
Year 19	$169,070	1,552	$61,644	$334,443	2,672	$121,939
Year 20	$171,252	1,561	$62,439	$341,734	2,698	$124,597
NPV	**$2,822,698**	**27,775**	**$1,029,166**	**$5,140,481**	**46,041**	**$1,874,238**
Annual Eqv**	**$214,654**	**2,112**	**$78,264**	**$390,912**	**3,501**	**$142,528**

Source: DataSource

All figures in 2008 dollars.

* Final output multipliers were used to determine employment and earnings. See the Discussion on Multipliers in Section 4.2.4.1 for more information.

** Annual equivalent values were calculated using a discount rate of 0.04375.

4.3.3.2 Summary of Projected Economic Growth for Fargo MSA: With-Project

The additional output in the region that results from general economic growth can be translated into additional employment and earnings in the area. Table C-60 below summarizes economic output, employment, and earnings for the two With-Project cases.

Table C-60 Fargo MSA Economy: With-Project ($1,000's)

	Conservative Growth *Case 3*			Moderate Growth *Case 4*		
	Additional Output (MSA GDP)	Additional Employment*	Additional Earnings*	Additional Output (MSA GDP)	Additional Employment*	Additional Earnings*
Year 1	$321,542	2,854	$117,236	$427,683	3,349	$155,935
Year 2	$331,478	2,893	$120,858	$445,260	3,410	$162,344
Year 3	$341,721	2,932	$124,593	$463,561	3,471	$169,016
Year 4	$352,280	2,972	$128,443	$482,613	3,534	$175,962
Year 5	$363,165	3,012	$132,411	$502,448	3,598	$183,194
Year 6	$374,387	3,053	$136,503	$523,099	3,663	$190,724
Year 7	$385,956	3,095	$140,721	$544,598	3,729	$198,563
Year 8	$397,882	3,137	$145,069	$566,981	3,797	$206,723
Year 9	$410,176	3,179	$149,552	$590,284	3,865	$215,220
Year 10	$422,851	3,222	$154,173	$614,545	3,935	$224,065
Year 11	$435,917	3,266	$158,937	$639,803	4,007	$233,274
Year 12	$449,387	3,311	$163,848	$666,099	4,079	$242,862
Year 13	$463,273	3,356	$168,911	$693,475	4,153	$252,844
Year 14	$477,588	3,401	$174,130	$721,977	4,228	$263,235
Year 15	$492,345	3,448	$179,511	$751,650	4,304	$274,054
Year 16	$507,559	3,494	$185,058	$782,543	4,382	$285,318
Year 17	$523,242	3,542	$190,776	$814,706	4,461	$297,045
Year 18	$539,411	3,590	$196,671	$848,190	4,542	$309,253
Year 19	$556,078	3,639	$202,748	$883,051	4,624	$321,963
Year 20	$573,261	3,688	$209,013	$919,344	4,708	$335,196
NPV	**$7,880,155**	**60,355**	**$2,873,133**	**$11,469,219**	**73,544**	**$4,181,718**
Annual Eqv**	**$599,252**	**4,590**	**$218,489**	**$872,185**	**5,593**	**$318,002**

Source: DataSource

All figures in 2008 dollars.

* Final output multipliers were used to determine employment and earnings. See the Discussion on Multipliers in Section 4.2.4.1 for more information.

** Annual equivalent values were calculated using a discount rate of 0.04375.

4.3.3.3 Summary of Projected State and Local Tax Revenue for Fargo MSA: Without-Project

The State and local tax revenues for the Fargo-Moorhead region are summarized in Table C-61 below based on the economic output, employment, and earnings.

Table C-61 Projected State and Local Tax Revenue for Fargo MSA: Without-Project ($1,000's)

	Conservative Growth *Case 1*			Moderate Growth *Case 2*		
	Additional State Tax Revenue*	Additional Local Tax Revenue**	Additional Total Revenue	Additional State Tax Revenue*	Additional Local Tax Revenue**	Additional Total Revenue
Year 1	$3,759	$913	$4,672	$6,262	$1,484	$7,746
Year 2	$3,832	$941	$4,773	$6,429	$1,537	$7,966
Year 3	$3,907	$970	$4,877	$6,602	$1,592	$8,193
Year 4	$3,984	$1,000	$4,983	$6,779	$1,648	$8,428
Year 5	$4,062	$1,031	$5,093	$6,962	$1,707	$8,669
Year 6	$4,143	$1,062	$5,205	$7,150	$1,768	$8,918
Year 7	$4,226	$1,095	$5,321	$7,344	$1,831	$9,175
Year 8	$4,311	$1,129	$5,440	$7,543	$1,897	$9,440
Year 9	$4,398	$1,164	$5,562	$7,749	$1,965	$9,714
Year 10	$4,487	$1,201	$5,688	$7,960	$2,036	$9,996
Year 11	$4,579	$1,238	$5,817	$8,178	$2,109	$10,287
Year 12	$4,673	$1,277	$5,950	$8,402	$2,185	$10,587
Year 13	$4,769	$1,317	$6,086	$8,633	$2,264	$10,897
Year 14	$4,868	$1,359	$6,227	$8,871	$2,346	$11,217
Year 15	$4,970	$1,402	$6,372	$9,116	$2,431	$11,547
Year 16	$5,074	$1,446	$6,520	$9,368	$2,519	$11,888
Year 17	$5,181	$1,492	$6,674	$9,629	$2,611	$12,239
Year 18	$5,291	$1,540	$6,831	$9,897	$2,706	$12,602
Year 19	$5,404	$1,589	$6,993	$10,173	$2,804	$12,977
Year 20	$5,520	$1,640	$7,160	$10,457	$2,906	$13,364
NPV	**$76,202**	**$20,505**	**$96,707**	**$135,552**	**$34,879**	**$170,431**
Annual Eqv* **	**$5,795**	**$1,559**	**$7,354**	**$10,308**	**$2,652**	**$12,961**

Source: DataSource

All figures in 2008 dollars.

* Additional State Tax Revenue includes: Sales Tax, Personal Income Tax, Corporate Income Tax, and Other Miscellaneous Taxes and Revenues.

** Additional Local Tax Revenue includes: Sales Tax and Other Miscellaneous Taxes and Revenues.

*** Annual equivalent values were calculated using a discount rate of 0.04375.

4.3.3.4 Summary of Projected State and Local Tax Revenue for Fargo MSA: With-Project

The State and local tax revenues for the Fargo-Moorhead region are summarized in Table C-62 below based on economic output, employment, and earnings.

Table C-62 Projected State & Local Tax Revenue for Fargo MSA: With-Project ($1,000's)

	Conservative Growth *Case 3*			Moderate Growth *Case 4*		
	Additional State Tax Revenue*	Additional Local Tax Revenue**	Additional Total Revenue	Additional State Tax Revenue*	Additional Local Tax Revenue**	Additional Total Revenue
Year 1	$8,619	$1,936	$10,555	$11,122	$2,352	$13,474
Year 2	$8,914	$2,015	$10,928	$11,599	$2,461	$14,060
Year 3	$9,219	$2,096	$11,315	$12,096	$2,576	$14,671
Year 4	$9,535	$2,182	$11,716	$12,614	$2,695	$15,309
Year 5	$9,862	$2,270	$12,132	$13,155	$2,821	$15,975
Year 6	$10,201	$2,363	$12,563	$13,719	$2,952	$16,670
Year 7	$10,551	$2,459	$13,010	$14,307	$3,089	$17,396
Year 8	$10,915	$2,559	$13,473	$14,921	$3,233	$18,153
Year 9	$11,290	$2,663	$13,954	$15,561	$3,383	$18,944
Year 10	$11,680	$2,772	$14,452	$16,228	$3,541	$19,769
Year 11	$12,083	$2,885	$14,968	$16,925	$3,705	$20,630
Year 12	$12,500	$3,003	$15,503	$17,652	$3,878	$21,530
Year 13	$12,932	$3,126	$16,058	$18,409	$4,059	$22,468
Year 14	$13,380	$3,254	$16,633	$19,200	$4,248	$23,448
Year 15	$13,843	$3,387	$17,230	$20,025	$4,446	$24,471
Year 16	$14,323	$3,526	$17,849	$20,885	$4,653	$25,538
Year 17	$14,820	$3,671	$18,491	$21,783	$4,870	$26,653
Year 18	$15,335	$3,821	$19,156	$22,720	$5,097	$27,817
Year 19	$15,868	$3,978	$19,847	$23,697	$5,335	$29,031
Year 20	$16,421	$4,142	$20,562	$24,716	$5,584	$30,299
NPV	**$199,788**	**$47,684**	**$247,472**	**$279,664**	**$61,260**	**$340,924**
Annual Eqv* **	**$15,193**	**$3,626**	**$18,819**	**$21,267**	**$4,659**	**$25,926**

Source: DataSource

All figures in 2008 dollars.

* Additional State Tax Revenue includes: Sales Tax, Personal Income Tax, Corporate Income Tax, and Other Miscellaneous Taxes and Revenues.

** Additional Local Tax Revenue includes: Sales Tax and Other Miscellaneous Taxes and Revenues.

*** Annual equivalent values were calculated using a discount rate of 0.04375.

4.3.3.5 Determination of Loss of Business Confidence

To determine a range for the loss of business confidence, the potential outcomes of the four combinations of the scenarios were compared as follows:

Potential Outcomes:

Low = (With–Project, Conservative) - (Without-Project, Moderate)

Medium Low = (With-Project, Conservative) - (Without-Project, Conservative)

Medium High = (With-Project, Moderate) - (Without-Project, Moderate)

High = (With-Project, Moderate) - (Without-Project, Conservative)

Table C-63 summarizes loss of business confidence for output, employment, earnings, State tax revenues, local taxing district revenues, and total tax revenues given four potential outcomes. The results are presented as annual equivalent values using a 4.375 percent discount rate over 20 years.

Table C-63 Annual Equivalent Values for Loss of Business Confidence ($1,000's)

	Low	Medium Low	Medium High	High
Output (MSA GDP)	$208,340	$384,598	$481,273	$657,531
Employment	1,089	2,478	2,091	3,481
Earnings	$75,962	$140,226	$175,474	$239,738
State Tax Revenue	$4,885	$9,398	$10,959	$15,472
Local Tax Revenue	$974	$2,067	$2,006	$3,099
Total Tax Revenue	$5,859	$11,465	$12,965	$18,572

All figures in 2008 dollars.

The results show that not providing a permanent flood damage reduction solution may cost the region between $210 million and $660 million per year in GDP (2008 dollars). It would also cost the region between 1,089 and 3,481 jobs and between $5.9 and $18.6 million in local and State tax revenue.

4.3.4 Business Departing Fargo-Moorhead; Moving Overseas

A potential impact of a failed flood fight in Fargo Moorhead is that a business may move out of the area. This business may leave the region to another location in the United States, or could relocate internationally. This section presents the economic impact of the loss of a hypothetical company that leaves the Fargo-Moorhead area. This hypothetical manufacturing company is assumed to have $16.5 million in annual revenues and 150 workers.
The loss to the region is the direct loss of annual revenues and a further $5.3 million in indirect and induced output. In addition to the 150 direct jobs, a further 48 indirect and induced jobs would be lost due to the region. The Federal, State and local tax revenue lost is estimated at $2.0 million per year.

4.4 Summary and Conclusions

This section summarizes the regional economic impacts for the Fargo-Moorhead flood diversion project in terms of economic output, employment, and tax revenue. The results incorporate regional impacts associated with construction, avoided flood damages (including avoided loss of business income), and loss of business confidence.

All results summarized are shown as annual values. Within this section, the results are presented in two tables for each subsection. The first table summarizes the results for the Without-Project conditions and three With-Project alternatives; North Dakota East 35k cfs, Minnesota Short 35k cfs, and Minnesota Short 20k cfs. The second table calculates the net regional impact of the With-Project alternatives according to the formulae:

Net Regional Economic Benefit = *With-Project* alternative – *Without-Project* alternative

4.4.1 Economic Output

Table C-64 summarizes the changes in economic output within the Fargo-Moorhead MSA associated with each of the flood diversion alternatives. The table highlights the benefit (positive) and cost (negative) effects associated with construction, avoided flood impacts, and loss of business income.

Table C-64 Summary of Changes in Economic Output in the Fargo-Moorhead MSA ($1,000's)

		With-Project		
	Without-Project	North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
Construction Impacts				
Construction	$0	$12,895	$11,380	$8,670
Operations & Maintenance		($1,870)	($1,777)	($1,358)
Avoided Flood Impacts				
Loss of Business Income	($87,468)	$0	$0	$0
NED Construction Benefits	$32,233	$4,186	$5,902	$9,858
Direct Damages	($61,676)	($8,007)	($11,042)	($18,666)
Loss of Business Confidence (Low)	($208,340)			
Total	($325,251)	**$7,204**	**$4,464**	($1,496)

Table C-65 presents the net change in regional economic output for the North Dakota East 35k cfs, Minnesota Short 35k cfs, and Minnesota Short 20k cfs alternatives.

Table C-65 Changes in Economic Output in the Fargo-Moorhead MSA for the With–Project Alternatives ($1,000's)

	North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
Construction Impacts			
Construction	$12,895	$11,380	$8,670
Operations and Maintenance	($1,870)	($1,777)	($1,358)
Avoided Flood Impacts			
Loss of Business Income	$87,468	$87,468	$87,468
NED Construction Benefits	($28,047)	($26,331)	($22,375)
Direct Damages	$53,669	$50,635	$43,010
Loss of Business Confidence (Low)	$208,340	$208,340	$208,340
Total Increase in GDP	**$332,455**	**$329,715**	**$323,755**

The change in economic output within the Fargo-Moorhead MSA is estimated to be about $330 million per year. Approximately two-thirds of this impact is associated with the assumed loss of business confidence. The North Dakota alternative provides slightly more regional benefits than the Minnesota alternatives.

4.4.2 Employment

Table C-66 summarizes the changes in employment within the Fargo-Moorhead MSA associated with each of the With-Project alternatives.

Table C-66 Summary of Changes in Employment in the Fargo-Moorhead MSA

	Without-Project	With-Project		
		North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
Construction Impacts				
Construction*	0	825	728	555
Operations & Maintenance		26	25	19
Avoided Flood Impacts				
Loss of Business Income	-913			
NED Construction Benefits	337	44	62	103
Loss of Business Confidence (Low)	-1,089			
Total	**-1,665**	**895**	**815**	**677**

** Employment during construction is the annual equivalent jobs over 50 years.*

Table C-67 presents the net change in employment for the North Dakota East 35k cfs, Minnesota Short 35k cfs, and Minnesota Short 20k cfs alternatives.

Table C-67 Changes in Employment in the Fargo-Moorhead MSA for the With-Project Alternative

	North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
Construction Impacts			
Construction*	825	728	555
Operations & Maintenance	26	25	19
Avoided Flood Impacts			
Loss of Business Income	913	913	913
NED Construction Benefits	-293	-275	-234
Loss of Business Confidence (Low)	1,089	1,089	1,089
Total	**2,560**	**2,480**	**2,342**

** Employment during construction is the annual equivalent jobs over 50 years.*

The With-Project alternatives would produce between 2,340 and 2,560 jobs within the local region.

4.4.3 State and Local Tax Revenue

Table C-68 summarizes the annual changes in State and local tax revenue within the Fargo-Moorhead MSA associated with each of the With-Project alternatives.

Table C-68 Summary of Changes in Annual Tax Revenue in the Fargo-Moorhead MSA ($1,000's)

		With-Project		
	Without-Project	North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
Construction Impacts				
Construction	$0	$4,115	$3,659	$2,788
Operations & Maintenance		$90	$86	$65
Avoided Flood Impacts				
Loss of Business Income	($3,044)			
NED Construction Benefits	$1,122	$122	$172	$288
Loss of Business Confidence (Low)	($5,859)			
Total	($7,781)	**$4,327**	**$3,917**	**$3,140**

Table C-69 presents the net annual change in State and local tax revenue for the North Dakota East 35k cfs, Minnesota Short 35k cfs and Minnesota Short 20k cfs alternatives.

Table C-69 Changes in Annual Tax Revenue in the Fargo-Moorhead MSA for the With-Project Alternative ($1,000's)

	North Dakota East 35k cfs	Minnesota Short 35k cfs	Minnesota Short 20k cfs
Construction Impacts			
Construction	$4,115	$3,659	$2,788
Operations & Maintenance	$90	$86	$65
Avoided Flood Impacts			
Loss of Business Income	$3,044	$3,044	$3,044
NED Construction Benefits	($1,000's)	($950)	($834)
Loss of Business Confidence (Low)	$5,859	$5,859	$5,859
Total	**$12,109**	**$11,968**	**$10,922**

The With-Project alternatives would produce an estimated $10.9–$12.1 million of State and local tax revenues.

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Exhibit A

HEC-FDA Output Damages Used in RED Analysis

Structural Damages

Current Conditions

	Estimated Annual Damages ($,000)						
	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$8	$1	$2	$10	$14	---	$36
Apartment	$877	$735	$91	$152	$0	---	$1,855
College	$824	$3	$0	$19	$0	---	$845
Commercial	$7,438	$3,003	$801	$181	$50	---	$11,473
Public	$699	$855	$11	$31	$87	---	$1,683
Residential	$4,963	$6,058	$2,181	$1,997	$2,625	---	$17,825
Emergency	---	---	---	---	---	$0	
Total	$14,809	$10,655	$3,087	$2,391	$2,776		$33,720

North Dakota East 35k cfs

	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$1	$0	$0	$1	$1	---	$4
Apartment	$103	$84	$13	$17	$0	---	$217
College	$105	$1	$0	$8	$0	---	$114
Commercial	$987	$367	$150	$43	$4	---	$1,552
Public	$94	$93	$2	$10	$5	---	$205
Residential	$598	$626	$264	$303	$498	---	$2,290
Emergency	---	---	---	---	---	$0	
Total	$1,889	$1,172	$429	$383	$508		$4,380

Minnesota South 35k cfs

	Estimated Annual Damages ($,000)						
	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$1	$0	$0	$5	$10	---	$17
Apartment	$102	$81	$22	$16	$0	---	$221
College	$102	$1	$0	$8	$0	---	$110
Commercial	$977	$353	$143	$45	$19	---	$1,537
Public	$94	$92	$2	$10	$37	---	$235
Residential	$607	$681	$847	$322	$1,765	---	$4,222
Emergency	---	---	---	---	---	$0	
Total	$1,882	$1,208	$1,015	$406	$1,831		$6,340

Minnesota South 20k cfs

	Estimated Annual Damages ($,000)						
	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$2	$0	$1	$6	$11	---	$20
Apartment	$222	$179	$34	$36	$0	---	$471
College	$217	$1	$0	$10	$0	---	$228
Commercial	$1,997	$757	$251	$65	$23	---	$3,093
Public	$181	$193	$3	$14	$43	---	$434
Residential	$1,262	$1,441	$1,063	$570	$1,861	---	$6,198
Emergency	---	---	---	---	---	$0	
Total	$3,882	$2,571	$1,351	$700	$1,938		$10,440

Contents Damages

Current Conditions

	Estimated Annual Damages ($,000)						
	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$221	$1	$1	$9	$13	---	$245
Apartment	$1,244	$1,069	$131	$338	$0	---	$2,783
College	$80	$0	$0	$15	$0	---	$96
Commercial	$10,175	$4,665	$1,056	$289	$58	---	$16,242
Public	$829	$691	$12	$47	$64	---	$1,643
Residential	$3,782	$5,413	$1,578	$1,533	$1,774	---	$14,081
Emergency	---	---	---	---	---	$0	
Total	$16,331	$11,839	$2,778	$2,232	$1,910		$35,090

North Dakota East 35k cfs

	Estimated Annual Damages ($,000)						
	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$25	$0	$0	$1	$1	---	$28
Apartment	$146	$122	$19	$38	$0	---	$325
College	$10	$0	$0	$6	$0	---	$17
Commercial	$1,351	$571	$198	$69	$5	---	$2,193
Public	$112	$75	$2	$15	$4	---	$208
Residential	$456	$560	$191	$233	$337	---	$1,776
Emergency	---	---	---	---	---	$0	
Total	$2,100	$1,328	$410	$363	$346		$4,550

Minnesota South 35k cfs

	Estimated Annual Damages ($,000)						
	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$24	$0	$0	$5	$9	---	$39
Apartment	$144	$117	$32	$37	$0	---	$331
College	$10	$0	$0	$6	$0	---	$16
Commercial	$1,336	$548	$189	$72	$22	---	$2,167
Public	$111	$74	$2	$15	$28	---	$230
Residential	$463	$609	$613	$247	$1,193	---	$3,124
Emergency	---	---	---	---	---	$0	
Total	$2,089	$1,349	$836	$382	$1,252		$5,910

Minnesota South 20k cfs

	Estimated Annual Damages ($,000)						
	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$57	$0	$0	$5	$10	---	$72
Apartment	$315	$261	$48	$80	$0	---	$704
College	$21	$0	$0	$8	$0	---	$29
Commercial	$2,732	$1,176	$330	$104	$27	---	$4,369
Public	$215	$156	$3	$21	$32	---	$426
Residential	$962	$1,288	$769	$438	$1,258	---	$4,714
Emergency	---	---	---	---	---	$0	
Total	$4,301	$2,880	$1,152	$655	$1,327		$10,320

Other Damages

Current Conditions

	Estimated Annual Damages ($,000)						
	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$0	$0	$0	$0	$0	---	$0
Apartment	$420	$315	$46	$67	$0	---	$848
College	$0	$0	$0	$0	$0	---	$0
Commercial	$1,182	$4	$3	$36	$0	---	$1,224
Public	$2	$0	$0	$40	$0	---	$41
Residential	$346	$533	$300	$127	$328	---	$1,634
Emergency	---	---	---	---	---	$0	
Total	$1,949	$852	$349	$269	$328		$3,750

North Dakota East 35k cfs

	Estimated Annual Damages ($,000)						
	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$0	$0	$0	$0	$0	---	$0
Apartment	$49	$36	$7	$8	$0	---	$99
College	$0	$0	$0	$0	$0	---	$0
Commercial	$157	$0	$1	$9	$0	---	$166
Public	$0	$0	$0	$13	$0	---	$13
Residential	$42	$55	$36	$19	$62	---	$215
Emergency	---	---	---	---	---	$0	
Total	$248	$92	$43	$48	$62		$490

Minnesota South 35k cfs

	Estimated Annual Damages ($,000)						
	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$0	$0	$0	$0	$0	---	$0
Apartment	$49	$35	$11	$7	$0	---	$102
College	$0	$0	$0	$0	$0	---	$0
Commercial	$155	$0	$0	$9	$0	---	$165
Public	$0	$0	$0	$13	$0	---	$13
Residential	$42	$60	$117	$20	$220	---	$460
Emergency	---	---	---	---	---	$0	
Total	$246	$95	$128	$49	$220		$740

Minnesota South 20k cfs

	Estimated Annual Damages ($,000)						
	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$0	$0	$0	$0	$0	---	$0
Apartment	$106	$77	$17	$16	$0	---	$216
College	$0	$0	$0	$0	$0	---	$0
Commercial	$317	$1	$1	$13	$0	---	$332
Public	$0	$0	$0	$17	$0	---	$18
Residential	$88	$127	$147	$36	$232	---	$630
Emergency	---	---	---	---	---	$0	
Total	$512	$205	$164	$82	$232		$1,200

Total Damages

Current Conditions

	Estimated Annual Damages ($,000)						
	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$229	$2	$3	$20	$27	---	$281
Apartment	$2,541	$2,120	$268	$557	$0	---	$5,486
College	$904	$3	$0	$34	$0	---	$941
Commercial	$18,794	$7,671	$1,860	$505	$108	---	$28,939
Public	$1,530	$1,545	$23	$118	$151	---	$3,368
Residential	$9,090	$12,005	$4,059	$3,657	$4,727	---	$33,539
Emergency	---	---	---	---	---	$0	
Total	$33,089	$23,346	$6,214	$4,892	$5,013		$72,550

North Dakota East 35k cfs

	Estimated Annual Damages ($,000)						
	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$26	$0	$1	$2	$2	---	$31
Apartment	$298	$243	$38	$62	$0	---	$641
College	$115	$1	$0	$15	$0	---	$130
Commercial	$2,495	$939	$348	$121	$8	---	$3,911
Public	$207	$169	$4	$38	$9	---	$426
Residential	$1,096	$1,241	$491	$556	$897	---	$4,281
Emergency	---	---	---	---	---	$0	
Total	$4,236	$2,592	$882	$794	$917		$9,420

Minnesota South 35k cfs

	Estimated Annual Damages ($,000)						
	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$25	$0	$1	$10	$20	---	$56
Apartment	$295	$232	$66	$60	$0	---	$653
College	$112	$1	$0	$14	$0	---	$127
Commercial	$2,469	$902	$332	$125	$42	---	$3,869
Public	$205	$166	$4	$39	$65	---	$478
Residential	$1,112	$1,350	$1,576	$589	$3,178	---	$7,806
Emergency	---	---	---	---	---	$0	
Total	$4,217	$2,652	$1,979	$837	$3,304		$12,990

Minnesota South 20k cfs

	Estimated Annual Damages ($,000)						
	Fargo North	Fargo South	West Fargo	Moorhead	Cass County	Emergency	Total
Agricultural	$59	$1	$1	$11	$21	---	$92
Apartment	$644	$516	$99	$131	$0	---	$1,391
College	$238	$1	$0	$17	$0	---	$257
Commercial	$5,046	$1,934	$581	$182	$51	---	$7,795
Public	$396	$349	$7	$52	$74	---	$877
Residential	$2,311	$2,856	$1,979	$1,044	$3,352	---	$11,542
Emergency	---	---	---	---	---	$0	
Total	$8,695	$5,656	$2,667	$1,437	$3,498		$21,950

EXHIBIT B

Marshall and Swift Occupancy Codes

OCCID	Definition	Occ_Name	Cat_name	Sales_Class
127	Winery Shop	112	Commercial	L
133	Storage Shed, Prefabricated	114	Commercial	N
135	Hoop Greenhouse, Arch-Rib, Small (under 4,500 square feet)	98	Commercial	M
138	Hoop Greenhouse, Arch-Rib, Large (over 9,000 square feet)	98	Commercial	M
139	Straight Wall Greenhouse, Large (over 9,000 square feet)	98	Commercial	M
140	Modified Hoop Greenhouse, Medium (4,500 - 9,000 square feet)	98	Commercial	M
141	Hoop Greenhouse, Arch-Rib, Medium (4,500 - 9,000 square feet)	98	Commercial	M
157	Storage, Maintenance Building	114	Commercial	N
158	Special Education Classrooms	116	Public	N
170	Institutional Greenhouse, Small (under 4,500 square feet)	98	Commercial	M
171	Institutional Greenhouse, Medium (4,500 - 9,000 square feet)	98	Commercial	M
172	Institutional Greenhouse, Large (over 9,000 square feet)	98	Commercial	M
173	Educational Wing, Church	116	Public	N
174	Pavilion	Pub1	Public	N
175	Skating Rink, Ice	113	Commercial	L
176	Skating Rink, Roller	113	Commercial	L
181	Storage Shed, Prefabricated, Secure	114	Commercial	N
183	Starter Booth, Golf	98	Commercial	L
184	Shelter, Arena	98	Commercial	N
185	Truck Wash	98	Commercial	L
300	Apartment (High Rise)	Apt1	Apartment	N
301	Armory	98	Commercial	N
302	Auditorium	116	Public	N
303	Showroom, Automobile	29	Commercial	L
304	Bank	115	Commercial	N
305	Barn	Storage	Agricultural	N
306	Bowling Center	113	Commercial	L
308	Church with Sunday School	116	Public	N
309	Church	116	Public	N
311	Clubhouse	401	Commercial	N
313	Hospital, Convalescent	52	Commercial	H
314	Country Club	401	Commercial	L
316	Dairy	Storage	Agricultural	N
318	Store, Department	104	Commercial	M
319	Store, Discount	105	Commercial	M
321	Dormitory	Apt2	Apartment	N
322	Fire Station (Staffed)	Pub2	Public	N
323	Fraternal Building	401	Commercial	N
324	Fraternity House	401	Commercial	N
326	Storage Garage	114	Commercial	N
327	Governmental Building	Pub2	Public	N
328	Storage Hangar	114	Commercial	N
329	Hangar, Maintenance and Office	229	Commercial	N
330	Home For The Elderly	52	Commercial	L
331	Hospital	52	Commercial	H
335	Jail, Correctional Facility	Pub2	Public	N
336	Laundromat	107	Commercial	L
337	Library, Public	Pub2	Public	N
339	Storage, Lumber Shed, Horizontal	105	Commercial	L
340	Market	108	Commercial	L
341	Office, Medical	115	Commercial	L
342	Mortuary	133	Commercial	L
343	Motel	132	Commercial	M

OCCID	Definition	Occ_Name	Cat_name	Sales_Class
344	Office Building	115	Commercial	L
345	Parking Structure	98	Commercial	M
348	Rectory	116	Public	N
349	Restaurant, Fast Food	109	Commercial	M
350	Restaurant, Table Service	110	Commercial	M
352	Multiple Residence (Low Rise)	Apt1	Apartment	N
353	Store, Retail	111	Commercial	M
356	Classroom (Elementary and Secondary School)	116	Public	N
358	Gymnasium (Elementary and Secondary School)	116	Public	N
363	Physical Education Building (Elementary and Secondary School)	116	Public	N
364	Science Classrooms (Elementary and Secondary School)	116	Public	N
365	Elementary School (Entire)	116	Public	N
368	Classroom (College)	College1	College	N
369	Commons (College)	College1	College	N
370	Gymnasium (College)	College1	College	N
372	Library, College	College1	College	N
373	Technical Trades Building (College)	College1	College	N
376	Science Building (College)	College1	College	N
377	College (Entire)	College1	College	N
378	Stable	Storage	Agricultural	N
379	Theater, Live Stage	131	Commercial	VL
380	Theater, Cinema	131	Commercial	L
381	Veterinary Hospital	50	Commercial	M
384	Barber Shop	106	Commercial	L
386	Warehouse, Mini	114	Commercial	L
387	Warehouse, Transit	114	Commercial	L
390	Storage, Lumber Building, Vertical	114	Commercial	L
391	Storage, Material Building	114	Commercial	L
392	Industrial Engineering Building	405	Commercial	L
393	Labor Dormitory	Apt1	Apartment	N
396	Hog Barn	Storage	Agricultural	N
397	Sheep Barn	Storage	Agricultural	N
403	Shower Building	98	Commercial	N
406	Warehouse, Storage	114	Commercial	L
407	Warehouse, Distribution	114	Commercial	L
408	Service Station	102	Commercial	M
409	T-Hangar	114	Commercial	L
410	Automotive Center	102	Commercial	M
413	Shopping Center, Community	104	Commercial	M
414	Shopping Center, Regional	104	Commercial	M
418	Health Club	115	Commercial	M
419	Market, Convenience	108	Commercial	M
421	Storage, Grain	Storage	Agricultural	L
423	Mini-Lube Garage	102	Commercial	L
426	Day Care Center	115	Commercial	L
427	Fire Station (Volunteer)	Pub1	Public	N
428	Horse Arena	98	Commercial	L
431	Outpatient (Surgical) Center	50	Commercial	H
432	Restroom Building	98	Commercial	N
434	Self-Serve Car Wash	98	Commercial	L
435	Drive-Thru Car Wash	98	Commercial	L
436	Car Wash, Automatic	98	Commercial	L
442	Tavern/Bar	112	Commercial	L

OCCID	Definition	Occ_Name	Cat_name	Sales_Class
443	Central Bank	115	Commercial	L
444	Office, Dental	50	Commercial	L
446	Supermarket	103	Commercial	M
447	Storage Facility, Cold	405	Commercial	M
451	Multiple Residence, Senior Citizen (Low Rise)	Apt2	Apartment	N
454	Shell, Industrial Building	405	Commercial	L
455	Auto Dealership, Complete	29	Commercial	L
456	Tool Shed	114	Commercial	L
458	Warehouse Discount Store	105	Commercial	L
459	Shopping Center, Mixed with Residential Units	105	Commercial	M
468	Shed, Material Storage	114	Commercial	L
470	Storage, Equipment Shop	114	Commercial	VL
471	Utility Building, Light Commercial	98	Commercial	VL
472	Shed, Equipment	114	Commercial	VL
473	Shelter, Material	114	Commercial	N
476	Storage, Farm Implement	Storage	Agricultural	N
477	Utility Building, Farm	Storage	Agricultural	N
478	Shed, Farm Implement	Storage	Agricultural	N
479	Shed, Farm Utility Storage	Storage	Agricultural	N
481	Museum	Pub2	Public	VL
482	Convention Center	Pub2	Public	L
483	Fitness Center	401	Commercial	L
484	High School (Entire)	116	Public	N
485	Natatorium	116	Public	N
486	Field House	116	Public	N
487	Vocational School	116	Public	N
488	Bookstore (School)	116	Public	N
490	Kennel	98	Commercial	L
491	Government Community Service Building	Pub2	Public	N
492	Shell, Office Building	115	Commercial	VL
493	Storage, Flathouse	Storage	Agricultural	N
494	Industrial Light Manufacturing	405	Commercial	L
495	Industrial Heavy Manufacturing	405	Commercial	L
496	Laboratory	50	Commercial	L
498	Broadcast Facility	115	Commercial	M
499	Laundry/Dry Cleaners	107	Commercial	M
508	Car Wash Canopy	98	Commercial	L
514	Community Center	401	Commercial	VL
515	Casino	112	Commercial	H
518	Lath Shade House (Greenhouse)	98	Commercial	L
519	Shade Shelter (Greenhouse)	98	Commercial	L
523	Storage, Golf Cart Building	114	Commercial	N
526	Shed, Service Garage	102	Commercial	L
527	Municipal Service Garage	102	Commercial	L
528	Service Repair Garage	102	Commercial	L
529	Snack Bar	109	Commercial	L
530	Restaurant, Cafeteria	110	Commercial	M
531	Mini-Mart Convenience Store	108	Commercial	M
532	Florist Shop	56	Commercial	L
533	Warehouse Food Store	103	Commercial	L
534	Warehouse Showroom Store	105	Commercial	L
540	Motel Room, 2 Story, Double Row	132	Commercial	M
543	Motel Room, 1 Story, Single Row	132	Commercial	M

OCCID	Definition	Occ_Name	Cat_name	Sales_Class
544	Office-Apartment (Motel)	132	Commercial	M
552	Recreational Enclosure	98	Commercial	VL
554	Shed Office Structure	115	Commercial	VL
555	Quonset, Light Commercial Arch-Rib	98	Commercial	L
556	Storage, Bulk Oil	Storage	Agricultural	N
557	Quonset, Farm Utility Arch-Rib	Storage	Agricultural	N
558	Quonset, Farm Implement Arch-Rib	Storage	Agricultural	N
561	Shed, Feeder Barn	Storage	Agricultural	N
562	Shed, Farm Commodity Storage	Storage	Agricultural	N
566	Shelter, Farm Sun Shade	Storage	Agricultural	N
571	Passenger Terminal	115	Commercial	N
574	Visitor Center	Pub2	Public	N
577	Parking Levels	98	Commercial	M
578	Mini Bank	115	Commercial	N
580	Truck Stop	98	Commercial	L
581	Post Office, Main	Pub2	Public	N
582	Post Office, Branch	Pub2	Public	N
584	Warehouse, Mega	114	Commercial	L
585	Penthouse, Mechanical	405	Commercial	L
588	Motel, Extended Stay	132	Commercial	M
589	Multiple Residence, Assisted Living (Low Rise)	Apt2	Apartment	N
594	Hotel, Full Service	132	Commercial	M
595	Hotel, Limited Service	132	Commercial	M
597	Retail Mixed with Office Units	111	Commercial	M
598	Relocatable Classroom	116	Public	N
600	Administration Building	Pub2	Public	N
700	Store, Department, Mall Anchor	104	Commercial	M
710	Retirement Community Complex (Multiple Residence)	Apt2	Apartment	N
984	Luxury Apartment (High Rise)	Apt2	Apartment	N
987	Multiple Residence (Low Rise), Interior Space	Apt2	Apartment	N
993	Office Building, Interior Space	115	Commercial	L

EXHIBIT C
Local and State Tax Detailed Calculations
– Construction Used for RED Analysis

Construction

Detailed Calculations for State & Local Tax Revenue

North Dakota East 35k cfs

All values are in $1,000

Revenues for the State and Local Taxing Districts During Construction

Sales Tax to be Collected

Construction Workers' Spending Subject to Sales Tax

An estimated 33% of the spending of direct construction workers and related indirect workers will be subject to sales taxes. Further, an estimated 70% of this spending will be in the Fargo-Moorhead area. If this is the case, retail sales in the area generated by workers during construction will be as follows.

Taxable Retail Sales in the Area to be Generated by Construction Workers	
Year 1	$35,242
Year 2	$35,242
Year 3	$35,242
Year 4	$35,242
Year 5	$35,242
Year 6	$35,242
Year 7	$35,242
Year 8	$35,242
Total	$281,934

Source: Impact DataSource calculations based on estimated spending in the area

Sales Tax Collections

The states of North Dakota and Minnesota and local taxing districts will collect the following sales tax on construction workers' spending:

Estimated Sales Tax Collections on Construction Workers' Spending			
	States	Local Taxing Districts	Total
Effective sales tax rate	5.33%	1.65%	
Year 1	$1,879	$580	$2,459
Year 2	$1,879	$580	$2,459
Year 3	$1,879	$580	$2,459
Year 4	$1,879	$580	$2,459
Year 5	$1,879	$580	$2,459
Year 6	$1,879	$580	$2,459
Year 7	$1,879	$580	$2,459
Year 8	$1,879	$580	$2,459
Total	$15,034	$4,639	$19,673

Source: Sales tax rates for each state and local taxing districts obtained from each state's department of revenue or local taxing district. Effective sales tax rates, blending the tax rates of two states and several local taxing districts, were determined in calculations by Impact DataSource based on the number of business establishments in Cass and Clay Counties.

Lodging Tax to be Collected

Construction Workers' Spending on Lodging

An estimated 20% of the direct construction workers may be from out-of-town and stay in local motels during construction of the project. If this is the case, there is double occupancy and a nightly room rate at local motels where construction workers stay is $85, then the construction workers from out of town spend the following amounts that will be subject to lodging taxes:

Taxable Lodging Sales	
	Amount
Year 1	$3,968
Year 2	$4,087
Year 3	$4,209
Year 4	$4,336
Year 5	$4,466
Year 6	$4,600
Year 7	$4,738
Year 8	$4,880
Total	$35,283

Lodging Tax Collections

The states and local taxing districts will collect the following lodging tax on spending by out-of-town construction workers on lodging:

Estimated Lodging Tax Collections on Out-of-Town Construction Workers' Spending on Lodging			
	States	Local Taxing Districts	Total
Effective lodging tax rate	0%	3%	
Year 1	$0	$119	$119
Year 2	$0	$123	$123
Year 3	$0	$126	$126
Year 4	$0	$130	$130
Year 5	$0	$134	$134
Year 6	$0	$138	$138
Year 7	$0	$142	$142
Year 8	$0	$146	$146
Total	$0	$1,058	$1,058

Source: Lodging taxes for local taxing districts obtained from each state's department of revenue or local taxing district. Effective lodging tax rates, blending the tax rates of multiple local taxing districts, were determined in calculations by Impact DataSource based on the number of business establishments in Cass and Clay Counties.

State Personal Income Taxes to be Collected

During construction, salaries of direct, indirect and induced workers may be subject to North Dakota and Minnesota personal income taxes. If this is the case, the states will collect the following personal income taxes:

Estimated State Personal Income Taxes to be Collected During Construction				
	Total Direct and Indirect Construction Payrolls	Percent of Salaries Subject to State Personal Income Tax	Effective Personal Income Tax Rate as a Percent of Total Income	Total Personal Income Tax Collections
Year 1	$152,562	100%	2.547%	$3,885
Year 2	$152,562	100%	2.547%	$3,885
Year 3	$152,562	100%	2.547%	$3,885
Year 4	$152,562	100%	2.547%	$3,885
Year 5	$152,562	100%	2.547%	$3,885
Year 6	$152,562	100%	2.547%	$3,885
Year 7	$152,562	100%	2.547%	$3,885
Year 8	$152,562	100%	2.547%	$3,885
Total	$1,220,494			$31,081

Source: Personal income tax rates were obtained from each state's department of revenue. Effective state personal income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on median household income in the area and the percentage of labor force in Cass and Clay Counties. The percent of workers whose salaries will be subject to personal income taxes in the two states are Impact DataSource estimates.

State Corporate Income Taxes to be Collected

During construction and equipment installation, an estimated 8% of the total economic output generated by construction activities or business income may be subject to North Dakota or Minnesota corporate income tax. If this is the case, the states will collect the following corporate income taxes during construction:

Estimated Corporate Income Taxes to be Collected During Construction				
	Total Direct and Indirect Construction Spending/ Revenues for Businesses	Percent of Revenues Subject to State Corporate Income Tax	Effective Corporate Income Tax Rate as a Percent of Net Income	Total Corporate Income Tax Collections
Year 1	$226,719	8%	7.003%	$1,270
Year 2	$226,719	8%	7.003%	$1,270
Year 3	$226,719	8%	7.003%	$1,270
Year 4	$226,719	8%	7.003%	$1,270
Year 5	$226,719	8%	7.003%	$1,270
Year 6	$226,719	8%	7.003%	$1,270
Year 7	$226,719	8%	7.003%	$1,270
Year 8	$226,719	8%	7.003%	$1,270
Total	$1,813,755			$10,161

Source: Corporate income tax rates were obtained from each state's department of revenue. Effective state corporate income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on the percentage of business establishments in Cass and Clay Counties. The percent of total business revenues that will be subject to state corporation income taxes in the two states are Impact DataSource estimates.

Other Taxes, User Fees, Charges for Services and Miscellaneous Revenues for the States and Local Taxing Districts Collected from Construction Workers

During construction, the states and local taxing districts will collect other taxes, user fees, charges for services, and miscellaneous revenues primarily from workers. These estimated annual revenues to be collected per worker are shown below:

Annual Miscellaneous Revenues Collected Per Worker	
States	$764.41
Local taxing districts	$500

Source: Miscellaneous revenues per worker for states calculated by Impact DataSource from information shown in the general fund budgets of each state along with the number of workers in each state. Further, miscellaneous revenues for each state were blending to obtain an average by Impact DataSource based on relative number of workers in Cass and Clay Counties. Miscellaneous revenues for local taxing districts are Impact DataSource estimates.

If these estimated miscellaneous revenues are received by the states and local taxing districts for each worker and an estimated 70% of the workers may live in the Fargo-Moorhead area, the following revenues will be received during the project's construction:

Estimated Miscellaneous Revenues for the States and Local Taxing Districts During Construction					
	Number of Workers in the States	Number of Local Workers	Miscellaneous Revenues		
			State	Local Taxing Districts	Total
Year 1	2,079	1,455	$1,589	$1,040	$2,629
Year 2	2,079	1,455	$1,589	$1,040	$2,629
Year 3	2,079	1,455	$1,589	$1,040	$2,629
Year 4	2,079	1,455	$1,589	$1,040	$2,629
Year 5	2,079	1,455	$1,589	$1,040	$2,629
Year 6	2,079	1,455	$1,589	$1,040	$2,629
Year 7	2,079	1,455	$1,589	$1,040	$2,629
Year 8	2,079	1,455	$1,589	$1,040	$2,629
Total			$12,715	$8,317	$21,033

Source: Percent of total direct and indirect construction workers who may live in the Fargo-Moorhead area is an Impact DataSource estimate.

Summary of Taxes and Other Revenues to be Collected by the States and Local Taxing Districts During Construction

Revenues for the States

During construction, the project will generate the following revenues for the states:

Total Revenues for the States During Construction						
	Sales Taxes	Lodging Taxes	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$1,879	$0	$1,270	$3,885	$1,589	$8,624
Year 2	$1,879	$0	$1,270	$3,885	$1,589	$8,624
Year 3	$1,879	$0	$1,270	$3,885	$1,589	$8,624
Year 4	$1,879	$0	$1,270	$3,885	$1,589	$8,624
Year 5	$1,879	$0	$1,270	$3,885	$1,589	$8,624
Year 6	$1,879	$0	$1,270	$3,885	$1,589	$8,624
Year 7	$1,879	$0	$1,270	$3,885	$1,589	$8,624
Year 8	$1,879	$0	$1,270	$3,885	$1,589	$8,624
Total	$15,034	$0	$10,161	$31,081	$12,715	$68,992

Revenues for Local Taxing Districts

During construction, the project will generate the following revenues for local taxing districts:

Total Revenues for Local Taxing District During Construction				
	Sales Taxes	Lodging Taxes	Other Taxes and Revenues	Total Revenues
Year 1	$580	$119	$1,040	$1,739
Year 2	$580	$123	$1,040	$1,742
Year 3	$580	$126	$1,040	$1,746
Year 4	$580	$130	$1,040	$1,750
Year 5	$580	$134	$1,040	$1,753
Year 6	$580	$138	$1,040	$1,757
Year 7	$580	$142	$1,040	$1,762
Year 8	$580	$146	$1,040	$1,766
Total	$4,639	$1,058	$8,317	$14,014

$694.79

Total Revenues for the States and Local Taxing Districts

During construction, the project will generate the following total revenues for the states and local taxing districts:

Total Revenues for the States and Local Taxing Districts During Construction						
	Sales Tax Collections	Lodging Taxes	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$2,459	$119	$1,270	$3,885	$2,629	$10,363
Year 2	$2,459	$123	$1,270	$3,885	$2,629	$10,366
Year 3	$2,459	$126	$1,270	$3,885	$2,629	$10,370
Year 4	$2,459	$130	$1,270	$3,885	$2,629	$10,374
Year 5	$2,459	$134	$1,270	$3,885	$2,629	$10,377
Year 6	$2,459	$138	$1,270	$3,885	$2,629	$10,381
Year 7	$2,459	$142	$1,270	$3,885	$2,629	$10,386
Year 8	$2,459	$146	$1,270	$3,885	$2,629	$10,390
Total	$19,673	$1,058	$10,161	$31,081	$21,033	$83,006

Summary of Total Revenues for the States and Local Taxing Districts

During construction, the project will generate the following total revenues for the states and local taxing districts:

Summary of Annual Tax Revenues for the States and Local Taxing Districts During Construction	
States of North Dakota and Minnesota	$3,420
Local taxing districts	$695
Total	$4,115

Construction

Detailed Calculations for State & Local Tax Revenue

Minnesota South 35k cfs

All values are in $1,000

Revenues for the State and Local Taxing Districts During Construction

Sales Tax to be Collected

Construction Workers' Spending Subject to Sales Tax

An estimated 33% of the spending of direct construction workers and related indirect workers will be subject to sales taxes. Further, an estimated 70% of this spending will be in the Fargo-Moorhead area. If this is the case, retail sales in the area generated by workers during construction will be as follows.

Taxable Retail Sales in the Area to be Generated by Construction Workers	
Year 1	$41,467
Year 2	$41,467
Year 3	$41,467
Year 4	$41,467
Year 5	$41,467
Year 6	$41,467
Total	$248,800

Source: Impact DataSource calculations based on estimated spending in the area

Sales Tax Collections

The states of North Dakota and Minnesota and local taxing districts will collect the following sales tax on construction workers' spending:

Estimated Sales Tax Collections on Construction Workers' Spending			
	States	Local Taxing Districts	Total
Effective sales tax rate	5.33%	1.65%	
Year 1	$2,211	$682	$2,893
Year 2	$2,211	$682	$2,893
Year 3	$2,211	$682	$2,893
Year 4	$2,211	$682	$2,893
Year 5	$2,211	$682	$2,893
Year 6	$2,211	$682	$2,893
Total	$13,267	$4,093	$17,361

Source: Sales tax rates for each state and local taxing districts obtained from each state's department of revenue or local taxing district. Effective sales tax rates, blending the tax rates of two states and several local taxing districts, were determined in calculations by Impact DataSource based on the number of business establishments in Cass and Clay Counties.

Lodging Tax to be Collected

Construction Workers' Spending on Lodging

An estimated 20% of the direct construction workers may be from out-of-town and stay in local motels during construction of the project. If this is the case, there is double occupancy and a nightly room rate at local motels where construction workers stay is $85, then the construction workers from out of town spend the following amounts that will be subject to lodging taxes:

Taxable Lodging Sales	
	Amount
Year 1	$4,669
Year 2	$4,809
Year 3	$4,953
Year 4	$5,102
Year 5	$5,255
Year 6	$5,413
Total	$30,201

Lodging Tax Collections

The states and local taxing districts will collect the following lodging tax on spending by out-of-town construction workers on lodging:

Estimated Lodging Tax Collections on Out-of-Town Construction Workers' Spending on Lodging			
	States	Local Taxing Districts	Total
Effective lodging tax rate	0%	3%	
Year 1	$0	$140	$140
Year 2	$0	$144	$144
Year 3	$0	$149	$149
Year 4	$0	$153	$153
Year 5	$0	$158	$158
Year 6	$0	$162	$162
Total	$0	$906	$906

Source: Lodging taxes for local taxing districts obtained from each state's department of revenue or local taxing district. Effective lodging tax rates, blending the tax rates of multiple local taxing districts, were determined in calculations by Impact DataSource based on the number of business establishments in Cass and Clay Counties.

State Personal Income Taxes to be Collected

During construction, salaries of direct, indirect and induced workers may be subject to North Dakota and Minnesota personal income taxes. If this is the case, the states will collect the following personal income taxes:

Estimated State Personal Income Taxes to be Collected During Construction				
	Total Direct and Indirect Construction Payrolls	Percent of Salaries Subject to State Personal Income Tax	Effective Personal Income Tax Rate as a Percent of Total Income	Total Personal Income Tax Collections
Year 1	$179,509	100%	2.547%	$4,571
Year 2	$179,509	100%	2.547%	$4,571
Year 3	$179,509	100%	2.547%	$4,571
Year 4	$179,509	100%	2.547%	$4,571
Year 5	$179,509	100%	2.547%	$4,571
Year 6	$179,509	100%	2.547%	$4,571
Total	$1,077,054			$27,428

Source: Personal income tax rates were obtained from each state's department of revenue. Effective state personal income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on median household income in the area and the percentage of labor force in Cass and Clay Counties. The percent of workers whose salaries will be subject to personal income taxes in the two states are Impact DataSource estimates.

State Corporate Income Taxes to be Collected

During construction and equipment installation, an estimated 8% of the total economic output generated by construction activities or business income may be subject to North Dakota or Minnesota corporate income tax. If this is the case, the states will collect the following corporate income taxes during construction:

Estimated Corporate Income Taxes to be Collected During Construction				
	Total Direct and Indirect Construction Spending/ Revenues for Businesses	Percent of Revenues Subject to State Corporate Income Tax	Effective Corporate Income Tax Rate as a Percent of Net Income	Total Corporate Income Tax Collections
Year 1	$266,765	8%	7.003%	$1,495
Year 2	$266,765	8%	7.003%	$1,495
Year 3	$266,765	8%	7.003%	$1,495
Year 4	$266,765	8%	7.003%	$1,495
Year 5	$266,765	8%	7.003%	$1,495
Year 6	$266,765	8%	7.003%	$1,495
Total	$1,600,591			$8,967

Source: Corporate income tax rates were obtained from each state's department of revenue. Effective state corporate income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on the percentage of business establishments in Cass and Clay Counties. The percent of total business revenues that will be subject to state corporation income taxes in the two states are Impact DataSource estimates.

Other Taxes, User Fees, Charges for Services and Miscellaneous Revenues for the States and Local Taxing Districts Collected from Construction Workers

During construction, the states and local taxing districts will collect other taxes, user fees, charges for services, and miscellaneous revenues primarily from workers. These estimated annual revenues to be collected per worker are shown below:

Annual Miscellaneous Revenues Collected Per Worker	
States	$764.41
Local taxing districts	$500

Source: Miscellaneous revenues per worker for states calculated by Impact DataSource from information shown in the general fund budgets of each state along with the number of workers in each state. Further, miscellaneous revenues for each state were blending to obtain an average by Impact DataSource based on relative number of workers in Cass and Clay Counties. Miscellaneous revenues for local taxing districts are Impact DataSource estimates.

If these estimated miscellaneous revenues are received by the states and local taxing districts for each worker and an estimated 70% of the workers may live in the Fargo-Moorhead area, the following revenues will be received during the project's construction:

Estimated Miscellaneous Revenues for the States and Local Taxing Districts During Construction					
	Number of Workers in the States	Number of Local Workers	Miscellaneous Revenues		
			State	Local Taxing Districts	Total
Year 1	2,447	1,713	$1,870	$1,223	$3,094
Year 2	2,447	1,713	$1,870	$1,260	$3,130
Year 3	2,447	1,713	$1,870	$1,298	$3,168
Year 4	2,447	1,713	$1,870	$1,337	$3,207
Year 5	2,447	1,713	$1,870	$1,377	$3,247
Year 6	2,447	1,713	$1,870	$1,418	$3,289
Total			$11,222	$7,913	$19,135

Source: Percent of total direct and indirect construction workers who may live in the Fargo-Moorhead area is an Impact DataSource estimate.

Summary of Taxes and Other Revenues to be Collected by the States and Local Taxing Districts During Construction

Revenues for the States

During construction, the project will generate the following revenues for the states:

Total Revenues for the States During Construction						
	Sales Taxes	Lodging Taxes	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$2,211	$0	$1,495	$4,571	$1,870	$10,147
Year 2	$2,211	$0	$1,495	$4,571	$1,870	$10,147
Year 3	$2,211	$0	$1,495	$4,571	$1,870	$10,147
Year 4	$2,211	$0	$1,495	$4,571	$1,870	$10,147
Year 5	$2,211	$0	$1,495	$4,571	$1,870	$10,147
Year 6	$2,211	$0	$1,495	$4,571	$1,870	$10,147
Total	$13,267	$0	$8,967	$27,428	$11,222	$60,885

Revenues for Local Taxing Districts

During construction, the project will generate the following revenues for local taxing districts:

Total Revenues for Local Taxing District During Construction				
	Sales Taxes	Lodging Taxes	Other Taxes and Revenues	Total Revenues
Year 1	$682	$140	$1,223	$2,046
Year 2	$682	$144	$1,260	$2,087
Year 3	$682	$149	$1,298	$2,129
Year 4	$682	$153	$1,337	$2,172
Year 5	$682	$158	$1,377	$2,217
Year 6	$682	$162	$1,418	$2,263
Total	$4,093	$906	$7,913	$12,913

Total Revenues for the States and Local Taxing Districts

During construction, the project will generate the following total revenues for the states and local taxing districts:

Total Revenues for the States and Local Taxing Districts During Construction						
	Sales Tax Collections	Lodging Taxes	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$2,893	$140	$1,495	$4,571	$3,094	$12,193
Year 2	$2,893	$144	$1,495	$4,571	$3,130	$12,234
Year 3	$2,893	$149	$1,495	$4,571	$3,168	$12,276
Year 4	$2,893	$153	$1,495	$4,571	$3,207	$12,320
Year 5	$2,893	$158	$1,495	$4,571	$3,247	$12,364
Year 6	$2,893	$162	$1,495	$4,571	$3,289	$12,410
Total	$17,361	$906	$8,967	$27,428	$19,135	$73,797

Summary of Total Revenues for the States and Local Taxing Districts

During construction, the project will generate the following total revenues for the states and local taxing districts:

Summary of Annual Tax Revenues for the States and Local Taxing Districts During Construction	
States of North Dakota and Minnesota	$3,018
Local taxing districts	$640
Total	$3,659

Construction

Detailed Calculations for State & Local Tax Revenue

Minnesota South 20k cfs

All values are in $1,000

Revenues for the State and Local Taxing Districts During Construction

Sales Tax to be Collected

Construction Workers' Spending Subject to Sales Tax

An estimated 33% of the spending of direct construction workers and related indirect workers will be subject to sales taxes. Further, an estimated 70% of this spending will be in the Fargo-Moorhead area. If this is the case, retail sales in the area generated by workers during construction will be as follows.

Taxable Retail Sales in the Area to be Generated by Construction Workers	
Year 1	$31,594
Year 2	$31,594
Year 3	$31,594
Year 4	$31,594
Year 5	$31,594
Year 6	$31,594
Total	$189,562

Source: Impact DataSource calculations based on estimated spending in the area

Sales Tax Collections

The states of North Dakota and Minnesota and local taxing districts will collect the following sales tax on construction workers' spending:

Estimated Sales Tax Collections on Construction Workers' Spending			
	States	Local Taxing Districts	Total
Effective sales tax rate	5.33%	1.65%	
Year 1	$1,685	$520	$2,205
Year 2	$1,685	$520	$2,205
Year 3	$1,685	$520	$2,205
Year 4	$1,685	$520	$2,205
Year 5	$1,685	$520	$2,205
Year 6	$1,685	$520	$2,205
Total	$10,108	$3,119	$13,227

Source: Sales tax rates for each state and local taxing districts obtained from each state's department of revenue or local taxing district. Effective sales tax rates, blending the tax rates of two states and several local taxing districts, were determined in calculations by Impact DataSource based on the number of business establishments in Cass and Clay Counties.

Lodging Tax to be Collected

Construction Workers' Spending on Lodging

An estimated 20% of the direct construction workers may be from out-of-town and stay in local motels during construction of the project. If this is the case, there is double occupancy and a nightly room rate at local motels where construction workers stay is $85, then the construction workers from out of town spend the following amounts that will be subject to lodging taxes:

Taxable Lodging Sales	
	Amount
Year 1	$3,557
Year 2	$3,664
Year 3	$3,774
Year 4	$3,887
Year 5	$4,004
Year 6	$4,124
Total	$23,010

Lodging Tax Collections

The states and local taxing districts will collect the following lodging tax on spending by out-of-town construction workers on lodging:

Estimated Lodging Tax Collections on Out-of-Town Construction Workers' Spending on Lodging			
	States	Local Taxing Districts	Total
Effective lodging tax rate	0%	3%	
Year 1	$0	$107	$107
Year 2	$0	$110	$110
Year 3	$0	$113	$113
Year 4	$0	$117	$117
Year 5	$0	$120	$120
Year 6	$0	$124	$124
Total	$0	$690	$690

Source: Lodging taxes for local taxing districts obtained from each state's department of revenue or local taxing district. Effective lodging tax rates, blending the tax rates of multiple local taxing districts, were determined in calculations by Impact DataSource based on the number of business establishments in Cass and Clay Counties.

State Personal Income Taxes to be Collected

During construction, salaries of direct, indirect and induced workers may be subject to North Dakota and Minnesota personal income taxes. If this is the case, the states will collect the following personal income taxes:

Estimated State Personal Income Taxes to be Collected During Construction				
	Total Direct and Indirect Construction Payrolls	Percent of Salaries Subject to State Personal Income Tax	Effective Personal Income Tax Rate as a Percent of Total Income	Total Personal Income Tax Collections
Year 1	$136,769	100%	2.547%	$3,483
Year 2	$136,769	100%	2.547%	$3,483
Year 3	$136,769	100%	2.547%	$3,483
Year 4	$136,769	100%	2.547%	$3,483
Year 5	$136,769	100%	2.547%	$3,483
Year 6	$136,769	100%	2.547%	$3,483
Total	$820,615			$20,898

Source: Personal income tax rates were obtained from each state's department of revenue. Effective state personal income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on median household income in the area and the percentage of labor force in Cass and Clay Counties. The percent of workers whose salaries will be subject to personal income taxes in the two states are Impact DataSource estimates.

State Corporate Income Taxes to be Collected

During construction and equipment installation, an estimated 8% of the total economic output generated by construction activities or business income may be subject to North Dakota or Minnesota corporate income tax. If this is the case, the states will collect the following corporate income taxes during construction:

Estimated Corporate Income Taxes to be Collected During Construction				
	Total Direct and Indirect Construction Spending/ Revenues for Businesses	Percent of Revenues Subject to State Corporate Income Tax	Effective Corporate Income Tax Rate as a Percent of Net Income	Total Corporate Income Tax Collections
Year 1	$203,250	8%	7.003%	$1,139
Year 2	$203,250	8%	7.003%	$1,139
Year 3	$203,250	8%	7.003%	$1,139
Year 4	$203,250	8%	7.003%	$1,139
Year 5	$203,250	8%	7.003%	$1,139
Year 6	$203,250	8%	7.003%	$1,139
Total	$1,219,502			$6,832

Source: Corporate income tax rates were obtained from each state's department of revenue. Effective state corporate income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on the percentage of business establishments in Cass and Clay Counties. The percent of total business revenues that will be subject to state corporation income taxes in the two states are Impact DataSource estimates.

Other Taxes, User Fees, Charges for Services and Miscellaneous Revenues for the States and Local Taxing Districts Collected from Construction Workers

During construction, the states and local taxing districts will collect other taxes, user fees, charges for services, and miscellaneous revenues primarily from workers. These estimated annual revenues to be collected per worker are shown below:

Annual Miscellaneous Revenues Collected Per Worker	
States	$764.41
Local taxing districts	$500

Source: Miscellaneous revenues per worker for states calculated by Impact DataSource from information shown in the general fund budgets of each state along with the number of workers in each state. Further, miscellaneous revenues for each state were blending to obtain an average by Impact DataSource based on relative number of workers in Cass and Clay Counties. Miscellaneous revenues for local taxing districts are Impact DataSource estimates.

If these estimated miscellaneous revenues are received by the states and local taxing districts for each worker and an estimated 70% of the workers may live in the Fargo-Moorhead area, the following revenues will be received during the project's construction:

Estimated Miscellaneous Revenues for the States and Local Taxing Districts During Construction					
	Number of Workers in the States	Number of Local Workers	Miscellaneous Revenues		
			State	Local Taxing Districts	Total
Year 1	1,864	1,305	$1,425	$932	$2,357
Year 2	1,864	1,305	$1,425	$960	$2,385
Year 3	1,864	1,305	$1,425	$989	$2,414
Year 4	1,864	1,305	$1,425	$1,018	$2,443
Year 5	1,864	1,305	$1,425	$1,049	$2,474
Year 6	1,864	1,305	$1,425	$1,081	$2,505
Total			$8,550	$6,029	$14,579

Source: Percent of total direct and indirect construction workers who may live in the Fargo-Moorhead area is an Impact DataSource estimate.

Summary of Taxes and Other Revenues to be Collected by the States and Local Taxing Districts During Construction

Revenues for the States

During construction, the project will generate the following revenues for the states:

Total Revenues for the States During Construction						
	Sales Taxes	Lodging Taxes	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$1,685	$0	$1,139	$3,483	$1,425	$7,731
Year 2	$1,685	$0	$1,139	$3,483	$1,425	$7,731
Year 3	$1,685	$0	$1,139	$3,483	$1,425	$7,731
Year 4	$1,685	$0	$1,139	$3,483	$1,425	$7,731
Year 5	$1,685	$0	$1,139	$3,483	$1,425	$7,731
Year 6	$1,685	$0	$1,139	$3,483	$1,425	$7,731
Total	$10,108	$0	$6,832	$20,898	$8,550	$46,388

Revenues for Local Taxing Districts

During construction, the project will generate the following revenues for local taxing districts:

Total Revenues for Local Taxing District During Construction				
	Sales Taxes	Lodging Taxes	Other Taxes and Revenues	Total Revenues
Year 1	$520	$107	$932	$1,559
Year 2	$520	$110	$960	$1,590
Year 3	$520	$113	$989	$1,622
Year 4	$520	$117	$1,018	$1,655
Year 5	$520	$120	$1,049	$1,689
Year 6	$520	$124	$1,081	$1,724
Total	$3,119	$690	$6,029	$9,838

$487.75

Total Revenues for the States and Local Taxing Districts

During construction, the project will generate the following total revenues for the states and local taxing districts:

Total Revenues for the States and Local Taxing Districts During Construction						
	Sales Tax Collections	Lodging Taxes	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$2,205	$107	$1,139	$3,483	$2,357	$9,290
Year 2	$2,205	$110	$1,139	$3,483	$2,385	$9,321
Year 3	$2,205	$113	$1,139	$3,483	$2,414	$9,353
Year 4	$2,205	$117	$1,139	$3,483	$2,443	$9,386
Year 5	$2,205	$120	$1,139	$3,483	$2,474	$9,420
Year 6	$2,205	$124	$1,139	$3,483	$2,505	$9,455
Total	$13,227	$690	$6,832	$20,898	$14,579	$56,226

Summary of Total Revenues for the States and Local Taxing Districts

During construction, the project will generate the following total revenues for the states and local taxing districts:

Summary of Annual Tax Revenues for the States and Local Taxing Districts During Construction	
States of North Dakota and Minnesota	$2,300
Local taxing districts	$488
Total	$2,788

EXHIBIT D

Local and State Tax Detailed Calculations

– Operations and Maintenance Used for RED Analysis

Operations & Maintenance

Detailed Calculations for State & Local Tax Revenue

North Dakota East 35k cfs

All values are in $1,000

Revenues for the State and Local Taxing Districts During the Project's Operations

Sales Tax to be Collected

Workers' Spending Subject to Sales Tax

An estimated 33% of the spending of direct workers and related indirect workers will be subject to sales taxes. Further, an estimated 80% of this spending will be in the Fargo-Moorhead area. If this is the case, retail sales in the area generated by workers during the project's operations will be as follows.

Taxable Retail Sales in the Area to be Generated by Workers	
Year 1	$316
Year 2	$316
Year 3	$316
Year 4	$316
Year 5	$316
Year 6	$316
Year 7	$316
Year 8	$316
Year 9	$316
Year 10	$316
Year 11	$316
Year 12	$316
Year 13	$316
Year 14	$316
Year 15	$316
Year 16	$316
Year 17	$316
Year 18	$316
Year 19	$316
Year 20	$316
Total	$6,325

Source: Impact DataSource calculations based on estimated spending in the area

Sales Tax Collections

The states of North Dakota and Minnesota and local taxing districts will collect the following sales tax on workers' spending:

Estimated Sales Tax Collections on Workers' Spending			
	States	Local Taxing Districts	Total
Effective sales tax rate	5.33%	1.65%	
Year 1	$17	$5	$22
Year 2	$17	$5	$22
Year 3	$17	$5	$22
Year 4	$17	$5	$22
Year 5	$17	$5	$22
Year 6	$17	$5	$22
Year 7	$17	$5	$22
Year 8	$17	$5	$22
Year 9	$17	$5	$22
Year 10	$17	$5	$22
Year 11	$17	$5	$22
Year 12	$17	$5	$22
Year 13	$17	$5	$22
Year 14	$17	$5	$22
Year 15	$17	$5	$22
Year 16	$17	$5	$22
Year 17	$17	$5	$22
Year 18	$17	$5	$22
Year 19	$17	$5	$22
Year 20	$17	$5	$22
Total	$337	$104	$441

Source: Sales tax rates for each state and local taxing districts obtained from each state's department of revenue or local taxing district. Effective sales tax rates, blending the tax rates of two states and several local taxing districts, were determined in calculations by Impact DataSource based on the number of business establishments in Cass and Clay Counties.

State Personal Income Taxes to be Collected

During the project's operation salaries of all direct, indirect and induced workers may be subject to North Dakota and Minnesota personal income taxes. If this is the case, the states will collect the following personal income taxes:

Estimated State Personal Income Taxes to be Collected During the Project's Operations				
	Total Direct and Indirect Workers' Payrolls	Percent of Salaries Subject to State Personal Income Tax	Effective Personal Income Tax Rate as a Percent of Total Income	Total Personal Income Tax Collections
Year 1	$1,198	100%	2.547%	$31
Year 2	$1,198	100%	2.547%	$31
Year 3	$1,198	100%	2.547%	$31
Year 4	$1,198	100%	2.547%	$31
Year 5	$1,198	100%	2.547%	$31
Year 6	$1,198	100%	2.547%	$31
Year 7	$1,198	100%	2.547%	$31
Year 8	$1,198	100%	2.547%	$31
Year 9	$1,198	100%	2.547%	$31
Year 10	$1,198	100%	2.547%	$31
Year 11	$1,198	100%	2.547%	$31
Year 12	$1,198	100%	2.547%	$31
Year 13	$1,198	100%	2.547%	$31
Year 14	$1,198	100%	2.547%	$31
Year 15	$1,198	100%	2.547%	$31
Year 16	$1,198	100%	2.547%	$31
Year 17	$1,198	100%	2.547%	$31
Year 18	$1,198	100%	2.547%	$31
Year 19	$1,198	100%	2.547%	$31
Year 20	$1,198	100%	2.547%	$31
Total	$23,958			$610

Source: Personal income tax rates were obtained from each state's department of revenue.
Effective state personal income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on median household income in the area and the percentage of labor force in Cass and Clay Counties. The percent of workers whose salaries will be subject to personal income taxes in the two states are Impact DataSource estimates.

State Corporate Income Taxes to be Collected

During the project's operations, an estimated 8% of the total economic output generated by indirect businesses may be subject to North Dakota or Minnesota corporate income taxes. This analysis assumes that a public entity may operate the project and, therefore, its net income will not be subject to state corporate income taxes. If this is the case, the states will collect the following corporate income taxes during the project's operations:

Estimated Corporate Income Taxes to be Collected During the Project's Operations				
	Revenues for Indirect Businesses	Percent of Revenues Subject to State Corporate Income Tax	Effective Corporate Income Tax Rate as a Percent of Net Income	Total Corporate Income Tax Collections
Year 1	$1,141	8%	7.003%	$6
Year 2	$1,141	8%	7.003%	$6
Year 3	$1,141	8%	7.003%	$6
Year 4	$1,141	8%	7.003%	$6
Year 5	$1,141	8%	7.003%	$6
Year 6	$1,141	8%	7.003%	$6
Year 7	$1,141	8%	7.003%	$6
Year 8	$1,141	8%	7.003%	$6
Year 9	$1,141	8%	7.003%	$6
Year 10	$1,141	8%	7.003%	$6
Year 11	$1,141	8%	7.003%	$6
Year 12	$1,141	8%	7.003%	$6
Year 13	$1,141	8%	7.003%	$6
Year 14	$1,141	8%	7.003%	$6
Year 15	$1,141	8%	7.003%	$6
Year 16	$1,141	8%	7.003%	$6
Year 17	$1,141	8%	7.003%	$6
Year 18	$1,141	8%	7.003%	$6
Year 19	$1,141	8%	7.003%	$6
Year 20	$1,141	8%	7.003%	$6
Total	$22,825			$128

Source: Corporate income tax rates were obtained from each state's department of revenue. Effective state corporate income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on the percentage of business establishments in Cass and Clay Counties. The percent of total business revenues that will be subject to state corporation income taxes in the two states are Impact DataSource estimates.

Other Taxes, User Fees, Charges for Services and Miscellaneous Revenues for the States and Local Taxing Districts Collected from Workers

During the project's operations, the states and local taxing districts will collect other taxes, user fees, charges for services, and miscellaneous revenues primarily from workers. These estimated annual revenues to be collected per worker are shown below:

Annual Miscellaneous Revenues Collected Per Worker	
States	$764.41
Local taxing districts	$500

Source: Miscellaneous revenues per worker for states calculated by Impact DataSource from information shown in the general fund budgets of each state along with the number of workers in each state. Further, miscellaneous revenues for each state were blending to obtain an average by Impact DataSource based on relative number of workers in Cass and Clay Counties. Miscellaneous revenues for local taxing districts are Impact DataSource estimates.

If these estimated miscellaneous revenues are received by the states and local taxing districts for each worker and an estimated 80% of the workers may live in the Fargo-Moorhead area, the following revenues will be received during the project's operations:

Estimated Miscellaneous Revenues for the States and Local Taxing Districts During the Project's Operations					
	Number of Workers in the States	Number of Local Workers	Miscellaneous Revenues		
			State	Local Taxing Districts	Total
Year 1	26	21	$20	$11	$31
Year 2	26	21	$20	$11	$31
Year 3	26	21	$20	$11	$31
Year 4	26	21	$20	$11	$31
Year 5	26	21	$20	$11	$31
Year 6	26	21	$20	$11	$31
Year 7	26	21	$20	$11	$31
Year 8	26	21	$20	$11	$31
Year 9	26	21	$20	$11	$31
Year 10	26	21	$20	$11	$31
Year 11	26	21	$20	$11	$31
Year 12	26	21	$20	$11	$31
Year 13	26	21	$20	$11	$31
Year 14	26	21	$20	$11	$31
Year 15	26	21	$20	$11	$31
Year 16	26	21	$20	$11	$31
Year 17	26	21	$20	$11	$31
Year 18	26	21	$20	$11	$31
Year 19	26	21	$20	$11	$31
Year 20	26	21	$20	$11	$31
Total			$403	$211	$614

Source: Percent of total direct and indirect workers who may live in the Fargo-Moorhead area is an Impact DataSource estimate. Annual increases in miscellaneous of 3% are Impact DataSource estimates

Summary of Taxes and Other Revenues to be Collected by the States and Local Taxing Districts During the Project's Operations

Revenues for the States

During the project's operations, the project will generate the following revenues for the states:

Total Revenues for the States During the Project's Operations					
	Sales Taxes	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$17	$6	$31	$20	$74
Year 2	$17	$6	$31	$20	$74
Year 3	$17	$6	$31	$20	$74
Year 4	$17	$6	$31	$20	$74
Year 5	$17	$6	$31	$20	$74
Year 6	$17	$6	$31	$20	$74
Year 7	$17	$6	$31	$20	$74
Year 8	$17	$6	$31	$20	$74
Year 9	$17	$6	$31	$20	$74
Year 10	$17	$6	$31	$20	$74
Year 11	$17	$6	$31	$20	$74
Year 12	$17	$6	$31	$20	$74
Year 13	$17	$6	$31	$20	$74
Year 14	$17	$6	$31	$20	$74
Year 15	$17	$6	$31	$20	$74
Year 16	$17	$6	$31	$20	$74
Year 17	$17	$6	$31	$20	$74
Year 18	$17	$6	$31	$20	$74
Year 19	$17	$6	$31	$20	$74
Year 20	$17	$6	$31	$20	$74
Total	$337	$128	$610	$403	$1,478

Revenues for Local Taxing Districts

During the project's operations, the project will generate the following revenues for local taxing districts:

Total Revenues for Local Taxing District During the Project's Operations			
	Sales Taxes	Other Taxes and Revenues	Total Revenues
Year 1	$5	$11	$16
Year 2	$5	$11	$16
Year 3	$5	$11	$16
Year 4	$5	$11	$16
Year 5	$5	$11	$16
Year 6	$5	$11	$16
Year 7	$5	$11	$16
Year 8	$5	$11	$16
Year 9	$5	$11	$16
Year 10	$5	$11	$16
Year 11	$5	$11	$16
Year 12	$5	$11	$16
Year 13	$5	$11	$16
Year 14	$5	$11	$16
Year 15	$5	$11	$16
Year 16	$5	$11	$16
Year 17	$5	$11	$16
Year 18	$5	$11	$16
Year 19	$5	$11	$16
Year 20	$5	$11	$16
Total	$104	$211	$315

Total Revenues for the States and Local Taxing Districts

During the project's operations, the project will generate the following total revenues for the states and local taxing districts:

Total Revenues for the States and Local Taxing Districts During the Project's Operations					
	Sales Tax Collections	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$22	$6	$31	$31	$90
Year 2	$22	$6	$31	$31	$90
Year 3	$22	$6	$31	$31	$90
Year 4	$22	$6	$31	$31	$90
Year 5	$22	$6	$31	$31	$90
Year 6	$22	$6	$31	$31	$90
Year 7	$22	$6	$31	$31	$90
Year 8	$22	$6	$31	$31	$90
Year 9	$22	$6	$31	$31	$90
Year 10	$22	$6	$31	$31	$90
Year 11	$22	$6	$31	$31	$90
Year 12	$22	$6	$31	$31	$90
Year 13	$22	$6	$31	$31	$90
Year 14	$22	$6	$31	$31	$90
Year 15	$22	$6	$31	$31	$90
Year 16	$22	$6	$31	$31	$90
Year 17	$22	$6	$31	$31	$90
Year 18	$22	$6	$31	$31	$90
Year 19	$22	$6	$31	$31	$90
Year 20	$22	$6	$31	$31	$90
Total	$441	$128	$610	$614	$1,793

Summary of Total Revenues for the States and Local Taxing Districts

During the project's operations, the project will generate the following total revenues for the states and local taxing districts:

Summary of Annual Tax Revenues for the States and Local Taxing Districts During the First Twenty Years of the Project's Operations	
States of North Dakota and Minnesota	$74
Local taxing districts	$16
Total	$90

Operations & Maintenance

Detailed Calculations for State & Local Tax Revenue

Minnesota South 35k cfs

All values are in $1,000

Revenues for the State and Local Taxing Districts During the Project's Operations

Sales Tax to be Collected

Workers' Spending Subject to Sales Tax

An estimated 33% of the spending of direct workers and related indirect workers will be subject to sales taxes. Further, an estimated 80% of this spending will be in the Fargo-Moorhead area. If this is the case, retail sales in the area generated by workers during the project's operations will be as follows.

Taxable Retail Sales in the Area to be Generated by Workers	
Year 1	$302
Year 2	$302
Year 3	$302
Year 4	$302
Year 5	$302
Year 6	$302
Year 7	$302
Year 8	$302
Year 9	$302
Year 10	$302
Year 11	$302
Year 12	$302
Year 13	$302
Year 14	$302
Year 15	$302
Year 16	$302
Year 17	$302
Year 18	$302
Year 19	$302
Year 20	$302
Total	$6,037

Source: Impact DataSource calculations based on estimated spending in the area

Sales Tax Collections

The states of North Dakota and Minnesota and local taxing districts will collect the following sales tax on workers' spending:

Estimated Sales Tax Collections on Workers' Spending			
	States	Local Taxing Districts	Total
Effective sales tax rate	5.33%	1.65%	
Year 1	$16	$5	$21
Year 2	$16	$5	$21
Year 3	$16	$5	$21
Year 4	$16	$5	$21
Year 5	$16	$5	$21
Year 6	$16	$5	$21
Year 7	$16	$5	$21
Year 8	$16	$5	$21
Year 9	$16	$5	$21
Year 10	$16	$5	$21
Year 11	$16	$5	$21
Year 12	$16	$5	$21
Year 13	$16	$5	$21
Year 14	$16	$5	$21
Year 15	$16	$5	$21
Year 16	$16	$5	$21
Year 17	$16	$5	$21
Year 18	$16	$5	$21
Year 19	$16	$5	$21
Year 20	$16	$5	$21
Total	$322	$99	$421

Source: Sales tax rates for each state and local taxing districts obtained from each state's department of revenue or local taxing district. Effective sales tax rates, blending the tax rates of two states and several local taxing districts, were determined in calculations by Impact DataSource based on the number of business establishments in Cass and Clay Counties.

State Personal Income Taxes to be Collected

During the project's operation salaries of direct, indirect and induced workers may be subject to North Dakota and Minnesota personal income taxes. If this is the case, the states will collect the following personal income taxes:

Estimated State Personal Income Taxes to be Collected During the Project's Operations				
	Total Direct and Indirect Workers' Payrolls	Percent of Salaries Subject to State Personal Income Tax	Effective Personal Income Tax Rate as a Percent of Total Income	Total Personal Income Tax Collections
Year 1	$1,143	100%	2.547%	$29
Year 2	$1,143	100%	2.547%	$29
Year 3	$1,143	100%	2.547%	$29
Year 4	$1,143	100%	2.547%	$29
Year 5	$1,143	100%	2.547%	$29
Year 6	$1,143	100%	2.547%	$29
Year 7	$1,143	100%	2.547%	$29
Year 8	$1,143	100%	2.547%	$29
Year 9	$1,143	100%	2.547%	$29
Year 10	$1,143	100%	2.547%	$29
Year 11	$1,143	100%	2.547%	$29
Year 12	$1,143	100%	2.547%	$29
Year 13	$1,143	100%	2.547%	$29
Year 14	$1,143	100%	2.547%	$29
Year 15	$1,143	100%	2.547%	$29
Year 16	$1,143	100%	2.547%	$29
Year 17	$1,143	100%	2.547%	$29
Year 18	$1,143	100%	2.547%	$29
Year 19	$1,143	100%	2.547%	$29
Year 20	$1,143	100%	2.547%	$29
Total	$22,869			$582

Source: Personal income tax rates were obtained from each state's department of revenue.
Effective state personal income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on median household income in the area and the percentage of labor force in Cass and Clay Counties. The percent of workers whose salaries will be subject to personal income taxes in the two states are Impact DataSource estimates.

State Corporate Income Taxes to be Collected

During the project's operations, an estimated 8% of the total economic output generated by indirect businesses may be subject to North Dakota or Minnesota corporate income taxes. This analysis assumes that a public entity may operate the project and, therefore, its net income will not be subject to state corporate income taxes. If this is the case, the states will collect the following corporate income taxes during the project's operations:

Estimated Corporate Income Taxes to be Collected During the Project's Operations				
	Revenues for Indirect Businesses	Percent of Revenues Subject to State Corporate Income Tax	Effective Corporate Income Tax Rate as a Percent of Net Income	Total Corporate Income Tax Collections
Year 1	$1,084	8%	7.003%	$6
Year 2	$1,084	8%	7.003%	$6
Year 3	$1,084	8%	7.003%	$6
Year 4	$1,084	8%	7.003%	$6
Year 5	$1,084	8%	7.003%	$6
Year 6	$1,084	8%	7.003%	$6
Year 7	$1,084	8%	7.003%	$6
Year 8	$1,084	8%	7.003%	$6
Year 9	$1,084	8%	7.003%	$6
Year 10	$1,084	8%	7.003%	$6
Year 11	$1,084	8%	7.003%	$6
Year 12	$1,084	8%	7.003%	$6
Year 13	$1,084	8%	7.003%	$6
Year 14	$1,084	8%	7.003%	$6
Year 15	$1,084	8%	7.003%	$6
Year 16	$1,084	8%	7.003%	$6
Year 17	$1,084	8%	7.003%	$6
Year 18	$1,084	8%	7.003%	$6
Year 19	$1,084	8%	7.003%	$6
Year 20	$1,084	8%	7.003%	$6
Total	$21,685			$121

Source: Corporate income tax rates were obtained from each state's department of revenue. Effective state corporate income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on the percentage of business establishments in Cass and Clay Counties. The percent of total business revenues that will be subject to state corporation income taxes in the two states are Impact DataSource estimates.

Other Taxes, User Fees, Charges for Services and Miscellaneous Revenues for the States and Local Taxing Districts Collected from Workers

During the project's operations, the states and local taxing districts will collect other taxes, user fees, charges for services, and miscellaneous revenues primarily from workers. These estimated annual revenues to be collected per worker are shown below:

Annual Miscellaneous Revenues Collected Per Worker	
States	$764.41
Local taxing districts	$500

Source: Miscellaneous revenues per worker for states calculated by Impact DataSource from information shown in the general fund budgets of each state along with the number of workers in each state. Further, miscellaneous revenues for each state were blending to obtain an average by Impact DataSource based on relative number of workers in Cass and Clay Counties. Miscellaneous revenues for local taxing districts are Impact DataSource estimates.

If these estimated miscellaneous revenues are received by the states and local taxing districts for each worker and an estimated 80% of the workers may live in the Fargo-Moorhead area, the following revenues will be received during the project's operations:

Estimated Miscellaneous Revenues for the States and Local Taxing Districts During the Project's Operations					
	Number of Workers in the States	Number of Local Workers	Miscellaneous Revenues		
			State	Local Taxing Districts	Total
Year 1	25	20	$19	$10	$29
Year 2	25	20	$19	$10	$29
Year 3	25	20	$19	$10	$29
Year 4	25	20	$19	$10	$29
Year 5	25	20	$19	$10	$29
Year 6	25	20	$19	$10	$29
Year 7	25	20	$19	$10	$29
Year 8	25	20	$19	$10	$29
Year 9	25	20	$19	$10	$29
Year 10	25	20	$19	$10	$29
Year 11	25	20	$19	$10	$29
Year 12	25	20	$19	$10	$29
Year 13	25	20	$19	$10	$29
Year 14	25	20	$19	$10	$29
Year 15	25	20	$19	$10	$29
Year 16	25	20	$19	$10	$29
Year 17	25	20	$19	$10	$29
Year 18	25	20	$19	$10	$29
Year 19	25	20	$19	$10	$29
Year 20	25	20	$19	$10	$29
Total			$384	$201	$586

Source: Percent of total direct and indirect workers who may live in the Fargo-Moorhead area is an Impact DataSource estimate. Annual increases in miscellaneous of 3% are Impact DataSource estimates

Summary of Taxes and Other Revenues to be Collected by the States and Local Taxing Districts During the Project's Operations

Revenues for the States

During the project's operations, the project will generate the following revenues for the states:

Total Revenues for the States During the Project's Operations					
	Sales Taxes	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$16	$6	$29	$19	$71
Year 2	$16	$6	$29	$19	$71
Year 3	$16	$6	$29	$19	$71
Year 4	$16	$6	$29	$19	$71
Year 5	$16	$6	$29	$19	$71
Year 6	$16	$6	$29	$19	$71
Year 7	$16	$6	$29	$19	$71
Year 8	$16	$6	$29	$19	$71
Year 9	$16	$6	$29	$19	$71
Year 10	$16	$6	$29	$19	$71
Year 11	$16	$6	$29	$19	$71
Year 12	$16	$6	$29	$19	$71
Year 13	$16	$6	$29	$19	$71
Year 14	$16	$6	$29	$19	$71
Year 15	$16	$6	$29	$19	$71
Year 16	$16	$6	$29	$19	$71
Year 17	$16	$6	$29	$19	$71
Year 18	$16	$6	$29	$19	$71
Year 19	$16	$6	$29	$19	$71
Year 20	$16	$6	$29	$19	$71
Total	$322	$121	$582	$384	$1,410

Revenues for Local Taxing Districts

During the project's operations, the project will generate the following revenues for local taxing districts:

Total Revenues for Local Taxing District During the Project's Operations			
	Sales Taxes	Other Taxes and Revenues	Total Revenues
Year 1	$5	$10	$15
Year 2	$5	$10	$15
Year 3	$5	$10	$15
Year 4	$5	$10	$15
Year 5	$5	$10	$15
Year 6	$5	$10	$15
Year 7	$5	$10	$15
Year 8	$5	$10	$15
Year 9	$5	$10	$15
Year 10	$5	$10	$15
Year 11	$5	$10	$15
Year 12	$5	$10	$15
Year 13	$5	$10	$15
Year 14	$5	$10	$15
Year 15	$5	$10	$15
Year 16	$5	$10	$15
Year 17	$5	$10	$15
Year 18	$5	$10	$15
Year 19	$5	$10	$15
Year 20	$5	$10	$15
Total	$99	$201	$301

Total Revenues for the States and Local Taxing Districts

During the project's operations, the project will generate the following total revenues for the states and local taxing districts:

Total Revenues for the States and Local Taxing Districts During the Project's Operations					
	Sales Tax Collections	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$21	$6	$29	$29	$86
Year 2	$21	$6	$29	$29	$86
Year 3	$21	$6	$29	$29	$86
Year 4	$21	$6	$29	$29	$86
Year 5	$21	$6	$29	$29	$86
Year 6	$21	$6	$29	$29	$86
Year 7	$21	$6	$29	$29	$86
Year 8	$21	$6	$29	$29	$86
Year 9	$21	$6	$29	$29	$86
Year 10	$21	$6	$29	$29	$86
Year 11	$21	$6	$29	$29	$86
Year 12	$21	$6	$29	$29	$86
Year 13	$21	$6	$29	$29	$86
Year 14	$21	$6	$29	$29	$86
Year 15	$21	$6	$29	$29	$86
Year 16	$21	$6	$29	$29	$86
Year 17	$21	$6	$29	$29	$86
Year 18	$21	$6	$29	$29	$86
Year 19	$21	$6	$29	$29	$86
Year 20	$21	$6	$29	$29	$86
Total	$421	$121	$582	$586	$1,711

Summary of Total Revenues for the States and Local Taxing Districts

During the project's operations, the project will generate the following total revenues for the states and local taxing districts:

Summary of Annual Tax Revenues for the States and Local Taxing Districts During the First Twenty Years of the Project's Operations	
States of North Dakota and Minnesota	$71
Local taxing districts	$15
Total	$86

Operations & Maintenance

Detailed Calculations for State & Local Tax Revenue

Minnesota South 20k cfs

All values are in $1,000

Revenues for the State and Local Taxing Districts During the Project's Operations

Sales Tax to be Collected

Workers' Spending Subject to Sales Tax

An estimated 33% of the spending of direct workers and related indirect workers will be subject to sales taxes. Further, an estimated 80% of this spending will be in the Fargo-Moorhead area. If this is the case, retail sales in the area generated by workers during the project's operations will be as follows.

Taxable Retail Sales in the Area to be Generated by Workers	
Year 1	$230
Year 2	$230
Year 3	$230
Year 4	$230
Year 5	$230
Year 6	$230
Year 7	$230
Year 8	$230
Year 9	$230
Year 10	$230
Year 11	$230
Year 12	$230
Year 13	$230
Year 14	$230
Year 15	$230
Year 16	$230
Year 17	$230
Year 18	$230
Year 19	$230
Year 20	$230
Total	$4,600

Source: Impact DataSource calculations based on estimated spending in the area

Sales Tax Collections

The states of North Dakota and Minnesota and local taxing districts will collect the following sales tax on workers' spending:

Estimated Sales Tax Collections on Workers' Spending			
	States	Local Taxing Districts	Total
Effective sales tax rate	5.33%	1.65%	
Year 1	$12	$4	$16
Year 2	$12	$4	$16
Year 3	$12	$4	$16
Year 4	$12	$4	$16
Year 5	$12	$4	$16
Year 6	$12	$4	$16
Year 7	$12	$4	$16
Year 8	$12	$4	$16
Year 9	$12	$4	$16
Year 10	$12	$4	$16
Year 11	$12	$4	$16
Year 12	$12	$4	$16
Year 13	$12	$4	$16
Year 14	$12	$4	$16
Year 15	$12	$4	$16
Year 16	$12	$4	$16
Year 17	$12	$4	$16
Year 18	$12	$4	$16
Year 19	$12	$4	$16
Year 20	$12	$4	$16
Total	$245	$76	$321

Source: Sales tax rates for each state and local taxing districts obtained from each state's department of revenue or local taxing district. Effective sales tax rates, blending the tax rates of two states and several local taxing districts, were determined in calculations by Impact DataSource based on the number of business establishments in Cass and Clay Counties.

State Personal Income Taxes to be Collected

During the project's operation salaries of direct, indirect and induced workers may be subject to North Dakota and Minnesota personal income taxes. If this is the case, the states will collect the following personal income taxes:

Estimated State Personal Income Taxes to be Collected During the Project's Operations				
	Total Direct and Indirect Workers' Payrolls	Percent of Salaries Subject to State Personal Income Tax	Effective Personal Income Tax Rate as a Percent of Total Income	Total Personal Income Tax Collections
Year 1	$871	100%	2.547%	$22
Year 2	$871	100%	2.547%	$22
Year 3	$871	100%	2.547%	$22
Year 4	$871	100%	2.547%	$22
Year 5	$871	100%	2.547%	$22
Year 6	$871	100%	2.547%	$22
Year 7	$871	100%	2.547%	$22
Year 8	$871	100%	2.547%	$22
Year 9	$871	100%	2.547%	$22
Year 10	$871	100%	2.547%	$22
Year 11	$871	100%	2.547%	$22
Year 12	$871	100%	2.547%	$22
Year 13	$871	100%	2.547%	$22
Year 14	$871	100%	2.547%	$22
Year 15	$871	100%	2.547%	$22
Year 16	$871	100%	2.547%	$22
Year 17	$871	100%	2.547%	$22
Year 18	$871	100%	2.547%	$22
Year 19	$871	100%	2.547%	$22
Year 20	$871	100%	2.547%	$22
Total	$17,424			$444

Source: Personal income tax rates were obtained from each state's department of revenue.
Effective state personal income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on median household income in the area and the percentage of labor force in Cass and Clay Counties. The percent of workers whose salaries will be subject to personal income taxes in the two states are Impact DataSource estimates.

State Corporate Income Taxes to be Collected

During the project's operations, an estimated 8% of the total economic output generated by indirect businesses may be subject to North Dakota or Minnesota corporate income taxes. This analysis assumes that a public entity may operate the project and, therefore, its net income will not be subject to state corporate income taxes. If this is the case, the states will collect the following corporate income taxes during the project's operations:

Estimated Corporate Income Taxes to be Collected During the Project's Operations				
	Revenues for Indirect Businesses	Percent of Revenues Subject to State Corporate Income Tax	Effective Corporate Income Tax Rate as a Percent of Net Income	Total Corporate Income Tax Collections
Year 1	$829	8%	7.003%	$5
Year 2	$829	8%	7.003%	$5
Year 3	$829	8%	7.003%	$5
Year 4	$829	8%	7.003%	$5
Year 5	$829	8%	7.003%	$5
Year 6	$829	8%	7.003%	$5
Year 7	$829	8%	7.003%	$5
Year 8	$829	8%	7.003%	$5
Year 9	$829	8%	7.003%	$5
Year 10	$829	8%	7.003%	$5
Year 11	$829	8%	7.003%	$5
Year 12	$829	8%	7.003%	$5
Year 13	$829	8%	7.003%	$5
Year 14	$829	8%	7.003%	$5
Year 15	$829	8%	7.003%	$5
Year 16	$829	8%	7.003%	$5
Year 17	$829	8%	7.003%	$5
Year 18	$829	8%	7.003%	$5
Year 19	$829	8%	7.003%	$5
Year 20	$829	8%	7.003%	$5
Total	$16,577			$93

Source: Corporate income tax rates were obtained from each state's department of revenue. Effective state corporate income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on the percentage of business establishments in Cass and Clay Counties. The percent of total business revenues that will be subject to state corporation income taxes in the two states are Impact DataSource estimates.

Other Taxes, User Fees, Charges for Services and Miscellaneous Revenues for the States and Local Taxing Districts Collected from Workers

During the project's operations, the states and local taxing districts will collect other taxes, user fees, charges for services, and miscellaneous revenues primarily from workers. These estimated annual revenues to be collected per worker are shown below:

Annual Miscellaneous Revenues Collected Per Worker	
States	$764.41
Local taxing districts	$500

Source: Miscellaneous revenues per worker for states calculated by Impact DataSource from information shown in the general fund budgets of each state along with the number of workers in each state. Further, miscellaneous revenues for each state were blending to obtain an average by Impact DataSource based on relative number of workers in Cass and Clay Counties. Miscellaneous revenues for local taxing districts are Impact DataSource estimates.

If these estimated miscellaneous revenues are received by the states and local taxing districts for each worker and an estimated 80% of the workers may live in the Fargo-Moorhead area, the following revenues will be received during the project's operations:

Estimated Miscellaneous Revenues for the States and Local Taxing Districts During the Project's Operations					
			Miscellaneous Revenues		
	Number of Workers in the States	Number of Local Workers	State	Local Taxing Districts	Total
Year 1	19	15	$15	$8	$22
Year 2	19	15	$15	$8	$22
Year 3	19	15	$15	$8	$22
Year 4	19	15	$15	$8	$22
Year 5	19	15	$15	$8	$22
Year 6	19	15	$15	$8	$22
Year 7	19	15	$15	$8	$22
Year 8	19	15	$15	$8	$22
Year 9	19	15	$15	$8	$22
Year 10	19	15	$15	$8	$22
Year 11	19	15	$15	$8	$22
Year 12	19	15	$15	$8	$22
Year 13	19	15	$15	$8	$22
Year 14	19	15	$15	$8	$22
Year 15	19	15	$15	$8	$22
Year 16	19	15	$15	$8	$22
Year 17	19	15	$15	$8	$22
Year 18	19	15	$15	$8	$22
Year 19	19	15	$15	$8	$22
Year 20	19	15	$15	$8	$22
Total			$293	$153	$446

Source: Percent of total direct and indirect workers who may live in the Fargo-Moorhead area is an Impact DataSource estimate. Annual increases in miscellaneous of 3% are Impact DataSource estimates

Summary of Taxes and Other Revenues to be Collected by the States and Local Taxing Districts During the Project's Operations

Revenues for the States

During the project's operations, the project will generate the following revenues for the states:

Total Revenues for the States During the Project's Operations					
	Sales Taxes	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$12	$5	$22	$15	$54
Year 2	$12	$5	$22	$15	$54
Year 3	$12	$5	$22	$15	$54
Year 4	$12	$5	$22	$15	$54
Year 5	$12	$5	$22	$15	$54
Year 6	$12	$5	$22	$15	$54
Year 7	$12	$5	$22	$15	$54
Year 8	$12	$5	$22	$15	$54
Year 9	$12	$5	$22	$15	$54
Year 10	$12	$5	$22	$15	$54
Year 11	$12	$5	$22	$15	$54
Year 12	$12	$5	$22	$15	$54
Year 13	$12	$5	$22	$15	$54
Year 14	$12	$5	$22	$15	$54
Year 15	$12	$5	$22	$15	$54
Year 16	$12	$5	$22	$15	$54
Year 17	$12	$5	$22	$15	$54
Year 18	$12	$5	$22	$15	$54
Year 19	$12	$5	$22	$15	$54
Year 20	$12	$5	$22	$15	$54
Total	$245	$93	$444	$293	$1,075

Revenues for Local Taxing Districts

During the project's operations, the project will generate the following revenues for local taxing districts:

Total Revenues for Local Taxing District During the Project's Operations			
	Sales Taxes	Other Taxes and Revenues	Total Revenues
Year 1	$4	$8	$11
Year 2	$4	$8	$11
Year 3	$4	$8	$11
Year 4	$4	$8	$11
Year 5	$4	$8	$11
Year 6	$4	$8	$11
Year 7	$4	$8	$11
Year 8	$4	$8	$11
Year 9	$4	$8	$11
Year 10	$4	$8	$11
Year 11	$4	$8	$11
Year 12	$4	$8	$11
Year 13	$4	$8	$11
Year 14	$4	$8	$11
Year 15	$4	$8	$11
Year 16	$4	$8	$11
Year 17	$4	$8	$11
Year 18	$4	$8	$11
Year 19	$4	$8	$11
Year 20	$4	$8	$11
Total	$76	$153	$229

Total Revenues for the States and Local Taxing Districts

During the project's operations, the project will generate the following total revenues for the states and local taxing districts:

Total Revenues for the States and Local Taxing Districts During the Project's Operations					
	Sales Tax Collections	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$16	$5	$22	$22	$65
Year 2	$16	$5	$22	$22	$65
Year 3	$16	$5	$22	$22	$65
Year 4	$16	$5	$22	$22	$65
Year 5	$16	$5	$22	$22	$65
Year 6	$16	$5	$22	$22	$65
Year 7	$16	$5	$22	$22	$65
Year 8	$16	$5	$22	$22	$65
Year 9	$16	$5	$22	$22	$65
Year 10	$16	$5	$22	$22	$65
Year 11	$16	$5	$22	$22	$65
Year 12	$16	$5	$22	$22	$65
Year 13	$16	$5	$22	$22	$65
Year 14	$16	$5	$22	$22	$65
Year 15	$16	$5	$22	$22	$65
Year 16	$16	$5	$22	$22	$65
Year 17	$16	$5	$22	$22	$65
Year 18	$16	$5	$22	$22	$65
Year 19	$16	$5	$22	$22	$65
Year 20	$16	$5	$22	$22	$65
Total	$321	$93	$444	$446	$1,304

Summary of Total Revenues for the States and Local Taxing Districts

During the project's operations, the project will generate the following total revenues for the states and local taxing districts:

Summary of Annual Tax Revenues for the States and Local Taxing Districts During the First Twenty Years of the Project's Operations	
States of North Dakota and Minnesota	$54
Local taxing districts	$11
Total	$65

EXHIBIT E

Local and State Tax Detailed Calculations

– Avoided Flood Damages Used for RED Analysis

Avoided Flood Losses

Detailed Calculations for State & Local Tax Revenue

All values are in $1,000

Reduction of State and Local Tax Revenue from Loss of Business Income

Assuming that 33% of earnings would have been used to purchase taxable items and workers would have made 80% of such purchases in the area, the table below calculates the reduction in States and Locals sales tax revenue.

Reduction in States and Local Sales Tax Revenue in the Fargo-Moorhead Region Due to Loss of Business Income				
	Existing	Diversion Project		
	Conditions	ND E 35k	MN S 35k	MN S 20k
Reduction in Taxable Spending	$8,419	$0	$0	$0
States Sales Tax (effective sales tax rate 5.33%)	$449	$0	$0	$0
Local Sales Tax (effective sales tax rate 1.65%)	$139	$0	$0	$0

Based on workers' lost earnings, the table below calculates the loss in states personal income tax.

Reduction in States and Local Personal Income Tax Revenue in the Fargo-Moorhead Region Due to Loss of Business Income				
	Existing	Diversion Project		
	Conditions	ND E 35k	MN S 35k	MN S 20k
Workers' Loss in Income	$31,891	$0	$0	$0
States Personal Income Tax (effective sales tax rate 2.55%)	$812	$0	$0	$0

Based the reduction in output, the table below calculates the loss in states corporate income tax.

Reduction in States and Local Personal Income Tax Revenue in the Fargo-Moorhead Region Due to Loss of Business Income				
	Existing	Diversion Project		
	Conditions	ND E 35k	MN S 35k	MN S 20k
Reduction in Output	$87,468	$0	$0	$0
Reduction Taxable Corporate Income (assumed to be 8% of Output)	$6,997	$0	$0	$0
States Corporate Income Tax (effective corporate income tax rate 7.003%)	$490	$0	$0	$0

Based on the reduction in employment, the reduction in miscellaneous tax revenue is calculated below.

Reduction in States and Local Miscellaneous Tax Revenue in the Fargo-Moorhead Region Due to Loss of Business Income				
	Existing	Diversion Project		
	Conditions	ND E 35k	MN S 35k	MN S 20k
Reduction in employment in region	913	0	0	0
States Miscellaneous Tax Revenue ($764 per worker)	$698	$0	$0	$0
Local Miscellaneous Tax Revenue ($500 per worker)	$457	$0	$0	$0

The table below summarizes the total loss in states and local tax revenues due to loss of business income.

Total Increase in States and Local Tax Revenue in the Fargo-Moorhead Region Due to Loss of Business Income				
	Existing	Diversion Project		
	Conditions	ND E 35k	MN S 35k	MN S 20k
Reduction in States Tax Revenue	$2,449	$0	$0	$0
Reduction in Local Tax Revenue	$595	$0	$0	$0
Total Reduction in States and Local Tax Revenue	$3,044	$0	$0	$0

Increase of State and Local Tax Revenue from Reconstruction

Assuming that 33% of earnings are used to purchase taxable items and workers would have made 80% of such purchases in the area, the table below calculates the Increase in States and Locals sales tax revenue.

Increase in States and Local Sales Tax Revenue in the Fargo-Moorhead Region Due to Reconstruction				
	Existing	Diversion Project		
	Conditions	ND E 35k	MN S 35k	MN S 20k
Increase in Taxable Spending	$3,103	$403	$568	$949
States Sales Tax (effective sales tax rate 5.33%)	$165	$21	$30	$51
Local Sales Tax (effective sales tax rate 1.65%)	$51	$7	$9	$16

Based on the additional earnings, the table below calculates the loss in states personal income tax.

Increase in States Personal Income Tax Revenue in the Fargo-Moorhead Region Due to Reconstruction				
	Existing	Diversion Project		
	Conditions	ND E 35k	MN S 35k	MN S 20k
Increase in earnings in region	$11,752	$1,526	$2,152	$3,594
States Personal Income Tax (effective sales tax rate 2.55%)	$299	$39	$55	$92

Based the increase in output, the table below calculates the increase in states corporate income tax.

Increase in States Corporate Income Tax Revenue in the Fargo-Moorhead Region Due to Loss of Business Income				
	Existing	Diversion Project		
	Conditions	ND E 35k	MN S 35k	MN S 20k
Increase in Output	$32,233	$4,186	$5,902	$9,858
Increase Taxable Corporate Income (assumed to be 8% of Output)	$2,579	$335	$472	$789
States Corporate Income Tax (effective corporate income tax rate 7.003%)	$181	$23	$33	$55

Based on the increase in employment, the increase in miscellaneous tax revenue is calculated below.

Increase in States and Local Miscellaneous Tax Revenue in the Fargo-Moorhead Region Due to Reconstruction				
	Existing	Diversion Project		
	Conditions	ND E 35k	MN S 35k	MN S 20k
Increase in employment in region	337	44	62	103
States Miscellaneous Tax Revenue ($764 per worker)	$257	$33	$47	$79
Local Miscellaneous Tax Revenue ($500 per worker)	$168	$22	$31	$51

The table below summarizes the total increase in states and local tax revenues due to reconstruction

Total Increase in States and Local Tax Revenue in the Fargo-Moorhead Region Due to Reconstruction				
	Existing	Diversion Project		
	Conditions	ND E 35k	MN S 35k	MN S 20k
Increase in States Tax Revenue	$903	$94	$132	$221
Increase in Local Tax Revenue	$219	$28	$40	$67
Total Increase in States and Local Tax Revenue	$1,122	$122	$172	$288

Summary of Changes in State and Local Tax Revenue

Total Increase in States and Local Tax Revenue in the Fargo-Moorhead Region Due to Reconstruction				
	Existing	Diversion Project		
	Conditions	ND E 35k	MN S 35k	MN S 20k
Increase in States Tax Revenue	$1,547	-$94	-$132	-$221
Increase in Local Tax Revenue	$376	-$28	-$40	-$67
Total Increase in States and Local Tax Revenue	$1,923	-$122	-$172	-$288

EXHIBIT F
Local and State Tax Detailed Calculations
– Loss of Business Confidence

Loss of Business Confidence

Detailed Calculations for State & Local Tax Revenue

All values are in $1,000

Economic Growth for Case 1: No Diversion, Conservative Growth

The table below translate the GDP growth into job and salary growth using RIMS II multipliers for the region for Case 1. Our projections begin in 2010.

Economic Impacts for Fargo MSA Case 1: No Diversion: Conservative Growth			
	Additional Output (MSA GDP)	Additional Employment*	Additional Earnings*
Year 1	$134,236	1,402	$48,943
Year 2	$135,968	1,410	$49,574
Year 3	$137,722	1,418	$50,214
Year 4	$139,498	1,426	$50,862
Year 5	$141,298	1,434	$51,518
Year 6	$143,121	1,442	$52,182
Year 7	$144,967	1,450	$52,855
Year 8	$146,837	1,458	$53,537
Year 9	$148,731	1,467	$54,228
Year 10	$150,650	1,475	$54,927
Year 11	$152,593	1,483	$55,636
Year 12	$154,562	1,492	$56,354
Year 13	$156,556	1,500	$57,081
Year 14	$158,575	1,509	$57,817
Year 15	$160,621	1,517	$58,563
Year 16	$162,693	1,526	$59,318
Year 17	$164,791	1,534	$60,084
Year 18	$166,917	1,543	$60,859
Year 19	$169,070	1,552	$61,644
Year 20	$171,252	1,561	$62,439

Revenues for the State and Local Taxing Districts for Case 1: No Diversion, Conservative Growth

Sales Tax to be Collected

Additional Workers' Spending Subject to Sales Tax

An estimated 33% of the spending of additional workers will be subject to sales taxes. Further, an estimated 80% of this spending will be in the Fargo-Moorhead area. If this is the case, retail sales in the area resulting from the general economic growth will be as follows:

Taxable Retail Sales in the Area to be Generated by Growth	
Year 1	$12,921
Year 2	$13,088
Year 3	$13,256
Year 4	$13,427
Year 5	$13,601
Year 6	$13,776
Year 7	$13,954
Year 8	$14,134
Year 9	$14,316
Year 10	$14,501
Year 11	$14,688
Year 12	$14,877
Year 13	$15,069
Year 14	$15,264
Year 15	$15,461
Year 16	$15,660
Year 17	$15,862
Year 18	$16,067
Year 19	$16,274
Year 20	$16,484
Total	$292,680

Source: Impact DataSource calculations based on estimated spending in the area

Sales Tax Collections

The states of North Dakota and Minnesota and local taxing districts will collect the following sales tax on workers' spending:

Estimated Sales Tax Collections on Workers' Spending			
	States	Local Taxing Districts	Total
Effective sales tax rate	5.33%	1.65%	
Year 1	$689	$213	$902
Year 2	$698	$215	$913
Year 3	$707	$218	$925
Year 4	$716	$221	$937
Year 5	$725	$224	$949
Year 6	$735	$227	$961
Year 7	$744	$230	$974
Year 8	$754	$233	$986
Year 9	$763	$236	$999
Year 10	$773	$239	$1,012
Year 11	$783	$242	$1,025
Year 12	$793	$245	$1,038
Year 13	$804	$248	$1,052
Year 14	$814	$251	$1,065
Year 15	$824	$254	$1,079
Year 16	$835	$258	$1,093
Year 17	$846	$261	$1,107
Year 18	$857	$264	$1,121
Year 19	$868	$268	$1,136
Year 20	$879	$271	$1,150
Total	$15,607	$4,815	$20,423

Source: Sales tax rates for each state and local taxing districts obtained from each state's department of revenue or local taxing district. Effective sales tax rates, blending the tax rates of two states and several local taxing districts, were determined in calculations by Impact DataSource based on the number of business establishments in Cass and Clay Counties.

State Personal Income Taxes to be Collected

As a result of the economic growth in this scenario, additional workers' salaries will be subject to North Dakota and Minnesota personal income taxes. It is projected the states will collect the following personal income taxes:

Estimated State Personal Income Taxes to be Collected				
	Additional Workers' Salaries	Percent of Salaries Subject to State Personal Income Tax	Effective Personal Income Tax Rate as a Percent of Total Income	Total Personal Income Tax Collections
Year 1	$48,943	100%	2.547%	$1,246
Year 2	$49,574	100%	2.547%	$1,262
Year 3	$50,214	100%	2.547%	$1,279
Year 4	$50,862	100%	2.547%	$1,295
Year 5	$51,518	100%	2.547%	$1,312
Year 6	$52,182	100%	2.547%	$1,329
Year 7	$52,855	100%	2.547%	$1,346
Year 8	$53,537	100%	2.547%	$1,363
Year 9	$54,228	100%	2.547%	$1,381
Year 10	$54,927	100%	2.547%	$1,399
Year 11	$55,636	100%	2.547%	$1,417
Year 12	$56,354	100%	2.547%	$1,435
Year 13	$57,081	100%	2.547%	$1,454
Year 14	$57,817	100%	2.547%	$1,472
Year 15	$58,563	100%	2.547%	$1,491
Year 16	$59,318	100%	2.547%	$1,511
Year 17	$60,084	100%	2.547%	$1,530
Year 18	$60,859	100%	2.547%	$1,550
Year 19	$61,644	100%	2.547%	$1,570
Year 20	$62,439	100%	2.547%	$1,590
Total	$1,108,635			$28,232

Source: Personal income tax rates were obtained from each state's department of revenue.
Effective state personal income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on median household income in the area and the percentage of labor force in Cass and Clay Counties. The percent of workers whose salaries will be subject to personal income taxes in the two states are Impact DataSource estimates.

State Corporate Income Taxes to be Collected

As a result of economic growth in this scenario, an estimated 8% of the total economic output will be subject to North Dakota or Minnesota corporate income taxes. If this is the case, the states will collect the following corporate income taxes over the next twenty years:

Estimated Corporate Income Taxes to be Collected				
	Additional Output (MSA GDP)	Percent of Revenues Subject to State Corporate Income Tax	Effective Corporate Income Tax Rate as a Percent of Net Income	Total Corporate Income Tax Collections
Year 1	$134,236	8%	7.003%	$752
Year 2	$135,968	8%	7.003%	$762
Year 3	$137,722	8%	7.003%	$772
Year 4	$139,498	8%	7.003%	$782
Year 5	$141,298	8%	7.003%	$792
Year 6	$143,121	8%	7.003%	$802
Year 7	$144,967	8%	7.003%	$812
Year 8	$146,837	8%	7.003%	$823
Year 9	$148,731	8%	7.003%	$833
Year 10	$150,650	8%	7.003%	$844
Year 11	$152,593	8%	7.003%	$855
Year 12	$154,562	8%	7.003%	$866
Year 13	$156,556	8%	7.003%	$877
Year 14	$158,575	8%	7.003%	$888
Year 15	$160,621	8%	7.003%	$900
Year 16	$162,693	8%	7.003%	$911
Year 17	$164,791	8%	7.003%	$923
Year 18	$166,917	8%	7.003%	$935
Year 19	$169,070	8%	7.003%	$947
Year 20	$171,252	8%	7.003%	$959
Total	$3,040,658			$17,035

Source: Corporate income tax rates were obtained from each state's department of revenue. Effective state corporate income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on the percentage of business establishments in Cass and Clay Counties. The percent of total business revenues that will be subject to state corporation income taxes in the two states are Impact DataSource estimates.

Other Taxes, User Fees, Charges for Services and Miscellaneous Revenues for the States and Local Taxing Districts Collected from Workers

Over the next twenty years, the states and local taxing districts will collect other taxes, user fees, charges for services, and miscellaneous revenues primarily from workers. These estimated annual revenues to be collected per worker are shown below:

Annual Miscellaneous Revenues Collected Per Worker	
States	$764.41
Local taxing districts	$500

Source: Miscellaneous revenues per worker for states calculated by Impact DataSource from information shown in the general fund budgets of each state along with the number of workers in each state. Further, miscellaneous revenues for each state were blending to obtain an average by Impact DataSource based on relative number of workers in Cass and Clay Counties. Miscellaneous revenues for local taxing districts are Impact DataSource estimates.

If these estimated miscellaneous revenues are received by the states and local taxing districts for each additional worker under this scenario, the following revenues will be received:

Estimated Miscellaneous Revenues for the States and Local Taxing Districts				
		Miscellaneous Revenues		
	Number of Local Workers	State	Local Taxing Districts	Total
Year 1	1,402	$1,071	$701	$1,772
Year 2	1,410	$1,110	$726	$1,836
Year 3	1,418	$1,150	$752	$1,902
Year 4	1,426	$1,191	$779	$1,970
Year 5	1,434	$1,233	$807	$2,040
Year 6	1,442	$1,278	$836	$2,113
Year 7	1,450	$1,323	$866	$2,189
Year 8	1,458	$1,371	$897	$2,268
Year 9	1,467	$1,420	$929	$2,349
Year 10	1,475	$1,471	$962	$2,433
Year 11	1,483	$1,524	$997	$2,520
Year 12	1,492	$1,578	$1,032	$2,611
Year 13	1,500	$1,635	$1,069	$2,704
Year 14	1,509	$1,694	$1,108	$2,801
Year 15	1,517	$1,754	$1,147	$2,902
Year 16	1,526	$1,817	$1,189	$3,006
Year 17	1,534	$1,882	$1,231	$3,113
Year 18	1,543	$1,950	$1,275	$3,225
Year 19	1,552	$2,020	$1,321	$3,341
Year 20	1,561	$2,092	$1,368	$3,460
Total		$30,563	$19,992	$50,555

Source: Percent of total direct and indirect workers who may live in the Fargo-Moorhead area is an Impact DataSource estimate. Annual increases in miscellaneous of 3% are Impact DataSource estimates

Summary of Taxes and Other Revenues to be Collected by the States and Local Taxing Districts for Case 1

Revenues for the States

The table below summarizes the projected revenues for states under Case 1.

Total Revenues for the States for Case 1: No Diversion, Conservative Growth					
	Sales Taxes	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$689	$752	$1,246	$1,071	$3,759
Year 2	$698	$762	$1,262	$1,110	$3,832
Year 3	$707	$772	$1,279	$1,150	$3,907
Year 4	$716	$782	$1,295	$1,191	$3,984
Year 5	$725	$792	$1,312	$1,233	$4,062
Year 6	$735	$802	$1,329	$1,278	$4,143
Year 7	$744	$812	$1,346	$1,323	$4,226
Year 8	$754	$823	$1,363	$1,371	$4,311
Year 9	$763	$833	$1,381	$1,420	$4,398
Year 10	$773	$844	$1,399	$1,471	$4,487
Year 11	$783	$855	$1,417	$1,524	$4,579
Year 12	$793	$866	$1,435	$1,578	$4,673
Year 13	$804	$877	$1,454	$1,635	$4,769
Year 14	$814	$888	$1,472	$1,694	$4,868
Year 15	$824	$900	$1,491	$1,754	$4,970
Year 16	$835	$911	$1,511	$1,817	$5,074
Year 17	$846	$923	$1,530	$1,882	$5,181
Year 18	$857	$935	$1,550	$1,950	$5,291
Year 19	$868	$947	$1,570	$2,020	$5,404
Year 20	$879	$959	$1,590	$2,092	$5,520
Total	$15,607	$17,035	$28,232	$30,563	$91,438

Revenues for Local Taxing Districts

The table below summarizes the projected revenues for local taxing districts under Case 1.

Total Revenues for Local Taxing Districts for Case 1: No Diversion, Conservative Growth			
	Sales Taxes	Other Taxes and Revenues	Total Revenues
Year 1	$213	$701	$913
Year 2	$215	$726	$941
Year 3	$218	$752	$970
Year 4	$221	$779	$1,000
Year 5	$224	$807	$1,031
Year 6	$227	$836	$1,062
Year 7	$230	$866	$1,095
Year 8	$233	$897	$1,129
Year 9	$236	$929	$1,164
Year 10	$239	$962	$1,201
Year 11	$242	$997	$1,238
Year 12	$245	$1,032	$1,277
Year 13	$248	$1,069	$1,317
Year 14	$251	$1,108	$1,359
Year 15	$254	$1,147	$1,402
Year 16	$258	$1,189	$1,446
Year 17	$261	$1,231	$1,492
Year 18	$264	$1,275	$1,540
Year 19	$268	$1,321	$1,589
Year 20	$271	$1,368	$1,640
Total	$4,815	$19,992	$24,807

Total Revenues for the States and Local Taxing Districts

The table below summarizes the increase in total revenues for the states and local taxing districts under Case 1.

Total Revenues for the States and Local Taxing Districts for Case 1: No Diversion, Conservative Growth					
	Sales Tax Collections	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$902	$752	$1,246	$1,772	$4,672
Year 2	$913	$762	$1,262	$1,836	$4,773
Year 3	$925	$772	$1,279	$1,902	$4,877
Year 4	$937	$782	$1,295	$1,970	$4,983
Year 5	$949	$792	$1,312	$2,040	$5,093
Year 6	$961	$802	$1,329	$2,113	$5,205
Year 7	$974	$812	$1,346	$2,189	$5,321
Year 8	$986	$823	$1,363	$2,268	$5,440
Year 9	$999	$833	$1,381	$2,349	$5,562
Year 10	$1,012	$844	$1,399	$2,433	$5,688
Year 11	$1,025	$855	$1,417	$2,520	$5,817
Year 12	$1,038	$866	$1,435	$2,611	$5,950
Year 13	$1,052	$877	$1,454	$2,704	$6,086
Year 14	$1,065	$888	$1,472	$2,801	$6,227
Year 15	$1,079	$900	$1,491	$2,902	$6,372
Year 16	$1,093	$911	$1,511	$3,006	$6,520
Year 17	$1,107	$923	$1,530	$3,113	$6,674
Year 18	$1,121	$935	$1,550	$3,225	$6,831
Year 19	$1,136	$947	$1,570	$3,341	$6,993
Year 20	$1,150	$959	$1,590	$3,460	$7,160
Total	$20,423	$17,035	$28,232	$50,555	$116,245

Summary of Total Revenues for the States and Local Taxing Districts

The following total revenues for the states and local taxing districts over the next 20 years of projected growth are shown below for Case 1.

Summary of Total Revenues for the States and Local Taxing Districts Under Case 1: No Diversion, Conservative Growth	
States of North Dakota and Minnesota	$91,438
Local taxing districts	$24,807
Total	$116,245

Economic Growth for Case 2: No Diversion, Moderate Growth

The table below translates the GDP growth into job and salary growth using RIMS II multipliers for the region for Case 2. We assume the projections in this analysis begin in 2010.

Economic Impacts for Fargo MSA
Case 2: No Diversion, Moderate Growth

	Additional Output (MSA GDP)	Additional Employment	Additional Earnings
Year 1	$226,849	2,250	$82,710
Year 2	$231,794	2,272	$84,513
Year 3	$236,847	2,294	$86,355
Year 4	$242,010	2,316	$88,238
Year 5	$247,286	2,338	$90,161
Year 6	$252,677	2,360	$92,127
Year 7	$258,185	2,383	$94,135
Year 8	$263,814	2,406	$96,187
Year 9	$269,565	2,429	$98,284
Year 10	$275,442	2,452	$100,427
Year 11	$281,446	2,476	$102,616
Year 12	$287,582	2,499	$104,853
Year 13	$293,851	2,523	$107,139
Year 14	$300,257	2,547	$109,475
Year 15	$306,803	2,572	$111,861
Year 16	$313,491	2,597	$114,300
Year 17	$320,325	2,621	$116,792
Year 18	$327,308	2,647	$119,338
Year 19	$334,443	2,672	$121,939
Year 20	$341,734	2,698	$124,597

Revenues for the State and Local Taxing Districts for Case 2: No Diversion, Moderate Growth

Sales Tax to be Collected

Additional Workers' Spending Subject to Sales Tax

An estimated 33% of the spending of additional workers will be subject to sales taxes. Further, an estimated 80% of this spending will be in the Fargo-Moorhead area. If this is the case, retail sales in the area resulting from the general economic growth will be as follows:

Taxable Retail Sales in the Area to be Generated by Growth	
Year 1	$21,835
Year 2	$22,311
Year 3	$22,798
Year 4	$23,295
Year 5	$23,803
Year 6	$24,322
Year 7	$24,852
Year 8	$25,393
Year 9	$25,947
Year 10	$26,513
Year 11	$27,091
Year 12	$27,681
Year 13	$28,285
Year 14	$28,901
Year 15	$29,531
Year 16	$30,175
Year 17	$30,833
Year 18	$31,505
Year 19	$32,192
Year 20	$32,894
Total	$540,157

Source: Impact DataSource calculations based on estimated spending in the area

Sales Tax Collections

The states of North Dakota and Minnesota and local taxing districts will collect the following sales tax on workers' spending:

Estimated Sales Tax Collections on Workers' Spending			
	States	Local Taxing Districts	Total
Effective sales tax rate	5.33%	1.65%	
Year 1	$1,164	$359	$1,524
Year 2	$1,190	$367	$1,557
Year 3	$1,216	$375	$1,591
Year 4	$1,242	$383	$1,625
Year 5	$1,269	$392	$1,661
Year 6	$1,297	$400	$1,697
Year 7	$1,325	$409	$1,734
Year 8	$1,354	$418	$1,772
Year 9	$1,384	$427	$1,811
Year 10	$1,414	$436	$1,850
Year 11	$1,445	$446	$1,890
Year 12	$1,476	$455	$1,932
Year 13	$1,508	$465	$1,974
Year 14	$1,541	$476	$2,017
Year 15	$1,575	$486	$2,061
Year 16	$1,609	$496	$2,106
Year 17	$1,644	$507	$2,151
Year 18	$1,680	$518	$2,198
Year 19	$1,717	$530	$2,246
Year 20	$1,754	$541	$2,295
Total	$28,804	$8,887	$37,691

Source: Sales tax rates for each state and local taxing districts obtained from each state's department of revenue or local taxing district. Effective sales tax rates, blending the tax rates of two states and several local taxing districts, were determined in calculations by Impact DataSource based on the number of business establishments in Cass and Clay Counties.

State Personal Income Taxes to be Collected

As a result of the economic growth in this scenario, additional workers' salaries will be subject to North Dakota and Minnesota personal income taxes. It is projected the states will collect the following personal income taxes:

Estimated State Personal Income Taxes to be Collected				
	Additional Workers' Salaries	Percent of Salaries Subject to State Personal Income Tax	Effective Personal Income Tax Rate as a Percent of Total Income	Total Personal Income Tax Collections
Year 1	$82,710	100%	2.547%	$2,106
Year 2	$84,513	100%	2.547%	$2,152
Year 3	$86,355	100%	2.547%	$2,199
Year 4	$88,238	100%	2.547%	$2,247
Year 5	$90,161	100%	2.547%	$2,296
Year 6	$92,127	100%	2.547%	$2,346
Year 7	$94,135	100%	2.547%	$2,397
Year 8	$96,187	100%	2.547%	$2,449
Year 9	$98,284	100%	2.547%	$2,503
Year 10	$100,427	100%	2.547%	$2,557
Year 11	$102,616	100%	2.547%	$2,613
Year 12	$104,853	100%	2.547%	$2,670
Year 13	$107,139	100%	2.547%	$2,728
Year 14	$109,475	100%	2.547%	$2,788
Year 15	$111,861	100%	2.547%	$2,849
Year 16	$114,300	100%	2.547%	$2,911
Year 17	$116,792	100%	2.547%	$2,974
Year 18	$119,338	100%	2.547%	$3,039
Year 19	$121,939	100%	2.547%	$3,105
Year 20	$124,597	100%	2.547%	$3,173
Total	$2,046,049			$52,104

Source: Personal income tax rates were obtained from each state's department of revenue.
Effective state personal income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on median household income in the area and the percentage of labor force in Cass and Clay Counties. The percent of workers whose salaries will be subject to personal income taxes in the two states are Impact DataSource estimates.

State Corporate Income Taxes to be Collected

As a result of economic growth in this scenario, an estimated 8% of the total economic output will be subject to North Dakota or Minnesota corporate income taxes. If this is the case, the states will collect the following corporate income taxes over the next twenty years:

Estimated Corporate Income Taxes to be Collected				
	Additional Output (MSA GDP)	Percent of Revenues Subject to State Corporate Income Tax	Effective Corporate Income Tax Rate as a Percent of Net Income	Total Corporate Income Tax Collections
Year 1	$226,849	8%	7.003%	$1,271
Year 2	$231,794	8%	7.003%	$1,299
Year 3	$236,847	8%	7.003%	$1,327
Year 4	$242,010	8%	7.003%	$1,356
Year 5	$247,286	8%	7.003%	$1,385
Year 6	$252,677	8%	7.003%	$1,416
Year 7	$258,185	8%	7.003%	$1,446
Year 8	$263,814	8%	7.003%	$1,478
Year 9	$269,565	8%	7.003%	$1,510
Year 10	$275,442	8%	7.003%	$1,543
Year 11	$281,446	8%	7.003%	$1,577
Year 12	$287,582	8%	7.003%	$1,611
Year 13	$293,851	8%	7.003%	$1,646
Year 14	$300,257	8%	7.003%	$1,682
Year 15	$306,803	8%	7.003%	$1,719
Year 16	$313,491	8%	7.003%	$1,756
Year 17	$320,325	8%	7.003%	$1,795
Year 18	$327,308	8%	7.003%	$1,834
Year 19	$334,443	8%	7.003%	$1,874
Year 20	$341,734	8%	7.003%	$1,915
Total	$5,611,709			$31,439

Source: Corporate income tax rates were obtained from each state's department of revenue. Effective state corporate income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on the percentage of business establishments in Cass and Clay Counties. The percent of total business revenues that will be subject to state corporation income taxes in the two states are Impact DataSource estimates.

Other Taxes, User Fees, Charges for Services and Miscellaneous Revenues for the States and Local Taxing Districts Collected from Workers

Over the next twenty years, the states and local taxing districts will collect other taxes, user fees, charges for services, and miscellaneous revenues primarily from workers. These estimated annual revenues to be collected per worker are shown below:

Annual Miscellaneous Revenues Collected Per Worker	
States	$764.41
Local taxing districts	$500

Source: Miscellaneous revenues per worker for states calculated by Impact DataSource from information shown in the general fund budgets of each state along with the number of workers in each state. Further, miscellaneous revenues for each state were blending to obtain an average by Impact DataSource based on relative number of workers in Cass and Clay Counties. Miscellaneous revenues for local taxing districts are Impact DataSource estimates.

If these estimated miscellaneous revenues are received by the states and local taxing districts for each additional worker under this scenario, the following revenues will be received:

Estimated Miscellaneous Revenues for the States and Local Taxing Districts				
		Miscellaneous Revenues		
	Number of Local Workers	State	Local Taxing Districts	Total
Year 1	2,250	$1,720	$1,125	$2,845
Year 2	2,272	$1,789	$1,170	$2,959
Year 3	2,294	$1,860	$1,217	$3,077
Year 4	2,316	$1,934	$1,265	$3,199
Year 5	2,338	$2,011	$1,316	$3,327
Year 6	2,360	$2,091	$1,368	$3,460
Year 7	2,383	$2,175	$1,423	$3,597
Year 8	2,406	$2,262	$1,479	$3,741
Year 9	2,429	$2,352	$1,538	$3,890
Year 10	2,452	$2,446	$1,600	$4,045
Year 11	2,476	$2,543	$1,663	$4,207
Year 12	2,499	$2,645	$1,730	$4,374
Year 13	2,523	$2,750	$1,799	$4,549
Year 14	2,547	$2,860	$1,871	$4,730
Year 15	2,572	$2,974	$1,945	$4,919
Year 16	2,597	$3,092	$2,023	$5,115
Year 17	2,621	$3,216	$2,103	$5,319
Year 18	2,647	$3,344	$2,187	$5,531
Year 19	2,672	$3,477	$2,274	$5,752
Year 20	2,698	$3,616	$2,365	$5,981
Total		$51,156	$33,461	$84,616

Source: Percent of total direct and indirect workers who may live in the Fargo-Moorhead area is an Impact DataSource estimate. Annual increases in miscellaneous of 3% are Impact DataSource estimates

Summary of Taxes and Other Revenues to be Collected by the States and Local Taxing Districts for Case 2

Revenues for the States

The table below summarizes the projected revenues for states under Case 2.

Total Revenues for the States for Case 2: No Diversion, Moderate Growth					
	Sales Taxes	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$1,164	$1,271	$2,106	$1,720	$6,262
Year 2	$1,190	$1,299	$2,152	$1,789	$6,429
Year 3	$1,216	$1,327	$2,199	$1,860	$6,602
Year 4	$1,242	$1,356	$2,247	$1,934	$6,779
Year 5	$1,269	$1,385	$2,296	$2,011	$6,962
Year 6	$1,297	$1,416	$2,346	$2,091	$7,150
Year 7	$1,325	$1,446	$2,397	$2,175	$7,344
Year 8	$1,354	$1,478	$2,449	$2,262	$7,543
Year 9	$1,384	$1,510	$2,503	$2,352	$7,749
Year 10	$1,414	$1,543	$2,557	$2,446	$7,960
Year 11	$1,445	$1,577	$2,613	$2,543	$8,178
Year 12	$1,476	$1,611	$2,670	$2,645	$8,402
Year 13	$1,508	$1,646	$2,728	$2,750	$8,633
Year 14	$1,541	$1,682	$2,788	$2,860	$8,871
Year 15	$1,575	$1,719	$2,849	$2,974	$9,116
Year 16	$1,609	$1,756	$2,911	$3,092	$9,368
Year 17	$1,644	$1,795	$2,974	$3,216	$9,629
Year 18	$1,680	$1,834	$3,039	$3,344	$9,897
Year 19	$1,717	$1,874	$3,105	$3,477	$10,173
Year 20	$1,754	$1,915	$3,173	$3,616	$10,457
Total	$28,804	$31,439	$52,104	$51,156	$163,503

Revenues for Local Taxing Districts

The table below summarizes the projected revenues for local taxing districts under Case 2.

Total Revenues for Local Taxing Districts for Case 2: No Diversion, Moderate Growth			
	Sales Taxes	Other Taxes and Revenues	Total Revenues
Year 1	$359	$1,125	$1,484
Year 2	$367	$1,170	$1,537
Year 3	$375	$1,217	$1,592
Year 4	$383	$1,265	$1,648
Year 5	$392	$1,316	$1,707
Year 6	$400	$1,368	$1,768
Year 7	$409	$1,423	$1,831
Year 8	$418	$1,479	$1,897
Year 9	$427	$1,538	$1,965
Year 10	$436	$1,600	$2,036
Year 11	$446	$1,663	$2,109
Year 12	$455	$1,730	$2,185
Year 13	$465	$1,799	$2,264
Year 14	$476	$1,871	$2,346
Year 15	$486	$1,945	$2,431
Year 16	$496	$2,023	$2,519
Year 17	$507	$2,103	$2,611
Year 18	$518	$2,187	$2,706
Year 19	$530	$2,274	$2,804
Year 20	$541	$2,365	$2,906
Total	$8,887	$33,461	$42,348

Total Revenues for the States and Local Taxing Districts

The table below summarizes the increase in total revenues for the states and local taxing districts under Case 2.

Total Revenues for the States and Local Taxing Districts for Case 2: No Diversion, Moderate Growth					
	Sales Tax Collections	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$1,524	$1,271	$2,106	$2,845	$7,746
Year 2	$1,557	$1,299	$2,152	$2,959	$7,966
Year 3	$1,591	$1,327	$2,199	$3,077	$8,193
Year 4	$1,625	$1,356	$2,247	$3,199	$8,428
Year 5	$1,661	$1,385	$2,296	$3,327	$8,669
Year 6	$1,697	$1,416	$2,346	$3,460	$8,918
Year 7	$1,734	$1,446	$2,397	$3,597	$9,175
Year 8	$1,772	$1,478	$2,449	$3,741	$9,440
Year 9	$1,811	$1,510	$2,503	$3,890	$9,714
Year 10	$1,850	$1,543	$2,557	$4,045	$9,996
Year 11	$1,890	$1,577	$2,613	$4,207	$10,287
Year 12	$1,932	$1,611	$2,670	$4,374	$10,587
Year 13	$1,974	$1,646	$2,728	$4,549	$10,897
Year 14	$2,017	$1,682	$2,788	$4,730	$11,217
Year 15	$2,061	$1,719	$2,849	$4,919	$11,547
Year 16	$2,106	$1,756	$2,911	$5,115	$11,888
Year 17	$2,151	$1,795	$2,974	$5,319	$12,239
Year 18	$2,198	$1,834	$3,039	$5,531	$12,602
Year 19	$2,246	$1,874	$3,105	$5,752	$12,977
Year 20	$2,295	$1,915	$3,173	$5,981	$13,364
Total	$37,691	$31,439	$52,104	$84,616	$205,851

Summary of Total Revenues for the States and Local Taxing Districts

The following total revenues for the states and local taxing districts over the next 20 years of projected growth are shown below for Case 2.

Summary of Total Revenues for the States and Local Taxing Districts Under Case 2: No Diversion, Moderate Growth	
States of North Dakota and Minnesota	$163,503
Local taxing districts	$42,348
Total	$205,851

Economic Growth for Case 3: With Diversion, Conservative Growth

The table below translates the GDP growth into job and salary growth using RIMS II multipliers for the region for Case 3. Our projections in this analysis begin in 2010.

Economic Impacts for Fargo MSA Case 3: With Diversion, Conservative Growth			
	Additional Output (MSA GDP)	Additional Employment	Additional Earnings
Year 1	$321,542	2,854	$117,236
Year 2	$331,478	2,893	$120,858
Year 3	$341,721	2,932	$124,593
Year 4	$352,280	2,972	$128,443
Year 5	$363,165	3,012	$132,411
Year 6	$374,387	3,053	$136,503
Year 7	$385,956	3,095	$140,721
Year 8	$397,882	3,137	$145,069
Year 9	$410,176	3,179	$149,552
Year 10	$422,851	3,222	$154,173
Year 11	$435,917	3,266	$158,937
Year 12	$449,387	3,311	$163,848
Year 13	$463,273	3,356	$168,911
Year 14	$477,588	3,401	$174,130
Year 15	$492,345	3,448	$179,511
Year 16	$507,559	3,494	$185,058
Year 17	$523,242	3,542	$190,776
Year 18	$539,411	3,590	$196,671
Year 19	$556,078	3,639	$202,748
Year 20	$573,261	3,688	$209,013

Revenues for the State and Local Taxing Districts for Case 3: With Diversion, Conservative Growth

Sales Tax to be Collected

Additional Workers' Spending Subject to Sales Tax

An estimated 33% of the spending of additional workers will be subject to sales taxes. Further, an estimated 80% of this spending will be in the Fargo-Moorhead area. If this is the case, retail sales in the area resulting from the general economic growth will be as follows:

Taxable Retail Sales in the Area to be Generated by Growth	
Year 1	$30,950
Year 2	$31,907
Year 3	$32,892
Year 4	$33,909
Year 5	$34,957
Year 6	$36,037
Year 7	$37,150
Year 8	$38,298
Year 9	$39,482
Year 10	$40,702
Year 11	$41,959
Year 12	$43,256
Year 13	$44,592
Year 14	$45,970
Year 15	$47,391
Year 16	$48,855
Year 17	$50,365
Year 18	$51,921
Year 19	$53,526
Year 20	$55,179
Total	$839,298

Source: Impact DataSource calculations based on estimated spending in the area

Sales Tax Collections

The states of North Dakota and Minnesota and local taxing districts will collect the following sales tax on workers' spending:

Estimated Sales Tax Collections on Workers' Spending			
	States	Local Taxing Districts	Total
Effective sales tax rate	5.33%	1.65%	
Year 1	$1,650	$509	$2,160
Year 2	$1,701	$525	$2,226
Year 3	$1,754	$541	$2,295
Year 4	$1,808	$558	$2,366
Year 5	$1,864	$575	$2,439
Year 6	$1,922	$593	$2,515
Year 7	$1,981	$611	$2,592
Year 8	$2,042	$630	$2,672
Year 9	$2,105	$650	$2,755
Year 10	$2,170	$670	$2,840
Year 11	$2,237	$690	$2,928
Year 12	$2,307	$712	$3,018
Year 13	$2,378	$734	$3,112
Year 14	$2,451	$756	$3,208
Year 15	$2,527	$780	$3,307
Year 16	$2,605	$804	$3,409
Year 17	$2,686	$829	$3,514
Year 18	$2,769	$854	$3,623
Year 19	$2,854	$881	$3,735
Year 20	$2,942	$908	$3,850
Total	$44,756	$13,809	$58,565

Source: Sales tax rates for each state and local taxing districts obtained from each state's department of revenue or local taxing district. Effective sales tax rates, blending the tax rates of two states and several local taxing districts, were determined in calculations by Impact DataSource based on the number of business establishments in Cass and Clay Counties.

State Personal Income Taxes to be Collected

As a result of the economic growth in this scenario, additional workers' salaries will be subject to North Dakota and Minnesota personal income taxes. It is projected the states will collect the following personal income taxes:

Estimated State Personal Income Taxes to be Collected				
	Additional Workers' Salaries	Percent of Salaries Subject to State Personal Income Tax	Effective Personal Income Tax Rate as a Percent of Total Income	Total Personal Income Tax Collections
Year 1	$117,236	100%	2.547%	$2,986
Year 2	$120,858	100%	2.547%	$3,078
Year 3	$124,593	100%	2.547%	$3,173
Year 4	$128,443	100%	2.547%	$3,271
Year 5	$132,411	100%	2.547%	$3,372
Year 6	$136,503	100%	2.547%	$3,476
Year 7	$140,721	100%	2.547%	$3,584
Year 8	$145,069	100%	2.547%	$3,694
Year 9	$149,552	100%	2.547%	$3,808
Year 10	$154,173	100%	2.547%	$3,926
Year 11	$158,937	100%	2.547%	$4,047
Year 12	$163,848	100%	2.547%	$4,173
Year 13	$168,911	100%	2.547%	$4,301
Year 14	$174,130	100%	2.547%	$4,434
Year 15	$179,511	100%	2.547%	$4,571
Year 16	$185,058	100%	2.547%	$4,713
Year 17	$190,776	100%	2.547%	$4,858
Year 18	$196,671	100%	2.547%	$5,008
Year 19	$202,748	100%	2.547%	$5,163
Year 20	$209,013	100%	2.547%	$5,323
Total	$3,179,161			$80,960

Source: Personal income tax rates were obtained from each state's department of revenue.
Effective state personal income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on median household income in the area and the percentage of labor force in Cass and Clay Counties. The percent of workers whose salaries will be subject to personal income taxes in the two states are Impact DataSource estimates.

State Corporate Income Taxes to be Collected

As a result of economic growth in this scenario, an estimated 8% of the total economic output will be subject to North Dakota or Minnesota corporate income taxes. If this is the case, the states will collect the following corporate income taxes over the next twenty years:

Estimated Corporate Income Taxes to be Collected				
	Additional Output (MSA GDP)	Percent of Revenues Subject to State Corporate Income Tax	Effective Corporate Income Tax Rate as a Percent of Net Income	Total Corporate Income Tax Collections
Year 1	$321,542	8%	7.003%	$1,801
Year 2	$331,478	8%	7.003%	$1,857
Year 3	$341,721	8%	7.003%	$1,914
Year 4	$352,280	8%	7.003%	$1,974
Year 5	$363,165	8%	7.003%	$2,035
Year 6	$374,387	8%	7.003%	$2,097
Year 7	$385,956	8%	7.003%	$2,162
Year 8	$397,882	8%	7.003%	$2,229
Year 9	$410,176	8%	7.003%	$2,298
Year 10	$422,851	8%	7.003%	$2,369
Year 11	$435,917	8%	7.003%	$2,442
Year 12	$449,387	8%	7.003%	$2,518
Year 13	$463,273	8%	7.003%	$2,595
Year 14	$477,588	8%	7.003%	$2,676
Year 15	$492,345	8%	7.003%	$2,758
Year 16	$507,559	8%	7.003%	$2,844
Year 17	$523,242	8%	7.003%	$2,931
Year 18	$539,411	8%	7.003%	$3,022
Year 19	$556,078	8%	7.003%	$3,115
Year 20	$573,261	8%	7.003%	$3,212
Total	$8,719,500			$48,850

Source: Corporate income tax rates were obtained from each state's department of revenue. Effective state corporate income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on the percentage of business establishments in Cass and Clay Counties. The percent of total business revenues that will be subject to state corporation income taxes in the two states are Impact DataSource estimates.

Other Taxes, User Fees, Charges for Services and Miscellaneous Revenues for the States and Local Taxing Districts Collected from Workers

Over the next twenty years, the states and local taxing districts will collect other taxes, user fees, charges for services, and miscellaneous revenues primarily from workers. These estimated annual revenues to be collected per worker are shown below:

Annual Miscellaneous Revenues Collected Per Worker	
States	$764.41
Local taxing districts	$500

Source: Miscellaneous revenues per worker for states calculated by Impact DataSource from information shown in the general fund budgets of each state along with the number of workers in each state. Further, miscellaneous revenues for each state were blending to obtain an average by Impact DataSource based on relative number of workers in Cass and Clay Counties. Miscellaneous revenues for local taxing districts are Impact DataSource estimates.

If these estimated miscellaneous revenues are received by the states and local taxing districts for each additional worker under this scenario, the following revenues will be received:

Estimated Miscellaneous Revenues for the States and Local Taxing Districts				
		Miscellaneous Revenues		
	Number of Local Workers	State	Local Taxing Districts	Total
Year 1	2,854	$2,181	$1,427	$3,608
Year 2	2,893	$2,277	$1,490	$3,767
Year 3	2,932	$2,378	$1,555	$3,933
Year 4	2,972	$2,482	$1,624	$4,106
Year 5	3,012	$2,591	$1,695	$4,287
Year 6	3,053	$2,705	$1,770	$4,475
Year 7	3,095	$2,825	$1,848	$4,672
Year 8	3,137	$2,949	$1,929	$4,878
Year 9	3,179	$3,079	$2,014	$5,092
Year 10	3,222	$3,214	$2,102	$5,316
Year 11	3,266	$3,355	$2,195	$5,550
Year 12	3,311	$3,503	$2,291	$5,795
Year 13	3,356	$3,657	$2,392	$6,050
Year 14	3,401	$3,818	$2,498	$6,316
Year 15	3,448	$3,986	$2,607	$6,594
Year 16	3,494	$4,162	$2,722	$6,884
Year 17	3,542	$4,345	$2,842	$7,187
Year 18	3,590	$4,536	$2,967	$7,503
Year 19	3,639	$4,736	$3,098	$7,833
Year 20	3,688	$4,944	$3,234	$8,178
Total		$67,724	$44,298	$112,022

Source: Percent of total direct and indirect workers who may live in the Fargo-Moorhead area is an Impact DataSource estimate. Annual increases in miscellaneous of 3% are Impact DataSource estimates

Summary of Taxes and Other Revenues to be Collected by the States and Local Taxing Districts for Case 3

Revenues for the States

The table below summarizes the projected revenues for states under Case 3.

Total Revenues for the States for Case 3: With Diversion, Conservative Growth					
	Sales Taxes	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$1,650	$1,801	$2,986	$2,181	$8,619
Year 2	$1,701	$1,857	$3,078	$2,277	$8,914
Year 3	$1,754	$1,914	$3,173	$2,378	$9,219
Year 4	$1,808	$1,974	$3,271	$2,482	$9,535
Year 5	$1,864	$2,035	$3,372	$2,591	$9,862
Year 6	$1,922	$2,097	$3,476	$2,705	$10,201
Year 7	$1,981	$2,162	$3,584	$2,825	$10,551
Year 8	$2,042	$2,229	$3,694	$2,949	$10,915
Year 9	$2,105	$2,298	$3,808	$3,079	$11,290
Year 10	$2,170	$2,369	$3,926	$3,214	$11,680
Year 11	$2,237	$2,442	$4,047	$3,355	$12,083
Year 12	$2,307	$2,518	$4,173	$3,503	$12,500
Year 13	$2,378	$2,595	$4,301	$3,657	$12,932
Year 14	$2,451	$2,676	$4,434	$3,818	$13,380
Year 15	$2,527	$2,758	$4,571	$3,986	$13,843
Year 16	$2,605	$2,844	$4,713	$4,162	$14,323
Year 17	$2,686	$2,931	$4,858	$4,345	$14,820
Year 18	$2,769	$3,022	$5,008	$4,536	$15,335
Year 19	$2,854	$3,115	$5,163	$4,736	$15,868
Year 20	$2,942	$3,212	$5,323	$4,944	$16,421
Total	$44,756	$48,850	$80,960	$67,724	$242,290

Revenues for Local Taxing Districts

The table below summarizes the projected revenues for local taxing districts under Case 3.

Total Revenues for Local Taxing Districts for Case 3: With Diversion, Conservative Growth			
	Sales Taxes	Other Taxes and Revenues	Total Revenues
Year 1	$509	$1,427	$1,936
Year 2	$525	$1,490	$2,015
Year 3	$541	$1,555	$2,096
Year 4	$558	$1,624	$2,182
Year 5	$575	$1,695	$2,270
Year 6	$593	$1,770	$2,363
Year 7	$611	$1,848	$2,459
Year 8	$630	$1,929	$2,559
Year 9	$650	$2,014	$2,663
Year 10	$670	$2,102	$2,772
Year 11	$690	$2,195	$2,885
Year 12	$712	$2,291	$3,003
Year 13	$734	$2,392	$3,126
Year 14	$756	$2,498	$3,254
Year 15	$780	$2,607	$3,387
Year 16	$804	$2,722	$3,526
Year 17	$829	$2,842	$3,671
Year 18	$854	$2,967	$3,821
Year 19	$881	$3,098	$3,978
Year 20	$908	$3,234	$4,142
Total	$13,809	$44,298	$58,107

Total Revenues for the States and Local Taxing Districts

The table below summarizes the increase in total revenues for the states and local taxing districts under Case 3.

Total Revenues for the States and Local Taxing Districts for Case 3: With Diversion, Conservative Growth					
	Sales Tax Collections	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$2,160	$1,801	$2,986	$3,608	$10,555
Year 2	$2,226	$1,857	$3,078	$3,767	$10,928
Year 3	$2,295	$1,914	$3,173	$3,933	$11,315
Year 4	$2,366	$1,974	$3,271	$4,106	$11,716
Year 5	$2,439	$2,035	$3,372	$4,287	$12,132
Year 6	$2,515	$2,097	$3,476	$4,475	$12,563
Year 7	$2,592	$2,162	$3,584	$4,672	$13,010
Year 8	$2,672	$2,229	$3,694	$4,878	$13,473
Year 9	$2,755	$2,298	$3,808	$5,092	$13,954
Year 10	$2,840	$2,369	$3,926	$5,316	$14,452
Year 11	$2,928	$2,442	$4,047	$5,550	$14,968
Year 12	$3,018	$2,518	$4,173	$5,795	$15,503
Year 13	$3,112	$2,595	$4,301	$6,050	$16,058
Year 14	$3,208	$2,676	$4,434	$6,316	$16,633
Year 15	$3,307	$2,758	$4,571	$6,594	$17,230
Year 16	$3,409	$2,844	$4,713	$6,884	$17,849
Year 17	$3,514	$2,931	$4,858	$7,187	$18,491
Year 18	$3,623	$3,022	$5,008	$7,503	$19,156
Year 19	$3,735	$3,115	$5,163	$7,833	$19,847
Year 20	$3,850	$3,212	$5,323	$8,178	$20,562
Total	$58,565	$48,850	$80,960	$112,022	$300,397

Summary of Total Revenues for the States and Local Taxing Districts

The following total revenues for the states and local taxing districts over the next 20 years of projected growth are shown below for Case 3.

Summary of Total Revenues for the States and Local Taxing Districts Under Case 3: With Diversion, Conservative Growth	
States of North Dakota and Minnesota	$242,290
Local taxing districts	$58,107
Total	$300,397

Economic Growth for Case 4: With Diversion, Moderate Growth

The table below translates the GDP growth into job and salary growth using RIMS II multipliers for the region for Case 4. The projections in this analysis begin in 2010.

Economic Impacts for Fargo MSA Case 4: With Diversion, Moderate Growth			
	Additional Output (MSA GDP)	Additional Employment	Additional Earnings
Year 1	$427,683	3,349	$155,935
Year 2	$445,260	3,410	$162,344
Year 3	$463,561	3,471	$169,016
Year 4	$482,613	3,534	$175,962
Year 5	$502,448	3,598	$183,194
Year 6	$523,099	3,663	$190,724
Year 7	$544,598	3,729	$198,563
Year 8	$566,981	3,797	$206,723
Year 9	$590,284	3,865	$215,220
Year 10	$614,545	3,935	$224,065
Year 11	$639,803	4,007	$233,274
Year 12	$666,099	4,079	$242,862
Year 13	$693,475	4,153	$252,844
Year 14	$721,977	4,228	$263,235
Year 15	$751,650	4,304	$274,054
Year 16	$782,543	4,382	$285,318
Year 17	$814,706	4,461	$297,045
Year 18	$848,190	4,542	$309,253
Year 19	$883,051	4,624	$321,963
Year 20	$919,344	4,708	$335,196

Revenues for the State and Local Taxing Districts for Case 4: With Diversion, Moderate Growth

Sales Tax to be Collected

Additional Workers' Spending Subject to Sales Tax

An estimated 33% of the spending of additional workers will be subject to sales taxes. Further, an estimated 80% of this spending will be in the Fargo-Moorhead area. If this is the case, retail sales in the area resulting from the general economic growth will be as follows:

Taxable Retail Sales in the Area to be Generated by Growth	
Year 1	$41,167
Year 2	$42,859
Year 3	$44,620
Year 4	$46,454
Year 5	$48,363
Year 6	$50,351
Year 7	$52,421
Year 8	$54,575
Year 9	$56,818
Year 10	$59,153
Year 11	$61,584
Year 12	$64,116
Year 13	$66,751
Year 14	$69,494
Year 15	$72,350
Year 16	$75,324
Year 17	$78,420
Year 18	$81,643
Year 19	$84,998
Year 20	$88,492
Total	$1,239,953

Source: Impact DataSource calculations based on estimated spending in the area

Sales Tax Collections

The states of North Dakota and Minnesota and local taxing districts will collect the following sales tax on workers' spending:

Estimated Sales Tax Collections on Workers' Spending			
	States	Local Taxing Districts	Total
Effective sales tax rate	5.33%	1.65%	
Year 1	$2,195	$677	$2,873
Year 2	$2,285	$705	$2,991
Year 3	$2,379	$734	$3,114
Year 4	$2,477	$764	$3,241
Year 5	$2,579	$796	$3,375
Year 6	$2,685	$828	$3,513
Year 7	$2,795	$862	$3,658
Year 8	$2,910	$898	$3,808
Year 9	$3,030	$935	$3,965
Year 10	$3,154	$973	$4,128
Year 11	$3,284	$1,013	$4,297
Year 12	$3,419	$1,055	$4,474
Year 13	$3,560	$1,098	$4,658
Year 14	$3,706	$1,143	$4,849
Year 15	$3,858	$1,190	$5,048
Year 16	$4,017	$1,239	$5,256
Year 17	$4,182	$1,290	$5,472
Year 18	$4,354	$1,343	$5,697
Year 19	$4,533	$1,398	$5,931
Year 20	$4,719	$1,456	$6,175
Total	$66,121	$20,401	$86,522

Source: Sales tax rates for each state and local taxing districts obtained from each state's department of revenue or local taxing district. Effective sales tax rates, blending the tax rates of two states and several local taxing districts, were determined in calculations by Impact DataSource based on the number of business establishments in Cass and Clay Counties.

State Personal Income Taxes to be Collected

As a result of the economic growth in this scenario, additional workers' salaries will be subject to North Dakota and Minnesota personal income taxes. It is projected the states will collect the following personal income taxes:

Estimated State Personal Income Taxes to be Collected				
	Additional Workers' Salaries	Percent of Salaries Subject to State Personal Income Tax	Effective Personal Income Tax Rate as a Percent of Total Income	Total Personal Income Tax Collections
Year 1	$155,935	100%	2.547%	$3,971
Year 2	$162,344	100%	2.547%	$4,134
Year 3	$169,016	100%	2.547%	$4,304
Year 4	$175,962	100%	2.547%	$4,481
Year 5	$183,194	100%	2.547%	$4,665
Year 6	$190,724	100%	2.547%	$4,857
Year 7	$198,563	100%	2.547%	$5,057
Year 8	$206,723	100%	2.547%	$5,264
Year 9	$215,220	100%	2.547%	$5,481
Year 10	$224,065	100%	2.547%	$5,706
Year 11	$233,274	100%	2.547%	$5,941
Year 12	$242,862	100%	2.547%	$6,185
Year 13	$252,844	100%	2.547%	$6,439
Year 14	$263,235	100%	2.547%	$6,704
Year 15	$274,054	100%	2.547%	$6,979
Year 16	$285,318	100%	2.547%	$7,266
Year 17	$297,045	100%	2.547%	$7,564
Year 18	$309,253	100%	2.547%	$7,875
Year 19	$321,963	100%	2.547%	$8,199
Year 20	$335,196	100%	2.547%	$8,536
Total	$4,696,791			$119,608

Source: Personal income tax rates were obtained from each state's department of revenue.
Effective state personal income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on median household income in the area and the percentage of labor force in Cass and Clay Counties. The percent of workers whose salaries will be subject to personal income taxes in the two states are Impact DataSource estimates.

State Corporate Income Taxes to be Collected

As a result of economic growth in this scenario, an estimated 8% of the total economic output will be subject to North Dakota or Minnesota corporate income taxes. If this is the case, the states will collect the following corporate income taxes over the next twenty years:

Estimated Corporate Income Taxes to be Collected				
	Additional Output (MSA GDP)	Percent of Revenues Subject to State Corporate Income Tax	Effective Corporate Income Tax Rate as a Percent of Net Income	Total Corporate Income Tax Collections
Year 1	$427,683	8%	7.003%	$2,396
Year 2	$445,260	8%	7.003%	$2,495
Year 3	$463,561	8%	7.003%	$2,597
Year 4	$482,613	8%	7.003%	$2,704
Year 5	$502,448	8%	7.003%	$2,815
Year 6	$523,099	8%	7.003%	$2,931
Year 7	$544,598	8%	7.003%	$3,051
Year 8	$566,981	8%	7.003%	$3,176
Year 9	$590,284	8%	7.003%	$3,307
Year 10	$614,545	8%	7.003%	$3,443
Year 11	$639,803	8%	7.003%	$3,584
Year 12	$666,099	8%	7.003%	$3,732
Year 13	$693,475	8%	7.003%	$3,885
Year 14	$721,977	8%	7.003%	$4,045
Year 15	$751,650	8%	7.003%	$4,211
Year 16	$782,543	8%	7.003%	$4,384
Year 17	$814,706	8%	7.003%	$4,564
Year 18	$848,190	8%	7.003%	$4,752
Year 19	$883,051	8%	7.003%	$4,947
Year 20	$919,344	8%	7.003%	$5,151
Total	$12,881,912			$72,170

Source: Corporate income tax rates were obtained from each state's department of revenue. Effective state corporate income tax rates, blending the tax rates North Dakota, were determined in calculations by Impact DataSource based on the percentage of business establishments in Cass and Clay Counties. The percent of total business revenues that will be subject to state corporation income taxes in the two states are Impact DataSource estimates.

Other Taxes, User Fees, Charges for Services and Miscellaneous Revenues for the States and Local Taxing Districts Collected from Workers

Over the next twenty years, the states and local taxing districts will collect other taxes, user fees, charges for services, and miscellaneous revenues primarily from workers. These estimated annual revenues to be collected per worker are shown below:

Annual Miscellaneous Revenues Collected Per Worker	
States	$764.41
Local taxing districts	$500

Source: Miscellaneous revenues per worker for states calculated by Impact DataSource from information shown in the general fund budgets of each state along with the number of workers in each state. Further, miscellaneous revenues for each state were blending to obtain an average by Impact DataSource based on relative number of workers in Cass and Clay Counties. Miscellaneous revenues for local taxing districts are Impact DataSource estimates.

If these estimated miscellaneous revenues are received by the states and local taxing districts for each additional worker under this scenario, the following revenues will be received:

Estimated Miscellaneous Revenues for the States and Local Taxing Districts				
		Miscellaneous Revenues		
	Number of Local Workers	State	Local Taxing Districts	Total
Year 1	3,349	$2,560	$1,675	$4,235
Year 2	3,410	$2,685	$1,756	$4,441
Year 3	3,471	$2,815	$1,841	$4,657
Year 4	3,534	$2,952	$1,931	$4,883
Year 5	3,598	$3,096	$2,025	$5,120
Year 6	3,663	$3,246	$2,123	$5,369
Year 7	3,729	$3,404	$2,227	$5,631
Year 8	3,797	$3,569	$2,335	$5,904
Year 9	3,865	$3,743	$2,448	$6,191
Year 10	3,935	$3,925	$2,567	$6,492
Year 11	4,007	$4,116	$2,692	$6,808
Year 12	4,079	$4,316	$2,823	$7,139
Year 13	4,153	$4,526	$2,960	$7,486
Year 14	4,228	$4,746	$3,104	$7,850
Year 15	4,304	$4,977	$3,255	$8,232
Year 16	4,382	$5,219	$3,414	$8,632
Year 17	4,461	$5,473	$3,580	$9,052
Year 18	4,542	$5,739	$3,754	$9,492
Year 19	4,624	$6,018	$3,936	$9,954
Year 20	4,708	$6,310	$4,128	$10,438
Total		$83,434	$54,574	$138,009

Source: Percent of total direct and indirect workers who may live in the Fargo-Moorhead area is an Impact DataSource estimate. Annual increases in miscellaneous of 3% are Impact DataSource estimates

Summary of Taxes and Other Revenues to be Collected by the States and Local Taxing Districts for Case 4

Revenues for the States

The table below summarizes the projected revenues for states under Case 4.

Total Revenues for the States for Case 4: With Diversion, Moderate Growth					
	Sales Taxes	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$2,195	$2,396	$3,971	$2,560	$11,122
Year 2	$2,285	$2,495	$4,134	$2,685	$11,599
Year 3	$2,379	$2,597	$4,304	$2,815	$12,096
Year 4	$2,477	$2,704	$4,481	$2,952	$12,614
Year 5	$2,579	$2,815	$4,665	$3,096	$13,155
Year 6	$2,685	$2,931	$4,857	$3,246	$13,719
Year 7	$2,795	$3,051	$5,057	$3,404	$14,307
Year 8	$2,910	$3,176	$5,264	$3,569	$14,921
Year 9	$3,030	$3,307	$5,481	$3,743	$15,561
Year 10	$3,154	$3,443	$5,706	$3,925	$16,228
Year 11	$3,284	$3,584	$5,941	$4,116	$16,925
Year 12	$3,419	$3,732	$6,185	$4,316	$17,652
Year 13	$3,560	$3,885	$6,439	$4,526	$18,409
Year 14	$3,706	$4,045	$6,704	$4,746	$19,200
Year 15	$3,858	$4,211	$6,979	$4,977	$20,025
Year 16	$4,017	$4,384	$7,266	$5,219	$20,885
Year 17	$4,182	$4,564	$7,564	$5,473	$21,783
Year 18	$4,354	$4,752	$7,875	$5,739	$22,720
Year 19	$4,533	$4,947	$8,199	$6,018	$23,697
Year 20	$4,719	$5,151	$8,536	$6,310	$24,716
Total	$66,121	$72,170	$119,608	$83,434	$341,333

Revenues for Local Taxing Districts

The table below summarizes the projected revenues for local taxing districts under Case 4.

Total Revenues for Local Taxing Districts for Case 4: With Diversion, Moderate Growth			
	Sales Taxes	Other Taxes and Revenues	Total Revenues
Year 1	$677	$1,675	$2,352
Year 2	$705	$1,756	$2,461
Year 3	$734	$1,841	$2,576
Year 4	$764	$1,931	$2,695
Year 5	$796	$2,025	$2,821
Year 6	$828	$2,123	$2,952
Year 7	$862	$2,227	$3,089
Year 8	$898	$2,335	$3,233
Year 9	$935	$2,448	$3,383
Year 10	$973	$2,567	$3,541
Year 11	$1,013	$2,692	$3,705
Year 12	$1,055	$2,823	$3,878
Year 13	$1,098	$2,960	$4,059
Year 14	$1,143	$3,104	$4,248
Year 15	$1,190	$3,255	$4,446
Year 16	$1,239	$3,414	$4,653
Year 17	$1,290	$3,580	$4,870
Year 18	$1,343	$3,754	$5,097
Year 19	$1,398	$3,936	$5,335
Year 20	$1,456	$4,128	$5,584
Total	$20,401	$54,574	$74,975

Total Revenues for the States and Local Taxing Districts

The table below summarizes the increase in total revenues for the states and local taxing districts under Case 4.

Total Revenues for the States and Local Taxing Districts for Case 4: With Diversion, Moderate Growth					
	Sales Tax Collections	Corporate Income Taxes	Personal Income Taxes	Other Taxes and Revenues	Total
Year 1	$2,873	$2,396	$3,971	$4,235	$13,474
Year 2	$2,991	$2,495	$4,134	$4,441	$14,060
Year 3	$3,114	$2,597	$4,304	$4,657	$14,671
Year 4	$3,241	$2,704	$4,481	$4,883	$15,309
Year 5	$3,375	$2,815	$4,665	$5,120	$15,975
Year 6	$3,513	$2,931	$4,857	$5,369	$16,670
Year 7	$3,658	$3,051	$5,057	$5,631	$17,396
Year 8	$3,808	$3,176	$5,264	$5,904	$18,153
Year 9	$3,965	$3,307	$5,481	$6,191	$18,944
Year 10	$4,128	$3,443	$5,706	$6,492	$19,769
Year 11	$4,297	$3,584	$5,941	$6,808	$20,630
Year 12	$4,474	$3,732	$6,185	$7,139	$21,530
Year 13	$4,658	$3,885	$6,439	$7,486	$22,468
Year 14	$4,849	$4,045	$6,704	$7,850	$23,448
Year 15	$5,048	$4,211	$6,979	$8,232	$24,471
Year 16	$5,256	$4,384	$7,266	$8,632	$25,538
Year 17	$5,472	$4,564	$7,564	$9,052	$26,653
Year 18	$5,697	$4,752	$7,875	$9,492	$27,817
Year 19	$5,931	$4,947	$8,199	$9,954	$29,031
Year 20	$6,175	$5,151	$8,536	$10,438	$30,299
Total	$86,522	$72,170	$119,608	$138,009	$416,308

Summary of Total Revenues for the States and Local Taxing Districts

The following total revenues for the states and local taxing districts over the next 20 years of projected growth are shown below for Case 4.

Summary of Total Revenues for the States and Local Taxing Districts Under Case 4: With Diversion, Moderate Growth	
States of North Dakota and Minnesota	$341,333
Local taxing districts	$74,975
Total	$416,308

EXHIBIT G

Phase IV Frequency-Stage-Damage Curves by Reach for Existing Conditions (2011)

Exhibit G contains stage-damage relationships for each reach in the study area under existing conditions. Existing conditions are conditions present in the year 2011, prior to any significant changes in economic, hydrologic, or hydraulic changes. The only exception is for projects that will be completed in then near term, such as the Oakport Levee and other flood risk management projects currently in design or construction phases. A discussion of projects that have been included in existing conditions can be found in Appendix C under Without-Project Conditions.

Damages are displayed for Subtotaled for each category into three broader categories:

Res & Apt	Total of Residential and Apartment Categories
Com&Farm	Total of Commercial, Agricultural, Farm, and CropStorage Categories
Pub&College	Total of Public and College Categories

Damages for Transportation, Sewer&Infrastructure, and Emergency Cost damages are presented in a separate reach

All values are given in October 2011 Price Levels - in $1,000's

The stages shown are the water surface elevation in feet above see level (NAVD88) and are referenced at the index hydraulic cross section of the reach.

Delineation of reaches can be found in Exhibits I and J.

FDA Stream Name:	RRV	Vertical Datum:	NAVD88
FDA Reach:	Fargo North End	Price Level:	Oct_2011
Reach Index Location:	437.95		

Exceedance Probability	Stage	Damage by Damage Categories ($000) Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	893.6	6,878.1	3,684.9	312.1	10,875.0
0.05	895.8	52,433.0	28,090.4	2,379.2	82,902.5
0.02	897.8	131,120.0	70,246.2	5,949.7	207,315.9
0.01	899.1	180,962.8	96,948.6	8,211.4	286,122.8
0.005	900.4	231,997.1	124,289.8	10,527.1	366,814.0
0.002	902.0	298,598.3	159,970.8	13,549.2	472,118.3

FDA Stream Name:	RRV	Vertical Datum:	NAVD88
FDA Reach:	Bridgewood	Price Level:	Oct_2011
Reach Index Location:	437.78		

Exceedance Probability	Stage	Damage by Damage Categories ($000) Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	894.9	-	-	-	-
0.05	897.3	-	-	-	-
0.02	899.7	45,296.5	121,761.0	21,963.7	189,021.2
0.01	901.1	77,705.9	208,880.4	37,678.6	324,264.9
0.005	902.4	106,636.4	286,647.7	51,706.6	444,990.7
0.002	904.2	127,344.7	342,313.5	61,747.7	531,405.8

FDA Stream Name:	RRV	Vertical Datum:	NAVD88
FDA Reach:	New North	Price Level:	Oct_2011
Reach Index Location:	436.41		

Exceedance Probability	Stage	Damage by Damage Categories ($000) Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	895.9	2,560.6	4,925.2	1,069.0	8,554.9
0.05	898.5	17,206.8	33,096.3	7,183.4	57,486.4
0.02	901.2	107,001.4	205,810.8	44,670.1	357,482.2
0.01	902.7	188,771.0	363,090.1	78,806.7	630,667.8
0.005	904.3	255,959.9	492,324.4	106,856.1	855,140.4
0.002	906.3	324,170.1	623,521.9	135,332.3	1,083,024.3

FDA Stream Name:	RRV	Vertical Datum:	NAVD88
FDA Reach:	Downtown North	Price Level:	Oct_2011
Reach Index Location:	434.37		

Exceedance Probability	Stage	Damage by Damage Categories ($000) Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	896.7	316.3	4,873.5	768.0	5,957.8
0.05	899.5	964.3	14,856.9	2,341.2	18,162.5
0.02	902.4	6,238.3	96,108.4	15,145.2	117,491.8
0.01	904.1	16,288.4	250,944.1	39,545.0	306,777.4
0.005	906.0	24,339.1	374,976.6	59,090.5	458,406.2
0.002	908.0	29,410.5	453,106.0	71,402.7	553,919.1

FDA Stream Name:	Red	Vertical Datum:	NGVD88
FDA Reach:	Downtown South	Price Level:	Oct_2011
Reach Index Location:	RST_15		

Exceedance Probability	Stage	Damage by Damage Categories ($000) Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	897.6	-	-	-	-
0.05	900.5	-	-	-	-
0.02	903.7	93,414.8	127,933.8	8,712.1	230,060.7
0.01	905.6	209,449.2	286,846.0	19,533.8	515,829.0
0.005	907.7	286,196.7	391,954.5	26,691.5	704,842.7
0.002	909.9	342,196.0	468,646.5	31,914.2	842,756.7

FDA Stream Name:	Red	Vertical Datum:	NGVD88
FDA Reach:	New South	Price Level:	Oct_2011
Reach Index Location:	RST_7		

Exceedance Probability	Stage	Damage by Damage Categories ($000) Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	897.8	-	-	-	-
0.05	900.8	-	-	-	-
0.02	904.0	32,251.8	66,100.7	3,714.4	102,066.9
0.01	905.9	119,353.2	244,617.0	13,745.7	377,715.9
0.005	908.0	168,114.5	344,555.0	19,361.5	532,031.0
0.002	910.3	213,358.3	437,283.0	24,572.1	675,213.4

FDA Stream Name:	Red	Vertical Datum:	NGVD88
FDA Reach:	Underwood Area	Price Level:	Oct_2011
Reach Index Location:	RST_1		

Exceedance Probability	Stage	Damage by Damage Categories ($000) Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	898.3	246.7	393.1	22.8	662.6
0.05	901.3	4,206.6	6,702.0	388.1	11,296.6
0.02	904.6	124,023.6	197,595.7	11,441.8	333,061.1
0.01	906.6	222,926.8	355,169.4	20,566.1	598,662.3
0.005	908.7	330,917.3	527,221.5	30,528.8	888,667.6
0.002	910.9	425,202.0	677,438.1	39,227.1	1,141,867.2

FDA Stream Name:	Red	Vertical Datum:	NGVD88
FDA Reach:	Fargo South (RR)	Price Level:	Oct_2011
Reach Index Location:	RST_15		

Exceedance Probability	Stage	Damage by Damage Categories ($000) Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	901.0	8,586.1	4,976.2	911.6	14,473.8
0.05	904.0	74,718.9	43,304.5	7,932.8	125,956.2
0.02	907.1	541,056.4	313,578.6	57,443.0	912,078.0
0.01	908.9	939,836.0	544,698.6	99,780.7	1,584,315.3
0.005	910.9	1,348,884.0	781,772.0	143,208.8	2,273,864.8
0.002	913.2	1,748,195.0	1,013,198.1	185,602.7	2,946,995.7

FDA Stream Name	Sheyenne	Vertical Datum:	NAVD88
FDA Reach	Fargo South (Sheyenne)	Price Level	Oct_2011
Reach Index Location	172308		

Exceedance	Damage by Damage Categories ($000)				
Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	904.6	-	-	-	-
0.05	905.1	-	-	-	-
0.02	905.2	-	-	-	-
0.01	905.2	-	-	-	-
0.005	905.3	-	-	-	-
0.002	905.3	2,974.1	11.7	-	2,985.8

FDA Stream Name	WBRN	Vertical Datum:	NAVD88
FDA Reach	West Fargo Downtown	Price Level	Oct_2011
Reach Index Location	451.37		

Exceedance	Damage by Damage Categories ($000)				
Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	896.8	-	-	-	-
0.05	899.5	-	-	-	-
0.02	902.4	85,406.8	52,350.4	657.3	138,414.6
0.01	904.1	416,462.7	255,272.0	3,205.4	674,940.1
0.005	906.0	594,204.4	364,219.3	4,573.4	962,997.1
0.002	908.0	752,526.1	461,263.5	5,791.9	1,219,581.5

FDA Stream Name	Wdhayenne	Vertical Datum:	NAVD88
FDA Reach	West Fargo South	Price Level	Oct_2011
Reach Index Location	172308		

Exceedance	Damage by Damage Categories ($000)				
Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	904.6	-	-	-	-
0.05	905.1	-	-	-	-
0.02	905.2	-	-	-	-
0.01	905.2	-	-	-	-
0.005	905.3	-	-	-	-
0.002	905.3	18,301.5	-	-	18,301.5

FDA Stream Name	HRRN	Vertical Datum:	NAVD88
FDA Reach	Harwood (HRN)	Price Level	Oct_2011
Reach Index Location	432.84		

Exceedance	Damage by Damage Categories ($000)				
Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	889.2	1,153.7	94.9	505.0	1,753.6
0.05	891.0	2,829.3	232.7	1,238.5	4,300.5
0.02	892.8	4,998.2	411.1	2,188.0	7,597.3
0.01	893.9	6,602.3	543.1	2,890.2	10,035.6
0.005	894.9	8,141.7	669.7	3,564.1	12,375.5
0.002	896.0	9,873.6	812.2	4,322.2	15,008.0

FDA Stream Name	[illegible]	Vertical Datum	NAVD88
FDA Reach	[illegible]	Price Level	Oct_2011
Reach Index Location	[illegible]		

Exceedance Probability	Stage	Damage by Damage Categories ($000) Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	888.5	355.1	-	0.9	356.1
0.05	889.7	940.4	-	2.5	942.9
0.02	890.8	1,685.8	-	4.5	1,690.3
0.01	891.1	1,943.8	-	5.2	1,949.0
0.005	891.3	2,181.8	-	5.8	2,187.6
0.002	891.5	2,842.2	-	7.6	2,849.8

FDA Stream Name	[illegible]	Vertical Datum	NAVD88
FDA Reach	[illegible]	Price Level	Oct_2011
Reach Index Location	[illegible]		

Exceedance Probability	Stage	Damage by Damage Categories ($000) Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	892.9	1,640.0	147.9	-	1,787.9
0.05	895.1	6,444.0	334.9	-	6,778.9
0.02	897.2	8,300.0	558.0	-	8,858.0
0.01	898.5	14,500.0	701.2	-	15,201.2
0.005	899.9	17,000.0	829.5	-	17,829.5
0.002	901.6	21,000.0	1,022.8	-	22,022.8

FDA Stream Name	[illegible]	Vertical Datum	NAVD88
FDA Reach	[illegible]	Price Level	Oct_2011
Reach Index Location	[illegible]		

Exceedance Probability	Stage	Damage by Damage Categories ($000) Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	903.7	2,768.0	138.7	43.5	2,950.2
0.05	906.9	10,999.5	551.1	172.8	11,723.4
0.02	909.8	23,357.0	1,170.2	366.9	24,894.0
0.01	911.3	33,391.9	1,673.0	524.5	35,589.4
0.005	912.8	44,864.3	2,247.7	704.7	47,816.7
0.002	914.8	59,621.3	2,987.1	936.5	63,544.8

FDA Stream Name	[illegible]	Vertical Datum	NAVD88
FDA Reach	[illegible]	Price Level	Oct_2011
Reach Index Location	[illegible]		

Exceedance Probability	Stage	Damage by Damage Categories ($000) Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	892.9	1,662.0	-	-	1,662.0
0.05	895.1	1,378.0	-	-	1,378.0
0.02	897.2	2,661.6	-	-	2,661.6
0.01	898.5	2,822.4	-	-	2,822.4
0.005	899.9	2,927.7	-	-	2,927.7
0.002	901.6	3,116.1	-	-	3,116.1

FDA Stream Name	BRRN	Vertical Datum	NAVD88
FDA Reach	B South (RRN)	Price Level	Oct_2011
Reach Index Location	465.1		

Exceedance	Damage by Damage Categories ($000)				
Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	903.7	810.9	23.7	-	834.6
0.05	906.9	3,548.4	103.5	-	3,651.9
0.02	909.8	7,607.2	221.9	-	7,829.1
0.01	911.3	10,873.6	317.2	-	11,190.8
0.005	912.8	14,607.8	426.1	-	15,033.9
0.002	914.8	19,553.8	570.4	-	20,124.2

FDA Stream Name	Asheyenne	Vertical Datum	NAVD88
FDA Reach	A Sheyenne	Price Level	Oct_2011
Reach Index Location	172308		

Exceedance	Damage by Damage Categories ($000)				
Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	904.6	-	-	-	6,045.6
0.05	905.1	-	-	-	11,016.8
0.02	905.2	-	-	-	13,811.4
0.01	905.2	-	-	-	14,418.3
0.005	905.3	-	-	-	15,368.1
0.002	905.3	17,181.1	50.1	16.2	17,247.5

FDA Stream Name	ShySA	Vertical Datum	NAVD88
FDA Reach	Sheyenne Storage A	Price Level	Oct_2011
Reach Index Location	368		

Exceedance	Damage by Damage Categories ($000)				
Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	889.0	118.7	0.1	-	118.8
0.05	890.2	502.5	0.4	-	502.9
0.02	891.2	2,408.9	2.1	-	2,411.0
0.01	891.8	3,918.4	3.4	-	3,921.8
0.005	892.0	4,583.7	4.0	-	4,587.6
0.002	892.3	6,493.5	5.6	-	6,499.1

FDA Stream Name	RRN	Vertical Datum	NAVD88
FDA Reach	Kingnes	Price Level	Oct_2011
Reach Index Location	434.61		

Exceedance	Damage by Damage Categories ($000)				
Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	890.0	163.5	43.5	-	207.1
0.05	891.8	795.6	211.8	-	1,007.5
0.02	893.5	1,837.7	489.3	-	2,327.0
0.01	894.5	2,442.6	650.4	-	3,092.9
0.005	895.5	2,942.0	783.3	-	3,725.4
0.002	896.7	3,665.4	976.0	-	4,641.3

FDA Stream Name	RRN	Vertical Datum:	NAVD88
FDA Reach	Oakport	Price Level:	Oct_2011
Reach Index Location	440.31		

Exceedance	Damage by Damage Categories ($000)				
Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	892.9	-	-	-	-
0.05	895.2	-	-	-	-
0.02	897.2	-	-	-	-
0.01	898.5	-	-	-	-
0.005	899.9	-	-	-	-
0.002	901.6	41,613.9	130.6	27.4	41,772.0

FDA Stream Name	RRN	Vertical Datum:	NAVD88
FDA Reach	North of Moorhead	Price Level:	Oct_2011
Reach Index Location	442.93		

Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	893.572	993.354	21.8769	0.108279	1015.34
0.05	895.8	3,539.1	77.9	0.4	3,617.4
0.02	897.8	8,707.8	191.8	0.9	8,900.5
0.01	899.1	13,220.4	291.2	1.4	13,513.0
0.005	900.4	18,364.6	404.5	2.0	18,771.1
0.002	902.0	26,137.4	575.6	2.8	26,715.9

FDA Stream Name	RRN	Vertical Datum:	NAVD88
FDA Reach	Moorhead North	Price Level:	Oct_2011
Reach Index Location	443.61		

Exceedance	Damage by Damage Categories ($000)				
Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	895.9	39.3	18.2	3.6	61.1
0.05	898.5	2,392.7	1,111.2	218.6	3,722.5
0.02	901.2	17,629.9	8,187.8	1,610.5	27,428.1
0.01	902.7	35,638.8	16,551.6	3,255.5	55,445.9
0.005	904.3	67,576.0	31,384.2	6,172.9	105,133.0
0.002	906.3	134,708.2	62,562.3	12,305.3	209,576.0

FDA Stream Name	RRN	Vertical Datum:	NAVD88
FDA Reach	Moorhead Central	Price Level:	Oct_2011
Reach Index Location	452.7		

Exceedance	Damage by Damage Categories ($000)				
Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	897.8	60.6	6.0	4.2	70.7
0.05	900.8	4,558.4	448.5	314.3	5,321.1
0.02	904.0	43,297.8	4,259.8	2,984.9	50,542.5
0.01	905.9	112,313.5	11,049.8	7,742.8	131,106.0
0.005	908.0	232,492.5	22,873.5	16,027.9	271,394.0
0.002	910.3	398,668.0	39,222.4	27,484.0	465,374.0

FDA Stream Name	RRN	Vertical Datum:	NAVD88
FDA Reach	Moorhead South	Price Level:	Oct_2011
Reach Index Location	460.78		

Exceedance	Damage by Damage Categories ($000)				
Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	901.0	1,384.4	133.5	32.3	1,550.3
0.05	904.0	15,958.4	1,539.5	372.6	17,870.5
0.02	907.1	61,845.0	5,966.1	1,444.1	69,255.2
0.01	908.9	107,314.6	10,352.5	2,505.8	120,173.0
0.005	910.9	179,600.7	17,325.8	4,193.7	201,120.0
0.002	913.2	281,209.3	27,127.8	6,566.3	314,903.0

FDA Stream Name	RRN	Vertical Datum:	NAVD88
FDA Reach	South of Moorhead	Price Level:	Oct_2011
Reach Index Location	468.9		

Exceedance	Damage by Damage Categories ($000)				
Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
0.1	905.5	46.9	8.9	0.5	56.3
0.05	908.5	332.3	63.2	3.4	398.9
0.02	911.1	911.5	173.2	9.2	1,093.9
0.01	912.3	1,423.8	270.6	14.4	1,708.8
0.005	913.7	1,978.9	376.1	20.0	2,375.0
0.002	915.6	2,718.6	516.7	27.5	3,262.8

FDA Stream Name	CRRN	Vertical Datum:	NAVD88
FDA Reach	South of Thompson	Price Level:	Oct_2011
Reach Index Location	328.41		

Exceedance	Damage by Damage Categories (1,000's)					
Probability	Stage	Res & Apt	Commercial	Pub&College	Farm	Total
0.1	841.6	0.0	-	-	0.0	0.0
0.05	845.6	2.7	-	-	3.4	6.1
0.02	850.1	54.0	-	-	66.9	120.9
0.01	853.0	191.2	-	-	236.8	428.1
0.005	855.6	517.3	-	-	640.5	1,157.8
0.002	858.6	1,560.6	-	-	1,932.5	3,493.1

FDA Stream Name	CRRN	Vertical Datum:	NAVD88
FDA Reach	Dimas MN&ND	Price Level:	Oct_2011
Reach Index Location	335.01		

Exceedance	Damage by Damage Categories (1,000's)					
Probability	Stage	Res & Apt	Commercial	Pub&College	Farm	Total
0.1	845.8	7.5	0.3	0.1	7.3	15.2
0.05	850.1	18.0	0.8	0.2	17.5	36.5
0.02	855.0	147.3	6.8	1.5	143.9	299.5
0.01	858.2	343.1	15.9	3.5	335.1	697.6
0.005	861.2	834.2	38.7	8.6	814.7	1,696.2
0.002	864.6	2,619.1	121.4	27.1	2,557.6	5,325.2

FDA Stream Name	CRRN	Vertical Datum:	NAVD88
FDA Reach	Shelly MN&ND	Price Level:	Oct_2011
Reach Index Location	399.73		

Exceedance	Damage by Damage Categories (1,000's)					
Probability	Stage	Res & Apt	Commercial	Pub&College	Farm	Total
0.1	856.5	3.9	-	0.0	7.8	11.8
0.05	860.1	42.5	-	0.0	84.6	127.0
0.02	863.9	449.0	-	0.1	894.2	1,343.2
0.01	866.4	1,119.4	-	0.2	2,229.4	3,349.0
0.005	868.5	1,902.7	-	0.4	3,789.4	5,692.5
0.002	871.0	3,118.5	-	0.6	6,210.7	9,329.8

FDA Stream Name	CRRN	Vertical Datum:	NAVD88
FDA Reach	Parley-Hendrum MN&ND	Price Level:	Oct_2011
Reach Index Location	381.71		

Exceedance	Damage by Damage Categories (1,000's)					
Probability	Stage	Res & Apt	Commercial	Pub&College	Farm	Total
0.1	866.6	29.1	-	-	53.2	82.3
0.05	868.7	230.2	-	-	421.1	651.4
0.02	870.8	994.5	-	-	1,819.1	2,813.6
0.01	872.0	1,623.4	-	-	2,969.2	4,592.6
0.005	873.2	2,071.9	-	-	3,789.6	5,861.5
0.002	874.5	2,669.9	-	-	4,883.4	7,553.3

FDA Stream Name	CRRN	Vertical Datum:	NAVD88
FDA Reach	Halstad MN&ND	Price Level:	Oct_2011
Reach Index Location	397.8		

Exceedance	Damage by Damage Categories (1,000's)					
Probability	Stage	Res & Apt	Commercial	Pub&College	Farm	Total
0.1	872.7	49.2	0.2	-	93.3	142.7
0.05	874.6	244.5	1.0	-	463.7	709.2
0.02	876.4	876.3	3.5	-	1,662.1	2,541.9
0.01	877.4	1,615.3	6.4	-	3,063.9	4,685.7
0.005	878.1	2,363.6	9.4	-	4,483.4	6,856.4
0.002	878.9	3,024.7	12.1	-	5,737.3	8,774.0

FDA Stream Name	CRRN	Vertical Datum:	NAVD88
FDA Reach	Georgetown MN&ND	Price Level:	Oct_2011
Reach Index Location	414.98		

Exceedance	Damage by Damage Categories (1,000's)					
Probability	Stage	Res & Apt	Commercial	Pub&College	Farm	Total
0.1	879.9	184.8	1.3	1.4	142.3	329.8
0.05	881.2	637.4	4.5	4.7	490.8	1,137.4
0.02	882.4	1,565.4	11.2	11.4	1,205.5	2,793.5
0.01	883.2	2,302.0	16.4	16.8	1,772.8	4,108.0
0.005	883.8	3,036.8	21.7	22.2	2,338.7	5,419.3
0.002	884.4	3,796.1	27.1	27.7	2,923.4	6,774.3

FDA Stream Name	BRRN	Vertical Datum:	NAVD88
FDA Reach	Intermediate MN&ND	Price Level:	Oct_2011
Reach Index Location	423.98		

Exceedance	Damage by Damage Categories (1,000's)					
Probability	Stage	Res & Apt	Commercial	Pub&College	Farm	Total
0.1	883.2	28.6	-	-	50.1	78.7
0.05	884.5	102.7	-	-	180.4	283.1
0.02	885.6	294.7	-	-	517.5	812.1
0.01	886.3	472.3	-	-	829.4	1,301.7
0.005	886.8	660.9	-	-	1,160.5	1,821.4
0.002	887.5	893.7	-	-	1,569.4	2,463.0

FDA Stream Name	RRN	Vertical Datum:	NAVD88
FDA Reach	Upstream (RRN)	Price Level:	Oct_2011
Reach Index Location	500.01		

Exceedance	Damage by Damage Categories					
Probability	Stage	Res & Apt	Commercial	Pub&College	Farm	Total
0.1	916.3	7.8	0.1	0.1	0.7	8.8
0.05	919.4	150.3	2.2	2.7	13.7	168.9
0.02	922.8	3,677.8	53.5	65.9	334.2	4,131.5
0.01	924.9	10,887.9	158.5	195.0	989.4	12,230.8
0.005	927.0	19,784.0	288.0	354.3	1,797.9	22,224.2
0.002	929.7	40,971.8	596.4	733.8	3,723.3	46,025.3

FDA Stream Name	Wild Rice ND	Vertical Datum:	NAVD88
FDA Reach	Upstream Wild Rice	Price Level:	Oct_2011
Reach Index Location	32.12		

Exceedance	Damage by Damage Categories					
Probability	Stage	Res & Apt	Commercial	Pub&College	Farm	Total
0.1	923.1	62.1	-	0.4	33.2	95.7
0.05	926.5	611.0	-	3.6	326.8	941.3
0.02	929.7	2,199.7	-	13.0	1,176.4	3,389.1
0.01	931.6	4,569.9	-	26.9	2,444.0	7,040.8
0.005	933.1	7,393.9	-	43.5	3,954.3	11,391.8
0.002	934.6	11,056.0	-	65.1	5,912.8	17,033.9

All Reaches — Price Level: Oct_2011

Exceedance Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
		Damage by Damage Categories ($000)			
0.1	Varies by Reach	30,157.3	19,880.3	3,675.5	53,713.0
0.05	Varies by Reach	205,787.4	132,735.4	22,558.8	361,081.5
0.02	Varies by Reach	1,361,316.4	1,281,011.5	178,398.1	2,820,726.0
0.01	Varies by Reach	2,741,286.4	2,663,937.5	338,255.7	5,743,479.6
0.005	Varies by Reach	3,983,076.3	3,788,412.0	483,664.5	8,255,152.8
0.002	Varies by Reach	5,380,389.1	4,809,520.1	621,690.0	10,811,599.2

All Downstream Reaches — Price Level: Oct_2011

Exceedance Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
		Damage by Damage Categories ($000)			
0.1	Varies by Reach	303.1	356.0	1.4	660.5
0.05	Varies by Reach	1,277.9	1,667.9	4.9	2,950.7
0.02	Varies by Reach	4,381.1	6,330.6	13.0	10,724.8
0.01	Varies by Reach	7,666.7	11,475.4	20.6	19,162.6
0.005	Varies by Reach	11,387.4	17,086.6	31.2	28,505.2
0.002	Varies by Reach	17,682.5	25,974.9	55.4	43,712.7

All Metro Reaches — Price Level: Oct_2011

Exceedance Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
		Damage by Damage Categories ($000)			
0.1	Varies by Reach	29,784.3	19,490.2	3,673.5	52,948.1
0.05	Varies by Reach	203,748.1	130,724.9	22,547.6	357,020.6
0.02	Varies by Reach	1,351,057.7	1,273,116.7	178,306.3	2,802,480.7
0.01	Varies by Reach	2,718,162.0	2,648,870.2	338,013.2	5,705,045.3
0.005	Varies by Reach	3,944,511.0	3,765,285.2	483,235.5	8,193,031.7
0.002	Varies by Reach	5,310,678.8	4,773,312.7	620,835.7	10,704,827.3

All Upstream Reaches — Price Level: Oct_2011

Exceedance Probability	Stage	Res & Apt	Com&Farm	Pub&College	Total Damage
		Damage by Damage Categories ($000)			
0.1	Varies by Reach	69.9	34.0	0.5	104.4
0.05	Varies by Reach	761.3	342.6	6.3	1,110.2
0.02	Varies by Reach	5,877.5	1,564.2	78.8	7,520.5
0.01	Varies by Reach	15,457.7	3,591.9	221.9	19,271.6
0.005	Varies by Reach	27,177.9	6,040.2	397.8	33,616.0
0.002	Varies by Reach	52,027.8	10,232.6	798.8	63,059.2

EXHIBIT H

Phase IV EAD by Reach by Category for Existing Conditions (2011)

Expected Annual Damage by Damage Categories and Damage Reaches

(Expected Annual Damages in $1,000's - Price Level Oct 2011)

	Residential	Commercial	Public	Total
Fargo North				
Fargo North End	8,169.0	4,376.5	370.7	12,916.1
Ridgewood	2,325.0	6,249.7	1,127.4	9,702.1
Near North	5,954.2	11,452.5	2,485.7	19,892.4
Downtown North	473.5	7,295.6	1,149.7	8,918.8
Downtown South	5,202.9	7,125.5	485.2	12,813.6
Near South	2,510.3	5,144.9	289.1	7,944.3
Lindenwood Area	6,627.0	10,558.3	611.4	17,796.7
Subtotal	31,261.9	52,202.8	6,519.1	89,984.0
Fargo South				
Fargo South (RRN)	30,586.2	17,726.7	3,247.3	51,560.0
Fargo South(Sheyenne)	73.2	0.3	-	73.5
Subtotal	30,659.4	17,727.0	3,247.3	51,633.5
West Fargo				
WF Downtown (RRN)	8,934.4	5,476.4	68.8	14,479.5
WF South (Sheyenne)	880.8	-	-	880.8
Subtotal	9,815.2	5,476.4	68.8	15,360.3
Harwood				
Harwood Red	388.2	31.9	170.0	590.1
Harwood Shy	127.7	-	0.3	128.1
Subtotal	515.9	31.9	170.3	718.2
Cass County				
A North (RRN)	1,621.4	46.4	-	1,667.8
A South (RRN)	1,846.8	92.5	29.0	1,968.4
B North (RRN)	404.2	-	-	404.2
B South (RRN)	571.9	16.7	-	588.6
Subtotal	4,444.4	155.6	29.0	4,629.0
A Sheyenne	2,419.9	7.1	2.3	2,429.3
Sheyenne Storage A	131.4	0.1	-	131.6
Subtotal	2,551.3	7.2	2.3	2,560.8

Moorhead/Clay County	(Expected Annual Damages in $1,000's - Price Level Oct 2011) Residential	Commercial	Public	Total
Kragnes	118.4	31.5	-	149.9
Oakport	163.9	0.5	0.1	164.6
North of Moorhead	619.1	13.6	0.1	632.8
Moorhead North	1,433.7	665.9	131.0	2,230.6
Moorhead Central	4,147.1	408.0	285.9	4,841.1
Moorhead South	4,258.4	410.8	99.4	4,768.6
South of Moorhead	58.6	11.1	0.6	70.4
Subtotal	10,799.3	1,541.5	517.1	12,857.9
Grand Total	90,047.4	77,142.4	10,553.8	177,743.6

Downstream - CRRN	(Expected Annual Damages in $1,000's - Price Level Oct 2011) Residential	Commercial	Public	Farm	Total
XS-324.41	11.7	-	-	14.5	26.2
XS-335.01	23.7	1.1	0.2	23.2	48.2
XS-359.73	36.8	-	0.0	73.3	110.2
XS-381.71	56.3	-	-	102.9	159.1
XS-397.8	57.7	0.2	-	109.4	167.3
XS-414.98	108.3	0.8	0.8	83.4	193.2
Subtotal	294.4	2.1	1.0	406.7	704.3
					-
Dowmstream - BRRN					
XS-423.96	21.4	-	-	37.5	58.9
Total Downstream	315.8	2.1	1.0	444.2	763.2

Upstream	(Expected Annual Damages in $1,000's - Price Level Oct 2011) Residential	Commercial	Public	Farm	Total
RRN	389.2	5.7	7.0	35.4	437.2
Wild Rice	165.8	-	1.0	88.7	255.4
Total Upstream	554.99	5.67	7.95	124.02	692.63

EXHIBIT I

Phase IV Reach & Levee Configuration

Metro Area Reaches, Beginning Damage, and Levees

Fargo Moorhead Metro Feasibility Study

Reach	Stream	Bank	WSP Index RM	Dnstrm	Upstrm	TOL	Target Stage	Beginning Damage Stage	Beginning Damage Frequency
Fargo North End	RRN	Left	442.93	437	447.3	---	892.39	886.74	0.2
Ridgewood	RRN	Left	447.78	447.3	448.2	898	898	888.13	0.2
Near North	RRN	Left	449.61	448.2	450.9	---	895.1	889.14	0.2
Downtown North	RRN	Left	451.37	450.9	451.7	---	894.25	894.02	0.1
Downtown South	RRN	Left	452.25	451.7	452.6	902.2	902.2	882.38	0.5
Near South	RRN	Left	452.7	452.6	453	904*	904	895.14	0.1
Lindenwood Area	RRN	Left	454.1	453	455.3	---	900.64	898.44	0.05
Z_Other**	RRN	Both	650	600	700				
Fargo South									
From RRN	RRN	Left	460.28	455.3	464	---	901.48	898.52	0.1
From Sheyenne	Sheyenne	Both	172308	160670	186000	---	904.72	905.59	0.002
West Fargo									
WF Downtown	WRRN	Left	451.37	447.42	455.23	---	900.03	902.94	0.005
WF South	Wsheyenne	Both	172308	160670	186000	---	904.81	905.59	0.002
Harwood									
Harwood Red	HRRN	Left	432.84	430.23	433.83				
Harwood Sheyenne	Hsheyenne	Both	67984	94542	72114				
Cass County									
ANorth (RRN)	ARRN	Left	440.31	422.69	449.09	---	892.99	895.36	0.01
ASouth (RRN)	ARRN	Left	465.1	460	482	---	896.77	898.15	0.2
BNorth (RRN)	BRRN	Left	440.31	422.69	449.09	---	889.33	890.11	0.1
BSouth (RRN)	BRRN	Left	465.1	460	482	---	905.06	898.15	0.2

Metro Area Reaches, Beginning Damage, and Levees

Fargo Moorhead Metro Feasibility Study

Reach	Stream	Bank	WSP Index RM	Dnstrm	Upstrm	TOL	Target Stage	Beginning Damage Stage	Beginning Damage Frequency
ASheyenne	Asheyenne	Both	172308	55000	232850	---	904.16	905.16	0.05
ShySA		Both	166	140	179	---	892.5	890.38	0.02
Moorhead									
Kragnes	RRN	Right	434.61	428	437	---	888.34	887.73	0.1
Oakport	RRN	Right	440.31	437	442.14	900.5	900.5	897.07	0.02
North of Moorhead	RRN	Right	442.93	442.14	447	---	892.26	892.88	0.05
Moorhead North	RRN	Right	449.61	447	451.7	---	896.61	889.14	0.2
Moorhead Central	RRN	Right	452.7	451.7	455.28	---	900.07	891.15	0.2
Moorhead South	RRN	Right	460.28	455.28	468.3	---	900.29	897.14	0.1
South of Moorhead	BRRN	Right	468.9	468.3	478.9	---	905.27	906.98	0.05

*Geotechnical failure analysis

Stage	890	895	897.4	900	903.95
Probability of failure	0	0.01	0.01	0.21	0.26

**This is a dummy reach for calculating Emergency, Transportation, and Sewer&Infrastructure Damages
Frequency and Ratings curves from XS 452.7 are used in this reach

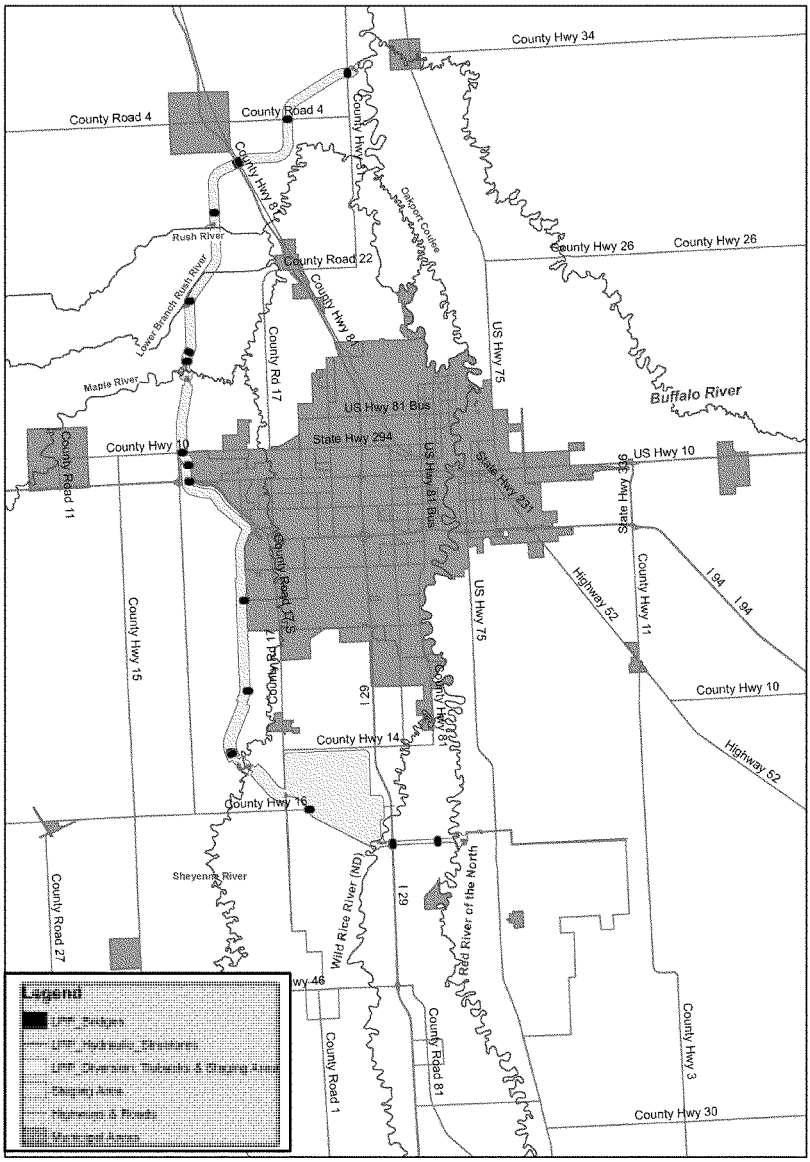
Downstream and Upstream Reaches, Beginning Damage, and Levees

Fargo Moorhead Metro Feasibility Study

Reach	Stream	Bank	WSP Index RM	Dnstrm	Upstrm
Downstream					
South of Thompson - XS 324.41	CRRN	Both	324.41	316.26	328.19
Climax MN&ND - XS 335.01	CRRN	Both	335.01	328.19	349.71
Shelly MN&ND - XS 359.73	CRRN	Both	359.73	349.71	370.03
Perley-Hendrum MN&ND - XS 381.71	CRRN	Both	381.71	370.03	385.04
Halstad MN&ND - XS 397.8	CRRN	Both	397.80	385.04	406.51
Georgetown MN&ND - XS 414.98	CRRN	Both	414.98	406.51	431.95
Intermediate - XS 423.96	BRRN	Both	423.96	419.92	432.55
Upstream_Red	RRN	Both	500.01	478	525
Upstream_WR	Wild Rice ND	Both	32.12	11	43

EXHIBIT J

Maps of Reaches & Alternatives



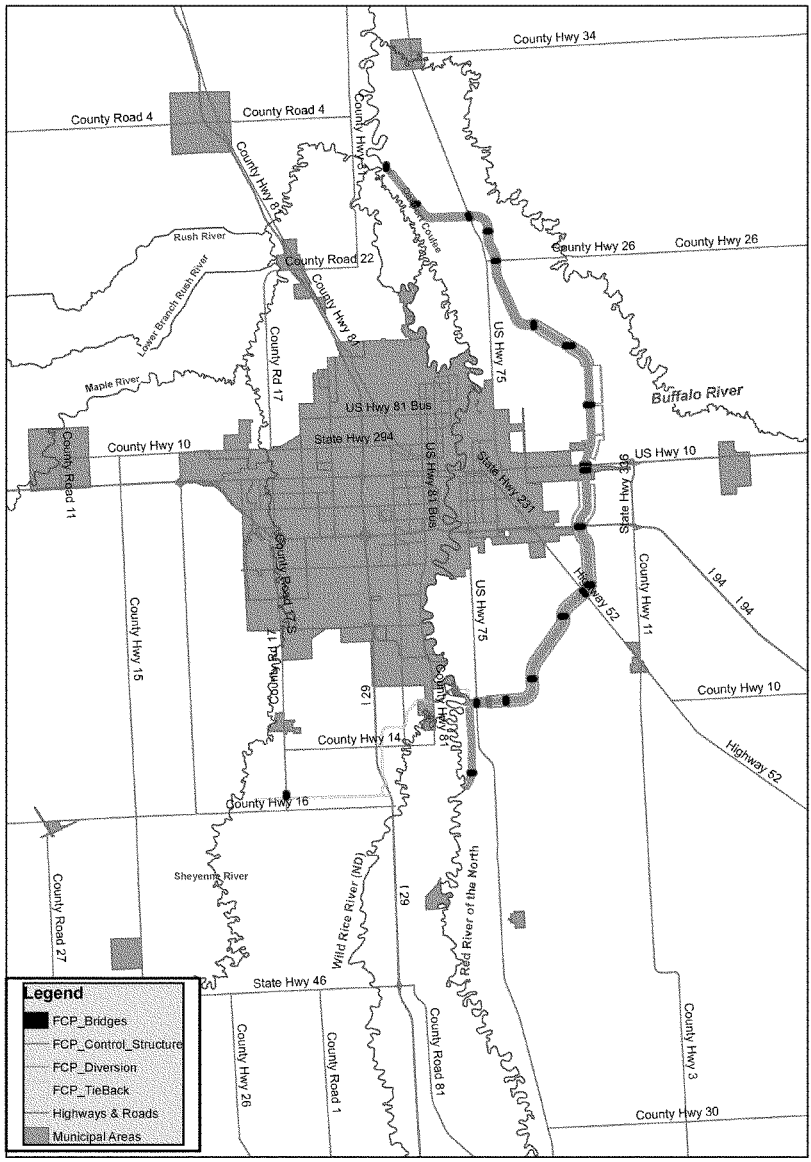
Locally Preferred Plan (LPP)

St. Paul District
Economics

US Army Corps of Engineers®

0 0.5 1 2 3 4 Miles

N



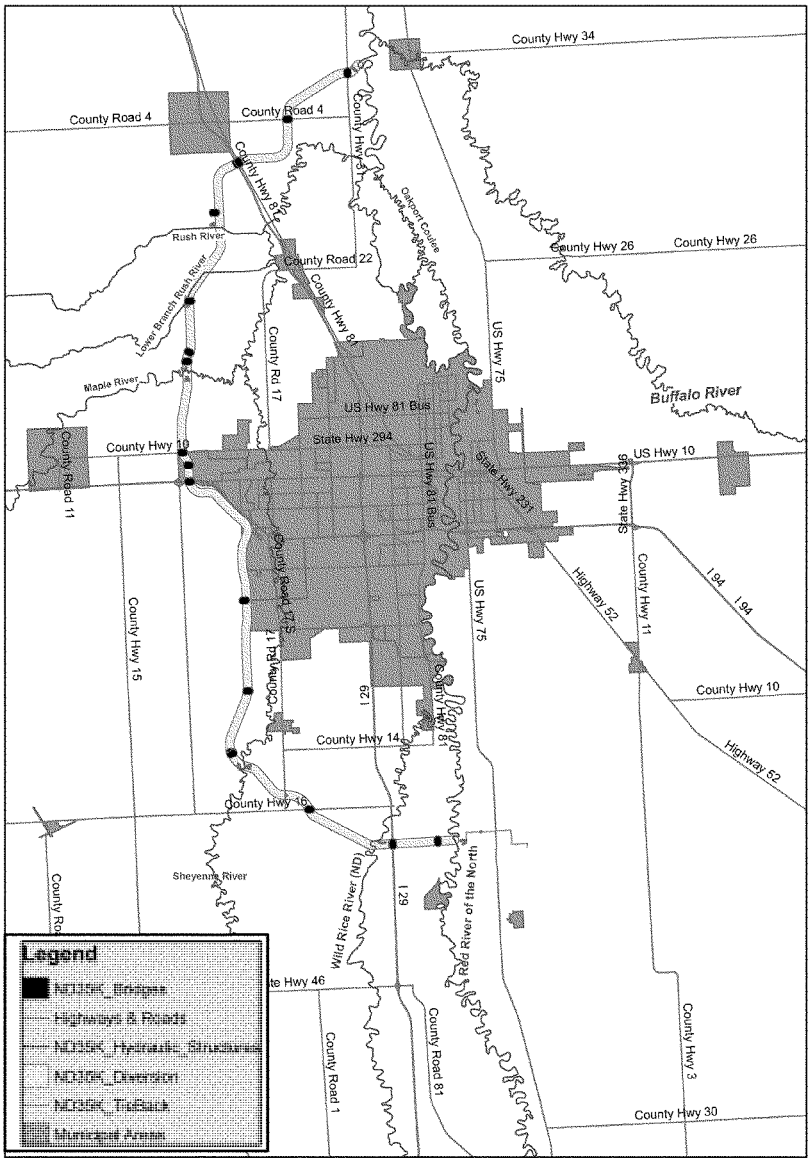
Federally Comparable Plan (FCP)

St. Paul District
Economics

US Army Corps of Engineers®

0 0.5 1 2 3 4 Miles

N



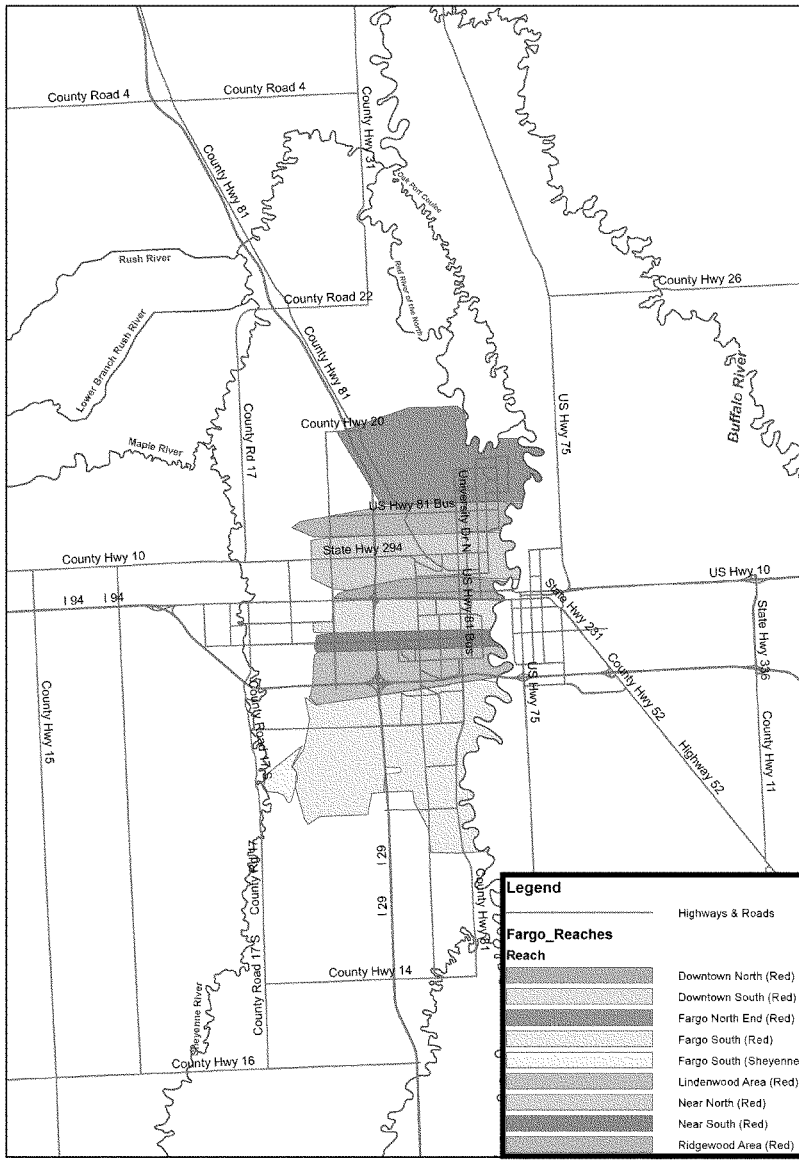
North Dakota 35,000 cfs (ND35K)

St. Paul District
Economics

US Army Corps of Engineers®

0 0.5 1 2 3 4 Miles

N



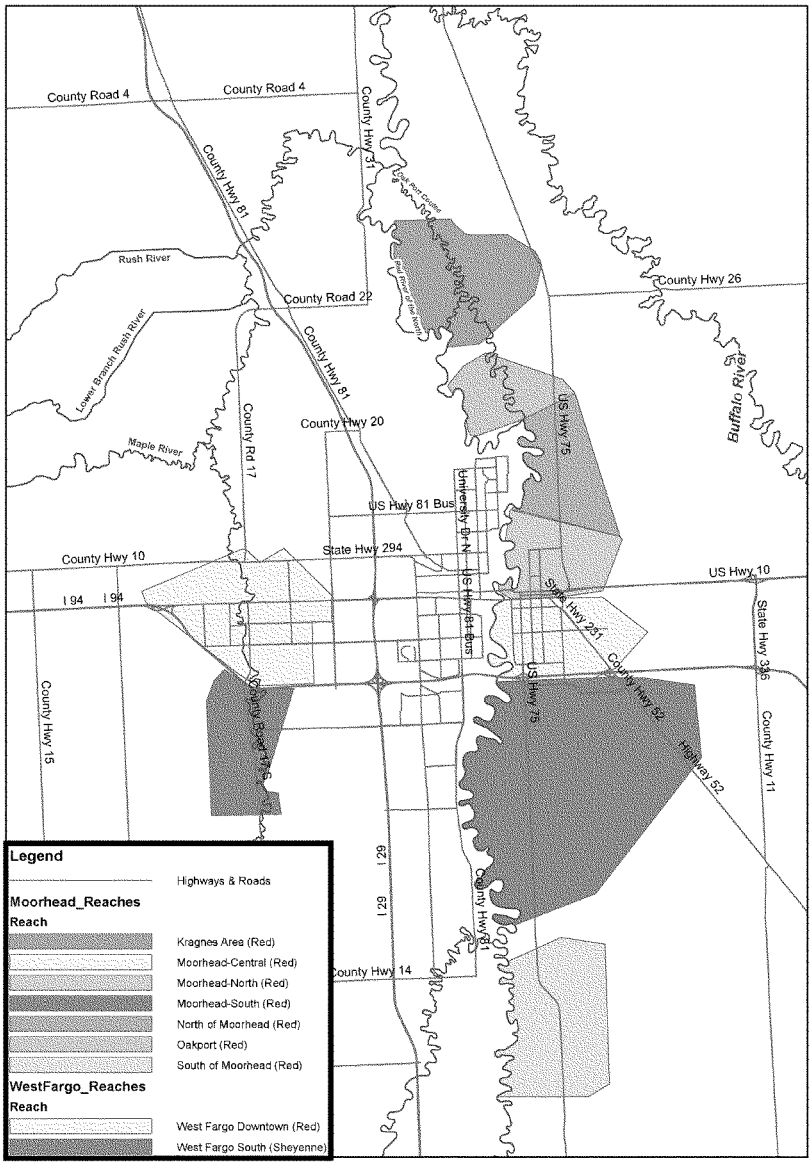
Fargo Reaches

St. Paul District
GIS CENTER
US Army Corps of Engineers®

Imagery Courtesy of NAIP, 2008

0 0.35 0.7 1.4 2.1 2.8 Miles

N



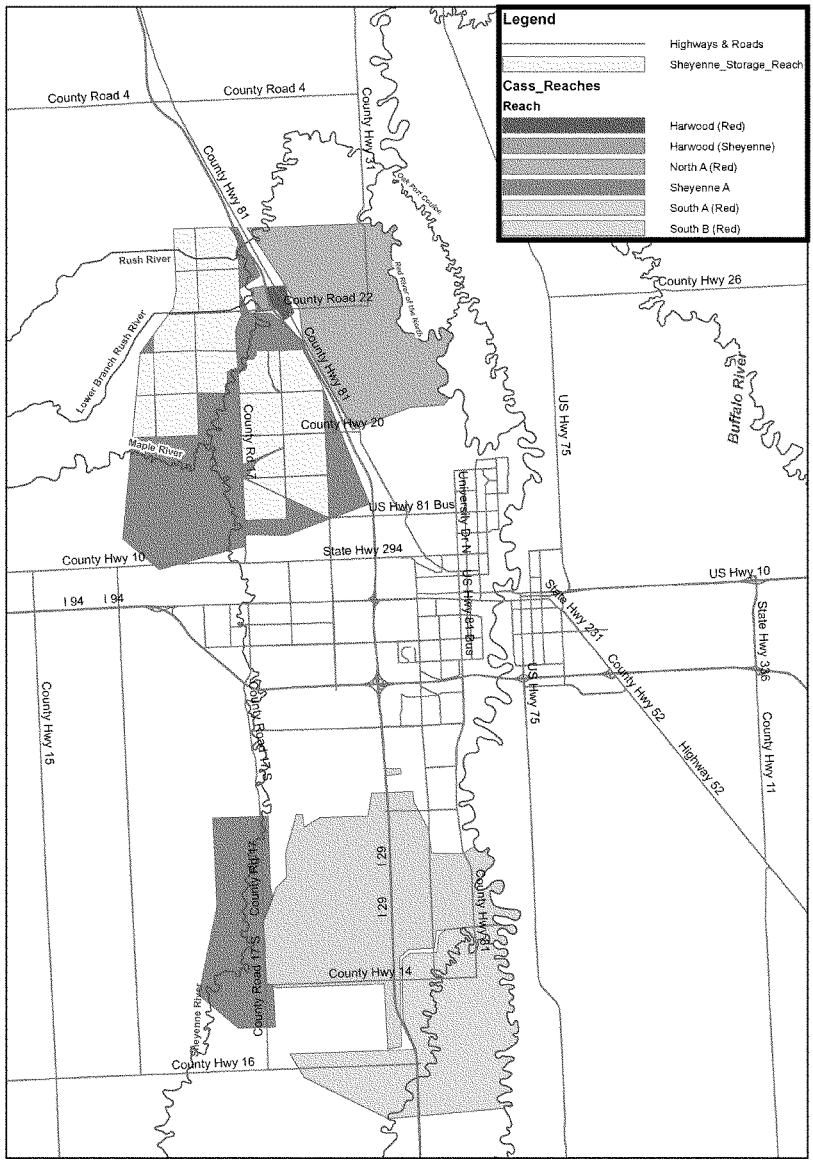
West Fargo & Moorhead Reaches

St. Paul District
GIS CENTER
US Army Corps of Engineers®

Imagery Courtesy of NAIP, 2008

0 0.35 0.7 1.4 2.1 2.8
Miles

N



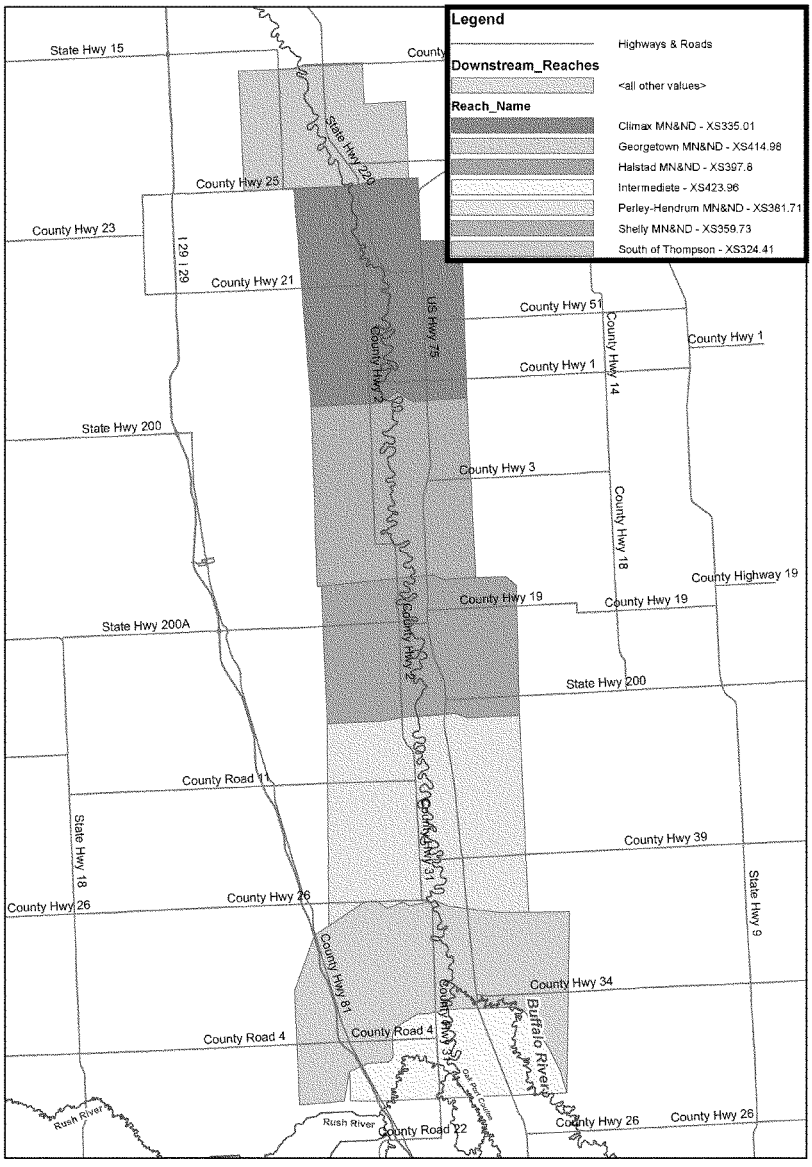
Cass County Reaches

St. Paul District
GIS CENTER
US Army Corps of Engineers®

Imagery Courtesy of NAIP, 2008

0 0.35 0.7 1.4 2.1 2.8 Miles

N



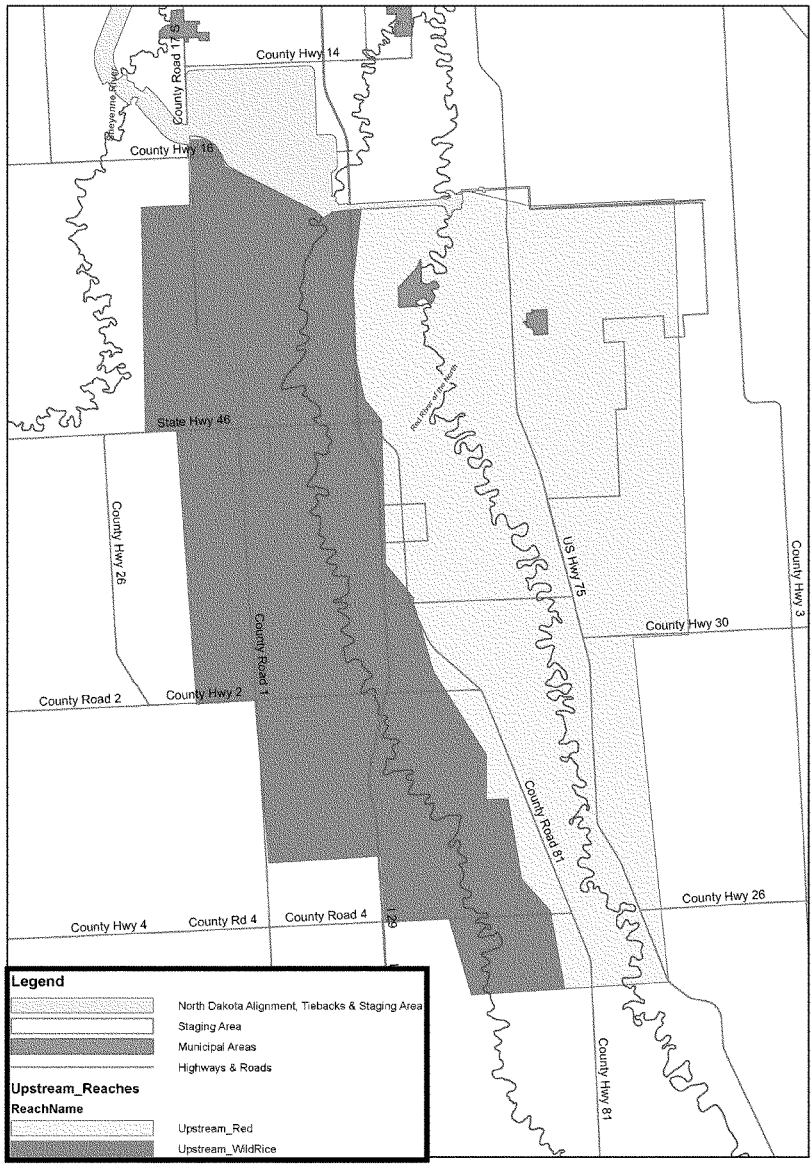
Downstream Reaches

St. Paul District
GIS CENTER
US Army Corps of Engineers®

Imagery Courtesy of NAIP, 2008

0 0.5 1 2 3 4 Miles

N



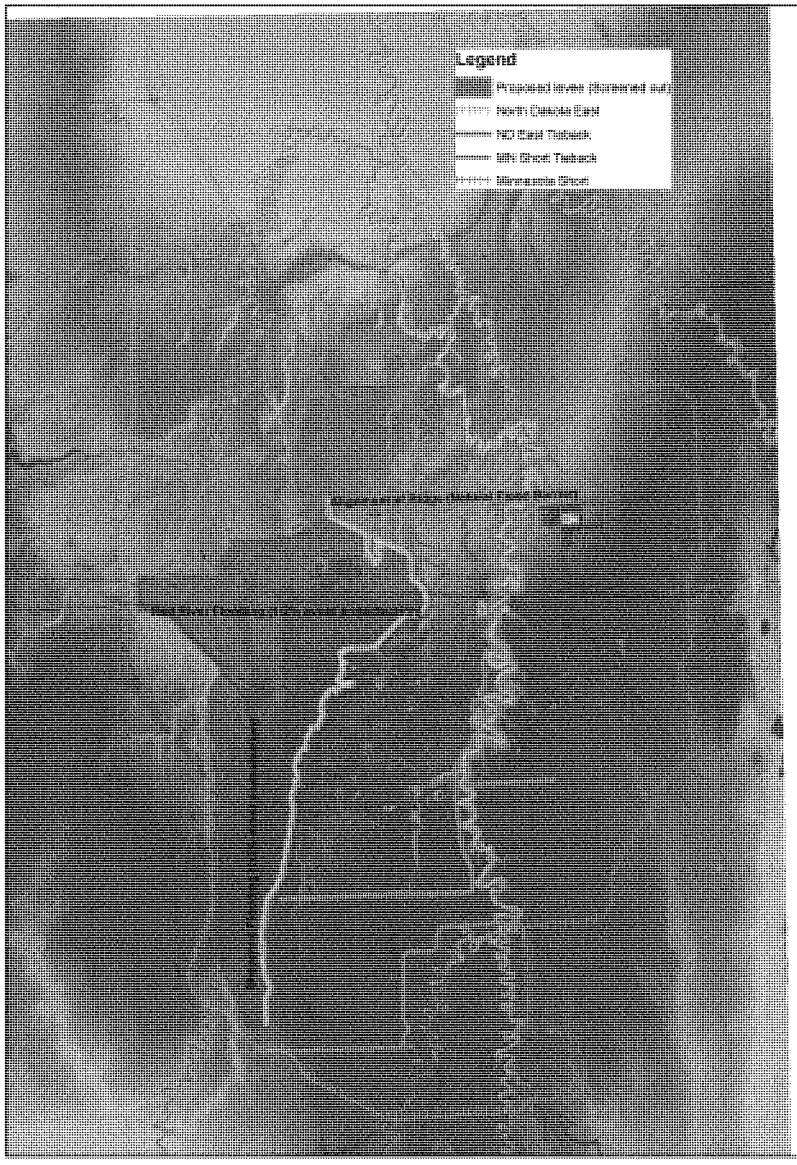
Upstream Reaches

St. Paul District
GIS CENTER
US Army Corps of Engineers®

Imagery Courtesy of NAIP, 2008

0 0.3 0.6 1.2 1.8 2.4 Miles

N



Shaded Relief & Geographic Features

St. Paul District
GIS CENTER
US Army Corps of Engineers®

0 0.35 0.7 1.4 2.1 2.8 Miles

N

EXHIBIT K

Interest during Construction

Phase IV Interest During Construction

Fargo-Moorhead Metro Feasibility Study

	Scheduled Construction Cost					
	ND35K	ND w/Staging	MN35K	Rec ND35k	Rec NDwStaging	Rec MN
May-2012	$87,348	$102,647	$80,345			
Dec-2012	$174,696	$205,293	$160,689			
Dec-2013	$174,696	$205,293	$160,689			
Dec-2014	$174,696	$205,293	$160,689			
Dec-2015	$174,696	$205,293	$160,689			
Dec-2016	$174,696	$205,293	$160,689			
Dec-2017	$174,696	$205,293	$160,689			$15,747
Dec-2018	$174,696	$205,293	$160,689	$19,418	$18,158	$15,747
Dec-2019	$174,696	$205,293		$19,418	$18,158	
Nominal Total	$1,484,913	$1,744,991	$1,205,169	$38,835	$36,315	$31,494
			Compounding			
Years to base						
8	$33,348	$39,189	$30,674	$0	$0	$0
7	$57,133	$67,140	$52,552	$0	$0	$0
6	$47,949	$56,347	$44,105	$0	$0	$0
5	$39,129	$45,982	$35,992	$0	$0	$0
4	$30,658	$36,028	$28,200	$0	$0	$0
3	$22,523	$26,467	$20,717	$0	$0	$0
2	$14,710	$17,286	$13,530	$0	$0	$1,326
1	$7,206	$8,468	$6,628	$801	$749	$650
0	$0	$0	$0	$0	$0	$0
Total I&DDC	$252,655	$296,907	$232,398	$801	$749	$1,975
Present Worth of Installation Costs	$1,737,568	$2,041,898	$1,437,567	$39,636	$37,064	$33,469

*Discount Rate is 4-1/8%

**If a cost is incurred between Dec-1 2019 and Dec-1 2020, it is said to be incurred in the base year

All costs are compounded or discounted to the base year (i.e. if a cost is incurred on Feb-1 2019, it accrues one year of interest)

Phase III Interest During Construction

Fargo-Moorhead Metro Feasibility Study

		Scheduled Construction Cost					
	ND E 35k	MN S 35	MN S 30	MN S 25	MN S 20	Rec ND	Rec MN
May-2012	$72,786	$71,106	$66,007	$61,971	$57,073		
Dec-2012	$145,571	$142,213	$132,013	$123,942	$114,147		
Dec-2013	$145,571	$142,213	$132,013	$123,942	$114,147		
Dec-2014	$145,571	$142,213	$132,013	$123,942	$114,147		
Dec-2015	$145,571	$142,213	$132,013	$123,942	$114,147		
Dec-2016	$145,571	$142,213	$132,013	$123,942	$114,147		
Dec-2017	$145,571	$142,213	$132,013	$123,942	$114,147		$17,121
Dec-2018	$145,571	$142,213	$132,013	$123,942	$114,147	$17,376	$17,121
Dec-2019	$145,571					$17,376	
Nominal Total	$1,237,355	$1,066,597	$990,099	$929,562	$856,101	$34,753	$34,243
		Compounding					
Years to base							
8	$29,736	$29,050	$26,967	$25,318	$23,317	$0	$0
7	$50,878	$49,705	$46,140	$43,319	$39,895	$0	$0
6	$42,644	$41,660	$38,672	$36,308	$33,438	$0	$0
5	$34,755	$33,953	$31,518	$29,591	$27,252	$0	$0
4	$27,196	$26,569	$24,663	$23,155	$21,325	$0	$0
3	$19,954	$19,494	$18,096	$16,989	$15,647	$0	$0
2	$13,016	$12,716	$11,804	$11,082	$10,206	$0	$1,531
1	$6,369	$6,222	$5,776	$5,422	$4,994	$760	$749
0	$0	$0	$0	$0	$0	$0	$0
Total I&DDC	$224,548	$219,368	$203,635	$191,184	$176,075	$760	$2,280
Present Worth of Installation Costs	$1,461,904	$1,285,965	$1,193,733	$1,120,745	$1,032,176	$35,513	$36,522

*Discount Rate is 4-3/8%

**If a cost is incurred between Dec-1 2019 and Dec-1 2020, it is said to be incurred in the base year

All costs are compounded or discounted to the base year (i.e. if a cost is incurred on Feb-1 2019, it accrues one year of interest)

EXHIBIT L

EAD, EAB, EEAD, & EEAB

EEAD by Reach ($1,000's)
Without Project Conditions (all analysis years) - Upstream & Downstream

	EEAD*
South of Thompson	$26
Climax MN&ND	$48
Shelly MN&ND	$110
Halstad MN&ND	$159
Perley-Hendrum MN&ND	$167
Georgetown MN&ND	$193
Intermediate Downstream	$59
Upstream - Inlet to Abercrombie	$693
Total EEAD Downstream	$763
Total EEAD Upstream	$693

*EAD is constant for each analysis year, therefore EEAD = EAD

EAD & EEAD by Reach ($1,000's)
Without Project Conditions - Metro Area

Analysis Year		Fargo	West Fargo	Cass Co.	Moorhead & Clay Co.	Emergency	Other Infrastruture	Traffic
EAD 2019	2019	$150,316	$15,360	$7,909	$12,858	$7,739	$291	$4,029
EAD 2043	2043	$123,634	$12,962	$26,706	$10,615	$6,311	$237	$3,290
EAD 2068	2068	$102,990	$10,896	$34,724	$8,876	$5,239	$197	$2,728
EAD 2019		$150,316	$15,360	$7,909	$12,858	$7,739	$291	$4,029
# years to next analysis year	2019-2043	24	24	24	24	24	24	24
Annual Change		-$1,067	-$96	$752	-$90	-$57	-$2	-$30
Annual Discount Factor		0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream		$2,195,668	$226,342	$237,026	$188,052	$112,723	$4,241	$58,709
EAD 2043		$123,634	$12,962	$26,706	$10,615	$6,311	$237	$3,290
# years to next analysis year	2043-2068	25	25	25	25	25	25	25
Annual Change		-$826	-$83	$321	-$70	-$43	-$2	-$22
Annual Discount Factor		0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream		$702,391	$73,879	$181,890	$60,387	$35,812	$1,346	$18,660
Discount Rate		4.125%						
Total Present Worth		$2,898,060	$300,221	$418,915	$248,439	$148,534	$5,587	$77,369
EEAD		$137,806	$14,276	$19,920	$11,814	$7,063	$266	$3,679

EAD & EEAD by Reach ($1,000's)
ND35k & ND w/Staging - Metro Area

Analysis Year		Fargo	West Fargo	Cass Co.	Moorhead & Clay Co.	Emergency	Other Infrastruture	Traffic
EAD 2019	2019	$17,709	$2,026	$1,529	$1,925	$719	$24	$364
EAD 2043	2043	$14,865	$1,714	$5,601	$1,692	$578	$20	$300
EAD 2068	2068	$12,455	$1,452	$7,821	$1,483	$453	$16	$240
EAD 2019		$17,709	$2,026	$1,529	$1,925	$719	$24	$364
# years to next analysis year	2019-2043	24	24	24	24	24	24	24
Annual Change		-$114	-$12	$163	-$9	-$6	$0	-$3
Annual Discount Factor		0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream		$260,475	$29,875	$48,454	$28,774	$10,420	$354	$5,319
EAD 2043		$14,865	$1,714	$5,601	$1,692	$578	$20	$300
# years to next analysis year	2043-2068	25	25	25	25	25	25	25
Annual Change		-$96	-$10	$89	-$8	-$5	$0	-$2
Annual Discount Factor		0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream		$84,626	$9,796	$39,449	$9,789	$3,215	$110	$1,682
Discount Rate		4.125%						
Total Present Worth		$345,101	$39,671	$87,903	$38,563	$13,635	$464	$7,000
EEAD		$16,410	$1,886	$4,180	$1,834	$648	$22	$333

EAD & EEAD by Reach ($1,000's)
MN35k - Metro Area

Analysis Year		Fargo	West Fargo	Cass Co.	Moorhead & Clay Co.	Emergency	Other Infrastruture	Traffic
EAD 2019	2019	$17,834	$2,875	$4,626	$2,008	$704	$28	$402
EAD 2043	2043	$15,255	$2,668	$8,652	$1,777	$584	$23	$339
EAD 2068	2068	$12,960	$2,341	$12,603	$1,560	$463	$18	$273
EAD 2019		$17,834	$2,875	$4,626	$2,008	$704	$28	$402
# years to next analysis year	2019-2043	24	24	24	24	24	24	24
Annual Change		-$103	-$8	$161	-$9	-$5	$0	-$3
Annual Discount Factor		0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream		$264,030	$43,819	$96,727	$30,083	$10,314	$405	$5,918
EAD 2043		$15,255	$2,668	$8,652	$1,777	$584	$23	$339
# years to next analysis year	2043-2068	25	25	25	25	25	25	25
Annual Change		-$92	-$13	$158	-$9	-$5	$0	-$3
Annual Discount Factor		0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream		$87,277	$15,446	$62,200	$10,289	$3,262	$129	$1,902
Discount Rate		4.125%						
Total Present Worth		$351,307	$59,265	$158,927	$40,373	$13,577	$535	$7,820
EEAD		$16,705	$2,818	$7,557	$1,920	$646	$25	$372

EAB & EEAB by Reach ($1,000's)
ND35k & ND w/Staging - Metro Area

Analysis Year		Fargo	West Fargo	Cass Co.	Moorhead & Clay Co.	Emergency	Other Infrastruture	Traffic
EAB 2019	2019	$132,607	$13,335	$6,380	$10,932	$7,020	$267	$3,666
EA8 2043	2043	$108,769	$11,248	$21,105	$8,923	$5,734	$218	$2,989
EAB 2068	2068	$90,535	$9,444	$26,903	$7,393	$4,786	$181	$2,488
EAB 2019		$132,607	$13,335	$6,380	$10,932	$7,020	$267	$3,666
# years to next analysis year	2019-2043	24	24	24	24	24	24	24
Annual Change		-$954	-$83	$589	-$80	-$51	-$2	-$27
Annual Discount Factor		0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream		$1,935,193	$196,467	$188,572	$159,277	$102,303	$3,887	$53,390
EAB 2043		$108,769	$11,248	$21,105	$8,923	$5,734	$218	$2,989
# years to next analysis year	2043-2068	25	25	25	25	25	25	25
Annual Change		-$729	-$72	$232	-$61	-$38	-$1	-$20
Annual Discount Factor		0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream		$617,765	$64,083	$142,440	$50,598	$32,597	$1,236	$16,978
Discount Rate		4.125%						
Total Present Worth		$2,552,958	$260,550	$331,012	$209,875	$134,900	$5,123	$70,368
EEAB		$121,396	$12,389	$15,740	$9,980	$6,415	$244	$3,346

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EAB & EEAB by Reach ($1,000's)
MN35k - Metro Area

Analysis Year		Fargo	West Fargo	Cass Co.	Moorhead & Clay Co.	Emergency	Other Infrastruture	Traffic
EAB 2019	2019	$132,482	$12,486	$3,283	$10,850	$7,035	$264	$3,627
EAB 2043	2043	$108,379	$10,294	$18,054	$8,838	$5,727	$214	$2,951
EAB 2068	2068	$90,029	$8,555	$22,121	$7,316	$4,776	$178	$2,455
EAB 2019		$132,482	$12,486	$3,283	$10,850	$7,035	$264	$3,627
# years to next analysis year	2019-2043	24	24	24	24	24	24	24
Annual Change		-$964	-$88	$591	-$81	-$52	-$2	-$27
Annual Discount Factor		0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream		$1,931,639	$182,523	$140,299	$157,968	$102,408	$3,835	$52,791
EAB 2043		$108,379	$10,294	$18,054	$8,838	$5,727	$214	$2,951
# years to next analysis year	2043-2068	25	25	25	25	25	25	25
Annual Change		-$734	-$70	$163	-$61	-$38	-$1	-$20
Annual Discount Factor		0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream		$615,114	$58,433	$119,689	$50,098	$32,549	$1,217	$16,758
Discount Rate		4.125%						
Total Present Worth		$2,546,752	$240,956	$259,988	$208,066	$134,958	$5,052	$69,549
EEAB		$121,101	$11,458	$12,363	$9,894	$6,417	$240	$3,307

EAD & EEAD by Categories ($1,000's)
Without Project Conditions

Analysis Year		Residential	Commercial	Public	Farm	Emergency	Other Infrastruture	Traffic
EAD 2019	2019	$92,191	$82,994	$10,553	$705	$7,739	$291	$4,029
EAD 2043	2043	$82,046	$82,618	$8,675	$579	$6,311	$237	$3,290
EAD 2068	2068	$71,556	$78,209	$7,236	$486	$5,239	$197	$2,728
EAD 2019		$92,191	$82,994	$10,553	$705	$7,739	$291	$4,029
# years to next analysis year	2019-2043	24	24	24	24	24	24	24
Annual Change		-$406	-$15	-$75	-$5	-$57	-$2	-$30
Annual Discount Factor		0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream		$1,384,038	$1,298,639	$154,117	$10,293	$112,723	$4,241	$58,709
EAD 2043		$82,046	$82,618	$8,675	$579	$6,311	$237	$3,290
# years to next analysis year	2043-2068	25	25	25	25	25	25	25
Annual Change		-$420	-$176	-$58	-$4	-$43	-$2	-$22
Annual Discount Factor		0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream		$473,880	$492,063	$49,306	$3,296	$35,812	$1,346	$18,660
Discount Rate		4.125%						
Total Present Worth		$1,857,919	$1,790,702	$203,424	$13,589	$148,534	$5,587	$77,369
EEAD		$88,300	$85,100	$9,700	$600	$7,100	$300	$3,700
Total EEAD		$194,800						

EEAD, EEAB & Induced Damage - Upstream and Downstream ($1,000's)

	EEAD	Induced Damage	EEAB
Upsteam			
Without	$693 -	-	
ND-E-35k	$729	$36 -	
ND w/Staging	$183 -		$509
MN-S-35k	$729	$36 -	
Downsteam			
Without	$763 -	-	
ND-E-35k	$879	$116 -	
ND w/Staging	$646 -		$117
MN-S-35k	$879	$116 -	
Total			
Without	$1,456	$0	$0
ND-E-35k	$1,608	$153	$0
ND w/Staging	$829	$0	$627
MN-S-35k	$1,608	$153	$0

EAD & EEAD - Future Development ($1,000's)

Analysis Year		Without Project Condtions	Without - Existing Economic Conditions
	2019	$198,502	$189,803
	2043	$183,755	$156,969
	2068	$165,650	$131,534

Analysis Year		Net Change EAD ($1,000's) Without - Existing Economic Conditions
	2019	$8,699
	2043	$26,786
	2068	$34,116
Annual Equiv.		$194,800.00 $167,700.00

Analysis Year		Without Project Condtions	Without - Existing Economic Conditions	Additional Damage Due to Development ($)	Additional Damage Due to Development (%)
EAD 2019	2019	$198,502	$189,803	$8,699	4.4%
EAD 2043	2043	$183,755	$156,969	$26,786	14.6%
EAD 2068	2068	$165,650	$131,534	$34,116	20.6%
EAD 2019		$198,502	$189,803	$8,699	4.4%
# years to next analysis year		24	24		
Annual Change	2019-2043	-$590	-$1,313		
Annual Discount Factor		0.9604	0.9604		
Present Worth of Stream		$3,022,753	$2,667,575	$355,177	11.8%
EAD 2043		$183,755	$156,969	$26,786	14.6%
# years to next analysis year		25	25		
Annual Change	2043-2068	-$724	-$1,017		
Annual Discount Factor		0.9604	0.9604		
Present Worth of Stream		$1,074,362	$858,247	$216,115	20.1%
Discount Rate		4.125%			
Total Present Worth		$4,097,115	$3,525,822		
EEAD		$194,800	$167,700	$27,100	13.9%

EXHIBIT M

Benefits Uncertainty & Project Performance

Distribution of EEAB - Benefits Needed for Unity BCR ($1,000's)

Plan Name	Annual Costs	EEAB Needed for BCR of 1.0 *	Probability that FRM EEAB Exceeds Indicated Values		
			0.75	0.5	0.25
ND w/Staging	$ 97,894	$ 85,877	$ 89,500	$ 140,900	$ 212,500
ND-E-35k	$ 78,627	$ 67,650	$ 89,500	$ 140,900	$ 212,500
MN Short 35k	$ 67,788	$ 60,134	$ 89,700	$ 142,300	$ 215,700

* Difference between this figure and annual costs is other benefits (flood insurance cost savings and floodproofing cost savings)
Note: Does not include Recreation costs and benefits

EAD & EEAD - Mean Values ($1,000's)

Analysis Year		Without Project	ND w/Staging	ND-E-35k	MN-S-45k	MN-S-40k	MN-S-35k	MN-S-30k	MN-S-25k	MN-S-20k
EAD 2019	###	$198,502	$24,295	$24,295	$20,319	$23,901	$28,476	$35,828	$40,833	$57,159
EAD 2043	###	$183,755	$24,770	$24,770	$22,313	$25,354	$29,299	$35,995	$42,284	$54,719
EAD 2068	###	$165,650	$23,920	$23,920	$25,050	$26,750	$30,219	$35,887	$42,501	$53,500
EAD 2019		$198,502	$24,295	$24,295	$20,319	$23,901	$28,476	$35,828	$40,833	$57,159
# years to next analysis year	2019-2043	24	24	24	24	24	24	24	24	24
Annual Change		-$590	$19	$19	$80	$58	$33	$7	$58	-$98
Annual Discount Factor		0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream		$3,022,753	$368,471	$368,471	$330,488	$383,379	$451,298	$562,594	$648,770	$881,270
EAD 2043		$183,755	$24,770	$24,770	$22,313	$25,354	$29,299	$35,995	$42,284	$54,719
# years to next analysis year	2043-2068	25	25	25	25	25	25	25	25	25
Annual Change		-$724	-$34	-$34	$110	$56	$37	-$4	$9	-$49
Annual Discount Factor		0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream		$1,074,362	$142,777	$142,777	$142,389	$157,652	$180,506	$218,767	$257,818	$330,016
Discount Rate		4.125%								
Total Present Worth		$4,097,115	$511,248	$511,248	$472,877	$541,031	$631,804	$781,361	$906,588	$1,211,286
EEAD		$194,800	$24,300	$24,300	$22,500	$25,700	$30,000	$37,200	$43,100	$57,600

*Extra year of discounting added for North Dakota Alternatives

EAB & EEAB - Mean Values ($1,000's)

Analysis Year			ND w/Staging	ND-E-35k	MN-S-45k	MN-S-40k	MN-S-35k	MN-S-30k	MN-S-25k	MN-S-20k
EAB 2019	###		$174,207	$174,207	$178,183	$174,601	$170,026	$162,675	$157,669	$141,343
EAB 2043	###		$158,986	$158,986	$161,442	$158,401	$154,456	$147,760	$141,471	$129,036
EAB 2068	###		$141,730	$141,730	$140,600	$138,900	$135,431	$129,763	$123,149	$112,150
EAB 2019			$174,207	$174,207	$178,183	$174,601	$170,026	$162,675	$157,669	$141,343
# years to next analysis year	2019-2043		24	24	24	24	24	24	24	24
Annual Change			-$609	-$609	-$670	-$648	-$623	-$597	-$648	-$492
Annual Discount Factor			0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream			$2,534,533	$2,534,533	$2,692,265	$2,639,373	$2,571,455	$2,460,159	$2,373,983	$2,141,482
EAB 2043			$158,986	$158,986	$161,442	$158,401	$154,456	$147,760	$141,471	$129,036
# years to next analysis year	2043-2068		25	25	25	25	25	25	25	25
Annual Change			-$690	-$690	-$834	-$780	-$761	-$720	-$733	-$675
Annual Discount Factor			0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream			$889,023	$889,023	$931,973	$916,710	$893,855	$855,595	$816,544	$744,346
Discount Rate		4.125%								
Total Present Worth			$3,423,556	$3,423,556	$3,624,238	$3,556,083	$3,465,310	$3,315,754	$3,190,527	$2,885,828
EEAB			$162,800	$162,800	$172,300	$169,100	$164,800	$157,700	$151,700	$137,200

*Extra year of discounting added for North Dakota Alternatives

EAB and EEAB - 75% Exceedance Values ($1,000's)

Analysis Year			ND w/Staging	ND-E-35k	MN-S-45k	MN-S-40k	MN-S-35k	MN-S-30k	MN-S-25k	MN-S-20k
EAB 2019	###		$101,114	$101,114	$101,299	$99,872	$97,851	$94,400	$91,990	$83,616
EAB 2043	###		$84,435	$84,435	$83,407	$82,408	$81,009	$78,393	$75,700	$69,984
EAB 2068	###		$68,860	$68,860	$66,635	$66,124	$64,977	$63,008	$60,612	$56,056
EAB 2019			$101,114	$101,114	$101,299	$99,872	$97,851	$94,400	$91,990	$83,616
# years to next analysis year	2019-2043		24	24	24	24	24	24	24	24
Annual Change			-$667	-$667	-$716	-$699	-$674	-$640	-$652	-$545
Annual Discount Factor			0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream			$1,425,792	$1,425,792	$1,480,214	$1,460,418	$1,432,482	$1,383,406	$1,343,936	$1,228,658
EAB 2043			$84,435	$84,435	$83,407	$82,408	$81,009	$78,393	$75,700	$69,984
# years to next analysis year	2043-2068		25	25	25	25	25	25	25	25
Annual Change			-$623	-$623	-$671	-$651	-$641	-$615	-$604	-$557
Annual Discount Factor			0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream			$457,261	$457,261	$466,975	$462,076	$454,171	$439,818	$424,150	$392,173
Discount Rate		4.125%								
Total Present Worth			$1,883,054	$1,883,054	$1,947,189	$1,922,494	$1,886,654	$1,823,224	$1,768,086	$1,620,831
EEAB			$89,500	$89,500	$92,600	$91,400	$89,700	$86,700	$84,100	$77,100

*Extra year of discounting added for North Dakota Alternatives

EAB and EEAB - 50% Exceedance Values ($1,000's)

Analysis Year			ND w/Staging	ND-E-35k	MN-S-45k	MN-S-40k	MN-S-35k	MN-S-30k	MN-S-25k	MN-S-20k
EAB 2019	###		$154,130	$154,130	$156,587	$153,798	$150,156	$144,381	$140,170	$126,487
EAB 2043	###		$135,722	$135,722	$136,378	$134,201	$131,473	$126,272	$121,356	$111,647
EAB 2068	###		$116,619	$116,619	$114,618	$113,558	$111,150	$107,085	$102,141	$93,883
EAB 2019			$154,130	$154,130	$156,587	$153,798	$150,156	$144,381	$140,170	$126,487
# years to next analysis year	2019-2043		24	24	24	24	24	24	24	24
Annual Change			-$736	-$736	-$808	-$784	-$747	-$724	-$753	-$594
Annual Discount Factor			0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream			$2,213,894	$2,213,894	$2,332,898	$2,292,862	$2,241,273	$2,154,204	$2,083,958	$1,893,383
EAB 2043			$135,722	$135,722	$136,378	$134,201	$131,473	$126,272	$121,356	$111,647
# years to next analysis year	2043-2068		25	25	25	25	25	25	25	25
Annual Change			-$764	-$764	-$870	-$826	-$813	-$767	-$769	-$711
Annual Discount Factor			0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream			$748,785	$748,785	$777,240	$766,694	$750,868	$721,967	$691,985	$636,415
Discount Rate		4.125%								
Total Present Worth			$2,962,679	$2,962,679	$3,110,138	$3,059,556	$2,992,140	$2,876,170	$2,775,943	$2,529,798
EEAB			$140,900	$140,900	$147,900	$145,500	$142,300	$136,800	$132,000	$120,300

*Extra year of discounting added for North Dakota Alternatives

EAB and EEAB - 25% Exceedance Values ($1,000's)

Analysis Year			ND w/Staging	ND-E-35k	MN-S-45k	MN-S-40k	MN-S-35k	MN-S-30k	MN-S-25k	MN-S-20k
EAB 2019	###		$225,609	$225,609	$231,499	$226,744	$220,742	$210,948	$204,366	$182,862
EAB 2043	###		$208,639	$208,639	$212,503	$208,498	$203,345	$194,367	$186,070	$169,506
EAB 2068	###		$187,822	$187,822	$187,008	$184,706	$180,061	$172,492	$163,722	$149,026
EAB 2019			$225,609	$225,609	$231,499	$226,744	$220,742	$210,948	$204,366	$182,862
# years to next analysis year	2019-2043		24	24	24	24	24	24	24	24
Annual Change			-$679	-$679	-$760	-$730	-$696	-$663	-$732	-$534
Annual Discount Factor			0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream			$3,298,224	$3,298,224	$3,514,413	$3,444,391	$3,355,418	$3,206,809	$3,093,323	$2,785,968
EAB 2043			$208,639	$208,639	$212,503	$208,498	$203,345	$194,367	$186,070	$169,506
# years to next analysis year	2043-2068		25	25	25	25	25	25	25	25
Annual Change			-$833	-$833	-$1,020	-$952	-$931	-$875	-$894	-$819
Annual Discount Factor			0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604	0.9604
Present Worth of Stream			$1,170,921	$1,170,921	$1,231,424	$1,211,171	$1,181,044	$1,129,820	$1,078,190	$981,916
Discount Rate		4.125%								
Total Present Worth			$4,469,145	$4,469,145	$4,745,838	$4,655,563	$4,536,463	$4,336,629	$4,171,513	$3,767,883
EEAB			$212,500	$212,500	$225,700	$221,400	$215,700	$206,200	$198,400	$179,200

*Extra year of discounting added for North Dakota Alternatives

Project Performance by Reach (Target Stages - Annual Exceedance Probabilities - Long-Term Risk - Conditional Non-Exceedance Probabilities)
Existing Conditions

				Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
Reach	Index River Mile	Top of Levee	Target Stage	Median	Expected	10	30	50	10%	4%	2%	1%	0.40%	0.20%
Fargo North End	442.93	---	893.80	9.00%	9.44%	62.91%	91.62%	99.30%	59.32%	5.51%	0.38%	0.02%	0.00%	0.00%
Ridgewood	447.78	898	898.00	3.42%	3.98%	33.38%	63.78%	86.88%	98.38%	57.60%	17.60%	3.45%	0.27%	0.03%
Near North	449.61	---	897.30	6.33%	7.02%	51.71%	83.79%	97.37%	83.86%	15.72%	1.54%	0.08%	0.00%	0.00%
Downtown North	451.37	---	898.10	6.56%	7.24%	52.82%	84.71%	97.66%	82.52%	13.31%	1.09%	0.04%	0.00%	0.00%
Downtown South	452.25	902.2	902.20	2.75%	3.17%	27.52%	55.27%	79.99%	99.76%	73.76%	26.66%	5.16%	0.31%	0.02%
Near South	452.7	904	904.00	3.33%	3.66%	31.09%	60.57%	84.46%	92.42%	73.16%	43.59%	16.49%	2.44%	0.37%
Lindenwood Area	454.1	---	902.07	3.65%	4.13%	34.41%	65.15%	87.86%	98.86%	53.87%	12.25%	1.37%	0.03%	0.00%
Z_Other	650		900.61	4.69%	5.19%	41.33%	73.64%	93.05%	96.09%	34.74%	5.19%	0.37%	0.00%	0.00%
Fargo South														
From RRN	460.28	---	903.08	5.75%	6.30%	47.86%	80.37%	96.14%	90.42%	20.15%	2.02%	0.09%	0.00%	0.00%
From Sheyenne	172308	---	904.54	9.96%	11.04%	68.96%	94.63%	99.71%	50.61%	0.00%	0.00%	0.00%	0.00%	0.00%
West Fargo														
WF Downtown	451.37	---	902.00	2.03%	2.28%	20.60%	43.83%	68.45%	99.95%	88.33%	50.21%	17.43%	2.42%	0.35%
WF South	172308	---	904.44	11.65%	12.54%	73.82%	96.49%	99.88%	35.31%	0.00%	0.00%	0.00%	0.00%	0.00%
Harwood														
Harwood Red	432.84	---	887.92	12.83%	13.58%	76.75%	97.39%	99.93%	23.61%	0.67%	0.02%	0.00%	0.00%	0.00%
Harwood Sheyenne	67984	---	887.30	17.86%	17.91%	86.10%	99.28%	99.99%	4.79%	0.00%	0.00%	0.00%	0.00%	0.00%
Cass County														
ANorth (RRN)	440.31	---	890.21	16.36%	16.97%	84.43%	99.04%	99.99%	6.84%	0.02%	0.00%	0.00%	0.00%	0.00%
ASouth (RRN)	465.1	---	899.64	20.05%	20.06%	89.34%	99.63%	100.00%	1.70%	0.00%	0.00%	0.00%	0.00%	0.00%
BNorth (RRN)	440.31	---	886.75	25.47%	26.00%	95.07%	99.95%	100.00%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%
BSouth (RRN)	465.1	---	901.11	15.23%	15.96%	82.43%	98.71%	99.98%	9.42%	0.02%	0.00%	0.00%	0.00%	0.00%
ASheyenne	172308	---	902.25	47.94%	47.74%	99.85%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ShySA	166	---	890.01	5.40%	5.97%	45.96%	78.53%	95.39%	88.83%	26.66%	1.02%	0.00%	0.00%	0.00%
Moorhead														
Kragnes	434.61	---	889.57	10.81%	11.12%	69.25%	94.76%	99.73%	42.49%	3.11%	0.26%	0.02%	0.00%	0.00%
Oakport	440.31	900.5	900.50	0.24%	0.34%	3.33%	8.12%	15.57%	100.00%	99.99%	99.35%	93.83%	68.38%	41.94%
North of Moorhead	442.93	---	892.83	11.31%	11.82%	71.57%	95.69%	99.81%	35.46%	1.20%	0.04%	0.00%	0.00%	0.00%
Moorhead North	449.61	---	898.17	4.97%	5.48%	43.11%	75.59%	94.04%	93.94%	32.08%	5.26%	0.47%	0.01%	0.00%
Moorhead Central	452.7	---	900.67	4.62%	5.12%	40.90%	73.15%	92.79%	96.36%	35.84%	5.50%	0.40%	0.00%	0.00%
Moorhead South	460.28	---	902.22	7.06%	7.71%	55.17%	86.55%	98.19%	78.82%	9.41%	0.53%	0.01%	0.00%	0.00%
South of Moorhead	468.9	---	905.54	9.35%	9.84%	64.50%	92.49%	99.44%	55.64%	2.59%	0.07%	0.00%	0.00%	0.00%
Downstream														
Georgetown MN&ND - XS 414.98	414.98	---	879.06	12.89%	13.37%	76.18%	97.23%	99.92%	24.56%	2.49%	0.22%	0.00%	0.00%	0.00%
Halstad MN&ND - XS 397.8	397.80	---	872.91	8.81%	9.31%	62.38%	91.32%	99.25%	59.55%	6.08%	0.24%	0.00%	0.00%	0.00%
Perley-Hendrum MN&ND - XS 381.71	381.71	---	867.25	7.69%	8.24%	57.69%	88.36%	98.64%	64.34%	19.60%	5.37%	1.63%	0.28%	0.00%
Shelly MN&ND - XS 359.73	359.73	---	860.15	4.53%	4.91%	39.55%	71.59%	91.93%	96.21%	40.41%	9.73%	2.01%	0.34%	0.00%
Climax MN&ND - XS 335.01	335.01	---	849.35	5.40%	5.73%	44.56%	77.11%	94.76%	92.62%	28.84%	5.95%	0.81%	0.00%	0.00%
South of Thompson - XS 324.41	324.41	---	846.59	3.80%	4.13%	34.39%	65.14%	87.85%	98.65%	53.50%	15.99%	3.30%	0.57%	0.18%
Intermediate - XS 423.96	423.96	---	882.00	14.65%	15.12%	80.59%	98.34%	99.97%	11.97%	0.65%	0.00%	0.00%	0.00%	0.00%
Upstream														
Upstream_Red	500.01	---	920.28	3.73%	4.01%	33.57%	64.03%	87.06%	98.92%	54.51%	17.40%	7.54%	1.09%	0.27%
Upstream_WR	32.12	---	924.42	7.50%	7.90%	56.10%	87.23%	98.37%	70.48%	13.16%	1.33%	0.00%	0.00%	0.00%

400

Project Performance by Reach (Target Stages - Annual Exceedance Probabilities - Long-Term Risk - Conditional Non-Exceedance Probabilities)
ND w/Staging - LPP

				Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
Reach	Index River Mile	Top of Levee	Target Stage	Median	Expected	10	30	50	10%	4%	2%	1%	0.40%	0.20%
Fargo North End	442.93	---	893.80	0.42%	0.55%	5.36%	12.87%	24.09%	100.00%	99.98%	98.70%	86.72%	44.55%	17.08%
Ridgewood	447.78	898	898.00	0.23%	0.29%	2.89%	7.07%	13.64%	99.99%	100.00%	99.84%	96.72%	72.54%	41.32%
Near North	449.61	---	897.30	0.33%	0.43%	4.17%	10.09%	19.17%	99.99%	100.00%	99.48%	92.57%	56.99%	25.64%
Downtown North	451.37	---	898.10	0.33%	0.43%	4.22%	10.23%	19.41%	99.99%	100.00%	99.46%	92.34%	56.18%	24.89%
Downtown South	452.25	902.2	902.20	0.20%	0.25%	2.47%	6.07%	11.77%	99.99%	100.00%	99.91%	97.74%	77.38%	47.11%
Near South	452.7	904	904.00	0.32%	0.39%	3.82%	9.27%	17.69%	99.52%	99.50%	99.26%	96.29%	77.18%	50.71%
Lindenwood Area	454.1	---	902.07	0.24%	0.30%	2.96%	7.23%	13.94%	99.99%	100.00%	99.84%	96.69%	71.72%	39.78%
Z_Other	650	---	900.61	0.27%	0.35%	3.42%	8.34%	15.98%	99.99%	100.00%	99.73%	95.34%	65.74%	33.27%
Fargo South														
From RRN	460.28	---	903.08	0.31%	0.40%	3.93%	9.53%	18.15%	99.98%	100.00%	99.59%	93.66%	59.85%	27.83%
From Sheyenne	172308	---	904.54	0.01%	0.01%	0.10%	0.25%	0.50%	99.95%	99.97%	99.97%	99.97%	99.95%	99.95%
West Fargo														
WF Downtown	451.37	---	902.00	0.16%	0.20%	1.95%	4.81%	9.40%	99.99%	100.00%	99.96%	98.64%	83.57%	56.62%
WF South	172308	---	904.44	0.01%	0.01%	0.10%	0.25%	0.50%	99.95%	99.97%	99.97%	99.97%	99.95%	99.95%
Harwood														
Harwood Red	432.84	---	887.92	1.04%	2.08%	18.97%	40.89%	65.06%	98.05%	87.14%	67.90%	39.64%	10.76%	2.68%
Harwood Sheyenne	67984	---	887.30	1.58%	1.73%	16.05%	35.43%	58.31%	99.96%	98.53%	87.54%	0.00%	0.00%	0.00%
Cass County														
ANorth (RRN)	440.31	---	890.21	0.93%	1.81%	16.66%	36.60%	59.80%	98.11%	91.62%	75.84%	44.24%	10.60%	2.18%
ASouth (RRN)	465.1	---	899.64	0.76%	1.10%	10.46%	24.13%	42.44%	99.25%	98.95%	92.44%	63.41%	17.70%	3.97%
BNorth (RRN)	440.31	---	886.75	20.28%	20.60%	90.04%	99.69%	100.00%	0.14%	0.00%	0.00%	0.00%	0.00%	0.00%
BSouth (RRN)	465.1	---	901.11	0.59%	0.76%	7.31%	17.30%	31.60%	99.98%	99.91%	96.64%	75.43%	27.82%	7.77%
ASheyenne	172308	---	902.25	31.35%	31.49%	97.72%	99.99%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ShySA	166	---	890.01	1.53%	1.71%	15.86%	35.06%	57.83%	99.96%	97.58%	89.18%	0.00%	0.00%	0.00%
Moorhead														
Kragnes	434.61	---	889.57	0.63%	0.91%	8.77%	20.51%	36.81%	99.90%	98.74%	92.13%	68.97%	26.24%	8.24%
Oakport	440.31	900.5	900.50	0.04%	0.04%	0.39%	0.98%	1.95%	100.00%	100.00%	100.00%	99.95%	98.31%	91.39%
North of Moorhead	442.93	---	892.83	0.53%	0.69%	6.73%	15.99%	29.42%	99.99%	99.90%	97.15%	78.83%	32.83%	10.51%
Moorhead North	449.61	---	898.17	0.28%	0.36%	3.54%	8.62%	16.49%	99.99%	100.00%	99.69%	94.89%	64.34%	32.12%
Moorhead Central	452.7	---	900.67	0.27%	0.34%	3.38%	8.24%	15.80%	99.99%	100.00%	99.74%	95.43%	66.04%	33.60%
Moorhead South	460.28	---	902.22	0.35%	0.45%	4.43%	10.70%	20.26%	99.98%	100.00%	99.40%	91.60%	53.85%	22.88%
South of Moorhead	468.9	---	905.54	0.41%	0.53%	5.13%	12.33%	23.15%	99.98%	99.99%	99.04%	88.34%	46.31%	17.42%
Downstream														
Georgetown MN&ND - XS 414.98	414.98	---	879.06	11.59%	12.27%	72.99%	96.21%	99.86%	36.39%	3.64%	0.21%	0.00%	0.00%	0.00%
Halstad MN&ND - XS 397.8	397.80	---	872.91	7.47%	7.93%	56.25%	87.34%	98.40%	76.32%	8.34%	0.28%	0.00%	0.00%	0.00%
Perley-Hendrum MN&ND - XS 381.71	381.71	---	867.25	7.38%	8.03%	56.69%	87.63%	98.48%	67.85%	19.01%	4.28%	1.19%	0.21%	0.00%
Shelly MN&ND - XS 359.73	359.73	---	860.15	4.59%	4.97%	39.93%	72.04%	92.18%	96.00%	39.44%	9.11%	2.06%	0.35%	0.00%
Climax MN&ND - XS 335.01	335.01	---	849.35	5.51%	5.83%	45.14%	77.71%	95.03%	92.18%	27.45%	5.44%	0.88%	0.14%	0.00%
South of Thompson - XS 324.41	324.41	---	846.59	3.93%	4.24%	35.16%	66.14%	88.53%	98.49%	51.25%	14.67%	3.47%	0.63%	0.19%
Intermediate - XS 423.96	423.96	---	882.00	6.04%	6.12%	46.81%	79.36%	95.74%	97.23%	20.86%	2.29%	0.41%	0.00%	0.00%
Upstream														
Upstream_Red	500.01	---	920.28	6.88%	7.25%	52.90%	84.78%	97.68%	68.54%	27.11%	10.24%	3.93%	0.81%	0.24%
Upstream_WR	32.12	---	924.42	7.54%	7.90%	56.09%	87.23%	98.37%	70.69%	12.88%	1.22%	0.00%	0.00%	0.00%

Project Performance by Reach (Target Stages - Annual Exceedance Probabilities - Long-Term Risk - Conditional Non-Exceedance Probabilities)

ND35k

				Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
Reach	Index River Mile	Top of Levee	Target Stage	Median	Expected	10	30	50	10%	4%	2%	1%	0.40%	0.20%
Fargo North End	442.93 ---		893.80	0.42%	0.55%	5.36%	12.87%	24.09%	100.00%	99.98%	98.70%	86.72%	44.55%	17.08%
Ridgewood	447.78	898	898.00	0.23%	0.29%	2.89%	7.07%	13.64%	99.99%	100.00%	99.84%	96.72%	72.54%	41.32%
Near North	449.61 ---		897.30	0.33%	0.43%	4.17%	10.05%	19.17%	99.99%	100.00%	99.48%	92.57%	56.99%	25.64%
Downtown North	451.37 ---		898.10	0.33%	0.43%	4.22%	10.23%	19.41%	99.99%	100.00%	99.46%	92.34%	56.18%	24.89%
Downtown South	452.25	902.2	902.20	0.20%	0.25%	2.47%	6.07%	11.77%	99.99%	100.00%	99.91%	97.74%	77.38%	47.11%
Near South	452.7	904	904.00	0.32%	0.39%	3.82%	9.27%	17.69%	99.52%	99.50%	99.26%	96.29%	77.18%	50.71%
Lindenwood Area	454.1 ---		902.07	0.24%	0.30%	2.96%	7.23%	13.94%	99.99%	100.00%	99.84%	96.69%	71.72%	39.78%
Z_Other	650		900.61	0.27%	0.35%	3.42%	8.34%	15.98%	99.99%	100.00%	99.73%	95.34%	65.74%	33.27%
Fargo South														
From RRN	460.28 ---		903.08	0.31%	0.40%	3.93%	9.53%	18.15%	99.98%	100.00%	99.59%	93.66%	59.85%	27.83%
From Sheyenne	172308 ---		904.54	0.01%	0.01%	0.10%	0.25%	0.50%	99.95%	99.97%	99.97%	99.97%	99.95%	99.95%
West Fargo														
WF Downtown	451.37 ---		902.00	0.16%	0.20%	1.95%	4.81%	9.40%	99.99%	100.00%	99.96%	98.64%	83.57%	56.62%
WF South	172308 ---		904.44	0.01%	0.01%	0.10%	0.25%	0.50%	99.95%	99.97%	99.97%	99.97%	99.95%	99.95%
Harwood														
Harwood Red	432.84		887.92	1.04%	2.08%	18.97%	40.89%	65.06%	98.05%	87.14%	67.90%	39.64%	10.76%	2.68%
Harwood Sheyenne	67984		887.30	1.58%	1.73%	16.05%	35.43%	58.31%	99.96%	98.53%	87.54%	0.00%	0.00%	0.00%
Cass County														
ANorth (RRN)	440.31 ---		890.21	0.93%	1.81%	16.66%	36.60%	59.80%	98.11%	91.62%	75.84%	44.24%	10.60%	2.18%
ASouth (RRN)	465.1 ---		899.64	0.76%	1.10%	10.46%	24.13%	42.44%	99.25%	98.95%	92.44%	63.41%	17.70%	3.97%
BNorth (RRN)	440.31 ---		886.75	20.28%	20.60%	90.04%	99.69%	100.00%	0.14%	0.00%	0.00%	0.00%	0.00%	0.00%
BSouth (RRN)	465.1 ---		901.11	0.59%	0.76%	7.31%	17.30%	31.60%	99.98%	99.91%	96.64%	75.43%	27.82%	7.77%
ASheyenne	172308 ---		902.25	31.35%	31.49%	97.72%	99.99%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ShySA	166 ---		890.01	1.53%	1.71%	15.86%	35.06%	57.83%	99.96%	97.58%	89.18%	0.00%	0.00%	0.00%
Moorhead														
Kragnes	434.61 ---		889.57	0.63%	0.91%	8.77%	20.51%	36.81%	99.90%	98.74%	92.13%	68.97%	26.24%	8.24%
Oakport	440.31	900.5	900.50	0.04%	0.04%	0.39%	0.98%	1.95%	100.00%	100.00%	100.00%	99.95%	98.31%	91.39%
North of Moorhead	442.93 ---		892.83	0.53%	0.69%	6.73%	15.99%	29.42%	99.99%	99.90%	97.15%	78.83%	32.83%	10.51%
Moorhead North	449.61 ---		898.17	0.28%	0.36%	3.54%	8.62%	16.49%	99.99%	100.00%	99.69%	94.89%	64.34%	32.12%
Moorhead Central	452.7 ---		900.67	0.27%	0.34%	3.38%	8.24%	15.80%	99.99%	100.00%	99.74%	95.43%	66.04%	33.60%
Moorhead South	460.28 ---		902.22	0.35%	0.45%	4.43%	10.70%	20.26%	99.98%	100.00%	99.40%	91.60%	53.85%	22.88%
South of Moorhead	468.9 ---		905.54	0.41%	0.53%	5.13%	12.33%	23.15%	99.98%	99.99%	99.04%	88.34%	46.31%	17.42%
Downstream														
Georgetown MN&ND - XS 414.98	414.98 ---		879.06	13.59%	14.13%	78.21%	97.78%	99.95%	13.08%	0.23%	0.00%	0.00%	0.00%	0.00%
Halstad MN&ND - XS 397.8	397.80 ---		872.91	10.12%	10.23%	66.02%	93.27%	99.55%	48.25%	2.34%	0.00%	0.00%	0.00%	0.00%
Perley-Hendrum MN&ND - XS 381.71	381.71 ---		867.25	8.73%	8.97%	60.94%	90.47%	99.09%	58.41%	11.72%	1.78%	0.29%	0.00%	0.00%
Shelly MN&ND - XS 359.73	359.73 ---		860.15	5.14%	5.53%	43.37%	75.86%	94.17%	93.27%	31.57%	6.52%	1.24%	0.28%	0.00%
Climax MN&ND - XS 335.01	335.01 ---		849.35	5.97%	6.27%	47.66%	80.18%	96.07%	89.24%	22.75%	4.08%	0.51%	0.00%	0.00%
South of Thompson - XS 324.41	324.41 ---		846.59	4.32%	4.65%	37.85%	69.55%	90.73%	97.56%	44.29%	11.22%	2.03%	0.44%	0.17%
Intermediate - XS 423.96	423.96 ---		882.00	15.40%	15.92%	82.34%	98.69%	99.98%	2.32%	0.00%	0.00%	0.00%	0.00%	0.00%
Upstream														
Upstream_Red	500.01 ---		920.28	3.76%	4.05%	33.83%	64.38%	87.31%	98.78%	53.88%	17.08%	7.58%	1.10%	0.28%
Upstream_WR	32.12 ---		924.42	8.10%	8.32%	58.04%	88.60%	98.70%	64.63%	11.74%	1.39%	0.00%	0.00%	0.00%

402

Project Performance by Reach (Target Stages - Annual Exceedance Probabilities - Long-Term Risk - Conditional Non-Exceedance Probabilities)

MN35k - FCP

				Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
Reach	Index River Mile	Top of Levee	Target Stage	Median	Expected	10	30	50	10%	4%	2%	1%	0.40%	0.20%
Fargo North End	442.93 ---		893.80	0.55%	0.80%	7.69%	18.12%	32.96%	99.97%	99.25%	94.16%	74.19%	31.51%	10.79%
Ridgewood	447.78	898	898.00	0.23%	0.29%	2.89%	7.08%	13.66%	100.00%	100.00%	99.82%	96.55%	72.35%	41.48%
Near North	449.61 ---		897.30	0.35%	0.46%	4.47%	10.80%	20.44%	100.00%	99.99%	99.27%	90.97%	53.57%	23.33%
Downtown North	451.37 ---		898.10	0.35%	0.46%	4.48%	10.82%	20.46%	100.00%	100.00%	99.30%	91.13%	53.46%	23.06%
Downtown South	452.25	902.2	902.20	0.19%	0.24%	2.39%	5.87%	11.39%	1.00%	100.00%	99.92%	97.91%	78.55%	48.88%
Near South	452.7	904	904.00	0.33%	0.40%	3.97%	9.64%	18.34%	99.50%	99.46%	99.08%	95.83%	77.25%	51.50%
Lindenwood Area	454.1 ---		902.07	0.23%	0.29%	2.86%	7.00%	13.52%	100.00%	100.00%	99.85%	96.84%	72.66%	41.00%
Z_Other	650 ---		900.61	0.27%	0.35%	3.45%	8.41%	16.11%	100.00%	100.00%	99.73%	95.27%	65.72%	33.47%
Fargo South														
From RRN	460.28 ---		903.08	0.30%	0.39%	3.83%	9.29%	17.73%	99.99%	100.00%	99.61%	93.95%	61.00%	28.93%
From Sheyenne	172308 ---		904.54	9.96%	11.04%	68.94%	94.62%	99.71%	50.68%	0.00%	0.00%	0.00%	0.00%	0.00%
West Fargo														
WF Downtown	451.37 ---		902.00	0.16%	0.19%	1.87%	4.60%	9.00%	100.00%	100.00%	99.96%	98.77%	84.55%	58.20%
WF South	172308 ---		904.44	11.65%	12.55%	73.83%	96.50%	99.88%	35.29%	0.00%	0.00%	0.00%	0.00%	0.00%
Harwood														
Harwood Red	432.84 ---		887.92	7.72%	9.82%	64.44%	92.46%	99.43%	59.55%	14.86%	3.31%	0.65%	0.08%	0.02%
Harwood Sheyenne	67984 ---		887.30	17.86%	17.91%	86.11%	99.28%	99.99%	4.79%	0.00%	0.00%	0.00%	0.00%	0.00%
Cass County														
ANorth (RRN)	440.31 ---		890.21	5.57%	7.44%	53.86%	85.54%	97.91%	74.82%	33.72%	13.45%	4.29%	0.60%	0.09%
ASouth (RRN)	465.1 ---		899.64	0.77%	1.13%	10.72%	24.68%	43.27%	99.26%	98.76%	91.74%	62.01%	16.83%	3.69%
BNorth (RRN)	440.31 ---		886.75	25.47%	25.99%	95.07%	99.95%	100.00%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%
BSouth (RRN)	465.1 ---		901.11	15.23%	15.96%	82.42%	98.71%	99.98%	9.42%	0.02%	0.00%	0.00%	0.00%	0.00%
ASheyenne	172308 ---		902.25	47.93%	47.73%	99.85%	100.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ShySA	166 ---		890.01	5.40%	5.97%	45.96%	78.53%	95.39%	88.82%	26.66%	1.02%	0.00%	0.00%	0.00%
Moorhead														
Kragnes	434.61 ---		889.57	3.56%	4.75%	38.53%	70.37%	91.22%	91.05%	53.35%	25.11%	9.78%	2.16%	0.53%
Oakport	440.31	900.5	900.50	0.04%	0.04%	0.39%	0.98%	1.95%	100.00%	100.00%	100.00%	99.95%	98.32%	91.40%
North of Moorhead	442.93 ---		892.83	0.83%	1.42%	13.31%	30.03%	51.05%	99.53%	94.57%	80.02%	51.86%	16.15%	4.41%
Moorhead North	449.61 ---		898.17	0.28%	0.37%	3.66%	8.91%	17.02%	100.00%	100.00%	99.64%	94.27%	62.92%	31.23%
Moorhead Central	452.7 ---		900.67	0.27%	0.35%	3.42%	8.33%	15.97%	100.00%	100.00%	99.74%	95.38%	66.14%	33.89%
Moorhead South	460.28 ---		902.22	0.35%	0.45%	4.36%	10.56%	20.00%	99.99%	100.00%	99.41%	91.79%	54.47%	23.45%
South of Moorhead	468.9 ---		905.54	9.35%	9.84%	64.49%	92.49%	99.44%	55.64%	2.59%	0.07%	0.00%	0.00%	0.00%
Downstream														
Georgetown MN&ND - XS 414.98	414.98 ---		879.06	13.59%	14.13%	78.21%	97.78%	99.95%	13.08%	0.23%	0.00%	0.00%	0.00%	0.00%
Halstad MN&ND - XS 397.8	397.80 ---		872.91	10.12%	10.23%	66.02%	93.27%	99.55%	48.25%	2.34%	0.00%	0.00%	0.00%	0.00%
Perley-Hendrum MN&ND - XS 381.71	381.71 ---		867.25	8.73%	8.97%	60.94%	90.47%	99.09%	58.41%	11.72%	1.78%	0.29%	0.00%	0.00%
Shelly MN&ND - XS 359.73	359.73 ---		860.15	5.14%	5.53%	43.37%	75.86%	94.17%	93.27%	31.57%	6.52%	1.24%	0.28%	0.00%
Climax MN&ND - XS 335.01	335.01 ---		849.35	5.97%	6.27%	47.66%	80.18%	96.07%	89.24%	22.75%	4.08%	0.51%	0.00%	0.00%
South of Thompson - XS 324.41	324.41 ---		846.59	4.32%	4.65%	37.85%	69.55%	90.73%	97.56%	44.29%	11.22%	2.03%	0.44%	0.17%
Intermediate - XS 423.96	423.96 ---		882.00	15.40%	15.92%	82.34%	98.69%	99.98%	2.32%	0.00%	0.00%	0.00%	0.00%	0.00%
Upstream														
Upstream_Red	500.01 ---		920.28	3.76%	4.05%	33.83%	64.38%	87.31%	98.78%	53.88%	17.08%	7.58%	1.10%	0.28%
Upstream_WR	32.12 ---		924.42	8.10%	8.32%	58.04%	88.60%	98.70%	64.63%	11.74%	1.39%	0.00%	0.00%	0.00%

Project Performance by Reach (Target Stages - Annual Exceedance Probabilities - Long-Term Risk - Conditional Non-Exceedance Probabilities)
Net Change - ND w/Staging - LPP

				Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
Reach	Index River Mile	Top of Levee	Target Stage	Median	Expected	10	30	50	10%	4%	2%	1%	0.40%	0.20%
Fargo North End	442.93 ---		893.80	8.58%	8.89%	57.55%	78.75%	75.21%	40.68%	94.47%	98.31%	86.70%	44.55%	17.08%
Ridgewood	447.78	898	898.00	3.19%	3.69%	30.49%	56.70%	73.23%	1.61%	42.40%	82.24%	93.26%	72.27%	41.28%
Near North	449.61 ---		897.30	6.01%	6.60%	47.54%	73.70%	78.21%	16.14%	84.28%	97.94%	92.50%	56.99%	25.64%
Downtown North	451.37 ---		898.10	6.23%	6.81%	48.60%	74.49%	78.25%	17.47%	86.68%	98.37%	92.30%	56.18%	24.89%
Downtown South	452.25	902.2	902.20	2.55%	2.92%	25.04%	49.20%	68.22%	0.23%	26.24%	73.25%	92.59%	77.08%	47.08%
Near South	452.7	904	904.00	3.01%	3.27%	27.27%	51.30%	66.77%	7.10%	26.34%	55.67%	79.80%	74.74%	50.34%
Lindenwood Area	454.1 ---		902.07	3.42%	3.83%	31.45%	57.92%	73.92%	1.13%	46.13%	87.59%	95.32%	71.69%	39.78%
Z_Other	650 ---		900.61	4.42%	4.85%	37.91%	65.30%	77.07%	3.90%	65.26%	94.54%	94.97%	65.73%	33.27%
Fargo South														
From RRN	460.28 ---		903.08	5.44%	5.90%	43.93%	70.84%	78.00%	9.56%	79.85%	97.57%	93.57%	59.85%	27.83%
From Sheyenne	172308 ---		904.54	9.95%	11.03%	68.86%	94.38%	99.21%	49.34%	99.97%	99.97%	99.97%	99.95%	99.95%
West Fargo														
WF Downtown	451.37 ---		902.00	1.87%	2.08%	18.65%	39.02%	59.05%	0.04%	11.67%	49.75%	81.21%	81.13%	56.26%
WF South	172308 ---		904.44	11.64%	12.53%	73.72%	96.24%	99.38%	64.64%	99.97%	99.97%	99.97%	99.95%	99.95%
Harwood														
Harwood Red	432.84 ---		887.92	11.79%	11.49%	57.79%	56.50%	34.87%	74.44%	86.47%	67.88%	39.64%	10.76%	2.68%
Harwood Sheyenne	67984 ---		887.30	16.27%	16.17%	70.05%	63.85%	41.69%	95.17%	98.53%	87.54%	0.00%	0.00%	0.00%
Cass County														
ANorth (RRN)	440.31 ---		890.21	15.43%	15.16%	67.76%	62.44%	40.19%	91.27%	91.60%	75.84%	44.24%	10.60%	2.18%
ASouth (RRN)	465.1 ---		899.64	19.30%	18.96%	78.88%	75.50%	57.56%	97.55%	98.95%	92.44%	63.41%	17.70%	3.97%
BNorth (RRN)	440.31 ---		886.75	5.19%	5.40%	5.03%	0.26%	0.00%	0.12%	0.00%	0.00%	0.00%	0.00%	0.00%
BSouth (RRN)	465.1 ---		901.11	14.64%	15.20%	75.11%	81.41%	68.38%	90.55%	99.88%	96.64%	75.43%	27.82%	7.77%
ASheyenne	172308 ---		902.25	16.60%	16.25%	2.13%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ShySA	166 ---		890.01	3.87%	4.26%	30.10%	43.47%	37.56%	11.13%	70.92%	88.17%	0.00%	0.00%	0.00%
Moorhead														
Kragnes	434.61 ---		889.57	10.19%	10.21%	60.48%	74.25%	62.91%	57.40%	95.62%	91.87%	68.95%	26.24%	8.24%
Oakport	440.31	900.5	900.50	0.19%	0.30%	2.94%	7.14%	13.63%	0.00%	0.01%	0.65%	6.12%	29.92%	49.45%
North of Moorhead	442.93 ---		892.83	10.78%	11.12%	64.84%	79.70%	70.39%	64.53%	98.70%	97.11%	78.83%	32.83%	10.51%
Moorhead North	449.61 ---		898.17	4.70%	5.12%	39.57%	66.97%	77.55%	6.05%	67.92%	94.44%	94.43%	64.33%	32.12%
Moorhead Central	452.7 ---		900.67	4.35%	4.78%	37.52%	64.91%	76.99%	3.64%	64.15%	94.24%	95.02%	66.04%	33.60%
Moorhead South	460.28 ---		902.22	6.71%	7.26%	50.75%	75.85%	77.93%	21.16%	90.58%	98.87%	91.59%	53.85%	22.88%
South of Moorhead	468.9 ---		905.54	8.94%	9.31%	59.37%	80.16%	76.29%	44.34%	97.40%	98.97%	88.34%	46.31%	17.42%
Downstream														
Georgetown MN&ND - XS 414.98	414.98 ---		879.06	1.29%	1.10%	3.19%	1.02%	0.07%	11.83%	1.16%	0.00%	0.00%	0.00%	0.00%
Halstad MN&ND - XS 397.8	397.80 ---		872.91	1.33%	1.38%	6.13%	3.98%	0.85%	16.78%	2.26%	0.03%	0.00%	0.00%	0.00%
Perley-Hendrum MN&ND - XS 381.71	381.71 ---		867.25	0.30%	0.22%	1.00%	0.70%	0.17%	3.51%	-0.59%	-1.10%	-0.44%	-0.07%	0.00%
Shelly MN&ND - XS 359.73	359.73 ---		860.15	-0.06%	-0.08%	-0.32%	-0.43%	-0.25%	-0.21%	-0.96%	-0.62%	0.05%	0.02%	0.00%
Climax MN&ND - XS 335.01	335.01 ---		849.35	-0.11%	-0.10%	-0.58%	-0.59%	-0.27%	-0.43%	-1.39%	-0.51%	0.07%	0.14%	0.00%
South of Thompson - XS 324.41	324.41 ---		846.59	-0.12%	-0.11%	-0.76%	-1.09%	-0.69%	-0.16%	-2.23%	-1.32%	0.17%	0.06%	0.01%
Intermediate - XS 423.96	423.96 ---		882.00	8.61%	9.00%	33.78%	18.98%	4.23%	85.26%	20.21%	2.29%	0.41%	0.00%	0.00%
Upstream														
Upstream_Red	500.01 ---		920.28	-3.15%	-3.23%	-19.33%	-20.75%	-10.62%	-30.38%	-27.40%	-7.16%	-3.61%	-0.28%	-0.04%
Upstream_WR	32.12 ---		924.42	-0.04%	0.00%	0.00%	0.00%	0.00%	0.21%	-0.28%	-0.11%	0.00%	0.00%	0.00%

Project Performance by Reach (Target Stages - Annual Exceedance Probabilities - Long-Term Risk - Conditional Non-Exceedance Probabilities)
Net Change - ND35k

				Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
Reach	Index River Mile	Top of Levee	Target Stage	Median	Expected	10	30	50	10%	4%	2%	1%	0.40%	0.20%
Fargo North End	442.93 ---		893.80	8.58%	8.89%	57.55%	78.75%	75.21%	40.68%	94.47%	98.31%	86.70%	44.55%	17.08%
Ridgewood	447.78	898	898.00	3.19%	3.69%	30.49%	56.70%	73.23%	1.61%	42.40%	82.24%	93.26%	72.27%	41.28%
Near North	449.61 ---		897.30	6.01%	6.60%	47.54%	73.70%	78.21%	16.14%	84.28%	97.94%	92.50%	56.99%	25.64%
Downtown North	451.37 ---		898.10	6.23%	6.81%	48.60%	74.49%	78.25%	17.47%	86.68%	98.37%	92.30%	56.18%	24.89%
Downtown South	452.25	902.2	902.20	2.55%	2.92%	25.04%	49.20%	68.22%	0.23%	26.24%	73.25%	92.59%	77.08%	47.08%
Near South	452.7	904	904.00	3.01%	3.27%	27.27%	51.30%	66.77%	7.10%	26.34%	55.67%	79.80%	74.74%	50.34%
Lindenwood Area	454.1 ---		902.07	3.42%	3.83%	31.45%	57.92%	73.92%	1.13%	46.13%	87.59%	95.32%	71.69%	39.78%
Z_Other	650 ---		900.61	4.42%	4.85%	37.91%	65.30%	77.07%	3.90%	65.26%	94.54%	94.97%	65.73%	33.27%
Fargo South														
From RRN	460.28 ---		903.08	5.44%	5.90%	43.93%	70.84%	78.00%	9.56%	79.85%	97.57%	93.57%	59.85%	27.83%
From Sheyenne	172308 ---		904.54	9.95%	11.03%	68.86%	94.38%	99.21%	49.34%	99.97%	99.97%	99.97%	99.95%	99.95%
West Fargo														
WF Downtown	451.37 ---		902.00	1.87%	2.08%	18.65%	39.02%	59.05%	0.04%	11.67%	49.75%	81.21%	81.15%	56.26%
WF South	172308 ---		904.44	11.64%	12.53%	73.72%	96.24%	99.38%	64.64%	99.97%	99.97%	99.97%	99.95%	99.95%
Harwood														
Harwood Red	432.84 ---		887.92	11.79%	11.49%	57.79%	56.50%	34.87%	74.44%	86.47%	67.88%	39.64%	10.76%	2.68%
Harwood Sheyenne	67984 ---		887.30	16.27%	16.17%	70.05%	63.85%	41.69%	95.17%	98.53%	87.54%	0.00%	0.00%	0.00%
Cass County														
ANorth (RRN)	440.31 ---		890.21	15.43%	15.16%	67.76%	62.44%	40.19%	91.27%	91.60%	75.84%	44.24%	10.60%	2.18%
ASouth (RRN)	465.1 ---		899.64	19.30%	18.96%	78.88%	75.50%	57.56%	97.55%	98.95%	92.44%	63.41%	17.70%	3.97%
BNorth (RRN)	440.31 ---		886.75	5.19%	5.40%	5.03%	0.26%	0.00%	0.12%	0.00%	0.00%	0.00%	0.00%	0.00%
BSouth (RRN)	465.1 ---		901.11	14.64%	15.20%	75.11%	81.41%	68.38%	90.55%	99.88%	96.64%	75.43%	27.82%	7.77%
ASheyenne	172308 ---		902.25	16.60%	16.25%	2.13%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ShySA	166 ---		890.01	3.87%	4.26%	30.10%	43.47%	37.56%	11.13%	70.92%	88.17%	0.00%	0.00%	0.00%
Moorhead														
Kragnes	434.61 ---		889.57	10.19%	10.21%	60.48%	74.25%	62.91%	57.40%	95.62%	91.87%	68.95%	26.24%	8.24%
Oakport	440.31	900.5	900.50	0.19%	0.30%	2.94%	7.14%	13.63%	0.00%	0.01%	0.65%	6.12%	29.92%	49.45%
North of Moorhead	442.93 ---		892.83	10.78%	11.12%	64.84%	79.70%	70.39%	64.53%	98.70%	97.11%	78.83%	32.83%	10.51%
Moorhead North	449.61 ---		898.17	4.70%	5.12%	39.57%	66.97%	77.55%	6.05%	67.92%	94.44%	94.43%	64.33%	32.12%
Moorhead Central	452.7 ---		900.67	4.35%	4.78%	37.52%	64.91%	76.99%	3.64%	64.15%	94.24%	95.02%	66.04%	33.60%
Moorhead South	460.28 ---		902.22	6.71%	7.26%	50.75%	75.85%	77.93%	21.16%	90.58%	98.87%	91.59%	53.85%	22.88%
South of Moorhead	468.9 ---		905.54	8.94%	9.31%	59.37%	80.16%	76.29%	44.34%	97.40%	98.97%	88.34%	46.31%	17.42%
Downstream														
Georgetown MN&ND - XS 414.98	414.98 ---		879.06	-0.71%	-0.77%	-2.09%	-0.35%	-0.03%	-11.48%	-2.25%	-1.22%	0.00%	0.00%	0.00%
Halstad MN&ND - XS 397.8	397.80 ---		872.91	-1.31%	-0.92%	-3.64%	-1.95%	-0.30%	-11.29%	-3.74%	-0.24%	0.00%	0.00%	0.00%
Perley-Hendrum MN&ND - XS 381.71	381.71 ---		867.25	-1.04%	-0.73%	-3.25%	-2.11%	-0.45%	-5.93%	-7.88%	-3.60%	-1.33%	-0.28%	0.00%
Shelly MN&ND - XS 359.73	359.73 ---		860.15	-0.61%	-0.62%	-3.82%	-4.28%	-2.25%	-2.95%	-8.84%	-3.21%	-0.77%	-0.06%	0.00%
Climax MN&ND - XS 335.01	335.01 ---		849.35	-0.57%	-0.54%	-3.11%	-3.07%	-1.31%	-3.38%	-6.09%	-1.87%	-0.31%	0.00%	0.00%
South of Thompson - XS 324.41	324.41 ---		846.59	-0.32%	-0.52%	-3.46%	-4.42%	-2.88%	-1.09%	-9.21%	-4.77%	-1.28%	-0.13%	-0.01%
Intermediate - XS 423.96	423.96 ---		882.00	-0.75%	-0.80%	-1.75%	-0.35%	-0.01%	-9.64%	-0.65%	0.00%	0.00%	0.00%	0.00%
Upstream														
Upstream_Red	500.01 ---		920.28	-0.03%	-0.04%	-0.26%	-0.35%	-0.25%	-0.15%	-0.63%	-0.32%	0.05%	0.01%	0.00%
Upstream_WR	32.12 ---		924.42	-0.66%	-0.42%	-1.95%	-1.37%	-0.33%	-5.86%	-1.43%	0.06%	0.00%	0.00%	0.00%

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Project Performance by Reach (Target Stages - Annual Exceedance Probabilities - Long-Term Risk - Conditional Non-Exceedance Probabilities)

Net Change - MN35k - FCP

				Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
Reach	Index River Mile	Top of Levee	Target Stage	Median	Expected	10	30	50	10%	4%	2%	1%	0.40%	0.20%
Fargo North End	442.93	---	893.80	8.46%	8.65%	55.23%	73.50%	66.34%	40.65%	93.74%	93.77%	74.17%	31.51%	10.70%
Ridgewood	447.78	898	898.00	3.20%	3.69%	30.49%	56.70%	73.22%	1.62%	42.40%	82.23%	93.10%	72.08%	41.44%
Near North	449.61	---	897.30	5.99%	6.57%	47.24%	72.99%	76.94%	16.14%	84.28%	97.73%	90.89%	53.57%	23.33%
Downtown North	451.37	---	898.10	6.21%	6.78%	48.35%	73.90%	77.20%	17.48%	86.68%	98.21%	91.08%	53.40%	25.06%
Downtown South	452.25	902.2	902.20	2.56%	2.93%	25.13%	49.40%	68.60%	98.76%	26.24%	73.26%	92.75%	78.25%	48.86%
Near South	452.7	904	904.00	3.00%	3.25%	27.11%	50.94%	66.11%	7.08%	26.29%	55.49%	79.34%	74.81%	51.13%
Lindenwood Area	454.1	---	902.07	3.42%	3.84%	31.54%	58.15%	74.34%	1.14%	46.13%	87.60%	95.47%	72.63%	41.00%
Z_Other	650	---	900.61	4.42%	4.84%	37.88%	65.23%	76.94%	3.91%	65.26%	94.53%	94.90%	65.71%	33.47%
Fargo South														
From RRN	460.28	---	903.08	5.45%	5.92%	44.03%	71.07%	78.42%	9.57%	79.85%	97.60%	93.86%	61.00%	28.93%
From Sheyenne	172308	---	904.54	0.00%	0.01%	0.02%	0.01%	0.00%	0.07%	0.00%	0.00%	0.00%	0.00%	0.00%
West Fargo														
WF Downtown	451.37	---	902.00	1.88%	2.09%	18.74%	39.23%	59.45%	0.05%	11.67%	49.75%	81.34%	82.13%	57.85%
WF South	172308	---	904.44	0.00%	0.00%	-0.01%	0.00%	0.00%	-0.02%	0.00%	0.00%	0.00%	0.00%	0.00%
Harwood														
Harwood Red	432.84	---	887.92	5.11%	3.75%	12.31%	4.93%	0.50%	35.94%	14.19%	3.29%	0.65%	0.08%	0.02%
Harwood Sheyenne	67984	---	887.30	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Cass County														
ANorth (RRN)	440.31	---	890.21	10.78%	9.55%	30.56%	15.50%	2.08%	67.98%	33.70%	13.45%	4.29%	0.60%	0.09%
ASouth (RRN)	465.1	---	899.64	19.28%	18.93%	78.62%	74.95%	56.73%	97.56%	98.76%	91.74%	62.01%	16.83%	3.69%
BNorth (RRN)	440.31	---	886.75	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
BSouth (RRN)	465.1	---	901.11	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ASheyenne	172308	---	902.25	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ShySA	166	---	890.01	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Moorhead														
Kragnes	434.61	---	889.57	7.25%	6.38%	30.72%	24.39%	8.50%	48.56%	50.24%	24.85%	9.76%	2.16%	0.53%
Oakport	440.31	900.5	900.50	0.19%	0.30%	2.94%	7.14%	13.63%	0.00%	0.01%	0.65%	6.12%	29.94%	49.46%
North of Moorhead	442.93	---	892.83	10.48%	10.40%	38.26%	65.66%	48.77%	64.07%	93.37%	79.98%	51.86%	16.15%	4.41%
Moorhead North	449.61	---	898.17	4.69%	5.11%	39.45%	66.68%	77.02%	6.06%	67.92%	94.38%	93.80%	62.91%	31.23%
Moorhead Central	452.7	---	900.67	4.35%	4.78%	37.48%	64.82%	76.82%	3.64%	64.15%	94.23%	94.98%	66.14%	33.89%
Moorhead South	460.28	---	902.22	6.71%	7.27%	50.81%	75.99%	78.19%	21.17%	90.58%	98.88%	91.77%	54.47%	23.45%
South of Moorhead	468.9	---	905.54	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%
Downstream														
Georgetown MN&ND - XS 414.98	414.98	---	879.06	-0.71%	-0.77%	-2.03%	-0.55%	-0.03%	-11.48%	-2.23%	-0.22%	0.00%	0.00%	0.00%
Halstad MN&ND - XS 397.8	397.80	---	872.91	-1.31%	-0.92%	-3.64%	-1.95%	-0.30%	-11.29%	-3.74%	-0.24%	0.00%	0.00%	0.00%
Perley-Hendrum MN&ND - XS 381.71	381.71	---	867.25	-1.14%	-0.73%	-3.25%	-2.11%	-0.45%	-5.93%	-7.88%	-4.60%	-1.33%	-0.28%	0.00%
Shelly MN&ND - XS 359.73	359.73	---	860.15	-0.61%	-0.62%	-3.82%	-4.28%	-2.25%	-2.95%	-8.84%	-3.21%	-0.77%	-0.06%	0.00%
Climax MN&ND - XS 335.01	335.01	---	849.35	-0.57%	-0.59%	-3.11%	-3.07%	-1.31%	-3.38%	-6.09%	-1.87%	-0.31%	0.00%	0.00%
South of Thompson - XS 324.41	324.41	---	846.59	-0.52%	-0.52%	-3.40%	-4.42%	-2.88%	-1.09%	-9.21%	-4.77%	-1.28%	-0.13%	-0.01%
Intermediate - XS 423.96	423.96	---	882.00	-0.75%	-0.80%	-1.73%	-0.35%	-0.01%	-9.64%	-0.69%	0.00%	0.00%	0.00%	0.00%
Upstream														
Upstream_Red	500.01	---	920.28	-0.03%	-0.00%	-0.26%	-0.35%	-0.25%	-0.13%	-0.63%	-0.32%	0.05%	0.01%	0.00%
Upstream_WR	32.12	---	924.42	-0.60%	-0.42%	-1.95%	-1.37%	-0.33%	-5.86%	-1.43%	0.06%	0.00%	0.00%	0.00%

EXHIBIT N

Calculation of Flood Proof Cost Savings

Table xx - Calculation of Floodproofing Cost Savings

Annual land demanded for growth (2018 - 2068)	266						
Number of years	50						
Total land demanded for growth (2018 - 2068)	13,300						
	Tier 1	Tier 2	Fargo	Total	Acres benefited per year	Savings per acre	Savings per year
Area available for future growth	6300	11800	1600	19700			
Growth areas in 100-year flood plain	5100	7800	800	13700			
100-yr land opened by ND 35k and 30k plans	5000	6900	800	12700			
Land benefitted	5000	5400	800	11200	224	$ 46,550	$ 10,427,200
Land outside of 100-yr floodplain	1200		800	2000			
Land req floodproofing	100			100			
	6300	5400	1600	13300			
100-yr land opened by MN Short 35k and 30k plans	4600	1600	500	6700			
Land benefitted	4600	1600	500	6700	134	46,550	6,237,700
Land outside of 100-yr floodplain	1200		800	2000			
Land req floodproofing	500	3800	300	4600			
	6300	5400	1600	13300			
100-yr land opened by MN Short 25k plan	4600	1600	500	6700			
Land benefitted	4600	1600	500	6700	134	46,550	6,237,700
Land outside of 100-yr floodplain	1200		800	2000			
Land req floodproofing	500	3800	300	4600			
	6300	5400	1600	13300			
100-yr land opened by MN Short 20k plan	4300	1600	500	6400			
Land benefitted	4300	1600	500	6400	128	46,550	5,958,400
Land outside of 100-yr floodplain	1200		800	2000			
Land req floodproofing	800	3800	300	4900			
	6300	5400	1600	13300			
100-yr land opened by MN Short 15k plan	3700	1600	500	5800			
Land benefitted	3700	1600	500	5800	116	46,550	5,399,800
Land outside of 100-yr floodplain	1200		800	2000			
Land req floodproofing	1400	3800	300	5500			
	6300	5400	1600	13300			

ATTACHMENT 1

Fargo-Moorhead Nonresidential and Residential Structure Inventory and Surveys

Final Project Report Fargo-Moorhead Nonresidential and Residential Structure Inventory and Nonresidential Surveys

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U.S. Army Corps of Engineers
St. Paul District

December 2009

Final Project Report Fargo-Moorhead Nonresidential and Residential Structure Inventory and Nonresidential Surveys

December 2009

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RED RIVER OF THE NORTH FEASIBILITY STUDY
BASELINE ECONOMIC ANALYSIS REPORT

RESIDENTIAL INVENTORY ANALYSIS & NONRESIDENTIAL FLOOD DAMAGE SURVEY

December 2009

1.0 INTRODUCTION

The U.S. Army Corps of Engineers (USACE), St. Paul District, is conducting the Fargo-Moorhead Feasibility Study. As part of that baseline economic analysis, URS Group, Inc. (URS) conducted the field collection and analysis of selected structures, which consisted of the following tasks:

1. Through site reconnaissance, collect structure details for all nonresidential structures and a random sample of residential structures within the study area.
2. Estimate the depreciated structure value for each structure inventoried in the field using the Marshall & Swift (M&S) estimating software.
3. Calculate an adjustment factor based on the difference between the tax assessment value and the M&S depreciated structure value for the residential structures inventoried.
4. Develop and facilitate Office of Management and Budget (OMB) approval of a survey instrument to estimate potential flood damages at nonresidential structures.
5. Collect flood damage information through onsite interviews for selected nonresidential structures.

The study area consisted of the 500-year floodplain along the Red River of the North and several tributaries within the Fargo-Moorhead metropolitan area. Therefore the study area covers both sides of the river and parts of both North Dakota and Minnesota.

Data collected from the structure inventory and nonresidential surveys are to be incorporated into the overall economic analysis. The methodology and a summary of the collected data are contained in this report.

2.0 STRUCTURE INVENTORY

The purpose of the structure inventory was to collect data on selected residential and all nonresidential structures in the Red River of the North watershed. All information collected in the field was recorded in a field data collection tool and entered into the M&S software once field work was completed.

URS identified the structures to be inventoried from three tax databases. The tax assessor data were obtained from the City of Fargo, ND, as well as Clay County, MN and Cass County, ND. The tax data were compiled and formatted in order to be consistent with field software input requirements. URS delineated the study area using FEMA's floodplain map for the 0.2-percent-annual-chance event (500-year floodplain) provided by the St Paul District.

An inventory of all residential structures in the study area was not completed for this effort due to the size of the Red River watershed and the number of residential structures within the floodplain. Instead, a random sample of residential structures was selected to be inventoried. Over 3,200 residential structures were inventoried. The inventoried structures were used to create adjustment factors to apply to the remaining structures in the study area. Further details on the steps taken to calculate these factors are provided later in this section.

2.1 Field Database

The field database was constructed using tax databases from the City of Fargo, Clay County, and Cass County. The three databases were combined and overlain on the delineated floodplain map. Any structures outside of this map were removed from the field database and considered outside of the study area.

There are two primary ways to break down the tax information, by tax parcel or by building footprint. How the information is being used typically dictates which way the information is dissected. Sometimes reporting information by tax parcel is sufficient. However, structure inventories collect information by individual structures, not by parcel to ensure flood damages and benefits are calculated correctly. There are several instances in the study area where multiple structures exist on one parcel, so the building footprints were used to populate the field database instead of the tax parcels. This made field collection easier by having more structures identified in the database prior to fieldwork starting. This provided a more accurate count of structures to allowing better estimates of the required field efforts.

Using building footprints provided the extra benefit of excluding tax parcels with no structures. However, the field crews drove the entire area in case newer buildings had been constructed or the footprint file was not completely accurate. In addition, large buildings that cover multiple tax parcels were reduced to one entry. These buildings are larger industrial buildings or shopping complexes.

The study area was divided into several smaller survey areas using roads as boundaries. These survey areas allowed multiple teams to work simultaneously without duplicating efforts. Each

team inventoried their assigned area until it was completed and then moved on to a newly assigned area.

2.2 Data Collection

Four two-person teams performed the data collection. Each team was equipped with a laptop computer and a digital camera. All structure information was collected from outside the structure and recorded in the database. A letter of introduction containing a project description and contact information was available to provide to property owners upon request.

The characteristics collected for each structure were based on fields used in the M&S Residential and Commercial Estimator Programs to calculate depreciated replacement value and new replacement value.

The following information was collected for each residential structure:

- Address
- Photograph of structure
- Latitude and Longitude
- Characteristics
  - Type of structure (e.g., single family)
  - Type of foundation
  - Finished floor area
  - Effective age
  - Quality of construction
  - Condition of structure
  - Style of structure (e.g., one story)
  - Type of exterior wall (e.g., siding)
  - Type of roofing
  - Presence of garage
  - Presence of other outbuildings
  - Presence of fireplaces
  - Height of the first floor in relation to the adjacent grade
  - Presence of basement

URS estimated the finished floor area of each structure utilizing an aerial photograph and tracing tool available on each computer. The effective age of each structure was estimated using a combination of factors: the style in which the structure was built, the appearance, and any improvements done to the original structure. The effective age takes into account renovations to

a structure since the original construction. The construction quality of the building was determined by looking at the workmanship in relation to the materials used. The appearance and condition of the structure in relation to the effective age determined the physical condition of the buildings.

The following information was collected for each nonresidential structure:

- Name of business
- Address
- Photograph of structure
- Latitude and Longitude
- Characteristics
  - General use of structure (occupancy code)
  - Effective age
  - Total floor area
  - Construction class (e.g., masonry bearing walls)
  - Story height
  - Quality of construction
  - Number of stories
  - Perimeter shape
  - Height of the first floor in relation to the adjacent grade

The survey teams used aerial maps to locate the selected residential or nonresidential structures. Structures that no longer exist were deleted from the database. Additional unmarked nonresidential structures that are clearly within the study area were added to the database. Some database entries were deleted in the field due to incorrect identifications as structures (e.g., a dumpster was marked as a structure) or because the structure had recently been demolished. Occasionally, structures were inaccessible and attributes could not be collected. This occurred when structures were located in high security areas or inside compounds the field crews could not gain access to (e.g., National Guard installation or parts of the airport).

To more accurately estimate the depreciated replacement value, the surveyors assigned an M&S 3-digit occupancy code to each structure based on its use (Table 1). Use is determined by the activities conducted in the building as observed during the field survey and by company name. The predominant use of, or activity performed in, a structure determines both the type of construction and quality of materials used. For example, the construction design and the materials used for a fast food restaurant can be very different than those used for a warehouse or a small office.

Table 1: List of 3-Digit Occupancy Codes Used

OCCID	Definition	OCCID	Definition
127	Winery Shop	421	Storage, Grain
133	Storage Shed, Prefabricated	423	Mini-Lube Garage
135	Hoop Greenhouse, Arch-Rib, Small (under 4,500 square feet)	426	Day Care Center
138	Hoop Greenhouse, Arch-Rib, Large (over 9,000 square feet)	427	Fire Station (Volunteer)
139	Straight Wall Greenhouse, Large (over 9,000 square feet)	428	Horse Arena
140	Modified Hoop Greenhouse, Medium (4,500 - 9,000 square feet)	431	Outpatient (Surgical) Center
141	Hoop Greenhouse, Arch-Rib, Medium (4,500 - 9,000 square feet)	432	Restroom Building
157	Storage, Maintenance Building	434	Self-Serve Car Wash
158	Special Education Classrooms	435	Drive-Thru Car Wash
170	Institutional Greenhouse, Small (under 4,500 square feet)	436	Car Wash, Automatic
171	Institutional Greenhouse, Medium (4,500 - 9,000 square feet)	442	Tavern/Bar
172	Institutional Greenhouse, Large (over 9,000 square feet)	443	Central Bank
173	Educational Wing, Church	444	Office, Dental
174	Pavilion	446	Supermarket
175	Skating Rink, Ice	447	Storage Facility, Cold
176	Skating Rink, Roller	451	Multiple Residence, Senior Citizen (Low Rise)
181	Storage Shed, Prefabricated, Secure	454	Shell, Industrial Building
183	Starter Booth, Golf	455	Auto Dealership, Complete
184	Shelter, Arena	456	Tool Shed
185	Truck Wash	458	Warehouse Discount Store
300	Apartment (High Rise)	459	Shopping Center, Mixed with Residential Units
301	Armory	468	Shed, Material Storage
302	Auditorium	470	Storage, Equipment Shop
303	Showroom, Automobile	471	Utility Building, Light Commercial
304	Bank	472	Shed, Equipment
305	Barn	473	Shelter, Material
306	Bowling Center	476	Storage, Farm Implement
308	Church with Sunday School	477	Utility Building, Farm
309	Church	478	Shed, Farm Implement
311	Clubhouse	479	Shed, Farm Utility Storage
313	Hospital, Convalescent	481	Museum
314	Country Club	482	Convention Center
316	Dairy	483	Fitness Center
318	Store, Department	484	High School (Entire)
319	Store, Discount	485	Natatorium
321	Dormitory	486	Field House
322	Fire Station (Staffed)	487	Vocational School
323	Fraternal Building	488	Bookstore (School)
324	Fraternity House	490	Kennel
326	Storage Garage	491	Government Community Service Building

OCCID	Definition	OCCID	Definition
327	Governmental Building	492	Shell, Office Building
328	Storage Hangar	493	Storage, Flathouse
329	Hangar, Maintenance and Office	494	Industrial Light Manufacturing
330	Home For The Elderly	495	Industrial Heavy Manufacturing
331	Hospital	496	Laboratory
335	Jail, Correctional Facility	498	Broadcast Facility
336	Laundromat	499	Laundry/Dry Cleaners
337	Library, Public	508	Car Wash Canopy
339	Storage, Lumber Shed, Horizontal	514	Community Center
340	Market	515	Casino
341	Office, Medical	518	Lath Shade House (Greenhouse)
342	Mortuary	519	Shade Shelter (Greenhouse)
343	Motel	523	Storage, Golf Cart Building
344	Office Building	526	Shed, Service Garage
345	Parking Structure	527	Municipal Service Garage
348	Rectory	528	Service Repair Garage
349	Restaurant, Fast Food	529	Snack Bar
350	Restaurant, Table Service	530	Restaurant, Cafeteria
352	Multiple Residence (Low Rise)	531	Mini-Mart Convenience Store
353	Store, Retail	532	Florist Shop
356	Classroom (Elementary and Secondary School)	533	Warehouse Food Store
358	Gymnasium (Elementary and Secondary School)	534	Warehouse Showroom Store
363	Physical Education Building (Elementary and Secondary School)	540	Motel Room, 2 Story, Double Row
364	Science Classrooms (Elementary and Secondary School)	543	Motel Room, 1 Story, Single Row
365	Elementary School (Entire)	544	Office-Apartment (Motel)
368	Classroom (College)	552	Recreational Enclosure
369	Commons (College)	554	Shed Office Structure
370	Gymnasium (College)	555	Quonset, Light Commercial Arch-Rib
372	Library, College	556	Storage, Bulk Oil
373	Technical Trades Building (College)	557	Quonset, Farm Utility Arch-Rib
376	Science Building (College)	558	Quonset, Farm Implement Arch-Rib
377	College (Entire)	561	Shed, Feeder Barn
378	Stable	562	Shed, Farm Commodity Storage
379	Theater, Live Stage	566	Shelter, Farm Sun Shade
380	Theater, Cinema	571	Passenger Terminal
381	Veterinary Hospital	574	Visitor Center
384	Barber Shop	577	Parking Levels
386	Warehouse, Mini	578	Mini Bank
387	Warehouse, Transit	580	Truck Stop
390	Storage, Lumber Building, Vertical	581	Post Office, Main
391	Storage, Material Building	582	Post Office, Branch
392	Industrial Engineering Building	584	Warehouse, Mega
393	Labor Dormitory	585	Penthouse, Mechanical
396	Hog Barn	588	Motel, Extended Stay
397	Sheep Barn	589	Multiple Residence, Assisted Living (Low

OCCID	Definition	OCCID	Definition
			Rise)
403	Shower Building	594	Hotel, Full Service
406	Warehouse, Storage	595	Hotel, Limited Service
407	Warehouse, Distribution	597	Retail Mixed with Office Units
408	Service Station	598	Relocatable Classroom
409	T-Hangar	600	Administration Building
410	Automotive Center	700	Store, Department, Mall Anchor
413	Shopping Center, Community	710	Retirement Community Complex (Multiple Residence)
414	Shopping Center, Regional	984	Luxury Apartment (High Rise)
418	Health Club	987	Multiple Residence (Low Rise), Interior Space
419	Market, Convenience	993	Office Building, Interior Space

During the inventory, the replacement value for nonresidential structures containing multiple businesses (e.g., a strip mall) was calculated with each business' M&S occupancy code representing a percentage of the total structure (e.g., a strip mall contained 70 percent retail and 30 percent fast-food restaurant).

2.3 Structure Values

Relevant data for each structure was entered into the M&S Residential Estimator and Commercial Estimator programs. The M&S programs were used to calculate depreciated replacement values for each residential and nonresidential structure based on the concepts of effective age, quality, condition, and other structural parameters. The depreciated replacement values were based on the most recently released M&S quarterly values (December 2008 for residential and January 2009 for nonresidential).

Because the survey teams did not enter the interior of any structures, a number of characteristics typically entered into the M&S programs—such as the method of heating and cooling, type of plumbing, and the type of interior floor covering—could not be recorded. Default values were used for characteristics that could not be determined during the structure inventory.

2.4 Tax Assessor Data

Tax assessor databases typically record multiple values for each property, such as land value, improvement value, and total value. Because improvement value captures the value of any structures built on the land, it was used as the tax assessor structure value to compare to the replacement values calculated by M&S.

Major structure characteristics in the tax assessor data were compared with those in the field data to determine the presence of inconsistencies or trends in either set of data. The square footage[1] data field present in the residential tax assessor data is a major factor in structure value. For

[1] Square footage refers to the total square feet for a given structure, not the square footage of the structure's footprint. The square footages collected in the field take into account the number of stories for each structure.

structures located within Fargo, these values in the tax assessor data did not exactly match the field estimates, but the values were close. The tax assessor data generally records to the nearest whole square foot. Field-collected square footage data were estimated from outside of the structures using aerial photographs.

The structure square footage data in the Fargo tax assessor database was found to be fairly accurate. Therefore, in cases for which square footage field estimates were more than 20 percent different from the tax assessor data, the square footage value from the tax assessor data was used to calculate the depreciated structure value. If a square footage estimate was less than 20 percent off from the tax assessor data then the field data was used. Adjusting the square footage values provided a more direct comparison between the tax assessor value and the M&S value since square footage is one of the major drivers in calculating a structure value. The depreciated residential structure values from the M&S programs were approximately 5 percent greater than the depreciated structure values from tax assessor data for Fargo.

The Moorhead structures did not have the same discrepancies in the field square footage versus tax assessor square footage. Therefore the field data was determined to be more accurate for the Minnesota side of the study area so no adjustments were made to the collected data. For Moorhead, the depreciated residential structure values from the M&S programs were approximately 30 percent greater than the tax assessor values.

With the discrepancies in the Fargo field data and the considerable differences between the Fargo and Moorhead adjustment factors, URS conducted additional analyses of residential structures in the City of Fargo to determine if the M&S residential structure values are really within 4 to 5 percent of the tax assessor value. The City of Fargo tax assessor provided a more detailed file than what was originally provided on a set of structures selected by the St. Paul District from the city's database. This file contained the size of the basements as a percentage of the footprint (None, 25 percent, 50 percent, 75 percent, or 100 percent) and the percent of basement that is finished.

This more detailed tax data was entered into the M&S residential program. All residential data was entered into the M&S program as recorded by the tax assessor, including the specific heating type; none of the field data was used. The one exception was "Franklin stoves" which were entered as fireplaces because that was the closest option in the software. Because of the time it takes to manually enter structures into M&S, approximately 380 residential structures were valuated this way.

Using the revised structure values, an updated adjustment factor was calculated for residential structures in the City of Fargo. The updated adjustment factor resulted in a 28 percent increase in the tax assessor improvement values. This result is closer to the findings in Moorhead and similar studies conducted previously in Fargo by St. Paul District. A large component of the increase resulted from entering characteristics of finished basements.

2.5 Results

A total of 10,460 residential and nonresidential structures were inventoried during the field work. In the final analysis 7,233 nonresidential structures and 804 residential structures were used (Table 2). One-and-half-story structures are captured in the appropriate one-story category.

Table 2: Number of Structures Inventoried

Structure Type	Number Inventoried
Residential	
One Story, With Basement	583
One Story, No Basement	18
Two Story, With Basement	147
Two Story, No Basement	36
Bilevel/Split-Level	20
Total Residential	**804**
Nonresidential	
Commercial	7,189
Industrial	5
Agricultural	39
Total Nonresidential	**7,233**

Table 3 provides descriptive statistics about the residential structures inventoried. One-and-half-story structures are captured in the appropriate one-story category.

Table 3: Descriptive Statistics for Residential Structures

Category	Average	Maximum	Minimum	Standard Deviation
One Story, With Basement				
Square feet	1,385	9,140	480	593.5
Depreciated replacement value	$127,802	$961,258	$57,721	$56,842.5
One Story, No Basement				
Square feet	1,120	1,836	528	326.9
Depreciated replacement value	$91,505	$172,574	$47,422	$34,399.1
Two Story, With Basement				
Square feet	2,251	5,000	884	906.2
Depreciated replacement value	$191,212	$554,165	$81,816	$100,436.0
Two Story, No Basement				
Square feet	1,580	1,700	830	156.8
Depreciated replacement value	$100,362	$111,716	$65,320	$9,834.1
Split-Level/Bi-Level				
Square feet	2,273	3,000	1,440	517.2
Depreciated replacement value	$187,957	$244,958	$112,946	$31,804.2

Table 4 provides descriptive statistics about the nonresidential structures collected during the inventory.

Table 4: Descriptive Statistics for Nonresidential Structures

Category	Average	Maximum	Minimum	Standard Deviation
Commercial (General)				
Square Feet	15,080	509,460	30	31,283
Depreciated replacement value	$1,295,158	$110,035,558	$241	$3,758,049
Industrial				
Square Feet	15,802	27,470	2,000	10,862.2
Depreciated replacement value	$1,182,878	$3,084,140	$256,183	$1,198,789.9
Agricultural				
Square Feet	2,027	33,660	110	6,030
Depreciated replacement value	$30,260	$601,877	$794	$100,397

Each nonresidential structure inventoried was assigned two depth-damage functions (DDFs): one to represent the structure and the other to represent the contents. The DDFs were provided by the St. Paul District. The DDF assigned to the structure was based on the construction type of the structure, while the DDF assigned to the contents was based on the type of business/activities conducted in the structure.

Once the URS data was analyzed it needed to be connected to the St. Paul District's data files in order to update the structure elevations and structure values. The St. Paul District provided five Hydrologic Engineering Center – Flood Damage Analysis (HEC-FDA) formatted files, which included two files for the City of Fargo, two files for Cass County, and one file for the City of Moorhead. Because the St. Paul District files reflect information on parcels and the URS files reflect information on structures, creating a specific match when multiple structures exist on a single parcel proved problematic. A detail methodology outline employed by URS to address this and other issues is provided in Appendix A.

Once a crosswalk between the tax assessor database, USACE database, and URS database was completed, the final HEC-FDA files were updated with new structure values and elevations and submitted to the St. Paul District. The hydrologic and hydraulic (H&H) data used by the St. Paul District were imported into the ArcMap software to ensure the correct river station numbers were assigned to the structures based on building location, not tax parcel, or nearest tax parcel.

These HEC-FDA data files were delivered to the St. Paul District in several formats. Data relevant to the economic analysis was provided in the HEC-FDA program format. Backup data was provided on a compact disc, including the field database containing the information collected during the inventory, field photographs, and a spreadsheet showing the factors used to adjust the Fargo and Clay County tax values to the current M&S depreciated replacement values.

3.0 NONRESIDENTIAL SURVEYS

Most nonresidential structures can be sorted into one of the DDFs discussed previously. However, some structures are unique and not represented well by the DDFs or have subterranean levels that are not accounted for with the DDFs. The purpose of the nonresidential surveys was to obtain data to more accurately estimate potential flood damages of the contents of unique structures than can be estimated by the indirect DDFs. Data were collected at selected facilities and used to calculate DDFs for the contents of each structure at the facility, cleanup costs, and other valuable items on the property (e.g., equipment stored in a maintenance yard). The resulting direct DDFs replaced the indirect DDFs originally assigned to the structure. Direct DDFs calculate damages in direct dollar amounts while indirect DDFs calculate the damages as a percent of the total damage value. To collect the data, URS developed a survey instrument that asked respondents to provide information on historical flood damages and to estimate damages for different levels of flooding. The surveys were completed through interviews conducted with representatives of the selected facilities.

3.1 Survey Instrument

The survey instrument was developed based on surveys that had been previously developed for other studies. Prior to conducting any interviews, OMB approval of the survey instrument was required. URS prepared an information package containing basic information on the purpose of the survey, the selection of facilities, and the basis from which the survey instrument was derived. The information package was submitted to OMB through the USACE Mississippi Valley Division and was approved for use in January 2009 (Appendix B).

The survey instrument steps respondents through the process of identifying the placement and value of contents within each structure at a facility. Respondents were asked to separate the contents into three categories (equipment, furniture, and inventory/products), and indicate the placement and value for each category. Respondents were then asked to estimate the amount of damage that would occur if the structure flooded. For the amount of damage, respondents were asked to provide a low, most likely, and high value to account for uncertainty. In addition to the contents in the structures, respondents were asked to identify cleanup costs (if the facility had been flooded previously) and hypothetical preparedness costs if flooding were imminent. Other items of value that may be located on the facility grounds were also noted.

3.2 Selection of Facilities to Interview

A separate goal of the inventory was to determine which nonresidential structures warranted an interview. The selection of these facilities was conducted prior to the inventory and focused on industrial-type facilities that appeared to contain unique or expensive contents. The initial list was developed by Houston Engineering (a URS subcontractor) based on large improvement values obtained from the tax assessors' databases. This list was then revised to account for field observations and Houston Engineering's knowledge of the area. Finally, URS and Houston Engineering held discussions with the St. Paul District to finalize the list of selected facilities.

Houston Engineering contacted the 66 facilities identified in Table 5 for interviews.

Table 5: Facilities Contacted for Interviews

Company	Survey Status	Company	Survey Status
702 Communications	Completed	Gremada Industries	Unavailable
Air National Guard	Incomplete	Hector International Airport	Completed
Alien Technology Corporation	Completed	Hjemkomst Center	Completed
American Crystal Sugar	Completed	Ideaone	Completed
American Steel	Unavailable	Infinity Windows	Completed
American Steel Systems	Unavailable	Integrity Windows (2 locations)	Completed
BNSF Railway	No Response	Johnston Fargo Culvert	Unavailable
Cardinal Insulating Glass Co	No Response	Knight Printing	Unavailable
Cargill Oil Seed	Completed	Larkin Properties LLP	No Response
Cass Clay Creamery	Completed	McNeilus Steel	Completed
Clay County Law Enforcement	Completed	Meritcare – South University	Completed
CNH America LLC	Completed	Microsoft Corporation	No Response
Cretex Concrete Products North	Completed	Mid America Steel Inc.	Completed
D&M Industries	Declined	Minnkota Windows	Unavailable
Dacotah Paper	Completed	Nash-Finch Co	No Response
Dakota Fence	Declined	National Guard Recruiting Station	No Response
Dakota Specialty Milling	Incomplete	NDDOT	Completed
Drayton Enterprise	No Response	NDSU	No Response
DS Beverages Inc: Anheuser-Busch Red Hook & Monster	No Response	Nordick Group Inc.	Declined
Eventide Senior Living Communities	Completed	Northern Pipe Products Inc.	Completed
FAA- Airport	Declined	Northern Water Works Supply	Completed
Fargo Park District (Edgewood Golf Course)	Completed	Pan-O-Gold Baking Co	Completed
Fargo Parts & Equipment	Declined	Phoenix International Corp. (2 locations)	Completed
Fargo Public Library	No Response	Phyllis Thurlow	No Response
Fargo Tank & Steel	Unavailable	PRACS	No Response
Fargo Wastewater Treatment Plant	Completed	Qwest Corporate Communications	Completed
Fargo Water Equipment Co	Unavailable	RDO Equipment	No Response
Fargo Water Treatment Plant	Completed	Sara Lee Bakery Group	No Response
Fargodome	Completed	Smurfit-Stone Container Corporation	Completed
Ferguson Enterprises	Completed	Swanston Equipment	No Response
Gary Westerholm & Timothy Dockter	No Response	Tecton Products	No Response
Gem of Fargo LLC	Completed	The Forum	No Response
GPK Products Inc	Completed	Trollwood Performing Arts School	Completed

3.3 Contact and Interview Process

Houston Engineering initially contacted the majority of the selected facilities by telephone and some by site visits. Efforts were made to obtain the contact information for the persons deemed best suited to participate in the interview, such as business owners, office managers, or facilities engineers. When possible, respondents were provided with the survey questionnaire and cover letter by e-mail prior to the scheduled interview. A majority of the surveys were conducted in person; however, a few preferred to respond by e-mail. Multiple follow-up phone calls and e-mails were exchanged with the selected facilities to ensure as many responses as possible (contacts and attempted contacts were recorded). Despite multiple follow-ups, some facilities either declined interviews or simply did not respond to inquiries.

During the interviews process, some respondents had difficulty estimating the damages to their facilities. Business owners and facilities managers were best able to address the questions on the survey. Office managers were not as familiar with the value of the contents and often had difficulty answering the questions. Thirty-three surveys were completed, resulting in the collection of information for 86 structures.

3.4 Analysis of Survey Data

Direct DDFs for contents were calculated for the structures at facilities where interviews were conducted. The direct DDFs were calculated by multiplying the total value of the contents for each category by the percent damage at each level of inundation. The estimated damages for the three categories (equipment, furniture, and inventory/products) were aggregated by depth to estimate the total damage at each level of flooding. These calculations were conducted for each of the uncertainty values (low, most likely, and high). The resulting flood damage levels, which were unique to each structure, ranged anywhere from -27.5 to 6 feet above the ground elevation.

In addition to estimating the potential damages to contents, respondents were also asked to provide information on clean-up costs (if the respondent had been flooded previously), valuable property on the grounds, and potential flood damage reduction measures they would undertake if flooding was imminent. When respondents provided this information, an other[2] category was used to represent the cost to implement flood preparedness measures. These DDFs started at -2 feet, with the assumption that emergency preparedness plans would begin to be implemented when the elevation of the water was within 2 feet of the elevation of the structure.

Data obtained from the surveys were provided to the St. Paul District in a HEC-FDA program compatible format. This information is not presented in this report to maintain the confidentiality of the facilities surveyed.

[2] 'Other' refers to any costs indicated by the respondent that cannot be captured in the structure damage category or content damage category.

4.0 FIRST FLOOR AND GROUND ELEVATIONS

Professional land surveyors were used to collect first floor elevations (FFEs) and ground elevations for a random sample of 300 structures. The FFEs for the selected structures were then compared to the FFE values provided in the HEC-FDA files. FFE values in the St. Paul District's Moorhead HEC-FDA files were directly compared to the FFE values collected by surveyors for Moorhead. In the St. Paul District's Fargo HEC-FDA files, the ground elevation values were added to the foundation height values and then compared to the FFE values collected by surveyors for Fargo.

A statistical analysis of the results was performed to determine the differences in elevation values in each study area. For Fargo, the surveyed FFE was approximately 1.8 feet higher on average than the FFE provided by the St. Paul District. For Moorhead, the difference was approximately 1 foot. The findings were documented on a spreadsheet and provided to the St. Paul District.

5.0 SUMMARY

The structure inventory and nonresidential interviews were conducted to produce data necessary for the Fargo-Moorhead Feasibility Study economic analysis. The data consisted of two components: a structure inventory and nonresidential survey. The structure inventory provides a representative account of selected structures located in the flood plain for the 0.2-percent-annual-chance event (500-year floodplain) along the Red River of the North and several tributaries within the Fargo-Moorhead metropolitan area. The data gathered was used to determine the depreciated replacement values for the residential and nonresidential structures. The survey included interviews conducted at selected nonresidential facilities to develop unique DDFs for content damages and emergency preparedness costs. The resulting data from the structural inventory and nonresidential interviews was compiled into the HEC-FDA format and delivered to the St. Paul District. This report has been reviewed by the St. Paul District and all comments have been addressed in the final report. Comments are provided in Appendix C.

APPENDIX A
URS METHODOLOGY

URS Methodology

1. **Industrial Interviews**
   - Identification of facilities to interview
     - Initial priority list was developed by Houston Engineering based on characteristics contained in the assessor's database (e.g., heavy manufacturing) and large improvement values.
     - Initial priority list was revised to account for field observations and knowledge of the area (e.g., waste water plant was moved higher in priority list).
     - Discussions were held with the USACE to finalize the list.
   - Interviews
     - Houston Engineering initially contacted the majority of the indentified facilities by telephone, other facilities were visited in-person (drop by).
     - The interviewer asked to speak to the appropriate person (e.g., facility manager, owner).
     - When possible, respondents were provided with the survey questionnaire and cover letter by e-mail prior to the scheduled interview.
     - A majority of the interviews were conducted in-person with respondents.
     - Some respondents preferred to respond by e-mail.
     - The data from the surveys were recorded on paper and later transferred to an electronic database.
   - Development of content depth damage function (DDF) for each structure
     - The total content value (Questions 15) was multiplied by the estimated percent damage (Question 17) for the three categories (equipment, furniture, and inventory) to determine the dollar damage for each level of flooding.
     - The estimated dollar damages for the categories were added together to determine the total dollar damage for contents.
     - The DDF for contents was created based on the estimated damages for each level of flooding.
   - Development of structure DDF for each structure
     - The characteristics of the structures were obtained during the structure inventory.
     - The structure characteristics were used to estimate a depreciated structure value using Marshall & Swift (M&S) commercial estimating program.
     - The HEC-FDA data provided by the USACE was reviewed to determine the DDF that was assigned to the structure.
     - The percent damage assigned to the structure was obtained from the USACE provided curves.
     - The structure component of the DDF was multiplied by the structure value to determine dollar damage for the structure.
     - The DDF for each structure was created based on the estimated damages for each level of flooding.
   - Development of "other" DDF for each structure

  - Information obtained from the interviews was reviewed to determine if additional damages or costs (e.g., emergency response costs) were provided.
  - Information provided from respondents on emergency response costs was calculated into "other" category for the DDF.
  - The emergency response was assumed to begin when flooding was predicted to be within 2 feet of the first floor elevation (FFE), therefore the damages were assigned as one time costs starting at -2 feet of the FFE.
- The direct DDFs developed for each structure were incorporated into a text file that could be imported into HEC-FDA.

2. Preparing Database for Field Collection

- URS received tax assessor databases from USACE and provided a hard copy of the Federal Emergency Management Agency (FEMA) 500-year floodplain map for the area.
- The floodplain map was then digitized in ArcGIS to define the boundaries for the structure inventory fieldwork.
- Structures from the tax assessor database were imported into ArcGIS. Any structure outside of the floodplain boundaries was assumed to be outside of the study area and removed.
- Any structure classified as commercial by the tax assessor was kept for the field collection database. Residential structures were randomly selected from within the study area in order to calculate adjustment factors. Ten percent, or approximately 3,000 residential structures, was determined as a sufficient for the adjustment factor calculations and was the stipulated amount in the scope of work.
  - After the initial random selection of residential structures, they were reviewed to ensure that an adequate number of structures would be collected in each tax assessor area. Because the tax assessment practices may be different in each area, enough data was collected to calculate an adjustment factor per area.
  - Large mobile home parks were removed from the database to allow the field crews to focus on permanent structures.
  - The West Fargo database was found to contain insufficient information.
  - Structures were selected and classified as either residential or nonresidential by hand from the aerial photos. Any misclassification was corrected during field collection.
- The large study area was broken into smaller survey areas in order to divide the field collection effort among the survey teams. Main roads were typically used as dividing lines.
- The database was loaded into the field data collection tool according to the steps outlined in the software's Administration Guide.
- The required software, aerial photos, and field data collection tool database was loaded onto each field computer. The software was tested on each computer prior to beginning field collection to ensure it was installed correctly and working properly.

3. **Fist Floor Elevations**
   - Surveyors from Houston Engineering and the URS Minneapolis office were used to collect ground elevations and FFEs for a random sample of 300 structures.
   - FFEs for the selected structures were compared to the FFE values provided in the USACE's HEC-FDA files.
     - For Moorhead, the FFEs listed in the USACE's HEC-FDA files were compared directly to the FFEs provided by the surveyors.
     - For Fargo, the FFEs for the structures contained in the USACE's HEC-FDA files were determined by adding the ground elevation to the foundation height.
   - A statistical analysis of the results was conducted showing the differences in elevation values for each study area.
     - The FFEs obtained from the surveyors were used as the base value.
     - The USACE-estimated FFEs were used as the experimental values.
     - The actual differences (in feet) were used for the uncertainty anlaysis.
   - A spreadsheet containing the evaluated structures and findings was provided to the USACE.

4. **Structure Inventory Field Collection**
   - All surveyors received training prior to beginning fieldwork to ensure each team collected data under the same set of assumptions. Some data fields (effective age) can be more subjective than others (square footage); therefore, the training focused on improving consistency across surveyors for these fields.
   - Each surveyor was also given time to become familiar with using the field data collection tool prior to the start of field work.
   - Detailed reference guides were provided to each surveyor and put in each field vehicle in case questions arose in the field.
   - All characteristics required for evaluation in the M&S software (square footage, effective age, quality, condition, exterior wall type, roof type, occupancy type if nonresidential, etc.) were collected by the survey teams. Photographs of all inventoried structures were taken.
   - Three or four survey teams (depending on the week of field work) collected data at the same time. Daily debriefs occurred at the end of each day to discuss problems experienced in the field and to gauge progress towards completion.
   - Field teams rotated partners throughout the data collection process to help ensure consistency across the surveyors.
   - Field teams were instructed to drive each road in their assigned survey areas in case nonresidential structures existed that were not identified within the database.
   - If the database indicated that a structure should be present that was in fact not present, not a structure (electrical box, etc.), or had been demolished, the structure was marked as deleted by the survey team with a statement as to why the structure should be deleted.
   - If a structure could not be reached by the survey team, it was marked as inaccessible with a statement to why it was inaccessible (gated with no guard, on military base, etc.).

5. Data Analysis

- Structure data collected during fieldwork were entered into the appropriate M&S estimating software program (Residential or Commercial).
- The structure values calculated by the M&S programs were then imported into the main structure database.
- Any nonresidential structures that were identified in the field and added to the database were assigned a PIN based on the tax parcel maps using ArcGIS.
- This PIN number was used to match the USACE data from the HEC-FDA files to the URS structure database. Matches that could not be made directly because of multiple structures with the same PIN number were made by hand. Structures that URS was not able to match to a USACE PIN were placed in a separate file from the matched structures by HEC-FDA area (Fargo North, Fargo South, Cass County North, Cass County South, and Moorhead).
- Residential Structures
    - The M&S structure values were compared to the tax assessor values in order to determine the appropriate adjustment factor for each area.
        - The initial adjustment factors raised questions and additional investigation was required.
            - Additional analysis revealed discrepancies in the square footage between the URS database and the tax assessor database for some of the structures collected in Fargo, most notably bi-level structures.
            - For any structure with a difference in area greater than 20 percent, the URS surveyed area was replaced with the tax assessor's square footage.
            - The M&S dollars per square foot value was then applied to the tax assessor's square footage for these structures and compared to the tax assessor's structure value. This comparison resulted in an adjustment factor of 1.045 or a 4.5 percent increase.
            - The structure values developed by URS for Moorhead were approximately 30 percent greater than the values determined by the tax assessor, resulting in an adjustment factor of 1.30, or a 30 percent increase. This adjustment factor was applied to all residential structures in Moorhead.
    - A sample of the City of Fargo residential structures was re-entered manually into M&S using more detailed information (e.g., the presence of a finished basement) from the tax assessor. This allowed for a more accurate comparison between the tax assessor value and the M&S value.
        - The adjustment factor for the City of Fargo was calculated to be a 28 percent increase. This result is more in line with previous studies in the area, increasing confidence in this set of data.
        - The elevation, station, and DDF were retained from the HEC-FDA file provided by the USACE—besides the structure value increase, the residential structures in the USACE HEC-FDA files were returned unchanged.

- Nonresidential Structures
    - The depreciated structure values developed using M&S were compared to those contained in the tax assessor databases.
        - Significant discrepancies between the two values were identified.
        - Structures with significant discrepancies were evaluated to identify the root cause (e.g., size difference).
    - The field-collected data was evaluated for outliers (e.g., size and $/sq ft).
        - Structures considered to have outlier values were evaluated to determine if the data was correct.
        - Adjustments were made as appropriate.
    - The DDFs provided by the USACE were assigned to structures based on the occupancy code identified during the field work and the list of DDFs provided by the USACE.
    - Nonresidential structures were assigned the same river station and elevation as contained in the HEC-FDA files provided by the USACE.
    - Structure values for multi-story structures were adjusted by dividing the total structure values by the number of floors to give a single, first-floor value.
    - Apartments with sub-terrain levels were assigned a DDF of Apt2. These apartments were identified by the FFE adjustment that URS determined while in the field.
- Random Sampling
    - A random sample of nonresidential structures was selected and scrutinized in order to identify the reason for the discrepancies between the URS and tax assessor's data.
    - This analysis revealed unreasonably low assessed values in terms of cost per square foot for a majority of structures. Results provided strong justification for URS calculated values.
    - A PowerPoint file containing pictures of each of 40 randomly sampled structures, with adjoining tables comparing the total and per square foot values of the surveyed and assessed areas, was created and provided to the USACE.

APPENDIX B
NONRESIDENTIAL INTERVIEW SURVEY FORM

COMMERCIAL AND INDUSTRIAL FLOOD DAMAGE SURVEY

(Personal Interview)

OMB Control Number: 0710-0001

Expires: 30-Sep-2009

The public report burden for this information collection is estimated to average 40 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this data collection, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters Services, Executive Services Directorate, Information Management Division, and the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, D.C. 20503, Attn.: Desk Officer for U.S. Army Corps of Engineers. Respondents should be aware that notwithstanding any other provision of law, an agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. Please DO NOT RETURN your completed form to either of these offices.

***Be sure to notify each person to be interviewed that responding to questions is voluntary.**

COMMERCIAL AND INDUSTRIAL FLOOD DAMAGE SURVEY
PRIMARY SURVEY FORM

OMB#: 0710-0001
Expires: 30-Sep-09

Attach Business Card Here

Firm Name: _____

This survey is focused on damages that could occur to the contents of structures at your facility in the event of future flooding. Contents are defined as items that would be relocated in the event that the facility moves to another location, such as furniture, equipment, products, and raw materials. For this survey contents were divided in three categories:

- **Equipment**: Physical items that are used for the production process or the operation of the facility (e.g., generators, machinery, production tables, paint booths, robotics, racks, conveyors, floor scrubbers, computers/servers, etc.). These items would most likely be removed if the business relocates to another facility.
- **Furniture**: Physical items necessary for the conduct of business or delivery of a product (e.g., desks, chairs, bookcases, artwork, etc.). As with equipment, this category is focused on free-standing and attached furniture that would be removed in the event of relocation.
- **Inventory/Products**: Items that are used in the production process or result from the production process, or consumables used as part of the business activities. Items include raw materials, finished products, replacement parts, medical consumables, cleaning products, food, pharmaceuticals, software, building materials, office supplies, etc.

Business Information

Address_____

Contact Name _____

Contact's Title _____ Telephone # _____

Interviewer_____ Date_____ Time _____

1. Type of business _____
2. Total number of buildings on site _____
3. Number of years business has been at this location _____

Flood History and Mitigation

4. Has your facility been flooded in the past? Yes No

If "Yes," please complete Questions 5 and 6. If "No," skip to Question 7.

5. Please estimate the damages to your business from past flooding events. Please give a single set of combined damages for all floors in all buildings.

Date of the flooding event:		Date of the flooding event:	
Water depth above first floor:		Water depth above first floor:	
Contents damage estimate ($):		Contents damage estimate ($):	
Structure damage estimate ($):		Structure damage estimate ($):	
Number of lost business days:		Number of lost business days:	
Amount of lost net income ($):		Amount of lost net income ($):	
Cost of cleanup ($):		Cost of cleanup ($):	

6. Briefly describe any permanent flood mitigation measures that have been implemented to reduce potential flood damage. _____

_____

_____

_____

_____

Building Information

*(Questions 7-17 are to be answered for your **primary building only**. If there are multiple buildings at the facility, a supplemental sheet is provided that asks for similar information.)*

7. Building #: _____
8. Brief description of function of the building and its contents: _____
9. Year building was constructed: _____
10. Building Construction Type (e.g. brick): _____
11. Number of floors (including basement, if any): _____
12. Building footprint: _____ feet by _____ feet = _____square feet
13. Does the building have a basement? Yes No If yes: _____ square feet finished area
    _____ square feet unfinished area
14. Is there a seasonal variation in the value of inventory in this building? Yes No
    If yes, what is the average value of your inventory during the following time periods:
    January – March $_____ April – June $_____
    July – September $_____ October – December $_____
15. Relative to the 1st floor elevation of the building, what is the current value of the contents and where are they located vertically? (up through 1st floor only)

Height (ft)	Equipment ($)	Furniture ($)	Inventory/products ($)
0.0 ft			
1.0 ft			
3.0 ft			
6.0 ft			
Total			

Notes to interviewer:

- Shaded areas are for buildings with a subterranean level only. Please fill in appropriate values for the depth (e.g., -1.0 ft, -3.0 ft, -6.0 ft). Leave shaded areas blank if no subterranean level exists.
- The values in the columns should be a cumulative total, starting from the lowest level of the structure.

Susceptibility to Flood Damage

The amount of damage due to flooding can vary considerably depending on conditions (e.g., quality of water, duration of flood). When completing the following section, you will be asked to provide a range for potential damages. In addition to the most likely damage amount due to flooding, you will also be asked to provide a low and high estimate. Please use the following definitions:

- *"Most Likely" – reasonable amount of damage expected to occur during an average flood.*
- *"Low" – reasonable low estimate of damages assuming that the flood conditions are less than a typical flood (e.g., short duration, relatively clean floodwaters) or the contents were less impacted than typically estimated (e.g., motors were sealed well).*

- *"High" – reasonable high estimate of damages assuming that the flood conditions are worse than a typical flood (e.g., long duration, highly contaminated floodwaters) or the contents were more impacted than typically estimated (e.g., motors need total replacement).*

16. At what elevation, relative to the 1st floor of the building, does flood damage to **contents** begin? (+ or – ; will only be negative if there is a subterranean level) _____ feet
17. Please estimate damage to contents corresponding with water depths above/below the building's 1st floor elevation. (Express damage in either **$ or % of total value**.)

Flood Depth	Equipment			Furniture			Inventory/products		
	Low	Most Likely	High	Low	Most Likely	High	Low	Most Likely	High
0.0 ft									
0.5 ft									
1.0 ft									
3.0 ft									
6.0 ft									

Notes to interviewer:

- Shaded areas are for buildings with a subterranean level only. Please fill in appropriate values for the depth (e.g., -1.0 ft, -3.0 ft, -6.0 ft). Leave shaded areas blank if no subterranean level exists.
- The values in the columns should be a cumulative total, starting from the lowest level of the structure.

Other Information

18. Other than the principal structures, are there any other valuable items on your property that flood waters could damage?
    - Not readily movable (landscaping, electrical equipment, pipes, trailers on blocks, etc.)

Type	Current Value ($)	Height Above Ground (ft.)

- Movable (cars, trucks, trailers, etc.)

Type	Current Value ($)

19. Emergency Measures/Plans:

a. What emergency measures/plans, if any, would you take to reduce damage if eminent flooding was forewarned? _____

_____

_____

_____

b. What is the estimated cost to implement these emergency measures? $_____

c. How much time is required to implement these emergency measures? _____ hours

COMMERCIAL AND INDUSTRIAL FLOOD DAMAGE SURVEY
SUPPLEMENTAL SURVEY FORM

OMB#: 0710-0001
Expires: 30-Sep-09

Firm Name: _____

This supplemental survey form is to be used for each additional building at your facility. Information for each building is needed to estimate damages that could occur to the contents of all structures at your facility in the event of future flooding.

1. Building #: _____
2. Brief description of function of the building and its contents: _____
3. Year building was constructed: _____
4. Building Construction Type (e.g. brick): _____
5. Number of floors (including basement, if any): _____
6. Building footprint: _____ feet by _____ feet = _____square feet
7. Does the building have a basement? Yes No If yes: _____ square feet finished area
   _____ square feet unfinished area
8. Is there a seasonal variation in the value of inventory in this building? Yes No
   If yes, what is the average value of your inventory during the following time periods:
   January – March $_____ April – June $_____
   July – September $_____ October – December $_____
9. Relative to the 1st floor elevation of the building, what is the current value of the contents and where are they located vertically? (up through 1st floor only)

Height (ft)	Equipment ($)	Furniture ($)	Inventory/products ($)
0.0 ft			
1.0 ft			
3.0 ft			
6.0 ft			
Total			

Notes to interviewer:
- Shaded areas are for buildings with a subterranean level only. Please fill in appropriate values for the depth (e.g., -1.0 ft, -3.0 ft, -6.0 ft). Leave shaded areas blank if no subterranean level exists.
- The values in the columns should be a cumulative total, starting from the lowest level of the structure.

Susceptibility to Flood Damage

10. At what elevation, relative to the 1st floor of the building, does flood damage to **contents** begin? (+ or – ; will only be negative if there is a subterranean level) _____ feet
11. Please estimate damage to contents corresponding with water depths above/below the building's 1st floor elevation. (Express damage in either **$ or % of total value**.)

Flood Depth	**Equipment**			**Furniture**			**Inventory/products**		
	Low	Most Likely	High	Low	Most Likely	High	Low	Most Likely	High
0.0 ft									
0.5 ft									
1.0 ft									
3.0 ft									
6.0 ft									

Notes to interviewer:

- Shaded areas are for buildings with a subterranean level only. Please fill in appropriate values for the depth (e.g., -1.0 ft, -3.0 ft, -6.0 ft). Leave shaded areas blank if no subterranean level exists.
- The values in the columus should be a cumulative total, starting from the lowest level of the structnre.

APPENDIX C
RESPONSE TO COMMENTS

This appendix contains all comments from the St. Paul District on the draft report and the corresponding URS responses.

Comments from Jeff McGrath:

General Comment: Report looks good; good job of describing procedures, data sources, and products. We should be able to use most, if not all of this, for our own feasibility report.

Comment 1: Page 1, line 1 - Change "...Red River of the North Feasibility Study" to

"...Fargo-Moorhead Feasibility Study". Make this change also on Page 13, line 2 of Section 5 Summary.

URS Response: Text changed as requested in both paragraphs in the report.

Comment 2: There are two Page 1's

URS Response: Page numbering corrected.

Comment 3: Section 2, para 2, line 4 - Change "...FEMA a floodplain map..." to "...FEMA's floodplain map..."

URS Response: Text changed as requested.

Comment 4: Page 6, Section 2.4, 2nd paragraph - Does square footage refer to the area of the structure footprint or does it include all floor space of all floors? Please clarify.

URS Response: A footnote was added stating that the term "square footage" includes all floor space from all floors, not just the structure's footprint.

Comment 5: Page 7, line 1 - Does the "5 percent greater" figure refer to just residential structures or to commercial structures as well? Same comment regarding the "30 percent" figure in the next paragraph. Please clarify.

URS Response: These percentages refer to just the residential structures from the tax assessor. The text in both paragraphs has been clarified.

Comment 6: Section 2.5 - Do these results pertain just to Fargo? It seems the number of residential structures inventoried, 381, refers to Fargo. How many residential structures in Moorhead were inventoried. Does the nonresidential figure of 7,233 include Moorhead also? Do Tables 3 and 4 include Moorhead data also?

URS Response: This was an error for the residential figures. When the tables were updated using the Fargo residential values from the manual entry into M&S, the Moorhead

results were inadvertently dropped. The non-residential figures are correct, and include Moorhead and West Fargo, in Tables 2 and 4. The residential figures in Tables 2 and 3 have been corrected to reflect survey efforts and results for Moorhead. There were 423 residential structures inventoried in Moorhead.

Comment 7: Page 9, paragraph 1 - State the source of the DDF's. Are these the new functions from IWR's recent Draft report?

URS Response: The second sentence of this paragraph states that the DDFs were provided by the St. Paul District. If another source should be stated, please let us know the source of the DDFs that were provided to URS. Because DDFs were provided to URS, the new generic curves from IWR were not used.

Comment 8: Page 9, last line - Does "...county data..." refer to the assessor's structure value data? Please clarify. Fargo data comes from Fargo's city assessor.

URS Response: Yes, it is from the assessor's database. This sentence was changed and now reads: "...and a spreadsheet showing the factors used to adjust the Fargo and Clay County tax values..."

Comment 9: Page 10, Section 3.0 - Please describe the difference between indirect DDF's and direct DDF's.

URS Response: The difference between indirect and direct DDFs is now described in the report.

Comments Rick Carlson

Comment 10: Page 2, Section 2.2 Data Collection – For each residential structure, no mention was made on the presence or absence of a basement. Did you also determine the latitude and longitude or was that already provided.

URS Response: A statement that we did collect information on basements and the latitude and longitude has been added to the report.

ATTACHMENT 2
Transportation Analysis

Fargo-Moorhead Metro Feasibility Study

Transportation Analysis

U.S. Army Corps of Engineers
St. Paul District

February 2010

Prepared by:
URS Corporation
200 Orchard Ridge Drive
Gaithersburg, MD 20878

Fargo-Moorhead Metro Feasibility Study

Transportation Analysis

February 2010

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Executive Summary

The purpose of this study is to provide a transportation analysis of the effects of a major flood event in the Fargo-Moorhead metropolitan area. The U.S. Army Corps of Engineers (USACE), St. Paul District is investigating the feasibility of installing permanent flood mitigation measures to minimize future flood damage in the area. This study compares the short-term economic impacts of disruption to the transportation system caused by catastrophic flooding events to the transportation impacts resulting from the implementation of a permanent flood mitigation measure in the Fargo-Moorhead metropolitan area.

Our analysis considered the transportation impacts of the March 2009 flood and flood fight in the Fargo-Moorhead area. During the flood fight, roadways along the Red River were submerged or used as footings for temporary levees, central corridors were repurposed as sand bag distribution routes, and roads were congested with emergency vehicles. Based on interviews with a number of key stakeholders, it is clear that the impacts of a failed flood fight would have a much broader and more severe impact. Disruption would extend across transportation modes and include the interstate system.

To quantify the potential transportation impacts from severe flooding, an estimated average annual flood damage amount was generated based on the cost of the travel delay and increased travel time and distance result from rerouting trips for the prevailing transportation modes in the Fargo Moorhead metropolitan area. Trip unit cost was determined based on two factors, driver-related costs and vehicle-related costs. The cumulative costs were then evaluated according to a series of event responses for eight flood recurrence intervals (2-year, 5-year, 10-year, 20-year, 50-year, 100-year, 200-year, and 500-year events). This study considered flood damages for two scenario alternatives, With Project Conditions and Without Project Conditions. Based on our analysis, the estimated Average Annual Flood Damage is $1,503,000 for Without Project Conditions. In contrast, the With Project Condition incorporating flood diversion alternatives proposed by the St. Paul District would effectively negate flood related transportation impacts within the area. Therefore, the average annual direct transportation benefit of the proposed diversions is $1,503,000.

Fargo-Moorhead Metro Feasibility Study

Regional Economic Development Study

February 2010

1.0 TRANSPORTATION DELAY ANALYSIS

1.1 Transportation Overview

A major flood event can cause measurable and potentially significant impacts to a transportation network. These effects include:

- Prolonged closure of major highways and arterials
- Delayed rail freight movement
- Delayed truck freight movement
- Airport closure
- Major road congestion resulting from a declared evacuation

The purpose of this study is to provide a transportation analysis of the effects of a major flood event in the Fargo-Moorhead metropolitan area. The U.S. Army Corps of Engineers (USACE), St. Paul District is investigating the feasibility of installing permanent flood mitigation measures to minimize future flood damage in the area. This study compares the short-term economic impacts on the transportation system caused by catastrophic flooding events to the transportation impacts resulting from the implementation of a permanent flood mitigation measure in the Fargo-Moorhead metropolitan area. To determine the transportation cost of flooding, the study examines impacts on the local network, main roadway arterials, rail, transit, and air service. Rerouted trips and travel delays are quantified for each identified travel mode. The study's focus is the additional cost of each trip that is delayed or rerouted during a flood event.[1] Primary study outputs are presented as annualized average dollar costs. Secondary outputs include a narrative analysis of the March 2009 successful flood fight.

The complex nature of the study's scope (addressing multiple modes during an atypical event) and its short timeline dictate a high-level and generalized approach to analysis that draws heavily on assumptions based on input from local stakeholders and nationally available surveys.[2]

The high-level approach of this analysis assumes a general consistency of transportation activity throughout the duration of the flood event.[3] The multi-staged temporal nature of a flood event

[1] The study does not quantify the economic loss of trips cancelled due to flooding nor the related loss of economic activity that does not take place due to transportation network disruption. Additionally, this study does not include the cost of repairing the transportation network caused by flood damage or the flood fight. These costs are taken into account in other portions of the overall feasibility study.

[2] To effectively compare of the Without Project Condition and the With Project Condition the study holds population and traffic volumes constant at 2009 levels. This assumption may lead to an under estimation of transportation damages as volumes increase over time.

(i.e., progressive flooding and disruption, possible evacuation, and recovery process) warrants a more detailed analysis to fully capture the evolving transportation demands.[4]

1.2 Transportation Methodology

This section provides an overview of the data sources used for this study and the data analysis methods.

Data Gathering

Data gathering for this study included in-person interviews, phone and e-mail correspondences with public agencies and interest groups in the Fargo-Moorhead metropolitan area and the collection of national data figures.

Data Analysis

This study provides a comparative analysis of the short-term economic loss resulting from the transportation network for the Without Project and With Project Alternatives. The Without Project scenario involves a quantitative analysis of the transportation impacts of a catastrophic flood based on present-day conditions. The total cost includes the cost of a flood fight with the assumption that the fight would be lost and the flood would prevail. For the purposes of this study, we will call this scenario the Without-Project Condition (Flood Fight and Flood-Fight Failure). The With Project scenario involves a quantitative analysis of the transportation impacts of new permanent flood control measures put in place, the With Project Condition. The following provides further details on these two conditions.

Without Project Condition

A. Flood Fight (modeled on the March 2009 event) – The product of this scenario is an anecdotal narrative based on interviews and data collection of traffic and transportation disruption during and after the March 2009 flood fight. This includes the identification of road closures, duration, reroutes, loss of service, and emergency and general traffic management operations. These outputs are used to assist in capturing to the extent possible actions taken and costs involved in a catastrophic flood event.

B. Flood-Fight Failure – This scenario represents the current conditions along the Red River in the Fargo-Moorhead area. Hydrology layers provided by the St. Paul District were utilized to identify points of disruption along each of the identified transportation corridors, likely reroute corridors, and costs of delays (including fuel, additional maintenance, and opportunity costs). Estimated trips that would occur in this scenario are quantified. Results are presented as damage frequencies that correlate with the USACE provided hydrology.

For the purposes of the USACE study, scenarios A and B of the Without Project Condition are evaluated together as a series of event responses for eight flood recurrence intervals (2-year, 5-year, 10-year, 20-year, 50-year, 100-year, 200-year, and 500-year events).

---

[3] Described in further detail in later sections.

[4] The North Dakota State University – Upper Great Plains Transportation Institute has already conducted surveys and developed models that examine flood evacuations.

With Project Condition

A. Condition with New Permanent Flood Control Measures Fully Installed – The St. Paul District stated that the With Project alternative will have a residual risk that will be negligible for transportation. This scenario assumes no transportation disruptions due to flooding events.

B. Impacts during Construction of Permanent Flood Control Measures – The construction of any With Project alternative could take from 6–9 years to complete. Each alternative would impact roadway and rail traffic and require additional temporary and permanent crossings on the network. This study does not include transportation delay estimates due to construction, but delays could be significant and should be considered as part of any project analysis as the construction plans are made available.

A transportation analysis process was developed that takes into account the drastic change in travel opportunity and behavior during a flooding event. The process includes the following steps (also outlined in Figure 1.1):

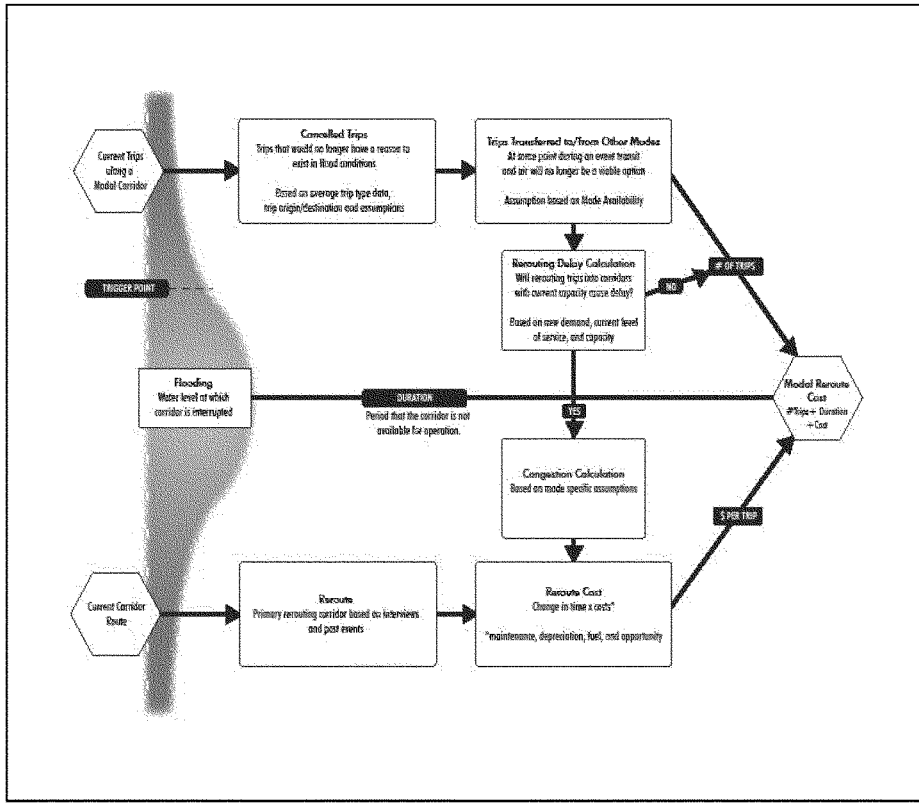


Figure 1-1: Transportation Analysis Process

Step 1 – Corridor Disruption – Each corridor for each identified mode has a point (flood elevation) at which it is no longer viable for transportation use. For secondary roads, highways, and railways, the disruption point occurs when water overtops the corridor itself. Other closures may be caused by secondary actions; some local roads may close in order to accommodate flood-fight activities and the airport may close at a pre-identified flood level. Although the airport may not flood, employees and passengers would not be able to access the airport due to flooded roads.

Step 2 – Event Duration – For the purposes of this study, event duration is the elapsed time from the point that the corridor (or network element) goes offline to the point that it is online again. Event duration includes the time for closure (due to flooding or flood-related causes), recovery, and reconstruction, and culminates when the corridor is reopened. Event duration is calculated based on St. Paul District hydrographs for the Red River and assumptions relating to the length of time it will take to clear flood debris and reopen corridors.

Step 3 – Trip Cancellation and Modal Shift – Travel behavior changes drastically during a flood event. This study assumes that trips to destinations in flooded areas would be cancelled. Residents with flooded properties are less likely to make their regular trips. Some modes (bus transit and air travel) would not be available after a certain disruption point. Many trips on these modes would also be cancelled, and some trips that would have taken place on these modes would be shifted to other modes. Trips in this study are based on existing trip conditions (2009). For the purposes of this study, current land use and transportation conditions are held constant. Trip cancellation estimates are based on national travel behavior surveys (i.e., Journey to Work, National Household Travel Survey, etc.) and local social and demographic information. Trips that were not cancelled, but would have taken place on modes that are no longer available, are assumed to be transferred to auto trips.

Step 4 – Reroute Corridor – For the purposes of this study, a reroute corridor is identified for each primary corridor that is disrupted. The reroute corridor is assumed to absorb all diverted trips from the primary corridor. The difference in travel distance between the primary corridor and the reroute corridor provides the basis for the trip delay estimates. Geo-spatial analysis and flooding reroute assumptions based on past events and stakeholder interviews were used to identify reroute corridors for each mode.

Step 5 – Cost of Delay – Cost of delay is derived by calculating the delay distance and multiplying it by the per mile cost of travel for each mode.

Cost of Trip Delay = (# of Trips) * (Incremental Reroute Cost) * (Per Unit Cost)

Note:

Incremental Reroute Cost = Δ in the time and/or distance resulting from a rerouted trip.
Per Unit Cost = Per unit cost of time and/or distance. For example, the per mile cost of a rerouted trip would involve fuel and vehicle maintenance and depreciation costs per mile. A per minute delay cost would be a function of opportunity cost based on area median family income.

1.3 Transportation Impacts

2009 Flood Fight

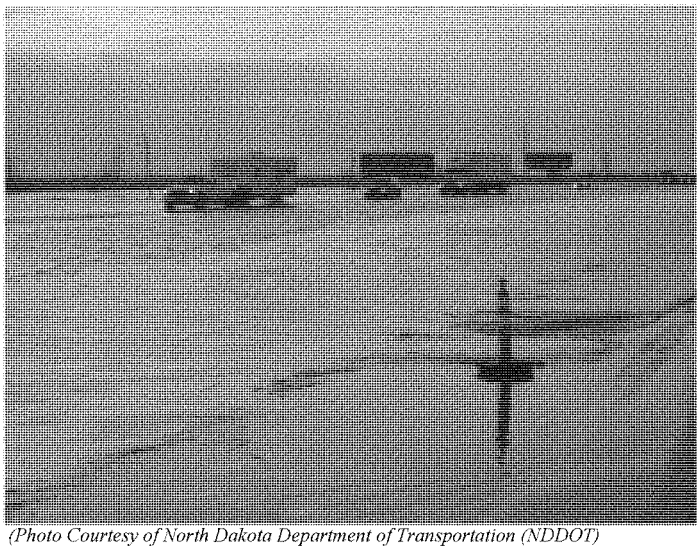
Examining the successful flood fight of March 2009 is an important element in projecting transportation impacts of future flood events. The 2009 flood fight presented extensive transportation challenges to the road network as water levels forced road closures at all levels radiating from the Red River, including a portion of Interstate 29 (I-29), the major north-south interstate that runs through the City of Fargo). Impairment of the road network not only affected private auto trips, which is the prevalent mode of transportation in the area, but also severely diminished capacity in public transportation (including paratransit) and caused schedule delays in truck freight and intercity bus service. Rail and air transportation were fully operational during the flood fight and experienced no closures or delays.

(Photo Courtesy of Cass County Government)

Figure 1-2: A Cass County Road on March 28, 2009

The 2009 flood fight included extensive inter- and intra-agency cooperation to address transportation needs at the local, county, State, and Federal levels. North Dakota Governor John Hoeven declared a statewide emergency flood disaster and activated 500 National Guard troops on March 13, 2009 (Cass County Sheriff's Office 2009). On the same day, City of Fargo Mayor Dennis Walaker asked businesses to close and non-essential employees to return home. Road closures commenced on March 18, 2009, with Oak Street closed from 8 Avenue N to 12 Avenue N. The City of Fargo closed the road to facilitate completion of an emergency levee. Over the next 6 days, 39 municipal arterial and collector roads were closed. Numerous local roads were also closed (pers. Comm. City of Fargo).[5] Duration of arterial and collector road closures ranged from 2 days to accommodate flood-fight activities[6] to 74 days[7] to accommodate flood wall construction. At the county level, segments of county roads were closed in Cass County. Six county roads are located either within the jurisdiction of the City of Fargo or along its periphery.[8] County roads 31 and 22 were closed along the northern edge of Fargo. County road 31 was closed from March 29 through May 6. County Road 22 was closed from March 30 through May 1. Closures for these two roads averaged 35 days. The remaining County roads were either protected or managed by the City of Fargo. I-29 was reduced to one lane beginning March 25 as drain plugs were installed.

[5] Due to resource constraints and minimal traffic impacts from the local roads, data on the local roads were not provided.
[6] University Drive from 32 Avenue North to County road 20.
[7] Elm Street from 14 Avenue North to 15 Avenue North.
[8] County roads 81, 6, 17, 20, 31, and 22.



(Photo Courtesy of North Dakota Department of Transportation (NDDOT)

Figure 1-3: 2009 Flood: Interstate 29

The Metro Area Transit (MAT) ran buses on a reduced schedule during the flood fight. On March 25, road conditions caused problems that resulted in a further reduction of transit service. On March 26, buses on five routes were removed from service to transport volunteers for the flood fight. Additional buses were pulled on March 27 and March 30 for flood relief. On affected routes, no service was provided due to flooding on March 28. Service on specific routes was suspended on March 30 and some bus service was cancelled on March 31. Paratransit for the City of Fargo was diminished to only one vehicle at times.

The 2009 flood fight was uniquely successful. Environmental, temporal, and human elements combined to prevent large-scale flooding during an event of greater than 100-year severity. This level of success, and luck, cannot be assumed for future events. For the purposes of this study, a 100-year or greater flood is assumed to lead to levee breaches and some degree of flooding within in the study area.

Individual Modal Analysis

The study addresses each mode individually to take into account each mode's unique characteristics and variables. The discussions below summarize each mode's profile and assumptions, identified reroutes, and trip value calculations:

Roadway Network Analysis

The roadway network is divided into three sub-modal calculations: local private traffic, regional private traffic, and truck freight traffic.

Local Private Traffic

- Profile and Assumptions – Local traffic along the Red River will be disrupted long before any catastrophic flooding takes place. The 2009 flood fight demonstrated that extensive closures are needed to mobilize volunteers and prepare sandbags, and that roadways close to the river often provide the foundation for temporary levees. Local traffic would be further reduced by calls from the city and State government for businesses to close and residents to stay home. For these reasons, local traffic is addressed separately from the regional traffic that would be less severely constrained by a flood event.
- Reroutes – Rerouted private auto trips crossing the Red River would be directed along the nearest unaffected East/West corridors depending on the affected corridor and the level of flooding. Local disruption during the flood fight and flooding event is treated with a general multiplier.
- Calculations – Table 1.1 outlines the cumulative cost of rerouting local private auto trips. The cost is a function of several variables. In particular, the additional distance traveled as a result of a detour, number of trips that are likely to still take place during a flood, and the additional time required to complete the detour, were estimated. These variables were combined with the average vehicle maintenance cost and the opportunity cost of a private auto trip (Table 1.2), as well as the opportunity cost of the driver, to collectively calculate the cumulative cost of rerouting local private auto trips.

Table 1-1: Daily Auto Rerouting Cost from Disruption of Major Roadway Corridors by Severity of Flood Event

	Flood Event*	Number of Trips**	Adjusted Trips *****	Total Trip Miles	Average Vehicle Maintenance Costs (Mileage Related)	Time (hh:mm:ss)	Opportunity Costs (Time Related)	Total Costs
Local Disruption	>=50-year	***	8,000	32,000	$ 10,347	800:00:00	$ 51,362	$ 61,709
Local Disruption	100-year	***	10,400	41,600	$ 13,451	1040:00:00	$ 66,771	$ 80,222
Local Disruption	200-year	***	12,800	51,200	$ 16,556	1280:00:00	$ 82,179	$ 98,735
Local Disruption	500-year	***	19,200	76,800	$ 24,833	1920:00:00	$ 123,269	$ 148,102
Main St./US10	50-year	20,600	5,606	28,030	$ 9,064	840:54:25	$ 35,992	$ 45,056
Main St./US10	<=100-year	20,600	2,060	539,720	$ 174,518	9716:20:00	$ 241,663	$ 416,181
NP Ave	50-year	7,600	2,068	10,341	$ 3,344	310:14:15	$ 13,279	$ 16,623
NP Ave	<=100-year	7,600	760	199,120	$ 64,385	3584:40:00	$ 26,584	$ 90,970
1st Ave.	50-year	16,600	4,517	22,587	$ 7,304	677:37:26	$ 29,003	$ 36,307
1st Ave.	<=100-year	16,600	1,660	434,920	$ 140,631	7829:40:00	$ 194,738	$ 335,369
12th Ave.	<=20-year	1,475	401	2,007	$ 649	60:12:38	$ 2,577	$ 3,226
12th Ave.	<=100-year	1,475	148	38,645	$ 12,496	695:42:30	$ 17,304	$ 29,799
Broadway	50-year	2,425	660	3,300	$ 1,067	98:59:25	$ 4,237	$ 5,304
Broadway	<=100-year	2,425	243	63,535	$ 20,544	1143:47:30	$ 28,448	$ 48,992
I-94 Auto	<=100-year	48,000	4,800	1,257,600	$ 406,645	22640:00:00	$ 327,449	$ 734,093
I-29 Auto	<=50-year	30,200	8,219	78,076	$ 25,246	38764:15:48	$ 560,658	$ 585,904

* For each rerouting option, the designated Flood Event indicates the threshold at which the corridor would be affected. The study assumes a failed flood fight at a severity between a 50- and 100-year event.

** Number of Trips enumerates auto trips that occur on a typical day.

*** Local Disruption indicates access limitations on local streets along the river during flood-fight activities. Local disruption has a non-linear increase as flood severity increases.

**** Adjusted Trips enumerates the auto trips that would occur during a flood event.

Table 1-2: Average Vehicle Maintenance Cost per Mile (Mileage-Related Costs)[9]

Vehicle Cost per Mile (2009)*		
Gas	$	0.10
Maintenance	$	0.05
Tires	$	0.01
Depreciation	$	0.15
Air Pollution	$	0.02
cost per mile for average passenger car	$	0.32

Opportunity cost of private auto trips was calculated using the USACE cost-of-delay process (Table 1.3) (USACE 2004). The cost-of-delay calculation involved a three-tiered criteria based on length of trip delay (0–5 minutes, 6–15 minutes, and more than 15 minutes). The trip type is based on the personal value of time saved and was categorized as either work or non-work. USACE multipliers were applied to each trip type for each delay range based on a percentage of the median income of the Fargo-Moorhead Metropolitan Statistical Area (MSA). Non-work trips are designated as social/recreational trips in Table 1.3. In accordance with the USACE process, work trip-delay costs undergo a vehicle occupancy rate multiplier. For trips delayed more than 1 hour, an average hourly salary was used to calculate the cost of delay.

Table 1-3: Opportunity Cost of a Private Auto Trip (Time-Related Costs)

Delay Range		% of hourly salary (Median Family Income)		Median Family Income - Fargo MSA
				$50,331
0-5 Minutes				
	Work Trips	6.40%	$	1.55
	Social/Reacreational	1.30%	$	0.31
6-15 minutes				
	Work Trips	32.20%	$	7.79
	Social/Recreational	23.10%	$	5.59
>15 Minutes				
	Work Trips	53.80%	$	13.02
	Social Recreational	60%	$	14.52
> 1 hour				
	All Trips =	Trip Time *	$	24.20

*USACE, 2004 ER 1105-2-100, Median Income from the 2008 US Census estimate

Regional Private Traffic

- Profile and Assumptions – The study defines regional traffic as private auto trips that originate or conclude at a destination outside of the metro area or trips that utilize the highway system. These trips were broken into East/West (I-94 and Route 10) and

[9] Based on AAA 2009 "Your Driving Costs." Depreciation based on 20,000 miles of annual travel per vehicle. Pollution calculation based on Federal Highway Administration (FHWA), Highway Economic Requirements System: Technical Report-2002.

North/South (Route 81/I-29 and Route 75). Regional traffic cancellations were estimated using the Journey to Work survey, and local travel behavior profiles were used to identify trips unlikely to take place during a flooding event.

- Reroutes – Rerouted regional private auto trips would be directed along the nearest unaffected East/West and North/South highway corridors depending on the affected corridor and the level of flooding.
- Calculations – See Local Private Traffic for calculation assumptions.

Truck Freight

- Profile and Assumptions – The study area is primarily a pass-through for regional long-haul trucking. Fargo does have a few triple-trailer staging areas that are used to convert double-trailer rigs coming from Minnesota[10] to triple-trailer rigs heading west. This study assumes that most truck trips will not be cancelled; they will be rerouted around the flood area.
- Reroutes – Rerouted truck freight trips would be directed along the nearest unaffected East/West and North/South highway corridors depending on the affected corridor and the level of flooding.
- Calculations – Table 1.4 provides a breakdown of the vehicle-based and driver-based costs on a per mile basis that motor carriers must absorb in the event of disruption to their travel routes.[11] These data were derived from the American Transportation Research Institute.

Table 1-4: Truck Freight Cost of Roadway Disruption per Mile

Truck Freight Marginal Expenses	Costs Per Mile
Vehicle-based	
Fuel-Oil Costs	0.634
Truck/Trailer Lease or Purchase Payments	0.206
Repair and Maintenance	0.092
Fuel Taxes	0.062
Truck Insurance Premiums	0.06
Tires	0.03
Air Pollution	0.05
Driver-based	
Driver Pay	0.441
Driver Benefits	0.126
Driver Bonus Payments	0.036
Total Marginal Costs	**$1.69**

Derived from American Transportation Research Institute 2009 Survey. Pollution calculation based on FHWA 2002.

Table 1.5 provides a comparative analysis of per mile and per time rerouting costs for auto and truck trips on I-94 and I-29, the two major Interstates that run through Fargo. See the Local Private Traffic discussion for the methodology used to derive the average vehicle maintenance costs and the opportunity costs.

[10] The State of Minnesota does not allow triple trailers.
[11] For this analysis, the per mile costs were applied.

Table 1-5: Auto and Truck Rerouting Cost from Disruption of I-94 and I-29*

	Flood Event	Number of Trips	Adjusted Trips	Total Trip Miles	Mileage-Related Losses	Time	Time-Related Losses	Total Losses
Local Trucks Rerouting								
Trucks I-94	100-year	2,270	1,816	475,792	$ 826,926	10706:50:00	**	$ 826,926
Trucks I-29	50-year	1,700	1,360	12,920	$ 22,455	861:20:00	**	$ 22,455
Through Traffic on Major Roadways								
Auto I-94	100-year	13,000	3,538	251,184	$ 81,220	22750:00:00	$ 565,833	$ 647,053
Trucks I-94	100-year	2,230	2,230	158,330	$ 275,178	3902:30:00	**	$ 275,178
Auto I-29	50-year	11,100	3,021	28,697	$ 9,279	1913:07:52	$ 47,583	$ 56,862
Trucks I-29	50-year	1,300	1,300	12,350	$ 21,464	823:20:00	**	$ 21,464

* The existing profile and elevation of I-94 is higher than I-29. I-94 is assumed not to experience any service interruption during a 50-year or smaller flood event, while I-29 would. However, I-94 would experience service interruption during a 100-year or greater flood event.
** Truck calculations are all based on per mile costs.

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Transit

Transit trips are very important to the mostly elderly, underage, and non-car owning populations. Disruption of transit service has a disproportionate impact on these groups. These impacts are incorporated in the Other Social Effects (OSE) study. For the purposes of this Study, the MAT's low threshold for service cancellation and limited ridership in the study area (compared to other modes) indicate that it would have marginal impacts on the costs of transportation disruption.

Rail Freight

- Profile and Assumptions – The Burlington Northern/Santa Fe (BNSF) Railway runs two rail lines across the Red River within the study area. These lines carry roughly 60 trains per day, with about 80 cars per train. The Southern Minneapolis Line primarily carries western bituminous coal from Wyoming and Montana to locations in Minnesota, Chicago, and Detroit, and along the Mississippi River for further distribution. The Northern Duluth line primarily carries cargo containers from the ports of Seattle and Tacoma. Containers trains switch to the southern line in Fargo and continue east to Minneapolis/St. Paul, Chicago, and Detroit. The Fargo area is primarily a pass through for West/East freight and disruption would have little impact on local freight delivery or manufacturing. BNSF also owns a multimodal yard in Dilworth, MN, that is not currently active.
- Reroutes – In a flood diversion situation, coal cars would be transferred to southern BNSF lines through South Dakota. This study assumes containers will be redirected along Union Pacific rail lines through the southern Great Plain States.
- Calculations – Table 1.6 provides the estimated total cost per flood event of a rail freight delay for the two main BNSF rail lines that cross into Fargo.[12] The total cost was calculated based on fuel, operation and maintenance, and crew wages per train. Data sources include the Rail Short Haul Intermodal Corridor Case Studies (Foundation for Intermodal Research & Education in Association with the U.S. Department of Transportation and the Federal Railroad Administration), the Association of American Railroads (AAR), and the 2008 BNSF Class I Railroad Annual Report.

Table 1-6: Rail Freight Reroute Cost

Original Route Corridor	Total Reroute Miles	Total Cost of Delay
Southern Minneapolis - Southern Great Northern Railway Bridge	90,000	$ 47,595,000
Northern Duluth - North Pacific Railway Bridge (Parallel to I-94)	18,000	$ 9,519,000
		$ 57,114,000

[12] A 5-day reroute duration is assumed for all flood events of 100-year severity or greater.

Air Travel Analysis

Air Passenger Travel (Hector)

- Profile and assumptions – Hector International Airport is the commercial airport for the greater Fargo-Moorhead area. It is primarily an origin and destination airport and has few connecting flights. Hector was not affected by the 2009 flood; however, airport staff indicated that, in a flooding event, the airport would suspend operations before water levels topped operational surfaces due to the likelihood that personnel living in the area would not be able to access the airport. This study assumes that many individual trips via air will be cancelled or postponed once the airport is closed. These cancellations are identified based on trip type and destination assessments.
- Reroutes – For the remaining individual air trips, this study assumes passengers will drive to the nearest airport that has their corresponding destination flight available.
- Calculations – Once the airport is closed and the remaining trip demand is calculated, remaining trips are treated as regional transportation trips.

Air Freight

Hector International Airport is not an active air freight hub. The vast majority of air freight to and from the region has its origin or destination in Sioux City, IA, or Grand Forks, ND. The impact of flooding on air freight is assumed to be marginal and is not further explored in this study.

1.4 Transportation Findings

The transportation impacts of the March 2009 flood and flood fight on the Fargo-Moorhead area were significant. During the flood fight, roadways along the Red River were submerged or used as footings for temporary levees, central corridors were repurposed as sand bag distribution routes, and roads were congested with emergency vehicles. The impacts of a failed flood fight would have a much broader and more severe impact. Disruption would extend across transportation modes and include the interstate system.

Table 1.7 presents the aggregated impact for each mode based on flood severity/probability. A duration was calculated for each corridor for the given flood event probability. Local Traffic disruption costs are estimated to jump drastically for a 50-year event due to the flood-fight activities. Local reroutes will increase as flooding severity increases (100-year to 500-year) due to expanding flood coverage and prolonged closure duration (related in part to lower priority roads remaining closed longer while higher priority roads are restored). Air and Rail Traffic are unaffected until a 100-year event (and the assumption of a failed flood fight). Once offline, the impacts to Air Traffic are limited by the assumption that a large percentage of trips will be canceled or rescheduled. The degree of damage to Rail Freight, once it is disrupted, is held constant as the severity of flooding increases (from 100-year to 500-year). This assumption is based on the longer-term necessity of planning the cross-country diversion and the high elevation of the tracks along the river. The impacts would drastically increase if the rail bed were damaged during flooding.

Table 1-7: Aggregated Monetary Impact by Mode for Each Identified Probability[13] (Dollar amount rounded to the nearest 1,000)

		Automobile								
	Probable	Local Traffic		Regional Truck and Traffic		Air Traffic		Rail Freight		
Chance Event	Occurrence	Duration*	Impact	Duration	Impact	Duration	Impact	Duration	Impact	Total
50% (2-year)	0.5	0	$ -	0	$ -	0	$ -	0	$ -	$ -
20% (5-year)	0.2	0	$ -	0	$ -	0	$ -	0	$ -	$ -
10% (10-year)	0.1	0-18	$ 1,125,000	0	$ -	0	$ -	0	$ -	$ 1,125,000
5% (20-year)	0.05	0-24	$ 1,442,000	0	$ -	0	$ -	0	$ -	$ 1,442,000
2% (50-year)	0.02	3-47	$ 3,884,000	0.5	$ 50,000	0	$ -	0	$ -	$ 3,934,000
1% (100-year)	0.01	3.5-47	$ 22,668,000	1.5	$ 2,775,000	2	$ 401,000	5	$ 57,114,000	$ 82,958,000
0.5% (200-Year)	0.005	4-47	$ 24,546,000	2	$ 3,700,000	3	$ 602,000	5	$ 57,114,000	$ 85,962,000
0.2% (500-year)	0.002	4.5-47	$ 27,734,000	2.5	$ 4,625,000	4	$ 802,000	5	$ 57,114,000	$ 90,275,000
0%	0.000	4.5-47	$ 27,734,000	2.5	$ 4,625,000	4	$ 802,000	5	$ 57,114,000	$ 90,275,000

*Range represents the low and high of local closers during each event probability. Local road closer durations are based on closers during the 2009 flood fight event, USACE inundation estimates, and estimates of time required for debris clearance and roadway repair. Secondary local roads are assumed to remain closed longer in events where Interstates are also interrupted, because interstates will receive resource priority.

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[13] Study assumes flood-fight failure between the 50-year and 100-year event probabilities.

In Table 1.8, Estimated Damage totals from Table 1.7 are multiplied by the probability of the occurrence of each severity event. The results are added together to produce an estimated Average Annual Flood Damage.

Table 1-8: Average Annual Damage of Transportation Impacts for the Fargo-Moorhead Area without Project Conditions (Dollar amount rounded to the nearest 1,000)

Chance Event	Probable Occurrence	Incremental Probability	Estimated Damage	Average Damages	Annual Flood Damages
50% (2-year)	0.5		$ -		
		0.3		$ -	$ -
20% (5-year)	0.2		$ -		
		0.1		$ 563,000	$ 56,000
10% (10-year)	0.1		$ 1,125,000		
		0.05		$ 1,284,000	$ 64,000
5% (20-year)	0.05		$ 1,442,000		
		0.03		$ 2,683,000	$ 81,000
2% (50-year)	0.02		$ 3,925,000		
		0.01		$ 43,427,000	$ 434,000
1% (100-year)	0.01		$ 82,929,000		
		0.005		$ 84,426,000	$ 422,000
0.5% (200-Year)	0.005		$ 85,923,000		
		0.003		$ 88,075,000	$ 264,000
0.2% (500-year)	0.002		$ 90,227,000		
		0.002		$ 90,227,000	$ 181,000
0%	0.000		$ 90,227,000		
Total Average Annual Flood Damages					**$ 1,503,000**

The estimated Average Annual Flood Damage is $1,503,000. Flood diversion alternatives proposed by the St. Paul District would effectively negate flood related transportation impacts within the area. Therefore, the average annual direct transportation benefit of the proposed diversions is $1,503,000.

Transportation Impact Excluding Trip Cancelation

Due to the inherent uncertainty of estimating trip cancelation in a flood event a second analysis explored transportation disruption and delay excluding all trip cancelation assumptions. Tables 1-9 and 1-10 represent the monetary impact of flooding on transportation assuming no trip cancelation during a flood event.

Table 1-9: Aggregated Monetary Impact by Mode for Each Identified Probability (Assuming No Trip Cancellation)

		Automobile		Air	Rail	
Chance Event	Probable Occurrence	Local Traffic	Regional Truck and Traffic	Air Traffic	Freight	Total
50% (2-year)	0.5	$ -	$ -	$ -	$ -	$ -
20% (5-year)	0.2	$ -	$ -	$ -	$ -	$ -
10% (10-year)	0.1	$ 8,439,000	$ -	$ -	$ -	$ 8,439,000
5% (20-year)	0.05	$ 10,526,000	$ -	$ -	$ -	$ 10,526,000
2% (50-year)	0.02	$ 20,420,000	$ 129,000	$ -	$ -	$ 20,550,000
1% (100-year)	0.01	$ 228,306,000	$ 3,647,000	$ 937,000	$ 57,114,000	$ 290,005,000
0.5% (200-Year)	0.005	$ 255,585,000	$ 4,863,000	$1,406,000	$ 57,114,000	$ 318,968,000
0.2% (500-year)	0.002	$ 277,736,000	$ 6,079,000	$1,874,000	$ 57,114,000	$ 342,804,000
0%	0.000	$ 277,736,000	$ 6,079,000	$1,874,000	$ 57,114,000	$ 342,804,000

Table 1-10: Average Annual Damage of Transportation Impacts for the Fargo-Moorhead Area without Project Conditions (Assuming No Trip Cancelation)

Chance Event	Probable Occurrence	Incremental Probability	Estimated Damage	Average Damages	Annual Flood Damages
50% (2-year)	0.5		$ -		
		0.3		$ -	$ -
20% (5-year)	0.2		$ -		
		0.1		$ 4,220,000	$ 422,000
10% (10-year)	0.1		$ 8,439,000		
		0.05		$ 94,830,000	$ 474,000
5% (20-year)	0.05		$ 10,526,000		
		0.03		$ 15,538,000	$ 466,000
2% (50-year)	0.02		$ 20,550,000		
		0.01		$ 155,277,000	$ 1,553,000
1% (100-year)	0.01		$ 290,005,000		
		0.005		$ 304,487,000	$ 1,522,000
0.5% (200-Year)	0.005		$ 318,968,000		
		0.003		$ 330,886,000	$ 993,000
0.2% (500-year)	0.002		$ 342,804,000		
		0.002		$ 342,804,000	$ 686,000
0%	0.000		$ 342,804,000		
Total Average Annual Flood Damages					**$ 6,116,000**

Exclusion of trip cancelation assumptions provides a much larger Average Annual Flood Damages of $6,116,000.

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Appendix D
Other Social Effects
Fargo-Moorhead Metropolitan Area Flood Risk Management

Final Feasibility Report and Environmental Impact Statement

July 2011

US Army Corps of Engineers ®

Appendix D

Other Social Effects

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Attachment 1 – January 2009, Loss of Life Analysis, Without Project
Attachment 2 – June 2011, Draft Loss of Life Analysis, With Project

1.0 Introduction

The Fargo-Moorhead metropolitan area has a relatively high risk of flooding. The highest river stages have usually occurred as a result of spring snowmelt, but summer rainfall events have also led to significant flood damages. The residents of Fargo-Moorhead have been successful at preventing significant damages during past flood events by constructing emergency levees along large portions of the Red River. Constructing the emergency levees takes significant financial and human resources, causes business and traffic disruptions, and is taxing to the social fabric of the communities. Although the emergency levees have been successful in the past, they are at high risk of catastrophic failure, which would result in significant damage in the area.

Because of the high risk, flood risk management alternatives are being evaluated for the area. These alternatives are being studied through the Fargo-Moorhead Flood Risk Management Feasibility Study being conducted by the U.S. Army Corps of Engineers (USACE), St. Paul District.

1.1 Purpose

The purpose of this appendix is to describe the Other Social Effects (OSE) component of the Fargo-Moorhead Flood Risk Management Feasibility Study. Implementing flood risk management alternatives could have varying impacts on the life of the residents and the social fabric of the communities in the study area. By considering the human impact and evaluating alternatives from an OSE perspective, the analysis can be used in alternative plan formulation and in the decision making process for choosing an alternative that provides high levels of social benefits.

1.2 Study Area

The study area extends along the Red River, between Abercrombie, ND, and the Canadian border (Figure D-1). It includes portions of 12 counties in North Dakota and Minnesota and the Fargo-Moorhead Metropolitan Statistical Area (MSA). The MSA covers portions of Cass County, ND, and Clay County, MN. During the early phases of this study, the Fargo-Moorhead metro area was considered the extent of the study area; therefore, the initial screening of alternatives only considered impacts to the residents of the Fargo-Moorhead metro area (Section 3 of this appendix). The study area was expanded during later phases of the study to include the areas upstream and downstream of the metro area (Section 4 of this appendix).

1.3 Overview of Other Social Effects

The USACE views "social well-being factors as constituents of life that influence personal and group definitions of satisfaction, well-being, and happiness. The distribution of resources; the character and richness of personal and community associations; the social vulnerability and resilience of individuals, groups, and communities; and the ability to participate in systems of governance are all elements that help define well-being and influence to what degree water resources solutions will be judged as complete, effective, acceptable, and fair." (USACE, 2009) It is the OSE account that considers these elements and assures that they are properly weighted, balanced, and considered during the planning process under the USACE's Four Accounts Planning Framework.

Figure D-1: Study Area

This appendix follows the guidance set forth by the USACE Institute for Water Resources (IWR) in the *Handbook on Applying "Other Social Effects" Factors in Corps of Engineers Water Resources Planning* (USACE, 2009). The handbook describes the procedures for analyzing and using OSE criteria in the planning process by identifying seven social factors that describe the social fabric of a community. The social factors are based on conventional psychological Human Needs Theory and Abraham Maslow's Hierarchy of Needs. Table D-1 lists and describes the social factors.

Table D-1: Social Factors

Social Factor	Description
Health and Safety	Refers to perceptions of personal and group safety and freedom from risks
Economic Vitality	Refers to the personal and group definitions of quality of life, which is influenced by the local economy's ability to provide a good standard of living
Social Connectedness	Refers to a community's social networks within which individuals interact; these networks provide significant meaning and structure to life
Identity	Refers to a community member's sense of self as a member of a group, in that they have a sense of definition and grounding
Social Vulnerability and Resiliency	Refers to the probability of a community being damaged or negatively affected by hazards, and its ability to recover from a traumatic event
Participation	Refers to the ability of community members to interact with others to influence social outcomes
Leisure and Recreation	Refers to the amount of personal leisure time available and whether community members are able to spend it in preferred recreational pursuits

Source: Handbook on Applying "Other Social Effects" Factors in Corps of Engineers Water Resources Planning (USACE, 2009).

1.4 Organization of Appendix

The OSE appendix is organized as follows:

- Section 1 provides an introduction to OSE
- Section 2, Community Characteristics and Other Social Effects Factors, provides background information on the socioeconomic and a baseline profile of the social factors of the study area. This describes the existing and future without project conditions for the study area.
- Section 3, Initial Screening of Alternatives, provides an initial evaluation and screening of the flood risk management alternatives considered
- Section 4, Evaluation of Alternatives, provides a detailed OSE analysis of the alternatives carried forward in the study
- Section 5, References, lists the references cited in this appendix.

2.0 Community Characteristics and Other Social Effects Factors

This section describes the existing and future without project conditions, including socioeconomic characteristics and a baseline profile of the communities and residents of the study area. Without project conditions serve as the basis for evaluating alternatives.

2.1 Socioeconomic Characteristics of the Study Area

This section presents an overview of the major socioeconomic characteristics and trends, including demographics and economics, of the study area. The data were developed from various data sources including the latest 2010 U.S. Census. In certain instances where 2010 Census Data was not available, data from the 2000 U.S. Census was utilized. Other data sources that were analyzed include the Population and Housing Narrative Profile of the American Community Survey (ACS) for the years 2006, 2007, 2008, and 2009 U.S. Census Bureau estimates.

2.1.1 Population Size and Composition

According to the 2009 ACS, the population of the Fargo-Moorhead metropolitan area is estimated to be 194,839 persons. Based on the 2010 census, the total population in the 12-county study area is estimated to be 377,631 persons (U.S. Census Bureau, 2010 Census). As reported by the 2009 ACS estimates, the gender ratio within the metro area is nearly 1:1 (50 percent male and 50 percent female) and the median age is 30.2 years. Nationally, the population is 51 percent female and the median age is 36.7 years. Persons under 18 years old represent 23 percent of the population, which is lower than the national percentage of 25 percent. The percentage of residents over the age of 65 years (10.2 percent) is also lower in the metro area than the national percentage of 13 percent (U.S. Census Bureau, 2009 ACS). The communities downstream of the metro area have lower percentages of persons under 5 years old, but higher concentrations of persons over 65 years old. It can generally be said of the downstream communities that, on average, they have a slightly higher percentage of older persons than is found in the metro area.

With the exception of Clay County, MN and Polk County, MN, and Grand Forks and Cass Counties, ND, all the other counties in the study area experienced a decline in population between 2000 and 2010. The decreases ranged from 4.4 percent to as much as 16.1 percent. Over the past 50 years, the communities downstream of the Fargo-Moorhead metro area have seen population losses of between 10 and 35 percent. The population of nearly every city and township between Fargo-Moorhead and Thompson, ND has decreased, with the exception of Oakport and Kragnes Townships, which are located immediately downstream of the metro area (U.S Census Bureau, 2000).

2.1.2 Household Structure

The ACS estimates from 2009 indicate that the average size of the 84,330 households in the metro area is 2.3 persons, compared to an average size of 2.6 persons nationally. In 2000, there were nearly 70,000 households in the metro area and a total 128,262 households in the 12-county study area (U.S. Census Bureau, 2000 Census). In the metro area, more than half (58 percent) of these households consisted of families (46 percent married couples and 12 percent other). The majority of nonfamily households consisted of persons living alone, which represented 32 percent of all households. The percentage of married-couple families closely mirrored ACS estimates for the United States as a whole (50 percent); the percentage of households of persons

living alone was higher than the estimate for the United States (27 percent); and the percentage of other nonfamily households in the United States was correspondingly lower (6 percent nationally).

2.1.3 Race and Ethnic Diversity

While ethnic diversity in the metro area stands markedly lower than that in the United States as a whole, there seems to be an upward trend in the ratio of non-White residents to White residents. Between 2000 and 2010, nearly all the counties in the study area reported an increase in their share of minority persons. While an estimated 13 percent of U.S. residents were foreign-born in 2006 through 2008, only 4 percent of persons living in the metro area during that period were foreign-born (U.S. Census Bureau, 2009 ACS) . Between 2000 and 2005, immigrants accounted for 54 percent of the Fargo-Moorhead metro area's growth. The universities in the Fargo-Moorhead metro area also attract a foreign student population, adding to its diversity.

Tables D-2 and D-3 show the racial and ethnic characteristics of the North Dakota and Minnesota counties, from upstream to downstream based on the latest 2010 Census.

Table D-2: Population Characteristics of Study Areas–North Dakota

Race	North Dakota											
	Richland County		Cass County		Traill County		Grand Forks County		Walsh County		Pembina County	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
White	15,507	95.0%	137,308	91.7%	7,809	96.2%	60,358	90.3%	10,391	93.5%	7,077	95.5%
Non-Hispanic White	15,351	94.1%	135,530	90.5%	7,693	94.7%	59,271	88.6%	9,834	88.4%	6,947	93.7%
Hispanic White	156	1.0%	1,778	1.2%	116	1.4%	1,087	1.6%	557	5.0%	130	1.8%
Non-White	814	5.0%	12,470	8.3%	312	3.8%	6,503	9.7%	728	6.5%	336	4.5%
Black or African American alone	110	0.7%	3,428	2.3%	42	0.5%	1,361	2.0%	25	0.2%	21	0.3%
American Indian and Alaska Native alone	330	2.0%	1,827	1.2%	64	0.8%	1,657	2.5%	168	1.5%	144	1.9%
Asian alone	88	0.5%	3,532	2.4%	21	0.3%	1,292	1.9%	36	0.3%	11	0.1%
Native Hawaiian and Other Pacific Islander alone	9	0.1%	52	0.0%	1	0.0%	40	0.1%	4	0.0%	2	0.0%
Some other race alone	67	0.4%	798	0.5%	89	1.1%	553	0.8%	345	3.1%	58	0.8%
Two or more races	210	1.3%	2,833	1.9%	95	1.2%	1,600	2.4%	150	1.3%	100	1.3%
Total	16,321	100.0%	149,778	100.0%	8,121	100.0%	66,861	100.0%	11,119	100.0%	7,413	100.0%
Minority Population	970	5.9%	14,248	9.5%	428	5.3%	7,590	11.4%	1,285	11.6%	466	6.3%

Source: U.S. Department of Commerce, U.S. Census Bureau, 2010. SF1 and SF3 Tables.

Table D-3: Population Characteristics of Study Areas–Minnesota

Race	Minnesota											
	Wilkin County		Clay County		Norman County		Polk County		Marshall County		Kittson County	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
White	6,381	97.0%	54,684	92.7%	6,455	94.2%	29,495	93.3%	9,119	96.6%	4,484	98.5%
Non-Hispanic White	6,294	95.7%	53,434	90.6%	6,293	91.8%	28,497	90.2%	8,952	94.8%	4,434	97.4%
Hispanic White	87	1.3%	1,250	2.1%	162	2.4%	998	3.2%	167	1.8%	50	1.1%
Non-White	195	3.0%	4,315	7.3%	397	5.8%	2,105	6.7%	320	3.4%	68	1.5%
Black or African American alone	15	0.2%	842	1.4%	13	0.2%	270	0.9%	26	0.3%	11	0.2%
American Indian and Alaska Native alone	64	1.0%	803	1.4%	109	1.6%	453	1.4%	43	0.5%	4	0.1%
Asian alone	18	0.3%	846	1.4%	25	0.4%	218	0.7%	19	0.2%	16	0.4%
Native Hawaiian and Other Pacific Islander alone	0	0.0%	21	0.0%	0	0.0%	2	0.0%	3	0.0%	0	0.0%
Some other race alone	27	0.4%	528	0.9%	92	1.3%	497	1.6%	148	1.6%	12	0.3%
Two or more races	71	1.1%	1,275	2.2%	158	2.3%	665	2.1%	81	0.9%	25	0.5%
Total	6,576	100.0%	58,999	100.0%	6,852	100.0%	31,600	100.0%	9,439	100.0%	4,552	100.0%
Minority Population	282	4.3%	5,565	9.4%	559	8.2%	3,103	9.8%	487	5.2%	118	2.6%

Source: U.S. Department of Commerce, U.S. Census Bureau, 2010. SF1 and SF3 Tables.

Based on 2010 U.S. Census data, downstream communities in both North Dakota and Minnesota had smaller minority populations than Cass County, ND and Clay County, MN with the exceptions being Grand Forks County, ND and Polk County, MN (U.S. Census Bureau, 2010 Census). As reported by the 2010 U.S. Census, the Hispanic/Latino population downstream of Fargo represents 2.4 percent of the entire population. Within Moorhead, Hispanic persons account for 4.5 percent of the total population. As reported by the 2000 U.S. Census, comparing the populations that "speak English less than 'very well'" finds larger non-English proficient

populations in Fargo and Moorhead than in their respective downstream communities (U.S. Census Bureau, 2000). In North Dakota, the non-English proficient population downstream is 4.5 percent smaller, on average, than in Fargo. In Minnesota, the difference between the downstream communities and Moorhead is 6.4 percent (U.S. Census Bureau, 2000).

The percentage of residents who speak a language other than English at home was markedly lower in the Fargo-Moorhead metro area than in the United States as a whole (20 percent of persons more than 5 years old nationally vs. 6 percent in the metro area). Approximately one-third of these persons speak Spanish (U.S. Census Bureau, 2009 ACS).

2.1.4 Education

According to the 2000 census, 39 percent of the population in the Fargo-Moorhead metro area had an associate degree or higher (compared to 27 percent nationally). In 2009, the percentage of residents in the metro area with an associate degree or higher increased to 45 percent of the population (U.S. Census Bureau, 2009 ACS). During the same time period, persons with a high school diploma accounted for nearly 26 percent of the population in the metro area compared to 29 percent nationally.

As more recent data on the educational attainment of the population is not available for the all 12 study area counties, data from the 2000 U.S. Census was utilized to better understand the levels of educational attainment. All the downstream study area counties in ND had higher percentage of persons with a high school diploma compared to levels exhibited in Fargo. Similarly, the downstream counties in Minnesota had persons with higher levels of persons with a high school diploma than was found in Moorhead. However, persons with College and Bachelor's degrees were higher in Fargo and Moorhead compared to the downstream counties in their respective states. Tables D-4 and D-5 show the levels of educational attainment in the study area counties in North Dakota and Minnesota.

Table D-4: Educational Attainment in Study Areas–North Dakota

Geographic Area	High School Graduates (age 25+)	College Graduates (age 25+)
North Dakota	27.9%	24.5%
Cass County	22.9%	26.9%
Pembina County	31.9%	24.0%
Walsh County	32.1%	24.2%
Grand Forks County	24.4%	27.7%
Traill County	25.9%	27.4%
Richland County	27.4%	25.0%

Source: U.S. Department of Commerce, U.S. Census Bureau, 2000.

Table D-5: Educational Attainment in Study Areas–Minnesota

Geographic Area	High School Graduates (age 25+)	College Graduates (age 25+)
Minnesota	28.8%	24.0%
Clay County	28.2%	25.4%
Kittson County	34.5%	22.9%
Marshall County	37.0%	21.5%
Polk County	31.7%	23.9%
Norman County	34.9%	24.9%
Wilkin County	32.5%	23.5%

Source: U.S. Department of Commerce, U.S. Census Bureau, 2000.

2.1.5 Housing

In 2009 (U.S. Census Bureau, 2009 ACS) there were 87,115 occupied housing units in the metro area, compared to 73,356 in 2000 (U.S. Census Bureau, 2000 Census). Nearly six percent of the housing units stood vacant (much lower than the national average of 12 percent), 58 percent were single-unit structures, 39 percent were multi-unit structures, and 3 percent were mobile homes. The median value of owner-occupied housing units was $142, 800. Table D-6 shows the housing data for the study area (U.S. Census Bureau, 2009 ACS).

Table D-6: Housing Data in the Study Area

Geographic Area	Housing Units	Percent of Occupied Housing Units
North Dakota	309,043	88.3%
Cass County	64,139	95.2%
Pembina County	4,067	83.3%
Walsh County	5,739	85.1%
Grand Forks County	29,304	91.5%
Traill County	3,760	89.5%
Richland County	7,695	86.8%
Minnesota	2,301,307	89.6%
Clay County	22,976	92.7%
Kittson County	2,738	75.5%
Marshall County	4,885	85.4%
Polk County	14,677	85.2%
Norman County	3,499	84.0%
Wilkin County	3,106	87.0%

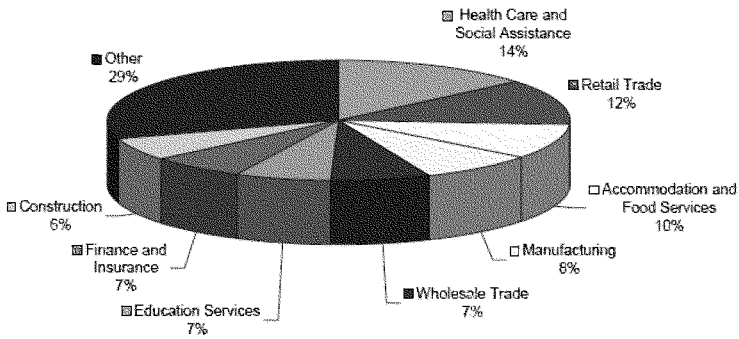
Source: U.S. Department of Commerce, U.S. Census Bureau, 2005-2009 American Community Survey 5-Year Estimates.

Based on 2009 estimates (U.S. Census Bureau, 2009 ACS), the median monthly housing cost for mortgaged owners was lower than the comparable national statistic ($1,316 in the metro area and

$1,486 nationally). For non-mortgaged owners the cost was $446, which is comparable to the national statistic of $419 and for renters the cost was $597, which is markedly lower than the $817 national statistic. Nearly 14 percent of non-mortgaged owners spent 30 percent of their household income on housing, compared to 16 percent nationally; 46 percent of renters (50 percent nationally) fell into this category. More than three-quarters (77.7 percent) of residents lived in the same house they had lived in 1 year before.

2.1.6 Industrial and Occupational Structure

Historically, the economy in the metro area has been dependent on agriculture, however, that has changed substantially in recent decades, shifting to retail trade, healthcare, higher education, and manufacturing. The top 10 employers in the Fargo-Moorhead metro area are Sanford Health System, North Dakota State University, Microsoft, US Bank Service Center, and Innovis Health. Figure D-2 shows the percentage of employees by industry.



Source: Greater Fargo Moorhead Economic Development Corporation (January 2010)

Figure D-2: Employees by Major Industry in the Fargo-Moorhead Metro Area (2nd Quarter 2009)

The Fargo-Moorhead metro area has one of the lowest unemployment rates in the Nation. In October 2009, the unemployment rate in the metro area was 3.7, and the national unemployment average during March 2009 was 8.6 percent (U.S. Bureau of Labor and Statistics, 2009). As recently as December 2010, the State unemployment average in North Dakota was 3.8 percent and in Minnesota it was 6.9 percent, compared to the national average of 9.4 percent (U.S. Bureau of Labor and Statistics, 2010).

2.1.7 Journey to work

For commutes to work in Fargo-Moorhead metropolitan area, the proportion of workers who drove alone was somewhat higher than in the United States as a whole (82 percent versus 76 percent nationally), and the proportion who carpooled (9 percent) or used public transportation (1

percent) were somewhat lower. Notably, an estimated 7.1 percent of occupied households had no vehicle available (ACS pooled data from 2006–2008).

The mean travel time to work in all 12 counties in the study area was less than 25 minutes and, with the exception of Marshall and Norman Counties, MN, commute times were less than 20 minutes (U.S. Census Bureau, 2000).

2.2 Baseline Profile of Communities

This section presents a baseline profile of the communities in the study area. This profile follows the seven social factors described in Section 1.3. It reflects how residents of the study area perceive themselves and their communities, describes the quality of life in the area, and identifies the challenges residents face from flooding. The baseline profile provides a context from which to assess the impacts of the proposed alternatives. These are considered the existing and future without project conditions social characteristics.

Data and information for the baseline profile were collected from multiple sources, including local nonprofit organizations, interviews with local representatives (conducted in December 2009 and January 2010), observations of the study area, and research conducted by sociologists following major flood events in other areas. The information on the impacts of repeated flood threats and successful "flood fights" (steps a community takes before an event to reduce flood damage to their homes and businesses) draws significantly from the 2009 flood event.

2.2.1 Health and Safety

2.2.1.1 Loss-of-Life

Flooding in the study area poses a loss of life hazard to residents, flood fight workers, and volunteers in the form of levee failure, drowning and hypothermia. A loss-of-life analysis for the without project condition is presented in Attachment 1.

2.2.1.2 Stress

An issue of great concern to the study area's residents is the threat of catastrophic flooding. The frequency and magnitude of the flooding and continual flood risk takes a toll on both the mental and physical health of the residents. Residents have reported a high stress level caused by the flood threat, including loss of sleep and mental anguish. Although the residents of the metro area have not lost a flood fight, the threat of doing so always exists.

Residents face two forms of stress related to the ongoing flood threat: 1) the chronic stress caused by the continuing threat of flooding and annual flood fights, and 2) the stress that would be created if they ever lost a flood fight. Research on the effects of stress (generally defined as an environmental change followed by an attempt by the individuals experiencing the stress to adapt) on health has established the detrimental effects of stress—particularly chronic stress—on physical and mental health. The well-documented health effects of stress include physical illness, mental illness, and substance abuse (Dodge and Martin, 1970; House, Umberson, and Landis, 1986; Langer and Michael, 1963; Pearlin, 1989; Thoits, 1995). This research also clearly shows that these health effects do not occur uniformly in populations; certain groups (e.g., minorities, low-income populations) experience much more severe effects than persons with higher incomes or non-minority groups.

The effects of this stress on the community were evident during in-depth interviews with individuals involved in coordinating volunteers and aiding Fargo's residents during flood events and flood fights. It was clear not only that this stress exists, but that it can also be very difficult to detect because the culture of the community involves exhibiting high levels of resilience. This was clearly reflected in comments from the Fargo Emergency Manager, Leon Schlafman. When asked whether the community hopes not to have to fight the flood again, he initially responded, "We did it, we can do it again." Although this response was very stoic, Schlafman admitted that a high level of fear exists in the community.

Professor Robert Littlefield of North Dakota State University echoed the theme of resilience in his description of the spring 2009 event. "When everyone said, 'We need help' [to fight the flood], everyone came. No one left when they said, 'Go home and rest.'" Littlefield noted a strong ethos of "one individual can make a difference" in both the community culture and the flood fight. He also noted, though, that the flood fight and the continued threat of flooding have taken a toll on the community; although residents are very willing to fight—with what he characterized as a "we built it, we'll keep it" mentality—residents are tired, stating unequivocally that "we need a permanent solution [to the flooding]."

Ruth Bachmeier of Fargo Cass Public Health stated that there were high levels of stress from the flood event. She pointed out that if no permanent solution to the ongoing flooding is found, "we'll continue to have more stressors on stressed people."

Time and again, residents' stoicism, unwillingness to complain, and unease with asking for or receiving help were witnessed. One relief official summed it up by saying, "We put a pretty good face on." Fargo Cass Public Health's Bachmeier provided a similar account, stating simply, "We don't talk about mental health much here, it's taboo." One disaster coordinator stated that she and friends in the mental health field have wondered aloud, "When does that smoldering fire flame up?"

As one disaster relief coordinator said, "We have disaster fatigue. We've been through this so many times, it's almost second nature. But we're already seeing stressors [December 2009] from a wet fall—people saying, 'Oh, my God, are we doing to do this again? We have this cumulative stress. I've heard stories—we just cleaned up from [20]05, now we have 6 feet of water."

The stress on those who help the victims is also apparent. One disaster coordinator stated that, during the flood fight, "The last thing I did every day, when I went to work, was look around my house and hope it was still there when I came back."

The interview material outlined above gives a good sense of the stress caused by the ongoing threat of flooding and flood fights. Given the stress, many of the individuals interviewed stated that it would be a "huge hardship" or "almost unthinkable" to have to fight a flood again. When the effects of the flood event are coupled with the effects of the ongoing threat of flooding, one can expect them to be both widespread and persistent.

2.2.1.3 Health Care and Emergency Facilities

Access to critical facilities can be limited during floods. In some cases critical facilities need to be evacuated. In addition to interrupting trauma care, the temporary closing of medical facilities would result in the interruption of normal public health operations.

Medical facilities in the Fargo-Moorhead metro area that are at risk due to flooding include the Roger Maris Cancer Center, Multiple Sclerosis MS Center, Parkinson's Clinic, Eating Disorder Institute, Pediatric Cardiology Clinic, Sanford Heart Center, and Innovis Health Cancer Center (www.gfmedc.com/healthcare), and several other facilities.

Rural communities are separated from their larger urban neighbors. The four nearest cities downstream of the metro area are 16 to 23 miles from an urgent care facility and 23 to 35 miles from a hospital.

The evacuation of special needs or vulnerable populations presents additional risks. In addition to the previously mentioned medical facilities, there are eight nursing homes, multiple assisted-living facilities and group homes, and two large congregate living facilities. Critical care and nursing home patients, particularly dementia patients, may suffer negative effects during evacuation.

During the 2009 event, many of the health care facilities in the metro area evacuated their patients and residents. Hospitals airlifted many of their critical patients to hospitals in Grand Forks, ND, Sioux Falls, SD, and Minneapolis and St. Paul, MN. Other special needs or vulnerable populations were evacuated to facilities outside of the study area.

2.2.1.4 Other Health and Safety Hazards

Other health and safety hazards due to flooding include: large-scale community evacuation, potential contamination of the drinking water supply, and spoilage of food through loss of refrigeration or floodwater contamination. Flooding of buildings introduces multiple contaminants into the water including sewage, fuel oil, pesticides, and solvents. The cleanup of flooded structures exposes individuals to potential adverse health effects from exposure to contaminants, bacteria, and molds.

2.2.2 Economic Vitality

The metro area's business environment has proven to be an economic engine for the region, and it continues to grow. According to the Greater Fargo-Moorhead Economic Development Corporation (GFMEDC), the metro area is ranked:

- No. 5 in *Forbes* ranking of the Top College Towns for Jobs in May 2009.
- No. 7 in *Forbes* ranking of the Best Places for Business and Careers in March 2009. The index ranks cities according to the cost of doing business, educational attainment of the population, income growth, projected job growth, and net migration. This is the sixth consecutive year that Fargo has been among the top 10 for small metropolitan areas.
- No. 1 city in North Dakota for entrepreneurial startups, according to *Business Week*.
- No. 8 in MSN and CareerBuilder.com's October 2008 list of the 25 Best Markets to Find a Job.

With one of the lowest unemployment rates in the Nation, the Fargo-Moorhead metro area has, for the last 5 years, experienced gains in income and employment that exceed the national average. Also, according to Moody's Economy.com, the Fargo-Moorhead economy continues to rank among the highest in vitality for U.S. metropolitan areas (GFMEDC, 2009). Although the median household income is below the national average, residents describe the area as economically prosperous.

The Fargo-Moorhead metro area unemployment rate in October 2009 was 3.5 percent, which increased from 1.6 percent in October 2000 despite seasonal fluctuations (Job Service North Dakota, 2010). The unemployment rate in March 2009 hit a 10-year high at 5.1 percent, coinciding with the flood event. Unemployment increased temporarily because businesses were closed due to the flood fight efforts.

There is a perception in the community that flood risk to some extent hinders growth. Following the 2009 flood event, the GFMEDC distributed a questionnaire to major local business owners, asking how a flood and the continued flood threat would affect them. The results of the survey revealed anxiety among business owners, and indicated that many of the businesses would leave the region in the event of a failed flood fight. In some cases, the loss of business in the metro area would have an impact at a national level, as business owners stated that they would rebuild operations outside of the United States.

Despite the continued flood risk, there is a lack of preparedness among business owners. Many prudent preparedness measures, such as developing a disaster plan, organizing methods to contact employees following an event, and having essential documents stored offsite, are not

typically taken. This lack of preparedness could hinder business recovery efforts in the aftermath of a catastrophic event.

2.2.3 Social Connectedness

Residents in the area typically describe the Fargo-Moorhead metro area as a good place to live, citing quality health care, a good location, good schools, low unemployment, and a relatively prosperous economy. There is a strong belief in local leaders and residents rely heavily on the decisions of local leaders during flooding events. A large portion of the community is also involved in religious activities that enable social and cultural bonding.

During the 2009 flood fight, residents of the study area came together to protect their communities. In Fargo there were approximately 100,000 volunteers fighting the flood, and in Moorhead there were approximately 20,000. Past flooding events, while negatively impacting the region, have also served as a major social event, as people from all walks of life and from all over the area pulled together to save their community. In the process, people got to know their neighbors very well.

Evidence from the interviews indicates that the social networks connecting friends and family in the area are strong. This is not an area that appears to have high levels of social isolation. Social networks appear to be large and extensive, and to contain high proportions of strong ties to close friends and family, as well as weaker ties to neighbors. This creates the *potential* for high levels of social support, for individuals to help each other.

Two key forms of social support exist during disasters: instrumental social support (tangible aid) and emotional support. Instrumental support can come from either strong or weaker ties, but it is more likely to come from strong ties. Research shows that individuals whose social networks contain a higher proportion of strong ties and are more dense (i.e., with a higher proportion of network members who are connected to one another) before a disaster are more likely than people whose networks lack these characteristics to receive instrumental social support from their networks (Hurlbert, Haines, and Beggs, 2000). Put simply, research suggests that, because dense networks with stronger ties are more likely to give support on a routine basis, individuals are more likely to get support during and after a disaster if they're embedded in that type of social network.

Given the anecdotal evidence collected about social networks in the area, it is expected that high levels of instrumental social support would be given and received in the community. The evidence gathered during interviews supports that expectation. Evidence abounds that high levels of instrumental social support were often given, with neighbors, friends, and family helping each other to deal with the flood fight and the effects of the flooding. For example, disaster relief volunteer Charlotte Robbins noted that there are a fair number of "snowbirds" in the metro area—people who travel to warmer parts of the country during the winter. When the 2009 flood event occurred, some of these snowbirds had not yet returned to their houses. Robbins noted that their friends or family members typically cared for their property. Another disaster coordinator stated that very little of his funds go into sheltering, because residents of the area "can always find a place to stay, with family and friends."

All evidence gathered suggests that, despite the strong social networks and the high levels of instrumental social support in the area, emotional support may well be lacking. As one disaster

coordinator stated, "One of our biggest needs is emotional and spiritual care. We have folks who don't know how to ask for help. It's a very foreign thing for them."

2.2.4 Identity

The study area was occupied by a number of Native American tribes before the arrival of Europeans and other immigrants. Some of these tribes included the Dakota/Lakota Nation, the Assiniboine, and the Cheyenne. Other occupants included French-Canadian fur trappers, who roamed the region and mixed with the Chippewa Native Americans to form a group called the Metis. The largest ethnic groups in the region today (from largest to smallest) are Norwegian, German, Other (Asian, African American, Arab, Latino), Swedish, Irish, English, and French.

When settlement activities began in earnest around the mid-1800s, railroads played a major role in development. The study area experienced rapid population growth due to the availability of cheap, fertile farmland. There were 74,360 farms in North Dakota in 1910, a number that has been declining since 1950. North Dakota is the most rural State in the Nation, with farms covering 90 percent of the land area.

While the study area's population is very homogenous compared to the national average, its residents are very welcoming and helpful to new immigrants. A number of civic organizations and volunteers donate time and resources to refugees. Grand Forks and Fargo also host a World Refugee Day as part of the United Nation's effort to spotlight the plight of the world's refugees.

In addition to being welcoming to refugees, the residents of the study area have a long history of an attitude of "fight and recover." In 1893, a fire broke out in Fargo and destroyed 31 city blocks. Despite the devastation, the residents immediately set about to rebuild, making the city better than it had been before. The same "fight and recover" attitude remains today, evidenced by the residents' willingness to band together and protect their communities from the floods that continue to threaten the area.

Research done by Professor Littlefield supports this impression of the culture of the area and of the community's determination. In an analysis of newspaper data from the period in which the 2009 flood fight occurred, he identified three dominant images in the photographs: 1) men—although women were strongly represented among individuals fighting the flood, pictorial representations in the media tended to focus much more on men; 2) machines, with representations of the machinery used to fight the flood and to "dominate nature" (as Littlefield summarized it, this was very much a "we will win" theme); and 3) military, with representations of National Guard personnel—uniformed individuals standing ready to protect and preserve the area from the flood threat.

Another relief coordinator noted the ethnic heritage, describing it as a "Norwegian, German culture of 'we pull ourselves up by our bootstraps.' We're a very determined people—quitting is not in our makeup. Everything they have could be on the street, for the trash, and folks here would say, 'I'm OK, help the guy down the street.'"

2.2.5 Social Vulnerability and Resiliency

The metro area has a relatively high risk of flooding. A 500-year flood event would flood almost the entire city of Fargo and a large portion of Moorhead. While residents have never lost a flood fight, there is a pronounced threat of a catastrophic flood event that the community is not prepared to handle.

Despite the fact that flood threats persist and that each year could bring another flood event, there seems to be little recognition among the residents that a flood fight could be lost, resulting in catastrophic flooding. When asked whether a culture of preparedness exists in the area, Fargo Emergency Manager Leon Schlafman responded primarily in terms of the residents' willingness to fight and recover. It appears that they are very prepared to fight floods but not to lose flood fights or to deal with the effects of a catastrophic event. As Sarah Lepp of First Link stated bluntly, "There's a strong belief that it won't happen here."

Many prudent preparedness measures appear to remain "off the radar" for a number of residents. So, although a willingness and readiness to fight floods exists, there also seems to be a very different culture of preparedness than that seen in other high-risk areas, such as those that are prone to hurricanes.

Fortunately, the residents' demonstrated strong desire to fight floods and protect their community could also be a benefit in the recovery efforts if a catastrophic flood event occurred. The "we pull ourselves up by our bootstraps" attitude mentioned earlier demonstrates the potential resiliency of the community to a catastrophic event.

It is important to recognize that certain components of the population are more vulnerable than others. For example, any housing lost in rural communities would be difficult to replace on a temporary basis. If appropriate accommodations could not be found with family or friends, rural residents would be forced to seek them in Fargo, Moorhead, or Grand Forks, which would place them some distance away from their property, jobs, and social networks. Research has also established that vulnerable populations (e.g., minorities, low-income) tend to bear the effects of an event more strongly. During the 2009 flood event, low-wage workers suffered greater economic hardship and were more affected by business closures and transportation difficulties.

2.2.6 Participation

Residents in the study area exhibit a high rate of participation in civic activities. For example, in Fargo the average voter turnout for presidential election years is above the national average (in 2008, 67.8 percent in Fargo vs. 56.8 percent nationally). In the 2010 election, voters turned out in record numbers.

There are a number of media outlets in the study area, including local radio stations, newspapers, and television stations. Local governments also hold public forums for civic issues.

As part of the Fargo-Moorhead Metro Feasibility Study, the study team has held a number of public meetings. Turnout has been high, both in the metro and rural areas, and citizens continue to voice their concerns, opinions and questions related to flood risk management. The study team has generally found the public to be well informed and interested in issues that affect their community.

The turnout of thousands of volunteers for the 2009 flood fight and the support churches provided during the evacuation further shows evidence of a high participation rate. The residents of Fargo, in particular, have great confidence in local officials. During the 2009 flood fight, residents relied on the mayor's experience and judgment on whether to evacuate.

The volunteer effort encompassed more than 100,000 volunteers in Fargo; it is estimated that approximately 70 percent came from the immediate local area. Notably, students (university and high school students initially, and middle school students later) played a highly visible role in fighting the flood. Schools in Fargo closed for nearly 2 weeks, and local schools provided bag lunches and bused students to the Fargo Dome to assist with the sandbagging efforts. Even West Fargo, which experienced virtually no flooding, sent students to assist in the effort.

Sandbag production was a monumental task, with approximately a half-million sandbags produced per day during the entire 2009 flood fight period, for a total of approximately 3 million sandbags in a 1-week period. As the Fargo Emergency Manager stated, "We attacked it like war" in Fargo. Professor Littlefield offered a similar characterization, stating that the area was "a battle zone."

2.2.7 Leisure and Recreation

The metro area has a number of recreational activities, including ice-skating, figure skating, youth and adult hockey, volleyball, basketball, track, soccer, walking, cross-country skiing, ballroom dancing, table tennis, and broom ball. There are also 39 casinos in public establishments, with profits used for public causes. The area features neighborhood and regional public parks covering over 3,000 acres, 7 public golf courses within Fargo-Moorhead, and soccer

and softball/baseball complexes. Biking and walking trails run for more than 99 miles throughout Fargo, Moorhead and West Fargo. There are a number of annual celebrations, including the Fargo Film Festival, Downtown Street Fair, Pioneer Days, Fargo Blues Festival, and Christmas on the Prairie.

Residents of the study area tend to be active in recreational activities. This is evidenced by the numbers that participate in sporting events throughout the year. Many residents are engaged in hunting or fishing. Fargo-Moorhead is a regional hub for the arts, with many local painters, musicians, street fairs, and music venues.

The planning commissions in Fargo and Moorhead aim to increase the "walkability" of their cities and neighborhoods. Participants in Moorhead planning workshops suggested that a park should be within walking distance of all homes and that they would like to see an increase in the connectivity of neighborhoods. The City of Fargo also aims to use smart growth principles to keep the city as compact as possible to limit expensive infrastructure and keep down the cost of energy.

Outside the metro area, numerous parks line the river. Boaters have access to the water from boat ramps on both sides of the river. There are also several shore-fishing facilities. In the unincorporated areas of Clay County, parks and recreation is the second largest land-use category, accounting for 3 percent of the land area. There are five area state parks provide year-round outdoor recreation activities within a short driving distance of Fargo Moorhead. Most state parks provide camping, swimming, boating/canoeing, fishing and hiking/biking/snowmobile trails. The Cities of Grand Forks and East Grand Forks are about 90 miles from Fargo-Moorhead and offer additional recreation opportunities.

2.2.8 Summary of Baseline Profile

Residents of the study area represent a cohesive community with a great deal of fortitude. As the data show, this is not an affluent community, but it is much more ethnically and racially homogenous than the U.S. population and highly cohesive, culturally. This strong community has banded together repeatedly to fight floods and, to date, has succeeded in its efforts. Residents clearly have strong spirits and many reasons to be proud. The scope of the volunteer effort to fight floods and the level of coordination involved is clearly exceptional and highly effective. These characteristics are repeatedly highlighted, both in the media's and in residents' accounts of what has transpired. The community clearly takes pride in its ability to band together to fight floods.

However, qualitative evidence suggests that effects of the stress created by the chronic flood threat and of the acute stress created by flood fights lie under the surface. Given the continued threats and the empirical research on the effects of chronic stress, there is little doubt that flood risk is a social cost to the community.

The baseline profile indicates that there is a high level of risk to Health and Safety and Economic Vitality in the study area. The level of risk to Health and Safety is evidenced by the chronic mental and physical stress of the continued flood threat. Flooding also presents a risk to life (discussed in Attachment 1). Because the metro area is a regional healthcare hub, a catastrophic event would cause widespread Health and Safety concerns, as regional residents would have to travel farther for health care services. The economy of the metro area has been very robust and is an economic driver for the region. A very large flood would impact many businesses and homes,

and would be extremely costly. Damage from smaller floods has occurred frequently in the past. Numerous flood fights have also been costly. If a catastrophic event did occur, long-term consequences could result, as there is a potential for businesses to relocate to other regions.

3.0 Initial Evaluation of Other Social Effects

This section includes a brief description of the alternatives considered during the initial plan formulation stage and the assessment of the OSE of the alternatives. The evaluation and screening of these alternatives was completed in earlier phases of the study. This section re-evaluates the alternatives based on other social effects in order to reaffirm previous screenings and for the purposes of developing an OSE screening tool. Alternatives are screened in Appendix O of the main report based on a range of criteria, not limited to OSE.

The assessment contained in this section is based on the seven social factors described in Section 1.3. Assessing each social factor involved evaluating a set of metrics that are pertinent to that social factor.

As discussed in Section 1.2, the Fargo-Moorhead metro area was considered the extent of the study area in the early phases of the study; consequently, the initial screening of alternatives only considered impacts to the residents of the Fargo-Moorhead metro area. The study area was expanded during later phases of the study to include the areas upstream and downstream of the metro area (Section 4 of this appendix).

3.1 Description of Alternatives

Ten with-project alternatives were identified during the initial plan formulation stage. The alternatives were developed to a concept level of detail for initial screening purposes (see Appendix O of the Main Report) for more information on the alternatives and on the initial screening process). The initial screening relied on existing information, the development of new information, expert judgment, public input, and existing studies.

The initial flood risk management alternatives developed are:

1. Flood barriers
2. Diversion channels
3. Non-structural measures
4. Flood storage
5. Tunneling
6. Bridge replacement or modification
7. Interstate 29 (I-29) viaduct
8. Dredging and widening
9. Wetland and grassland restoration
10. Cut-off channels

Each alternative is described briefly below.

3.1.1 Flood Barriers

Flood barriers would include using permanent flood barrier systems, such as levees, floodwalls, gate closures, and pump stations.

3.1.2 Diversion Channels

Diversion channels would route flood flows around the metro area, reducing flood stages in the natural channels through the area. Control structures on the Red River would be required to divert flows into the diversion channels and drop structures would be required to allow local drainage to enter these channels. Four separate alignments (each involving a diversion channel and one or more tie-back levees) have been analyzed as part of this study.

3.1.3 Non-structural Measures

Non-structural measures would reduce the risk to property by altering individual residential and non-residential structures rather than redirecting floodwaters away from property. Non-structural measures would involve a variety of actions, including acquiring structures, relocating structures to other parts of a property, and elevating structures above the design flood level.

3.1.4 Flood Storage

Flood storage would involve both preserving natural floodplain areas and building dams and other water retention facilities to hold water during flood events. Flood storage concepts include large dams, distributed smaller storage sites, controlled field runoff, use or modification of the constructed road network to store water (the "waffle plan"), storage ponds used for water conservation, and payment to landowners for water retention. Facilities would be located in any watershed upstream of the Fargo-Moorhead metro area and distribution would be throughout that area.

3.1.5 Tunneling

Large tunnels would be used to divert flows under the communities, functioning in a similar manner as a diversion channel, only underground. It was estimated that three 30-foot diameter tunnels of approximately 25 miles in length would be required. The tunnels would require easements to tunnel under private property and disposal areas for approximately 10 million cubic yards of excavated material.

3.1.6 Bridge Replacement or Modification

Bridges can restrict flow during flood events. Under this alternative, bridges crossing the Red River would be replaced or modified to increase conveyance in the channel and reduce flood stages.

3.1.7 Interstate 29 Viaduct

The I-29 corridor would be reconstructed to serve as an open viaduct during floods. The reconstructed corridor would function as an interstate highway during non-flood times. During a flood event, it would essentially be a diversion channel.

3.1.8 Dredging and Widening

Dredging and widening would involve digging the Red River channel deeper and wider to allow more flow to pass through the Fargo-Moorhead metro area. This alternative could also be considered under existing bridges to prevent the damming effect the bridges can create.

3.1.9 Wetland and Grassland Restoration

Wetland and grassland restoration would include restoring drained wetlands and grasslands, and changing land use practices in the watersheds upstream of the Fargo-Moorhead metro area. The wetlands and grasslands would reduce peak runoff, change flood frequency, and store water during flooding. The features would be distributed throughout the upstream portion of the Red River Basin and would generally provide low-level storage that would primarily be used for wetlands and habitat.

3.1.10 Cut-off Channels

Building cut-off channels across meanders in the river would provide a straighter path for the water to follow through the Fargo-Moorhead metro area and would potentially reduce peak flood stages. The channels would be designed with a bottom elevation above a certain design stage to allow the river to flow naturally until a design event, when the excess would flow into the cut-off channel. Four cut-off channels in the Fargo-Moorhead metro area were constructed as part of a Federal flood control project completed in 1963.

3.2 Initial Screening Methodology

The initial screening of alternatives and evaluation of the impacts of the alternatives on the communities have been captured in a screening matrix. The seven social factors evaluated in the baseline profile were carried through to the initial screening phase to provide a basis of assessment.

3.2.1 Social Factor Metrics

Metrics have been identified for each of the social factor categories. These metrics relate to potential impacts on a community as a result of implementing an alternative. They are based on standard metrics developed by the IWR, however Regional Healthcare was included under the Health and Safety social factor because the metro area is a considered a regional healthcare center—with the potential to impact people well outside of the immediate study area. The metrics and their descriptions are presented in Table D-7.

Table D-7: Description of Metrics

Social Factor/Metric	Description
Health and Safety	
Mental Health	Issues affecting the overall mental health of a person, such as anxiety and stress (e.g., threat of flooding, transportation concerns, noise)
Physical Health	Issues affecting a person's physical health (e.g., air quality, diseases)
Physical Safety	Safety issues that could cause bodily harm to a person (e.g., floodwaters, crime)
Regional Healthcare	Issues affecting the healthcare services provided in the region (e.g., impacts to hospitals and specialized clinics)
Economic Vitality	
Business Climate	Issues affecting the ability of a community to retain and attract businesses
Employment Opportunities	Issues affecting the availability of a community to provide employment opportunities for residents
Financial Impacts	Issues affecting a person or group's standard of living (e.g., taxes, property values)
Municipal Services	Issues affecting the local tax base and the ability to provide municipal services
Social Connectedness	
Community Cohesion	Issue affecting local social networks, including personal networks
Community Facilities	Issues affecting access to local community-related facilities (e.g., libraries, community centers, religious establishments)
Identity	
Cultural Identity	Issues affecting sense of cultural identify within a community (e.g., historical or cultural significance)
Community Identify	Issues affecting sense of community identity (e.g., local sports, how others see the area)
Social Vulnerability and Resiliency	
Residents of Study Area	Issues affecting the overall risk to the population within the study area
Socially Vulnerable Groups	Issues affecting socially vulnerable groups (e.g., low-income, minority, elderly, and disabled populations, and children)
Participation	
Public Participation	Issues affecting overall public involvement in community matters (e.g., trust in local officials, public interest in community)
Leisure and Recreation	
Recreational Activities	Issues affecting access to or availability of recreational activities (e.g., parks, trails, viewsheds)

In addition to the social factors described in the handbook, impacts to the human environment should also consider Environmental Justice (EJ) and Public Safety. These topics are critical components of the impacts to the human environment and are intertwined with many components of the OSE analysis. Although these topics are not explicitly covered in the OSE

analysis, they are addressed in other sections of the overall study (see Chapter 5 of the Main Report).

3.2.2 Scoring

Because some social factors are not easily quantified, this evaluation relies on a scoring system with a scale of -3 to +3, with -3 indicating significant negative effects on a particular metric and +3 indicating significant beneficial effects (see Table D-8). **The score is an assessment of the relative impact an alternative would have on a particular metric in relation to the without-project alternative. The assessment is made from an overall planning perspective (not necessarily reflecting impacts to individuals or small groups)**. For example, a diversion channel to reduce flooding might have a significant beneficial effect to the residents at risk of flooding and be given a score of +3 for the Residents of Study Area metric. On the other hand, a small scale non-structural alternative (relocation) might benefit the residents being relocated and leave a large majority of the residents susceptible to flooding; therefore, it would receive a score of 0 or +1 (most of the residents would be susceptible to the same flood risk with relocation as with the without-project alternative).

Table D-8: Key to Scoring Metrics in Matrix

Score	In Relation to the Without-Project (No Action) Alternative, the With-Project Alternative Has…
-3	Significant negative effects ("show-stopper")
-2	Moderate negative effects
-1	Minor negative effects
0	Negligible effects (no impact)
+1	Minor beneficial effects
+2	Moderate beneficial effects
+3	Significant beneficial effects

3.3 Evaluation of Social Factors

As identified during the baseline assessment, the mental stress associated with the continued threat of flooding and the flood fight efforts is a significant issue to the communities in the study area. The baseline assessment also identified continued Economic Vitality as a major concern in the study area. It has been shown that flooding poses a risk to the Economic Vitality of the region due to costly flood fights, numerous past floods, and the risk of a catastrophic event. Therefore, the Health and Safety and Economic Vitality social factors weigh heavily in the overall OSE evaluation of the alternatives.

The results of the initial screening of alternatives are presented in Table D-9. Following Table D-9 is a brief overview of each alternative, with special attention paid to any metrics with a score of -3 or +3 to help decision makers understand the particular issue and why the score was selected.

Table D-9: Initial Screening of Alternatives

Social Factor and Metrics	Alternatives									
	Flood Barriers	Diversion Channels	Non-structural Measures	Flood Storage	Tunneling	Bridge Replacement or Modification	Interstate 29 Viaduct	Dredging and Widening	Wetland and Grassland Restoration	Cut-off Channels
	D / E	D / E	D / E	D / E	D / E	D / E	D / E	D / E	D / E	D / E
Health and Safety										
Mental Health	2 / 2	3 / 3	0 / 0	2 / 2	3 / 3	0 / 1	3 / 3	1 / 1	0 / 1	1 / 1
Physical Health	2 / 2	3 / 2	0 / 0	2 / 2	3 / 2	0 / 1	3 / 2	1 / 1	0 / 1	1 / 1
Physical Safety	0 / 2	0 / 2	0 / 0	0 / 2	0 / 2	0 / 1	0 / 2	0 / 1	0 / 1	0 / 1
Regional Healthcare	0 / 2	0 / 3	0 / 0	0 / 2	0 / 3	0 / 1	0 / 3	0 / 1	0 / 1	0 / 1
Economic Vitality										
Business Climate	2 / 2	2 / 3	0 / 0	2 / 2	3 / 3	0 / 1	3 / 3	1 / 1	0 / 1	1 / 1
Employment Opportunities	2 / 2	2 / 3	0 / 0	2 / 2	3 / 3	0 / 1	3 / 3	1 / 1	0 / 1	1 / 1
Financial Impacts	-1 / 1	-2 / 1	0 / 0	-1 / 1	-2 / 1	0 / 0	-2 / 1	-1 / 1	0 / -1	-1 / 1
Municipal Services	-1 / 2	-2 / 2	0 / 0	-1 / 1	0 / 2	0 / 0	-1 / 2	0 / 1	-1 / 0	0 / 1
Social Connectedness										
Community Cohesion	-1 / 2	0 / 2	0 / 0	0 / 2	0 / 2	0 / 1	0 / 2	0 / 1	0 / 1	0 / 1
Community Facilities	0 / 2	0 / 2	0 / 0	0 / 2	0 / 2	0 / 0	0 / 2	0 / 1	0 / 1	0 / 1
Identity										
Cultural Identity	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Community Identify	1 / 1	1 / 1	0 / 0	1 / 1	1 / 1	0 / 1	1 / 1	1 / 1	0 / 0	1 / 1
Social Vulnerability and Resiliency										
Residents of Study Area	-1 / 2	0 / 2	0 / 0	0 / 1	0 / 2	0 / 1	0 / 2	0 / 1	0 / 1	0 / 1
Socially Vulnerable Groups	-1 / 2	0 / 2	0 / 0	0 / 0	0 / 2	0 / 1	0 / 2	0 / 1	0 / 1	0 / 1
Participation										
Public Participation	1 / 2	1 / 2	0 / 0	0 / 1	0 / 2	0 / 1	1 / 2	0 / 1	0 / 1	1 / 1
Leisure and Recreation										
Recreational Activities	-1 / 1	0 / 1	1 / 0	0 / 1	0 / 1	0 / 0	0 / 1	1 / 1	1 / 1	0 / 1

Notes:

- Impacts are measured in comparison to the Without-Project Alternative
- D = impacts to daily lifes (no flooding); E = impacts during a flood event
- Scores can range from -3 (significant negative impact) to +3 (significant beneficial impact)
- No more than 25 percent of the metric scores for an alternative should be either a -3 or +3

3.3.1 Flood Barriers

Although the construction of flood barriers would require the acquisition of nearly 1,000 homes, the larger community would experience the benefits of a large reduction in flood risk. The cities of Grand Forks North Dakota and East Grand Forks Minnesota implemented a large scale levee system that has provided opportunities for park space, recreation, and river access. Flood barriers in Fargo Moorhead could provide similar opportunities. A residual risk also remains due to overtopping or a catastrophic breach of the barriers. Flood barriers potentially induce stage increases upstream or downstream.

3.3.2 Diversion Channels

Although the diversion channels would require large tracts of land for construction, communities at risk would receive significant beneficial effects and reduced flood risk. However, the financial cost of the alternative and the loss of tax base might be a burden to communities. Diversion channels have residual flood risk, however they usually do not make the consequences of a catastrophic flood worse. Diversion channels likely induce upstream or downstream stage increases.

3.3.3 Non-structural Measures

Non-structural measures reduce flood risk by reducing the amount of damage caused by flooding without modifying flood behavior. These measures include elevation, relocation, acquisition, and floodproofing of structures, local levees or floodwalls (small and around individual structures), flood warning systems, flood preparedness plans, and flood insurance. Non-structural plans can be considered on a comprehensive basis for the large portions of the study area, or just for specific problem areas. A large scale non-structural plan will reduce risks to health and safety and reduce the need to flood fight.

3.3.4 Flood Storage

Flood storage alternatives entail creating a number of impoundments of various size distributed throughout the Red River Basin and sub-basins upstream of Fargo-Moorhead. Flood storage alternatives are effective in reducing flood stages for more frequent events and could have substantial benefits basin-wide. The impoundments would require a large amount of land, mostly farm fields. Flows would likely be stored into the growing season.

3.3.5 Tunneling

Impacts of the tunneling alternative are similar to those of the diversion channels alternative, although at a smaller scale. The financial cost of tunneling would be very high and might be a burden to communities. Tunnels have residual flood risk, however they usually do not make the consequences of a catastrophic flood worse.

3.3.6 Bridge Replacement or Modification

Bridge replacement or modification reduces stages by minimizing the obstruction that bridges create during high flows. Generally bridge replacement or modification is effective in local reaches and for smaller flood events, but do little for reaches further away from bridges. There is

generally a high cost associated with bridge replacement and modification. The alternative would have minimal impacts on the daily life of residents.

3.3.7 Interstate 29 Viaduct

Construction of the I-29 viaduct would result in similar impacts as the diversion channel alternative, however on a smaller scale. There would be substantial disruption of traffic patterns associated with this alternative.

3.3.8 Dredging and Widening

The dredging and widening alternative would reduce flood risk. However, risk reduction is anticipated to be small, leaving a large residual risk to residents. The alternative would have minimal impacts on the daily life of residents. This alternative would have substantial impacts to ecosystems.

3.3.9 Wetland and Grassland Restoration

Wetland and grassland restoration measures are similar to flood storage in that they store water and reduce runoff; however restoration sites are designed to maximize environmental quality. Typical wetland restoration projects are designed to hold water level fluctuations to less than two feet in order to avoid environmental impacts in the wetland. Flood storage impoundments would be designed to fluctuate as much as the terrain or embankments would allow in order to maximize storage. Wetland and grassland restoration could be implemented on a similar geographic scale as flood storage, however it would be less effective in reducing peak flows.

3.3.10 Cut-off Channels

The cut-off channels alternative would provide flood risk reduction. However, risk reduction is anticipated to be small, leaving a large residual risk to residents. The alternative would have minimal impacts to the daily life of residents.

3.4 Summary of Initial Screening of Project Alternatives

Based on the results of the initial screening of alternatives, none of the alternatives appear to have significant negative effects on the residents and communities in the study area. Significant positive effects for the Health and Safety and Economic Vitality could be realized from the flood barriers, diversion channels, non-structural and flood storage alternatives.

4.0 Alternatives Analysis

Based on the alternatives screening from Appendix O of the Main Report, four alternatives were carried forward for further analysis. The following section presents the OSE analysis of these alternatives, which takes into consideration greater refinement of the specific characteristics of the alternatives and additional analysis of the impacts of the alternatives.

4.1 Description of Alternatives Carried Forward

During the Phase IV screening of alternatives, four alternatives were carried forward (see section 8.4 of Appendix O): the No Action Alternative, one Minnesota Diversion alternative, and two North Dakota Diversion alternatives

The selected alignment of diversion channel for each alternative would be outside of the metro area through land that is currently in agricultural use. For each diversion alternative, a control structure would be required on the upstream portion of the Red River to divert flows into the selected diversion channel and drop structures would be required to allow local drainage to enter the diversion channel. Tie-back levees at the southern limits of the project area would be necessary to tie into high ground. No tie-back levees would be necessary at the north limits of the project area. Land use plans adopted by Clay County, MN, and Cass County, ND, do not include any proposals for future development along the proposed alignments. Based on the proposed alignment for the Minnesota Short Diversion, the City of Dilworth could experience some loss of developable land.

Section 3.11 through 3.13 of the Main Report provide a detailed description of the alternatives carried forward. A brief description of the three alternatives along with maps is provided below.

4.1.1 ND35K – North Dakota Diversion – 35,000 cfs with Downstream Impacts

The ND35K would divert floodwaters through North Dakota along a 36-mile-long diversion channel. The diversion channel would start approximately 4 miles south (upstream) of the confluence of the Red and Wild Rice Rivers and extending west and north around the cities of Horace, Fargo, West Fargo, and Harwood, ND (see Figure D-3). The diversion capacity for this alternative is 35,000 cubic feet per second (cfs). The ND35K induces downstream stage increases greater than 2-feet in some areas during certain flood events. Few mitigation measures for the downstream impacts would be economically justified.

This alternative would include substantial recreation features similar to those discussed in Appendix M of the Main Report.

4.1.2 LPP (Locally Preferred Plan) – North Dakota Diversion with Staging, Storage Cell, and Upstream Impacts

The LPP would follow the same alignment as the ND35K (see Figure D-4). The diversion capacity for this alternative is approximately 20,000 cfs. A storage cell would be placed at the southern end of the project area. The control structures, diversion inlet weir and the tie-back levees would be designed to stage water upstream and in the storage cell. The LPP would increase stages upstream by more than 8-feet during a 1-percent chance flood event. The LPP would require buying out and relocating between 800 and 1,200 structures upstream, between 200 and 400 of which are households.

This alternative would include substantial recreation features as discussed in Appendix M of the FEIS.

4.1.3 FCP (Federally Comparable Plan) – Minnesota Short Diversion – 35,000 cfs with Downstream Impacts

The FCP would divert floodwaters through Minnesota along a 25-mile-long diversion channel (see Figure D-5). The diversion channel would start at the confluence of the Red and Wild Rice Rivers and extend east and north, ending near the confluence of the Red and Sheyenne Rivers. The diversion capacity for this alternative is 35,000 cubic feet per second. The FCP induces downstream stage increases greater than 1-foot in some areas during certain flood events. Few mitigation measures for the downstream impacts would be economically justified.

This alternative would include substantial recreation features similar to those discussed in Appendix M of the Main Report.

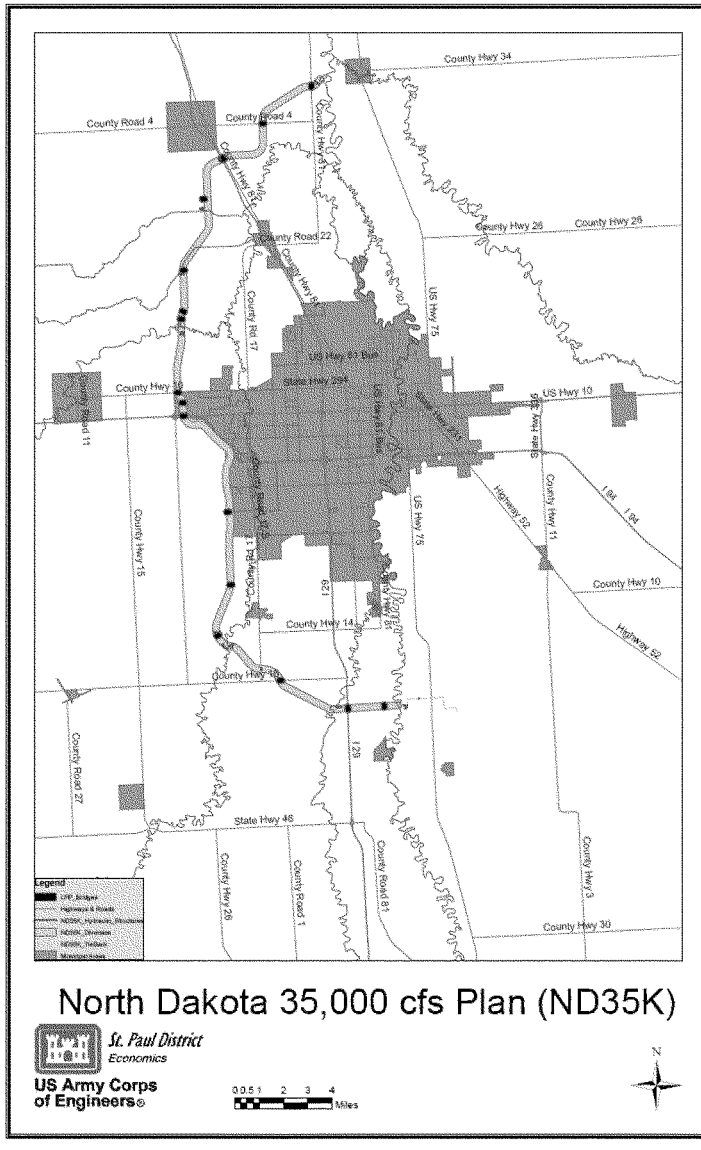


Figure D-3: North Dakota 35,000 cfs Plan (ND 35K)

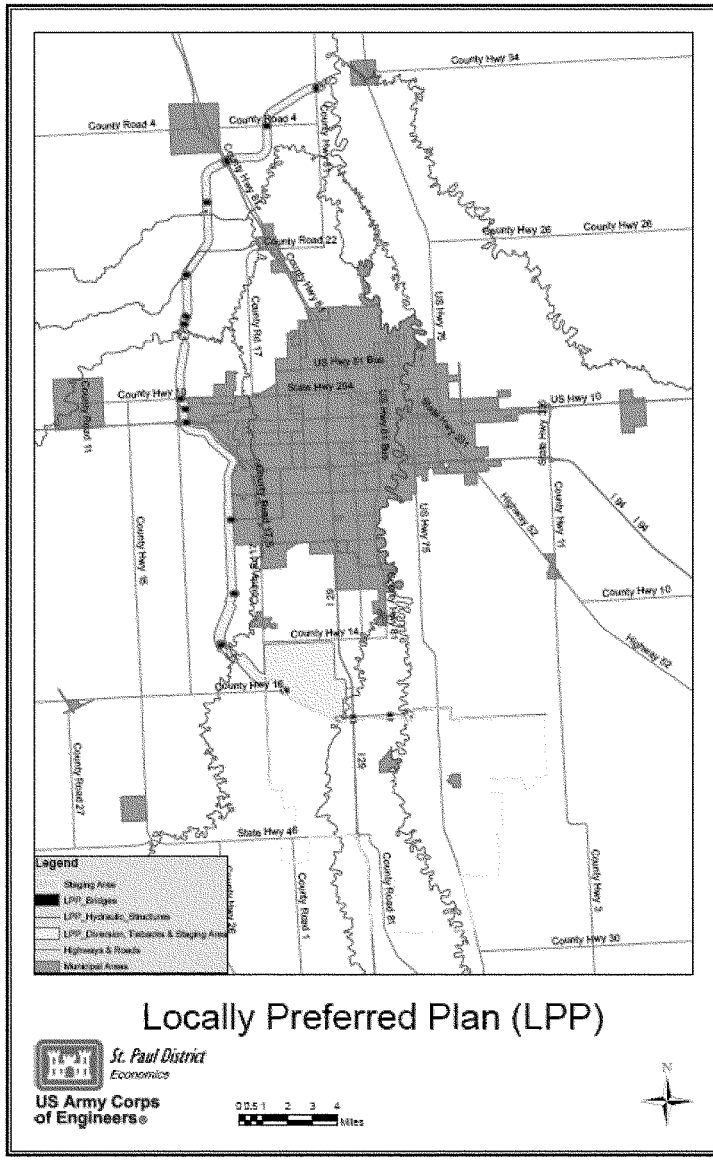


Figure D-4: Locally Preferred Plan (LPP)

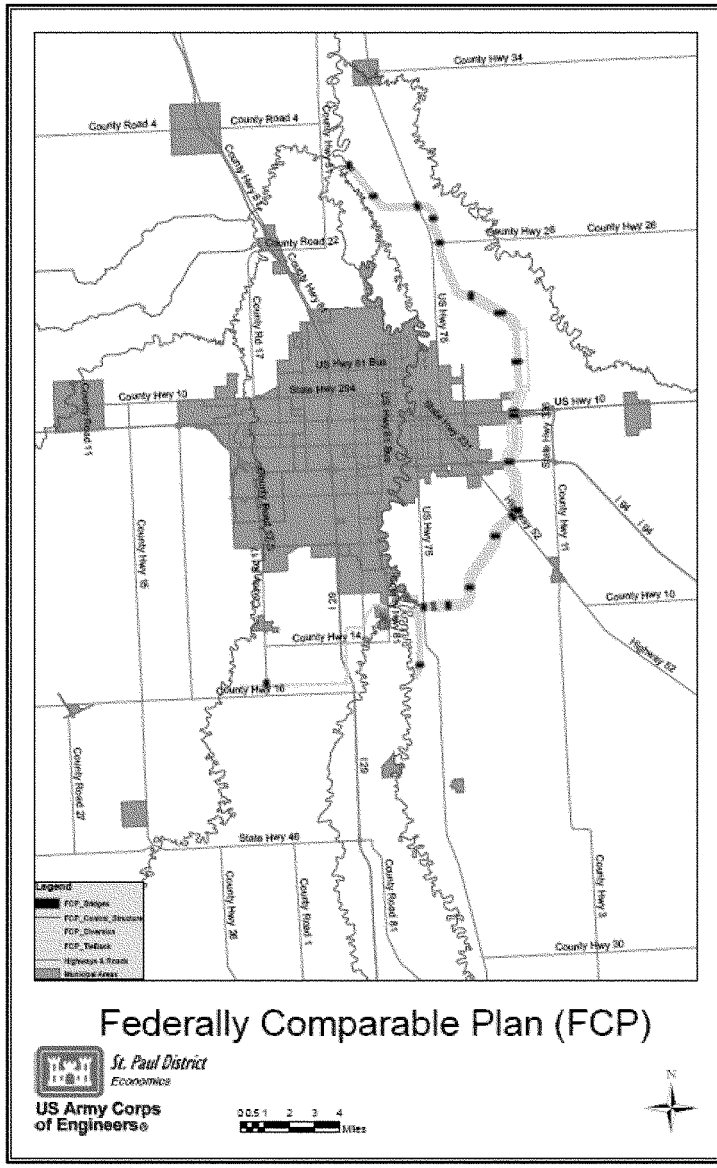


Figure D-5: Federally Comparable Plan (FCP)

4.2 Revision to the Study Area

During the initial screening of alternatives, the study area was identified as the Fargo-Moorhead metropolitan area. However, further analysis determined that the alternatives had the potential to induce flood damage outside of the metro area. To account for induced impacts, the study area was expanded from Abercrombie, ND, to the border with Canada. To better evaluate the impacts, the study area was divided into four subareas. These subareas and the identified impacts are described in Table D-10. See Chapter 5 of the Main Report for additional information on the impacts of the alternatives.

Table D-10: Impacts to Subareas

Subarea	Location	Impact During 1-Percent-Annual-Chance Flood Event
Area 1 (upstream of metro area)	Abercrombie, ND (approximately River Mile 523), to north of Oxbow, ND (approximately River Mile 478)	The LPP could cause induced flooding of up to 99 inches. The FCP could cause induced flooding of up to 7 inches.
Area 2 (metro area)	North of Oxbow, ND (approximately River Mile 478), to south of Georgetown, ND (approximately River Mile 433)	Area 2 would see a reduction in floodwater under all alternatives.
Area 3 (immediately downstream of metro area)	Georgetown, ND (approximately River Mile 433), to south of Thompson, ND (approximately River Mile 316)	The ND35K could cause induced flooding of up to 26 inches. The FCP could cause induced flooding of up to 13 inches. The LPP could reduce flood stages by up to 3 inches.
Area 4 (downstream of Area 3)	South of Thompson, ND (approximately River Mile 316), to the Canadian border (approximately River Mile 155)	The ND35K could cause induced flooding of up to 16 inches. The FCP could cause induced flooding of up to 7 inches. The LPP could cause induced flooding of up to 4 inches.

4.3 Other Social Effect Evaluation of Alternatives

The OSE evaluation of the alternatives was framed around the seven social factors used during the initial screening of alternatives. However, the evaluation took into consideration additional detail and information on the alternatives and their potential impacts. The metrics and scoring system for each social factor were the same as those used in the initial screening (Section 3). As with the initial screening, the evaluation of alternatives was in relation to the without-project condition. As noted earlier, Environmental Justice is addressed in section 5.2.3.3 of the Main Report.

4.3.1 Health and Safety

As identified during the baseline assessment, the stress associated with the continued threat of flooding and the flood fight efforts is a significant issue to the communities in the study area; therefore, the Health and Safety social factor weighs heavily in the overall OSE evaluation of the alternatives. Table D-11 shows the results of the refined evaluation by subarea. An overall evaluation of each alternative follows.

Table D-11: Health and Safety Social Factor

Social Factor: Health and Safety	Metrics			
ND35K	Mental Health	Physical Health	Physical Safety	Regional Healthcare
	D / E	D / E	D / E	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	0 / 0	0 / 0	0 / 0	0 / 0
Area 2 (Fargo-Moorhead metro area)	3 / 3	2 / 2	0 / 3	0 / 3
Area 3 (immediately downstream of Fargo-Moorhead metro area)	-1 / 0	-1 / -1	0 / -1	0 / -1
Area 4 (downstream of Area 3)	-1 / -1	-1 / -1	0 / -1	0 / -1
LPP				
	D / E	D / E	D / E	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	-1 / -1	0 / -1	0 / -1	0 / -1
Area 2 (Fargo-Moorhead metro area)	3 / 3	3 / 3	0 / 3	0 / 3
Area 3 (immediately downstream of Fargo-Moorhead metro area)	0 / 0	0 / 0	0 / 0	0 / 0
Area 4 (downstream of Area 3)	-1 / -1	-1 / -1	0 / -1	0 / -1
FCP				
	D / E	D / E	D / E	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	0 / 0	0 / 0	0 / 0	0 / 0
Area 2 (Fargo-Moorhead metro area)	3 / 3	3 / 3	0 / 3	0 / 3
Area 3 (immediately downstream of Fargo-Moorhead metro area)	-1 / -1	-1 / -1	0 / -1	0 / -1
Area 4 (downstream of Area 3)	-1 / -1	-1 / -1	0 / -1	0 / -1

4.3.1.1 ND35K

The ND35K would have little impact on the current flooding conditions in Area 1; therefore, the residents would be expected to experience similarly high levels of stress and anxiety as they do under the without-project conditions.

Area 2 would be expected to experience a significant decrease in flood-related stress due to the reduction in flooding. This reduction of stress is anticipated to be similar to that experienced by the residents of Grand Forks, ND, when permanent flood risk management measures were

constructed following the 1997 flood event. Stress would be reduced during a flood event as well as throughout the year.

Area 3 would be expected to see an increase in flood-related stress due to the increase in flood stages during flood events. Residents in Area 4 could also see an increase in stress associated with flooding, but the impacts would be minimal and might not be noticeable.

Healthcare centers are concentrated in the metro area, with many residents inside and outside the study area relying on medical services provided by existing facilities. The risk of an interruption to these services would be greatly reduced with The ND35K, which allows for the continued operation of the healthcare facilities during an event.

4.3.1.2 LPP

The LPP would have a negative impact on the current flooding conditions in Area 1; therefore, the residents would be expected to experience higher levels of stress and anxiety than they do under the without-project conditions. This stress could increase due to the relocation of residents, which would disrupt daily activities and social networks. However, it is anticipated that the relocated residents would settle in areas that are not prone to flooding, thereby reducing their overall flood-related stress.

Area 2 would be expected to experience a significant decrease in flood-related stress due to the reduction in flooding. This reduction of stress is anticipated to be similar to that experienced by the residents of Grand Forks, ND, when permanent flood risk management measures were constructed following the 1997 flood event. Stress would be reduced during a flood event as well as throughout the year.

The LPP would decrease flood stages slightly in Area 3 and increase stages slightly in area 4; therefore, the residents would be expected to experience similar levels of stress and anxiety as they do under the without-project conditions. The positive and negative impacts to areas 3 and 4 are small (smaller than the ND35K and FCP) and might not be noticeable.

The metro area is the healthcare center for the region, with many residents inside and outside the study area relying on medical services provided by existing facilities. The risk of an interruption to these services would be greatly reduced with The LPP, which allows for the continued operation of the healthcare facilities during an event.

4.3.1.3 FCP

The FCP would have some impact on the current flooding conditions in Area 1; the impacts to Area 1 are small, and the residents would be expected to experience similarly high levels of stress and anxiety as they do under the without-project conditions.

Area 2 would be expected to experience a significant decrease in flood-related stress due to the reduction in flooding. This reduction of stress is anticipated to be similar to that experienced by the residents of Grand Forks, ND, when permanent flood risk management measures were constructed following the 1997 flood event. Stress would be reduced during a flood event as well as throughout the year.

Area 3 would be expected to see an increase in flood-related stress due to the increase in flood stages during flood events. Residents in Area 4 could also see an increase in stress associated with flooding, but the impacts would be minimal and might not be noticeable.

The metro area is the healthcare center for the region, with many residents inside and outside the study area relying on medical services provided by existing facilities. Risk to these services would be greatly reduced with The FCP, which allows for continued operation during an event.

4.3.1.4 Overview of Health and Safety Social Factor

It is important to note that the upstream and downstream communities already experience flooding, and that the health and safety concerns noted above currently exist. There are already flood fights and the danger of local levees overtopping; therefore, the increased frequency of flood events and water levels from the alternatives could increase this risk. While removing the stress, anxiety, and related psychological effects of flooding from those living in the metro area, a successful flood risk mitigation project in the metro area might, to some degree, intensify this burden on the downstream or upstream communities with induced impacts. The impact could be heightened by the residents' perception of their inability to affect any change or otherwise influence the decision making of people living in the metro area.

The LPP would result in the least induced impacts to the downstream communities as a whole, while also benefiting the large population of the metro area. It is expected that the residents in the upstream areas affected by the LPP would relocate to areas not prone to flooding, thereby reducing their flood-related stress in the long run. The ND35K and FCP would have similar benefits and induced impacts from a Health and Safety perspective.

The metro area is also considered a regional employment center. A catastrophic flood event would cause significant unemployment in the region, resulting in increased stress caused by loss of wages. Implementation of any of the alternatives would reduce the risk of a catastrophic event.

It is also important to recognize that none of the alternatives considered would eliminate flood risk. Although the risk of failure of a properly designed and constructed project is very small, Attachment 2 to this Appendix evaluates the potential for loss of life due to a breach of the LPP tie-back levees.

4.3.2 Economic Vitality

As identified during the baseline assessment, the study area is economically robust, with relatively low unemployment and a solid and diverse employment base. However, the economic development of the region would suffer greatly if a catastrophic event occurred. The various diversion alignments also impact development in different ways. Therefore, the Economic Vitality social factor also weighs heavily in the overall OSE evaluation of the alternatives. An additional metric ("Development") was added to the analysis to address land development impacts caused by the alternatives. Table D-12 shows the results of the refined evaluation by subarea. An overall evaluation of each alternative follows.

Table D-12: Economic Vitality Social Factor

Social Factor: Economic Vitality	Metrics				
ND35K	Business	Employment	Financial	Municipal	Development
	D / E	D / E	D / E	D / E	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Area 2 (Fargo-Moorhead metro area)	2 / 3	2 / 3	3 / 3	3 / 3	3 / 0
Area 3 (immediately downstream of Fargo-Moorhead metro area)	-1 / -2	-1 / -2	-1 / -1	-1 / -1	-2 / 0
Area 4 (downstream of Area 3)	0 / -1	0 / -1	0 / 0	0 / 0	0 / 0
LPP					
	D / E	D / E	D / E	D / E	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	-1 / -2	-2 / -2	-1 / 0	-1 / 0	-3 / 0
Area 2 (Fargo-Moorhead metro area)	2 / 3	2 / 3	3 / 3	3 / 3	2 / 0
Area 3 (immediately downstream of Fargo-Moorhead metro area)	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Area 4 (downstream of Area 3)	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
FCP					
	D / E	D / E	D / E	D / E	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Area 2 (Fargo-Moorhead metro area)	2 / 3	2 / 3	-2 / 3	-2 / 3	2 / 0
Area 3 (immediately downstream of Fargo-Moorhead metro area)	-1 / -2	-1 / -2	-1 / -1	-1 / -1	-2 / 0
Area 4 (downstream of Area 3)	0 / -1	0 / -1	0 / 0	0 / 0	0 / 0

4.3.2.1 ND35K

The ND35K would have little impact on the current flooding conditions in Area 1; therefore, the residents would be expected to experience similar economic growth and vitality as they do under the without-project conditions.

Area 2 would be expected to experience a significant benefit in Economic Vitality due to the reduction flood risk. This reduction in risk is anticipated to allow the metro area to continue to attract business from outside the area and to grow economically. Existing businesses would be less vulnerable and might be willing to expand in the area as opposed to moving to another region. Due to the reduction in flood risk, future land development could be undertaken at a reduced cost.

Area 3 could see a decrease in Economic Vitality, particularly in the agricultural sector, due to the increase in downstream flood stages during flood events. Residents in Area 4 could also experience decreased Economic Vitality associated with increased flooding; however, the impacts would be minimal and might not be noticeable. Due to the increase in flood risk, future land development in these areas would be more costly.

The ND35K would permanently remove a large tract of land within Area 2 from agricultural production, affecting the agricultural output and tax base of the local communities. The reduction

in tax base and the cost of the project could limit the ability of the local municipalities to provide services to its residents.

4.3.2.2 LPP

The LPP would greatly impact the Economic Vitality of Area 1. Due to the induced flooding and acquisitions of structures, it would be expected that businesses would relocate to other areas in the region. Future land development would be limited in Area 1 due to restrictions imposed by flowage easements and the increase in flood risk. A loss of tax revenue may impact the ability of local municipalities to provide services to the remaining residents in their jurisdictions.

Area 2 would be expected to experience a significant benefit in Economic Vitality due to the reduction in flood risk. This reduction in risk is anticipated to allow the metro area to continue to attract business from outside the area and to grow economically. Existing businesses would feel less vulnerable and might be willing to expand in the area rather than in another region. Due to the reduction in flood risk, future land development could be undertaken at a reduced cost.

Minimal impacts on the flood risk are expected for Areas 3 and 4; therefore, the impacts to Economic Vitality would be similar to the without-project condition.

Among the three alternatives, the LPP would permanently remove the most land from agricultural production. Although it is anticipated that much of the land in the storage and staging areas could continue to be farmed, flood risk would be increased, and building of structures to support farming would be limited in those areas. These changes could reduce the agricultural output and tax base of the local communities. This reduction could limit the services provided by the municipalities to its residents.

4.3.2.3 FCP

Similar to the ND35K, The FCP would have little impact on the current flooding conditions in Area 1; therefore, the residents would be expected to experience similar economic growth and vitality as they do under the without-project conditions.

Area 2 would be expected to experience a significant benefit in Economic Vitality due to the reduced flood risk. This reduction is anticipated to allow the metro area to continue to attract businesses from outside the area and to grow economically. Existing business owners would feel less vulnerable and might be willing to expand in the area. However, the community of Dilworth, MN, has expressed concern over the potential impact the Minnesota short alignment would have. The diversion channel would replace approximately 1,116 acres of undeveloped land, 407 of which could otherwise be developed in the next 30 years. Due to the reduction in flood risk, future land development could be undertaken at a reduced cost. However, municipalities in Minnesota have expressed concern that the alignment of the diversion channel would limit their development opportunities.

Area 3 would be expected to see a decrease in Economic Vitality, particularly in the agricultural sector, due to the increase in flood stages during flood events. Residents in Area 4 could also experience an impact to Economic Vitality associated with increased flooding; however, the impacts would be minimal and might not be noticeable. Due to the increase in flood risk, future land development would be more costly.

The FCP would permanently remove a large tract of land in Area 2 from agricultural production, affecting the agricultural output and tax base of the local communities. The reduction in tax base and the cost of the project could limit the local municipalities' ability to provide services to its residents.

4.3.2.4 Overview of Economic Vitality Social Factor

The metro area is a regional employment center. A catastrophic flood event would cause significant business losses and higher unemployment. Implementing any of the alternatives would greatly reduce the risk and add to the Economic Vitality to the metro area.

The LPP would result in the least induced impacts to downstream communities, while also benefiting the large population of the metro area. However, The LPP would also permanently remove the most land from agricultural production, thereby reducing the agricultural output and tax base of the local communities.

4.3.3 Social Connectedness

The baseline profile indicated that residents in the study area have strong Social Connectedness, which has helped them during the frequent flood fight efforts. As part of their daily life, residents participate in various activities at community facilities such as schools, churches and hospitals. Although Social Connectedness is important, it was not weighted as heavily in the overall planning process as Health and Safety and Economic Vitality. Table D-13 shows the results of the refined evaluation by subarea. An overall evaluation of each alternative follows.

Table D-13: Social Connectedness Social Factor

Social Factor: Social Connectedness	Metrics	
ND35K	Community	Community
	D / E	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	0 / 0	0 / 0
Area 2 (Fargo-Moorhead metro area)	-1 / 2	0 / 2
Area 3 (immediately downstream of Fargo-Moorhead metro area)	-2 / -2	0 / -1
Area 4 (downstream of Area 3)	0 / 0	0 / -1
LPP		
	D / E	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	-3 / -1	-3 / -1
Area 2 (Fargo-Moorhead metro area)	-1 / 2	0 / 2
Area 3 (immediately downstream of Fargo-Moorhead metro area)	0 / 0	0 / 0
Area 4 (downstream of Area 3)	0 / 0	0 / 0
FCP		
	D / E	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	0 / 0	0 / 0
Area 2 (Fargo-Moorhead metro area)	-1 / 2	0 / 2
Area 3 (immediately downstream of Fargo-Moorhead metro area)	-2 / -2	0 / -1
Area 4 (downstream of Area 3)	0 / 0	0 / -1

4.3.3.1 ND35K

The ND35K would have little impact on the current flooding conditions in Area 1; therefore, the residents would not be expected to experience impacts to their Social Connectedness. It is expected that they would still band together during a flood fight, as they do under the without-project conditions.

Area 2 would be expected to experience a significant benefit from the ND35K from the reduced flood risk. The flood fight efforts that have mobilized the community in the past would not be expected to occur, and implementing the alternative would result in little disruption to normal community activities during a flood event. Impacts on the local road network from the alignment of the diversion channel might cause the rural residents to experience disruption of and separation from current activities.

Area 3 could see an increase in flooding, causing potential impacts on the daily activities and community life of the residents, such as increased disruption to school and church activities. Communities in Area 3 have expressed concern that the additional flooding resulting from the ND35K could drive residents away from affected areas and cause property value depreciation.

Over the past 50 years, the downstream communities have seen population losses of between 10 and 35 percent. Every downstream city and township between Fargo-Moorhead and Thompson, ND, has lost population, with the exception of Oakport and Kragnes Townships, MN, which are immediately north of the metro area. The incremental increase in downstream flood risk associated with the proposed project is not likely to change the historic trends appreciably. The more significant causes of these trends are noted in the *Clay County Comprehensive Plan*, which cites the "city's distance from the major growth areas within the County and surrounding land use patterns" as current impediments to growth.

Residents in Area 4 could also experience an impact on Social Connectedness with increased flooding, but the impacts would be minimal and might not be noticeable.

4.3.3.2 LPP

The LPP would cause significant social disruptions for the communities and residents in Area 1, with the potential for a large number of residents to be displaced. This could be especially detrimental to small towns, such as Oxbow, ND, which prides itself on having a small-town character. The relocations would disrupt such community activities as school and church functions, as well as the social networks among residents. Local school district officials have expressed concern that this alternative would conflict with their future school development plans.

Area 2 would be expected to experience a significant benefit from the LPP from a reduced flood risk. The flood fight efforts that have mobilized the community in the past would not be expected to occur as frequently, and flood events would result in less frequent disruption to normal community activities during a flood event after implementation of the alternative. The impacts to the local road network from the alignment of the diversion channel might cause the rural residents to experience the disruption of and separation from current activities.

The LPP would have little impact on the current flooding conditions in Areas 3 and 4; therefore, the residents would not be expected to experience impacts to their Social Connectedness. It is expected that they would still band together during a flood fight.

4.3.3.3 FCP

As with the ND35K, the FCP would have little impact on the current flooding conditions in Area 1; therefore, the residents would not be expected to experience impacts to their Social Connectedness. It is expected that they would still band together during a flood fight.

Area 2 would be expected to experience a significant benefit from the FCP from a reduced flood risk. The flood fight efforts that have mobilized the community in the past would not be expected to occur, and flood events would result in little disruption to normal community activities during a flood event after implementation of the alternative. The impacts on the local road network from the alignment of the diversion channel might cause the rural residents to experience minor disruption and separation from current activities. However, the larger population within the area would not be impacted.

Area 3 could see an increase in flooding, causing potential impacts to the daily activities and community life of the residents, such as an increase in the disruption to school and church activities. Communities in Area 3 have expressed concern that the additional flooding resulting from the FCP could drive residents away from affected areas and cause property value

depreciation. Over the past 50 years, the downstream communities have seen population losses of between 10 and 35 percent. Every downstream city and township between Fargo-Moorhead and Thompson, ND, has lost population, with the exception of Oakport and Kragnes Townships, MN, which are immediately north of the metro area. The incremental increase in flood risk associated with the proposed project is not likely to change the historic trends appreciably. The more significant causes of these trends are noted in the *Clay County Comprehensive Plan*, which cites the "city's distance from the major growth areas within the County and surrounding land use patterns" as current impediments to growth.

Residents in Area 4 could also experience an impact on Social Connectedness with increased flooding, but the impacts would be minimal and might not be noticeable.

4.3.3.4 Overview of Social Connectedness Social Factor

The LPP would have a significant impact on the Social Connectedness of the communities and residents of Area 1 due to the relocation of residents. The ND35K and FCP could have negative impacts on the Social Connectedness in Area 3 because of the induced downstream flooding and disruptions to daily activities. All three alternatives would benefit Area 2 because the flood risk would be reduced, as would disruptions to daily activities during an event.

All three alternatives would create additional burdens on communities outside of Area 2 affected by induced flood impacts, which may result in resentment toward the residents and political institutions of the metro area. This resentment would increase an already apparent social, cultural, and political divide in the region. Increasing frustration and resentment could be expected, given the sentiments these residents have expressed and their perception of their political situation.

4.3.4 Identity

The baseline profile indicated the residents of the study area identify with their Scandinavian roots and a pioneering spirit. This Identity has helped residents during the frequent flood fight efforts, with a "we pull ourselves up by our bootstraps" attitude. Although Identity is important, it was not weighted as heavily in the overall planning process as Health and Safety and Economic Vitality. Table D-14 shows the results of the refined evaluation by subarea. An overall evaluation of each alternative follows.

Table D-14: Identity Social Factor

Social Factor: Identity	Metrics	
ND35K	Cultural	Community
	D / E	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	0 / 0	0 / 0
Area 2 (Fargo-Moorhead metro area)	0 / 0	0 / 1
Area 3 (immediately downstream of Fargo-Moorhead metro area)	0 / 0	-1 / -1
Area 4 (downstream of Area 3)	0 / 0	-1 / -1
LPP		
	D / E	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	0 / 0	-2 / -1
Area 2 (Fargo-Moorhead metro area)	0 / 0	0 / 1
Area 3 (immediately downstream of Fargo-Moorhead metro area)	0 / 0	0 / 0
Area 4 (downstream of Area 3)	0 / 0	0 / 0
FCP		
	D / E	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	0 / 0	0 / 0
Area 2 (Fargo-Moorhead metro area)	0 / 0	0 / 1
Area 3 (immediately downstream of Fargo-Moorhead metro area)	0 / 0	-1 / -1
Area 4 (downstream of Area 3)	0 / 0	-1 / -1

4.3.4.1 ND35K

The ND35K would have little impact on the current flooding conditions in Area 1; therefore, the residents would not be expected to experience impacts to their Identity as a result of the similar economic growth and vitality as the experience under the without-project conditions. It is expected that they would still band together during a flood fight.

Area 2 would be expected to experience a significant benefit from the ND35K from a reduction in flood risk and the need for flood fight efforts. Although Area 2 would not be expected to change in cultural make-up as a result of implementing the alternative, implementation might reduce the residents' perception that they live in a flood-prone community.

Area 3 would be expected to see an increase in flooding. This induced flooding could increase the residents' perception that they, as rural residents, are not as important as residents of the metro area.

Residents in Area 4 could also experience an impact on their Identity that is associated with increased flooding, but the impact would be minimal and might not be noticeable.

4.3.4.2 The LPP

The LPP would cause significant disruptions to the communities and residents in Area 1. Due to the mitigation measures, a large number of residents might be displaced. This could be particularly detrimental to small towns, such as Oxbow, ND, which prides itself on having a small-town character. Some citizens in Area 1 claim a family heritage in the area longer than 100 years with historic ties to the land. While farming of the land may continue, people would not be allowed to reside in large parts of Area 1. Churches and other social identity groups within Area 1 would be significantly affected as members relocate to other communities.

Area 2 would be expected to experience a significant benefit from the LPP from a reduction in flood risk and the need for flood fight efforts. Although Area 2 would not be expected to change in cultural make-up as a result of implementing the alternative, implementation might reduce the residents' perception that they live in a flood-prone community.

The LPP would have little impact on the current flooding conditions in Areas 3 and 4; therefore, the residents would not be expected to experience impacts to their Identity.

4.3.4.3 FCP

As with the ND35K, the FCP would have little impact on the current flooding conditions in Area 1; therefore, the residents would not be expected to experience impacts to their Identity with respect to the without-project conditions. It is expected that they would still band together during a flood fight.

Area 2 would be expected to experience a significant benefit from the FCP from a reduction in flood risk and the need for flood fight efforts. Although Area 2 would not be expected to change in cultural make-up as a result of implementing the alternative, implementation might reduce the residents' perception that they live in a flood-prone community.

Area 3 would be expected to see an increase in flooding. This induced downstream flooding could increase the residents' perception that they, as rural residents, are not as important as residents of the metro area.

Residents in Area 4 could also experience an impact on their Identity associated with increased flooding, but the impact would be minimal and might not be noticeable.

4.3.4.4 Overview of Identity Social Factor

The ND35K and FCP would not likely affect cultural and community Identity significantly. The LPP could have negative impacts on the Identity of the towns and residents in Area 1, who would be displaced as a result of the mitigation measures and might lose the Identity associated with small towns. The ND35K and FCP could have negative impacts on the Identity of residents located in Areas 3 and 4, the downstream portion subject to increased flood risk. This induced downstream flooding could increase the residents' perception that they, as rural residents, are not as important as residents of the metro area. Area 2 would benefit from all of the alternatives.

4.3.5 Social Vulnerability and Resilience

Although residents of the metro area have not yet lost a flood fight, there is a pronounced threat of a catastrophic flood event for which the community is not prepared. As identified during the baseline assessment, the residents' demonstrated strong desire to fight the flood and protect their

community could also be a benefit in the recovery efforts if a catastrophic flood event occurred. Table D-15 shows the results of the refined evaluation of Social Vulnerability by subarea. An overall evaluation of each alternative follows.

Table D-15: Social Vulnerability and Resiliency Social Factor

Social Factor: Social Vulnerability and Resiliency	Metrics	
ND35K	Residents of	Socially
	D / E	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	0 / 0	0 / 0
Area 2 (Fargo-Moorhead metro area)	0 / 3	0 / 2
Area 3 (immediately downstream of Fargo-Moorhead metro area)	0 / -2	0 / -1
Area 4 (downstream of Area 3)	0 / -1	0 / -1
LPP		
	D / E	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	0 / -2	0 / -1
Area 2 (Fargo-Moorhead metro area)	0 / 3	0 / 2
Area 3 (immediately downstream of Fargo-Moorhead metro area)	0 / 0	/ 0
Area 4 (downstream of Area 3)	0 / 0	0 / 0
FCP		
	D / E	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	0 / 0	0 / 0
Area 2 (Fargo-Moorhead metro area)	0 / 3	0 / 2
Area 3 (immediately downstream of Fargo-Moorhead metro area)	0 / -2	0 / -1
Area 4 (downstream of Area 3)	0 / -1	0 / -1

4.3.5.1 ND35K

The ND35K would have little impact on the current flooding conditions in Area 1; therefore, the residents would not be expected to experience any adverse impacts to Social Vulnerability. It is expected that they would still band together during a flood fight.

Area 2 would be expected to experience a significant benefit from the ND35K from a reduction in flood risk and the need for flood fight efforts. The residents would experience a decrease in Social Vulnerability from a catastrophic flood event, allowing them to focus their efforts on other tasks.

Residents in Area 3 would see an increase in flooding. The induced flooding would expose additional residents to flooding and increase damage to property. The increased depth of flood

waters may overtop existing and emergency flood risk management measures designed to protect the residents.

Residents in Area 4 would also be exposed to increased risk due to induced flooding; however, the impacts would be minimal.

4.3.5.2 LPP

The LPP would cause significant disruptions to the communities and residents in Area 1. A large number of residents might be relocated under this alternative. However, it is anticipated that they would relocate to areas that are not prone to flooding, thus reducing their Social Vulnerability. Residents not relocated would experience greater risk during an event. Area 2 would be expected to experience a significant benefit from the LPP from a reduction in flood risk and the need for flood fight efforts. The residents would experience a decrease in their Social Vulnerability to a catastrophic flood event, allowing them to focus their efforts on other tasks.

The LPP would have little impact on the current flooding conditions in Areas 3 and 4; therefore, the residents would not be expected to experience negative impacts from the alternative.

4.3.5.3 FCP

The FCP would have little impact on the current flooding conditions in Area 1; therefore, the residents would not be expected to experience adverse impacts to Social Vulnerability. It is expected that they would still band together during a flood fight.

Area 2 would be expected to experience a significant benefit from the FCP from a reduction in flood risk and the need for flood fight efforts. The residents would experience a decrease in their Social Vulnerability to a catastrophic flood event, allowing them to focus their efforts on other tasks.

Residents in Area 3 would see an increase in flooding. The induced flooding would expose additional residents to flooding and increase the damage to property. The increased depth of flood waters may overtop existing and emergency flood risk management measures designed to protect residents.

Residents in Area 4 would also be exposed to increased risk due to induced flooding; however the impacts would be minimal.

4.3.5.4 Overview of Social Vulnerability and Resiliency Social Factor

All of the alternatives would significantly reduce the flood risk to the large population in Area 2. However, this benefit comes at a cost to residents outside of the Fargo-Moorhead metro area.

The ND35K and FCP would increase the flood risk to downstream residents in Areas 3 and 4. Area 3 would be particularly affected and could see flood stages increase by 12.5 to 24 inches during a 1-percent-chance event. This induced flooding would cause additional hardship in an area that already has significant risk.

The LPP would increase the flood risk in Area 1; however mitigation measures would relocate residents who would be impacted by induced flooding. The mitigation measure could lower the overall risk to residents by relocating them to areas not prone to flooding. Therefore, it is

anticipated that The LPP would have the greatest benefit to the residents of the overall study area.

4.3.6 Participation

In the metro area, Participation is high. As discussed in the baseline profile, thousands of volunteers turned out during the 2009 flood fight, and local churches provided valuable support during the evacuation. The residents of Fargo, in particular, have great confidence in local officials to keep them out of harm's way. During the initial screening of alternatives, it was thought that Participation would not be significantly impacted by the diversion channels. However, as the impacts of the current alternative are realized by the residents of the study area, Participation has become a greater social factor in the overall OSE evaluation. Table D-16 shows the results of the refined evaluation by subarea. An overall evaluation of each alternative follows.

Table D-16: Participation Social Factor

Social Factor: Participation	Metrics
ND35K	Public
	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	0 / 0
Area 2 (Fargo-Moorhead metro area)	1 / 2
Area 3 (immediately downstream of Fargo-Moorhead metro area)	-1 / -2
Area 4 (downstream of Area 3)	-1 / -1
LPP	
	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	-2 / -2
Area 2 (Fargo-Moorhead metro area)	1 / 2
Area 3 (immediately downstream of Fargo-Moorhead metro area)	0 / 0
Area 4 (downstream of Area 3)	0 / 0
FCP	
	D / E
Area 1 (upstream of the Fargo-Moorhead metro area)	0 / 0
Area 2 (Fargo-Moorhead metro area)	-2 / 2
Area 3 (immediately downstream of Fargo-Moorhead metro area)	-1 / -2
Area 4 (downstream of Area 3)	-1 / 1

4.3.6.1 ND35K

The ND35K would have little impact on the current flooding conditions in Area 1; therefore, it is anticipated that there would be little change in Participation in this area.

Area 2 would significantly benefit from the ND35K, leading to the residents having greater confidence in the agencies and local politician of the area.

The ND35K would negatively impact the residents of Areas 3 and 4. The induced flooding could lead to less confidence in the agencies and local politicians by the residents of these areas and to greater animosity toward the population of the Fargo-Moorhead metro area.

4.3.6.2 LPP

The LPP would negatively affect the residents of Area 1. The induced flooding and relocations could lead to less confidence in the agencies and local officials by the residents of these areas and to greater animosity toward the population of the Fargo-Moorhead metro area.

Area 2 would significantly benefit from the LPP, leading to the residents having greater confidence in the agencies and local officials of the area.

The LPP would have little impact on the current flooding conditions in Areas 3 and 4; therefore, it is anticipated that there would be little change in Participation in this area.

4.3.6.3 FCP

Similar to the ND35K, the FCP would have little impact on the current flooding conditions in Area 1; therefore, it is anticipated that there would be little change in Participation in this area.

Area 2 would significantly benefit from the FCP; however, during public meetings and workshops, many residents in Minnesota expressed a deep dissatisfaction with the FCP. Because the majority of the benefits are on the North Dakota side of the river and the diversion channel would cause land loss and disruptions in Minnesota, they feel that they would be disproportionately burdened by this alternative. This dissatisfaction could lead to loss of confidence in public officials to look after their interests.

The FCP would negatively affect the residents of Areas 3 and 4. The induced flooding could lead to residents of these areas having less confidence in the agencies and local officials and more animosity toward the population of the Fargo-Moorhead metro area.

4.3.6.4 Overview of Participation Social Factor

Because all of the alternatives have impacts on areas outside of the Fargo-Moorhead metro area, it can be expected that residents of these areas would lose confidence in the ability of the agencies and local officials to protect them, resulting in a decrease in Participation.

Following public meetings, it became evident that the residents of Minnesota felt disproportionately affected by the FCP. This resistance could create difficulties implementing this alternative.

Overall, the LPP would negatively affect the fewest residents in the study area, although residents of Area 1 would be expected to lose confidence in public officials due to the induced flooding and relocations.

4.3.7 Leisure and Recreation

In general, area residents are active. The number and variety of activities in the area indicate that the recreational facilities are widely used by residents. During the baseline profile, Leisure and Recreation was not seen as a significant concern of the residents; therefore, it did not weigh as heavily as other social factors. Table D-17 shows the results of the refined evaluation of Leisure and Recreation by subarea. An overall evaluation of each alternative follows.

Table D-17: Leisure and Recreation Social Factor

Social Factor: Leisure and Recreation	Metrics
ND35K	Recreational Activities
	D / E
Upstream Impact Area 1 -- Abercrombie to Oxbow	0 / 0
Metro Impact Area -- Fargo-Moorhead (north of Oxbow to south of Georgetown)	2 / 2
Downstream Impact Area 1 -- Georgetown to Thompson	0 / -1
Downstream Impact Area 2 -- Thompson to the Canadian Border	0 / 0
LPP	
	D / E
Upstream Impact Area 1 -- Abercrombie to Oxbow	1 / -1
Metro Impact Area -- Fargo-Moorhead (north of Oxbow to south of Georgetown)	2 / 2
Downstream Impact Area 1 -- Georgetown to Thompson	0 / 0
Downstream Impact Area 2 -- Thompson to the Canadian Border	0 / 0
FCP	
	D / E
Upstream Impact Area 1 -- Abercrombie to Oxbow	0 / 0
Metro Impact Area -- Fargo-Moorhead (north of Oxbow to south of Georgetown)	3 / 2
Downstream Impact Area 1 -- Georgetown to Thompson	0 / -1
Downstream Impact Area 2 -- Thompson to the Canadian Border	0 / 0

4.3.7.1 ND35K

The ND35K would have little impact on the current flooding conditions in Area 1; therefore, it would not be expected to have an impact on Leisure and Recreation.

Area 2 would see a significant reduction in flood levels from the ND35K. Because fewer efforts would need to be expended for flood fighting, and recreational activities would be accessible during a flood event, residents of Area 2 would see a benefit in Leisure and Recreation.

The ND35K would negatively impact the residents of Areas 3 and 4. The induced flooding could lead to greater flood fight effort and less access to recreational areas during a flood event. Therefore, the ND35K would to lead to less Leisure and Recreation for the residents.

4.3.7.2 LPP

The LPP would negatively affect the residents of Area 1. The induced flooding could lead to greater flood fight effort and less access to recreational areas during a flood event. However, the relocation of residents and the implementation of the storage cell could increase the land area available for recreational purpose. Leisure and Recreation benefits could be experienced by residents of a larger area if the land is converted to passive recreation purposes, such as nature viewing.

Area 2 would see a significant reduction in flood levels from the LPP. Because fewer efforts would need to be expended for flood fighting, and recreational activities would be accessible during an event, residents of Area 2 would see a benefit in Leisure and Recreation.

The LPP would have little impact on the current flooding conditions in Areas 3 and 4; therefore it would not be expected to have an impact to Leisure and Recreation.

4.3.7.3 FCP

Similar to the ND35K, the FCP would have little impact on the current flooding conditions in Area 1; therefore, it would be expected to have no impact on Leisure and Recreation.

Area 2 would see a significant reduction in flood levels from the FCP. Because fewer efforts would need to be expended for flood fighting, and recreational activities would be accessible during an event, residents of Area 2 would see a benefit in Leisure and Recreation.

The FCP would negatively affect the residents of Areas 3 and 4. The induced flooding could lead to greater flood fight effort and less access to recreational areas during a flood event. Therefore, the ND35K would to lead to less Leisure and Recreation for the residents.

4.3.7.4 Overview of Leisure and Recreation Social Factor

All of the alternatives would provide Leisure and Recreation benefits for the residents of Area 2 by reducing efforts needed for flood fight and allowing access to recreation activities during a flood event. The recreation features that are part of each plan will also provide additional recreation opportunities near Area 2. However, residents outside of the Fargo-Moorhead metro area would be negatively affected during a flood event by varying degrees, depending on the alternative.

Due to the mitigation activities, the LPP could increase the amount of land area available for recreational activities. These activities would benefit the residents of a larger area than Area 1. Therefore, the LPP would have the greatest overall benefits to Leisure and Recreation.

4.4 Snmmary of Alternative Analysis

Three with-project alternatives were carried forward for further analysis following the initial screening. All three alternatives involved the construction of a diversion channel that would divert floodwaters around the Fargo-Moorhead metro area. Although the Fargo-Moorhead metro area would significantly benefit from a reduction in flood risk, further analysis revealed that areas outside the metro area would be negatively affected, leading to an expansion of the study area. The OSE analysis of the three alternatives took into consideration additional information on the impacts of the alternatives on the residents of the study area.

During the baseline profile, the Health and Safety and Economic Vitality social factors were identified as most important to the residents of the study area. Therefore, these social factors were weighed more heavily during the analysis of alternatives. Implementation of any of the alternatives would significantly improve both the Health and Safety and Economic Vitality social factors of the residents of Area 2. Preserving the medical infrastructure and economic activities in Area 2 would indirectly benefit the entire study area. However, areas outside of the Fargo-Moorhead metro area would not receive any direct benefits from the alternatives, and depending on the alternative, these areas would be negatively affected due to increased flood risk. It is anticipated that the LPP would have the least negative impacts due to the mitigation measures and a smaller population in the negatively affected area.

The Participation social factor took on greater prominence throughout the study as residents of the study area became more aware of the alternatives and engaged in the process through public meetings and workshops. During these meetings, it became apparent that there was opposition to the FCP from residents in Minnesota, who felt that they were disproportionately bearing the burden of the impacts of the alignment of the diversion channel while receiving relatively few benefits. This opposition could hurt residents' confidence in the ability of resource agencies and local officials to look out for their best interests.

Due to the smaller population and mitigation measures, it is anticipated that the LPP would have the greatest social benefit in the study area as a whole. The only significant negative impacts on social factors was identified for the residents in Area 1, who would experience a significant disruption in the Social Connectedness social factor due to the relocations associated with the mitigation measures. The impacts on this social factor may be lessened by certain types of mitigation measures, such as relocating the town and all of the residents as a whole.

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Attachment 1

Fargo-Moorhead Metro Feasibility Study
Analysis of the potential for loss of life due to flooding
January 5, 2009

5 Pages

Fargo-Moorhead Metro Feasibility Study
Analysis of the potential for loss of life due to flooding
January 5, 2009

Under existing conditions, a potential for the loss of life due to flooding of the Red River of the North exists in the greater Fargo-Moorhead area. An analysis of the magnitude of the potential for loss of life must consider two distinct scenarios:

- An anticipated overtopping of the levees
- An unexpected, sudden levee failure during a flood event

Anticipated Failure

In the case of an anticipated failure, the flood is predicted and an evacuation order is implemented throughout the city. It is assumed that the evacuation order will be given with adequate warning time such that 100% of the population receives and reacts to the warning well before the actual overtopping of the levees. The loss of life potential applies to only the small percentage of the population that makes the decision not to evacuate.

An accounting of the Population at Risk (PAR) for various flood events was performed by taking the water surface profiles (developed with steady flow modeling), and intersecting it with a 30ft x 30ft Digital Elevation Model (DEM) based on the most recent elevation dataset in order to create a depth grid for each flood event across the entire floodplain. These depth grids were then used to extract depths at each of the structures used in the project economic analysis. The structures were then split up into depth classes in order to calculate the PAR and estimated Loss of Life (LOL). Results are shown in Table 1 below.

	# of structures					
			Depth of Flooding			
Event	wet	dry	<2'	2' - 13'	13' - 15'	>15
10yr	300	48580	93	196	3	8
20yr	559	48321	197	339	10	13
50yr	2582	46298	2057	490	13	22
100yr	13439	35441	9086	4254	54	45
200yr	34570	14310	18972	15444	61	93
500yr	41908	6972	9736	31954	78	140

Table 1. Depth of Flooding in Fargo-Moorhead

In order to estimate the population associated with each structure, a gross average population per structure was calculated as the total metro population (202,684 people) was divided by the number of structures (48,880). This resulted in an average population of 4.15 people per structure. This is a gross approximation that did not account for differences in structure occupancy types (e.g. Residential, Commercial, Agricultural, Health), but is considered adequate for this level of analysis.

For the analysis it was assumed that 98% percent of the population would decide to evacuate upon receiving the warning of imminent levee failure. Those who remain are subject to a fatality rate which depends on the depth of flooding at their structure. The fatality rates used are shown in Table 2 below. Based on this information, an estimated LOL was calculated for various flood events.

Fatality Rates for those remaining in their homes	
0' - 2'	**0**
2' - 13'	**0.0002**
13' - 15'	**0.12**
>15'	**0.91**

Table 2. Fatality Rates used in analysis

Event	Estimated PAR	Reamining After Evacuation	Estimated LOL
10yr	858	17	**1**
20yr	1501	30	**1**
50yr	2177	44	**2**
100yr	18050	361	**4**
200yr	64670	1293	**8**
500yr	133403	2668	**12**

Table 3. Estimated Loss of Life in Fargo-Moorhead (anticipated failure w/ evacuation order)

Note that PAR & LOL was determined for various flood events, including smaller, more frequent events. Considering the fact that the area has successfully contained floods in excess of the 100-year magnitude, an evacuation would not likely be ordered for these events. The PAR is calculated for the all events to highlight the increased level of risk for larger floods as compared to smaller floods.

Unexpected Failure

In the case of an unexpected failure, the potential for loss of life is significantly greater than for the case of an anticipated failure. As warning time is greatly diminished, the potential for loss of life applies of the entire population that lives within the ultimate inundated area. An unexpected failure could occur during a relatively frequent event and cause significant LOL due to the lack of adequate warning.

To determine a worst case LOL for unexpected failure, 0% evacuation is assumed and the same fatality rates based on depth at individual structures that were used for the anticipated failure scenario are applied. To assume 0% evacuation is to assume that the entire city floods immediately with no warning and no time to attempt to evacuate. In the event of an actual unexpected failure, the arrival of flood waters at an individual structure will depend on proximity to the breach, the size of the levee breach, available storage capacity of the area behind the levees, and topography of the protected area. In the case of Fargo, a large north-to-south ridge would tend to delay or meter floodwaters that cross it. Embankments at Main Avenue, Interstate 94, Interstate 29, and the railroad lines

would have a similar delaying effect. Therefore the assumption of 0% evacuation (shown below in Table 4) should be considered a maximum Loss of Life event, and an extreme upper bound for a sudden failure scenario.

Event	Estimated PAR	Estimated LOL: Lower Bound 98% Evac **	Estimated LOL: Extreme Upper Bound 0% Evac ***
10yr	858	1	32
20yr	1501	1	54
50yr	2177	2	90
100yr	18050	4	200
200yr	64670	8	394
500yr	133403	12	594

** i.e. Anticipated Failure
*** i.e. Unexpected Failure, no Warning

Table 4. Estimated maximum LOL in Fargo-Moorhead (no warning)

Unexpected Failure: Rate of Rise Analysis

The actual arrival time and rate of rise of floodwaters in the cities of Fargo and Moorhead in the event of an unexpected levee failure would be determined by the actual location of the breach, the river stage, the size of the breach, the formation time of the breach, as well as other factors. An estimate for the rate of rise of floodwaters after a breach was performed using an HEC-RAS unsteady levee breach model with the intent of addressing the worst case in terms of location, flood event, and breach conditions.

The city interior was modeled as a series of storage areas connected by weir flow between the defining ridges within the topography (e.g. I-94, RR embankments, Main Ave). The levee was breached at the highest levee in the area near Island Park. The Red River was assumed to maintain an elevation of 906' through the levee breach model run. The following breach parameters were used: 250' Breach Bottom Width, 0.5 Side Slopes, 880' breach bottom elevation, 2 hour breach formation time.

The levee breach model resulted in a maximum rate of rise in the storage cells near to the breach of approximately 20 feet per hour. Storage cells located further away from the location of the breach experienced a slightly slower rate of rise and experienced some delay in the arrival. Overall, the water rose very fast, with the great majority of the storage cells reaching their maximum water surface elevation of 906' within less than 24 hours. The modeled water level rise for all storage cells are plotted against time and shown in Chart 1.

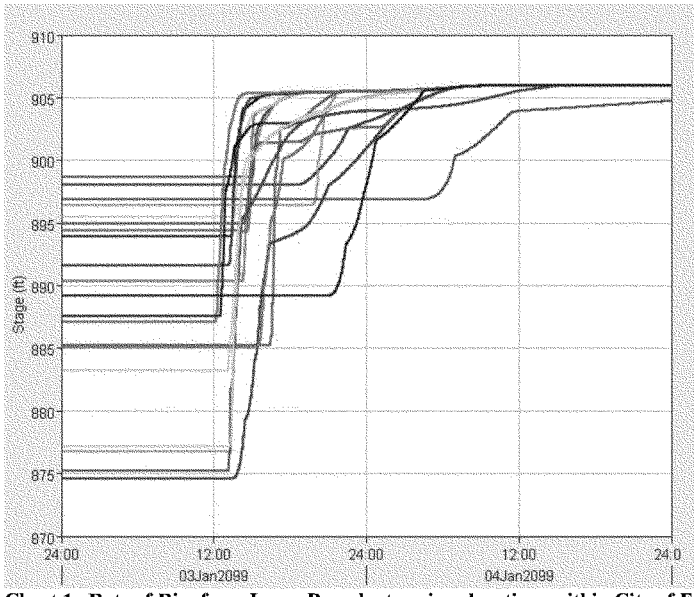

Chart 1. Rate of Rise from Levee Breach at various locations within City of Fargo

Other Considerations

Special consideration should be given to a variety of complex conditions that are likely to surround a sudden failure of the levee system during a large flood event.

- *Active Flood Fight:* It is possible that a large group of emergency flood workers (sandbaggers) could be working near to the area of the breach. Evacuation capacity for a large group may be limited in terms of vehicle rider space (busses are commonly used to shuttle sandbaggers) and available evacuation routes.
- *Extreme Weather Conditions:* Spring-time snow-melt driven flood events are typical for the Fargo-Moorhead Area, and are often accompanied by extreme temperatures and weather conditions. In the event of a levee failure, hypothermia would likely present the primary Loss of Life threat rather than drowning. The fatality rates would likely be higher than those derived from empirical data.
- *Warning Time for a Piping Failure:* During a flood fight, constant levee surveillance is emphasized. It is possible that an active failure would be identified with enough warning time to evacuate much of the population.
- *Topography of the Fargo Floodplain:* The elevation of the floodplain on the North Dakota side of the Red River of the North generally drops off from east to west and slopes away from the river. This topography has to potential to cut off the evacuation routes and leave some individuals who are trying to escape floodwaters stranded in the event of a major flood event or levee breach.
- *Grand Forks, ND Levee Breach, 1997:* An unexpected levee breach due to overtopping was experienced in the Red River Basin in April of 1997 at Grand Forks and East Grand Forks. No evacuation of the population took place until

after the levee had been overtopped, and emergency evacuation required the use of helicopters to carry people that were stranded on isolated high ground. The event resulted in no loss of life.

- *Erodability of Frozen Clay Levees:* Typically, studies that investigate levee breach formation examine non-frozen material. It has been noted that during a spring flood event on the Red River, the existing earthen embankments are typically frozen and are more resistant to erosion than in their unfrozen state. It is possible that if earthen levees were to breach in the Fargo-Moorhead area, the breach opening would be relatively small and reduce the rate of rise of floodwaters in the interior area.
- *Secondary Levees:* During a flood event, it is typical for secondary/back-up levees to be construction in some vulnerable areas to serve to purpose of containing levee a potential levee breach in a smaller area and not allowing floodwaters to spread throughout the urban interior.
- *High Alert of Population:* During an extreme flood event, even if an evacuation order is not issued, the population is typically situational aware of the elevated river stage and the temporary nature of the flood protection system. In the event of a failure, reaction times would likely be faster than for an un-aware population.
- *Continued Floodplain Development:* The Fargo-Moorhead area is experiencing population growth and continued development within the floodplain. This trend increases exposure to the risk to loss of life in the area over time.

With Project Conditions

A feasibility report for Flood Risk Mitigation is being developed for the Fargo-Moorhead metro area which will consider various diversion channel alternatives. The alternatives being considered follow different alignments and have different capacities, but all share a similar design concept of a gated control structure upstream of the cities that would hold water levels at similar to existing conditions upstream and reduce flood flows through town while passing flood flows into the diversion channel. The designs also include a tie back levee upstream of the project area.

The diversion channel will eliminate the need to construct emergency levees through the urban area for all but the extreme flood events (depending on the size of the diversion selected), and thus greatly diminish the risk of loss of life due to a failure of the urban levees.

With the construction of a diversion channel the potential for failure is still present, but the probability of failure is greatly reduced as a new system would consist of well designed, engineered features as opposed to the temporary nature of the current flood fight scheme.

Potential failure modes of the feasibility study alternatives include structural failure of the control structure, seepage and piping at the tie-back levee, overtopping of the tie-back levee, seepage and piping of the diversion channel containment levee, and overtopping of diversion channel containment levee. In general, these failure modes all would lead to inundation of primarily rural areas with very low population densities as compared with to the areas threatened by the failure of the existing system.

Attachment 2

Fargo –Moorhead Metro Feasibility Study
Levee Breach and Loss of Life Analysis
Draft Report – June 29 2011

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Draft Report (5 pages)
Plates
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Plate 2: Loss of Life Results, 100yr Breach – Lower Bounds, LPP 100yr Levee Breach Depths
Plate 3: Loss of Life Results, 100yr Breach – Lower Bounds, LPP 100yr Warning Times
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Fargo –Moorhead Metro Feasibility Study
Levee Breach and Loss of Life Analysis
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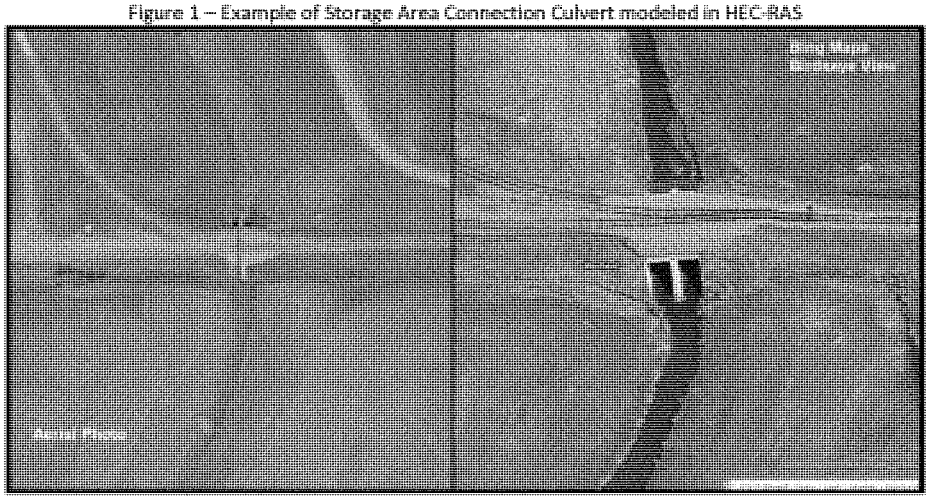
Hydraulic Modeling

An unsteady HEC-RAS model was provided by the St. Paul District for the Locally Preferred Plan (LPP), which includes the Red River Diversion through Fargo, North Dakota. Part of the Scope of Work included splitting two storage areas into several, to better model the flow of water through the protected area. The St. Louis District split these areas into smaller storage areas, and connected them with new storage area connections in the model. The HEC-GeoRAS toolbar for ArcGIS 9.3 was utilized to complete this work. At the request of the St. Paul District, additional storage areas were added to the model, along the Red River in Moorhead, Minnesota. Storage Area Connections and Lateral Structures were added in this area as well.

In many locations, there are culverts that run underneath the roads that separate the storage areas. In order to correctly model the flow of water between the storage areas, these connections were placed in the HEC-RAS model. Aerial photography, provided by the St. Paul District, was used to identify the locations of culverts along the storage area connection lines. The Birdseye View option on the Bing Maps website was also used to confirm the location and shape/size of the culverts. If the culvert was visible but not measureable, the shape seen on the maps was used and dimensions were estimated using engineering judgment. If the culvert was seen but the shape was unknown, the dimensions were assumed. This 'default culvert' was a concrete box culvert, 2.9' rise by 2.9' span. This matches the assumptions used in the rest of the model when survey information was not available. Figure 1 shows an example of a culvert that was located using aerial photography (on the left) and dimensioned using Bing Maps (on the right).

Figure 1 – Example of Storage Area Connection Culvert modeled in HEC-RAS



The following plans were run: 10 year; 10 year with levee breach; 100 year; 100 year with levee breach; 2 x 500 year; and 2 x 500 year with levee breach. The levee breach was identical for all of the runs. The base width of the breach was 500', side slopes of 0 (vertical walls), invert elevation of 908', and formation time of 2 hours. The location of the levee breach was on a storage area connection between storage area "Area 1" and storage area "WRSA329" and the breach occurred at the peak water surface elevation of the flood. It's very likely that emergency levees would be constructed through the projected area for the 2 x 500 year event, which would increase loss of life potential, but in order to see the loss of life effect due to the staging area alone emergency levees were not included as part of this analysis.

The model output was generated using RAS Mapper, the new GIS tool built in to the HEC-RAS program. RAS Mapper allows the user to generate depth grids and arrival time grids for all of the executed plans in the project. Depth grids show how deep the flooding will be in the study area, and the arrival time grids show when the flooding arrives (when the depth of flooding reaches 2' at a given location).

Loss of Life Modeling

To model the consequences for all of the plans, the HEC-FIA program was used. HEC-FIA is typically used to compute the economic consequences (structural damages, agricultural damages, etc) of a specific event. With population data, it can also compute loss of life. This is especially critical when dealing with scenarios like levee breaches. Since the economic consequences have been previously modeled using other software, this work focused on the loss of life computations using the HEC-FIA program.

The St. Paul District provided a structure inventory, exported from the HEC-FDA model used previously in this study, which included approximately 50,000 structures. The inventory included data such as structure coordinates, occupancy type, and population (both day and night). A hazard area polygon was created that shows areas inundated to at least 2' of depth. This polygon identifies the areas at risk during a flood event. HEC-FIA uses the hazard area polygons, along with the depth grids and arrival time grids to determine loss of life for each of the simulations.

Three different groups of parameters were used to estimate loss of life for the Levee Breach runs. They appear in Table 1 below. The base estimate of loss of life uses reasonable estimates for the warning issuance, mobilization curve, and evacuation velocity. A sensitivity analysis was performed to provide an extreme upper and lower bound for the loss of life estimate.

Table 1 – Parameters Used in HEC-FIA for Loss of Life Simulation for Levee Breach Runs

	Base Estimate	**Extreme Lower Bound**	**Extreme Upper Bound**
Warning System	EBS, Sirens, Auto-Dial Telephones	EBS, Sirens, Auto-Dial Telephones	EBS
Mobilization Curve	Above Average (ultimate evacation = 100%)	Above Average (ultimate evacation = 100%)	Below Average (ultimate evacation = 93%)
Evacuation Velocity	10 mph	15 mph	5 mph
Warning Issuance Time	Initiation of Breach	24 hours prior to Initiation of Breach	4 hours after Initiation of Breach
Fatality Rates	FIA Defaults 0.0002/0.12/0.91	Defaults -20% 0.00016/0.096/0.728	Defaults +20% 0.00024/0.144/1.092
Fatality Zone Depths	FIA Defaults (1-story) 2'/13'/15'	Defaults +1' 2'/14'/16'	Defaults -1' 2'/12'/14'

Breach Initiation times were estimated using the arrival time grids for the various plans. The HEC-RAS model used 12 hour intervals for the output, which decreases the accuracy of the breach initiation time. In the future, an alternative to using the arrival time grids would be to decrease the intervals for the HEC-RAS output so that a better estimate of breach initiation time can be taken from the model.

A Double-Warning Time was used for all of the breach runs. This allows the user to simulate different warning times for structures based on their location, in relation to the inundation areas. It was assumed that structures experiencing flooding during a normal event (100yr for example) would be notified well in advance of the levee breach and would have ample time to evacuate. The initial warning time for this zone was set at the start of the simulation (15 March 2006, 1200). The other structures that would experience flooding due to the levee breach alone would be warned according to the three different scenarios listed in Table 1 on the previous page. This allows us to determine the loss of life that is directly attributed to the levee breach. Due to the location of some structures near the rivers, there are some areas that do show some loss of life regardless of the double-warning time.

When analyzing the loss of life results from the HEC-FIA simulations, it is important to know that the total life loss is a sum of all of the fatalities for the entire structure inventory. Many times, the values for life loss for an individual structure are very small, say 0.00001 people. This is due to the algorithms that calculate the life loss based on depth of water at the structure, warning time, and so on. When looking at the plates that show where the loss of life occurred, it is important to know that the number of structures that experience life loss greater than 0 will be larger than the totals shown in Table 2 in this report. The percentages shown on the plates represent the percentage of people at risk in each individual structure. The plates showing the location of the life loss are important, because they represent the areas that are most prone to life loss during the individual flooding events.

Table 2 shows the life loss results from the HEC-FIA simulations. The 10yr and 100yr non-breach runs were not simulated since the LPP is designed for these events. Population at Risk (PAR) is the number of

people that are potentially at risk from the flood inundation. In general, Life Loss represents the total number of fatalities from people who choose not to leave, have not been warned to leave in time, or are caught evacuating and cannot reach high ground before the floodwaters arrive. The results are also broken down into Day/Night. This is important when dealing with a mixture of occupancy types. Industrial/Commercial buildings tend to have a higher population during the day, while Residential buildings tend to have a higher population during the night.

Results from the HEC-FIA modeling for the 100yr Levee Breach can be seen in the plates following this report.

Plate 1 shows the depth grid that was generated by HEC-RAS. The range of depths was chosen to give a general sense of the threshold depths required to cause life loss in a one story.

Plates 2 and 3 show the results for the Life Loss simulation for the 100yr Breach run with the Extreme Lower Bounds warning scenario. Plate 2 shows the results overlaid on the depth grid, while Plate 3 shows the results overlaid on the double-warning polygon. The areas in pink were warned at the start of the simulation, while the areas in green were warned 24 hours prior to the levee breach.

Plates 4 and 5 show the results for the Life Loss simulation for the 100yr Breach run with the Base Estimate warning scenario. Plate 4 shows the results overlaid on the depth grid, while Plate 5 shows the results overlaid on the double-warning polygon. The areas in pink were warned at the start of the simulation, while the areas in green were warned at the start of the levee breach.

Plates 6 and 7 show the results for the Life Loss simulation for the 100yr Breach run with the Extreme Upper Bounds warning scenario. Plate 6 shows the results overlaid on the depth grid, while Plate 7 shows the results overlaid on the double-warning polygon. The areas in pink were warned at the start of the simulation, while the areas in green were warned 4 hours after the start of the levee breach.

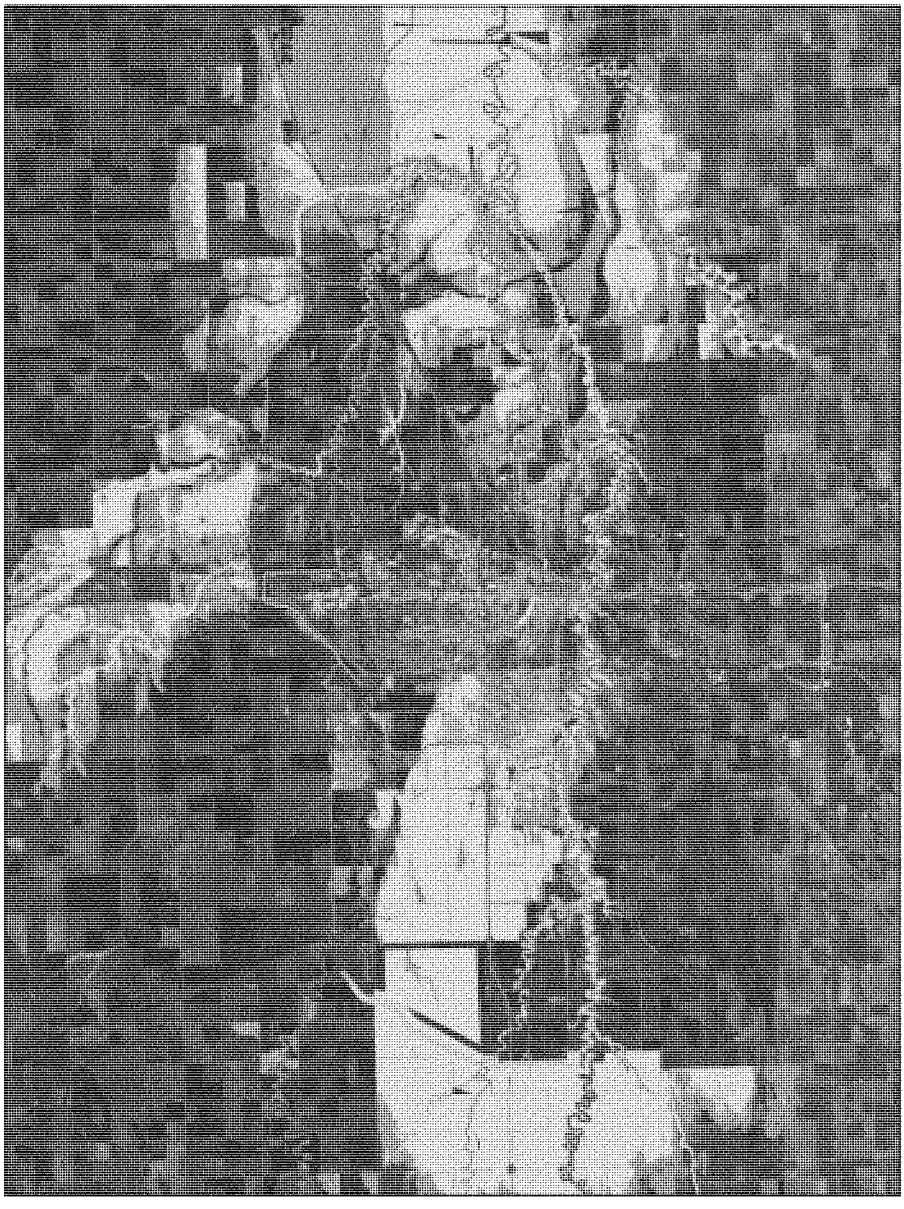
Table 2 – Loss of Life Results for LPP from HEC-FIA

Plan	Warning Scenario	Day		Night	
		PAR	Life Loss	PAR	Life Loss
10yr Breach	Extreme Lower	863	0	686	0
	Base Estimate	863	0	686	0
	Extreme Upper	863	0	686	0
100yr Breach	Extreme Lower	18976	2	24596	0
	Base Estimate	18976	2	24596	1
	Extreme Upper	18976	31	24596	9
500x2	Extreme Lower	20877	0	25040	0
	Base Estimate	20877	0	25040	0
	Extreme Upper	20877	9	25040	6
500x2 Breach	Extreme Lower	74694	5	76523	3
	Base Estimate	74694	7	76523	4
	Extreme Upper	74694	350	76523	241

Existing conditions are also being analyzed as part of this study, but the results are not available at the time of this draft report. An earlier Loss of Life analysis performed in 2009 for existing conditions estimated life loss at 1, 4, and 12 for the 10yr, 100yr, and 500yr events, respectively. These numbers are based on assumptions similar to the Base Estimate warning scenario.

Conclusions

The results from the Loss of Life simulation performed with the HEC-FIA software package gives the public an idea of the potential danger zones during a levee breach. It is important to remember that, while the software shows a life loss of 31 people during the day for the 100yr Breach, Extreme Upper warning scenario, those fatalities are spread across approximately 2700 structures in the study area. The results are useful to both the agencies responsible for emergency response during a flood event and the public living and working in the area.



0 ft - 2 ft

2 ft - 15 ft

15 ft - 24 ft

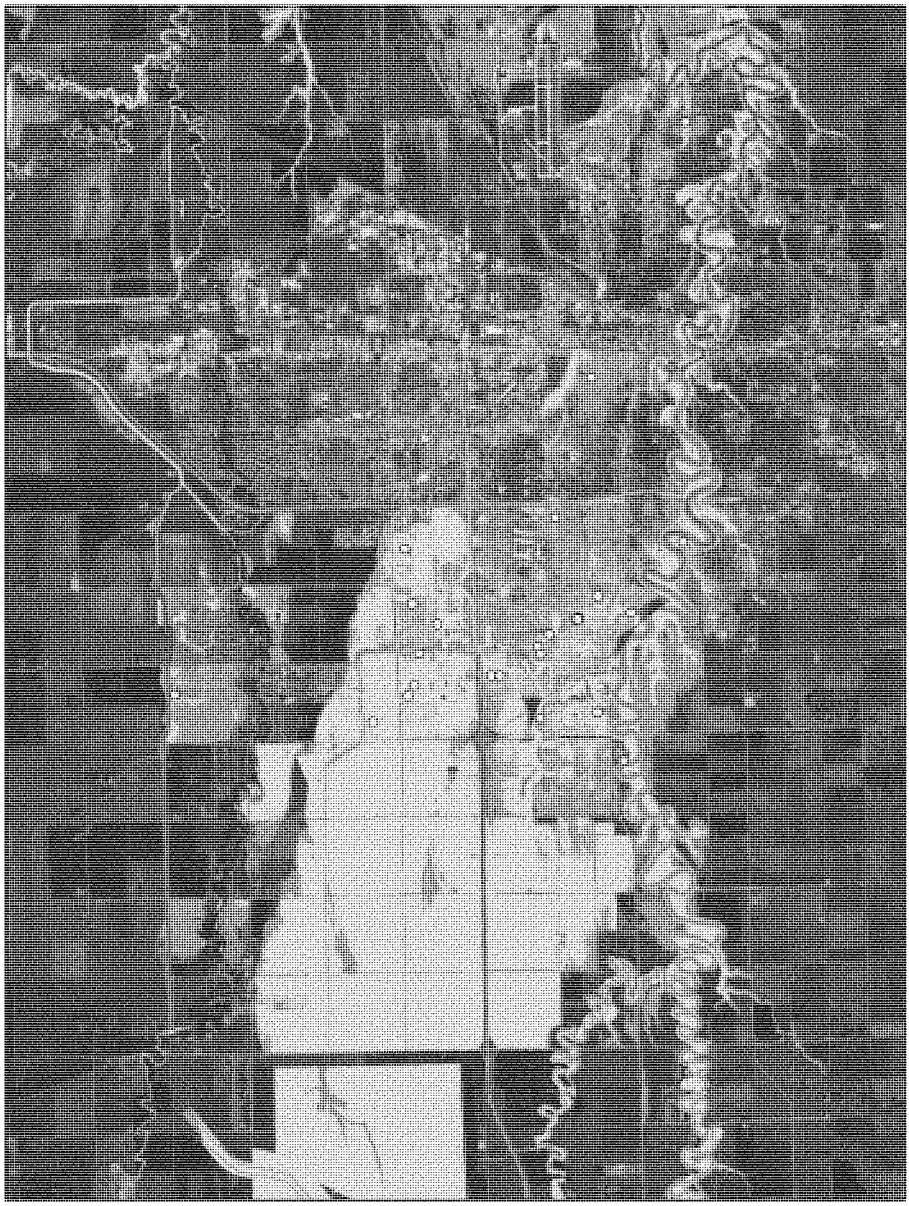
> 24 ft

HEC-RAS Modeling
100yr Breach - Depth Grid

N

0 10,000 20,000 Feet

Plate 1



100yr Breach Lower Bounds Loss of Life

- 0% - 0.5%
- 0.5% - 1%
- 1% - 3%
- 3% - 5%
- 5% - 10%
- 10% - 50%
- 50% - 100%

Loss of Life Results
100yr Breach - Lower Bounds

as a percentage of population in each individual structure

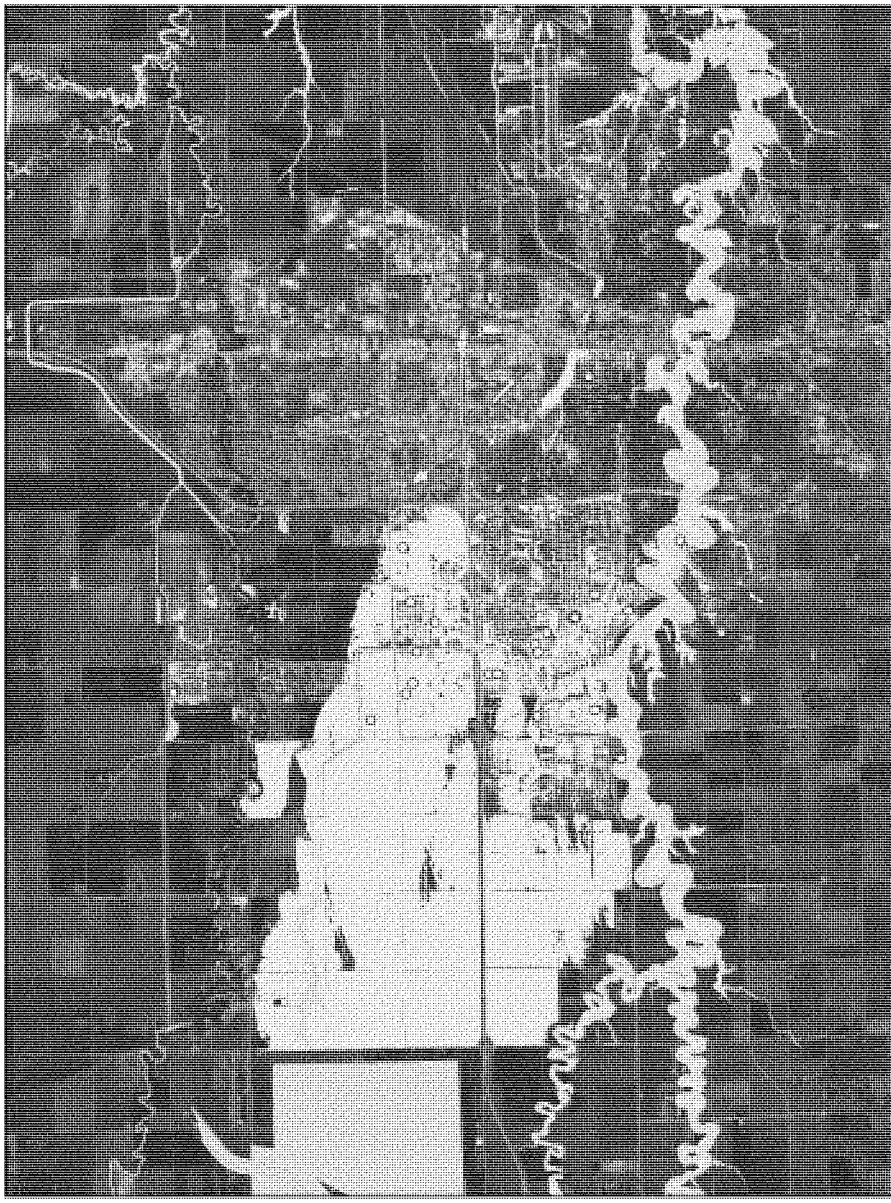
LPP 100yr Levee Breach Depths

- 0 ft - 2 ft
- 2 ft - 15 ft
- 15 ft - 24 ft
- > 24 ft

N

0 5,000 10,000 Feet

Plate 2



100yr Breach Lower Bounds Loss of Life

- 0% - 0.5%
- 0.5% - 1%
- 1% - 3%
- 3% - 5%
- 5% - 10%
- 10% - 50%
- 50% - 100%

Loss of Life Results
100yr Breach - Lower Bounds

as a percentage of population in each individual structure

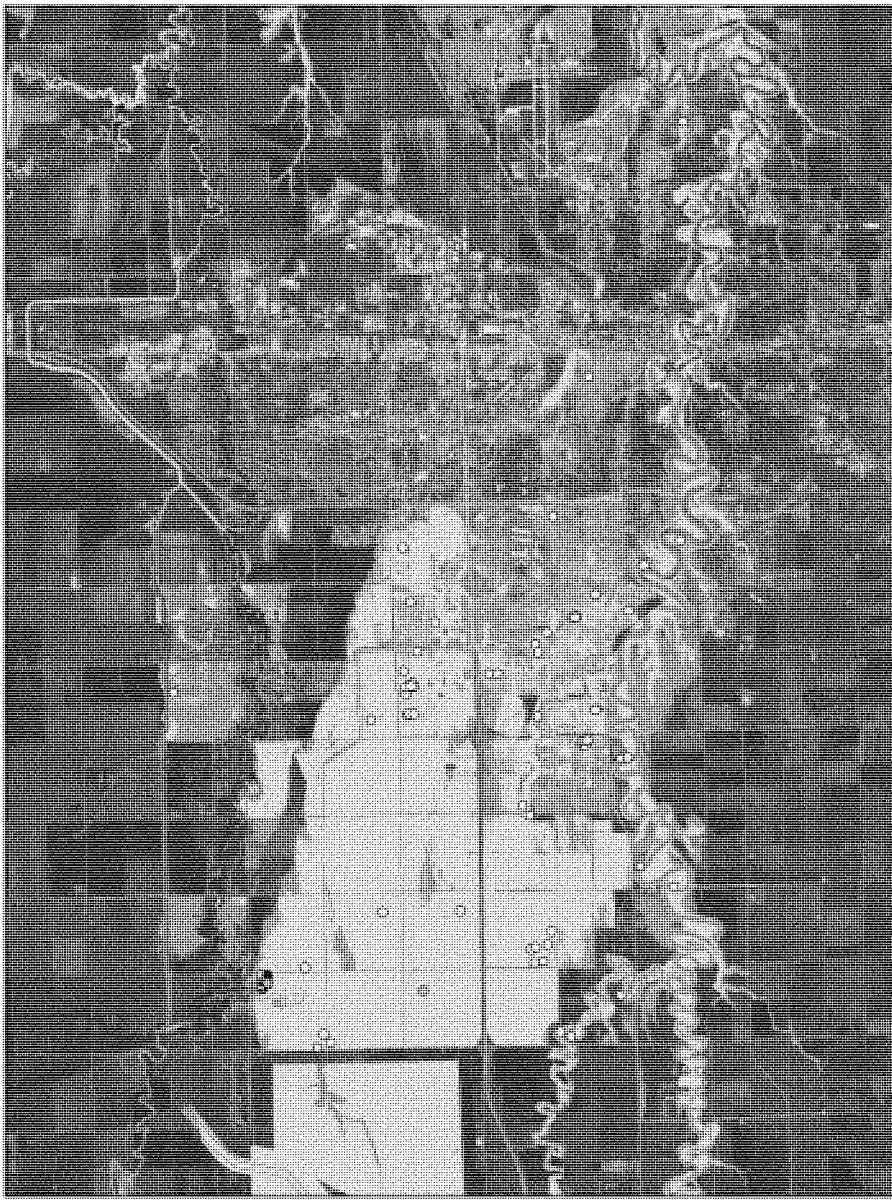
LPP 100yr Warning Times

- 24 Hours Prior to Time of Breach
- Early Warning

N

0 5,000 10,000 Feet

Plate 3



100yr Breach Base Estimate Loss of Life

- 0% - 0.5%
- 0.5% - 1%
- 1% - 3%
- 3% - 5%
- 5% - 10%
- 10% - 50%
- 50% - 100%

Loss of Life Results
100yr Breach - Base Estimate

as a percentage of population in each individual structure

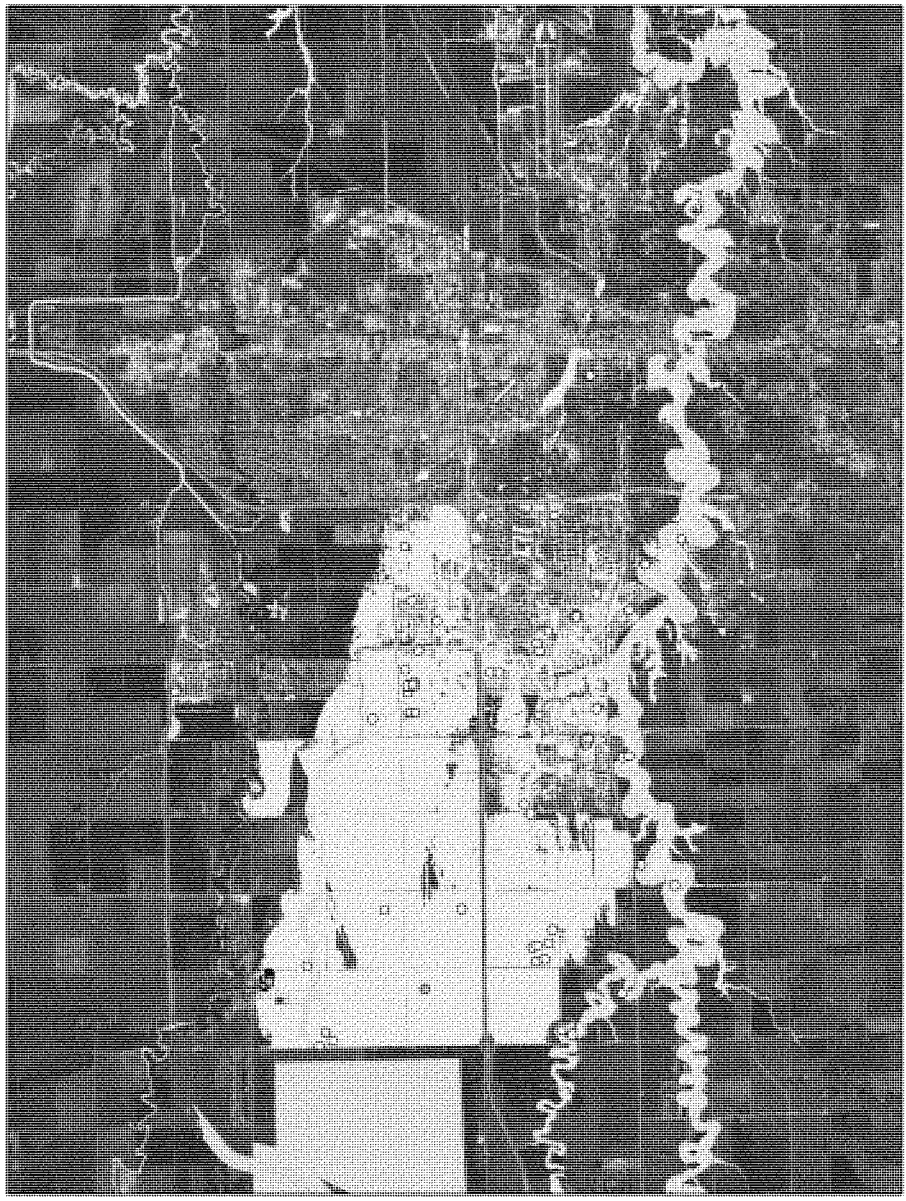
LPP 100yr Levee Breach Depths

- 0 ft - 2 ft
- 2 ft - 15 ft
- 15 ft - 24 ft
- > 24 ft

N

0 5,000 10,000 Feet

Plate 4



100yr Breach Base Estimate Loss of Life

- 0% - 0.5%
- 0.5% - 1%
- 1% - 3%
- 3% - 5%
- 5% - 10%
- 10% - 50%
- 50% - 100%

Loss of Life Results
100yr Breach - Base Estimate

as a percentage of population in each individual structure

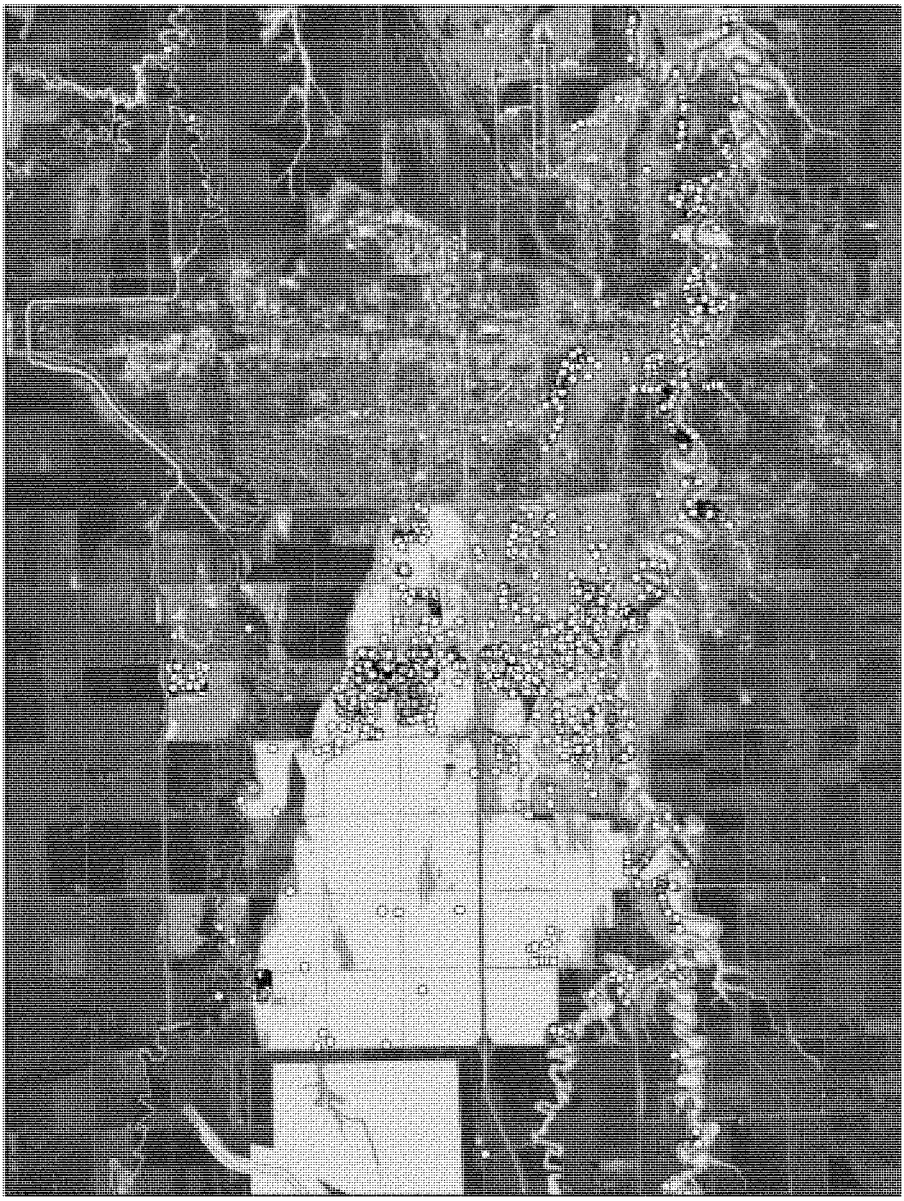
LPP 100yr Warning Times

- At Time of Breach
- Early Warning

N

0 5,000 10,000 Feet

Plate 5



100yr Breach Upper Bounds Loss of Life

- 0% - 0.5%
- 0.5% - 1%
- 1% - 3%
- 3% - 5%
- 5% - 10%
- 10% - 50%
- 50% - 100%

Loss of Life Results
100yr Breach - Upper Bounds

as a percentage of population in each individual structure

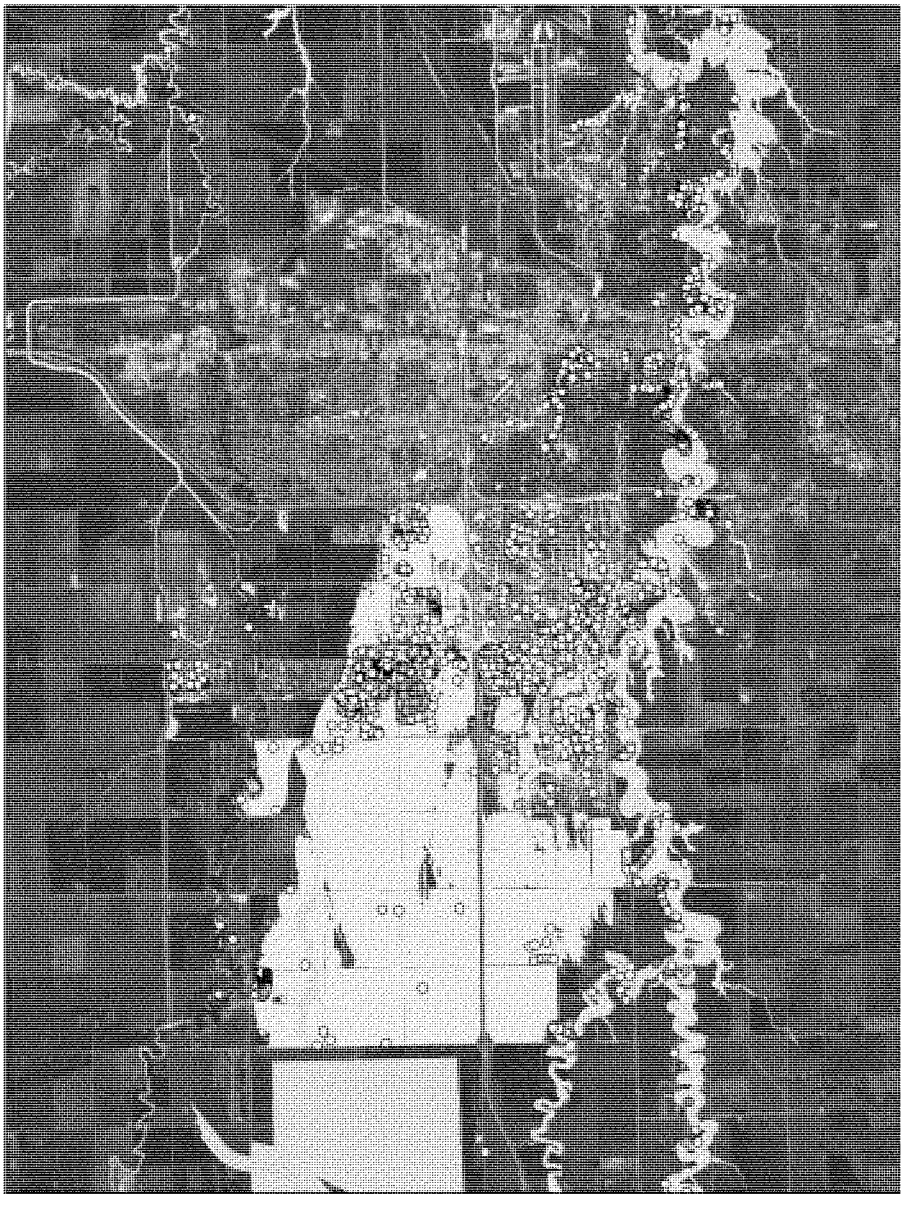
LPP 100yr Levee Breach Depths

- 0 ft - 2 ft
- 2 ft - 15 ft
- 15 ft - 24 ft
- > 24 ft

N

0 5,000 10,000 Feet

Plate 6



100yr Breach Upper Bounds Loss of Life

- 0% - 0.5%
- 0.5% - 1%
- 1% - 3%
- 3% - 5%
- 5% - 10%
- 10% - 50%
- 50% - 100%

Loss of Life Results
100yr Breach - Upper Bounds

as a percentage of population in each individual structure

LPP 100yr Warning Times

- 4 Hours After Time of Breach
- Early Warning

N

0 5,000 10,000 Feet

Plate 7

Appendix E
Cultural Resources

Fargo-Moorhead Metropolitan Area Flood Risk Management

Final Feasibility Report and Environmental Impact Statement

July 2011

US Army Corps of Engineers ®

Prepared by:
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USACE-MVP-0000087999

1.0 APPENDIX E – CULTURAL RESOURCES

1.1 INTRODUCTION

This appendix contains existing data on recorded prehistoric and historic archeological sites and historic standing structures; leads to such sites and structures by informants or in written documents which have not been field verified by a professional archeologist or historian; and previous cultural resources investigations in the project area; and is based on information contained in the files at the Historic Preservation Division, State Historical Society of North Dakota, Bismarck, through May 1997 (Ketz and Schmidt 1997); in various cultural resources investigation reports at the Corps of Engineers' St. Paul District office; in the Southern Red River and Sheyenne River Study Units chapters of the *North Dakota Comprehensive Plan for Historic Preservation: Archeological Component* (SHSND 2008); and in the archeological site, standing structure, and report files at the State Historic Preservation Office, Minnesota Historical Society, St. Paul. In addition, the National Register of Historic Places (National Register) was most recently checked on March 8, 2011. This appendix covers all of the alternatives analyzed in Feasibility Phase 2, Screening #1 (see Section 3.4 of the main report). The various alternatives are depicted in Figures 1, 2 and 3 in this Appendix. The North Dakota Mini-Diversion Alignment extends from the Maple River to the outlet at the Red River along the same alignment as the North Dakota East and West Diversion alternatives.

The North Dakota East Diversion and associated tie-back levee has since been renamed the ND35K Plan. The Minnesota Short Diversion and its associated features has since been redesignated the Federally Comparable Plan (FCP). A modified North Dakota East Diversion has become the Locally Preferred Plan (LPP), with modifications including a shift in the northwest part of the diversion alignment to avoid Ditch 13, an extension of the tie-back levee alignment in Minnesota, and the addition of an upstream storage area (Storage Area #1) and its associated tie-back levee alignment in North Dakota. Archeological and architectural site information from a partially completed Phase I survey of the North Dakota East (ND35K and LPP) and Minnesota Short (FCP) diversion alignments in 2010 have been added to this Appendix from the Draft EIS version, as have sections on the LPP and the FCP.

1.2 KNOWN CULTURAL RESOURCES

1.2.1 Moorhead, Minnesota Levee Alignment

There are two prehistoric archeological sites (21CY48, 21CY68), four historic archeological sites and two site leads (21CY5, 21CY66, 21CY67, 21CY71, 21CYg, 21CYr), and sixteen historic standing structures (CY-MHC-002, CY-MHC-005, CY-MHC-011, CY-MHC-012, CY-MHC-024, CY-MHC-025, CY-MHC-030, CY-MHC-055, CY-MHC-059, CY-MHC-060, CY-MHC-061, CY-MHC-062, CY-MHC-064, CY-MHC-066, CY-MHC-068, CY-OAK-001) within one-sixteenth mile (330 feet/100 meters) of the levee centerline (Table E-1.) The John Bergquist House (1870) at 719

10th Avenue North, the Fairmont Creamery Company at 801 2nd Avenue North, and the Randolph M. Probstfield House on County Road 96 are listed on the National Register of Historic Places. The Kassenborg Block (1898) on Main Avenue, the Red River Bridge on Main Avenue, and the Douglas House (1872) at 111 4th Street South, have been determined eligible for listing on the National Register. Prehistoric archeological sites 21CY48 and 21CY68, three historic archeological sites (21CY71-Harris Homestead, 21CYg-Probstfield Post Office, 21CYr-Red River Trail), and architectural site CY-MHC-064 (Moorhead Country Club (1938) at 11th Street and 18th Avenue North) are crossed by the levee centerline. The Red River Trail (21CYr) is crossed six times by this levee alignment.

1.2.2 Fargo, North Dakota Levee Alignment

There are two prehistoric archeological sites and one prehistoric isolated find (32CSX196, 32CS4442, 32CS4443), four historic archeological sites and one site lead (32CSX30, 32CS142, 32CS4671, 32CS4673, 32CS5087), three historic standing structures (32CS4474, 32CS5083, and the Dibley House), and one historic district within one-sixteenth mile (330 feet/100 meters) of the levee centerline (Table E-2). The Dibley House at 331 8th Avenue South and the North Side Builder's Residential Historic District are listed on the National Register. This historic district is located between the Ben Franklin School area on the west and the El Zagal Golf Course on the east, and extends south to 12th Avenue North between 4th Street North and 1st Street North. The alignment crosses through the historic district near the golf course. Prehistoric archeological sites 32CSX196, 32CS4442, and 32CS4443, and historic archeological site 32CS4673 are also crossed by the levee centerline.

1.2.3 North Dakota West Diversion Alignment

There are four prehistoric archeological sites (32CS42, 32CS43, 32CS44, 32CS201), two historic archeological site leads (32CSX35, 32CSX238b), and four historic standing structures (32CS4461, 32CS4462, 32CS5090, 32CS5091) within one-half mile either side of the diversion centerline (Table E-3). No National Register listed historic properties are present along this alignment. The Sheyenne River Bridge (32CS4462), located where an east-west section line road crosses that river in Warren Township, has been determined eligible to the National Register. None of these ten sites or structures is crossed by the diversion centerline.

1.2.4 North Dakota East Diversion Alignment (part of the ND35K Plan)

There are four prehistoric archeological sites (32CS42, 32CS43, 32CS44, 32CS201), one historic archeological site lead (32CSX238b), and four historic standing structures (32CS4461, 32CS4462, 32CS5090, 32CS5091) within one-half mile either side of the diversion centerline (Table E-4). No National Register listed historic properties are present along this alignment. The Sheyenne River Bridge (32CS4462), located where an east-west section line road crosses that river in Warren Township, has been determined eligible to the National Register. Only prehistoric archeological site 32CS42 is crossed

by the diversion centerline and that site was determined not eligible to the National Register in 1988 in connection with the Horace-West Fargo Flood Control Project.

A partial survey of this alignment in 2010 recorded six historic artifact scatters (FM1-2, FM2-2, FM2-5, FM2-6, FM2-7, FM4-7), one isolated prehistoric projectile point (FM2-8), 11 historic farmsteads (ND-1 to ND-7, ND-10, ND12 to ND-14), 1 historic railroad crossing (ND-8), 1 historic house (ND-9), 1 historic bridge (ND-15), 1 collapsed granary (ND-16), and 1 collapsed house (ND-17). Of these, two farmsteads (ND-5 and ND-14) and one historic artifact scatter (FM2-2) are recommended eligible to the National Register; six farmsteads (ND-3, ND-4, ND-7, ND-10, ND-12 and ND-13) have undetermined eligibility; and the remaining eight structures, five sites and one isolated find are recommended not eligible to the National Register.

1.2.5 North Dakota Mini-Diversion Alignment (Maple River to Red River outlet)

There are two prehistoric archeological sites (32CS43, 32CS201), one historic archeological site lead (32CSX238b), and one historic standing structure (32CS4461) within one-half mile either side of the diversion centerline (Table E-5). No National Register listed historic properties are present along this alignment. None of these three sites and structures is crossed by the diversion centerline.

1.2.6 North Dakota East and West Diversions Tie-Back Levee Alignment (part of the ND35K Plan)

There is one historic archeological site lead (21CYr) within one-sixteenth mile (330 feet/100 meters) of the tie-back levee centerline (Table E-6). No National Register listed historic properties are present along this alignment. The Red River Trail (21CYr) is crossed once by this levee alignment.

A partial survey of this alignment in 2010 recorded three isolated historic artifacts (FM3-3, FM3-4, FM3-6), one historic artifact scatter (FM3-2), and one railroad track segment (FM3-5). The railroad track segment (FM3-5) is recommended as eligible to the National Register, while the remaining historic site and three isolated finds are recommended as not eligible.

1.2.7 Minnesota Long Diversion Alignment

There are three prehistoric archeological sites (21CY3, 21CY19, 21CY55), three historic archeological site leads (21CYk, 21CYl, 21CYr), and five historic standing structures (CY-DWC-003, CY-HCR-002, CY-KRG-001, CY-KRG-004, CY-KRG-005) within one-half mile either side of the diversion centerline (Table E-7). The John Olness House (CY-KRG-001) on U.S. Highway 75 at Kragnes is listed on the National Register. The historic ghost towns of Ruthruff (21CYk) and Lafayette (21CYl[el]), and the Red River Trail (21CYr) are crossed by the diversion centerline; the latter oxcart trail is crossed three times.

1.2.8 Minnesota Long Diversion Tie-Back Levee Alignment

There is one historic archeological site (32CS5079) within one-sixteenth mile (330 feet/100 meters) of the tie-back levee centerline (Table E-8). No National Register listed historic properties are present along this alignment. No recorded sites or structures are crossed by the levee centerline.

1.2.9 Minnesota Short Diversion Alignment (part of the FCP)

There are three prehistoric archeological sites (21CY3, 21CY19, 21CY55), four historic archeological site leads (21CYk, 21CYl, 21CYo, 21CYr), and four historic standing structures (CY-DWC-003, CY-KRG-001, CY-KRG-004, CY-KRG-005) within one-half mile either side of the diversion centerline (Table E-9). The John Olness House (CY-KRG-001) on U.S. Highway 75 at Kragnes is listed on the National Register. The historic ghost towns of Ruthruff (21CYk) and Lafayette (21CYl[el]), and the Red River Trail (21CYr) are crossed by the diversion centerline; the latter oxcart trail is crossed three times.

A partial survey of this alignment in 2010 recorded four historic artifact scatters (FM1-1, FM2-1, FM2-9, FM2-11), a former school site (FM2-4), two isolated prehistoric stone flakes (FM2-3, FM2-12), one isolated prehistoric projectile point (FM4-6), 11 historic farmsteads (MN-1 to MN-6, MN-13 to MN-17), five historic houses (MN-7, MN-9 to MN-12), and one historic railroad (MN-8). Of these, one historic farmstead (MN-14) and the former school site (FM2-4) are recommended as eligible to the National Register; one farmstead (MN-6) and the railroad (MN-8) have undetermined eligibility; and the remaining four sites, 14 structures, and three isolated finds are recommended as not eligible to the National Register.

1.2.10 Minnesota Short Diversion Red River Breakout Channel Alignment (part of the FCP)

There are two historic archeological site leads (21CYo, 21CYr) within one-quarter mile either side of the breakout channel centerline (Table E-10). No National Register listed historic properties are present along this alignment. The historic ghost town of Burlington (21CYo) is crossed by the breakout channel centerline. The breakout channel centerline follows the Red River Trail (21CYr) for roughly one mile and crosses it farther south as well.

A partial survey of this alignment in 2010 recorded one historic artifact scatter (FM4-4) and two historic farmsteads (MN-18, MN-19). One farmstead (MN-19) is recommended as eligible to the National Register and the other farmstead and the historic artifact scatter are recommended as not eligible to the National Register.

1.2.11 Minnesota Short Diversion Tie-Back Levee Alignment (part of the FCP)

There is one historic archeological site lead (32CSX1) within one-sixteenth mile (330 feet/100 meters) of the tie-back levee centerline (Table E-11). No National Register listed historic properties are present along this alignment. The Holy Cross Mission site (32CSX1) is crossed by the tie-back levee centerline.

A partial survey of this alignment in 2010 recorded prehistoric campsite and historic artifact scatter site (FM4-3) at the control structure location and tie-back levee alignment on the east side of the Red River. This site is recommended as eligible to the National Register. The Meridian Highway site (32CS2657) and one historic farmstead (ND-11) are crossed by the tieback levee alignment in North Dakota. Both the highway site and the farmstead are recommended as not eligible to the National Register.

1.2.12 Minnesota Short Diversion Wild Rice River Breakout Channel Alignment (part of the FCP)

There are no recorded architectural sites for this alignment (Table E-12). No National Register listed or eligible properties are present along this alignment.

A partial survey of this alignment in 2010 recorded one historic artifact scatter (FM-A) at this location. This historic archeological site is recommended as eligible to the National Register.

1.2.13 FCP

The FCP is the same as the Minnesota Short Diversion Alignment with Red River Breakout Channel, Tie-Back Levee, and Wild Rice River Breakout Channel alignments (refer to paragraphs 1.2.9 through 1.2.12 above and tables E-9 through E-12 below).

1.2.14 ND35K Plan

The ND35K Plan is the same as the North Dakota East Diversion Alignment and its associated tie-back levee alignment (refer to paragraphs 1.2.4 and 1.2.6 above and Tables E-4 and E-6 below).

1.2.15 LPP (Modified North Dakota East Diversion with Storage Area and Two Tie-Back Levee Alignments)

There are five prehistoric archeological sites (32CS42, 32CS43, 32CS44, 32CS201, 32CS4563), one prehistoric isolated find (FM2-8), nine historic archeological sites (32CS5078, FM1-2, FM2-2, FM2-5, FM2-6, FM2-7, FM3-2, FM4-1, FM4-7), three historic isolated finds (FM3-3, FM3-4, FM3-6), four historic archeological site leads (32CSX33, 32CSX131, 32CSX238b, 21CYr), one church (32CS114), two bridges (32CS4462, ND-15), 13 historic farmsteads (ND-1 to ND-7, ND-10 to ND-14), two railroad segments (FM3-5, ND-8), one historic house (ND-9), one collapsed granary

(ND-16), and one collapsed house (ND-17) within one-half mile either side of the diversion centerline or within 100 meters/330 feet of either side of the tie-back levee centerlines or in Storage Area #1 or within 100 meters/330 feet of its exterior boundary (Table E-13).

No National Register of Historic Places listed historic properties are present in this alternative. Bridge site 32CS4462 has been determined eligible to the National Register and historic archeological site FM2-2 and architectural sites FM3-5, ND-5 and ND-14 are recommended eligible to the National Register. Prehistoric archeological sites 32CS43, 32CS201 and 32CS4563, church site 32CS114, farmsteads ND-3, ND-4, ND-7, ND-10, ND-12 and ND-13, and historic site leads 32CSX33, 32CSX131, 32CSX238b, and 21CYr have undetermined eligibility to the National Register. Archeological sites 32CS42 and 32CS44 have been determined not eligible to the National Register in 1988 in conjunction with the Horace-West Fargo Flood Control Project. The remaining eight sites, four isolated finds, and 10 structures are recommended as not eligible to the National Register.

Four prehistoric archeological sites, five historic archeological sites, three isolated finds, two unverified historic archeological sites, eight farmsteads, and four other structures lie within the footprints of the diversion, its tie-back levee alignments, and Storage Area #1 (see Table E-13). The location of an unverified lead to the Red River oxcart trail (21CYr) along the east side of the Red River is crossed by the tie-back levee alignment.

1.3 PREVIOUS CULTURAL RESOURCES INVESTIGATIONS

1.3.1 Moorhead, Minnesota In-Town Levee Alignment

Previous cultural resources surveys within the one-eighth-mile-wide Moorhead in-town levee alignment include a 1979 inventory of historic standing structures in the city of Moorhead (Moorhead Community Development Department 1979), a 1978 archeological survey of M. B. Johnson Park (Michlovic 1978a), and a 2002 survey of the TH 10 (Main Avenue) Bridge crossing of the Red River (Penner 2002). In addition, archeological testing has been conducted at historic sites 21CY5 (Historic Moorhead) (Michlovic 1997a, 1997b) and 21CY67 (Historic Probstfield Farm) (Michlovic and Kitch 1999). Legal locations involved include:

MCDD (1979) in city of Moorhead;
Michlovic (1978a) in T140N, R48W, Section 29;
Michlovic (1997a, 1997b) in T139N, R48W, Section 5;
Michlovic and Kitch (1999) in T140N, R48W, Section 21; and
Penner (2002) in T139N, R48W, Section 8.

1.3.2 Fargo, North Dakota In-Town Levee Alignment

Previous cultural resources surveys within the one-eighth-mile-wide Fargo in-town levee alignment include a 1978 survey in parts of the lower Sheyenne River Basin (Vehik 1978), 1985-1986 architectural surveys in the city of Fargo (Fiege 1986; Granger 1986),

a 1990 pipeline survey (Schweigert 1990), a 1999 survey of three bank protection areas along the Red River (Gnabasik 1999), a 2002 suvey of the TH 10 (Main Avenue) Bridge crossing of the Red River (Penner 2002), a 2003 archeological survey of the CSAH 22 (Minnesota) and County Road 20 (North Dakota) Bridge over the Red River (Mulholland et al. 2003), and the 2009 survey of the Fargo Southside Study Area (URS Group 2009). Legal locations involved include:

Vehik (1978) in T140N, R49W, Sections 4, 9, 17 and 30; and T138N, R49W, Section 18;
Fiege (1986) in [at NDSHPO – to be accessed if this alternative is selected];
Granger (1986) in [at NDSHPO – to be accessed if this alternative is selected];
Schweigert (1990) in T140N, R49W, Sections 32 and 33;
Gnabasik (1999) in T140N, R48W, Sections 19 and 32;
Penner (2002) in T139N, R48W, Sections 7 and 8;
Mulholland et al. (2003) in T140N, R48W, Sections 18 and 19; and
URS Group (2009) in T139N, R48W, Section 30; T139N, R49W, Section 36; and T138N, R49W, Sections 1, 8, 11, 12, 14 and 17.

1.3.3 North Dakota West Diversion Alignment

Previous cultural resources surveys within the one-mile-wide North Dakota west diversion alignment include a 1978 survey in parts of the lower Sheyenne River Basin (Vehik 1978), a 1986 survey of the Horace-West Fargo Flood Control Project (Floodman 1988), a 1986 archeological survey and test excavations in Cass County (Michlovic 1986), a 1990 pipeline survey (Schweigert 1990), and the 2009 survey of the Fargo Southside Study Area (URS Group 2009). Phase II testing to the evaluate the National Register of Historic Places eligibility of archeological sites 32CS42 and 32CS44 resulted in determinations that they were not eligible to the National Register (Persinger 1988). Legal locations involved include:

Vehik (1978) in T141N, R49W, Section 10; T138N, R50W, Sections 24 and 25; and T138N, R49W, Section 30;
Michlovic (1986) in T138N, R50W, Section 36;
Floodman (1988) in T139N, R50W, Sections 2 and 11;
Persinger (1988) in T139N, R50W, Section 11;
Schweigert (1990) in T140N, R50W, Section 14; and
URS Group (2009) in T137N, R49W, Sections 3, 4 and 10.

1.3.4 North Dakota East Diversion Alignment (part of the ND35K Plan)

Previous Phase I cultural resources investigations within the one-mile-wide North Dakota East Diversion alignment include a 1978 survey of parts of the lower Sheyenne River Basin (Vehik 1978), a 1986 survey of the Horace-West Fargo Flood Control Project (Floodman 1988), a 1986 archeological survey and test excavations in Cass County (Michlovic 1986), a 1990 pipeline survey (Schweigert 1990), and the 2009 survey of the Fargo Southside Study Area (URS Group 2009). Phase II testing to the evaluate the National Register of Historic Places eligibility of archeological sites 32CS42 and 32CS44 for the Horace-West Fargo Flood Control Project resulted in determinations that they

were not eligible to the National Register (Persinger 1988). A partial survey of this alignment was conducted in 2010 (URS/Tucker 2010). Legal locations involved include:

Vehik (1978) in T141N, R49W, Section 10; T139N, R50W, Sections 13, 24, 25 and 36; T139N, R49W, Sections 18, 19, 30 and 31; T138N, R50W, Sections 1, 12, 13, 24 and 25; and T138N, R49W, Sections 6, 7, 18 and 30;

Michlovic (1986) in T138N, R50W, Section 36;

Floodman (1988) in T139N, R50W, Sections 1, 2, 11, 12 and 13; and T139N, R49W, Sections 18 and 19;

Persinger (1988) in T139N, R50W, Section 11;

Schweigert (1990) in T140N, R50W, Section 14; and

URS Group (2009) in T137N, R49W, Sections 3, 4 and 10.

URS/Tucker (2010) in T141N, R50W, Section 25; T140N, R50W, Section 23; T139N, R50W, Sections 2, 12, 13, 25 and 36; T139N, R49W, Section 18; T138N, R50W, Sections 12, 13, 24 and 25; T138N, R49W, Sections 30, 31 and 32; T137N, R49W, Sections 3, 4, 10, 11 and 12; and T137N, R48W, Section 7.

1.3.5 North Dakota Mini-Diversion Alignment

Previous cultural resources surveys within the one-mile-wide North Dakota Mini-Diversion alignment include a 1978 survey in parts of the lower Sheyenne River Basin (Vehik 1978), a 1986 survey of the Horace-West Fargo Flood Control Project (Floodman 1988), and a 1990 pipeline survey (Schweigert 1990). Legal locations involved include:

Vehik (1978) in T141N, R49W, Section 10;

Floodman (1988) in T139N, R50W, Sections 2 and 11; and

Schweigert (1990) in T140N, R50W, Section 14.

1.3.6 North Dakota East and West Diversions Tie-Back Levee Alignment (part of the ND35K Plan)

In 2010 a cultural resources survey was conducted along the one-eighth-mile-wide North Dakota East and West Diversions Tie-Back Levee alignment, which is located in Minnesota. Legal locations involved include:

URS/Tucker (2010) in T137N, R48W, Sections 4, 5, 7, 8, 9 and 10.

1.3.7 Minnesota Long Diversion Alignment

There have been no previous cultural resources surveys within the one-mile-wide Minnesota Long Diversion alignment in Minnesota, except for maybe fieldwork in connection with the Statewide Archaeological Survey in Clay County in 1978 (Michlovic 1978b, 1979). Previous cultural resources surveys within that portion of the one-mile-wide Minnesota Long Diversion alignment in North Dakota include a 1978 survey along parts of the lower Sheyenne River Basin (Vehik 1978). Legal locations involved include:

Vehik (1978) in T141N, R49W, Section 13.

1.3.8 Minnesota Long Diversion Tie-Back Levee Alignment

Previous cultural resources surveys within the one-eighth-mile-wide Minnesota Long Diversion Tie-Back Levee alignment, which is located in North Dakota, include the 2009 survey of the Fargo Southside Study Area (URS Group 2009). Legal locations involved include:

URS Group (2009) in T137N, R49W, Sections 3, 4, 5, 6, 7, 8, 9 and 10.

1.3.9 Minnesota Short Diversion Alignment (part of the FCP)

The Statewide Archaeological Survey in Clay County in 1978 (Michlovic 1978b, 1979) may have included part of the one-mile-wide Minnesota Short Diversion alignment. Previous cultural resources surveys within that portion of the Minnesota Short Diversion alignment in North Dakota include a 1978 survey along parts of the lower Sheyenne River Basin (Vehik 1978). A partial survey of this diversion alignment was conducted in 2010 (URS/Tucker 2010). Legal locations involved include:

Vehik (1978) in T141N, R49W, Section 13;

URS/Tucker (2010) in T141N, R48W, Sections 18, 29, 20, 27, 28, 30 and 34; T140N, R48W, Sections 3, 4, 10, 24 and 36; T140N, R47W, Section 30; T139N, R47W, Section 6; T139N, R48W, Sections 1, 12, 13, 24, 25, 35 and 36; and T138N, R48W, Sections 2, 3, 10, 15, 16 and 17.

1.3.10 Minnesota Short Diversion Red River Breakout Channel Alignment (part of the FCP)

The Statewide Archaeological Survey in Clay County in 1978 (Michlovic 1978b, 1979) may have included part of the one-half mile-wide Minnesota Short Diversion Red River Breakout Channel alignment. In 2010 a cultural resources survey was conducted along part of this breakout channel alignment (URS/Tucker 2010). Legal locations involved include:

URS/Tucker (2010) in T138N, R48W, Sections 20, 29 and 32.

1.3.11 Minnesota Short Diversion Tie-Back Levee Alignment (part of the FCP)

Previous cultural resources surveys within the one-eighth-mile-wide Minnesota Short Tie-Back Levee alignment, which is located in North Dakota, include the 2009 survey of the Fargo Southside Study Area (URS Group 2009). A partial survey of this alignment including the location of the control structure across the Red River was conducted in 2010 (URS/Tucker 2010). Legal locations involved include:

URS Group (2009) in T138N, R48W, Section 18; and T138N, R49W, Sections 13, 24, 26, 33, 34 and 35.

URS/Tucker (2010) in T138N, R48W, Sections 17 and 18; and T138N, R49W, Sections 13, 23, 24, 26, 31, 33, 34 and 35.

1.3.12 Minnesota Short Diversion Wild Rice River Breakout Channel Alignment (part of the FCP)

Part of the one-half mile wide Minnesota Short Diversion Wild Rice River Breakout Channel alignment was surveyed for cultural resources in 2010 (URS/Tucker 2010). Legal locations involved include:

URS/Tucker (2010) in T138N, R49W, Section 35.

1.3.13 FCP

Previous cultural resources survey information is the same as for the Minnesota Short Diversion Alignment with Red River Breakout Channel, Tie-Back Levee, and Wild Rice River Breakout Channel Alignments (refer to paragraphs 1.3.9 through 1.3.12 above)

1.3.14 ND35K Plan

Previous cultural resources survey information is the same as for the North Dakota East Diversion Alignment and its associated tie-back levee alignment (refer to paragraphs 1.3.4 and 1.3.6 above).

1.3.15 LPP

Previous Phase I cultural resources investigations within the LPP's diversion alignment, tie-back levee alignment and Storage Area #1 in North Dakota and tie-back levee alignment in Minnesota include a 1978 survey of parts of the lower Sheyenne River Basin (Vehik 1978), a 1986 survey of the Horace-West Fargo Flood Control Project (Floodman 1988), a 1990 pipeline survey (Schweigert 1990), and the 2009 survey of the Fargo Southside Study Area (URS Group 2009). Phase II testing to the evaluate the National Register of Historic Places eligibility of archeological sites 32CS42 and 32CS44 for the Horace-West Fargo Flood Control Project resulted in determinations that they were not eligible to the National Register (Persinger 1988). A partial survey of this plan's alignments was conducted in 2010 (URS/Tucker 2010). Legal locations involved include:

Vehik (1978) in T141N, R49W, Sections 10 and 15; T139N, R50W, Sections 13, 24, 25 and 36; T139N, R49W, Sections 18, 19, 30 and 31; T138N, R50W, Sections 1, 12, 13, 24 and 25; and T138N, R49W, Sections 6, 7, 18 and 30;

Floodman (1988) in T139N, R50W, Sections 2, 11, 12 and 13; and T139N, R49W, Section 18;

Persinger (1988) in T139N, R50W, Section 11;

Schweigert (1990) in T140N, R50W, Section 14; and

URS Group (2009) in T137N, R49W, Sections 3, 4 and 10.

URS/Tucker (2010) in T140N, R50W, Section 23; T139N, R50W, Sections 2, 12, 13, 25 and 36; T139N, R49W, Section 18; T138N, R50W, Sections 12, 13, 24 and 25; T138N, R49W, Sections 30, 31 and 32; T137N, R49W,

Sections 3, 4, 10, 11and 12; and T137N, R48W, Sections 4, 5, 7, 8, 9 and 10.

1.4 FUTURE CULTURAL RESOURCES INVESTIGATIONS AND COORDINATION

Until 2010, less than five percent of the proposed levee and diversion alignments had been previously surveyed for cultural resources and those were mainly spot locations that were investigated. The one exception, which pertains to the North Dakota East Diversion Alignment, the ND35K Plan, and the LPP, is the existing Horace-West Fargo diversion alignment, which was surveyed for cultural resources in 1988, with sites 32CS42, 32CS43 and 32CS44 being recorded during that survey. In 2010, a Phase I cultural resources investigation was started for the North Dakota East Diversion alignment and its associated tie-back levee in Minnesota and the Minnesota Short Diversion alignment and its associated Red River breakout channel alignment in Minnesota, along with its associated Wild Rice River breakout channel alignment and its associated tie-back levee alignment in North Dakota. In 2011, the Phase I cultural resources investigation survey shifted to surveying the LPP diversion alignment, its two tie-back levee alignments, and its associated storage area. The North Dakota East/ND35K diversion alignment, the Minnesota Short/FCP diversion alignment, and their respective associated tieback levee and breakout channel alignments will not be surveyed further.

The area within the selected diversion plan's construction limits will need a Phase I cultural resources investigation for any areas not already surveyed, to locate any prehistoric or historic archeological sites and standing structures in the project area. Buildings and structures in the cities of Fargo and Moorhead were inventoried in the 1980s. Additional architectural inventory work will be necessary in Cass County, North Dakota, and Clay County, Minnesota, for any diversion and associated tie-back levee(s), storage area, staging area, and/or breakout channel alignments selected for the project.

Those buildings and structures that are 50 years old or older (built prior to 1960) and archeological sites, which are within the selected diversion alignment and related project areas, will need to have their eligibility to the National Register of Historic Places evaluated. For archeological sites this means formal testing at the site to determine its potential to contain important information on the prehistory or history of the area. For architectural sites, this means research into whether there are any significant historical events or persons associated with the building or structure, and determining the historical integrity of the building or structure's architecture. Depending on what the standing structure is, archeological testing may be necessary to determine if there are significant historic artifact deposits associated with it.

A Programmatic Agreement has been negotiated between the St. Paul District, U.S. Army Corps of Engineers, the Minnesota State Historic Preservation Officer, and the North Dakota State Historic Preservation Officer, with the city of Fargo and the city of Moorhead as concurring parties. The Cass County (North Dakota) and Clay County (Minnesota) Boards of Commissioners were also invited to be concurring parties to the Programmatic Agreement. The Advisory Council on Historic Preservation has declined

to become involved in the project. The Programmatic Agreement covers the Corps' compliance with Section 106 of the National Historic Preservation Act (NHPA), as amended, per its implementing regulation 36 CFR Part 800, Protection of Historic Properties, section 800.14(b).

In addition, Indian tribes with historic connections to the project area, including the Sisseton-Wahpeton Oyate of the Lake Traverse Reservation, the White Earth Band of Minnesota Chippewa, the Leech Lake Band of Ojibwe, the Turtle Mountain Band of Chippewa, the Upper Sioux Community of Minnesota, the Lower Sioux Indian Community of Minnesota, the Spirit Lake Nation of North Dakota, the Red Lake Band of Chippewa Indians, Bois Forte Band of Chippewa Indians, the Three Affiliated Tribes (Mandan, Hidatsa and Arikara Nation), the Northern Cheyenne Tribe, the Standing Rock Sioux Tribe, the Yankton Sioux Tribe, the Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation, the Crow Creek Sioux Tribe, and the Flandreau Santee Sioux Tribe, were contacted by letter from the Corps' District Engineer to the respective tribal chairman or chairwoman to determine if they wished to consult under Section 106 of the NHPA regarding traditional, religious, or cultural resources important to them which may be affected by the project. These tribes have been invited to be concurring parties to the Programmatic Agreement.

Finally, adverse effects to National Register eligible or listed historic properties, which cannot be avoided, should be minimized to the extent practicable. Unavoidable impacts to such historic properties will need to be mitigated prior to project construction.

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Table E-1. Recorded archeological sites and standing structures along the Moorhead levee alignment (within 100 meters/330 feet of levee centerline).

SITE or STRUCTURE NUMBER	SITE NAME	DESCRIPTION or STREET ADDRESS	LOCATION	NATIONAL REGISTER STATUS
21CY5	Old City of Moorhead	Historic artifact scatter and structural ruins	T139N, R48W, Sections 5 and 6	Undetermined
21CY48*	Toll Bridge site	Prehistoric artifact scatter	T139N, R48W, Section 5	Undetermined
21CY66	Historic Moorhead 2	Historic artifact scatter and structural ruins	T139N, R48W, Section 8	Undetermined
21CY67	Probstfield Farm	Historic artifact scatter, structural ruins and standing structures	T140N, R48W, Section 21	Undetermined
21CY68*	Probstfield Farm 2	Prehistoric artifact scatter	T140N, R48W, Section 21	Undetermined

21CY71*	Harris Homestead	Historic artifact scatter and structural ruins	T139N, R48W, Section 8	Undetermined
21CYg*	Probstfield Post Office	Historic site lead	T140N, R48W, Section 29	Undetermined
21CYr*	Red River Trail	Historic site lead – oxcart trail (crosses trail at 6 locations)	T140N, R48W, Sections 8, 21 & 28 and T138N, R48W, Section 5	Undetermined
CY-MHC-002	John Bergquist House (1870)	719 10th Ave. N.	T139N, R48W, Section 5	Listed (5/7/80), B
CY-MHC-005	Nels Overby House (1879)	811 Elm St. S.	T139N, R48W, Section 7	Undetermined
CY-MHC-011	Emil Euren House (1882)	311 10th St. N.	T139N, R48W, Section 5	Undetermined
CY-MHC-012	Gust Euren House (1897)	303 10th St. N.	T139N, R48W, Section 5	Undetermined
CY-MHC-024	Knute Simonson House (1897)	112 4th St. S.	T139N, R48W, Section 8	Undetermined
CY-MHC-025	Kassenborg Block (1898)	xxx Main Ave.	T139N, R48W, Section 8	Eligible
CY-MHC-030	Alexander and Agnes Nelson House (1900)	500 9th St. N.	T139N, R48W, Section 5	Undetermined
CY-MHC-055	Barn	12th Ave. S. at Riverton Dr.	T139N, R48W, Section 18	Undetermined
CY-MHC-059	Red River Bridge	Main Ave. over Red River	T139N, R48W, Section 8	Eligible
CY-MHC-060	NPRR Bridge	Over Red River	T139N, R48W, Section 8	Undetermined
CY-MHC-061	Bridge	Center Ave. over Red River	T139N, R48W, Section 8	Undetermined
CY-MHC-062	Bridge	1st Ave. N. over Red River	T139N, R48W, Section 6	Undetermined
CY-MHC-064*	Moorhead Country Club (1938)	11th St. at 18th Ave. N.	T139N, R48W, Section 32	Undetermined
CY-MHC-066	Fairmont Creamery Company	801 2nd Ave. N.	T139N, R48W, Section 5	Listed (2/10/83), A
CY-MHC-068	Douglas House (1872)	111 4th St. S.	T139N, R48W, Section 8	Eligible
CY-OAK-001	Randolph M. Probstfield House	County Road 96	T140N, R48W, Section 21	Listed (5/7/80), B

*Site crossed by levee centerline.

Table E-2. Recorded archeological sites and standing structures along the Fargo levee alignment (within 100 meters/330 feet of levee centerline).

SITE or STRUCTURE NUMBER	SITE NAME	DESCRIPTION or STREET ADDRESS	LOCATION	NATIONAL REGISTER STATUS
32CSX30	Horace Railroad Station	Historic site lead	T138N, R49W, Section 17	Undetermined
32CSX196*		Isolated find - flake	T140N, R49W, Section 12	Undetermined
32CS142	Salem Cemetery	Cemetery	T138N, R49W, Section 1	Not Eligible
32CS4442*		Late Prehistoric cultural material scatter	T140N, R48W, Section 18	Undetermined
32CS4443*		Late Prehistoric cultural material scatter	T140N, R48W, Section 18	Undetermined
32CS4474	Red River Bridge (1937)	NP Ave. and 4th St.	T139N, R48W, Section 7	Undetermined
32CS4671		Historic storage building ruin (1872-1897)	T139N, R48W, Section 7	Undetermined
32CS4673*		Historic multi-unit dwelling ruin (1871-1937)	T139N, R48W, Section 7	Undetermined
32CS5083	Lemke Farm	House and shed	T139N, R48W, Section 30	Not Eligible
32CS5087	Sunset Gardens Cemetery	Cemetery	T139N, R49W, Section 36	Not Eligible
	Dibley House	331 8th Ave. S.	T139N, R48W, Section 7	Listed (11/25/80), C
*	North Side Fargo Builder's Residential Historic District	Ben Franklin School area to El Zagal Golf Course and 12th Ave. N. to 4th and 1st Streets	T140N, R48W, Section 31	Listed (4/7/87), A, C, g

*Site crossed by levee centerline.

Table E-3. Recorded archeological sites and standing structures along the North Dakota West Diversion alignment (within one-half mile either side of diversion centerline).

SITE or STRUCTURE NUMBER	SITE NAME	DESCRIPTION or STREET ADDRESS	LOCATION	NATIONAL REGISTER STATUS

32CSX35		Historic site lead – school	T138N, R50W, Section 11	Undetermined
32CSX238b		Historic site lead – cultural material scatter and trail at Red River	T142N, R49W, Section 25	Undetermined
32CS42		Prehistoric cultural material scatter	T139N, R50W, Section 11	Not Eligible
32CS43		Prehistoric cultural material scatter	T139N, R50W, Section 2	Undetermined
32CS44		Prehistoric cultural material scatter	T139N, R50W, Section 11	Not Eligible
32CS201		Prehistoric cultural material scatter	T141N, R49W, Section 10	Undetermined
32CS4461	Maple River Bridge	Bridge on N-S section line road (Raymond Twp.)	T140N, R50W, Sections 23 and 24	Undetermined
32CS4462	Sheyenne River Bridge	Bridge on south jog in E-W section line road (Warren Twp.)	T138N, R50W, Section 36	Eligible
32CS5090		Rural residence	T138N, R49W, Section 30	Not Eligible
32CS5091		Rural residence	T138N, R49W, Section 30	Not Eligible

*Site crossed by diversion centerline.

Table E-4. Recorded archeological sites and standing structures along the North Dakota East Diversion alignment (within one-half mile either side of diversion centerline) (part of ND35K Plan).

SITE or STRUCTURE NUMBER	SITE NAME	DESCRIPTION or STREET ADDRESS	LOCATION	NATIONAL REGISTER STATUS
32CSX238b		Historic site lead – cultural material scatter and trail at Red River	T142N, R49W, Section 25	Undetermined
32CS42*		Prehistoric cultural material scatter	T139N, R50W, Section 11	Not Eligible
32CS43		Prehistoric cultural material scatter	T139N, R50W, Section 2	Undetermined
32CS44		Prehistoric cultural material scatter	T139N, R50W, Section 11	Not Eligible
32CS201		Prehistoric cultural material scatter	T141N, R49W, Section 10	Undetermined

32CS4461	Maple River Bridge	Bridge on N-S section line road (Raymond Twp.)	T140N, R50W, Sections 23 and 24	Undetermined
32CS4462	Sheyenne River Bridge	Bridge on south jog in E-W section line road (Warren Twp.)	T138N, R50W, Section 36	Eligible
32CS5090		Rural residence	T138N, R49W, Section 30	Not Eligible
32CS5091		Rural residence	T138N, R49W, Section 30	Not Eligible
FM1-2		Historic cultural material scatter	T139N, R50W, Section 13	Recommended Not Eligible
FM2-2		Historic cultural material scatter	T137N, R49W, Section 10	Recommended Eligible
FM2-5		Historic cultural material scatter	T137N, R49W, Section 12	Recommended Not Eligible
FM2-6		Historic homestead	T138N, R50W, Section 24	Recommended Not Eligible
FM2-7		Historic cultural material scatter	T138N, R50W, Section 24	Recommended Not Eligible
FM2-8		Isolated find – side-notched projectile point	T140N, R50W, Section 23	Recommended Not Eligible
FM4-7		Historic cultural material scatter	T137N, R48W, Section 7	Recommended Not Eligible
ND-1	Ihnken Farm	Farmstead (c. 1930) 2368 173rd Ave. SE	T142N, R49W, Section 35	Recommended Not Eligible
ND-2	Anders Farm	Farmstead (c. 1930) 17135 25th St. SE	T141N, R49W, Section 3	Recommended Not Eligible
ND-3	Krogh Farm	Farmstead 9610 76th Ave. N	T140N, R50W, Section 2	Undetermined
ND-4	J. Johnson Farm	Farmstead 3405 19th Ave. NW	T140N, R50W, Section 26	Undetermined
ND-5	Deede Farm	Farmstead (c. 1920)	T139N, R50W, Section 11	Recommended Eligible
ND-6	Rice Farm	Farmstead (c. 1950) 1152 21st Ave. W	T139N, R49W, Section 18	Recommended Not Eligible
ND-7	Belanger Farm	Farmstead 8501 81st St. S	T139N, R50W, Section 13	Undetermined
ND-8		BNSF Railroad crossing (c. 1900)	T138N, R50W, Section 25	Recommended Not Eligible
ND-9	Delaney House	House (c. 1925) 10615 81st St. S	T138N, R50W, Section 25	Recommended Not Eligible
ND-10	M. Johnson Farm	Farmstead 7806 112th Ave. S	T138N, R49W, Section 31	Undetermined

ND-12	Loffelmacher Farm	Farmstead 5806 124th Ave. S	T137N, R49W, Section 5	Undetermined
ND-13	Brodshaug Farm #2	Farmstead 4857 172nd Ave. SE	T137N, R49W, Section 4	Undetermined
ND-14*	Brodshaug Farm #1	Farmstead (c. 1900) 17272 SE 49th St.	T137N, R49W, Section 10	Recommended Eligible
ND-15		Bridge over Wild Rice River (1953)	T137N, R49W, Section 11	Recommended Not Eligible
ND-16		Collapsed Granary (c. 1900)	T137N, R49W, Section 10	Recommended Not Eligible
ND-17		Collapsed House (1912) 17550 49th St. SE	T137N, R48W, Section 7	Recommended Not Eligible

*Site crossed by diversion centerline.

Table E-5. Recorded archeological sites and standing structures along the North Dakota Mini-Diversion (Maple River to Red River) alignment (within one-half mile either side of diversion centerline).

SITE or STRUCTURE NUMBER	SITE NAME	DESCRIPTION or STREET ADDRESS	LOCATION	NATIONAL REGISTER STATUS
32CSX238b		Historic site lead – cultural material scatter and trail at Red River	T142N, R49W, Section 25	Undetermined
32CS43		Prehistoric cultural material scatter	T139N, R50W, Section 2	Undetermined
32CS201		Prehistoric cultural material scatter	T141N, R49W, Section 10	Undetermined
32CS4461	Maple River Bridge	Bridge on N-S section line road (Raymond Twp.)	T140N, R50W, Sections 23 and 24	Undetermined

*Site crossed by diversion centerline.

Table E-6. Recorded archeological sites and standing structures along the North Dakota East and West Diversions Tie-Back Levee alignment (within 100 meters/330 feet of levee centerline) (part of ND35K Plan).

SITE or STRUCTURE NUMBER	SITE NAME	DESCRIPTION or STREET ADDRESS	LOCATION	NATIONAL REGISTER STATUS
21CYr*	Red River Trail	Historic site lead – oxcart trail (crosses trail at 1 location)	T137N, R48W, Sections 5 and 8	Undetermined

FM3-2		Historic cultural material scatter	T137N, R48W, Section 5	Recommended Not Eligible
FM3-3		Isolated find – Historic artifact	T137N, R48W, Section 8	Recommended Not Eligible
FM3-4		Isolated find – Historic artifact	T137N, R48W, Section 8	Recommended Not Eligible
FM3-5		GN/BNSF railroad segment	T137N, R48W, Section 9	Recommended Eligible
FM3-6		Isolated find – Historic artifact	T137N, R48W, Section 9	Recommended Not Eligible

*Site crossed by levee centerline.

Table E-7. Recorded archeological sites and standing structures along the Minnesota Long Diversion alignment (within one-half mile either side of diversion centerline).

SITE or STRUCTURE NUMBER	SITE NAME	DESCRIPTION or STREET ADDRESS	LOCATION	NATIONAL REGISTER STATUS
21CY3		Prehistoric cultural material scatter	T141N, R49W, Section 13	Undetermined
21CY19		Prehistoric lithic scatter	T141N, R48W, Section 30	Undetermined
21CY55		Prehistoric lithic scatter	T141N, R49W, Section 13	Undetermined
21CYk*	Ruthruff	Historic site lead – Ghost Town	T139N, R48W, Section 36	Undetermined
21CYl* (el)	Lafayette	Historic site lead – Ghost Town	T141N, R48W, Section 18 and T141N, R49W, Section 13	Undetermined
21CYr*	Red River Trail	Historic site lead – oxcart trail (crosses trail at 3 locations)	T141N, R48W, Sections 18 and 34 and T137N, R48W, Section 5	Undetermined
CY-DWC-003	Northern Pacific shop buildings	Dilworth	T139N, R48W, Sections 11 and 12	Undetermined
CY-HCR-002	Ole Thompson House	Holy Cross Twp.	T137N, R48W, Section 6	Undetermined
CY-KRG-001	John Olness House	U.S. Highway 75 at Kragnes	T141N, R48W, Section 27	Listed (5/7/80), B, C
CY-KRG-004	Kragnes Bar	Kragnes – east side of Main Street	T141N, R48W, Section 34	Undetermined
CY-KRG-005	Warehouse	Kragnes – east side	T141N, R48W,	Undetermined

		of Main Street	Section 34	

*Site crossed by diversion centerline.

Table E-8. Recorded archeological sites and standing structures along the Minnesota Long Diversion Tie-Back Levee alignment (within 100 meters/330 feet of levee centerline).

SITE or STRUCTURE NUMBER	SITE NAME	DESCRIPTION or STREET ADDRESS	LOCATION	NATIONAL REGISTER STATUS
32CS5079		Historic cultural material scatter	T137N, R49W, Section 5	Not Eligible

*Site crossed by levee centerline.

Table E-9. Recorded archeological sites and standing structures along the Minnesota Short Diversion alignment (within one-half mile either side of diversion centerline) (part of FCP).

SITE or STRUCTURE NUMBER	SITE NAME	DESCRIPTION or STREET ADDRESS	LOCATION	NATIONAL REGISTER STATUS
21CY3		Prehistoric cultural material scatter	T141N, R49W, Section 13	Undetermined
21CY19		Prehistoric cultural material scatter	T141N, R48W, Section 30	Undetermined
21CY55		Prehistoric cultural material scatter	T141N, R49W, Section 13	Undetermined
21CYk*	Ruthruff	Historic site lead – Ghost Town	T139N, R48W, Section 36	Undetermined
21CYl* (el)	Lafayette	Historic site lead – Ghost Town	T141N, R48W, Section 18 and T141N, R49W, Section 13	Undetermined
21CYo	Burlington	Historic site lead – Ghost Town	T138N, R48W, Sections 19 and 20	Undetermined
21CYr*	Red River Trail	Historic site lead – oxcart trail (crosses trail at 3 locations)	T141N, R48W, Sections 18 and 34 and T138N, R48W, Section 17	Undetermined
CY-DWC-003	Northern Pacific shop buildings	Dilworth	T139N, R48W, Sections 11 and 12	Undetermined
CY-KRG-001	John Olness	U.S. Highway 75 at	T141N, R48W,	Listed (5/7/80),

	House	Kragnes	Section 27	B, C
CY-KRG-004	Kragnes Bar	Kragnes – east side of Main Street	T141N, R48W, Section 34	Undetermined
CY-KRG-005	Warehouse	Kragnes – east side of Main Street	T141N, R48W, Section 34	Undetermined
FM1-1		Historic cultural material scatter	T139N, R48W, Section 36	Recommended Not Eligible
FM2-1		Historic cultural material scatter	T140N, R48W, Section 24	Recommended Not Eligible
FM2-3		Isolated find – modified flake	T138N, R48W, Section 2	Recommended Not Eligible
FM2-4		Former school site	T139N, R48W, Section 35	Recommended Eligible
FM2-9		Historic cultural material scatter	T139N, R48W, Section 12	Recommended Not Eligible
FM2-11		Historic cultural material scatter	T141N, R49W, Section 13	Recommended Not Eligible
FM2-12		Isolated find – flake	T141N, R49W, Section 13	Recommended Not Eligible
FM4-6		Isolated find – projectile point	T138N, R48W, Section 18	Recommended Not Eligible
MN-1	Fossum Farm	Farmstead (1948) 12109 15th St. NW	T141N, R48W, Section 18 and T141N, R49W, Section 13	Recommended Not Eligible
MN-2	Montplaisir Farm	Farmstead (1973) 12547 15th St. NW	T141N, R48W, Section 18	Recommended Not Eligible
MN-3	Jacobsen Farm	Farmstead (1988) 7330 28th St. N	T140N, R48W, Section 9	Recommended Not Eligible
MN-4	Pederson Farm	Farmstead (1961) 3356 50th Ave. N	T140N, R48W, Section 10	Recommended Not Eligible
MN-5	Fischer Farm	Farmstead (1941) 9467 50th St. N	T140N, R47W, Section 30	Recommended Not Eligible
MN-6	Fiandaca Farm	Farmstead (c. 1930) 5526 28th Ave. N	T139N, R48W, Section 12	Undetermined
MN-7	Jones House	House (1910) 313 Adams Ave.	T139N, R48W, Section 12	Recommended Not Eligible
MN-8		BNSF Railroad 925 Center Ave. E	T139N, R48W, Section 12	Undetermined
MN-9		House (1920) 305 Adams Ave.	T139N, R48W, Section 12	Recommended Not Eligible
MN-10	Hawk House	House (1938) 301 Adams Ave.	T139N, R48W, Section 12	Recommended Not Eligible
MN-11*	Nettleton House	House (1910) 21 Bean Ave.	T139N, R48W, Section 13	Recommended Not Eligible

MN-12	Anderson House	House (1900) 14 Prior St.	T139N, R48W, Section 36	Recommended Not Eligible
MN-13	Kolo Farm	Farmstead (1994) 5343 28th Ave. S	T139N, R48W, Section 35	Recommended Not Eligible
MN-14*	Allen-Kounovsky Farm	Farmstead (1913) 5471 50th Ave. S	T138N, R48W, Section 2	Recommended Eligible
MN-15	Sillers Farm	Farmstead (1935) 5555 45th St. S	T138N, R48W, Section 3	Recommended Not Eligible
MN-16	M. Nyquist Farm	Farmstead (1951) 6498 40th St. S	T138N, R48W, Section 10	Recommended Not Eligible
MN-17*	R. and J. Nyquist Farm	Farmstead (1952) 6541 40th St. S	T138N, R48W, Section 17	Recommended Not Eligible

*Site crossed by diversion centerline.

Table E-10. Recorded archeological sites and standing structures along Minnesota Short Red River Diversion Breakout Channel alignment (within one-quarter mile either side of channel centerline) (part of FCP).

SITE or STRUCTURE NUMBER	SITE NAME	DESCRIPTION or STREET ADDRESS	LOCATION	NATIONAL REGISTER STATUS
21CYo*	Burlington	Historic site lead – Ghost Town	T138N, R48W, Sections 19 and 20	Undetermined
21CYr*	Red River Trail	Historic site lead – oxcart trail (follows trail for ca. 1 mile and crosses trail at 1 location)	T138N, R48W, follows in Sections 17 and 20 and crosses in Section 32	Undetermined
FM4-4		Historic cultural material scatter	T138N, R48W, Section 31	Recommended Not Eligible
MN-18	Ball Farm	Farmstead (1961) 3428 80th Ave. S	T138N, R48W, Section 32	Recommended Not Eligible
MN-19	Scheving Farm	Farmstead (1930) 8719 Hwy 75 S	T138N, R48W, Section 31	Recommended Eligible

*Site crossed by breakout channel centerline.

Table E-11. Recorded archeological sites and standing structures along Minnesota Short Diversion Tie-Back Levee alignment (within 100 meters/330 feet of levee centerline) (part of FCP).

SITE or STRUCTURE NUMBER	SITE NAME	DESCRIPTION or STREET ADDRESS	LOCATION	NATIONAL REGISTER STATUS

32CSX1*	Holy Cross Mission	Historic site lead	T138N, R49W, Section 13	Undetermined
FM4-3		Prehistoric campsite and historic cultural material scatter	T138N, R48W, Section 18	Recommended Eligible
32CS2657	Meridian Highway	Historic highway	T138N, R49W, Section 13 and T138N, R48W, Section 18	Recommended Not Eligible
ND-11	Thompson Farm	Farmstead (c. 1960) 11908 38th St. S	T138N, R49W, Section 35	Recommended Not Eligible

*Site crossed by levee centerline.

Table E-12. Recorded archeological sites and standing structures along Minnesota Short Diversion Wild Rice River Breakout Channel alignment (within one-quarter mile either side of channel centerline) (part of FCP).

SITE or STRUCTURE NUMBER	SITE NAME	DESCRIPTION or STREET ADDRESS	LOCATION	NATIONAL REGISTER STATUS
FM-A		Historic cultural material scatter	T138N, R49W, Section 26	Recommended Eligible

*Site crossed by channel centerline.

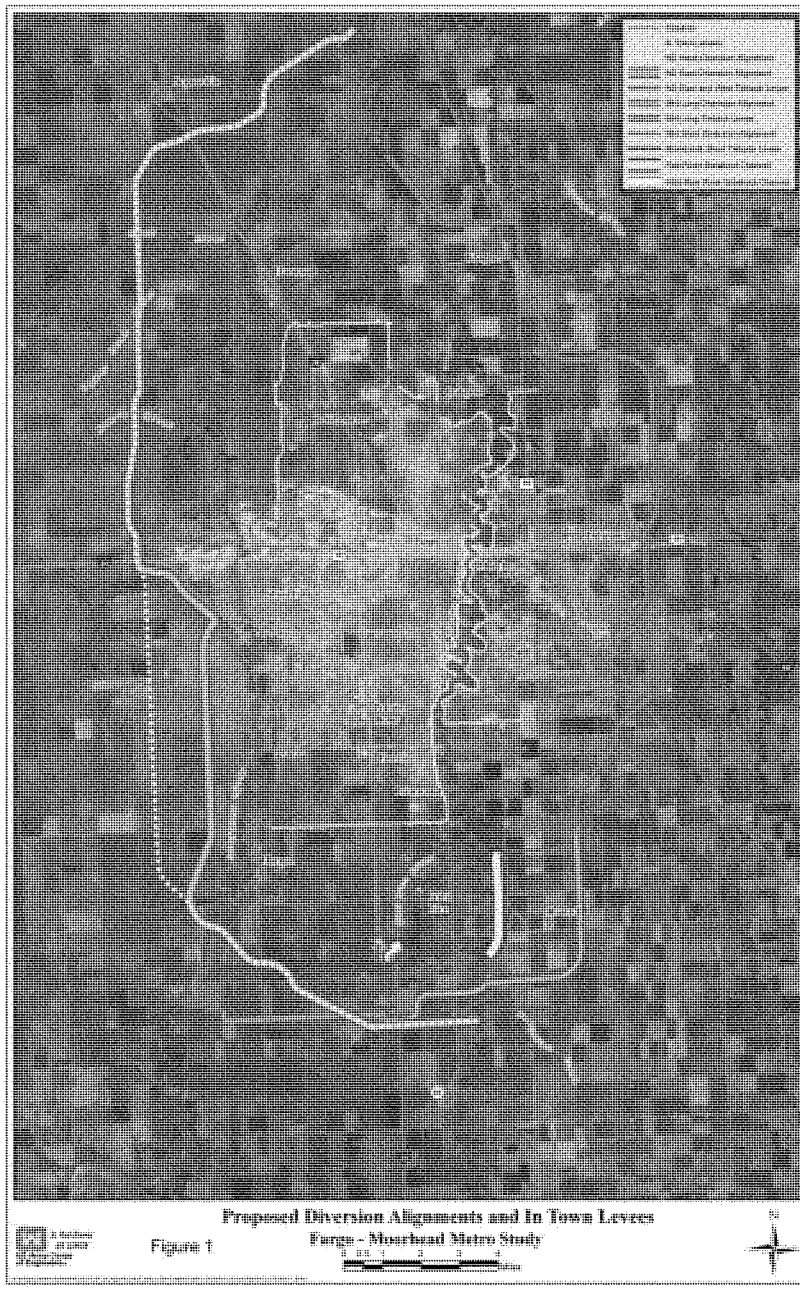
Table E-13. Recorded archeological sites and standing structures along the Locally Preferred Plan (LPP) alignment (within one-half mile either side of diversion centerline or within 100 meters/330 feet of tie-back levee centerlines or within Storage Area #1 or 100 meters/330 feet of its exterior boundary).

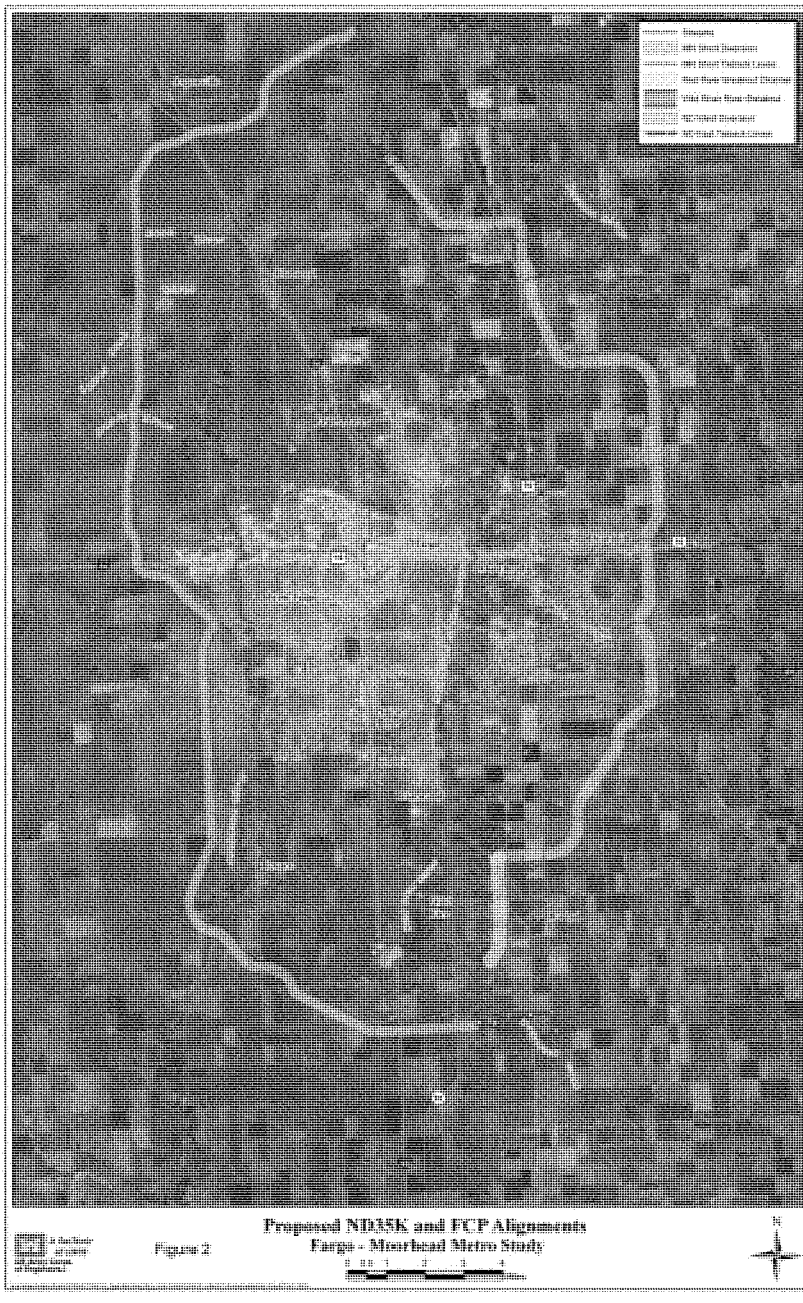
SITE or STRUCTURE NUMBER	SITE NAME	DESCRIPTION or STREET ADDRESS	LOCATION	NATIONAL REGISTER STATUS
32CSX33*		Historic site lead – archeological site	T138N, R49W, Section 34	Undetermined
32CSX131*		Historic site lead – Unknown type	T141N, R49W, Section 15	Undetermined
32CSX238b		Historic site lead – cultural material scatter and trail at Red River	T142N, R49W, Section 25	Undetermined
21CYr*	Red River Trail	Historic site lead – Red River oxcart trail	T137N, R48W, Sections 5 and 8	Undetermined
32CS42*		Prehistoric cultural material scatter	T139N, R50W, Section 11	Not Eligible

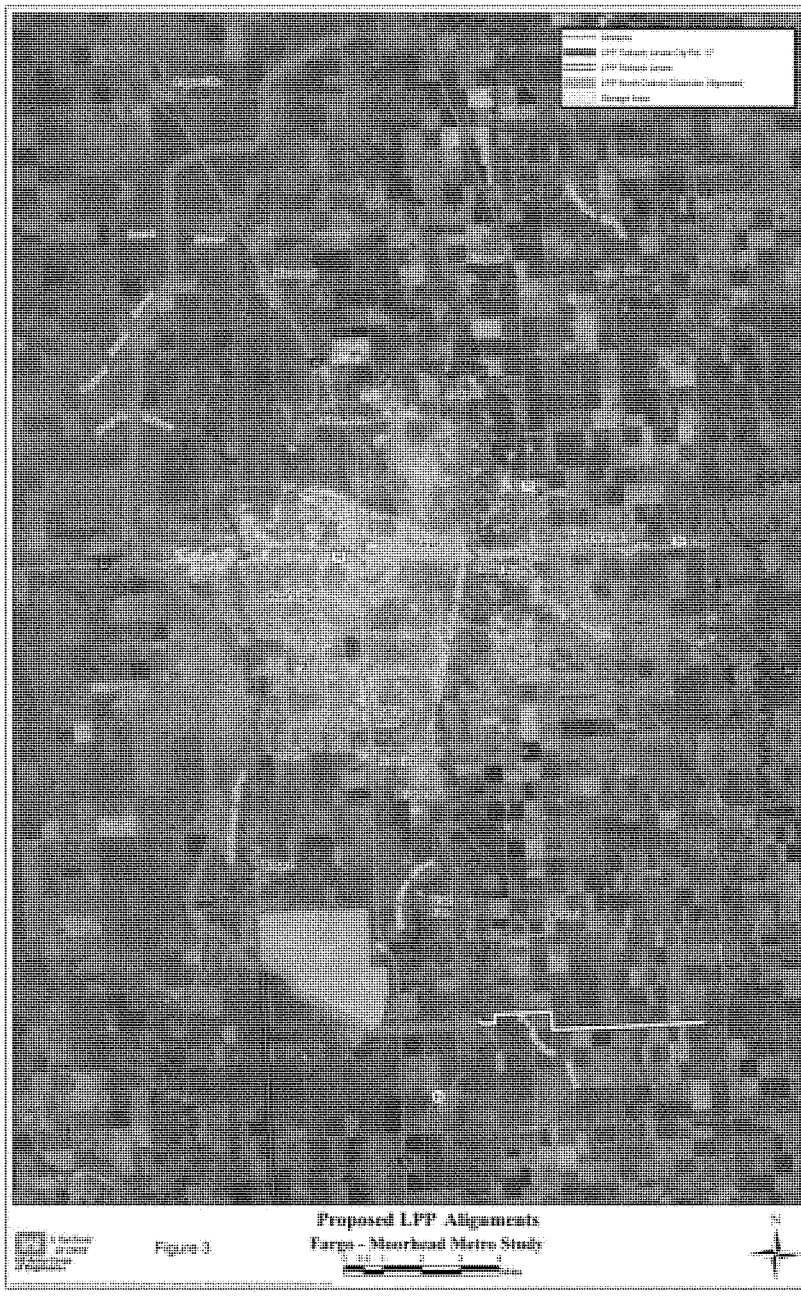
32CS43*		Prehistoric cultural material scatter	T139N, R50W, Section 2	Undetermined
32CS44*		Prehistoric cultural material scatter	T139N, R50W, Section 11	Not Eligible
32CS114	St. Benedict Catholic Church	Historic church	T138N, R49W, Section 34	Undetermined
32CS201*		Prehistoric cultural material scatter	T141N, R49W, Section 10	Undetermined
32CS4462	Sheyenne River Bridge	Bridge on south jog in E-W section line road (Warren Twp.)	T138N, R50W, Section 36	Eligible
32CS4563		Prehistoric cultural material scatter	T141N, R49W, Section 15	Undetermined
32CS5076	Tessier Farm	Farmstead	T138N, R49W, Section 27	Recommended Not Eligible
32CS5078		Historic cultural material scatter	T138N, R49W, Section 34	Recommended Not Eligible
FM1-2*		Historic cultural material scatter	T139N, R50W, Section 13	Recommended Not Eligible
FM2-2		Historic cultural material scatter	T137N, R49W, Section 10	Recommended Eligible
FM2-5		Historic cultural material scatter	T137N, R49W, Section 12	Recommended Not Eligible
FM2-6*		Historic homestead	T138N, R50W, Section 24	Recommended Not Eligible
FM2-7*		Historic cultural material scatter	T138N, R50W, Section 24	Recommended Not Eligible
FM2-8*		Isolated find – projectile point	T140N, R50W, Section 23	Recommended Not Eligible
FM3-2*		Historic cultural material scatter	T137N, R48W, Section 5	Recommended Not Eligible
FM3-3*		Isolated find – historic artifact	T137N, R48W, Section 8	Recommended Not Eligible
FM3-4*		Isolated find – historic artifact	T137N, R48W, Section 8	Recommended Not Eligible
FM3-5		GN/BNSF railroad segment	T137N, R48W, Section 9	Recommended Eligible
FM3-6*		Isolated find – historic artifact	T137N, R48W, Section 9	Recommended Not Eligible
FM4-1		Historic cultural material scatter	T141N, R50W, Section 25	Recommended Not Eligible
FM4-7*		Historic cultural material scatter	T137N, R48W, Section 7	Recommended Not Eligible
ND-1	Ihnken Farm	Farmstead (c. 1930)	T142N, R49W,	Recommended

		2368 173rd Ave. SE	Section 35	Not Eligible
ND-2*	Anders Farm	Farmstead (c. 1930) 17135 25th St. SE	T141N, R49W, Section 3	Recommended Not Eligible
ND-3	Krogh Farm	Farmstead 9610 76th Ave. N	T140N, R50W, Section 2	Undetermined
ND-4*	J. Johnson Farm	Farmstead 3405 19th Ave. NW	T140N, R50W, Section 26	Undetermined
ND-5*	Deede Farm	Farmstead (c. 1920)	T139N, R50W, Section 11	Recommended Eligible
ND-6	Rice Farm	Farmstead (c. 1950) 1152 21st Ave. W	T139N, R49W, Section 18	Recommended Not Eligible
ND-7	Belanger Farm	Farmstead 8501 81st St. S	T138N, R50W, Section 13	Undetermined
ND-8*		BNSF Railroad crossing (c. 1900)	T138N, R50W, Section 25	Recommended Not Eligible
ND-9*	Delaney House	House (c. 1925) 10615 81st St. S	T138N, R50W, Section 25	Recommended Not Eligible
ND-10*	M. Johnson Farm	Farmstead 7806 112th Ave. S	T138N, R49W, Section 31	Undetermined
ND-11	Thompson Farm	Farmstead (c. 1960) 11908 38th St. S	T138N, R49W, Section 35	Recommended Not Eligible
ND-12*	Loffelmacher Farm	Farmstead 5806 124th Ave. S	T137N, R49W, Section 5	Undetermined
ND-13*	Brodshaug Farm #2	Farmstead 4857 172nd Ave. SE	T137N, R49W, Section 4	Undetermined
ND-14*	Brodshaug Farm #1	Farmstead (c. 1900) 17272 SE 49th St.	T137N, R49W, Section 10	Recommended Eligible
ND-15*		Bridge over Wild Rice River (1953)	T137N, R49W, Section 11	Recommended Not Eligible
ND-16*		Collapsed Granary (c. 1900)	T137N, R49W, Section 10	Recommended Not Eligible
ND-17*		Collapsed House (1912) 17550 49th St. SE	T137N, R48W, Section 7	Recommended Not Eligible

*Site in diversion, tie-back levee, or storage area footprints.


Proposed Diversion Alignments and In Town Levees
Fargo - Moorhead Metro Study
Figure 1


Proposed ND35K and FCP Alignments
Fargo - Moorhead Metro Study
Figure 2


Proposed LPT Alignments
Fargo - Moorhead Metro Study
Figure 3

Appendix F
Environmental

Fargo-Moorhead Metropolitan Area Flood Risk Management

Final Feasibility Report and Environmental Impact Statement

July 2011

US Army Corps of Engineers ®

Prepared by:
U.S. Army Corps of Engineers
St. Paul District
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USACE-MVP-0000087978

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1.0 INTRODUCTION

The purpose of this appendix is to provide supporting information for the feasibility study report and EIS. The information in this appendix includes wetland code definitions, a table indicating types and quantities of wetlands identified within project area using the National Wetland Inventory, a photo log from the wetland delineation completed for this project, water quality data, Farmland Conversion Impact Ratings, mitigation accounting spreadsheet, meeting notes from the natural resource agency meetings, threatened and endangered species information, documentation gathered and used to quantify impacts to floodplain forest, the scoping document and the Wetland Determination Report.

1.1 Wetland Code Definitions

SYSTEMS

[R] Riverine - The Riverine System includes all wetlands and deepwater habitats contained in natural or artificial channels periodically or continuously containing flowing water or which forms a connecting link between the two bodies of standing water. Upland islands or Palustrine wetlands may occur in the channel, but they are not part of the Riverine System.

[P] Palustrine - The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, emergents, mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean derived salts is below 0.5 ppt. Wetlands lacking such vegetation are also included if they exhibit all of the following characteristics:

1. are less than 8 hectares (20 acres);

2. do not have an active wave-formed or bedrock shoreline feature;

3. have at low water a depth less than 2 meters (6.6 feet) in the deepest part of the basin;

4. have a salinity due to ocean-derived salts of less than 0.5 ppt.

[L] Lacustrine - The Lacustrine System includes wetlands and deepwater habitats with all of the following characteristics:

1. situated in a topographic depression or a dammed river channel;

2. lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% areal coverage.

3. total area exceeds 8 hectares (20 acres).

SUBSYSTEMS

Lacustrine

(2) Littoral - All wetland habitats in the Lacustrine System. Extends from shoreward boundary to 2 meters (6.6 feet) below annual low water or to the maximum extent of nonpersistent emergents, if these grow at depths greater than 2 meters.

Riverine

(2) Lower Perennial - This Subsystem is characterized by a low gradient and slow water velocity. There is no tidal influence, and some water flows throughout the year. The substrate consists mainly of sand and mud. The floodplain is well developed. Oxygen deficits may sometimes occur.

(4) Intermittent - This Subsystem includes channels that contain flowing water only part of the year, but may contain isolated pools when the flow stops.

CLASSES

[FO] Forested - Characterized by woody vegetation that is 6 m tall or taller.

[SS] Scrub-Shrub - Includes areas dominated by woody vegetation less than 6 m (20 feet) tall. The species include true shrubs, young trees (saplings), and trees or shrubs that are small or stunted because of environmental conditions.

[SB] Streambed - Includes all wetlands contained within the Intermittent Subsystem of the Riverine System and all channels of the Estuarine System or of the Tidal Subsystem of the Riverine System that are completely dewatered at low tide.

[EM] Emergent - Characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants.

[AB] Aquatic Bed - Includes wetlands and deepwater habitats dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years. Aquatic beds generally occur in water less than 2 meters (6.6 feet) deep and are placed in the Littoral Subsystem (if in Lacustrine System).

[UB] Unconsolidated Bottom - Includes all wetlands and deepwater habitats with at least 25% cover of particles smaller than stones (less than 6-7 cm), and a vegetative cover less than 30%.

[US] Unconsolidated Shore - Includes all wetland habitats having three characteristics:

(1) unconsolidated substrates with less than 75% areal cover of stones, boulders, or bedrock;

(2) less than 30% areal cover of vegetation other than pioneering plants; and

(3) any of the following water regimes: irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded, intermittently flooded, saturated, seasonal-tidal, temporary-tidal, or artificially flooded. Intermittent or intertidal channels of the Riverine System or intertidal channels of the Estuarine System are classified as Streambed. Landforms such as beaches, bars, and flats are included in the Unconsolidated Shore class.

SUBCLASS

(1) Broad-leaved Deciduous - Woody angiosperms (trees or shrubs) with

relatively wide, flat leaves that are shed during the cold or dry season; e.g., black ash (Fraxinus nigra).

SPECIAL MODIFIER

[x] Excavated - Lies within a basin or channel excavated by man.

WATER REGIME

[A] Temporarily Flooded - Surface water is present for brief periods during growing season, but the water table usually lies well below the soil surface. Plants that grow both in uplands and wetlands may be characteristic of this water regime.

[C] Seasonally Flooded - Surface water is present for extended periods especially early in the growing season, but is absent by the end of the growing season in most years. The water table after flooding ceases is variable, extending from saturated to the surface to a water table well below the ground surface.

[d] Partly Drained - The water level has been artificially lowered, but the area is still classified as wetland because soil moisture is sufficient to support hydrophytes. Drained areas are not considered wetland if they can no longer support hydrophytes. This modifier is also used to indicate extensive ditch networks in wetlands where, due to the extreme number and narrow width of the ditches, individual delineation is impossible. Individual ditches shall be broken out as linears (with Excavated modifier) when they approximate the pen line width on the photography and if the area is not overly complex.

[F] Semipermanently Flooded - Surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at or very near the land's surface.

[G] Intermittently Exposed - Surface water is present throughout the year except in years of extreme drought.

[h] Diked/Impounded - Created or modified by a man-made barrier or dam which obstructs the inflow or outflow of water. Originally, Diked and Impounded are described as separate modifiers (Cowardin et al. 1979). They have been combined here due to photointerpretation limitations. For clarification of the extent of impoundment see discussion of Lacustrine System limits.

[K] Artificially Flooded - The amount and duration of flooding is controlled by means of pumps or siphons in combination with dikes or dams. The vegetation growing on these areas cannot be considered a reliable indicator of water regime. The Artificially Flooded modifier should be used with water and waste-water treatment facilities. Neither wetlands within or resulting from leakage from man-made impoundments, nor irrigated pasturelands supplied by diversion ditches or artesian wells are included under this modifier. Artificially Flooded can be used

with any non-tidal water regime. The Artificially Flooded (K) symbol should always be listed before other water regime codes (e.g. PUBKF).

1.2 Total Wetlands Acres Within Project Area

Type	Wetland Code	Acres
Lacustrine, Littoral, Aquatic Bed, Intermittently Exposed, Excavated	L2ABGx	761.44
Lacustrine, Littoral, Unconsolidated bottom, Artificially Flooded, Intermittently Exposed, Excavated	L2UBKGx	91.01
Palustrine, Aquatic Bed, Semipermanently Flooded	PABF	77.25
Palustrine, Aquatic Bed, Semipermanently Flooded, Diked/Impounded	PABFh	1.04
Palustrine, Aquatic Bed, Semipermanently Flooded, Excavated	PABFx	26.61
Palustrine, Emergent, Aquatic Bed, Semipermanently Flooded	PEM/ABF	24.28
Palustrine, Emergent, Forested, Broad-Leaved Deciduous, Seasonally Flooded	PEM/FO1C	7.07
Palustrine, Emergent, Forested, Seasonally Flooded	PEM/FOC	28.64
Palustrine, Emergent/Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded	PEM/SS1C	26.34
Palustrine, Emergent/ Unconsolidated Bottom, Semipermanently Flooded	PEM/UBF	2.09
Palustrine, Emergent, Temporarily Flooded	PEMA	163.05
Palustrine, Emergent, Temporarily Flooded, Partially Drained/Ditched	PEMAd	181.92
Palustrine, Emergent, Temporarily Flooded. Excavated	PEMAx	24.83
Palustrine, Emergent, Seasonally Flooded	PEMC	174.59
Palustrine, Emergent, Seasonally Flooded, Partially Drained/Ditched	PEMCd	71.22
Palustrine, Emergent, Seasonally Flooded, Excavated	PEMCx	242.63
Palustrine, Emergent, Semipermanently Flooded	PEMF	69.33
Palustrine, Emergent, Semipermanently Flooded, Partially Drained/Ditched	PEMFd	7.13
Palustrine, Emergent, Semipermanently Flooded, Excavated	PEMFx	32.12
Palustrine, Forested/ Emergent, Seasonally Flooded	PFO/EMC	3.98
Palustrine, Forested, Broad-Leaved Deciduous/ Emergent, Seasonally Flooded	PFO1/EMC	0.55
Palustrine, Forested, Broad-Leaved Deciduous, Temporarily Flooded	PFO1A	7.58
Palustrine, Forested, Broad-Leaved Deciduous, Seasonally Flooded	PFO1C	5.21
Palustrine, Forested, Temporarily Flooded	PFOA	31.53
Palustrine, Forested, Temporarily Flooded, Drained/Ditched	PFOAd	3.20
Palustrine, Forested, Seasonally Flooded	PFOC	10.56
Palustrine, Scrub-Shrub, Emergent, Seasonally Flooded	PSS/EMC	7.17
Palustrine, Scrub-Shrub, Emergent, Seasonally Flooded, Excavated	PSS/EMCx	10.33
Palustrine, Scrub-Shrub, Forested, Seasonally Flooded	PSS/FOC	5.38
Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Emergent, Seasonally Flooded	PSS1/EMC	1.33
Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded	PSS1C	11.41
Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded, Partially Drained/Ditched	PSS1Cd	0.91

Palustrine, Scrub-Shrub, Temporarily Flooded	PSSA	13.25
Palustrine, Scrub-Shrub, Seasonally Flooded	PSSC	2.57
Palustrine, Unconsolidated Bottom, Semipermanently Flooded	PUBF	6.47
Palustrine, Unconsolidated Bottom, Semipermanently Flooded, Diked/Impounded	PUBFh	2.97
Palustrine, Unconsolidated Bottom, Semipermanently Flooded, Excavated	PUBFx	21.79
Palustrine, Unconsolidated Bottom, Intermittently Exposed	PUBG	0.31
Palustrine, Unconsolidated Bottom, Intermittently Exposed, Excavated	PUBGx	15.54
Palustrine, Unconsolidated Bottom, Artificially Flooded, Intermittently Exposed, Excavated	PUBKGx	74.71
Riverine, Lower Perennial, Unconsolidated Bottom, Intermittently Exposed	R2UBG	241.53
Riverine, Lower Perennial, Unconsolidated Bottom, Permanently Flooded	R2UBH	2114.90
Riverine, Lower Perennial, Unconsolidated Shore, Temporarily Flooded	R2USA	2.08
Riverine, Lower Perennial, Unconsolidated Shore, Seasonally Flooded	R2USC	2.10
Riverine, Intermittent, Streambed, Semipermanently Flooded	R4SBF	0.69
Riverine, Intermittent, Streambed, Semipermanently Flooded, Excavated	R4SBFx	15.33
Total		4625.97

1.3 Photo Logs

Photo Point 1 – Roadside ditch: west side wet, east side some evidence, but more marginal.

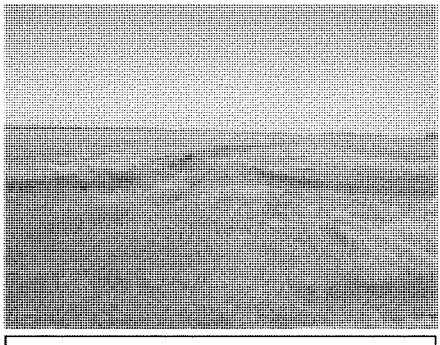

Photo Point 2 – Waterway with drown-out sparsely vegetated close to road.

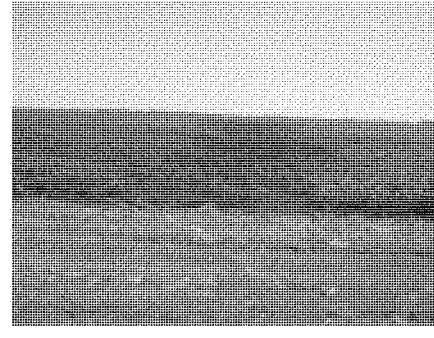

Photo Point 3 – Drown-out along the south side of CR-16.

Photo Point 4 - Drown-out along the south side of CR-16.

Photo Point 5 - Drown-out along the south side of CR-16.

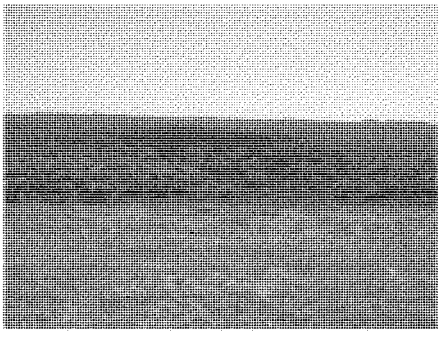

Photo Point 6 - Drown-out along the south side of CR-16.

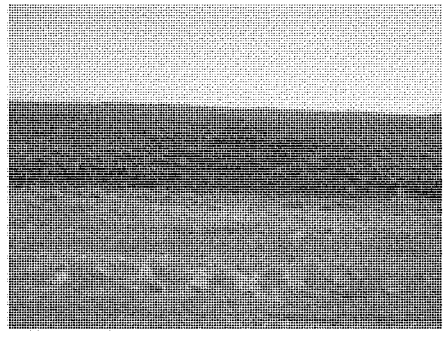

Photo Point 7 - Drown-out along the south side of CR-16.

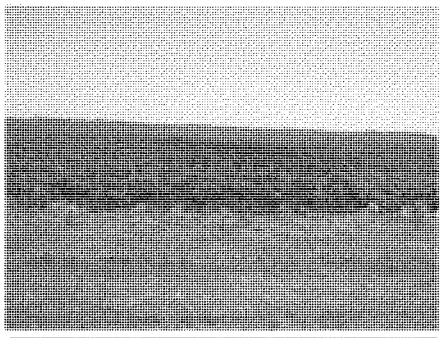

Photo Point 8 - Drown-out along the south side of CR-16.

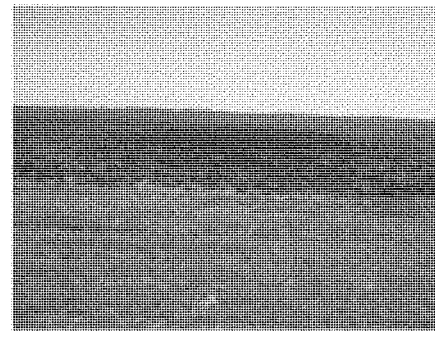

Photo Point 9 - Drown-out along the south side of CR-16.

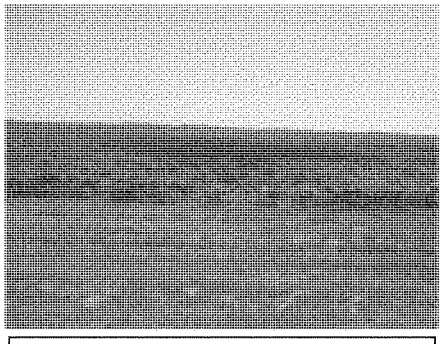

Photo Point 10 - Drown-out along the south side of CR-16.

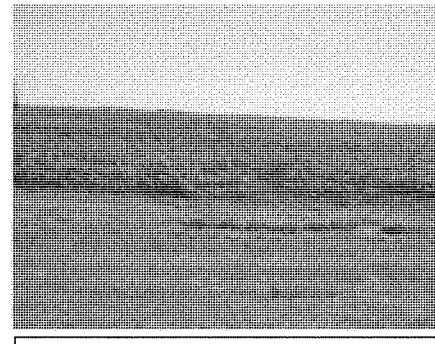

Photo Point 11 - Drown-out along the south side of CR-16.

Photo Point 12 – Ditch along the north side of CR-16.

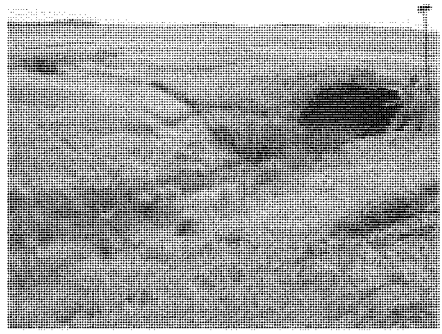

Photo Point 13 – Road side ditch at the corner of 172nd Ave SE and 49th Street.

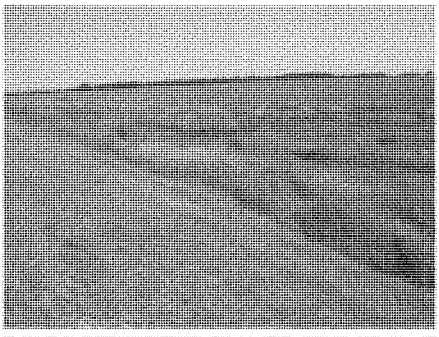

Photo point 14 - Road side ditch at the corner of 172nd Ave SE and 49th Street.

Photo Point 15 – Road side ditch and drown out along the south side of 49th Street.

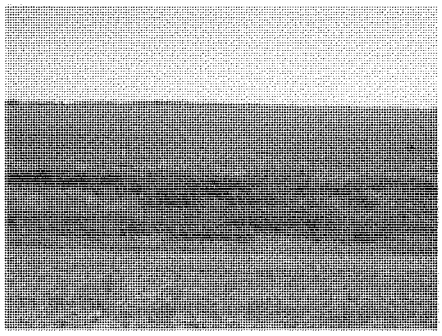

Photo point 16 - Road side ditch and drown out along the south side of 49th Street.

Photo point 18 - Road side ditch and drown out along the south side of 49th Street.

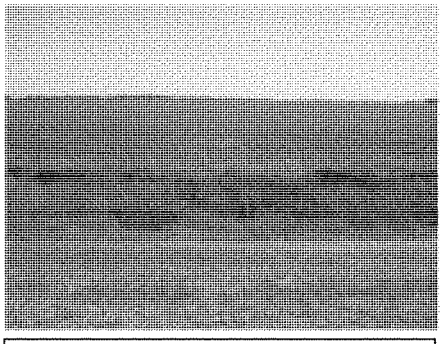

Photo point 17 - Road side ditch and drown out along the south side of 49th Street.

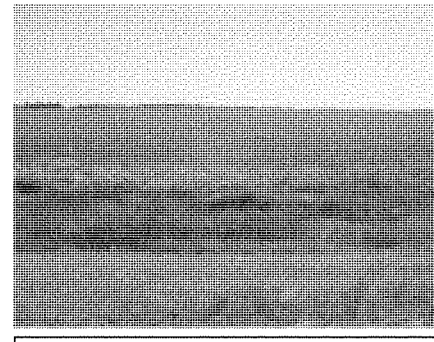

Photo point 19 - Road side ditch and drown out along the south side of 49th Street.

Photo point 20 - Road side ditch and drown out along the south side of 49th Street.

Photo point 21 - Road side ditch and drown out along the south side of 49th Street.

Photo point 22 – Drown-out along the north side of 49th Street, running east-west.

Photo point 23 – Drown-out along the north side of 49th Street.

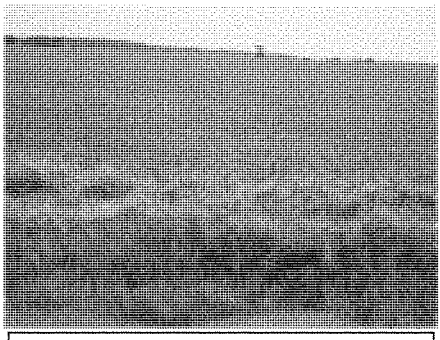

Photo Point 24 - Road side ditch and drown out along the south side of 49th Street.

Photo Point 25 - Road side ditch and drown out along the south side of 49th Street.

Photo Point 26 – Small pooled wetland area between two farm fields on the north side of 49th Street.

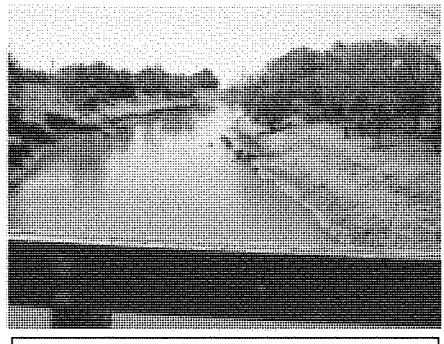

Photo Point 27 – West side of the Wild Rice River from the bridge of 173rd Ave.

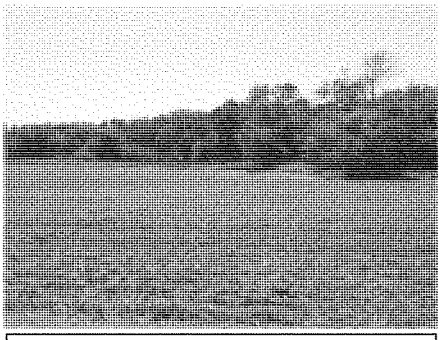

Photo Point 28 – Wild Rice River just beyond the tree line, pictured from 173rd Avenue.

Photo Point 29 – Ditches along the east and west side of Highway 29; some areas wet and others not wet.

Photo Point 30 - Ditches along the east and west side of Highway 29; some areas wet and others not wet.

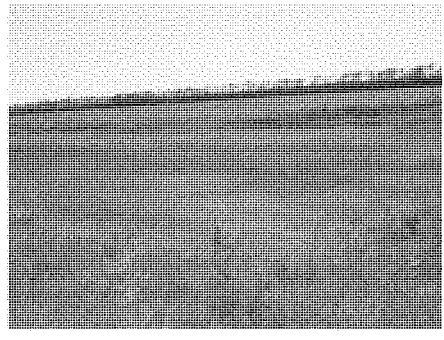

Photo Point 31 - Ditches along the east and west side of Highway 29; some areas wet and others not wet.

Photo Point 32 – Drown-out on the south side of 49th Street.

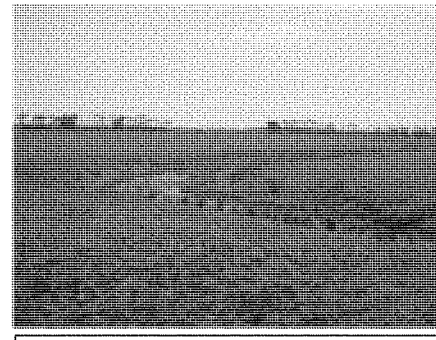

Photo Point 33 – Ditch with flowing water and wetland fringe on the south side of 49th Street.

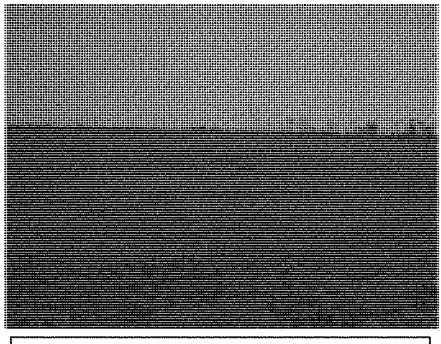

Photo Point 34 – Drown-out/swale on the south side of 49th Street.

Photo Point 35 – Drown-out on the east side of unnamed road running adjacent to the east of Highway 29.

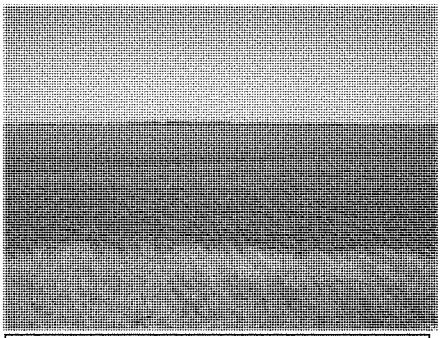

Photo Point 36 - Drown-out on the east side of unnamed road running adjacent to the east of Highway 29.

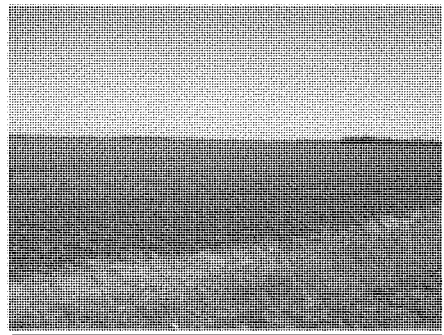

Photo Point 37 - Drown-out on the east side of unnamed road running adjacent to the east of Highway 29.

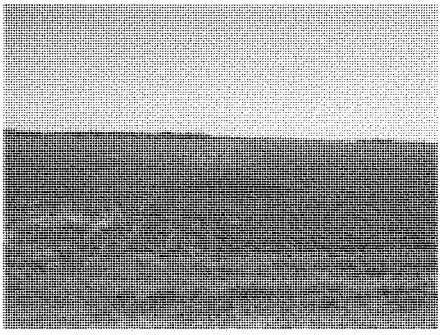

Photo Point 38 – Drown out on the south side of 49th Street.

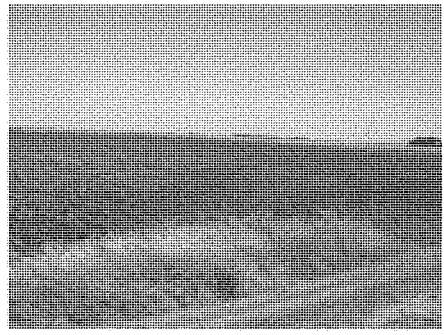

Photo Point 39 – Road side ditch and drown-out on the east side of CR-59.

Photo Point 40 – Drown-out on the south side of Highway 4.

Photo Point 41 – unknown depression in distance on the north side of Highway 4.

Photo Point 42 – Drown-out on the south side of Highway 4.

Photo Point 43 – Intermittent stream/drainage on the north side of Highway 4; connects to another larger stream to the north in the distant tree line.

Photo Point 44 - Intermittent stream/drainage on the north side of Highway 4; connects to another larger stream to the north in the distant tree line.

Photo Point 45 - Intermittent stream/drainage on the south side of Highway 4; connects to another larger stream to the north.

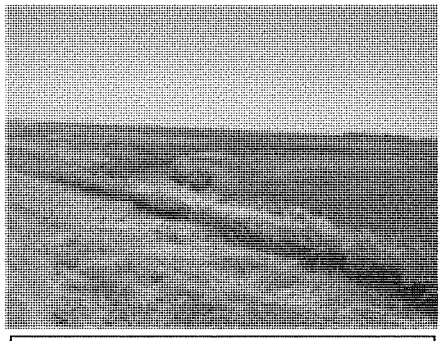

Photo Point 46 – Stream/Drainage on the south side of Highway 4; connects to a larger stream to the north.

Photo Point 47 – Stream/Drainage on the north side of Highway 4; connects to a larger stream to the north along the tree line.

Photo Point 48 – Drainage swale on the north side of Highway 4.

Photo Point 49 - Drainage swale on the south side of Highway 4.

Photo Point 50 – Drown-out on the west side of CR-59.

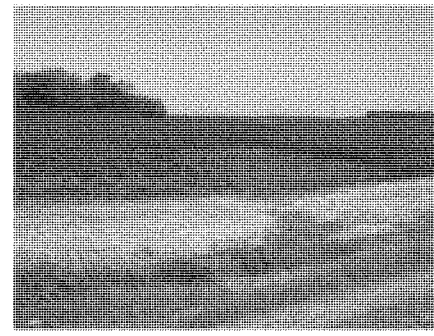

Photo Point 51 – Drown-out on the east side of CR-59.

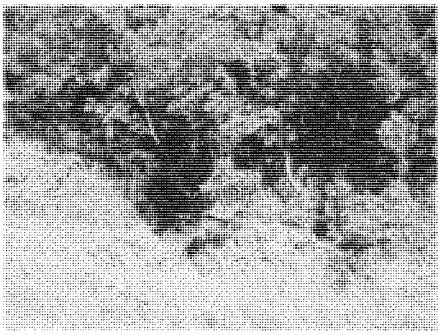

Photo Point 52 – Intermittent stream draining into the Red River; picture toward the west from CR-59.

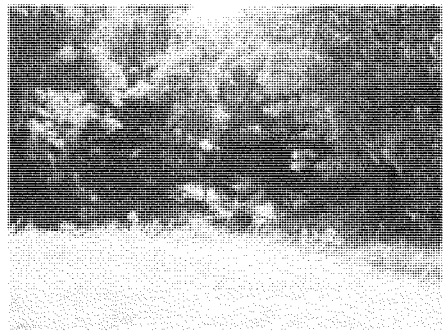

Photo Point 53 - Intermittent stream draining into the Red River; picture toward the east from CR-59.

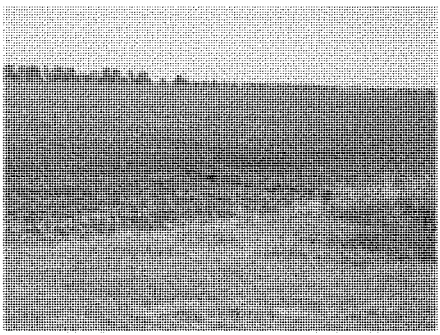

Photo Point 54 – Drown-out on the east side of CR 59.

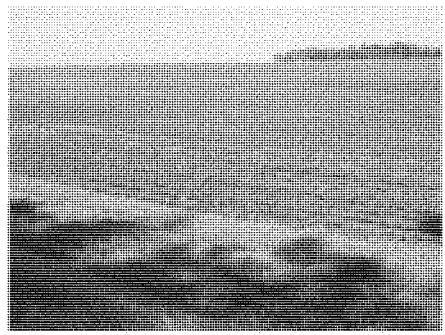

Photo Point 55 – Large depressional basin on the east side of CR-59; some crop stress apparent.

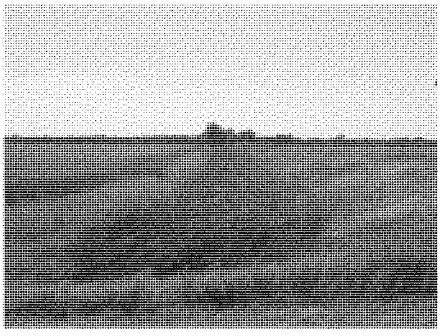

Photo Point 56 – Large ditch running east; pictured from Highway 75.

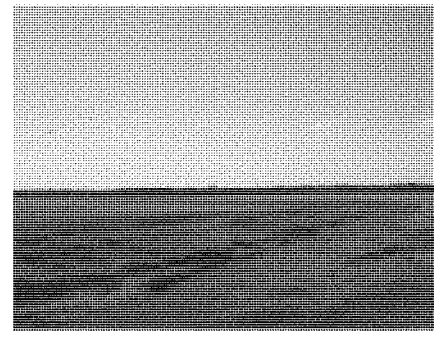

Photo Point 57 – Large drainage ditch/intermittent stream running east, draining into the Red River; Picture taken from Highway 75.

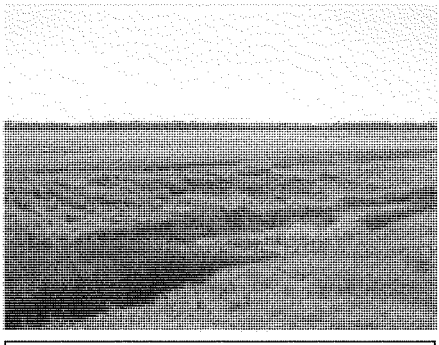

Photo Point 58 - Large drainage ditch/intermittent stream running east, draining into the Red River; Picture taken from Highway 75.

Photo Point 59 – Wetland/Intermittent stream draining east into the Red River; Picture take from 173rd Avenue facing east.

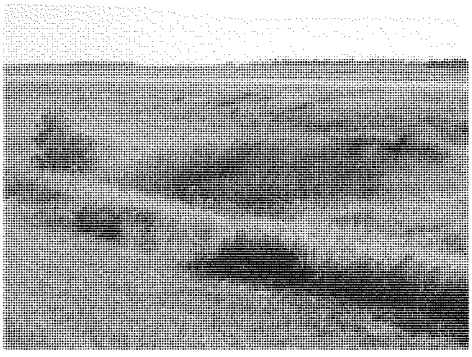

Photo Point 60 - Wetland/Intermittent stream draining east into the Red River; Picture take from Highway 29 facing east.

Photo Point 1 – MnRAM site 14-MN-JCD

Photo Point 2 - MnRAM site 14-MN-JCD

Photo Point 3 - MnRAM site 14-MN-JCD

Photo Point 4 – MnRAM site 0-MN-JCD; floodplain forest

Photo Point 5 - MnRAM site 0-MN-JCD; floodplain forest

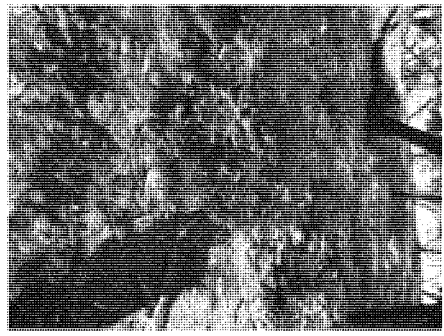

Photo Point 6 - MnRAM site 0-MN-JCD; floodplain forest

Photo Point 7 - MnRAM site 0-MN-JCD; sugar beet field adjacent to floodplain forest; crop was stunted in areas and leaves were yellowing

Photo Point 8 - MnRAM site 0-MN-JCD; sugar beet field adjacent to floodplain forest; crop was stunted in areas and leaves were yellowing

Photo Point 9 - MnRAM site 0-MN-JCD; sugar beet field adjacent to floodplain forest; crop was stunted in areas and leaves were yellowing

Photo Point 10 - MnRAM site 0-MN-JCD; sugar beet field adjacent to floodplain forest; crop was stunted in areas and leaves were yellowing

Photo Point 11 - MnRAM site 0-MN-JCD; sugar beet field adjacent to floodplain forest; crop was stunted in areas and leaves were yellowing

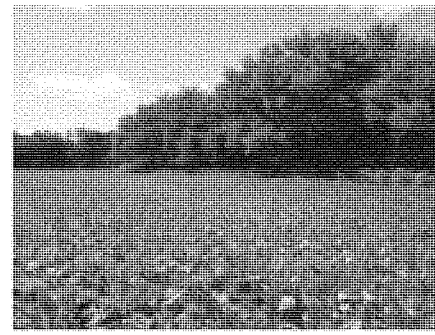

Photo Point 12 - MnRAM site 0-MN-JCD; sugar beet field adjacent to floodplain forest; crop was stunted in areas and leaves were yellowing

Photo Point 13 - MnRAM site 0-MN-JCD; sugar beet field adjacent to floodplain forest; crop was stunted in areas and leaves were yellowing

Photo Point 14 – Drown-out area off County Road 59

Photo Point 15 – Drown-out area off County Road 59

Photo Point 16 – MnRAM site 11-ND-JCD; Soybean crop showing signs of stress

Photo Point 17 – MnRAM site 11-ND-JCD; Soybean crop showing signs of stress

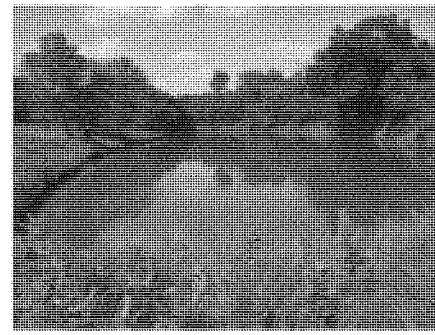

Photo Point 18 – MnRAM site 12-ND-JCD; open water pond with minimal wetland fringe connecting to Wild Rice River

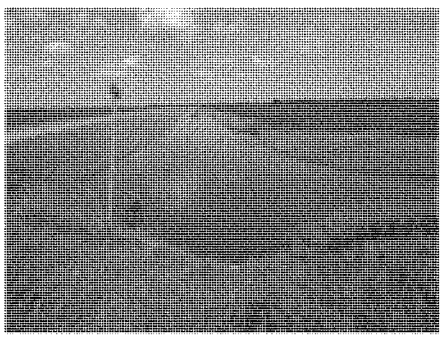

Photo Point 19 – Ditch and crop stressed drownouts along 49th Street.

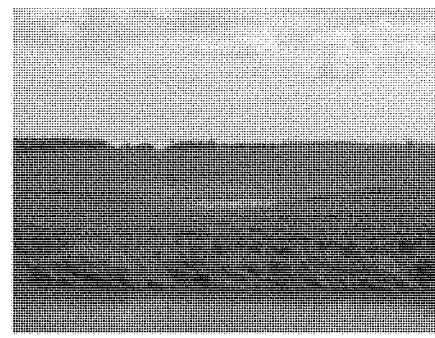

Photo Point 20 – Ditch and crop stressed drownouts along 49th Street.

Photo Point 21 – Ditch and crop stressed drownouts along 49th Street.

Photo Point 22 – MnRAM 134-ND-JCD shallow marsh area along 173rd Avenue and Highway 29.

Photo Point 23 – MnRAM 134-ND-JCD shallow marsh area along 173rd Avenue and Highway 29.

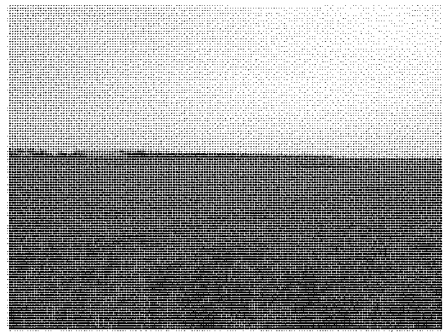

Photo Point 24 – MnRAM 8-ND-JCD; wetland in wheat field

Photo Point 25 – MnRAM 8-ND-JCD; wetland in wheat field

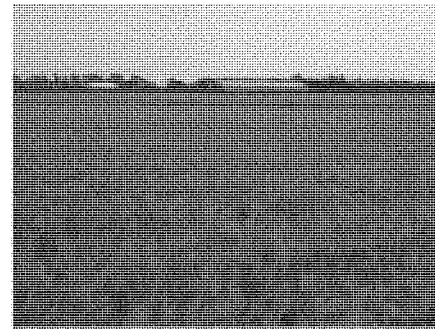

Photo Point 26 – MnRAM 8-ND-JCD; wetland in wheat field

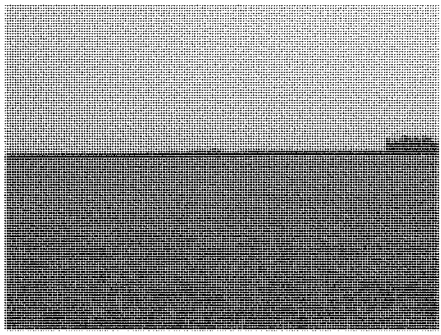

Photo Point 27 – MnRAM 8-ND-JCD; wetland in wheat field

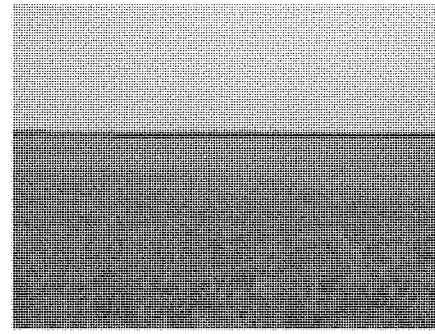

Photo Point 28 – MnRAM 8-ND-JCD; wetland in wheat field

Photo Point 29 – MnRAM 8-ND-JCD; wetland in wheat field

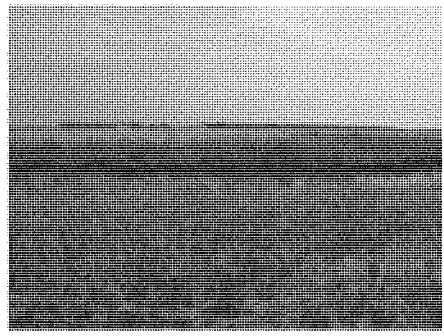

Photo Point 30 – MnRAM 8-ND-JCD; wetland in wheat field

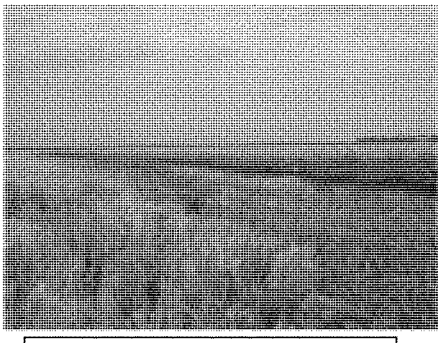

Photo Point 31 – MnRAM 8-ND-JCD; wetland in wheat field

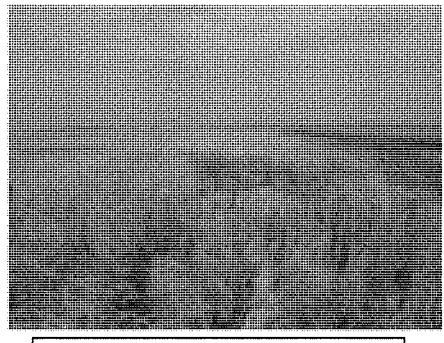

Photo Point 32 – MnRAM 8-ND-JCD; wetland in wheat field

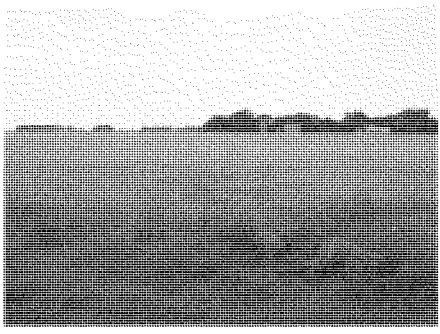

Photo Point 33 – Ditch and drownouts along 169th Avenue

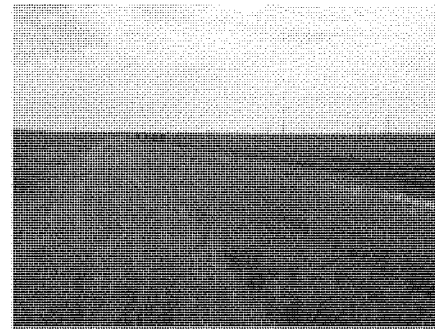

Photo Point 34 – Ditch and drownouts along 169th Avenue

Photo Point 35 – Ditch and drownouts along 169th Avenue

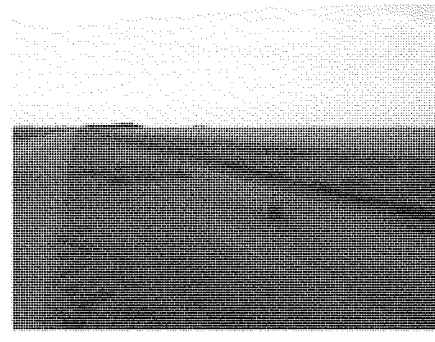

Photo Point 36 – Ditch and drownouts along 169th Avenue

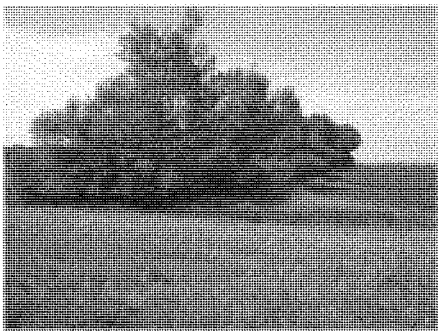

Photo Point 37 – Ditch and drownouts along 169th Avenue

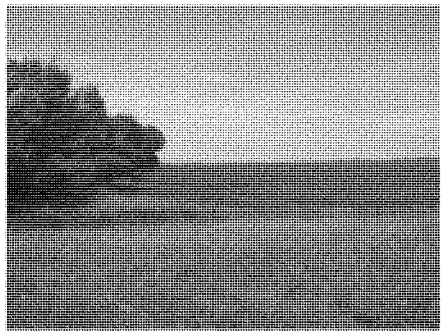

Photo Point 38 – Ditch and drownouts along 169th Avenue

Photo Point 39 – Ditch and drownouts along 169th Avenue

Photo Point 40 – Ditch and drownouts along 169th Avenue

Photo Point 41 – MnRAM 33-ND-MRB; Arrowhead area near old oxbow

Photo Point 42 – MnRAM 33-ND-MRB; Arrowhead area near old oxbow

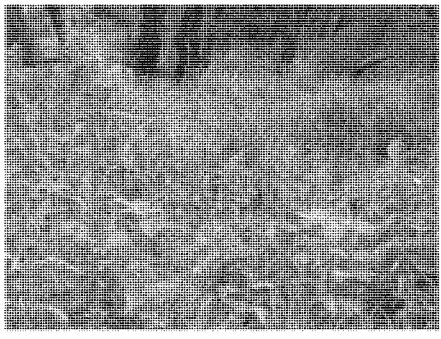

Photo Point 43 – MnRAM 33-ND-MRB; Arrowhead area near old oxbow

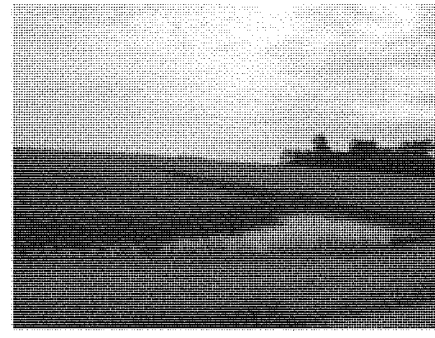

Photo Point 44 – Ditches and drown outs along multiple areas of the project corridor.

Photo Point 45– Ditches and drown outs along multiple areas of the project corridor.

Photo Point 46– Ditches and drown outs along multiple areas of the project corridor.

Photo Point 47– Ditches and drown outs along multiple areas of the project corridor.

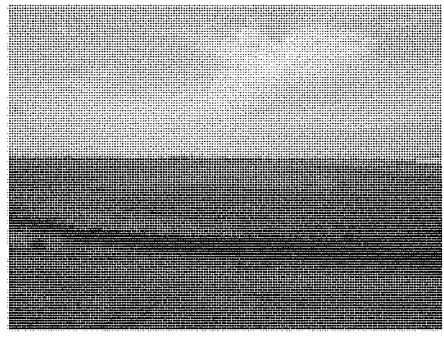

Photo Point 48– Ditches and drown outs along multiple areas of the project corridor.

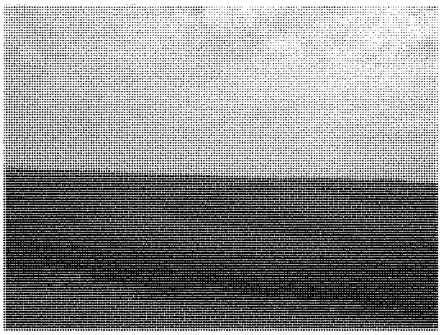

Photo Point 49– Ditches and drown outs along multiple areas of the project corridor.

Photo Point 50– Ditches and drown outs along multiple areas of the project corridor.

Photo Point 51– Ditches and drown outs along multiple areas of the project corridor.

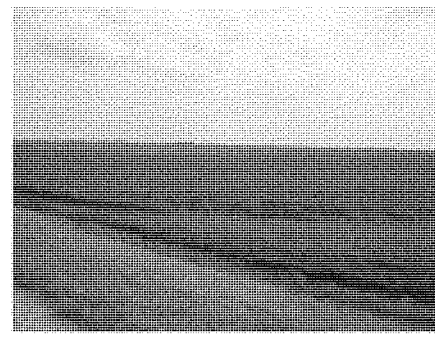

Photo Point 52– Ditches and drown outs along multiple areas of the project corridor.

Photo Point 53– Ditches and drown outs along multiple areas of the project corridor.

Photo Point 54 – Ditches and drown outs along multiple areas of the project corridor.

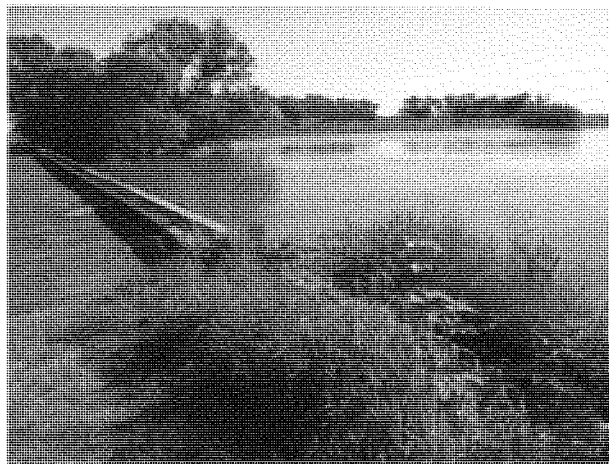

Photo Point 1.1 – *168th Ave SE Maple River Bridge Crossing*
Maple River is almost overtopping the bridge, and the surrounding fields are flooded.

Photo Point 1.2 – *168th Ave SE Maple River Bridge Crossing*
Adjacent field to the SE of the Maple River is flooded. Maple River flows just beyond the tree line in the distance.

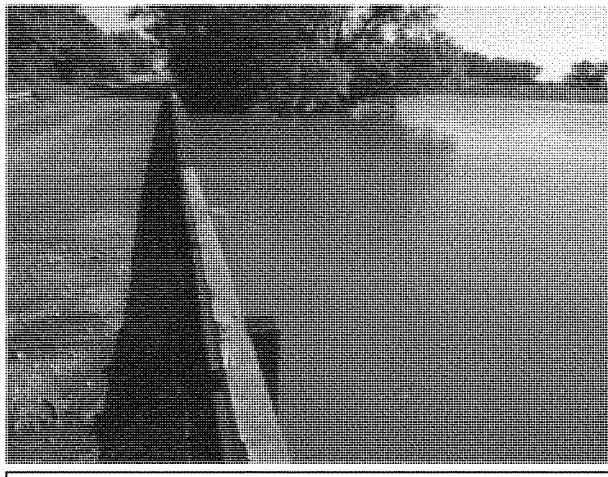

Photo Point 1.3 – *168th Ave SE Maple River Bridge Crossing*
Maple River is almost overtopping the bridge, and the surrounding fields are flooded. (Facing North)

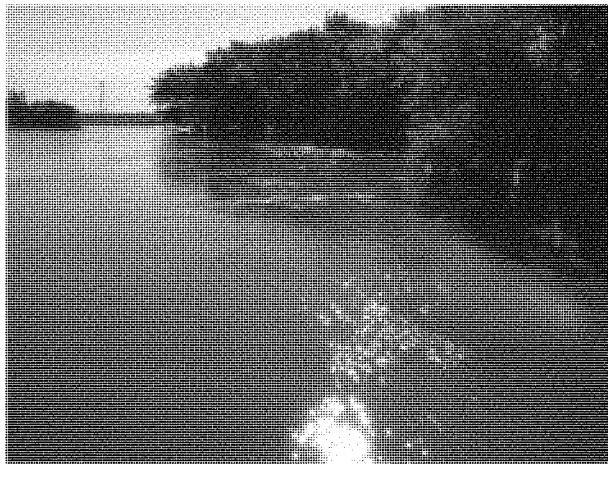

Photo Point 1.4 – *168th Ave SE Maple River Bridge Crossing*
Maple River is almost overtopping the bridge, and the surrounding fields are flooded. (Facing West)

Photo Point 2.1 – *CR20/33rd Street SE & 167th Ave SE*
Maple River spillway location and Maple River aqueduct location at a distance.

Photo Point 2.2 – *CR20/33rd Street SE & 167th Ave SE*
Maple River spillway location and Maple River aqueduct location at a distance.

Photo Point 2.3 – *CR20/33rd Street SE & 167th Ave SE*
Maple River spillway location and Maple River aqueduct location at a distance.

Photo Point 3.1 – *168th Ave SE & 40th St SE*
Looking at the diversion alignment from a distance, which is adjacent to the existing Sheyenne Diversion. Fields are saturated with water.

Photo Point 3.2 – *168th Ave SE & 40th St SE*
Looking at the diversion alignment from a distance, which is adjacent to the existing Sheyenne Diversion. Fields are saturated with water.

Photo Point 3.3 – *168th Ave SE & 40th St SE*
Looking at the diversion alignment from a distance, which is adjacent to the existing Sheyenne Diversion. Fields are saturated with water.

Photo Point 3.4 – *168th Ave SE & 40th St SE*
Looking at the diversion alignment from a distance, which is adjacent to the existing Sheyenne Diversion. Fields are saturated with water.

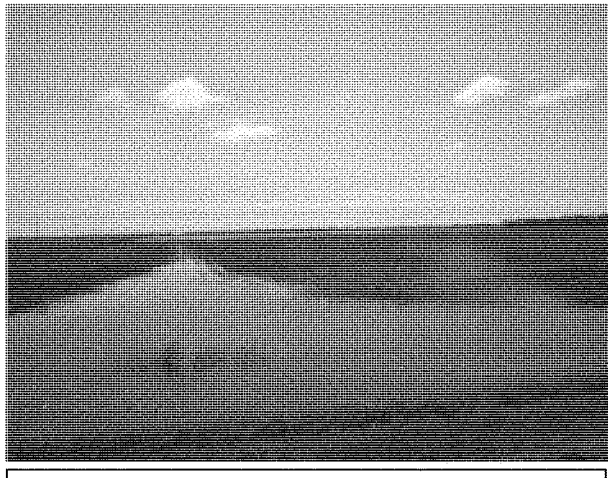

Photo Point 4.1 – *168th Ave SE & 42nd St SE*
Looking at the diversion alignment from a distance, which is adjacent to the existing Sheyenne Diversion. Fields are saturated with water.

Photo Point 4.2 – *168th Ave SE & 42nd St SE*
Looking at the diversion alignment from a distance, which is adjacent to the existing Sheyenne Diversion. Fields are saturated with water.

Photo Point 5.1 – *168th Ave SE & 46th St SE*
Existing Sheyenne Diversion; river banks full to top. (South Facing)

Photo Point 5.2 – *168th Ave SE & 46th St SE*
Existing Sheyenne Diversion; river banks full to top.
(Southeast Facing)

Photo Point 5.3 – *168th Ave SE & 46th St SE*
Existing Sheyenne Diversion; river banks full to top.
(Southwest Facing)

Photo Point 5.4 – *168th Ave SE & 46th St SE*
Existing Sheyenne Diversion; river banks full to top. (North Facing)

Photo Point 5.5 – *168th Ave SE & 46th St SE*
Existing Sheyenne Diversion; river banks full to top. (Northwest Facing)

Photo Point 5.6 – *168th Ave SE & 46th St SE*
Existing Sheyenne Diversion; river banks full to top. (Northeast Facing)

Photo Point 6.1 – *CR16/48th St SE & 171st Ave SE*
Looking into Storage Area 1 and diversion alignment.

Photo Point 6.2 – *CR16/48th St SE & 171st Ave SE*
Looking into Storage Area 1; diversion alignment runs adjacent to the south end of the storage area.

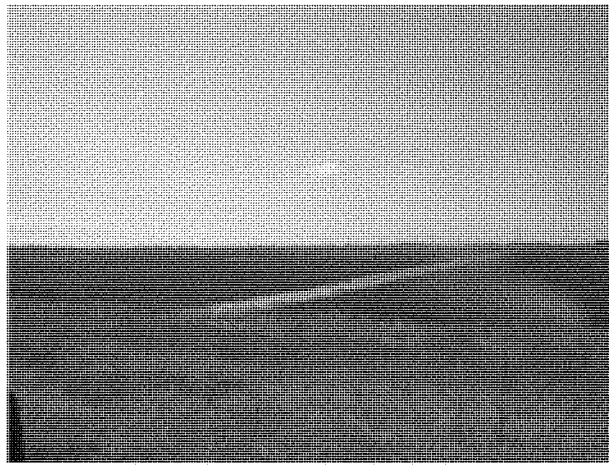

Photo Point 7.1 – *CR16/48th St SE & 172nd Ave SE*
Looking into Storage Area 1; diversion alignment runs adjacent to the south end of the storage area.

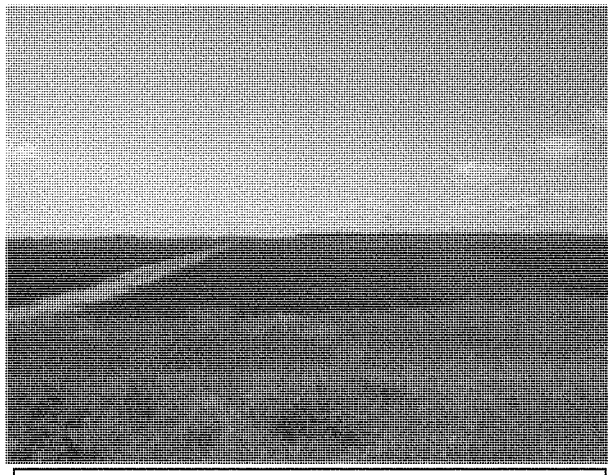

Photo Point 7.2 – *CR16/48th St SE & 172nd Ave SE*
Looking into Storage Area 1; diversion alignment runs adjacent to the south end of the storage area.

Photo Point 7.3 – *CR16/48th St SE & 172nd Ave SE*
Looking into Storage Area 1; diversion alignment runs adjacent to the south end of the storage area.

1.4 Water Quality Data Collected in 2008/2009

Station_ID	START_DATE	START_TIME	Chloride/Total/ 4500-CL-(E)/mg/l	Dissolved oxygen (DO)/DO PROBE/mg/l	Hardness, carbonate /Total/13D _1/mg/l CaCO3	Nitrogen, ammonia as N/Total/3 50_1/mg/l	Nitrogen, Kjeldahl/Total/351_ 2/mg/l	Nitrogen, Nitrite (NO2) - Nitrate (NO3) as/Total/3 53_2/mg/l	pH/FLD PH/None	Phosphorus as P/Total/36 5_3/mg/l	Phosphorus, orthophosphate as P/Total/360_3/mg/l	Solids, Total Suspended (TSS)/Suspended/254 D/mg/l	Solids, Volatile/Suspended /160_4/mg/l	Specific conductance/FLD CONDUCTANCE/uS/cm	Stream Physical Appearance, Minnesota (choice 1/	Stream Recreational Suitability (choice list)/CSMP-CONDSUIT 1/	TD (RP to water)	Sulfur, sulfate (SO4) as SO4/Total /D516/mg/l	Temperature, water/FLD TEMP/deg C	Transparency, tube with disk/CSMP TTUBE60/cm	Transparency, tube with disk/FLD TTUBE120/cm	Turbidity (NTU)	Turbidity (FNU)
S002-097	11/04/2008	13:55:00	23.8	11.03	454	< 0.04	0.96	1.08	8.19	0.258	0.179	49	9	1069	2.CLOUDY	4.POOR	35.21	298	7.27	16		40.3	29.3
S002-097	12/01/2008	14:41:00	30.8	13.02	524	0.075	0.533	1.26	8.25	0.230	0.182	16	3	1227	2.CLOUDY	3.FAIR	36.33	306	-0.02	31.5		19.5	10.9
S002-097	02/09/2009	10:33:00	26.4	12.14	356	0.141	1.19	1.53	7.93	0.273	0.241	6	4	820	1A.CLEAR	2.GOOD		163	0.27		98	5.38	4.8
S002-097	03/03/2009	10:37:00	23.5	12.97	359	0.081	0.788	1.45	7.81	0.259	0.226	6	2	769	1A.CLEAR	2.GOOD		129	0.39		75	5.12	5.6
S002-097	03/24/2009	16:35:00					1.9	0.22		0.499	0.048	326	34		3.MUDDY	4.POOR						243	
S002-097	03/26/2009	15:40:00		4.51			2.05	0.32	7.75	0.389	0.041	296	46	283	3.MUDDY	5.VERY POOR			0.16	3		275	198.9
S002-097	03/29/2009	11:58:00		7.98			1.38	0.6	7.97	0.304	0.098	164	24	289	3.MUDDY	4.POOR			0.88	4		174	135.8
S002-097	04/02/2009	13:42:00	13.6	10.02	190	< 0.04	1.26	0.73	7.92	0.273	0.113	114	19	407	3.MUDDY	5.VERY POOR		104	1.01	5.5		112	84.1
S002-097	04/03/2009	11:00:00					1.05	0.72		0.277	0.121	107	16		3.MUDDY	4.POOR				6.5		102	
S002-097	04/05/2009	12:45:00		10.24			1.15	0.68	7.90	0.277	0.130	109	16	468	3.MUDDY	4.POOR			2.22	6.5		100	72.9
S002-097	04/05/2009	12:46:00					1.27	0.67		0.282	0.126	113	15									96.6	
S002-097	04/05/2009	12:46:00		10.28					7.84					469	3.MUDDY	4.POOR			2.20	6.5			74.3
S002-097	04/07/2009	08:57:00		10.69			1.25	0.72	8.18	0.303	0.132	134	21	499	3.MUDDY	4.POOR			2.38	7.5		117	80.7
S002-097	04/09/2009	09:32:00		10.75			1.29	0.65	7.86	0.306	0.146	141	17	537	3.MUDDY	5.VERY POOR			3.71	7		118	86.6
S002-097	04/13/2009	09:00:00		9.61			1.19	0.54	7.86	0.301	0.137	120	12	499	3.MUDDY	4.POOR			6.74	8.5		103	78.3
S002-097	04/15/2009	10:20:00		8.16			1.19	0.23	7.62	0.269	0.096	112	15	426	3.MUDDY	5.VERY POOR			7.53	8.5		95	72.2
S002-097	04/17/2009	08:29:00		8.68			1.04	0.15	7.73	0.233	0.092	74	8	432	2.CLOUDY	4.POOR			9.28	12.5		64.3	51.4
S002-097	04/20/2009	09:17:00		9.05			1.11	0.15	7.98	0.226	0.115	57	11	519	2.CLOUDY	4.POOR	10.07		10.26	14		49.9	40.9
S002-097	04/23/2009	13:40:00		9.27			1.23	0.27	7.96	0.259	0.130	76	11	602	3.MUDDY	4.POOR	10.96		10.27	10		68.3	51
S002-097	04/27/2009	10:01:00		9.72			1.15	0.15	8.09	0.244	0.109	93	13	633	3.MUDDY	4.POOR	12		9.30	8		84.2	65.5
S002-097	04/30/2009	14:04:00		9.74			1.05	0.07	8.06	0.223	0.112	70	10	672	2.CLOUDY	4.POOR	13.4		9.53	11.5		62.1	48.2
S002-097	05/05/2009	09:48:00		9.33			0.877	0.1	8.16	0.210	0.115	54	8	774	2.CLOUDY	4.POOR	17.12		12.04	14.5		47.6	39
S002-097	05/07/2009	10:09:00	17.6	8.79	331	0.074	1	0.09	8.18	0.215	0.113	61	5	780	2.CLOUDY	4.POOR	18.83	201	13.39	11.5		80.2	40.7
S002-097	05/12/2009	09:20:00		8.88			0.918	0.25	8.15	0.224	0.136	72	10	786	2.CLOUDY	4.POOR	22.58		13.35	12		57.3	46.5
S002-097	05/14/2009	10:17:00		9.25			1.05	0.21	8.23	0.215	0.122	74	< 5	778	3.MUDDY	4.POOR	23.2		13.57	12.5		54.9	49.8
S002-097	05/18/2009	13:32:00		9.22			0.852	0.23	8.22	0.206	0.111	79	9	828	2.CLOUDY	4.POOR	24.53		14.01	11.5		52.5	47.3
S002-097	05/20/2009	09:22:00		9.18			0.881	0.18	8.27	0.204	0.106	91	16	815	2.CLOUDY	4.POOR	25.37		14.79	12		63.3	50
S002-097	05/27/2009	11:14:00		8.18			0.825	0.45	8.12	0.280	0.125	142	13	799	3.MUDDY	4.POOR	29.05		16.51	9.5		95.7	79.4
S002-097	05/28/2009	10:03:00		8.34			1.22	0.53	8.17	0.297	0.136	153	14	790	3.MUDDY	4.POOR	29.03		16.86	8.5		96.5	82.5
S002-097	06/01/2009	13:21:00		8.14			1.16	0.56	8.13	0.297	0.129	172	16	823	3.MUDDY	4.POOR	30.26		17.98	9		111	87.2
S002-097	06/04/2009	10:09:00	18.0	8.30	358	< 0.04	1.131	0.35	8.24	0.287	0.121	157	14	785	3.MUDDY	4.POOR	31.33	181	18.53	8.5		101	81.6
S002-097	06/04/2009	10:10:00	18.2		364	< 0.04	1.194	0.35		0.293	0.120	159	14					168				98.6	
S002-097	06/04/2009	10:10:00		8.24					8.22					784	3.MUDDY	4.POOR	31.36		18.54	8.5			82.4
S002-097	06/08/2009	12:59:00		8.67			1.12	< 0.02	8.27	0.244	0.107	98	8	755	3.MUDDY	4.POOR	32.94		15.87	12		68.4	53.1
S002-097	06/11/2009	11:16:00		9.34			1	0.46	8.29	0.232	0.120	84	10	683	2.CLOUDY	4.POOR	33.32		15.87	11.5		55.1	46.8
S002-097	06/15/2009	13:53:00		8.56			1.17	0.36	8.29	0.240	0.102	18	11	650	2.CLOUDY	4.POOR	33.82		19.86	12		72.4	60.9
S002-097	06/17/2009	20:28:00		8.05			0.954	0.45	8.27	0.277	0.104	150	14	628	3.MUDDY	4.POOR	32.44		20.22	11.5		80.3	71.8
S002-097	06/18/2009	14:26:00		7.36			1.66	0.8	8.20	0.536	0.106	532	29	773	3.MUDDY	5.VERY POI	27.93		20.03	4		349	260.6
S002-097	06/19/2009	08:45:00		6.26			2.66	3.94	7.91	0.762	0.224	672	52	372	3.MUDDY	5.VERY POI	25.1		19.04	2.5		539	436.1
S002-097	06/22/2009	13:19:00		5.37			1.36	2.45	7.74	0.412	0.212	152	19	406	3.MUDDY	4.POOR	19.28		21.72	5		186	150
S002-097	06/24/2009	09:32:00		5.20			1.22	1.72	7.74	0.330	0.225	71	6	506	3.MUDDY	4.POOR	18.62		22.54	9.5		71.8	63.4
S002-097	06/26/2009	10:20:00		5.23			1.22	1.2	7.68	0.358	0.270	58	5	593	2.CLOUDY	4.POOR	20.25		22.64	13		58.7	50.1
S002-097	06/29/2009	15:41:00		5.77			1.48	0.69	7.83	0.437	0.271	172	16	754	3.MUDDY	5.VERY POI	25.57		22.61	7		116	110.2
S002-097	07/09/2009	15:21:00	19.4	6.65	403	0.068	1.37	0.6	8.05	0.426	0.206	261	22	838	3.MUDDY	5.VERY POI	33.43	201	24.27	6		173	134.7
S002-097	07/21/2009	10:52:00		7.20			1.11	0.8	7.90	0.370	0.172	172	19	551	3.MUDDY	4.POOR	32.36		20.37	6		149	115.4
S002-097	07/29/2009	14:36:00		7.51			1.02	0.4	8.16	0.264	0.119	145	10	732	3.MUDDY	4.POOR	36		23.09	9		102	87.1
S002-097	08/12/2009	10:06:00	16.8	7.52	279	< 0.04	0.968	0.59	8.26	0.300	0.189	108	12	603	2.CLOUDY	4.POOR	37.24	111	22.98	9		88.9	73.2
S002-097	08/12/2009	10:07:00	16.4		283	< 0.04	0.872	0.58		0.296	0.162	109	11					108				88	
S002-097	08/12/2009	10:07:00		7.46					8.26					603	2.CLOUDY	4.POOR	37.2		22.97	9.5			71.5
S002-097	08/26/2009	11:49:00		8.25			0.734	0.71	8.31	0.306	0.206	71	6	589	2.CLOUDY	4.POOR	37.03		21.31	9.5		62.3	47.3
S002-097	09/16/2009	10:06:00	18.4	7.86	250	< 0.04	0.92	0.93	8.36	0.346	0.239	80	10	577	2.CLOUDY	4.POOR	38.4	95.8	21.63	14.5		64.7	51.6
S002-097	10/05/2009	09:20:00	20.4	10.09	332	0.091	0.963	0.68	8.40	0.308	0.152	185	15	668	3.MUDDY	5.VERY POI	34.13	142	11.16	8		122	102.8
S002-097	10/07/2009	15:15:00		9.78			1.82	1.83	7.98	0.500	0.278	247	22	767	3.MUDDY	5.VERY POI	34.29		9.89	6		192	150.8
S002-097	10/09/2009	09:44:00		10.18			1.42	1.52	8.22	0.400	0.245	152	16	846	3.MUDDY	5.VERY POI	33.69		8.66	8		112	93.8
S002-097	10/26/2009	12:02:00		10.30					7.95					966	3.MUDDY	5.VERY POI	30.44		5.87	6			156.2

Prime and Unique Farmland Summary as of 7-March 2011

Prime and Unique Farmland would be the following:

FCP = 5,668 for diversion and an additional 872 acres for the tie back levee, for a total of acres = 6540.

LPP = 5,500 for diversion and an additional 214 acres for the Cty 17 tie back levee, and an additional 434 for the eastern tie-back levee and an additional 730 for the perimeter of the storage area for a total of 6,878 acres.

ND35K = 5,455 for the diversion and an additional 434 acres for the tie-back levees, for a total of 5,889.

March 7, 2011

Mr. Terry Birkenstock
Chief, Environmental and GIS Branch
US Army Corps of Engineers
190 East 5th St, Suite 401
St Paul, MN 55101

Subject: Form AD-1006
RE: Farmland Conversion Impact Rating for the Fargo-Moorhead Metropolitan Area Flood Risk Management Project

Dear Mr. Birkenstock,

The NRCS portion of the AD-1006 "Farmland Conversion Impact Rating" for the Fargo-Moorhead Metropolitan Area Flood Risk Management Project has been completed as requested. I changed the acreage figures for Sites A and C on the form per phone conversation with Jonathan Sobiech. Please send me a copy of the form when it is completed.

Should you have any questions concerning the AD-1006 please contact me at 701-252-1460, extension 115.

Sincerely,

FREDERICK P. AZIZ
Area Resource Soil Scientist

Enclosure

cc: Steven Seiler, State Soil Liaison, NRCS, Bismarck, ND
Lee Voigt, Acting DC, NRCS, Fargo, ND
Stuart N. Blotter, ASTC (FO), NRCS, Jamestown, ND
Jonathan Sobiech, Forester, US, ACE, St Paul, MN

U.S. Department of Agriculture

FARMLAND CONVERSION IMPACT RATING

PART I *(To be completed by Federal Agency)*	Date Of Land Evaluation Request 2/19/11
Name Of Project Fargo Moorhead Metro Flood Risk Reduction	Federal Agency Involved US Army Corps of Engineers
Proposed Land Use Diversion Channel	County And State Cass, North Dakota

PART II *(To be completed by NRCS)*		Date Request Received By NRCS	
Does the site contain prime, unique, statewide or local important farmland? *(If no, the FPPA does not apply – do not complete additional parts of this form).*	Yes ☑ No ☐	Acres Irrigated 8745	Average Farm Size 830
Major Crop(s) Soybeans, Corn	Farmable Land In Govt. Jurisdiction Acres: 1,084,302 % 97	Amount Of Farmland As Defined in FPPA Acres: 925,155 % 83	
Name Of Land Evaluation System Used Cass County LE	Name Of Local Site Assessment System None	Date Land Evaluation Returned By NRCS 3/7/11	

		Alternative Site Rating			
PART III *(To be completed by Federal Agency)*		Site A	Site B	Site C	Site D
A. Total Acres To Be Converted Directly		6,556.0	224.0	820.0	
B. Total Acres To Be Converted Indirectly					
C. Total Acres In Site		6,556.0	224.0	820.0	0.0
PART IV *(To be completed by NRCS)* Land Evaluation Information					
A. Total Acres Prime And Unique Farmland		5,500.1	214.7	729.8	
B. Total Acres Statewide And Local Important Farmland		31.2	0.0	0.0	
C. Percentage Of Farmland In County Or Local Govt. Unit To Be Converted		0.0	0.0	0.0	
D. Percentage Of Farmland In Govt. Jurisdiction With Same Or Higher Relative Value		53.3	53.3	53.3	
PART V *(To be completed by NRCS)* Land Evaluation Criterion Relative Value Of Farmland To Be Converted *(Scale of 0 to 100 Points)*		85	89	84	
PART VI *(To be completed by Federal Agency)* Site Assessment Criteria *(These criteria are explained in 7 CFR 658.5(b)*	Maximum Points				
1. Area In Nonurban Use		15	15	15	
2. Perimeter In Nonurban Use		10	10	10	
3. Percent Of Site Being Farmed		20	20	20	
4. Protection Provided By State And Local Government		0	0	0	
5. Distance From Urban Builtup Area					
6. Distance To Urban Support Services					
7. Size Of Present Farm Unit Compared To Average		10	10	10	
8. Creation Of Nonfarmable Farmland		5	5	5	
9. Availability Of Farm Support Services		3	3	3	
10. On-Farm Investments		5	5	5	
11. Effects Of Conversion On Farm Support Services		5	5	5	
12. Compatibility With Existing Agricultural Use		0	0	0	
TOTAL SITE ASSESSMENT POINTS	160	73	73	73	0
PART VII *(To be completed by Federal Agency)*					
Relative Value Of Farmland *(From Part V)*	100	85	89	84	
Total Site Assessment *(From Part VI above or a local site assessment)*	160	73	73	73	0
TOTAL POINTS *(Total of above 2 lines)*	260	158	162	157	0

Site Selected:	Date Of Selection	Was A Local Site Assessment Used? Yes ☐ No ☒

Reason For Selection:

(See Instructions on reverse side)

Final Feasibility Report and Environmental Impact Statement
July 2011

This form was electronically produced by National Production Services Staff

Clear Form

USACE-MVP-[illegible]-1006 (10-83)
Environmental

1.5 Farmland Conversion Impact Rating for North Dakota Diversion Alternative

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
SIBLEY SQUARE AT MEARS PARK
190 FIFTH STREET EAST, SUITE 401
ST. PAUL MN 55101-1638

December 7, 2009

Regional Planning and Environmental Division North
Environmental and GIS Branch

SUBJECT: Farmland Conversion Impact Rating for Alternatives for the Fargo-Moorhead Metropolitan Area Flood Risk Management Project

Mrs. Sharon Lean
Natural Resources Conservation Service
U.S. Department of Agriculture
1615 30th Avenue South
Moorhead, Minnesota 56560

Dear Mrs. Lean:

The St. Paul District, U.S. Army Corps of Engineers, is working on a flood risk management feasibility report for the Fargo, North Dakota, and Moorhead, Minnesota, metropolitan area. Several alternatives that would divert floodwaters around the cities have been studied, including diversion channels on the Minnesota side and the North Dakota side of the Red River.

The proposed diversion channels would be constructed through farmland. We have not selected an alternative yet, but we would like to submit the four leading alternatives for review in the Farmland Conversion Impact Rating. I have attached Form AD-1006, which includes the four alternatives on the Minnesota side. I have sent a similar package to Mr. Keith Weston of the Natural Resources Conservation Service in Fargo that includes four alternatives for diversions on the North Dakota side. I have attached the project fact sheet and an area map highlighting the proposed alternatives.

Site A represents the Minnesota Short Diversion Alternative built to a size that would pass 25,000 cubic feet per second (cfs), Site B represents the alternative that would pass 35,000 cfs, Site C represents the same diversion alternative but designed to pass 45,000, and Site D represents the tie-back levee for the North Dakota diversion channel.

If you have any questions or need further information, please call Jonathan Sobiech at (651) 290-5428.

Sincerely,

for Terry J. Birkenstock
Chief, Environmental and GIS Branch

3 Enclosures

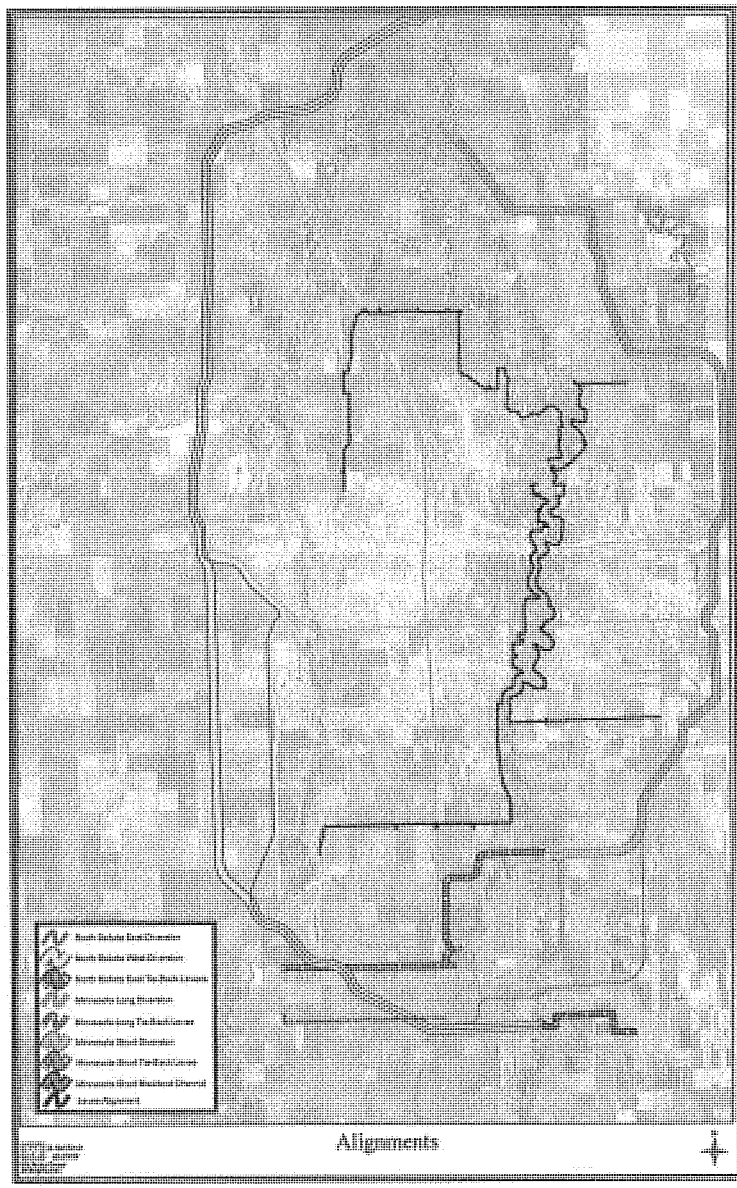

Figure 1. Diversion and levee alignments.

Army Corps of Engineers Centre, 190 Fifth Street East, St. Paul, MN 55101-1638

US Army Corps of Engineers
St. Paul District

Flood Risk Management: Fargo-Moorhead Metro, North Dakota and Minnesota

Location/Description

An emergency levee protects the city at Second Street during the 2009 flood.

Fargo, North Dakota, and Moorhead, Minnesota, are on the west and east banks, respectively, of the Red River of the North approximately 150 miles south of the Canada/United States border. In addition to the Red River, the Wild Rice, Sheyenne, Maple and Rush Rivers in North Dakota and the Buffalo River in Minnesota also cross the study area.

Background

The Fargo-Moorhead metropolitan area is a major health, educational, cultural, and commercial center serving southeastern North Dakota and west-central Minnesota. The area is prone to flooding; the Red River has exceeded flood stage in 50 of the past 106 years and every year from 1993 through 2009. A 500-year event would flood nearly the entire city of Fargo and a large portion of the city of Moorhead, as well as several smaller communities in the area. Flooding occurs not only from the rivers, but also from large rainfall events that overwhelm storm drainage systems. Average annual flood damages are estimated at more than $64 million.

Although emergency flood fights have been very successful in Fargo and Moorhead, the area is significantly vulnerable to flooding. Both the 1997 and 2009 flood events came close to overwhelming the emergency levee systems, and many homes outside the levees were damaged.

Status

The Corps and the cities of Fargo and Moorhead are jointly conducting this study. The study will assess the feasibility of measures to reduce flood risk in the entire metropolitan and surrounding area. The study will consider an array of potential alternatives including nonstructural flood proofing, diversion channels, levee/floodwall systems, and flood storage.

The study team held public meetings in November 2008 and May 2009 to request input regarding alternatives and potential impacts. The team is developing preliminary alternatives to determine which concepts are likely to be most cost-effective for reducing flood risk. Results of the initial screening are scheduled to be released at public meetings in October 2009.

The study is scheduled for completion in December 2010. The feasibility cost share agreement was signed on September 22, 2008.

Authority

This specifically authorized study originates from a resolution of the Senate Committee on Public Works, September 30, 1974.

Fiscal

Federal cost	$3,200,000
Non-federal cost	$3,050,000
Total estimated cost	$6,250,000
Fiscal year 2009 federal funds	$567,000
FY 2009 ARRA (Stimulus) funds	$222,000
Total federal funds through 2009	$1,389,000

Non-Federal funding is being provided by the cities of Fargo and Moorhead and the Buffalo-Red River Watershed District in Minnesota.

Public Affairs (651) 290-5201 (651) 290-5752(fax) cemvp-pa@usace.army.mil
http://www.mvp.usace.army.mil

U.S. Department of Agriculture

FARMLAND CONVERSION IMPACT RATING

PART I *(To be completed by Federal Agency)*	Date Of Land Evaluation Request 12/4/09
Name Of Project Fargo Moorhead Metro Flood Risk Reduction	Federal Agency Involved US Army Corps of Engineers
Proposed Land Use Diversion Channel	County And State Clay, Minnesota
PART II *(To be completed by NRCS)*	Date Request Received By NRCS

Does the site contain prime, unique, statewide or local important farmland? *(If no, the FPPA does not apply -- do not complete additional parts of this form).*	Yes ☐	No ☐	Acres Irrigated	Average Farm Size
Major Crop(s)	Farmable Land In Govt. Jurisdiction Acres: %		Amount Of Farmland As Defined In FPPA Acres: %	
Name Of Land Evaluation System Used	Name Of Local Site Assessment System		Date Land Evaluation Returned By NRCS	

PART III *(To be completed by Federal Agency)*	Alternative Site Rating			
	Site A	Site B	Site C	Site D
A. Total Acres To Be Converted Directly	5,475.0	6,545.0	7,455.0	100.0
B. Total Acres To Be Converted Indirectly	115.0	115.0	115.0	10.0
C. Total Acres In Site	5,590.0	6,660.0	7,570.0	110.0
PART IV *(To be completed by NRCS)* Land Evaluation Information				
A. Total Acres Prime And Unique Farmland				
B. Total Acres Statewide And Local Important Farmland				
C. Percentage Of Farmland In County Or Local Govt. Unit To Be Converted				
D. Percentage Of Farmland In Govt. Jurisdiction With Same Or Higher Relative Value				
PART V *(To be completed by NRCS)* Land Evaluation Criterion Relative Value Of Farmland To Be Converted *(Scale of 0 to 100 Points)*	0	0	0	0

PART VI *(To be completed by Federal Agency)* Site Assessment Criteria *(These criteria are explained in 7 CFR 658.5(b)*	Maximum Points				
1. Area In Nonurban Use					
2. Perimeter In Nonurban Use					
3. Percent Of Site Being Farmed					
4. Protection Provided By State And Local Government					
5. Distance From Urban Builtup Area					
6. Distance To Urban Support Services					
7. Size Of Present Farm Unit Compared To Average					
8. Creation Of Nonfarmable Farmland					
9. Availability Of Farm Support Services					
10. On-Farm Investments					
11. Effects Of Conversion On Farm Support Services					
12. Compatibility With Existing Agricultural Use					
TOTAL SITE ASSESSMENT POINTS	160	0	0	0	0
PART VII *(To be completed by Federal Agency)*					
Relative Value Of Farmland *(From Part V)*	100	0	0	0	0
Total Site Assessment *(From Part VI above or a local site assessment)*	160	0	0	0	0
TOTAL POINTS *(Total of above 2 lines)*	260	0	0	0	0

Site Selected:	Date Of Selection	Was A Local Site Assessment Used? Yes ☐ No ☐

Reason For Selection:

(See Instructions on reverse side) **Form AD-1006 (10-83)**

This form was electronically produced by National Production Services Staff

United States Department of Agriculture

NRCS

Natural Resources Conservation Service
1004 Frontier Drive
Fergus Falls, MN 56537

Helping People Help the Land

Phone: (218) 736-5445
FAX: (218) 736-7215

January 5, 2010

Terry J. Birkenstock
Chief, Environmental and GIS Branch
Department of the Army
St. Paul District, Corps of Engineers
Sibley Square at Mears Park
190 Fifth Street East, Suite 401
Saint Paul, MN 55101-1638

RE: Farmland Conversion Impact Rating for Alternatives for the Fargo-Moorhead Metropolitan Area Flood Risk Management Project

Dear Mr. Birkenstock:

I was forwarded the information you sent for the proposed project near the city of Moorhead in Clay County, MN. I have located the area on a soil map and filled out parts II, IV and V of the attached Farmland Conversion Impact Rating form (AD-1006).

At Site A, of the 5,590 acres affected, 5533.7 acres are classified as Prime Farmland, and 23.4 acres are considered Farmland of Statewide Importance. Site B consists of 6,593.4 acres of Prime Farmland and 26.6 acres of Farmland of Statewide Importance. Site C contains 7493.9 acres of Prime Farmland and 28.5 acres of Farmland of Statewide Importance. Each of these three alternatives has a relative value of 91 (on a scale of 1 to 100, with 100 being the most agriculturally productive farmland in Clay County, MN). Alternative Site D contains 102 acres of Prime Farmland and has a relative value of 77.

If you have any questions feel free to contact me at (218) 736-5445 extension 102 or by e-mail at Jeffrey.Hellerich@mn.usda.gov

Sincerely,

Jeff Hellerich

Jeff Hellerich
Area Resource Soil Scientist
Natural Resources Conservation Service
1004 Frontier Drive
Fergus Falls, MN 56537

cc: Sharon Lean, DC, NRCS, Moorhead, MN
File

The Natural Resources Conservation Service provides leadership in a partnership effort to help people conserve, maintain, and improve our natural resources and environment.
An Equal Opportunity Provider and Employer

U.S. Department of Agriculture

FARMLAND CONVERSION IMPACT RATING

PART I *(To be completed by Federal Agency)*	Date Of Land Evaluation Request 12/4/09
Name Of Project Fargo Moorhead Metro Flood Risk Reduction	Federal Agency Involved US Army Corps of Engineers
Proposed Land Use Diversion Channel	County And State Clay County, MN
PART II *(To be completed by NRCS)*	Date Request Received By NRCS

Does the site contain prime, unique, statewide or local important farmland? *(If no, the FPPA does not apply -- do not complete additional parts of this form).*	Yes ☑ No ☐	Acres Irrigated ----	Average Farm Size 532
Major Crop(s) Corn, Wheat, Soybeans	Farmable Land In Govt. Jurisdiction Acres: 606,292 % 90	Amount Of Farmland As Defined in FPPA Acres: 559,512 % 83	
Name Of Land Evaluation System Used ----------	Name Of Local Site Assessment System ----------	Date Land Evaluation Returned By NRCS	

PART III *(To be completed by Federal Agency)*	Alternative Site Rating Site A	Site B	Site C	Site D
A. Total Acres To Be Converted Directly	5,475.0	6,545.0	7,455.0	102.0
B. Total Acres To Be Converted Indirectly	115.0	115.0	115.0	10.0
C. Total Acres In Site	5,590.0	6,660.0	7,570.0	112.0
PART IV *(To be completed by NRCS)* Land Evaluation Information				
A. Total Acres Prime And Unique Farmland	5,533.7	6,593.4	7,493.9	102.0
B. Total Acres Statewide And Local Important Farmland	23.4	26.6	28.5	0.0
C. Percentage Of Farmland In County Or Local Govt. Unit To Be Converted	1.0	1.2	1.3	0.0
D. Percentage Of Farmland In Govt. Jurisdiction With Same Or Higher Relative Value	25.3	25.3	25.3	75.4
PART V *(To be completed by NRCS)* Land Evaluation Criterion Relative Value Of Farmland To Be Converted *(Scale of 0 to 100 Points)*	91	91	91	77

PART VI *(To be completed by Federal Agency)* Site Assessment Criteria *(These criteria are explained in 7 CFR 658.5(b)*	Maximum Points				
1. Area In Nonurban Use		14	14	14	14
2. Perimeter In Nonurban Use		10	10	10	10
3. Percent Of Site Being Farmed		20	20	20	20
4. Protection Provided By State And Local Government		0	0	0	0
5. Distance From Urban Builtup Area		0	0	0	0
6. Distance To Urban Support Services		0	0	0	0
7. Size Of Present Farm Unit Compared To Average		1	1	1	1
8. Creation Of Nonfarmable Farmland		10	10	10	10
9. Availability Of Farm Support Services		0	0	0	0
10. On-Farm Investments		5	5	5	5
11. Effects Of Conversion On Farm Support Services		0	0	0	0
12. Compatibility With Existing Agricultural Use		2	2	2	2
TOTAL SITE ASSESSMENT POINTS	160	62	62	62	62
PART VII *(To be completed by Federal Agency)*					
Relative Value Of Farmland *(From Part V)*	100	91	91	91	77
Total Site Assessment *(From Part VI above or a local site assessment)*	160	62	62	62	62
TOTAL POINTS *(Total of above 2 lines)*	260	153	153	153	139

Site Selected:	Date Of Selection	Was A Local Site Assessment Used? Yes ☐ No ☐

Reason For Selection:

(See Instructions on reverse side)

This form was electronically produced by National Production Services Staff

Minnesota Diversion Alternate routes for the MN35K diversion channel. The modified original diversion footprint is Site A and includes 5,822 acres to be converted directly, Site B is Alternate route 1 which follows the footprint of the original until toward the northern end where the route is moved further west, this route would convert 5,706 acres directly, and the final route is a little further west site C which would convert 5,783 acres directly. Site D on this form is the number acres that would be converted directly for the ND35k tieback levee.

For all three of the MN35K routes over 99% of the land is considered to be prime and unique farmland. For Site D the North Dakota tie back levee, over 95% is considered to be prime and unique farmland.

U.S. Department of Agriculture

FARMLAND CONVERSION IMPACT RATING

PART I *(To be completed by Federal Agency)*	Date Of Land Evaluation Request 4/29/10
Name Of Project Fargo Moorhead Flood Risk Reduction - MN Div	Federal Agency Involved US Army Corps of Engineers
Proposed Land Use Diversion Channel	County And State Clay County, MN
PART II *(To be completed by NRCS)*	Date Request Received By NRCS 4/29/10

Does the site contain prime, unique, statewide or local important farmland? *(If no, the FPPA does not apply -- do not complete additional parts of this form).*	Yes ☑	No ☐	Acres Irrigated ----- / Average Farm Size 532
Major Crop(s) Corn, Wheat, Soybeans	Farmable Land In Govt. Jurisdiction Acres: 606,292 % 90		Amount Of Farmland As Defined in FPPA Acres: 559,512 % 83
Name Of Land Evaluation System Used Minnesota Crop Productivity Index	Name Of Local Site Assessment System ----------		Date Land Evaluation Returned By NRCS 5/3/10

PART III *(To be completed by Federal Agency)*	Alternative Site Rating Site A	Site B	Site C	Site D
A. Total Acres To Be Converted Directly	5,822.40	5,706.90	5,783.90	454.20
B. Total Acres To Be Converted Indirectly	0.00	0.00	0.00	0.00
C. Total Acres In Site	5,822.40	5,706.90	5,783.90	454.20
PART IV *(To be completed by NRCS)* Land Evaluation Information				
A. Total Acres Prime And Unique Farmland	5,781.90	5,668.50	5,745.50	434.90
B. Total Acres Statewide And Local Important Farmland	19.30	11.00	11.90	7.10
C. Percentage Of Farmland In County Or Local Govt. Unit To Be Converted	0.9600	0.9400	0.9500	0.0700
D. Percentage Of Farmland In Govt. Jurisdiction With Same Or Higher Relative Value	31.00	25.30	25.30	62.50
PART V *(To be completed by NRCS)* Land Evaluation Criterion Relative Value Of Farmland To Be Converted *(Scale of 0 to 100 Points)*	90	91	91	86

PART VI *(To be completed by Federal Agency)* Site Assessment Criteria *(These criteria are explained in 7 CFR 658.5(b)*	Maximum Points	Site A	Site B	Site C	Site D
1. Area In Nonurban Use		14	14	14	14
2. Perimeter In Nonurban Use		10	10	10	10
3. Percent Of Site Being Farmed		20	20	20	20
4. Protection Provided By State And Local Government		0	0	0	0
5. Distance From Urban Builtup Area		0	0	0	0
6. Distance To Urban Support Services		0	0	0	0
7. Size Of Present Farm Unit Compared To Average		1	1	1	1
8. Creation Of Nonfarmable Farmland		10	10	10	10
9. Availability Of Farm Support Services		0	0	0	0
10. On-Farm Investments		5	5	5	5
11. Effects Of Conversion On Farm Support Services		0	0	0	0
12. Compatibility With Existing Agricultural Use		2	2	2	2
TOTAL SITE ASSESSMENT POINTS	160	62	62	62	62
PART VII *(To be completed by Federal Agency)*					
Relative Value Of Farmland *(From Part V)*	100	90	91	91	86
Total Site Assessment *(From Part VI above or a local site assessment)*	160	62	62	62	62
TOTAL POINTS *(Total of above 2 lines)*	260	152	153	153	148

Site Selected:	Date Of Selection	Was A Local Site Assessment Used? Yes ☐ No ☐

Reason For Selection:

(See Instructions on reverse side) **Form AD-1006 (10-83)**

This form was electronically produced by National Production Services Staff

1.5 Farmland Conversion Impact Rating for Minnesota Diversion Alternative

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
SIBLEY SQUARE AT MEARS PARK
190 FIFTH STREET EAST, SUITE 401
ST. PAUL MN 55101-1638

December 7, 2009

Regional Planning and Environmental Division North
Environmental and GIS Branch

SUBJECT: Farmland Conversion Impact Rating for Alternatives for the Fargo-Moorhead Metropolitan Area Flood Risk Management Project

Mr. Keith Weston
Natural Resources Conservation Service
U.S. Department of Agriculture
4660 Amber Valley Parkway South
Fargo, North Dakota 58104

Dear Mr. Weston:

The St. Paul District, U.S. Army Corps of Engineers, is working on a flood risk management feasibility report for the Fargo, North Dakota, and Moorhead, Minnesota, metropolitan area. Several alternatives that would divert floodwaters around the cities have been studied, including diversion channels on the Minnesota side and the North Dakota side of the Red River.

The proposed diversion channels would be constructed through farmland. We have not selected an alternative yet, but we would like to submit to you four leading alternatives for review in the Farmland Conversion Impact Rating. I have attached Form AD-1006, which includes four alternatives on the North Dakota side. I have sent a similar package to Mrs. Sharon Lean of the Natural Resources Conservation Service in Moorhead that includes three alternatives for diversions on the Minnesota side. I have attached the project fact sheet and an area map highlighting the proposed alternatives.

Site A represents the North Dakota West Diversion Alternative built to a size that would pass 35,000 cubic feet per second (cfs), Site B represents the same diversion alternative but designed to pass 45,000 cfs, Site C represents the North Dakota East Diversion and Site D represents the tie-back levee for the Minnesota Short diversion channel.

If you have any questions or need further information, please call Jonathan Sobiech at (651) 290-5428.

Sincerely,

for Terry J. Birkenstock
Chief, Environmental and GIS Branch

3 Enclosures

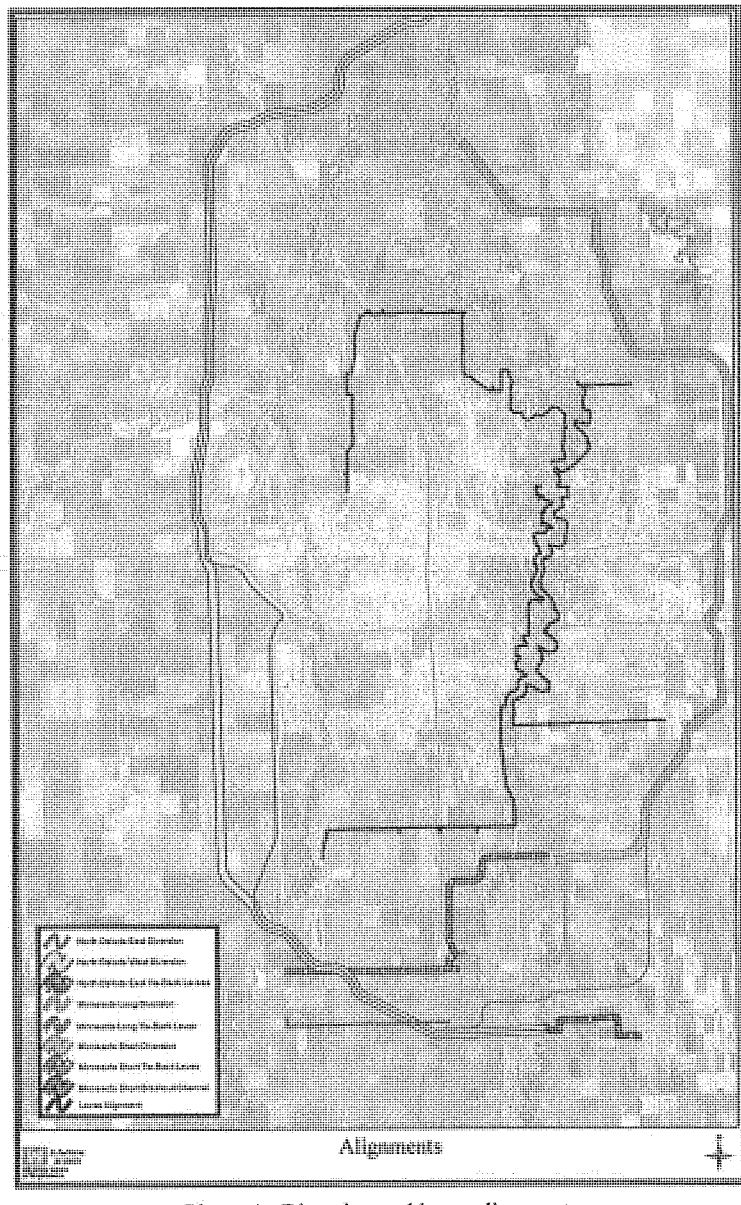

Figure 1. Diversion and levee alignments.

Army Corps of Engineers Centre, 190 Fifth Street East, St. Paul, MN 55101-1638

US Army Corps of Engineers
St. Paul District

Flood Risk Management: Fargo-Moorhead Metro, North Dakota and Minnesota

Location/Description

An emergency levee protects the city at Second Street during the 2009 flood.

Fargo, North Dakota, and Moorhead, Minnesota, are on the west and east banks, respectively, of the Red River of the North approximately 150 miles south of the Canada/United States border. In addition to the Red River, the Wild Rice, Sheyenne, Maple and Rush Rivers in North Dakota and the Buffalo River in Minnesota also cross the study area.

Background

The Fargo-Moorhead metropolitan area is a major health, educational, cultural, and commercial center serving southeastern North Dakota and west-central Minnesota. The area is prone to flooding; the Red River has exceeded flood stage in 50 of the past 106 years and every year from 1993 through 2009. A 500-year event would flood nearly the entire city of Fargo and a large portion of the city of Moorhead, as well as several smaller communities in the area. Flooding occurs not only from the rivers, but also from large rainfall events that overwhelm storm drainage systems. Average annual flood damages are estimated at more than $64 million.

Although emergency flood fights have been very successful in Fargo and Moorhead, the area is significantly vulnerable to flooding. Both the 1997 and 2009 flood events came close to overwhelming the emergency levee systems, and many homes outside the levees were damaged.

Status

The Corps and the cities of Fargo and Moorhead are jointly conducting this study. The study will assess the feasibility of measures to reduce flood risk in the entire metropolitan and surrounding area. The study will consider an array of potential alternatives including nonstructural flood proofing, diversion channels, levee/floodwall systems, and flood storage.

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Public Affairs (651) 290-5201 (651) 290-5752(fax) cemvp-pa@usace.army.mil
http://www.mvp.usace.army.mil

U.S. Department of Agriculture

FARMLAND CONVERSION IMPACT RATING

PART I *(To be completed by Federal Agency)*	Date Of Land Evaluation Request 12/4/09
Name Of Project Fargo Moorhead Metro Flood Risk Reduction	Federal Agency Involved US Army Corps of Engineers
Proposed Land Use Diversion Channel	County And State Cass, North Dakota
PART II *(To be completed by NRCS)*	Date Request Received By NRCS

Does the site contain prime, unique, statewide or local important farmland? *(If no, the FPPA does not apply -- do not complete additional parts of this form).*	Yes ☐	No ☐	Acres Irrigated / Average Farm Size
Major Crop(s)	Farmable Land In Govt. Jurisdiction Acres: %		Amount Of Farmland As Defined in FPPA Acres: %
Name Of Land Evaluation System Used	Name Of Local Site Assessment System		Date Land Evaluation Returned By NRCS

PART III *(To be completed by Federal Agency)*	Alternative Site Rating			
	Site A	Site B	Site C	Site D
A. Total Acres To Be Converted Directly	6,400.0	7,220.0	6,385.0	900.0
B. Total Acres To Be Converted Indirectly	145.0	145.0	145.0	50.0
C. Total Acres In Site	6,545.0	7,365.0	6,530.0	950.0
PART IV *(To be completed by NRCS)* Land Evaluation Information				
A. Total Acres Prime And Unique Farmland				
B. Total Acres Statewide And Local Important Farmland				
C. Percentage Of Farmland In County Or Local Govt. Unit To Be Converted				
D. Percentage Of Farmland In Govt. Jurisdiction With Same Or Higher Relative Value				
PART V *(To be completed by NRCS)* Land Evaluation Criterion Relative Value Of Farmland To Be Converted *(Scale of 0 to 100 Points)*	0	0	0	0
PART VI *(To be completed by Federal Agency)* Site Assessment Criteria *(These criteria are explained in 7 CFR 658.5(b)* — Maximum Points				
1. Area In Nonurban Use				
2. Perimeter In Nonurban Use				
3. Percent Of Site Being Farmed				
4. Protection Provided By State And Local Government				
5. Distance From Urban Builtup Area				
6. Distance To Urban Support Services				
7. Size Of Present Farm Unit Compared To Average				
8. Creation Of Nonfarmable Farmland				
9. Availability Of Farm Support Services				
10. On-Farm Investments				
11. Effects Of Conversion On Farm Support Services				
12. Compatibility With Existing Agricultural Use				
TOTAL SITE ASSESSMENT POINTS — 160	0	0	0	0
PART VII *(To be completed by Federal Agency)*				
Relative Value Of Farmland *(From Part V)* — 100	0	0	0	0
Total Site Assessment *(From Part VI above or a local site assessment)* — 160	0	0	0	0
TOTAL POINTS *(Total of above 2 lines)* — 260	0	0	0	0

Site Selected:	Date Of Selection	Was A Local Site Assessment Used? Yes ☐ No ☐

Reason For Selection:

(See Instructions on reverse side) Form AD-1006 (10-83)

This form was electronically produced by National Production Services Staff

United States Department of Agriculture

NRCS

Natural Resources Conservation Service
P.O. Box 2096
Jamestown, ND 58402-2096

January 8, 2010

Mr. Terry Birkenstock
Chief, Environmental and GIS Branch
US Army Corps of Engineers
190 East 5th St, Suite 401
St Paul, MN 55101

Subject: Form AD-1006
RE: Farmland Conversion Impact Rating for Alternatives for the Fargo-Moorhead Metropolitan Area Flood Risk Management Project

Dear Mr. Birkenstock,

The NRCS portion of the AD-1006 "Farmland Conversion Impact Rating" for the Alternatives for the Fargo-Moorhead Metropolitan Area Flood Risk Management Project has been completed as requested. I changed the acreage figure for Site B on the form per phone conversation with Jonathan Sobiech. Please send me a copy of the form when it is completed.

Should you have any questions concerning the AD-1006 please contact me at 701-252-1460, extension 115.

Sincerely,

FREDERICK P. AZIZ
Area Resource Soil Scientist

Enclosure

cc: Steven Seiler, State Soil Liaison, NRCS, Bismarck, ND
Keith Weston, DC, NRCS, Fargo, ND

w/o encl.
Michael D. Collins, ASTC (FO), NRCS, Jamestown, ND
Jonathan Sobiech, Forester, US, ACE, St Paul, MN

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U.S. Department of Agriculture

FARMLAND CONVERSION IMPACT RATING

PART I *(To be completed by Federal Agency)*	Date Of Land Evaluation Request 12/4/09
Name Of Project Fargo Moorhead Metro Flood Risk Reduction	Federal Agency Involved US Army Corps of Engineers
Proposed Land Use Diversion Channel	County And State Cass, North Dakota
PART II *(To be completed by NRCS)*	Date Request Received By NRCS 12/14/09

Does the site contain prime, unique, statewide or local important farmland? *(If no, the FPPA does not apply -- do not complete additional parts of this form).*	Yes ☑ No ☐	Acres Irrigated 8745	Average Farm Size 830
Major Crop(s) Soybeans, Corn	Farmable Land In Govt. Jurisdiction Acres: 1,084,302 % 97	Amount Of Farmland As Defined in FPPA Acres: 925,155 % 83	
Name Of Land Evaluation System Used Cass County LE	Name Of Local Site Assessment System None	Date Land Evaluation Returned By NRCS 1/8/10	

PART III *(To be completed by Federal Agency)*		Alternative Site Rating Site A	Site B	Site C	Site D
A. Total Acres To Be Converted Directly		6,400.0	6,500.0	6,385.0	900.0
B. Total Acres To Be Converted Indirectly		145.0	145.0	145.0	50.0
C. Total Acres In Site		6,545.0	6,645.0	6,530.0	950.0
PART IV *(To be completed by NRCS)* Land Evaluation Information					
A. Total Acres Prime And Unique Farmland		5,811.2	5,927.4	5,455.4	872.6
B. Total Acres Statewide And Local Important Farmland		0.0	0.0	0.0	0.0
C. Percentage Of Farmland In County Or Local Govt. Unit To Be Converted		0.6	0.6	0.6	0.1
D. Percentage Of Farmland In Govt. Jurisdiction With Same Or Higher Relative Value		59.3	59.3	59.3	59.3
PART V *(To be completed by NRCS)* Land Evaluation Criterion Relative Value Of Farmland To Be Converted *(Scale of 0 to 100 Points)*		81	81	81	81
PART VI *(To be completed by Federal Agency)* Site Assessment Criteria *(These criteria are explained in 7 CFR 658.5(b)*	Maximum Points				
1. Area In Nonurban Use		15	15	15	15
2. Perimeter In Nonurban Use		10	10	10	10
3. Percent Of Site Being Farmed		20	20	20	20
4. Protection Provided By State And Local Government		0	0	0	0
5. Distance From Urban Builtup Area					
6. Distance To Urban Support Services					
7. Size Of Present Farm Unit Compared To Average		10	10	10	10
8. Creation Of Nonfarmable Farmland		5	5	5	5
9. Availability Of Farm Support Services		3	3	3	3
10. On-Farm Investments		5	5	5	5
11. Effects Of Conversion On Farm Support Services		5	5	5	5
12. Compatibility With Existing Agricultural Use		0	0	0	0
TOTAL SITE ASSESSMENT POINTS	160	73	73	73	73
PART VII *(To be completed by Federal Agency)*					
Relative Value Of Farmland *(From Part V)*	100	81	81	81	81
Total Site Assessment *(From Part VI above or a local site assessment)*	160	73	73	73	73
TOTAL POINTS *(Total of above 2 lines)*	260	154	154	154	154

Site Selected:	Date Of Selection	Was A Local Site Assessment Used? Yes ☐ No ☐

Reason For Selection:

(See Instructions on reverse side)

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Final Feasibility Report and Environmental Impact State
July 2011

Clear Form

USACE-MVP-000008-AD-1006 (10-83)
Environmental

1.6 Instructions for Farmland Conversion Impact Rating

STEPS IN THE PROCESSING THE FARMLAND AND CONVERSION IMPACT RATING FORM

Step 1 – Federal agencies involved in proposed projects that may convert farmland, as defined in the Farmland Protection Policy Act (FPPA) to nonagricultural uses, will initially complete Parts I and III of the form.

Step 2 – Originator will send copies A, B and C together with maps indicating locations of site(s), to the Natural Resources Conservation Service (NRCS) local field office and retain copy D for their files. (Note: NRCS has a field office in most counties in the U.S. The field office is usually located in the county seat. A list of field office locations are available from the NRCS State Conservationist in each state).

Step 3 – NRCS will, within 45 calendar days after receipt of form, make a determination as to whether the site(s) of the proposed project contains prime, unique, statewide or local important farmland.

Step 4 – In cases where farmland covered by the FPPA will be converted by the proposed project, NRCS field offices will complete Parts II, IV and V of the form.

Step 5 – NRCS will return copy A and B of the form to the Federal agency involved in the project. (Copy C will be retained for NRCS records).

Step 6 – The Federal agency involved in the proposed project will complete Parts VI and VII of the form.

Step 7 – The Federal agency involved in the proposed project will make a determination as to whether the proposed conversion is consistent with the FPPA and the agency's internal policies.

INSTRUCTIONS FOR COMPLETING THE FARMLAND CONVERSION IMPACT RATING FORM

Part I: In completing the "County And State" questions list all the local governments that are responsible for local land controls where site(s) are to be evaluated.

Part III: In completing item B (Total Acres To Be Converted Indirectly), include the following:

1. Acres not being directly converted but that would no longer be capable of being farmed after the conversion, because the conversion would restrict access to them.

2. Acres planned to receive services from an infrastructure project as indicated in the project justification (e.g. highways, utilities) that will cause a direct conversion.

Part VI: Do not complete Part VI if a local site assessment is used.

Assign the maximum points for each site assessment criterion as shown in § 658.5 (b) of CFR. In cases of corridor-type projects such as transportation, powerline and flood control, criteria #5 and #6 will not apply and will, be weighed zero, however, criterion #8 will be weighed a maximum of 25 points, and criterion #11 a maximum of 25 points.

Individual Federal agencies at the national level, may assign relative weights among the 12 site assessment criteria other than those shown in the FPPA rule. In all cases where other weights are assigned relative adjustments must be made to maintain the maximum total weight points at 160.

In rating alternative sites, Federal agencies shall consider each of the criteria and assign points within the limits established in the FPPA rule. Sites most suitable for protection under these criteria will receive the highest total scores, and sites least suitable, the lowest scores.

Part VII: In computing the "Total Site Assessment Points" where a State or local site assessment is used and the total maximum number of points is other than 160, adjust the site assessment points to a base of 160. Example: if the Site Assessment maximum is 200 points, and alternative Site "A" is rated 180 points:

$$\frac{\text{Total points assigned Site A}}{\text{Maximum points possible}} = \frac{180}{200} \times 160 = 144 \text{ points for Site "A."}$$

Site Assessment Scoring for the Twelve Factors Used in FPPA

The Site Assessment criteria used in the Farmland Protection Policy Act (FPPA) rule are designed to assess important factors other than the agricultural value of the land when determining which alternative sites should receive the highest level of protection from conversion to non agricultural uses.

Twelve factors are used for Site Assessment and ten factors for corridor-type sites. Each factor is listed in an outline form, without detailed definitions or guidelines to follow in the rating process. The purpose of this document is to expand the definitions of use of each of the twelve Site Assessment factors so that all persons can have a clear understanding as to what each factor is intended to evaluate and how points are assigned for given conditions.

In each of the 12 factors a number rating system is used to determine which sites deserve the most protection from conversion to non-farm uses. The higher the number value given to a proposed site, the more protection it will receive. The maximum scores are 10, 15 and 20 points, depending upon the relative importance of each particular question. If a question significantly relates to why a parcel of land should not be converted, the question has a maximum possible protection value of 20, whereas a question which does not have such a significant impact upon whether a site would be converted, would have fewer maximum points possible, for example 10.

The following guidelines should be used in rating the twelve Site Assessment criteria:

1. How much land is in non-urban use within a radius of 1.0 mile from where the project is intended?

More than 90 percent:	15 points
90-20 percent:	14 to 1 points
Less than 20 percent:	0 points

This factor is designed to evaluate the extent to which the area within one mile of the proposed site is non-urban area. For purposes of this rule, "non-urban" should include:

- Agricultural land (crop-fruit trees, nuts, oilseed)
- Range land
- Forest land
- Golf Courses
- Non paved parks and recreational areas
- Mining sites
- Farm Storage
- Lakes, ponds and other water bodies
- Rural roads, and through roads without houses or buildings
- Open space
- Wetlands
- Fish production
- Pasture or hayland

Urban uses include:

- Houses (other than farm houses)
- Apartment buildings
- Commercial buildings
- Industrial buildings
- Paved recreational areas (i.e. tennis courts)
- Streets in areas with 30 structures per 40 acres
- Gas stations

- Equipment, supply stores
- Off-farm storage
- Processing plants
- Shopping malls
- Utilities/Services
- Medical buildings

In rating this factor, an area one-mile from the outer edge of the proposed site should be outlined on a current photo; the areas that are urban should be outlined. For rural houses and other buildings with unknown sizes, use 1 and 1/3 acres per structure. For roads with houses on only one side, use one half of road for urban and one half for non-urban.

The purpose of this rating process is to insure that the most valuable and viable farmlands are protected from development projects sponsored by the Federal Government. With this goal in mind, factor S1 suggests that the more agricultural lands surrounding the parcel boundary in question, the more protection from development this site should receive. Accordingly, a site with a large quantity of non-urban land surrounding it will receive a greater
number of points for protection from development. Thus, where more than 90 percent of the area around the proposed site (do not include the proposed site in this assessment) is non-urban, assign 15 points. Where 20 percent or less is
non-urban, assign 0 points. Where the area lies between 20 and 90 percent non-urban, assign appropriate points from 14 to 1, as noted below.

Percent Non-Urban Land within 1 mile	Points
90 percent or greater	15
85 to 89 percent	14
80 to 84 percent	13
75 to 79 percent	12
70 to 74 percent	11
65 to 69 percent	10
60 to 64 percent	9
55 to 59 percent	8
50 to 54 percent	7
45 to 49 percent	6
40 to 44 percent	5
35 to 39 percent	4
30 to 24 percent	3
25 to 29 percent	2
21 to 24 percent	1
20 percent or less	0

2. How much of the perimeter of the site borders on land in non-urban use?

More than 90 percent:	l0 points
90 to 20 percent:	9 to 1 point(s)
Less than 20 percent:	0 points

This factor is designed to evaluate the extent to which the land adjacent to the proposed site is non-urban use. Where factor #1 evaluates the general location of the proposed site, this factor evaluates the immediate perimeter of the site. The definition of urban and non-urban uses in factor #1 should be used for this factor.

In rating the second factor, measure the perimeter of the site that is in non-urban and urban use. Where more than 90 percent of the perimeter is in non-urban use, score this factor 10 points. Where less than 20 percent, assign 0 points. If a road is next to the perimeter, class the area according to the

use on the other side of the road for that area. Use 1 and 1/3 acre per structure if not otherwise known. Where 20 to 90 percent of the perimeter is non-urban, assign points as noted below:

Percentage of Perimeter Bordering Land	Points
90 percent or greater	10
82 to 89 percent	9
74 to 81 percent	8
65 to 73 percent	7
58 to 65 percent	6
50 to 57 percent	5
42 to 49 percent	4
34 to 41 percent	3
27 to 33 percent	2
21 to 26 percent	1
20 percent or Less	0

3. How much of the site has been farmed (managed for a scheduled harvest or timber activity) more than five of the last ten years?

More than 90 percent:	20 points
90 to 20 percent:	19 to 1 point(s)
Less than 20 percent:	0 points

This factor is designed to evaluate the extent to which the proposed conversion site has been used or managed for agricultural purposes in the past 10 years.

Land is being farmed when it is used or managed for food or fiber, to include timber products, fruit, nuts, grapes, grain, forage, oil seed, fish and meat, poultry and dairy products.

Land that has been left to grow up to native vegetation without management or harvest will be considered as abandoned and therefore not farmed. The proposed conversion site should be evaluated and rated according to the percent, of the site farmed.

If more than 90 percent of the site has been farmed 5 of the last 10 years score the site as follows:

Percentage of Site Farmed	Points
90 percent or greater	20
86 to 89 percent	19
82 to 85 percent	18
78 to 81 percent	17
74 to 77 percent	16
70 to 73 percent	15
66 to 69 percent	14
62 to 65 percent	13
58 to 61 percent	12
54 to 57 percent	11
50 to 53 percent	10
46 to 49 percent	9
42 to 45 percent	8
38 to 41 percent	7
35 to 37 percent	6
32 to 34 percent	5
29 to 31 percent	4
26 to 28 percent	3

23 to 25 percent	2
20 to 22 percent percent or Less	1
Less than 20 percent	0

4. Is the site subject to state or unit of local government policies or programs to protect farmland or covered by private programs to protect farmland?

Site is protected:	20 points
Site is not protected:	0 points

This factor is designed to evaluate the extent to which state and local government and private programs have made efforts to protect this site from conversion.

State and local policies and programs to protect farmland include:

State Policies and Programs to Protect Farmland

1. Tax Relief:

   A. Differential Assessment: Agricultural lands are taxed on their agricultural use value, rather than at market value. As a result, farmers pay fewer taxes on their land, which helps keep them in business, and therefore helps to insure that the farmland will not be converted to nonagricultural uses.

      1. Preferential Assessment for Property Tax: Landowners with parcels of land used for agriculture are given the privilege of differential assessment.

      2. Deferred Taxation for Property Tax: Landowners are deterred from converting their land to nonfarm uses, because if they do so, they must pay back taxes at market value.

      3. Restrictive Agreement for Property Tax: Landowners who want to receive Differential Assessment must agree to keep their land in - eligible use.

   B. Income Tax Credits

   Circuit Breaker Tax Credits: Authorize an eligible owner of farmland to apply some or all of the property taxes on his or her farmland and farm structures as a tax credit against the owner's state income tax.

   C. Estate and Inheritance Tax Benefits

   Farm Use Valuation for Death Tax: Exemption of state tax liability to eligible farm estates.

2. "Right to farm" laws:

   Prohibits local governments from enacting laws which will place restrictions upon normally accepted farming practices, for example, the generation of noise, odor or dust.

3. Agricultural Districting:

   Wherein farmers voluntarily organize districts of agricultural land to be legally recognized geographic areas. These farmers receive benefits, such as protection from annexation, in exchange for keeping land within the district for a given number of years.

4. Land Use Controls: Agricultural Zoning.

Types of Agricultural Zoning Ordinances include:

A. Exclusive: In which the agricultural zone is restricted to only farm-related dwellings, with, for example, a minimum of 40 acres per dwelling unit.

B. Non-Exclusive: In which non-farm dwellings are allowed, but the density remains low, such as 20 acres per dwelling unit.

Additional Zoning techniques include:

A. Sliding Scale: This method looks at zoning according to the total size of the parcel owned. For example, the number of dwelling units per a given number of acres may change from county to county according to the existing land acreage to dwelling unit ratio of surrounding parcels of land within the specific area.

B. Point System or Numerical Approach: Approaches land use permits on a case by case basis.

LESA: The LESA system (Land Evaluation-Site Assessment) is used as a tool to help assess options for land use on an evaluation of productivity weighed against commitment to urban development.

C. Conditional Use: Based upon the evaluation on a case by case basis by the Board of Zoning Adjustment. Also may include the method of using special land use permits.

5. Development Rights:

A. Purchase of Development Rights (PDR): Where development rights are purchased by Government action.

Buffer Zoning Districts: Buffer Zoning Districts are an example of land purchased by Government action. This land is included in zoning ordinances in order to preserve and protect agricultural lands from non-farm land uses encroaching upon them.

B. Transfer of Development Rights (TDR): Development rights are transferable for use in other locations designated as receiving areas. TDR is considered a locally based action (not state), because it requires a voluntary decision on the part of the individual landowners.

6. Governor's Executive Order: Policy made by the Governor, stating the importance of agriculture, and the preservation of agricultural lands. The Governor orders the state agencies to avoid the unnecessary conversion of important farmland to nonagricultural uses.

7. Voluntary State Programs:

A. California's Program of Restrictive Agreements and Differential Assessments: The California Land Conservation Act of 1965, commonly known as the Williamson Act, allows cities, counties and individual landowners to form agricultural preserves and enter into contracts for 10 or more years to insure that these parcels of land remain strictly for agricultural use. Since 1972 the Act has extended eligibility to recreational and open space lands such as scenic highway corridors, salt ponds and wildlife preserves. These contractually restricted lands may be taxed differentially for their real value. One hundred-acre districts constitute the minimum land size eligible.

Suggestion: An improved version of the Act would state that if the land is converted after the contract expires, the landowner must pay the difference in the taxes between market value for the land and the agricultural tax value which he or she had been

paying under the Act. This measure would help to insure that farmland would not be converted after the 10 year period ends.

B. Maryland Agricultural Land Preservation Program: Agricultural landowners within agricultural districts have the opportunity to sell their development rights to the Maryland Land Preservation Foundation under the agreement that these landowners will not subdivide or develop their land for an initial period of five years. After five years the landowner may terminate the agreement with one year notice.

As is stated above under the California Williamson Act, the landowner should pay the back taxes on the property if he or she decides to convert the land after the contract expires, in order to discourage such conversions.

C. Wisconsin Income Tax Incentive Program: The Wisconsin Farmland Preservation Program of December 1977 encourages local jurisdictions in Wisconsin to adopt agricultural preservation plans or exclusive agricultural district zoning ordinances in exchange for credit against state income tax and exemption from special utility assessment. Eligible candidates include local governments and landowners with at least 35 acres of land per dwelling unit in agricultural use and gross farm profits of at least $6.000 per year, or $18,000 over three years.

8. Mandatory State Programs:

A. The Environmental Control Act in the state of Vermont was adopted in 1970 by the Vermont State Legislature. The Act established an environmental board with 9 members (appointed by the Governor) to implement a planning process and a permit system to screen most subdivisions and development proposals according to specific criteria stated in the law. The planning process consists of an interim and a final Land Capability and Development Plan, the latter of which acts as a policy plan to control development. The policies are written in order to:

- prevent air and water pollution;
- protect scenic or natural beauty, historic sites and rare and irreplaceable natural areas; and
- consider the impacts of growth and reduction of development on areas of primary agricultural soils.

B. The California State Coastal Commission: In 1976 the Coastal Act was passed to establish a permanent Coastal Commission with permit and planning authority The purpose of the Coastal Commission was and is to protect the sensitive coastal zone environment and its resources, while accommodating the social and economic needs of the state. The Commission has the power to regulate development in the coastal zones by issuing permits on a case by case basis until local agencies can develop their own coastal plans, which must be certified by the Coastal Commission.

C. Hawaii's Program of State Zoning: In 1961, the Hawaii State Legislature established Act 187, the Land Use Law, to protect the farmland and the welfare of the local people of Hawaii by planning to avoid "unnecessary urbanization". The Law made all state lands into four districts: agricultural, conservation, rural and urban. The Governor appointed members to a State Land Use Commission, whose duties were to uphold the Law and form the boundaries of the four districts. In addition to state zoning, the Land Use Law introduced a program of Differential Assessment, wherein agricultural landowners paid taxes on their land for its agricultural use value, rather than its market value.

D. The Oregon Land Use Act of 1973: This act established the Land Conservation and Development Commission (LCDC) to provide statewide planning goals and guidelines.

Under this Act, Oregon cities and counties are each required to draw up a comprehensive plan, consistent with statewide planning goals. Agricultural land preservation is high on the list of state goals to be followed locally.

If the proposed site is subject to or has used one or more of the above farmland protection programs or policies, score the site 20 points. If none of the above policies or programs apply to this site, score 0 points.

5. How close is the site to an urban built-up area?

The site is 2 miles or more from an urban built-up area	15 points
The site is more than 1 mile but less than 2 miles from an urban built-up area	10 points
The site is less than 1 mile from, but is not adjacent to an urban built-up area	5 points
The site is adjacent to an urban built-up area	0 points

This factor is designed to evaluate the extent to which the proposed site is located next to an existing urban area. The urban built-up area must be 2500 population. The measurement from the built-up area should be made from the point at which the density is 30 structures per 40 acres and with no open or non-urban land existing between the major built-up areas and this point. Suburbs adjacent to cities or urban built-up areas should be considered as part of that urban area.

For greater accuracy, use the following chart to determine how much protection the site should receive according to its distance from an urban area. See chart below:

Distance From Perimeter of Site to Urban Area	Points
More than 10,560 feet	15
9,860 to 10,559 feet	14
9,160 to 9,859 feet	13
8,460 to 9,159 feet	12
7,760 to 8,459 feet	11
7,060 to 7,759 feet	10
6,360 to 7,059 feet	9
5,660 to 6,359 feet	8
4,960 to 5,659 feet	7
4,260 to 4,959 feet	6
3,560 to 4,259 feet	5
2,860 to 3,559 feet	4
2,160 to 2,859 feet	3
1,460 to 2,159 feet	2
760 to 1,459 feet	1
Less than 760 feet (adjacent)	0

6. How close is the site to water lines, sewer lines and/or other local facilities and services whose capacities and design would promote nonagricultural use?

None of the services exist nearer than 3 miles from the site	15 points
Some of the services exist more than one but less than 3 miles from the site	10 points
All of the services exist within 1/2 mile of the site	0 points

This question determines how much infrastructure (water, sewer, etc.) is in place which could facilitate nonagricultural development. The fewer facilities in place, the more difficult it is to develop an area. Thus, if a proposed site is further away from these services (more than 3 miles distance away), the site should be awarded the highest number of points (15). As the distance of the parcel of land to services decreases, the number of points awarded declines as well. So, when the site is equal to or further than 1 mile but less than 3 miles away from services, it should be given 10 points. Accordingly, if this distance is 1/2 mile to less than 1 mile, award 5 points; and if the distance from land to services is less than 1/2 mile, award 0 points.

Distance to public facilities should be measured from the perimeter of the parcel in question to the nearest site(s) where necessary facilities are located. If there is more than one distance (i.e. from site to water and from site to sewer), use the average distance (add all distances and then divide by the number of different distances to get the average).

Facilities which could promote nonagricultural use include:

- Water lines
- Sewer lines
- Power lines
- Gas lines
- Circulation (roads)
- Fire and police protection
- Schools

7. Is the farm unit(s) containing the site (before the project) as large as the average-size farming unit in the county? (Average farm sizes in each county are available from the NRCS field offices in each state. Data are from the latest available Census of Agriculture, Acreage of Farm Units in Operation with $1,000 or more in sales.)

As large or larger:	10 points
Below average: Deduct 1 point for each 5 percent below the average, down to 0 points if 50 percent or more is below average	9 to 0 points

This factor is designed to determine how much protection the site should receive, according to its size in relation to the average size of farming units within the county. The larger the parcel of land, the more agricultural use value the land possesses, and vice versa. Thus, if the farm unit is as large or larger than the county average, it receives the maximum number of points (10). The smaller the parcel of land compared to the county average, the fewer number of points given. Please see below:

Parcel Size in Relation to Average County Size	Points
Same size or larger than average (l00 percent)	10
95 percent of average	9
90 percent of average	8
85 percent of average	7
80 percent of average	6
75 percent of average	5
70 percent of average	4
65 percent of average	3
60 percent of average	2
55 percent of average	1
50 percent or below county average	0

State and local Natural Resources Conservation Service offices will have the average farm size information, provided by the latest available Census of Agriculture data

8. If this site is chosen for the project, how much of the remaining land on the farm will become non-farmable because of interference with land patterns?

Acreage equal to more than 25 percent of acres directly converted by the project	10 points
Acreage equal to between 25 and 5 percent of the acres directly converted by the project	9 to 1 point(s)
Acreage equal to less than 5 percent of the acres directly converted by the project	0 points

This factor tackles the question of how the proposed development will affect the rest of the land on the farm The site which deserves the most protection from conversion will receive the greatest number of points, and vice versa. For example, if the project is small, such as an extension on a house, the rest of the agricultural land would remain farmable, and thus a lower number of points is given to the site. Whereas if a large-scale highway is planned, a greater portion of the land (not including the site) will become non-farmable, since access to the farmland will be blocked; and thus, the site should receive the highest number of points (10) as protection from conversion

Conversion uses of the Site Which Would Make the Rest of the Land Non-Farmable by Interfering with Land Patterns

Conversions which make the rest of the property nonfarmable include any development which blocks accessibility to the rest of the site Examples are highways, railroads, dams or development along the front of a site restricting access to the rest of the property.

The point scoring is as follows:

Amount of Land Not Including the Site Which Will Become Non-Farmable	Points
25 percent or greater	10
23 - 24 percent	9
21 - 22 percent	8
19 - 20 percent	7
17 - 18 percent	6
15 - 16 percent	5
13 - 14 percent	4
11 - 12 percent	3
9 - 11 percent	2
6 - 8 percent	1
5 percent or less	0

9. Does the site have available adequate supply of farm support services and markets, i.e., farm suppliers, equipment dealers, processing and storage facilities and farmer's markets?

All required services are available	5 points
Some required services are available	4 to 1 point(s)
No required services are available	0 points

This factor is used to assess whether there are adequate support facilities, activities and industry to keep the farming business in business. The more support facilities available to the agricultural

landowner, the more feasible it is for him or her to stay in production. In addition, agricultural support facilities are compatible with farmland. This fact is important, because some land uses are not compatible; for example, development next to farmland cam be dangerous to the welfare of the agricultural land, as a result of pressure from the neighbors who often do not appreciate the noise, smells and dust intrinsic to farmland. Thus, when all required agricultural support services are available, the maximum number of points (5) are awarded. When some services are available, 4 to 1 point(s) are awarded; and consequently, when no services are available, no points are given. See below:

Percent of Services Available	Points
100 percent	5
75 to 99 percent	4
50 to 74 percent	3
25 to 49 percent	2
1 to 24 percent	1
No services	0

10. Does the site have substantial and well-maintained on farm investments such as barns, other storage buildings, fruit trees and vines, field terraces, drainage, irrigation, waterways, or other soil and water conservation measures?

High amount of on-farm investment	20 points
Moderate amount of non-farm investment	19 to 1 point(s)
No on-farm investments	0 points

This factor assesses the quantity of agricultural facilities in place on the proposed site. If a significant agricultural infrastructure exists, the site should continue to be used for farming, and thus the parcel will receive the highest amount of points towards protection from conversion or development. If there is little on farm investment, the site will receive comparatively less protection. See-below:

Amount of On-farm Investment	Points
As much or more than necessary to maintain production (100 percent)	20
95 to 99 percent	19
90 to 94 percent	18
85 to 89 percent	17
80 to 84 percent	16
75 to 79 percent	15
70 to 74 percent	14
65 to 69 percent	13
60 to 64 percent	12
55 to 59 percent	11
50 to 54 percent	10
45 to 49 percent	9
40 to 44 percent	8
35 to 39 percent	7
30 to 34 percent	6
25 to 29 percent	5
20 to 24 percent	4
15 to 19 percent	3
10 to 14 percent	2
5 to 9 percent	1
0 to 4 percent	0

11. Would the project at this site, by converting farmland to nonagricultural use, reduce the support for farm support services so as to jeopardize the continued existence of these support services and thus, the viability of the farms remaining in the area?

Substantial reduction in demand for support services if the site is converted	10 points
Some reduction in demand for support services if the site is converted	9 to 1 point(s)
No significant reduction in demand for support services if the site is converted	0 points

This factor determines whether there are other agriculturally related activities, businesses or jobs dependent upon the working of the pre-converted site in order for the others to remain in production. The more people and farming activities relying upon this land, the more protection it should receive from conversion. Thus, if a substantial reduction in demand for support services were to occur as a result of conversions, the proposed site would receive a high score of 10; some reduction in demand would receive 9 to 1 point(s), and no significant reduction in demand would receive no points.

Specific points are outlined as follows:

Amount of Reduction in Support Services if Site is Converted to Nonagricultural Use	Points
Substantial reduction (100 percent)	10
90 to 99 percent	9
80 to 89 percent	8
70 to 79 percent	7
60 to 69 percent	6
50 to 59 percent	5
40 to 49 percent	4
30 to 39 percent	3
20 to 29 percent	2
10 to 19 percent	1
No significant reduction (0 to 9 percent)	0

12. Is the kind and intensity of the proposed use of the site sufficiently incompatible with agriculture that it is likely to contribute to the eventual conversion of the surrounding farmland to nonagricultural use?

Proposed project is incompatible with existing agricultural use of surrounding farmland	10 points
Proposed project is tolerable of existing agricultural use of surrounding farmland	9 to 1 point(s)
Proposed project is fully compatible with existing agricultural use of surrounding farmland	0 points

Factor 12 determines whether conversion of the proposed agricultural site will eventually cause the conversion of neighboring farmland as a result of incompatibility of use of the first with the latter. The more incompatible the proposed conversion is with agriculture, the more protection this site receives from conversion. Therefor-, if the proposed conversion is incompatible with agriculture, the site receives 10 points. If the project is tolerable with agriculture, it receives 9 to 1 points; and if the proposed conversion is compatible with agriculture, it receives 0 points.

CORRIDOR - TYPE SITE ASSESSMENT CRITERIA

The following criteria are to be used for projects that have a linear or corridor - type site configuration connecting two distant points, and crossing several different tracts of land. These include utility lines, highways, railroads, stream improvements, and flood control systems. Federal agencies are to assess the suitability of each corridor-type site or design alternative for protection as farmland along with the land evaluation information.

For Water and Waste Programs, corridor analyses are not applicable for distribution or collection networks. Analyses are applicable for transmission or trunk lines where placement of the lines are flexible.

(1) How much land is in nonurban use within a radius of 1.0 mile form where the project is intended?

(2)	More than 90 percent	(3)	15 points
(4)	90 to 20 percent	(5)	14 to 1 point(s).
(6)	Less than 20 percent	(7)	0 points

(2) How much of the perimeter of the site borders on land in nonurban use?

(3)	More than 90 percent	(4)	10 point(s)
(5)	90 to 20 percent	(6)	9 to 1 points
(7)	less than 20 percent	(8)	0 points

(3) How much of the site has been farmed (managed for a scheduled harvest or timber activity) more than five of the last 10 years?

(4)	More than 90 percent	(5)	20 points
(6)	90 to 20 percent	(7)	19 to 1 point(s)
(8)	Less than 20 percent	(9)	0 points

(4) Is the site subject to state or unit of local government policies or programs to protect farmland or covered by private programs to protect farmland?

Site is protected	20 points
Site is not protected	0 points

(5) Is the farm unit(s) containing the site (before the project) as large as the average - size farming unit in the County? (Average farm sizes in each county are available from the NRCS field offices in each state. Data are from the latest available Census of Agriculture, Acreage of Farm Units in Operation with $1,000 or more in sales.)

As large or larger	10 points
Below average deduct 1 point for each 5 percent below the average, down to 0 points if 50 percent or more below average	9 to 0 points

(6) If the site is chosen for the project, how much of the remaining land on the farm will become non-farmable because of interference with land patterns?

Acreage equal to more than 25 percent of acres directly converted by the project	25 points
Acreage equal to between 25 and 5 percent of the acres directly convened by the project	1 to 24 point(s)
Acreage equal to less than 5 percent of the acres directly converted by the project	0 points

(7) Does the site have available adequate supply of farm support services and markets, i.e., farm suppliers, equipment dealers, processing and storage facilities and farmer's markets?

All required services are available	5 points
Some required services are available	4 to 1 point(s)
No required services are available	0 points

(8) Does the site have substantial and well-maintained on-farm investments such as barns, other storage building, fruit trees and vines, field terraces, drainage, irrigation, waterways, or other soil and water conservation measures?

High amount of on-farm investment	20 points
Moderate amount of on-farm investment	19 to 1 point(s)
No on-farm investment	0 points

(9) Would the project at this site, by converting farmland to nonagricultural use, reduce the demand for farm support services so as to jeopardize the continued existence of these support services and thus, the viability of the farms remaining in the area?

Substantial reduction in demand for support services if the site is convened	25 points
Some reduction in demand for support services if the site is convened	1 to 24 point(s)
No significant reduction in demand for support services if the site is converted	0 points

(10) Is the kind and intensity of the proposed use of the site sufficiently incompatible with agriculture that it is likely to contribute to the eventual conversion of surrounding farmland to nonagricultural use?

Proposed project is incompatible to existing agricultural use of surrounding farmland	10 points
Proposed project is tolerable to existing agricultural use of surrounding farmland	9 to 1 point(s)
Proposed project is fully compatible with existing agricultural use of surrounding farmland	0 points

1.7 Mitigation Spreadsheet Describing Costs

Fargo/Moorehead Metro Flood Study: Mitigation Cost Estimate

Impacts for either diversion alternative (NO or MN)
Definite impacts for ND drains in that require mitigation
Unlikely but potential impacts for MD that require monitoring, could require mitigation down the road.

Mitigation Total for MN Alignment:	**$20,764,967**	
Mitigation Total for ND Alignment:	**$60,518,728**	

Red River Control Structure Footprint

Impact Area:	10	acres
Mitigation Ratio:	2	to 1
Mitigation Area:	20	acres
Total Mitigation Cost:	***$6,673,527***	Assumes 75ft width stream re-meander

Red River Fish Passage

Provide Gates that are 50-ft wide	$5,000,000	Assumed value
Provide rock rapids at the control weir (Red OR Wild Rice)	$10,000,000	Assumed value
Increase width of fish bypass gates and channel	$3,000,000	Assumed value - assigned the original cost for fish bypass channel
Fish Passage Monitoring at RR Fish ByPass Channel	$150,000	
Total Mitigation Cost:	***$18,150,000***	

Geomorphic Impact to Red River

Impact Distance - MN Diversion	45.5	Miles
Impact Distance - ND Diversion	63.0	Miles
Mitigation Cost	N/A	
Pre-construct geomorphic survey	$750,000	
Post-construct geomorphic survey	$750,000	
Pre-contruct biotic surveys	$500,000	
Post-construct biotic surveys	$500,000	
Total Mitigation Cost	***$2,500,000***	

Wild Rice River Control Structure Footprint

Impact Area:	10	acres	Assumes 0.75 miles of impact X 110ft wide channel
Mitigation Ratio:	2	to 1	
Mitigation Area:	20	acres	
Total Mitigation Cost:	***$6,673,527***	Assumes 75ft width stream re-meander	

Geomorphic Impact to Wild Rice River

Impact Distance	13.9	Miles	
Impact Area	74.9	Acres	Distance X Width of 110ft
Mitigation Cost	$4,791,000	Assumes buffering as mitigation method	
Pre-construct geomorphic survey	$150,000		
Post-construct geomorphic survey	$150,000		
Pre-contruct biotic surveys	$100,000		
Post-construct biotic surveys	$100,000		
Total Mitigation Cost	***$5,291,000***		

Rush River Channel Abandonment

Impact Area	15.3	acres	2.8 miles Long X 45ft wide
Mitigation Area	0	acres	
Mitigation Cost	$0	Assumes re mitigate by use of re-meander in flood channel	
Pre-contruct biotic surveys (Rush River)	$40,000	Assumes three surveys at $50k	
Post-construct biotic surveys (new channel)	$200,000	Assumes four surveys at $150k	
Total Mitigation Cost:	***$240,000***		

Lower Rush River Channel Abandonment

Impact Area	12.7	acres	3.5 miles long X 30ft width
Mitigation Area	0	acres	
Mitigation Cost	$0	Assumes re mitigate by use of re-meander in flood channel	
Pre-contruct biotic surveys (Rush River)	$40,000	Assumes three surveys at $50k	
Post-construct biotic surveys (new channel)	Combined in Rush		
Total Mitigation Cost:	***$40,000***		

Sheyenne River Tributary Structure Footprint

Impact Area:	7.6	acres	7.6 110ft wide X 3000 ft long
Mitigation Ratio:	2	to 1	
Mitigation Area:	15.2	acres	
Total Mitigation Cost:	***$5,064,849***	Assumes 75ft width stream re-meander	

Geomorphic Impact to Sheyenne River

Impact Distance	43.1	Miles
Impact Area	261.2	Acres — Distance X Width of 110ft
Mitigation Cost	N/A	
Pre-construct geomorphic survey	$500,000	
Post-construct geomorphic survey	$500,000	
Pre-contruct biotic surveys	$250,000	
Post-construct biotic surveys	$250,000	
Total Mitigation Cost	***$1,500,000***	

Maple River Tributary Structure Footprint

Impact Area:	8.8	acres	8.953195044 100ft wide X 3700 ft long
Mitigation Ratio:	2	to 1	Add 15ft to include footprint of overflow weir
Mitigation Area:	17.9	acres	
Total Mitigation Cost:	***$5,974,026***	Assumes 75ft width stream re-meander	

Geomorphic Impact to Maple River

Impact Distance	3.6	Miles	
Impact Area	21.8	Acres	Distance X Width of 50ft
Mitigation Cost	N/A		
Pre-construct geomorphic survey	$40,000		
Post-construct geomorphic survey	$40,000		
Pre-contruct biotic surveys	$40,000		
Post-construct biotic surveys	$40,000		
Total Mitigation Cost	***$160,000***		

Wetland Impacts to Project Area	Direct Acres	Indirect acr.	Trip Impact acr	Total acr.	Total Cost
MN Diversion Wetlands Excavation	24.5	85	--	109.5	$3,285,000
ND East Diversion Wetlands Excavation	21.6	60	143	224.6	$10,645,340

Forest mitigation to Project Area	Acres	Total Cost
MN Diversion	5.3	$157,440
ND Diversion	37.4	$368,640

River Meander Mitigation

Assume 1/2 mile buffer, with 1/4 mile on each side of stream
This equates to 320 acres land per mile restored
Assume 25% contingency on area of land to be purchased to account for RE flexibility for transactions
This results in 400 acres of land per mile restored

Assume:	the need to establish vegetation on 250ft of immediate buffer on each side (60 acres per mile)	
Assume:	$4,000 per acre for easment costs	
Assume:	$3,000 per acre for revegetation costs	
Assume:	$750,000 for structures, riprap or earth moving to recreate meanders	
Real Estate:	$1,600,000	
Revegetation:	$180,000	
Structures:	$750,000	
Contingency 20%	$508,000	
Total Cost per Mile:	$3,038,000	

Acres per Mile at Assumed Stream Width:	
50ft:	6 acres
75ft:	9.1 acres
100ft:	12.1 acres

Riparian Corridor Mitigation

Assume 150 ft buffer on each side of stream.
This equates to 36.4 acres of buffer per stream mile
Assume 25% contingency on area of land to be purchased to account for RE flexibility for transactions
This results in 45.5 acres of land per mile buffered

Assume:	the need to establish vegetation (45.5 acres per mile)	
Assume:	$4,000 per acre for easment costs	
Assume:	$3,000 per acre for revegetation costs	
Real Estate:	$182,000	
Revegetation:	$136,500	
Contingency 30%	$63,700.0	
Total Cost per Mile:	$382,200	

Wetland Impacts and Bank Mitigation

Assume:	$30,000 per acre for wetland bank mitigation

Riparian Forest Mitigation
Assume $4,500 per acre
Assume $360 per acre for reforestation costs

Minnesota Diversion	
Real Estate MN:	$131,200
Reforestation Cost	$26,240
Total	$157,440
North Dakota Diversion	
Real Estate ND	$307,200
Reforestation Cost	$61,440
	$368,640

1.8 Agency Meeting Notes

Fargo-Moorhead Metro Feasibility Study
NEPA Scoping Meeting with Agencies

Date: Wednesday, 02-Sep-09
Time: 1:00-3:00 p.m.
Location: Fargo library community room, 102 3rd Street North, Fargo.

1. **Attendees**: Cass County: Keith Berndt; Clay County: Tim Magnusson; Moorhead: Jody Bertrand; Fargo: April Walker, Mark Bittner, Nathan Boerboom; Corps St. Paul District: Jon Sobiech, Craig Evans, Aaron Snyder; MN DNR: Tom Carlson, Bob Merritt; NDSWC: Randy Gjestvang; USDA-NRCS: Sharon Lean

   Attendees via telephone: EPA: Robin Coursen; FEMA: Steve Hardegen, Mike Hillenberg; ND Game and Fish: Bruce Kreft; MN DNR: Nathan Kestner, Bob Bezek; USFWS: Richard Davis

2. Information to add to Scoping Document:
   a. Robin Coursen would like to see the list of prior studies incorporated into the document.
   b. Robin would like to add a broader alternative to the document; she will provide the verbiage to Jon. The alternative is a sustainable alternative that looks at use of zoning, enlarging the floodway, redevelopment and new growth, etc.
   c. Develop Screening criteria. Coursen
   d. Add objectives after the Purpose and Need Statement. Coursen and Kreft.

3. Questions asked:
   a. Is the Waffle project in or out? Coursen

      Corps: The waffle project has been looked at and is currently being looked at through other studies; this study is on a fast track and will not look at storage alternatives as thoroughly as could be.

      MN DNR: Merritt said the volume of water from flooding overwhelms any potential upstream storage.

   b. Can a Diversion channel be designed with Wetland Restoration in mind? Will the Corps pursue this if a diversion is the preferred alternative? Richard Davis FWS.

      Corps: Yes it can be and will be looked at.

4. Issues to Add:
   a. Natural Resource Habitat along entire impacted area. Merritt
   b. Slope stability along river corridor. Merritt
   c. Upstream Water Quantity Issues. Randy G

5. General comments:

a. Robin Coursen would like to look at our Economic analysis guidance. Craig will send her link to it.
b. Will we combine alternatives? Combining alternatives can lessen impacts. Coursen
c. There is no such thing as a permanent easement in North Dakota law, only a 99 year maximum. Randy G.
d. Do we have all of the agencies we need to participate? We need to add Pete Waller BWSR and Tom Fischer SE Cass WRD.

Fargo Moorhead Metro Feasibility Study
Resource Agency Meeting to discuss Impacts, Issues, Mitigation For Diversion Channel Alternatives
10-29-2009

Attendees: Jon Sobiech, Mike Lesher, Elliot Stefanik and Aaron Snyder USACE, Mike Buringrud NCWB, Joe Nigg Metro COG, Bonnie Johnson and Keith Berndt Cass County, Tom Carlson, Luther Aadland and Bob Merritt MN DNR, Pete Waller BWSR, Nathan Boerboom and Mark Bittner City of Fargo, Randy Gjestvang ND State Water Commission, Tom MacDonald and Brian LeMon Barr Engineering, Keith Weston ND NRCS, Tom Fischer SE Cass WRD, Rodger Olson, Jody Bertrand and Bob Zimmerman City of Moorhead, Sharon Lean MN NRCS, Jack Frederick MPCA, Erik Jones and Gregg Thielman Houston Engineering, Lee Beauvais Moore Engineering, Tim Magnusson Clay County, Pam Gulleson Senator Dorgan's Office, Mike Hillenburg FEMA, Bruce Kreft ND Game and Fish, Jim Louie EPA Region 8, Matt Mesker, and Richard Davis FWS.

Meeting Agenda

1. Introductions and go over Agenda. Identify objectives of the meeting.
    a. I.D. Issues concerns of the agencies associated with the diversion channel alternatives construction and operation.
    b. Identify design criteria for fish passage.
    c. Assist us to identify the impacts of the project and what we can do to avoid, minimize or mitigate those impacts.

2. Overview of project and where we are with it.

3. Discussion of the Diversion channel as designed.

4. Open it up to agencies to get their input on concerns, issues, design criteria

General Comments on overview of project to date:

Bob Merritt MN DNR: Why not make a shorter diversion on the North Dakota side? A shorter diversion on the ND side would have some additional costs because you would cross the Sheyenne River and the Sheyenne diversion at separate places. The Channel may also need to be made larger due to loss of head, additional costs would be anticipated.

What is the major cost difference between the diversion channels on the MN Side and North Dakota Side? The structures for crossing the tributaries on the ND side are the major cost difference between the MN and ND side diversions.

Mike Hillenburg – Asked about executive order 11988? This was discussed and agreed upon as an issue, it was addressed that the North Dakota side diversion and the MN Diversion are different in areas that they protect so they are not the same as far as practicable alternatives are concerned.

Fish Passage Questions, Issues, and Concerns related to diversion alternatives;

Luther Aadland MN DNR –

- Big red flag for Luther is the structure for the red river itself. How much analysis was given to the design of the structure?
- I have partnered with the corps on fish passage in the past and we know what works. Fish ladders haven't worked in the past.
- Culverts are a problem for fish passage. There are 90 different species of fish in the Red River all needing a little different flows, uniformed flows are not a good thing. Turbulent flows have worked in the past.
- Why the need for the structure, the Breckenridge bypass is a passive structure? I need to see proof that a passive approach will not work.
- Concept of manipulation by gates is another area of impacts. Having to manipulate gates will have an effect on the BC ratio as well.
- The intent was to not manipulate less than 5 year event.

Response to why the passive approach will not work:

- A passive design was looked at, using this approach would cause the size of the diversion to have to be larger which would cost more.
- Minimize the size of the diversion, lower profile through town, were reasons why it was eliminated.

What velocities going through the low flow culverts would be excessive?

- A general rule for flow through conduits to stand by is a couple feet per second. Natural channels you can have an excess of that up to 3 feet per second.

Will fish enter those types of structures?

- Aadland, the more you can emulate what fish will encounter in nature the better off you will be.

Barr Engineering – Looking at base flow, during high events like a 500 year event on the Maple flow is 9600 cfs which is much higher then 3 feet per second.

The timing of when we need to maintain certain velocities needs to be discussed.

Winter conditions fish passage?

- Whole groups of species that move throughout the summer, young of the year walleye, channel catfish, passage should be provided all the time for all species. There are winter migrations, but there isn't a lot of information on this.

Luther Aadland and others at this meeting have agreed to assist the corps and AE's to address fish passage issues. What information can we provide a sub group to show how we got to this point?

- **The Corps agreed to do a brief technical write-up to address how we went from the passive approach for the diversion to a structure.**

Bob Merritt MN DNR –

- Permit review on the MN Side; take steps to devise a positive cost benefit at the risk of environmental damages. Too suggest that a diversion as the acceptable alternative when we may have something else may be very difficult to sell. We do allow projects that are less then 1.

- The levee alternative doesn't have the impacts of the structure. There is not a way to mitigate for the structure.

- We are focused on minimizing the impacts.

- The problem the alternatives were trotted in front of the public without the true analysis of what are the benefits and the costs. The public has already made their mind up. This is the story we are getting from the corps. To be on the fast track as we are, and to suggest that there is only one alternative at this point is very premature, and to expect us to come up with a design for you in the time you want it is too much.

- If there is a viable alternative that will do the job it is our obligation to do it.

Corps Response:

- The levee and a ND diversion are alternatives. These could be carried on as a locally preferred plan; however, the ND diversion would require a B/C ratio above 1 for it to be a locally preferred plan.

- The issue is trying to find the optimum cost Benefit ratio, the higher the better is what the corps is looking at. We did look at a diversion channel that is passive and found it had an unacceptable BC ratio? There was also concern that reducing the upstream profiles would reduce overbank floodplain storage which increases the potential for downstream impacts.

- It appears that the reason for the structure is to focus on the lower flows. Should focus more on the 25, 50, 100 year etc..

What is the existing habitat on the five ND tributaries (Wild Rice, Sheyenne, Maple, Rush and Lower Rush) and there relationship with the Red?

Bruce Kreft –

- The fish migrate up these tribs for spawning during the spring months, they provide significant habitat for reproduction. The streams provide significant spawning habitat value, response to pulse events. The fish seem to seek the red in during the winter months, the interaction between the tributaries and the Red is very important.

Is this true for the Rush River and the Lower Rush, fish will migrate up the rush to some extent this will be looked at more?

- be sure to address sediment transport, flood flows, and habitat forming functions in the study

- be sure to include fish movement into tribs from by-pass channel during flood events.

- be sure to address fish stranding issue

- for fish stranding, can we model stage changes over time for a typical descending hydrograph.

- be sure to address energy transfer between channel intersecting, and avoid head-cutting.

Are there any existing structures on the five tribs on the ND side??

- The Sheyenne has a large structure near Lisbon, the Maple has a dam upstream. There is a low head damn in West Fargo on the Sheyenne. The state water commission has records of those. The West Fargo Diversion is also an impediment for the Sheyenne.

Bruce Kreft ND Game and Fish

- The five tributaries haven't identified any critical habitat, they all provide unique habitat, the Sheyenne has a large watershed area. It is important to note that fish are not the only issue these structures will impact other aquatic species including but not limited to mussels, invertebrates, etc.

Luther

- Mussels are an issue, migrating fish are necessary for mussel reproduction.

- Existing barriers, many of the barriers are inundated providing a window of passage, the more barriers the more unlikely there will be those windows of passage.

- The Sheyenne is the most significant tributary to the red.

Corps and AE's Question:

- What design criteria or considerations should be used to make the tributary structures more environmentally friendly? For fish and general aquatic habitats, riparian zone habitats, considerations would you like to see incorporated?

Luther:

- Sediment transport is a key element, bank full discharge is key to both red and other trib. Flows above the 2-5 year even start spilling into the floodplain.
- Key elements: You could have aggradations problems because it doesn't have the energy to carry it, mostly silt and sand load. Any time where you rob energy or the opposite can be a problem.
- Where flows are diverted from can be a problem.
- In stream habitat- MN has done a lot of modeling to monitor fish and other species, it is very complicated, some do well under low flow conditions, others feed in high discharge conditions. No matter what we are impacting some part of the species.

General Comments:

- Flood flows have gotten bigger over recent years.
- Projects that store flood water are generally a good thing.
- Problems that can be significant are those that cause sudden change in discharge and flow.
- Always leery when using gate controls in projects.

- If a river stops flowing during dry times and has a massive flood during high times it is not a good thing. Rivers that maintain constant flows have better fish and mussel assemblages.

Will more fish be forced up the Buffalo River if either diversion channel is built?

Flow regime of the diversion channels, do we reach a point where the flows are shut off and stranded?

Fish Stranding:
The design now has the weir being overtopped at a greater than 5 year event.
Some of this will be a function of what the weir looks like.

Will there be grade control within the diversion channel for incision? The slope is so minor that shouldn't be an issue.

The plan is too design a meandering pilot channel running down the middle of the diversion.

Footprint Impacts

Levee alternatives Impacts:

The Corps looked at the NWI for wetland impacts. Very minimal wetland impacts, the ones we have should be mitigatable.

Luther MN DNR –

- Is the intent to have levees devoid of trees?

The rule is too keep vegetation 15 feet away from the toes of the levee.

- The corridor is a real key element for terrestrial species movement along the red river.

FWS –

- Clearing of cottonwoods could impact bald eagle nests, this needs to be considered, there is a permit process for removing an eagle nest. Information of known eagle nests will be provided by the FWS.

NRCS Farmland protection Policy Act,

- Most of the area is prime farmland. There will be impacts of the riparian zones when crossing the rivers with the diversion channel. The straightening of the channel will have riparian impacts.

Wetland Conservation Act on the MN Side, similar to the corps.

Tom C MN DNR -

- Natural Heritage data base found the short beaked arrowhead plant as a species of special concern one location in a city park. The levee alignment will impact this.
- Very interested in types of vegetation for the diversion channel.

Diversion channel footprint impacts of the bypass channels.
Will the diversion channel be designed with herbaceous material inside it?

DNR is not aware of any native prairies or plant communities within the footprint of the diversion channels.

Buffalo River Aquifer – Make sure this is identified and not impacted.

NRCS –

- Fragmentation of family farms, and transportation issues for moving farming materials.

Luther MN DNR

- In river diversion structure, canoe pass and navigation through the structure.

Bob M MN DNR

- There are a fair number of drainages we will encounter, the interactions of the drainages. Also the ongoing discharge coming out of those ditches needs to be looked at. We get a substantial amount of erosion right now, that is a significant cost during the floods, and this will be an issue that will need to be addressed. We are lower then the gradient by quite a bit and need to address them like a tributary.
- There is potentially a significant aquifer (Border Aquifer) near the south end of the MN diversion. There is limited data on this. Need to get this data from Bob Merrit. We need to find out how deep it is and where it is.

Richard Davis –

- Would this diversion act as drainage to any of the adjacent wetlands?

- From a drainage standpoint, tile outlet drainages into the diversion channel, and the process of the continual wetness, tile will be something that is added as features of drainage.

It would be good to design the pilot channel with sinuousity to benefit sediment transport. Winnipeg has done a nice job of seeding the diversion.

An idea was shared to divert the five tributaries on the ND side into the diversion channel allowing no water to pass through the diversion.

SHPO has to be involved.

Water Resource District point of view, all drainage will be accommodated by this diversion. We will try not to ignore any drainage.

Have we looked into using some of the diverted water to create some wetland areas and offsetting impacts?

Notes from USDA NRCS Sharon Lean– Minnesota Side Diversion

- NRCS has identified 7 acres of additional wetlands that are not identified on the NWI.
- The project will impact prime farmland which will require a Farmland Conversion Impact Statement. This is needed when government funding is involved. Looking at the farmland impacted by the diversion, I find that all soils that are involved is considered prime farmland.
- Also SHPO will have to be involved. I have looked at the Archeological Site database and Historical Inventory database. There is at this time 24 sites that will be impacted. I also know through producers in these areas that there are more sites that have not been identified.

Due Outs:

- Main control structure on the Red River, write a technical memo to discuss the issue of a passive structure vs. hard structure. We will also take a more detailed look at the velocity passing through, adjust openings rough them up, through the openings, how frequently we can make them passable. Provide that to the agencies as quickly as we can. the design to improve fish movement through the structure

- Luther requests that we open this up a little bit more, there was a limited number of scenarios at looking at the passive, lets open a little bit to look at more scenarios that would work for a passive structure. He would much rather see controlling structure on a bypass vs the Red River.

- We agreed to have a sub committee to address the following issues:
    - the design to include passive features for fish
    - the design to improve fish movement through the structure

- This committee will consist of the following members: Luther Aadland and Bob Merritt MN DNR, Mike Lesher and Jon Sobiech Corps, Bruce Kreft ND Game and Fish, Richard Davis FWS, Tom MacDonald Barr, and Lee Beauvais Moore.

- Bruce Kreft ND Game and Fish will get over to the Rush and lower rush to take a look at that. ND Game and Fish would have difficulty to walk away from the Wild rice, Sheyenne, and Maple Rivers but have agreed to look at the Rush and Lower Rush.

Fargo Moorhead Metro
Fish Passage working meeting
November, 10 2009

Craig Evans PM, Jon Sobiech, Elliot Steffanik, Mike Lesher Corps, Richard Davis FWS, Luther Aadland Mn DNR, Bruce Kreft ND Game and Fish, Lee Beauvais, Jeff Volk, Stuart Dobberpuhl with Moore Engineering, Jody Bertrand and Bob Zimmerman Moorhead, Nathan Boerboom and Mark Bittner Fargo, Gregg Thielman Houston Engineering, Keith Berndt Cass County, and Brian Lemon and Miguel Wong with Barr Engineering.

Can the Red River control structure be designed to operate passively?

Passive control = a means to divert the flows into the diversion channel without a channel structure. Stuart explained the difference between Breckenridge diversion channel and our objectives for this project. Stu then went into the handout showing the differences between the no structure project and w/structure project.

Could you widen the entrance? You could it would help a little bit but not significantly enough to bring the benefits to where they would need to be to have a justified project.

Are the existing conditions considering future development or not? Only existing.

In order to have a feasible project we have to have a certain amount of benefits, a structure on the red for a diversion channel is needed in order to capture that quantity of benefits.

Red River Structure to divert water from Red River into Diversion.

What are some of the alternatives that you might use that will facilitate fish passage and canoe passage, etc.

- Ramp the bed up.
    - Issue with this is the huge head difference.

The initial structure has an impediment to fish 100% of the time, we need to look at structures where this will not be the case.

Luther said that the existing structure is not a mitigatable thing. We need to figure out the solutions.

Winnipeg structure (which opens from the bottom up)?

- This structure could raise the levels of the water upstream up to 4 feet at the 500 year event.
- The existing structure in Winnipeg has serious fish passage issues.

What will drive the design? Design criteria should include:

- Unimpeded passage up to the 5 year event.
- Proximity to fish passage from structure on the down stream side, needs to be very close so the fish will not have much trouble finding the passable channel.
- Less concerned about the light then the duration of excessive velocities.

Will a sturgeon seek out a higher opening as flows increase? If designed right they could find their way.

Are we in agreement that we have to have a structure on the Red River? Yes.

See attached concept drawings!

DNR likes the concept of building a channel around a structure on the Red vs. building a structure and cutting off an oxbow. The fish channel around the structure has to be designed in a way that it doesn't impact the number 1 goal of limiting flows through town.

They can work both concepts for this review.

Agencies would rather not abandon the channel, they wouldn't comment officially on this at this point. There experience shows that this hasn't worked well in the past, Drayton was an example.

The new structure would have a larger tainter gate with natural slot bottom and passage around the side. This is the preferred option now. It is not only better for handling fish passage but also better for handling debris.

Use option 1 but design the fish passage around the structure to mirror the abandoned channel which could mitigate for the abandoning of the existing channel, so it would be a one for one.

What Barr Said they can do:

- Verify gate by next week, carry option 1 forward with gate, and figure out if stair steps create any problems, with a matching section that replaces what is taken.

- Look at both options for a cost estimate realizing that option 2 will be making some aggressive geotechnical assumptions.

- They will deliver concept 1 and 2 sketches to Craig by tomorrow noon 11/11/09.

What we will want, is some type of a conceptual drawing of the gates, culverts would look like, etc.

North Dakota Diversion

Tributaries:

Currently designed to pass a 5 year flow. If the flow that passes through the diversion structure is reduced to below a 5 year the cost would be reduced significantly.

Potential changes include:

Take the top off of the trib culvert, to allow mixing with the diversion flow, this could be controlled with a gate at the end of the trib channel preventing too much flow to pass into the downstream portion of the trib.

Narrowing opening for trib flow will save money up to 10 million dollars but will do nothing for fish passage.

Raising the trib elevation allowing the entire diversion channel flow to go underneath the tributary. This would increase upstream elevations.

Providing more openings to allow the entire diversion flow underneath the tributary and designing the bed of the tributary with more natural material, earth, stones, etc.. This is the desired option for now realizing it will not allow for passage 100% of the time.

Goals for fish passage:
Elimination of the siphon is desirable.

Eliminating structures on the Rush and Lower rush would reduce cost but not as much as folks may think, in order to build a drop structure and a ramp there will be a cost.

Can we go lower then a 5 year flow through the tributaries?

We will continue to look at Figure 4 option to cost it out.

Due outs for the ND tributaries:

Deciding to mix waters.

Another issue is the velocities at the crossings?

Figuring out how the structures will work under conditions when we are not flooding. Making it work the 80% of the time we are not flooding.

Throw a date to get back to folks on going from a 5 year to a 2 year flow. Could we drop the rush and lower rush by maintaining the 5 year flow out of the maple.

Fargo Moorhead Metro Feasibility Study
Fish Passage Conceptual Drawings Meeting with AE and Corps Staff
12-3-2009

Attendees: Jon Sobiech, Mike Lesher, Elliot Stefanik, Jeff Hansen, Tony Fares, Craig Evans, Eric Wittine, and Randy Devendorf USACE, Keith Berndt Cass County, Nathan Boerboom, April Walker, and Mark Bittner City of Fargo, Brian LeMon, Miguel Wong, Greg Williams, Paul Nielsen, and Matt Metzger Barr Engineering, Jody Bertrand and Bob Zimmerman City of Moorhead, Erik Jones and Rick St Germaine Houston Engineering, Lee Beauvais and Stuart Dobberpuhl Moore Engineering

AGENDA
Red River Diversion
Fargo-Moorhead Metropolitan Flood Risk Management Project, Feasibility Study
Scoping Design of Hydraulic Structures and Cost Estimates Meeting – Barr Engineering Co.
Place: U.S. Army Corps of Engineers, St. Paul District – Executive Conference Room
Date/Time: December 2, 2009 – 12.00 m
Use Corps of Engineers call information:
Teleconference: 866-821-8922
Participant Passcode: 9059736

1. Introductions
2. Justification of Control Structure on the Red River of the North
3. Background information – Red River of the North (and Wild Rice River)
4. Preliminary design of Control Structure on the Red River of the North and Inlet Weir to Diversion
Channel: MN Short-20Kcfs, MN Short-35Kcfs and ND East-35Kcfs
5. Background information – North Dakota tributaries (work in progress)
6. Alternative designs of Hydraulic Structures (crossing/diversion) at North Dakota tributaries
(work in progress)
7. Main assumptions used in cost estimates (follow-up meeting with Jeff Hansen, Corps of
Engineers scheduled for December 8th or December 11th)
8. Discuss outline of presentation for meeting with Agencies on December 10th
9. Other

Meeting discussion

1. **The need for a diversion structure on the Main Stem of the Red was discussed and justified. Mn DNR seemed to not buy into this at the last meeting.**
    a. **We need to put together a technical write-up memo fleshing this out.**

2. **Discussed the conceptual drawings for the main stem structure. It was determined that we need to focus on passing fish for all situations up to a 5 year event, and we need to look at the 5-50 year event more closely.**
3. **For now we shouldn't worry about the 100 – 500 year event, fish can pass using the diversion channel at this point.**

4. **We discussed which concept we would prefer, at the meeting we decided we want at least 3 gates for redundancy. We need to get back to them on our chosen alternative.**

    a. **How will this concept handle large debris? They will get back to us on this.**

5. **Is boat passage a big issue? We need to work through this and get back to them, during meeting it was decided that boat passage is necessary for a 5 year event and lower, after that it will not be required based on safety issues and concerns.**

6. **This design effort needs to develop a list of issues that need to be addressed.**

    a. **How many gates, what type of gates, need to know this for the DEC 31 date.**
    b. **A Matrix to work through pros and cons will be developed to help guide the decision.**
7. **We need to share an Ice POC with BARR to start looking into the Ice jamming issues.**
8. **Building the structure in the wet vs. dry and how this affects cost, the AE's will develop this further and get back to us.**
9. **Cost**
    a. **Assumptions on Direct, indirect, labor, materials, schedule all affect contingencies.**
    b. **Barr will do some work to refine the estimates, they need to participate in the Jan 7th Cost and schedule Risk analysis.**

Tributaries

1. **Should we use a 2 year minimum or a 2 year maximum flow?**
2. **The 2 year flow issue was related to geomorphic needs to maintain some existing habitat condition.**
3. **Fish Passage, is still a problem, we discussed passing a 2 year event and passing a 5 year acceptable velocity to pass through.**

December 10 Agency Meeting

- **Focus on presenting the next iteration of design, showing what it will look like and discussing issues and concerns with it.**

ACTION ITEMS

- **Prepare a technical memo justifying why we are going with a structure on the Red vs. a passive approach.**
- **Determine how many gates we would prefer**
- **Determine what type of Gates we want for the structure.**
- **The AE will look into how the structure will handle Large Debris (cottonwoods)**
- **Is boat passage a big issue? We determined for a 5 year even and lower to allow passage, but after the 5 year event we would go with no passage. Need to address with agencies and follow up.**
- **AE's will develop a matrix with pros and cons of gated structures.**
- **Contact an Ice expert possibly from CRREL and provide contact to BARR.**
-

Notes from 10-Dec-09 FMMFS Fish Passage meeting
Fergus Falls DNR Office

Attendees:
Craig Evans, Aaron Snyder, Elliot Stefanik, Jon Sobiech, Mike Lesher with USACE, Nathan Boerboom, April Walker, and Mark Bittner city of Fargo, Lee Beauvais and Stuart Dobberpuhl Moore Engineering, Jason Benson and Tom Souey Cass County, Brian LeMon, Bill Spychalla, Omid Mohsemi, and Miguel Wong Barr Engineering, Dave Friedl, Nathan Kestner, Tom Groshens, Luther Audland, Tom Carlson and Bob Merritt MN DNR, Bob Zimmerman and Jody Bertrand city of Moorhead, Rick St Germain Houston engineering, Bruce Kreft NDGFD, and Rich Davis FWS

1. The Corps will write a short white paper to document the need for a control structure on the Red River main stem and how we arrived at that design.

2. Elliott presented slides to show the exceedence probability of various flows. During the wetter period we've seen recently, a 5-year event flow occurs less than 1% of the time for 11 months out of the year and only 8% of the time during April. For fish passage, we would like to be able to pass fish 100% of the time, but that may not be possible. 20-yr event (19,000 cfs) occurs less than 1% of the time during April. This info is based on the wetter portion of the flow records, and different assumptions about period of record would affect the results.

3. RRN Control Structure:

Miguel Wong presented info on the preliminary conceptual design of the RRN control structure. The purpose of this meeting is not to get a blessing of the concept but to get input on all of the design considerations. All of the preliminary work originally used the Phase 1 hydrology. The info presented today is based on Phase 2 hydrology.

Red River and Wild Rice flows are in the same order of magnitude. Design is based on coincidental flows on the Wild Rice for design flows on the Red. Design flows for the MN diversion vary significantly from median flow 360 to 500-year flow 53k cfs. Stages vary over 32 feet (elev. 880-913). Average velocities vary, but are generally less than 1.3 fps. Bottom elevation 861 top ws elev 913 = more than 50 feet difference between thalweg and water surface.

MN Short 35k diversion 500-yr event (53k cfs) would divert 35k cfs and allow 17.9 cfs into the city = less than a 20-year event. For most flow conditions, about a 5-year flow would be allowed into the city.

MN Short 20k would divert 20k and allow 33k into the city = more than existing 100-yr event. So with a 500 yr event you would be fighting something over a current 100-yr event. Bottom line—design is to maximize the amount of water that can be diverted.

Also, the elevation differences are very large, so a very large structure is needed.

ND diversion would start upstream of the Wild Rice confluence. 500-yr event with a 35k diversion would take 18k cfs from the Red and only allow 1400 cfs of wild rice flows plus 16k red flows into town. The project will only let between a 5-10 year event flow into town. Average flow velocities are 0.7 to 1.3 fps depending on flood event (average over most of the flood plain, but not all).

USGS measurements show that average velocities at the Fargo gage are about 2 fps for 2 yr to 5 yr flows.

Design concept we're currently proposing is intended to minimize impacts on events smaller than the 5-yr event. Most of the time (99.5% of the time), the structure would act like a bridge with minimal impacts to the flows. Could pass ice, fish and boats. Inlet weir would be set to keep flows up to the 5-yr event in the main channel.

Questions: what is the minimum width opening needed to pass ice—assumption now is 40 feet.

For events larger than the 5-yr event, the structure would block various openings to limit the flow coming through, but the structure would never entirely block the flow. During the larger events (100-yr plus) the lower openings would pass bed load and keep it from settling out upstream of the structure.

Need input on desired number of gates. Presented charts showing various configurations and openings required to pass various flows. Same or different widths? Various bottom elevations? More or fewer openings? Gates operable to various heights or just open or closed?

Preliminary modeling shows that this type of structure can achieve 1-2 fps average velocities up to the 5-yr event when the gates are not being operated. Once the gates go into operation, the head difference will drive velocities, and they increase substantially to the 13-20 fps range.

Luther noted that the existing cross section of the river is pertinent to the discussion. Miguel stated that the structure openings would actually provide more flow area than the existing condition. Luther suggested that the existing channel is elliptical, so it would be good to have the middle opening with a lower elevation than the sides.

Observed velocities by USGS across the channel for 2007 (about 8-yr event) vary from 0.5 to 3.5 cfs depending on distance from the banks.

Barr created a 2-D model to see how flow velocities vary across the channel (very preliminary). Models show up the to 5-yr event there will be areas that have flow velocities near 1.0 fps with some roughness built into the channel.

Goal for today—refine the concept

Question—what is the length of flow path? = about 50 feet of 2-3 fps.

Erosion protection will be needed downstream of the structure, but not a large cost relative to the rest of the structure.

Question—how will bed load sediment transport downstream be affected? Most of the bed load is fine-grained silt and clay rather than a sand material. Miguel consulted with Gary Parker and also worked on the Buffalo River. At this time, we know more work is needed, but it does not appear to be a large issue.

Luther noted that the RRN produces large volumes of sediment, even if the grain size is small.

For floods larger than the 5-year event (up to about 50-year) a side ramp could allow fish passage. Ramp slopes up to gated openings at various elevations that could be closed off if elevations exceed operational constraints.

Ice passage is an issue. Propose keeping minimum gate openings to 40 feet. Could use an ice control structure upstream of the gates to keep ice out.

Question—Aaron—could we let a 15-year event pass without operating the structure? Answer—it could be operated that way, but that would allow more water into town that what we're designing for.

April Walker said a 30-foot stage is about a 7 or 8-year event when 2nd Street floods. Elm street and 12th Ave bridge go under sooner. Fargo would not try to prevent those lower level damages from occurring. Houses are generally good to 35 foot stage. Bob Zimmerman said major disruption to traffic occurs at about 32 feet. Mark Bittner confirmed that the 30-foot stage is the "magic number" for Fargo.

Stu Dobberpuhl presented. 10-yr stage is about 32.7. Raising the weir crest operation would require a much larger weir. Luther was more concerned about the frequency of operation of the structure.

Luther—what are the damages on the more frequent events; are they things that could be moved? Good planning on behalf of the cities could be part of the solution and allow the less frequent operation. Passive intake at 1 foot above 5-yr event and beginning operation at 5-10 year event

To look at the concept, it would be helpful to model the proposed structure for moderate events without operation of the gates to see what those velocities would be.

Luther thought that a 30-foot gate width is probably a practical minimum.

Trash load could be addressed with booms to direct trees, etc. to a handling area.

Luther would rather see trash passed through the structure using larger gates. Booms that intercept trash would keep woody debris from the natural environment and cause problems during events. Bruce Kreft noted that this design is important to set precedent for other projects in the basin.

Bruce Kreft asked whether all of the concepts could handle navigation. The designs would allow boats up to about the 5-yr event. Wider gates would be better.

Tainter gates can be 40+ feet wide. Corps uses roller gates for openings larger than that. The number of gates affects redundancy. Need to be able to accomplish the operation with some gates out of commission and provide bulkheads for emergency closure.

Luther would like to match the bankfull capacity of the river and try to match the sill elevation to the existing channel bottom.

Miguel proposed picking a concept now to include in the report and cost out. Craig pointed out that the Corps needs a cost estimate within 20% of final, but details can change later if costs are reasonably within the estimate. Cost will be driven by excavation, concrete and number of piles related to width of the structure. Other considerations, ramps, etc. can be added for small increments of cost.

Elliott—we're wondering if there is comfort that these concepts will provide adequate fish passage. Is this general design acceptable?

Luther—two other elements haven't been discussed. The bypass and issues of off-channel vs existing channel location. Other places have used a more varied/slotted design with different elevations of weirs.

Bob Merritt noted that fish passage structures can be people magnets due to concentrating the fish. Possible enforcement issues. Luther is not too concerned about poaching. Look at Breckenridge design as a sample.

Tom Groshens—would storage affect the design of the project?
We would not design this project smaller if more storage was built. It could affect the frequency of events and allow it to operate less frequently.

Bruce Kreft—ND contributions from ag drainage will probably increase rather than decrease over time.

Luther reminded us that flooding is a cue for migration that is missed when we focus on percentage of time that flows occur.

Issue of where the structure gets built—in existing channel or adjacent to the existing channel. Abandoning existing channel could cause impacts. If we build adjacent, what happens to the existing channel?

Miguel showed aerial photo. Using a straight portion of the channel would minimize these impacts. Building in the existing channel would require construction during at least one snow-melt event—very risky for construction.

Mark Bittner assumes we would build the diversion before the control structure so flood flows would be diverted during construction.

Elliott—we need to factor mitigation into our cost estimate, so we need to make some assumptions.

Luther thinks placement of the structure is a very important consideration.

Miguel—at this time a safe assumption is to build off-channel.

Elliott—either temporary drainage of existing channel and build bypass or re-route channel and abandon the old channel. Need to identify what are the issues and how can we avoid, minimize or mitigate for them.

--Lunch—

4. Tributary crossing structures

Miguel presented slides on the trib crossings. Focus on Wild Rice, Sheyenne and Maple rivers. Our prior agreement for design was to drop the Lower Rush and Rush rivers into the diversion and compensate by letting more of the Maple flows come through.

Design is based on the coincidental flows on the tribs when the RRN has a design event. Goal is to keep the water surface in the diversion lower than the coincidental stages on the tribs so that the tribs can be captured in the channel.

2-yr depths 10+ feet.

Natural conditions on the Sheyenne River are 2-3 fps mean velocity. Wild Rice R. velocities for 2-yr event are 2-3 fps until larger events when more flood plain comes into play.

Phase 1 design allowed minimum 5 year flows to cross in the tribs. Cost about $50 million per structure to accomplish this. Box culverts assumed to be 200-400 feet wide with high velocities.

Phase 2 design (to be completed 31-Dec-09):

- Shorter transitions to concrete-lined sections (about 400 feet)

- Tribs pass minimum 2-yr flows into protected area
- Allow fish passage
- Minimize risk of ice jamming
- 3 major crossings: Wild Rice, sheyenne, Maple
- 2 drops: Lower Rush and Rush

Elliott noted that some of these assumptions may be less than desirable, but we are trying to see what could possibly make the ND diversion viable and still remain environmentally acceptable. For instance, the two drop structures at Rush and Lower Rush. We're balancing cost with environmental concerns. Unless BCR increases to 1.0, we cannot even consider it.
The diversion invert is significantly lower elevation than the tribs (12-15 feet).

Conceptual design scenarios:

1. Flow in trib, no flow over spillway, no flow in diversion
2. Flow in trib, flow over spillway, no flow in diversion
   Open channel flow in trib; gated openings kept open during event
   Could cause incresed stages upstream on tribs for moderate events
3. Flow in trib, flow in spillway, flow in diversion under aqueduct
4. Flow in trib, flow in spillway, flow in diversion over and under aqueduct
   Requires a wall on both sides of the diversion to keep diversion flows from spilling into the tribs.

Conceptual design of trib channels:

a. Use channel walls 6-8 feet high with additional removable gates/sidewalls that must be dropped when the diversion channel needs additional flow capacity. Would need to anticipate large events and drop the gates before the trib flows are up against them. Crest gates are used on other dams in the region. Operation during winter conditions could be difficult. Structure would probably be expensive.

b. Use a higher trib invert over the diversion channel. Would increase velocities to 5-6 fps over the diversion and back water up on the upstream side that would divert trib water into the diversion. Could cause sedimentation upstream.

c. Use a combination of box culverts with open channel on top, approx total height 8 to 8.5 feet, keep invert elevation same as existing trib invert.

d. Use multiple layers in both the trib and diversion.

e. Mark Bittner: use a separate diversion around the trib crossing to handle excess flows on the diversion.

Costs: Miguel believes that the revised structures could be significantly less expensive than the original design, or at least within the original cost. (Given that we're dropping the Rush and Lower Rush structures.)

Mark Bittner and Bob Zimmerman are not ready to drop these options yet.

Miguel thinks concept "b" is most viable.
Up to what event do we need to pass fish?

Bruce Kreft—want as much as possible to keep passable to fish under all conditions.

Elliott—there is no exact frequency we can specify that would be acceptable. If you could pass up to a 50-year event, that would be 99% of the time over all months.

Bruce—if that was acceptable as a first step, we could consider mitigation for the remaining loss of passability.

Tom Groshens: need similar info to what was presented for the RRN Control structure.

Luther—other issues: freeze-ups of the channel? Distribution of sediment moving down the tributary? (Miguel: sediment is a bigger issue on the Sheyenne and Maple)

Miguel: we would design the spillway into the diversion to be very efficient so that for even very large events on the tribs, the flow velocities through the crossings would be similar to the existing 2-year flood velocities.

Gates on the downstream end of the crossing would be required for events on the diversion larger than the 20-yr event.

Fargo prefers to see Mark's concept pursued. Bruce Kreft would like as much natural ground as possible.

Aaron—how would these structures function for a huge event like a 1000-yr event. How robust would it be?

Brian—they could be designed to handle any event.

Barr says details could be developed for one concept within a week.

Meeting via telcon scheduled for 22-Dec in the morning. Corps will coordinate this.

Barr will continue to look at concepts "b" and "e"—the raised trib invert with efficient diversion weir and Mark's concept with a high-level diversion around the trib crossing.

5. Mitigation? What options do we have to mitigate for footprint and other impacts we can't avoid. Need to discuss at a later time. Want to mitigate based on need, not cost, but we need to know what the cost is going to be.

6. Action items:
    a. Meeting to discuss footprint impacts.

b. Develop new refined designs for two trib concepts
c. Identify mitigation for any impacts to trib fish passage

Meeting Notes – Red River/Tributary December 22, 2009

Attendance: Craig Evans, Mike Lesher, Aaron Snyder, Elliot Stefanick, Jon Sobiech USACE, Brian Lemon, Katie Wenigmann, Omid Mohseni with BARR engineering at Corps office.
Dave Freidl, Tom Groshens, Bob Merritt, and Nathan Kestner MN DNR, Bruce Kreft North Dakota Game and Fish, and Richard Davis FWS via phone.
Lee Beauvais, Mike Opat, Stuart Dobberpuhl with Moore Engineering, April Walker, Nathan Boerboom, and Mark Bittner City of Fargo, Bob Zimmerman and Jody Bertrand City of Moorhead, Keith Berndt Cass Co., Gregg Thielman and Rick St. Germain Houston Engineering and Wade Frank and Kris Bakkegard with KLJ all together in West Fargo.

1) Connecting wild rice and red rivers, the weir will be on the west bank of the wild rice river. The inverts of the rivers were so close, that it was complex, this structure is simplified significantly.
2) The Sheyenne crossing is looking like a box over a box. No flow in diversion channel will ever flow over Sheyenne structure. All diversion flow goes under Sheyenne.
3) Maple is similar to before, lower flows under higher flows over.
4) Rush Rivers, simple drop structures step energy dissipation carrying flows into diversion channels, they will peel off low flow fish channel for the rush rivers. This will be on the west side, with a slope of 3% or less, should be 100% passage.
5) Rush Creating more channel than we are eliminating with the rush rivers, removing nearly 5 miles of channel and making 11 miles or so which will replace that with higher quality habitat.
6) ND East water surfaces –
    a. No pressurized flows 5-year
    b. Channel from wild rice to red slopes towards red.
    c. Pressurized flows on 10-year
    d. Elevation of weir is at the 5-year plus 1foot? Flow into diversion in excess of 5-year event. Coincidental flows may enter channel. Slightly less flow through town with a 5-year.
    e. Wild rice structure is a double weir structure, one on each side of river, this was done to keep 5-year red river flows from entering the wild rice.
    f. 10-year event pressurized flows - maple, 20- under Sheyenne and maple. 100 – Sheyenne and maple. 500 all and over maple.
    g. Any issues with getting flows we need into diversion? They don't see an issue with that.
    h. Sheyenne River channel stayed at 125 feet, maple to the red is 300 feet?
7) Wild Rice River
    a. Initially was $84 million. Currently dropped sustainably. Moving closer to $30 million.
    b. 2 large gates 30 feet wide are used for redundancy. When gets totally closed there will still be some flows into protected areas for bed loads.

c. A fish ramp will be included. Proposed to be 10 feet wide and 3 feet deep to maintain 1.3 feet of water depth.
d. Connecting channel vs diversion channel. The controlling weirs are now on the wild rice. The connecting channel is mainly a big ditch.
e. Flows enter connecting channel at 2-year but don't go over weir until the 5-year.
f. 7650 will go through town for a 5-year event – 1950 will be diverted for the 5-year event, this is based on the 2-year flows.
g. Anything over 2 year event on all tribs will go into diversion.
h. Operation plans could allow more flow into town, if desired.
i. Is there a cost benefit to not operate those gates? Don't need to operate as a flood benefit on a 5-year.
j. 99.5% of time gates are wide open.
k. Two 30 foot gates, that are approximately 22 feet high.
l. 30 and 35K look similar with velocities.
m. Tail water backs up and doesn't allow as much flows into the protected area for the large events 500-year and 100-year.
n. Complex flows at bottom of channels with boulders or rubble.
o. Will fish passage be needed at the 5-year event on the trib structure vs. at the 10-year.
p. Ice considerations 40 feet is optimal. 20 feet could work. On the red may make the center gate larger. On WR single gate may be recommended.
q. Could be sedimentation issues with the WR structure. Diverting the top portion of the flows which has less sediment. Less flow will be moving the material on the bottom, need to have morphodynamic modeling and sediment sampling in the future.
r. Will sediment be an issue in the connecting channel?
s. Would two levels of fish passage structures be necessary?
t. 10 feet for fish passage seems kind of narrow, should be more like 20 feet-30 feet?
u. How much of operation of structures will be during spawning runs, April, May, June? Walleyes, Pike, Sauger in April. Sturgeon in April, mostly in May and some in June.
v. Sturgeon have a narrow window in time for spawning. Fish can wait, but some won't. They may stack up until it's too late. Some species (northern pike) go back to the same locations each year. Other species might find available habitat. They may reabsorb their eggs if they can't find suitable habitat to drop their eggs.
w. Populations can reestablish themselves upstream after extremely large events.
x. Need Corps direction on fish passage, do we need two? Should they be at least 20 feet.

8) Sheyenne River Structure –
   a. Only allowing 2-year event into protected area. So flows are peeled off at that point.

b. The 500-year water surface in diversion never will crest over top of the tributary.
c. Increased flow area under the structure.
d. No mixing of diversion and trib waters.
e. Lowered invert of diversion 3 feet raised invert of Sheyenne approximately 1 foot.
f. This is a completely passive structure.
g. Drop structure will be necessary for energy dissipation to ensure channel stability.
h. Diversion is 250 feet for the 35K diversion and 225 feet for the 30K diversion. The tributary is 60 feet wide. Basically a box over a box.
i. How are flows limited into protected area? System acts passively no control. Should more positive control be incorporated?
j. Should include trash booms to handle debris.
k. Shortened the concrete lined section, the decrease of the invert will match the low flow channel so there will not be pooling under the structure.
l. Would include a winter low flow channel
m. Matched 2-year flow area with the flow area in the structure. Allows same flow through.
n. A rough bottom was included in both the diversion and the tributary. Across the entire channel area.
o. Sheyenne does transport sand, pulling water from top of flows, there are sedimentation issues that need to be modeled and examined in the future.
p. Design would be intended to not get anchor ice.

9) Maple River
   a. This structure passes 2-year maple flow, plus 2 yr lower rush, plus 2 yr rush into the protected area.
   b. Water goes over the tributary around the 100-year event.
   c. Maple structure has an open channel with winter crossing and with headwall upstream and gates downstream to limit flow into the protected area. Max flow into the protected area is 3550 cfs. Includes drop structure/headcutting structure. Upstream headwall is to keep diversion flows in the diversion—may not be needed.
   d. Gates will only be operated at large events greater then 100 year.
   e. There will be mixing of water between diversion and tributary.
   f. Gate operations necessary for large events.
   g. Diversion and tributary dimensions same as the Sheyenne.
   h. Tributary invert raised 1-2 feet.
   i. Sedimentation issues could occur due to raising the bottom of the tributaries, but not as much of an issue as it is with WR and the Sheyenne.
   j. Maple has same roughness factors included.

10) Follow up discussion
   a. What structures are most impacted if additional flows are required into the protected area?
   b. What about long term maintenance what is the design life? 50-100 years.
   c. Is access to all the structures included? Yes this will be included.

d. Would raising the invert basically be the same as a low-head dam? Hesitate to say this because of the not exact data, may or may not raise at all. This would be designed not to create a low head dam. If that happens riffle structures would be included. Worked to increase area under the structure to minimize the channel invert increase.
e. Maple flows go to 0 in the winter sometimes, 11 times in last 30 years. This could be a function of the data and the means of collection.
f. What are the velocities through the diversion structures. Sheyenne has 8 fps, maple 7.5 fps, for the 35K for the 500-year event.
g. At what point to diversion structures become impassible for fish?
h. Could a table on velocities in the diversion be added to the presentation?
i. Quality of habitat in the diversion would be low. The habitat would be more critical below the Rush and Lower Rush – the intent would be to do this to accommodate the two rivers.
j. Fish stranding? Is there an issue with fish moving into diversion, similar to how it would be with hydropower peaking? The weirs are designed to have a "v" notch to keep from having an immediate shut off and there would be a low flow channel with grade so the fish can have an out.
k. Sediment – you will need to figure that out and you will see sediment issues. This could be a long term maintenance issue.
l. FWS – concern regarding drying out of floodplain wetlands, 2-year events should maintain surface water connection to wetlands. This could be an impact over time if they were to lose hydrology. There could be a cost for mitigating those impacts. Floodplain wetlands downstream of diversions.
m. Corps told contractors to accommodate fish passage for the 20-year event.
n. Has enough been done on these designs to say we are OK to move forward? What are the agencies seeing? Seeking the agencies input and feedback.
o. What does the outlet of the diversion look like? This would be a riprap protected area, no special structure.

11) Mitigation Discussion
    a. How to account for the Rush and Lower Rush channels being abandoned? The base of the channel is intended to provide habitat to offset any impacts. How sustainable would this be? Would the pilot channel stay in place? If designed properly the pilot channel should maintain itself. The pilot channel would be meandered. The thought is that these features would offset the impact of cutting off the rivers.
        i. Important part is to make sure its not just a curvy run, we need to include habitat and diversity, variability within the channel, pool run, etc.
        ii. Looking for an "E" channel with well established vegetation and banks.
        iii. Don't want to restrict meander belt – may not have wide enough bottom to make a good belt width.
        iv. Goal to offset the loss from the straightened Rush and Lower Rush rivers.

v. The system would have to be stable and sustainable within the current channel width.
vi. Need to look at the confluence of where the Rush and Lower Rush intersect with the Sheyenne, what will some of those impacts look like? Need to maintain that habitat quality.
vii. What dimensions are necessary? Want to have fairly sinuous channel, want to maximize floodplain available. 20 bank full widths with an "e" channel or more.
viii. Can Corps supply any figures, with the drainage areas? Because its altered does the regional curve apply? Discharge and recurrence intervals.
ix. No woody growth will be allowed, no trees.
x. Use native vegetation.

b. What will happen to the existing rush and lower rush channels?
   i. The intent would be to abandon the existing channels.
   ii. Smart to maintain as a greenway and establish wetlands to use with internal drainage.
   iii. Corps should ask that these areas be maintained to provide some habitat value.

c. Are the Rush and Lower Rush rivers channelized and confined by levees? Unknown, most likely excavation and side cast placement.

d. Red River Control Structure –
   i. Construction in channel or adjacent to channel. There are concerns with constructability with in channel construction. Two options 1) build in dry adjacent to river, then rout river to structure, abandon existing channel. 2) Excavate temporary channel and then close natural channel to build structure, once complete reopen natural channel and close temporary channel. EIS to include flexibility to do either of those two. Options to mitigate or minimize impacts. Option 1 would have some in channel loss of habitat, looks like we would impact 2600 feet or so. Given width of river and the loss of .6 miles that would be 9 acres of habitat lost. To offset those impacts could remeander to offset these impacts, looked at remeandering 1-2 miles of the Ottertail river. Look to restore an equal number of acres on the Red, maybe a mile or two on both the MN and ND side, which could come to 12-20 acres of habitat.
   ii. Need to look at impacts to riparian forest and costs should be included. Forest and footprint impacts.
   iii. Large cost of remeanders would be for real estate costs, and get easements to revegetate.
   iv. Will building in dry have more mitigation needs? Yes that would be to mitigate the permanent loss of habitat.
   v. Option 2 has greater construction risks. Option 2 would avoid permanent loss of habitat in the Red. Reconnected once construction is over. There would still be some loss of habitat due to impacts. Looking at a 2-year window.

e. Loss of full fish passage – don't want this to be lost in the shuffle.
   i. What would the impacts be of the 0.5% to fish reproduction? Saying that it is less than significant may be a stretch.
   ii. Just upstream there are two dams Christine and Hickson, they can be passed with higher flows today – combined with some of the passage barriers with the diversion with the higher flows maybe the combination wouldn't allow fish passage.
   iii. Christine and Hickson are in the works to address fish passage for passage nearly 100% of the time. But if they are not then you have additional issues if these are not addressed by the proposed project. Could these two projects be wrapped into these two projects to use them as mitigation for the 0.5%? Possibly if the impact is significant, if not it would be difficult and if those are built would that get the impact down to less than significant.
   iv. Even with 500-year fish passage there will be an impact to the ability of the fish to move.
   v. Fish passage—still losing floodplain passage by providing a constriction at the channels. That needs to be acknowledged.
   vi. April Walker says that flood-fighting activities already prevent fish passage at the railroad bridge near first avenue in Fargo, so existing conditions may be worse than our conditions after construction.
   vii. Groshens says fish seem to try to get back to the same habitat each year. Probably wouldn't go looking for another spawning area. May either not drop eggs or just drop them where the fish can get—either way, low success rate for reproduction.
   viii. Doubt that fish would just find another place to spawn, they will do one of two things reabsorb or just dump eggs wherever.
   ix. If agencies don't believe that what we have done today are enough to avoid and minimize, what do we need to do to mitigate? Need to shoot for passage at all flows, maybe not possible but shoot as high as you can, is where we need to go.
   x. Corps to talk with consultants about 50-year for the Red River Structure. This should be accomplished.
   xi. Could diversion have some roughness included for fish passage at other location than just bridges and areas where drains enter?
   xii. Agencies think that habitat diversity would be a good thing. This would apply to MN and ND diversions along entire length.
   xiii. Could a meandering pilot channel be created through the entire channel? This applies to both MN and ND.
   xiv. Develop a 2D model for the diversion channels to get an estimate of what the pilot channel might look like? Corps to check on this.
   xv. There are other dams and impediments to the rivers that are in place, if the fish cannot get to the impediments that are being built with this project what is the purpose.

xvi. Is there a regional goal to reconnect the system? Goal to not segment the river anymore.
xvii. What are the differences between the MN side and the ND side? How do the plans differ from each other? What are the costs of those?

DNR and ND Game and Fish are both very interested in flood protection, but they also need to be concerned with the environment.

Lee Beauvais says the AEs will assume a need for fish passage up to a 50-year event. Agencies should assume 50-year for RRN and min 20-year event on tribs. Lee thinks Sheyenne and Maple should have acceptable velocities up to 100-year event. 20-year is doable on the WR.

These are our action items where we need information as soon as possible.

1) Is our approach for the Rush and Lower Rush rivers acceptable to avoid, minimize and mitigate any adverse impacts?

2) For the Red River structure, is Option #2 the preferred option for construction?

3) Is our proposed mitigation actions appropriate for Option #1?

4) Any recommendations where you would like to see mitigation done, with order of preference being: Red River close to project site; Tributaries close to project site; other Red River or trib locations further from site (e.g., over 30 miles).

5. Assuming we provide fish passage through/around Red River main structure for the 50 year event and passage through around the ND tribs for the 20 year event are impacts to fish migration and connectivity still significant?

6. If so what needs to be done to mitigate for the impacts?

Natural Resource & Environmental Presentation
3 February 2010
Memorandum of Comments

MVP
Edith Pang
Craig Evans
Aaron Snyder
Elliott Stefanik
Jon Sobiech
Tony Fares
Shannon Bauer
Terry Birkenstock
Mike Lesher
Elizabeth Killian

Call In
Keith Trego
Nathan Kestner
Amanda Hill
Robin Coursen

MN DNR
Mike Carroll
Dave Friedl
Tom Groshens
Peter Buesseler
*Tom Carlson
*Nathan Kestner

EPA
*Robin Coursen

FEMA
Steven Hardegen

Barr Engineering
Miguel Wong

Houston Engineering
Gregg Thielman
Erik Jones

Moore Engineering
Jeff Volk
Lee Beauvais

City of Moorhead
Jody Bertrand

City of Fargo
Nathan Boerboom
April Walker
Mark Bittner

Cass County
Bonnie Johnson
Keith Berndt

Clay County
Tim Magnusson

USDA NRCS
Sharon Lean MN
Betsy Hernandez ND
Keith Weston ND

ND Health Dept.
Mike Sauer

ND GFD
Bruce Kreft
Lynn Schlueter

Fargo Commission
Mike Williams

Sen. Dorgan
Pam Gulleson

North Dakota Natural Resources Trust
Keith Trego

North Dakota Water Commission
Randy Gjestvang

National Wildlife Federation
Amanda Hill

Dave (DNR)

Q: How is the term "significant impact" determined?

A: The term defines the point at which there is going to be noticeable impacts for connectivity and for footprint.

Bruce (DNR)

Q: There is Geomorphic Pre/Post consideration and studies, but is there any Pre/Post studying for the fish passage abilities?

A: The Red River has biotic studies built in that are not specific to fish passage, but could add a low cost approach to do post studies on the project.

Q: What if there is a significant issue how will the issue be paid for to mitigate after the project is completed?

A: Once the construction is done our funds are spent, but the locals could go to congress for another authorization. They could also see funds through our Continuing Authorities Program. Section 1135 involves modifications of existing projects for habitat restoration.

Randy

FYI there is a West Fargo aquifer that lies about 40-60' deep.

Mike

FYI we will be looking closely at the language in the plan for future fixes since future funding is not guaranteed.

Tom (DNR)

Q: There seems to be a flaw in the logic/concern and I need more science to stand behind your reasoning for why the fish passage has a non-significant impact and that no mitigation needs to be included.

A: Elliott provided a fish passage discussion showing hydraulic modeling and flow velocities which are passable up to a 50 year event. That discussion was followed up with fish passage thru the structures up to a 50 year event and additional money was added to increase the dimensions of the passages.

Steve (FEMA)

Q: Has there been time spent looking at how many structures will be affected from increasing the flood plain or areas downstream?

A: The 100 year flood plain doesn't expand, but the stage does increase 9 – 10". The duration stays the same, but since no extra damages are caused by the channels, we have found no takings as part of this project.

Dave

Q: I am not convinced that there are no geomorphic impacts. How quickly will the door close for the fish to leave the channel?

A: We will look to provide modeling to simulate this window and try to get the associated number and a solution to the fish sufficient time to emigrate.

Q: How will the jurisdiction be regulated if the alignment goes through ND?

A: (MN DNR) Both agencies will have an interest.

Peter (DNR)

Q: Monitor now – Come back later: Will you clarify the exact solutions that will be imposed for each situation if they need to come back later to show mitigation and fixes are required?

TEAM to further discuss impacts and mitigation:

- Bruce Kreft
- Rich Davis
- Tom Groshens
- Dave Freidl
- Miguel Wong
- Nathan Kestner
- Lynn Schluezer
- Luther Audland

NR Agency meeting
19-Feb-10, 0930
Centennial hall basement meeting room

North Dakota Game and Fish: Bruce Kreft and Lynn Schlueter
Minnesota DNR: Dave Freidl and Nathan Kestner
USFWS: Richard Davis
Corps: Craig Evans: Elliot Stefanik, and Jon Sobiech
Moore Engineering: Stu Dobberpuhl
Barr Engineering: Miguel Wong
City of Fargo: April Walker, Mark Bittner, and Nathan Boerbom
Houston Engineering: Mark Aanenson

Meeting Agenda

Discussion for impacts will follow this general approach:

Resource Category
- Impact assessment and determination
- Mitigation and/or monitoring (as appropriate)

9:30 Intro and Overview

9:45 Aquatics (MN Alignment)
- Footprint Impacts
- Geomorphic Impacts
- Connectivity Impacts
- Fish Stranding/Other

Aquatics (ND Alignment)
- Footprint Impacts
- Geomorphic Impacts
- Connectivity Impacts

12:30 Wetlands

1:00 Water Quality, Groundwater

1:30 T&E species; Upland habitat; Safety; Ice/Debris

2:00 Adjourn

Overview

Elliot Stefanik and Jon Sobiech presented a more detailed look at the impacts associated with the various diversion alignments (both MN and ND diversions). The approach was to go through these impacts based on the above agenda, then discuss the preliminary mitigation plans/ideas for each impact, and then to get reactions, ideas, and comments from the agencies on each proposal.

In general, no major ecological issues were identified that would require a diversion alignment be dropped from further consideration. In general, the agencies are much more concerned about impacts associated with the ND alignment, compared to the MN alignment. Concerns also remain on the significance of impacts to fish passage, and potential for fish stranding issues within the flood diversion channel.

The presentations used during the meeting were all provided before the meeting. The notes below capture the majority of what was said at the meeting. They do not capture all thoughts or conversations during the meeting. At the end of the notes is a compilation of action items that need to be done as a result of the meeting.

Notes:

Elliott—this will be a programmatic EIS and we anticipate that there would be specific supplements to address the specific impacts once details are known. Thus, their will continue to be detailed planning, coordination and public review beyond the initial EIS. Each major project feature could potentially need a supplemental NEPA document.

The corps presented the footprint of the proposed Red River Structure, and weir for MN side. The Corps is currently recommending stream re-meandering to re-create 20 acres of habitat to mitigate for the main structure on the Red River. Mitigation sites have not been identified. Such sites would ideally be on the Red River, an adjacent near-by tributary, or as a last resort, a more distant tributary location within the watershed.

The PDT team will optimize the MN alignment at a meeting next week February 23rd.

Dave Freidl – an impact to consider is one of channel length, and how the different actions could affect channel length and possible geomorphic effects.

Lynn S- noted that we should observe and learn from the Drayton Dam experience. This includes placement of a dam that modified channel conditions and resulted in bank instability around the site.

Miguel—we have produced an order of magnitude estimate of impacts. We are still looking for the exact location.

Agencies generally supported this approach for mitigation. MnDNR did have some suggestions of potential project sites where mitigation could be done.

Dave Freidl – can we roll the mitigation into one large project? Phase 2 feasibility studies for the Wild Rice Ecosystem restoration project, is one example?
Please Provide other identified areas for possible mitigation.

This type of action may be possible, but it also has to consider existing uses and authorizations, may have to de-authorize a federal project. For this reason, it is much more difficult to pursue stream remaindering in places where an existing authorized project is already in place.

Nathan – if there is something unique about an area that will be impacted it would be good to replace those features.

Dave F. There are lots of details that need to be discussed. The less you have to operate the Red River control structure gates the more comfortable we will be. A very detailed operational plan has to be developed before we construct and get a permit.

April W. Will base the decision of project operation on not wanting to build the 2nd street level which is at a 30 foot elevation, they have to get prepared at 24 feet in order to have it in place in time. The city is talking about the need for flood proofing inside the protected area.

Dave Friedl: MN DNR wants to stay involved in designing the fish passage structure(s). They have an interest to see any preliminary drawings, hydraulic data, etc for the structure.

Most of this information is available. Will need to do additional analyses to assess rates of water level decline within the flood diversion channel (as it relates to impacts with fish stranding). **We will provide this available information to the agencies.**

MN DNR fisheries regional managers met yesterday to discuss this project. Dan Lais is taking over for Bob Bezek. Points that came out:

1. Not comfortable that there are no significant impacts—will need more information. Even a well designed fish bypass channel would still result in a significant loss in connectivity. There will likely be a loss of fish passage, and there may be other places to improve fish passage to mitigate. Even with all impact minimization efforts in place, the remaining loss in connectivity is not "mitegateable" at the project site. There is no question that there will be lost connectivity, the way it is currently designed fish connectivity is reduced from a 5 year to 50 year event. However, implementation of fish passage at Drayton Dam, Christine Dams, similar to what has been done at other dams, would be adequate to off-set these impacts. DNR also has a lot of ideas to improve existing plans. Overall there will be a loss of migration. DNR has worked hard to minimize barriers. This project will remove the large events where fish passage occurs now. The more extreme events are perfect years for fish to move, great years for fish

distribution. We don't want to minimize this. Ultimately, this project will take away some connectivity and would like to put it back. MNDNR is not ready to draw the same conclusions. They expect a thorough impact analysis.

MnDNR noted that tag returns from lake sturgeon, have been observed all they way to Winnipeg for fish planted in the Otter Tail River. **Dave Freidl will provide this information to us.**

MN DNR also mentioned trap net surveys during the flood, 40 foot lead with a 6 foot box. 200-300 catfish, walleyes, mooneye, sauger, etc. Fish move out of the banks in large quantities during flood events. We have to be sure not to stack the fish up in the diversion channel. Also, efforts need to be implemented to ensure fish can migrate out of the flood diversion channel at the upstream control weir.

Elliott: Drayton Dam is frequently passable. How does improving passage there mitigate impacts in Fargo, 250 river miles upstream, when the concern is impacts that happen a small percentage of the time, and only at a high discharge? We need info to substantiate the link and explain why this mitigation is appropriate. Project currently does include $150,000 to monitor and to evaluate how effectively the fish use this structure.

Lynn: improving access there will increase the numbers of fish that can get to the fish passage structure at Fargo. Lynn also suggested the need to tie the impacts to species or guilds, etc. to really understand the impacts.

The Corps will need additional discussion and information to send up the chain as it relates to fish passage. MN DNR believes it is premature to say it is not a significant impact. The DNR is firm that they cannot mitigate on-site. Further discussion on fish passage was tabled for the remainder of the meeting, and will be revisited.

MN DNR's discussion largely centered on the MN option because of the sheer complexity of the North Dakota options.

Bruce Kreft: There is agency concern that their won't be money later to address issues that come up. If mitigation isn't proposed, we may not get funding later to correct was has been impaired. Can we set up a mitigation trust fund for future expenses?

Fish stranding issue: Dave would incorporate features to minimize the potential for stranding.

Elliott: we're not planning to build pools for waterfowl. We would try to taper flows off so the fish sense the need to move downstream in the diversion. Need to model the operations to reduce impacts.

We will look at fish stranding. We don't have anything to share today but will in the near future, look at rates of water decline to try and better describe the likelihood of stranding.

We recognize that fish can get up there up to a 5-15 year event, possibly up to a 20-year event and beyond, could be able to swim up there.

Luther didn't feel there is any feasible way to keep fish out of it, the key is to get them out and/or over.

Geomorphic issue – Red river structure in place in the Red. The project will pass a 5 year event, flows beyond that will go into the diversion channel. There is concern but it is our thought that the risk for impacts is low.

Preliminary conclusions are that the impacts are less then significant. However, to verify we propose to do pre-construction and post-construction monitoring to see if this is true. We will work with the agencies to set up that plan, looking at both geomorphic and biotic surveys.

Dave Freidl – A sediment analysis would be good to help with this determination. Ideally we should develop a plan to do a more formal assessment in the next few months, to have a better level of understanding.
Action item, we need to put someone on this for the scope of work. We can do this in the coming field season.

Lynn: Noted a recent USGS sediment load study for the Red River.
Miguel has already been looking at this and yes we will include this into our EIS.

ND alignment issues:

Issues with RRN structure are approximately the same.

Wild Rice

Wild Rice structure is similar to the Red River structure with weirs on both sides of the WR River.

Wild Rice will be passable for fish to a 5 year event, with a fish passage channel functional up to a 20 year event (instead of a 50 year event).

Lynn, there are problems with the structures; it is sort of a sediment bowl. Could result in geomorphic effects.

Sheyenne and Maple Structures
Roughened bottom to create some complexity.
2 year event flow velocities are the same as the existing conditions.

Design of the concrete channel for these structures is important for the fish to be able to swim through, it has to be understood that we have different species going through there.

Dave F. One tip on the design is to have a parabolic shape that can be used for different species you can do this using the roughness. Initial thought from the engineers is that this may be something we can accommodate for the final design. We have some flexibility.

Geomorphic effects on tributaries:

The MN DNR didn't see the connection between our mitigation proposal for the possible geomorphologic impacts to the Wild Rice and the impact; they indicated that the construction of additional length onto an already identified re-meandering project would provide more meaningful mitigation to offset the geomorphologic impacts.

The corps will work to make a better connection for mitigation for geomorphology mitigation on the Wild Rice River. This could possibly re-meandering, but also other options (possibly riparian corridor). We need flexibility here given real estate challenges associated with mitigation areas.

The preliminary conclusion for geomorphic effects on the Wild Rice was that there might be significant impacts that arise on the Wild Rice from the project. However, this will continue to be evaluated. Sediment transport on the Wild Rice may not be affected as much as we're assuming, because the backwater effects of the RRN keep velocities low in the lower reaches of the wild rice.

Maple and Sheyenne Rivers appears to have less sand in the bedload, so we don't expect significant adverse impacts. Existing project on the Sheyenne River diverts water out of the Sheyenne now—our project shouldn't be worse and might be better from a geomorphic perspective.

The existing Sheyenne diversion provides a good case study to look at to understand what might happen with the larger diversion.

Note that while effects may be similar Maple only has a 3 mile section whereas the Sheyenne is over 40 miles of River between the proposed structures and the confluence with the Red.

Provide the states Dave Freidl and Bruce Kreft with the study from West for the Sheyenne River.

The Agencies are asked to please provide ideas they have for specific projects, types of restoration actions or locations that might be useable for mitigation.

At this point in the meeting the question was asked by the corps if there is anything that they see presented today or in the past that would lead them to not permit this project, is there any show stoppers if you will, it was also asked if there is a preference between the alternatives.

The comfort level is lower with the complexity of the ND plan, and more environmental review will be needed, but there does not appear to be a showstopper issue that would keep us from pursuing the ND plan. There is a lot more uncertainty, when comparing the ND plan with MN plan.

Specifically, there is no objection today to diverting the Rush and Lower Rush rivers and creating a sinuous channel in the bottom of the diversion.

Mark B. asked what would make our project better?
Dave Friedl and Bruce Kreft both said we need to make the best possible fish passage, but there will still be impacts.

OTHER IMPACTS

Wetlands: our assumption is that we'll create wetlands in the bottom of the channel that will be better quality than existing.

Mark Aanenson and Rich Davis indicated that the agencies may object to that assumption on the MN side, because they would not be providing the same wetland function as the existing seasonal wetlands.

During delineation MNRAM should be used to see how quality can be replaced.

Nathan Kestner talked about the function of wetland habitat—one method to assess is MNRAM.

Mark Bittner: can we create wetland that recreates functions?

Nathan: MNDNR prefers wetland banking in the geographic area. This was a general statement with the thought established wetland bank sites have been accepted and are already functioning wetlands. The DNR is open to other mitigation options.

Rich Davis: check with local agencies that might want to create a bank.

Bruce Kreft: ND does not have any wetland mitigation banks. Would like to see government money go to public banks rather than private banks that could turn into private hunting areas.

Overall the quantity of wetlands impacted is small.

Groundwater: lateral effects will be very minimal because of the tight soils. There was consensus on this point.

Miguel talked to Ray Wuolo on Barr's staff. Ray thought that 2000 feet would be adequate separation—one mile is definitely OK.

Water quality:
Mark Bittner: do we have opportunities to incorporate things to improve water quality?

T&E species:
No T & E species in project area, mussels were brought up as something that may need to be looked at a little closer.

Question? Who purchases, owns and maintains mitigation areas, for instance, a re-meandered stream not located near the main project?

Question—when can we release the draft report to the state agencies for preliminary scoping comments?

Action Items:

- Corps will optimize the MN alignment Feb 23rd, using a variety of criteria (This was since completed).
- Agencies to provide the corps all the potential mitigation sites they have identified for re-meandering, fish passage, etc. for North Dakota and Minnesota. It's important to note agencies should provide a full range of ideas and locations.
- Corps to provide agencies all existing information on design and hydraulic evaluations. Additional modeling will be needed to further evaluate rate of stage reduction in the flood diversion, and possible effects to fish stranding.
- Mn DNR Dave Freidl will provide tag return data on sturgeon (We have subsequently received a PDF file providing some information on sturgeon in the basin, though more discussion would be helpful).
- Corps needs to develop a scope of work for geomorphic assessment for the Red.
- Provide Agencies the study done by West for the Corps Sheyenne River (This has been posted to our FTP site)

It's important for agencies to forward ideas they have for mitigation actions. This should include not only specific project ideas, but basic methods and/or locations where mitigation could be performed. While not discussed in detail at our meeting last Friday, we do have limitations with how we can implement mitigation. For example, mitigation usually is done from willing landowners. We also can't compromise an existing federal project without that project being de-authorized (e.g., a previous federal project for stream straightening can't be re-meandered without de-authorizing the project). We may not be able impact similar State or local projects that have done stream straightening. We will try to do stream re-meandering as our mitigation method, and we are basing our cost estimates off this approach. However, it may be difficult to find sites where we could

implement this mitigation. Thus, it's critical to get input from folks in the area on ideas for mitigation types and locations that might be acceptable for offsetting project impacts.

NR Agency Tele-conference
12-May-10, 0900

North Dakota Game and Fish: Bruce Kreft and Lynn Schlueter
North Dakota Department of Health: Mike Ell
Minnesota DNR: Tom Groshens, Luther Audland, and Nathan Kestner
USFWS: Richard Davis
Corps: Craig Evans: Elliot Stefanik, and Jon Sobiech
Moore Engineering: Stu Dobberpuhl
Barr Engineering: Miguel Wong
City of Fargo: April Walker and Mark Bittner
Houston Engineering: Mark Aanenson and Gregg Thielman
City of Moorhead: Bob Zimmerman

Overview

Elliot gave an overview of the comments our vertical team provided to include more detailed information for our mitigation plan. We just can't arbitrarily go with a 2:1 ratio for mitigation. We need to have more developed plans in place where we know that they are implementable.

Ideas for mitigation that were presented by Elliot and Jon:

1) Implement an on-going stream habitat study as mitigation.
    a. Wild Rice River (Corps SA study)
    b. Red Path Project (stream remeandering project by local agency)
2) Implement local fish passage projects as mitigation for footprint impacts.

Other ideas provided by agencies included:

1. Buffalo River through Hawley. (Erik Jones with Houston Engineering is the point of contact for this).
2. Bois de Sioux River
3. Agencies were in support of the other mentioned projects.
4. North Dakota is taking a hard serious look to find projects for stream re-meandering in their state, will get back to Corps soon.
5. The agency team liked the idea of using fish passage as mitigation for footprint impacts.

There was discussion of how difficult it would be to implement the Wild Rice River (MN) option. Reasons for the difficulty include:

1. This reach of the river is in the same watershed as the Hendrum, Halstad, and other cities that will be impacted by downstream impacts from the Fargo Moorhead project, and now they may get some more increased water with the proposed re-meander.

2. There is already known landowners opposed to this type of project within the Wild Rice River project area.

If the Agency team decides to pursure the option of fish passage the corps will need letters of support from the partnering agencies.

Mitigation will be done before or concurrently with project construction.

Scope of works
There were suggestions to use folks from N. Dakota State, UND, or S. Dakota State (Chuck Berry, Nels Troelstrup, and Steve Chipps).
Tom Groshens recommended using Chris Yoder or Ed Rankin with Midwest Biodiversity Institute, they are already doing fish monitoring on 20 sites on the Red River.
Other names mentioned that could help out include Nels Tronstrup and Steve Chips?

There were questions about doing early season monitoring while the flooding is occurring? There will be continued communication on this issue.

Due outs:
Corps
1. Look into cost of pit tags and floy tags to see how we can work with other groups to potentially tag some fish this summer.
2. Contact folks that are already going to do surveys in the Red River this summer.

Agencies
1. Continue to identify potential mitigation sites and report them back to the Corps.

Fargo-Moorhead Metropolitan Area Feasibility Study
Fargo Civic Center
Fargo Flood Study Agency Meeting

Meeting Held: June 10, 2010

ATTENDEES

NAME	COMPANY	CONTACT
April Walker (AW)	City of Fargo (FAR)	701-241-1554
Nathan Boerboom (NB)	City of Fargo (FAR)	701-476-6743
Mark Bittner (MB)	City of Fargo (FAR)	701-241-1572
Jody Bertrand (JB)	City of Moorhead (MOOR)	218-299-5388
L.R. Schlueter (LS)	North Dakota Fish & Game (NDFG)	701-662-3617
Bruce Kreft (BK)	North Dakota Fish & Game (NDFG)	701-328-6224
Nathan Kestner (NK)	Minnesota Department of Natural Resources (MDNR)	218-308-2672
Mike Ell (ME)	North Dakota Department of Health (NDDOH)	701-328-5214
Rich Davis (RD)	US Fish & Wildlife Service (USFWS)	
Mark Aanaeson (MA)	Houston Engineering (HE)	701-237-5065
Stuart Dobberpiehl (SD)	Moore Engineering (ME)	701-499-5823
Miguel Wong (MW)	Barr Engineering (BE)	952-832-2632
Chris Erickson (CE)	US Army Corps of Engineering (USACE)	651-290-5437
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Aaron Snyder (AS)	US Army Corps of Engineering (USACE)	651-290-5489
Jon Sobiech (JS)	US Army Corps of Engineering (USACE)	651-290-5428
Elliott Stefanik (ES)	US Army Corps of Engineering (USACE)	651-290-5260
Mike Lesher (ML)	US Army Corps of Engineering (USACE)	651-290-5637
Katie Young (KY)	US Army Corps of Engineering (USACE)	651-290-5259
Troy Maggied (TM)	US Army Corps of Engineering (USACE)	614-572-9691

I. Introductions:

a. All attendees introduced themselves and their party.

II. Public Meeting Presentation w/ Q&A

a. USACE reviewed the slideshow that had been presented to the community in Moorhead on 6/9 and will be presented to Fargo the evening of 6/10.
b. USACE noted that the downstream impact analysis currently ends with Halstead. Analysis of impacts to communities farther north of Halstead is currently underway.
c. USACE noted that the elements outlined in the recreation plan discussed in the presentation are the same for both the MN and ND plans, however no specifics have yet been designed.
d. USACE noted that the dollar amounts vary in some slides due to some being inflated through the midpoint of construction. The actual cost does not change, however for different discussions it is more useful to account for the time-value of money, whereas at other times it is more useful to use current dollars for all figures.
e. USACE noted that the 45-day review period for all agencies begins on 6/11.
f. USACE stated that all agencies have been sent hard copies of the draft report.

III. Update on Study Components

a. NDDOH asked for clarification on why the ND plan is preferred.
    i. FAR stated that the ND plan will provide for protection of more area in the northwest and southwest of the city once the diversion channel is operational.
    ii. USACE stated that one of the factors that make the MN 40K plan the NED plan is that the ND plan takes one more year to construct, reducing the benefits period to 49-years as opposed to the 50-years of benefits for the MN 40K plan. This slightly skews the benefit/cost ratio in favor of the MN plan.
b. USACE noted that some of the numbers presented may change slightly once the final location of the diversion channel is confirmed. The width of the channel and spoils is still not yet finalized as geotechnical studies and determination of the final location have yet to complete.
c. USACE stated that the Moorhead meeting went well, however there was only one comment from the public.

IV. Specific Discussion of Mitigation

a. USACE urged local sponsors and agencies to come to agreement on how much mitigation they want, where it should be, and who would perform this work. USACE asked if the sponsors wanted mitigation to be site specific or a system-wide approach with emphasis on fish passages.
    i. NDFG stated that they are struggling with deciding between the different measures. They are currently focusing on fish passages at specific sites.
    ii. USACE stated that they need to be able to demonstrate that the impacts from the project are off-set, however they can mix and match strategies to achieve this goal.
    iii. NDFG stated that they would need to tie into the whole system to thoroughly mitigate the project's impacts, however they haven't identified any specific problem sites yet.
    iv. USACE stated that the Draft Report identifies on-going efforts at mitigation and that they are open to discussing any means of mitigating impacts.
    v. The systemic concept seams good and the MNDNR is supportive of mitigation projects that when completed benefit the system as a whole but their approach as described in the DEIS needs some fleshing out. Preference is for project as close to the impacts site as possible and within the watershed (after hearing ND ask about statewide mitigation projects). With systemic/passage projects being discussed the preference would be for improvements downstream. I will discuss concept further with other DNR staff for consensus.
b. NDFG stated that they are willing to look for mitigation solutions in MN, since the rivers are all part of one system, however for political reasons they need to identify action to be taken in ND as well.
    i. NDDOH stated that the required mitigation will depend on the project.
    ii. USACE concurred, stating that mitigation that occurs within the basin and closest to the project will be the most beneficial. Mitigating in the main tributaries should be emphasized.
c. USACE stated that looking beyond the project area for benefits could be discussed if such mitigation adds value and if all agencies and local sponsors agree that this is a good solution.
    i. NDFG asked if they can go broader if long term benefits are found for the basin.
    ii. USACE stated this might be looked at, however policy dictates that the focus is on the watershed. USACE stated that they must show that all options in the basin have been investigated and that any solution outside the basin is agreed upon by all parties.
d. USDOH stated that Bois de Sioux had been previously channelized by the Corps. Could a re-meandering of this be considered as a solution?
    i. USACE stated that as this channelization was a Corps project, that original study and authorization must stand. Since this channel now belongs to the local sponsor, any re-meandering would need to go through another study for authorization.
e. USACE stated that impacts and potential mitigation must be linked and proven to work, and that this was stated in the report. If this is not clear in the report, USACE urged NDFS to comment so that it can be more strongly emphasized. However, USACE is open to big-picture mitigation solutions, including those outside of the project plan. USACE reiterated that the impacts caused by the project must be linked, documented, and off-set equally elsewhere.
    i. MNDNR stated that starting the search for mitigation within the project area and moving out is a good process. There is better chance to off-set project impacts closer to the project.
f. USACE stated that the group needs to move towards determining what changes will take place and begin to determine costs. Part of this process is determining specifically what mitigation will occur, and where. The agencies and local sponsors need to determine what process (system-wide fish passage or site specific) and what specific sites will be mitigated.
g. USACE stated that they can compensate footprint impacts with re-meandering mitigation elsewhere, however a ladder or fish-passage will be needed if it is desired by the agencies. USACE stated that they will need a letter from the agencies on whether the mitigation will be system-based or site-specific. This documentation will be needed before the project can move forward.
    i. The agencies agreed that a system-wide plan would be the best approach. NDFG indicated that they aren't yet convinced that the system-wide approach is the best, however that it should be looked at closely.
    ii. The agencies requested a description of benefits, costs, and impacts from USACE to help with their letter.
h. USACE emphasized that the review period is only 45-days and will close on 7/27. They need specific ideas to include in the report and urged the agencies to make this decision. USACE stated that they need to show progress on the plan and need to know how to measure the success of any proposed mitigation.
i. USACE stated that any transmitters for fish monitoring would need to be in-place this summer in order to be prepared for monitoring in the spring. If a plan is in place, USACE can proceed with equipment procurement and determine who will perform this work.
    i. All parties discussed elements of an appropriate sample size and the number of species. No agreement was reached on this at this time.

ii. NDDOH stated that the group also needs to research what information is already known. Prior research should be investigated and, if applicable, used in order to reduce redundancy.
iii. NDDOH stated that this information will not necessarily be used to measure mitigation efforts since actual mitigation efforts will not be known until the project is complete. However, all parties agreed that this information can determine if fish are moving as expected and whether the proposed structures will obstruct that movement.
iv. USACE again reiterated that they need the goals and objectives of mitigation clearly laid out soon due to the schedule of authorization, design, and construction.

j. Should there still he impacts after mitigation and project completion, USACE confirmed that there is no additional dollars for mitigation for the project once it is completed, however there may be a way to receive monitoring dollars, include it in the USACE CAP program, or that another agency could step-up and implement other mitigation.
k. USACE stated that they would like two seasons of biotic monitoring prior to the project. Ideally, the agencies, academia, and others would look at this data.
l. NDDOH wanted to confirm that the environmental monitoring won't impact the project.
    i. Both USACE and FAR concurred that this wouldn't occur. Even at the most aggressive schedule, there is sufficient time for any required environmental monitoring required.
m. USACE stated that in order to balance the sehedule with data collection and monitoring, the project will proceed on the best availahle data and continues to monitor post-project, using supplemental data when available
n. NDFG stated that three years is the rule of thumb for monitoring and that at least two species should be monitored, however this should be discussed further.
    i. USACE stated that field work will occur in 2011, but the scopes of work will be complete this year in order to be able to act in 2011. Both MNDNR and USACE agreed that the only work that could take place this year is the tagging of fish to be monitored
o. NDFG, NDDOH, and MNDNR all expressed interest in not only off-setting the impacts of the diversion channel, but also at enhancing habitat as well.
    i. NDFG suggested looking at buffers in select areas as well as riparian corridors to enhance water quality.
    ii. HE stated that existing oxbow wetlands could be allowed to come back and to plant them with native vegetation.
    iii. MNDNR stated that there are opportunities to enhance water quality and that the team should look at transferring function for function in mitigation efforts.
p. USACE stated that the MN plan impacts the environment the least. The EPA still needs to complete their review under Section 404 of the Clean Water Act. USACE agrees that the approach taken on the ND plan is the right approach, however the EPA disagrees. While the USACE Regulatory arm is not involved in the project, the USACE Civil works division will act in this role. Despite this difference, USACE believes that the matter will be settled without escalation.
    i. USACE stated that the EPA not be present at the mitigation meetings, however the EPA is comfortable if the USFWS and the state fisheries agencies are present.
q. MNDNR stated that fish passage improvements can be used in addition, not as a substitute to other mitigation projects and methods discussed to date (those which are easier to measure areas improved and biotic responses)
r. MNDNR does not share same conclusions with COE regarding no impacts to passage, however; fish passage improvement projects (as systemic mitigation) may help begin to address DNR's fish passage concerns.
s. MNDNRThe "future without the project" includes very likely forthcoming fish passage improvements at locations such as Christine & Hickson. COE fish mitigation project must not stymie existing initiatives and is less meaningful if the project is likely to occur without FM project funds injection.

V. Upcoming Work for Agency Team

a. USACE will send the updated mitigation plan to all parties the last week of the month. This will identify fish passages and other measures discussed. All parties are to provide feedback on this plan.
b. USACE will provide a list of what they will monitor, the timeframe, and the costs associated with this work. Scopes of work will be finalized in the near future.
c. BE will look at the low flow channels in the Rush and Lower Rush Rivers for examples of how to stabilize the low flow channel in the diversion channel. Rock could be used to stabilize this channel, but this would come at the expense of habitat. BE and MDNR both confirmed that they would provide details on more natural techniques for stream bank erosion measures to USACE by 6/25.

VI. Adjourn

a. USACE reminded all parties that EIS comments are due hack by 7/26.
b. USACE and NDFG will meet to discuss a possible inspection of the Red River tributaries.

c. USACE reminded all parties that they need to receive the letters noted above by the end of July. These can be integrated with the EIS comments.
d. All parties agreed to adjourn until the next meeting.

Respectfully Submitted,

THE U.S. ARMY CORPS OF ENGINEERS, ST. PAUL DISTRICT

Jon Sobiech / tmm
Environmental Specialist

Cc: Attendees
File

Fargo-Moorhead Metro Feasibility Study
Minnesota DNR Agenda, 11:00 AM
12-July-10 (Monday)

Minutes

Attendees:
MNDNR – Suzanne Jiwani, Kent Lokkesmoe, Pat Lynch
City of Fargo – Mark Bittner, April Walker
City of Moorhead – Bob Zimmerman
USACE – Judy DesHarnais, Craig Evans, Aaron Snyder, Terry Birkenstock, Joe Willging, Jon Sobiech, Mike Lesher, Lance Awsumb, Aaron Buesing, Damon Roberts, Tamara Cameron, Katie Young, Troy Maggied, Kelly Urbanek (Phone)

1. Project Overview
   -USACE reviewed previously presented data on hydrologic conditions, the anticipated effectiveness of the various diversion alternatives, and projected downstream impacts.

2. Discussion of Issues
   a. Downstream Impacts
      -USACE stated that their downstream analysis currently extends to Halstead. Analysis will continue down to Thompson and until "zero effect" is reached.
      -USACE stated that there are two steps to any potential Takings analysis. First, USACE's Office of Council has determined that there will be no requirement to buy a flowage easement. This decision was made based on the present flood depth and frequency without project. Any additional water added to the downstream communities will not be large enough or frequent enough to require a flowage easement. Secondly, once the downstream analysis is completed, a structure-by-structure analysis will take place on all improvements determined to be at risk of damage.
      i. MDNR concerns
         -MDNR stated that they believed USACE was being inconsistent in their policy of addressing downstream communities. They cited a previous project in Brown's Valley, MN in which they claim that the USACE required downstream impacts to be zero. USACE stated that they have no administrative record of this requirement, nor is it USACE policy. Moreover, the permit issued for the project does not address stage increases. MNDNR stated that Ed Eaton from USACE was the individual who required mitigation to zero impacts. Also included in the project, per MNDNR, were USACE employees Eric Norton and Terry Zein. MDNR will provide USACE with copies of correspondence requiring downstream mitigation to be zero on this project.
            -MDNR also cited the Holman Field Airport project as another project that required mitigation to be zero. Both parties agreed, however, that this was not a Corps project and so Corps policies are not in question.
         -MDNR stated that at this point they are unwilling to issue the project a permit, stating that downstream impacts need to be addressed.
            -Moorhead asked for guidance as to what form of mitigation the DNR would prefer to see for downstream communities. DNR stated that a fund for claims for damages could be set up. Moorhead stated that it would be very difficult to determine what damages were caused by the diversion and what were caused by the existing flooding frequency and height that was present before the diversion.
      ii. Corps authorities

- USACE stated that if it is determined the flood's impact to the improvement constitutes a Taking, compensation will be provided. If there is no determination of a Taking, then USACE has no authority to act. Any mitigation will fall to the Local Sponsors.
-MDNR stated that regardless of authority, they view it as the responsibility of USACE and the Local Sponsors to mitigate any increase in water levels at the downstream communities.

b. Channel Stability Effects
-USACE stated that they are looking at the geomorphology of the river to determine any impacts on the river's natural shape or route caused by the diversion channel.

c. Floodplain Impacts
-USACE stated that they are investigating the potential for a downstream community non-structural analysis. The goal of this would not be to mitigate against the incremental increase in water levels caused by the diversion, rather it would look to mitigate existing flooding conditions in the downstream communities.
-Fargo stated that they currently have a moratorium on new building until the diversion design and impact analysis are completed. Any new design in the city must comply with the new hydrology.
-MDNR stated that their environmental staff are finalizing the state EIS. Locals are required to pay for this. MDNR stated that new data doesn't need to be generated and the data developed by USACE can be used for the EIS.
-MDNR stated that they do not have a timeline for completion of the EIS at this point.
-USACE stated that a levee breach analysis is currently underway. USACE is coordinating with MDNR on this work.

3. Review and explanation of updated hydrology
-USACE explained the revised hydrology used on the project. This hydrology is the result of the recommendation of a panel of experts. The panel, consisting of climatologists, noted in the historical data a dry and a wet period. Currently, the Fargo-Moorhead area is in a wet period. The panel recommended that USACE use this data to determine their hydrology.
-With this new hydrology, flood levels are higher on average than the old hydrology. A "year 0" occurrence was previously 39.5 feet per the gage in Fargo. With the revised hydrology, the level is 42.4 at this same gage.
-USACE stated that the Cedar Rapids project also used the "truncated" hydrology based on the wet-dry weather cycle. Fargo-Moorhead is not the first or only USACE project to use this method.
-USACE noted that FEMA is still using the traditional hydrology for their Flood Rate Maps.
-USACE stated that the new hydrology required the use of unsteady modeling. FEMA won't use unsteady modeling due to some overland flow issues in North Dakota. FEMA hasn't made a determination but it is likely they will use only the traditional hydrologic analysis.
-USACE stated that they would continue to coordinate with FEMA to ensure that the various branch offices are on the same page with the work and revised hydrology used at Fargo-Moorhead.
-USACE will follow up with FEMA to determine what 1% chance flood level they are using for their Flood Rate Maps.

4. Benefit between states
-USACE stated that their benefit-cost (b/c) analysis does take into account quantifiable impacts to downstream communities. However, the b/c analysis only analyzed impacts caused by the incremental increase in water due to the diversion. The existing flooding levels were not addressed due to their being in effect before the diversion. The b/c analysis looks at conditions with a diversion and conditions without a diversion for the timeframe in which the diversion would be completed, 10 years from now.
-Temporary and emergency measures are not taken into account when considering downstream impacts.

-Proposed future levees and levee raises that have a high probability of being completed are taken into account.

-Any damage to roads and access due to the incremental increase in water levels are analyzed.

-The b/c analysis found little-to-no increase in the duration of flood levels due to the diversion.

-Fargo and Moorhead are also analyzing impacts and costs and benefits to the Fargo-Moorhead area and downstream communities. They look at what has occurred in the last 10 years and take into account projects that are anticipated to occur. One such project considered likely by Fargo-Moorhead, but not included in USACE's b/c analysis, is the Red Path project. MDNR concurred that this project is likely to go through.

5. Items for follow up:
    a. The DNR will provide the Corps with information on the Brown's Valley Permit.
    b. The Corps will talk with FEMA Region 8 to ensure that Region 8 and 5 are on the same page and that the Corps has a proper understanding of the requirements.
    c. The DNR will provide the Corps with what 1% chance event the state will be supporting with local levees. The Corps updated with "wet" and "dry", the Corps traditional, or the FEMA proposed.

Fargo-Moorhead Metropolitan Area Feasibility Study
Fargo Flood Study Agency Telecon

Telecon Held: July 28, 2010

ATTENDEES

NAME	AGENCY/COMPANY
April Walker (AW)	City of Fargo (FAR)
Mark Bittner (MB)	City of Fargo (FAR)
Bruce Kreft (BK)	North Dakota Fish & Game (NDFG)
Nathan Kestner (NK)	Minnesota Department of Natural Resources (MDNR)
Tom Groshens (TG)	Minnesota Department of Natural Resources (MDNR)
Tom Carlson (TC)	Minnesota Department of Natural Resources (MDNR)
Luther Aadland (LA)	Minnesota Department of Natural Resources (MDNR)
Mike Ell (ME)	North Dakota Department of Health (NDDOH)
Rich Davis (RD)	US Fish & Wildlife Service (USFWS)
Stuart Dobberpuhl (SD)	Moore Engineering (ME)
Aaron Snyder (AS)	US Army Corps of Engineering (USACE)
Jon Sobiech (JS)	US Army Corps of Engineering (USACE)
Elliott Stefanik (ES)	US Army Corps of Engineering (USACE)
Lynn Foss (LF)	Clay County Soil and Water
Dana Allen (DA)	EPA
Robin Coursen (RC)	EPA
Keith Weston (KW)	NRCS North Dakota
Keith Berndt (KB)	Cass County
Randy Gjestvang (RG)	North Dakota Water Commission
Bob Zimmerman (BZ)	City of Moorhead
Gregg Theilen (CT)	Houston Engineering

I. Introductions:

a. All attendees introduced themselves and their party.

II. Overview of latest happenings and schedule

a. USACE updated the team on status of ongoing efforts, including HTRW contract, wetland determinations, flood plain forest data collection, and reminded the team that the comment period was extended to August 9th at which time all comments are due.

III. Latest Status of Impacts

a. Issue 1
   i. USACE provided information for potential impacts to Wolverton creek created when a tie-back levee crosses the creek for the North Dakota alternative.
   ii. Discussion was also provided for the need for an overflow channel from the Wolverton Creek to the Red River.

b. Issue 2
   i. The fish passage structure on the Wild Rice River will have mixing with flows from the Wild Rice River and the diversion channel where flow from the red mixes with the Wild Rice. Fish could potentially be drawn upstream into the flood diversion channel, and end up in the Red River instead of back into the Wild Rice.
      1. Question was posed to the agencies whether it be a better idea to spend money on improving fish passage at some other dam to make it passable 100% of the time versus spending money at this location for fish passage during a small percent of the time knowing that the fish could still end up in the diversion or in the Red?
         a. BK stated that North Dakota would rather follow a systemic approach and spend the money on other dams in the area.
   ii. * USACE will provide diversion channel velocities for different discharges when the project is operating.
   iii. Question was asked whether new information regarding Wolverton Creek and Wild Rice River fish passage require new NEPA documentation. That answer will depend on the severity of the impacts. If the impacts don't

appreciably change, there likely will not be separate documentation. It will be coordinated with the agencies and included in the final.

c. Downstream impacts
   i. Several stakeholders keep hearing from locals and constituents that one way to mitigate for downstream impacts is upstream storage. USACE is not looking at using upstream storage to mitigate for downstream impacts. There are other initiatives occurring independently of this project that are looking at upstream storage.
   ii. Discussion of the current call will focus primarily on natural resources issues. Downstream impacts are still a major issue and continue to be assessed. New information on downstream impacts will continue to be coordinated with the agencies as soon as its available.

IV. Specific Discussion of Mitigation

i. USACE asked the group if they would prefer fish passage, stream restoration (to include re-meandering, riparian buffer zones, and possibly other actions), or a combination of the two as mitigation to offset all of the aquatic habitat footprint impacts.
   1. NK MNDNR made the point that from the MN perspective fish passage is necessary to offset impacts from connectivity but would not approve of using fish passage as mitigation for site specific aquatic footprint impacts.
   2. BK NDFG would like to see fish passage used as the approach for mitigation to offset aquatic habitat footprint impacts, but they are open to using the restoration approach as part of the mitigation. NDFG is concerned whether enough suitable sites can be found, with willing landowners, to do this form of mitigation.
   3. RD FWS wants to see a combination of the two approaches for mitigation.

ii. The group agreed that mitigation should be carried out as close to the impact as possible, if the impact is to the Red River the mitigation should be on the Red River if possible.
   1. There doesn't seem to be much of a need for re-meandering on the Red River because of the existing sinuosity.
   2. North Dakota doesn't have many locations identified for this type of mitigation.
   3. KW NRCS has EPA319 grants for stream restoration on the Maple, Sheyenne and Rush rivers. He noted that there may be willing landowners, but money is typically the constraint for these projects. The landowners are willing. USACE will communicate with Keith to discuss and identify some sites. North Dakota Department Health should also be involved in future discussions.

iii. USACE asked the group if the strategy of looking at Fish Passage at Drayton along with a few site specific stream restorations as a place to start a good idea.
   1. MN DNR re-iterated that they don't want to see fish passage as mitigation for any site specific aquatic habitat footprint impacts. They feel there should be mitigation for geomorphic impacts, downstream impacts and fish passage. MN also noted possible geomorphic impacts to the Red River, that these impacts haven't been adequately addressed in the Draft EIS, and that mitigation could be needed for this impact as well.
   2. North Dakota was ok with this approach for mitigation.

iv. DA and RC with EPA asked if the mitigation plan will be written up and sent out for comments. USACE outlined that this will be the case, and will include acreages, miles, other quantities included in the write-up. Will also include metrics for habitat quality, and provide an assessment resulting in typical "habitat units" used by USACE on all other projects..

v. TG asked if dam removal could be considered as acceptable mitigation for footprint impacts. The group discussed and agreed to look into this possibility.
   1. Drayton, Christine and Hickson dams were mentioned as possible dams to remove.
      a. USACE will look at bank stability in the areas of the mentioned dams and get back to the sponsors.
      b. Need response from MnDNR whether dam removal would be considered acceptable form of mitigation, and whether this fulfills their need of replaced "functions" when considering lost site-specific habitat.

V. Due Outs/Needs from agencies

a. Confirmation from MnDNR whether or not dam removal can be used as a form of mitigation that will offset aquatic footprint impacts.
b. Provide comments on the Draft EIS ASAP (due August 9).

c. Will need additional coordination with agencies during August as USACE moves towards a final EIS.
d. USACE will contact Keith Weston NRCS and Mike Ell North Dakota Department of Health to discuss locations for stream restorations.
e. USACE will get diversion channel velocities for different discharges when the project is operating.
f. USACE will look at bank stability in the areas of the mentioned dams and get back to the sponsors.

VI. Adjourn

Fargo-Moorhead Metropolitan Area Feasibility Study
Fargo Flood Study Agency Meeting

January 13, 2011

ATTENDEES

NAME	AGENCY/COMPANY
April Walker (AW)	City of Fargo (FAR)
Mark Bittner (MB)	City of Fargo (FAR)
Bruce Kreft (BK)	North Dakota Fish & Game (NDFG)
Nathan Kestner (NK)	Minnesota Department of Natural Resources (MDNR)
Tom Groshens (TG)	Minnesota Department of Natural Resources (MDNR)
Tom Carlson (TC)	Minnesota Department of Natural Resources (MDNR)
Lynn Schlueter	North Dakota Game and Fish
Rich Davis (RD)	US Fish & Wildlife Service (USFWS)
Steve Hardegen	FEMA Region 8
Ryan Pietramali	FEMA Region 8
Jon Sobiech (JS)	US Army Corps of Engineering (USACE)
Elliott Stefanik (ES)	US Army Corps of Engineering (USACE)
Terry Williams	US Army Corps of Engineering (USACE)
Aaron Buesing	US Army Corps of Engineering (USACE)
Joe Willging	US Army Corps of Engineering (USACE)
Andy Tuthill	US Army Corps of Engineering, CRREL
Nathan Boerboom	City of Fargo
Lee Beauvais	Moore Engineering
Jeff Volk	Moore Engineering
Jason Benson	Cass County
Jack Frederick	MnPCA
Dana Allen (DA)	EPA
Randy Gjestvang (RG)	North Dakota Water Commission
Bob Zimmerman (BZ)	City of Moorhead
Gregg Theilen (CT)	Houston Engineering

I. Introductions:

a. All attendees introduced themselves and their party.

II. Overview of latest happenings and schedule

a. Aaron Snyder with the Corps gave an overview of where ware to date on the project. This discussion included a detailed review of the Executive order 11988 and how it pertains to this project.

b.

III. Latest Status of Impacts

Miguel Wong with Barr Engineering gave a presentation on where we are with the Hydrology and Hydraulics for the project.

He also gave an overview on geomorphologic assessment and considerations. Geomorphic data and sediment transport information will be far more robust in the Supplemental Draft EIS than was in the Draft EIS. He also gave a brief summary on some of the findings and expected conclusions.

IV. Specific Discussion of Mitigation

i. USACE asked the group if they would prefer fish passage, stream restoration (to include re-meandering, riparian buffer zones, and possibly other actions), or a combination of the two as mitigation to offset all of the aquatic habitat footprint impacts.

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US Army Corps of Engineers St. Paul District	PROJECT TITLE: Fargo Moorhead	COMPUTED BY:	DATE: 1/13/2011	SHEET:
	SUBJECT TITLE: Resource Agency Meeting	CHECKED BY:	DATE	CONTRACT NO.

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Jason Benson	Cass County	bensonj@casscountynd.gov
Jeffry Volk	Moore Eng. Inc	jvolk@mooreengineeringinc.com

Meeting Notes – Biotic Sampling Techniques January 26, 2011

Attendance: Bruce Kreft, Lynn Schlueter, Mike Ell, Tom Groshens, Elliott Stefanick, Jon Sobiech, and Andre Delorme

Elliot started discussion referencing the Biological Monitoring presentation we used at the agency meeting January 13, 2011. The purpose of the meeting was to discuss bio monitoring for the project over the life of the project and more specifically to start this summer season 2011.

Tom Groshens asked that we have a control site upstream of the impacted area for the 500 hundred year event.

Mike Ell stressed the importance of laying out a design that assesses project impacts, and that it is reproducible so folks 20 years from now can use the data we can gather and reproduce similar data for comparisons, we don't want to generate information that is unusable in the future.

The entire group concluded that this effort will be hard because of the variability that is tied to these types of surveys.

Mike Ell indicated that the biggest concerns are impacts to biology; we need to sample as much as possible. We should start with an optimal process and pair it down as we move forward if we have to.

3 years of sampling is optimal. This could be substituted for 2 years where you replicate within years if necessary.

The two questions we are trying to answer with these surveys are:

1) The quality of the habitat that will be impacted.
2) What is the biota within the upstream and downstream areas.

Is IBI the right approach to be using, it is a hard call since North Dakota is only getting an IBI this year.

There is good protocol for wadable waters but large river protocols aren't as common, There is a large River Protocol that needs to be looked at from the PCA.

It was agreed upon by the group that whatever method we pick it has to be reproducible. There seemed to be consensus that a proportional approach is what folks are leaning toward. This means we may need to use two different approaches to complete the task.

MN PCA habitat methodology assessment is the preferred method for wadable waters. For big river or non-wadeable waters we need to look at a Qualitative method put out by the Ohio River EPA, Mike Ell Sent out email on this.

Fish Passage

The group expressed an interest to have pre-monitoring at the structure sites so we know quantity of fish passing the impacted areas before structures are built so we can compare these numbers to quantity of passage after project is in place at the structures. The Corps position is we don't see the value in this, we already agree that fish pass freely through those areas so why spend a bunch of money to prove something we already agree on?

There was some discussion and the corps agreed to look at the possibility of doing some pre-monitoring at these sites. (Ex. Acoustic study, cameras, etc.?)

# of species 5 representative species
# of fish to tag 50-100
Mid fall to tag the fish.

Mussels
Delorme pointed out that the Sheyenne River is 2nd only to the Red River in all of North Dakota for mussels. And a close 3rd is the Maple River. There is existing data for the Maple and Sheyenne (near Horace) that will be provided by Andre. We briefly described our strategy for Mussel surveys.

Natural Resource Agency Tele-conference
3-March-11, 1300

Participants: Nathan Kestner and Tom Groshens (MDNR); Lynn Schlueter and Bruce Kreft (NDGF); Mike Ell (NDDoH); Rich Davis (USFWS); Keith Weston (NRCS).

USACE gave a brief overview of the preliminary draft adaptive management write-up. This included review of key questions to address impacts and mitigation effectiveness; criteria to measure impacts and mitigation effectiveness; and monitoring methodology to adaptively evaluate impacts and mitigation effectiveness.

In general, there was no major opposition to the proposed questions that outline how impacts and mitigation effectiveness will be evaluated.

The criteria outlined for impacts to aquatic habitat also were generally acceptable. The agencies requested that criteria be better developed to measure impacts/mitigation for wetlands, bottomland forest, and connectivity. The criteria for connectivity need to address how connectivity mitigation will off-set footprint impacts.

The methodology outlined for evaluating aquatic habitat is generally acceptable. Gear types will include flexibility to cover wadeable and non-wadable streams (i.e., contractor will need mini-boom shocker to cover moderate stream sizes). The agencies requested USACE to consider additional gear types for monitoring. This could include trap nets and seining. In addition, the agencies also requested USACE consider additional methodologies to describe physical habitat within study sites.

FOLLOW-UP: To consider additional gear-types, we should include how we want to use the data to compare impacts or mitigation effectiveness. Please provide suggestions on: 1) level of effort for these other gear types within each survey site; and 2) how you want to see the data used to make comparisons. This should include metrics or criteria for data generated from these alternative gears.

The schedule for doing baseline monitoring for this year is as follows:
1) March 31st, finalize the Scope of Work for biological monitoring for this year
2) April 30th Advertise for contract; receive bids and work through negotiations.
3) May 21, award contract.
4) Recon work begins in June; fish and invertebrate monitoring July - Sept.

Action Items

Agencies to send remaining comments on the monitoring and adaptive management report that was sent to them. This includes the Follow-Up item above.

USACE will provide a revised Adaptive Management Plan to the agencies for review. As a substitute, USACE may send a draft of the Actual Scope of Work for monitoring. Corps will provide draft on or about March 16th, 2011.

For the Revised Draft Report/EIS. USACE should characterize the likelihood that Drayton Dam fish passage gets constructed outside of Fargo mitigation.

USACE will provide the agencies the available existing information on fish migrations. Agencies will review this and provide comments whether they think additional monitoring of fish movement is warranted. MnDNR comment remains that they feel additional baseline monitoring is warranted for fish movements.

USACE to improve the criteria to measure impacts/mitigation for wetlands, bottomland forest, connectivity and geomorphic impacts. Any suggestions here are welcome!

The reference to monitoring every 5 years for wetlands and bottomland forests is too generic. Base it off flood events, not regular intervals.

Flesh out discussion on contingency plans. Also reference new NEPA mitigation guidelines.

BARR	MINNEAPOLIS, MINNESOTA - HIBBING, MINNESOTA DULUTH, MINNESOTA ANN ARBOR, MICHIGAN - JEFFERSON CITY, MISSOURI		DATE	SHEET NO.
			PROJECT NAME	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	
BY	BY	TO	SUBJECT	
DATE	DATE	DATE		

NAME	ORGANIZATION	email
1) MIGUEL WONG	BARR ENGINEERING	mwong@barr.com
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Nathan Kestner	MN DNR	nathan.kestner@state.mn.us
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Gregg Thielman	Houston Engineering, Inc.	cgthielman@houstoneng.com
LEE BEAUVAIS	Moore Engineering Inc.	lbeauvais@mooreengineeringinc.com
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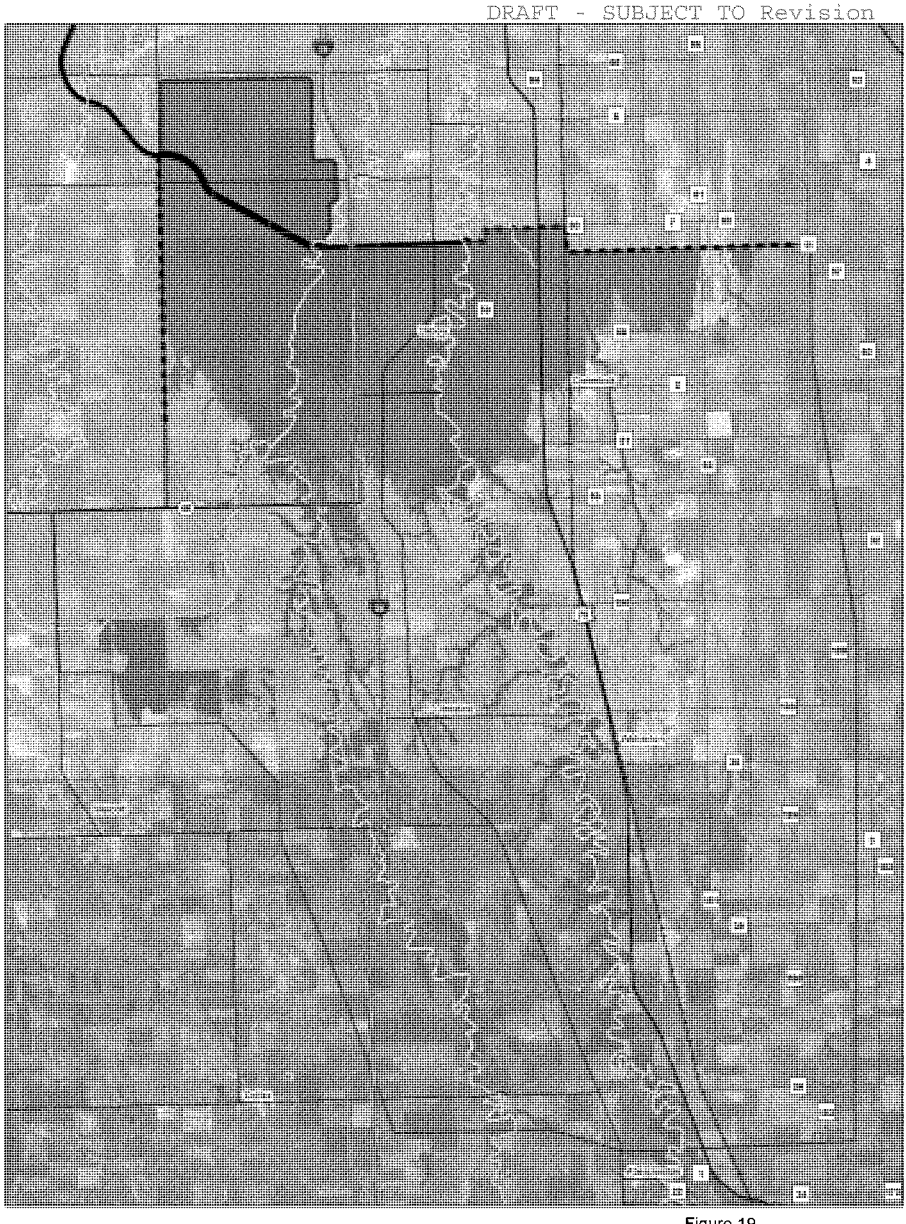

Figure 19

Inundation Map for the Model Existing Conditions and With Project for 2-percent Chance Event in the Red River of the North - South of Diversion Works - LPP

2% Existing (20,363 Acres)
LPP 2% (38,000 Acres)
Mapping Extent
Storage Area 1
LPP Diversion
LPP Tieback
Cities

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0 0.3750.75 1.5 2.25
Miles

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Environmental

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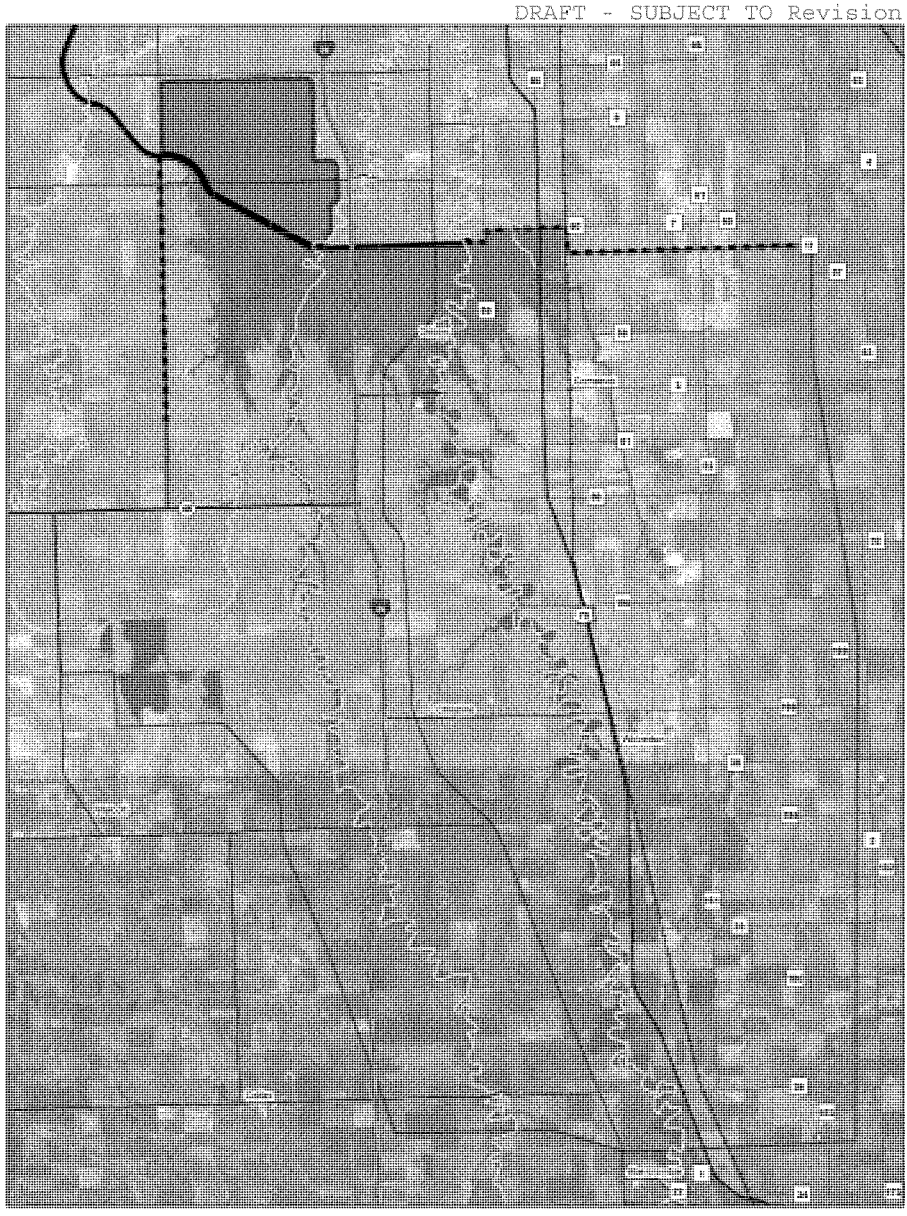

Figure 21

Inundation Map for the Model Existing Conditions and With Project for 10-percent Chance Event in the Red River of the North - South of Diversion Works - LPP

10% Existing (7,858 Acres)
LPP 10% (20,841 Acres)
Mapping Extent
Storage Area 1
LPP Diversion
LPP Tieback
Cities

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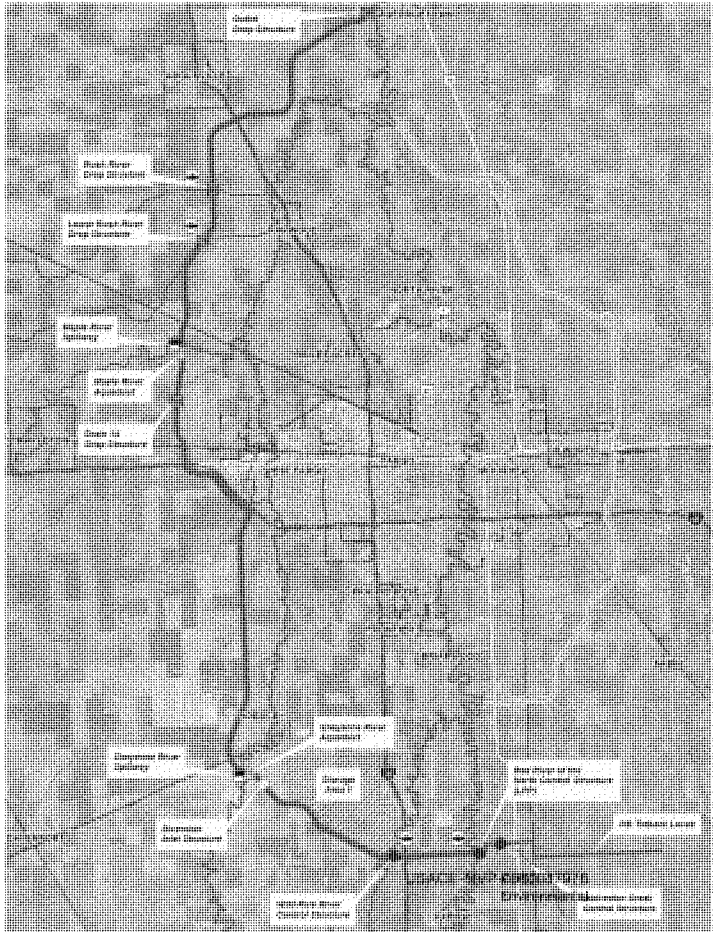
0 0.3750.75 1.5 2.25
Miles

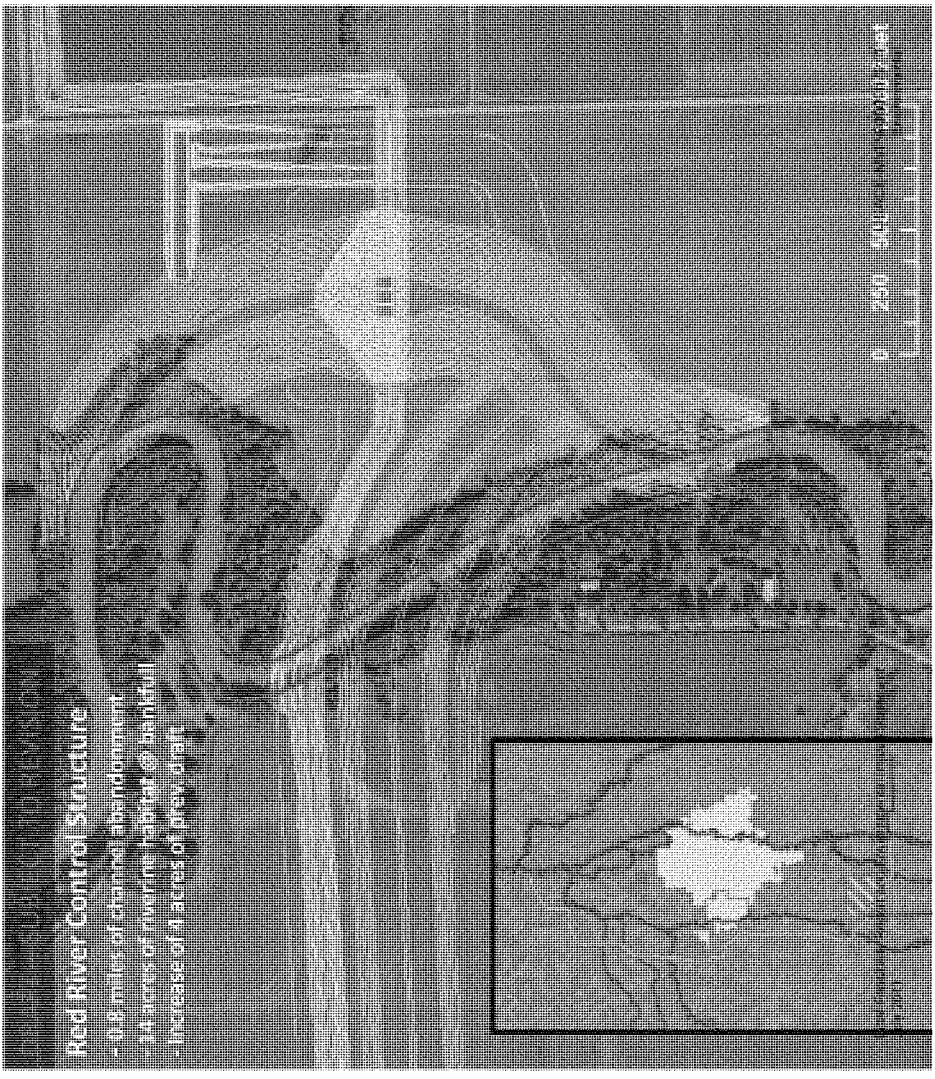
DRAFT – SUBJECT TO REVISION

General Layout

- Follows similar diversion alignment to previous EIS
- Structures are generally similar.
- Does include a flood storage area inside the diversion. Also an additional levee.

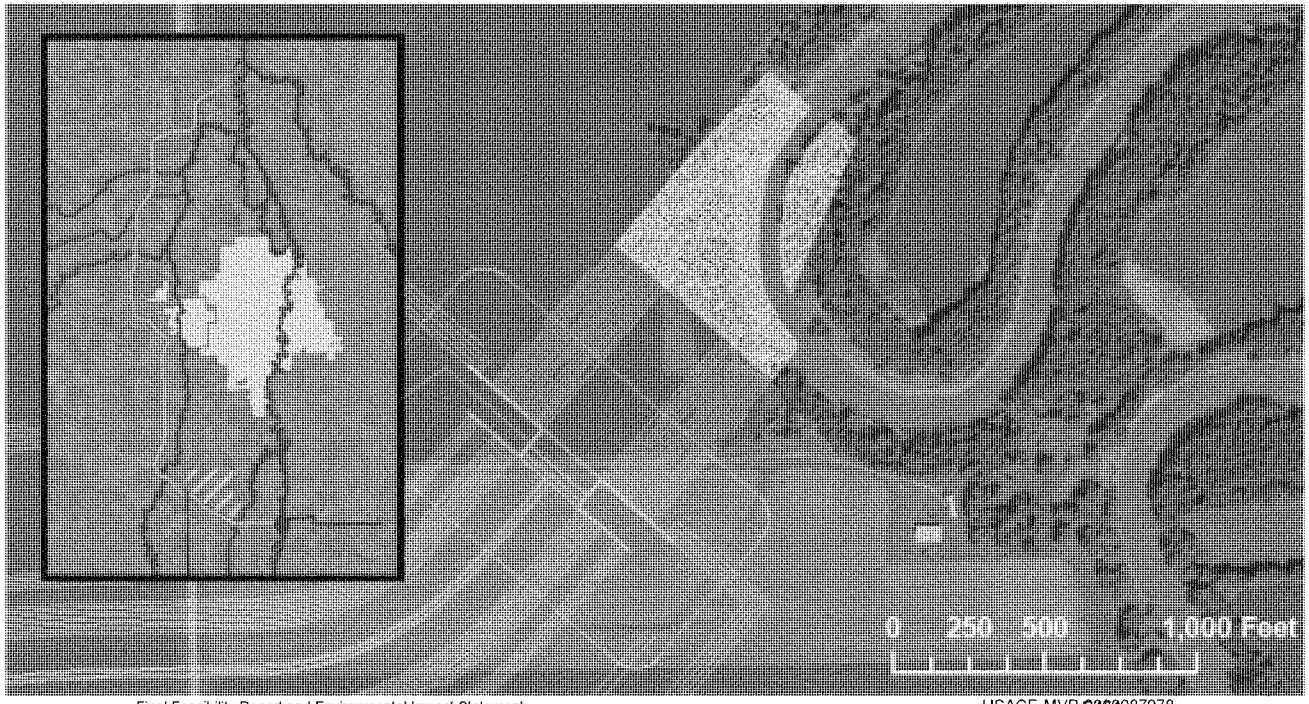


Final Feasibility Report and Environmental Impact Statement
July 2011



Red River Outlet Structure

- 0.1 to 0.2 miles of channel influenced
- grading and rock placement on both banks
- erosion and grade control



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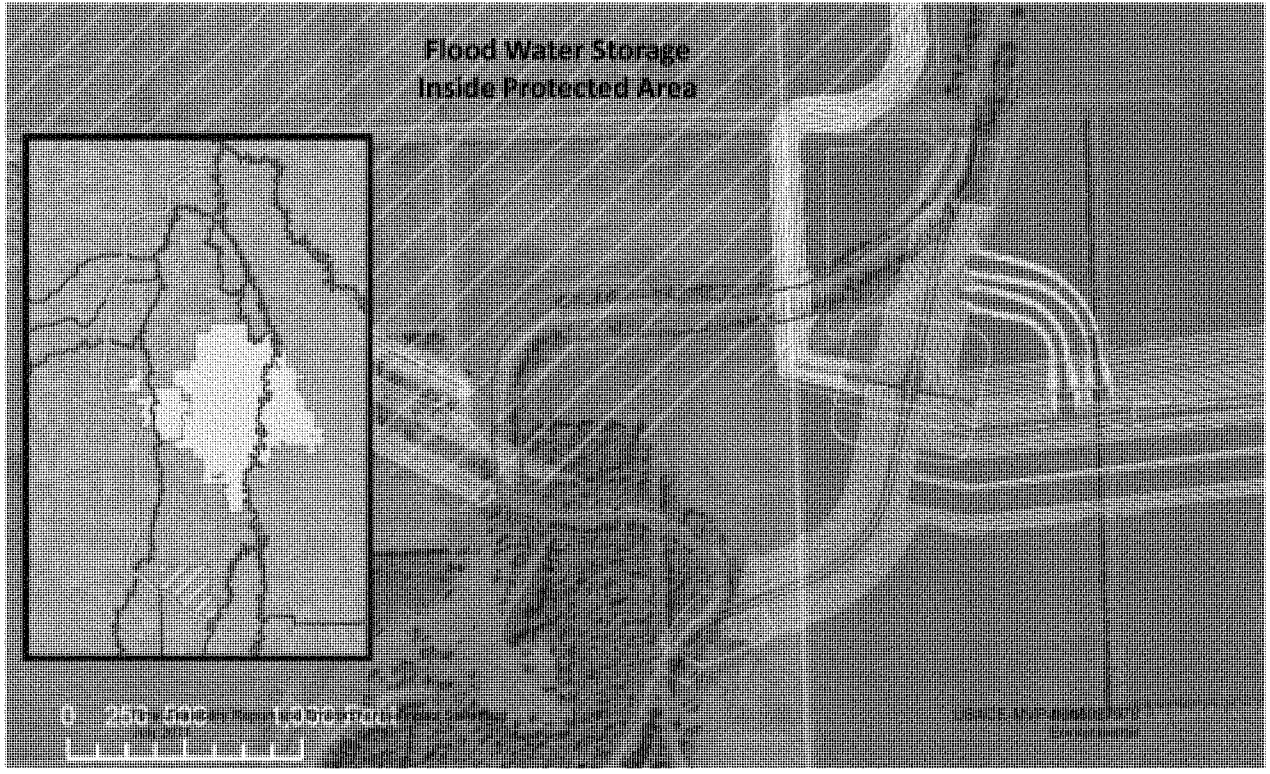
Wild Rice River Control Structure

- 0.8 to 0.9 miles of channel abandonment
- 12 acres of riverine habitat @ bankfull
- Similar to prev. draft



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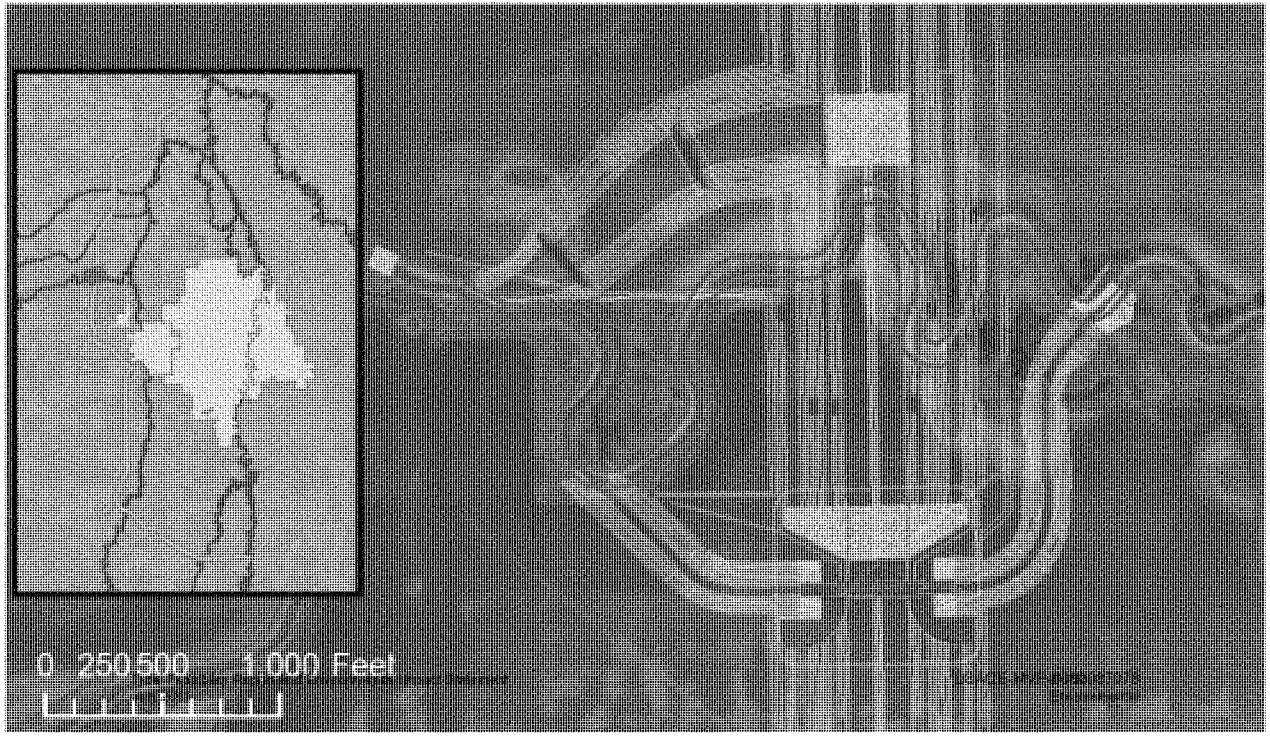
Shoyemie Aqueduct
0 250 500 1,000 Feet

Maple Aqueduct

- 1.1 miles of channel abandonment
- 10 to 11 acres of riverine habitat @ bankfull
- Slightly greater impact than previous draft
- Potential to shift diversion a few hundred feet west to reduce amount of impacted channel



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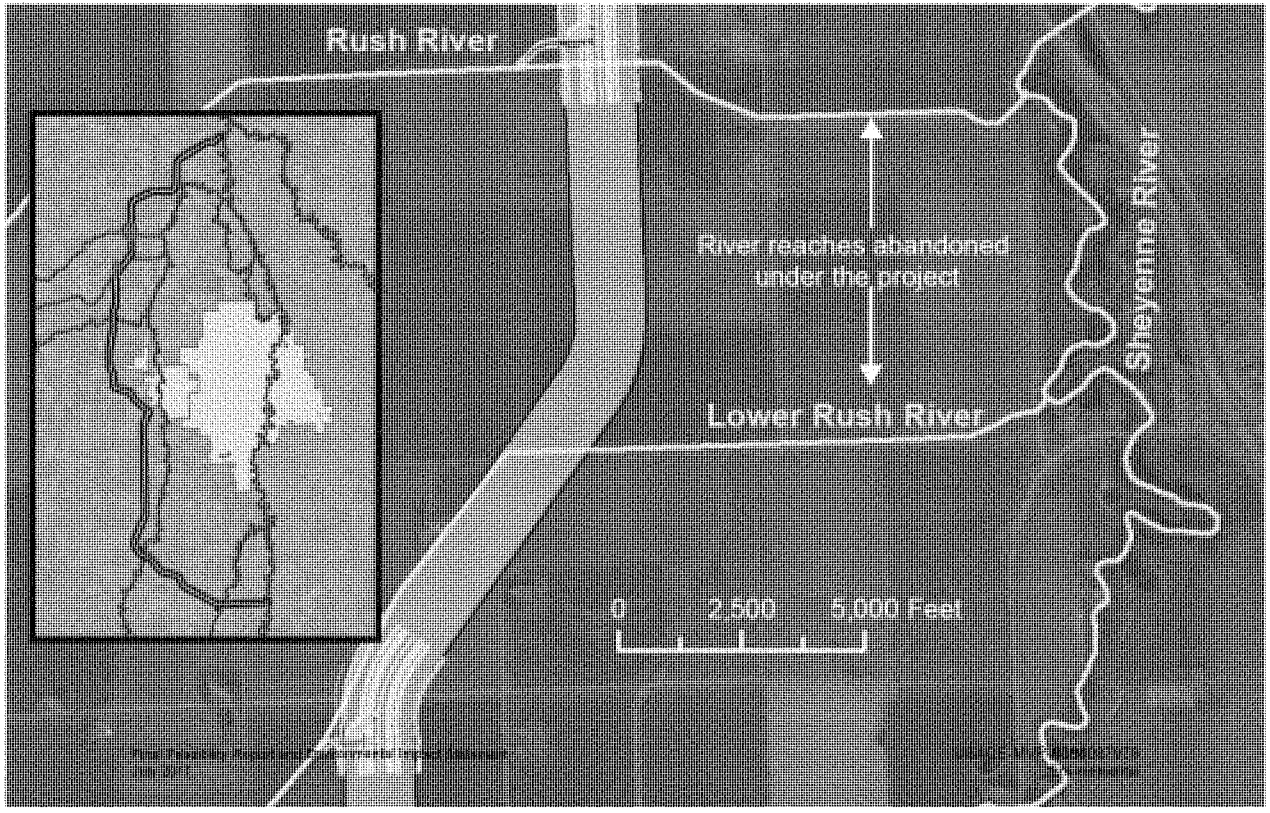
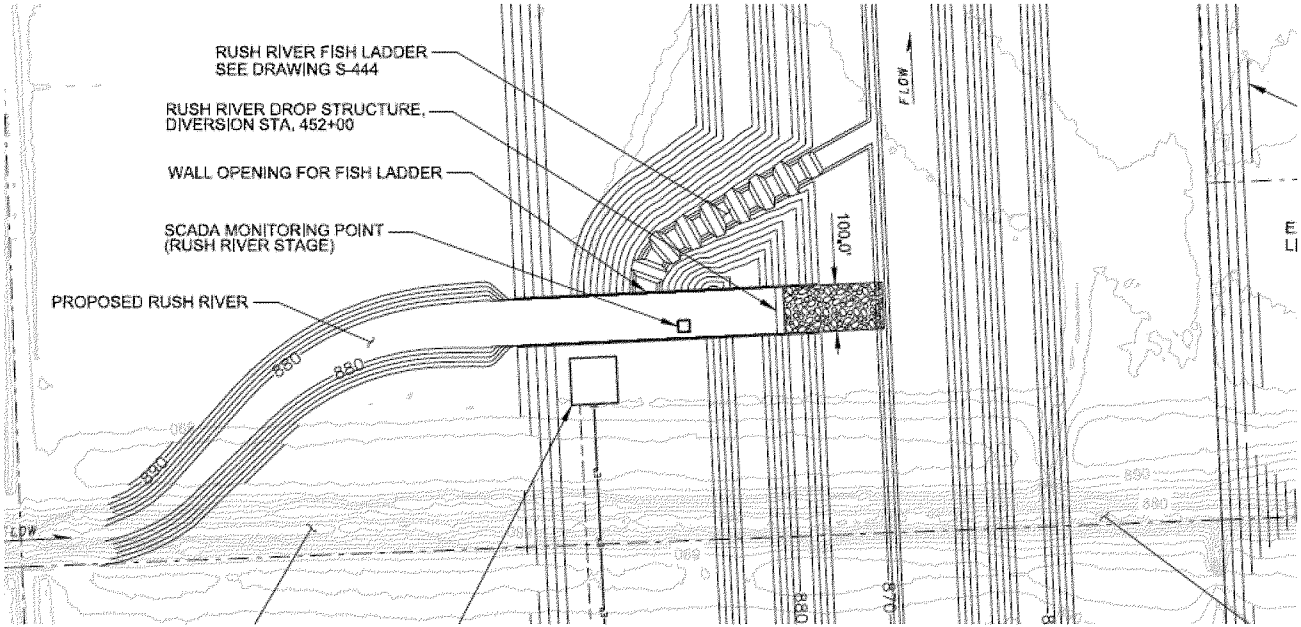
Rush and Lower Rush River abandonment

- 2.1 and 3.4 miles of channel moved to flood diversion
- Less area affected for Rush due to shift east for diversion alignment



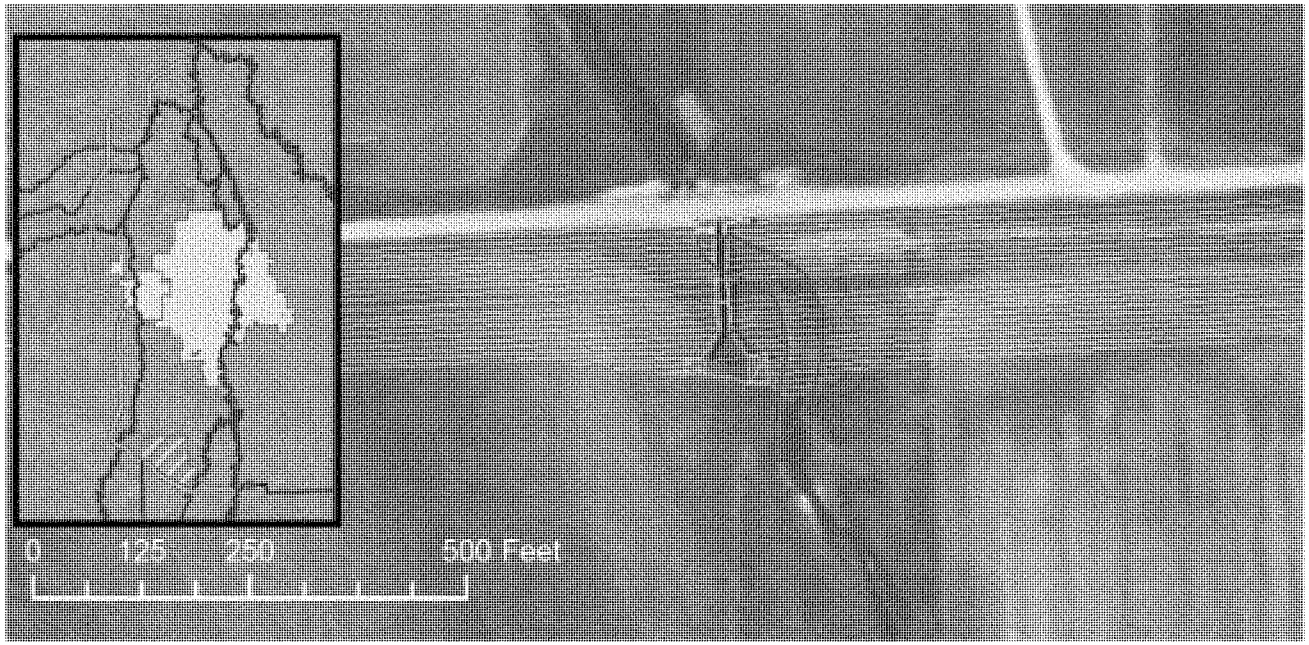
Overview of Rush River Structure

- Grade control to drop flow to diversion channel
- Separate fish passage channel that will operate 100% of time



Wolverton Creek Culvert through tie-back Levee

- 100 meters of channel modified or lost to culvert
- approx. 0.3 acres of creek habitat @ bankfull
- Feature wasn't in previous draft



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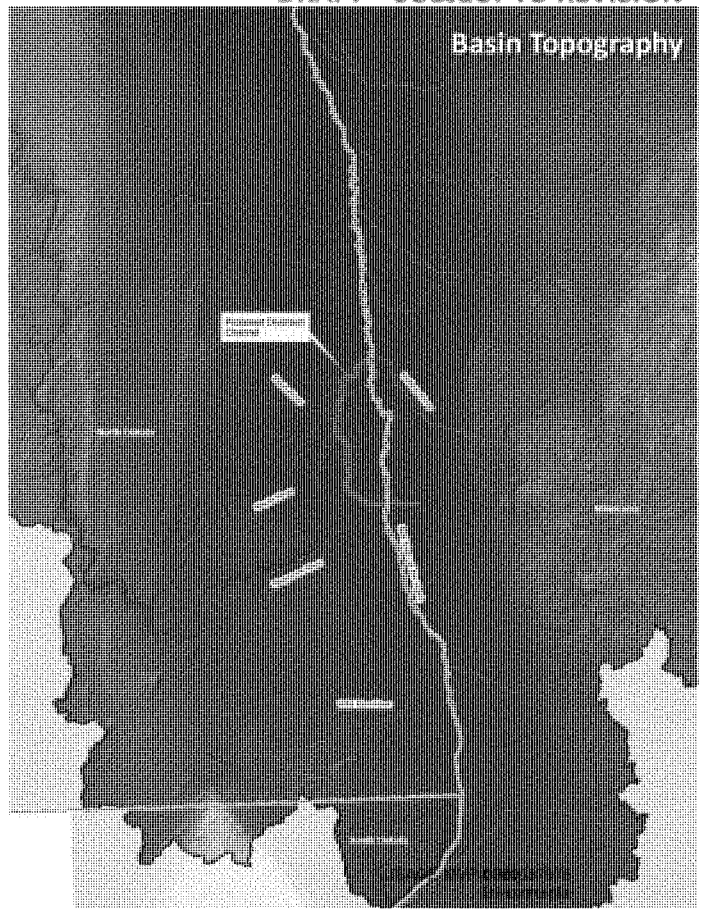
Impacts to Geomorphology and Sediment Transport

Three areas of impact considered:

1) Effect of altered hydraulics and sediment transport on downstream geomorphology.

2) Effect of altered channel length on channel stability

3) Effect of upstream staging on upstream geomorphology.

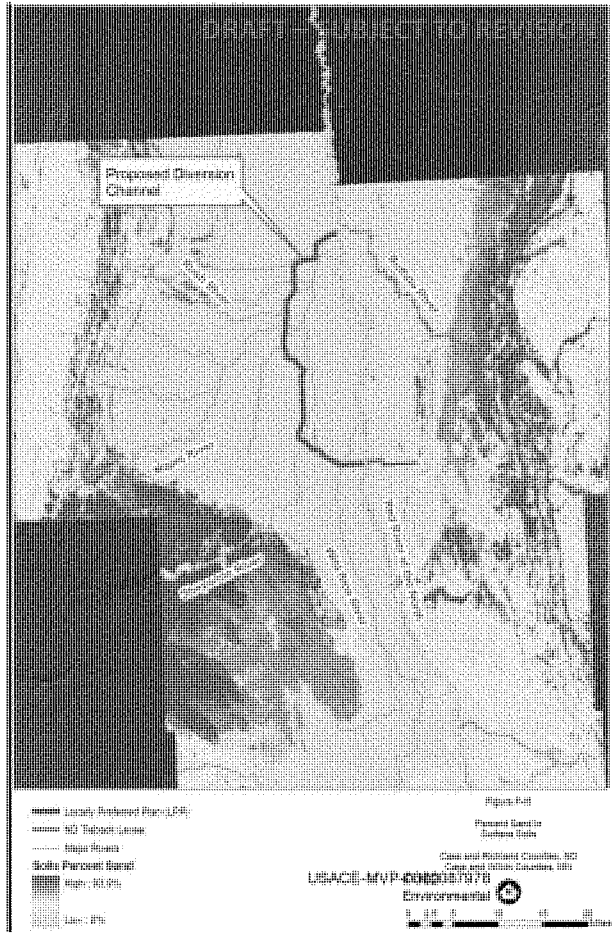


Impacts to Geomorphology and Sediment Transport

1) **Effect of altered hydraulics and sediment transport on downstream geomorphology.**

<u>Our conclusion</u>: the proposed project would not have a significant effect on sediment transport or downstream geomorphic conditions for the Red River or any of the tributaries

<u>Reasoning</u>: observations on sediment transport show that the vast majority of sediment is suspended, finer-grained material. The Sheyenne has not seen significant changes in geomorphic condition 20 years after its flood project.

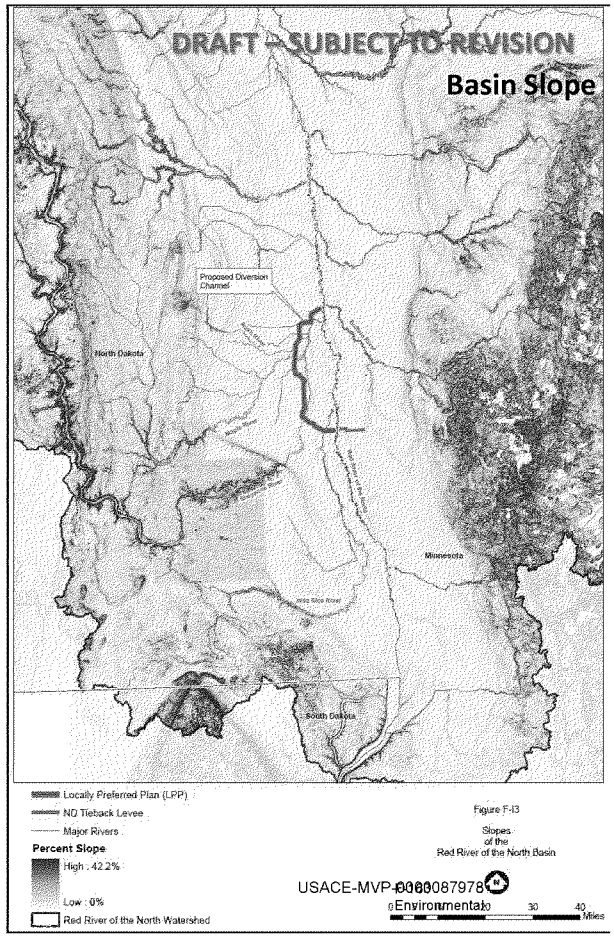


Impacts to Geomorphology and Sediment Transport

2) Effect of altered channel length on channel stability

<u>Our conclusion</u>: the proposed project would not have a significant effect on stream stability due to altered channel lengths.

<u>Reasoning</u>: Careful design would be able to minimize these impacts. This could include better sighting of project features (e.g. Maple). We also can maintain approximately the same channel velocities during lower-flow conditions by altering the length and cross-sectional area of the realigned channel. The locally increased slopes will likely not be out of the range of slopes observed in short reaches of the existing rivers. Under high-flow conditions, flow through the realigned channels will typically be tailwater controlled and velocities will not be sensitive to small local changes in slope.

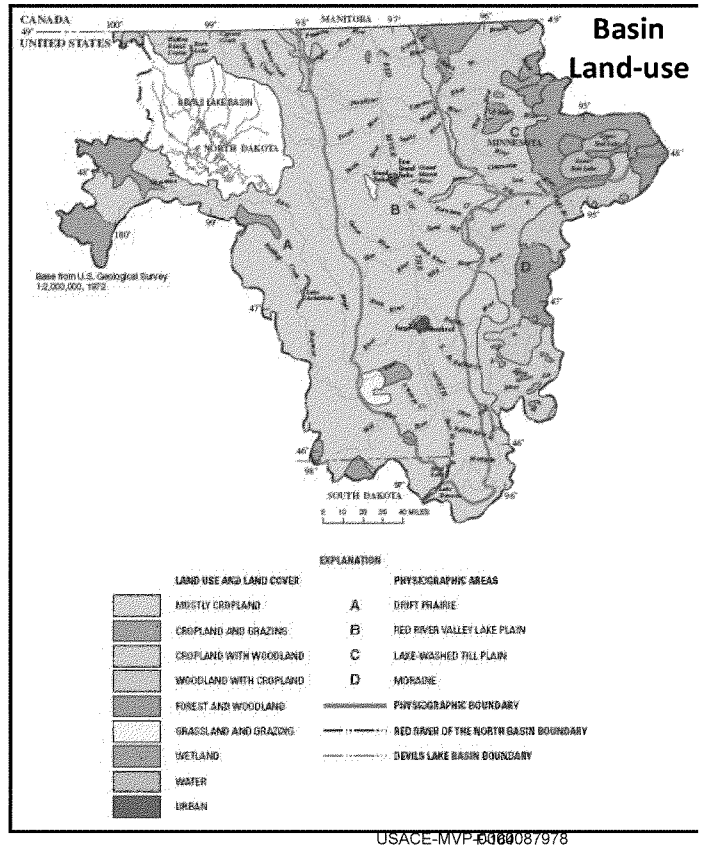


Impacts to Geomorphology and Sediment Transport

3) Effect of upstream staging on upstream geomorphology.

Our conclusion: the proposed project would not have a significant effect on upstream geomorphic conditions or bank stability

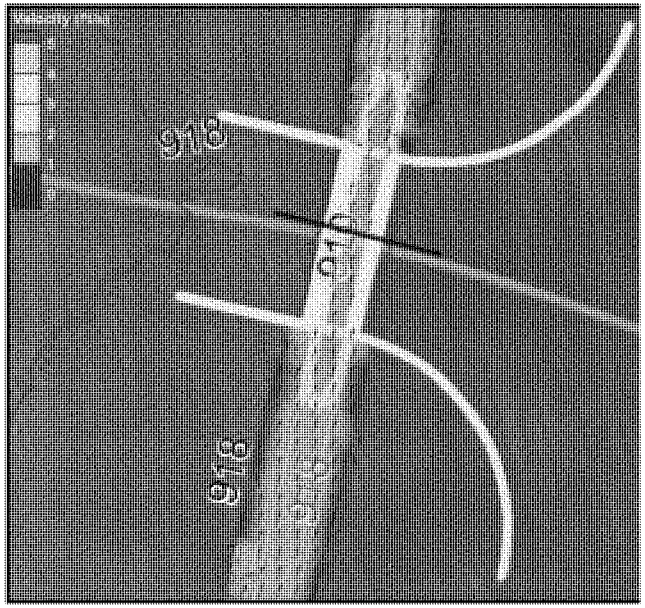
Reasoning: Upstream staging will not substantially change flow velocities near the RRN channel banks. Also, the stability of banks is likely more controlled by bankfull events, which would not be significantly affected by the Project. The frequency of Project Operations is tied to a flow (e.g., 9,600 cfs in the RRN at Fargo) that is equal to or larger than the bankfull discharge. We will not be increasing the frequency that upstream elevations hit bankfull. While the duration of bankfull conditions could be longer, the duration should not lead to a meaningful increase in bank failure because the Project is not increasing key de-stabilizing forces (with flow velocity, or boundary shear stress as proxies) applied on the channel banks.



Fish Passage Impacts – Sheyenne, Maple & Rush

- **Connectivity Issues on Sheyenne, Maple and Rush(s) remain similar to that in previous report.**
- **Designs should allow adequate depths, velocities and bottom substrates to facilitate fish movement through these structures.**
- **Connectivity impacts at these sites would remain less than significant (same as previous EIS).**

Sheyenne Aquaduct, 2-year flow event



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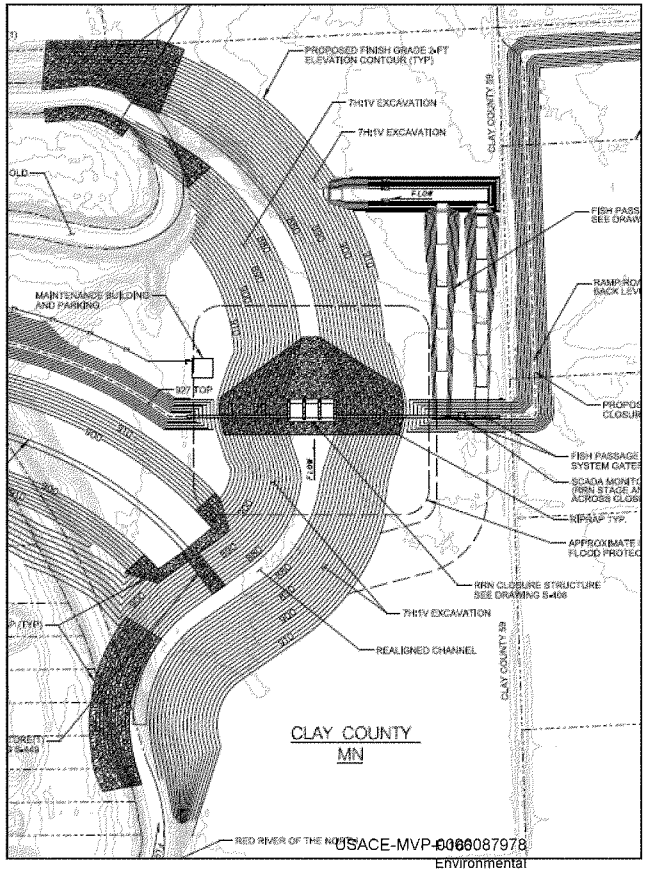
Fish Passage Impacts - Red & Wild Rice

Project Operations Summary

- To date, operations focused on eliminating downstream rises in flood elevations.
- Detailed Project Operations have yet to be developed.
- For the EIS we will make general assumptions on operations.
- For small floods project will go in to operation at 9,600 cfs at Fargo. Some staging anticipated, but unknown.
- For floods with a forecast peak of at least 17,000 cfs at Fargo, project will operate earlier, and stage water upstream.



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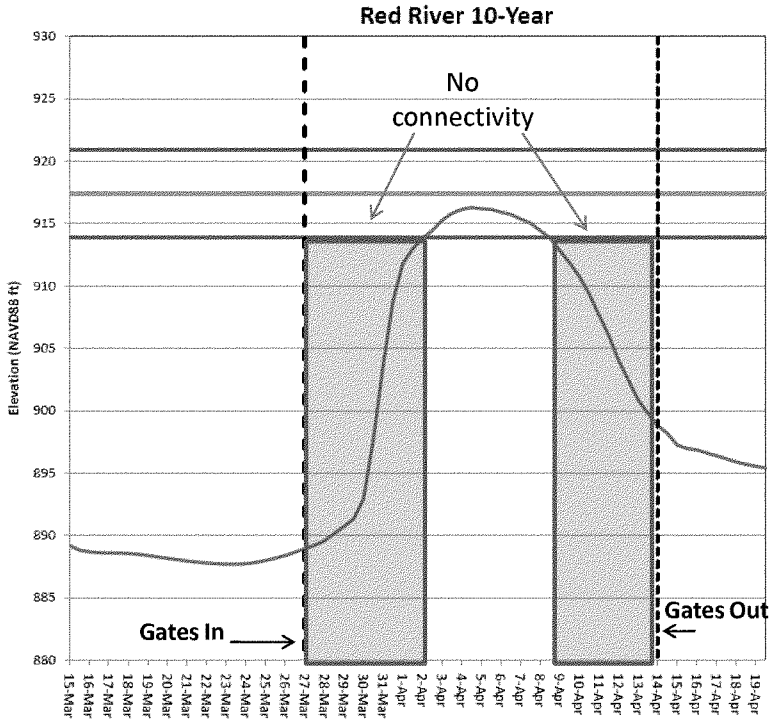
Environmental

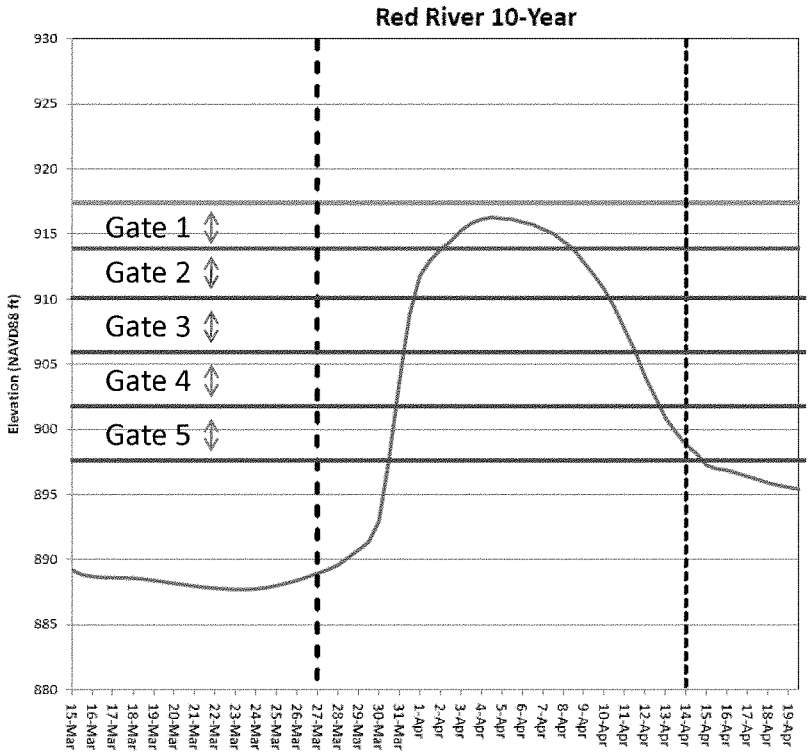
Fish Passage Impacts for Red River

- Design in report assumes two fish passage channels
- Simulated 10-year flood event requires upstream staging
- Fish passage channels go into operation with the project.
- Upstream staging of water results in connectivity gaps with only two fish passage channels.
- Even with fish passage across the hydrograph, the project operates for a longer period compared to previous EIS.
- Impacts for Wild Rice would be similar.



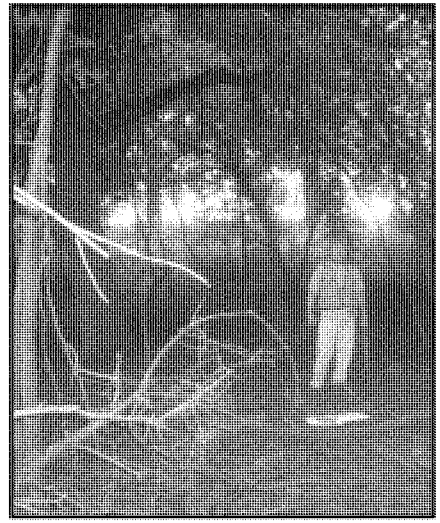
Fish Passage Mitigation

- Add three additional fish passageways to avoid/minimize (5 total).
- Implement Drayton Dam as mitigation for remaining connectivity impacts.
- Will consider other methods to reduce the amount of upstream staging needed.
  - Small levees in town to allow more flow through structure.
  - Operation of structure to better optimize hydraulics
  - Other



Other Ecological Impacts

- Floodplain Forest
  - LPP has 117 acres of riparian forest; 82 acres of Upland Forest/Shelter Belts
- Wetland impacts are substantially higher than previous EIS; however, these are farmed wetlands.
  - These farmed wetlands would still be replaced with wetlands at the bottom of the flood diversion channel.



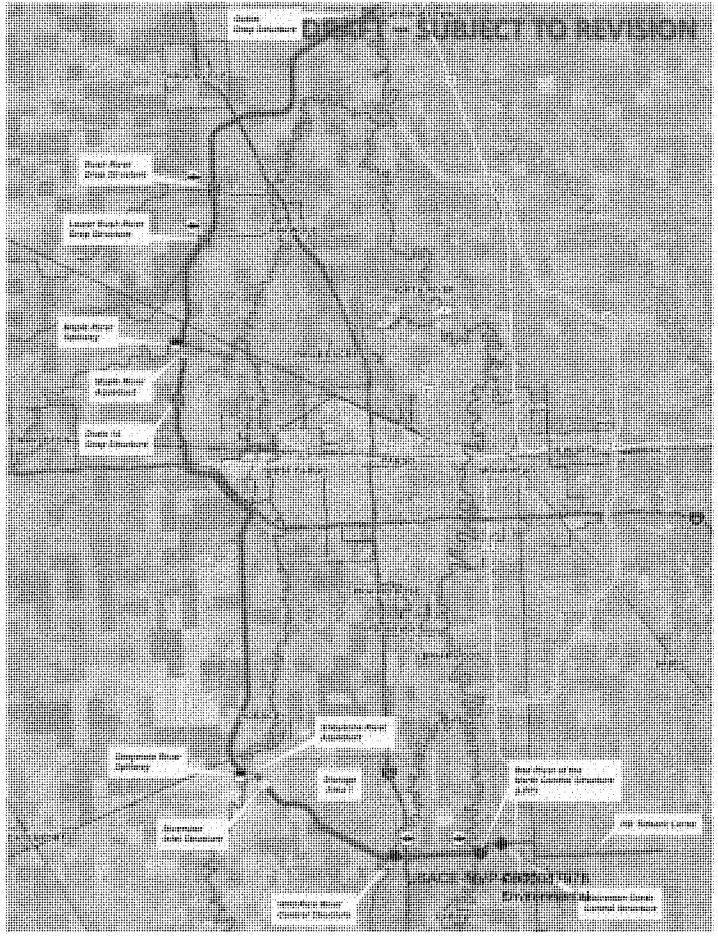
LPP

Wetland Type	Sum of Acres
Seasonally Flooded Basin	500
Shallow Marsh	239
Shallow Open Water	12
Wet Meadow	115
Grand Total	**866**

Mitigation

Still being developed, but…

- Mitigation for footprint impacts will likely look similar to previous EIS.
  - Will account for additional footprint on Red and Wolverton Creek.
  - Potential projects include Buffalo River; NRCS sites on the Maple and other tribs; will investigate other areas; and fish passage.
- No mitigation likely planned for geomorphic or wetland impacts.
- Fish connectivity will see mitigation
  - Additional fish passage channels.
  - Drayton Dam fish passage for connectivity impacts
  - Other structures/mechanisms to reduce impact of control structures on fish passage.
- Floodplain forest mitigation to be considered independently; or with stream restoration efforts.



F-M Metro Study Timeline:

- Mar 30-31 Meetings in Oxbow and West Fargo
- 27 Apr 11 SDEIS to EPA
- May /Jun11 Public Meeting(s)
- 20 Jun 11 Complete 45-day NEPA public comment period
- 1 Aug 11 Division Engineer's Transmittal (begin design)
- 7 Sept 11 Submit Draft Chief's Report and Final EIS to EPA for publication
- 1 Dec 11 Sign Chief's Report
- 1 Oct 12 Sign Project Partnership Agreement (soonest)
- Spring 2013 Begin Construction

Fargo-Moorhead Metropolitan Area Feasibility Study
Fargo Flood Study Agency Meeting

March 10, 2011

ATTENDEES

NAME	AGENCY/COMPANY
April Walker	City of Fargo
Nathan Boerboom	City of Fargo
Nathan Kestner	Minnesota Department of Natural Resources
Dave Friedl	Minnesota Department of Natural Resources
Tom Carlson	Minnesota Department of Natural Resources
Lynn Schlueter	North Dakota Game and Fish
Mike Ell	North Dakota Department of Health
Elliott Stefanik	US Army Corps of Engineering
Terry Williams	US Army Corps of Engineering
Brett Coleman	US Army Corps of Engineering
Lee Beauvais	Moore Engineering
Keith Berndt	Cass County
Mike Vavricka	MnPCA
Patrick Fridgen	North Dakota Water Commission
Bob Zimmerman	City of Moorhead
Gregg Theilen	Houston Engineering
Miguel Wong	Barr Engineering

I. Introductions:

a. All attendees introduced themselves and their party.

II. Overview of latest happenings and schedule

a. Brett Coleman and Terry Williams with the Corps gave a brief overview of where we are to date on the project.

III. Latest Status of Impacts

Majority of meeting focused on updated impact discussions. Elliott Stefanik with USACE and Miguel Wong with Barr Engineering lead discussions outlining likely impact conclusions for key ecological resources based on revised drawings and potential project operations. PowerPoint files of these presentations are attached. Presentation included extensive open conversation between USACE and the agencies on project features, operations and potential impacts.

IV. Action Items

a. USACE should consider including the most recent Red River discharge data within its frequency analysis for project operations.
b. Per request, USACE will address upstream bank stability issues and upstream floodplain sedimentation within the upcoming EIS.
c. USACE will further evaluate potential connectivity impacts/concerns on Wolverton Creek as a result of upstream staging under the LPP.
d. USACE must continue to make progress on the MN State EIS, including the need to address dam safety issues.
e. Various options will be considered to reduce the amount of upstream staging needed under the LPP, particularly during smaller flood events (e.g., 10-year flood event). One option is to allow more water to pass in to the protected area. Would be valuable to get from appropriate State agencies the amount of water level increase that would be acceptable for smaller flood events.
f. Agencies would appreciate an advance copy of the EIS if at all possible.

V. Adjourn

BARR

MINNEAPOLIS, MINNESOTA - HIBBING, MINNESOTA
DULUTH, MINNESOTA
ANN ARBOR, MICHIGAN - JEFFERSON CITY, MISSOURI

COMPUTED	CHECKED	SUBMITTED	DATE / SHEET NO.
BY	BY	TO	PROJECT NAME
DATE	DATE	DATE	PROJECT NUMBER
			SUBJECT

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TERRY WILLIAMS	USACE	Terry1.1.williams@usace.army.mil

DRAFT – SUBJECT TO REVISION

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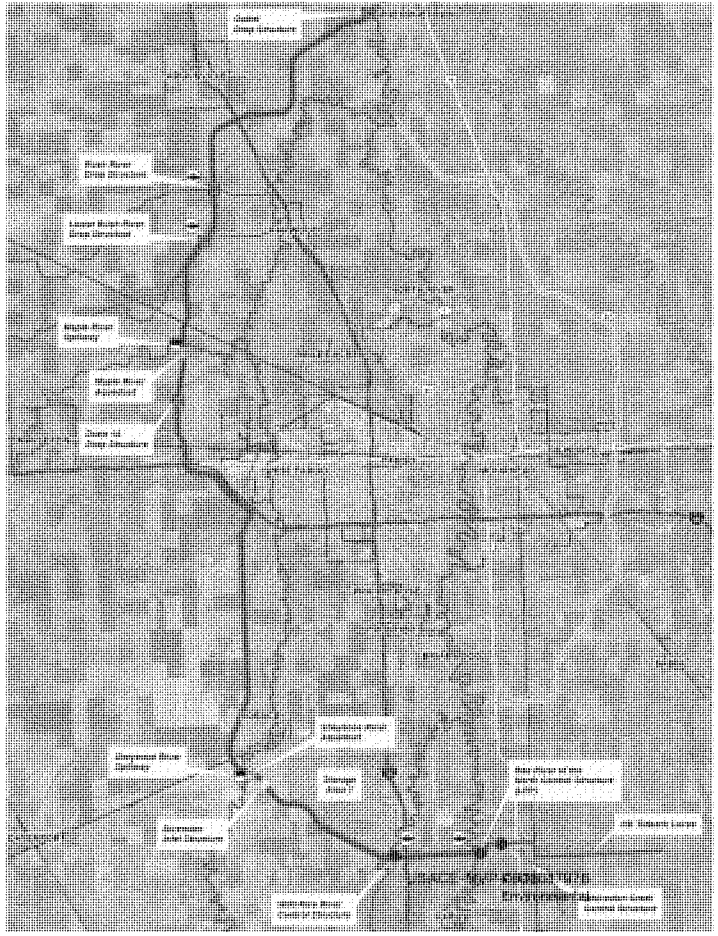

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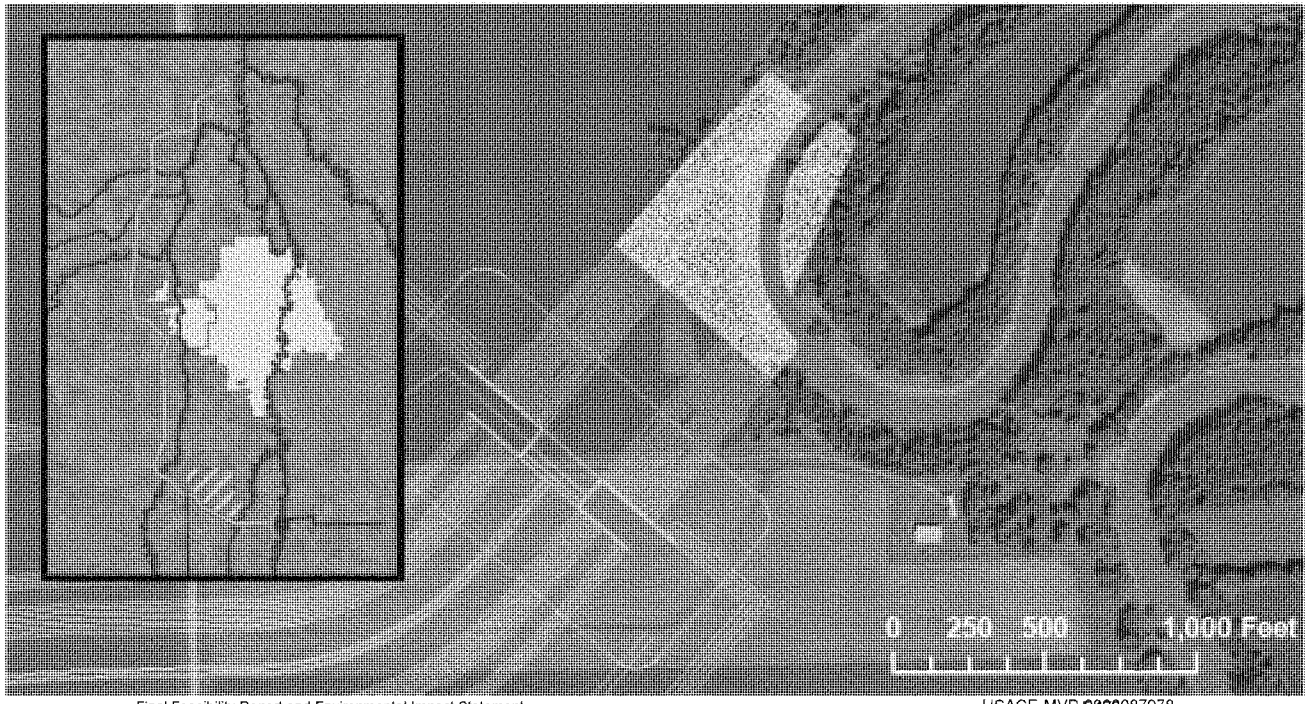
- grading and rock placement on both banks
- erosion and grade control



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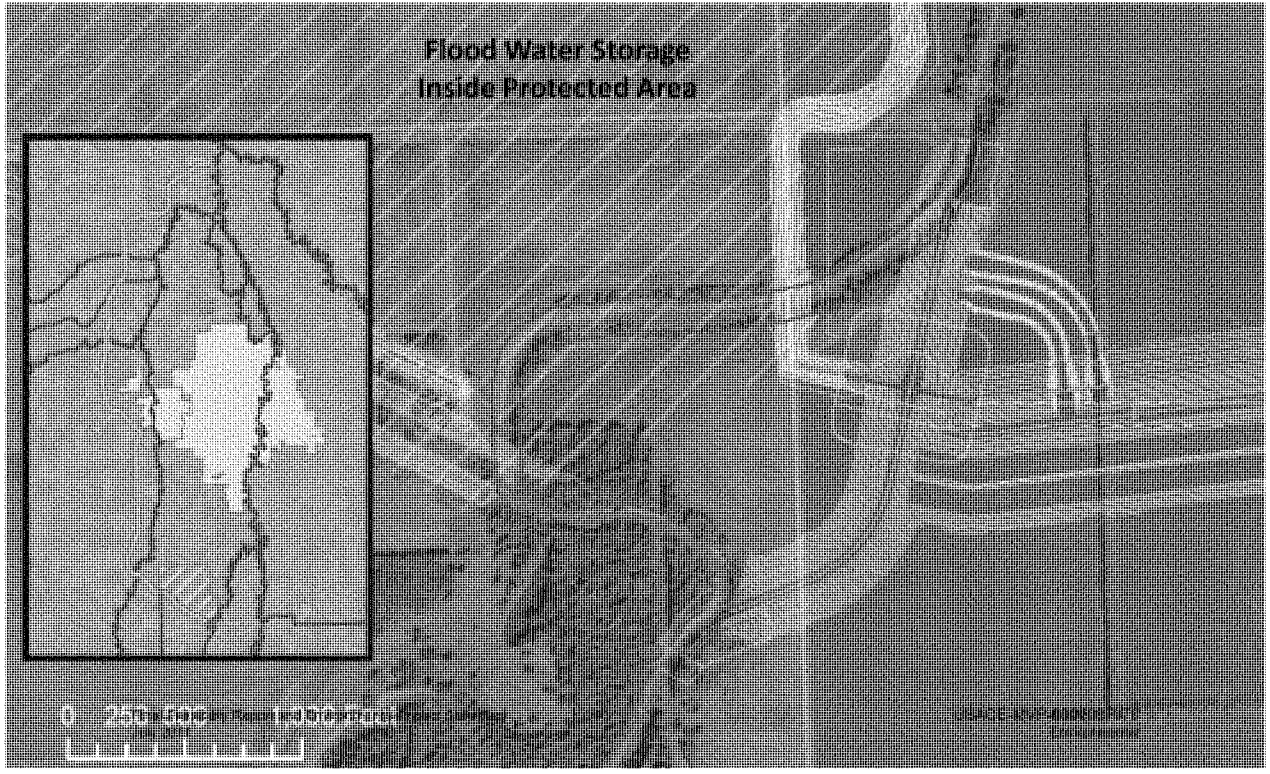
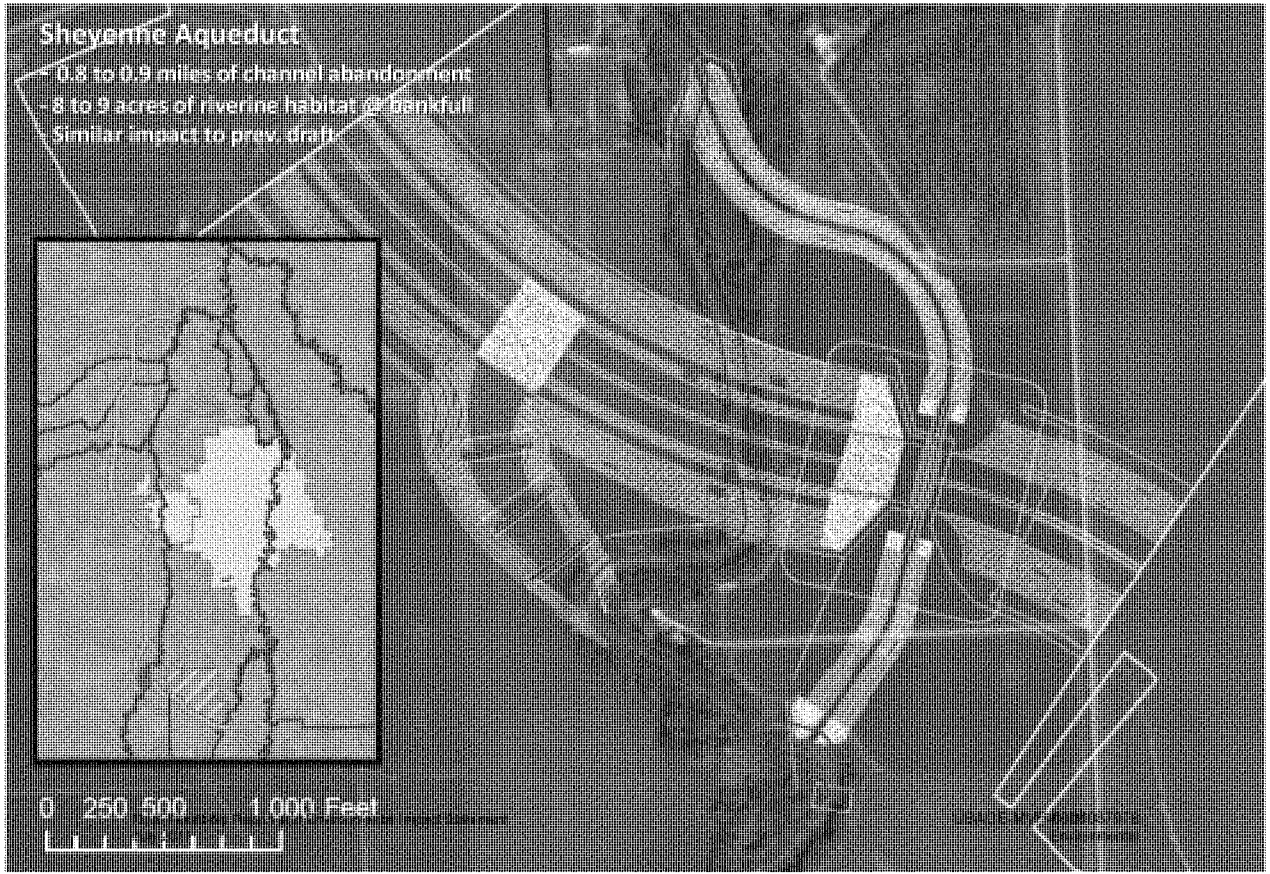
Wild Rice River Control Structure

- 0.8 to 0.9 miles of channel abandonment
- 12 acres of riverine habitat @ bankfull
- Similar to prev. draft




Sheyenne Aqueduct
- 0.8 to 0.9 miles of channel abandonment
- 8 to 9 acres of riverine habitat @ bankfull
Similar impact to prev. draft
0 250 500 1,000 Feet

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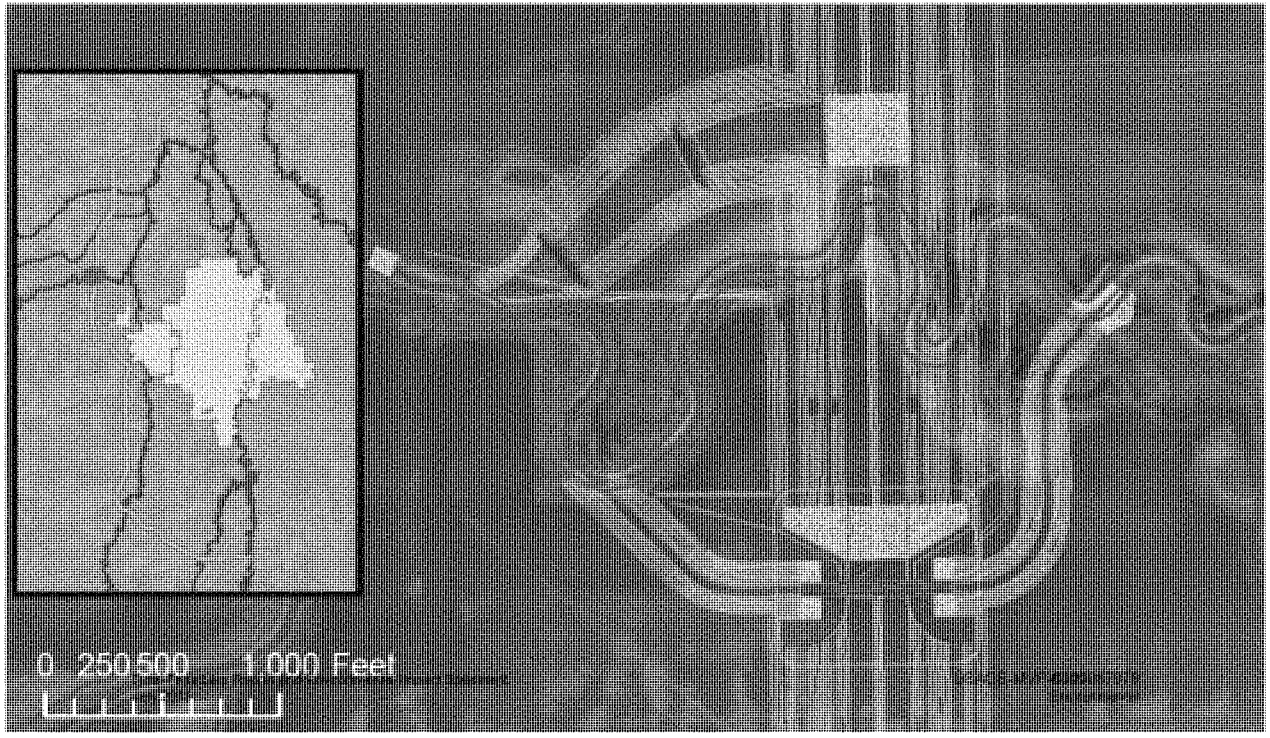
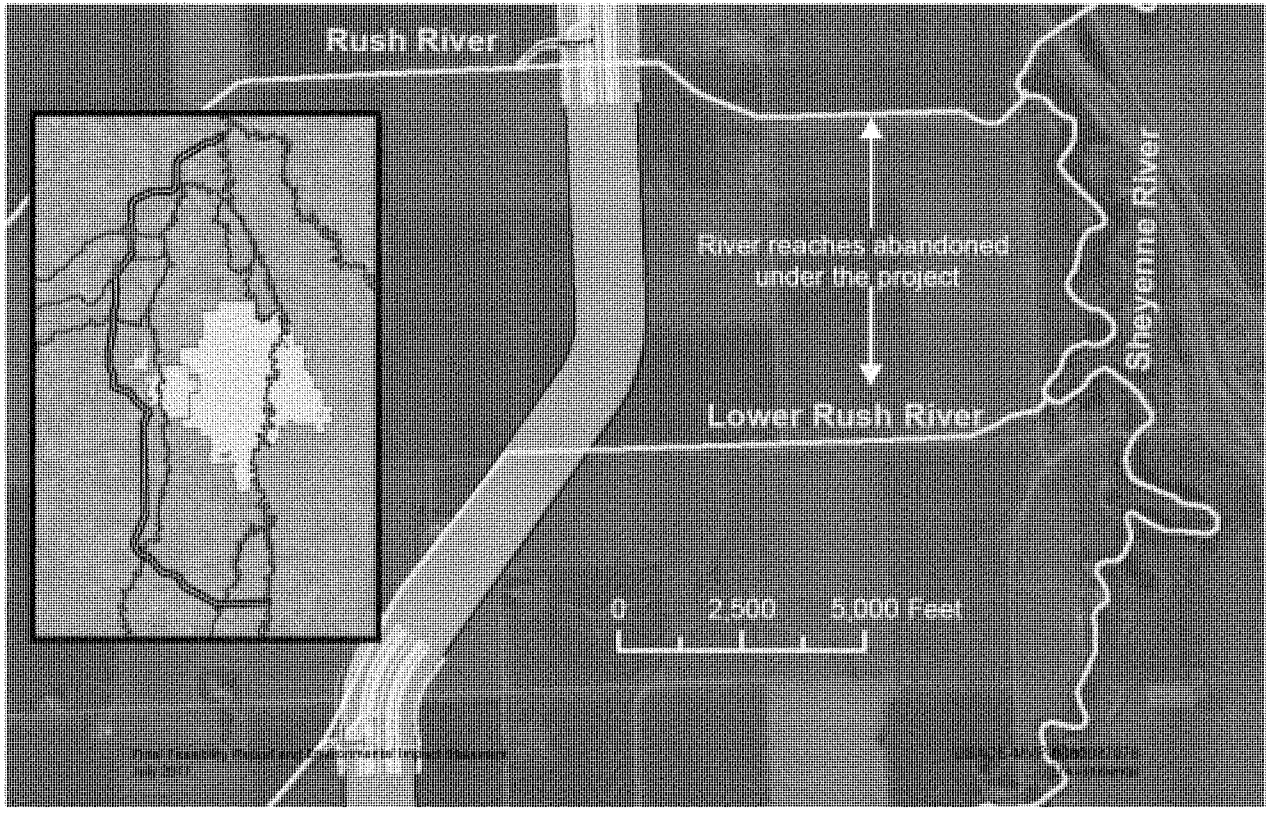
Maple Aqueduct

- 1.1 miles of channel abandonment
- 10 to 11 acres of riverine habitat @ bankfull
- Slightly greater impact than previous draft
- Potential to shift diversion a few hundred feet west to reduce amount of impacted channel



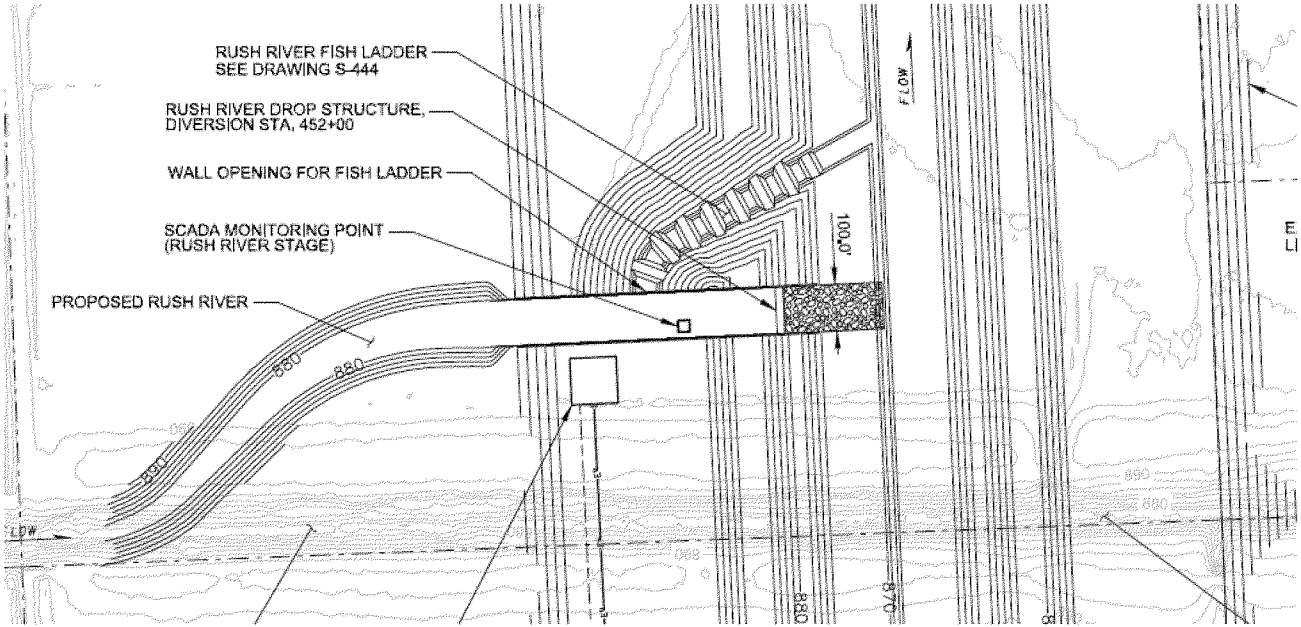
Rush and Lower Rush River abandonment

- 2.1 and 3.4 miles of channel moved to flood diversion
- Less area affected for Rush due to shift east for diversion alignment



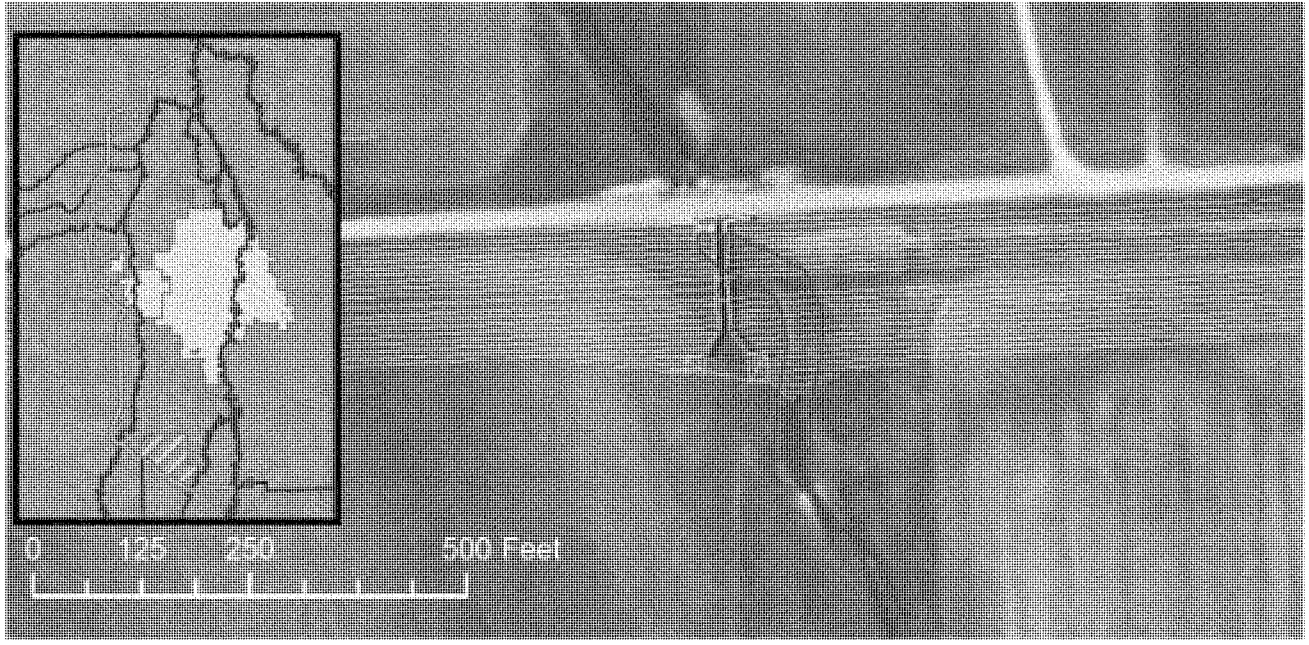
Overview of Rush River Structure

- Grade control to drop flow to diversion channel
- Separate fish passage channel that will operate 100% of time



Wolverton Creek Culvert through tie-back Levee

- 100 meters of channel modified or lost to culvert
- approx. 0.3 acres of creek habitat @ bankfull
- Feature wasn't in previous draft



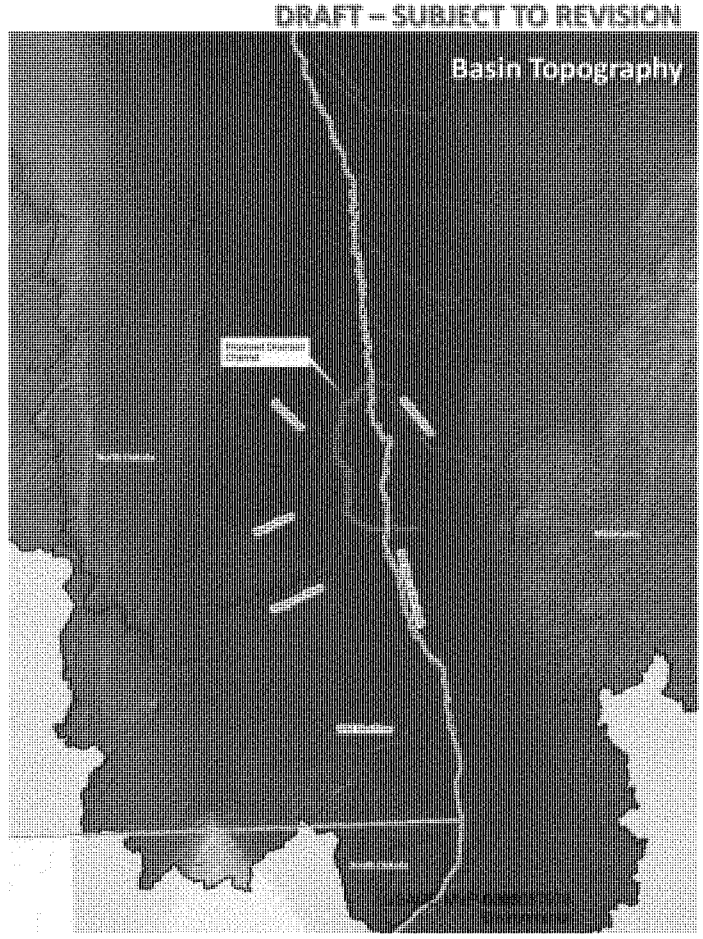
Impacts to Geomorphology and Sediment Transport

Three areas of impact considered:

1) Effect of altered hydraulics and sediment transport on downstream geomorphology.

2) Effect of altered channel length on channel stability

3) Effect of upstream staging on upstream geomorphology.

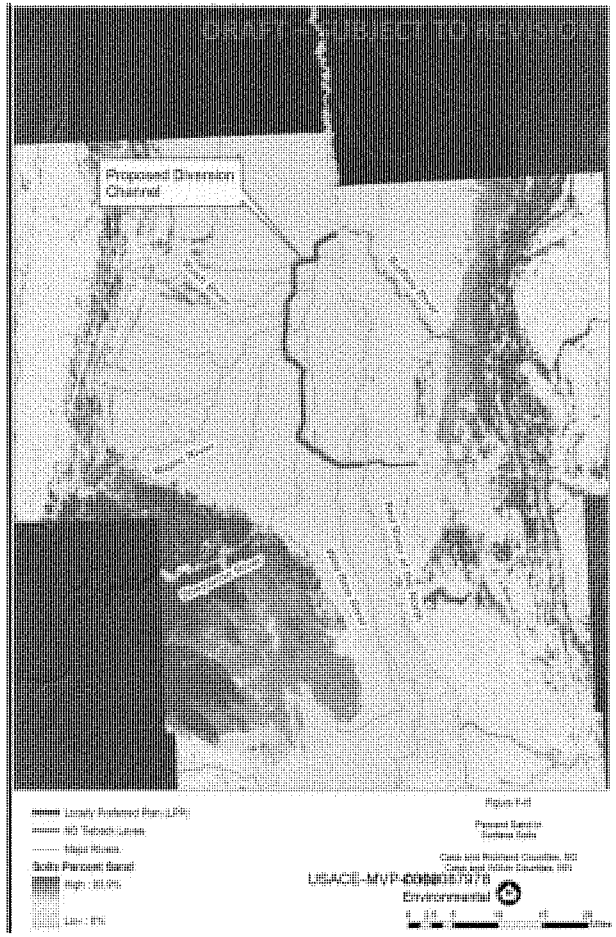


Impacts to Geomorphology and Sediment Transport

1) **Effect of altered hydraulics and sediment transport on downstream geomorphology.**

<u>Our conclusion</u>: the proposed project would not have a significant effect on sediment transport or downstream geomorphic conditions for the Red River or any of the tributaries

<u>Reasoning</u>: observations on sediment transport show that the vast majority of sediment is suspended, finer-grained material. The Sheyenne has not seen significant changes in geomorphic condition 20 years after its flood project.

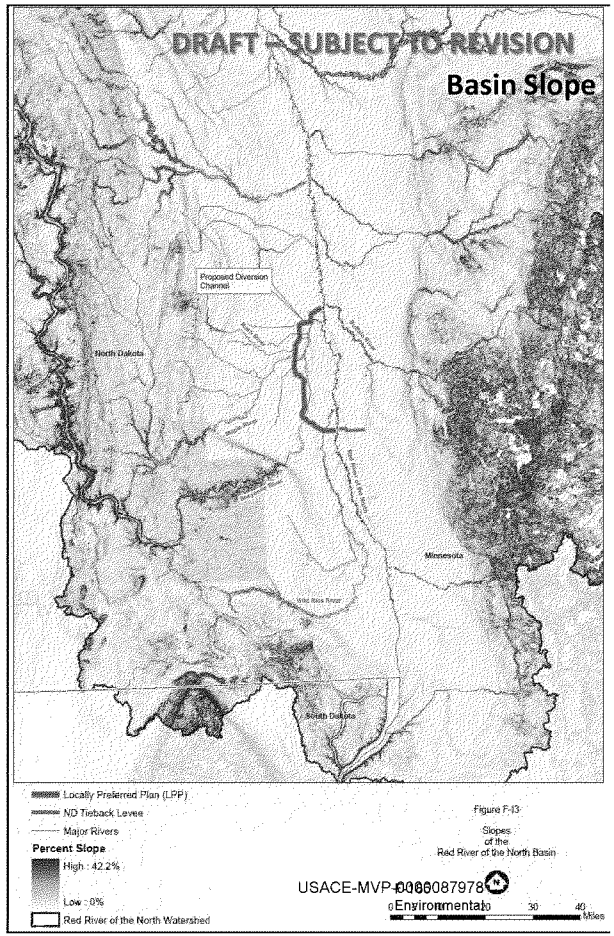


Impacts to Geomorphology and Sediment Transport

2) Effect of altered channel length on channel stability

Our conclusion: the proposed project would not have a significant effect on stream stability due to altered channel lengths.

Reasoning: Careful design would be able to minimize these impacts. This could include better sighting of project features (e.g. Maple). We also can maintain approximately the same channel velocities during lower-flow conditions by altering the length and cross-sectional area of the realigned channel. The locally increased slopes will likely not be out of the range of slopes observed in short reaches of the existing rivers. Under high-flow conditions, flow through the realigned channels will typically be tailwater controlled and velocities will not be sensitive to small local changes in slope.



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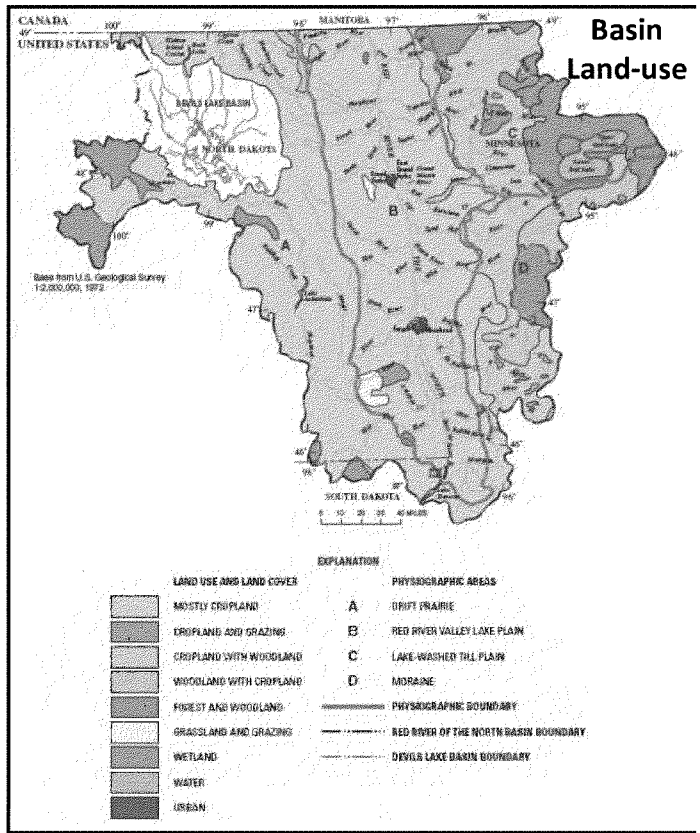
Impacts to Geomorphology and Sediment Transport

3) Effect of upstream staging on upstream geomorphology.

Our conclusion: the proposed project would not have a significant effect on upstream geomorphic conditions or bank stability

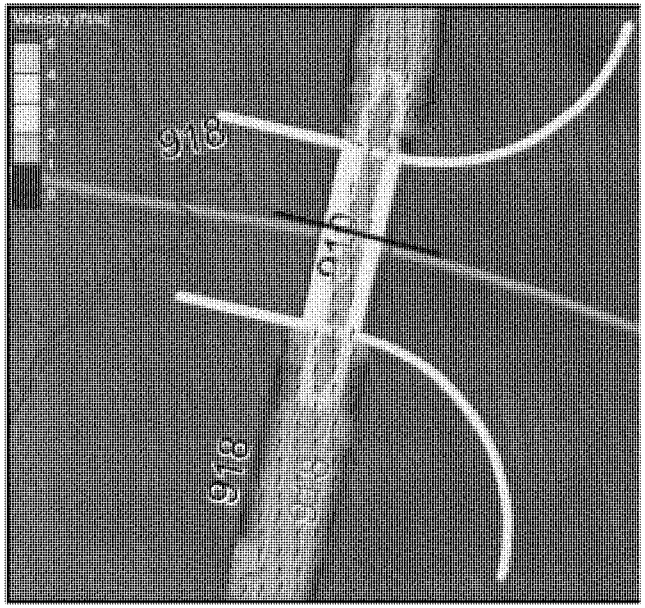
Reasoning: Upstream staging will not substantially change flow velocities near the RRN channel banks. Also, the stability of banks is likely more controlled by bankfull events, which would not be significantly affected by the Project. The frequency of Project Operations is tied to a flow (e.g., 9,600 cfs in the RRN at Fargo) that is equal to or larger than the bankfull discharge. We will not be increasing the frequency that upstream elevations hit bankfull. While the duration of bankfull conditions could be longer, the duration should not lead to a meaningful increase in bank failure because the Project is not increasing key de-stabilizing forces (with flow velocity, or boundary shear stress as proxies) applied on the channel banks.



Fish Passage Impacts – Sheyenne, Maple & Rush

- **Connectivity Issues on Sheyenne, Maple and Rush(s) remain similar to that in previous report.**
- **Designs should allow adequate depths, velocities and bottom substrates to facilitate fish movement through these structures.**
- **Connectivity impacts at these sites would remain less than significant (same as previous EIS).**

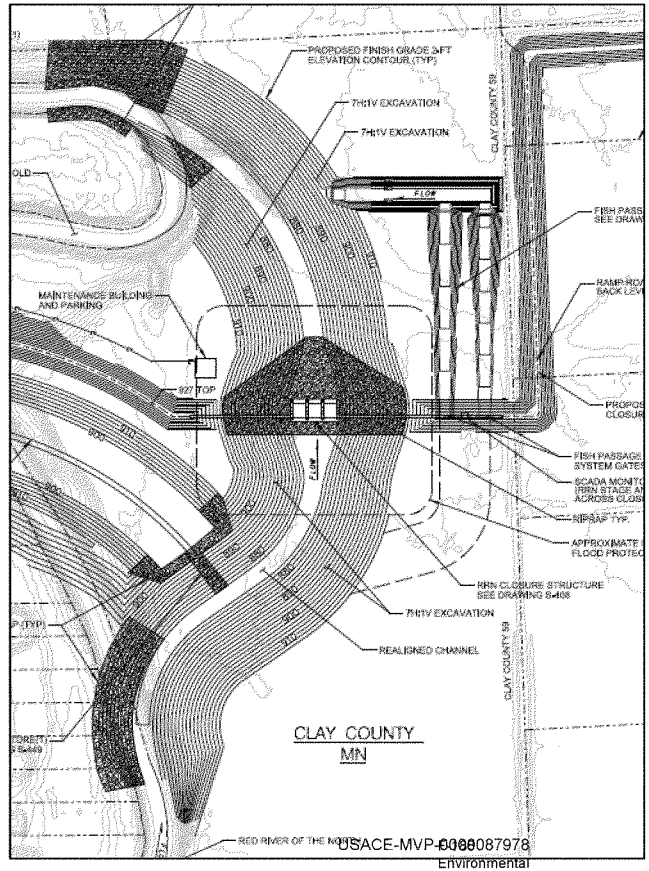
Sheyenne Aquaduct, 2-year flow event



Fish Passage Impacts - Red & Wild Rice

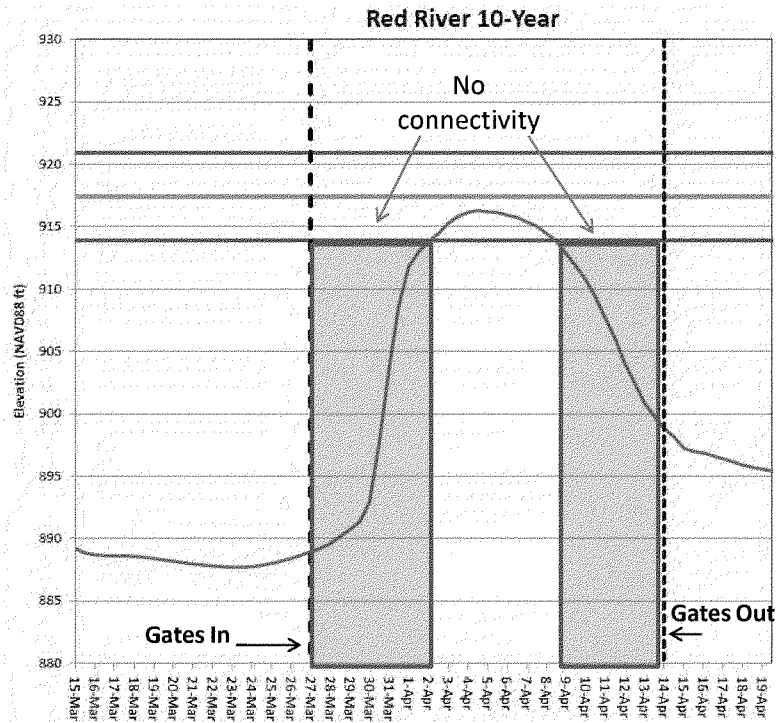
Project Operations Summary

- To date, operations focused on eliminating downstream rises in flood elevations.
- Detailed Project Operations have yet to be developed.
- For the EIS we will make general assumptions on operations.
- For small floods project will go in to operation at 9,600 cfs at Fargo. Some staging anticipated, but unknown.
- For floods with a forecast peak of at least 17,000 cfs at Fargo, project will operate earlier, and stage water upstream.



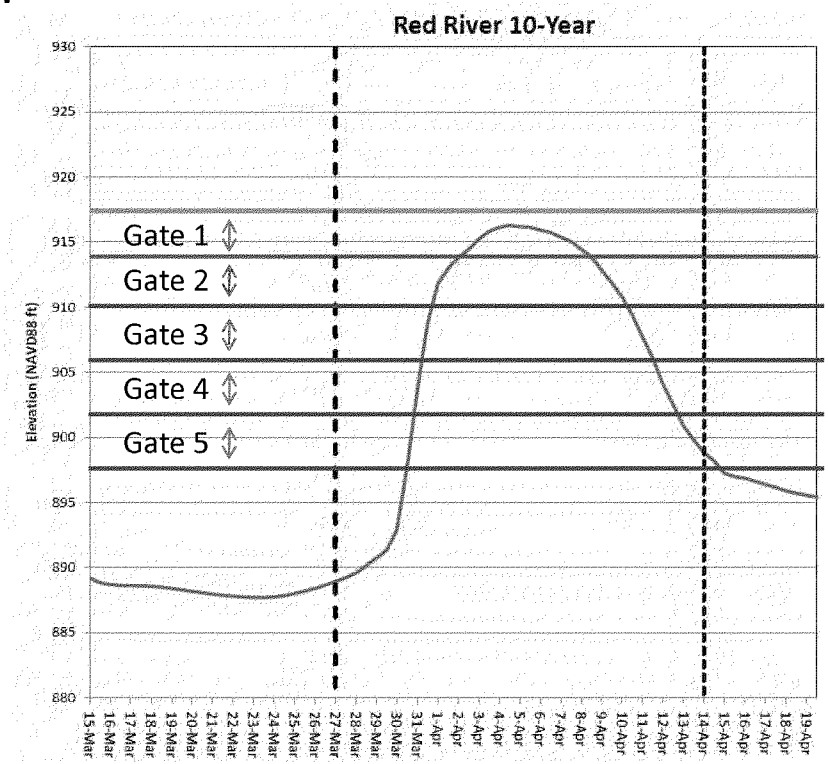
Fish Passage Impacts for Red River

- Design in report assumes two fish passage channels
- Simulated 10-year flood event requires upstream staging
- Fish passage channels go into operation with the project.
- Upstream staging of water results in connectivity gaps with only two fish passage channels.
- Even with fish passage across the hydrograph, the project operates for a longer period compared to previous EIS.
- Impacts for Wild Rice would be similar.



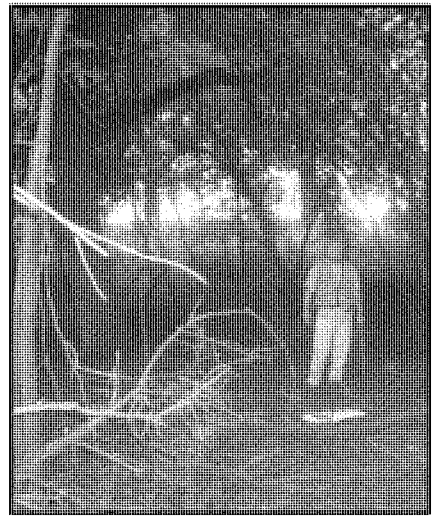
Fish Passage Mitigation

- Add three additional fish passageways to avoid/minimize (5 total).
- Implement Drayton Dam as mitigation for remaining connectivity impacts.
- Will consider other methods to reduce the amount of upstream staging needed.
  - Small levees in town to allow more flow through structure.
  - Operation of structure to better optimize hydraulics
  - Other



Other Ecological Impacts

- Floodplain Forest
  - LPP has 117 acres of riparian forest; 82 acres of Upland Forest/Shelter Belts
- Wetland impacts are substantially higher than previous EIS; however, these are farmed wetlands.
  - These farmed wetlands would still be replaced with wetlands at the bottom of the flood diversion channel.



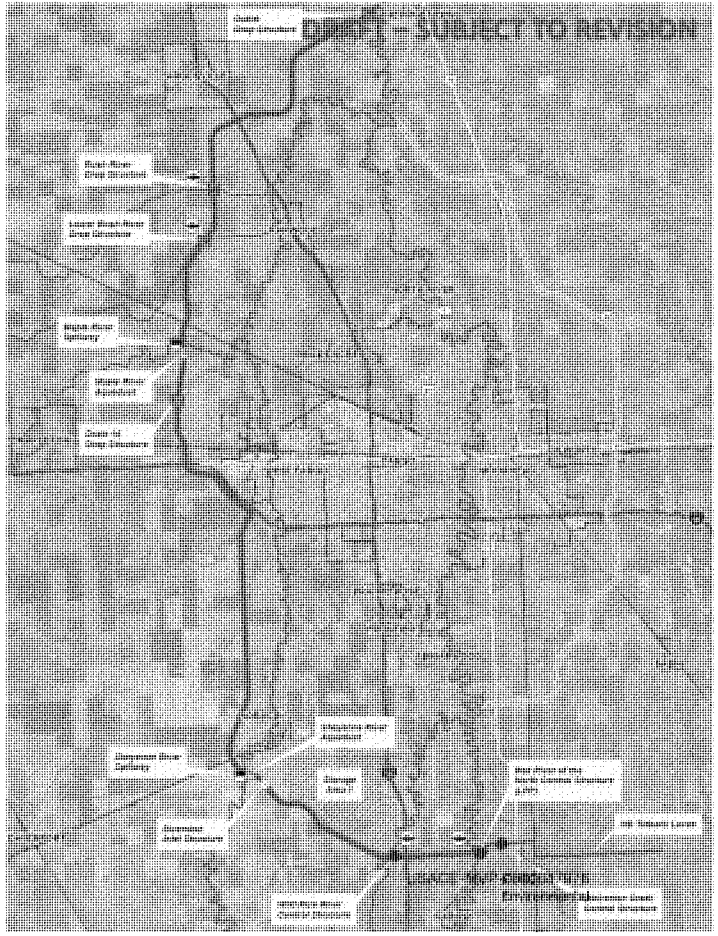
LPP

Wetland Type	Sum of Acres
Seasonally Flooded Basin	500
Shallow Marsh	239
Shallow Open Water	12
Wet Meadow	115
Grand Total	866

Mitigation

Still being developed, but…

- Mitigation for footprint impacts will likely look similar to previous EIS.
  - Will account for additional footprint on Red and Wolverton Creek.
  - Potential projects include Buffalo River; NRCS sites on the Maple and other tribs; will investigate other areas; and fish passage.
- No mitigation likely planned for geomorphic or wetland impacts.
- Fish connectivity will see mitigation
  - Additional fish passage channels.
  - Drayton Dam fish passage for connectivity impacts
  - Other structures/mechanisms to reduce impact of control structures on fish passage.
- Floodplain forest mitigation to be considered independently; or with stream restoration efforts.



F-M Metro Study Timeline:

- Mar 30-31 Meetings in Oxbow and West Fargo
- 27 Apr 11 SDEIS to EPA
- May /Jun11 Public Meeting(s)
- 20 Jun 11 Complete 45-day NEPA public comment period
- 1 Aug 11 Division Engineer's Transmittal (begin design)
- 7 Sept 11 Submit Draft Chief's Report and Final EIS to EPA for publication
- 1 Dec 11 Sign Chief's Report
- 1 Oct 12 Sign Project Partnership Agreement (soonest)
- Spring 2013 Begin Construction

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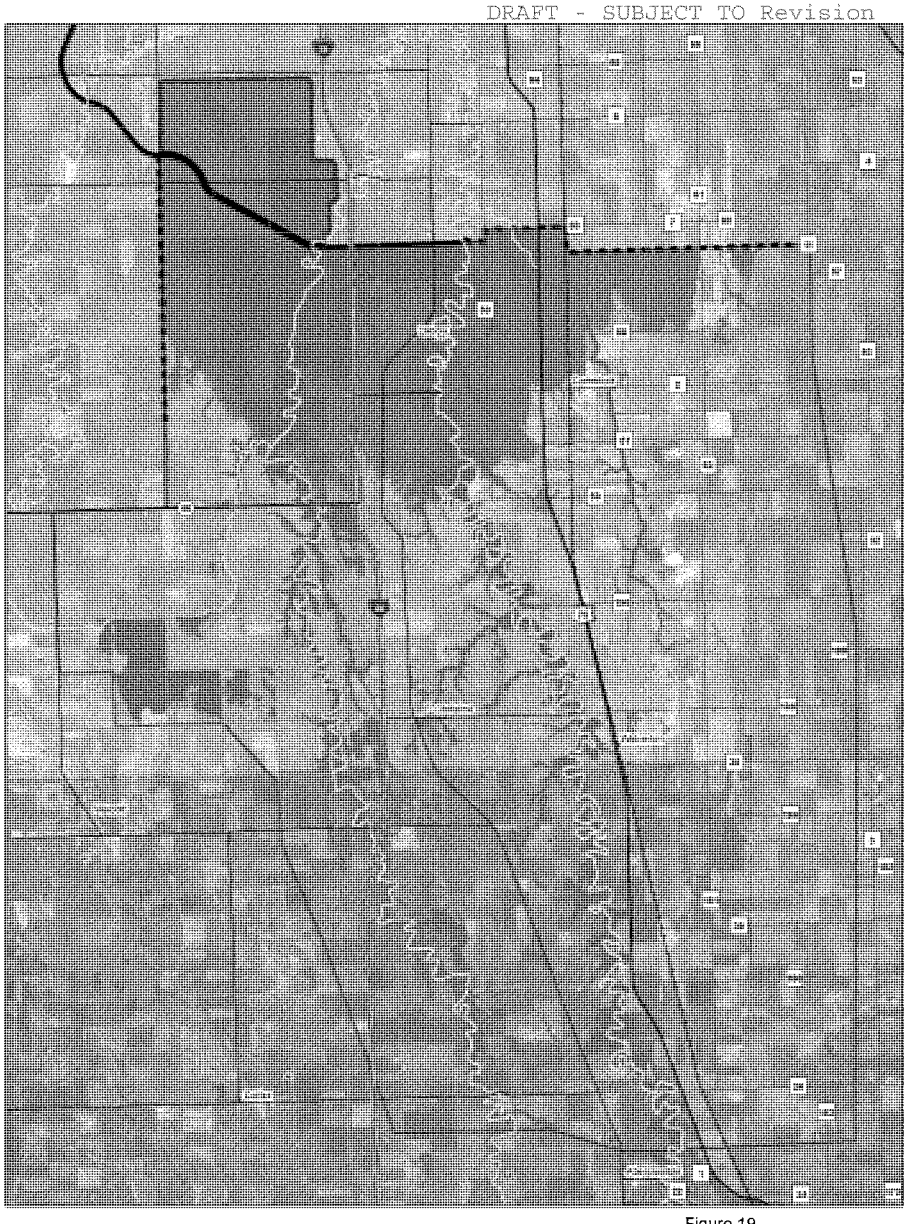

Figure 19

Inundation Map for the Model Existing Conditions and With Project for 2-percent Chance Event in the Red River of the North - South of Diversion Works - LPP

2% Existing (20,363 Acres)

LPP 2% (38,000 Acres)

Mapping Extent

Storage Area 1

LPP Diversion

LPP Tieback

Cities

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0 0.375 0.75 1.5 2.25 Miles

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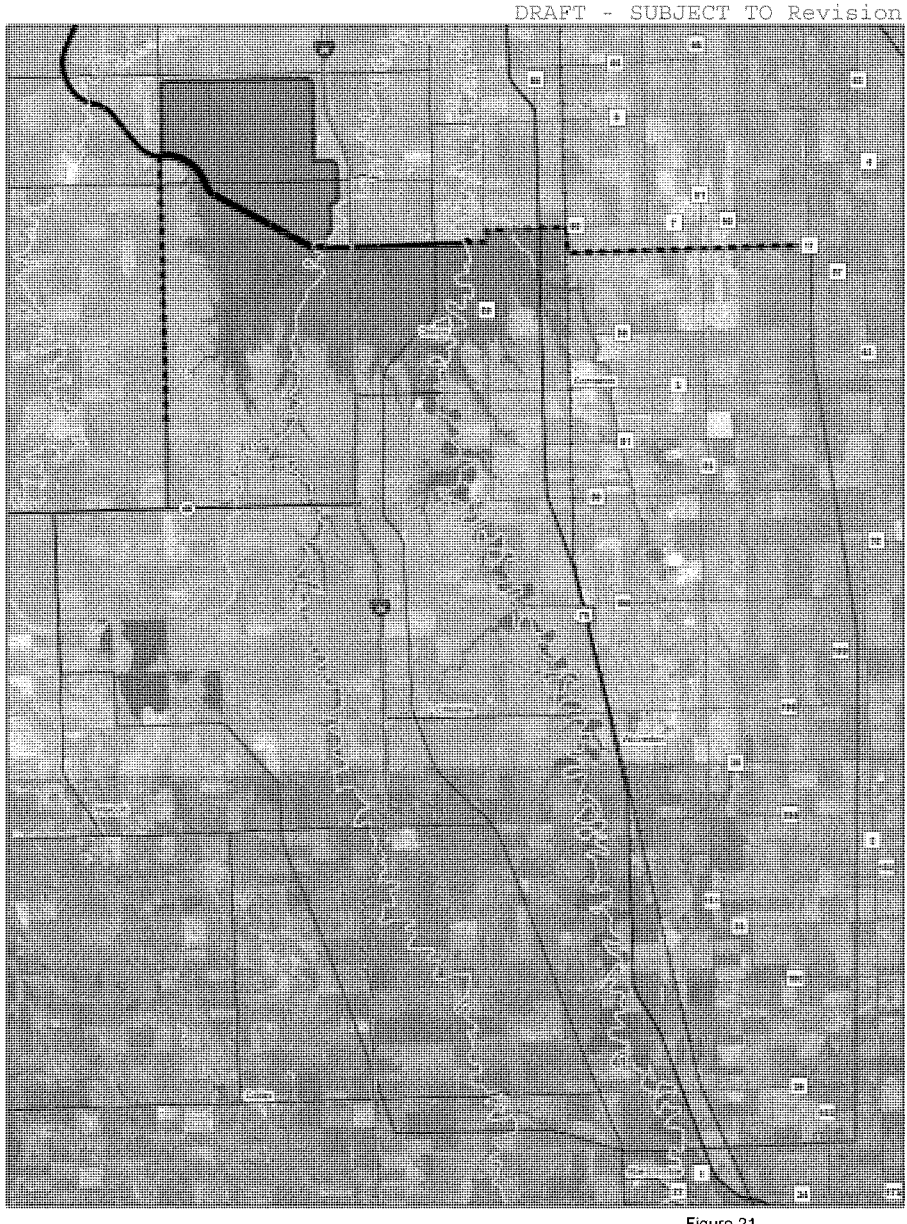

Figure 21

Inundation Map for the Model Existing Conditions and With Project for 10-percent Chance Event in the Red River of the North - South of Diversion Works - LPP

10% Existing (7,858 Acres)
LPP 10% (20,841 Acres)
Mapping Extent
Storage Area 1
LPP Diversion
LPP Tieback
Cities

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0 0.3750.75 1.5 2.25
Miles

USACE-MVP-0009087978
Environmental

Fargo-Moorhead Metropolitan Area Feasibility Study
Fargo Flood Study Agency Meeting

May 25, 2011

ATTENDEES

NAME	AGENCY/COMPANY
April Walker	City of Fargo
Bruce Kreft	North Dakota Fish & Game
Lynn Schlueter	North Dakota Game and Fish
Nathan Kestner	Minnesota Department of Natural Resources
Tom Groshens	Minnesota Department of Natural Resources
Tom Carlson	Minnesota Department of Natural Resources
Dave Friedl	Minnesota Department of Natural Resources
Rich Davis	US Fish & Wildlife Service
Keith Weston	Natural Resource Conservation Service
Sharon Lean	Natural Resource Conservation Service
Mike Ell	North Dakota Department of Health
Ryan Pietramali	FEMA Region 8
Jon Sobiech	US Army Corps of Engineering
Elliott Stefanik	US Army Corps of Engineering
Terry Williams	US Army Corps of Engineering
Aaron Snyder	US Army Corps of Engineers
Craig Evans	US Army Corps of Engineers
Brett Coleman	US Army Corps of Engineers
Lee Beauvais	Moore Engineering
Patrick Fridgen	North Dakota Water Commission
Randy Gjestvang	North Dakota Water Commission
Bob Zimmerman	City of Moorhead
Gregg Thielman	Houston Engineering

I. Introductions

II. Overview of latest happenings and schedule

a. Brett Coleman with the Corps gave the presentation from the Public Meetings during the week.

III. Discussion Items

Agencies were given several opportunities to ask questions regarding the draft report out for public review. Few questions were asked on the draft report. Brief discussion was held on the following study items:

- Clarification on mitigation contingency planning.
- Status of mitigation sites, and mitigation dollar differences between the 2010 Draft EIS and the 2011 Supplemental Draft EIS.
- Impact conclusion for Wolverton Creek,
- Brief discussion of recent meetings with a potential contractor for the biotic surveys, and the tentative plans for biotic surveys later this summer.
- Brief introduction of the concept of routing the Lower Rush River to the Rush River prior to passing into the Diversion Channel. Purpose is to avoid a drop structure only for the Lower Rush; potentially providing some cost savings.
- Brief discussion of meeting with NRCS the previous day to locate mitigation sites .
- FEMA stated that they are still discussing internally the CLOMAR process and buyouts of Oxbow, Bakke, Hickson.
- Agencies requested to be kept informed on the status of the loss of life and breach analyses.

IV. Due Outs/Needs from agencies

a. Provide comments on the Draft EIS ASAP (due June 20).
b. USACE will update on biological monitoring status, providing agencies an opportunity to participate.
c. USACE will continue planning for mitigation sites, and will coordinate with the agencies as appropriate.

V. Adjourn

1.9 Threatened and Endangered Species

1.9.1 Minnesota Special Status Species Clay County

Minnesota Special Concern Species with Potential to Occur in Clay County

Common Name	Scientific Name	Habitat Utilized	Potential to Occur in Study Area
Mammals			
Plains pocket mouse	*Perognathus flavescens*	Upland prairie, savanna	**No potential.** Required habitat not present in study area.
Prairie vole	*Microtus ochrogaster*	Upland prairie, savanna	**No potential.** Required habitat not present in study area.
Birds			
Bald eagle	*Haliaeetus leucocephalus*	Lake shores, rivers	**Moderate potential.** Generally avoids areas with human activities.
Greater prairie chicken	*Tympanuchus cupido*	Upland prairie	**No potential.** Required habitat not present in study area.
Marbled godwit	*Limosa fedoa*	Native grassland adjacent to a complex of wetlands.	**No potential.** Required habitat not present in study area.
Nelson's sharp-tailed Sparrow	*Ammodramus nelsoni*	Non-forested rich peatland, wet meadows, sedge wetlands.	**No potential.** Required habitat not present in study area.
Yellow rail	*Coturnicops noveboracensis*	Non-forested rich peatland, wet meadows.	**No potential.** Required habitat not present in study area.
Reptiles			
Plains hognosed snake	*Heterodon nasicus*	Upland prairie, savanna, subterrain.	**No potential.** Required habitat not present in study area.
Fish			
Lake sturgeon	*Acipenser fulvescens*	Red River, recovery program has been implemented	**Moderate potential.** Fish Passage is being designed as part of project.
Mussels			
Black sandshell mussel	*Ligumia recta*	Large permanent streams.	**Moderate potential.** Majority of proposed action will be above high water mark on the Red River.
Creek heelsplitter	*Lasmigona compressa*	Small rivers, streams	**No potential.** Species has not been recorded within the study area.
Insects		Large permanent streams.	**Low potential.** Species has not been recorded within the study area.
Arogos skipper	*Atrytone arogos*	Upland prairie	**No potential.** Habitat not present in study area.

Minnesota Special Concern Species with Potential to Occur in Clay County

Common Name	Scientific Name	Habitat Utilized	Potential to Occur in Study Area
Insects			
Regal fritillary	*Speyeria idalia*	Upland and lowland prairies.	**No potential.** Habitat used by species not present in study area.
Leonard's skipper	*Hesperia leonardus*	Upland prairie	**No potential.** Required habitat not present in study area.
Powesheik skipper	*Oarisma poweskeik*	Upland and lowland prairies.	**No potential.** Required habitat not present in study area.
Red-tailed prairie leafhopper	*Aflexia rubranura*	Upland prairie	**No potential.** Required habitat not present in study area.
Plants		Low, usually sandy prairies.	**Low potential.** Species has not been recorded within the study area.
Blanket flower	*Gaillaria aristata*	Sandy or other well drained soils with full sun to partial shade.	**Low potential.** Most soils in Minnesota study are not classified as well drained.
Blunt sedge	*Carex obtusata*	Wet meadows, marshes, open-wet woodlands.	**No potential.** Required habitat not present in study area.
Few-flowered spike-rush	*Eleocaris quinqueflora*	Occurs on wetlands, bogs, springs, and other moist areas. Frequently is a wetland indicator species.	**Low potential.** Moist areas are quite limited within study area.
Felwort	*Gentianella Amarella* ssp.	Usually occurs in wetlands, moist edges of woodlands, and moist areas within roadside ditches	**Low potential.** Moist areas are quite limited within study area.
Dry sedge	*Carex xerantica*	Grasslands and prairie slopes	**No potential.** Required habitat not present in study area.
Drummond's campion	*Silene drummondii*	Upland prairies	**No potential.** Required habitat not present in study area.
Clustered broom rape	*Orobanche fasciculate*	Parasitic plant and host plants generally occur in open areas within dry prairies or in loose sandy soils.	**No potential.** Required habitat for host plants not present in study area.
Hall's sedge	*Carex hallii*	Occurs in low prairies and sandy sloughs.	**No potential.** Habitat not present in study area.

Minnesota Special Concern Species with Potential to Occur in Clay County

Common Name	Scientific Name	Habitat Utilized	Potential to Occur in Study Area
Plants			
Least moonwort	*Botrychium simplex*	Rich black ash and cedar swamps and most prairies and disturbed areas.	**No potential.** Required habitat not present in study area.
Small white lady's slipper	*Cypridium candidum*	Open tall grass prairies on dry hillsides with calcareous soils	**No potential.** Required habitat not present in study area.
Red three-awn	*Aristida purpurea* var. *longiseta*	Upland dry or semi-desert grasslands and frequently an indicated of a disturbed site.	**No potential.** Required habitat not present in study area.
Prairie moonwort	*Botrychium campestre*	Occurs in exposed areas within dry prairies and within sand dunes.	**No potential.** Required habitat not present in study area.
Plains reedgrass	*Calamagrrrrostis montanensis*	Dry, upland grasslands	**No potential.** Required habitat not present in study area.
Oat-grass	*Helicotrichon hooker*	Dry meadows	**No potential.** Required habitat not present in study area.
Nuttall's sunflower	*Helianthus nuttallii*	Occurs on moist or recent soils generally in moist meadows, slough margins, and wet roadside ditches.	**No potential.** Required habitat not present in study area.
Northern singlespike sedge	*Carex scirpoiden*	Occurs in wet meadows, and mixed prairies. Often at edge of wet meadows on sunny sites that contain calcareous soils.	**No potential.** Required habitat not present in study area.
Northern gentian	*Gentiana affinis*	Occurs in wet meadows, shores, springs, seepage areas, and low prairies.	**No potential.** Required habitat not present in study area.
Louisiana broom rape	*Orobanche ludoviciana*	Parasitic plant and host plants generally occur in drier areas often in sand or sandy grasslands.	**No potential.** Required habitat for host plants not present in study area.

1.9.2 Minnesota State Threatened and Endangered Species Clay County

Minnesota State Listed Threatened and Endangered Species with Potential to Occur in Clay County					
Common Name	**State Classification**	**Scientific Name**	**Habitat Utilized**	**Reasons for Decline**	**Potential to Occur in Study Area**
Birds					
Baird's sparrow	Endangered	*Ammodramus bairdii*	**Upland prairie.** Restricted to Northern Great Plains and Southern Canadian Prairie Provinces.	Conversion of native prairies to cropland, gravel mining, and nest parasitism by cow birds.	**Low potential.** No native prairies in study area. Most observations in Minnesota are from Felton Prairie in Clay County
Burrowing owl	Endangered	*Athene cunicularia*	**Upland prairie.** Needs burrows formed by other animals (prairie dogs, badgers, etc.).	Loss of pastures and prairies in western Minnesota. Prior to listing In 1984 probably down to 10 breeding pairs. Reintroduction program to date has not been successful.	**Low potential.** No native upland prairie area in study area.
Chestnut-collared longspur	Endangered	*Calcarius ornatus*	**Upland prairie**. In Minnesota has been found almost exclusively at Felton Prairie in Clay County. Breeding territory is usually well drained prairie away from trees and shrubs.	Listed reasons include conversion to cropland, gravel mining area, and in recent years wind farm development.	**Low potential.** No native prairie areas within the study area.
Henslow's sparrow	*Ammodramus Henslowii*	Endangered	**Upland and lowland prairie.** Species required uncultivated grassland or old fields with standing dead vegetation and a substantial litter layer.	Listed reasons include; gravel mining, conversion of native prairie to cropland and urban sprawl. Nest failure can be caused by cattle tramping, snakes, and small mammals.	**Low potential**. No native prairie areas within the study area.

Minnesota State Listed Threatened and Endangered Species with Potential to Occur in Clay County

Common Name	State Classification	Scientific Name	Habitat Utilized	Reasons for Decline	Potential to Occur in Study Area
Sprague's pipit	Endangered	*Anthus spagueii*	**Upland prairie**. Prior to the 1960s, the species was observed annually at Felton Prairie in Clay County. Since 1986, few observation at Felton Prairie or Minnesota in general.	Conversion of native prairies to cropland and gravel mining operations. Conservation efforts need to include protecting and management of remaining native prairie areas.	**Low potential.** No native prairie areas within the study area.
Trumpeter swan	*Cygnus buccinator*	Threatened	**Marsh, littoral zone of lakes.** Was extirpated from Minnesota with lasting breeding population about 1885. Although recovery efforts occurred in the 1960s and 1970, the program gained strength since 1982 and over 350 individuals were released since that time and presently over 2,400 free flyers exist.	Threats are loss of marsh habitat, lead poisoning, collisions with electric power line, and illegal shooting.	**No potential.** No marsh or lakes are located within the study area.
Wilson's phalarope	*Phalaropus tricolor*	Endangered	**Lowland prairie, non-forested rich peatland, wet meadow.** Most frequently found in wet prairie, rich fen, and other grass or sedge dominated wetland. It a shore bird that breeds in the northwest quadrant of the US.	Loss of prairie habitat contributed to its decline. However other factors yet to be determined have also contributed to decline as presently suitable habitat that is un-occupied occurs in Minnesota	**Low potential.** The wetland habitat utilized by the species is not located in the study area

Minnesota State Listed Threatened and Endangered Species with Potential to Occur in Clay County

Common Name	State Classification	Scientific Name	Habitat Utilized	Reasons for Decline	Potential to Occur in Study Area
Invertebrates					
Assiniboia skipper	Endangered	*Hesperia comma assiniboia*	**Upland prairie**. Found in native dry prairie where midheight and short grasses occur. Occurrence in Clay County is primarily Felton Prairie.	Primary threat is overgrazing of prairie areas and conversion of native prairies to cropland and gravel mining areas.	**Low potential**. Study area does not contain any areas with native prairie.
Dakota skipper	Threatened	*Hesperic dactae*	**Upland prairie**. Prefers drymesic to dry prairie with midheight grasses and some topography relief.	Primary threat is conversion of native prairies to other uses including crop production gravel mining, urban development, and recently to wind farms	**Low potential.** Study area does not contain any native prairie areas.
Garita skipper	Threatened	*Darisma garita*	**Upland prairie, savanna**. Northwest Minnesota is the eastern limit of the range it range. It is a grassland species that is dependent upon the survival of its native prairie habitat. It was recorded in Clay County in the late 1960s.	Its decline in abundance is attributable to the conversion of native prairies to cropland, mining areas, and urban development.	**Low potential.** Study area does not contain any native prairie areas.
Uhler's artic	Enangered	*Oenis uhler varuna*	**Upland prairie.** Minnesota is on the eastern edge of its range. One breeding colony has been regularly observed at a large dry prairie site in Clay County.	Conversion of native prairie to cropland and gravel mining areas.	**Low potential.** No upland prairie areas are located within the study area.

Minnesota State Listed Threatened and Endangered Species with Potential to Occur in Clay County					
Common Name	**State Classification**	**Scientific Name**	**Habitat Utilized**	**Reasons for Decline**	**Potential to Occur in Study Area**
Plants					
Hair-like beak rush	Threatened	*Rhynchospora capillacea*	**Non-forested rich peatland.** Predominantly restricted to calcareous fens. These fens are localized, fragile wetlands that are dependant on specific hydrological and geological conditions and are rare in Minnesota. There is a concentration of these fens along the ancient beach ridges of Glacial Lake Agassiz.	Most of these fens have been destroyed by agricultural and gravel mining activities and water management projects.	**Low potential**. This type of wetlands is not located in study area and proposed action would not impact groundwater that discharges to a calcareous fen.
Sterile sedge	Threatened	*Carex sterilis*	**Non-forested rich peatland**. In Minnesota, this species occurs almost exclusively in small, fragile calcareous fens. These fens are localized, fragile wetlands that are dependant on specific hydrological and geological conditions. There is a concentration of these fens along the ancient beach ridges of Glacial Lake Agassiz.	Habitat destruction (conversion to cropland) and water table drawdown (mining) has destroyed most of these fens. The conservation of this species is tied directly to the conservation of these calcareous fens.	**Low potential**. This type of wetlands is not located in study area and proposed action would not impact groundwater that discharges to a calcareous fen.
Whorled nut-rush	Threatened	*Scleria Verticillata*	**Non-forested rich peatland**. This species occurs almost exclusively in small, fragile calcareous fens. These fens are localized, fragile wetlands that are dependant on specific	Most of these fens have been destroyed by agricultural and gravel mining activities and water management projects.	**Low potential.** This type of wetlands is not located in study area and proposed action would not impact groundwater that discharges to a calcareous fen.

			hydrological and geological conditions and are rare in Minnesota. There is a concentration of these fens along the ancient beach ridges of Glacial Lake Agassiz.		

North Dakota Special Status Species with Potential to Occur in Cass County

Common Name	Scientific Name	Habitat Utilized	Potential to Occur in Study Area
Mammals			
Virginia opossum	*Didelphis virginiana*	Wooded areas, especially along rivers and streams.	**Low potential**. Species has not been recorded within the study area.
Southern flying squirrel	*Glaucomys volans*	Heavy deciduous forests.	**Low potential**. Species has not been recorded within the study area.
Water shrew	*Sorex palustris*	Grassy and shrubby areas along banks of streams, ponds, and lakes, and around potholes in bogs or forests.	**Low potential.** Species has not been recorded within the study area.
Eastern spotted skunk	*Spilogale putorius*	Forest edge, riparian woodland, fence rows, and shelterbelts.	**Low potential.** Species has not been recorded within the study area.
Birds			
Whip-poor-will	*Caprimulgus vociferus*	Woods, especially near fields	**Moderate potential.** The species has been reported in the city of Fargo.
Northern cardinal	*Cardinalis cardinalis*	Shrubs and small trees along margins of woods or in forest openings	**Moderate potential.** Species has been reported in Fargo.
Olive-sided flycatcher	*Contopus cooperi*	Forest and woodlands, especially in burned-over areas with standing dead trees in mixed coniferous-deciduous forest.	**No potential.** Species has not been reported to occur within study area
Pileated woodpecker	*Dryocopus pileatus*	Late successional stages of coniferous or deciduous forest, also younger forests that have scattered large, dead trees.	**Low potential.** Species has not been recorded within the study area.
Franklin's gull	*Larus pipixcan*	Lakes, marshes, ponds, and rivers	**Low potential.** Species has not been recorded within the study area.
Hooded merganser	*Lophpdytes cucullatus*	Wood bordered rivers and large creeks, and adjoining oxbows with large populations of small fish.	**Low potential.** Species has not been recorded within the study area.
Northern mocking bird	*Mimus polyglottos*	Parklands, cultivated lands, and second growth habitats	**Low potential.** Species has not been recorded within the study area.

North Dakota Special Status Species with Potential to Occur in Cass County

Common Name	Scientific Name	Habitat Utilized	Potential to Occur in Study Area
Birds			
Blue grosbeak	*Passerina caerulea*	Deciduous woodlands, scattered shrubs in dry fields, thickets near water, farms, old fields, forest edge.	**Low potential.** Species has not been recorded within the study area.
Eastern bluebird	*Sialia sialis*	Forest edge, open woodland interspersed with or adjacent to grazed or mowed grassland. Margins of floodplain and upland deciduous forest.	**Low potential.** Species has not been recorded within the study area.
Solitary vireo	*Vireo solitarius*	Coniferous and mixed open forests and edges.	**No potential.** Required habitat is not located within study area.
Reptiles			
Prairie skink	*Eumeces septentrionalis*	Sandy areas such as sand dunes and sandy grassland.	**No potential.** Habitat used by species not present in study area.
Amphibians			
Mudpuppy	*Necturus maculosus*	Red River	**Low potential.** Species has not been recorded within the study area.
Northern leopard frog	*Rana pipens*	Usually permanent water. In summer inhabits wet meadows and fields.	**Low potential.** Species has not been recorded within the study area.
Fish			
Yellow bullhead	*Ameiurus natalis*	Lakes, ponds, slow moving streams with aquatic vegetation.	**Low potential.** Species has not been recorded within study area but is found in the Red River.
Lake chubsucker	*Erimyzon sucetta*	Ponds, lakes, oxbows, sloughs with clear water.	**No potential.** Habitat used by species not present in study area.
Western silvery minnow	*Hybognathus argyritis*	Larger prairie streams with not much current and sand bottoms.	**Low potential.** Species has not been recorded within the study area.
Silver chub	*Hubopsis storeriana*	Sand-silt, grave-bottomed rivers and lakes.	**No potential.** Habitat used by species not present in study area.
Greater redhorse	*Moxostoma valenciennesi*	Clear, moderate to fast flowing rivers.	**Low potential.** Habitat used by species not common in study area.
Rosyface shiner	*Notropis rubellus*	Medium sized streams in shallow water over gravel.	**Low potential.** Habitat used by species not present in study area. Species found in Red River.

Fish			
River darter	*Percina shumardi*	Large rivers in deep chutes and riffles with swift current and gravel bottoms.	**Low potential.** Species Extirpated from the tributaries but is still found in Red River.
Trout-perch	*Percopsis omiscomaycus*	Lakes, deep flowing creeks, and rivers over sand.	**Moderate potential.** Species is present in the Red River and all of the tributaries in the study area.
Northern redbelly dace	*Phoxinus eos*	Slow flowing creeks with clear water and vegetation.	**Moderate potential.** Species has been identified in the Red, Sheyenne, and Rush Rivers.
Mussels			
Wabash pigtoe mussel	*Fusconaia flava*	Large permanent streams.	**Moderate potential.** Species has been sampled in the Sheyenne River, near study area.
Black sandshell mussel	*Ligumia recta*	Large permanent streams.	**Moderate potential.** Species has been sampled in the Sheyenne River, near study area.
Mapleleaf mussel	*Quadrula quadrula*	Large permanent streams.	**Moderate potential.** Species has been sampled in the Red River, near study area.
Insects			
Belfragi's chlorochroan bug	*Chlorochroa belfragii*	Native wet prairie habitats, swamps, marshes, seeps	**No potential.** Habitat used by species not present in study area.
Acastus checkerspot	*Chlosyne acastus*	Sagebrush scrub, pinyon-juniper woodland, and dry gulches.	**No potential.** Habitat used by species not present in study area.
Ottoe skipper	*Hesperia ottoe*	Mid-grass to tall grass prairies and dry fields.	**No potential.** Habitat used by species not present in study area.
Tawny crescent	*Phyciodes batesii*	Moist forest borders in riparian situations and moist valley bottoms that border riparian woodlands	**No potential.** Habitat used by species not present in study area.
Regal fritillary	*Speyeria idalia*	Virgin tall grass prairies	**No potential.** Habitat used by species not present in study area.
Plants			
Sullivant's milkweed	*Asciepias sullivantii*	Mesic tallgrass prairies	**No potential.** Habitat used by species not present in study area.
Fescue sedge	*Carex festucacea*	Wooded areas.	**Low potential.** Species has not been recorded within the study area.
Richardson's sedge	*Carexrichardsonii*	Low, usually sandy prairies.	**No potential.** Habitat used by species not present in study area.

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Plants

Blue cohosh	*Caulophyllum thalictroides*	Most rich woods	**Low potential.** Species has not been reported in study area. In 1982 the species was reportedly located in the vicinity of the study area.
Downy hawthorn	*Crataegus mollis*	Open mesic woods	**Low potential.** Species has not been recorded within the study area
Brook flatsedge	*Cyperus bipartitus*	Cool, spring-fed streams	**No potential.** Habitat used by species not present in study area.
White lady's slipper	*Cypripedium candidum*	Low prairies, wet meadows.	**No potential.** Habitat used by species not present in study area.
Crested woodfern	*Dryopteris cristate*	Swampy woods and thickets, seeps	**No potential.** Habitat used by species not present in study area.
Wolf's spikerush	*Eleocharis wolfii*	Shore and low, wet prairies.	**No potential.** Habitat used by species not present in study area.
Meadow horsetail	*Equisetum pretense*	Moist boggy woods, shady river banks and shores.	**Low potential.** Species has not been recorded within the study area.
Wild geranium	*Geranium maculatum*	Rich eastern, deciduous woods.	**Low potential.** Species has not been recorded within the study area.
Small-flowered lipocarpha	*Lipocarpha micrantha*	Wet sandy areas, sandbars.	**No potential.** Habitat used by species not present in study area.
One-flowered broom rape	*Orobanche uniflora*	Damp woods and thickets.	**Low potential.** Species has not been recorded within the study area.
Downy phlox	*Phlox pilosa*	Mesic prairies of open woods.	**No potential.** Habitat used by species not present in study area.
Prickly gooseberry	*Ribes cyonsbati*	Moist rich woods.	**Low potential.** Species has not been recorded within the study area.
Zigzag goldenrod	*Solidago flexicaulis*	Rich deciduous wood.	**Low potential.** Species has not been recorded within the study area.
Sessile-leaved bellwort	*Uvularia sessilifolia*	Rich deciduous wood.	**Low potential.** Species has not been recorded within the study area.
Bog violet	*Viola conspersa*	Moist woods, stream banks.	**Low potential**. Species has not been recorded within the study area.

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1.10 Floodplain Forest Mitigation Field Work

Floodplain Forest field notes: 7/19/2010

Minnesota Diversion Alternative: Red River MN Inlet (beginning of Diversion channel)

Bruce Kreft with the North Dakota Game and Fish and Jon Sobiech gathered data for the impacted area on the Red River where the Minnesota Diversion would begin. The larger tracts of forest are on the East side or Minnesota side which is why we chose to analyze this side only. The tract of forest on the North Dakota side (west side) was a very thin stand and could be seen from the opposite bank, it was determined that the stand was representative of the analyzed stand.

Information gathered included tree identification, size, health, quantity, vegetation identification, Secchi readings, shoreline observations, snag tree counts, cavity counts, and a variety of other criteria to gather information for Habitat Evaluation Procedures models including the Belted King Fisher, Mink, Gray Squirrel, Black Capped Chickadee, and wood duck.

This area was broken up into two stands, the stand along the river and the stand that runs parallel to another unnamed drainage, both areas would be impacted by the designed project.

The first stand is an 80 foot wide corridor along the Red River; this appears to be a bit larger but similar to the corridor on the North Dakota side of the river. On the land side of the 80 foot wide corridor is a somewhat restored prairie that will also be impacted. The species in the prairie included some native grasses and forbs. There were also a fair number of non-natives and invasives, the stand hasn't been managed for a few years based on observation. The forested corridor is a nice looking stand containing a diverse mix of species including bur oak, green ash, American elm, basswood, with a scattering of prickly ash in the understory and Virginia wild rye as ground cover.

The dominant overstory for this stand is green ash and American elm, with bur oak a dominant overstory species on the north end of the stand. The dominant mid-story species is hackberry and boxelder with average heights at 10 feet, there is also a scattering of prickly ash more notably toward the north end of the stand. The dominant understory species is Virginia wild rye, mint and beggars-tick. Based on a transect conducted the stand consists of 20% bur oak, 40% green ash, 35% American elm, and 5% basswood. The average DBH for the stand is 11 inches and the average height is 45 feet tall.

The average crown cover of the first stand is 90% coverage, with a ground cover of only 25% most likely due to the common flooding in the area.

Overall the stand was fairly healthy (eight of the trees rated out to be fair); the fair species had some die-back on the lower limbs. There were 20 cavities counted along this stand, and approximately 30 snags per acre with an average DBH of 13. The basal area for this stand is 110 ft^2/acre, with approximately 360 trees per acre.

The second stand is a larger more homogeneous stand consisting of a monoculture of fairly small green ash with a few American elm mixed in. It was also noted that there were some large bur oak at the northern end of the stand where there is slightly higher ground. This stand followed an unnamed drainage with running water source approximately 1-2 feet deep and 6-10 feet wide. The dominant overstory of this stand is green ash with a few American elm scattered throughout the overstory, there were also a few hackberry, boxelder and cottonwood within this stand. The mid-story was made up of green ash at an average of 25 feet tall and American elm at 20 feet tall. The understory consisted of

wood nettle, mint, mustard, and beggars-tick. The transect revealed that approximately 70% of the stand is green ash with approximately 30% of the stand being American elm, the average diameter of the overstory species for the stand is 10 inches with an average height of 41 feet.

The average crown cover of the second stand is 70% coverage, with a ground cover of only 35%.

Overall the stand was fairly healthy (four of the trees rated out to be fair); the fair species had some die-back on the lower limbs. There were 7 cavities counted along this stand, and approximately 20 snags per acre with an average DBH of 15 inches. The basal area for this stand is 75 ft^2/acre, with approximately 400 trees per acre.

The stands were combined for the HEP analysis for this area.

Belted Kingfisher:

V2 The Secchi readings averaged out to be 8 inches in this area of the Red River.

V3 15% of water surface obstruction in a 15 meter zone from shore.

V4 45 % of the water depth is 24 inches deep or greater.

V5 5 % of the stream has riffles.

V6 All of the subsections in this area have perches for king fishers.

V7 There are no soil banks containing 70-96% sand, it is mostly clayey sand in this area, there are locations within a mile that have steep faces void of vegetation and greater than 1.5 meters in height.

Gray Squirrel

V1 15% of the canopy is hard mast trees (Bur Oak) no other hard mast tree species were found in the stand.

V2 There were 25 Bur Oak trees found in this stand, that was the only hard mast species.

V3 77% of the ground was shaded by canopy cover.

V4 The mean dbh for the stand is 14 inches.

Wood Duck

V1 There were 27 suitable cavities in the entire stand, 3 cavities per acre.

V2 There were no nest boxes found at either site.

V3 the total nesting opportunities equals 3 nesting sites per acre.

V4 Approximately 20% of the water surface is covered by potential brood cover.

Black Capped chickadee

V1 77% of the ground was shaded by canopy cover.

V2 Average height of the overstory trees is approximately 43 feet.

V4 There is approximately 15 snags per acre that would measure between 4-10 inches DBH.

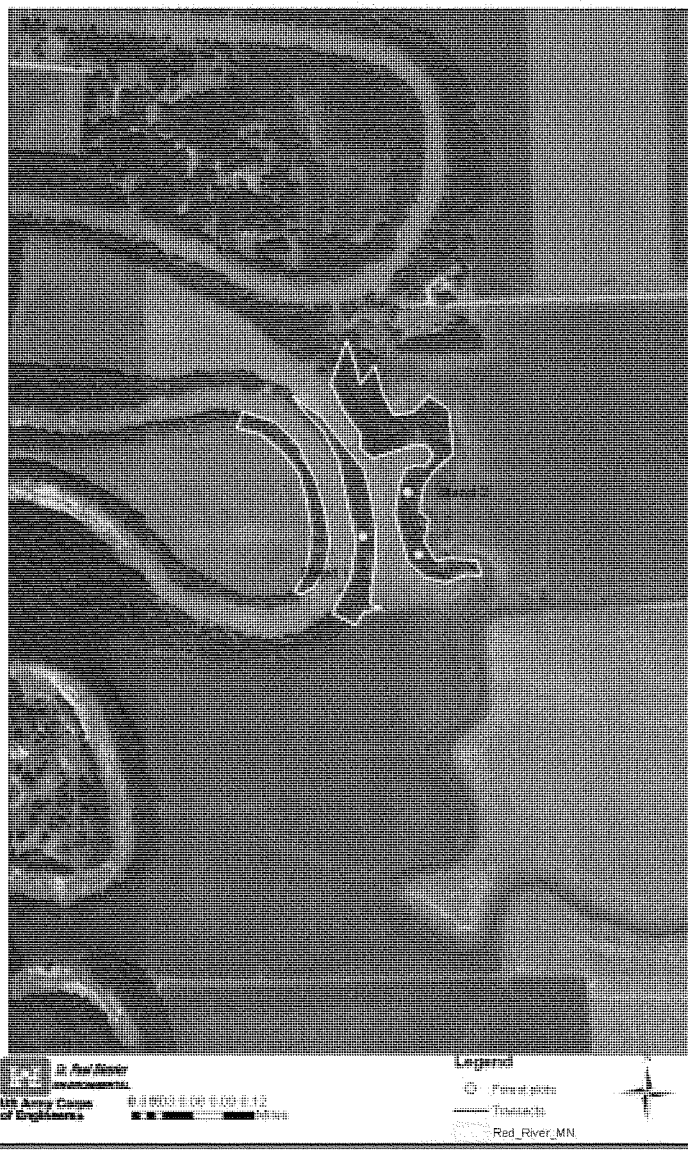
Mink

V1 77 % canopy closure

V2 100 percent of the year there is surface water present

V4 80% canopy closure within 328 feet of water's edge.

Floodplain Forest impacted by Minnesota Diversion Inlets



Floodplain Forest field notes 7/19/2010

Minnesota Diversion Alternative: Red River MN Inlet to Smaller Diversion channel

Bruce Kreft with the North Dakota Game and Fish and Jon Sobiech gathered data for the impacted area on the Red River where the smaller Diversion would leave the river before connecting with MN diversion channel further north. The forest on the Minnesota side of the river was all that was analyzed because permission was not granted for the lands on the North Dakota side in this area. Based on field observations the stands on the North Dakota side are representative of the Minnesota stands we analyzed.

Information gathered included tree identification, size, health, quantity, vegetation identification, Secchi readings, shoreline observations, snag tree counts, cavity counts, and a variety of other criteria to gather information for Habitat Evaluation Procedures models including the Belted King Fisher, Mink, Gray Squirrel, Black Capped Chickadee, and wood duck.

Overall the stand seemed to vary from a younger very aggressively regenerating stand; this stand was very narrow approximately 100 feet wide before abutting up to an agriculture field. The stand looked very good, the middle of the stand contained much more mature trees and we noted a large infestation of the non-native invasive garlic mustard plant. Garlic mustard is extremely aggressive plant that can take over the entire understory preventing tree species from regenerating. The garlic mustard appeared to have a pretty good foothold already, but the area was less than acre in size where it was found. This area had much larger tree's including several Bur Oak.

Two stand mapping plots were done for this stand information gathered on this field sheet showed that the dominant overstory tree species for this stand is green ash and bur oak; secondary dominant overstory species include American elm, boxelder, and hackberry. Based on the transect conducted the stand consists of 10% elm and 90% green ash. The average diameters at breast height (DBH) for the overstory tree species are 12 inches and the average height is 45 feet. The mid story was dominated by boxelder trees with average heights at 15 feet and hackberry with average heights of 10 feet. There were also bur oak, green ash, boxelder and hackberry seedlings.

The average crown cover is 90% coverage for the entire stand, with a ground cover of only 78%. Other species of interest included Virginia wild Rye.

Overall the stand was very healthy other than the presence of the garlic mustard. The basal area for the stand is 110 ft^2/acre. There is approximately 610 trees per acre, approximately 5 snags per acre, and 7 cavities counted during the stand exam.

Belted Kingfisher:

V2 The Secchi readings averaged out to be 7 inches in this area of the Red River.

V3 10% of water surface obstruction in a 15 meter zone from shore.

V4 85% of the water depth is 24 inches deep or greater.

V5 5 % of the stream has riffles.

V6 All of the subsections in this area have perches for king fishers.

V7 There are no soil banks containing 70-96% sand, it is mostly clayey sand in this area, there are locations within a mile that have steep faces void of vegetation and greater than 1.5 meters in height.

Gray Squirrel

V1 40% of the canopy is hard mast trees (Bur Oak).

V2 28 Bur Oak trees found in this stand.

V3 90% of the ground was shaded by canopy cover.

V4 The mean dbh for the stand is 12 inches.

Wood Duck

V1 There were 10 suitable cavities in the entire stand, there is 1.2 suitable cavities per acre.

V2 There were no nest boxes found.

V3 the total nesting opportunites equals 1.2 per acre.

V4 10% of the water surface is covered by potential brood cover.

Black Capped chickadee

V1 90% of the ground was shaded by canopy cover.

V2 Average height of the overstory trees is approximately 45 feet.

V4 5 snags per acre

Mink

V1 90 % canopy closure

V2 100 percent of the year there is surface water present

V4 90% canopy closure within 328 feet of water's edge.

Floodplain Forest Impacted by Minnesota Diversion South Inlet
St. Paul District
ENVIRONMENTAL
US Army Corps of Engineers
0 0.0125 0.05 0.075 0.1
Miles
Legend
Forest plots
Transects
Red_River_MN
N

Floodplain Forest field notes 7/20/2010

Minnesota Diversion Alternative: Red River Minnesota Outlet (diversion back into the Red River)

Jon Sobiech gathered data for the impacted area on the Minnesota side of the Red River, at the location where the Minnesota Diversion channel would be re-entering the Red River. The North Dakota side was observed from the other bank because permission was not granted for the North Dakota Side. The stands are very similar and representative of each other.

Information gathered included tree identification, size, health, quantity, vegetation identification, Secchi readings, shoreline observations, snag tree counts, cavity counts, and a variety of other criteria to gather information for Habitat Evaluation Procedures models including the Belted King Fisher, Mink, Gray Squirrel, Black Capped Chickadee, and wood duck.

Two stand mapping plots were done for this stand, information gathered on the field sheets showed that the dominant overstory tree species for this stand is green ash, secondary dominant species is American elm and boxelder, with the only other tree species being a few bur oak trees at the edge of the stand near agriculture fields approximately 400 feet from the water's edge. Based on the transect conducted the stand consists of 5% elm, 20% boxelder, and 75% green ash. The average diameters at breast height (DBH) for the overstory tree species are 15 inches and the average height is 56 feet. The mid story was dominated by American elm and green ash trees with average heights at 15-20 feet. Other Mid-story species included boxelder. The understory consisted of several American elm seedlings, stinging nettle, green ash seedlings, wild grape vines, beggars-tick, and reed canary grass.

The average crown cover was 63% coverage for the entire stand, with a ground cover of 50% most likely due to the common flooding in the area. The stand was very monotypic only consisting of the aforementioned species there were no other tree species present other then the few bur oak trees near the agriculture fields.

Overall the stand was very healthy (all 20 trees in the transect rated good), with very little invasive species present. The basal area for the stand is 105ft^2/acre. There are approximately 580 trees per acre, approximately 40 snags per acre, and 11 cavities counted during the stand exam.

Belted Kingfisher:

V2 The Secchi readings averaged out to be 6 inches in this area of the Red River.

V3 5% of water surface obstruction in a 15 meter zone from shore.

V4 60 % of the water depth is 24 inches deep or greater.

V5 5% of the stream has riffles.

V6 All of the subsections in this area have perches for king fishers.

V7 There are no soil banks containing 70-96% sand, it is mostly clayey sand in this area, there are locations within a mile that have steep faces void of vegetation and greater than 1.5 meters in height..

Gray Squirrel

V1 5% of the canopy is hard mast trees (Bur Oak), There were only a few bur oak in this stand and they were on the very edge.

V2 There were 4 Bur Oak found in this stand.

V3 63% of the ground was shaded by canopy cover.

V4 The mean dbh for the stand is 15 inches.

Wood Duck

V1 There were 11 suitable cavities in the entire stand, 1.4 per acre.

V2 There were no nest boxes found in the area.

V3 the total nesting opportunites equals 1.4

V4 10% of the water surface is covered by potential brood cover.

Black Capped chickadee

V1 63% of the ground was shaded by canopy cover.

V2 Average height of the overstory trees is approximately 56 feet.

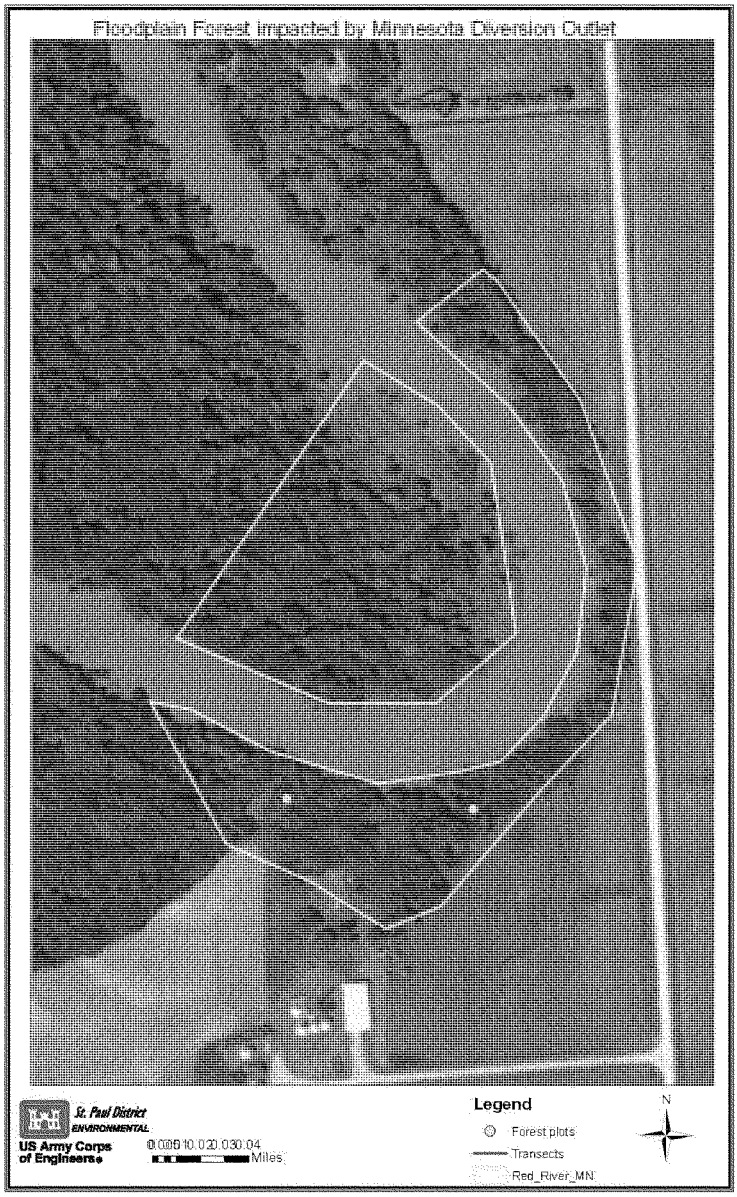
V4 40 snags per acre

Mink

V1 63 % canopy closure

V2 100 percent of the year there is surface water present

V4 50% canopy closure within 328 feet of water's edge.


Floodplain Forest Impacted by Minnesota Diversion Outlet
St. Paul District
ENVIRONMENTAL
US Army Corps of Engineers
0 0.005 0.01 0.02 0.03 0.04
Miles
Legend
Forest plots
Transects
Red_River_MN
N

Floodplain Forest field notes 7/19/2010

North Dakota Diversion Alternative: Red River North Dakota Inlet (beginning of diversion channel)

Bruce Kreft with the North Dakota Game and Fish and Jon Sobiech gathered data for the impacted area on the North Dakota side of the Red River, at the location where the North Dakota Diversion channel would be placed diverting water out of the Red River. The Minnesota side was observed from the other bank because permission was not granted on the Minnesota side.

Information gathered included tree identification, size, health, quantity, vegetation identification, Secchi readings, shoreline observations, snag tree counts, cavity counts, and a variety of other criteria to gather information for Habitat Evaluation Procedures models including the Belted King Fisher, Mink, Gray Squirrel, Black Capped Chickadee, and wood duck.

Two stand mapping plots were done for this stand information gathered on this field sheet showed that the dominant overstory tree species for this stand is the Green Ash and Boxelder, a secondary dominant species is the American Elm, with scattered Black Willow near the water's edge and a few large bur oak trees at the edge of the agriculture fields and at the southern end of the stand near a house. Based on the transect conducted the stand consists of 40% elm, 20% boxelder, 15% bur oak, 5% hackberry, and 20% green ash. The average diameters at breast height (DBH) for the overstory tree species are 15 inches and the average height is 52 feet. The mid story was dominated by boxelder trees with average heights at 20 feet. Other Mid-story species included American elm and hackberry. There were a few bur oak seedlings in the understory.

The average crown cover was 90% coverage for the entire stand, with a ground cover of only 5% most likely due to the common flooding in the area. Other species of interest included Virginia wild Rye, nettles, Choke cherry, moonseed, beggars-tick and violets.

Overall the stand was very healthy (only two trees rated lower then good), with very little invasive species. The basal area for the stand is 95ft^2/acre. There are approximately 240 trees per acre, approximately 20 snags per acre, and 15 cavities counted during the stand exam. If the stand was left alone it would continue as a Green Ash, American elm, and boxelder stand with some willows creeping in along the drainage areas and the bur oak encroaching when the flooding doesn't occur so often.

Belted Kingfisher:

V2 The Secchi readings averaged out to be 10 inches in this area of the Red River.

V3 10% of water surface obstruction in a 15 meter zone from shore.

V4 70 % of the water depth is 24 inches deep or greater.

V5 5 % of the stream has riffles.

V6 All of the subsections in this area have perches for king fisher's.

V7 There are no soil banks containing 70-96% sand, it is mostly clayey sand in this area, there are locations within a mile that have steep faces void of vegetation and greater than 1.5 meters in height.

Gray Squirrel

V1 10% of the canopy is hard mast trees (Bur Oak).

V2 There were 15 Bur Oak trees found in this stand.

V3 90% of the ground was shaded by canopy cover.

V4 The mean dbh for the stand is 15 inches.

Wood Duck

V1 There were 15 suitable cavities in the entire stand, 2.4 suitable cavities per acre.

V2 One nest box was found during the surveys.

V3 the total nesting opportunities for this area are 2.6 cavities per acre.

V4 10% of the water surface is covered by potential brood cover.

Black Capped chickadee

V1 90% of the ground was shaded by canopy cover.

V2 Average height of the overstory trees is approximately 50 feet.

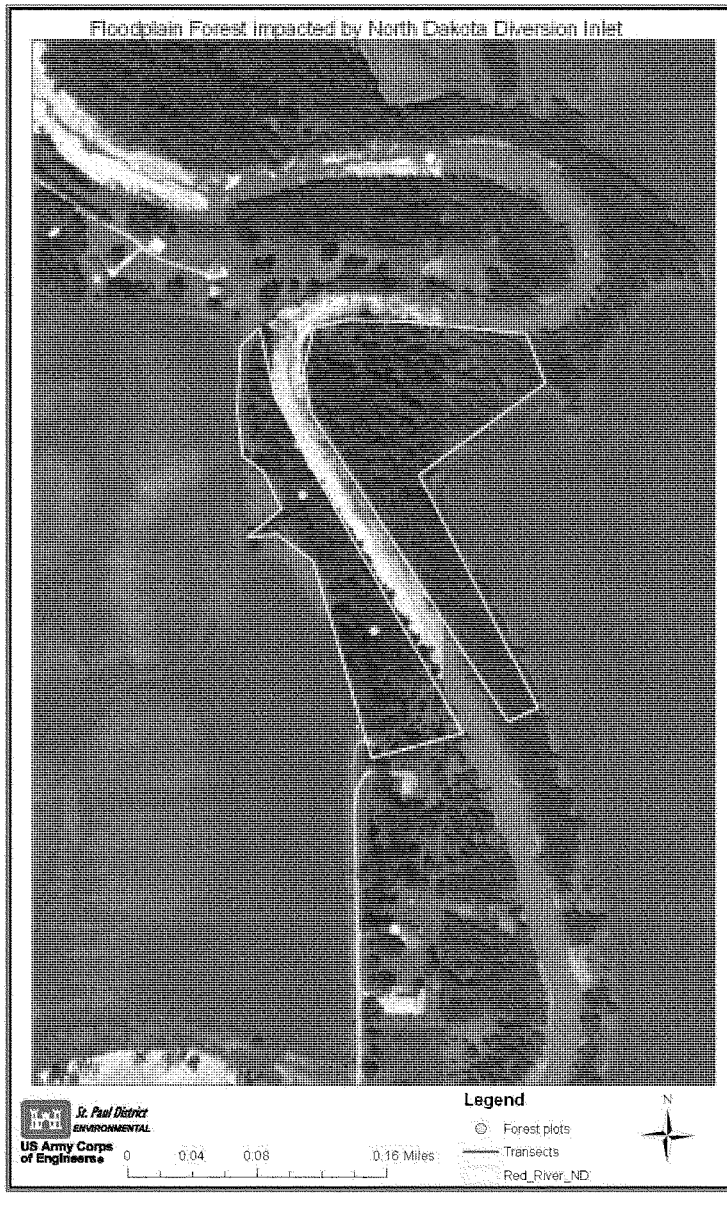
V4 20 snags per acre

Mink

V1 90 % canopy closure

V2 100 percent of the year there is surface water present

V4 80% canopy closure within 328 feet of water's edge.


Floodplain Forest Impacted by North Dakota Diversion Inlet
St. Paul District
ENVIRONMENTAL
US Army Corps of Engineers
0
0.04
0.08
0.16 Miles
Legend
Forest plots
Transects
Red_River_ND
N

Floodplain Forest field notes 7/20/2010

North Dakota Diversion Alternative: Red River North Dakota Outlet (diversion back into the Red River)

Jon Sobiech gathered data for the impacted area on the Minnesota side of the Red River, at the location where the North Dakota Diversion channel would be re-entering the Red River. The North Dakota side was observed from the other bank because permission was not granted for the North Dakota Side. The stands are very similar and representative of each other.

Information gathered included tree identification, size, health, quantity, vegetation identification, Secchi readings, shoreline observations, snag tree counts, cavity counts, and a variety of other criteria to gather information for Habitat Evaluation Procedures models including the Belted King Fisher, Mink, Gray Squirrel, Black Capped Chickadee, and wood duck.

Three stand mapping plots were done for this stand, information gathered on the field sheets showed that the dominant overstory tree species for this stand is green ash and boxelder, the secondary dominant species is the American elm, there were also a few black willow in the stand. Based on the transect conducted the stand consists of 15% elm, 50% boxelder, and 35% green ash. The average diameters at breast height (DBH) for the overstory tree species are 10 inches and the average height is 45 feet. The mid story was dominated by boxelder, American elm and green ash trees with average heights at 10-20 feet. The understory consisted of beggar- tick, nettle and coneflowers, along the river there was smart weed, dock and reed canary grass.

The average crown cover was 85% coverage for the entire stand, with a ground cover of 45% most likely due to the common flooding in the area which was evident by the still cracking soil indicating that the water had receded recently. The stand was very monotypic only consisting of the aforementioned species there were no other tree species present.

Overall the stand was fairly healthy with some of the trees showing die-back from being suppressed by the larger trees and possibly due to extended flooding. Fourteen of the trees in the transect are in good condition while 6 are in fair condition and one tree was rated poor; the basal area for the stand is 106 ft^2/acre. There is approximately 440 trees per acre, between 20-30 snags per acre, and 30 cavities counted during the stand exam.

Belted Kingfisher:

V2 The Secchi readings averaged out to be 7 inches in this area of the Red River.

V3 5% of water surface obstruction in a 15 meter zone from shore.

V4 60 % of the water depth is 24 inches deep or greater.

V5 5% of the stream has riffles.

V6 All of the subsections in this area have perches for king fishers.

V7 There are no soil banks containing 70-96% sand, it is mostly clayey sand in this area, there are locations within a mile that have steep faces void of vegetation and greater than 1.5 meters in height.

Gray Squirrel

V1 There are no hard mast trees in this stand.

V2 No mast trees

V3 85% of the ground was shaded by canopy cover.

V4 the mean dbh for the stand is 10 inches.

Wood Duck

V1 There were 30 suitable cavities counted in during the walk through of the stand, it was determined that there are 4.3 cavities per acre.

V2 there were no nest boxes found in the area.

V3 total of V1 plus V2 (.18 X V1) + (.95 X V2) = .774

V4 5% of the water surface is covered by potential brood cover, the majority of the water's edge is completely exposed.

Black Capped chickadee

V1 85% of the ground was shaded by canopy cover.

V2 Average height of the over story trees is approximately 45 feet.

V4 20-30 snags per acre, 10-15 snags per acre between 4-10 inches DBH.

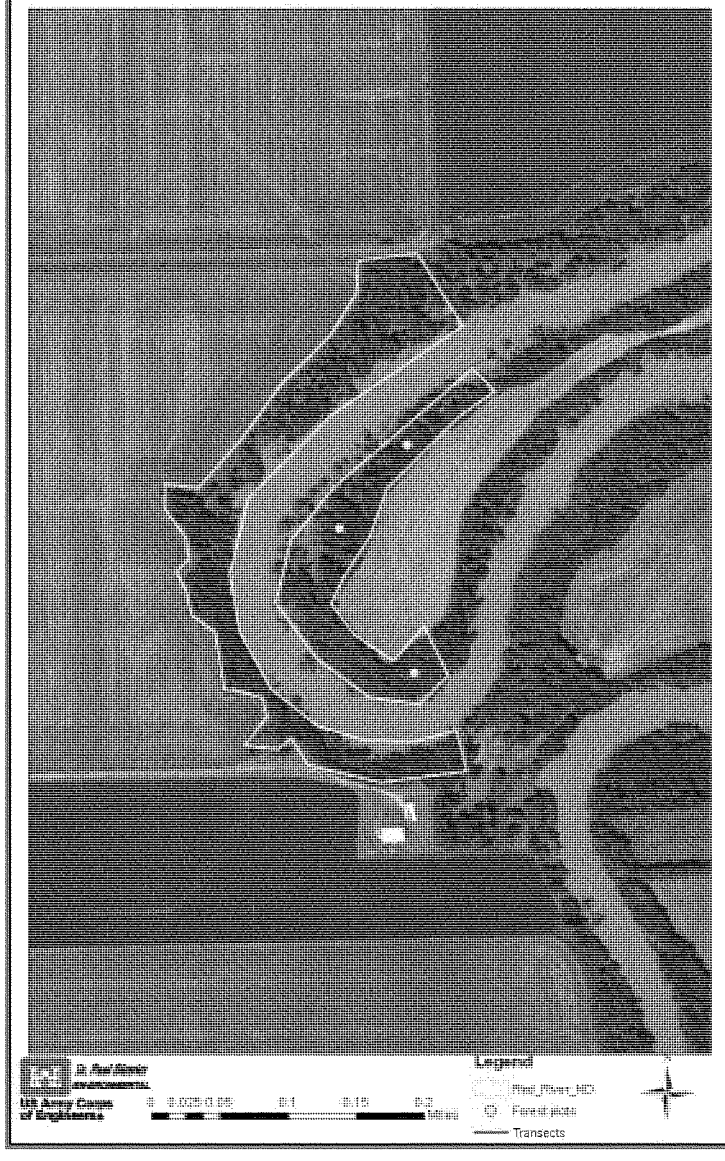
Mink

V1 85 % canopy closure

V2 100 percent of the year there is surface water present

V4 35% canopy closure within 328 feet of water's edge.

Floodplain Forest impacted by North Dakota Inlet



Floodplain Forest field notes 7/19/2010

North Dakota Diversion Alternative: Sheyenne River

Bruce Kreft with the North Dakota Game and Fish and Jon Sobiech gathered data for the impacted area on the Sheyenne River where the North Dakota Diversion would intersect the river. The larger tract of forest is on the east side of the River so that is the stand that was analyzed. The opposite bank was observed and notes were taking from the surveyed stand.

Information gathered included tree identification, size, health, quantity, vegetation identification, Secchi readings, shoreline observations, snag tree counts, cavity counts, and a variety of other criteria to gather information for Habitat Evaluation Procedures models including the Belted King Fisher, Mink, Gray Squirrel, Black Capped Chickadee, and wood duck.

Overall the stand was very poor, at the beginning near the home of David and Annette Delaney there were several basswood trees, which was surprising because there were very few basswoods observed anywhere else, it was obvious that some basswood were planted at the homestead many years ago and I think they have spread regenerated in the southern part of the stand. The south end of the stand was on a ridge and it gradually got lower in elevation as we headed downstream (north). The majority of the stand was a scattering of larger boxelder and ash tree with the entire midstory dominated by buckthorn a European invasive species.

Two stand mapping plots were done for this stand, information gathered on this field sheet indicate that the dominant overstory tree species for this stand is American elm and Boxelder, a secondary dominant species is the American basswood. Based on the transect conducted the stand consists of 30% elm, 55% boxelder, 5% buckthorn, and 10% green ash. The average diameters at breast height (DBH) for the overstory tree species are 13 inches and the average height is 51 feet. The mid story was dominated by buckthorn at an average height of 8 feet; there were also some scattered elm in the midstory averaging 10 feet.

The average crown cover was 75% coverage for the entire stand, with a ground cover of 60% which is a result of being shaded out by the buckthorn. The understory consisted of mainly wood nettle and beggars-tick.

Overall the stand was in poor health (only eight trees rated good, with one of them being buckthorn). The other trees rated either poor or fair. The future of the stand looks to be buckthorn with very little other regeneration. The basal area for the stand is 95^2/acre. There are approximately 380 trees per acre, approximately 5 snags per acre, and 11 cavities counted during the stand exam.

Belted Kingfisher:

V2 The Secchi readings averaged out to be 7 inches in this area of the Red River.

V3 10% of water surface obstruction in a 15 meter zone from shore.

V4 30 % of the water depth is 24 inches deep or greater.

V5 5% of the stream has riffles.

V6 All of the subsections in this area have perches for king fisher's.

V7 There are no soil banks containing 70-96% sand, it is mostly clay in this area, however the other nesting requirements are within .5 miles of the area and there are species present so it is assumed that they are nesting in the silty clay.

Gray Squirrel

V1 0% of the canopy is hard mast trees.

V2 There were no hard mast trees found in the stand.

V3 75% of the ground was shaded by canopy cover.

V4 The mean dbh for the stand is 13 inches.

Wood Duck

V1 There were 11 suitable cavities in the entire stand, 3.5 suitable cavities per acre.

V2 No nest boxes were found in the stand.

V3 the total nesting opportunities equals 3.5 per acre.

V4 10% of the water surface is covered by potential brood cover.

Black Capped chickadee

V1 75% of the ground was shaded by canopy cover.

V2 Average height of the overstory trees is approximately 51 feet.

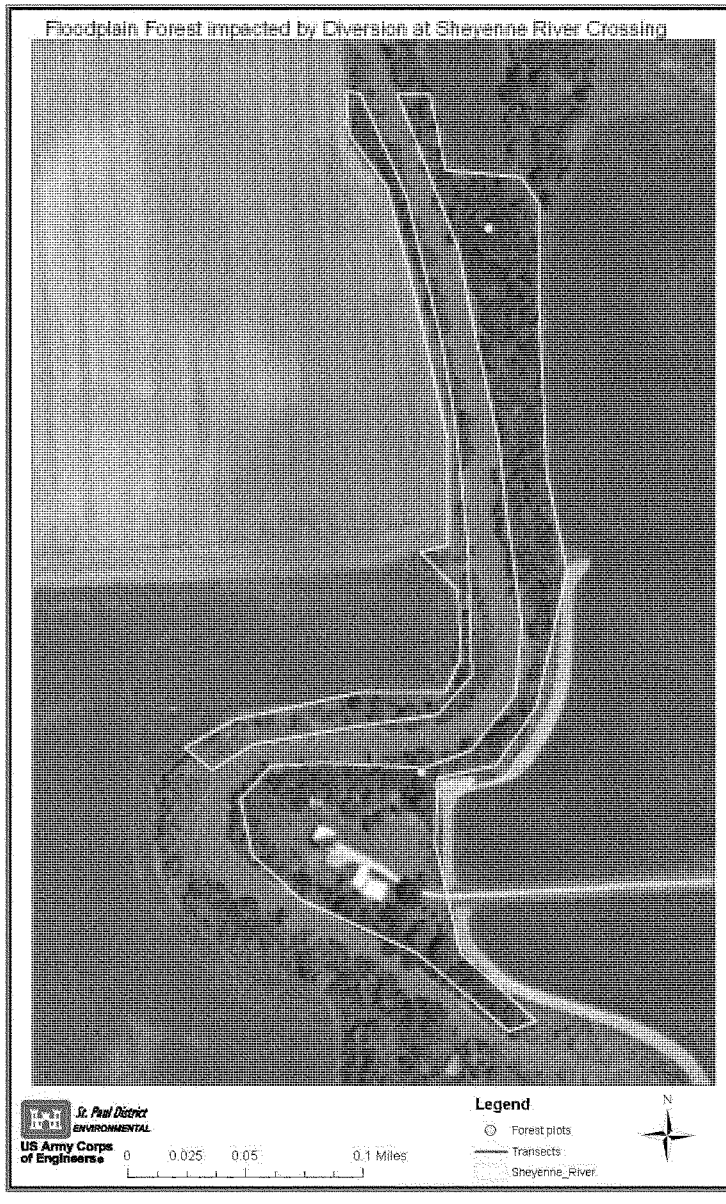
V4 5 snags per acre between 4-10 inches DBH

Mink

V1 75 % canopy closure

V2 100 percent of the year there is surface water present

V4 70% canopy closure within 328 feet of water's edge.


Floodplain Forest impacted by Diversion at Sheyenne River Crossing
St. Paul District
ENVIRONMENTAL
US Army Corps of Engineers
0
0.025
0.05
0.1 Miles
Legend
Forest plots
Transects
Sheyenne_River
N

Floodplain Forest field notes 7/19/2010

North Dakota Diversion Alternative: Wild Rice River Crossing

Bruce Kreft with the North Dakota Game and Fish and Jon Sobiech gathered data for the impacted area on the East side of the Wild Rice River, at the location where the North Dakota Diversion channel would cross the Wild Rice River.

Information gathered included tree identification, size, health, quantity, vegetation identification, Secchi readings, shoreline observations, snag tree counts, cavity counts, and a variety of other criteria to gather information for Habitat Evaluation Procedures models including the Belted King Fisher, Mink, Gray Squirrel, Black Capped Chickadee, and wood duck.

Four stand mapping plots were done for this stand, information gathered on this field sheet indicates that the dominant overstory tree species for this stand are Green ash, bur oak, and boxelder, other overstory tree species observed include American elm and hackberry. Based on the transect conducted the stand consists of 10% elm, 20% boxelder, 15% bur oak, 20% hackberry, and 35% green ash. The average diameters at breast height (DBH) for the overstory tree species are 13 inches and the average height is 46 feet. The mid story was dominated by green ash average height 20 feet, hackberry average height 15 feet, elm average height 25 feet and boxelder average height of 15 feet, there were also scattered choke cherry at an average height of 12 feet tall.

The average overall crown cover for the stand is 85%, with a ground cover that covers 70% of the area. The dominant understory species is beggars-tick, wood nettle, wild grape, violet, and moonseed. An average green ash tree was cored and it was determined to be 45 years old, this tree had a DBH of 15 and is 62 feet tall.

There was obvious snagging and clearing that occurred near this stand, there were several stumps along the shoreline of the river leaving the river's edge pretty much void of any overhanging shrubs or tree cover. A secchi reading was taken at 3 sites and 7 inches of clarity was revealed at all 3 sites.

Overall the stand was very healthy (only one tree rated lower then good), with very little invasive species present in the stand. There is approximately 300 trees per acre, with another 400-500 seedlings and saplings per acre, the basal area for the stand is 125 ft^2/acre. There were between 20-25 snags per acre with 12 cavities counted within the stand. A family of wood ducks was sighted; the ducklings were very small and were obviously hatched within the stand.

Belted Kingfisher:

V2 The Secchi readings averaged out to be 7 inches.

V3 5% of water surface obstruction in a 15 meter zone from shore.

V4 50% of the water depth is 24 inches deep or greater.

V5 5 % of the stream has riffles.

V6 All of the subsections in this area have perches for king fishers.

V7 There are soil banks very near the site that meat the criteria of steep banks, no vegetation, and greater the 1.5 meters in height, however the percentage of sand varies.

Gray Squirrel

V1 20% of the canopy is hard mast trees (Bur Oak).

V2 There were approximately 35 Bur Oak found in this stand 1 species.

V3 85% of the ground was shaded by canopy cover.

V4 The mean dbh for the stand is 13 inches.

Wood Duck

V1 There were 12 suitable cavities counted in the stand, approximately 5 per acre.

V2 There were no nest boxes found during the surveys.

V3 There are approximately 5 nesting opportunities per acre.

V4 5% of the water surface is covered by potential brood cover.

Black Capped chickadee

V1 85% of the ground was shaded by canopy cover.

V2 Average height of the overstory trees is approximately 48 feet.

V4 There are approximately 10-15 snags per acre, average diameter of snags is approximately 12 inches DBH. There are approximately 7-10 snags per acre between 4-10 inches DBH.

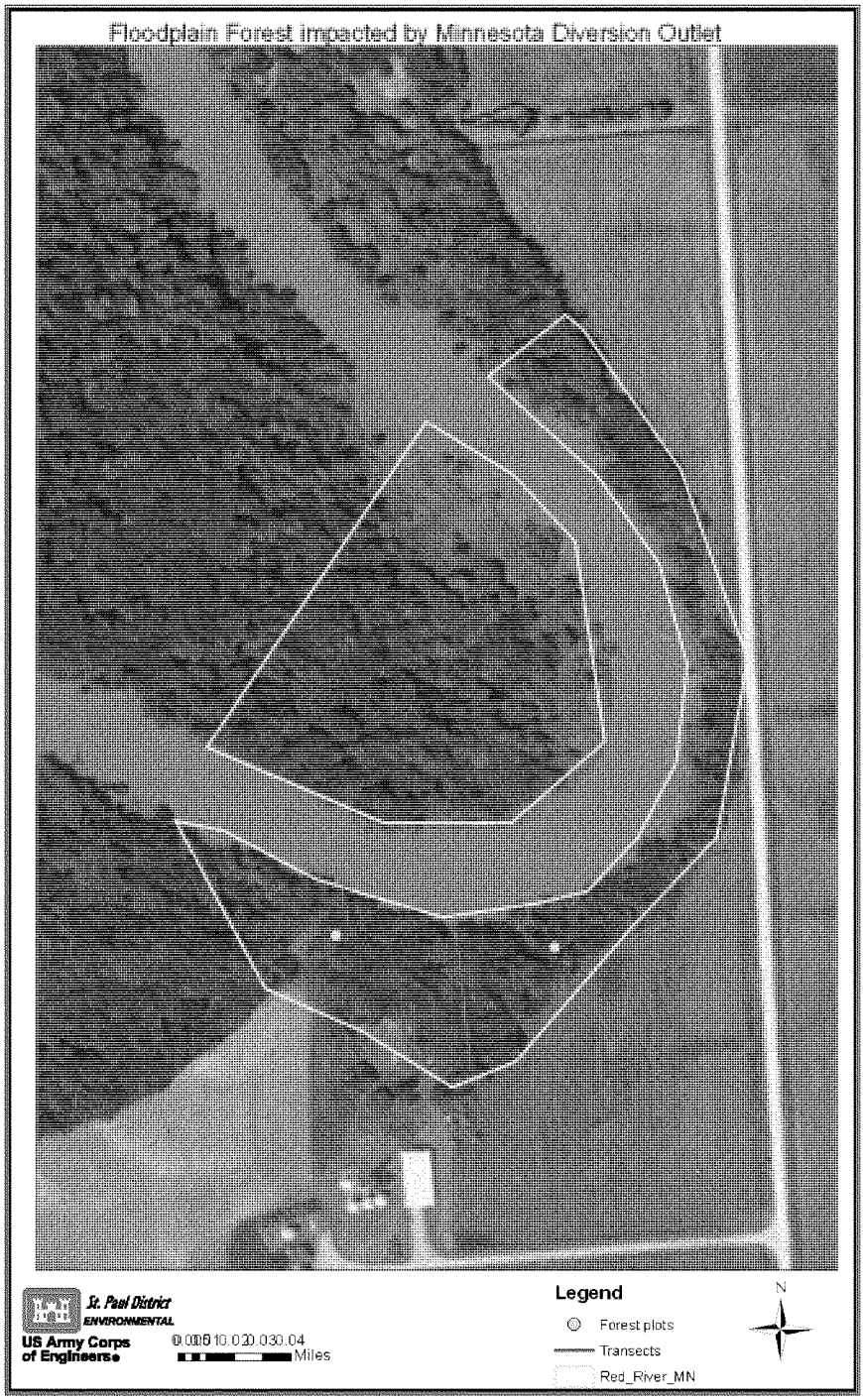
Mink

V1 85 % canopy closure

V2 100 percent of the year there is surface water present

V4 70% canopy closure within 328 feet of water's edge.

Floodplain Forest impacted by Wild Rice River Crossing


Floodplain Forest impacted by Minnesota Diversion Outlet
St. Paul District
ENVIRONMENTAL
US Army Corps of Engineers
0 0.005 0.01 0.02 0.03 0.04
Miles
Legend
Forest plots
Transects
Red_River_MN
N

Red River MN Inlet (Diversion back into Red) 7-20-10

US Army Corps of Engineers St. Paul District	PROJECT TITLE	COMPUTED BY:	DATE	SHEET
	SUBJECT TITLE	CHECKED BY: Sobieck	DATE	CONTRACT NO.

Number	Species	Distance	Diameter	Condition	Notes
1	Boxelder	3	10	G	Red squirrel
2	G. Ash	17	10	G	
3	"	1	7	G	
4	"	3	7	G	
5	"	5	7	G	
6	"	1	7	G	
7	Boxelder	33	9	G	
8	G. Ash	4	5	G	
9	Boxelder	4	7	G	
10	"	12	8	G	
11	"	8	10	G	
12	G. Ash	11	8	G	
13	"	3	9	G	
14	G. Ash	25	8	G	
15	"	1	8	G	
16	"	8	9	G	
17	"	2	8	G	
18	A Elm	25	6	G	
19	G. Ash	4	8	G	
20	Boxelder	7	7	G	
		4.85			

Red River MN Inlet (Diversion back into Red) ?

Stand Map Field Sheet

Pool # ____ Compartment # ____ Location name ____ Cruiser(s) Sobiech
BAF ____ Date 7-20-10

Stand # 1

Workspace

Plot # ___ BA ___ % Understory 60 %Crown 65
Waypoint # ___ * Snags 11 * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1) G. Ash III	3	14	45
2) elm II	2	7	35
3) Boxelder III	3	24	60
4)			
5)			
6)			
7)			

Dominant Mid-story	/ Ave Ht	Notable Species
1) elm	20	Moonseed
2) Green Ash	20	
3)		

Dominant Understory	/ Ave Ht
1) Stinging nettle	3
2) elm seedling	1
3) Ash seedling	1

Stand # 2

Plot # ___ BA ___ % Understory 40 %Crown 60
Waypoint # ___ * Snags 116 * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1) Boxelder II	2	14	50
2) elm I	1	13	50
3) G. Ash III III	10	15	65
4)			
5)			
6)			
7)			

Dominant Mid-story	/ Ave Ht	Notable Species
1) elm	12	
2) G. Ash	15	
3)		

Dominant Understory	/ Ave Ht
1) elm seedling	1
2) Grape	1
3) Reed (Ann. G. Ash)	

Stand # ____

Plot # ___ BA ___ % Understory ___ %Crown ___
Waypoint # ___ * Snags ___/___ * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1)		
2)		
3)		
4)		
5)		
6)		
7)		

Dominant Mid-story	/ Ave Ht	Notable Species
1)		
2)		
3)		

Dominant Understory	/ Ave Ht
1)	
2)	
3)	

Stand # ____

Plot # ___ BA ___ % Understory ___ %Crown ___
Waypoint # ___ * Snags ___/___ * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht / # Tree
1)		
2)		
3)		
4)		
5)		
6)		
7)		

Dominant Mid-story	/ Ave Ht	Notable Species
1)		
2)		
3)		

Dominant Understory	/ Ave Ht
1)	
2)	
3)	

Stand # ____

Plot # ___ BA ___ % Understory ___ %Crown ___
Waypoint # ___ * Snags ___/___ * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1)		
2)		
3)		
4)		
5)		
6)		
7)		

Dominant Mid-story	/ Ave Ht	Notable Species
1)		
2)		
3)		

Dominant Understory	/ Ave Ht
1)	
2)	
3)	

Stand # ____

Plot # ___ BA ___ % Understory ___ %Crown ___
Waypoint # ___ * Snags ___/___ * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1)		
2)		
3)		
4)		
5)		
6)		
7)		

Dominant Mid-story	/ Ave Ht	Notable Species
1)		
2)		
3)		

Dominant Understory	/ Ave Ht
1)	
2)	
3)	

Floodplain Forest impacted by Minnesota Diversion Inlets

CAVITIES ~~IIII~~ 11

Red River MN S ~~outlet~~ inlet Diversion

Number	Species	Distance	Diameter	Condition	Notes
1	G. Ash	9	10	G	Great Elm, Hackberry Regen
2	"	6	7	G	
3	"	9	7	F	
4	"	9	6	F	Wild Rye
5	Elm	12	8	G	
6	G Ash	13	9	F	
7	Elm	14	10	G	
8	G Ash	17	12	G	
9	G. Ash	12	7	G	
10	G. Ash	15	9	G	
11	Elm	15	11	G	
12	G Ash	13	8	G	
13	G Ash	2	9	G	
14	G. Ash	7	9	G	
15	"	7	6	G	
16	"	1	9	G	
17	"	1	9	~~G~~ F	
18	Elm	28	7	G	
19	Elm	6	7	G	
20	Elm	13	7	G	
		10.45	8.65		

Red River MN ~~outlet~~ to Diversion channel
inlet

Stand Map Field Sheet

Pool # ____ Compartment # ____ Location name ____ Cruiser(s) ____
BAF ____ Date ____

Stand # 1

Workspace

Plot # ____ BA ____ % Understory 25 %Crown 90
Waypoint # ____ * Snags 3/13 * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1) G. Ash 1/1/1/1	6	8	45
2) elm 1/1/1	4	7	45
3) Boxelder	1	7	40
4)			
5)			
6)			
7)			

Dominant Mid-story	/ Ave Ht	Notable Species
1) Hackberry	4	
2) Boxelder	12	
3)		

Dominant Understory	/ Ave Ht
1) Wild Rye	2
2) Mint	3
3)	

Stand # 2

Plot # ____ BA ____ % Understory 50 %Crown 60
Waypoint # ____ * Snags 2/12 * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1) G. Ash 1	1	12	50
2) Cottonwood 1	1	21	65
3) Boxelder 1/1/1	3	13	40
4) elm	2	12	40
5)			
6)			
7)			

Dominant Mid-story	/ Ave Ht	Notable Species
1) G. Ash	25	edge of [illegible]
2)		Carrin flare
3)		snow berry

Dominant Understory	/ Ave Ht
1) Mint	3
2) Mustard	3
3)	

Stand # 3

Plot # ____ BA ____ % Understory 25 %Crown 80
Waypoint # ____ * Snags 2/17 * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1) G. Ash 1	4	13	45
2) Hackberry 1	2	5	30
3) elm 1	2	7	30
4)			
5)			
6)			
7)			

Dominant Mid-story	/ Ave Ht	Notable Species
1) elm	20	
2)		
3)		

Dominant Understory	/ Ave Ht
1) Wind nettle	3
2) Mint	3
3) mustard	

Stand # ____

Plot # ____ BA ____ % Understory ____ %Crown ____
Waypoint # ____ * Snags ___/___ * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht / # Tree
1)		
2)		
3)		
4)		
5)		
6)		
7)		

Dominant Mid-story	/ Ave Ht	Notable Species
1)		
2)		
3)		

Dominant Understory	/ Ave Ht
1)	
2)	
3)	

Stand # ____

Plot # ____ BA ____ % Understory ____ %Crown ____
Waypoint # ____ * Snags ___/___ * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1)		
2)		
3)		
4)		
5)		
6)		
7)		

Dominant Mid-story	/ Ave Ht	Notable Species
1)		
2)		
3)		

Dominant Understory	/ Ave Ht
1)	
2)	
3)	

Stand # ____

Plot # ____ BA ____ % Understory ____ %Crown ____
Waypoint # ____ * Snags ___/___ * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1)		
2)		
3)		
4)		
5)		
6)		
7)		

Dominant Mid-story	/ Ave Ht	Notable Species
1)		
2)		
3)		

Dominant Understory	/ Ave Ht
1)	
2)	
3)	

Cavities

Red River MA outlet to Dresser channel

Number	Species	Distance	Diameter	Condition	Notes
1	B. OAK	17	31	G	Thin strip along bank
2	G. Ash	15	5	f	
3	A. Elm	15	11	G	50 feet
4	B. OAK	16	24	f	Prickly Ash
5	B. OAK	18	19	f	wild rye
6	B. OAK	6	27	G	
7	Elm	10	4	G	
8	G Ash	10	7	G	
9	G Ash	14	5	G	
10	G. Ash	5	7	f	
11	Basswood	4	7	G	
12	G. Ash	7	7	f	
13	G. Ash	8	8	f	
14	A. Elm	16	8	G	
15	G. Ash	6	7	f	
16	Elm	7	12	G	
17	Elm	26	10	G	
18	Elm	10	11	G	
19	G. Ash	3	7	f	
20	Elm	11	9	f	
		11.75 Avg	11.7 Avg		

Floodplain Forest impacted by Minnesota Diversion South Inlet
St. Paul District
ENVIRONMENTAL
US Army Corps of Engineers
0 0.0125 0.025 0.050 0.075 0.1
Miles
Legend
Forest plots
Transects
Red_River_MN
N

Red River MN Shad South ~~outlet~~ inlet to Diversion

Stand Map Field Sheet

Pool # ____ Compartment # ____ Location name ____ Cruiser(s) Sobiech + Kreft

BAF ____ Date 7-19-10

Stand # 1

Workspace

Plot # ___ BA ___ % Understory 90 %Crown 90
Waypoint # ____ * Snags 1/18 * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1) B OAK I	1	4	25
2) HACKberry II	2	7	25
3) elm II	2	7	35
4) G. Ash III	3	10	25
5)			
6)			
7)			

Dominant Mid-story	/ Ave Ht	Notable Species
1) HACKberry	10	mustard evergreen
2)		
3)		

Dominant Understory	/ Ave Ht
1) Garlic mustard	3
2)	
3)	

Stand # 2

Plot # ___ BA ___ % Understory 65 %Crown 55
Waypoint # ____ * Snags ___/___ * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1) B OAK III	7	20	58
2) Boxelder III	4	11	95
3) G. Ash III	3	22	55
4)			
5)			
6)			
7)			

Dominant Mid-story	/ Ave Ht	Notable Species
1) boxelder	15	
2)		
3)		

Dominant Understory	/ Ave Ht
1) HACKberry	2
2) G. Mustard	3
3) rye	2

Stand # ____

Plot # ___ BA ___ % Understory ___ %Crown ___
Waypoint # ____ * Snags ___/___ * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1)		
2)		
3)		
4)		
5)		
6)		
7)		

Dominant Mid-story	/ Ave Ht	Notable Species
1)		
2)		
3)		

Dominant Understory	/ Ave Ht
1)	
2)	
3)	

Stand # ____

Plot # ___ BA ___ % Understory ___ %Crown ___
Waypoint # ____ * Snags ___/___ * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht / # Tree
1)		
2)		
3)		
4)		
5)		
6)		
7)		

Dominant Mid-story	/ Ave Ht	Notable Species
1)		
2)		
3)		

Dominant Understory	/ Ave Ht
1)	
2)	
3)	

Stand # ____

Plot # ___ BA ___ % Understory ___ %Crown ___
Waypoint # ____ * Snags ___/___ * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1)		
2)		
3)		
4)		
5)		
6)		
7)		

Dominant Mid-story	/ Ave Ht	Notable Species
1)		
2)		
3)		

Dominant Understory	/ Ave Ht
1)	
2)	
3)	

Stand # ____

Plot # ___ BA ___ % Understory ___ %Crown ___
Waypoint # ____ * Snags ___/___ * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1)		
2)		
3)		
4)		
5)		
6)		
7)		

Dominant Mid-story	/ Ave Ht	Notable Species
1)		
2)		
3)		

Dominant Understory	/ Ave Ht
1)	
2)	
3)	

Red River Mr ~~Outlet~~ Inlet to Diversion #2

Number	Species	Distance	Diameter	Condition	Notes
1	G. Ash	17	18	G	mosquito
2	G. Ash	8	14	G	
3	G. Ash	1	11	G	
4	Elm	12	7	G	
5	elm	9	7	G	
6	G. Ash	13	6	G	
7	"	5	7	G	
8	"	4	9	G	
9	"	6	7	G	
10	"	5	9	F	
11	"	9	10	F	
12	"	3	8	F	
13	"	10	6	G	
14	"	4	7	G	
15	"	8	6	G	
16	"	16	9	F	
17	"	5	11	F	
18	"	12	27	F	
19	"	16	7	F	
20	"	8	9	F	Bur Oaks started at end
		8.55	9.75		

Floodplain Forest impacted by North Dakota Diversion Inlet
St. Paul District
ENVIRONMENTAL
US Army Corps of Engineers
0
0.04
0.08
0.16 Miles
Legend
Forest plots
Transects
Red_River_ND
N

Stand Map Field Sheet

Pool # ____ Compartment # ____ Location name ____ Cruiser(s) Sibiel
BAF ____ Date 7-19-10

Stand # 1
Workspace

Plot # ____ BA ____ % Understory 5 %Crown 65
Waypoint # ____ * Snags 0 / 0 * Mast 0 / 0
Dominant Overstory and # / Avg DBH / Ave Ht
1) Black Oak / 3 / 27 / 70
2) Post Oak / 2 / 4 / 15
3) Elm / 1 / 14 / 60
4) ____ / ____ / ____ / ____
5) ____ / ____ / ____ / ____
6) ____ / ____ / ____ / ____
7) ____ / ____ / ____ / ____
Dominant Mid-story / Ave Ht / Notable Species
1) Post Oak / 30
2) Elm / 28
3) Hickory / 33
Dominant Understory / Ave Ht
1) Wild Plum
2) Post Oak / 15
3) Hickory

Stand # 2

Plot # ____ BA ____ % Understory 5 %Crown 95
Waypoint # ____ * Snags 4 / 9 * Mast ___ / ___
Dominant Overstory and # / Avg DBH / Ave Ht
1) Post Oak / ____ / ____ / 35
2) Willow / 1 / 24 / 63
3) Elm / 3 / ____ / 12
4) ____ / ____ / ____ / ____
5) ____ / ____ / ____ / ____
6) ____ / ____ / ____ / ____
7) ____ / ____ / ____ / ____
Dominant Mid-story / Ave Ht / Notable Species
1) Post Oak / 27
2) Elm / 20
3) ____ / ____
Dominant Understory / Ave Ht
1) ____ / ____
2) ____ / ____
3) ____ / ____

Stand # ____

Plot # ____ BA ____ % Understory ____ %Crown ____
Waypoint # ____ * Snags ___ / ___ * Mast ___ / ___
Dominant Overstory and # / Avg DBH / Ave Ht
1) ____ / ____ / ____ / ____
2) ____ / ____ / ____ / ____
3) ____ / ____ / ____ / ____
4) ____ / ____ / ____ / ____
5) ____ / ____ / ____ / ____
6) ____ / ____ / ____ / ____
7) ____ / ____ / ____ / ____
Dominant Mid-story / Ave Ht / Notable Species
1) ____ / ____
2) ____ / ____
3) ____ / ____
Dominant Understory / Ave Ht
1) ____ / ____
2) ____ / ____
3) ____ / ____

Stand # ____

Plot # ____ BA ____ % Understory ____ %Crown ____
Waypoint # ____ * Snags ___ / ___ * Mast ___ / ___
Dominant Overstory and # / Avg DBH / Ave Ht / # Tree
1) ____ / ____ / ____ / ____
2) ____ / ____ / ____ / ____
3) ____ / ____ / ____ / ____
4) ____ / ____ / ____ / ____
5) ____ / ____ / ____ / ____
6) ____ / ____ / ____ / ____
7) ____ / ____ / ____ / ____
Dominant Mid-story / Ave Ht / Notable Species
1) ____ / ____
2) ____ / ____
3) ____ / ____
Dominant Understory / Ave Ht
1) ____ / ____
2) ____ / ____
3) ____ / ____

Stand # ____

Plot # ____ BA ____ % Understory ____ %Crown ____
Waypoint # ____ * Snags ___ / ___ * Mast ___ / ___
Dominant Overstory and # / Avg DBH / Ave Ht
1) ____ / ____ / ____ / ____
2) ____ / ____ / ____ / ____
3) ____ / ____ / ____ / ____
4) ____ / ____ / ____ / ____
5) ____ / ____ / ____ / ____
6) ____ / ____ / ____ / ____
7) ____ / ____ / ____ / ____
Dominant Mid-story / Ave Ht / Notable Species
1) ____ / ____
2) ____ / ____
3) ____ / ____
Dominant Understory / Ave Ht
1) ____ / ____
2) ____ / ____
3) ____ / ____

Stand # ____

Plot # ____ BA ____ % Understory ____ %Crown ____
Waypoint # ____ * Snags ___ / ___ * Mast ___ / ___
Dominant Overstory and # / Avg DBH / Ave Ht
1) ____ / ____ / ____ / ____
2) ____ / ____ / ____ / ____
3) ____ / ____ / ____ / ____
4) ____ / ____ / ____ / ____
5) ____ / ____ / ____ / ____
6) ____ / ____ / ____ / ____
7) ____ / ____ / ____ / ____
Dominant Mid-story / Ave Ht / Notable Species
1) ____ / ____
2) ____ / ____
3) ____ / ____
Dominant Understory / Ave Ht
1) ____ / ____
2) ____ / ____
3) ____ / ____

11.x
37.2 ac

NO outlet

Number	Species	Distance	Diameter	Condition	Notes
1	elm	3 feet	9	P	dying
2	[illegible]	11	6.5	[illegible]	
3	Boxelder	1	3.5	G	
4	Boxelder	3	7.5	G	
5	G. Ash	12.5	8	G	
6	elm	27	10.5	F	split
7	G. Ash	12	5.5	G	
8	elm	3	15	G	
9	elm	3	11	G	
10	G. Ash	17	8	G	
11	elm	5	13	G	
12	boxelder	20	5	G	
13	elm	23	17	G	
14	G. Ash	2[illegible]	5	G	
15	B. OAK	35	40	G	edge of field
16	B. OAK	15	28	G	
17	elm	9	8	G	
18	Hackberry	6	4	G	
19	elm	11	9	G	chile cherry
20	B. OAK	12	31	G	

Moon scale

Floodplain Forest impacted by North Dakota Inlet

Cavities: ~~IIII~~ ~~IIII~~ ~~IIII~~ Wood duck boxes

US Army Corps of Engineers St. Paul District	PROJECT TITLE: Red River ND Inlet (Diversion back into Red River)	COMPUTED BY:	DATE: 7-20-10	SHEET
	SUBJECT TITLE:	CHECKED BY:	DATE:	CONTRACT NO.:

Number	Species	Distance	Diameter	Condition	Notes
1	Box Elder	6	8	G	
2	"	10	6	G	
3	"	5	6	G	
4	"	8	10	G	
5	G. Ash	15	12	G	
6	"	8	18	G	
7	Boxelder	8	8	G	
8	G. Ash	7	8	Poor	
9	"	16	14	G	
10	Boxelder	14	8	F	
11	G. Ash	18	14	G	
12	Boxelder	9	5	G	
13	elm	7	6	G	
14	G. Ash	13	26	G	
15	Boxelder	11	8	F	
16	G. Ash	18	9	F	
17	Boxelder	7	8	F	
18	"	10	10	F	
19	elm	12	8	G	
20	Elm	5	12	F	

no ~~inlet~~ outlet

Stand Map Field Sheet

Pool # ____ Compartment # ____ Location name ____ Cruiser(s) Sabie
BAF ____ Date 7-20-10

Stand # 1
Workspace

Plot # ___ BA ___ % Understory 60 %Crown 95
Waypoint # ___ * Snags 3/24 * Mast ___/___
Dominant Overstory and # / Avg DBH / Ave Ht
1) G Ash IIII / 10 / 7 / 45
2) ___ / ___ / ___ / ___
3) ___ / ___ / ___ / ___
4) ___ / ___ / ___ / ___
5) ___ / ___ / ___ / ___
6) ___ / ___ / ___ / ___
7) ___ / ___ / ___ / ___
Dominant Mid-story / Ave Ht Notable Species
1) Boxelder / 10
2) G Ash / 20
3) Elm / 15
Dominant Understory / Ave Ht
1) ? / ___
2) Nettle / 2
3) ___ / ___

Stand # 2

Plot # ___ BA ___ % Understory 30 %Crown 70
Waypoint # ___ * Snags 2/20 * Mast ___/___
Dominant Overstory and # / Avg DBH / Ave Ht
1) Elm IIII / 4 / 10 / 45
2) Boxelder II / 3 / 20 / 50
3) G Ash II / 2 / 9 / 52
4) ___ / ___ / ___ / ___
5) ___ / ___ / ___ / ___
6) ___ / ___ / ___ / ___
7) ___ / ___ / ___ / ___
Dominant Mid-story / Ave Ht Notable Species
1) Elm / 20
2) ___ / ___
3) ___ / ___
Dominant Understory / Ave Ht
1) ? / ___
2) Cone flower / 3
3) Nettle / 2

Stand # 3

Plot # ___ BA ___ % Understory 10 %Crown 55
Waypoint # ___ * Snags 3/26 * Mast ___/___
Dominant Overstory and # / Avg DBH / Ave Ht
1) G Ash IIII / 2 / 9 / 50
2) Elm II / 2 / 9 / 45
3) Boxelder III / 7 / 8 / 40
4) ___ / ___ / ___ / ___
5) ___ / ___ / ___ / ___
6) ___ / ___ / ___ / ___
7) ___ / ___ / ___ / ___
Dominant Mid-story / Ave Ht Notable Species
1) Boxelder / 25
2) ___ / ___
3) ___ / ___
Dominant Understory / Ave Ht
1) ___ / ___
2) ___ / ___
3) ___ / ___

Stand # ___

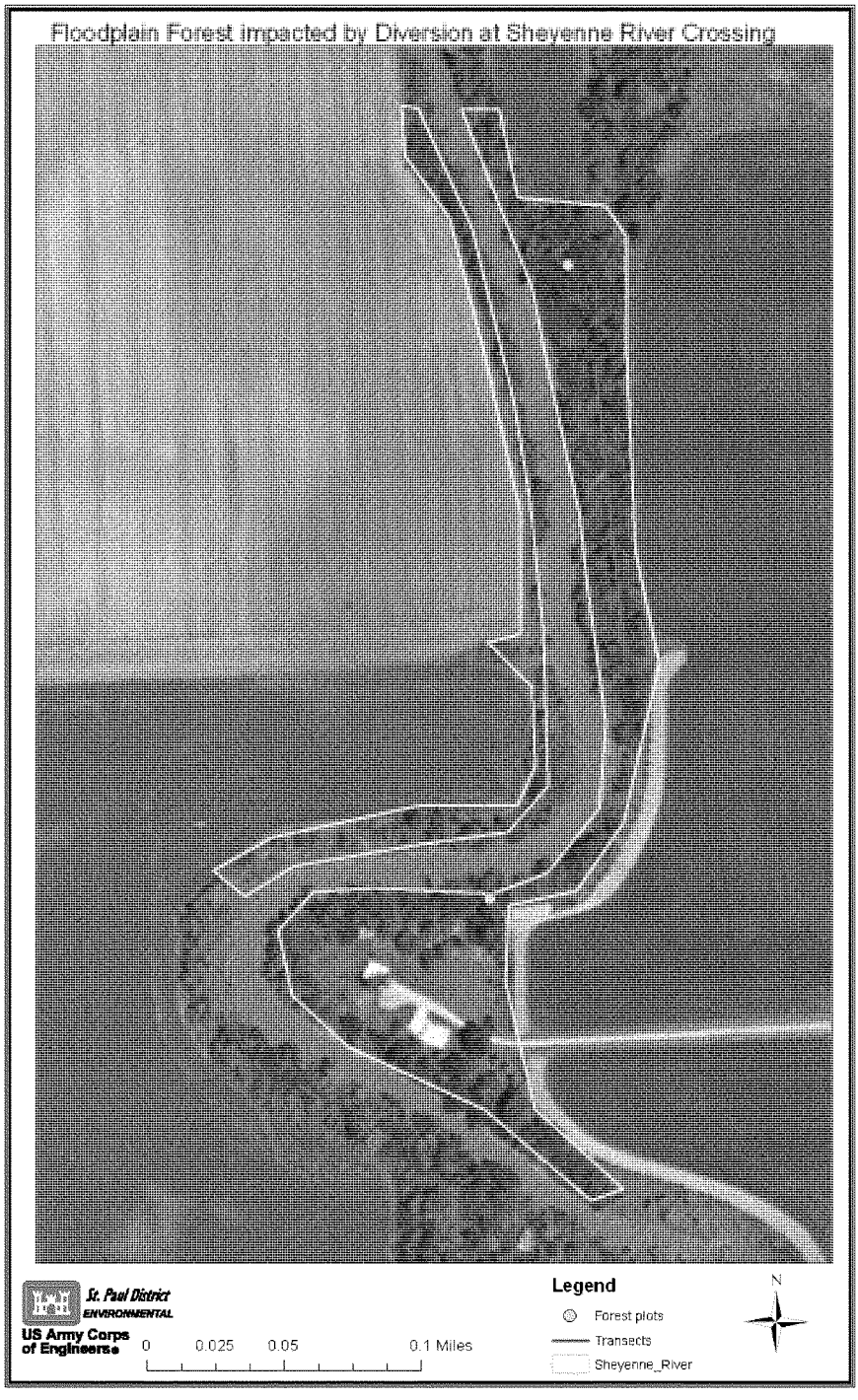
Plot # ___ BA ___ % Understory ___ %Crown ___
Waypoint # ___ * Snags ___/___ * Mast ___/___
Dominant Overstory and # / Avg DBH / Ave Ht / # Tree
1) ___ / ___ / ___ / ___
2) ___ / ___ / ___ / ___
3) ___ / ___ / ___ / ___
4) ___ / ___ / ___ / ___
5) ___ / ___ / ___ / ___
6) ___ / ___ / ___ / ___
7) ___ / ___ / ___ / ___
Dominant Mid-story / Ave Ht Notable Species
1) ___ / ___
2) ___ / ___
3) ___ / ___
Dominant Understory / Ave Ht
1) ___ / ___
2) ___ / ___
3) ___ / ___

Stand # ___

Plot # ___ BA ___ % Understory ___ %Crown ___
Waypoint # ___ * Snags ___/___ * Mast ___/___
Dominant Overstory and # / Avg DBH / Ave Ht
1) ___ / ___ / ___ / ___
2) ___ / ___ / ___ / ___
3) ___ / ___ / ___ / ___
4) ___ / ___ / ___ / ___
5) ___ / ___ / ___ / ___
6) ___ / ___ / ___ / ___
7) ___ / ___ / ___ / ___
Dominant Mid-story / Ave Ht Notable Species
1) ___ / ___
2) ___ / ___
3) ___ / ___
Dominant Understory / Ave Ht
1) ___ / ___
2) ___ / ___
3) ___ / ___

Stand # ___

Plot # ___ BA ___ % Understory ___ %Crown ___
Waypoint # ___ * Snags ___/___ * Mast ___/___
Dominant Overstory and # / Avg DBH / Ave Ht
1) ___ / ___ / ___ / ___
2) ___ / ___ / ___ / ___
3) ___ / ___ / ___ / ___
4) ___ / ___ / ___ / ___
5) ___ / ___ / ___ / ___
6) ___ / ___ / ___ / ___
7) ___ / ___ / ___ / ___
Dominant Mid-story / Ave Ht Notable Species
1) ___ / ___
2) ___ / ___
3) ___ / ___
Dominant Understory / Ave Ht
1) ___ / ___
2) ___ / ___
3) ___ / ___


Floodplain Forest impacted by Diversion at Sheyenne River Crossing
St. Paul District
ENVIRONMENTAL
US Army Corps of Engineers
0
0.025
0.05
0.1 Miles
Legend
Forest plots
Transects
Sheyenne_River
N

#1 Ran Parallel to River

#2 Buckthorn throughout site

Basswood near southern end?

Sheyenne River

Number	Species	Distance	Diameter	Condition	Notes
1	Elm	17	17	F	
2	Buckthorn	12	~~3.5~~ 4	G	
3	Box elder	13	26	F	
4	Boxelder	6	17	P	
5	Boxelder	22	11	G	
6	G. Ash	10	8	G	
7	Boxelder	9	9	F	
8	Boxelder	15	7	F	
9	Boxelder	14	21	F	
10	elm	15	5	P	
11	G Ash	10	18	G	
12	Elm	13	10	G	
13	Elm	18	5	G	
14	Boxelder	4	13	F	
15	Boxelder	18	14	F	
16	Boxelder	2	17	F	
17	Boxelder	2	17	F	
18	elm	2	6	G	
19	Boxelder	2	15	P	
20		13	15	G	

Sheyenne River

Cavity

Buckthorn mono cultures

Stand Map Field Sheet

Pool # ____ Compartment # ____ Location name ____ Cruiser(s) Kreft and Sobieck

BAF ____ Date 7-19-10

Stand # 1

Workspace

Plot # ____ BA ____ % Understory 70 %Crown 75

Waypoint # ____ * Snags 1 / 10 * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1) Elm	46	13	54
2) Box elder	3	17	45
3)			
4)			
5)			
6)			
7)			

Dominant Mid-story	/ Ave Ht	Notable Species
1) Buckthorn	10	bassword
2) elm	10	
3)		

Dominant Understory	/ Ave Ht
1) wood nettle	2
2)	
3)	

Bassword

Stand # 2

Plot # ____ BA 10 % Understory 50 %Crown 75

Waypoint # ____ * Snags 0 / 10 * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1) Elm	4	13	80
2) Basswood	3	12	50
3) Box elder	3	14	45
4)			
5)			
6)			
7)			

Dominant Mid-story	/ Ave Ht	Notable Species
1) elm	10	
2) Buckthorn	6	
3)		

Dominant Understory	/ Ave Ht
1) nettle	
2) Bassword	
3)	

Stand # ____

Plot # ____ BA ____ % Understory ____ %Crown ____

Waypoint # ____ * Snags ___/___ * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1)		
2)		
3)		
4)		
5)		
6)		
7)		

Dominant Mid-story	/ Ave Ht	Notable Species
1)		
2)		
3)		

Dominant Understory	/ Ave Ht
1)	
2)	
3)	

Stand # ____

Plot # ____ BA ____ % Understory ____ %Crown ____

Waypoint # ____ * Snags ___/___ * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht / # Tree
1)		
2)		
3)		
4)		
5)		
6)		
7)		

Dominant Mid-story	/ Ave Ht	Notable Species
1)		
2)		
3)		

Dominant Understory	/ Ave Ht
1)	
2)	
3)	

Stand # ____

Plot # ____ BA ____ % Understory ____ %Crown ____

Waypoint # ____ * Snags ___/___ * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1)		
2)		
3)		
4)		
5)		
6)		
7)		

Dominant Mid-story	/ Ave Ht	Notable Species
1)		
2)		
3)		

Dominant Understory	/ Ave Ht
1)	
2)	
3)	

Stand # ____

Plot # ____ BA ____ % Understory ____ %Crown ____

Waypoint # ____ * Snags ___/___ * Mast ___/___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1)		
2)		
3)		
4)		
5)		
6)		
7)		

Dominant Mid-story	/ Ave Ht	Notable Species
1)		
2)		
3)		

Dominant Understory	/ Ave Ht
1)	
2)	
3)	

Floodplain Forest impacted by Wild Rice River Crossing

Wild Rice River

Number	Species	Distance ft	Diameter	Condition	Notes
1	elm	12	14	G	
2	G Ash	15	7	G	
3	G. Ash	13	15	F	
4	G Ash	12	5	G	
5	G. Ash	10	10	G	
6	"	13	9	G	
7	Hackberry	10	7	G	
8	B. Oak	9	25	G	
9	B. Oak	16	25	G	
10	Hackberry	14	8	G	
11	boxelder	6	6	G	
12	Hackberry	11	9	G	
13	Boxelder	17	9	G	
14	Boxelder	8	7	G	
15	boxelder	12	7	G	
16	Hackberry	18	11	G	
17	B. Oak	5	36	G	
18	elm	10	7	G	
19	G. Ash	12	12.5	G	
20	G. Ash	16	13	G	

12 feet spacing

Wild Rice

Stand Map Field Sheet

Pool # ____ Compartment # ____ Location name ____ Cruiser(s) Kroft Subject
BAF ____ Date 7-19-2010

Stand # 1 Avg ht 48ft

Workspace

Plot # ___ BA ___ % Understory 90 %Crown 80
Waypoint # ___ * Snags 1 / 120 * Mast ___ / ___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1) G. Ash	4 / 9	45
2) B. Oak	3 / 34	105
3) Basswood	/ 7	30
4) Hackberry	1 / 12	35
5) Elm	2 / 8	45
6)	/	/
7)	/	/

Dominant Mid-story	/ Ave Ht	Notable Species
1) G. Ash	/ 20	two Diam classes
2) Elm	/ 30	Hackberry
3) Basswood	/ 15	sedge

Dominant Understory	/ Ave Ht	
1) Ho Maple	/	
2) Ho Willow	/	
3) Unknown	/	

Stand # 2 Avg ht 40

Plot # ___ BA ___ % Understory 50 %Crown 90
Waypoint # ___ * Snags 2 / 12 * Mast ___ / ___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1) Basswood Hill	7 / 8	30
2) G. Ash II	4 / 10	50
3) Hackberry	1 / 6	35
4) B. Oak	1 / 30	65
5)	/	/
6)	/	/
7)	/	/

Dominant Mid-story	/ Ave Ht	Notable Species
1) Basswood	/ 15	Sp Arsenal Sting
2)	/	
3)	/	

Dominant Understory	/ Ave Ht	
1)	/	
2)	/	
3)	/	

B. OAK 37 30 26 40 / 4 = 13 3 12 / 4 = 3

Stand # 3 Avg ht 46

Plot # 3 BA ___ % Understory 75 %Crown 75
Waypoint # ___ * Snags 1 / 12 * Mast ___ / ___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1) G. Ash	1 / 10	45
2) B. Oak	3 / 26	60
3) Hackberry	2 / 8	35
4)	/	/
5)	/	/
6)	/	/
7)	/	/

Dominant Mid-story	/ Ave Ht	Notable Species
1) Chokecherry	/ 12	
2) Hackberry	/ 12	
3)	/	

Dominant Understory	/ Ave Ht	
1) None	/	
2)	/	
3)	/	

Stand # 4

Plot # 4 BA ___ % Understory 75 %Crown 90
Waypoint # ___ * Snags 120 * Mast 1 / 34

Tree	/ Avg DBH	/ Ave Ht / #
1) G. Ash	9 / 13	50
2) B. Oak	1 / 34	55
3) Basswood	1 / 21	41
4)	/	/
5)	/	/
6)	/	/
7)	/	/

Dominant Mid-story	/ Ave Ht	Notable Species
1) Hackberry	/ 15	sedge
2)	/	
3)	/	

Dominant Understory	/ Ave Ht	
1) Violet	/	
2)	/	
3)	/	

50

Stand # ____

Plot # ___ BA ___ % Understory ___ %Crown ___
Waypoint # ___ * Snags ___ / ___ * Mast ___ / ___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1)	/	/
2)	/	/
3)	/	/
4)	/	/
5)	/	/
6)	/	/
7)	/	/

Dominant Mid-story	/ Ave Ht	Notable Species
1)	/	
2)	/	
3)	/	

Dominant Understory	/ Ave Ht	
1)	/	
2)	/	
3)	/	

Stand # ____

Plot # ___ BA ___ % Understory ___ %Crown ___
Waypoint # ___ * Snags ___ / ___ * Mast ___ / ___

Dominant Overstory and #	/ Avg DBH	/ Ave Ht
1)	/	/
2)	/	/
3)	/	/
4)	/	/
5)	/	/
6)	/	/
7)	/	/

Dominant Mid-story	/ Ave Ht	Notable Species
1)	/	
2)	/	
3)	/	

Dominant Understory	/ Ave Ht	
1)	/	
2)	/	
3)	/	

30 20-25 snags Acre

G. Ash 15 DBH 62 age 45 year

Scoping Document

Fargo-Moorhead Metropolitan Area Flood Risk Management Environmental Impact Statement

US Army Corps of Engineers ®

Prepared by:
U.S. Army Corps of Engineers
St. Paul District
190 Fifth Street East, Suite 401
St. Paul, Minnesota 55101-1638

September 2009

Fargo-Moorhead Metropolitan Area Flood Risk Management

SCOPING DOCUMENT

Environmental Impact Statement

September 2009

Prepared by:

U.S. Army Corps of Engineers
St. Paul District
190 Fifth Street East, Suite 401
St. Paul, Minnesota 55101-1638

Printed on Recycled Paper

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1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

This Scoping Document was prepared to address alternatives, issues and other important information pertaining to the problematic flooding in the Fargo, North Dakota-Moorhead, Minnesota metropolitan area.

As directed by congress, the U.S. Army Corps of Engineers, St Paul District (USACE), is preparing an Environmental Impact Statement (EIS) under the terms of the National Environmental Policy Act (NEPA) for the Fargo-Moorhead Metropolitan Area Flood Risk Management Feasibility Study.

The Fargo-Moorhead Metropolitan Area is located in the Red River of the North Basin. This study is authorized by a September 30, 1974, Resolution of the Senate Committee on Public Works.

A Reconnaissance Report for the Fargo-Moorhead metropolitan area was approved by the Corps Mississippi Valley Division on April 08, 2008. Based on the recommendations contained in the Reconnaissance Report, the City of Fargo, the City of Moorhead, and the Federal Government entered into a Feasibility Cost Share Agreement on September 22, 2008. The feasibility study is cost shared 50/50 between the two non-Federal sponsors and the Federal Government. Funds to initiate the feasibility study were provided in the Consolidated Appropriations Act, 2008, approved December 26, 2007 (Public Law 110-161).

The study will produce a decision document in the form of a feasibility report and associated NEPA document in accordance with the Corps Planning Guidance Notebook, ER 1105-2-100, and the Project Management Plan. The feasibility study will investigate measures to reduce flood risk and analyze the potential for Federal participation in implementing a flood damage reduction project in the Fargo-Moorhead Metropolitan Area.

The feasibility study will focus on reducing flood risk in the entire Fargo-Moorhead Metropolitan area.

The USACE issued a Notice of Intent in the Federal Register on May 5, 2009.

1.2 RIOR STUDIES, REPORTS, AND PROJECTS

a. Reports

Since the 1940s, the Corps of Engineers and others have prepared numerous reports on the Red River of the North basin. The following reports contain the most relevant information for the current effort:

1. House Document 185, 81st Congress, 1st Session, dated May 24, 1948. This report proposed a comprehensive plan for the Red River of the North basin. The plan included channel improvements, levees and floodwalls in Fargo and Moorhead. Other components of the plan included the Orwell Reservoir on the Ottertail River in Minnesota; channel improvements on the lower Sheyenne, Maple and Rush Rivers in North Dakota; channel improvements on the Mustinka, Ottertail, Wild Rice, Marsh and Sand Hill Rivers in Minnesota; channel improvements

along the Bois de Sioux and upper Red Rivers near Wahpeton, North Dakota/Breckenridge, Minnesota; and local flood protection works on the Red River in Grand Forks, North Dakota/East Grand Forks, Minnesota. The study found that channel improvements along the lower 31.6 miles of the Wild Rice River in North Dakota were economically justified, but the majority of affected local interests did not support the project, so it was not recommended. The report specifically recommended no further investigations in the Buffalo River basin and several other basins in Minnesota.

2. Section 205, Flood Control Reconnaissance Report, Red River of the North at Fargo, North Dakota, Corps of Engineers, May 1967. This study evaluated the potential to build a portion of the levee in Fargo that had been approved as part of the 1948 comprehensive plan but was later omitted from the constructed project. The study concluded that the proposed project was not economically feasible and did not warrant further Federal involvement at that time.

3. Fargo-Moorhead Urban Study, Corps of Engineers, May 1985. This study was a cooperative Federal, State and local planning effort aimed at developing viable solutions to water and related land resource problems, needs and concerns for 1980 to 2030. The study area encompassed 13 townships in Cass County, North Dakota, and Clay County, Minnesota. The study addressed water supply, water conservation, flood risk management, energy conservation and water resources data management. The study evaluated the potential to construct levees, floodwalls and channel modifications in Fargo and Moorhead. The report concluded that extremely long levees or floodwalls would be required to ring the urban areas to provide adequate protection from larger floods, and the costs would greatly exceed the damages prevented. Therefore, Federal participation in Fargo and Moorhead flood risk management projects was not recommended. However, the report did support further studies for flood control in Harwood and Rivertree Park, North Dakota.

4. "Living with the Red," International Joint Commission, November 2000. In June 1997, following record-setting flooding on the Red River of the North, the governments of Canada and the United States asked the International Joint Commission (IJC) to examine and report on the causes and effects of damaging floods in the Red River basin, and to make recommendations on means to reduce, mitigate and prevent harm from future flooding." The IJC established the International Red River Basin Task Force to undertake the necessary studies. The task force produced its report in April 2000. The IJC's report, entitled "Living with the Red," was completed in November 2000. These reports included discussion of the flooding in the Fargo-Moorhead area. The report cited hydraulic and hydrologic analyses conducted after the 1997 flood that indicated flood risks in the Fargo-Moorhead area were likely greater than previously thought. The report supported a basin-wide flood mitigation approach including reduction in flows, strengthening of existing protection structures, and use of other techniques. The report recommended that Federal, State and local governments should "expedite the study of flood risk potential and implement plans for flood protection measures for the Fargo-Moorhead area."

5. Reconnaissance Study, Red River Basin, Minnesota, North Dakota, South Dakota, Corps of Engineers, September 2001. This study, supported by supplemental information, was approved

in October 2002. The study recommended three initial feasibility studies to be followed by additional studies throughout the basin. Only the initial three studies were approved in 2002. The additional proposed studies would be considered for approval on the basis of additional 905(b) analyses. The Fargo-Moorhead and Upstream feasibility study, currently underway, was one of the initial studies recommended and approved in the reconnaissance study.

6. Final Environmental Impact Statement (FEIS) for the Red River Valley Water Supply Project, U.S. Department of the Interior, Bureau of Reclamation, December 21, 2007. The purpose of the proposed project is to meet the comprehensive water quality and quantity needs of the Red River Valley through the year 2050. The needs were identified as municipal, rural and industrial water; water quality; aquatic environment; recreation; and water conservation measures. The preferred alternative would import water to the Red River basin from the Missouri River via the Garrison Diversion and the Sheyenne River.

7. Fargo-Moorhead Downtown Framework Plan Update, Fargo-Moorhead Council of Governments, City of Fargo, and City of Moorhead, June 2007. This report builds upon earlier planning efforts in both Fargo and Moorhead. Many of the concepts presented depend on implementation of effective flood risk management strategies.

b. Current Studies

The following studies are being conducted:

1. Fargo-Moorhead and Upstream Feasibility Study, Corps of Engineers. The study began in August 2004. The study area is the entire headwaters of the Red River of the North upstream (south) of the Fargo-Moorhead metropolitan area. The major tributaries are the Mustinka, Bois de Sioux, and Ottertail Rivers in Minnesota and the Wild Rice River in North Dakota. The study is evaluating alternatives that would restore wetland habitat and reduce flood damages. The major underlying assumption is that a system of surface water storage sites upstream of Fargo-Moorhead would reduce flood stages and flood damages downstream. It is also assumed that water storage could be accomplished in ways that would restore aquatic ecosystems and increase habitat for wildlife. Phase 1 analyses, completed in June 2005, showed that distributed flood storage could provide significant economic benefits, but additional study of environmental benefits is needed to justify a Federal project. The North Dakota State Water Commission and the City of Moorhead are jointly sponsoring the study. Additional cost-share partners include the Southeast Cass Water Resource District; Richland County Water Resource District; Red River Joint Water Resource District; city of Fargo; Buffalo-Red River Watershed District; Bois de Sioux Watershed District; Minnesota Department of Natural Resources; Minnesota Board of Water and Soil Resources; Minnesota Pollution Control Agency; South Dakota Department of Game, Fish, and Parks; and Red River Basin Commission.

2. Fargo Southside Flood Control Project, City of Fargo, North Dakota. Since the 1997 flood, the city of Fargo and the Southeast Cass County Water Resource District have been planning for a flood risk management project to protect developments in the area south of Fargo and north

and west of the Wild Rice River up to 4 miles south of its confluence with the Red River. Several alternatives have been explored, including combinations of levees, diversion channels, channel modifications, and flood storage.

3. Oakport Township, Minnesota. The Buffalo-Red River Watershed District is working on a flood risk management reduction project for Oakport Township. The project would be designed to protect areas of town to a level equal to the 1997 flood plus 3 feet. The watershed district is still finalizing levee alignments for two ring levees on either side of Oakport Coulee. The project would also include buying some homes that cannot be protected by the levee system. A Corps of Engineers study performed under the Section 205 Continuing Authority was terminated in December 2002 after it was determined that national economic benefits were insufficient to support further Federal efforts.

4. Flood Insurance Study Update, Federal Emergency Management Agency (FEMA). FEMA is updating the flood insurance maps for the Fargo-Moorhead area. As a result of recent flood events and revised hydrologic and hydraulic modeling, FEMA is likely to increase the 1-percent-chance flood elevation on the order of 1 foot above the current administratively determined elevation.

c. Existing Water Resource Projects

1. The Lake Traverse project, including White Rock Dam and Reservation Dam, provides flood storage at the headwaters of the Bois de Sioux and Red River of the North. The project was authorized by the 1936 Flood Control Act, and construction was completed in 1948. The project is operated by the Corps of Engineers, St. Paul District.

2. Baldhill Dam and Lake Ashtabula provide water storage for flood control and water supply on the Sheyenne River. The project was authorized by the 1944 Flood Control Act, and construction was originally completed in 1951. The dam was modified in 2004 to raise the flood control pool by 5 feet. (The pool raise was part of the Sheyenne River project.)

3. The Orwell Dam provides water storage for flood control and water supply on the Ottertail River. The dam was included in the Corps' 1947 comprehensive plan for the Red River basin and authorized by the Flood Control Acts of 1948 and 1950. Construction of the dam was completed in 1953; it provides 8,600 acre-feet of storage.

4. Fargo levees: The Corps participated in a permanent flood control project completed in Fargo in 1963. The project was recommended in the Corps' 1947 comprehensive plan for the Red River basin and authorized by the Flood Control Acts of 1948 and 1950. The project included four channel cutoffs, the Midtown Dam, and a 3,500-foot levee east of Fourth Street South between First Avenue South and Tenth Avenue South. The top of levee is at approximately a 40.0-foot stage. The city later extended the levee south to Thirteenth Avenue. Fargo has several other publicly and privately owned sections of levee throughout the city. The current line of protection has top elevations that vary from a stage of 30 feet to 42 feet, but several reaches are

at or below 37 feet. (Note: the proposed new FEMA 1-percent-chance flood stage is expected to be approximately 39.3 feet.)

5. Moorhead levees: There are no federally constructed levees in Moorhead. The Corps proposed an 1,800-foot-long levee in the 1947 comprehensive plan for the Red River basin. It was authorized by the Flood Control Acts of 1948 and 1950, but the city declined to participate in the project. The city has built four small levees and several lift stations and control structures on storm water lines that can be closed or operated during high-water events. The city has also installed valves on the sanitary sewer lines at several individual flood-prone residences to prevent floodwater from inundating the system. The city also builds emergency levees when necessary.

6. The Sheyenne River project was authorized by the 1986 Water Resources Development Act. The project originally included four components: a 5-foot raise of the Baldhill Dam flood control pool; a dam to provide approximately 35,000 acre-feet of storage on the Maple River; a 7.5-mile flood diversion channel from Horace to West Fargo, North Dakota; and a 6.7-mile flood diversion channel at West Fargo. The Southeast Cass Water Resource District and the St. Paul District, Corps of Engineers, signed cost share agreements for the West Fargo Diversion project in 1988 and the Horace to West Fargo Diversion in 1990. The projects were essentially completed in 1993 and 1994. A pump station was added to the West Fargo project in 2003 and emergency generators were provided in 2007. The Maple River dam was deauthorized in 2002 for Federal participation, and the Southeast Cass Water Resource District completed the project without Federal assistance in 2007. These projects protect the cities of Horace and West Fargo and the west side of Fargo from Sheyenne River flooding. From Horace to West Fargo, the system is designed for a 1-percent-chance event plus 2 feet. At West Fargo, the channel and left bank levee contain the 1-percent-chance event plus 2 feet, and the right bank levee is higher, providing the city with protection from the Standard Project Flood plus 3 feet. Although these features reduce the risk associated with Sheyenne River flooding, these cities are still potentially affected by floods on the Wild Rice and Red Rivers that are larger than the 1% chance event.

7. A Section 208 (1954 Flood Control Act) clearing and snagging project was completed in Fargo-Moorhead in 1991 to remove trees affected by Dutch elm disease. Dead and dying trees were removed along a 9.7-mile reach of the Red River of the North.

8. Three Section 14 (1946 Flood Control Act) emergency streambank protection projects were completed in Fargo between 2001 and 2003. Erosion from the Red River of the North occurred at three separate project locations. At Reach A, erosion along 4,100 feet of riverbank threatened a levee near 37th Avenue. At Reach B, erosion along a 950-foot reach threatened Kandi Lane and North Broadway and utilities located beneath them. At Reach C, erosion along a 1,900-foot reach threatened Elm Street between 13th and 17th Avenues North and the utilities located beneath it. The erosion progressed to within 50 feet of the roadway. The projects involved shaping the banks and placing rockfill or granular fill and riprap along the eroded areas.

9. Two Section 206 (1996 Water Resource Development Act) aquatic ecosystem restoration projects were implemented to improve fish passage over two dams on the Red River within the metropolitan area. Rock slope fishways were constructed at the 12th Avenue North Dam and the 32nd Avenue South Dam in 2002 and 2004, respectively. A similar fishway was constructed at the Midtown Dam in 1998 without Corps construction assistance.

10. A Section 205 (1948 Flood Control Act) small flood control project is under construction for Fargo's Ridgewood neighborhood. The project will tie into a recently reconstructed floodwall at the Department of Veterans Affairs hospital.

1.3 DEFINITION OF AN ENVIRONMENTAL IMPACT STATEMENT

An EIS is a written document required by NEPA to be prepared for "major federal actions significantly affecting the quality of the human environment." Major federal actions are defined in the regulations implementing NEPA as actions "with effects that may be major and which are potentially subject to Federal control and responsibility" (40 CFR 1508.18). An EIS describes the purpose and need for an action, any alternatives that were considered in detail (including no action), the nature of the environment to be affected, and the nature and significance of the environmental effects of a proposed action and alternatives. Mitigation measures must also be described for any effects determined by the agency to be significant under the standards set in the regulations.

1.4 DEFINITION OF SCOPING

Scoping is a vital part of the NEPA process, and is one of the first steps undertaken when planning an EIS.

- It is an "early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action" (40 CFR 1501.7).
- It provides agencies with a method to determine the scope of analysis in an EIS, meaning the nature of the actions, the alternatives, and the impacts to be analyzed.
- It helps agencies to "identify and eliminate from detailed study the issues which are not significant or which have been covered by prior environmental review" (40 CFR 1501.7).
- It involves Federal, State, and local agencies, affected Indian tribes, the proponent of an action, and other interested persons (40 CFR 1501.7).
- It is one of the 17 methods of reducing excess paperwork, and one of the 12 methods for reducing delay, as outlined in the regulations implementing NEPA (40 CFR 1500.4 and 1500.5).

No standard format for scoping exists. Agencies have wide discretion in conducting scoping, as long as they get the results needed to continue the NEPA process. The USACE chose to hold meetings with other agencies and officials, and with the public. In addition, written comments were solicited through the Federal Register notices, announcements in local media, and the USACE web pages.

1.5 HOW THIS SCOPING DOCUMENT WILL BE USED

For a complex project such as the Fargo-Moorhead Metro study, it is important to define at the outset what specific environmental studies need to be reviewed or conducted before a decision is made. This Scoping Document, based on oral and written input from Federal, State, and local agencies, and other interested persons, describes the scope of actions, alternatives, and impacts to be studied in the Fargo-Moorhead Metro EIS and identifies the significant environmental issues that will be studied in detail, as well as those that are not significant or that have been covered elsewhere.

1.6 INPUT ANALYZED FOR THIS SCOPING DOCUMENT

Input analyzed for this Supplemental Scoping Document came from four sources:

1. Meetings with Federal, State, local agencies, and other entities.
2. A series of four public meetings, two held in November 2008 and two held in May 2009.
3. A scoping meeting held in May 2009.
4. Written comments submitted by agencies, organizations, and the interested public.

1.7 PROJECT STATUS UPDATE

1.7.1 Purpose and Need

The Purpose and Need Statement reads as follows: "The purpose of the proposed action is to reduce flood risk, flood damages and flood protection costs related to the flooding in the Fargo-Moorhead Metropolitan area."

1.7.2 Objectives

1. Reduce flood risk and flood damages in the Fargo-Moorhead metropolitan area.

2. Restore or improve degraded riverine and riparian habitat in and along the Red River of the North, Wild Rice River (North Dakota), Sheyenne River (North Dakota), and Buffalo River (Minnesota).

3. Provide additional wetland habitat in conjunction with other project features.

4. Provide recreational opportunities in conjunction with other project features.

1.7.3 Alternative Update

The proposed alternatives to address the flooding in the Fargo-Moorhead Metro area are as follows: The USACE will identify and evaluate the proposed actions and alternatives in the EIS, which will be

prepared according to federal NEPA regulations. The USACE will evaluate in detail only those alternatives that meet the purpose and need, as discussed earlier. The alternatives to be evaluated by this EIS are described below.

Alternatives

No Action: Continue emergency measures

Nonstructural measures
- Buy and relocate flood-prone structures
- Flood-proofing
- Elevate structures
- Flood warning systems
- Flood insurance
- Wetlands
- Grasslands
- Pay landowners for water retention

Flood barriers
- Levees
- Floodwalls
- Invisible floodwalls
- Gate closures
- Pump Stations

Increase conveyance
- Diversion channels around the study area
- In Minnesota
- In North Dakota

Increase conveyance in Oakport Coulee
Cutoff channels (to short-cut existing meanders)
Flattening the slopes on river bank
Replacing Bridges
Underground tunnels
Interstate 29 viaduct
Dredge river deeper and wider

Flood storage
- Large dams upstream
- Distributed storage
- Controlled field runoff
- Storage ponds, also used for water conservation

Figure 1 Fargo-Moorhead Metro Feasibility Study Area

2.0 SCOPING AND PUBLIC MEETING INFORMATION

2.1 PURPOSE OF MEETINGS

As part of the scoping process, the USACE, conducted 4 public meetings: two in Fargo N.D. and two in Moorhead, MN. In addition, an agency scoping meeting was held in Fargo, North Dakota. These meetings were held in November 2008 and May 2009 by the USACE to facilitate public involvement for the project and to supplement the NEPA scoping process conducted for the Fargo-Moorhead Metro project.

The introductory meetings held in Moorhead, MN on November 17, 2008 and Fargo, ND on November 18, 2008 were held to introduce the public to the Fargo-Moorhead metro feasibility study, and to inform the public about the activities that would be undertaken in the following months to formulate a plan of action for the Fargo-Moorhead Metro region.

The purpose of the May meetings was to update the public on the current status of the study, to seek any comments regarding the alternatives that the USACE would be carrying into the next phases of the study, and to identify any issues associated with those alternatives. The public was also asked if there were any additional alternatives, concerns, or issues that should be examined. These meetings served to fulfill part of the USACE scoping requirements under NEPA. In addition to accepting oral and written comments at the meetings, the USACE also accepted comments by mail and electronic mail (e-mail).

The goals of the public involvement process are to inform and educate the public and to solicit feedback throughout the planning and design process. The methods used to achieve the goals of the public involvement plan include informing and educating the public about the project in order to identify their concerns. This public involvement process also functions for NEPA scoping as required by the Council on Environmental Quality (CEQ). Scoping requirements are quite specific as described in 40 CFR, Section 1501.7. Of particular importance are the requirements to invite participation by affected Tribal, Federal, State, and local agencies, and other interested individuals or groups; to determine the scope and the significant issues to be analyzed in depth in the Environmental Impact Statement (EIS); and to determine alternatives to be addressed in the EIS.

The meeting notes in Appendix A provide a summary of the oral and written comments received during the comment period for the public scoping meetings. These meeting notes identify the general themes and trends of verbal and written comments received at the meetings. Appendix B contains the written comments that were received at the meetings or during the comment period. Appendix C contains the verbal questions and answers from the public meetings and the scoping meeting.

2.2 MEETING INFORMATION

The meeting dates, times, the approximate number of attendees and meeting locations are shown in Table 1. At the meetings, the USACE presented an overview of the project and project status, identified how comments should be submitted, and then opened the meeting for questions and answers followed by formal comments and statements. The USACE also accepted mailed (or e-mailed) written comments.

TABLE 1

PUBLIC SCOPING MEETINGS SCHEDULE

Location	Date	Time	Attendees	Meeting Location
Moorhead , MN	November 17, 2008	7:00 p.m.	50	City Council Chambers
Fargo, ND	November 18, 2008	7:00 p.m.	40	Prairie Rose Inn
Fargo, ND	May 19, 2009	5:30 p.m.	115	The Centennial Hall Fargo N.D.
Fargo, ND	May 20, 2009	10:00 a.m.	44	The Centennial Hall Fargo N.D
Moorhead, MN	May 20, 2009	5:30 p.m.	140	Hanson Theatre University of Minnesota Moorhead Campus, MN

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3.0 UPDATED SCOPING SUMMARY

3.1 GEOGRAPHIC SCOPE OF ANALYSIS

The geographic scope of analysis for the environmental impacts of the proposed action and alternatives consists of the Fargo-Moorhead Metropolitan region, located within the area from approximately 12 miles west to 5 miles east of the Red River and from 20 miles north to 20 miles south of Interstate Highway 94. This includes the Red River and the downstream portions of the Buffalo River, Wild Rice River (ND), Sheyenne River, Maple River, Rush River and other contributing streams that enter the Red River in the study area (Figure 1). In North Dakota the study area includes a portion of Cass County and the cities of Fargo, West Fargo, Hickson, Oxbow, Wild Rice, Frontier, Briarwood, Prairie Rose, Horace, Reiles Acres, and Harwood. In Minnesota the study area includes a portion of Clay County and the cities of Moorhead, Dilworth, Oakport, Rustad, Kragnes and Georgetown.

3.2 SCOPE OF ALTERNATIVES

The following measures will be evaluated in the EIS, and their potential effectiveness discussed. Detailed analyses and project design may result in changes in project features.

1. **Future Without the Proposed Project**: The measures identified with this alternative are the base condition upon which other alternatives are to be compared for impact assessment under NEPA. This alternative assumes that the types of emergency measures currently being pursued in the project area will continue to be implemented as necessary due to flooding. These emergency measures include such actions as raising levees to protect the cities of Fargo, ND and Moorhead, MN as well as surrounding cities, constructing temporary levees and floodwalls in various areas, and sandbagging.

2. **Levee/Floodwalls:**
   This feasibility study evolved from the City of Fargo's initial request that the Corps study a levee and floodwall plan to protect the city's downtown area. The communities in the study area have historically relied on both temporary and permanent levees to prevent flood damages, and they have been largely successful.

   The City of Fargo is developing a levee/floodwall plan for a large area south of Interstate Highway 94 between the Red River, Wild Rice River and Sheyenne River. The plan, called the Fargo Southside Flood Control Project, is being designed to be certified to FEMA as providing 100-year level of protection to the area. For this feasibility study, the proposed Fargo Southside Flood Control Project will be considered as one potential alternative.

   The City of Fargo has also investigated levee/floodwall alternatives to provide a continuous line of protection to the entire city at a 100-year level of protection. Their preliminary plans also proposed levees on the Moorhead side to mitigate for potential increased water levels caused by the Fargo levees. These studies have shown that the flood plain is very flat and only slightly above the 100-year flood elevation, so there is very little ground high enough to match a "100-year plus freeboard" elevation. Consequently, levees must be extended several miles away from the river in order to provide sufficient height to account for risk and uncertainty. It would be difficult to provide a certifiable level of protection higher than 100-year level using levees due to the general lack of high ground to tie into.

Levees and other properly designed and constructed flood barriers can prevent damages from most flood events that do not exceed their maximum design event. However, flood events may overtop the barriers or cause unexpected breaches at levels below the design event, leading to catastrophic failure of the system. For that reason, there is always residual flood risk to areas "protected" by flood barriers, and that risk is often misunderstood or ignored by people using those areas. Levees may confine the river and significantly affect river stages upstream, particularly for very large flood events.

This feasibility study will evaluate levee and floodwall features alone and in concert with other potential measures as part of a flood risk management system for the study area.

3. **Diversion Channels:**
Diversion channels could be used to route flood flows around the metropolitan area, thus reducing stages in the natural channel through town. Diversions have been employed successfully on other projects in the Red River Basin, including projects at Breckenridge, MN, Grand Forks, ND / East Grand Forks, MN and, most notably, Winnipeg, Manitoba. A diversion channel is being proposed as part of the recently approved Roseau, MN project.

During Phase 1 of this study, a preliminary design was developed for a diversion channel on the Minnesota side of the Red River. Other potential alignments will be investigated during the study (Figure 1), including alignments in both Minnesota and North Dakota, and incorporating the existing Sheyenne Diversion from Horace to West Fargo.

Diversions generally provide better risk reduction than levee/floodwall alternatives, because they cannot fail suddenly and catastrophically like a flood barrier can. If a diversion fails to perform, flood stages are no higher than they would have been without the project in place. However, diversions do not eliminate flood risk, and they are not fool-proof measures. Significant residual risk often remains from flood events larger than the design event, and there is potential for blockage of the channel due to ice and debris.

Diversions must be carefully designed to avoid increasing stages upstream or downstream. They must also be designed to avoid or minimize environmental impacts. It would be possible to build aquatic habitat into a diversion alternative, thereby increasing wetland functions in the study area.

4. **Nonstructural Measures:**

   a. **Relocation of Structures:**
   This measure allows for moving structures as part of the project and buying the land upon which the structures are located. It makes most sense when structures can be relocated from a high flood hazard area to an area that is completely out of the flood plain. As discussed above, this is not possible within Fargo and may not be possible within Moorhead. Therefore, any structure relocation would consist of moving the structure from an area of high flood hazard to an area of lower flood hazard and then using the nonstructural measure of elevation to achieve the desired level of flood risk reduction within the metro area. Development of relocation sites where structures could be moved to achieve the planning objectives and retain such aspects as community tax base, neighborhood cohesion, etc would

be investigated as being part of any relocation project. This measure is applicable anywhere in the metro area.

b. Buyout and Demolition of Structures:
This measure requires buying the structure and the land as part of the project. The structure is either demolished or sold to others and relocated to a location beyond the flood plain, all as part of the project. This measure will be considered, and is applicable anywhere in the metro area. Ecosystem restoration and/or recreational amenities could be pursued on the purchased lands for either this option or the Relocation of Structures option.

c. Elevation of Structures:
This measure requires lifting the structure above a particular flood event. In the metro area, the most acceptable elevation measure might be on extended foundation walls. Since most of the structures to be elevated have basements under them, the concept would be to elevate the basement off the ground. Then, depending on the design flood elevation, the elevated basement could be fully developed if the basement floor was above the Flood Insurance Rate Map (FIRM) base flood elevation (BFE) or the design flood elevation, whichever is higher. Basements could be kept undeveloped and wet flood-proofed to equalize hydrostatic force, or could be developed with more comprehensive wet flood-proofing concepts. Owners with fully developed pre-elevated basements would be compensated if the post-elevated basement cannot be developed. This measure is applicable anywhere in the metro area unless the required elevation is greater than 15 feet above the adjacent grade. Velocity and hydrodynamic force would also have to be considered. This measure is generally applicable throughout the metro area depending on flood depth and floodway location.

d. Removal of Basement:
This measure requires filling the existing basement without elevating the remainder of the structure. This would occur if the structure's first floor was above the BFE or above the design elevation, whichever is higher. Adding on to the side of the structure as part of the project would be possible with this measure so as to compensate the owner for the lost basement space. If the add-on is not possible due to lot constraints or because the owner opposed it, compensation for the lost basement space would be in order to the owner. This measure would only be applicable where the design flood depth is relatively small [first floor already above the design depth]. Hydrodynamic force would also be a consideration. This measure is applicable throughout the metro area.

e. Dry Flood Proofing
This measure concerns water-proofing the structure. This can be done to residential structures as well as all other types. This measure achieves flood risk reduction but it is not recognized by the National Flood Insurance Program (NFIP) for any flood insurance premium rate reduction if applied to residential property. Based upon tests at the Corps Engineering Research and Development Center (ERDC), a "conventional" built structure can generally only be dry flood proofed up to three feet on the walls. A structural analysis of the wall strength would be required if it was desired to achieve higher protection. A sump pump is required and perhaps a French drain system is installed as part of the project. Closure panels are used at openings. This concept does not work with basements. It will not work with crawl spaces in the metro area due to the long duration of flood. This measure will work in the metro area if design flood depths are generally less than three feet and on an

appropriate structure as discussed. Hydrodynamic force would also be a consideration. This measure has potential applicability throughout the metro area.

f. Wet Flood Proofing

This measure is applicable as either a stand alone measure or as a measure combined with other measures such as elevation as discussed above. As a stand alone measure, all construction materials and finishing materials need to be water resistant. All utilities must be elevated above the design flood elevation. Because of these requirements, wet flood proofing of finished residential structures is generally not recommended. Wet flood proofing is quite applicable to commercial and industrial structures when combined with a flood warning, flood preparedness, flood response plan. This measure is generally not applicable to large flood depths and high velocity flows.

g. Berms, Levees, and Floodwalls

This measure is applicable to locations within the metro area. As nonstructural measures, berms, levees and walls are generally no higher than 6 feet above grade and are not certifiable for the NFIP meaning that flood insurance and flood plain management requirements of the NFIP are still applicable in the protected area. These nonstructural measures are intended to reduce the frequency of flooding, but not eliminate flood plain management and flood insurance. These measures can be used for all types of structures in the metro area. They can be around a single structure or a small group of structures. With application of these measures to be nonstructural, they cannot raise the water surface elevation of the 100 year flood by any more than 0.00 feet. These measures must be placed with velocity in mind.

h. Flood Warning, Preparedness, Evacuation Plans and Pertinent Equipment Installation

These measures are applicable to the metro area. All of the above nonstructural measures with the exception of buyout and of relocation to a completely flood free site require the development and implementation of flood warning/preparedness planning. The development of such plans and the installation of pertinent equipment such as data gathering devices [rain gages, stream gages], data processing equipment [computer hardware and software], and dial out devices [cellular, land line] can be part of the project.

i. Land Acquisition

Land acquisition can be in either the form of fee title or permanent easement with preference to fee title. Land use after acquisition is open space use via deed restriction that prohibits any type of development that can sustain flood damages or restrict flood flows. Land acquired as part of a nonstructural project can be converted to a new use such as ecosystem restoration and/or recreation that is open space based such as trails, canoe access, etc. Conversion of previously developed land to open space means that infrastructure no longer needed, such as utilities, streets, sidewalks, etc., can be removed as part of the project. The conversion to new use [ecosystem restoration and/or recreation] can also be part of the project. By incorporating "new uses of the permanently evacuated flood plains" into the nonstructural flood risk reduction project, the economic feasibility of the buyout or relocation is enhanced. This is due to partial transfer from flood risk reduction costs to ecosystem restoration, and also by adding benefits [and costs] of recreation. This will be determined by use of the "Separable Costs/Remaining Benefits" guidance. Other Federal agencies such as the NRCS have

permanent easement programs to restore wetlands in "evacuated" flood plains that could be used in a collaborative mode with a Corps nonstructural program.

j. Flood Plain Management Plans

A flood plain management plan [FPMP] is required of the Corps non-Federal project sponsor. The intent of a FPMP is to "protect" the Corps partnered project from diminishing the frequency of flood risk reduction provided by the project. This is a non-Federal sponsor-required activity but, if done during the feasibility phase of study, can be cost shared on the same basis as the feasibility study. This makes sense for the local sponsor from the cost share and also from the holistic flood risk reduction perspective. This latter perspective makes sense for the Corps as well. By integrating the FPMP with the feasibility study, both the FPMP and the ultimate project are bettered. This should be done within this feasibility study.

k. Vertical Construction for Residential Occupancy

This concept refers to condominium living within flood plains, where the at-grade floor is used for open-space uses and the upper stories (which are all above even the most infrequent flood) are used for residence. This vertical construction is proposed for consideration within the metro area, especially in Fargo, because no area within a close proximity to Fargo is high enough above the Red River flood plain, or that of its tributaries, for flood-free residential construction. This may be the same for Moorhead. This concept to change residential construction from single family homes to vertical construction will probably face tough political/social criticism. However, it merits consideration if the metro area is to achieve a No Flood Risk status in the long term.

5. Flood Storage

Flood storage involves both preserving natural flood plain areas and also building dams and other water retention facilities to hold water during flood events. Natural storage in the floodplain occurs as the water rises and fills up low-lying areas adjacent to the rivers. Constructed flood storage projects (impoundments) can be located on the main channel of a river or "off-channel" on a ditch or other man-made connection to a river. Impoundments may be designed to remain dry until a flood event or to retain a pool during non-flood times for conservation or water supply purposes. The effectiveness of flood storage depends on many factors, including distance from the benefited area, volume of water retained, timing of the storage, size of the drainage area controlled, and the amount of runoff contributed from the controlled area during each particular flood event.

There are three existing Corps-owned flood storage projects in the Red River Basin that benefit the study area: Lake Traverse, Orwell Lake, and Lake Ashtabula. Opportunities exist to build additional flood storage, but previous studies have found insufficient Federal interest to support Federal involvement in such projects. The studies have also shown that flood storage alone cannot provide an acceptable level of risk reduction for the Fargo-Moorhead metropolitan area.

The St. Paul District's Fargo-Moorhead and Upstream Area Feasibility Study is currently assessing the viability of multi-purpose projects to provide both flood storage and aquatic ecosystem restoration. Phase 1 of that study determined in 2005 that it may be possible to build 400,000 acre-feet of flood storage in the watershed using projects of 2,000 to 20,000 acre-feet each. An impoundment downstream of White Rock Dam near the ND/SD border that could provide up to 60,000 acre-feet of storage was also considered. (Note: this is the most storage the study team thought possible, due to limits of topography and landowner willingness.) Such a system of

impoundments could reduce the flood stage in Fargo-Moorhead by up to 1.6 feet. The economic benefits of the system have not been fully assessed, but preliminary analyses showed that the National economic development benefits in the Fargo-Moorhead metropolitan area would equal less than one third of the cost, so it appears unlikely that there is sufficient Federal interest based solely on flood damage reduction. It should be noted, however, that lack of Federal economic justification does not imply that flood storage should not be built or is not justified from a Regional or local perspective. On the contrary, it is probable that local jurisdictions will find compelling reasons to construct flood storage projects.

Despite the lack of Federal financial involvement, the Cass County Joint Water Resource District recently built a dam on the Maple River upstream and approximately 35 miles southwest of Fargo, ND. The Bois de Sioux Watershed District in the headwaters of the Red River Basin and the Buffalo-Red River Watershed District are also designing and constructing flood storage projects. These smaller projects provide incremental benefits, but they are not sufficient to prevent major flood damages in the Fargo-Moorhead Metro area.

It is likely that additional flood storage will be built upstream of the study area, but that storage alone is not likely to adequately reduce flood risk to the study area over the next 50 years.

6. Tunneling
A series of tunnels underneath the city was proposed. Potential advantages cited for the concept include: this would require very little real estate acquisition, very little bridge or road building or modification, and the soil in the project area is very soft and would be easy to bore.

7. Bridge Replacement or Modification
Bridges can restrict the flow during flood events. The study will assess the effects of existing bridges and consider modifying them or re-constructing bridges to allow more flow through and prevent the backing up of water.

8. Interstate 29 viaduct
Reconstructing the Interstate 29 corridor to serve as an open viaduct during floods was proposed. The reconstructed corridor would function as an interstate highway during non-flood times.

9. Dredging and Widening the River
Digging the Red River channel deeper and wider will allow for more flow to pass through the Fargo-Moorhead Metro area was proposed. This alternative could also be looked at underneath existing bridges to prevent the damming effect the bridges can create.

10. Wetland and Grassland Restoration
Restoration of grassland and wetlands to reduce peak runoff and serve as water storage during flooding events was proposed.

11. Cut-off channels
Building cut-off channels across meanders in the cities was proposed. This would provide the water a straighter path through the city and potentially reduce peak stages.

12. Sustainability Alternative
This alternative would include a combination of non-structural (Alternatvie 4), wetland restoration (Alternative 10) upper basin storage (Alternative 5) and cropping-landuse changes.

13. Combinations of the Above Alternatives

The alternatives listed above will be assessed in combination with other alternatives.

3.3 SCOPE OF ISSUES TO BE ADDRESSED IN THE EIS

The USACE has identified issues that would need to be addressed in the EIS through input from public scoping meetings in 2009 and internal and interagency meetings, discussions, and correspondence. Many issues, such as cultural resources and relations with other states and nations, must be addressed due to some form of legal requirement (law, Executive Order, regulation, treaty, or other agreement) and will be covered in the EIS to the extent necessary to ensure that these legal requirements are fully met. Examples include procedural coordination concerning any identified threatened or endangered species and cultural resources.

Based on the scoping process and the analysis of written and oral comments received as part of the scoping meetings, the USACE has determined which issues will be evaluated and which will be summarized in the EIS.

3.3.1 Significant Issues to be Evaluated in the EIS

The following issues were identified by the USACE through input from public scoping meetings and agencies as significant, requiring evaluation in the EIS. The importance of these issues may change as the EIS process proceeds.

3.3.1.1 Downstream Water Quality

This issue includes questions about sulfates, total dissolved solids, mercury, and other water quality parameters in the Sheyenne, Wild Rice, Buffalo, Rush, and Red Rivers.

3.3.1.2 Downstream and Upstream Water Quantity

This issue includes downstream and Upstream flooding both with and without storm events, questions regarding specific water levels at specific locations on the Sheyenne, Wild Rice, and Red Rivers, and discussions on water storage impacts.

3.3.1.3 Buffalo River Aquifer

This issue concerns the East side diversion alternative. There is concern that the Buffalo River Aquifer may be negatively impacted.

3.3.1.4 Social Issues

This issue includes impacts to neighborhoods, homeowners, farmers, and other residents within the study area.

3.3.1.5 Economic Issues

This issue includes questions about infrastructure impacts (such as sewers, roads, and levees), as well as specific issues around tax base, economic viability of businesses (including farms), and the effects on agriculture and other businesses. It also includes issues about cost-benefit and other standard economic analyses.

3.3.1.6 Flood Fighting

This issue includes how the current and historical flood fights affect the planning for a permanent flood control project.

3.3.1.7 Environmental

This issue includes potential effects on any threatened or endangered species that may occur in the geographic scope of analysis. This issue will be analyzed due to legal requirements related to Federal threatened and endangered species.

3.3.1.8 Wetlands

This issue includes the potential for reclaiming wetlands or, at a minimum, maintaining the existing wetlands.

3.3.1.9 Land use and Floodplain growth

This includes floodplain development, protecting land for development purposes, and existing land use versus future land uses.

3.3.1.10 Downstream Erosion and Sedimentation

This issue includes impacts to riverbanks and shorelines on the Red Rivers and its tributaries within the study area. It involves questions about bank stabilization (mitigation), severity of erosive effects, overbank flooding, elevation of the floodplain, effects on river stage, short- and long-term water level changes and combined discharges.

3.3.1.11 Cultural Resources

This issue includes potential effects on archaeological and historical resources (including traditional cultural properties) that may be eligible for the National Register of Historic Places. This issue will be analyzed due to legal requirements.

3.3.1.12 Fish Passage

This issue includes how fish passages will be impacted by selected alternatives. Will existing passage ways be influenced?

3.3.1.13 Flooding

This issue includes the environmental benefit of some lighter level of flooding; some fish species depend on it.

3.3.1.14 Downstream Aquatic Resources

This issue includes topics related to fishery health, effects on riverbank (riparian) vegetation, Red and Sheyenne River fishery, mussels and plankton, and other nutrients.

3.3.1.15 Fargo Southside Project

This includes the Fargo Southside project being developed by the city of Fargo; many folks think this project and the Fargo-Moorhead Southside project have similar purposes.

3.3.1.16 Executive Order 11988

This issue includes undeveloped lands that may be inside the protected area as a result of the project constructed.

3.3.1.17 Natural Resources Habitat

This issue includes natural resource habitat along the entire impacted area.

3.3.1.18 Slope Stability

This issue includes slope stability along all impacted river corridors in the study area.

3.3.2 Issues to be Summarized or Not Addressed in this EIS

The following issues were identified as not significant, not significantly impacted by the project or beyond the scope of analysis for this EIS. They will be summarized in the EIS or dismissed as not significant.

3.3.2.1 Noise

Noise was not identified as a significant issue.

3.3.2.2 Air

Air was not identified as a significant issue.

3.3.2.3 Mineral Resources

Mineral resources were not identified as a significant issue.

3.3.2.4 Energy Production

Energy production was not identified as a significant issue.

3.4 ADDITIONAL COMMENTS

Many oral and written comments were received at the public meetings, along with numerous technical questions that were responded to at the meetings by USACE and the sponsors from Fargo and Moorhead.

APPENDIX A

COMMENT SUMMARY
SCOPING MEETINGS

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SCOPING MEETING COMMENT SUMMARY
Fargo Moorhead Metro Study

This appendix summarizes the general trends and themes of verbal comments presented at the meetings and contained in written comments during the public comment period. Comments have been divided into categories or issues. Written comments are included in Appendix B. Where a comment was summarized from a written comment, the written comment identification code is noted. The written comment identification code is composed of:

- Submittal date code (e.g., April 20, 2009=090420).
- Name of commenter (if known).

This code allows the reader to identify and review written comments in Appendix B related to the summaries presented here. Comments without the code were summarized from verbal comments made at the meetings. Written comments read at the meetings are summarized under the written comments section for each issue and can be found in Appendix C. Some comments can be found under more than one issue.

1.0 TIMING/SCHEDULE

1.1 VERBAL COMMENTS SUMMARIZED FROM SCOPING MEETINGS

What is driving the timeline? How is this coordinated with the Fargo Southside Project?

If the diversion project proceeded in 2012, what would be the completion date?

It appears that the earliest the project would be constructed would be 10 years from now. How can we protect ourselves in the meantime?

2.0 SCOPE OF ALTERNATIVES/GEOGRAPHIC SCOPE OF ANALYSIS

2.1 UPPER BASIN STORAGE

2.1.1 Verbal Comments Summarized From Scoping Meetings

Waffle Storage concept should be reconsidered where farmers are paid for storage when needed.

I don't understand levees. What is wrong with building dams like the Garrison Dam?

Timing is also an issue if water can be retained at its origin. The time between the pre-crest level and the post-crest level was a few hours – if water can be retained even that long, the peak should decrease.

Are we still considering the "waffle plan"?

2.1.2 Written Comments Submitted During the Comment Period

090417_Fitzpatrick – I am thinking of 2 to 3 overflow canals, dug to the overflow level of the river that would carry the extra water to a large pit, where the water would be pumped out and used for productive uses throughout the summer.

090519_Bach - What about off-line storage on North Dakota side south of Wild Rice? Has that been looked at? Probably need 8 to 10 sections of land, dig 20 feet deep.

090520_ Mark Nokken – Water retention to keep floods at a manageable level.

090521_Sandt – All fields should have gates on them holding water back during flood events; this would be controlled by a water board.

090606_Tweeten – Build successive weir pools upstream of affected areas. During low-flow periods the basin of the pools could be native grass to support nesting birds and other wildlife, which after time could be valued as a hunting resource.

090525_Keller – I feel permanent flood protection must include multiple solutions; in conjunction with a diversion channel I would like to see a series of large holding ponds up and down the river in both Minnesota and North Dakota.

090606_Breker – I am interested in the economic analysis in all potential upstream water retention.

090606_Ista – We need assistance to build retention on the Wild Rice River to decrease flows.

090622_NWF – The waffle project, combined with wetland restoration is also a viable alternative. The waffle plan is simple, existing roads serve as levees to store water in farmers' fields. One square mile holding water 1 foot deep will store more than 200 million gallons of water.

090624_NDWF – We ask that you please include Red River basin and watershed-wide solutions that incorporate wetlands and grasslands.

The multiple functions wetlands and grasslands can provide in holding snow, runoff water and rain can reduce pressure on levees and dams.

These natural resources can also reduce river and stream flows enough to decrease the impacts of dramatic flooding on communities.

090629_Bezek_MNDNR – The employment of water retention should be included in the mix of alternatives. Opportunities exist to increase and improve ecosystem and wetland restoration, wildlife habitat and provide recreational opportunities through the use of multipurpose water retention areas.

090630_Fetch - I propose two methods that seem to be much less expensive than a diversion and have merit in lowering flooding. One is the "waffle concept" that has been researched in detail by scientists at the University of North Dakota in Grand Forks. Clearly we can use the existing ditches by controlling runoff through the culverts in the spring.

A second method that I propose is a retention strategy that could use low-lying farmland adjacent to major rivers to hold water. If low-lying land adjacent to the Red River was purchased and a series of perpendicular ditching was cut (20 to 30 feet deep and perhaps the same width extending several hundred feet) using large backhoes or D5 Caterpillar equipment, water could be diverted and held, and pumped out later.

090709_EPA – A range of alternatives should be developed including waffle approach, enlarging floodways through land use as well as levee and channel diversions, nonstructural approaches that restore natural floodplain connectivity, including enhancement or creation of wetlands and other flood reduction techniques.

090811_FPC – We ask the Corps to review management of current water storage in dams when a 100-year+ flood is predicted. If necessary change the law or guidelines to maximize benefits for floods over the 100-year mark.

No Date_Stern – Two-way pipeline to reservoir behind Garrison – flood relief in spring, water supply in summer during dry years.

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Anonymous – Build retention areas along the rivers that feed the Red. That's where it starts. Pay the farmers to hold the water. This will cause no permanent damage to land compared to diversions or channel extensions or oversized dikes. Some floodwalls or smaller dikes will be needed in some areas.

2.2 INCREASE CONVEYANCE

2.2.1 Verbal Comments Summarized From Scoping Meetings

Can we just widen the river that's there?

Could the regional solution include the Sheyenne Diversion, or does the existence of the Sheyenne Diversion make us go into Minnesota with a new diversion?

Where would a Minnesota diversion go?

The Sheyenne Diversion project created ponding where there was no flood problem before. Beware of creating unanticipated problems.

Could we increase conveyance through town?

Has any thought been given to buying out a larger portion of the river to create a larger river to convey more water?

Have you thought about using the I-29 corridor as a diversion?

Are you talking about diverting the entire river or would the water be diverted at a certain elevation?

How do bridges constrict the flow?

Has a study been completed that will identify the reason for the increase in flooding frequency? Could the river be dredged to create a deeper river that would increase conveyance?

If bridges are a constriction along the river, why are we not looking at reconfiguring the pilings like on the LA River? Can we have a standardized measuring system for stages given that there are variations in stage measurements? I am in favor of dredging and straightening of the Red River.

How do you accommodate traffic over a 2,000-foot-wide ditch? Why wouldn't the diversion channel go through Fargo on the west?

The diversions go through dry land. Why can't they be located in areas where the land is wet?

2.2.2 Written Comments Submitted During the Comment Period

090519_Kathy Laney – I vote for a diversion: long-term solution, allows Fargo-Moorhead to still be a river city, provides protection to surrounding small communities. Start now! If we could sell our home we would move out of community.

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090519_Charles D. Dunnell – Number one choice is: diversion channel, second choices modify or add onto the West Fargo diversion.

090520_Olson - I resent the diversion planned on my property: (Stanley Township, South of County 14, Sections 25 and 26). This is devastating to the beautiful farmstead (which has been in our family since the 1880s) the tranquility and beauty of the river, the adjacent wooded area and the farm acreage. It is difficult for me to believe that this type of devastation could be handed to me.

It is not true that I am not interested in flood control. If need be, I will approve the planned dike (wet side) on the west rim of the property.

I chose to not develop my property. Others did, knowing they were in harm's way.

090520_A Saharieff – Please consider: dredging the river under the three bridges; Main Avenue, NP Avenue, and the Railroad trestle. Also design and build torpedo-shaped flow accelerators in front and behind the bridge support abutments. Flow must be enhanced for levees to work. Please consider dredging and cross cutting the river channel

090520_Koppang – I drew out the diversion option on the Minnesota side during a lull in this year's flood battle. My drawing closely mimics the drawing the Corps provided at the public meeting for the east side diversion.

090520_Neuhauser - One of three options would be to divert the water around town, but this would be expensive due to land acquisitions, bridge and road construction, and very time consuming.
What I am proposing is a tunnel system underneath the city. Very small land acquisition, very little bridge and road construction, and the soils are easy to bore through.

090520_Deanne Sperling – Diversion seems the most practical solution.

090520_Gary Shramstad – I suggest a diversion of the Sheyenne from McVille to the Red River north of Grand Forks. This would alleviate flooding on the Sheyenne and Red, since the Sheyenne headwaters are north of Bismarck. It would also solve the problem of Devils Lake overflowing.

090520_Reinke - Having attended the flood presentation at Moorhead State I believe the only real resolve to the long-term flood problem must involve some type of diversion.

Water retention and other forms of water control may offer some form of relief, but they are only band-aids to the overall problem.

It was an excellent presentation.

090519_Cousins - I feel any plan must include a diversion channel. The cities that have one seem to do well – Breckenridge, West Fargo and Winnipeg. I would like to see a combination plan, levees and a diversion channel.

A 500-foot-wide, 20 feet deep below field elevation, and a 2,000-foot top width diversion channel seems excessive.

What is the cfs for a 100-year flood and what cfs would the diversion channel handle?

What is the proposed water depth and velocity of the diversion channel?

Would a diversion channel be detrimental to anyone downstream?

090521_Linnertz – Run a diversion from the Red River around the west side of West Fargo, to include the Red, Wild Rice, and Sheyenne Rivers. Continue the same to the confluence of the Red and Sheyenne.

090521_Linnertz – Create the Red River Diversion to the east as referenced in the meeting, and create an extension of the West Fargo Diversion utilizing Drain 41.

090602_Majkrzak – I propose you consider the I-29 right-of-way as an open viaduct during major floods and as a roadway during normal flows. I also suggest a split in I-29 to create a North Dakota side and a Minnesota side; these would serve as mini diversion channels holding and forcing flows north protecting the cities from overland flooding from small creeks and coulees from the east and west directions.

090606_Lahren – Why do you need a 500-foot-wide bottom for a diversion?

090606_Sell – The diversion is the only answer! But it doesn't need to be 500 feet wide; it should be 50 feet wide. We need a 100-year solution!! The alternative of the North Dakota diversion from the Wild Rice River to north of Harwood is very good.

090608_Bergan – We need 100-year solution; the only method of flood protection that is sure to work is a diversion around Fargo-Moorhead. A 500-foot-wide bottom seems too wide; a 50-foot width is what we need. The North Dakota side may be better for political reasons.

090619_Bergan – We now know that the Main Avenue bridge acts as a dam at about 40 feet, attached pictures. At about 41 feet the water will back up and flow around both ends of the bridge and into the cities. The diversion is the only answer.

090621_Siemens – I don't understand why folks are so reluctant to put permanent flood protection in place. All the water that went through Fargo went through Winnipeg this spring. The flood waters were a non-event in Winnipeg thanks to the diversion.

Putting up floodwalls, levees, etc., is a collection of band-aids that you can never be sure will really do the job; they also require a lot of maintenance.

Defacing riverfront property with walls, levees, etc., is a horrible thing. What will happen to property values in the nicest neighborhoods in Fargo?

Originally they said it could not be done in Winnipeg either; but people with vision, foresight and determination made it happen.

It is not a question of can we do it or should we do it, the only questions should be HOW QUICKLY CAN WE GET A DIVERSION BUILT?

090622_Bergan – I have attached proposed design criteria for protection of Fargo Moorhead metro to 50 feet.

1. Where would it start and end? Wild Rice River west of I-29 and end north of Argusville.
2. What areas would be protected? Both side of the river for the length of the diversion and to some extent about 10 miles south of the inlet.
3. What cities/areas would be protected? Fargo, Moorhead, West Fargo, Oakport, Briarwood, Round Hill, Hickson, Horace, Oxbow, Harwood, and more.
4. How much would be diverted? The total flow of the Wild Rice and the overland flooding from there to West Fargo which is about one-half the flow of the Red River. Additional amounts from the Red River could be added if needed at a later time to maintain the best balance.
5. How much will the Federal Government pay? 65 percent or $650 million of a $1 billion project.
6. Where will the other money come from? States of North Dakota and Minnesota and the cities of Fargo and Moorhead.
7. Does it work? It has worked as advertised in West Fargo, Winnipeg and other areas.
8. How soon could it be started? If a diversion could be selected as the method it should shorten the process.
9. Will it take a lot of farmland out of production? No, estimate it will only take 600 acres out and change 4,000 from corn to alfalfa.
10. Why are we having these large floods? Wet cycle- see Devils Lake - 8 of 10 record floods in the last 40 years.
11. What happens if the flood exceeds the capacity of the diversion? It overflows to the west and north over farmland.
12. Does it dump water on Harwood? No – will enter the Red way north of Harwood and it is the same amount of water.
13. What is the size? It is estimated to be 20 to 30 feet deep and average 75 feet wide at the bottom and maybe 500 to 700 feet at the top.
14. Can eminent domain be used to acquire the land? Yes – same as would be needed for a levee system.
15. What is the probability of a crest over the 2009 level? The National Weather Service on 4-4-09 indicated a 10 percent chance of 44.6 feet for the second crest.
16. Should we build more dams? Valley City had a major flood this year and about 100 percent of the water from its drainage area is stored in Devils Lake or flows into the Baldhill Dam. Spillways washing out such as Clausen Springs.

Facts for a split flow diversion

1. The 1826 flood was 40 percent larger than the 1997 flood in Winnipeg. April 4, 2009, the National Weather Service said there was a 10 percent chance of a 44.6-foot crest in Fargo. Fargo-Moorhead, not just property along the river could be flooded.
2. A plan is needed to allow us a chance to survive a flood of this magnitude.
3. A 700-year flood can occur at any time – it could be next year.
4. We are in a wet cycle.
5. The Red River soil is unstable.
6. Fargo-Moorhead is the last major community in the valley with no significant permanent protection.
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September 14, 2009

7. Sending one-half the water into a diversion would make fighting a large flood manageable.
8. Must have a zero possibility of over a 40-foot flood so that the Main Avenue bridge does not act as a dam.
9. The design could route any water over say 22 feet until you reach say 30 feet down the diversion then about one-half the entire flow.
10. The flow in a diversion is expected to be below ground level. Spoil banks would be more like a dike on the east side of the diversion.
11. Topping the diversion would flow west and north into fields.
12. Topping the proposed Corps levees would inundate the cities.
13. Physics – the amount of water is not increased at the outlet by the diversion.
14. Levees have many failure modes such as design flaws, shifting soil, water over or under, through, etc.
15. Squeezing the water (i.e., in levees) increases the height of the flood.
16. The slopes can be used to grow alfalfa.
17. Buyouts along the river are not required.
18. Residents of Fargo-Moorhead can feel secure during a flood.
19. Stress would be reduced and lives saved (relocating the elderly and sick).
20. Will increase values along the river and in the cities.
21. The 2009 flood had a huge negative impact on the Fargo-Moorhead economy – West Acres Mall closed for days.

090622_Feist - Please consider the diversion plan as the permanent solution for flood control, for the Fargo-Moorhead metropolitan area. One only has to look to Winnipeg to see how successful that diversion has been at protecting their city from flood waters.

090623_Satrang - I am writing to let you know that I support a diversion for flood protection of Fargo-Moorhead and the surrounding areas. The Corps of Engineers has requested public comments. The diversion is the only sure protection. We need something that will protect us against a 500-year flood level! The only method of flood protection that is sure to work is a diversion around Fargo/Moorhead. Please urge the Corps to focus all efforts on a diversion.

The 500-foot width projected for the bottom of the diversion by the Corps is too wide. A much narrower bottom width would work well based upon comparisons to the original Winnipeg diversion. This should reduce the cost significantly and would give it a favorable cost benefit ratio.

A diversion should start on the North Dakota side at the Wild Rice River as suggested by the Corps, and should be started on the west side of I-29.

Dikes and floodwalls are a very poor solution to a very complex problem.

090623_Solberg - I am writing in support of a diversion channel as the best option to protect Fargo-Moorhead from the Red River floods.

There are other alternatives out there, but I feel that the diversion channel should be the favored solution.

090624_Furness – I would like to add my voice to the growing number of people who are advocating for a significant diversion solution to the increasingly frequent flooding of the Red River.

I have been encouraging officials to search for solutions involving a combination of water storage, dike protection and diversion. Diversion, if feasible, seems like the best long term solution.

090629_Boe – We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090629_Bolin - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090629_Cosette - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090629_Finch – Why not dredge the river wider and deeper? Cement the bottom and sides to hold the banks.

090629_Halvorson - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090629_Schock - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090629_Tillman - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide, it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090630_Altendorf - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090630_Bender - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090630_Bredell – I wanted to let you know that I support a diversion for the Fargo-Moorhead area. A dike system is a band-aid that will fail in time.

090630_Cronin - I am in total agreement with the group of people proposing a North Dakota diversion channel west of the city of Fargo. I have several reasons to support their position:
1) A large amount of the water entering the Red River channel comes from the west. It is logical to keep it on the west side instead of going the long way around the city.
2) Keeping the diversion in North Dakota limits the amount of political infighting that will happen when water crosses any type of border.

3) In addition to the Wild Rice River a west side channel could collect water from the Sheyenne, Maple and Rush. It offers a greater choice of design and function.
4) Being able to provide solutions to more rivers brings more people on board with the project. I don't think that many people outside of Fargo are excited about paying for Fargo's flood control with a sales tax. I know many people in my area would be in full support of the taxes and project if it offered diversion like protection for us. I also think that people would be more comfortable about helping drain Devils Lake through the Sheyenne if there was diversion protection.

090630_Forknell - As a resident of North Dakota, I am in strong support of the recently presented diversion that would run through North Dakota. The only method of flood protection that is sure to work is a diversion. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090630_Hannaher - I am writing this note to you today to encourage you to consider a diversion as opposed to a levee system to protect the Fargo-Moorhead area.

The facts are in and my concerns are focused on the long term reliability of a levee system given that we have a soil structure that really has no structure. In my opinion even if we put pilings down to bedrock to support a levee system the risk will always be there for wash outs due to water pressure between the pilings. Those weak points would not manifest until a flood occurs again and would put the city at risk.

090630_Hegg - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090630_Hoefs - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090630_Mitchell- We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

I have lived along the river for the past 35 years and 27 of those years there were only three floods, now since 97 it seems like every other year there is concern for our towns and property. This diversion is the only thing that makes sense to me; diking only raises the levels beside the worry of a breaching. I feel the Corp of Engineers should take a serious look at this proposal and consider the long range of PERMANENT flood control.

090630_Moen - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090630_Passolt - Please put the diversion project (Western Diversion) that ex-Gov.Schaefer is promoting as your #1 Option to protect Fargo-Moorhead and surrounding area.

I've read several articles about some of the alternatives and my current house is located in an area where they were proposing a dike in my backyard even before the flood of 2009. It's a good thing the proposed dike wasn't built because it would've been too low.

I believe the Western Diversion is the answer to these issues; please make it your #1 Option.

090630_Pfeiffer - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090630_Werlinger - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090701_Gates - I own a home in Fargo, and like many others in the community, I am concerned that a dike/levee solution will not provide the necessary protection that our cities require. I am sure you are aware, the best way to ensure our community is not faced with billions of dollars in flood damages when a 42 to 43 foot flood hits is a diversion through Minnesota or North Dakota.

I do not see how a levee system can offer a 99.9 percent assurance, especially considering the unpredictable nature of the Red River.

How can dikes or levees protect to 45 feet when the automobile and railroad bridges downtown start holding back water at 41 feet?

A diversion can keep the river well below 40 feet in even the worst flood, and the damage would be minimal in the event of a failure.

A diversion system can be designed that not only protects against major floods, but can keep the river below 25 feet through town during "nuisance" floods as well. The area's best parks, golf courses, and trails begin taking on damage at this level. Conversely, a dike/levee project will require many riverside property buyouts, lessen the recreational and visual appeal of the river, and it does not provide a solution for the "nuisance" floods that have become so common during the summer months.

090701_Ortmeier - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

It seems only logical to use the form of a diversion ditch rather than levees to avoid catastrophic failure due to breach.

Levee system will only funnel a higher volume of water THROUGH the communities where it can do the most damage if a breach occurs.

090702_Dickerson - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090712_Dufault - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

I live in West Fargo and it has already proved invaluable that we have a diversionary channel. It's just really too bad that the rest of the city has not had this done yet.

090714_Engler - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090715_Clasen - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090715_Heidt - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090715_Hoefs - I would like to urge you to strongly consider a diversion to protect Fargo-Moorhead from future flooding. There are many flood control options on the table right now, and I believe a diversion plan may not be getting due consideration. Given the enormous expense of fighting floods and funding flood protection the public deserves a thorough review of this proven method of flood control.

090717_Bergman - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090717_Holscher - I am writing to inform you of my support for the split flow diversion that has been recommended by the Flood Protection Coalition for the Fargo-Moorhead Community. For permanent flood protection, the advantages of the diversion far outweigh the advantages of a levee or other type of system.

Major areas that I like about the diversion are:

1. If the water level would exceed the diversion, the flooding goes to fields to the north and west and not inundating the cities of Fargo, Moorhead, West Fargo, et al.
2. There is the ability to add containment for some of the spring runoff that could be used in dry years which could negate the need for a pipeline to the Garrison Diversion.
3. We can do it all right here in North Dakota and eliminate the red tape of having to work with two states which means getting it done in a more timely fashion.

090722_Fujimoto - We need a 100-year solution! The only method of flood protection that is sure to work is a diversion. But it doesn't need to be 500 feet wide; it should be 50 feet wide. The alternative of the North Dakota diversion to start at the Wild Rice River and end north of Harwood is very good.

090722_Jensen - Here are my observations as a non-engineer:

1. The Grand Forks temporary dikes were overwhelmed in 1997.
2. The Grand Forks permanent dikes held in 2009.
3. The flood levels are becoming more unpredictable.
4. Fargo and Grand Forks temporary and permanent dikes are expensive.
5. Failure of a dike is ruinous to a community and its businesses and their futures.
6. A dike has a structural limit.
7. Diversions in West Fargo and Winnipeg have a clear history of success.
8. Diversions do not need to be rebuilt and do not increase upstream water levels.
9. Increasing upstream water levels will adversely affect farmlands.
10. Diversions assist the river to flow more freely.
11. A temporary dike can be constructed to assist a diversion. A diversion cannot be constructed rapidly to assist a dike system.

Choosing a diversion appears to be the best option. Choosing the cheap or easy option does not stand the test of time well. Please use wisdom in your decision.

090811_FPC – The Flood Protection Coalition proposes a 20,000-cfs diversion increasing in size as it flows north on the North Dakota side, diverting the Wild Rice and adding water from the Red only if the cost is justified.

A control structure on the Red should be avoided if possible because it will potentially raise the river level to the south and provide little or no benefit to that area.

An option to any North Dakota plan could be to divert only the Wild Rice River west of I29 to reduce costs.

Please evaluate whether or not the area of the Sheyenne diversion under the I-94 Bridge can be made deeper and wider to get by without replacing the bridge until the next time the interstate is worked on.

We feel very strongly that any flood protection plan must protect our community from a 500-year event and a diversion on the North Dakota side of the river is the only viable option.

2.3 FLOOD BARRIERS

2.3.1 Verbal Comments Summarized From Scoping Meetings

Why do we need floodwalls in Harwood Groves if you're going to build a diversion?

If a levee is constructed, up to what level will it be constructed? If I want a permit to construct my own levee can I construct it to the level of the 1997 flood?

What is the value in building levies above the 40-foot stage?

2.3.2 Written Comments Submitted During the Comment Period

090519_Mathern - Our home was right next to the dike – we support a permanent dike plan even it affects our view of river and change to our property.

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090520_Neuhauser – One of three options would be to build large flood walls through town.

090521_Sandt – Water tubes similar to those used in the flood this year should be on hand to be used for helping with flooding.

090606_Wolf – How are you determining where the levees will be constructed if that is the chosen alternative?

090811_FPC – The Flood Protection Coalition believes the levee system designed for a 100 year flood as proposed in the preliminary Corps plan is not acceptable and is not comparable to a diversion system that will protect us from a 500 year flood.

2.4 POLITICAL

2.4.1 Verbal Comments Summarized From Scoping Meetings

2.4.2 Written Comment Submitted During the Comment Period

090520_Olson - The Fargo Flood Plan is too restricted in scope. It appears as if developing the area is a priority, rather than flood control. My assumption is that politics has entered in. Individuals with prestige are spared intervention of flood control. This was verbalized at one meeting.

090521_Sandt – I suggest developing a Water Commission Board that has the authority to drain lands when it is appropriate to decrease flooding.

2.5 OTHER GEOGRAPHIC SCOPE OF ALTERNATIVES

2.5.1 Verbal Comment Summarized From Scoping Meetings

2.5.2 Written Comments Submitted During the Comment Period

090520_Jill Johnson-Davidson – We would like our property protected. No one interviewed my neighborhood last September (Woodlawn Point, Moorhead). Proud survivors, who live with river. What is least damage: dredge or diversions – both have impact. End building permits on spongy wetland. Permit and enforce coordinated farm runoff. What is best for the river and her health? Don't only listen to or believe city officials especially about buyouts – ask residents directly. Why are there more floods, higher crests – what are the contributing factors that can be mitigated. Moorhead's goal was to protect infrastructure not homes or people. Fargo diked extensively; raised water in our neighborhoods. We were not contacted in September – based on our location, I would think we would be. Diversion number one choice. Explore contributing causes of why floods have increased. We love the river – for us, the river is not the problem – the flood is not the problem.

090519_Cousins - I would like to see a combination plan, levees and a diversion channel.

090520_A Saharieff - Design and build torpedo-shaped flow accelerators in front and behind the bridge support abutments. Flow must be enhanced for levees to work.

090520_Chuck Stenso – Buy out homes on west side of River Drive. Build berm to 46 to 48 feet along west curb. Area could have bike path/picnic area.

090606_Headrick – How will Corps handle existing structures, such as Sheyenne diversion; could they be altered to work better for full region protection, or will they be left as is?

090606_Koski – How can you adjust your project for a river that flows north into a frozen drainage channel?

090622_NWF – Evaluate wetland restoration and other nonstructural approaches as an alternative for flood control and protection.

From our perspective, levee construction and diversions are very expensive, threaten downstream communities with additional flood hazard and offer no environmental benefits.

Wetland restoration can reduce flood peaks, shift timing of events, while providing benefits to include clean water, larger fish and wildlife populations and enhance recreational opportunities.

Evidence suggests that wetland drainage over time had significantly impacted flooding in the Red River basin. The area has experienced 8 of the 10 all-time record flood crests in the past 30 years.

The study must develop a Wetland Restoration Alternative.

The prairie pothole region provides viable wetland restoration opportunities.

090624_NDWF – We ask that you please include Red River basin and watershed-wide solutions that incorporate wetlands and grasslands.

The multiple functions wetlands and grasslands can provide in holding snow, runoff water and rain can reduce pressure on levees and dams.

These natural resources can also reduce river and stream flows enough to decrease the impacts of dramatic flooding on communities.

090709_EPA – A range of alternatives should be developed including waffle approach, enlarging floodways through land use as well as levee and channel diversions, nonstructural approaches that restore natural floodplain connectivity, including enhancement or creation of wetlands and other flood reduction techniques.

Land use planning and floodway zoning in the Fargo Metro area should be disclosed in this study.

No Date_Dave Anderson – I believe we must utilize every measure – barriers, diversion, and storage to ensure the greatest level of protection

3.0 SCOPE OF ISSUES

3.1 INFRASTRUCTURE PROTECTION

3.1.1 Verbal Comment Summarized From Scoping Meetings

What are the realistic options other than a diversion?

Why build homes where the low ground and flooding is?

Could you explain what an invisible wall is? How will a cut-off channel make things better?

I'm trying to build something in my backyard – how high should I build it? Who will provide me with that guidance?

Could you talk more about nonstructural solutions such as buyouts?

Moorhead still has walkout basements, could those be flood proofed as part of the project?

3.1.2 Written Comments Submitted During the Comment Period

090624_Moberg - My question or concern is that the city of West Fargo is considering doing a development of 240 homes out by me, on the outside of the diversion and if the development is not done correctly this development is going to have problems during the next flood and it might also impact my flooding problem. So I am wondering how we go about making sure that the city of West Fargo is doing this correctly and not impacting the existing flooding problem we already have.

3.2 WATER QUALITY/WATER USERS

3.2.1 Verbal Comments Summarized From Scoping Meetings

3.2.2 Written Comments Submitted During the Comment Period

090606_Haugen – Is there an aquifer newly discovered South of Moorhead, west over the proposed diversion, and east of the Red? We wouldn't cause potential damage to clean water source in times of drought?

090629_Bezek_MNDNR – The potential for impacts to the Buffalo Aquifer need to be addressed in the consideration of alternatives.

3.3 WATER QUANTITY

3.3.1 Verbal Comments Summarized From Scoping Meetings

We thought the 1997 flood was much larger than a 100-year event.

Do all new developments build ponds to hold water, i.e., to not impact flood levels?

Winnipeg has 700-year level of protection from its bypass channel. Is that an option for Fargo-Moorhead?

What is the depth of water at Fargo vs farther north—does the river get deeper as it goes north?

Do any of your rules require that your projects be neutral down river (i.e. not making conditions worse downstream)?

3.3.2 Written Comments Submitted During the Comment Period

090522_Vaa – I am concerned about the hydrograph that was presented at the public meetings depicting that the peak flow from the 2009 event was higher then the 1897 event. I believe that this is misleading to the public and contributes to the perception that they have survived the worst flood event in recorded history. This can be attributed to the fact that in 1897 the width of the river at the Veterans Memorial Bridge was about 1 mile wide, and in 2009 the width is less than ¼ mile wide.
I think the Corps should include in their presentations that the 2009 flood is not the flood of record.

090525_Keller – I feel that the Minnesota diversion alternative would protect folks in Fargo-Moorhead metro I fear it will cause additional issues for residents downstream.

3.4 FLOOD FIGHTING

3.4.1 Verbal Comments Summarized From Scoping Meetings

3.4.2 Written Comments Submitted During the Comment Period

090519_Bach - Is the goal of the project to eliminate the need for any temp/emergency levees/diking? If so, is there a protection level and are those costs included in the diversion costs?

090520_Miller - Is there a temporary flood fight design and plan which is being replaced by he permanent flood damage reduction considerations described in the article? (US Army Corps of Engineers unveils flood protection plans, by Helmut Schmidt)
Is there a flood hazard mitigation project listed in one or both communities and/or their respective county's hazard mitigation plan for floods?

3.5 SOCIAL ISSUES

3.5.1 Verbal Comments Summarized From Scoping Meetings

Will my house be impacted?

There will be a water war if Fargo puts 9 inches of water onto Minnesota.

What effect will the project have on the people who live at the confluence of the Wild Rice and the Red River area and those upstream?

Will your June 22nd deadline and project timeline be distributed within a public notice? Does this include an EIS as well?

On the topic of growth, will you be able to show us the growth plan for both cities? Will this include the cities' strategies for addressing flooding issues?

The diversion plan is routed toward Highway 75 – there would be issues with affecting the floodplain of the Buffalo River in this area. There are also potential issues with ditch systems that would require a hearing process.

There are two omissions in the presentation – you didn't address the land use problem. Farmers want to drain the land as quickly as possible, which is understandable, but it exacerbates flooding.

3.5.2 Written Comments Submitted During the Comment Period

090520_Olson - The Fargo Flood Plan is too restricted in scope. It appears as if developing the area is a priority, rather than flood control. My assumption is that politics has entered in. Individuals with prestige are spared intervention of flood control. This was verbalized at one meeting.

I resent the diversion planned on my property: (Stanley Township, South of County 14, Sections 25 and 26). This is devastating to the beautiful farmstead (which has been in our family since the 1880's), the tranquility and beauty of the river, the adjacent wooded area and the farm acreage. It is difficult for me to believe that this type of devastation could be handed to me.

It is not true that I am not interested in flood control. If need be, I will approve the planned dike (wet side) on the west rim of the property.

I chose to not develop my property. Others did, knowing they were in harm's way. Now I am needing to sacrifice my property when my family worked so hard to keep its ownership. Our family never asked for any assistance from the Federal, State, county, township or local governments. We kept working. By the way, the buildings on the farmstead have never experienced flood water.

090522_Vaa – I have concerns that this study might influence my possibility of a buyout. Could buyouts affect future plans for levee alignments?

090811_FPC – It is our understanding that the diversion option sizes have recently been changed; and, therefore, we believe more public comment is warranted.

3.6 ECONOMIC ISSUES

3.6.1 Verbal Comments Summarized From Scoping Meetings

What will the feasibility study cost the locals?

Will the feasibility study make any recommendations on how to finance this project?

How do we know that the Federal funding will be there for the study and the project?

Where does the money go?

How much of the $625 million in the first estimate is attributed to the Southside Project? How would you characterize the economic value of the project?

In determining costs, are costs just related to physical damage, or is unemployment resulting from the flood keeping people from work factored in?

Is there a diversion channel that would reduce the costs per mile?

Does the $600-million estimate comprise the current Southside estimate?

3.6.2 Written Comments Submitted During the Comment Period

090519_ Mathern - Our hospital was evacuated by Governor's order. There was a loss of $750,000 net income during this time though very little property damage; such losses need to be included in the cost benefit analysis

090520_Paul & Deborah Kukowski – Thank you for the information. Concern: Economic and noneconomic impact of any diversion project on the communities and agriculture industry north of Kragnes, Minnesota.

090520_Koppang – Is there a breakdown of damages for Moorhead versus Fargo, or Minnesota communities versus North Dakota communities?

Are there cost breakdowns on a per capita basis for various local and/or state governmental entities involved under the two scenarios?

The damage estimates for 100-year flood seemed to indicate much more affected developed acreage in North Dakota versus Minnesota; the disparity seemed to grow for the 500-year event.

Will the damage estimates be used to determine the amount of dollars an individual local government is responsible for, once that project has an estimated price tag?

090606_Breker – I am interested in the economic analysis in all potential upstream water retention.

090608_ Bergan – How can the diversion have less total benefit?

090811_FPC – Fargo, North Dakota, voters recently showed their commitment by voting overwhelmingly to approve a tax increase to help pay for permanent flood protection.

Property values in our downtown and riverfront areas can be enhanced with a diversion system where they would be impacted downward by a levee system.

3.7 ENVIRONMENTAL

3.7.1 Verbal Comment Summarized From Scoping Meetings

How much impact analysis has been done in regard to wetlands and waters at this point?

You should consider channel stability, erosion and deposition in both the Red River as well as tributaries as a result of the project.

What will happen with fish passage in the area? How will they be affected by channel diversions? Is the U.S. Fish and Wildlife Service present?

The environmental impacts from flood fighting will be looked at as a temporary impact?

More probability should be incorporated to assess both environmental and economic risks. Environmental analysis should include the flood fight (temporary levies in place) as well as the alternative of no temporary action (no dikes or levies).

The city of Moorhead has concerns with the Buffalo Aquifer and wants to ensure that it is not impacted. A number of utilities cross the area where the concept diversion was planned; please take this into account.

North Dakota has a list of conservation priorities – there may be an interest in preserving some level of flooding for the benefit of the river ecosystem. Some fish species will be dependent on a natural flooding regime in certain areas.

Have you looked at the Minnesota Department of Natural Resources Heritage Information system?

What about wetland reclamation between Lake Traverse and Fargo Moorhead?

3.7.2 Written Comments Submitted During the Comment Period

090528_Erik_Jones – With regards to an eastern diversion channel, there would be issues with affecting the floodplain of the Buffalo River. There are also potential issues with ditch systems which would require a hearing process.

Potential impacts to the Buffalo River floodplain are related to breakouts from the Buffalo River in the Kragnes area. The latest flood insurance study (tentatively published yet this year) has breakouts along

the Buffalo River in the reach of the Buffalo River between about 80th Avenue North and 120th Avenue North. Considerations in the design of the diversion would be to take a careful look at the height of spoil banks along the diversion ditch. The preliminary diversion ditch cross-section had 14-foot-high spoil banks which may prevent the breakouts from the Buffalo River and hold enough water in the Buffalo River to affect the 100-year flood elevation.

3.8 STUDY AREA

3.8.1 Verbal Comments Summarized From Scoping Meetings

3.8.2 Written Comments Submitted During the Comment Period

090521_Linnertz- The flood control mentions nothing about the area of the Sheyenne River from the egress of the West Fargo Diversion to the Red River, this area floods terribly and should be included in the study area.

090622_NWF – We urge you to expand the study area to include all upstream watershed basins.

3.9 FARGO SOUTHSIDE PROJECT

3.9.1 Verbal Comments Submitted During the Comment Period

Southside Project
a. Building levee (and storage) does not depend upon channel approval.
b. Will Fargo begin levees before 1st phase Corps is finished?

Will the Southside Development be incorporated into your analysis as built?

Your project should take place before Fargo proceeds with its Southside project.

How does this study interface with the Fargo Southside (FSS) project?

If regional protection is the goal, why is Fargo's Southside Levee not on the table for a Corps project?

Execute Order 11988 on Floodplain Management (minimizing development in the floodplain) should be considered. Growth impacts from the Southside Project may open up the need for a more comprehensive analysis.

Can you confirm that there will be no impact from the FSS project?

FSS channel extensions will directly impact some landowners. What will happen if they are built and then the Corps diversion is built later?

FSS project is proposing 3 miles of channel extensions. Aren't these environmentally problematic?

There is concern that the whole FSS proposed package may not be implementable, especially the channel extensions in Minnesota.

Will the Corps look at the future with and without the FSS project?

Would Fargo build the FSS project without all of the proposed features?

Will the Southside Project solve the flood problem?

Could you talk about how the Southside Project will be synchronized with the USACE project? If Southside goes forward, how does it affect your project?

What is the impact of the Fargo Southside Flood Protection Plan? Will that area be factored into your benefit-cost ratio?

What impact does the Rose Creek project (the Fargo Southside Project) have on the Moorhead levees and the overall project?

3.9.2 Written Comments Submitted During the Comment Period

090519_Pat Staples – Please coordinate Southside Fargo Project with your plan. This needs to be synchronized!! Diversions appear to be the best long-term solution.

090606_Armfeld – Unless the Southside project is an important and a part of your plan why proceed?

090622_NWF – The Corps needs to consider the simultaneous actions of the FMM project and the Southside project, which calls into question requirements under NEPA regarding connected actions. These two actions are similar and would need to be handled in such a way.

090707_NDSWC – The North Dakota State Water Commission has pledged $75 million toward the Fargo Southside Flood control project. We would request an expedited analysis of the FSFC project and its role in the various alternatives with regards to the Fargo Moorhead Metro project.

We would like to see any alternatives to be designed for larger events than those with 1-percent chance of occurrence.

We would like to see a host of alternatives developed to not only include levee options but diversions as well.

090709_EPA – We are concerned that the study goals and planning objectives for the Fargo Moorhead Metro study appear to be inextricably linked with the Fargo-Southside Flood Control Project.

090811_FPC – It should be noted the planned south side flood protection would not be needed and would save $175 million.

3.10 TECHNICAL ISSUES

3.10.1 Verbal Comments Summarized From Scoping Meetings

What are the new 100-year and 500-year FEMA flood stages?

I don't understand how a 100-year flood could have a 1 in 4 chance of occurring over the next 30 years.

Did you factor in all historic events to figure out the 100-year and 500-year stages?

What is the level of protection we're looking for?

Are you designing a passive system or an active system?

It seems like we're doing the studies backwards—shouldn't we do the macro study first?

If we already know the micro solutions, why do the macro study?

I question the 1:4 odds you presented. The projects we're talking about will protect us.

Clarify "channelization."

Any other alternative routes would need to take place before the end of the feasibility phase, correct?

Will nonstructural solutions involve any efforts to lower the peak?

Will this only deal with flooding on the Red River, or will this be a regional study, e.g., including the Wild Rice River?

Will you be allowing limited flooding, or mitigating all flooding, e.g., agricultural field flooding? An indirect effect of flood protection may be to prevent all flooding in rural areas, which should be considered in your analysis.

Would the diversion have a grassed bottom or concrete? Who performs long-term maintenance? How will you ensure that the diversion does not result in a 30-mile-long stagnant pool of water?

How did you determine where your starting point and ending point would be for the Minnesota (east) diversion? Where does the water end up?

What is the current base flood elevation?

Flood fighting should not be counted in the No-Action alternative. No flood protection measures in place should be the baseline for initial water surface elevations

3.10.2 Written Comments Submitted During the Comment Period

090606_Ista – How far downstream do you measure impacts?

090606_Lahren – Why do you need a 500-foot-wide bottom for a diversion?

090714_Rhuland - I have a question about the $625-million levee plan that was discussed at the recent meetings. I assume that there is a map available detailing what this project would look like in my neighborhood. Is that true? If so, can I get a look at what the area by Southwood Drive, 11th Street, and the Fargo Country Club looks like? In addition, how many homes would need to be removed for this project?

090811_FPC – We are concerned that any diversion plans are thoroughly studied with an effort to keep costs as low as possible. In addition, in order to evaluate the benefit-cost ratios properly, all possible benefits need to be discovered and properly applied to the ratios.

The benefits from reducing a 500- or 700-year flood to a winnable level should be included minus the costs of fighting the lower level flood. The cost effectiveness to fight a 100-year flood one time in 500 years versus making a larger diversion needs to be ascertained.

3.11 POLITICAL

3.11.1 Verbal Comments Summarized From Scoping Meetings

All of the cities that are developing should talk about their future plans before they build something that will be in the path of our project.

Cutoffs in Minnesota cannot be built without eminent domain, and Fargo cannot condemn land in Minnesota. They need to start working with a Minnesota partner.

How have you been working with mayors, other elected officials and other organizations?

Does USACE have a say in how we protect ourselves? I currently have a clay dike in my backyard and I could raise it – does USACE have anything to say about that?

Who is the decision maker that will identify which plan will be presented to Congress?

Why doesn't USACE have more jurisdictions over the root of the problem, which is the drainage of the landscape upstream?

Will you be looking at impacts downstream towards Canada?

FEMA, USFWS, EPA and the USACE should meet to discuss issues. At first glance, EPA believes that there may be similar and connected actions between the Southside and USACE projects.

Are there other stakeholders that should be involved?

Fargo and Cass County have proceeded with identifying buyouts, but Moorhead has not. What is the involvement of USACE and what is the hierarchy for decision making?

The goal of the FSS project is to get FEMA certification to avoid the need for flood insurance.

Is there a potential for FEMA's policies regarding flood insurance and grandfathering rates to change?

How does the future flood map affect development?

3.12 LAND USE AND FLOODPLAIN GROWTH

3.12.1 Verbal Comments Summarized From Scoping Meetings

Why build homes where the low ground and flooding is?

Benefit-cost ration — is that taking into account urban sprawl and future development?

Execute Order 11988 on Floodplain Management (minimizing development in the floodplain) should be considered. Growth impacts from the Southside Project may open up the need for a more comprehensive analysis.

When you look at the "future without project" do you look at future development in the area?

3.12.2 Written Comments Submitted During the Comment Period

090629_Bezek_MNDNR – It is recommended that structural flood protection measures not be utilized to promote development in currently undeveloped areas prone to flooding.

090709_EPA – The current land use planning and floodway zoning for Fargo and Moorhead should be disclosed in this study. Growth and redevelopment planning for the region should also be examined.

Indirect effects analysis should address the growth-inducing effects of the project related to changes in pattern of land use including impacts on farmland and other agricultural lands and population density. Changes in land use patterns should disclose local land use policies for Fargo and Moorhead related to residential and commercial building in or near floodways.

3.13 OTHER

3.13.1 Verbal Comments Summarized From Scoping Meetings

Great team. Great presentation. Very credible Federal presentation. ☺

Very informative – Thank you

Very good presentation

Good start. Flood stage info- 39.5 on maps and graphs

Thank you for your time and efforts to help our community. I will pray for you and all your endeavors.

Lots of good information. Very Interesting. Thank you

Great job. Please notify of next meeting. Thanks.

Informative!! Thanks!

You done good!

Thanks for an outstanding presentation!

Why not protecting or including Forest River in the floodplain?

Kevin did an excellent job!

Might be good to know what the above sea level drop is between Wild Rice and Sheyenne confluence with the Red.

Hoping for protection in Harwood Groves area ASAP. Not waiting for additional 5 years.

What have we learned from the floods in Iowa last summer?

It seems like common sense to hold off on other projects until this regional plan is complete.

What other projects does the Corps have right now?

Why is the Corps coming in now?

What is in Phase 1—what will we know in April 2009?

Are the slides available in printed form, or can they be e-mailed out to people upon request?

Our comments are due on June 22nd…are we commenting on diversion channels, levees, etc.? Do you want us to reiterate our comments in writing?

Are you looking at executing an Official Cooperating Agency Agreement?

Why can't you build dikes on buyout land? Why wasn't Fargo flooding addressed with the Grand Forks project?

3.13.2 Written Comments Submitted During the Comment Period

090526_Bigger- Where would be the best place to find information regarding alternatives, sizes of diversion channels, etc.

090606_Headrick – How much info will be on your website as you continue to work on the study over the next 4 months?

No Date_Elise & John Leitch – Hurry, Hurry, Hurry!

090519_Shirley Syverson – Good informational meeting.

090519_Daniel Holm – Excellent presentation! Good materials, appreciate the effort to get feedback from the group

090520_Calvin Singleton – Need info, flood proofing by fill with clay.

090520_ Patte Kratky – As co-president of league of women voters of the Red River Valley and member of River Keepers, I offer my services to the planning boards, as a concierge. Please contact me at 701-235-8200 ext 7-204 currently or at my email address, a message maybe left at 218-233-8382 or email. We were displaced by the flood and are repairing our home. LWV is non-partisan, non-profit grass roots organization.

090709_EPA – The purpose and need for this project should clearly describe the current problem, and future problems that will result if the project is not implemented. EPA recommends that the signatories to the MOU for this project have an opportunity to comment on the "Purpose and Need" prior to alternatives development.

APPENDIX B

WRITTEN COMMENTS
SCOPING MEETINGS

Moorhead, Minnesota November Meeting

- Anonymous Comments

Fargo, North Dakota November Meeting

- Anonymous Comments

Fargo, North Dakota May Agency Scoping Meeting

- Robin Coursen EPA
- Nancy Steinberger, FEMA
- Rick Archer, Ulteig
- 090528_Erik_Jones
- 090622_NWF
- 090624_NDWF
- 090629_Bezek_MN_DNR
- 090707_NDSWC
- 090709_EPA

Fargo, ND and Moorhead, MN May Meetings and Other Comments Received

- 090417_Fitzpatrick
- 090520_Koppang
- 090520_Miller
- 090520_Neuhauser
- 090520_Neuhauser
- 090608_Sandt
- 090608_Sandt
- 090606_Tweeten
- 090606_Tweeten
- 090521_Linnertz
- 090522_Vaa
- 090528_Vaa
- 090525_Keller
- 090526_Bigger
- 090602_Majkrzak
- 090606_Armfeld
- 090606_Breker
- 090606_Haugen
- 090606_Headrick
- 090606_Ista
- 090606_Keller
- 090606_Koski
- 090606_Lahren
- 090606_Sell
- 090606_Wolf
- 090608_Bergan
- 090619_Bergan
- 090621_Siemens
- 090622_Bergan
- 090622_Feist
- 090623_Satrang
- 090623_Solberg
- 090624_Furness
- 090624_Moberg
- 090629_Boe
- 090629_Bolin
- 090629_Cossette
- 090629_Finch
- 090629_Halvorsen
- 090629_Schock
- 090629_Tillman
- 090630_Altendorf
- 090630_Bender
- 090630_Bredell
- 090630_Cronin
- 090630_Fetch
- 090630_Forknell
- 090630_Hannaher
- 090630_Hegg
- 090630_Hoefs
- 090630_Mitchell

- 090630_Moen
- 090630_Passolt
- 090630_Pfeiffer
- 090630_Werlinger
- 090701_Gates
- 090701_Ortmeier
- 090702_Dickerson
- 090712_Dufault
- 090714_Engler
- 090714_Rhuland
- 090715_Clasen
- 090715_Heidt
- 090715_Hoefs
- 090717_Bergman
- 090717_Holscher
- 090722_Fujimoto
- 090722_Jensen
- 090811_FPC
- 090606_Matthew Breker
- 090606_Jim Armfeld
- No Date_Dave Anderson
- No Date_Elise & John Leitch
- 090606_Charles Koski
- No Date_John Stern
- 090519_Kathy Laney
- 090519_Shirley Syverson
- 090606_Daryl Lahren
- 090519_Daniel Holm
- 090519_Charles D. Dunnell
- 090519_Pat Staples
- 090520_A Saharieff
- 090606_Diane Ista
- 090520_ Patte Kratky
- 090520_ Mark Nokken
- 090520_Jill Johnson-Davidson
- 090520_Calvin Singleton
- 090520_Gary Shramstad
- 090606_Deb Haugen
- 090520_Paul & Deborah Kukowski
- 090606_Barbara Headrick
- 090520_Chuck Stenso
- 090520_Deanne Sperling
- 090606_Stanley Wolf
- Nancy Steinberger
- Rick Archer
- Anonymous
- 090520_Reinke
- 090519_Cousins
- 090519_Bach
- 090519_ Mathern
- 090519_Mathern
- 090519_Mathern
- 090520_Olson

Appendix B
Written Comments
Scoping Meetings

Moorhead, Minnesota November 17, 2008 Public Meeting

Fargo, North Dakota November 18, 2008 Public Meeting

Fargo, North Dakota May 20, 2009 Agency Meeting

Fargo, North Dakota May 19, 2009 Public Meeting

Moorhead, Minnesota May 20, 2009 Public Meeting

Fargo-Moorhead Metro Feasibility Study
Public Meetings, Moorhead Nov 17th, 2008

1) Informative!! Thanks!
2) You done good!
3) Thanks for an outstanding presentation!
4) The projected cost is likely far in excess of potential benefit. Your study should take place before Fargo proceeds with its Southside flood project.
5) Lots of good information. Very Interesting. Thank you
6) Great job. Please notify of next meeting. Thanks.
7) Southside Project
    a. Building levee (& storage) does not depend upon channel approval.
    b. Will Fargo begin levees before 1st phase corps is finished?
8) Great team. Great presentation. Very credible Federal presentation. ☺
9) Very informative – Thank you
10) Very good presentation
11) Good start. Flood stage info- 39.5 on maps and graphs
12) Thank you for your time and efforts to help our community. I will pray for you and all your endeavors.

Fargo-Moorhead Metro Feasibility Study
Public Meetings,
Fargo, North Dakota Nov 18th, 2008

1)
    a. Question doing macro study after implementing micro solutions.
    b. Question assumption that floods are going to get much worse in future as evidence does not support this.
    c. Waffle Storage concept should be reconsidered where farmers are paid for storage when needed.
2) Why not protecting or including Forest River in the floodplain?
3) Kevin did an excellent job!
4) Might be good to know what the above sea level drop is between Wild Rice and Sheyenne confluence with the Red.
5) Hoping for protection in Harwood Groves area asap. Not waiting for additional 5 yrs.

Fargo-Moorhead Metro Feasibility Study
Agency Meeting,
Fargo, North Dakota May 20th, 2009

Robin Coursen EPA

EPA is concerned that these two projects are about to commence two separate EISs with basically the same purpose and need; to control flooding in the Fargo-Moorhead metropolitan area. Further, EPA believes that the Fargo Southside Project is a connected action to the Fargo-Moorhead Project. As part of the scoping process for the Fargo Southside Project and in accordance with 40 CFR Section 1508.25, EPA recommends that FEMA as lead agency, should determine (in consultation with other resource agencies) whether the Fargo Southside Project is a similar or connected action to the Fargo-Moorhead Flood Control Project and whether it requires a single comprehensive EIS. In addition, FEMA should also consult with the U.S. Army Corp of Engineers (COE) to determine whether the project is a "single and complete project" (33 CFR 330.2(i) and whether it meets the test of "Independent Utility" when considering simultaneous, possibly connected, actions for flood control that COE will be permitting for both of these projects. The Corps and the Cities of Fargo and Moorhead are jointly conducting this study. The study will assess the feasibility of measures to reduce flood risk in the entire metropolitan and surrounding area. The study will consider an array of potential alternatives including non-structural flood-proofing, diversion channels, levee/floodwall systems, and flood storage.

EPA believes that the Fargo-Moorhead Project is connected with Fargo Southside in its environmental results (flood control for the region) and impacts (particularly wetlands and riparian habitat). We are concerned that the completion of the Fargo Southside EIS independent of the Fargo-Moorhead Flood Control Project will:

1. Minimize analysis of full cumulative environmental effects resulting from both projects
2. Unacceptably influence or limit the alternatives analysis for the Fargo-Moorhead Flood Control Project
3. Cause duplicative expenditure of public resources by both State and Federal agencies involved with both projects
4. Not comprehensively address the regional flood control problem and
5. Not result in good decision making that is in conformance with CEQ NEPA regulations.

Although the Southside Flood Project and the Fargo and Moorhead Flood Risk Management Project are projects led by different agencies—FEMA and COE respectively, EPA strongly recommends that both agencies consider that these projects are connected or similar actions as described under 40 CFR Sec. 1508.25 of the CEQ regulations.

Nancy Steinberger FEMA Region 8 Denver Federal Center
Please keep me in the loop on H & H modeling efforts. FEMA is currently working on models for the Sheyenne and Maple Rivers. We have a preliminary digital flood insurance rate map coming to Fargo in Summer 09 and a Cass County DFIRM shortly thereafter (1 year out).
"No Action" should not include flood fighting. Emergency measures can cause a rise in flood elevations. If that's the baseline, the project could slip through as not causing a rise even if it does. Flood permits from all affected communities will be required. A CLOMAR and LOMR will be required.

Rick Archer, Ulteig Engineering, INC
Recent 2009 flooding has resulted in discrepancies between projected river gage water surface elevations with recorded flood discharges. This may be due to different stream set-up conditions (Sheyenne) than what original flood plain model is showing, or due to flood fight efforts. I would like COE to look more closely at Hydraulic conditions that may be leading to WSE discrepancies.

090827_Coursen_EPA

EPA Region 8 Draft of Fargo scoping comments 08/27/09

Studies:
It would be helpful to understand how the information in previous studies, reports and projects will be integrated and utilized in the Feasibility Study and what additional studies, e.g. hydrologic basin wide flow regimes, climate/precipitation analysis, are anticipated to be undertaken. Do the studies conducted to date answer many of the questions that have been asked in this scoping document by reviewers? E.g. what percent of high flows are due to increased flow rates from precipitation? What percent of high flows are due to increased flow rates from wetland drainage/and or lack of wetland drainage where agricultural development and urban sprawl has taken over wetland/upland storage. A look at the entire basin is necessary to examine the effectiveness of wetland restoration or waffling or other non-structural alternatives.

Regarding Climate Change studies: What does the most current data show for anticipated flood frequency, timing and severity?

Purpose and Need:
The Purpose and Need statement is fairly good; not too narrow, not too broad.

Objectives of the project should be discussed with the purpose and need and could include reducing peak flows, slowing runoff, sustainable cost effective solutions that mimic natural processes, and exploring opportunities for recreation/open space.

EPA suggests that this document discuss how the process of alternatives development will proceed and how alternatives will be screened. EPA recommends that the purpose and need statement be accompanied by some criteria to measure whether or not alternatives meet the purpose and need and objectives of the project. Such criteria could be utilized for screening purposes and could include but not be limited to the following: Meets project purpose and need and objectives, sustainability and or ability to mimic natural processes, technical feasibility/implementability, capital costs, O and M and/or adaptive management costs, ability to phase if project costs are incremental, cost benefits or economic value (ecological/recreational/carbon offsets for riparian and wetland restoration).

How will the cooperating agencies be involved with this process?

Alternatives Analysis:

The alternatives analysis should include a ***Sustainability Alternative*** that looks at a number of approaches. Sustainable development and the use of zoning, agricultural/conservation easements to maintain/enlarge the floodway should be addressed. How will redevelopment and new growth be encouraged to develop in a

manner that protects the homes, roads, and other infrastructure from flood risk and/or damage. This alternative could also explore nature mimicry to address flooding through non structural measures such as wetland, riparian habitat, and grasslands. This alternative could also explore the secondary benefits of recreational development (wetlands to open space/fish habitat) and possibly crop selection for high water usage (from upland grasslands or former agricultural land used for distributed storage areas).

Strategic Planning:

Since the costs of such projects are the primary obstacles to implementation, the Corps could explore ways to tier the EIS so that funding could happen incrementally. The Phase I of the Feasibility Study indicates that you are already considering this type of scenario.

090528_Erik_Jones

From: Erik Jones
To: Sobiech, Jonathan J MVP;
cc: Bruce Albright;
Subject: RE: Fargo Moorhead Metro Scoping Meeting
Date: Thursday, May 28, 2009 5:10:07 PM
Attachments: Figure13D_SurfaceWaterResourcesMap_Northern.pdf
Figure13A_SurfaceWaterResourcesMap_Western_portrait.pdf
Figure13C_SurfaceWaterResourcesMap_Moorhead.pdf

Jon,

Here is the additional information pertaining to the question below:

Erik Jones, Houston Engineering
Q. The diversion plan is routed towards Highway 75 - there would be issues with affecting the floodplain of the Buffalo River in this area. There are also potential issues with ditch systems which would require a hearing process.
A. Please provide us of additional information.

Additional Info:

As shown on the preliminary MN diversion route map as distributed at the meeting (labeled "PLATE 1"), the following legal County Ditches would be affected (from south to north): Clay County Ditches Nos. 33, 32, 9, 41, Lateral 1 of County Ditch 41, 35, 51, and Lateral 1 of County Ditch 20. If the diversion route were moved further north/south, additional legal ditch systems could be affected. I've attached a series of maps showing the various ditch locations. From north to south they are labeled "Northern", "Moorhead", and "Western" corresponding to planning regions within the Watershed's Management Plan. Following MN drainage law (Minnesota Statutes 103E.)These systems might proceed under 103E.227 IMPOUNDING AND DIVERSION OF DRAINAGE SYSTEM WATERS. The Watershed District would need to confirm the statute under which the proceeding would follow but I believe 103E.227 would be correct.

For portions of some of the ditch systems, it may make sense to abandon (MN Statutes 103.811) and other systems may require a redetermination of Benefits due to the drainage area being severed by the diversion ditch. A redetermination would need to follow Minnesota Statute 103E.351.

All of these proceedings require one hearing regardless of the statute. This would be required for each system, although the hearings may be able to be grouped together or in series if it makes sense.

More detail on Minnesota Drainage Law (MS 103E) can be found at the following

link:

https://www.revisor.leg.state.mn.us/statutes/?year=2008&id=103E

Potential impacts to the Buffalo River Floodplain are related to breakouts from the Buffalo River in the Kragnes area. The latest Flood insurance study (tentatively published yet this year) has breakouts along the Buffalo River in the reach of the Buffalo River between about 80th Avenue North and 120th Avenue North. Considerations in the design of the diversion would be to take a careful look at the height of spoil banks along the diversion ditch. The preliminary diversion ditch cross-section had 14 foot high spoil banks which may prevent the breakouts from the Buffalo River and hold enough water in the Buffalo River to affect the 100-year flood elevation.

If you have questions, let me know.

Thanks,

Erik S. Jones, PE LSI Project Manager

1401 21st Avenue North, Fargo, ND 58102
Phone: 701.237.5065 / Fax: 701.237.5101
Direct Phone: 701.499.2055

Email: ejones@houstoneng.com
Website: www.houstoneng.com
Note: We have moved.New address above

-----Original Message-----
From: Sobiech, Jonathan J MVP [mailto:Jonathan.J.Sobiech@usace.army.mil]
Sent: Thursday, May 28, 2009 2:32 PM
To: chad.severts@state.mn.us; michele.walker@dnr.state.mn.us; tom.grashens@dnr.state.mn.us; bob.bezek@dnr.state.mn.us; thomas.carlson@dnr.state.mn.us; julie@redriverbasincommission.org; rgjestvang@nd.gov; pfridge@nd.gov; C. Gregg Thielman; allison.myhre@mail.house.gov; andy.martin@klobuchar.senate.gov; bkreft@nd.gov; nancy.steinberger@dhs.gov; jeanine.petterson@dhs.gov; mike.hillenburg@dhs.gov; kris.carlson@ulteng.com; jvolk@moorengineeringinc.com; david.overbo@co.clay.mn.us; john.frederick@state.mn.us; brrwd@bville.mn.net; markbrodshaug@gmail.com; Erik Jones; Coursen.Robin@epamail.epa.gov; truskowski.brent@epa.gov; steven.hardegen@dhs.gov
Subject: Fargo Moorhead Metro Scoping Meeting

I have attached a draft of the notes from the Scoping meeting, I would like all of

the folks that commented to review it to make sure we captured your comments accurately, if you could look it over and get it back to me NLT 5-June 09 that would be great. I will look at the comments incorporate them and send out the final memo for record. Thanks to all of you for participating. Again I ask that you send me any other contacts that are necessary for this EIS. Thanks. Jon

Jonathan Sobiech
Forester
US Army Corps of Engineers
190 East 5th St, Suite 401
St Paul, MN 55101
Office phone 651-290-5428
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fax 651-290-5258

090622_NWF

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June 22, 2009

Terry J. Birkenstock, Chief,
Environmental and Economic Analysis
Branch, 190 Fifth Street East, St. Paul,
MN 55101–1638

Re: Scoping Comments on Proposed Flood Risk Management Project on the Red River of the North

Dear Mr. Birkenstock:

On behalf of the National Wildlife Federation, we offer these scoping comments on the Environmental Impact Statement being prepared by the Corps of Engineers on the Flood Risk Management Project on the Red River of the North.

In the Notice of Intent (74 Fed. Reg. 20684, May 5, 2008), the Corps of Engineers proposed to evaluate measures for reducing flood risk in the Fargo-Moorhead Metropolitan Study Area. Alternatives to be evaluated include, but are not limited to, levees and floodwalls, diversion channels, non-structural flood proofing, relocation of flood prone structures, and flood storage.

In order to evaluate a full range of alternatives, we urge the COE to 1) expand the study area to include all upstream watershed basins and 2) evaluate wetland restoration and other non-structural approaches as an alternative for flood control and protection.

In preparing this scoping letter, we have been impressed by the amount and quality of the literature available that evaluates wetland restoration and other non-structural mechanisms as an alternative to structural approaches to flood control. From our perspective, levee construction and diversions are very expensive, threaten downstream communities with additional flood hazard and offer no environmental benefits. In contrast, wetland restoration can reduce flood peaks and shift the timing of flood events even while providing a broad array of ancillary benefits including cleaner water, larger fish and wildlife populations and enhanced recreational opportunities. We note too, that such benefits have real economic value.

In addition to much research on the positive benefits of wetland restoration, related studies have also demonstrated that wetland drainage in the Red River basin have significantly increased both

the timing and size of Red River floods and also that wetland drainage continues to effect thousands of acres annually. Wetland restoration will help offset these destructive land use practices that are so costly in terms of water quality, wildlife and flood costs.

Because wetland restoration and better watershed management are an economical, ecological and sustainable method for flood control, we strongly urge for the Army Crops of Engineers to go beyond the "quick-fix", expensive and finite solution of levees and diversions, and consider looking "upstream" to a watershed/wetland approach to managing flooding on the Red River.

A. The EIS Must Utilize a Larger Study Area and Evaluate the Impacts of Wetland Drainage on Flood Frequency, Flood Timing and Flood Severity.

The Notice of Intent suggests that the EIS being prepared by the Corps will only evaluate flood impacts and alternatives measures to prevent flooding within the Fargo-Moorhead Metropolitan Area. This limited study area will not allow the Corps to accurately evaluate the causes of increased flooding in the Red River Basin or the full range of alternative remedies, including wetland restoration and other watershed management possibilities. Ample evidence demonstrates that wetland drainage throughout the Red River basin has significantly contributed to increased flood frequencies and flood peaks.

The prairie pothole wetlands of the northern Great Plains are one of the world's great natural resource treasures. Within this 300,000 square mile area, retreating glaciers left tens of thousands of small depressions that seasonally fill with water and provide habitat for millions of waterfowl, shore birds and other wildlife species. Almost since farming began in this region in the mid 1800's, wetland drainage has been employed to increase tillable acreage and to facilitate other agricultural activities. The cumulative impacts of this wetland drainage have been staggering. Over the last 100 years, and especially since the end of the Second World War, over 50% of the region's wetlands have been drained with over 90% in some watershed basins.

In addition to the severe impacts to wildlife and water quality, wetland drainage has also impacted the timing, frequency and severity of floods throughout the region. Wetland drains and channels literally crisscross the entire region and dramatically accelerate spring run-off and reduce upstream, upland water storage capacity.

For example, much of the damage caused by the extensive flooding along the Mississippi River in 1993 resulted from levee failure as the river reestablished historic connections to the floodplain as well as the loss of upstream wetland storage and the alteration of the landscape that encouraged water to quickly drain into the nearest river or stream. Indeed, a recent study by The Wetlands Initiative noted that the wetlands lost in the upper Mississippi River had the capacity to retain all of the water that caused the 1993 flooding. Thus, although elaborate storage dam and levee systems can "reclaim" the floodplain for agriculture and human settlement in most years, the increasingly frequent and inevitable large floods the Great Plains and Midwest are seeing impose high disaster costs to society.

Evidence strongly suggests that wetland drainage has significantly impacted flooding in the Red river basin. In fact, the Red River basin has experience 8 of the 10 all time record flood crests in the past 30 years. One study dealing with watershed contributions to the Red River was published 28 years ago by soil scientists at North Dakota State University. It found an average 60% increase in stream flow rates and concluded that:

> Significant increases in flow to the Maple, Wild Rice and Goose Rivers have occurred over the last 30 to 40 years. Flow rates were shown to be related to climate (precipitation), however, there appears to be no chance in precipitation patterns to account for increase in flow rates. Predicted flow rates were shown to be closely related to basin size due to land drainage in the Maple River and Goose River basins.

Since this study was published, wetland drainage has continued throughout the Red River.

Based on this information, the EIS should enlarge the study area to include all upstream river basins above Fargo-Moorhead. In taking this step, the EIS will necessarily have to evaluate the impacts on flood crests, flood frequencies and flood severity of wetland drainage. Through this evaluation, the EIS can then take the next and most critical step – evaluating the benefits of wetland restoration in terms of reducing these flood impacts.

B. The EIS Must Develop a Wetland Restoration Alternative

Restoring upstream storage capacity must be studied as an alternative to flood mitigation for the Red River. Several studies have demonstrated the effectiveness and feasibility of restoring wetlands or using upland depressions to temporarily store water during a flood event. One such study concluded that, "non-structural means as temporary storage of runoff on agricultural lands in the upland areas of the watershed during periods when flood risks are high, may provide ecological benefits...at the same time diminishing the threat of downstream flooding."[1] Another study concluded that, "floodwater attenuation is one of the most widely recognized ecosystem services provided by restored wetlands..." The potential storage capacity on USDA program lands in the PPR alone is, conservatively, 56,513 ha-m (458,151 acre-feet) of water, if filled to maximum capacity.[2] Additionally, restoring drained and farmed wetlands could increase the water retention capacity of a watershed in the PPR of Minnesota, "by up to 63%."[3] Depressional wetlands in the Devils Lake basin of North Dakota have the potential to store around 72% of the total runoff volume from a 2-year frequency runoff event and 41% of a 100-year frequency runoff event.[4]

1. The Restoration of Wetlands can significantly reduce flood frequency and severity while also providing vital ecosystem benefits.

The benefits of wetland restoration are numerous. Wetlands provide various ecosystem services to farmers and communities, recreational opportunities, global warming mitigation, and most importantly, flood control. One study concluded that, "wetlands on [USDA] program lands [in the PPR] have significant potential to intercept and store precipitation that otherwise might

contribute to "downstream" flooding.[5] Additionally, the "conversion of cultivated cropland to grassland cover as part of conservation programs results in a reduction in surface runoff and, ultimately, reduces the rate at which a basin refills and overflows.[6]

An Army Corps study on the Charles River in Massachusetts concluded that the floodplain wetlands were so effective for flood control the Corps purchased the wetlands rather than drain them to build a levee system. Maintaining the 3,400 ha of wetlands in the Charles River basin rather than draining them saved Boston an additional $17 million in flood damages per year.[7] Another study looking at the relationship between upstream wetland drainage and downstream flooding concluded that, the increase in peak stream flow was significant for all sizes of streams when wetlands were removed.[8]

Utilizing wetlands for flood protections provide a multitude of additional benefits. Increasing wetland habitat will provide stability to migrating and nesting bird habitats as well as numerous other species of wildlife. This in turn creates opportunities for hunting, fishing, bird watching, hiking and other types of recreation. Wetlands also serve as nature's kidneys, filtering polluted water and releasing cleaner water into both nearby ground and surface waters. This improves water quality. Wetlands further serve to recharge ground and surface waters, meaning that while they prevent flooding in wet times, they serve to replenish and retain adequate water supplies and stream flow during drier times. As climate change increases the severity and frequency of both floods and droughts, these functions will become crucial to maintaining healthy aquatic systems and to protecting communities from the impacts of climate change. Wetlands play at least two critical roles in mitigating the effects of climate change, "one in the management of greenhouse gases (especially carbon dioxide) and the other in physically buffering climate change impacts."[9] Studies show the great potential for wetlands to act as carbon sinks to sequester carbon, thus mitigating the impacts of global warming. USGS data suggests that terrestrial carbon capture may be greater in wetlands over smaller acreage than the potential capture on a larger area of cropland.[10]

Given the multitude of benefits in addition to flood protection that wetland restoration provides, especially in light of the many challenges presented by climate change, it is the most effective, affordable, and ecologically sound solution for the Red River basin, and must be given the full consideration of the Army Corps of Engineers, when preparing the EIS for the proposed flood protection plan, found at 74 FR 20684.

2. The Prairie Pothole Region (PPR) Provides Viable Wetland Restoration Opportunities

The prairie landscape, prior to major drainage and alteration after European settlement, was defined by its wetlands.[11] This system of wetlands is still vitally important today, but in need of restoration to provide the functions it once provided. The significance of the prairie wetland landscape is exemplified in the Prairie Pothole Region (PPR) of the United States and Canada. This area extends over 300,000 square miles from north central Iowa and western Minnesota

through North and South Dakota, into eastern Montana and north into Canada. The unique Prairie Pothole ecosystem is the result of retreating glaciers, which left the landscape dotted with pothole wetlands.[12] Despite the harsh climate of wet/dry cycles, winter freezing and varied salinity, "the PPR is an extremely productive area for both agricultural products and wildlife."[13] The PPR ecosystem is of "unparalleled importance to breeding waterfowl and many other species of wetland wildlife," in addition to acting as a nutrient sink, storing runoff to reduce flooding, sequestering carbon and providing other "environmental and socio-economic values."[14] The PPR hosts more than 300 species of birds which rely on this region – "177 species for breeding and nesting habitat and another 130 for feeding and resting during spring and fall migrations."[15] The PPR is a vital resting and replenishing area for migratory birds. Waterfowl banded in the PPR have been found in 46 other states, 10 Canadian provinces and 23 other countries.[16] In addition to birds, muskrats, foxes, deer and a variety of other wildlife rely on the PPR.[17]

Besides a rich wildlife habitat, the PPR captures precipitation and mitigates flooding. Historically, over "80% of the land surface drained into potholes rather than streams and rivers," where the water would then evaporate or seep into the ground, recharging underground aquifers.[18] Grasslands further reduced the runoff of water and sediment, creating a more stable water level and enabled the area to host a diverse community of native grasses, sedges, rushes and other submersed vegetation.[19] Given the multitude of benefits provided by the PPR, the InterGovernmental Panel on Climate Change (IPCC) concluded in a special report that, "Any additional stress [to the PPR] would be of great concern and could be accommodated only through active programs to protect, enhance, and increase wetland areas in this region."[20]

3. The Waffle Project, combined with Wetland Restoration is also a viable alternative.

One effort currently being studied and potentially implemented in the Red River basin is called the Waffle Project. The Energy & Environmental Research Center (EERC) "recognized the need for alternative methods of flood protection to augment existing flood protection measures. This sentiment was mirrored by other major organizations and agencies in the Red River Basin, and it was determined that innovative concepts of nonstructural measures should be explored to augment the design capacities of structural measures planned to protect against future floods similar in scope to, or greater than, the 1997 flood."[21]

As Minnesota Public Radio reported in 2006, "the waffle plan is simple. Existing roads serve as levees to store water in farmers' fields. The potential for storage is amazing. One square mile storing water a foot deep would hold more than 200 million gallons of water."[22] Because this plan looks to slow the movement of water entering the system at any time, the chances of flooding are greatly minimized. The additional benefit of the plan would allow the retained water to recharge the aquifer and prevent droughts in the future. The Waffle Plan is also a more affordable solution to mitigating flood damage, with the pricetag to implement the Plan across the Red River basin "estimated at $50 million. The protective dike system in Grand Forks cost $397 million."[23] And, the estimated cost of levees or a diversion channel along the Red River far exceed Grand Forks at $625 million and $909 million, respectively.

In this economy, haphazard spending for a levee or diversion project is not only unwarranted, but also irresponsible management of resources, both economically and ecologically. And the extraneous building costs are not a one-time expense. Levees will require continued spending for maintenance and upkeep, and they are uncertain to retain flood waters in our world of extreme weather patterns, so greater structures may have to be built in the future, at greater costs, in order to seize the swelling waters of the Red River.

When the Waffle Project is implemented in conjunction with continued wetland restoration, a successful and long-term flood protection plan results. Programs such as the Waffle Project, Wetland Reserve Program, and other studies and programs through Ducks Unlimited, US Fish & Wildlife, and numerous other agencies and organizations, provide ample data and opportunity to implement wetland restoration as a significant option to prevent flooding downstream.

C. The EIS Must Utilize a Larger Study Area and Consider Wetland Restoration Alternatives in Order to Comply With the National Environmental Policy Act.

An additional requirement for the Army Corps to consider in its EIS are the simultaneous actions of the Fargo-Moorehead Metro Project and the Southside Flood Control Project, which calls into question requirements under NEPA regarding connected actions. An assessment of cumulative impacts is required by the Council on Environmental Quality (CEQ) regulations under NEPA.[24] Cumulative effects are defined as," the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions ."[25]

When considering whether there are cumulative effects or connected actions, an agency must look at the scope of the proposed project and must consider 3 types of actions: connected actions, cumulative actions and similar actions.[26] A connected action means that there is a close relationship between actions which must be considered in a single EIS. Similarly, a single EIS must be prepared for cumulative actions, which when viewed with other actions "have cumulatively significant impacts and should therefore be discusses in the same impact statement."[27] A similar action is one, when viewed with other proposed or reasonably foreseeable actions have similarities that would be reasonable to analyze together in a single impact statement.[28] In the context of the Fargo-Moorhead and Southside Projects, given their timing, scope, relatedness, and proximity, the projects would be considered cumulative actions, and are required, by NEPA, to be considered under a single EIS.[29]

Thank you for considering the comments on the Notice of Intent. Please feel free to contact any us if you would like additional information.

Terry J. Birkenstock
6/22/2009
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Thomas France

Thomas France, Regional Executive Director

Endnotes:

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[20] InterGovernmental Panel on Climate Change, *The Regional Impacts of Climate Change* ch. 8: North America, http://www.ipcc.ch/ipccreports/sres/regional/202.htm (accessed June 22, 2009).
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[24] *See* Council on Environmental Quality, *Considering Cumulative Effects Under the National Environmental Policy Act* (Jan. 1997).
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[27] 40 C.F.R. § 1508.25(a)(2).
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[29] 42 USC §§ 4321, et. seq. *See also*, *Kleppe v. Sierra Club*, 427 U.S. 390, 96 S.Ct. 2718 (1976).

090624_NDWF

Beauchamp, Francis MVP

From: Jennifer Kross [jkross@ducks.org]
Sent: Wednesday, June 24, 2009 10:12 AM
To: Evans, Craig O MVP; Snyder, Aaron M MVP
Subject: Red River Flood input from North Dakota Wildlife Federation

Attachments: NDWF Flood Protection Response 6 18 09.pdf; Brun et al 1981 Stream Flow.pdf

NDWF Flood rotection Response. Brun et al 1981 Stream Flow.pd...

Mr. Evans and Mr. Snyder,

Attached is a letter from the North Dakota Wildlife Federation with comments regarding Red River flood protection efforts. Also attached is a copy of a document on stream flow changes in the Red River Valley. Thank you for accepting our input. I am also sending a copy of this letter to Mayor Dennis Walaker, Mayor Mark Voxland, Senator Kent Conrad, Senator Byron Dorgan, and Representative Earl Pomeroy for their information.

Please contact me if you would like to further discuss this issue.

Jennifer

Jennifer P. Kross

Ducks Unlimited, Communications Biologist

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090624_NDWF

Jennifer P. Kross on behalf of
North Dakota Wildlife Federation
320 17th Ave. NE
Jamestown, ND 58401
701-368-9329
June 24, 2009
RE: Flood protection planning for Fargo/Moorhead

ATTN: Craig Evans and Aaron Snyder
U.S. Army Corps of Engineers
St. Paul District
Sibley Square at Mears Park
190 5th Street East, Suite 401
St. Paul, MN 55101-1638

Mr. Evans and Mr. Snyder,
On behalf of the North Dakota Wildlife Federation (NDWF) I am writing to encourage you to incorporate use of natural resources and wetlands in efforts to protect Fargo/Moorhead from future flooding. Multiple factors led to the flooding that occurred in Fargo/Moorhead this year and the NDWF believes that it is necessary to use multiple solutions that span the entire watershed for flood protection planning.

North Dakota has a wealth of natural resource managers and professionals who can advise on flood solutions that involve wetland and grassland use throughout the Red River basin. The North Dakota Game and Fish Department and the staff at National Wildlife Refuges in the basin have experience and expertise to provide long-term, sustainable solutions that will reduce flood waters that devastate our communities as well as enrich our state's wildlife habitat.

One significant example where wetlands helped save a community from devastating flooding occurred in 2000 when the Turtle River flooded. The U.S. Fish and Wildlife Service opened up Kellys Slough National Wildlife Refuge and diverted 20,000 acre feet of water to the refuge. The water absorbed by the wetlands provided much need relief for the town of Manvel. Roger Hollevoet manager of U.S. Fish and Wildlife Service at Devils Lake Wetlands Management District was quoted as saying, "wetlands are more or less nature's natural sponges. They are a valuable component of flood control."

In the Turtle River case it was rain water that caused flooding, but wetlands can be used for multipurpose water management and help to absorb excessive snow melt and spring

runoff. The multiple functions wetlands and grasslands can provide in holding snow, runoff water and rain can reduce pressures on levees and dams. These natural resources can also reduce river and stream flows enough to decrease the impact of dramatic flooding on communities.

When planning flood control for the Fargo/Cass County area we ask that you please include Red River Basin and watershed wide solutions that incorporate wetlands and grasslands. We are available for consult on how to implement these strategies.

Sincerely,

Jennifer P. Kross
Executive Board Member
North Dakota Wildlife Federation
701-368-9329
jkross@ducks.org

CC: Mayor Dennis Walaker
Mayor Mark Voxland
Senator Kent Conrad
Senator Byron Dorgan
Representative Earl Pomeroy

Enclosure: (1) *Stream Flow Changes in the Southern Red River Valley of North Dakota* by L. J. Brun, J. L. Richardson, J. W. Enz and J. K. Larsen

1981

090624_NDWF

Stream Flow Changes in the Southern Red River Valley of North Dakota

L. J. Brun, J. L. Richardson, J. W. Enz and J. K. Larsen

Climatic events in recent years have had major impact on the economic well-being of many North Dakotans. The summer flood of 1975 destroyed thousands of acres of crops in the southern Red River Valley, caused major soil erosion, destroyed bridges, and damaged homes, farmsteads, and other property. The statewide spring and summer drought of 1980 was comparable to that of 1934 and 1936, resulting in complete crop failure in some areas. These events are directly attributable to extreme climatic situations.

At the same time, flooding has occurred in recent years when the climatic conditions would not be regarded as extreme and in areas where flooding previously has not been a serious problem. Old time residents of Enderlin, along the Maple River, state that flooding had never been a problem until about 20 years ago. Now, houses in a major section of the town have been abandoned because of repeated flooding.

The problem of flooding is a controversial and emotional issue. There are charges and statements as to causes and solutions for the problem. Many are unsubstantiated and erroneous. In this report the authors address three conditions frequently discussed in relation to flooding problems. These are:

1. Have stream and river flow increased?
2. Has there been a climatic change that can be related to increased stream and river flow?
3. Has agricultural land drainage affected stream and river flow?

Changes in Flow

Discharge data from nine gaging stations were analyzed to determine if changes in flow over time have occurred. Locations are shown in Figure 1. There were three comparisons of flow with time using linear regression. This simple statistical test will tell if flow rates are increasing, decreasing or unchanged over the time period measurements have been made. These comparisons were:

1. Mean annual flow for the water year (Oct. 1 of one year through Sept. 30 of the following year) versus time in years.
2. The maximum daily flow in a given water year versus time in years.
3. The mean spring flow (for March, April and May) in a given water year versus time in years.

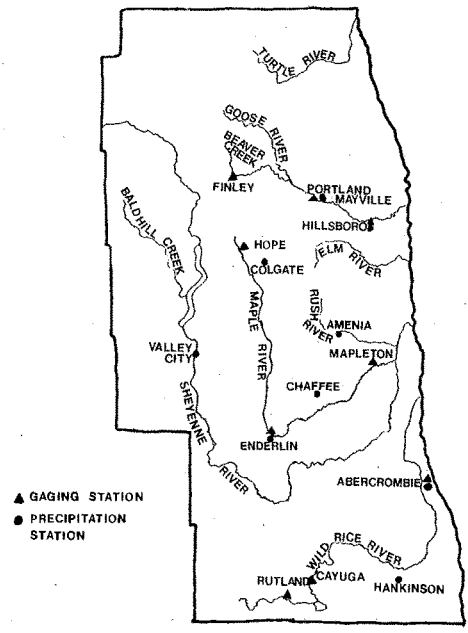

FIGURE 1. Locations of stream gaging stations and precipitation stations used in stream flow analysis.

From: North Dakota Farm Research V.38, pp. 11-14. NDSU Catalog: Periodical 630.72 N81.op

Brun and Richardson are associate professors, Enz is assistant professor, Larsen is research assistant, Department of Soils.

The analyses were done by indexing the first water year as 1 and incrementing each following water year by 1 through the period of record. Flow was then correlated with the indexed years for the nine gaging stations. Discharge or flow is expressed in cubic feet per second. Results are shown in Table 1.

A consistent pattern for all three comparisons emerged. At nearly all locations, the regression equations indicate that the flow rates have increased with time. They further indicate that the flows have increased faster at stations further downstream. In fact, at the last gaging station on a river the relationship between flow and time is usually statistically significant. For example, this means there is a 99 per cent probability that the mean annual flow at Hillsboro has increased with time and only a 1% probability that these data would have occurred by chance.

The headwaters of the Maple River near Hope show a negative correlation, implying flow has decreased with time. However, the Colgate precipitation data for this short time period also have a negative correlation with time (Table 3) which is the reason for this observation.

The Climate Factor

The flow analyses show flow rates have increased on a year-to-year basis except for the Maple River near Hope. The question is to determine if the increased flows could be due to a climatic factor. To address this question two analyses were performed again, using linear regression. If it can be shown that flow rates are related to climate and also shown that the climatic factor (precipitation) has increased in a fairly regular manner over the last 20 to 40 years, a reasonable explanation would exist for the increase in flow rates.

In Table 2 there is a comparison of Mean Annual Flow with Mean Annual Precipitation (both for the water year) and Mean Spring Flow (based on March, April and May) with Winter plus Spring Precipitation (Nov. through the following May). In all cases a positive correlation exists and in many cases there is a statistically significant relationship indicating flow rates increase as precipitation increases. While Table 2 shows flow rates are related to precipitation, it still leaves much of the observed variation in flow unexplained.

Next is a comparison of Mean Annual Precipitation (for the water year) with time as shown in Table 3. At some stations comparisons were made over different time periods to correspond to the available stream flow data. For example, the precipitation data at Colgate were evaluated for three time periods corresponding to the flow data at Hope, Enderlin and Mapleton. There is no detectable pattern or change with a similar number of positive and negative correlations.

So far our analysis has shown:

1. Flow rates have increased with time.

TABLE 1. Comparison of flow rates (ft^3/s) with time (water year) at nine sites in southeastern ND where r is the correlation coefficient, n the number of years and SIG the level of statistical significance.

WATER YEAR	LOCATION	EQUATION	r	n	SIG.
		MEAN ANNUAL FLOW (MAF)-TIME (T)			
OCT 64-SEP 65 TO OCT 77-SEP 77	MAPLE RIVER NR HOPE	MAF = −0.32 (T) + 5.36	−0.73	14	1%
OCT 56-SEP 57 TO OCT 77-SEP 78	MAPLE RIVER NR ENDERLIN	MAF = 1.56 (T) + 20.8	0.27	22	25%
OCT 44-SEP 45 TO OCT 74-SEP 75	MAPLE RIVER NR MAPLETON	MAF = 3.46 (T) + 18.1	0.40	31	2.5%
OCT 59-SEP 60 TO OCT 78-SEP 79	WILD RICE RIVER NR RUTLAND	MAF = −0.017 (T) + 9.60	−0.01	20	--
OCT 56-SEP 57 TO OCT 78-SEP 79	WILD RICE RIVER NR CAYUGA	MAF = 0.16 (T) + 17.2	0.05	23	--
OCT 32-SEP 33 TO OCT 77-SEP 78	WILD RICE RIVER NR ABERCROMBIE	MAF = 1.34 (T) + 41.7	0.21	46	20%
OCT 64-SEP 65 TO OCT 78-SEP 79	BEAVER CREEK NR FINLEY	MAF = 0.11 (T) + 9.12	0.08	15	--
OCT 39-SEP 40 TO OCT 74-SEP 75	GOOSE RIVER NR PORTLAND	MAF = 0.71 (T) + 17.5	0.19	36	25%
OCT 31-SEP 32 TO OCT 78-SEP 79	GOOSE RIVER AT HILLSBORO	MAF = 2.24 (T) + 12.8	0.38	46	1%
		MAXIMUM DAILY FLOW (MDF)-TIME (T)			
OCT 64-SEP 65 TO OCT 77-SEP 78	MAPLE RIVER NR HOPE	MDF = −21.1 (T) + 33.8	−0.63	14	2.5%
OCT 56-SEP 57 TO OCT 78-SEP 79	MAPLE RIVER NR ENDERLIN	MDF = 69.4 (T) + 364	0.29	22	20%
OCT 44-SEP 45 TO OCT 74-SEP 75	MAPLE RIVER NR MAPLETON	MDF = 84.6 (T) + 585	0.34	31	5%
OCT 59-SEP 60 TO OCT 78-SEP 79	WILD RICE RIVER NR RUTLAND	MDF = 5.59 (T) + 140	0.12	20	--
OCT 56-SEP 57 TO OCT 78-SEP 79	WILD RICE RIVER NR CAYUGA	MDF = 7.24 (T) + 217	0.13	23	--
OCT 32-SEP 33 TO OCT 77-SEP 78	WILD RICE RIVER NR ABERCROMBIE	MDF = 28.5 (T) + 851	0.21	46	20%
OCT 64-SEP 65 TO OCT 78-SEP 79	BEAVER CREEK NR FINLEY	MDF = −2.75 (T) + 484	−0.03	15	--
OCT 39-SEP 40 TO OCT 74-SEP 75	GOOSE RIVER NR PORTLAND	MDF = 13.0 (T) + 883	0.10	36	--
OCT 31-SEP 32 TO OCT 78-SEP 79	GOOSE RIVER AT HILLSBORO	MDF = 75.3 (T) + 54.2	0.39	46	1%
		MEAN SPRING FLOW (MSF)-TIME (T)			
OCT 64-SEP 65 TO OCT 77-SEP 78	MAPLE RIVER NR HOPE	MSF = −0.75 (T) + 15.1	−0.50	14	10%
OCT 56-SEP 57 TO OCT 78-SEP 79	MAPLE RIVER NR ENDERLIN	MSF = 4.66 (T) + 55.1	0.27	22	25%
OCT 44-SEP 45 TO OCT 74-SEP 75	MAPLE RIVER NR MAPLETON	MSF = 6.87 (T) + 86.6	0.34	31	10%
OCT 59-SEP 60 TO OCT 78-SEP 79	WILD RICE RIVER NR RUTLAND	MSF = 0.38 (T) + 22.4	0.07	20	--
OCT 56-SEP 57 TO OCT 78-SEP 79	WILD RICE RIVER NR CAYUGA	MSF = 1.54 (T) + 33.7	0.15	23	--
OCT 32-SEP 33 TO OCT 77-SEP 78	WILD RICE RIVER NR ABERCROMBIE	MSF = 3.41 (T) + 120	0.18	46	25%
OCT 64-SEP 65 TO OCT 78-SEP 79	BEAVER CREEK NR FINLEY	MSF = 0.73 (T) + 30.4	0.13	15	--
OCT 39-SEP 40 TO OCT 74-SEP 75	GOOSE RIVER NR PORTLAND	MSF = 2.24 (T) + 66.6	0.16	36	--
OCT 31-SEP 32 TO OCT 78-SEP 79	GOOSE RIVER AT HILLSBORO	MSF = 7.57 (T) + 42.6	0.34	46	2.5%

2. Flow rates increase as precipitation increases.
3. There has been no significant increase or decrease in precipitation over the period in which flow rates have increased.

Land Drainage

Considerable surface drainage of agricultural land in North Dakota has occurred within the last 30 to 40 years. Water that once was held in fields, depressions and sloughs now is free to drain into streams and rivers. However, little information can be found on the magnitude of change due to drainage. To evaluate this question the natural drainage basin and the drained land in the Maple River and Goose River catchment basins above the Glacial Lake Agassiz Plain were determined. United States Geological Survey maps were used to calculate the total acreage in each catchment basin. A ground survey was conducted during the summer of 1979 to determine the acreage in the natural drainage basin and the additional acreage that now drains in the basin as a result of land drainage. These data, shown in Table 4, indicate the current drainage basin is much greater due to land drainage.

The effects of drainage on flow rates at Enderlin and Portland were evaluated. The acreage in the natural drainage basin and the acreage in the current drainage basin were compared with the mean annual flow, the maximum daily flow and the mean spring flow obtained from the prediction equations in Table 1. In using the flow prediction equations we have assumed drainage started near the time when flow records began and has proceeded annually in a fairly uniform manner.

The regression analysis shows the increase in predicted flow is strongly related to increase in drainage area in each basin (Table 5). The analysis indicates that approximately 50 per cent of the increase in predicted mean annual flow, 36 per cent of the increase in predicted maximum daily flow, and 70 per cent of the increase in predicted mean spring flow is due to increased drainage area. In the second part of Table 5 we assumed the same proportion of land drainage upstream from Mapleton and Hillsboro as there was upstream from Enderlin and Portland, respectively. Any error in

TABLE 2. Comparison of flow rates (ft^3/s) with precipitation (in) at six sites in southeastern ND where r is the correlation coefficient, n the number of years and SIG the level of statistical significance.

WATER YEAR	LOCATION	EQUATION	r	n	SIG.
	MEAN ANNUAL FLOW (MAF) - MEAN ANNUAL PRECIPITATION (MAP)				
OCT 64-SEP 65 TO OCT 77-SEP 78	MAPLE RIVER NR HOPE-COLGATE	MAF = 0.10 (MAP) + 1.13	0.25	14	--
OCT 56-SEP 57 TO OCT 77-SEP 78	MAPLE RIVER NR ENDERLIN-ENDERLIN	MAF = 2.62 (MAP) – 17.15	0.42	22	5%
OCT 32-SEP 33 TO OCT 77-SEP 78	WILD RICE RIVER NR ABERCROMBIE-HANKINSON	MAF = 8.23 (MAP) – 91.52	0.45	46	1%
OCT 56-SEP 57 TO OCT 77-SEP 78	WILD RICE RIVER NR ABERCROMBIE-ABERCROMBIE	MAF = 8.57 (MAP) – 98.82	0.45	22	5%
OCT 39-SEP 40 TO OCT 74-SEP 75	GOOSE RIVER NR PORTLAND-MAYVILLE	MAF = 3.50 (MAP) – 37.57	0.34	36	5%
OCT 32-SEP 33 TO OCT 77-SEP 78	GOOSE RIVER AT HILLSBORO-HILLSBORO	MAF = 2.11 (MAP) + 26.29	0.11	41	--
	MEAN SPRING FLOW (MSF) - WINTER + SPRING PRECIPITATION (PWS)				
OCT 64-SEP 65 TO OCT 77-SEP 78	MAPLE RIVER NR HOPE-COLGATE	MSF = 0.05 (PWS) + 9.06	0.01	14	--
OCT 56-SEP 57 TO OCT 77-SEP 78	MAPLE RIVER NR ENDERLIN-ENDERLIN	MSF = 9.01 (PWS) + 39.73	0.17	22	--
OCT 32-SEP 33 TO OCT 77-SEP 78	WILD RICE RIVER NR ABERCROMBIE-HANKINSON	MSF = 26.11 (PWS) – 7.56	0.26	48	10%
OCT 56-SEP 57 TO OCT 77-SEP 78	WILD RICE RIVER NR ABERCROMBIE-ABERCROMBIE	MSF = 33.99 (PWS) – 52.61	0.30	22	20%
OCT 39-SEP 40 TO OCT 74-SEP 75	GOOSE RIVER NR PORTLAND-MAYVILLE	MSF = 41.82 (PWS) – 188.51	0.65	36	1%
OCT 32-SEP 33 TO OCT 77-SEP 78	GOOSE RIVER AT HILLSBORO-HILLSBORO	MSF = 52.53 (PWS) – 146.53	0.37	41	2.5%

TABLE 3. Comparison of precipitation (in) with time (water year) at nine sites in southeastern ND where r is the correlation coefficient, n the number of years and SIG the level of statistical significance.

PRECIPITATION (PPT) - TIME (T)

WATER YEAR	LOCATION	EQUATION	r	n	SIG.
OCT 64-SEP 65 TO OCT 77-SEP 78	COLGATE	PPT = – 0.31 (T) + 21.14	– 0.30	14	25%
OCT 56-SEP 57 TO OCT 77-SEP 78	COLGATE	PPT = – 0.01 (T) + 18.53	– 0.01	22	--
OCT 44-SEP 45 TO OCT 77-SEP 78	COLGATE	PPT = 0.02 (T) + 17.64	0.05	35	--
OCT 44-SEP 45 TO OCT 77-SEP 78	VALLEY CITY	PPT = – 0.03 (T) + 19.44	– 0.08	35	--
OCT 32-SEP 33 TO OCT 77-SEP 78	HILLSBORO	PPT = 0.02 (T) + 19.41	0.06	43	--
OCT 63-SEP 64 TO OCT 77-SEP 78	CHAFFEE	PPT = 0.00 (T) + 20.10	0.00	15	--
OCT 56-SEP 57 TO OCT 77-SEP 78	ENDERLIN	PPT = – 0.11 (T) + 22.56	– 0.11	22	--
OCT 39-SEP 40 TO OCT 74-SEP 75	MAYVILLE	PPT = 0.03 (T) + 18.87	0.09	36	--
OCT 32-SEP 33 TO OCT 77-SEP 78	HANKINSON	PPT = 0.05 (T) + 18.83	0.14	46	--
OCT 56-SEP 57 TO OCT 77-SEP 78	AMENIA	PPT = – 0.02 (T) + 21.48	– 0.03	22	--
OCT 50-SEP 51 TO OCT 77-SEP 78	AMENIA	PPT = 0.10 (T) + 19.13	0.17	28	--
OCT 56-SEP 57 TO OCT 77-SEP 78	ABERCROMBIE	PPT = – 0.10 (T) + 22.75	– 0.13	22	--

this assumption would be small since the ground survey of the drainage basins above Enderlin and Portland are a large part of the Mapleton and Hillsboro basins, respectively. The current drainage upstream from Mapleton was estimated to be 64 per cent greater than the natural drainage, while the current drainage upstream from Hillsboro was estimated to be 180 per cent greater the natural drainage. This gave even higher correlations of predicted flow to acreage than the previous case (Table 5).

TABLE 4. Acreage in Maple River and Goose River basins and changes due to land drainage.

Total Catchment Basin	Natural Drainage Basin	Drained Land Estimate	Total Current Drainage Basin
	Maple River		
636,000 acres	126,800 acres (19.9%)	80,700 acres (12.7%)	207,500 acres (32.6%)
	Goose River		
609,800 acres	110,700 acres (18.2%)	199,000 acres (32.6%)	309,700 acres (50.8%)

TABLE 5. Comparison of predicted flow rates (ft^3/s) to natural drainage and current drainage area where r is the correlation coefficient.

Flow	Predicted flow rates for: Enderlin		Portland		r
	Natural Drainage	Current Drainage	Natural Drainage	Current Drainage	
	126,800 acres	207,500 acres	110,700 acres	309,700 acres	
	(ft^3/s)	(ft^3/s)	(ft^3/s)	(ft^3/s)	
Mean Annual	22.38	55.12	16.21	43.06	0.72
Maximum Daily	433.4	1891	896.0	1351	0.60
Mean Spring	59.76	157.6	68.84	147.2	0.84

	Predicted flow rates for: Mapleton		Hillsboro		
	Natural Drainage	Current Drainage	Natural Drainage	Current Drainage	
	1.00 Weighted acres	1.64 Weighted acres	1.00 Weighted acres	2.80 Weighted acres	
	(ft^3/s)	(ft^3/s)	(ft^3/s)	(ft^3/s)	
Mean Annual	21.56	125.4	15.04	115.8	0.79
Maximum Daily	669.6	3208	129.5	3528	0.86
Mean Spring	93.47	299.6	50.17	390.8	0.93

Conclusions

Significant increases in flow on the Maple, Wild Rice and Goose Rivers have occurred over the last 30 to 40 years. Flow rates were shown to be related to climate (precipitation); however, there appears to be no change in precipitation patterns to account for the increase in flow rates. Predicted flow rates were shown to be closely related to changes in basin size due to land drainage in the Maple River and Goose River basins. It appears that land drainage is a factor aggravating the flooding problem in eastern North Dakota; however, no attempt was made to quantify its overall significance.

Acknowledgement

The authors express their appreciation to Mr. Russell E. Harkness, US Geological Survey, Water Resources Division, Bismarck, ND for providing computer printouts of stream flow data used in this analysis.

continued from page 9

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090629_Bezek_MN_DNR

Fargo/Moorhead Feasibility Study Scoping Comments
Bob Bezek [Bob.Bezek@dnr.state.mn.us]

Jon,

In response to the initial meeting you had in Fargo and your request for some input based on that meeting, comments were solicited from Department staff. While I did get some input back it was very general in nature. I think it would have been helpful to have a formal request to respond to. That being said, following is a summation of the comments we received.

1. Continue to consult Natural Heritage data.

2. It is anticipated that a channel diversion through agriculture land will not have significant impacts to wildlife resources for production or movement. Depending on the type of vegetation and management practices employed some benefits may be realized in a diversion channel.

3. Levees and floodwalls along the river may effect the movement of some species of wildlife such as geese, but would not be significant in either a negative or positive way.

4. The employment of water retention should be included in the mix of alternatives. Opportunities exist to increase and improve ecosystem and wetland restoration, wildlife habitat and provide recreational opportunities through the use of multipurpose water retention areas.

5. Attached for consideration is Technical Paper 12 (Wetland Hydrology & Biodiversity in the Red River Basin, Minnesota) developed by the Red River Flood Damage Reduction Work Group.

6. The potential for impacts to the Buffalo Aquifer need to be addressed in the consideration of alternatives.

7. Many regional flood mitigation efforts are either under way or planned by groups such as the Red River Water Management Board and the Red River Basin Commission. Every effort should be made to identify all possible partners to leverage money and benefits where ever possible.

8. It is recommended that structural flood control measures not be utilized to promote development in currently undeveloped areas prone to flooding.

Again, these are just some initial comments. Once you compile the comments you have received from others it might help to route those to our staff as well. Thanks for the opportunity to provide input Jon.

Best Regards, Bob Bezek

Robert J. Bezek
NW Regional Hydrologist
MN DNR Waters - Bemidji
(o) 218-308-2621
(c) 218-760-7096

090707_NDSWC

North Dakota State Water Commission

900 EAST BOULEVARD AVENUE, DEPT 770 • BISMARCK, NORTH DAKOTA 58505-0850
701-328-2750 • TDD 701-328-2750 • FAX 701-328-3696 • INTERNET: http://swc.nd.gov

July 7, 2009

US Army Corps of Engineers
ATTN: Craig Evans
190 East 5th St, Suite 401
St. Paul, MN 55101

Dear Mr. Evans:

The purpose of this letter is to provide some initial comments on the Fargo-Moorhead Metropolitan Area Feasibility Study. Your efforts to study permanent flood control options in the Fargo-Moorhead, and surrounding areas are an important first step in providing much-needed flood protection for that area.

As you know, the State of North Dakota, through the Water Commission, has pledged $75 million toward the Fargo Southside Flood Control (FSFC) Project. With that in mind, I would respectfully request an expedited analysis of the FSFC Project, and its role in various alternatives. This might allow local sponsors to proceed with construction on this component as soon as possible, with the understanding that the costs would be part of the non-federal share of the overall Fargo-Moorhead Metro Area project costs.

In addition, considering the magnitude of 2009 spring flood events, and those of years past, I would also respectfully request that any flood protection alternatives developed be designed for larger events than those with a one percent chance of occurrence. As an example, the Grand Forks-East Grand Forks project was constructed to provide protection for up to a 250-year event.

Furthermore, I would encourage the Corps to develop a range of alternatives that will provide a host of options for the project area. These should include not only levee alternatives, but diversion options as well.

Once again, Fargo and Moorhead were fortunate enough to escape a record flood event this past spring. But who knows how many more times those communities can pull off the seemingly impossible. For that reason, I support your commitment to this process, and I applaud your expedited approach, as time is of the essence.

Our agency looks forward to working with the Corps in the coming months and years, with the ultimate goal of providing permanent flood control for the Fargo-Moorhead metro area. If you have any questions, please feel free to contact Randy Gjestvang in our Red River office at 701-282-2318, or email rgjestvang@nd.gov.

Sincerely,

Dale L. Frink
State Engineer

DLF:pmf:ds/1955

090709_EPA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
http://www.epa.gov/region08

Ref: EPR-N

JUL 09 2009

Mr. Jonathan Sobiech
US Army Corps of Engineers
190 East 5th St, Suite 401
St Paul, MN 55101\

RE: Fargo-Moorhead Metropolitan Feasibility Study, North Dakota and Minnesota

Dear Mr. Sobiech:

Thank you for the opportunity to provide you with early scoping comments on the Fargo-Moorhead Metropolitan Feasibility Study. This project, which is a cooperative effort between the communities of Fargo and Moorhead with the U.S. Army Corps of Engineers (USACE), will address the high risk of flood damage to urban infrastructure from the Red River of the North, the Wild Rice River, the Buffalo River, and the Sheyenne River. In addition, the project will address opportunities for ecological and wildlife habitat restoration in these watersheds.

Since this project spans two EPA regional offices, we have coordinated with Region 5 and together we have determined that Region 8 will remain the project lead. EPA Region 8 is very interested in the proposed project and in becoming a cooperating agency for the eventual Environmental Impact Statement (EIS). Several sections of EPA Region 8 will be involved in reviewing the project information, including water quality, watershed, and Clean Water Act 404 permits.

Our overriding concern about scoping for this project has been that the study goals and planning objectives appear to be inextricably linked with the Fargo-Southside Flood Control Project. However, the Federal Emergency Management Agency (FEMA) recently determined that they will no longer be developing an EIS for the larger Fargo-Southside project. Rather, they will do an Environmental Assessment for a discrete part of that larger project which includes only Drain 27 and 53. EPA believes that this will lead to better alternatives development for the Fargo-Metrowide Feasibility Study to address a regional system for flood risk reduction.

Our specific comments for scoping are enclosed. Thank you for the opportunity to comment. If you have any questions, please contact me at (303) 312-6004 or you may also contact the project lead, Robin Coursen, at (303) 312-6695.

Sincerely,

Larry Svoboda, Director
NEPA Program
Ecosystems Protection and Remediation

Enclosure

Cc: Brent Truskowski, EPR-W

090709_EPA

Fargo-Moorhead Feasibility Study
EPA Pre-Scoping Comments

Purpose and Need:
The purpose and need statement for this project should clearly describe the current "problem" (flooding), and further, the future problems that will result if the project this not implemented (impacts to the riverine ecology, riparian habitat, wetlands, agricultural impacts, economic impacts, health and safety, etc.). EPA recommends that the signatories to the MOU for this project have an opportunity to comments on "purpose and need" prior to alternatives development.

Alternatives:
An alternative analysis that rigorously explores a range of options as well as a combination of options for addressing flooding should be developed. This should include, but not be limited to alternatives that examine watershed-wide or diffuse storage (Waffle approach), enlarging floodways through land use as well as levee and channel diversions. We also encourage you to examine non-structural approaches that restore natural floodplain connectivity, including the enhancement or creation of wetlands and other flood reduction techniques based on fluvial geomorphic principles. Such techniques could include restoration of natural channel dimensions, planform and gradient.

The current land use planning and floodway zoning for Fargo and Moorhead should be disclosed in this study. Growth and redevelopment planning for the region should also be examined and included in these alternatives. Such planning could reduce the cost of flood protection, protect floodways and minimize flood damage. For example, evaluate where there are opportunities for cluster development that would reduce infrastructure costs and preserve open space and floodways.

Finally, the criteria for describing impacts and ranking these alternatives should be comprehensive and clearly described.

Indirect Effects:
The indirect effects analysis should address the growth-inducing effects of the project related to changes in the pattern of land use (including impacts on prime farmland and other agricultural lands), and population density. Changes in land use patterns should disclose local land use policies for Fargo and Moorhead related to residential and commercial building in or near floodways.

Red River Basin Collaboration:
We acknowledge your representation on the International Joint Commission Red River Board and we recommend that the USACE assure on-going collaboration with the following organizations regarding river basin flood issues and any trans-boundary environmental concerns.

Red River Basin Commission: Lance Yohe, Director
http://www.redriverbasincommission.org/

International Water Institute: Chuck Fritz, Director
http://www.internationalwaterinstitute.org/

Climate Change Data:
EPA recommends that the affects of climate change on future flooding be incorporated into the analysis for this study. For your information, a recently released report from John Holdren, President Obama's Director of Science and Technology Policy highlights new information regarding climate change stress on water resources in the west. Thirteen science based agencies participated in development of this report. EPA recommends that the USACE consider this report, among other, in the feasibility study for this project. See http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts.

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090417_Fitzpatrick

Beauchamp, Francis MVP

From: Davidson, Mark D MVP
Sent: Saturday, April 18, 2009 11:45 AM
To: 'michael fitzpatrick'
Subject: RE: Busy now

Mike,

I have passed your e-mail onto the 2 Fargo-Moorhead Metro Feasibility Study project managers. Thanks!

Mark

-----Original Message-----
From: michael fitzpatrick [mailto:fitzrite@msn.com]
Sent: Friday, April 17, 2009 7:59 PM
To: Davidson, Mark D MVP
Subject: RE: Busy now

Mark,
Thanks for getting back. I am thinking of a system of 2 or 3 overflow canals, dug to the overflow level of the river, which would carry extra water away from the river to a deep pit which is then pumped out and the water used for productive uses over the course of the summer and fall so that it is empty for the following spring. I would suggest or reccomend using solar powered pumps. The goal being to conserve some of that extra water which is going to be a valuable resource and relieve the flooding. If you get a free minute or if the project manager gets a free minute, please let me know what you think. I have seen where there are some federal grants to work with for projects like this.

Mike

> Subject: Busy now
> Date: Fri, 17 Apr 2009 10:51:44 -0500
> From: Mark.D.Davidson@usace.army.mil
> To: fitzrite@msn.com
>
> Mike - right now we are very busy with the flood fight.
> I wouldn't be able to talk to you for a few weeks.
>
> If you write down your ideas concerning the flooding in the Red River
> area I will pass them on to the project manager for the Fargo-Moorhead
> flood study.
> Thanks!
>
> Mark
>
> -----Original Message-----
> From: michael fitzpatrick [mailto:fitzrite@msn.com]
> Sent: Friday, April 17, 2009 8:40 AM
> To: Davidson, Mark D MVP

> Subject:
>
> Dear Mr Davidson,
> My name is Michael Fitzpatrick and I live in Saint Paul. I have an
> idea to propose and discuss regarding the flooding of the Red River.
> Is it possible to discuss this over the phone or only via email?
Please respond.
> Thankyou.
>
> Mike
>

090520_Koppang

Beauchamp, Francis MVP

From: Awsumb, Lance G MVP
Sent: Tuesday, May 26, 2009 3:41 PM
To: Snyder, Aaron M MVP; Evans, Craig O MVP; Bluhm, Kevin W MVP; McGrath, Jeffrey L MVP
Subject: FW: Cost/benefit breakdown

Guys,
I spoke with the gentleman who sent the below email and told him I could forward his question to the right person. I don't know how much information I can give him, so I have not responded. I think maybe this should go with the formal comments, as well.
If you would like me to respond, let me know.

Thanks,

Lance

-----Original Message-----
From: Roger Koppang [mailto:koppang@cord.edu]
Sent: Wednesday, May 20, 2009 11:50 PM
To: Awsumb, Lance G MVP
Subject: Cost/benefit breakdown

Lance,

I attended the community meeting tonight presented by your group, the U.S. Army Corps of Engineers (St Paul District), at the Hansen Theater at Moorhead State University Moorhead. Just before leaving, I asked you a question concerning the breakdown of damages in the event of 2 catastrophic flood levels in the Fargo/Moorhead community. One level, the "100 year flood", had estimated worst case scenario costs of $2.2 billion. The second scenario, a "500 year flood", had estimated worst case damages of $6.5 billion.

My question: Is there a breakdown of those damages for Moorhead versus Fargo, or Minnesota communities versus North Dakota communities? The 500 year flood scenario seemed to indicate significant damage estimates even in West Fargo, for instance. Also, are there cost breakdowns on a per capita basis for the various local and/or state governmental entities involved under the two scenarios? The damage estimates for a 100 year flood seemed to indicate much more affected developed acreage in North Dakota versus Minnesota. The disparity seemed to grow under the 500 year flood scenario.

In the event a large scale flood prevention/flood control project goes forth, would these same damage estimates (which could also be viewed as potential benefits) breakdowns, presented in a ratio format, be used in determining the amount of dollars an individual local government is responsible for, once that project has an estimated price tag? It seems

1

the benefits gained should determine the costs to a community.

Before I left you tonight, I mentioned my questions could be considered "divisive", yet in reality there are 2 very different communities significantly involved in this process. Those 2 communities are in 2 different states, with two different sets of prevailing economic conditions, and most likely 2 very different methods of funding any local share of a joint project.

Your groups presentation was very thorough and informative. I look forward to the next one. For what it's worth, I drew out the Diversion option during a lull in this year's flood battle. My drawing seems to closely mimic your group's diverson option. My plan had estimated land acquistion costs of $25-$30 million. It began down by Rustad, MN, and re-entered the Red River channel north of Kragness, MN. The only real obstacle in my plan was the Moohead airport. I guess another not so obvious, but still very significant obstacle might be the Buffalo River Aquifer. My point in telling you this is not to portray myself as a forward thinking, visionary individual, but rather to illustrate my belief that a diversion canal on the Minnesota side of the Red River seems so straight forward, so logical, so doable, so obvious. I also do acknowledge there's much more than basic land acquistion in a project of this scope, but the attraction of such a concept is the notion of making every flood a smaller flood, and even possibly making the truly epic floods manageable.

Thanks for your time and your efforts.

Roger Koppang
629 Maple Lane
Moorhead, MN 56560

090520_Miller

Beauchamp, Francis MVP

From: Miller, D Les NWP
Sent: Wednesday, May 20, 2009 12:25 PM
To: Evans, Craig O MVP
Subject: Flood Protection Plans - Fargo-Moorhead - Temporary Plans Also

Follow Up Flag: Follow up
Due By: Monday, May 25, 2009 10:00 AM
Flag Status: Flagged

Hi Craig,

When I read the article below I was wondering about the following:

- Is there a temporary flood fight design and plan which is being replaced by the permanent flood damage reduction considerations described in the article?
- Is there a flood hazard mitigation project listed in one or both communities and/or their respective county's hazard mitigation plan for floods?

Thanks,

Les

D. Leslie Miller, P.E. (Les)
Flood Preparedness Program Manager
U.S. Army Corps of Engineers, Portland District Readiness Branch (CENWP-OD-E)
333 SW First Avenue
Portland, OR 97204-3495
Office: 503-808-4400
FAX: 503-808-4405
d.les.miller@usace.army.mil

US Army Corps of Engineers unveils flood protection plans
By Helmut Schmidt
The Forum, Fargo, N.D.
May 20, 2009

Fargo-Moorhead residents got their first shot Tuesday at brainstorming solutions for permanent flood protection.

About 75 residents and several dozen local officials heard the U.S. Army Corps of Engineers unveil two possibilities for flood control: a $909 million, 30-mile Red River diversion channel; and $625 million in levees along the Red River in the metro.

The levee plan includes Fargo's $161 million Southside Flood Control Project.

"The time for new ideas is right now," said project co-director Craig Evans, speaking during a two-hour informational and comment-gathering session at Fargo's downtown Centennial Hall.

"Maybe somebody out there has a nugget we haven't thought of," Evans said.

Evans said annual flood damage in Fargo-Moorhead averages $64 million.

But costs could leap if there is a catastrophic failure of flood protection. Such a failure would cost the area about $2.1 billion in a 100-year-flood, $5 billion in a 250-year flood and $6.5 billion in a 500-year flood, corps figures show.

The Red River at Fargo has exceeded flood stage in 51 of the past 107 years, and every year from 1993 through 2009, a corps report said.

That means the odds of having a Red River flood greater than the 2009 flood are one in five for someone who takes out a 30-year mortgage, the corps estimates.

The aim of the study is to get "the highest level of protection we can justify," Evans said, whether that's 50-year or 500-year flood protection.

If Congress authorizes the corps to build a project, the federal government would pay 65 percent of the costs, with the remainder picked up by local governments.

The diversion plan being studied is the shortest route and likely the least expensive, running through Minnesota from the confluence of the Wild Rice and Red rivers south of Fargo, north to a point northwest of Kragnes, according to the speakers and a corps report.

The diversion would be a massive project involving 17 highway and four railway bridges, Evans said. It would be 20 feet deep and 500 feet wide across the bottom, requiring 2,000 feet of right of way along its path to handle the dredged earth.

Other diversions in North Dakota and Minnesota will also be studied.

Kevin Bluhm, a corps spokesman, said the alternatives will be more fully worked up in the next four months with a cost-benefit analysis. Then the corps will return to the area in September or October to gather more input.

A corps timetable has the study finalized by September 2010, and sent to Congress by that December. April 2012 would be the earliest work would start, Bluhm and Evans said.

Completion of the project will depend on how quickly funding is provided by Congress.

Julie Olson, a resident of Maple Prairie, a subdivision south of Fargo on the Red River, said she knows the more global project will take time. In the meantime, she hopes Southside Flood Control moves ahead.

"It's a huge process. It's not going to happen overnight," she said.

As part of the study, the corps will test soil in the area this summer, Bluhm said.

South Fargo resident Eric Bach said he thought the corps plan was "pretty preliminary … but it's good to get it out in public."

Jerry Baldwin worries his home on Fargo's Southwood Drive may be sought for a buyout, but he hopes the corps can find "a long-term solution for the area."

Fargo City Engineer Mark Bittner said the corps' plans were not a big surprise, but he said costs were lower than expected.

"Seems to me there's a positive cost-benefit, which is good," Bittner said.

090520_Neuhauser

Bill Neuhauser P.E.
21494 Coaley Bay drive
Detroit Lakes, MN
218-847-9718

Craig Evans
U.S. Army Corps of Engineers

You have ask for other options to getting the water around Fargo/Moorhead, the way I looked at this is that there are three ways to get water around an object. One is to divert it around with a diversion, which can be very expensive with land acquisitions and bridge and road constructions and not too mention very time consuming. Second is to go through town with large flood walls: This has similar disadvantages as the diversion mostly the cost. And then the third method I'm going to propose to you.

The third method is not necessary a new method, in fact it has been used in numerous places around the world to solve issues similar to ours. The cost for this is the big question that will probably involve asking contractors for their input. I have found instances for this method being use or being proposed to be used in cities like Bangkok, Cincinnati and Seattle.

The job at hand is not necessary to divert all of the flows of the Red River around the FM area, but instead an amount the will drop the flows through town to a manageable height.

Looking at the graphs from the 2009 flood the flows at the high pt were around 31k at the 40.82. There are two questions that need to be answered here? Just what is the flow that the Corps wants to design for? And what gauge height would be acceptable to flow though the city?

What I'm proposing is a series of tunnels under the city. Now before you stop reading think about the cost advantages to this. Very small land and ROW acquisition is required, none or very little road and bridge building would be required and the current soils under Fargo/Moorhead are glacier till which we all know is very soft and very easy to bore though. All three of the links below are for tunnels and all but one are though granite! Meaning very expensive! The real challenge to this is finding a path under the city that would miss any existing pilings. My first thought was to tunnel under the interstate but when I thought of the pilings this wouldn't work.

My preliminary design calls out for about 80,000 ft of tunnels and with three 30ft dia tunnels this would get us about 15k of flow. This is assuming a 15ft drop from the

upstream to down stream. Large pumps would probably need to be added to this design but this 15k number is assuming gravity flow. We would dig down at a slope to 70 or 80 ft deep and then hold the bottom of the tunnel until the north end of the city and which time we would then let the water percolate or pump back up to the surface. Don't hold me to these numbers the software I used to calc this is not design to calculate tunnel flows but culverts.

You ask for other solutions, well this is thinking outside the box! We could call it the FM tube!

Thanks for your time
Bill Neuhauser P.E.
21494 Coaley Bay Dr.
Detroit Lakes, MN 56501

http://www.ita-aites.org/cms/fileadmin/filemounts/general/pdf/ItaAssociation/Organisation/Members/MemberNations/Thailand/U-1BMA.pdf

http://www.enquirer.com/editions/2001/08/12/loc_the_big_drain_giant.html

http://www.discovery.org/a/8231

Phraya River Project.

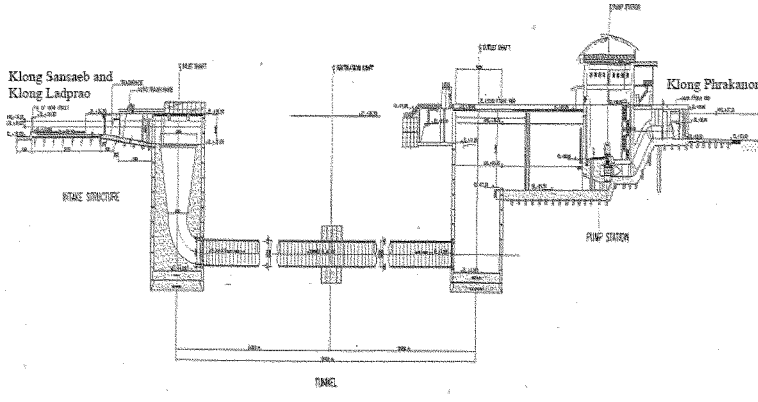

Figure 2. Longitudinal section of BMA water drainage tunnel project.

090520_Neuhauser

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Saturday, June 06, 2009 11:50 AM
To: 'billneu@arvig.net'
Cc: Snyder, Aaron M MVP; Schmit, Thomas A MVP
Subject: RE: Alternative flood protection idea for Fargo

Attachments: FM Flood alternative.doc

FM Flood alternative.doc

Mr. Neuhauser,
Thank you for the suggestion and information on the innovative tunnels. There is a similar system in San Antonio, Texas that we are aware of. We really appreciate every new idea, and it will be considered. As we continue our study, we would like the public to be involved as much as possible.

For more information on the study:

We have a project information paper posted on our Website:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1455

We also have a project Website where we'll post our slides and handouts from the public meetings:
http://www.internationalwaterinstitute.org/feasibility/index.htm

Thanks again for your interest and ideas,

Craig Evans
Senior Planner & Project Manager
St. Paul District
U.S. Army Corps of Engineers
Office: (651) 290-5594
Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

-----Original Message-----
From: bill neuhauser [mailto:billneu@arvig.net]
Sent: Wednesday, May 20, 2009 9:21 AM
To: Evans, Craig O MVP; Snyder, Aaron M MVP
Subject: Alternative flood protection idea for Fargo

Please see attached doc.

Bill Neuhauser P.E.

090608_Sandt

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Monday, June 08, 2009 9:42 AM
To: 'jay'
Cc: Snyder, Aaron M MVP; Schmit, Thomas A MVP
Subject: RE: Please Pass these comments on at the Flood meetings

Mr. Sandt,
We are considering all possible alternatives, and I did not mean to imply that we wouldn't consider your suggestions. I just wanted to point out that the Corps has limited authorities, and it seemed more appropriate to me that your issues be addressed through the political process than through our techincal study.

The Corps has no position on your first suggestion to set up a new Water Commission Board. If such a board is established, we will be happy to work with it, but we have no role in that political issue.

We are looking at flood storage in another feasibility study, the Fargo-Moorhead and Upstream study that began in 2004. We are also aware of the EERC's "waffle plan" study that seems very similar to your #2 suggestion. Because those concepts would need to be implemented across the entire basin, they are geographically out of our Fargo-Moorhead Metro study scope. Initial work has shown us that it will be difficult to find economic justification for the type of storage you suggest, and the model of storing water temporarily on farmed land does not fit our existing authorities to build permanent Federal projects. These types of projects are more likely to be built and managed by a local watershed district or county drainage authority.

Your third suggestion is for local action to prepare for flood-fighting. Again, this is not a Corps responsibility. We can provide assistance during floods, but we do not provide equipment for each community to store and maintain.

Thanks, again, for your interest in this study.

Craig Evans
Senior Planner & Project Manager
St. Paul District
U.S. Army Corps of Engineers
Office: (651) 290-5594
Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

-----Original Message-----
From: jay [mailto:jay@iconcmo.com]
Sent: Monday, June 08, 2009 8:38 AM
To: Evans, Craig O MVP
Cc: Snyder, Aaron M MVP; Schmit, Thomas A MVP
Subject: Re: Please Pass these comments on at the Flood meetings

090608_Sandt

Dear Craig:

I am confused as to the answer provided. The first statement says that they will be considered in the study process then the next statement says they are beyond the scope of the study. The second statement I disagree with because the Army Corp of Engineers should be taking all the viable options that are available to limit the following: widen the river, dams, diversions, holding areas, etc. Having water gates in the area that are controlled would act as a holding area which I believe is one of the options currently on the table or at least been brought up by local leaders. While these items can be passed on to legislature, an opinion from the Corp does speak louder than one citizen which has already advised the local authorities of these options.

Secondly, any study that is done that is costing millions of dollars should look at every alternative that might be feasible. Correct me if I am wrong but normally there is an initial study which sort of separates the best options from the rest of the pack. Then a second study is done on those very best options to find out what would be the best solution. Not looking at all the options on the first pass through and dismissing them as "beyond the scope" is saying that they don't even get looked at in the first round to be disqualified with a viable reason. It would be a different story if the initial view of the mentioned options were not feasible, but to not even look at them is ignoring a possible solution that would work by itself or in conjunction with others. In addition, it is proven that holding water onto farming fields does decrease flooding which is the goal overall. If anything can decrease flooding it should be looked at and not dismissed because it is out of scope.
Thank you.
Jason Sandt

Evans, Craig O MVP wrote:

Mr. Sandt,
Thank you for sending us your suggestions. We will consider them in our
study process.

All three issues you raised appear to be beyond the scope of our study. I
encourage you to share your ideas with your local and state political
representatives who may be able to influence those issues.

For more information on the study:

We have a project information paper posted on our Website:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1455

We also have a project Website where we'll post our slides and handouts from

2

the public meetings:
http://www.internationalwaterinstitute.org/feasibility/index.htm

Thanks again for your interest and ideas,

Craig Evans
Senior Planner & Project Manager
St. Paul District
U.S. Army Corps of Engineers
Office: (651) 290-5594
Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

From: jay [mailto:jay@iconcmo.com]
Sent: Wednesday, May 20, 2009 4:20 PM
To: Engineering Proxy
Subject: Please Pass these comments on at the Flood meetings

To all City Leaders and Other Government Officials:
City of Moorhead
City of Fargo
Army Corp of Engineers
State of MN
State of ND

There are 3 issues that should be addressed out side of the proposed solutions that the Corp has suggested. These suggestions would take less time to implement and money until the future project is in place several years down the road.

1. Development of a Water Commission Board that has the authority to drain fields and outer areas when it is appropriate to decrease flooding and keep river levels under control. Water run off does increase the river levels and should be addressed just like in other states by a Water Commission that has the authority to supervise the drainage from fields. Run off water is more of a threat in level areas like FM than other areas across the USA because everything just sits around until spring.
2. The next thing goes in hand with the above item. All fields should have gates on them that can be controlled by the Water Board and

fines should
be imposed for anyone that is tampering with those gates or digging ditches
to drain their fields. Although I can respect the farmers ambition to get
into the fields in spring this does not justify ruining other people's
property to do it.
3. The next item is to have the water tubes that were used in the flood
this year for a few homes on hand in various sizes within the city storage
facilities. There is a company that does this and the cities can contract
with them. The company even guarantees that the system will work.

The reason I am emailing this is because I can not attend in person to bring
these issue forward but I would welcome your input or any questions on my
comments here. I would like to know any feedback from these suggestions and
what the agencies do with these comments. Thank you.

Jason Sandt 701-866-1388

--
Thank you for contacting Icon Systems
Jay - Icon
Phone 1-800-596-4266
Fax 218-236-0235
Company Website: http://www.iconcmo.com
http://churchsoftware.blogspot.com/2007_11_14_archive.html

090606_Tweeten

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Saturday, June 06, 2009 11:36 AM
To: 'able.management@yahoo.com'
Cc: Snyder, Aaron M MVP; Schmit, Thomas A MVP
Subject: RE: Fargo-Moorhead flood mitigation public input

Mr. Tweeten,
Thank you for your suggestions and very valuable information. We will consider your input in our study process. Water storage is currently being studied in our ongoing Fargo-Moorhead Upstream Feasibility Study. For the Metro study, we are considering storage as a supplement to other flood mitigation measures. With the topography of the land being as flat as it is, it would difficult for storage to be a stand alone alternative. As we continue our study, we would like the public to be involved as much as possible.

For more information on the study:

We have project information papers posted on our Website:

Metro study:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1455

Upstream study:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=907

We also have a project Website where we'll post our slides and handouts from the public meetings:
http://www.internationalwaterinstitute.org/feasibility/index.htm

Thanks again for your interest and ideas,

Craig Evans
Senior Planner & Project Manager
St. Paul District
U.S. Army Corps of Engineers
Office: (651) 290-5594
Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

----- Original Message -----
From: Joel at Able Executive Management Services
<able.management@yahoo.com>
To: Bluhm, Kevin W MVP
Sent: Wed May 20 10:16:35 2009
Subject: Fargo-Moorhead flood mitigation public input

Here is my suggestion for the Corps' efforts to control flooding of the

090606_Tweeten

Red River of the North around Fargo.

Build successive weir pools upstream of affected areas. In low-flow periods the basin of the pools will be native grasses used by ground nesting birds and other wildlife. After their establishment they'll be valued as a hunting resource.

Underlying the increase in flood damage is the loss of natural wetlands through current farming practices. Efforts to make low lying fields productive by tiling to the network of drainage ditches leading to the river exacerbates this.

While the acquisition of larger tracts may be required, there are advantages to the construction of successive weir pools over building a diversion
channel: (1) Acquisition of the land is less complicated than the need for a continuous channel. The problem in acquiring the rights of way for a channel is that one landowner may resist and hold up the entire project. The specific placement of a given weir pool need not be dictated by a single landowner. This should lead to a lower price per acre. It will lead to lower legal bills and less time in court, too. (2) The solution is closer to the natural stream cycle. While it does not restore the watershed to its native state, the creation of grassland flood zones emulates the natural model. (3) Cost of the weirs is offset by reduced disruption of highway and railroad bridges required of the channel (4) Introduction of this environmental plan may coincide with other economic and commercial interests. Specifically, the location of waste disposal. Determination of landfill sites would articulate nicely with the engineering required of such a project.

Thank you for the opportunity to be included in the participation process.

Joel Tweeten
2641 Vernon Avenue South
St. Louis Park MN 55416
952-393-2193

090521_Linnertz

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Thursday, May 21, 2009 11:33 AM
To: 'thomas.linnertz@sba.gov'
Cc: Snyder, Aaron M MVP
Subject: Re: Fargo Flood control

Attachments: image001.gif

image001.gif

Tom,
Thanks for your suggestions. We intend to look at alternatives like the ones you mention, and I'll pass your e-mail on to our team.

We will also be looking for other ways to reduce the flood risk in your area, and some buyouts may be possible under a non-structural plan. We won't know for several months.

Please feel free to contact me any time if you have more thoughts on our study.

Thanks,
Craig Evans
Senior Planner
St. Paul District
USACE
651-290-5594

From: Linnertz, Thomas J.
To: Evans, Craig O MVP
Cc: Tom Linnertz (H)
Sent: Thu May 21 09:53:20 2009
Subject: Fargo Flood control

Craig:

I am sorry I was unable to attend the flood control meeting in Fargo on Tuesday due to conflicts in scheduling. I have read the story in the paper. I Live in the Lakshure Develoment approximately 2 miles south of Harwood. The flood control mentions nothing about the area of the Sheyenne River from the egress of the West Fargo Diversion to the Red River. This area floods terribly. This area also remained in flood

1

stage for somewhere around 3 weeks after the flood was declared over in Fargo.

This Sheyenne River area needs also to be addressed or the properties purchased and the same made into a flood way. The situation continues to worsen as more efficient methods of field drainage and drain tile are installed.

I have two suggestions

1. Run the Red River Diversion around the west side of West Fargo, to include the Red, Wild Rice Sheyenne. Continue the same to confluence of the Red and Sheyenne. I am quite sure this suggestion would be very expensive and possibly meet with tremendous rejection from anyone in the Sheyenne basin area around West Fargo and Harwood. I believe this may have been discussed before and it was determined not economically feasible.

2. Create the Red River Diversion as per the meeting, and create an extension of the West Fargo Diversion utilizing what I believe is called drain 41. this would then run from the egress of the West Fargo Diversion, across/under co Rd 17, roughly diagonal to Drain 41 some where between 12th Ave and Co Rd 19 and west of 57th st N., through Lakeshure Addition and under I-29 just south of Harwood. I am just a lay person but when looking at this on Google Earth it appears to be an almost natural drain way or possibly and earlier channel of the Sheyenne River. This would involve buyout of possibly only the a few homes close the egress of the present West Fargo Diversion and then protection or buyout of the homes at Lakeshure Addition. I live in Lakeshure Addition properly handled this could become quite a effective drain way. Also, while I like my house, I am not so enamored with it that I would not take a fair market buyout.

Please don't hesitate to contact me if you have any questions. Cell 701-793-7312

Tom Linnertz

Senior Business Development Specialist

North Dakota District Office, SBA (NDDO)

U.S. Small Business Administration (SBA)

657 2nd Ave N, Suite 218, PO Box 3086

Fargo, North Dakota 58108

Ph 701-239-5131 x 215

Fax 202-481-5852

Email: Thomas.Linnertz@sba.gov

Web: www.sba.gov/nd

090522_Vaa

Beauchamp, Francis MVP

From: Vaa, Galen [Galen.Vaa@courts.state.mn.us]
Sent: Friday, May 22, 2009 1:08 PM
To: Snyder, Aaron M MVP
Subject: Fargo/Moorhead regional flood study

Dear Mr. Snyder:

I attended your presentation concerning the above subject matter at MSUM on Wednesday. You and your colleagues should be commended for a very fine review of this complicated issue. I have talked to a number of my neighbors (I live in Crestwood subdivision, exactly 3.3 linear miles south of I-94 on the Minnesota side of the Red River) and they all were impressed with your unbiased and fair presentation of the findings and possible solutions. However, I have two concerns.

My first concern in personal in nature. Unfortunately, my home was substantially damaged this spring and it is situated in the 100 year flood plain. Thus, I have applied for a FEMA buyout and the officer from Clay County who is handling this matter has informed me that my chances for a buyout look pretty good at this time. But, I have a "what if" question concerning this matter, based upon a comment you made at the Wednesday meeting at MSUM. "What if" your organization ultimately recommends that the proposed levee alternate should be implemented and not the diversion alternative. If that is the case, I am wondering if it would be possible for someone from the Corps to roughly estimate where this levee would be located in relationship to Crestwood Subdivision where my home is located. I looked at the diagram the Corps had prepared for the "levee" alternative and it appeared that the levee would be located either on the road which forms the eastern boundary of Crestwood Subdivision, or, would be located even a short distance east of the road.

Basically, I don't want my possibility of getting a buyout jeopardized by misinformation concerning the "potential" location of this "possible" levee. As you are aware, property that is bought out by FEMA usually cannot be used for any purpose, even flood prevention purposes. My home and lot are located directly next to the Red River. My lot is about 250 feet deep and my house is about 150 feet from the river bank and the west side of the house is about 50 feet from the established floodway. When I purchased the property in 1985, the lot was 300 feet deep, but erosion and slumping has consumed about the west 50 feet. I am assuming that even if a levee is ultimately built in accordance with a future Corps recommendation, that said levee would not be built that close to the river. One of the reasons for FEMA's consideration of a buyout of my property is the fact that backyard is subject to erosion

and slumping and is unstable.

Could someone from the Corps confirm that any future levee, if it is recommended and ultimately built, would be built on the township road that presently serves Crestwood or east of the road, and not close to the river across my present lot; thus, the officials at Clay County would not have to worry that a FEMA buyout for my house/lot might frustrate future plans to build a levee in the area? Again, I reside in Lot 11 of Crestwood Subdivision, which is located on the Red River (Minnesota side) just 1/3 mile south of the convent bride road (60th St. South in Moorhead), and at a latitude equivalent to 55th Ave South on the Fargo side of the river.

My second concern relates to the hydrology graph which the Corps has prepared that was shown at the MSUM meeting, which estimates the "peak flow" of the Red for various past flood events. This graph shows that the 2009 flood had a peak flow slightly higher than the 1897 flood. I believe that this is misleading to the public and contributes to the public perception that we have survived the worst flood event of recorded history and we therefore don't have to worry so much in the future.

Years ago, I was on the governing Board of the Clay County Historical Society. I have always enjoyed an interest in the history of the settlement of this region and the study of historic flood events that helped shape that history. The Clay County museum has some very specific historical records relating to the 1897 flood, which establish that the 40.3 foot crest occurred notwithstanding the fact that the width of the river at the Veterans Memorial Bridge in downtown Fargo extended from Broadway Avenue in Fargo on the west, and east to 8th Street in Moorhead, a distance of about a mile. The crest at the same VMB in 2009 of 40.82 feet involved a river whose width had been constricted to less than ¼ mile by the erection of dikes. Certainly, the "peak flow" of the Red in 1897 was significantly in excess of the "peak flow" in 2009, in light of the tremendous width of the Red in 1897, compared to 2009.

Also, a close friend of mine (Jay Leitch) who is a Moorhead resident, has written an authoritative book on the Red River entitled "A River Runs North". This book discusses the truly historic flood of 1826, in which the undiked Red River likely obtained a crest of at least 42.5 feet (and perhaps more) in Fargo. If you are ever in Winnipeg, you should visit "The Forks" area, which is a museum located at the confluence of the Red and Assiniboine in downtown Winnipeg. That region was settled in 1826, and accurate flood records show that the crest in that year was fully 9.1 meters (10 feet) higher than the next highest crest. It is a truly sobering exhibit for anyone living in the Red

River Basin!!

In light of the above, I suggest that you include in your presentation the fact that the 2009 flood is NOT the highest flood in Fargo in recorded history, according to historical documents. I believe that this information will instill a greater feeling in the local population and our local officials that something major needs to be done to prevent a real disaster if a flood similar to 1897 or 1826 should revisit this area.

Thank you for your consideration of the above. I look forward to hearing back from you concerning my first concern.

Galen J. Vaa

6273 -7th St. SW

Moorhead, MN, 56560

090528_Vaa

Beauchamp, Francis MVP

From: Vaa, Galen [Galen.Vaa@courts.state.mn.us]
Sent: Thursday, May 28, 2009 8:19 AM
To: Snyder, Aaron M MVP
Subject: Fargo/Moorhead Regional Flood Study

Dear Mr. Snyder:

Unfortunately, my email to you dated May 22, 2009 contains a typographical error. The reference to the great flood in Winnipeg in 1826, refers to a crest of fully 9.1 meters (10) feet higher than any other recorded crest. Actually, the record crest in Winnipeg in 1826 was 3.1 meters (10) feet higher than the next highest crest according to their historical records.

I look forward to your response to my email of May 22nd. Thank you.

Galen J. Vaa

090525_Keller

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Saturday, June 06, 2009 11:40 AM
To: 'lskeller@cableone.net'
Cc: Snyder, Aaron M MVP; Schmit, Thomas A MVP
Subject: RE: Flood control idea for Red River Valley

Mr. Keller,

Thank you for your suggestions and very valuable information. We will consider them in our study process. At our public meetings on May 19th and 20th, we tried to stress there is no plan that is a silver bullet; multiple alternatives could be implemented together to make the best plan. As we continue our study, we would like the public to be involved as much as possible.

For more information on the study:

We have a project information paper posted on our Website:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1455

We also have a project Website where we'll post our slides and handouts from the public meetings:
http://www.internationalwaterinstitute.org/feasibility/index.htm

Thanks again for your interest and ideas,

Craig Evans
Senior Planner & Project Manager
St. Paul District
U.S. Army Corps of Engineers
Office: (651) 290-5594
Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

-----Original Message-----
From: Lon Shelley CableOne [mailto:lskeller@cableone.net]
Sent: Monday, May 25, 2009 4:22 PM
To: Evans, Craig O MVP
Subject: Flood control idea for Red River Valley

Craig,

The latest idea I've been hearing about involves creating a large diversion channel around F-M on the Minnesota side. While I do feel this option will provide a permanent solution for residents of the F-M metro, I fear it will cause additional issues for residents downstream. For an example, research the recent events for residents living north of Winnipeg. There were several news reports of people becoming overwhelmed with the rapidly moving water coming from the Red and the diversion.

Due to the topography of the land, I feel permanent flood protection must include multiple solutions. In conjunction with a diversion channel to protect the major metropolitan areas, I'd like to see a series of large holding ponds up and down the river, both in North Dakota and Minnesota. I feel the best way to control flooding on the Red is to first control how fast the water enters the channel. Of course this means landowners (farmers) will be affected, but the solution does not mean they will have to permanently give up their land. During times of heavy flooding, landowners could be financially compensated as portions of their lands are used to hold excess flood waters. During normal or dry conditions, farmers would work their land as usual. Since major flooding is not an annual event, landowners should not have to be burdened too often.

Using a series of retention ponds may also have a beneficial financial impact on the proposed diversion, as the size and scope of that project could potentially be scaled back. Plus, these ponds could be constructed more quickly, giving a more immediate solution and allowing more time to complete the diversion.

Thank you for time,

Lon Keller
641 41st Ave S
Moorhead, MN 56560

090526_Bigger

Beauchamp, Francis MVP

From: Brant Bigger [b_bigger@netzero.com]
Sent: Tuesday, May 26, 2009 12:06 PM
To: Evans, Craig O MVP
Subject: RE: F-M flood meetings

Thank you for the information. The slides from the meeting indicate there's a mailing list for information. Can you please add me to that list? Thanks again, Brant.

Brant B. Bigger 13248 US Hwy 10
Lake Park, MN 56554-9631
218-234-6906
b_bigger@netzero.net

---------- Original Message ----------
From: "Evans, Craig O MVP" <craig.o.evans@usace.army.mil>
To: "Brant Bigger" <b_bigger@netzero.com>
Cc: "Snyder, Aaron M MVP" <Aaron.M.Snyder@usace.army.mil>, "Schmit, Thomas A MVP" <Thomas.A.Schmit@usace.army.mil>
Subject: RE: F-M flood meetings
Date: Thu, 21 May 2009 15:13:26 -0500

Hi Brant,
We did not publish any maps showing the preliminary alignments of either the levees or the diversion. In general, the levees would follow the river banks and tie into high ground east and west of the river. We plan to look at diversions in both MN and ND that would start near where the Wild Rice River enters the Red and end at the Red somewhere northwest of Kragnes, MN. That's as specific as we can really be right now. You can expect more specifics this fall.

We have a project information paper posted on our Website:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1455

We also have a project Website where we'll post our slides and handouts from the public meetings (look for that info next week):
http://www.internationalwaterinstitute.org/feasibility/index.htm

I hope you find this information helpful. Please let me know if you have any other questions about the Fargo-Moorhead Metro Feasibility Study.

Thanks,
Craig Evans
Senior Planner & Project Manager
St. Paul District
U.S. Army Corps of Engineers
Office: (651) 290-5594
Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

1

-----Original Message-----
From: Brant Bigger [mailto:b_bigger@netzero.com]
Sent: Thursday, May 21, 2009 12:53 PM
To: Evans, Craig O MVP
Subject: F-M flood meetings

Hello Craig,

I was unable to attend either of the informational meetings held in Fargo & Moorhead this week. I've looked on the Corps's website, but can't find any information about the proposed levees &/or diversion. Can you direct me to the correct information. I'm mainly looking for general information about the size of the diversion, its possible route & other items of that nature.
Thank you for your time & the hard work you & the rest of the Corp are putting into this project.

Brant B. Bigger 13248 US Hwy 10
Lake Park, MN 56554-9631
218-234-6906
b_bigger@netzero.net

Click here to find the perfect banking opportunity!
<http://thirdpartyoffers.netzero.net/TGL2242/fc/BLSrjpYZUDNmEYF6JnIll3zS
PODd2
fYk3bIWdyEtDQbzkbXigXAJJNr7YwI/>

090602_Majkrzak

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Tuesday, June 02, 2009 4:41 PM
To: Schmit, Thomas A MVP; Snyder, Aaron M MVP
Subject: FW: Red River Flooding

Thomas,
Please add this to our "ideas" folder and add Mr. Majkrzak to the e-mail list.

thanks,
Craig

-----Original Message-----
From: Evans, Craig O MVP
Sent: Tuesday, June 02, 2009 4:40 PM
To: 'Dave Majkrzak'
Subject: RE: Red River Flooding

Thanks for your suggestions, Dave. It was a pleasure visiting with you today. I'll add this concept to our list of alternatives, and we'll put you on our e-mail list for further updates.

Sincerely,
Craig Evans
Senior Planner & Project Manager
St. Paul District
U.S. Army Corps of Engineers
Office: (651) 290-5594
Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

-----Original Message-----
From: Dave Majkrzak [mailto:dave.majkrzak@crary.com]
Sent: Tuesday, June 02, 2009 4:19 PM
To: Evans, Craig O MVP
Subject: Red River Flooding

Thank you for your phone time discussing the flooding problems in the Fargo/Moorhead area of the Red River.

To summarize: I am proposing you consider the I-29 right of way as a potential open viaduct during major floods, and as a roadway during normal times. I also suggested a "split" in the Interstate I-29 traffic to create a ND side, and a MN side North/South "beltway". These driving road beltways would also be mini diversion channels, holding and forcing the water to flow north, protecting the cities from overland flooding from small creeks and coulees from the West, and East directions.

The goal of this would be to split the Red River flows into four (or maybe three, if the MN side was not deemed necessary) channels. These

channels would be the Red River, the I-29 viaduct, the West side beltway/diversion and the East side beltway/diversion. Possible transportation funds would be available as well, as the beltway driving needs would be a big asset to both cities.

Please put me on your distribution list.

Thank You. Phone 701-499-5926

David Majkrzak, P.E.

802 Sheyenne Street

West Fargo ND 58078

090606_Armfeld

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Saturday, June 06, 2009 9:21 AM
To: 'jimmel@ideaone.net'
Cc: Snyder, Aaron M MVP; Schmit, Thomas A MVP
Subject: Fargo-Moorhead Metro Feasibility Study reply

Mr. Armfeld,

Thank you for attending one of our public meetings in May. This e-mail is in response to your following question: "Unless the southside project is an important and a part of your plan why proceed?"

We are still in the preliminary stages of the Fargo-Moorhead Metro Feasibility study, but we know that our project needs to include the southern part of Fargo. We are currently on a parallel course with the city of Fargo's Southside Flood Control project. The city prefers to keep moving on their study so they will be ready to build something as soon as possible, regardless what happens with the Federal study. The Corps sees the proposed Fargo Southside project as one alternative to be considered along with the other concepts we will assess.

For more information on the study:

We have a project information paper posted on our Website:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1455

We also have a project Website where we'll post our slides and handouts from the public meetings:
http://www.internationalwaterinstitute.org/feasibility/index.htm

Thanks again for your interest,

Craig Evans
Senior Planner & Project Manager
St. Paul District
U.S. Army Corps of Engineers
Office: (651) 290-5594
Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

090606_Breker

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Saturday, June 06, 2009 9:33 AM
To: 'mjbreker@yahoo.com'
Cc: Snyder, Aaron M MVP; Schmit, Thomas A MVP
Subject: Response to question from Fargo-Moorhead Metro Feasibility Study

Mr. Breker,

Thank you for attending one of our public meetings in May. This e-mail is in response to your following question: "As a Fargo resident and farmer from the southern Red River Valley, I have interests in protecting both Fargo and my farm and cropland. I am interested in the economic analysis of all potential upstream water retention. Please contact me regarding the above."

The Fargo-Moorhead Metro Feasibility study is concentrating on actions we could take in the metropolitan area. The Corps is working on another study to look at potential water retention upstream of Fargo-Moorhead--the Fargo-Moorhead and Upstream Feasibility Study. We will incorporate information from the upstream study into our planning in the Metro study, and we will continue to look for flood storage opportunities.

For more information on the studies:

We have project information papers posted on our Website:

Metro study:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1455

Upstream study:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=907

We also have a project Website where we'll post our slides and handouts from the public meetings:
http://www.internationalwaterinstitute.org/feasibility/index.htm

Thanks again for your interest,

Craig Evans
Senior Planner & Project Manager
St. Paul District
U.S. Army Corps of Engineers
Office: (651) 290-5594
Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

090606_Haugen

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Saturday, June 06, 2009 10:33 AM
To: 'dlhaugen@cableone.net'
Cc: Snyder, Aaron M MVP; Schmit, Thomas A MVP
Subject: Response to question from Fargo-Moorhead Metro Feasibility Study

Ms. Haugen,

Thank you for attending our public meeting in Moorhead on May 20. This e-mail is in response to your following question: "Is there an aquifer newly discovered south of Moorhead, west over the proposed diversion, and east of the Red? We wouldn't cause potential damage to clean water source in times of drought?"

We are aware of the potential for our alternatives to affect groundwater, and we want to avoid any adverse impacts to aquifers. We are taking soil borings and working with the Minnesota Department of Natural Resources and other agencies to determine where aquifers exist. Our preliminary diversion alignment was chosen to be west of the known Buffalo aquifer.

For more information on the study:

We have a project information paper posted on our Website:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1455

We also have a project Website where we'll post our slides and handouts from the public meetings:
http://www.internationalwaterinstitute.org/feasibility/index.htm

Thanks again for your interest and comments,

Craig Evans
Senior Planner & Project Manager
St. Paul District
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Office: (651) 290-5594
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e-mail: craig.o.evans@usace.army.mil

090606_Headrick

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Saturday, June 06, 2009 10:11 AM
To: 'Barbr.headrick@gmail.com'
Cc: Snyder, Aaron M MVP; Schmit, Thomas A MVP
Subject: FW: Response to question from Fargo-Moorhead Metro Feasibility Study

Ms. Headrick,

Thank you for attending our public meeting in Moorhead on May 20. This e-mail is in response to your following questions: "How much will be on website as you work on study over next 4 months? How will Corps handle currently existing structures, such as the Sheyenne diversion in West Fargo, could they be altered to work better for the full region or must your project deal with it as is?"

Concerning your first question of updating the website: we may post some new information or correct some information that is no longer valid. Due to time constraints, the website will not have set update intervals.

Regarding currently existing structures: Since the study is in the preliminary stages, we are just beginning to study diversion alternatives in North Dakota. We will consider modifications to the Sheyenne diversion in addition to other possible diversion alignments in North Dakota and Minnesota.

For more information on the study:

We have a project information paper posted on our Website:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1455

We also have a project Website where we'll post our slides and handouts from the public meetings:
http://www.internationalwaterinstitute.org/feasibility/index.htm

Thanks again for your interest,

Craig Evans
Senior Planner & Project Manager
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Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

090606_Ista

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Saturday, June 06, 2009 9:57 AM
To: 'djista@loretel.net'
Cc: Snyder, Aaron M MVP; Schmit, Thomas A MVP
Subject: Response to question from Fargo-Moorhead Metro Feasibility Study

Ms. Ista,

Thank you for attending our public meeting in Moorhead on May 20. This e-mail is in response to the written comments you provided at the meeting regarding downstream impacts and the need for additional flood storage.

Regarding your question about measuring downstream impacts: we will measure the impacts of the project as far downstream as the impacts exist. We will also be studying the impacts upstream of a flood control project. Hence we are not only studying the Fargo-Moorhead metropolitan area, we will be studying any part of the Red River Valley that is affected from flood mitigation efforts in the F-M area. Our intent is to minimize any impacts, and the project will need to compensate for any economic impacts that rise to the level of a real estate "taking."

Regarding flood storage, we are considering flood storage in another feasibility study, the Fargo-Moorhead and Upstream Feasibility study that started in 2004. We are finding it difficult to show economic justification for Federal participation in flood storage in the upper Red River Basin, but we continue to look for opportunities to combine flood storage with ecosystem restoration in ways that may allow for Federal projects. We are also building hydrologic models that can assist local jurisdictions when they consider non-federal flood storage projects.

For more information on the Fargo-Moorhead Metro study:

We have a project information paper posted on our Website:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1455

We also have a project Website where we'll post our slides and handouts from the public meetings:
http://www.internationalwaterinstitute.org/feasibility/index.htm

Thanks again for your interest,

Craig Evans
Senior Planner & Project Manager
St. Paul District
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Office: (651) 290-5594
Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

Diane Ista - How far downstream do you measure impacts? We need assistance to River which would reduce the flows to the Red. djista@loretel.net See full comment in the written comment section.

090606_Keller

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Saturday, June 06, 2009 11:40 AM
To: 'lskeller@cableone.net'
Cc: Snyder, Aaron M MVP; Schmit, Thomas A MVP
Subject: RE: Flood control idea for Red River Valley

Mr. Keller,

Thank you for your suggestions and very valuable information. We will consider them in our study process. At our public meetings on May 19th and 20th, we tried to stress there is no plan that is a silver bullet; multiple alternatives could be implemented together to make the best plan. As we continue our study, we would like the public to be involved as much as possible.

For more information on the study:

We have a project information paper posted on our Website:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1455

We also have a project Website where we'll post our slides and handouts from the public meetings:
http://www.internationalwaterinstitute.org/feasibility/index.htm

Thanks again for your interest and ideas,

Craig Evans
Senior Planner & Project Manager
St. Paul District
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Office: (651) 290-5594
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e-mail: craig.o.evans@usace.army.mil

-----Original Message-----
From: Lon Shelley CableOne [mailto:lskeller@cableone.net]
Sent: Monday, May 25, 2009 4:22 PM
To: Evans, Craig O MVP
Subject: Flood control idea for Red River Valley

Craig,

The latest idea I've been hearing about involves creating a large diversion channel around F-M on the Minnesota side. While I do feel this option will provide a permanent solution for residents of the F-M metro, I fear it will cause additional issues for residents downstream. For an example, research the recent events for residents living north of Winnipeg. There were several news reports of people becoming overwhelmed with the rapidly moving water coming from the Red and the diversion.

Due to the topography of the land, I feel permanent flood protection must include multiple solutions. In conjunction with a diversion channel to protect the major metropolitan areas, I'd like to see a series of large holding ponds up and down the river, both in North Dakota and Minnesota. I feel the best way to control flooding on the Red is to first control how fast the water enters the channel. Of course this means landowners (farmers) will be affected, but the solution does not mean they will have to permanently give up their land. During times of heavy flooding, landowners could be financially compensated as portions of their lands are used to hold excess flood waters. During normal or dry conditions, farmers would work their land as usual. Since major flooding is not an annual event, landowners should not have to be burdened too often.

Using a series of retention ponds may also have a beneficial financial impact on the proposed diversion, as the size and scope of that project could potentially be scaled back. Plus, these ponds could be constructed more quickly, giving a more immediate solution and allowing more time to complete the diversion.

Thank you for time,

Lon Keller
641 41st Ave S
Moorhead, MN 56560

090606_Koski

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Saturday, June 06, 2009 9:40 AM
To: 'bonniek@i29.net'
Cc: Snyder, Aaron M MVP; Schmit, Thomas A MVP
Subject: Response to question from Fargo-Moorhead Metro Feasibility Study

Bonnie and Charles Koski,

Thank you for attending one of our public meetings in May. This e-mail is in response to your following question: "How can you adjust your project for a river that flows north into frozen drainage channel?"

Your question raises one of the many challenges in designing permanent flood mitigation in the Red River Valley. As we look at various alternatives, we will consider downstream conditions and factor them into our designs.

For more information on the study:

We have a project information paper posted on our Website:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1455

We also have a project Website where we'll post our slides and handouts from the public meetings:
http://www.internationalwaterinstitute.org/feasibility/index.htm

Thanks again for your interest,

Craig Evans
Senior Planner & Project Manager
St. Paul District
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Office: (651) 290-5594
Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

Charles Koski - Any project should consider redundancies to allow for modification of any catastrophic failure le diversion and modified flood barrier and or storage. How can you adjust your project for a river that flows north into frozen drainage channel?
bonniek@i29.net

090606_Lahren

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Saturday, June 06, 2009 9:42 AM
To: 'dlahren@aol.com'
Cc: Snyder, Aaron M MVP; Schmit, Thomas A MVP
Subject: Response to question from Fargo-Moorhead Metro Feasibility Study

Mr. Lahren,

Thank you for attending one of our public meetings in May. This e-mail is in response to your following question: "Why do you need a 500 ft wide base at the bottom of the diversion?"

The design of the diversion alternative is in the preliminary stages. The 500 feet is only preliminary and was used as a width that would carry an approximate volume of water around the metropolitian area. In the upcoming months we will be conducting further study into this topic, as well as optimizing the width and depth of a proposed diversion alternative.

For more information on the study:

We have a project information paper posted on our Website:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1455

We also have a project Website where we'll post our slides and handouts from the public meetings:
http://www.internationalwaterinstitute.org/feasibility/index.htm

Thanks again for your interest,

Craig Evans
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Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

090606_Sell

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Saturday, June 06, 2009 12:32 PM
To: 'FM Flood Group'
Cc: Snyder, Aaron M MVP; Schmit, Thomas A MVP
Subject: RE: Flood protection for Fargo

Mr. Sell,

Thank you for sharing your comments with us. We will consider them as we continue to refine our diversion alternatives along with several other concepts that could reduce flood risk in the study area.

Regarding the channel widths, I'm not sure where the channel is only 100 feet wide. I know that at the 32nd Ave. South Dam the channel is closer to 180 feet wide during most of the year, but during flood events it is significantly wider than that. The natural channel is also deeper than a diversion would likely be, so keep in mind that width is only one factor in our design. We will look at various cross sections to optimize the design.

As we continue our study, we would like the public to be involved as much as possible.

For more information on the study:

We have a project information paper posted on our Website:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1455

We also have a project Website where we'll post our slides and handouts from the public meetings:
http://www.internationalwaterinstitute.org/feasibility/index.htm

Thanks again for your interest and ideas,

Craig Evans
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e-mail: craig.o.evans@usace.army.mil

-----Original Message-----
From: FM Flood Group [mailto:fmflood@twoface.dreamhost.com]
Sent: Friday, June 05, 2009 2:21 PM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Rob Sell (robsell@gmail.com) by the FM Flood Control Group

Mr. Craig Evans:
Sorry about that, I meant to paste in something else and then I accidentally sent it out.

I have a tough time believing the corps recommendation that a a diversion would need to be 500 feet wide. why would we need a diversion 5 times as wide as the river is? I believe that the diversion study should be re-evaluated.

We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

In F-M the river is about 100 feet wide, in Winnipeg the river is about 450 feet wide (nearly 5 times as wide). The red river valley is full of ditches (drains). The diversion would just be a bigger ditch. A bottom width of about 50 feet appears to be what would be required based on the 2009 flow. The flow at Fargo was 29,100 cubic feet per second at 40.82 feet this spring. The cost with a smaller diversion could be significantly reduced and should give it a favorable cost benefit ratio.

The proposal of the Corp to start at the Wild Rice River and end way north of Harwood is very good. The diversion would offer better protection from overland flooding on the ND side of the river. Property will have to be taken by eminent domain; either homes along the river and drains for dikes and flood walls etc., or farmland for the diversion. The $909 million for the diversion would seem to have much greater benefits than the levees. We need to find a way to get a favorable cost benefit ratio or find another way to fund the diversion It should be selected immediately as the preferred method.
Sincerely
Rob Sell

090606_Wolf

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Saturday, June 06, 2009 10:23 AM
To: 'Ducksoup25@yahoo.com'
Cc: Snyder, Aaron M MVP; Schmit, Thomas A MVP
Subject: Response to question from Fargo-Moorhead Metro Feasibility Study

Mr. Wolf,

Thank you for attending our public meeting in Moorhead on May 20. This e-mail is in response to the written questions you provided at the meeting: "I live in section 6, Oakport Township, Clay County. I see that there is a proposed levee that encompasses the area between 70th Ave NW and 80th Ave NW from the river to Broadway St. Question: How did this levee become part of the proposal: At present there are only a dozen or more homes in the protected area, an area of about 300 acres. I live just north of the levee area – how will this affect my property?"

The layout of the proposed levee system is very preliminary, and we we are in the process of refining it. We must show that each levee section is economically justified, so if the section to which you refer doesn't make sense, our analyses should show that.

It is too early to say what impacts any of our proposals will have on properties downstream or upstream of the project. Our intent is to minimize impacts, and we would be required to compensate for any economic impacts that rise to the level of a real estate "taking."

You can expect more specifics on the levee layout and any potential impacts this fall.

For more information on the study:

We have a project information paper posted on our Website:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1455

We also have a project Website where we'll post our slides and handouts from the public meetings:
http://www.internationalwaterinstitute.org/feasibility/index.htm

Thanks again for your interest,

Craig Evans
Senior Planner & Project Manager
St. Paul District
U.S. Army Corps of Engineers
Office: (651) 290-5594
Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

090608_Bergan

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Monday, June 08, 2009 10:01 AM
To: 'Ron Bergan'
Cc: Schmit, Thomas A MVP; Snyder, Aaron M MVP
Subject: RE: Fargo diversion comments

Mr. and Mrs. Bergan,
Thank you for your suggestions and very valuable information about diversion alternatives. We will consider your comments in our study process.

For more information on the study:

We have a project information paper posted on our Website:
http://www.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1455

We also have a project Website where we'll post our slides and handouts from the public meetings:
http://www.internationalwaterinstitute.org/feasibility/index.htm

Thanks again for your interest and ideas,

Craig Evans
Senior Planner & Project Manager
St. Paul District
U.S. Army Corps of Engineers
Office: (651) 290-5594
Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

-----Original Message-----
From: Ron Bergan [mailto:ronb@facnd.com]
Sent: Sunday, June 07, 2009 6:15 PM
To: Evans, Craig O MVP; Snyder, Aaron M MVP
Subject: Fargo diversion comments

To the Army Corps of Engineers,

We need a 100 plus year solution. The only method of flood protection that is sure to work is a diversion around Fargo-Moorhead.

The failure of floodwalls, dikes, dams this spring is proof that these methods will not protect us for the next 100 years. We know this soil is very unstable, dikes settle and structures are damaged with the movement of the soil. Rodents, humans, etc do damage to the structures. The Oak Grove High School damage was a result of the new flood wall failure. From the Fargo Forum "eroding Clausen Springs Dam near Kathryn" and "LaMoure County keeping an eye on eroding dam - with an eroding spillway". Homes have been destroyed because they were sliding

into the river, the old Trollwood and Edgewood clubhouse were sliding into the river; roads, dikes, etc have been damaged or destroyed. Building 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point.

Even with permanent dikes, flood walls, etc we could have a failure, especially at the extreme predictions of possible heights projected for F-M in the 2009 flood fight. Our experience this year has made us realize that a flood over 45′ is possible. In that case F-M and surrounding area could suffer like Grand Forks did in 1997.

What will the height of the river be if the river hits a flood stage of 43′ with the Main Avenue bridge acting like a dam? Would that be 2′ to 4′ higher? If so would the river level be 46 feet?

The red river valley is full of ditches (drains). The diversion would just be a bigger ditch.

We do not have to send all the water in the Red River around the towns. At a flood level of maybe 25′, water could begin to flow into the diversion and maybe at 30′ the water flowing through the towns would equal the 2009 flood of 40.82′. The difference between a 40.82′ flood level and the flow rate at a 30′ flood level, would only require an area 20′ by 40′ to divert the water above the 30′ flood level if the speed is the same.

The 500 foot width projected for the bottom of the diversion by the Corps seems very wide. A bottom width of about 50′ appears to be what would be required based on three times the flow between 30′ and 41′ flood levels and also a comparison to the original Winnipeg diversion which was built to handle 60,000 cfs. The flow at Fargo was 29,100 cfs at 40.82′ this spring. This would reduce the cost significantly and should give it a favorable cost benefit ratio. The Winnipeg diversion is 30′ deep. The Winnipeg diversion worked great in the 1997 flood. In F-M the river is 100′ wide compared to 450′ in Winnipeg (nearly 5 times as wide).

Some information from Biot Report #392: August 26, 2006 about the Winnipeg expansion of the diversion after the 1997 flood: The diversion was widened to 350′ but not deepened. It increased the floodway capacity from 60,000 cfs to 140,000 cfs. The original diversion cost in today's dollars was $350 to $500 million. The expansion involved replacing 12 bridges, two railroad crossings and excavation of 27 million cubic yards of earth. It has been used to divert water in 20 of 37 years.

The North Dakota side may be better for political reasons. It would offer better protection from overland flooding as this appears to be greater on the ND side of the river. The diversion should start at the Wild Rice River as suggested by the Corps, but should be started on the west side of I29 at drain 47 and take all of its flow plus part of the Red River flow. Comparing the flow at Hixon to Fargo this would indicate about 15,000 cfs should be diverted. That is the amount needed to keep the river at 30 feet. Looking at topographical maps for the area the water will flow from the Wild Rice at Interstate 29 and around

West Fargo and north to the Red with no problems. The crossing of the Sheyenne will require structures or controls to only allow a limited amount of water to go through West Fargo. It may be best to use the West Fargo diversion and increase its capacity for the part around West Fargo. The area required for the flow under bridges should be approximately 70′ at bottom and 100′ at the top compared to the maybe 500′ width at the top needed to have gently sloping sides.

The land can continue to be used for farming with alfalfa hay grown on the slopes as Winnipeg does now.

Property will have to be acquired by eminent domain; either homes and land along the river and drains for levees, or farmland for the diversion.

Dikes, floodwalls, etc will raise the level of the river. As you force the water through a narrower space the water has no where else to go but up. Will that mean the river will be 6″ or 2′ higher? The exact amount will depend on the narrowest spot, river height, flow rates etc. Any extra height causes great concerns.

A diversion will lower the level through F-M. The higher the water the more difficult it is to protect F-M and the greater risk of a catastrophic failure. There is basically no chance of failure of a diversion.

The cost benefit ratio of the levee system was 1.1 for the $625 million dollar proposal and the diversion was shown at .65 which would equal $590 million. How can the diversion have less total benefit? It would cover a much greater area. We could save many of the homes now being considered for destruction. It would also save the view for many homeowners and therefore provide an economic benefit by the higher values. River frontage is the highest valued land for residential usage. It would add value to the total length on both sides of the river. Was the cost of maintaining and the repair and replacement of dikes, floodwall, etc calculated in the cost benefit ratios? The estimated 70 miles of protection for the area will require a lot of mowing, trimming, etc each year. Was the improved drainage for farmland along the diversion included? The dikes, floodwall and such things are unsightly. How was the possibility of failure to the levee system added to the benefit for the diversion? A failure at 43′ plus would totally flood at least one city – Corps projection $3 billion cost. The National Guard would not be patrolling the levees and instant response teams will not be at the ready. We believe the diversion would be worth at least twice the benefit of the other systems.

Was the time lost at work and the extra costs and lost business (stores closed 6-8 days, MeritCare, nursing homes, etc evacuations, school shutdowns, loss of visitors and events, etc), considered in the cost benefit ratio? How about the stress on all our people or the value of the ability for the area to grow?

Even if the diversion costs $1 billion, the $200 million Fargo is proposing for flood protection should cover its share. The diversion should be selected immediately as the preferred method.

What if Devils Lake overflows and erodes the 18′ of sediment in the old channel from previous times? This would most likely happen when we were experiencing flooding downstream so that it may also cause a failure of the Baldhill dam at Valley City.

If the estimate of 50 feet at the bottom is close and using some of these methods and suggestions, maybe it could be completed for $600 million. This is about the same cost as the $660 million budget for the recent expansion of the Winnipeg diversion to handle a 700 year flood.

Thanks for your consideration of our comments,

Ron and Mary Alice Bergan
311 11 Ave S
Fargo, ND 58103
701-237-3226

090619_Bergan

Beauchamp, Francis MVP

From: Ron Bergan [ronb@facnd.com]
Sent: Friday, June 19, 2009 4:50 PM
To: Evans, Craig O MVP
Cc: Schmit, Thomas A MVP; Snyder, Aaron M MVP
Subject: Fargo - main avenue flood problem at 40 feet

Attachments: G4TD2931.JPG; G4TD2944.JPG; G4TD2949.JPG; G4TD2956.JPG

G4TD2931.JPG G4TD2944.JPG G4TD2949.JPG G4TD2956.JPG

To the Army Corps of Engineers;

We now know that the main avenue bridge acts as a dam at about 40 feet, see the pictures. At about 41 feet the water will be backed up and flow over both ends of the bridge and into our cities. The diversion is the only answer.

I now believe the river was only at 40 feet; but, with a one inch dam created by the main avenue bridge, it caused the water to be between 1 ½' and 2' up on the beams and a river reading of 40.82' at 13 Avenue south. See the pictures taken today 6-19 by Brad Grosz of the branches caught up in the beams and structure. We have seen lots of branches in all areas we can see from walking on both sides of the bridge. I estimated the area between main avenue and I 94 covered by water at 40' to be 364 acres (roughly measured with the computer maps). One foot of restriction would add 17 feet of height to the water in this area in 24 hours! The river probably flows faster from the pressure as the water gets higher and my calculation is just a ballpark number. We are getting an engineer to look at these calculations.

Winnipeg expanded their diversion because the 1826 flood was 40% larger than the 1997 flood. We have also learned today that their $600 million expansion is significantly under budget. A levee system has a much higher chance of failure and a failure at a high flood level will put both cities under water.

We are asking the Corps to extend the public comment period two weeks. We have a committee of top business people and a well known person who

just agreed yesterday to lead the effort and hope we can get more time to develop and present information to the Corps. We will have a press conference next week. We believe the election to approve the flood protection sales tax which is June 30, 2009 will generate lots of discussion and comments for the Corps.

We believe the diversion has a much higher benefit to F-M and it does not have to cost more, I think it will be less costly. We should not have to be totally devastated to get some federal money.

Thanks for your consideration,

Ron Bergan, ceo

Fargo Assembly Co.

3300 7 Ave N

Fargo, ND 58102

Office 701-356-7400 Cell 701-361-0715

090621_Siemens

Beauchamp, Francis MVP

From: Snyder, Aaron M MVP
Sent: Sunday, June 21, 2009 8:18 AM
To: Schmit, Thomas A MVP; Evans, Craig O MVP
Subject: FW: Flood Protection

FYI - you probably got this already though.

Aaron M. Snyder
USACE Planner and Project Manager, PMP
MVD Plan Formulation Regional Technical Specialist
651-290-5489
612-518-0355 (Cell)
Aaron.M.Snyder@usace.army.mil

-----Original Message-----
From: Herb Siemens [mailto:herbanni@i29.net]
Sent: Friday, June 19, 2009 4:51 PM
To: Snyder, Aaron M MVP
Cc: fmflood@fmfloodcontrol.com
Subject: Flood Protection

Project Manager Snyder,

My wife and I moved to Fargo from Winnipeg 10 years ago.

I don't understand why people are so reluctant to put proper permanent flood protection in place. All the water that went thru Fargo (plus a lot more) went thru Winnipeg this spring. The "flood waters" were a non event in Winnipeg this year because of the diversion that they have in place. Without the diversion Winnipeg would have been in a horrible mess, but everything worked the way it was supposed to and there were no problems.

Putting up floodwalls, levee's, etc. is a collection of bandaids that you can never be sure will really do the job, they also require a lot of maintenance. Plus, they are very unsightly. Can you imagine walls & levee's along the river in Linden Wood Park, It won't be nearly as much fun to go there when you have to look at those things. The Fargo Parks Board say that they have spent over $1 million already this year on protection, cleanup etc. That number does not include lost revenue. As of today June 18 the river is going above flood stage again, the campground is closed. Everything will have to be cleanded up again and they continue to loose revenue.

Defacing river front property with walls, levee's etc is a horrible thing, what will happen to property values in the nicest neighborhood's in Fargo. In adition, the insecurity that people feel - worrying about floods takes a terribel toll on them and is very costly to businesses.

Originally they said it could not be done in Winnipeg either; but people with vision, forsight and determination made it happen. After the flood of '97 it was not very difficult to get all levels of government together to agree to double the size of the floodway. that expansion is basically complete now and helped save the City of Winnipeg again this spring. They have used the diversion there more than 20 times in the last 37 years, that is real proof of the cost benefit.

It is not a question of can we do it or should we do it, the only questions should be HOW QUICKLY CAN WE GET A DIVERSION BUILT?

Herb & Anni Siemens
404 8th Street South
Fargo, ND
58103

090622_Bergan

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Monday, June 22, 2009 3:43 PM
To: 'Ron Bergan'
Cc: Schmit, Thomas A MVP; Snyder, Aaron M MVP; Lesher, Michael D MVP; Sobiech, Jonathan J MVP; 'awalker@cityoffargo.com'; bob.zimmerman@ci.moorhead.mn.us; Buffalo Red River Watershed District; Jody Bertrand; Mark Bittner
Subject: RE: Fargo flood protection

Mr. Bergan,
Thank you for your e-mails. I forwarded the bridge information and photos to our hydraulic engineer to make sure our models accurately reflect existing conditions. We will consider your suggestions for diversion alternatives as we continue our study.

The Corps cannot endorse or comment on the information you propose to present to the press. We are conducting hydrologic modeling to inform the planning process, and we will use those models to assess several alternative widths, depths and alignments for diversions and levees. The preliminary cost estimate released in May was based on only one possible configuration, and it is by no means the final answer.

Regarding your request to extend our comment period two more weeks: we will accept your input when you can get it to us. However, we must begin the process of narrowing down the alternatives in order to stay on schedule. The June 22 date was set to ensure that we could address people's major concerns as we proceed with the study within the original schedule. Any significant comments received later in the process may delay completion of the study.

Thanks, again, for your interest in the feasibility study. I look forward to hearing more from you as soon as possible.

Craig Evans
Senior Planner & Project Manager
St. Paul District
U.S. Army Corps of Engineers
Office: (651) 290-5594
Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

-----Original Message-----
From: Ron Bergan [mailto:ronb@facnd.com]
Sent: Monday, June 22, 2009 3:08 PM
To: Evans, Craig O MVP
Cc: Schmit, Thomas A MVP; Snyder, Aaron M MVP
Subject: Fargo flood protection

Dear Craig,

We are developing some information for a press conference to support a diversion. We would consider any changes to our press material you think we should make. We know there are many details to work out such as finding a low cost way to cross the rivers.

Did you get the pictures I emailed you late Friday? They showed that the water was up on the beams of the Main Avenue Bridge and that that it makes a good dam. It appears we can not go over about 41 feet without flooding both cities. I will resend without the pictures.

Ron

Proposed Design Criteria for Protection of F-M to 50 Feet

River Level Flood Level with Levees	River Level with Diversion	Diversion Level
25′	22′ or less	100% above 22″ 25′
30′	22′	100% above 22′ Greater than 30′
35′	25′	100% above 25′ Greater than 35′
41′	30′ Difference used to calculate size needed 42-44′	
45′	32.5′ 45′ Topped	30′

50′ 35′
35′ Topped

Cost Comparison for Diversion

	Old Winnipeg	New Winnipeg	F/M
Volume	15,000 cu ft/sec	60,000 cu ft/sec	140,000 cu ft/sec
Depth	20-30′	30′	30′
Bottom Width (est.)	50′-100	150′	up to 350′
Top (field level)	500-700′	700-1000′	900-1200′
Spoil Bank Height (est.)	20′ (est.)	20′	30′ (est.)
Highway Bridges	12	12	12
Railroad Bridges	4	4	4
Drop in Elevation	35′ ?	26′	26′
Cost (in millions of dollars)	$600 (est.)	$350-$500 *	$600**

*In today's dollars

** Nearing completion and under budget

QUESTIONS AND ANSWERS ABOUT A DIVERSION

1. Where would it start and end? Wild Rice River west of I 29 and end north of Argusville.
2. What areas would be protected? Both side of the river for the length of the diversion and to some extent about 10 miles south of the inlet.
3. What cities/areas would be protected? Fargo, Moorhead, West Fargo, Oakport, Briarwood, Round Hill, Hickson, Horace, Oxbow, Harwood, and more.
4. How much would be diverted? The total flow of the Wild Rice and the overland flooding from there to West Fargo which is about one half the flow of the Red River. Additional amounts from the Red River could be added if needed at a later time to maintain the best balance.
5. How much will the Federal Government pay? 65% or $650 million of a $1 billion project.
6. Where will the other money come from? States of ND and Minn and the cities of Fargo and Moorhead.
7. Does it work? It has worked as advertised in West Fargo, Winnipeg and other areas.
8. How soon could it be started? If a diversion could be selected as the method it should shorten the process.
9. Will it take a lot of farmland out of production? No, estimate it will only take 600 acres out and change 4000 from corn to alfalfa.
10. Why are we having these large floods? Wet cycle- see Devils Lake - 8 of 10 record floods in the last 40 years.
11. What happens if the flood exceeds the capacity of the diversion? It overflows to the west and north over farmland.
12. Does it dump water on Harwood? No – will enter the Red way north of Harwood and it is the same amount of water.
13. What is the size? It is estimated to be 20 to 30 feet deep and average 75 feet wide at the bottom and maybe 500-700 feet at the top.
14. Can Eminent Domain be used to acquire the land? Yes – same as would be needed for a levee system.
15. What is the probability of a crest over the 2009 level? The national Weather Service on 4-4-09 indicated a 10% chance of 44.6 feet for the second crest.
16. Should we build more dams? Valley City had a major flood this year and about 100% of the water from its drainage area is stored in Devils Lake or flows into the Baldhill Dam. Spillways washing out such as Clausen Springs.
17. Should we hold the water on the land? This can work to a limited extent, but when it starts going overland it washes out the roads – see 2009 news articles.
18. Can the Corps assure us the levee system will not fail? No!

FACTS FOR A SPLIT FLOW DIVERSION

4

1. The 1826 flood was 40% larger than the 1997 flood in Winnipeg. April 4, 2009 the National Weather Service said there was a 10% chance of a 44.6 foot crest in Fargo. F-M, not just property along the river, could be flooded.
2. A plan is needed to allow us a chance to survive a flood of this magnitude.
3. A 700 year flood can occur at any time – it could be next year.
4. We are in a wet cycle.
5. The Red River soil is unstable.
6. F-M is the last major community in the valley with no significant permanent protection.
7. Sending one half the water into a diversion would make fighting a large flood manageable.
8. Must have a zero possibility of over a 40 foot flood so that the Main Avenue bridge does not act as a dam.
9. The design could route any water over say 22 feet until you reach say 30 feet down the diversion then about one half the entire flow.
10. The flow in a diversion is expected to be below ground level. Spoil banks would be more like a dike on the east side of the diversion.
11. Topping the diversion would flow west and north into fields.
12. Topping the proposed Corps levees would inundate the cities.
13. Physics – the amount of water is not increased at the outlet by the diversion.
14. Levees have many failure modes such as: design flaws, shifting soil, water over or under, through, etc.
15. Squeezing the water ie in levees increases the height of the flood.
16. The slopes can be used to grow alfalfa.
17. Buyouts along the river are not required.
18. Residents of F-M can feel secure during a flood.
19. Stress would be reduced and lives saved (relocating the elderly and sick).
20. Will increase values along the river and in the cities.
21. The 2009 foot flood had a huge negative impact on the F-M economy – West Acres Mall closed for days.

090622_Feist

Beauchamp, Francis MVP

From:	Matthew Feist [matthew.feist@gmail.com]
Sent:	Monday, June 22, 2009 6:00 PM
To:	Evans, Craig O MVP; Snyder, Aaron M MVP; DWalaker@cityoffargo.com; governor@nd.gov
Cc:	fmflood@fmfloodcontrol.com
Subject:	Public Input on Flood Control Measures for the Fargo-Moorhead Area

Hello,

I am writing this letter in conjunction through the efforts of the fmfloodcontrol.com website. It has come to my attention that today is the last day for public input to the Army Corps of Engineers, thus I am writing this letter now.

Please consider the diversion plan as the permanent solution for flood control, for the Fargo-Moorhead metropolitan area. One only has to look to Winnipeg to see how successful that diversion has been at protecting their city from flood waters. I also believe that the cost of the diversion can be reduced through modifying the width, depth and length of the diversion needed to protect the area. The use of local contractors and laborers would also surely reduce the total costs. Though I admit, I am not an expert in these matters.

With the City of Fargo about to vote on its sales tax initiative, we will be able to fund an estimated $200 million dollars, which would cover 22% of the total project's cost estimated $909 million dollar cost. With the City of Moorhead, State of Minnesota, and State of North Dakota covering the remaining 13% (along with the 65% federal share), I don't understand why the diversion isn't being strongly considered as the optimal solution. We need a permanent solution for flood control to ensure that the Fargo-Moorhead metropolitan area never has to deal with another 1997 or 2009 flood, or even worse, had we not had the freezing temperatures half way through the battle, a complete loss of the city.

Thank you for your time and consideration,

Matthew J. Feist

090623_Satrang

Beauchamp, Francis MVP

From: sat711rang@aol.com
Sent: Tuesday, June 23, 2009 12:00 AM
To: Evans, Craig O MVP
Subject: A Diversion Is Best For Main Street Fargo Moorhead

Mr. Craig Evans,

I am writing to let you know that I support a diversion for flood protection of F-M and the surrounding areas. The Corps of Engineers has requested public comments. The diversion is the only sure protection. We need something that will protect us against a 500 year flood level! The only method of flood protection that is sure to work is a diversion around Fargo/Moorhead. Please urge the Corps to focus all efforts on a diversion.

My wife and I live on the Red River. The failure of floodwalls, dikes, and dams this spring is proof that these methods will not protect Fargo-Moorhead. Soils in the Valley are unstable, dikes settle and structures are damaged with the movement of the soil. The Oak Grove High School damage was a result of the new flood protection system failing. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse are sliding into the river; roads, dikes, etc have been damaged or destroyed.

The 500 foot width projected for the bottom of the diversion by the Corps is too wide. A much narrower bottom width would work well based upon comparisons to the original Winnipeg diversion. This should reduce the cost significantly and would give it a favorable cost benefit ratio. The Winnipeg diversion is 30' deep. It has been used to divert water for 37 years. The Winnipeg diversion worked great in the 1997 flood when I lived in Drayton. I remember being interviewed on the radio after fighting the Drayton Flood Fight for 42 continuous hours without sleep. I warned that Winnipeg was in for big trouble. At the time I did understand the safety of their diversion project and its structural advantages for a successful flood fight.

A diversion should start on the North Dakota side at the Wild Rice River as suggested by the Corps, and should be started on the west side of I29. It may work to use the West Fargo diversion and increase its capacity for the part around West Fargo. Dikes and floodwalls are a very poor solution to a very complex problem. The extra height combined with the valleys unstable ground causes great long term concerns and it doesn't give us peace of mind that we are protected. A diversion will reduce the amount of water moving through the cities. In addition it would be 30 miles of water storage and that's significant and should be calculated. We could save the homes being considered for destruction. It would also save the view for many homeowners, including mine, and therefore provide economic benefit through higher=2 0home values and our quality of life. River frontage is the highest valued land for residential usage. A diversion will add value to the total length of both sides of the Red River.

The diversion should be selected immediately as the preferred method. Dams and control structures within the diversion could be added to provide water for dry years. It could be filled from spring runoff. If the other dams used for water storage were full, the diversion could be kept dry and even farmed for that year.

Fighting this years flood cost my business many thousands of dollars and because of your strong leadership we were successful at staying dry. I know that you will do what you feel is best for our city. As someone who has done business and lived in the Vall ey for many years, a diversion is the best option. West Fargo sleeps well at night with theirs and Fargo and Moorhead need a diversion and we need it really soon.

Thank you for having this process to express our opinions.

Kent Satrang
311 11th Avenue South
Condo Unit 104
Fargo, North Dakota

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090623_Solberg

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Tuesday, June 23, 2009 9:31 AM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Richard Solberg (rsolberg@statebanks.com) by the FM Flood Control Group

Mr. Craig Evans:
I am writing in support of a diversion channel as the best option to protect Fargo-Moorhead from the Red River floods.

While several suggestions have been made â€" all of them with hefty price tags, and none of them satisfying every community or individual with property at stake â€" I believe the diversion channel is likely the best option for permanent flood protection. A diversion channel is the long, long-term solution we need.

Of course, we have the option to do nothing â€" not really an option, as weâ€™ll continue to have to put up sandbag dikes more frequently than weâ€™d all like. An extensive levee system is also on the drawing board, but that solution will significantly devalue properties on the river, adversely affecting our property tax base. Levees will cut through the beautiful river corridor at the heart of our cities; and levees deteriorate and fail. The â€œwaffleâ€□ plan to contain water in fields has potential but needs testing â€" and buy-in from area farmers.

Yes, a diversion channel may or may not be a more costly action â€" but you have only to look at the success stories of West Fargo and Winnipeg to see the positive impact that a diversion channel can bring.

I believe a diversion channel should be the favored solution for permanent flood control in Fargo-Moorhead. Letâ€™s make this work and provide our communities the protection they need against further â€œ100-yearâ€□ or â€œ500-yearâ€□ floods.

Sincerely
Richard Solberg

090624_Furness

Beauchamp, Francis MVP

From: BruceFurn@aol.com
Sent: Wednesday, June 24, 2009 10:57 AM
To: Evans, Craig O MVP
Subject: (no subject)

Dear Craig,

I would like to add my voice to the growing number of people who are advocating for a significant diversion solution to the increasingly frequent flooding of the Red River.

I have been encouraging officials to search for solutions involving a combination of water storage, dike protection and diversion. Diversion, if feasible, seems like the best long term solution.

I understand the cost versus benefit analysis and how that affects a final decision. I'm simply asking the Corps of Engineers to keep an open mind and investigate all options. I believe that is your normal operating procedure.

Good luck with your effort and thanks for encouraging input for many sources.

Have a Great Day!
Bruce Furness

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090624_Moberg

Beauchamp, Francis MVP

From: Mike Moberg [mike_moberg@msn.com]
Sent: Thursday, June 25, 2009 11:52 AM
To: Evans, Craig O MVP
Subject: RE: Question about building

Thanks for the quick response, I will try and get a hold of Keith.

Thanks

> Subject: RE: Question about building
> Date: Wed, 24 Jun 2009 19:15:51 -0500
> From: craig.o.evans@usace.army.mil
> To: mike_moberg@msn.com
> CC: berndtk@casscountynd.gov; aaron.m.syder@usace.army.mil
>
> Mr. Moberg,
> I recommend that you talk to someone at Cass County to see if the
> proposed development is within West Fargo or under county
> jurisdiction. Either way, the developer should be following applicable
> flood-plain regulations to minimize flood risk to new buildings. The
> Corps does not regulate building construction in flood plains unless
> the project involves filling in wetlands, which would require a permit
under Section 404 of the Clean Water Act.
>
> Our point of contact at Cass County is the County Engineer, Mr. Keith
> Berndt (701-298-2372). I'm sure Mr. Berndt can give you a better
> answer than we can, or at least put you in touch with the right
person.
>
> Thanks,
> Craig Evans
> Senior Planner & Project Manager
> St. Paul District
> U.S. Army Corps of Engineers
> Office: (651) 290-5594
> Mobile: (612) 518-3413
> e-mail: craig.o.evans@usace.army.mil
>
> -----Original Message-----
> From: Mike Moberg [mailto:mike_moberg@msn.com]
> Sent: Wednesday, June 24, 2009 6:13 PM
> To: Evans, Craig O MVP; aaron.m.syder@usace.army.mil
> Subject: Question about building
>
> Craig or Aaron, I got your names from the Fargo-Moorhead Feasibility
> study web site, I don't know who to contact from the Corp about my
> question, so I thought I would start with you.
>
> I live north of west fargo, just outside the diversion, and in 2009 my
> house and neigborhood was surrounded by water for 25 days. In the past
> 12 years I have had to ring dike my house 4 times, and I don't even

> live on the Sheyenne river.
>
> My question or concern is that the city of West Fargo is considering
> doing a development of 240 homes out by me, on the outside of the
> diversion and if the development is not done correctly this
> developement is going to have problems during the next flood and it
might also impact my flooding problem.
> So I am wondering how we go about making sure that the city of West
> Fargo is doing this correctly and not impacting the existing flooding
> problem we already have.
>
> If you are not the correct people to talk to could you please give a
> contact person.
>
> Thanks,
>
> Mike Moberg
>
>
>
> _____
>
> Microsoft brings you a new way to search the web. Try Bing(tm) now
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090629_Boe

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Monday, June 29, 2009 12:09 PM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Steve and Julie Boe (sboe@cableone.net) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

In F-M the river is about 100 feet wide, in Winnipeg the river is about 450 feet wide (nearly 5 times as wide). The red river valley is full of ditches (drains). The diversion would just be a bigger ditch. A bottom width of about 50 feet appears to be what would be required based on the 2009 flow. The flow at Fargo was 29,100 cubic feet per second at 40.82 feet this spring. The cost with a smaller diversion could be significantly reduced and should give it a favorable cost benefit ratio.

The proposal of the Corps to start at the Wild Rice River and end way north of Harwood is very good. The diversion would offer better protection from overland flooding on the ND side of the river. Property will have to be taken by eminent domain; either homes along the river and drains for dikes and flood walls etc., or farmland for the diversion. The $909 million for the diversion would seem to have much greater benefits than the levees. We need to find a way to get a favorable cost benefit ratio or find another way to fund the diversion It should be selected immediately as the preferred method.
Sincerely
Steve and Julie Boe

090629_Bolin

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Monday, June 29, 2009 4:47 AM
To: Evans, Craig O MVP
Subject: Flood protection for Moorhead

This email was sent on behalf of W Bolin (wildbill918@hotmail.com) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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Sincerely
W Bolin

090629_Cossette

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Monday, June 29, 2009 4:25 AM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of David Cossette (dcossett@midamsteel.com) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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Sincerely
David Cossette

090629_Finch

Beauchamp, Francis MVP

From: ROGER FINCH [finchro@msn.com]
Sent: Monday, June 29, 2009 7:29 PM
To: Evans, Craig O MVP
Subject: Flood control

Why not dredge the Red River deeper and wider? Over the years it has filled in with sediment, trees, etc. To avoid having the banks sink into the river after dredging, you could cement the bottom and sides. It may not be THE answer, but every bit helps!

In the summer time when the river is low, you could dam off say 1/2 mile at a time. You would have two dams, one on each end of the construction site. You could pump the water from the south end, past the construction area, and release it down stream, past the north dam. After dredging and cementing each section, you release the dam to the South. The dam to the North now becomes the back up dam and you billed another north dam 1/2 mile further north etc.

This way you don't have to acquire additional land or right of way. On Modern Marvels, I have watched them dam up oceans in order to build bridges. The Red River should be a piece a cake!

Respectfully submitted,
Roger Finch
Moorhead, MN.

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090629_Halvorsen

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Monday, June 29, 2009 11:59 PM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Karrie Ann Halvorson (khalvorson@facnd.com) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

In F-M the river is about 100 feet wide, in Winnipeg the river is about 450 feet wide (nearly 5 times as wide). The red river valley is full of ditches (drains). The diversion would just be a bigger ditch. A bottom width of about 50 feet appears to be what would be required based on the 2009 flow. The flow at Fargo was 29,100 cubic feet per second at 40.82 feet this spring. The cost with a smaller diversion could be significantly reduced and should give it a favorable cost benefit ratio.

The proposal of the Corps to start at the Wild Rice River and end way north of Harwood is very good. The diversion would offer better protection from overland flooding on the ND side of the river. Property will have to be taken by eminent domain; either homes along the river and drains for dikes and flood walls etc., or farmland for the diversion. The $909 million for the diversion would seem to have much greater benefits than the levees. We need to find a way to get a favorable cost benefit ratio or find another way to fund the diversion It should be selected immediately as the preferred method.
Sincerely
Karrie Ann Halvorson

090629_Schock

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Monday, June 29, 2009 5:49 AM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Jane Schock (jschock@nodakmutual.com) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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Sincerely
Jane Schock

090629_Tillman

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Monday, June 29, 2009 7:58 AM
To: Evans, Craig O MVP
Subject: Flood protection for Moorhead

This email was sent on behalf of Joe Tillman (josephtillman@live.com) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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Sincerely
Joe Tillman

090630_Altendorf

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Tuesday, June 30, 2009 2:23 AM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Steve Altendorf (Steve_Altendorf@msn.com) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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Sincerely
Steve Altendorf

090630_Bender

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Tuesday, June 30, 2009 2:07 AM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Glenn A Bender (glenn@van-raden.com) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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Sincerely
Glenn A Bender

090630_Bredell

Beauchamp, Francis MVP

From: Bredell Brad and Michelle [bredellmic@yahoo.com]
Sent: Tuesday, June 30, 2009 8:04 PM
To: Evans, Craig O MVP; Snyder, Aaron M MVP
Cc: fmflood@fmfloodcontrol.com
Subject: flood control

Hi, I wanted to let you know that I support a diversion for the Fargo-Moorhead area. A dike system is a band aid that will fail in time. Wasn't the only major dike breach a PERMANANT flood wall at Oak Grove? Let's do it right the first time.

Thanks,

Brad Bredell
Fargo ND
701-306-3258

090630_Cronin

Beauchamp, Francis MVP

From: CRONIN PATRICK [pdcronin@ideaone.net]
Sent: Tuesday, June 30, 2009 2:29 PM
To: Evans, Craig O MVP; Snyder, Aaron M MVP; dwalaker@cityoffargo.com
Cc: fmflood@fmfloodcontrol.com
Subject: diversion proposal

To whom it may concern:

I am a ND resident but live outside of Fargo. In fact, I live in the area between West Fargo and Harwood where the Sheyenne Diversion reenters the river channel. Our area has seen many floods in recent years because of high levels on the Red, Sheyenne, Maple and Rush rivers.

The Sheyenne Diversion works great for West Fargo and is a good example of how well a diversion functions. Even with the higher Baldhill Dam and the addition of the Maple River Dam my area still flooded. It is unfortunate that the Sheyenne Diversion did not go further north so that it would protect my home as well my neighbors and those in and beyond Harwood.

I am in total agreement with the group of people proposing a ND diversion channel west of the city of Fargo. I have several reasons to support thier position:

1) A large amount of the water entering the Red River channel comes from the west. It is logical to keep it on the west side instead of going the long way around the city.
2) Keeping the diversion in North Dakota limits the amount of political infighting that will happen when water crosses any type of border.
3) In addition to the Wild Rice river a west side channel could collect water from the Sheyenne, Maple and Rush. It offers a greater choice of design and function.
4) Being able to provide solutions to more rivers brings more people on board with the project. I don't think that many people outside of Fargo are excited about paying for Fargo's flood control with a sales tax. I know many people in my area would be in full support of the taxes and project if it offered diversion like protection for us. I also think that people would be more comfortable about helping drain Devils Lake through the Sheyenne if there was diversion protection.

Thanks for all your effort in finding solutions to this problem.

Patrick Cronin
313 Ramona Ave
West Fargo, ND 58078

(701)281-1090

090630_Fetch

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Tuesday, June 30, 2009 9:30 AM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Tom Fetch (Tom.Fetch@agr.gc.ca) by the FM Flood Control Group

Mr. Craig Evans:
I live in Winnipeg currently, but grew up in Fargo and have property near Hickson. I have been flooded out twice, and nearly flooded two other times since 1989. Clearly the drainage system has changed dramatically in the past two decades and the river levels fluctuate very quickly even with relatively low precipitation and snow amounts.

Although Winnipeg is mainly protected by the diversion and this appears to be the main agenda topic for the fmfloodcontrol website, I would also propose two other methods that seem to be much less expensive and have merit in lowering flooding. One is the "waffle concept" that has been researched in detail by scientists at the University of North Dakota in Grand Forks. Clearly we can use the existing ditches by controlling runoff through the culverts in the spring. In combination with other methods, this would be a cheap and quick fix to do. A second method that I propose is a retention strategy that could use low lying farmland adjacent to major rivers to hold water. If low lying land adjacent to the Red River was purchased and a series of perpendicular ditching was cut (20-30 feet deep and perhaps the same width extending several hundred feet) using large backhoes or D5 Caterpillar equipment, water could be diverted and held, and pumped out later. This would be conceptually similar to a diversion, except that these trenches could be cut next to the river to hold the water and there would be no need to raise or construct new bridges or roadways. A primary cost item in the diversion in Winnipeg is that many bridges and railways had to be built.
Sincerely
Tom Fetch

090630_Forknell

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Tuesday, June 30, 2009 11:55 PM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Jon Forknell (jforknell@abs-usa.com) by the FM Flood Control Group

Mr. Craig Evans:
To Whom It May Concern,

As a resident of North Dakota, I am in strong support of the recently-presented diversion that would run through North Dakota.
The only method of flood protection that is sure to work is a diversion. Permanent levees can fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure.

The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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Sincerely,

Jon Forknell
3726 River Drive S

Fargo, ND 58104
Cell: 701-238-3207
E-mail: jforknell@abs-usa.com
Sincerely
Jon Forknell

090630_Hannaher

Beauchamp, Francis MVP

From: Paul Hannaher [PHannaher@hannahers.com]
Sent: Tuesday, June 30, 2009 9:07 AM
To: Evans, Craig O MVP; Snyder, Aaron M MVP; DWalaker@cityoffargo.com; tim.pawlenty@state.mn.us; mark.voxland@ci.moorhead.mn.us; rep.morrie.lanning@house.mn
Cc: fmflood@fmfloodcontrol.com
Subject: My support for more study of a diversion for the Fargo Moorhead region.

Good Morning Gentlemen,

I am writing this note to you today to encourage you to consider a diversion as opposed to a levee system to protect the Fargo-Moorhead area.

The facts are in and my concerns are focused on the long term reliability of a levee system given that we have a soil structure that really has no structure. In my opinion even if we put pilings down to bedrock to support a levee system the risk will always be there for wash outs due to water pressure between the pilings. Those weak points would not manifest until a flood occurs again and would put the city at risk.

This diversion plan also includes more of our friends and neighbors in surrounding smaller towns.

The city leaders of Fargo-Moorhead have proven to be a great team that makes smart decisions. We will all have to live with those decisions. Thank you for your service.

My opinion being shared; let me thank you for your team effort to keep that river tamed this spring. We don't want to EVER do that again.

Sincerely,

Paul

Paul Hannaher

Vice President

Hannaher's and OFUSA -Fargo

4324 20th Ave SW

Fargo, ND 58103

701.277.7222

www.hannahers.com <http://www.hannahers.com/>

P Please consider the environment before printing this email.

090630_Hegg

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Tuesday, June 30, 2009 12:57 AM
To: Evans, Craig O MVP
Subject: Flood protection for Moorhead

This email was sent on behalf of Bob J Hegg (bobhegg@cableone.net) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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Sincerely
Bob J Hegg

090630_Hoefs

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Tuesday, June 30, 2009 6:26 AM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Mylon Hoefs (mlhoefs@cableone.net) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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Sincerely
Mylon Hoefs

090630_Mitchell

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Tuesday, June 30, 2009 2:27 AM
To: Evans, Craig O MVP
Subject: Flood protection for Moorhead

This email was sent on behalf of Carole Mitchell (MitchCarole@aol.com) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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I have lived along the river for the past 35 years and twenty seven of those years there were only 3 floods, now since 97 it seems like every other year there is concern for our towns and property. Most people cannot take the stress or the loss of there property year after year forceing them to look for alternate places to live. This diversion is the only thing that makes sense to me, diking only raises the levels beside the worry of a breaching. I feel the cor of engineers should take a serious look at this proposal and consider the long range of PERMANET flood control.

Sincerely
Carole Mitchell

090630_Moen

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Tuesday, June 30, 2009 3:59 AM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Brenda Moen (bkmslade@gmail.com) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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Sincerely
Brenda Moen

090630_Passolt

Beauchamp, Francis MVP

From: dan passolt [danpassolt@yahoo.com]
Sent: Tuesday, June 30, 2009 10:34 PM
To: governor@nd.gov; tim.pawlenty@state.mn.us; DWalaker@cityoffargo.com; mark.voxland@ci.moorhead.mn.us; rep.morrie.lanning@house.mn; Evans, Craig O MVP; Snyder, Aaron M MVP
Subject: flood control-diversion

Please put the diversion project(Western Diversion) that ex-Gov.Schaefer is promoting as your #1 Option to protect FM and surrounding area. I have lived and worked in this area for over 30 years and prior to that was a student at UND. I've experienced several floods thru-out that time and experienced the trauma the area goes thru during and after the flood. In 1997-99 I was the Const. Mgr on the Grand Forks 1st and 2nd Congressional District 189 New Home Construction Project. I was fortunate to get an inside look at what it takes to re-build a city(it's not something a city should have to go thru and it's not fun). I'm hoping my current home of Fargo will never have to go thru this.
I've read several articles about some of the alternatives and my current house is located in an area where they were proposing a dike in my back yard even before the flood of 2009.
It's a good thing the proposed dike wasn't built cuz it would've been too low. I also own a business in West Fargo and have experienced how the Sheyenne diversion works during a flood. It's a huge selling point to people moving to the area when you can say if they buy in West Fargo they are protected from the flood waters. It works-we all know that!
It's a managable system that isn't complex! It protects all of Horace and West Fargo!
Since the Sales Tax has been approved a project will be funded by area wide buyers when they shop, and it only seems fair to then protect area wide with a diversion and not just dikes here and there.
You need to think of the future, the managability, the complexity, the magnitude and the fairness of any system you pick. I believe the Western Diversion is the answer to these issues please make it your #1 Option.

Dan Passolt
Homeland Developers
701-219-0150

090630_Pfeiffer

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Tuesday, June 30, 2009 1:52 AM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Juergen Pfeiffer (juergen.pfeiffer@yahoo.com) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

In F-M the river is about 100 feet wide, in Winnipeg the river is about 450 feet wide (nearly 5 times as wide). The red river valley is full of ditches (drains). The diversion would just be a bigger ditch. A bottom width of about 50 feet appears to be what would be required based on the 2009 flow. The flow at Fargo was 29,100 cubic feet per second at 40.82 feet this spring. The cost with a smaller diversion could be significantly reduced and should give it a favorable cost benefit ratio.

The proposal of the Corps to start at the Wild Rice River and end way north of Harwood is very good. The diversion would offer better protection from overland flooding on the ND side of the river. Property will have to be taken by eminent domain; either homes along the river and drains for dikes and flood walls etc., or farmland for the diversion. The $909 million for the diversion would seem to have much greater benefits than the levees. We need to find a way to get a favorable cost benefit ratio or find another way to fund the diversion It should be selected immediately as the preferred method. It will only take the prevention of one catastrophic flood to make this diversion pay for itself. A well- build diversion will provide peace of mind every spring for generations to come and that cannot be expressed in dollars. The people of Fargo-Moorhead and surrounding communities will be proud today and into the future for a wise and overdue decision being made today by leaders in our community.
Sincerely
Juergen Pfeiffer

090630_Werlinger

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Tuesday, June 30, 2009 1:14 AM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Kory Werlinger (kjwerli@yahoo.com) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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Sincerely
Kory Werlinger

090701_Gates

Beauchamp, Francis MVP

From: Jason Gates [jason.gates@fargoautomation.com]
Sent: Wednesday, July 01, 2009 11:08 AM
To: Snyder, Aaron M MVP
Subject: Fargo Moorhead Flood Protection

Mr. Snyder,

I own a home in Fargo, and like many others in the community, I am concerned that a dike/levy solution will not provide the necessary protection that our cities require. I am sure you are aware, the best way to ensure our community is not faced with billions of dollars in flood damages when a 42-43 foot flood hits is a diversion through Minnesota or North Dakota.

If the local, state, and federal governments are going to spend upwards of $750,000,000 on a flood protection system, then this system must offer a 99.9% assurance that it will not fail. I do not see how a levy system can offer this assurance, especially considering the unpredictable nature of the Red River. For instance, how can dikes or levies protect to 45 feet when the automobile and railroad bridges downtown start holding back water at 41 feet? Because of the topography of the valley, it makes no sense to force the water higher through town, a flood marginally higher than the one we had this spring would have a high probability of disaster, all it takes is one failure in the system and large portions of the city become submerged. A diversion can keep the river well below 40 feet in even the worst flood, and the damage would be minimal in the event of a failure.

Economically, the region has a lot to gain from a diversion; property values and recreational use through the Red River corridor would benefit. A diversion system can be designed that not only protects against major floods, but can keep the river below 25 feet through town during "nuisance" floods as well. The area's best parks, golf courses, and trails begin taking on damage at this level. Conversely, a dike/levy project will require many riverside property buy outs, lessen the recreational and visual appeal of the river, and it does not provide a solution for the "nuisance" floods that have become so common during the summer months.

Please take these thoughts into consideration as you analyze the various flood control options for our community.

Thank You,

Jason Gates, PE

090701_Ortmeier

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Wednesday, July 01, 2009 1:25 AM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Thomas C Ortmeier, MD (ortmeiert@yahoo.com) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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The proposal of the Corps to start at the Wild Rice River and end way north of Harwood is very good. The diversion would offer better protection from overland flooding on the ND side of the river. Property will have to be taken by eminent domain; either homes along the river and drains for dikes and flood walls etc., or farmland for the diversion. The $909 million for the diversion would seem to have much greater benefits than the levees. We need to find a way to get a favorable cost benefit ratio or find another way to fund the diversion It should be selected immediately as the preferred method.
It seems only logical to use the form of a diversion ditch rather than levees to avoid catastrophic failure due to breach. Using the ground for walls instead of artificial levees would give a much greater margin of safety and protection. In addition, a levee system will only funnel a higher volume of water THROUGH the communities where it can do the most damage if a breach occurs. If you review photos from the 2009 Fargo flood crest, the water was already lapping at the bottom of the Veterans Memorial Bridge. Levees would only make that problem worse and pose a larger threat to Fargo\'s major downtown infrastructure. I fully support the ND diversion project.

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Sincerely
Thomas C Ortmeier, MD

090702_Dickerson

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Thursday, July 02, 2009 2:57 PM
To: Evans, Craig O MVP
Subject: Flood protection for Moorhead

This email was sent on behalf of Laura Dickerson (mhddickerson@yahoo.com) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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Sincerely
Laura Dickerson

090712_Dufaul

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Sunday, July 12, 2009 12:42 PM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Natalie Dufault (personatali@ymail.com) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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I live in West Fargo and it has already proved invaluable that we have a diversionary channel. It\'s just really too bad that the rest of the city has not had this done yet. I really hope that this goes through, as it is necessary for all of our livelihood...

Sincerely,

Natalie Dufault
Sincerely

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090714_Engler

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Tuesday, July 14, 2009 11:50 PM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Karen (Engler) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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Sincerely
Karen

090714_Rhuland

Beauchamp, Francis MVP

From: Evans, Craig O MVP
Sent: Wednesday, July 15, 2009 9:21 AM
To: 'Dave Ruhland'
Cc: Snyder, Aaron M MVP
Subject: RE: Fargo/Moorhead Levee Option

Mr. Ruhland,
Thanks for your interest in the Fargo-Moorhead Metro Feasibility study. We are still working with very preliminary alignments, and we are not ready to share them with the public yet. We will have more details to share in October, when we plan to have more public meetings. Please realize that the alignments will continue to shift, even after October, as we optimize levee heights and investigate soil conditions. Given the preliminary nature of our alternatives, I cannot say at this time how many homes would need to be removed. Also remember, we are looking at a number of different concepts, including levees, diversions, storage and non-structural measures that may be used in combination with each other, and that will affect the answers to your questions as well.

Thanks for your patience as we continue the study.

Craig Evans
Senior Planner & Project Manager
St. Paul District
U.S. Army Corps of Engineers
Office: (651) 290-5594
Mobile: (612) 518-3413
e-mail: craig.o.evans@usace.army.mil

-----Original Message-----
From: Dave Ruhland [mailto:daveruhland@yahoo.com]
Sent: Tuesday, July 14, 2009 3:41 PM
To: Evans, Craig O MVP
Subject: Re: Fargo/Moorhead Levee Option

Craig,

Do you have any information about the below request?

Thanks,

Dave

--- On Fri, 5/22/09, Dave Ruhland <daveruhland@yahoo.com> wrote:

From: Dave Ruhland <daveruhland@yahoo.com>
Subject: Fargo/Moorhead Levee Option

To: craig.o.evans@usace.army.mil
Date: Friday, May 22, 2009, 10:54 AM

Hi Craig,

I have a question about the $625 million levee plan that was discussed at the recent meetings. I assume that there is a map available detailing what this project would look like in my neighborhood. Is that true? If so, can I get a look at what the area by Southwood Drive, 11th street, and the Fargo Country Club looks like? In addition, how many homes would need to be removed for this project?

Thanks,

Dave Ruhland
806 Southwood Drive
Fargo

090715_Clasen

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Wednesday, July 15, 2009 12:07 AM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Renee Clasen (egglady_nd@yahoo.com) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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The proposal of the Corps to start at the Wild Rice River and end way north of Harwood is very good. The diversion would offer better protection from overland flooding on the ND side of the river. Property will have to be taken by eminent domain; either homes along the river and drains for dikes and flood walls etc., or farmland for the diversion. The $909 million for the diversion would seem to have much greater benefits than the levees. We need to find a way to get a favorable cost benefit ratio or find another way to fund the diversion It should be selected immediately as the preferred method.
Sincerely
Renee Clasen

090715_Heidt

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Wednesday, July 15, 2009 12:44 AM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Lindsey Heidt (lheidt99@hotmail.com) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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Sincerely
Lindsey Heidt

090715_Hoefs

Beauchamp, Francis MVP

From: Dave Hoefs [davehf@facnd.com]
Sent: Wednesday, July 15, 2009 10:14 AM
To: Evans, Craig O MVP
Subject: Fargo-Moorhead Flood Control

Mr Evans:

I would like to urge you to strongly consider a diversion to protect Fargo-Moorhead from future flooding. There are many flood control options on the table right now and I believe a diversion plan may not be getting due consideration. Given the enormous expense of fighting floods and funding flood protection the public deserves a thorough review of this proven method of flood control.

Thank you,

David Hoefs
Senior Engineer
Fargo Assembly Company
Phone: 701-298-3803 ext. 361 / 701-356-7386 direct
Fax: 701-298-9597
Email: davehf@facnd.com

090717_Bergman

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Friday, July 17, 2009 2:11 PM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of John Bergman (jbergman@pinnip.com) by the FM Flood Control Group

Mr. Craig Evans:
Dear ND Officials

We need a 100 year solution! The best method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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We can make the diversion project become a reality if we all work together for this very important project.

If you should need help to get this project started you can contact me at 701-293-3281.

Thanks! John Bergman

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090717_Holscher

Beauchamp, Francis MVP

From: LOREN MICHELLE HOLSCHER [holscher6@msn.com]
Sent: Friday, July 17, 2009 2:55 PM
To: Evans, Craig O MVP; Snyder, Aaron M MVP; governor@nd.gov; dwalaker@cityoffargo.com
Cc: fmflood@fmfloodcontrol.com
Subject: FM Permanent Flood Control

I am writing to inform you of my support for the split flow diversion that has been recommended by the Flood Protection Coalition for the FM Community. For permanent flood protection, the advantages of the diversion far outweigh the advantages of a levee or other type of system.

Major areas that I like about the diversion are one, if the water level would exceed the diversion, the flooding goes to fields to the north and west and not inundating the cities of Fargo, Moorhead, West Fargo, etal. Two, there is the ability to add containment for some of the spring runoff that could be used in dry years which could negate the need for a pipeline to the Garrison Diversion. Three, we can do it all right here in North Dakota and eliminate the red tape of having to work with two states which means getting it done in a more timely fashion.

Thank you for the opportunity to convey my support.

Loren Holscher
1738 7th St S
Fargo, North Dakota

090722_Fujimoto

Beauchamp, Francis MVP

From: fmflood@fmfloodcontrol.com
Sent: Wednesday, July 22, 2009 11:47 AM
To: Evans, Craig O MVP
Subject: Flood protection for Fargo

This email was sent on behalf of Leah Fujimoto (LFuji@cableone.net) by the FM Flood Control Group

Mr. Craig Evans:
We need a 100 year solution! The only method of flood protection that is sure to work is a diversion. Permanent levees could fail, especially at the extreme predictions of possible heights that were projected for F-M in the 2009 flood fight. Levees pose a greater risk of a catastrophic failure. The 2009 flood made us realize that a flood over 45 feet is possible. Homes have been destroyed because they were sliding into the river, the old Trollwood and Edgewood clubhouse were sliding into the river, roads, dikes, etc have been damaged by the unstable soil along the river. Building anything 50 plus feet above the river bed and on the banks of the Red River is sure to fail at some point. It would not be necessary to reroute all of the water in the Red River around the towns. The Winnipeg diversion has worked great and protected their city in 1997. The floodway capacity was at 60,000 cfs in 1997. The original diversion price adjusted to today was $350 to $500 million.

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Sincerely
Leah Fujimoto

090722_Jensen

Beauchamp, Francis MVP

From: Mark Jensen [mark.jensen@und.nodak.edu]
Sent: Wednesday, July 22, 2009 10:23 PM
To: Evans, Craig O MVP; Snyder, Aaron M MVP; governor@nd.gov; DWalaker@cityoffargo.com; fmflood@fmfloodcontrol.com; Honeybun
Subject: Flood control method - a Fargo citizen.

Ladies and Gentlemen,
I am writing to express my "man in the street" level observations and conclusion regarding the Fargo flood control method.

I am trained in biology and organic chemistry. I teach surgery at UND medical school. This means I live in a world of observations and data to make the best decision in a complex environment.

Here are my observations as a non-engineer:
1. The Grand Forks temporary dikes were overwhelmed in 1997.
2. The Grand Forks permanent dikes held in 2009.
3. The flood levels are becoming more unpredictable.
4. Fargo and Grand Forks temporary and permanent dikes are expensive.
5. Failure of a dike is ruinous to a community and its businesses and their futures.
6. A dike has a structural limit.
7. Diversions in West Fargo and Winnipeg have a clear history of success.
8. Diversions do not need to be rebuilt, and do not increase upstream water levels.
9. Increasing upstream water levels will adversely affect farmlands.
10. Diversions assist the river to flow more freely.
11. A temporary dike can be constructed to assist a diversion. A diversion cannot be constructed rapidly to assist a dike system.

Choosing a diversion appears to be the best option.
Choosing the cheap or easy option does not stand the test of time well.
Please use wisdom in your decision.

Thank you for listening to me,
Mark Jensen, north Fargo resident.
4584 Riverwood Drive North
Fargo, ND 58102
701-277-1625.

090811_FPC

Beauchamp, Francis MVP

To: Sobiech, Jonathan J MVP
Subject: RE: flood protection for Fargo-Moorhead

-----Original Message-----
From: Ron Bergan [mailto:ronb@facnd.com]
Sent: Tuesday, August 11, 2009 4:23 PM
To: Evans, Craig O MVP; Snyder, Aaron M MVP
Cc: DWalaker@cityoffargo.com; mark.voxland@ci.moorhead.mn.us
Subject: flood protection for Fargo-Moorhead

August 11, 2009

To the Army Corps of Engineers;

Fargo, North Dakota voters recently showed their commitment by voting overwhelmingly to approve a tax increase to help pay for permanent flood protection. The Flood Protection Coalition for the F-M Community appreciates the work the Corps is doing to evaluate options for permanent flood protection. However, it is our understanding that the diversion option sizes have recently been changed; and, therefore, we believe more public comment is warranted.

It has been communicated that your study now only has on the North Dakota side a 30,000 cfs and a 40,000 cfs diversion both of which are larger at the north end. This compares to 25,000 cfs, 35,000 cfs and 45,000 cfs previously designed and still included in the study on the Minnesota side of the Red River. We are concerned that the plans being studied do not include a minimum sized plan with the proper specifications on the west side of the river. We are also concerned that any diversion plans are thoroughly studied with an effort to keep costs as low as possible. In addition, in order to evaluate the cost benefit ratios properly, all possible benefits need to be discovered and properly applied to the ratios.

The Flood Protection Coalition for the FM Community proposes a 20,000 cfs diversion increasing in size as it flows north on the North Dakota side, diverting the Wild Rice and adding water from the Red only if the cost is justified. This or any diversion plan should block the water from going east into Fargo and West Fargo; and, if the design capacity is exceeded, the water would flow to the west and north. The 500 year flood map shows water in this overflow area. The clay from the diversion could be used to build ring dikes around any affected properties and to raise roads and should be part of the costs/benefits. A control structure on the Red should be avoided if possible because it will potentially raise the river level to the south and provide little

or no benefit to that area.

An option to any North Dakota plan could be to divert only the Wild Rice River west of I29 to reduce costs. Not having a control structure on the Red River will lower the river level to the south and increase the benefit area. A study should show whether this would keep the river through F-M at a level at which the flood fight can be won even in a 500 year event. The peak flows at Hickson were 13,300 cfs in 1997 and 14,400 cfs in 2006 until this year. The provisional data for this year of 21,800 cfs does not fit with the data from other sites for this year. If it is correct, is it at about the 500 year flood level.? The Wild Rice, Sheyenne and Maple rivers appear to drain a larger area than the drainage area of the Red that flows through F-M; and, they have a much shorter route to the Red in the Fargo area when they are flowing overland, which would happen in a 500 year flood. We have shown that we can fight and win even a 40.82′ flood (29,100 cfs); the costs are low if we only do this once in 500 years. The costs were increased greatly in 2009 by the 43′ and 44′ crest predictions.

The Winnipeg diversion was increased from 60,000 cfs to 140,000 cfs by removing only 21 million more cubic meters of soil compared to the 76 million cubic meters removed originally; and no additional land was acquired. The 13 mile West Fargo diversion should be used and expanded for part of the plan. Please evaluate whether or not the area of the Sheyenne diversion under the I94 Bridge can be made deeper and wider to get by without replacing the bridge until the next time the interstate is worked on. The spoil banks could be used to increase the head pressure going under the bridge.

We also ask the Corps to review management of current water storage in dams when a 100 plus year flood is predicted. If necessary change the law or guidelines to maximize benefits for floods over the 100 year mark. The goal should be: when the inflow reaches the maximum controlled outflow the reservoir is empty, and continue the maximum outflow until such time as the storage is needed to reduce the peak. Calculate at that time if all or how much of the flow can be restricted. If we have extra water for some time before the peak, that is better than a higher peak. Fish can be restocked if needed.

The Flood Protection Coalition for the F-M Community believes the levee system designed for a 100 year flood as proposed in the preliminary Corps plan is not acceptable and is not comparable to a diversion system that will protect us from a 500 year flood. We feel very strongly that any flood protection plan must protect our community from a 500 year event and a diversion on the North Dakota side of the river is the only

viable option. As long as the diversion has a favorable cost benefit ratio and a large area benefits, then the bigger the diversion the better. We also would like to point out that a levee system will not be as durable or last as long as a diversion system. It is clear that levees fail and deteriorate as well as move water levels higher. We are also very concerned that an unsightly dike system in downtown Fargo-Moorhead will build walls between our communities and reverse the decades old effort to bring the communities together. Lastly, property values in our downtown and riverfront areas can be enhanced with a diversion system where they would be impacted downward by a levee system.

The benefit of saving the stated $61 million for proposed buyouts of riverfront property may, if protected from flooding by a diversion, increase to a value of $100 million. We believe the buyout money and the loss of property taxes are used in calculating benefits; but, are the Park District damages and loss of revenue included for all the summer floods? We think that the extensive drainage (500 plus miles of public drains in Cass and Clay counties) plays a big role in the summer floods. It should be noted the planned south side flood protection would not be needed and would save $175 million. Property taxes will also be lost in the south side plan and upkeep will be required. The benefits from reducing a 500 or 700 year flood to a winnable level should be included minus the costs of fighting the lower level flood. The cost effectiveness to fight a 100 year flood one time in 500 years versus making a larger diversion needs to ascertained.

Because homes do not have to be acquired along the river for levees or to raise the dikes, their value will be enhanced with a diversion and the absence of a large dike between the homes and the river. The integrity and beauty of the Red River, including the riparian forest, will be sustained for future generations.

Thanks for your consideration,

Flood Protection Coalition for the F-M Community Steering Committee,

Ed Schafer

Ron Offutt

Steve D. Scheel

Doug Burgum

Dick Solberg

Bruce Furness

Ron Bergan

Erv Inniger

Fargo-Moorhead Public Meeting
Written Comments
May 2009

090606_Matthew Breker – As a Fargo resident and farmer from the southern Red River Valley, I have interests in protecting both Fargo and my farm and cropland. I am interested in the economic analysis of all potential upstream water retention. Please contact me regarding the above. mjbreker@yahoo.com

090606_Jim Armfeld – Unless the Southside project is an important and apart of your plan why proceed? jimmel@ideaone.net (email address may be wrong)

No Date_Dave Anderson – I believe we must utilize every measure – barriers, diversion, and storage to ensure the greatest level of protection. dave@fmdowntown.com

No Date_Elise & John Leitch – Hurry, Hurry, Hurry! jel@cableone.net

090606_Charles Koski – Any project should consider redundancies to allow for modification of any catastrophic failure le diversion and modified flood barrier and or storage. How can you adjust your project for a river that flows north into frozen drainage channel?
bonniek@i29.net

No Date_John Stern – Outside the box idea: 2 way pipeline to reservoir behind Garrison – flood relief in spring, water supply in summer during dry years.
John.sherri.stern@gmail.com

090519_Kathy Laney – I vote for a diversion: long term solution, allows FM to still be a river city, provides protection to surrounding small communities. Start Now! If we could sell our home we would move out of community. Kathy.laney@live.com

090519_Shirley Syverson – Good informational meeting.

090606_Daryl Lahren – Why do you need a 500 ft wide base at the bottom of the diversion?
dlahren@aol.com

090519_Daniel Holm – Excellent presentation! Good materials, appreciate the effort to get feedback from the group. bowfrog@hotmail.com

090519_Charles D. Dunnell – Number one choice is: diversion channel, are we as smart as the Canadians!? This would keep old river bed for its beauty as it runs through the cities. Number two choice: could West Fargo diversion be modified/ added on to, so it would take water at Red River? dunnellc@yahoo.com

090519_Pat Staples – Please coordinate Southside Fargo Project with your plan. This needs to be synchronized!! Diversions appear to be the best long term solution. patstaples@cableone.net

Comments and Questions from Moorhead Public Meetings

090520_A Saharieff – Please consider: dredging the river under the 3 bridges; Main Ave, NP Ave, & the Rail Road tressle. Also design & build torpedo shaped flow accelerators in front and behind the bridge support abutments. Flow must be enhanced for levees to work. Please consider dredging and cross cutting the river channel

090606_Diane Ista – How far downstream do you measure impacts? 30 miles downstream are small communities that are very important to the agricultural economy as well as the social and cultural structure needed in our rural communities. These communities cannot take any more directed water; we are in danger of losing small towns. This will increase the infrastructure needed of FM as they move there. More farmland under concrete. No more water downstream!! We need assistance to build retention on the MN Wild Rice River which would reduce the flows to the Red. More water from diversion if tributaries to red reduce flow. djista@loretel.net

090520_ Patte Kratky – As co-president of league of women voters of the Red River Valley and member of River Keepers, I offer my services to the planning boards, as a concierge. Please contact me at 701-235-8200 ext 7-204 currently or at my email address, a message maybe left at 218-233-8382 or email. We were displaced by the flood and are repairing our home. LWV is non-partisan, non- profit grass roots organization. Patty4st04@aol.com

090520_ Mark Nokken – Water retention to keep floods at a manageable level. mnokken7@yahoo.com

090520_Jill Johnson-Davidson – We would like our property protected. No one interviewed my neighborhood last September, (Woodlawn Point, Moorhead). Proud survivors, who live with river. What is least damage: dredge or diversions – both have impact. End building permits on spongy wetland. Permit and enforce coordinated farm runoff. What is best for the river and her health? Don't only listen to or believe city officials especially about buyouts – ask residents directly. Why are there more floods, higher crests – what are the contributing factors that can be mitigated. Moorhead's goal was to protect infrastructure not homes or people. Fargo diked extensively; raised water in our neighborhoods. We were not contacted in September – based on our location, I would think we would be. Diversion number one choice. Explore contributing causes of why floods have increased. We love the river – for us, the river is not the problem – the flood is not the problem.
codirectorjjd@yahoo.com

090520_Calvin Singleton – Need info, flood proofing by fill with clay.
singleton@wapa.gov

090520_Gary Shramstad – I suggest a diversion of the Sheyenne from McVille to the Red River north of Grand Forks. This would alleviate flooding on the Sheyenne and Red, since the Sheyenne headwaters are north of Bismarck. It would also solve the problem of Devils Lake overflowing.

090606_Deb Haugen – Is there an aquifer newly discovered south of Moorhead, west over the proposed diversion, and east of the Red? We wouldn't cause potential damage to clean water source in times of drought? dlhaugen@cableone.net

090520_Paul & Deborah Kukowski – Thank you for the information. Concern: Economic and non-economic impact of any diversion project on the communities and agriculture industry north of Kragnes, MN. paulski@anyconnect.com

090606_Barbara Headrick – How much will be on website as you work on study over next 4 months? How will Corps handle currently existing structures, such as the Sheyenne diversion in West Fargo, could they be altered to work better for the full region or must your project deal with it as is? Barbr.headrick@gmail.com

090520_Chuck Stenso – Buy out homes on west side of River Dr. Build berm to 46-48 feet along west curb. Area could have bike path/picnic area.

090520_Deanne Sperling – Diversion seems the most practical solution. dmsperling@hotmail.com

090606_Stanley Wolf – I live in section 6, Oakport Township, Clay County. I see that there is a proposed levee that encompasses the area between 70th Ave NW and 80th Ave NW from the river to Broadway St. Question: How did this levee become part of the proposal: At present there are only a dozen or more homes in the protected area, an area of about 300 acres. I live just north of the levee area – how will this affect my property. Ducksoup25@yahoo.com

Nancy Steinberger – Please keep me in the loop on H & H modeling efforts. FEMA is currently working on models for the Sheyenne and Maple Rivers. We have a preliminary Digital Flood Insurance Rate Map coming to Fargo in the summer of 09' and a Cass county DFIRM shortly there after (about 1 yr out). No action should NOT include flood fighting. Emergency measures can cause a rise in flood elevations. If that's the baseline, the project could slip through as not causing a rise even if it does. Flood permits from all affected communities will be required. A CLOMR and LOMR will be required. Nancy.steinberger@dhs.gov

Rick Archer – Recent 2009 flooding has resulted in discrepancies between projected river gage water surface elevations with recorded flood discharges. This may be due to different stream d/s setup conditions (Sheyenne) than what original floodplain model is showing, or due to flood fight efforts. I would like Corps of Engineers to look more closely at hydraulic conditions that may be leading to water surface elevation discrepancies.

Anonymous – Build retention areas along the rivers that feed the Red. That's where it starts. Pay the farmers to hold the water. Flood costs should be less overall. Varies yearly. The longer the farmers hold the water the more money he gets. These farmers are losing income and need to be paid for their sacrifices. That sacrifice will vary every year, dry years nothing, low flood years only land close to FgoMhd will be paid. Extremely wet years, all areas will hold water for a time – the length of time that water is held determined by the flood level in FgoMhd, 34', 36', 38'? Whatever levees can handle in FMhd. That controls how long water is held and amount of compensation paid to a farmer for his delay in planting – longer he holds water, the bigger his loses, and the more compensation he gets – (later planting, less yield) ($ amount changes every 2 wks?)

These wet years, crop yields would be less and holding water would be like insurance, they would get some income from their land – guaranteed. Public resistance to flood control would be less – nothing permanently destroyed or damaged. Environmental problems be less. No permanent damage to land compared to diversions or channel extensions or oversized dikes. Some floodwalls or smaller dikes will be needed in some areas. This is one piece of the pie that should be studied. You solve a problem before it

is a problem, not after it has become one. That is what we're all trying to do, so let's resolve it at the start. Before the flood water gets here.

090520_Reinke - Having attended the flood presentation @ Moorhead State I believe the only real resolve to the long term flood problem must involve some type of diversion.

Water retention and other forms of water control may offer some form of relief, but they are only band aids to the overall problem.

It was an excellent presentation.

Gary C. Reinke
5327 BSouth Univ. Drive
Fargo, ND 58104
701 293 7084
GaryC_Reinke@msn.com

090519_Cousins I am a retired Clay Co. Engineer.

I have lived in Fgo-Mhd since 1950, except for 9 yrs. I feel a permanent flood is essential as it seems floods are becoming worse and the 2009 flood costs the area many, many millions of dollars plus tremendous private suffering.

I feel a levee plan has maximum height restrictions and I fell we are approaching that elevation. I feel any plan must include a diversion channel. The cities that have one seem to do well – Breckenridge, West Fargo and Winnipeg. I would like to see a combination plan, levees and a diversion channel.

I have several questions which will be answered as the study progresses. A 500 foot wide, 20 feet deep below field elevation, and a 2000 foot top width diversion channel seems excessive. I assume this is wider than the Red River. What is the CFS for a 100 year flood and what CFS would the diversion channel handle? What is the proposed water depth and velocity of the diversion channel? Would a diversion channel be detrimental to anyone downstream?

I thank you for your study and look forward to reviewing your recommendation.

John A. Cousins
1508 52 ½ Ave. No.
Moorhead, MN 56560
218 233 2384
Jac.bev@juno.com

090519_Bach - Is the goal of the project to eliminate the need for any temp/emerg. levees/ diking? If so, is there a protection level and are those costs included in the diversion costs?

What about off-line storage on ND side south of Wild Rice? Has that been looked @? Probably need 8-10 sections of land dig 20' deep.

Eris Bach
5505 16th St S
Fargo, ND 58104
ebach@srfconsulting.com

090519_ Mathern - Our hospital was evacuated by Governor's order. There was a loss of $750,000 net income during this time though very little property damage; such losses need to be included in the cost benefit analysis.

Tim Mathern
Prairie St. John's Hospital
510 4th St S
Fargo, ND 58103
701 476 7825
tmathern@prairie-stjohns.com

090519_Mathern State match dollars need to be directed toward a comprehensive regional flood prevention plan.

Senator Tim Mathern
429 16th Ave. S
Fargo, ND 58103
701 235 9817
tmathern@nd.gov

090519_Mathern - Our home was right next to the dike – we support a permanent dike plan even it it affects our view of river and change to our property.

Tim Mathern
429 16th Ave. S
Fargo, ND 58103
701 893 5016

090520_Olson - I am interested in flood control. Let the Army Corps of Engineers do the job: Once over and done. The cost is high but is worth every cent. To go through flooding is wasteful when a permanent solution can be attained.

The Fargo Flood Plan is too restricted in scope. It appears as if developing the area is a priority, rather than flood control. My assumption is that politics has entered in. Individuals with prestige are spared intervention of flood control. This was verbalized at one meeting.

I resent the diversion planned on my property: (Stanley Township, South of County 14, Sections 25 and 26). This is devastating to the beautiful farmstead (which has been in our family since the 1880's) the tranquility and beauty of the river, the adjacent wooded area and the farm acreage. It is difficult for me to believe that this type of devastation could be handed to me.

It is not true that I am not interested in flood control. If need be, I will approve the planned dike (wet side) on the West rim of the property.

I chose to not develop my property. Others did, knowing they were in harm's way. Now I am needing to sacrifice my property when my family worked so hard to keep its ownership. We worked so hard. Our family never asked for any assistance from the Federal, State, county, township or local governments. We kept working. By the way, the buildings on the farmstead have never experienced flood water. This really shows that Norwegians knew where to place their building sites.

Respectfully submitted by:

Irene L. Olson
2510 100th Ave South
Horace, ND 58047
218 233 3203

APPENDIX C

Written Questions and Answers from Scoping and Public Meetings

Appendix C
Question and Answers
During Scoping Meetings

Moorhead, Minnesota November 17, 2008 Public Meeting

Fargo, North Dakota November 18, 2008 Public Meeting

Fargo, North Dakota May 19, 2009 Public Meeting

Fargo, North Dakota May 20, 2009 Agency Meeting

Moorhead, Minnesota May 20, 2009 Public Meeting

Fargo-Moorhead Metro Feasibility Study
Public Meetings, Moorhead MN Nov 17th, 2008

Q: What are the new 100-yr and 500-yr FEMA flood stages?
A: 100-yr is 39.5' on the Fargo gage; 500-yr is approx. 41-42'; the old 100-yr was 38.3'

Q: We thought the 1997 flood was much larger than a 100-yr event.
A: During the event it may have been reported as a much larger event. After all analysis was completed, we determined that it was approximately a 100-yr event. The 1997 flood in Grand Forks was approximately a 125-yr event there.

Q: I don't understand how a 100-yr flood could have a 1 in 4 chance of occurring over the next 30 years.
A: That's the way the statistics work. . .

Q: Did you factor in all historic events to figure out the 100-yr and 500-yr stages?
A: Yes.

Q: Do all new developments build ponds to hold water, i.e. to not impact flood levels?
A: Kevin: The Corps assumes in our analyses that the local folks will use best management practices, and the Federal project will not make things worse for others, including ag producers.
A: Bob Z: All subdivisions must include ponds designed to hold a 100-yr runoff event and all houses must be elevated above the 100-yr elevation.

Q: Winnipeg has 700-yr level of protection from their bypass channel. Is that an option for F-M?
A: Yes. We will consider diversion channels.

Q: If regional protection is the goal, why is Fargo's Southside Levee not on the table for a Corps project?
A: April: The FSS project will have no impacts if all of the features are built.

Q: What have we learned from the floods in Iowa last summer?
A: We will be looking at all of the risks and put together a system to reduce them.

Q: What will the feasibility study cost the locals?
A:

Q: Asked to Bob Zimmerman: Can you confirm that there will be no impact from the FSS project?
A: I'm comfortable with the analyses Fargo has done, but I have not run the models myself.

Fargo-Moorhead Metro Feasibility Study
Public Meetings, Moorhead MN Nov 17th, 2008

Q: FSS channel extensions will directly impact some landowners. What will happen if they are built and then the Corps diversion is built later?
A: Both projects would stay in place, and we would expect them to both contribute benefits. We do consider impacts to landowners in our analyses of social effects, but our focus will be on doing the most good for the region while impacting as few people as necessary.

Q: Can we just widen the river that's there?
A: There are many issues with channelization, especially from an environmental perspective. The odds of obtaining a permit for channel widening are slim to none. All of our projects must be environmentally acceptable and go through the NEPA process to disclose and mitigate for any adverse environmental impacts.

Q: It seems like common sense to hold off on other projects until this regional plan is complete.
A: Bob Z. and Mike L.: Even with anything we would propose for a regional solution, there will still be a need for a levee on the south side of Fargo because the land is so low.

* * *
Moorhead City Council Member asked the following questions:

Q: What are the realistic options other than a diversion? Storage is too expensive upstream, and levees can't solve the whole problem.
A: We agree with your summary of the options.

Q: FSS project is proposing 3 miles of channel extensions. Aren't these environmentally problematic?
A: Mike L.: The environmental agencies generally do not like them, but they are more acceptable at a higher elevation that will be used less frequently.

* * *
Q: There is concern that the whole FSS proposed package may not be implementable, especially the channel extensions in Minnesota.

Q: Could the regional solution include the Sheyenne Diversion, or does the existence of the SD make us go into MN with a new diversion?
A: Mike L.: There are many complications with tributaries on the ND side. The complication in MN is higher ground, therefore higher expense.
A: Aaron: We will look at all alternatives to make sure we pick the best one.

Q: Where would a MN diversion go? Will my house be impacted?
A: We're not there yet, and we won't be in April either.

Fargo-Moorhead Metro Feasibility Study
Public Meetings, Moorhead MN Nov 17th, 2008

Q: What is the level of protection we're looking for?
A: We have to determine what makes economic sense, but we want as high a level as we can justify.
Q: Will the Corps look at the future with and without the FSS project?
A: Kevin: We'll work with our sponsors to determine what the appropriate future condition is.
A: Mike L.: I haven't thought about this yet.

Q: From Mike L. to April W: Would Fargo build the FSS project without all of the proposed features?
A: April: We're shooting for the least impact possible. It would be allowable under floodplain planning to raise water surface up to 9 inches.
A: Mark Bittner: Fargo has looked at diversions, and they're very expensive. There's a good chance the Corps will not find anything economically justified, and even if they do, the cost will be high, and it will take a long time to get funded.

Statement from Moorhead City Council member: There will be a water war if Fargo puts 9 inches of water onto Minnesota.

At this point, Kevin halted the discussion and summarized many of the issues. He asked folks to remember that the Corps study is different than FSS levee, and we're looking for a regional solution.

Q: Why build homes where the low ground and flooding is?

Q: The Sheyenne Diversion project created ponding where there was no flood problem before. Beware of creating unanticipated problems.

Q: Are you designing a passive system or an active system?
A: We want the system to be as passive as possible, but it will likely include pump stations that will need operations and maintenance.

Q: All of the cities that are developing should talk about their future plans before they build something that will be in the path of our project.

Q: Will the feasibility study make any recommendations on how to finance this project?
A: We will ask the sponsors to self-certify that they have the capacity to do the project. The Feasibility study will lay out all expected costs so the cities will know what is needed.

Q: How do we know that the Federal funding will be there for the study and the project?
A: We don't know that. We have to go through the steps to get a project authorized and then funded. All we have authority to do now is study the problem.

Fargo-Moorhead Metro Feasibility Study
Public Meetings, Moorhead MN Nov 17th, 2008

Q: What other projects does the Corps have right now.
A: FMMFS and Devils Lake are our two biggest projects in the RRN right now. We also have the Roseau project going into construction; Montevideo, MN; Ada, MN study, and several other smaller studies. (Forgot to mention Wahpeton-Breckenridge and Fargo-Ridgewood).

Q: Why is the Corps coming in now?
A: Local leaders asked us to study the regional flood problem.

Q: What is in Phase 1—what will we know in April 2009?
A: We will be able to show a list of alternatives that we plan to study and another list of alternatives we plan to drop from consideration.

That concluded the group Q&A session for 17-Nov.
* * *

Gaylen Vaa, 6273 7th St. SW, Moorhead (Briarwood) says cutoffs in Minnesota cannot be built without eminent domain, and Fargo cannot condemn land in MN. They need to start working with a MN partner.

Fargo-Moorhead Metro Feasibility Study
Public Meetings, Fargo ND Nov 18th, 2008

Q: How does this study interface with the Fargo Southside (FSS) project? The goal of that project is to get FEMA certification in order to avoid the need for flood insurance.
A: We're looking at the whole region—FSS is only one component. FSS is still necessary even if a bigger project is built. Anything we'd do on a larger scale would augment the other smaller projects. We will look to make sure the FSS features are still needed. The system would still have to convey smaller floods through town and have the larger features take flow off of the larger events. There is a city-wide meeting next Monday at the Civic Center.

Q: Here's the obvious question: why do we need floodwalls in Harwood Groves if you're going to build a diversion.
A: You're asking about a detail of the FSS project, and we need to talk about the larger system.

Q: It seems like we're doing the studies backwards—shouldn't we do the macro study first?
A: Macro scale may take several years. Micro scale will still be necessary.

Q: If we already know the micro solutions, why do the macro study?
A: The small projects provide a low level of risk reduction. We still need a larger system.

Q: I question the 1:4 odds you presented. The projects we're talking about will protect us.

Q: Where does the money go?
A: The Corps is spending the money for its work. Phase 1 will determine whether we want to continue.

Q: Could we increase conveyance through town?
A: Mike L.: There are things we could do, but many of them would have significant environmental issues. Bridges could be raised and openings improved.
Kevin: with channelization features we have to factor in environmental considerations.

Q: B/C ratio—is that taking into account urban sprawl and future development?
A: That's a little sticky from a Federal perspective. We count benefits for reducing flood risk to homes, commercial and public infrastructure, and agriculture. Future developments (intensification benefits) are highly scrutinized, because we don't want to promote growth in flood plains. We will include intensification benefits in the Regional Economic Analysis, but not in the Federal B/C ratio.

Fargo-Moorhead Metro Feasibility Study
Public Meetings, Fargo ND Nov 18th, 2008

Q: Clarify "channelization."
A: Channelization involving wholesale clearing and straightening of the natural river channel is problematic. Smaller cutoffs at higher elevations are less environmentally damaging.

Q: I don't understand levees. What is wrong with building dams like the Garrison Dam?
A: We don't have really good places to build dams. We are still looking at smaller dams, but they will have limited effectiveness. Channelization of the natural channel has problems. We are considering diversion channels.

Q: What is the depth of water at Fargo vs farther north—does the river get deeper as it goes north?
A: The volume of water does increase as you go downstream and pick up more tributaries.

Q: Are we still considering the "waffle plan?"
A: Scott Jutila: we have looked into that along with other types of distributed storage (in the FMUS study). It is relatively inefficient—we can't completely solve the problem using distributed storage. It may be part of the long-term solution, but not the total solution.
Lee Klapprodt: I concur with Scott. We need a combination of things including watershed management and flood infrastructure.

Q: Is there a potential for FEMA's policies re: flood insurance and grandfathering rates to change?
A: April W.: FEMA will currently grandfather people in if you carry flood insurance now (a loyal customer). That doesn't mean rates won't increase, but they won't move you to a higher rate class through re-mapping. There are no guarantees that FEMA will continue this practice.

Q: How does the future flood map affect development?
A: The City of Fargo provided preliminary FEMA data to developers so they could act accordingly. Local standards require first floor elevation 2.5' above the current base flood.

Q: What is the current base flood elevation?
A: The current elevation is 38.3 feet at the Fargo river gage. The new BFE will be 1' to 2.5' above the existing BFE, depending on where in town you are.

Fargo-Moorhead Metro Feasibility Study
Public Meetings, Fargo ND May 19th, 2009

Date: 05/19/09
Location: Fargo Centennial Hall, Public Meeting
Agenda
5:30 PM Open House
7:00 PM Presentation
7:55 PM Question & Answer

Q. The coverage area is the Fargo metropolitan area, but County officials have not been present. How have you been working with mayors, other elected officials and other organizations?
A. Our official sponsors are listed as the Cities of Fargo, Moorhead and the Buffalo Red Watershed District. Initially a meeting was set up with a large number of stakeholders and coordination continues to take place. Some work may occur in rural areas, but the focus continues to be the metropolitan areas.

Q. How much of the $625 million in the first estimate is attributed to the Southside Project? How would characterize the economic value of the project? Will the Southside Project solve the flood problem?
A. Southside Project totals approximately $160 million of the estimate. Benefits are correlated to the level of protection provided by the project. If flood protection is high enough, flood protection could be extended out beyond the City proper. This project is intended to address regional flood issues. USACE wants to ensure that solving one problem won't cause another one.

Q. It appears that the earliest the project would be constructed would be ten years from now. How can we protect ourselves in the meantime? Does the USACE have a say in how we protect ourselves? I currently have a clay dike in my backyard and I could raise it – does the USACE have anything to say about that?
A. It's a good question that crosses several different jurisdictions including municipal code, state and Federal law. Please provide us with your name and we will research the issue for you because others may also benefit who are in a similar situation. (Mike) The USACE will not likely have an issue with retaining a levy, but you should check with FEMA and your City. (City, Walker) If you are in the floodplain, there is a permit required. The City wants to ensure that your levy is designed properly and does not lie within the floodway.

Q. Could you explain what an invisible wall is? How will a cut-off channel make things better?
A. (Refers to slide) An invisible flood wall, such as those built in Grand Forks, are incorporated into structures and not noticeable as a flood protection measure. In some cases, the structural measures are only present during a flood, but the essence is that invisible measures are incorporated into the landscape. Such measures tend to be operation intensive. Channel cut-offs will shorten the time that it takes for the river to flow through the City which results in a lower water elevation.

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Q. In determining costs, are costs just related to physical damage, or is unemployment resulting from the flood keeping people from work factored in?
A. Flood damages are typically the primary driver, however, other costs such as those you mention are factored in. The National Economic Development criteria requires an evaluation of the cost to the Federal government but also the effects on the regional economy. Both losses will be looked at with this project. Productivity of the workforce and social stresses are real and evaluated in total costs, however this becomes very tricky. Often Congress asks for total costs without the social impacts but since Hurricane Katrina, the Federal government is much more sensitive to those issues.

Q. I live at the confluence of the Wild Rice and the Red River – what effect will the project have on the people how live in that area and those upstream.
A. The alternative we've looked at so far will reduce water surface elevations at the area you're talking about. The diversion needs to be looked at in detail to ensure that the water is not conveyed so quickly through the City that it will have a downstream impact.

Q. If a levy is constructed what level will it be constructed at? (For the City) If I want a permit to construct my own levy can I construct it to the level of the 1997 flood?
A. The specific elevation targeting is part of our overall plan development process. We are not there yet, so providing that information at this time would only be a guess. We'll be working on that in the near future. (City, Walker) The City does have a cost-share program, but will not cost-share for those homes on the buyout list. The City will allow you to raise the elevation of your property with a permit. The FEMA maps will be changed soon.

Q. I'm trying to build something in my backyard – how high should I build it? Who will provide me with that guidance?
A. (Refers to flood frequency slide) I would suggest you look at a graph like this and assess the risk of constructing something at a certain elevation. If you look at the recent history, there are higher stages and more frequent flooding in recent years. If you're concerned about the long-term viability of what you're building, you'll incorporate this into your plans. (City, Mark) We've had a number of flood failures in recent years. When making a decision, you need to look not only at your property, but also your neighbors' property to ensure that you're not causing more problems than you're fixing. We had a $125 million worth of damage with the 2000 rain event – even homes with protection were damaged. Building levies also affects the drainage in your yard and you need to take this into consideration.

Q. The diversion costs $900 million – that's $30 million a mile. Is there a diversion channel that would reduce the costs per mile? Any other alternative routes would need to take place before the end of this phase, correct?

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A. Part of the reason that the Minnesota side was looked at initially was that it was the shortest flow path and also fewer crossings. On the North Dakota side we would cross more highways and ultimately create a longer diversion channel. We will look at a number of alternatives, but this is a start. We will try to develop all of our alternatives that are reasonable and plausible by September. We hope to come back to you to present you with these alternatives when this is complete.

Q. The diversion will circumvent the City; has any thought been given to buying out a larger portion of the river to create a larger river to convey more water?
A. Making the river convey more water more quickly conflicts with the ecosystem preservation goals of the USACE. Straightening of rivers was once common, but is not often done anymore.

Q. The inherent problem that you have is trying to convey water down a frozen river. Have you thought about using the I-29 corridor as a diversion?
A. We haven't looked at that in detail. We have consulted with DOT and there are safety concerns about using right-of-way for flood control. Remember also, our concept diversion channel had a footprint of 2000 feet wide. The current interstate system does not have that sort of capacity so there are constraints in that particular area.

Q. Who is the decision maker that will identify which plan will be presented to Congress?
A. The initial decision maker is the Commander of the St. Paul District, USACE. The Commander will look to the project managers for affirmation that the stakeholders support the project, the USACE planning process has been followed and that the project makes sense. After a plan is submitted, Congress needs to make an appropriation for the project that will allow the construction to go forward.

Q. Are the slides available in printed form, or can they be e-mailed out to people upon request?
A. Yes – we will have the slides up on the website, but they are not up yet. Google "Fargo Moorhead Flood Study" and the first hit you have will likely be the website. Both the slides and the handouts will be posted by the beginning of next week. Please let us know if you need anything else.

Q. Why doesn't the USACE have more jurisdictions over the root of the problem which is the drainage of the landscape upstream?
A. We've been studying drainage issues around the Red River and also Devils Lake. While storage has been looked at as a possible solution, the problem is that the costs and land acreage required to address the issue are enormous. Further, the soil in this area is very fertile and using the land for storage takes it out of production. The use of the land for agriculture versus flood storage needs to be taken in to consideration with the cost-benefit analysis.

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Q. Could you talk about how the Southside Project will be synchronized with the USACE Project? If Southside goes forward, how does it affect your project?
A. As mentioned during the talk, the Southside Project is a non-Federal project and the local sponsor is working hard to ensure that the Southside Project does not adversely affect the USACE project. The USACE needs to be cognizant of the opportunities in the Southside area that may be in the Federal interest, however, we are not at that point yet. The City has an interest in moving forward with a project as soon as possible. (City, Mark) The City wants to ensure 100-year protection over the Southside area, although the City believes that 100-year protection is also necessary for the rest of the City. It appears that right now, we should be able to achieve a positive cost-benefit ratio for the Southside project. We want to get as much Federal money as we possibly can, but we don't want to jeopardize potential Federal funding; we will be working closely with the USACE to ensure that the Southside project does not increase flood stages.

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Q. Will the Southside Development be incorporated into your analysis as built?
A. No

Tom Grashens, MN DNR
Q. Will non-structural solutions involve any efforts to lower the peak?
A. No

Robin Coursen, EPA
Q. Will this only deal with flooding on the Red River, or will this be a regional study e.g. including the Wild Rice River?
A. This will be a regional study but focusing on the metro area. We want to understand the big picture.

Robin Coursen, EPA
Q. Will you be looking at impacts downstream towards Canada? Executive Order 11124 requires you to address transnational impacts.
A. No – we will limit the project area to focus on the Fargo metropolitan area. We will follow that guidance but assume that the impacts crossing into Canada will be minimal, if adverse at all. This will be addressed with the report. Noted that coordination will be performed with Canadian officials, (Robin will provide contacts she has).

Q. Does the $600 million estimate comprise the current Southside estimate?
A. That takes the Southside project in addition to protective levies on both sides of the river.

Brent Truskowski, EPA
Q. Are you talking about diverting the entire river or would the water be diverted at a certain elevation?
A. Just flows above a level specified in the alternative analysis.

Q. Will your June 22nd deadline and project timeline be distributed within a public notice? Does this include an EIS as well?
A. Public notice has been issued already. We have combined the EIS and Feasibility Study in the past, but haven't decided for this project yet.

Brent and Robin, EPA
Q. What is driving the timeline? How is this coordinated with the Fargo Southside Project?

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A. USACE wants to be responsive to the needs of the area to expedite the project and minimize the need to mobilize for another flood fight. Congressional authorization would like come in 2010 through a Water Resources Development Act bill. If we miss the opportunity in 2010, the next WRDA bill will presumably occur in 2012. (City, Mark) The City of Fargo believes that it would be ideal to coordinate the two projects to the greatest extent possible.

Brent Truskowski, EPA
Q. How much impact analysis has been done in regards to wetlands and waters at this point?
A. A fairly rough estimate – the goal is to minimize impacts looking at channel alignments, etc. based on the alternatives. We would like to hear about areas of special interest or concern at this point.

Brent Truskowski, EPA
Q. You should consider channel stability, erosion and deposition in both the Red River as well as tributaries as a result of the project.
A. USACE will look at that.

Robin Coursen, EPA
Q. What will happen with fish passage in the area? How will they be affected by channel diversions? Is the U.S. Fish & Wildlife Service present? FEMA, USFWS, EPA and the USACE should meet to discuss issues. 40 CFR Section 1508.25 "similar and connected actions" of the project. At first glance, EPA believes that there may be similar and connected actions between the Southside and USACE projects.
A. USACE will look at that in conjunction with the project looking at fisheries, riparian woodlands, etc. USFWS is not present. USACE will coordinate future meetings with EPA, FEMA and USFWS.

Brent Truskowski, EPA
Q. Will you be allowing limited flooding, or mitigating all flooding e.g. agricultural field flooding? An indirect effect of flood protection may be to prevent all flooding in rural areas which should be considered in your analysis.
A. We currently don't know how the National Economic Development Plan will materialize. The extent of the protection provided will be dictated by the design. We will consider your suggestion in the analysis.

Robin Coursen and Brent Truskowski, EPA
Q. Execute Order 11988 on Floodplain Management (minimizing development in the floodplain) should be considered. Growth impacts from the Southside Project may open up the need for a more comprehensive analysis.
A. Noted – the analysis will include evaluation of these alternatives.

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Nancy Steinberger, FEMA
Q. Flood fighting should not be counted in the No-Action alternative. No flood protection measures in place should be the baseline for initial water surface elevations.
A. The economic analysis will include this baseline. For the environmental analysis, this needs to be resolved.

Bob Bezek, MNDNR
Q. The environmental impacts from flood fighting will be looked at as a temporary impact?
A. That is our assumption at this time.

Tom Grashens, MNDNR
Q. By treating the economic and environmental assessments differently (in regards to the presence of temporary flood protection), aren't you hedging your bets? You should be consistent in your methodology. More probability should be incorporated to assess both environmental and economic risks. Environmental analysis should include the flood fight (temporary levies in place) as well as the alternative of no temporary action (no dikes or levies).
A. The likelihood of future flood fights is very real, but the long-term reliability of such measures are uncertain, therefore the economic assessment is based on the higher likelihood of the probability of failure. We acknowledge the perception, but we want to be realistic.

Dan Cimarosti, Corps NWO
Q. When you look at the "future without project" do you look at future development in the area?
A. That issue is problematic because USACE does not want to promote growth in the floodplain, but that is where the growth is projected by the City. Typically we would not look at that, but we need to obtain additional guidance from headquarters on this issue.
EPA

Q. On the topic of growth, will you be able to show us the growth plan for both cities? Will this include the City's strategies for addressing flooding issues?
A. Yes, growth projections will be included geographically, but not included in the analysis. We will rely on the City for the assessment of their strategies for managing future development.

Cliff McClain, Buffalo Watershed District
Q. The City of Moorhead has concerns with the Buffalo Aquifer and want to ensure that it is not impacted. A number of utilities cross the area where the concept diversion was planned, please take this into account.
A. We would ask that you provide us with information on the water utilities. Additional assessment will be performed to ensure that impacts will not occur to the aquifer. The

current alignment shows that the aquifer lies to the east of concept channel diversion, but this will be looked at in further detail.

Bruce Kreft, ND Fish and Game
Q. North Dakota has a list of conservation priorities – there may be an interest in preserving some level of flooding for the benefit of the river ecosystem. Some fish species (catfish, sturgeon) will be dependent on a natural flooding regime in certain areas.
A. This has been noted and will be looked at.

MN DNR
Q. Have you looked at the MDNR Heritage Information system?
A. Yes. This has been looked at and will be utilized in the future.

Erik Jones, Houston Engineering
Q. The diversion plan is routed towards Highway 75 – there would be issues with affecting the floodplain of the Buffalo River in this area. There are also potential issues with ditch systems which would require a hearing process.
A. Please provide us of additional information.

USACE
Q. USACE: Are there other individuals that should be involved?
A. Canadian counterparts to FEMA, USACE and EPA should be involved. Officials from Manitoba should also be contacted. Tribes should also be invited to attend. Transportation officials from both States should be involved as well as Federal Highway officials. 401B Certification from the State of North Dakota will likely be necessary.

Q. Our comments are due on June 22nd…are we commenting on diversion channels, levies, etc.? Do you want us to reiterate our comments in writing?
A. Feel free to comment on any aspects of the project, but also provide us with additional ideas for alternatives. We will provide meeting minutes, but you are welcome to submit in writing as well.

Q. Are you looking at executing an Official Cooperating Agency Agreement?
A. We may, but we're sorting that out, but we can talk about that at future meetings.

Fargo-Moorhead Metro Feasibility Study
Public Meeting, Moorhead MN May 20th, 2009

Date: 05/20/09
Location: Moorhead State University Hanson Hall, Public Meeting

Agenda
5:30 PM Open House
7:00 PM Presentation
7:50 PM Question & Answer

Q. If the diversion project proceeded in 2012, what would be the completion date?
A. Levy projects will proceed quicker than a diversion project, but everything depends on availability of funds from Congress. Three or four years would be an ideal timeline, but may be optimistic.

Q. There are two omissions in the presentation – you didn't address the land use problem. Farmers want to drain the land as quickly as possible, which is understandable, but it exacerbates flooding. Timing is also an issue if water can be retained at its origin. The time between the pre-crest level and the post-crest level was a few hours – if water can be retained even that long, the peak should decrease.
A. It certainly is an issue that is debated – especially with larger flood events. The assumption at this time is that storage will likely need to be provided through local projects as opposed to a USACE project. Would storage reduce the size and need for a super-structure? That's likely true, but it won't provide the entire solution.

Q. In 1897, the land in downtown Fargo was not built out to the river – that land was all filled in. A flood stage of 40 feet was recorded. When the Freedom Bridge was constructed, the river was constricted to a fraction of its previous width which has exacerbated flooding. If this flood occurred in 1897 without the bridge, a flood of that magnitude with the bridge would certainly be much worse. The only reason that this area was spared in the recent flood was the cold weather. The flood stage is misleading with an official change of the flood stage from 17 feet to 18 feet – this may be a conspiracy to alter the records. Levies may not help in the flooding. The flow is too restricted especially with the Freedom Bridge in town acting as a dam. Ice dams along bridges are another concern that, when they happen, will flood out the entire community regardless of the levy. Fargo-Moorhead needs the equivalent conveyance capacity to the preexisting river. Question – how do bridges constrict the flow and what is the value in building levies above the 40 foot stage?
A. We will look at a number of options including levies, diversions and non-structural solutions. Non-structural solutions include raising structures such as bridges.

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Q. Do any of your rules require that your projects be neutral down river (i.e. not making conditions worse downstream)?
A. Those are referred to as "induced damages" and are monitored very closely. USACE will be obligated to mitigate the effects of the project that would adversely affect others downstream.

Q. What is the impact of the Fargo Southside Flood Protection Plan? Will that area be factored into your cost-benefit ratio?
A. We're starting to look at that and acknowledge that it is a delicate situation. The City does not want to move forward with a project and jeopardize a potential future Federal project, but still has an interest in constructing a project soon. The City could move forward with the project on their own, but will likely wait to see what happens with the Feasibility Study.

Q. Has a study been completed that will identify the reason for the increase in flooding frequency? Could the river be dredged to create a deeper river that would increase conveyance?
A. There has been a tendency in the past to look at straightening channels and increasing conveyance as a preferred way to construct a flood control project, but this happens at a high cost to the environment. As to the frequency, there are both wet and dry cycles over time. There appears to be a wet cycle right now, but it is unclear how long it will last. We will look at these issues in detail in conjunction with the study.

Q. The options that you've looked at are mostly structural. Could you talk more about non-structural solutions such as buyouts?
A. Since Katrina, the focus has changed on this issue. In metropolitan areas, the dollars add up quickly for relocation efforts. If we look at pockets or neighborhoods and problem areas, the relocation tends to make sense for structures in high risk areas. We can also look at raising homes to provide protection, but this approach hasn't been very popular in the Midwest given the high number of basements. National experts will be brought in to advise on non-structural solutions.

Q. If bridges are a constriction along the river, why are we not looking at reconfiguring the pilings like on the LA River? Can we have a standardized measuring system for stages given that there are variations in stage measurements? I am in favor of dredging and straightening of the Red River – it's legal, efficient and will be 30% cheaper. Do we want to save homes or lily-pads?
A. Not aware of the LA River model, but we can talk to you individually about this during the open house. All of the modeling and plans will be completed in 1988 datum. There will be better continuity on stage data in the future, but there has been a reluctance locally to change. There is a national initiative to standardized datum to 1988 (NAVD 88). We have the standardization of data on this list of considerations for the study.

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Q. How do you accommodate traffic over a 2000 foot wide ditch? Why wouldn't the diversion channel go through Fargo on the west?
A. Yes – bridges will be reconstructed. We estimate at least seventeen road crossings and four rail crossings. The way the channel is configured, the bridge won't need to be 2000 feet long, but will be fairly large. We've looked at the diversion on the west and it may be a possibility, however, the Minnesota side is the shortest path from point A to point B. We'll be looking at both sides.

Q. What impact does the Rose Creek project (the Fargo Southside Project) have on the Moorhead levies and the overall project? Moorhead still has walkout basements, could those be flood-proofed as part of the project?
A. The Fargo Southside Project will be looked at as part of the study from a permitting standpoint, but the applicant (the City of Fargo) would be required to show that the project either does not change the stage or mitigates the impacts. Any type of levies that would be put in place through a local effort would be evaluated as a part of the study. USACE credits communities for flood protection work that is in place or will be in place in the near future. Flood-proofing walkouts may be part of a non-structural solution. (City) City supports the flood-proofing of structures but it would likely require a permit, and funding has not been identified that would be available to homeowners to do so.

Q. Fargo and Cass County have proceeded with identifying buyouts, but Moorhead has not. What is the involvement of USACE and what is the hierarchy for decision making?
A. FEMA will likely be involved in buyouts. (City) The City is looking at this issue and it will be discussed at the City Council level. Approximately 70 individuals have stepped forward for potential buyouts in Moorhead; interested parties are encouraged to contact the City. The City will seek funding from the Minnesota Department of Natural Resources as well as FEMA for future buyouts. (Clay County) For those outside of Moorhead, Clay County is also compiling a list of interested individuals.

Q. Would the diversion have a grassed bottom or concrete? Who performs long-term maintenance? How will you ensure that the diversion does not result in a 30 mile long stagnant pool of water?
A. Grassed bottom. USACE negotiates maintenance with the communities and that is specified in the plan and agreement. At the conceptual stage, the diversion would flow only during high water and should dry out over the summer. The details of any project are forthcoming.

Q. Why can't you build dikes on buyout land? Why wasn't Fargo flooding addressed with the Grand Forks project?
A. If you take money from FEMA for a buyout, you cannot build on that land at all – this includes private projects or USACE projects (with few exceptions). We'll be coordinating with FEMA on our project. USACE had been working directly with Grand

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Forks since the 1980's to identify flood protection for the City. It was coincidental that the flood event occurred at about the same time as progression on the project.

Q. The diversions go through dry land. Why can't they be located in areas where the land is wet?
A. This is a starting point for discussion looking at the shortest route around the City. Some people will be impacted by any project that would be constructed. Looking at a large scale solution will mean that certain individuals will have to sacrifice in order to ensure that everyone benefits to the greatest extent possible. There are real consequences to these decisions. The Minnesota (east) diversion is not the only route that can be constructed but is part of an initial look at solutions.

Q. How did you determine where your starting point and ending point would be for the Minnesota (east) diversion? Where does the water end up?
A. The concept is that the diversion would start at the Wild Rice River and enter back in before the Buffalo River near the Sheyenne. We would ensure that with any diversion, that the individuals living downstream will not be adversely affected.

Q. What about wetland reclamation between Lake Traverse and Fargo Moorhead?
A. Anything we can do to increase capacity in the watershed will help the problem, but not solve it. This will be looked at as part of the project and will be evaluated.

Fargo-Moorhead Metropolitan Area Flood Risk Reduction Project Wetland Determination Report Fargo, North Dakota/Moorhead, Minnesota

Wetland Determination Report For:
U.S. Army Corps of Engineers
Civil Works

US Army Corps of Engineers

St. Paul District

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July 13, 2011

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Introduction

During the 2010 growing season, the St. Paul District Army Corps of Engineers (ACOE) Regulatory Branch performed a wetland determination on behalf of St. Paul District ACOE Civil Works for the proposed corridor alternatives for the flood diversion of the Red River of the North around the Fargo-Moorhead metropolitan area (Note: hereinafter "Diversion" will be used and refers to all alternatives). Project location and alignment corridors for both the North Dakota and Minnesota alternatives are shown on Figure 1. Documentation of the wetland and other aquatic resources potentially impacted by the proposed Diversion was provided for Final Environmental Impact Statement (FEIS) required by the National Environmental Policy Act (NEPA). Additional project information can be found in detail in the FEIS.

Note: Forested wetland resources were not identified for this report. All forested resources, including forested wetlands, were identified and assessed under a separate section of the FEIS, therefore they were not included in this effort. In addition, areas of wetland outside of the diversion right-of-way footprint were not identified.

Methods

ACOE utilized the procedures outlined in the *1987 US Army Corps of Engineers Wetlands Delineation Manual* (Manual) and *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region (Version 2.0)* (Supplement) to perform the wetland determination. The Corps Training Team utilized the routine (Level 3) method (Manual Part IV, Section D, Subsection 3) outlined in the Manual with substantial effort spent with off-site review and field data collection made at representative locations. Therefore, the results of this effort comprise a determination of wetland locations, rather than a wetland delineation.

Definitions of key terms as used in this report relevant to wetland determinations:

Normal circumstances – The soil and hydrologic conditions that are normally present, without regard to whether the vegetation has been removed. (Manual)

Managed plant communities – Many natural plant communities throughout the Great Plains have been altered and are managed to meet human goals. Examples related to the Red River Valley include periodic disking or plowing, planting of non-native species such as agricultural cultivars and the use of herbicides. (Supplement)

Wetland hydrology – An area has wetland hydrology if it is periodically inundated or has soils saturated to the surface at some time during the growing season. (Manual)

Growing season – The growing season has begun on a site in a given year when either (1) two or more species of non-evergreen vascular plants exhibit biological activity (growth such as bud break or emergence from the ground), or (2) the soil temperature measured at the 12-in. depth is 41°F (5°C) or higher. For this region of North Dakota/Minnesota in the Red River Valley, the

start of the growing season averages during early- to mid-April and is typically two to three weeks earlier than safe planting dates for agricultural crops. (Supplement)

Off-Site Review

The following information was included in the off-site review:

- "Wetland Delineation Precipitation Data Retrieval from a Gridded Database" website, Minnesota Climatology Working Group
- Aerial photography obtained by the Corps:
  - USDA Farm Services Agency (FSA) Aerials 2003 -2006 and 2009-2010
- LiDAR data (2010)
- USDA digital Soil Survey Mapping/Web Soil Survey

Note: While the National Wetlands Inventory (NWI) mapping is an excellent tool that is used on a regular basis for initial identification of potential wetland areas, there are limitations with this mapping in agricultural regions. Through an interagency agreement developed in the 1970s between the U.S. Fish and Wildlife Service and the U.S.D.A. Natural Resources Conservation Service, "NWI maps, by design, do not show many farmed wetlands in most of the country [leading] to a significant underestimate of the amount of wetland in agricultural regions" (National Wetlands Newsletter, Vol. 19, No. 2, 1997). Therefore, NWI was not relied upon for identifying wetland resources along the project corridors.

Off-site procedures followed the concepts outlined in the Wetland Mapping Conventions for the State of Minnesota in the 1994 Interagency Cooperative Agreement and the Joint Mapping Conventions for North Dakota and South Dakota. However, due to the time constraints for reviewing the extremely large project area and because the State Mapping Conventions were developed prior to the advent of LiDAR and did not take into account the accuracy afforded with this data, professional judgment was ultimately employed in applying the Mapping Conventions on a qualitative rather than quantitative level. Not all land could be reviewed with every aerial available to measure the percentage of normal years with wet signatures that a particular wetland area exhibited. Rather, as noted below, LiDAR elevation data was correlated to areas with repeated signatures of wetness. (Note: October 2010 update to the North/South Dakota State Mapping Conventions and proposed update to Minnesota State Mapping Conventions both include the use of LiDAR data.)

The NRCS *Hydrology Tools* for *Wetland Delineation Procedure* (August, 1997) and Corps of Engineers guidance *Assessing and Using Meteorological Data to Evaluate Wetland Hydrology* (April, 2000) both recommend evaluation of precipitation for the 3 months prior to the date of the imagery and field site visits to assist in making determinations of normal circumstances. In general, for this northern portion of the country, aerial photography flights to create FSA slides are conducted during the last week of June or first week of July. Unless a specific date was provided for any aerials reviewed, July 1 was used as the date for determining antecedent precipitation, with April, May and June used as the 3-months prior. Using the "Wetland Delineation Precipitation Data Retrieval" website developed by the Minnesota Climatology Working Group (http://climate.umn.edu/wetland/), antecedent precipitation was obtained for the 3-months prior to every aerial photograph reviewed and site visit and then analyzed relative to the range of normal for that period (dry, normal or wet).

The presence of signatures due to wetness was identified in each of the aerials reviewed. As indicated in the State Mapping Conventions, a photo identified as taken following 'wet' antecedent precipitation, in this case 2005, was used to identify all possible locations of wetland areas. Remaining available aerials were then reviewed for recurring signatures of wetness. It appears that crops were planted later than usual in 2010, leaving the 2010 aerial with more ground surface visible than if the crops were in a later stage of growth and obscuring the ground surface. The July 2010 aerial best shows the lower lying areas in the landscape with regular signatures of wetness throughout the review. Finally, using ArcMap 10 with the detailed topographic mapping available from the LiDAR data and the 2009/2010 FSA aerial photographs (normal years), wetland lines were digitized around the lowest spots on the landscape corresponding to regular signatures of drown outs, crop stress, altered or late planting, brighter green areas in dry years and/or low albedo (areas of darker soil). (Albedo is the fraction of the total light striking a surface that is reflected back from that surface. An object that has a high albedo (near 1) is very bright; an object that has a low albedo (near 0) is dark.)

A note about soil saturation in aerial photography: While some might argue that X-ray vision is required to 'see' soils saturated within 12" on aerial photography, areas of low albedo in some years of aerial review exhibit a strong correlation to both the lower elevations identified in LiDAR and other signatures of wetness such as crop stress and drown outs. Furthermore, soils in the project area are predominantly mapped as fine-textured clays or silty clays, a high percentage of which are hydric soils from which some of the surface water is drained. Therefore, soils lower in the landscape would remain wet longer, resulting in areas with lower albedo due to wetness.

Figures LPP 1-4 of 4 and FCP 1-3 of 3 in Appendix A were developed to display the wetland polygons located within the project corridors, overlaid on 2009 FSA Aerial photography. Antecedent precipitation prior to the 2009 aerial flight was a normal.

On-Site Field Review

Antecedent precipitation was analyzed prior to each field review, as well as in relation to dates of aerial photography. On July 1-2, 2010, the team reviewed all Diversion Corridor alignments to ground-truth the images and signatures previously identified on aerial photography as wetland areas. Antecedent precipitation for this field review was normal. Following this ground-truthing field review, the team completed the off-site mapping of all the wetlands within the study area through July 2010. During July 27-30, 2010 the team returned to the study area to complete representative transects/data collection and functional assessments, using the Manual, the Supplement and Minnesota Routine Assessment Methodology for Evaluating Wetland Functions (MnRAM), Version 3.3, refining the extent of wetlands within all off-site mapped areas. Antecedent precipitation prior to the final field review at the end of July 2010 was wet, with nearly two inches of rain falling on July 27-28, 2010 in the project area. This precipitation provided the team with first-hand observations of the geomorphic positions in the landscape to which water flows.

Due to time constraints and similarity of the vast majority of wetlands within the study area, Corps staff chose not to delineate or assess functionality on every area determined to be

wetland. Instead, at least one randomly-chosen area representative of each type of wetland found within the Diversion alignments was verified through data collection along a transect and assessed for typical functionality. Sample points were taken to document the vegetation, soils, and hydrology indicators within representative upland and wetland locations. As part of the field verification process, soil pits were dug to at least 16 inches to describe the soil colors, using Munsell soil color charts, and to observe any hydrology indicators. Vegetation was documented using the standard plot sizes of a 30-foot radius for trees and woody vines, a 15-foot radius for saplings/shrubs, and a 5-foot radius for herbaceous species and woody seedlings. Percent areal cover was recorded for each plant species and dominants were determined using the "50/20 Rule." Ditch depths throughout the project corridors were estimated for use in lateral effect calculations.

Wetland plant communities were classified using the USACOE - St. Paul District, Eggers and Reed "Wetland Plants and Plant Communities of MN and WI" (1997). The wetland indicator status of plants was determined using the National List of Plant Species That Occur in Wetlands – Region 3 (1988). In accordance with the Great Plains Regional Supplement, the + and – have NOT been removed from the vegetation indicator status.

The determined wetland boundaries are depicted in Appendix A as Figures LPP 1-4 of 4 and FCP 1-3 of 3, overlaid on the 2009 Farm Services Agency (FSA) aerial imagery.

Assessment of impacts to aquatic resources as a result of the proposed Red River Diversion channels included completion of MnRAM V. 3.3 analyses on representative sites within the Diversion Corridors. As stated above, time constraints and similarity of wetlands within the study area allowed Corps staff to assess representative wetlands of each type found within the Diversion alignments. (Note: Although forested wetlands were not identified for this document, a short statement about the functionality of forested wetlands in the project area is included.)

Results

Off-Site Results and Discussion

Soil series in the project area are provided in Tables 1a and 1b. Table 1a lists soils found within the Minnesota Diversion, where at least 63% of the area is hydric soil. Table 1b lists soils found within the North Dakota Diversion, where over 90% of the area is hydric soil. Soils of the study area are dominantly associated with lake plains and floodplains and formed in calcareous clayey lacustrine sediments. They are very deep, poorly and very poorly drained and slowly permeable. Slope gradients are commonly less than 1 percent but range from 0 to 6 percent, with steeper slopes associated with side slopes of streams. Runoff is negligible except where accommodated by slope. Saturated hydraulic conductivity is slow. A system of surface drains associated with road ditches, section lines and agricultural fields remove surface (ponded) water from most soils[1]. A seasonal high water table is at the surface to about 3.0 feet below the surface at some time during the period of March through July; in lower lying depressional areas the water table is 1.0 foot above the surface to 2.0 feet below the surface at some time during the

[1] Land leveling is commonly practiced by agricultural producers in this region and aids in removing ponded water.

period of February through August. (Source: Official Soil Series Descriptions. USDA, NRCS. 2010).

Table 1a – Soils in Minnesota Diversion Corridor

Soil Series	Taxonomic Class	Map Units Present	Hydric	Approx. % of Corridor
Augsburg	Coarse-silty over clayey, mixed over smectitic, superactive, frigid Typic Calciaquolls	**a)** Augsburg silt loam	Yes	1
Bearden	Fine-silty, mixed, superactive, frigid Aeric Calciaquolls	**a)** Bearden silty clay loam; **b)** Bearden silt loam, 0-2% slopes	No	26
Colvin	Fine-silty, mixed, superactive, frigid Typic Calciaquolls	**a)** Colvin silty clay loam	Yes	11
Fargo	Fine, smectitic, frigid Typic Epiaquerts	**a)** Fargo silty clay, 0-2% slopes; **b)** Fargo silty clay, Swales; **c)** Fargo silty clay loam	Yes	48
Hegne w/Fargo inclusion	Fine, smectitic, frigid Typic Calciaquerts	**a)** Hegne-Fargo silty clays	Yes	1
Overly	Fine-silty, mixed, superactive, frigid Pachic Hapludolls	**a)** Overly silty clay loam	Partial	3
Wahpeton	Fine, smectitic, frigid Typic Hapluderts	**a)** Wahpeton silty clay. 0-2% slopes	No	2
Wheatville	Coarse-silty over clayey, mixed over smectitic, superactive, frigid Aeric Calciaquolls	**a)** Wheatville silt loam, 0-2% slopes	No	8

Table 1b – Soils in North Dakota Diversion Corridor

Soil Series	Taxonomic Class	Map Units Present	Hydric	Approx. % of Corridor
Bearden	Fine-silty, mixed, superactive, frigid Aeric Calciaquolls	**a)** Bearden silty clay loam	Partial	2
Cashel	Fine, smectitic, calcareous, frigid Aquertic Udifluvents	**a)** Cashel silt clay	Partial	2

Dovray	Fine, smectitic, frigid Cumulic Vertic Epiaquolls	a) Dovray silty clay	Yes	5
Fairdale	Fine-loamy, mixed, superactive, calcareous, frigid Mollic Udifluvents	a) Fairdale silt loam	Partial	1
Fargo	Fine, smectitic, frigid Typic Epiaquerts	a) Fargo silty clay; b) Fargo silty clay loam; c) Fargo silty clay, 1-3% slopes;	Yes	67
Hegne w/Fargo inclusion	Fine, smectitic, frigid Typic Calciaquerts	a) Hegne-Fargo silty clays	Yes	18
Overly	Fine-silty, mixed, superactive, frigid Pachic Hapludolls	a) Overly silty clay loam	Partial	3
Wahpeton	Fine, smectitic, frigid Typic Hapluderts	a) Wahpeton silty clay. 0-2% slopes	No	2

As mentioned, surface drains, typically two feet or less deep with flat side slopes, are constructed[2]. Except for lower lying depressions, the drains, in concert with land leveling, remove ponded water from most soils. Given the slow permeability of the area soil, their shallow and random pattern[3], the drains have a lesser effect on lowering the water table over larger areas of the landscape. Nonetheless, the lateral drainage effect of surface drains on the water table was estimated (Table 2) using the van Schilfgaarde equation (Hydrology Tools for Wetland Determination. Engineering Field Handbook, Chapter 19. USDA, NRCS. August, 1997 and Hydrology Tools for Wetland Determination, Minnesota Supplement 19-57 to the Engineering Field Handbook. USDA, NRCS. April, 2005). To calculate lateral effect, variables such as ditch depth were estimated by field visit (July 27-29, 2010) and soil parameters were estimated from the Web Soil Survey. The ditch depths analyzed in Table 2, below, represent the range of ditch depths observed during the field review. The "T" factor, or the duration of time for the drain to lower the water table one foot below the soil surface, was set at 14 days. Fourteen days is the required duration for determining wetland hydrology on hydrologically altered sites (Supplement).

[2] Subsurface drainage, such as tiling, is not a common practice in the study area.

[3] As used here, random means ditches that follow landscape drainage patterns, as opposed to a systematic arrangement of parallel drains.

Table 2 – Lateral drainage effect of surface drains of Red River Valley

Ditch depth (feet)	Lateral effect on each side of ditch
2	80
3	105
4	120
5	135
6	145
7	150

The surface drainage was initiated during European settlement of this area in order to make production of agricultural crops possible, and much of the land within the proposed diversion alignments is currently used for agricultural purposes. Although the surface drainage systems (ditches and land leveling) make agricultural production possible in many areas in most years, the ditches and land leveling have not eliminated wetland hydrology from entire fields during the growing season in most years. Many wetlands are farmed in most years, and crops are often lost or suffer wetness-related stress.

The NRCS *Hydrology Tools* for *Wetland Delineation Procedure* (August, 1997) and Corps of Engineers guidance *Assessing and Using Meteorological Data to Evaluate Wetland Hydrology* (April, 2000) both recommend evaluation of precipitation for the 3 months prior to the date of an aerial photograph to assist in making determinations of normal circumstances. Unless a specific date was identified for an aerial, July 1 was the date used to calculate antecedent precipitation for the three months prior to the photo. Antecedent precipitation was analyzed using the Wetland Delineation Data Retrieval website: http://climate.umn.edu/wetland/. Detailed data were obtained using the Moorhead Station (#215584). Table 3 below provides the antecedent precipitation analysis for the aerials reviewed.

Table 3 – Antecedent Precipitation (April, May, June) for July FSA Aerial Photos

Date of Imagery	Antecedent Precipitation
July 1, 2003	Wet
July 1, 2004	Normal
July 1, 2005	Wet
July 1, 2006	Dry
July 1, 2009	Normal
July 1, 2010	Normal

FSA aerial photography is generally flown during late June or early July. The intent of this photography is related to compliance with USDA Farm Programs; the main purpose is not for assessing hydrology and aiding the determination of wetland areas. However, they remain the most readily available aerials to view the landscape on an annual basis. These mid-summer flights generally miss nearly three months of the growing season, during which areas inundated or saturated within 12" of the surface meet the definition of wetland hydrology. Decisions made about whether an area is wetland based solely upon the FSA aerials would, therefore, result in a very conservative estimate of wetland. Again, use of LiDAR, correlated with repeated signatures

of wetness later in the growing season as shown on the FSA aerials, provides the best available data to make a determination of the full extent of wetlands on the landscape. The question for determining the extent of wetlands is not wetland hydrology based on mid-summer imagery. Rather, the question is the extent of wetland hydrology during the growing season in most years, which, as previously stated, begins in the Fargo-Moorhead area during early- to mid-April. Aerial photographs, LiDAR, the extent and location of hydric soils, and extent and estimated effect of drainage infrastructure when taken together offer an estimate of wetlands based on multiple parameters.

Upon review of available aerial imagery, Web Soil Survey and detailed topographic (LiDAR) data resources, extensive areas of hydric soils exhibiting regular wetland signatures were noted throughout the proposed Diversion corridors, as shown on Figures LPP 1-4 of 4 and FCP 1-3 of 3 in Appendix A. Using LiDAR data correlated to regular signatures of wetness such as saturated soil, crop stress and drown-outs, wetlands were identified in the lower lying areas and digitized as polygons in ArcMap 10. Table 4 below provides a summary of the total area of wetlands, by type, identified within the Diversion corridors.

Table 4 - Summary of the extent of wetlands (acres), by type, within the proposed Diversion corridors.

Wetland Type	**North Dakota/LPP Corridor (Total area: 8054 ac)**	**North Dakota/ND35K Corridor (Total area: 6560 ac)**	**Minnesota/FCP Corridor (Total area: 6415 ac)**
Approximate total acres hydric soil	7250	5900	4040
Farmed, seasonally flooded basin	790	720	800
Wet meadow	140	120	50
Shallow marsh	50	40	50
Shallow open water	10	10	10
Total Wetland Acreage	990	890	910
% Wetland	12%	14%	14%

On-Site Field Results and Discussion

Normal Circumstances

The corridors, especially in North Dakota, are dominantly hydric soil, with insufficient drainage infrastructure to eliminate wetland hydrology during the growing season in most years; as discussed, crops can be planted but are often lost in the lower lying areas in many years. It is the professional opinion of the wetland scientists involved with this review that the soils and hydrology normally present in the areas identified as wetlands in both off-site and on-site review will support a dominance of hydrophytes if normal farming operations were to cease.

Farmed, Seasonally Flooded Basins

The vast majority of wetland resources found within the project area are "managed plant communities" classified as farmed, seasonally flooded basins. These seasonally flooded basins are lower lying areas within actively planted agricultural fields from which shallow surface drains and land leveling have not eliminated wetland hydrology during the growing season in most years. Many of these lower lying areas are themselves shaped into shallow field ditches channeling water from the remainder of the fields. Prior to European settlement of the study area, this lake plain (see soils discussion) was dominated by wetland communities; these seasonally flooded basins are generally the remnants of the historic wetland areas.

Wetland boundaries were identified during off-site review using the LiDAR elevation data correlated to repeated signatures of wetness, and verified with the on-site ground-truth review. The hydric soil field indicators observed include A12 – Thick Dark Surface and F6 – Redox Dark Surface, while the hydrology indicators observed include D2 - Geomorphic Position, B8 – Sparsely Vegetated Concave Surface and, during the off-site review, C9 – Saturation Visible on Aerial Imagery.

Wet Meadows and Shallow Marshes

Wet meadows may have surface water only early in the growing season and are typically saturated into the latter part of the summer. Wet meadows in the study area are dominated by reed canarygrass (*Phalaris arundinacea*), sedges, other grasses and forbs. Shallow marshes typically have at least 6 inches of surface water throughout the growing season, and in the study area are dominated by cattail species (*Typha sp.*). Many field-side and roadside ditches traverse the area (see discussion of lateral effect), and, where these areas also exhibit the characteristics of wetlands, they were classified as wet meadows or shallow marshes, depending upon the predominant vegetation and depth of water present.

Wetland boundaries were identified during off-site review using the LiDAR elevation data correlated to repeated signatures of wetness, and verified with the on-site ground-truth review. The hydric soil field indicators observed include A12 – Thick Dark Surface and F6 – Redox Dark Surface, while the hydrology indicators observed include D2 - Geomorphic Position, A3 – Saturation, and, during the off-site review, B7 – Inundation Visible on Aerial Imagery and C9 – Saturation Visible on Aerial Imagery.

Shallow Open Water

In the North Dakota Diversion study area, there are a few shallow open water basins, where standing water from 3 to 6 feet is normally present throughout the growing season. Most of these areas appear to be excavated ponds, some of which are used as stormwater retention basins, except for one small pond adjacent to the Wild Rice River. There is one shallow open water area in the Minnesota Diversion study area just south of Interstate 94, which is a MnDOT mitigation area/stormwater basin. No sample points were taken at these locations; they are distinct features on the landscape with easily discernible topographic breaks.

Functional Assessment Discussion

Wetlands in this area have been significantly impacted by agricultural practices, including drainage, tillage and loss of the natural vegetation. The wet meadow, shallow marsh and floodplain forest areas, although usually left untouched by direct tillage, have been affected by the agricultural runoff containing sediment.

Wetlands found within those active agricultural lands provide limited levels of functionality within this environment due to the extensive drainage and overall alteration that has taken place in the region. The majority of wetlands within the review area are depressional field ditches and depressional isolated wetlands of the farmed, seasonally flooded basin type (see photos on Figures LPP 1-4 of 4 in Appendix A). Due to the extensive drainage systems, these seasonally flooded wetlands generally provide low function for Maintenance of Hydrologic Regime and Maintenance of Wetland Water Quality. Because the wetlands are found within agricultural fields, they also function at a low level in Maintenance of Character of Wildlife Habitat, and Aesthetics/Recreation/Education/Cultural benefit. Without natural vegetation, there is no opportunity to provide wildlife habitat and the wetlands don't provide any aesthetic or recreational 'value' to the human landscape.

The depressional wetland areas within agricultural fields do, however, generally provide moderate to high functionality for Flood/Storm-water Attenuation and also for Downstream Water Quality. Those wetlands that have been shaped into shallow field ditches provide a moderate level of flood/stormwater attenuation because they are able to hold some of the water on the landscape for at least a short period of time. Shallow isolated depressional wetlands provide a high level of functionality for flood/stormwater attenuation, as they are able to hold the water on the landscape until it can evaporate or infiltrate, rather than run off to nearby over-stressed water courses. All field wetlands provide a moderate level of functionality for protection of downstream water quality because they are able to filter at least some of the nutrients from the agricultural runoff before the water enters nearby waterways. The depressional wetlands generally do not provide any level of function for amphibian or fish habitat or shoreline protection, therefore functional analysis was not applicable in these areas.

Note: As previously stated, locations of forested wetland resources were not identified for this report. All forested resources, including forested wetlands, were identified and assessed under a separate section of the FEIS, therefore they were not included in this effort. However, a brief statement of floodplain forest functionality is included for reference. Floodplain forest wetlands provide a moderate level of functionality for maintenance of the hydrologic regime, as they are able to gradually feed the river system with water stored in the soils following flood events. The forested floodplains also provide a moderate level of shoreline protection and floodwater resistance by increasing the surface roughness resulting in an increased detention of high flows and reduced erosion, and ultimately reducing peak flows downstream. In addition, the forest canopy provides the wetland with the opportunity to provide a moderate level of function for wildlife habitat.

Conclusion

Based upon a preponderance of the evidence collected during both off-site and on-site review, extensive wetland areas exist throughout the Diversion corridors, as shown on Figures LPP 1-4 of 4 and FCP 1-3 of 3 in Appendix A and summarized in Table 4.

Data Sources:

Web Soil Survey. U.S.D.A. SSURGO Data obtained from: http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

Wetland Delineation Precipitation Data Retrieval, website developed by the Minnesota Climatology Working Group (http://climate.umn.edu/wetland/)

Literature Referenced/Technical Documents:

Environmental Laboratory. 1987. *1987 U.S. Army Corps of Engineers Wetlands Delineation Manual*. Technical Report Y-87-1, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

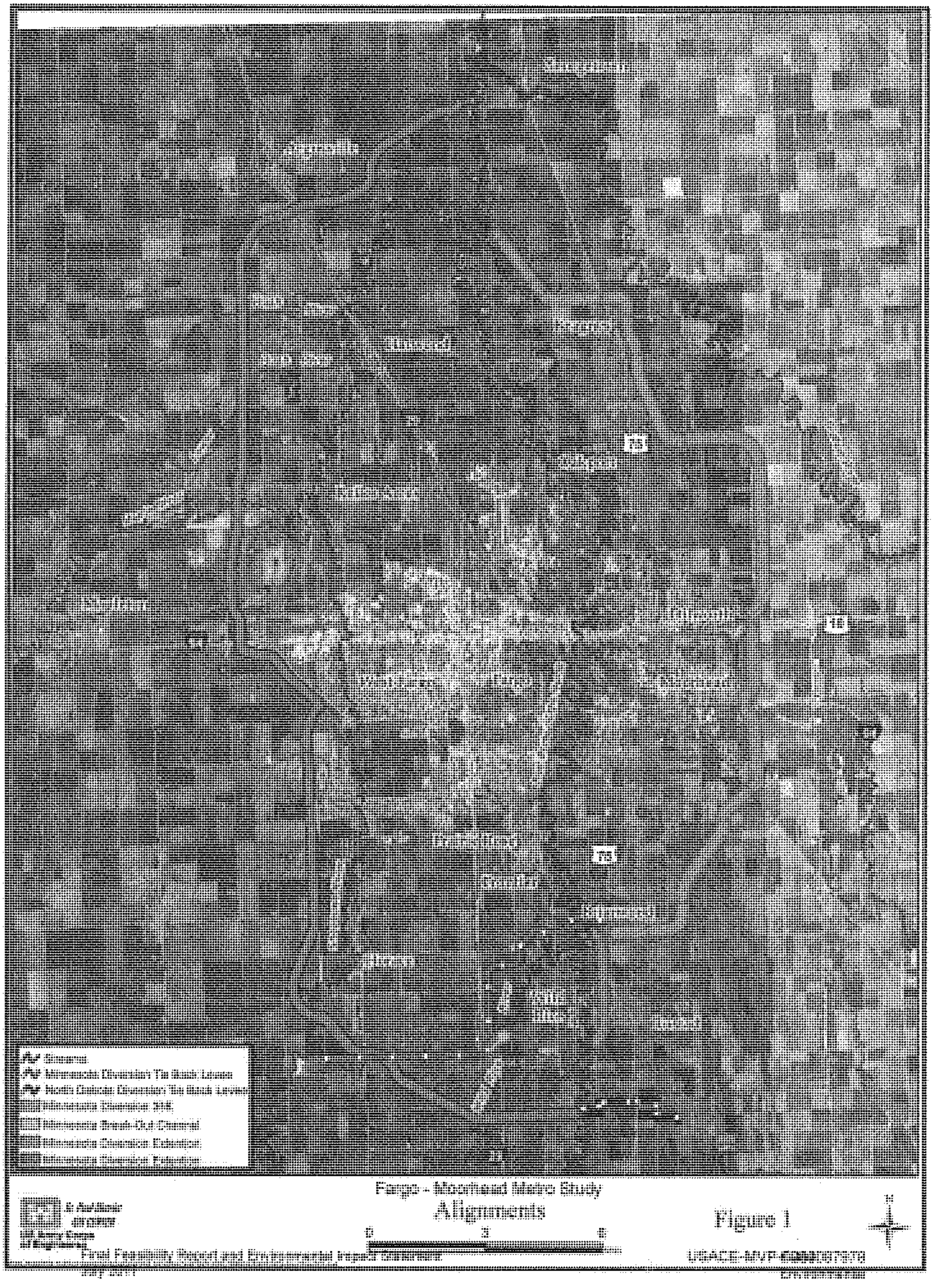
U.S. Army Engineer Research and Development Center. 2010. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region*. US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Eggers, Steve D. and Donald M. Reed. 1997. *Wetland Plants and Plant Communities of Minnesota and Wisconsin*. US Army Corps of Engineers, St. Paul District. 263pp, unclassified.

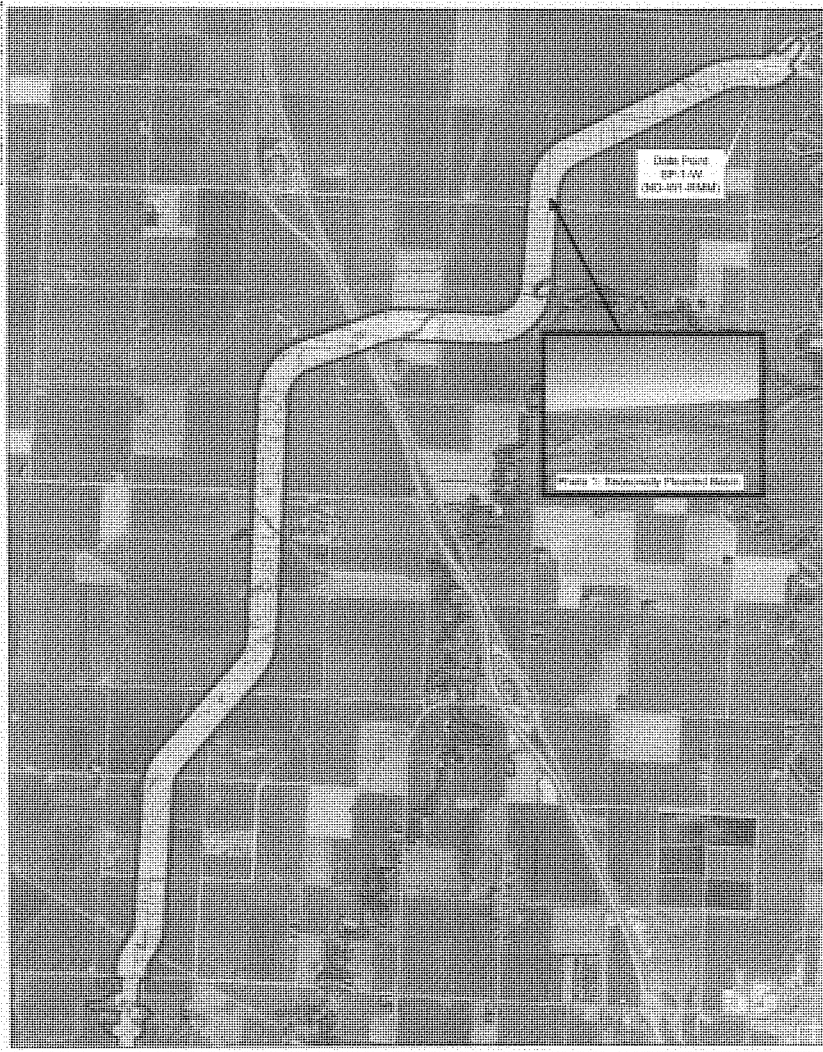
Appendix A

Figures

Figure 1: Fargo-Moorhead Metro Study - Alignments
Figures LPP 1 through 4 of 4: North Dakota Wetland Areas, including on-site photos
Figures FCP 1 through 3 of 3: Minnesota Wetland Areas


Fargo - Moorhead Metro Study
Alignments
Figure 1

Fargo Moorhead Flood Risk Reduction Project
LPP 1 of 4



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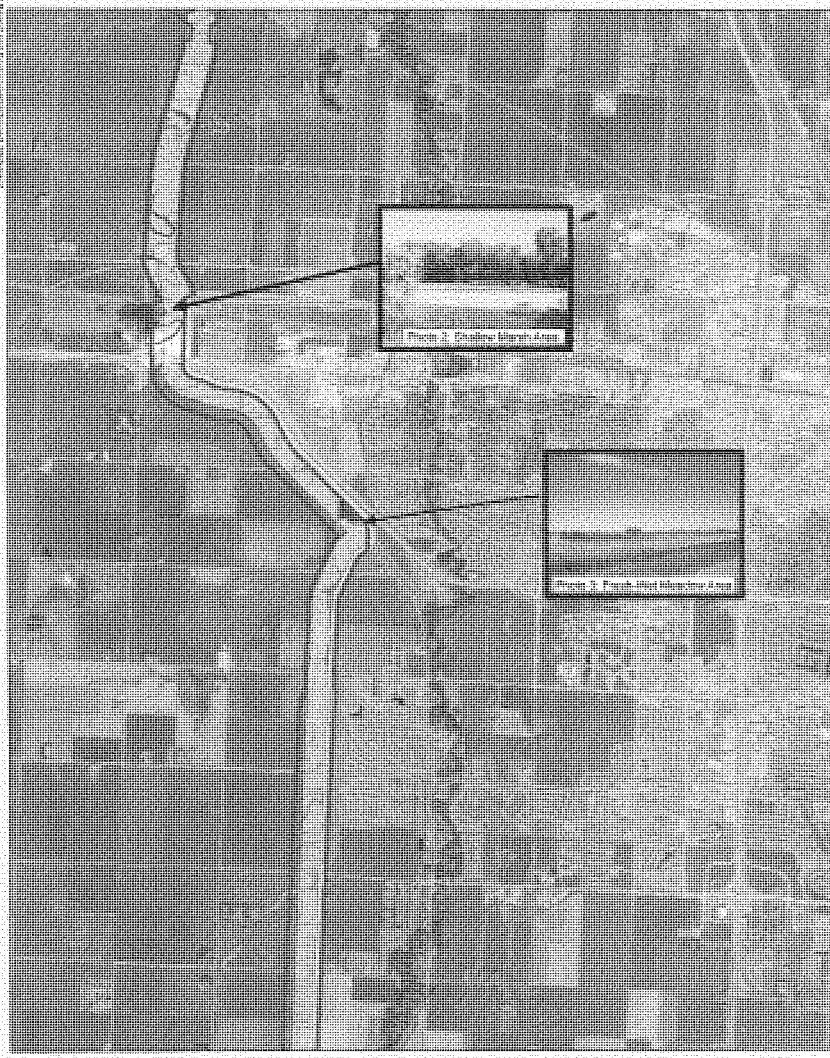
Fargo Moorhead Flood Risk Reduction Project
(North Dakota Diversion Page 2 of 4)



0 0.5 1 2
Miles

N
W E
S

Permanent Easement Area
Diversion footprint 1450ft Buffer

Wetland Type
Seasonally Flooded Basin
Shallow Marsh
Shallow Open Water
Wet Meadow

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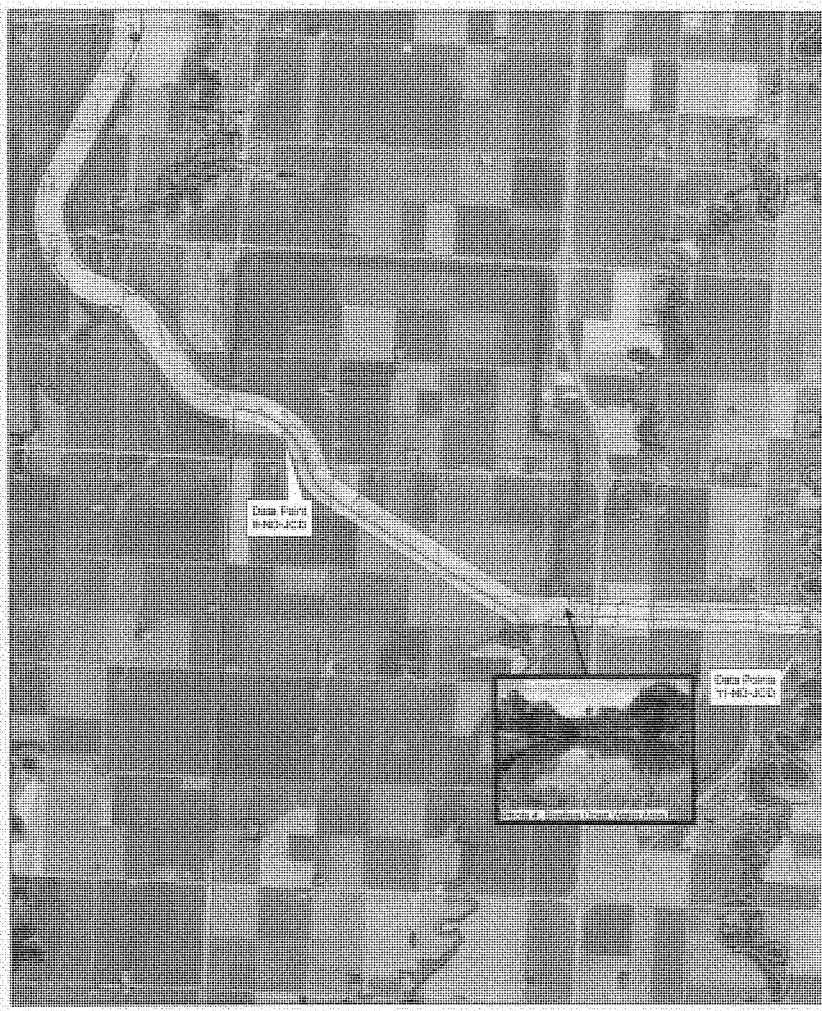
3/30/2011

Fargo Moorhead Flood Risk Reduction Project
(LPP Page 3 of 4)



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Fargo Moorhead Flood Risk Reduction Project
(LPP Page 4 of 4)

Fargo Moorhead Flood Risk Reduction Project
FCP 1 of 3

Wetland_Areas

Type

- Seasonally Flooded Basin
- Shallow Marsh
- Shallow Open Water
- Wet Meadow
- MN_West_Diversion_Footprint

0 0.5 1 2

Miles

N
W E
S

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Fargo Moorhead Flood Risk Reduction Project
FCP 2 of 3

0 0.5 1 2
Miles

N
W E
S

Wetland Type
Seasonally Flooded Basin
Shallow Marsh
Shallow Open Water
Wet Meadow

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FCP 3 of 3

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0 0.5 1 2
Miles

N
W E
S

Wetland Type
Seasonally Flooded Basin
Shallow Open Water

Final Feasibility Report and Environmental Impact Statement
July 2011

USACE-MVP-P000087978
Environmental

Appendix B

USDA Official Series Descriptions (OSDs) for Predominant (>10% area) Project Area Soils:

Bearden
Colvin
Fargo
Hegne

LOCATION BEARDEN ND+MN SD

Established Series
KWT-CJH
11/2002

BEARDEN SERIES

The Bearden series consists of very deep, somewhat poorly drained, moderately to slowly permeable soils that formed in calcareous silt loam and silty clay loam lacustrine sediments. These soils are on glacial lake plains and have slopes of 0 to 3 percent. Mean annual air temperature is 39 degrees F, and mean annual precipitation is 18 inches.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, frigid Aeric Calciaquolls

TYPICAL PEDON: Bearden silty clay loam on a plane slope of less than 1 percent under cropland. When described the soil was moist throughout. (Colors are for moist soil unless otherwise stated)

Ap--0 to 7 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; moderate very fine subangular blocky structure parting to moderate fine granular; very hard, friable, slightly sticky and slightly plastic; common fine roots; many fine pores; few threads of carbonates; strong effervescence (8 percent calcium carbonate); slightly alkaline; abrupt smooth boundary. (Combined A horizons 6 to 14 inches thick)

ABk--7 to 18 inches; dark gray (10YR 4/1) and very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) and dark gray (10YR 4/1) dry, gray (10YR 6/1) dry in the lower part; weak coarse and medium subangular blocky structure; very hard, friable, sticky and plastic; common fine roots; many fine pores; few fine masses of carbonates; disseminated carbonates throughout with the amount increasing with depth; violent effervescence (15 to 20 percent calcium carbonate); moderately alkaline; clear irregular boundary. (0 to 14 inches thick)

Bk1--18 to 28 inches; light olive brown (2.5Y 5/4) silty clay loam, light yellowish brown (2.5Y 6/4) dry; moderate medium and fine subangular blocky structure; hard, friable, sticky and plastic; few fine roots; many fine pores; violent effervescence (25 percent calcium carbonate); moderately alkaline; clear wavy boundary.

Bk2--28 to 36 inches; olive brown (2.5Y 4/4) silty clay loam, light yellowish brown (2.5Y 6/4) dry; few fine prominent gray (5Y 5/1) and few fine and medium prominent very dark brown (10YR 2/2) redoximorphic depletions; weak coarse subangular blocky structure parting to moderate fine and very fine subangular blocky; hard, friable, sticky and plastic; few fine pores; few masses of carbonates; violent effervescence (15 percent calcium carbonate); moderately alkaline; clear wavy boundary. (Combined Bk horizons 0 to 54 inches thick)

C1--36 to 46 inches; light olive brown (2.5Y 5/4) laminated silty clay loam, light yellowish brown (2.5Y 6/4) dry; common medium and fine prominent gray (5Y 5/1) redoximorphic depletions and common medium faint dark yellowish brown (10YR 4/4) redoximorphic concentrations; few black non-manganese spots; massive; very hard, friable, sticky and plastic; masses of gypsum crystals; few masses of carbonates; strong effervescence (15 percent calcium carbonate); moderately alkaline; gradual wavy

boundary.

C2--46 to 60 inches; light olive brown (2.5Y 5/4) laminated silty clay loam; light yellowish brown (2.5Y 6/4) dry; common prominent gray (5Y 5/1) redoximorphic depletions and many fine and medium distinct dark yellowish brown (10YR 4/4) and prominent strong brown (7.5YR 5/6) redoximorphic concentrations; massive; very hard, firm, sticky and plastic; few masses of carbonates; strong effervescence (15 percent calcium carbonate); slightly alkaline.

TYPE LOCATION: Pembina County, North Dakota, about 2 miles north and 3 miles east of St. Thomas; 640 feet east and 160 feet south of the northwest corner, sec. 29, T. 160 N., R. 52 W.

RANGE IN CHARACTERISTICS: The mollic epipedon ranges from 7 to 20 inches thick. The soil is slightly alkaline or moderately alkaline. Saline phases are recognized.

The Ap or A horizon has hue of 10YR, 2.5Y, 5Y, or is neutral, value of 2 or 3 and 3 to 5 dry, and chroma of 1 or less. It typically is silty clay loam but some is loam, silt loam, clay loam or silty clay. The A horizon contains 1 to 10 percent carbonates. Some pedons have tongues of A horizon extending into Bk horizon.

The ABk horizon has hue of 10YR, 2.5Y or is neutral, value of 2 to 5 and 3 to 6 dry, and chroma of 2 or less. It is silt loam or silty clay loam. It is slightly alkaline or moderately alkaline.

The Bk horizon has hue of 10YR, 2.5Y, or 5Y, value of 3 to 7 and 5 to 7 dry, and chroma of 1 to 4. It is silt loam or silty clay loam. It contains 15 to more than 30 percent carbonates. Most of this is disseminated. Some pedons contain few or common, faint to prominent redoximorphic features in this horizon. Some pedons have Bky or BCk horizons.

The C horizon has hue of 2.5Y or 5Y, value of 4 to 7 and 5 to 8 dry, and chroma of 2 to 4. In some pedons below 30 inches the hue is neutral and the chroma is 1 or less. The texture of the C horizon typically is silty clay loam or laminated silt loam and silty clay loam. In some pedons below a depth of 40 inches the textures range from gravelly coarse sand to clay. Some pedons do not have a C horizon within a depth of 60 inches.

COMPETING SERIES: These are the Cubden, Gunclub, McIntosh and Saunders series (it is assumed the Cubden series is competing pending on update in the classification). Cubden and McIntosh soils formed in a silt mantle over glacial till and have 2C horizons containing 15 percent fine sand and coarser. Gunclub soils have clay till within depths of 40 to 60 inches. Saunders soils are poorly drained and have silty clay and clay textures within a depth of 40 inches.

GEOGRAPHIC SETTING: Bearden soils are on level and nearly level glacial lake plains. Slopes are 0 to 3 percent. The soils formed in calcareous silt loam and silty clay loam lacustrine sediments. The climate is cool, subhumid. The mean annual air temperature ranges from 36 to 45 degrees F, and the mean annual precipitation from 15 to 24 inches. Frost-free period ranges from 90 to 145 days. Elevation ranges from 650 to 2000 feet above sea level.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Antler, Beotia, Colvin, Gardena, Glyndon, Hegne, Overly and Perella soils. Antler soils are on adjacent interbeach areas where lake sediments are moderately deep over till. They are fine-loamy. Beotia, Colvin, Overly and Perella soils are in a drainage sequence with Bearden soils. Beotia and Overly soils are at higher elevations in the lake plain. They do not have calcic horizons within depths of 16 inches and have Bw horizons. Colvin

and Perella soils are in swales and lower lying flats and basins. Colvin soils are poorly drained. Perella soils do not have calcic horizons within a depth of 16 inches. Glyndon soils are on adjacent areas. They are coarse-silty. Gardena soils are on nearby lake plains at higher elevations. They do not have calcic horizons within depths of 16 inches and are coarse-silty. Hegne soils are on adjacent lake plains. They are fine.

DRAINAGE AND PERMEABILITY: Somewhat poorly drained. Runoff is negligible to high. Permeability is slow to moderate. A seasonal high water table is at depths of 1.5 to 3.5 feet at some time during the period of April through June.

USE AND VEGETATION: Soils are nearly all cropped to small grains and row crops such as sugar beets. Native vegetation was big bluestem, switchgrass, western wheatgrass, and a variety of forbs.

DISTRIBUTION AND EXTENT: The Red River Valley in eastern North Dakota and northwestern Minnesota, and in glacial lake plains in northeastern South Dakota and central North Dakota. The series is of large extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Bismarck, North Dakota

SERIES ESTABLISHED: Ransom County, North Dakota, 1906.

REMARKS: Diagnostic horizons and features recognized in this pedon are: mollic epipedon - the zone from the surface of the soil to the depth of 7 inches (Ap horizon); calcic horizon the zone from 7 to 36 inches (ABk, Bk1, and Bk2 horizons); characteristics associated with wetness - calcic horizon (ABk, Bk1, and Bk2 horizons).

Were the soil has previously correlated as moderately well drained it should be recorrelated to the Rondell series (Aquic Calciudolls).

ADDITIONAL DATA: Type location laboratory data S54NDak-34-1; additional data ND51-P-6, S53ND-9-5, S53ND-9-6, S57ND-18-1, and S54ND-34-2.

National Cooperative Soil Survey
U.S.A.

LOCATION COLVIN ND+MN MT SD

Established Series
CJH
06/2001

COLVIN SERIES

The Colvin series consists of very deep, poorly and very poorly drained, moderately to slowly permeable soils formed in silt loam and silty clay loam sediments. These soils are in concave shallow swales and depressions on glacial lake plains, in outwash channels, on stream terraces and in drainageways on till plains. Slope ranges from 0 to 2 percent. Mean annual air temperature is 41 degrees F and mean annual precipitation is 18 inches.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, frigid Typic Calciaquolls

TYPICAL PEDON: Colvin silty clay loam on a level concave slope less than 1 percent under native grass. When described the soil was moist throughout. (Colors are for moist soil unless otherwise stated)

A--0 to 10 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak coarse prismatic structure parting to moderate medium granular; hard, friable, sticky and plastic; many roots; many fine pores; strong effervescence; slightly alkaline; clear wavy boundary. (6 to 16 inches thick)

Bkg1--10 to 20 inches; gray (5Y 6/1) and olive gray (5Y 5/2) silty clay loam, gray (N 6/0) and white (N 8/0) dry; very weak medium subangular blocky structure parting to weak fine granular; hard, friable, slightly sticky and plastic; common roots; common fine pores; few masses of carbonates; violent effervescence; moderately alkaline; gradual wavy boundary.

Bkg2--20 to 30 inches; light olive gray (5Y 6/2) and olive gray (5Y 5/2) silty clay loam, light gray (5Y 7/1) and gray (5Y 6/1) dry; common medium prominent light olive brown (2.5Y 5/6) redoximorphic concentrations; very weak fine subangular blocky structure; hard, friable, slightly sticky and plastic; few roots; common pores; strong effervescence; moderately alkaline; gradual wavy boundary. (Combined Bkg horizons 8 to 54 inches thick)

Cg--30 to 60 inches; olive gray (5Y 5/2) silty clay loam, light gray (5Y 7/2) dry; many coarse prominent yellowish brown (10YR 5/8) and few medium prominent yellowish red (5YR 5/6) redoximorphic concentrations; massive; hard, friable, sticky and plastic; strong effervescence in upper part, gradually decreases to slight effervescence at 50 inches; moderately alkaline.

TYPE LOCATION: LaMoure County, North Dakota; about 1 mile south and 2 miles east of Marion; about 75 feet north and 65 feet east of the southwest corner, sec. 18, T. 136 N., R. 60 W.

RANGE IN CHARACTERISTICS: The mollic epipedon ranges from 7 to 24 inches in thickness. The top of the calcic horizon is at depths of less than 16 inches. In some pedons the lower part of the mollic epipedon is part of the calcic horizon. The 10- to 40-inch particle-size control section typically has 20 to 30 percent noncarbonate clay and ranges from 18 to 35 percent. It contains less than 15 percent fine sand and coarser. Saline phases are recognized.

The A horizon has hue of 10YR, 2.5Y, 5Y or is neutral, value of 2 or 3 and 3 or 4 dry, and chroma of 1 or less. It typically is silt loam or silty clay loam, but the range includes clay loam and silty clay. It is neutral to moderately alkaline. Some pedons have an Ak or ABk horizon. Where present they have hue similar to the A horizon, and value of 3 or 4 and 4 to 6 dry, and chroma of 1 or 2.

The Bkg or Bk horizon has hue of 10YR, 2.5Y, 5Y or is neutral, value of 3 to 7 and 5 to 8 dry, and chroma of 2 or less. Chroma of 3 is allowed below a depth of 30 inches. It is silt loam or silty clay loam, but clay loam is allowed below a depth of 25 inches. It is slightly alkaline to strongly alkaline. It typically has a calcium carbonate equivalent of 20 to 50 percent. Some pedons have Bky, Bkz or BC horizons.

The Cg horizon has hue of 2.5Y or 5Y, value of 3 to 6 and 5 to 7 dry, and chroma of 1 to 4. It is silt loam or silty clay loam, but clay loam is allowed below a depth of 25 inches. The Cg horizon below depths of 40 inches typically has similar textures. However, in some pedons the texture ranges from sand to clay below a depth of 40 inches. The Cg horizon is massive, laminated or has weak grades of blocky structure. It typically contains few to many redoximorphic features with chroma of 3 to 8. It is slightly alkaline or moderately alkaline. Crystals of gypsum and other soluble salts are in some pedons. Some pedons do not have a C horizon within a depth of 60 inches.

COMPETING SERIES: These are the Bear Lake, Colake, Ojata, Regan and Winger series. Bear Lake soils have sola more than 60 inches thick and have lime nodules in the Bkg horizon. Colake soils do not have redoximorphic features within a depth of 40 inches. Ojata soils are strongly saline with conductivity exceeding 16 mmhos/cm. Regan soils contain more than 15 percent fine sand or coarser in the lower half of the control section. Winger soils have loamy glacial till in the lower part of the control section.

GEOGRAPHIC SETTING: Colvin soils are in level concave shallow swales and depressions on glacial lake plains, in outwash channels, on stream terraces and in drainageways on till plains. Slopes are 0 to 2 percent. The soils formed in silt loam and silty clay loam sediments. The mean annual air temperature ranges from 36 to 48 degrees F, and mean annual precipitation from 15 to 25 inches. Frost-free period ranges from 90 to 145 days. Elevation ranges from 650 to 2000 feet.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Ojata soils and Antler, Bearden, Borup, Gardena, Hegne, Lamoure, Overly, Perella and Rauville soils. Ojata soils are on nearby saline swales and depressions. Antler soils are on nearby interbeach areas. They are fine-loamy and have 2C horizons within depths of 20 to 40 inches of firm glacial till. Bearden, Overly and Perella soils are in a drainage sequence with Colvin soils. Bearden and Overly soils are on higher elevations. Overly soils have Bw horizons and do not have carbonates or calcic horizons within depths of 16 inches. Borup soils are on nearby lake plains where sediments contain less clay and more very fine sand. Hegne soils are on nearby lake plains where sediments are clays. Lamoure and Rauville soils are on nearby bottom lands and flood plains of outwash valleys and streams. Perella soils are on similar landscapes as Colvin soils. Perella soils do not have calcic horizons within depths of 16 inches.

DRAINAGE AND PERMEABILITY: Poorly and very poorly drained. Runoff ranges from negligible to medium depending on slope and surface texture. Water runs onto these soils and ponds for a time during wet seasons. The soils commonly are too wet to cultivate unless drained. Soils on stream terraces occasionally flood from stream overflow. Permeability is moderate to slow. An apparent seasonal high water table is at a depth of 0.0 to 1.5 feet at some time during the period of March through July in the poorly drained phase. It is at a depth of 1 foot above the surface to 1 foot below the surface at some time during the period of November through July in the very poorly drained phase.

USE AND VEGETATION: Soils are cropped to small grains. Undrained areas are used for pasture and hay. Native vegetation is slim sedge, wooly sedge, prairie cordgrass, and a variety of forbs and other sedges.

DISTRIBUTION AND EXTENT: Central and eastern North Dakota, western Minnesota and northeastern South Dakota. The soil is of large extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Bismarck, North Dakota

SERIES ESTABLISHED: Sargent County, North Dakota, 1961.

REMARKS: Diagnostic horizons and features recognized in this pedon are: mollic epipedon - the zone from the surface of the soil to a depth of 10 inches (A horizon); calcic horizon - the zone from 10 to 30 inches (Bkg1 and Bkg2 horizon); characteristics associated with wetness - calcic horizon (Bkg1 and Bkg2 horizons).

ADDITIONAL DATA: S66NDak-14-2; S66NDak-14-7; S66NDak-14-8; S67NDak-50- 3; S67NDak-50-4.

National Cooperative Soil Survey
U.S.A.

LOCATION FARGO ND+MN MT

Established Series
NDP-CJH
03/2005

FARGO SERIES

The Fargo series consists of very deep, poorly drained and very poorly drained, slowly permeable soils that formed in calcareous, clayey lacustrine sediments. These soils are on glacial lake plains, floodplains, and gently sloping side slopes of streams within glacial lake plains. Slopes range from 0 to 6 percent. Mean annual air temperature is 42 degrees F, and mean annual precipitation is 19 inches.

TAXONOMIC CLASS: Fine, smectitic, frigid Typic Epiaquerts

TYPICAL PEDON: Fargo silty clay on a level plane slope of less than 1/10 percent under cropland. When described the soil was dry from 0 to 8 inches and moist from 8 to 60 inches. (Colors are for moist soil unless otherwise stated)

Ap--0 to 8 inches; black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; moderate fine subangular blocky structure parting to strong fine granular; very hard, blocks friable, granules firm, very sticky and very plastic; many fine roots; many fine pores; neutral (pH 7.2); abrupt smooth boundary. (Combined A horizons 5 to 15 inches thick)

Bw--8 to 13 inches; black (10YR 2/1) and very dark gray (10YR 3/1) crushed and rubbed silty clay, very dark gray (10YR 3/1) and dark gray (10YR 4/1) crushed and rubbed, dry; moderate medium subangular blocky structure parting to strong very fine angular blocky; extremely hard, firm, very sticky and very plastic; many fine roots; many fine pores; faces of peds have shiny waxy sheen when moist; cracks filled with A material throughout; neutral (pH 7.0); abrupt wavy boundary.

Bss--13 to 21 inches; very dark gray (2.5Y 3/1) and very dark grayish brown (2.5Y 3/2) silty clay, gray (2.5Y 5/1) and dark grayish brown (2.5Y 4/2) dry; dark grayish brown (2.5Y 4/2) crushed and rubbed, grayish brown (2.5Y 5/2) dry; few fine prominent yellowish brown (10YR 5/6) redoximorphic concentrations; moderate coarse prismatic structure parting to strong fine and very fine angular blocky; extremely hard, firm, very sticky and very plastic; common fine roots; common pores; slickensides on vertical faces of peds; faces of blocks have waxy sheen when moist; slight effervescence in lower part, noneffervescent on tongues; cracks filled with A material throughout; slightly alkaline (pH 7.6); abrupt irregular boundary. (Combined Bw and Bss horizons 8 to 27 inches thick)

Bkg--21 to 32 inches; olive gray (5Y 5/2) silty clay, light gray (5Y 7/2) dry; common fine prominent dark yellowish brown (10YR 4/6) redoximorphic concentrations; weak medium subangular blocky structure parting to moderate fine angular blocky and granular; hard, friable, sticky and plastic; few roots; common fine pores; cracks filled with A material extend into this horizon; common fine masses of carbonates; strong effervescence; moderately alkaline (pH 8.0); clear wavy boundary. (0 to 26 inches thick)

Cg1--32 to 48 inches; grayish brown (2.5Y 5/2) silty clay, light gray (2.5Y 7/2) dry; common medium distinct brown (10YR 4/3) redoximorphic concentrations and gray (5Y 5/1) redoximorphic depletions;

weak medium subangular blocky structure parting to moderate very fine angular blocky and granular; very hard, firm, very sticky and very plastic; few fine roots; common pores; strong effervescence; moderately alkaline (pH 8.0); gradual wavy boundary.

Cg2--48 to 68 inches; olive (5Y 4/3) and pale olive (5Y 6/3) silty clay, pale olive (5Y 6/3) and pale yellow (5Y 8/3) dry; many medium prominent dark yellowish brown (10YR 4/4) redoximorphic concentrations; laminated, fractures to moderate very fine blocky structure; very hard, firm, very sticky and very plastic; few medium masses of carbonates; slight effervescence; moderately alkaline (pH 8.0); gradual wavy boundary.

Cg3--68 to 80 inches; pale olive (5Y 6/3) silty clay; pale yellow (5Y 8/3) dry; common medium prominent dark yellowish brown (10YR 4/4) redoximorphic concentrations; laminated, fractures to moderate very fine subangular blocky structure; very hard, firm, very sticky and very plastic; common medium masses of carbonates; few fine masses of iron-manganese; slight effervescence; moderately alkaline.

TYPE LOCATION: Traill County, North Dakota; about 9 miles south and 6 miles east of Hillsboro; 1170 feet south and 410 feet east of the northwest corner, sec. 29, T. 144 N., R. 49 W. Latitude 47 degrees, 15 minutes, 42.7 seconds N, Longitude 96 degrees, 55 minutes, 13.5 seconds W. Halstad SW, ND USGS 7.5 minute quadrangle.

RANGE IN CHARACTERISTICS: The 10- to 40-inch particle size control section averages between 40 and 60 percent clay and less than 15 percent fine sand and coarser. It is free of rock fragments. The mollic epipedon ranges from 8 to 40 inches in thickness. The depth to carbonates ranges from 11 to 42 inches. Saline phases are recognized.

The A horizon has hue of 10YR, 2.5Y, 5Y or is neutral, value of 2 and 3 or 4 dry, and chroma of 1 or less. It is clay, silty clay or silty clay loam. It is neutral or slightly alkaline.

The Bw and Bss horizons have hue of 10YR, 2.5Y or 5Y, value of 2 to 4 and 3 to 5 dry, and chroma of I or 2. They are clay, silty clay or silty clay loam. It is neutral to moderately alkaline. They typically have weak or moderate prismatic structure which parts to strong fine and very fine blocky structure. Some pedons do not have the prismatic structure. Slickensides and shiny, waxy surfaces of peds are common. Cracks filled with A material commonly extend through the Bw and Bss horizons and range from l/2 inch to 5 inches in width. Some pedons have a Bg horizon.

The Bkg horizon has hue of 10YR, 2.5Y or 5Y, value of 3 to 6 and 5 to 8 dry, and chroma of 1 or 2. It is clay, silty clay or silty clay loam. It is moderately alkaline. It contains 10 to 25 percent calcium carbonate equivalent diffused or in masses. Where it has more than 15 percent calcium carbonate equivalent, it does not have more than 5 percent as masses or decrease by more than 5 percent in a lower horizon.

The Cg horizon has hue of 2.5Y or 5Y, value of 3 to 6 and 5 to 8 dry, and chroma of 1 to 3. It is clay, silty clay or silty clay loam. It is moderately alkaline. It typically contains common to many distinct or prominent low to high chroma redoximorphic features. Some pedons contain gypsum crystals in the Cg horizons. Sediments are laminated in the lower part of the Cg horizon at depths of 36 to 60 inches in most pedons. Some pedons have a 2Cg horizon that is silt loam or sandy below a depth of 40 inches.

COMPETING SERIES: This is the Clearwater series. The Clearwater series has 2 to 8 percent rock fragments throughout and formed in till.

GEOGRAPHIC SETTING: Fargo soils are on level and nearly level glacial lake plains and flood plains and gently sloping side slopes of streams within glacial lake plains. Slope gradients commonly are less than 1 percent but range from 0 to 6 percent. The soils formed in calcareous, clayey lacustrine sediments. The climate is cool subhumid. Mean annual air temperature ranges from 36 to 45 degrees F, and mean annual precipitation from 15 to 23 inches. Most of the moisture falls in the spring and summer. Frost-free period ranges from 90 to 140 days. Elevation above sea level ranges from 650 to 1800 feet.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Bearden, Cashel, Dovray, Grano, Hegne, Ludden, Overly, Ryan and Wahpeton soils. Bearden and Overly soils are on nearby lake plains and are fine-silty. Cashel soils are on floodplains of larger streams and have fine stratification below the Ap horizon. Dovray and Grano soils are in concave swales and depressions on lake plains. Ludden soils are on floodplains of larger streams. Dovray do not have cracks filled with A material that extend through the Bw horizon. Grano and Ludden soils have carbonates at depths of less than 10 inches. Hegne soils are on slight rises and have calcic horizons within depths of 16 inches. They usually are in complex with Fargo soils. Ryan soils are on nearby areas where the lake sediments contain more salts and have natric horizons. Wahpeton soils are on levees and low terraces of large streams, commonly at slightly higher elevations than the lake plain and are moderately well drained.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Poorly drained and very poorly drained. Runoff is negligible to high depending on slope. Saturated hydraulic conductivity is slow. A system of legal drains, section lines, road ditches, and field drains remove surface water from most Fargo soils. A seasonal high water table is at the surface to 3.0 feet below the surface at some time during the period of March through July. It is 1.0 foot above the surface to 2.0 feet below the surface at some time during the period of February through August in the ponded, depressional or very poorly drained phases.

USE AND VEGETATION: The soils are nearly all cropped to small grains, soybeans and sugar beets. Native vegetation is western wheatgrass, Kentucky bluegrass and a variety of forbs.

DISTRIBUTION AND EXTENT: Mainly in the Red River Valley of the North in North Dakota and Minnesota; smaller areas in glaciolacustrine areas and in west-central Montana. The soil is extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Bismarck, North Dakota

SERIES ESTABLISHED: Grand Forks Area, North Dakota, 1902.

REMARKS: Diagnostic horizons and features recognized in this pedon are: mollic epipedon - the zone from the surface of the soil to a depth of 21 inches (Ap, Bw and Bss horizons); Vertisol criteria - cracks filled with A material extend through the Bw and Bss horizons and range from 1/2 to 5 inches in width, slickensides in the 13 to 21 inch layer (Bss horizon); the site will be redescribed in the future to better document the Vertisol criteria.

ADDITIONAL DATA: S51NDak-5-3; S51NDak-5-4; S51NDak-5-8; S51NDak-5-9; S53NDak-9-3; S53NDak-9-4; S54NDak-50-1; S54NDak-50-2; Soil Survey Investigation No. 2, pages 72 to 87. Also S64NDak-9-1; S64NDak-9-4; S64NDak-50-3; S64NDak-50-4; S65NDak-39-1; S65NDak-39-2; S65NDak-39-3; and S65NDak-39-4; and S65NDak-49-1 (Type Location 15 feet to the west of this lab sample) by Soils Department, North Dakota Agriculture Experiment Station.

LOCATION HEGNE MN+MT ND SD

Established Series
HRF-RBH-CJH
03/2005

HEGNE SERIES

The Hegne series consists of very deep, poorly drained soils that formed in clayey calcareous lacustrine sediments on glacial lake plains. These soils have slow or very slow permeability. They have slopes of 0 to 2 percent. Mean annual precipitation is about 20 inches. Mean annual air temperature is about 42 degrees F.

TAXONOMIC CLASS: Fine, smectitic, frigid Typic Calciaquerts

TYPICAL PEDON: Hegne silty clay, from a Hegne-Fargo complex, on a slightly convex slope of about 0.5 percent on a glacial lake plain in a cultivated field. (Colors are for moist soil unless otherwise stated)

Ap-- 0 to 10 inches; black (5Y 2.5/1) silty clay, very dark gray (5Y 3/1) dry; strong fine and medium subangular blocky structure; firm; common fine distinct olive gray (5Y 4/2) redoximorphic depletions; firm; few fine and medium roots; many fine rounded light gray (10YR 7/2) masses of carbonate; slightly effervescent; slightly alkaline (pH 7.6); clear wavy boundary. (7 to 16 inches thick)

Bkssg1-- 10 to 18 inches; about 60 percent olive gray (5Y 4/2), and 40 percent dark gray (5Y 4/1) silty clay; gray (5Y 6/1) and gray (5Y 5/1) dry; moderate medium subangular blocky structure; firm; few fine roots; few distinct intersecting slickensides tilted less than 45 degrees from horizontal; cracks filled with A material 1/4 to 3 inches wide and 2 to 4 feet apart; many fine masses of carbonate; violently effervescent; moderately alkaline (pH 8.4); clear wavy boundary.

Bkssg2-- 18 to 34 inches; olive gray (5Y 5/2) silty clay; light olive gray (5Y 6/2) dry; moderate fine and medium subangular blocky structure; firm; common fine faint dark gray (5Y 4/1) redoximorphic depletions; few very fine roots; few distinct intersecting slickensides tilted less than 60 degrees from horizontal; cracks filled with A material 1/4 to 2 inches wide and 2 to 4 feet apart; many fine masses of carbonate; violently effervescent; moderately alkaline (pH 8.3); clear wavy boundary. (Combined Bkg horizons 10 to 30 inches thick)

Bg-- 34 to 50 inches; olive gray (5Y 4/2) silty clay; weak fine and medium subangular blocky structure; friable; common medium distinct light olive brown (2.5Y 5/4) redoximorphic concentrations; few fine masses of carbonate; violently effervescent; moderately alkaline (pH 8.2); clear wavy boundary. (0 to 20 inches thick)

Cg1--50 to 68 inches; olive gray (5Y 5/2) silty clay; weak fine and medium subangular blocky soil fragments parting to weak fine platy; firm; common medium distinct gray (5Y 5/1) redoximorphic depletions and medium prominent strong brown (7.5YR 4/6) and common fine reddish yellow (7.5YR 6/6) redoximorphic concentrations; few medium carbonate coats on faces of peds; strongly effervescent; moderately alkaline (pH 8.2); clear wavy boundary.

Cg2-- 68 to 80 inches; olive (5Y 5/3) laminated silty clay; laminates part to weak fine platy fragments which part to weak fine subangular blocky fragments; firm; common medium distinct gray (5Y 5/1) redoximorphic depletions and common medium prominent strong brown (7.5YR 5/6) and strong brown (7.5YR 5/8) redoximorphic concentrations; few medium irregular light gray (2.5Y 7/2) carbonate coats on faces of peds; strongly effervescent; moderately alkaline (pH 8.2).

TYPE LOCATION: Marshall County, Minnesota; about 5 miles west and 2 miles north of Stephen; 600 feet south and 2100 feet east of the northwest corner of Sec. 22, T. 157 N., R. 49 W.; USGS STEPHEN quadrangle; Latitude 48 degrees 24 minutes 25 seconds N. and Longitude 96 degrees 59 minutes 22 seconds W.

RANGE IN CHARACTERISTICS: The thickness of the mollic epipedon ranges from 7 to 16 inches. These soils have free carbonates in all parts with calcium carbonate equivalent of 10 to 30 percent throughout. The higher values are in the calcic horizon. The depth to the calcic horizon is less than 16 inches. Typically most pedons do not have rock fragments. The particle-size control section ranges from 40 to 60 percent noncarbonate clay, with an average of 50 percent and less than 5 percent sand. The average linear extensibility is estimated to be about 10.7 centimeters in the upper 40 inches.

The A horizon has hue of 10YR, 2.5Y, 5Y or is neutral, value of 2 or 3, and chroma of 0 or 1. Texture is silty clay, clay or silty clay loam. Effervescence is slight to violent. Reaction is slightly alkaline or moderately alkaline. Tongues of A horizon extend to depths as much as 36 inches in some pedons.

The Bkssg horizon has hue of 2.5Y, 5Y or 10YR, value of 3 to 6, and chroma of 1 or 2. Chroma of 2 is allowed if there are distinct or prominent redoximorphic concentrations. Texture is clay or silty clay. Effervescence is strong or violent. Reaction is slightly alkaline or moderately alkaline.

The Bg horizon has hue of 2.5Y or 5Y, value of 3 to 6, and chroma of 1 or 2. Chroma of 2 is allowed if there are distinct or prominent redoximorphic concentrations. Texture is clay or silty clay. Effervescence is slight to violent. Reaction is slightly or moderately alkaline.

The C horizon has hue of 2.5Y or 5Y, value of 4 to 6, and chroma of 1 to 3. Distinct or prominent high chroma redoximorphic concentrations are present in most pedons. Texture is clay or silty clay. Silty clay loam textures with more than 35 percent noncarbonate clay are allowed. Effervescence is slight to strong. Reaction is slightly alkaline or moderately alkaline. Masses of gypsum crystals are in the B and C horizon in some pedons. Some pedons have sandy 2C horizons below a depth of 40 inches.

COMPETING SERIES: These are in the Reis series. Reis soils have more than 5 percent sand in the particle-size control section and formed in clayey glacial till.

GEOGRAPHIC SETTING: The Hegne soils have slightly convex to slightly concave slopes of less than 2 percent on glacial lake plains and in a few places these soils are on flood plains. These soils commonly are on the higher lying positions of microrelief topography. They formed in clayey lacustrine sediments of Late Wisconsin age. Mean annual air temperature ranges from 38 to 45 degrees F. Mean annual precipitation ranges from 15 to 27 inches. Frost-free days range from 90 to 140. Elevation above sea level ranges from 650 to 1800 feet.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the poorly drained Fargo soils which formed in similar sediments on glacial lake plains soils. The Hegne soils are found in a complex with these associated soils on slightly higher positions. Fargo soils do not contain a calcic horizon within 16 inches of the surface.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Poorly drained. Runoff is low or medium. Saturated hydraulic conductivity is slow or very slow. Depth to an apparent seasonal high water table when undrained is as high as 0.5 to 1.5 feet at some time from April to June in most years.

USE AND VEGETATION: Nearly all of these soils are cultivated. Principal crops are small grains and sugar beets. Native vegetation is tall grass prairie.

DISTRIBUTION AND EXTENT: Principally in the Red River Valley of northwestern Minnesota and eastern North Dakota, also in smaller glacial lake basins in western Minnesota and north-central North Dakota. These soils are extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Bismarck, North Dakota

SERIES ESTABLISHED: Sargent County, North Dakota, 1961.

REMARKS: The classification of these soils is in question as to whether they should be in the Typic or Aeric subgroup of Calciaquerts. This needs further investigation. This series was previously classified in the Typic Calciaquolls subgroup.

Diagnostic horizons and features recognized in this pedon are: mollic epipedon - the zone from the surface to 18 inches (Ap and A portion of A/Bkg horizons); calcic horizon - the zone from 10 to 34 inches (B portion of A/Bkg and Bkg horizons); vertic criteria - slickensides and cracks filled with A material in the zone from 10 to 34 inches (Bkssg1 and Bkssg2 horizons); aquic moisture regime.

ADDITIONAL DATA: Soil Interpretation Record number is MN0053.

National Cooperative Soil Survey
U.S.A.

Appendix C

Wetland Delineation Data Sheets

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: Red River Div. / ND Corridor City/County: / Cass Sampling Date: 07/29/2010
Applicant/Owner: ACOE State: ND Sampling Point: (SP-1-W) ND-WI-RMM
Investigator(s): Greg Larson, Ryan M., M.S. Section, Township, Range: GPS point recorded
Landform (hillslope, terrace, etc.): lake plain Local relief (concave, convex, none): Concave Slope (%): 0-2
Subregion (LRR): F Lat: Long: Datum:
Soil Map Unit Name: Fargo silty clay NWI classification: N/A
Are climatic / hydrologic conditions on the site typical for this time of year? Yes ___ No X (If no, explain in Remarks.)
Are Vegetation X, Soil ___, or Hydrology X significantly disturbed? Are "Normal Circumstances" present? Yes ___ No X
Are Vegetation ___, Soil X, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	Is the Sampled Area within a Wetland? Yes X No ___
Hydric Soil Present?	Yes X	No ___	
Wetland Hydrology Present?	Yes X	No ___	

Remarks: Moderately to high alkaline soils. – Above-normal, wet, antecedent precipitation

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30 ft)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	___ = Total Cover		
Sapling/Shrub Stratum (Plot size: 15 ft)			
1.			
2.			
3.			
4.			
5.			
	___ = Total Cover		
Herb Stratum (Plot size: 5 ft)			
1. Wheat cultivar			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	___ = Total Cover		
Woody Vine Stratum (Plot size: ___)			
1.			
2.			
	___ = Total Cover		

% Bare Ground in Herb Stratum ___

Dominance Test worksheet:
Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC–): ___ (A)
Total Number of Dominant Species Across All Strata: ___ (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: ___ (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	___	x 1 = ___
FACW species	___	x 2 = ___
FAC species	___	x 3 = ___
FACU species	___	x 4 = ___
UPL species	___	x 5 = ___
Column Totals:	___ (A)	___ (B)

Prevalence Index = B/A = ___

Hydrophytic Vegetation Indicators:
___ Dominance Test is >50%
___ Prevalence Index is ≤3.0[1]
___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
X Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ___

Remarks: Ag. field – planted to wheat

SOIL Sampling Point: SP-1-W

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-17	2.5Y 2.5/1						lc	
17-27	2.5Y 3/1						lc	
27-37	2.5Y 5/2		10YR 4/6	3	C	PL	lc	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- X Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ___

Depth (inches): ___

Hydric Soil Present? Yes X No ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- X Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- ___ Crayfish Burrows (C8)
- X Saturation Visible on Aerial Imagery (C9)
- X Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): ___

Water Table Present? Yes ___ No X Depth (inches): ___

Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): ___

Wetland Hydrology Present? Yes X No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: S-ND-JCD City/County: Cass Sampling Date: 7/29/10
Applicant/Owner: ADE State: ND Sampling Point: S-ND-JCD
Investigator(s): JCD, BW, MB Section, Township, Range: GPS point recorded
Landform (hillslope, terrace, etc.): floodplain Local relief (concave, convex, none): Concave Slope (%): 1
Subregion (LRR): F Lat: Long: Datum:
Soil Map Unit Name: Fargo silty clay NWI classification:
Are climatic / hydrologic conditions on the site typical for this time of year? Yes ~~X~~ No X (If no, explain in Remarks.)
Are Vegetation X, Soil X, or Hydrology X significantly disturbed? Are "Normal Circumstances" present? Yes No X
Are Vegetation ___, Soil X, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes X No ___	Is the Sampled Area within a Wetland? Yes X No ___	
Hydric Soil Present? Yes X No ___		
Wetland Hydrology Present? Yes X No ___		

Remarks: Intensive ag field currently in wheat. ~~Patch~~ Wetter than normal antecedent precip. Water course improved as ditch through field

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: N/A)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	= Total Cover		
Sapling/Shrub Stratum (Plot size: N/A)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
Herb Stratum (Plot size: ___)			
1. Wheat *	40		
2. Polygonum lapathifolium	5		FACW
3. Hibiscus trionum	2		UPL
4. – last year's soybeans – weak	2		NI
5. ~~Tra~~ Amaranthus albus	2		FACU
6.			
7.			
8.			
9.			
10.			
	= Total Cover		
Woody Vine Stratum (Plot size: N/A)			
1.			
2.			
	= Total Cover		

% Bare Ground in Herb Stratum 30

Dominance Test worksheet:
Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC–): ___ (A)
Total Number of Dominant Species Across All Strata: N/A (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: ___ (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ___	x 1 = ___
FACW species ___	x 2 = ___
FAC species ___	x 3 = ___
FACU species ___	x 4 = ___
UPL species ___	x 5 = ___
Column Totals: ___ (A)	___ (B)

Prevalence Index = B/A = N/A

Hydrophytic Vegetation Indicators:
___ Dominance Test is >50%
___ Prevalence Index is ≤3.0[1]
___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
X Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No ___

Remarks: Wheat in w/L clearly stressed – shorter, more sparse than in "upper" level of field. Opportunistic weeds.

25 plot – 100% wheat – no NT/water/south 'higher' in landscape

SOIL

Sampling Point: 8-ND-JCD

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
	See profile of plot 1 collected 7/28/10 along waterway at 14-MN-JCD							

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (LRR F)
- ___ 1 cm Muck (A9) (LRR F, G, H)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (LRR G, H)
- ___ 5 cm Mucky Peat or Peat (S3) (LRR F)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- X Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (MLRA 72 & 73 of LRR H)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (LRR I, J)
- ___ Coast Prairie Redox (A16) (LRR F, G, H)
- ___ Dark Surface (S7) (LRR G)
- ___ High Plains Depressions (F16) (LRR H outside of MLRA 72 & 73)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes X No ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) (where not tilled)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- X Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (where tilled)
- ___ Crayfish Burrows (C8)
- X Saturation Visible on Aerial Imagery (C9)
- X Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (LRR F)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): ___ ?? WT surface or water soaking in??

Water Table Present? Yes X No ___ Depth (inches): 6"/9"

Saturation Present? (includes capillary fringe) Yes X No ___ Depth (inches): ___

Wetland Hydrology Present? Yes X No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Recent rains - However - adjacent to waterway thru field visible in most aerials - lateral extent of w/L fringe

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: 11 - ND - JCD - City/County: Cass Sampling Date: 7/28/10
Applicant/Owner: ACE State: ND Sampling Point: ND-11-JCD-wet
Investigator(s): JCD, MB, BW Section, Township, Range: GPS point recorded
Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none): concave Slope (%): 0-2
Subregion (LRR): F Lat: Long: Datum:
Soil Map Unit Name: Cashel silty clay NWI classification: N/A
Are climatic / hydrologic conditions on the site typical for this time of year? Yes ___ No X (If no, explain in Remarks.)
Are Vegetation X, Soil X, or Hydrology X significantly disturbed? Are "Normal Circumstances" present? Yes ___ No X
Are Vegetation ___, Soil X, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓ No ✓	Is the Sampled Area within a Wetland? Yes ✓ No ___
Hydric Soil Present?	Yes ✓ No ___	
Wetland Hydrology Present?	Yes ✓ No ___	

Remarks: Wetter than normal antecedent precip.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. boxelder & tree Acer negundo	20	Y	FACW
2. elm, ~~[illegible]~~ ~~[illegible]~~ Ulmus americana	10	Y	FACW
3.			
4.			
	30 = Total Cover		

Sapling/Shrub Stratum (Plot size: N/A)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		

Herb Stratum (Plot size: 5')			
1. Soybeans - stressed	50%		
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	= Total Cover		

Woody Vine Stratum (Plot size: N/A)			
1.			
2.			
	= Total Cover		

% Bare Ground in Herb Stratum 50%

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC-): 2 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 66 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

✓ Dominance Test is >50%
___ Prevalence Index is ≤3.0[1]
___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
✓ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No ___

Remarks: Soybean field - crop stress

SOIL

Sampling Point: 11-ND-JCD-wet

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-24	10YR 2/1		7.5YR 4/6	2	C	M	SiC	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (LRR F)
- ___ 1 cm Muck (A9) (LRR F, G, H)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (LRR G, H)
- ___ 5 cm Mucky Peat or Peat (S3) (LRR F)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- X Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (MLRA 72 & 73 of LRR H)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (LRR I, J)
- ___ Coast Prairie Redox (A16) (LRR F, G, H)
- ___ Dark Surface (S7) (LRR G)
- ___ High Plains Depressions (F16) (LRR H outside of MLRA 72 & 73)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ___

Depth (inches): ___

Hydric Soil Present? Yes X No ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ✓ Surface Water (A1)
- ✓ High Water Table (A2)
- ✓ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) (where not tilled)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ✓ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (where tilled)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ✓ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (LRR F)

Field Observations:

Surface Water Present? Yes ✓ No ___ Depth (inches): ___

Water Table Present? Yes ✓ No ___ Depth (inches): 6

Saturation Present? (includes capillary fringe) Yes ✓ No ___ Depth (inches): ___

Wetland Hydrology Present? Yes X No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: 11-ND-JCD City/County: Cass / ND Sampling Date: 7/28/10
Applicant/Owner: ACE State: ND Sampling Point: ND-11-JCD UP
Investigator(s): JCD, BW, MB Section, Township, Range: GPS point recorded
Landform (hillslope, terrace, etc.): Terrace Local relief (concave, convex, none): Concave Slope (%): 2
Subregion (LRR): F Lat: Long: Datum:
Soil Map Unit Name: Cashel silty clay NWI classification: N/A
Are climatic / hydrologic conditions on the site typical for this time of year? Yes ___ No X (If no, explain in Remarks.)
Are Vegetation X, Soil X, or Hydrology X significantly disturbed? Are "Normal Circumstances" present? Yes ___ No X
Are Vegetation ___, Soil X, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes ___ No ✓
Hydric Soil Present? Yes X No ___
Wetland Hydrology Present? Yes ___ No ✓

Is the Sampled Area within a Wetland? Yes ___ No ✓

Remarks: Wetter than normal precip in 3 mos prior.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ___)	Absolute % Cover	Dominant Species?	Indicator Status
1. boxelder Acer negundo	20	Y	FACW
2. elm, American	10	Y	FACW
3.			
4.			
	30 = Total Cover		
Sapling/Shrub Stratum (Plot size: ___)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
Herb Stratum (Plot size: ___)			
1. Soybeans	100%		
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	100 = Total Cover		
Woody Vine Stratum (Plot size: ___)			
1.			
2.			
	= Total Cover		

% Bare Ground in Herb Stratum ___

Dominance Test worksheet:
Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): ___ (A)
Total Number of Dominant Species Across All Strata: ___ (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: N/A (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ___	x 1 = ___
FACW species ___	x 2 = ___
FAC species ___	x 3 = ___
FACU species ___	x 4 = ___
UPL species ___	x 5 = ___
Column Totals: ___ (A)	___ (B)

Prevalence Index = B/A = ___

Hydrophytic Vegetation Indicators:
___ Dominance Test is >50%
___ Prevalence Index is ≤3.0[1]
___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ___ No X

Remarks: Healthy soybean crop – Trees at edge of plot, not indicative of wetland in this location.

29 inch hole

SOIL

Sampling Point: 11-ND-JCD-UP

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-18	10YR 3/1		7.5YR 4/6	2%	C	M	SiC	
18-29+	10YR 3/1		7.5YR 4/6	1%	C	M	SiC	caecium carbonate @ 22 inches
			10YR 5/2	1%	D	M		↑ Unconsolidated

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (LRR F)
- ___ 1 cm Muck (A9) (LRR F, G, H)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (LRR G, H)
- ___ 5 cm Mucky Peat or Peat (S3) (LRR F)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ✓ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (MLRA 72 & 73 of LRR H)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (LRR I, J)
- ___ Coast Prairie Redox (A16) (LRR F, G, H)
- ___ Dark Surface (S7) (LRR G)
- ___ High Plains Depressions (F16) (LRR H outside of MLRA 72 & 73)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ___

Depth (inches): ___

Hydric Soil Present? Yes ✓ No ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) (where not tilled)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (where tilled)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (LRR F)

Field Observations:

Surface Water Present? Yes ___ No ___ Depth (inches): ___

Water Table Present? Yes ___ No ___ Depth (inches): ___

Saturation Present? (includes capillary fringe) Yes ___ No ___ Depth (inches): ___

Wetland Hydrology Present? Yes ___ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Soil was notably drier than wetland plot just a few feet away. Soybean crop here showing no stress.

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: 14-MN-JCD City/County: Co Clay Sampling Date: 7-28-10
Applicant/Owner: ACE State: Sampling Point: 14-MN-JCD
Investigator(s): JD, BM, MB Section, Township, Range: GPS point recorded
Landform (hillslope, terrace, etc.): floodplain terrace Local relief (concave, convex, none): none Slope (%): 0-2
Subregion (LRR): F Lat: Long: Datum:
Soil Map Unit Name: Fluvaquents - Haplaquolls complex NWI classification: N/A
Are climatic / hydrologic conditions on the site typical for this time of year? Yes ~~X~~ No X (If no, explain in Remarks.)
Are Vegetation X, Soil X, or Hydrology X significantly disturbed? Are "Normal Circumstances" present? Yes ____ No X
Are Vegetation ____, Soil X, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____
Hydric Soil Present?	Yes X	No ____
Wetland Hydrology Present?	Yes X	No ____

Is the Sampled Area within a Wetland? Yes X No ____

Remarks: Seasonally flooded 'basin' – edge of stream – amidst intensive ag cropping. "Wet" antecedent precip.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: N/A)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	____ = Total Cover		
Sapling/Shrub Stratum (Plot size: N/A)			
1.			
2.			
3.			
4.			
5.			
	____ = Total Cover		
Herb Stratum (Plot size: ____)			
1. Ragweed Amaranthus albus	20%	Y	FACU
2. Crab grass Digitaria sp.	2%	N	NL
3. Giant Ragweed Ambrosia trifida	3%	N	FAC
4. Lambs quarters Chenopodium album	1%	N	FAC
5.			
6.			
7.			
8.			
9.			
10.			
	26 = Total Cover	50: 13 20:	
Woody Vine Stratum (Plot size: N/A)			
1.			
2.			
	____ = Total Cover		

% Bare Ground in Herb Stratum ____

Dominance Test worksheet:
Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC–): ____ (A)
Total Number of Dominant Species Across All Strata: ____ (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: N/A (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	____	x 1 = ____
FACW species	____	x 2 = ____
FAC species	____	x 3 = ____
FACU species	____	x 4 = ____
UPL species	____	x 5 = ____
Column Totals:	____ (A)	____ (B)

Prevalence Index = B/A = N/A

Hydrophytic Vegetation Indicators:
___ Dominance Test is >50%
___ Prevalence Index is ≤3.0[1]
___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
X Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks: Sparsely vegetated concave surface amid wheat field, opportunistic weeds present in sparse abundance

SOIL

Sampling Point: 14-MN-JCD

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 2/1		7.5YR 4/6	2	C	M	SiCl	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (LRR F)
- ___ 1 cm Muck (A9) (LRR F, G, H)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (LRR G, H)
- ___ 5 cm Mucky Peat or Peat (S3) (LRR F)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- X Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (MLRA 72 & 73 of LRR H)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (LRR I, J)
- ___ Coast Prairie Redox (A16) (LRR F, G, H)
- ___ Dark Surface (S7) (LRR G)
- ___ High Plains Depressions (F16) (LRR H outside of MLRA 72 & 73)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ___

Depth (inches): ___

Hydric Soil Present? Yes ___ No ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- X Oxidized Rhizospheres on Living Roots (C3) (where not tilled)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- X Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- X Oxidized Rhizospheres on Living Roots (C3) (where tilled)
- ___ Crayfish Burrows (C8)
- X Saturation Visible on Aerial Imagery (C9)
- X Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (LRR F)

Field Observations:

Surface Water Present? Yes ___ No ___ Depth (inches): ___

Water Table Present? Yes ___ No ___ Depth (inches): ___

Saturation Present? (includes capillary fringe) Yes ___ No ___ Depth (inches): ___

Wetland Hydrology Present? Yes X No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Appendix D

MnRAM Results

Wetland Functional Assessment Summary
Fargo Moorhead Diversion

Wetland Name	WS	SA	Location	Hydrogeomorphology	Maint. of Hydrologic Regime	Flood/ Stormwater/ Attenuation	Downstream Water Quality	Maint. of Wetland Water Quality	Shoreline Protection
MN_W1_MTS	57	4	14-000-00-00-001	Depressional/Isolated (no discernable inlets or outlets)	Low	High	Moderate	Low	Not Applicable
ND_W1_RMM	57	4	00-000-00-00-001	Depressional/Isolated (no discernable inlets or outlets)	Low	High	Moderate	Low	Not Applicable

Wetland Functional Assessment Summary
Fargo Moorhead Diversion

Wetland Name	Location	Maint. of Char. of Wildlife Habitat	Maint. of Char. Fish Habitat	Maint. of Char. Amphibian Habitat	Aesthetics/ Recreation/ Education/ Cultural	Commercial Uses	Ground-Water Interaction	Additional Information: Wetland Restoration Potential	Additional Information: Additional Stormwater Treatment Needs	Additional Information: Wetland Sensitivity to Stormwater and Urban Develop.
MN_W1_MTS	14-000-00-00-001	Low	Not Applicable	Not Applicab	Low	Not Applicable	Combination Discharge, Recharge	Not Applicable	Low	Exceptional
ND_W1_RMM	00-000-00-00-001	Low	Not Applicable	Not Applicab	Low	Not Applicable	Combination Discharge, Recharge	Not Applicable	Low	Exceptional

Wetland Functional Assessment Summary

Wetland Name	Hydrogeomorphology	Maintenance of Hydrologic Regime	Flood/ Stormwater/ Attenuation	Downstream Water Quality	Maintenance of Wetland Water Quality	Shoreline Protection
ND-33 - Wheat Field Drown-o	Depressional/Isolated (no discernable inlets or outlets)	0.20	0.50	0.45	0.17	0.00
		Low	Moderate	Moderate	Low	Not Applicable

							Additional Information		
Wetland Name	Maintenance of Characteristic Wildlife Habitat Structure	Maintenance of Characteristic Fish Habitat	Maintenance of Characteristic Amphibian Habitat	Aesthetics/ Recreation/ Education/ Cultural	Commercial Uses	Ground-Water Interaction	Wetland Restoration Potential	Wetland Sensitivity to Stormwater and Urban Development	Additional Stormwater Treatment Needs
ND-33 - Wheat Field Dr	0.28	0.00	0.00	0.10	0.00	Recharge	0.00	0.10	0.17
	Low	Not Applicable	Not Applicable	Low	Not Applicable		Not Applicable	Exceptional	Low

Wetland Community Summary

		Vegetative Diversity/Integrity							
		Community							
Wetland Name	Location	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating
ND-33 - Wheat Field Drown-o				Seasonally Flooded Basin	0	0.1	0.10	0.10	0.00
							Low	Low	Not Applicable
							0.10	0.10	0.00

☑ *Denotes incomplete calculation data.*

Wetland Functional Assessment Summary
Fargo-Moorhead Red River Diversion

Wetland Name	WS	SA	Location	Hydrogeomorphology	Maint. of Hydrologic Regime	Flood/ Stormwater/ Attenuation	Downstream Water Quality	Maint. of Wetland Water Quality	Shoreline Protection
8-ND-JCD	0	NA	00-138-49-32-001	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed)	Low	Moderate	Moderate	Low	Not Applicable
7-ND-JCD	57	4	00-137-49-04-001	Depressional/Isolated (no discernable inlets or outlets)	Low	High	Moderate	Low	Not Applicable
11-ND-JCD	0	NA	00-137-48-07-001	Floodplain (outside waterbody banks)	Low	Moderate	Moderate	Low	Not Applicable
0-MN-JCD	57	4	14-137-48-07-001	Floodplain (outside waterbody banks)	Moderate	Moderate	Moderate	Moderate	Moderate
14-MN-JCD	57	4	14-137-48-08-001	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	Moderate	Low	Low	Not Applicable
134-ND-JCD	57	4	00-138-49-35-001	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	Moderate	Moderate	Moderate	Not Applicable

Wetland Functional Assessment Summary
Fargo-Moorhead Red River Diversion

									Additional Information	
Wetland Name	*Location*	*Maint. of Char. of Wildlife Habitat*	*Maint.of Char. Fish Habitat*	*Maint. of Char. Amphibian Habitat*	*Aesthetics/ Recreation/ Education/ Cultural*	*Commercial Uses*	*Ground-Water Interaction*	*Wetland Restoration Potential*	*Additional Stormwater Treatment Needs*	*Wetland Sensitivity to Stormwater and Urban Develop.*
8-ND-JCD	00-138-49-32-001	Low	Not Applicable	Not Applicab	Low	Not Applicable	Recharge	Not Applicable	Low	Exceptional
7-ND-JCD	00-137-49-04-001	Moderate	Not Applicable	Not Applicab	Low	Not Applicable	Recharge	Not Applicable	Low	Exceptional
11-ND-JCD	00-137-48-07-001	Low	Not Applicable	Not Applicab	Low	Low	Recharge	Not Applicable	Low	Exceptional
0-MN-JCD	14-137-48-07-001	Moderate	Not Applicable	Not Applicab	Low	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
14-MN-JCD	14-137-48-08-001	Low	Not Applicable	Not Applicab	Low	Low	Recharge	Not Applicable	Low	Exceptional
134-ND-JCD	00-138-49-35-001	Moderate	Not Applicable	Not Applicab	Low	Low	Recharge	Not Applicable	Moderate	Moderate

Wetland Functional Assessment Summary

Wetland Name	Hydrogeomorphology	Maintenance of Hydrologic Regime	Flood/ Stormwater/ Attenuation	Downstream Water Quality	Maintenance of Wetland Water Quality	Shoreline Protection
ND-19 - Shallow Open Water	Depressional/Isolated (no discernable inlets or outlets)	0.33	0.74	0.66	0.39	0.00
		Low	High	High	Moderate	Not Applicable

Wetland Name	Maintenance of Characteristic Wildlife Habitat Structure	Maintenance of Characteristic Fish Habitat	Maintenance of Characteristic Amphibian Habitat	Aesthetics/ Recreation/ Education/ Cultural	Commercial Uses	Ground-Water Interaction	Additional Information: Wetland Restoration Potential	Additional Information: Wetland Sensitivity to Stormwater and Urban Development	Additional Information: Additional Stormwater Treatment Needs
ND-19 - Shallow Open	0.35	0.00	0.10	0.42	0.00	Recharge	0.00	0.00	0.39
	Moderate	Not Applicable	Low	Moderate	Not Applicable		Not Applicable		Moderate

Wetland Community Summary

Wetland Name	Location	Vegetative Diversity/Integrity: Community: Cowardin Classification	Community: Circular 39	Community: Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating
ND-19 - Shallow Open Water							0.00	0.00	0.00
							Not Applicable	Not Applicable	Not Applicable
							0.00	0.00	0.00 ☑

☑ *Denotes incomplete calculation data.*

Wetland Functional Assessment Summary

Wetland Name	Hydrogeomorphology	Maintenance of Hydrologic Regime	Flood/ Stormwater/ Attenuation	Downstream Water Quality	Maintenance of Wetland Water Quality	Shoreline Protection
Proposed Diversion Cond.	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet), Riverine (within the river/stream banks), Floodplain (outside waterbody banks)	0.52	0.62	0.58	0.47	0.72
		Moderate	Moderate	Moderate	Moderate	High

							Additional Information		
Wetland Name	Maintenance of Characteristic Wildlife Habitat Structure	Maintenance of Characteristic Fish Habitat	Maintenance of Characteristic Amphibian Habitat	Aesthetics/ Recreation/ Education/ Cultural	Commercial Uses	Ground-Water Interaction	Wetland Restoration Potential	Wetland Sensitivity to Stormwater and Urban Development	Additional Stormwater Treatment Needs
Proposed Diversion Co	0.73	0.78	0.05	0.54	0.00	Combination Discharge, Recharge	0.00	0.50	0.47
	High	High	Low	Moderate	Not Applicable		Not Applicable	Moderate	Moderate

Wetland Community Summary

		Vegetative Diversity/Integrity							
		Community							
Wetland Name	Location	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating
Proposed Diversion Cond.	00-000-00-00-001	PEMCx	Type 3	Shallow Marsh	15	0.5	0.50	0.50	0.50
							Moderate	Moderate	Moderate
		PEMB	Type 2	Fresh (Wet) Meadow	85	0.5	0.50	0.50	0.50
							Moderate	Moderate	Moderate
					100		0.50	0.50	0.50

☑ *Denotes incomplete calculation data.*

Appendix G
Real Estate

Fargo-Moorhead Metropolitan Area Flood Risk Management

Final Feasibility Report and Environmental Impact Statement

August 2011

US Army Corps of Engineers ®

Prepared by:
U.S. Army Corps of Engineers
St. Paul District
180 Fifth Street East, Suite 700
St. Paul, Minnesota 55101-1678

FARGO – MOORHEAD METRO FEASIBILITY STUDY
Fargo, North Dakota and Moorhead, Minnesota
Appendix G
Real Estate Plan

1. GENERAL DESCRIPTION

This Real Estate Plan is a part of the feasibility report for the Fargo-Moorhead Metropolitan Area Flood Risk Management Study.

The selected plan is the Locally Preferred Plan (LPP), a North Dakota diversion channel with a capacity of 20,000 cfs, with upstream staging. The Federally Comparable Plan (FCP), used for cost sharing purposes, is a Minnesota diversion channel with a capacity of 35,000 cfs.

Without some staging or off-channel storage immediately upstream of the diversion works, a North Dakota diversion channel would result in increased flood levels that could extend to the Canadian border and beyond, with approximately 4,500 structures impacted in the United States. Staging and storing water immediately upstream of the diversion would be limited to a well defined area.

The Fargo-Moorhead Metropolitan Area has a relatively high risk of flooding. The highest river stages usually occur as a result of spring snowmelt, but summer rainfall events have also caused significant flood damages. The Red River of the North has exceeded the National Weather Service flood stage of 18 feet in 48 of the past 109 years, and every year from 1993 through 2011. The study area is between the Wild Rice River (North Dakota), the Sheyenne River, and the Red River of the North; inter-basin flows complicate the hydrology of the region and contribute to extensive flooding. Average annual flood damages in the Fargo-Moorhead Metropolitan Area are currently estimated at over $194.8 million.

Fargo and Moorhead are accustomed to dealing with flooding. Sufficient time is usually available to prepare for flood fighting because winter snowfall can be monitored to predict unusual spring runoff. Both communities have well documented standard operating procedures for flood fights. Both communities avoided major flood damage in the historic floods of 2009 and 1997 by either raising existing levees or building temporary barriers. Since the 1997 flood, and in the aftermath of the 2009 flood, both communities implemented mitigation measures including: acquisition of more than 100 Floodplain homes, raising and stabilizing existing levees, installing permanent pump stations, and improving storm sewer lift stations and the sanitary sewer system. Although emergency measures have been very successful, they may also contribute to an unwarranted sense of security that does not reflect the true flood risk in the area. Failure of emergency measures would be catastrophic and could result in billions of dollars in damages.

2. **PROJECT AUTHORIZATION**:

The Fargo-Moorhead Metropolitan Area is part of the Red River of the North Basin. The Red River Reconnaissance Study was authorized by a September 30, 1974, Resolution of the Senate Committee on Public Works:

> RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors be, and is hereby, requested to review reports on the Red River of the North Drainage Basin, Minnesota, South Dakota and North Dakota, submitted in House Document Numbered 185, 81st Congress, 1st Session, and prior reports, with a view to determining if the recommendations contained therein should be modified at this time, with particular reference to flood control, water supply, waste water management and allied purposes.

The Fargo-Moorhead metropolitan area was included in the Red River Basin Reconnaissance Study approved on September 19, 2002, but the level of detail in that report was insufficient to recommend a feasibility study specifically for measures in Fargo, North Dakota, and Moorhead, Minnesota. A supplemental Reconnaissance Study was approved by the Mississippi Valley Division on April 08, 2008.

Based on the recommendations contained in the Reconnaissance Report, the City of Fargo, the City of Moorhead, and the federal government entered into a Feasibility Cost Share Agreement on September 22, 2008. The study was cost shared 50/50 between the two non-federal sponsors and the federal government. Funds to initiate the feasibility study were provided in the Consolidated Appropriations Act, 2008, approved 26 December 2007 (Public Law 110- 161)

3. **PROJECT DESCRIPTION**:

The selected plan is the North Dakota 20,000 cfs diversion alignment with upstream staging and storage, this is also known as the Locally Preferred Plan (LPP). The National Economic Development (NED) Plan is the Minnesota 40,000 cfs diversion channel. The Federally Comparable Plan (FCP) is the Minnesota 35,000 cfs diversion channel. The NED and FCP follow the same alignments.

3.1 Federally Comparable Plan (Minnesota 35,000 cfs)

The Minnesota 35K short diversion alignment starts just north of the confluence of the Red and Wild Rice Rivers and extends a total of 25 miles east and north around the cities of Moorhead and Dilworth, ultimately re-entering the Red River near the confluence of the Red and Sheyenne Rivers.

The plan includes a large control structure on the Red River which is an operable structure with three tainter gates 50 feet wide and 47 feet high. The gates would normally be fully open, and the structure would not impede flow more than a typical highway

bridge up to about a 9,600 cfs flow event (approximately a 28-percent chance event) when the structure would be put into operation. Once upstream stages rose to an elevation of 898.3 feet (NAVD 1988), flows would begin to go over the diversion inlet weir. The weir would be constructed of sheetpile and rock.

The diversion channel has a maximum excavation depth of 30 feet with a maximum bottom width of 400 feet. The diversion has 1V on 7H side slopes at most locations with steeper 1V on 5H slopes at the 20 highway and 4 railroad bridges. The diversion channel will require the excavation of approximately 55 million cubic yards of material. The diversion channel would be protected with rock riprap at the point that it returns to the Red River.

Soil excavated to construct the channel would be piled adjacent to the channel to a maximum height of 15 feet. The soil disposal piles would be as wide as necessary to contain the excavated material. The spoil slopes are 1V on 7H and 1V on 10H for the diversion side and outside slopes respectively. Portions of the soil disposal piles would be constructed to serve as levees when the water surface in the channel is higher than the natural grade. The total footprint of the diversion channel and soil disposal piles has a maximum width of 2,800 feet, and will affect 6,415 acres of land. Efforts would be made to allow farming to continue on certain portions of the disposal areas, which could be accomplished by placing topsoil on the spoil piles.

In addition to the diversion channel, the plan includes two smaller channels upstream of the Red River control structure to prevent stage increases upstream of the project along the Red and Wild Rice Rivers. A supplementary channel parallels the Red River upstream of the entrance to the diversion channel to allow for additional capacity to offset the breakouts to Drains 27 and 53. This secondary "Minnesota short extension channel" is approximately 3.7 miles long and has a 215 foot bottom width, with side slopes similar to the diversion channel. A second, shorter channel, the Wild Rice River breakout channel, was added near the intersection of I-29 and Cass Highway 16. This channel, which is less than one mile long and crosses under I-29, will convey water across I-29 that would have naturally broken out to Drain 27 and has a 50 foot bottom width, with side slopes similar to the diversion channel.

The plan also includes a 9.9 mile tie-back levee at the southern limits of the project. The tie-back levee connects the Red River control structure to high ground and prevents flood water from flowing over land to the north and west into the protected area. The typical section for the tie-back levee has a top width of ten feet and side slopes of 1V on 4H. The tie-back levee would be constructed of impervious fill obtained from the channel excavation and covered with topsoil and turf.

3.2 Locally Preferred Plan (North Dakota 20,000 cfs with staging and storage)

The North Dakota east diversion alignment, shown in Figure F01, starts approximately four miles south of the confluence of the Red and Wild Rice Rivers and extends west and north around the cities of Horace, Fargo, West Fargo and Harwood. It ultimately re-

enters the Red River north of the confluence of the Red and Sheyenne Rivers near the city of Georgetown, MN. Along the 36 mile path it crosses the Wile Rice, Sheyenne, Maple, Lower Rush and Rush rivers and incorporates the existing Horace to West Fargo Sheyenne River diversion channel. The LPP includes 19 highway bridges and 4 railroad bridges that cross the diversion channel.

The plan includes a large operable control structure on the Red River with three tainter gates 50 feet wide and 47 feet high. The gates would normally be fully open. The structure would not impede flow more than a typical highway bridge when not in operation. The structure would be operated only when the forecasted peak flow of the incoming hydrograph in the Red River of the North at the USGS gage in Fargo is greater than 9,600 cfs (approximately a 28-percent chance event). When it is operated, the control structure would limit the flow passing into the natural Red River channel through the metropolitan area and would back water up into the staging area and Storage Area 1.

The proposed Wild Rice River control structure, similar to the Red River control structure, would be an operable structure with two tainter gates 30 feet wide and 30 feet high. The gates would normally be fully open. The structure would not impede flow more than a typical highway bridge when not in operation. The structure would be operated only when the forecasted peak flow of the incoming hydrograph in the Red River of the North at the USGS gage in Fargo is greater than 9,600 cfs. The Wild Rice River control structure would be conceptually the same as the Red River control structure, except that the Wild Rice structure would have only two gates.

The diversion inlet structure is a passive weir (no gates or other regulation controls) with an effective flow width of 90 feet and a concrete spillway with a crest elevation of 903.25 feet (NAVD1988). The inlet weir is located where the diversion channel crosses Cass County Highway 17 south of Horace, ND.

Hydraulic structures, known as aqueducts, would be located where the diversion crosses the Sheyenne and Maple rivers. The aqueducts would allow for flows in the diversion to pass underneath the existing river channel, while allowing a minimum of a 50-percent chance event flow to continue down the rivers. The excess water would be diverted into the diversion channel.

The structures located at the Lower Rush River and Rush River would include a combination of a vertical drop (also proposed for Drain 14), with a total width of 60 feet and 100 feet at the Lower Rush River and Rush River, respectively; and a fishway consisting of 40 feet wide riffle-pool sequences that would extend from the tributary channel down to the low flow pilot channel of the diversion channel. Both tributaries would be diverted into the diversion channel during all flow conditions.

The outlet structure located where the diversion returns to the Red River of the North would be a concrete spillway with a width of 250 feet and a crest elevation of 866.0 (NAVD 1988).

The typical depth for the diversion is approximately 20 feet, with a maximum depth of 35 feet near the inlet weir. The channel bottom width between the Red and the Wild Rice rivers is 250 feet. Between the Wild Rice River and the diversion inlet weir, the bottom width is 100 feet, and downstream of the diversion inlet weir the width is 250 feet. Generally all side slopes are 1V on 7H and some slopes include benching of varying widths. A low flow pilot channel would run along the bottom of this reach, and erosion protection at the toe of the main channel side slopes would be provided. Soil excavated to construct the channel would be piled adjacent to the channel to a maximum height of 15 feet. The soil disposal piles would be as wide as necessary to contain the excavated material. The spoil slopes are 1V on 7H and 1V on 10H for the diversion side and outside slopes respectively. Portions of the soil disposal piles would be constructed to serve as levees when the water surface in the channel is higher than the natural grade. The total footprint of the LPP diversion channel has a maximum width of 2,200 feet including areas for disposal piles. The affected acreage is 8,054 acres. It is anticipated that farming could continue on certain portions of the disposal areas, which could be accomplished by placing topsoil on the spoil piles.

The main line of flood protection at the south end of the project includes the embankments adjacent to the diversion channel, Storage Area 1 embankments, and a tie-back levee from the Red River control structure to high ground in Minnesota. A small control structure consisting of two 10-foot by 10-foot gated box culverts would be used where Wolverton Creek crosses the Minnesota tie-back levee. The structure would normally be open to allow the creek to pass through the levee, but during floods the structure would be closed to prevent flood flows from passing.

In order to nearly eliminate downstream impacts, upstream staging and storage of approximately 200,000 acre-feet immediately upstream of the diversion channel inlet would be required. The Red River and Wild Rice River control structures would be operated to raise water surface elevations to a maximum of 922.8 feet at the diversion inlet for all events up to a 0.2-percent chance event. Storage Area 1 is a 4,360-acre area on the north side of the LPP diversion channel between the Wild Rice River and the Sheyenne River, and will be formed by nearly 12 miles of embankments. Storage Area 1, combined with staging in the floodplain, will nearly eliminate impacts from the project on flood levels downstream of the diversion channel outlet. A tie-back levee along Cass County Road 17 (CR17) would be needed to keep staged water from crossing overland into the Sheyenne River. The levee would include construction of a ditch to capture local and overland flows. A portion of the CR17 tieback levee would be at an elevation lower than the other tie-back levees. This portion of the levee will act as an emergency spillway for extreme events that exceed the 0.2-percent chance event design capacity of the project.

3.3 Upstream Storage

The LPP includes storage and staging on the upstream side of the project. Much of the land impacted by this staging would be inundated with flood waters under existing conditions, but the staging raises the 1-percent chance flood stage about eight feet at the Red River Control Structure. In addition to the staging on areas outside (upstream) of

the protected areas, a large storage area, designated as Storage Area 1, was included in a location within the protected area. This area is located west (downstream) of the Wild Rice River and the approximate boundaries are formed by Interstate 29 on the east, County Road 14 on the north and County Road 17 on the West.

This upstream staging is part of the Locally Preferred Plan. The non-federal sponsors will be responsible for the acquisitions throughout the entire staging area. The impact of this upstream storage increases the potential to acquire lands in fee. See Section 11 (baseline cost estimate) of this REP for affects on LERRDs crediting.

The non-structural mitigation measures recommended consist of fee acquisitions, construction of ring levees and the acquisition of flowage easements. These measures are recommended within the staging and storage areas as indicated in Figures 27 and 39 of section 3.13.1.2 of the Main Report. The staging area is defined by the red boundary and the storage area is defined by the purple boundary shown in Figure 39; this area is needed for the operation of the project and a number of mitigation features are being recommended within this area. The proposed mitigation for the area is broken into two parts, one for homes, structures, and businesses and the other for agricultural lands. Impacted homes, structures, and businesses that have greater than 3 feet of flooding for the 1-percent chance event with the project in place would be purchased, those with 1 to 3 feet of flooding would be considered for ring levees or a purchase (a risk and safety analysis will be conducted for determination of viability of a ring levee), and those with less than 1 foot of flooding would have flowage easements purchased for the property. Farmsteads in the staging or storage area will be given additional consideration based on the depth of flooding, duration of flooding, and access. Acquisition of farmsteads will generally follow the mitigation plan listed above, however under some circumstances it may be viable to construct a ring levee or raise the farmstead. In any case, where farmsteads would have greater than 3 feet of flooding a buyout would be offered to the owner prior to consideration of other options. Impacts to agricultural lands in the staging area would be mitigated through the acquisition of flowage easements. A property-by-property analysis will be conducted to ensure that the specifics of each parcel are taken into account when determining the appropriate mitigation. Alternative mitigation options will be considered when application of the general rule does not result in adequate mitigation for a particular parcel.

Areas where fee acquisitions would occur include the communities of Oxbow, Hickson, and Bakke, ND. Comstock, MN would be impacted by the project and would generally have 1 to 3 feet of flooding with the LPP in place; a ring levee would be pursued for Comstock.

In areas with greater than 1 foot of flooding for the 1-percent chance event, no residential development will be allowed. In areas with less than 1 foot of flooding for the 1-percent chance event that are contained in the staging and storage areas, future residential development must be raised above the 0.2-percent chance event elevation.

Flowage easements will be acquired over agricultural land within the staging area. Agricultural lands would be impacted by the project primarily in the spring and it is anticipated that in most areas farming could continue without significant impacts. There is the potential for summer impacts which could cause damage to agricultural properties and in the past 108 years of record this would have occurred 4 times in 1975, 2005, 2007, and 2009. The largest summer flow occurred in 2007 with a flow of 13,500 cfs, in that situation only a small portion of the staging area would have been impacted by operation of the project. The summer operation plan will be revisited in during the design phase to determine if a different operating plan can be used in the summer to reduce agricultural impacts without causing additional damage to the Fargo-Moorhead communities. Local concerns have been raised regarding crop insurance within the storage and staging area and coordination has been ongoing with the USDA Risk Management Agency (RMA). The RMA has indicated that the purchase of crop insurance in these areas could still be obtained, however flood impacts resulting from the project may not be covered.

Some areas along the Red River, Wild Rice River and connected drains that are outside of the designated staging area will be affected by staging operations. Impacts outside of the designated staging area are estimated to be less than one foot of additional flood depth for a one percent chance event, and most of the impacted area would be inundated under existing conditions. A legal analysis will be conducted to determine if the impacts in these areas rise to the level of a taking under the Fifth Amendment of the U.S. Constitution. Outside of the designated staging area, landowners will be compensated appropriately for any takings.

4. NON-FEDERAL SPONSOR OWNED LER

The St. Paul District Engineering Division, Design Branch, identified preliminary project construction areas and furnished the Real Estate Division with projected acreages. In reviewing the project footprint identified on the current "Right-Of-Way General Plan" map, it appears that a very minimal amount of the required acreage for the project is Non-Federal Sponsor owned LER. There does not appear to be any NFS LER in the Minnesota Alignments, while there is 2.95 acres identified as potential NFS LER on the North Dakota side in the area where the diversion channel intersects with the previously completed Sheyenne River project.

5. ESTATES

The U.S. Army Corps of Engineers Standard Estates for Fee-Simple, Flood Protection Levee Easement, Flowage Easements, Permanent Channel Improvement Easement, Temporary Work Area Easement, may be used for the Project. The Standard Estate language for the various estates is provided below:

FLOOD PROTECTION LEVEE EASEMENT:

A perpetual and assignable right and easement in (the land described in Schedule A) (Tracts Nos. , and) to construct, maintain, repair, operate, patrol and replace a

flood protection levee, including all appurtenances thereto; reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

FLOWAGE EASEMENT (Occasional Flooding):

The perpetual right, power, privilege and easement occasionally to overflow, flood and submerge (the land described in Schedule A) (Tracts Nos. , and) in connection with the operation and maintenance of the _____ Flood Damage Reduction Project as authorized by the Act of Congress approved , together with all right, title and interest in and to the structures and improvements now situate on the land, excepting fencing (and also excepting (here identify those structures not designed for human habitation which the District Engineer determines may remain on the land)); provided that no structures for human habitation shall be constructed or maintained on the land, that no other structures shall be constructed or maintained on the land except as may be approved in writing by the representative of the United States in charge of the project, and that no excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of landfill; the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used and enjoyed without interfering with the use of the project for the purposes authorized by Congress or abridging the rights and easement hereby acquired; provided further that any use of the land shall be subject to Federal and State laws with respect to pollution.

FEE:

The fee simple title to (the land described in Schedule A) (Tracts Nos. , and), Subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT:

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. , and), for a period not to exceed , beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a work area, including the right to move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the Dawson Flood Damage Reduction Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right of way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired;

subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

CHANNEL IMPROVEMENT EASEMENT:

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____) for the purposes as authorized by the Act of Congress approved_____, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions therefrom; to excavate: dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements far public roads and highways, public utilities, railroads and pipelines.

6. EXISTING FEDERAL PROJECT(S):

Lands required for this project are not within the scope of any other known existing Federal project. The following projects have previously been completed in the Fargo-Moorhead area.

Fargo levees: The Corps participated in a permanent flood control project completed in Fargo in 1963. The project was recommended in the Corps' 1947 comprehensive plan for the Red River basin and authorized by the Flood Control Acts of 1948 and 1950. The project included four channel cutoffs, the Midtown Dam, and a 3,500-foot levee east of 4th Street South between 1st Avenue South and 10th Avenue South. The top of levee is at approximately a 40.0-foot stage. The city later extended the levee south to 13th Avenue. Fargo has several other publicly and privately owned sections of levee throughout the city. The current line of protection has top elevations that vary from a stage of 30 feet to 42 feet, but several reaches are at or below 37 feet. (Note: the proposed new FEMA 1-percent-chance flood stage is expected to be approximately 39.3 feet.)

Moorhead levees: No federally constructed levees are in Moorhead. The Corps proposed a 1,800-foot-long levee in the 1947 comprehensive plan for the Red River basin. It was authorized by the Flood Control Acts of 1948 and 1950, but the city declined to participate in the project. The city has built four small levees and several lift stations and control structures on storm water lines that can be closed or operated during high-water events. The city has also installed valves on the sanitary sewer lines at several individual flood-prone residences to prevent floodwater from inundating the system. The city also builds emergency levees when necessary.

The Sheyenne River project was authorized by the 1986 Water Resources Development Act. The project originally included four components: a 5-foot raise of the Baldhill Dam

flood control pool; a dam to provide approximately 35,000 acre-feet of storage on the Maple River; a 7.5-mile flood diversion channel from Horace to West Fargo, North Dakota; and a 6.7-mile flood diversion channel at West Fargo. The Southeast Cass Water Resource District and the St. Paul District, Corps of Engineers, signed cost share agreements for the West Fargo Diversion project in 1988 and the Horace to West Fargo Diversion in 1990. The projects were essentially completed in 1993 and 1994, respectively. A pump station was added to the West Fargo project in 2003 and emergency generators were provided in 2007. The Maple River dam was deauthorized in 2002 for Federal participation, and the Southeast Cass Water Resource District completed the project without Federal assistance in 2007. These projects protect the cities of Horace and West Fargo and the west side of Fargo from Sheyenne River flooding. From Horace to West Fargo, the system is designed for a 1-percent-chance event plus 2 feet. At West Fargo, the channel and left bank levee contain the 1-percent-chance event plus 2 feet; the right bank levee is higher, providing the city with protection from the Standard Project Flood plus 3 feet. Although these features reduce the risk associated with Sheyenne River flooding, these cities are still potentially affected by floods on the Wild Rice and Red Rivers that are larger than the 1-percent chance event.

A Section 208 (1954 Flood Control Act) clearing and snagging project was completed in Fargo-Moorhead in 1991 to remove trees affected by Dutch elm disease. Dead and dying trees were removed along a 9.7-mile reach of the Red River.

Three Section 14 (1946 Flood Control Act) emergency stream bank protection projects were completed in Fargo between 2001 and 2003. Erosion from the Red River of the North occurred at three separate project locations. At Reach A, erosion along 4,100 feet of riverbank threatened a levee near 37th Avenue. At Reach B, erosion along a 950-foot reach threatened Kandi Lane and North Broadway and utilities located beneath them. At Reach C, erosion along a 1,900-foot reach threatened Elm Street between 13th and 17th Avenues North and the utilities located beneath it. The erosion progressed to within 50 feet of the roadway. The projects involved shaping the banks and placing rockfill or granular fill and riprap along the eroded areas.

Two **Section 206 (1996 Water Resource Development Act)** aquatic ecosystem restoration projects were implemented to improve fish passage over two dams on the Red River within the metropolitan area. Rock slope fishways were constructed at the 12th Avenue North Dam and the 32nd Avenue South Dam in 2002 and 2004, respectively. A similar fishway was constructed at the Midtown Dam in 1998 without Corps construction assistance.

A Section 205 (1948 Flood Control Act) small flood control project is under construction for Fargo's Ridgewood neighborhood. The project will tie into a recently reconstructed floodwall at the Department of Veterans Affairs hospital.

7. FEDERALLY OWNED LANDS:

Preliminary alignments indicate that no Federally-owned lands appear to be within the LER required for the Project.

8. NAVIGATIONAL SERVITUDE:

Rights afforded the Federal government by way of Navigational Servitude may apply to the Red River Control Structure for both the Minnesota and North Dakota alignments. For the North Dakota alternative, small areas of Navigational Servitude may be affected as the channel crosses other rivers and tributaries. Determination of these areas will not be available until specific designs are formulated.

9. REAL ESTATE MAPS:

The Project Overview Map Figure F01 is included for Reference for FCP and LPP portion of the project. (Includes: Storage Area 1). 10, 50, 100 & 500 year Upstream Impacted Structure map also included. Real Estate Drawings for proposed diversion channel are included.

10. INDUCED FLOODING:

The upstream and downstream effects of a diversion channel continue to be analyzed. A preliminary takings analysis has been completed and there appear to be takings for all diversion channel alternatives. However, additional data with specific elevations is needed in order to complete the analysis. Each of the properties will need to be analyzed on a case by case basis. When the data becomes available, a takings analysis will be completed for both upstream and downstream to determine any additional LER as it may relate to individual homestead sites. A full takings analysis will be completed during PED.

11. BASELINE COST ESTIMATE:

The Federally Comparable Plan is the Minnesota Diversion, 35,000 cfs. Therefore, The Minnesota Short FCP, will set the basis for the cost share, although the North Dakota East Diversion, 20,000 cfs, is the Locally Preferred Plan. The following table is a synopsis of the estimated real estate land cost, and possible damages to the remainder parcels for these possibilities. A preliminary footprint is completed at this time, therefore, this cost estimate is based on the preliminary alignments. A preliminary gross appraisal was completed for the estimated alignment and acreages. An updated gross appraisal reflecting the current footprint including the upstream staging and storage area is currently being finalized.

The cost is estimated on 1133 tracts of land containing 393 residences and over 500 non-residential structures.

MINNESOTA DIVERSION CHANNEL – 35,000 CFS (FCP)

	Federal Costs	NFS Costs	Total
Lands / Damages	-	$42,049,500	$42,049,500
RE Administrative Costs	$323,441	$1,080,000	$1,403,441
Total	**$323,441**	**$43,129,500**	**$43,452,941**
Contingencies (25%)	$80,860	$10,782,375	$10,863235
Total	**$404,301**	**$53,911,875**	**$54,316,176**

NORTH DAKOTA DIVERSION LOCALLY PREFERRED PLAN – (LPP)
Grand total of all costs for LPP is $254,712,748 as outlined below:

DIVERSION CHANNEL AND STORAGE AREA

	Federal Costs	NFS Costs	Total
Lands / Damages*	-	$36,741,250	$36,741,250
RE Administrative Costs	$820,989	$2,628,000	$3,448,989
Total	**$820,989**	**$39,369,250**	**$40,190,239**
Contingencies (25%)	$205,247	$9,842,312	$10,047,559
SubTotal	**$1,026,236**	**$49,211,562**	**$50,237,798**

NOTE: * lands/damages for Diversion channel and Storage area include:

Type of property	*Value/acre or site*	*number of acres/sites*	*Approx. # of Sites*	*Total costs*
Acres/Fee	$3,900.00	4132	103	$16,114,800.00
Acres/Fee	$2,150.00	7171	179	$15,417,650.00
Acres/Easement	$800.00	136	5	$108,800.00
Non-Residential/Fee	$15,000.00	52	52	$780,000.00
Residential/Fee	$240,000.00	18	18	$4,320,000.00
				$36,741,250.00

UPSTREAM STAGING AREA

	Federal Costs	NFS Costs	Total
Lands / Damages**	-	$155,711,300	$155,711,300
RE Administrative Costs	$1,497,660	$6,371,000,	$7,868,660
Total	**$1,497,660**	**$162,082,300**	**$163,579,960**
Contingencies (25%)	$374,415	$40,520,575	$40,894,990
SubTotal	**$1,872,075**	**$202,602,875**	**$204,474,950**

NOTE: ** lands/damages for upstream storage include:

Type of property	*Value/acre or site*	*number of acres/sites*	*number of sites*	*Total costs*
Acres/Fee	$3,900.00	9750	244	$38,025,000.00
Acres/Fee	$2,150.00	11554	289	$24,841,100.00
Acres/Easement	$800.00	12659	316	$10,127,200.00
Non-Residential/Ease.	$140,000.00	165	165	$23,100,000.00
Non-Residential/Fee	$14,000.00	264	264	$3,696,000.00
Residential/Fee	$245,000.00	218	218	$53,410,000.00
Residential/Ease.	$16,000.00	157	157	$2,512,000.00
				$155,711,300.00

LLP TOTAL for lands and damages only is: $192,452,550

LPP TOTAL Real estate Base line cost estimate is: $254,712,748

Note: An estimate for environmental mitigation lands has been considered and included in the Total Project Cost estimate, Appendix L Cost Engineering, in the amount of $14,045,000 ($17,696,700 with contingencies). This possible future mitigation is addressed in Appendix F Environmental, Section 1.7 and is not included in the Real Estate Baseline cost estimate above.

Contingencies are added to account for potential severance damages due landowners whereby the larger parcel is adversely affected by a partial acquisition; and increases in market conditions at the time of acquisition; and potential effects following the completion of an Integrated Cost and Risk Assessment. Relocation Benefits are included as a part of the NFS Administrative Costs.

The basis for LERRDs crediting will be determined against the cost analysis of the FCP, all costs above the LERRDs crediting basis determined by the FCP for the LPP will be borne 100% by the non-federal sponsors.

12. PL 91-646 RESIDENCE / BUSINESS RELOCATIONS:

Based on mapping provided by the St. Paul District Design Branch, an estimated 504 structures (to include numerous farm sites) may need to be relocated under Public Law 91-646 requirements. A formal relocation plan and survey have not been conducted, but will be completed prior to the initiation of acquisition. The Baseline Cost Estimate includes an estimated value for these structures as well as the potential relocation benefits. The potential non-federal sponsors are all advised that PL91-646 must be adhered to throughout the process and that detailed documentation of expenses for LERRDs crediting must be conducted.

13. MINERAL ACTIVITY:

There is no present or anticipated mineral activity within the proposed project limits.

14. NON-FEDERAL SPONSOR ASSESSMENT:

It is anticipated that the non-federal sponsors will include both the cities of Fargo and Moorhead. The "Assessment of Non-Federal Sponsor's Real Estate Acquisition Capability" checklist is completed and attached for both Fargo and Moorhead. Both Cities have the legal authority, ample qualified personnel, and experience from previous projects necessary to acquire the necessary LER for the project.

15. ZONING:

No application or enactment of zoning ordinances will be utilized for the proposed project.

16. ACQUISITION SCHEDULE:

The following schedule is based on an anticipated duration of real estate related activities and begins at 0 months with the approval of the Feasibility Report: (it should be noted that the project will most likely be constructed in phases for which each phase will have a different acquisition time period)

Feasibility Report Approval	0 Month
Initiate Plans & Specifications	1 Month
Execute PPA	18 Months
Complete Plans and Specs	18 Months
Final Real Estate ROW Maps	18 Months
Sponsor Begins Acquisition	18 Months
Certify Real Estate	22 Months
Construction starts	24 Months

17. FACILITY/UTILITY RELOCATIONS:

A Preliminary Attorney's Opinion of Compensability has not been completed by the St. Paul District Office of Counsel at the time of this report. A Final Opinion will be completed during the Plans, Engineering and Design (PED) phase of the Project.

In accordance with ER 1165-2-131, the costs associated with the railroad bridges would be cost-shared between the Federal Government and the Sponsor.

18. ENVIRONMENTAL CLEARANCE:

A Phase I, Environmental Site Assessment (ESA), was completed for both the Minnesota and North Dakota diversion channel alternatives in December 2010. The ESA recommended a limited Phase II Environmental Site Assessment depending upon the ultimate selected diversion alternative. For the LPP a Phase I Supplemental HTRW will be completed to include the areas that were not identified in the December 2010 report.

These areas include the alignment shift along the northern portion of the diversion, the extensions on the tie-back levee in Minnesota, the tie-back levee along Hwy 17, the storage area and the staging area.

19. LANDOWNER ATTITUDE:

In general landowners have indicated an understanding that a permanent solution to the flood problems in the metro area is needed, however when speaking with individual landowners at the public meetings, there is opposition to the project by people directly impacted. Although there are those who accept the need for the project there is a divergence of attitudes and opinions as to the scope, need, design and alignment of the project. There will need to be more informational meetings to educate the public on the project as it progresses.

Numerous public meetings have been held (detailed in Section 6 and Appendix Q of the main report) and a website (http://www.internationalwaterinstitute.org/feasibility/index.htm) was established as the project's primary website. The purpose of this site was to deliver information to the public that was made available at public meetings and for distribution of information as part of the NEPA process. The website also gave the interested public opportunities to ask questions, submit comments through e-mail, or be added to an email mailing list.

20. NON-FEDERAL SPONSOR NOTIFICATION:

Although the potential NFS are identified, there is no firm determination on what entities will be the NFS for the PPA, and thus no formal notification of the risk of acquiring LER prior to the execution of the PPA has been made at this point. The non-federal sponsors for this study are the City of Fargo, North Dakota and the City of Moorhead, Minnesota. The cities have been supported and have received input during the study from the Southeast Cass Water Resource District; Cass County, ND; Buffalo-Red Watershed District; and Clay County, MN.

John P. Albrecht
Chief of Real Estate

4 Aug 2011
Date

ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY
Fargo/Moorhead Diversion Project - City of Fargo

	YES	NO	N/A
I. Legal Authority:			
a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes?	X		
b. Does the sponsor have the power of eminent domain for this project?	X		
c. Does the sponsor have "quick-take" authority for this project?	X		
d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary?	X		
e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn?		X	
COMMENTS:			
II. Human Resource Requirements:			
a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including PL 91-646, as amended?		X	
b. If the answer to II.a. is "yes", has a reasonable plan been developed to provide such training?			X
c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project?	X		
d. Is the sponsor's projected in-house staffing level sufficient considering its other workload, if any, and the project schedule?	X		
e. Can the sponsor obtain contractor support, if required, in a timely fashion?	X		
f. Will the sponsor likely request USACE assistance in acquiring real estate? (If "yes", provide description.)		X	
COMMENTS:			
III. Other Project Variables:			
a. Will the sponsor's staff be located within reasonable proximity to the project site?	X		
b. Has the sponsor approved the project/real estate schedule/milestones?	X		
COMMENTS:			
IV. Overall Assessment:			
a. Has the sponsor performed satisfactorily on other USACE projects?	X		
b. With regard to this project, the sponsor is anticipated to be:	**highly capable**		
	fully capable		
	moderately capable		
	marginally capable		
	insufficiently capable		
(If sponsor is believed to be "insufficiently capable", provide explanation).			
COMMENTS:			
V. Coordination:			
a. Has this assessment been coordinated with the sponsor?	X		
b. Does the sponsor concur with this assessment? (If "no", provide explanation)	X		
COMMENTS:			

Prepared by: Rodney R. Peterson

14 JUL, 2011

Realty Specialist

Reviewed and Approved by:

John P. Albrecht

Chief, Real Estate Division

ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY
Fargo/Moorhead Diversion Project - City of Moorhead

	YES	NO	N/A
I. Legal Authority:			
a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes?	X		
b. Does the sponsor have the power of eminent domain for this project?	X		
c. Does the sponsor have "quick-take" authority for this project?	X		
d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary?	X		
e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn?		X	
COMMENTS:			
II. Human Resource Requirements:			
a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including PL 91-646, as amended?		X	
b. If the answer to II.a. is "yes", has a reasonable plan been developed to provide such training?			X
c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project?	X		
d. Is the sponsor's projected in-house staffing level sufficient considering its other workload, if any, and the project schedule?	X		
e. Can the sponsor obtain contractor support, if required, in a timely fashion?	X		
f. Will the sponsor likely request USACE assistance in acquiring real estate? (If "yes", provide description.)		X	
COMMENTS:			
III. Other Project Variables:			
a. Will the sponsor's staff be located within reasonable proximity to the project site?	X		
b. Has the sponsor approved the project/real estate schedule/milestones?	X		
COMMENTS:			
IV. Overall Assessment:			
a. Has the sponsor performed satisfactorily on other USACE projects?	X		
b. With regard to this project, the sponsor is anticipated to be:	**highly capable**		
	fully capable		
	moderately capable		
	marginally capable		
	insufficiently capable		
(If sponsor is believed to be "insufficiently capable", provide explanation).			
COMMENTS:			
V. Coordination:			
a. Has this assessment been coordinated with the sponsor?	X		
b. Does the sponsor concur with this assessment? (If "no", provide explanation)	X		
COMMENTS:			

Prepared by: Rodney R. Peterson

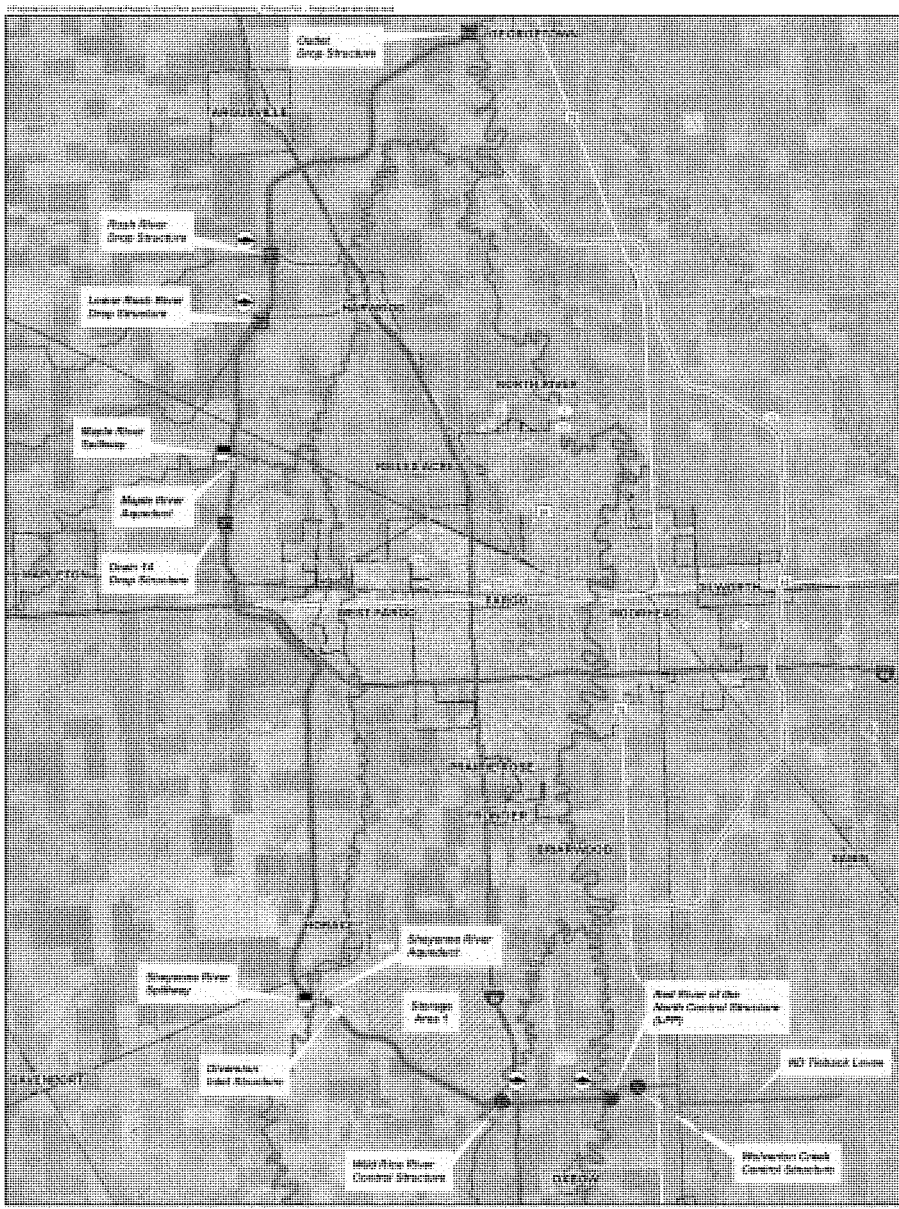
14 July, 2011

Realty Specialist

Reviewed and Approved by:

John P. Albrecht

Chief, Real Estate Division



Hydraulic Structures

- Weir
- Aqueduct
- Control Structure
- Drop Structure
- Spillway
- Fish Passageway

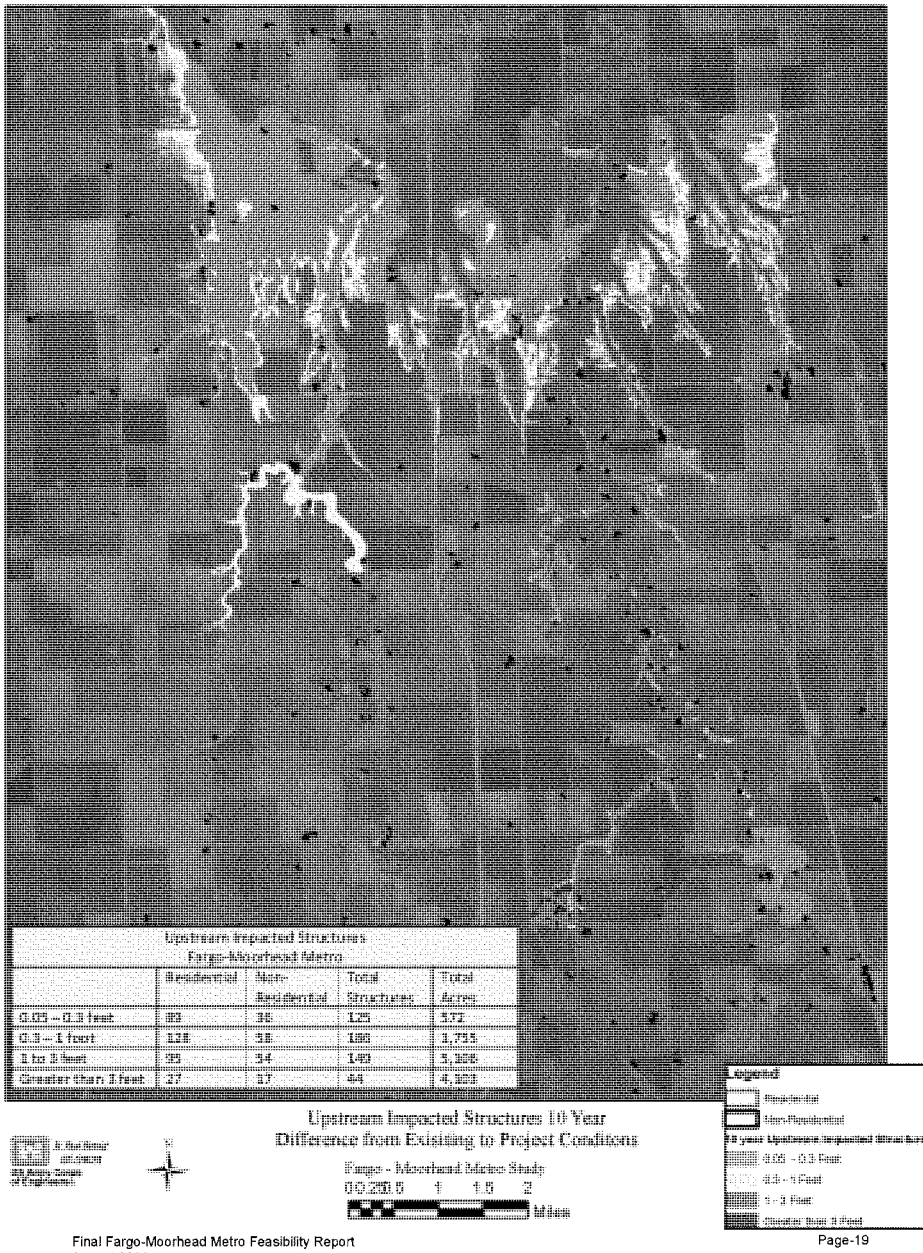
- ND Tieback Levee
- North Dakota Diversion Locally Preferred Plan (LPP)
- Minnesota Diversion Federally Comparable Plan (FCP)
- Channel Reclamation Reaches
- Storage Area 1

Figure F01

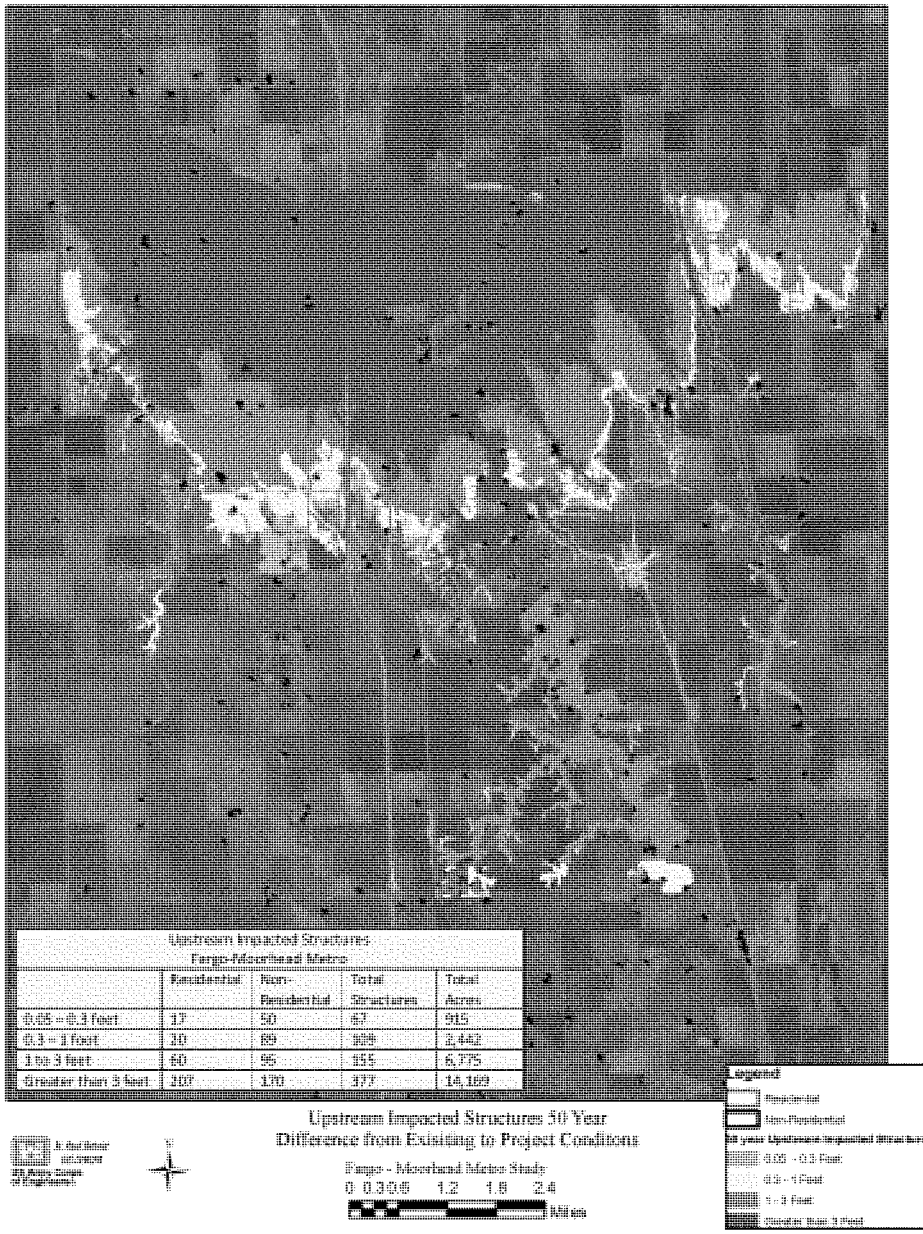
PROJECT OVERVIEW

Fargo - Moorhead Area

0 0.5 1 2 3 4 Miles

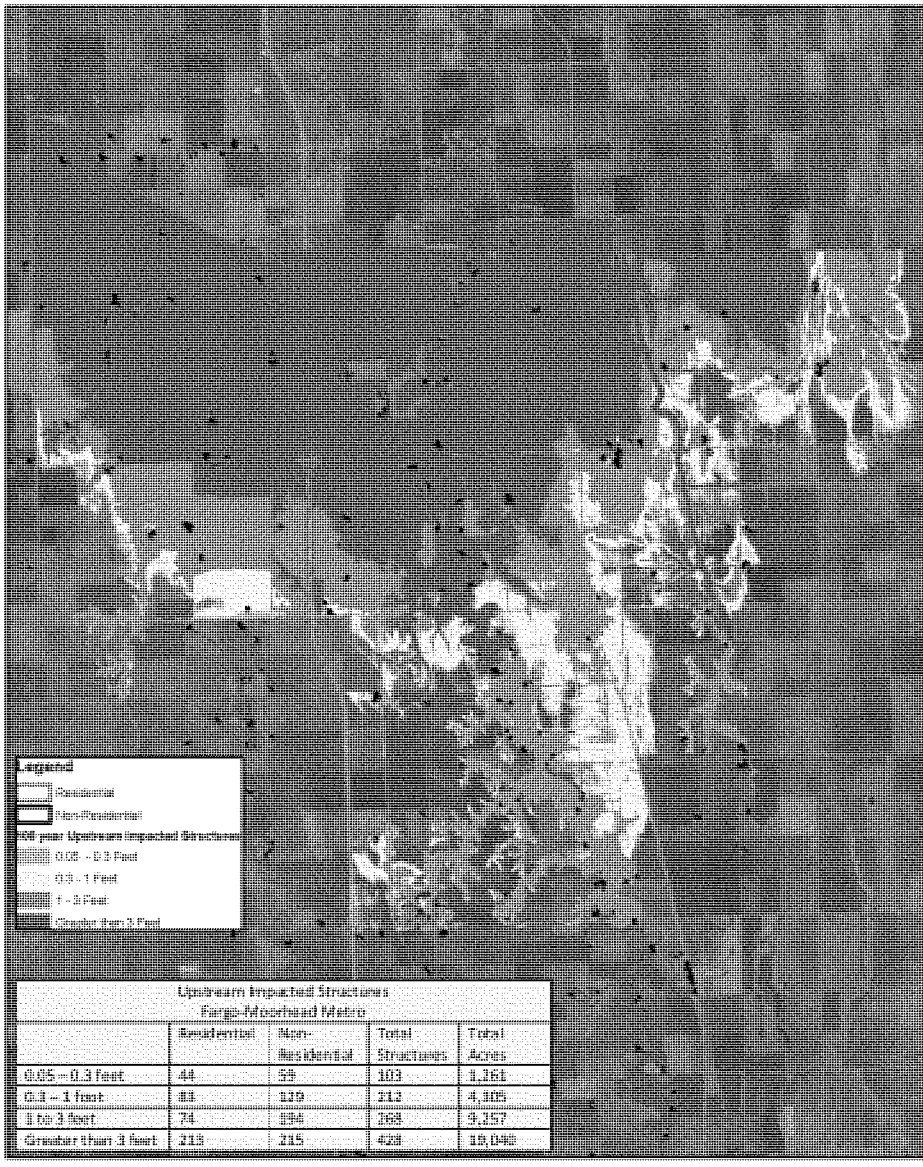


Upstream Impacted Structures Fargo-Moorhead Metro				
	Residential	Non-Residential	Total Structures	Total Acres
0.05 – 0.3 feet	92	33	125	172
0.3 – 1 foot	128	58	186	1,715
1 to 3 feet	99	34	133	1,355
Greater than 3 feet	27	17	44	4,300



Upstream Impacted Structures
Fargo-Moorhead Metro

	Residential	Non-Residential	Total Structures	Total Acres
0.05 - 0.3 feet	37	50	87	915
0.3 - 1 feet	30	89	119	3,442
1 to 3 feet	60	95	155	6,775
Greater than 3 feet	207	170	377	14,169



Upstream Impacted Structures
Fargo-Moorhead Metro

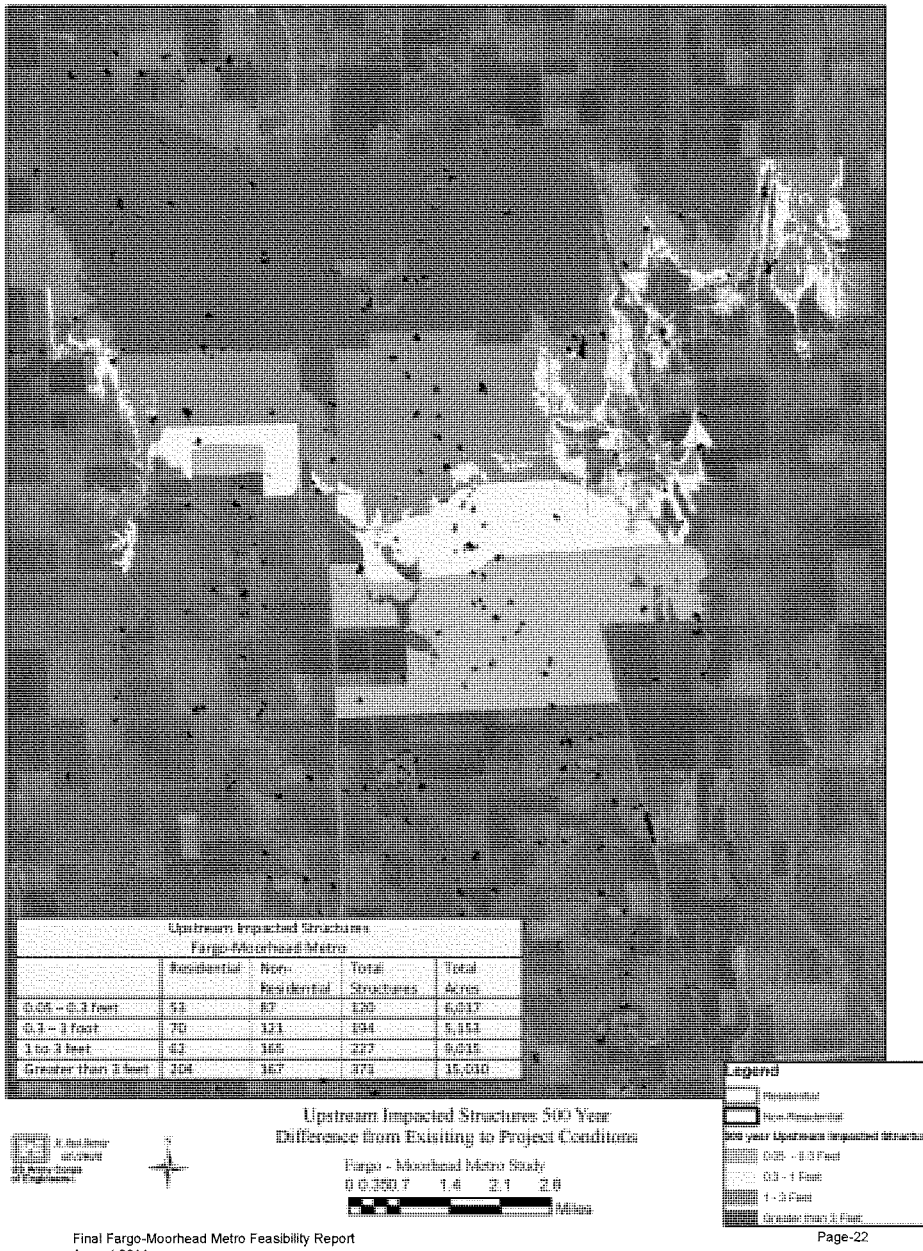
	Residential	Non-Residential	Total Structures	Total Acres
0.05 – 0.3 Feet	44	59	103	1,161
0.3 – 1 Feet	81	132	213	4,105
1 to 3 feet	74	134	168	5,157
Greater than 3 feet	213	215	428	15,040

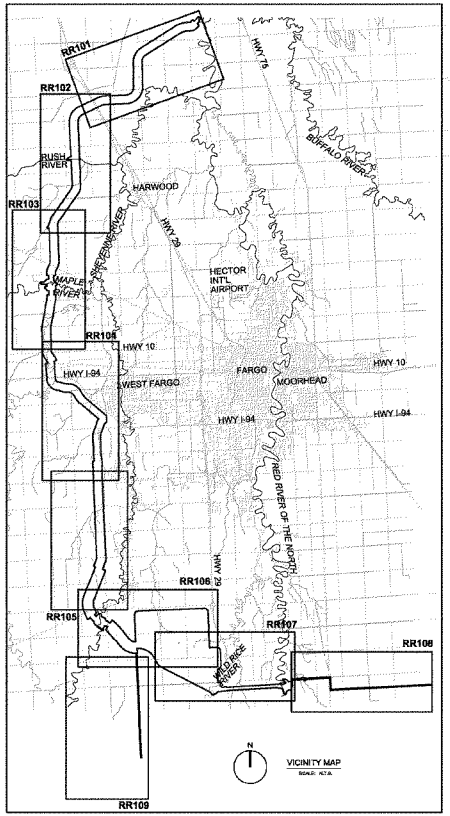
Upstream Impacted Structures 100 Year
Difference from Exisiting to Project Conditons

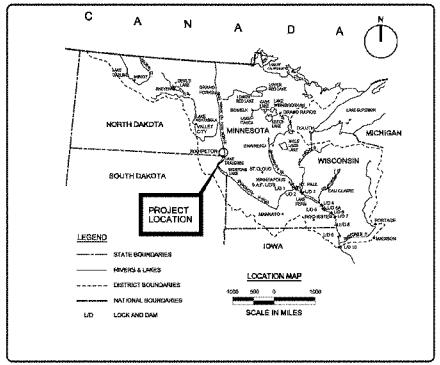
St. Paul District GIS CENTER
US Army Corps of Engineers®

Fargo - Moorhead Metro Study
0 0.350.7 1.4 2.1 2.8
Miles

N


Upstream Impacted Structures
Fargo-Moorhead Metro
Residential
Non-Residential
Total Structures
Total Acres
0.05 – 0.3 feet
53
87
120
6,017
0.3 – 1 foot
70
121
194
5,153
1 to 3 feet
62
165
227
9,015
Greater than 3 feet
204
167
371
15,010
Legend
Residential
Non-Residential
500 year Upstream Impacted Structures
0.05 - 0.3 Feet
0.3 - 1 Feet
1 - 3 Feet
Greater than 3 Feet
Upstream Impacted Structures 500 Year
Difference from Exisiting to Project Conditions
Fargo - Moorhead Metro Study
0 0.350.7 1.4 2.1 2.8
Miles





ACREAGE TABLE	
TEMPORARY WORK AREA EASEMENT =	139 ACRES
PERMANENT LEVEE EASEMENT =	11.435 ACRES

REAL ESTATE DRAWING INDEX			
AS-BUILT DRAWING NO.	SHEET REF.	DESCRIPTION	PROJECT I.D.
		REAL ESTATE DRAWINGS	
	RR001	VICINITY AND LOCATION MAPS , DRAWING INDEX & ACREAGE TABLE	FMM_RR001---.DGN
	RR101	REAL ESTATE PLAN SHEET 1 OF 9	FMM_RR101---.DGN
	RR102	REAL ESTATE PLAN SHEET 2 OF 9	FMM_RR102---.DGN
	RR103	REAL ESTATE PLAN SHEET 3 OF 9	FMM_RR103---.DGN
	RR104	REAL ESTATE PLAN SHEET 4 OF 9	FMM_RR104---.DGN
	RR105	REAL ESTATE PLAN SHEET 5 OF 9	FMM_RR105---.DGN
	RR106	REAL ESTATE PLAN SHEET 6 OF 9	FMM_RR106---.DGN
	RR107	REAL ESTATE PLAN SHEET 7 OF 9	FMM_RR107---.DGN
	RR108	REAL ESTATE PLAN SHEET 8 OF 9	FMM_RR108---.DGN
	RR109	REAL ESTATE PLAN SHEET 9 OF 9	FMM_RR109---.DGN

COORDINATE SYSTEM (HORIZONTAL CONTROL) NAD83
NORTH DAKOTA STATE PLANE ZONE SURVEY FEET
CORRECTION IS(ALL TO BE DETERMINED)

ELEVATION DATUM (VERTICAL CONTROL)
NAVD 1988
GEOID09

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DESIGNED BY: CHRIS MAY
DRAWN BY: CHRIS MAY
CHECKED BY: BARNES/BRAY
PLOT SCALE: NOT SCALE
DATE: 2011
REVISION NO.:
CONTRACT NO.:
FILE NUMBER:
SIZE: 24x36
FILE NAME: FMM_RR001.dgn

FARGO-MOORHEAD METRO FEASIBILITY REPORT
RED RIVER OF THE NORTH
CASS COUNTY, NORTH DAKOTA
FARGO NORTH DAKOTA, MOORHEAD MINNESOTA

REAL ESTATE DRAWINGS-LPP
VICINITY AND LOCATION MAPS
DRAWING INDEX & ACREAGE TABLE

Sheet ID
RR001

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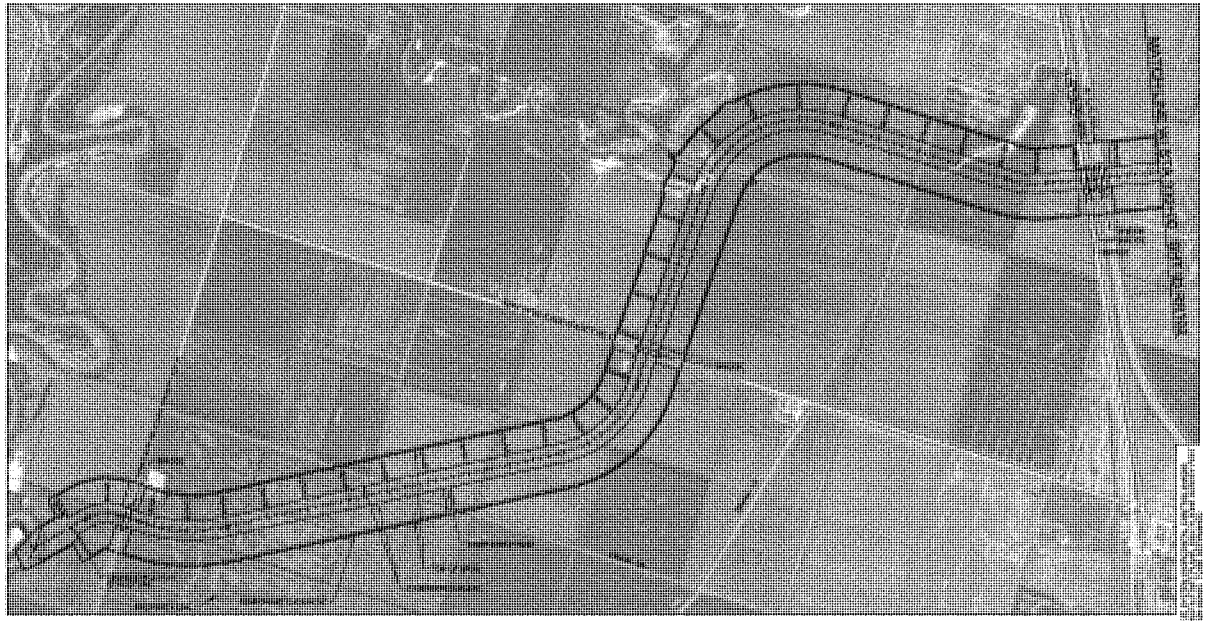
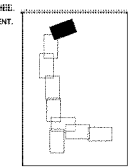


PLAN VIEW

NOTES:

1. [illegible]
2. TEMPORARY EASEMENTS - 15' BEYOND THE PERMANENT EASEMENT.
3. ONLY TEMPORARY EASEMENTS ARE DISPLAYED IN PLAN VIEW.



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RED RIVER OF THE NORTH
CASS COUNTY & CLAY COUNTY
FARGO NORTH DAKOTA, MOORHEAD MINNESOTA
REAL ESTATE DRAWINGS-LPP
NEAL ESTATE PLAN
SHEET 1 OF 9

Sheet ID
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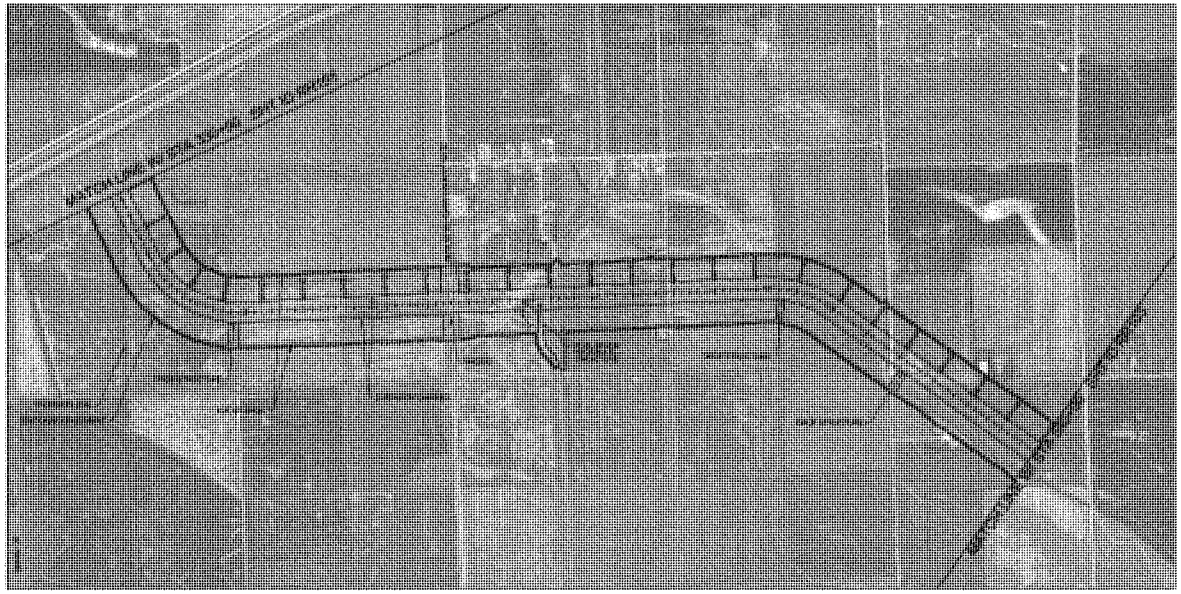
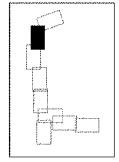


PLAN VIEW

1000' 500' 0 1000'

NOTES:

1. PERMANENT EASEMENTS - 30' OUTSIDE THE TOE OF SPOIL OR LEVEE.
2. TEMPORARY EASEMENTS - 15' BEYOND THE PERMANENT EASEMENT.
3. ONLY TEMPORARY EASMENTS ARE DISPLAYED IN PLAN VIEW.



ELEVATION DATUM (VERTICAL CONTROL): N.A.V.D. 1988 GEOID09

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DESIGNED BY: EAV
DRAWN BY: EAV
CHECKED BY: JAM
REVIEWED BY: MRS
PLOT SCALE: NOT SCALE
SIZE: FULL SCALE

DATE: 11-15-2011
DESCRIPTION NO.
CONTRACT NO.
FILE NUMBER

FARGO-MOORHEAD METRO FEASIBILITY REPORT
RED RIVER OF THE NORTH
CASS COUNTY & CLAY COUNTY
FARGO NORTH DAKOTA, MOORHEAD MINNESOTA
REAL ESTATE DRAWINGS-APP
REAL ESTATE PLAN
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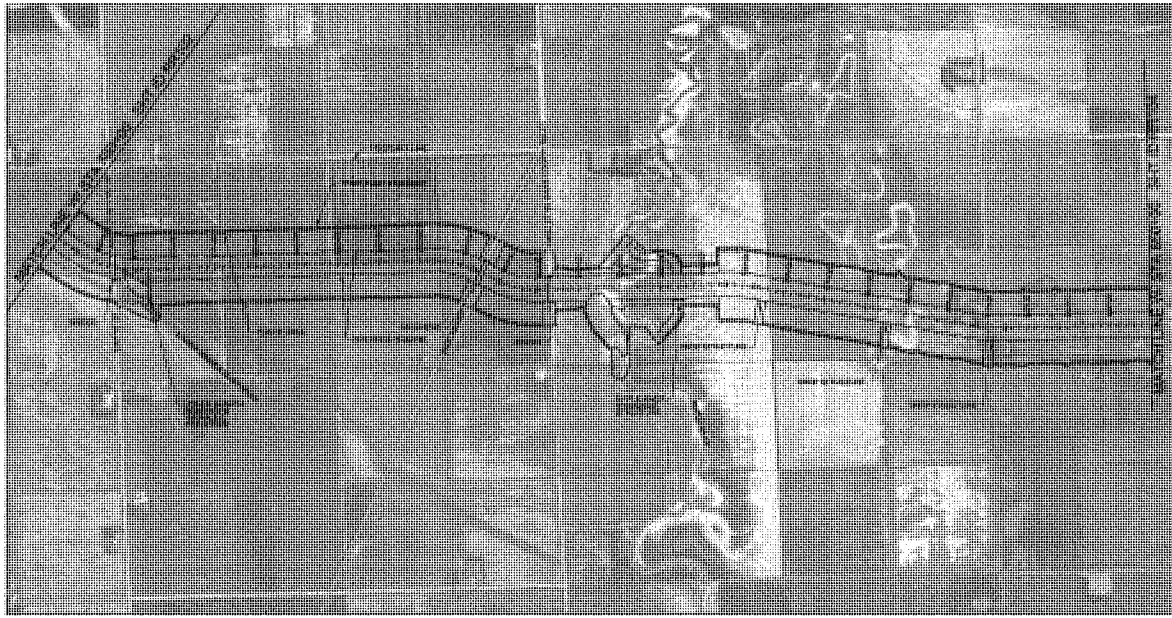
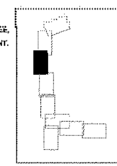


PLAN VIEW

NOTES:

1. PERMANENT EASEMENTS - 30' OUTSIDE THE TOE OF SPOIL OR LEVEE.
2. TEMPORARY EASEMENTS - 15' BEYOND THE PERMANENT EASEMENT.
3. ONLY TEMPORARY EASMENTS ARE DISPLAYED IN PLAN VIEW.



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RED RIVER OF THE NORTH
CASS COUNTY & CLAY COUNTY
FARGO NORTH DAKOTA, MOORHEAD MINNESOTA
REAL ESTATE DRAWINGS-LPP
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Sheet ID
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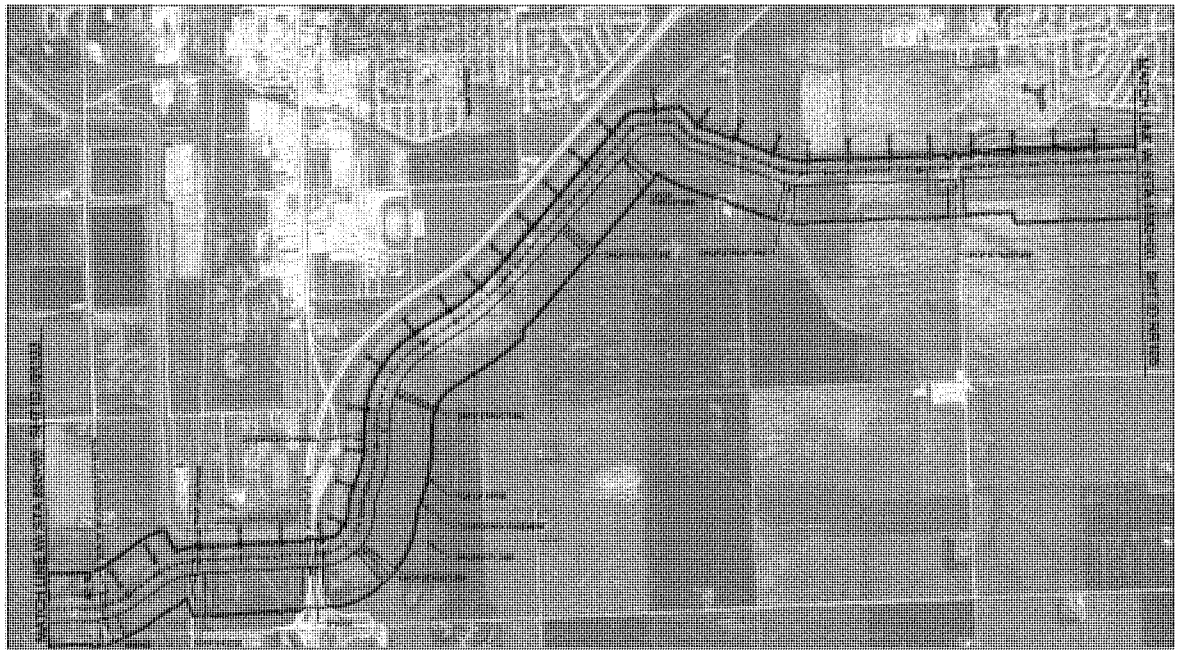

PLAN VIEW

1000' 500' 0 1000'

NOTES:

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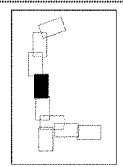

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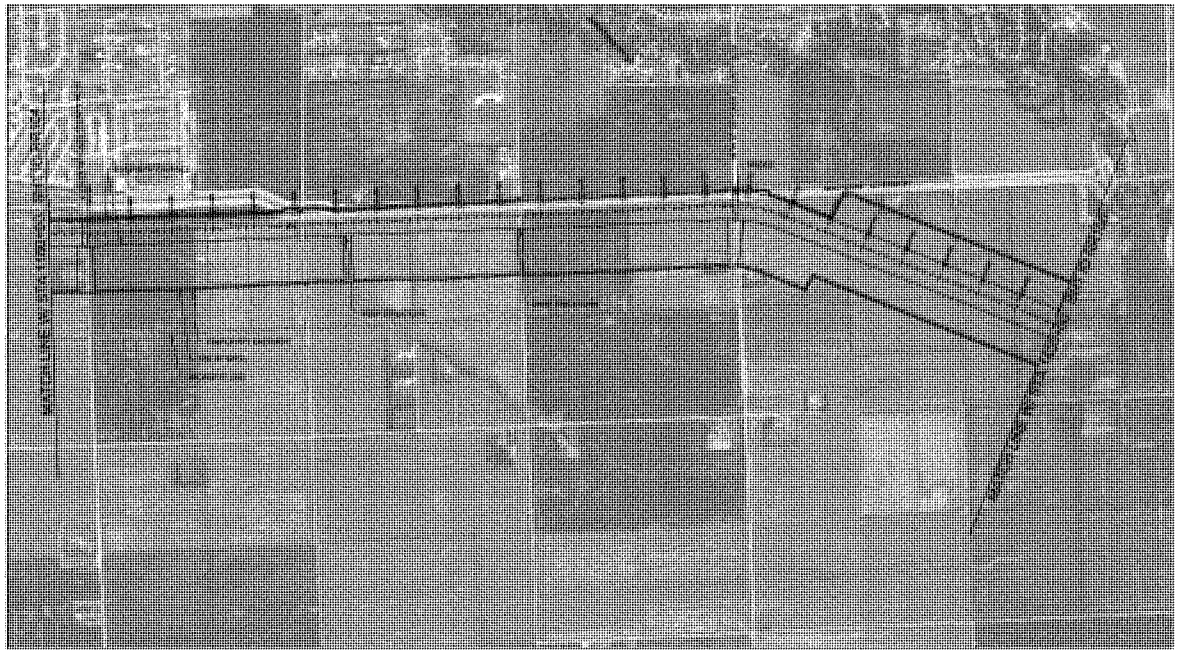

PLAN VIEW

1000' 500' 0 1000'

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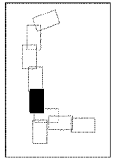

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RED RIVER OF THE NORTH
CASS COUNTY & CLAY COUNTY
FARGO NORTH DAKOTA, MOORHEAD MINNESOTA
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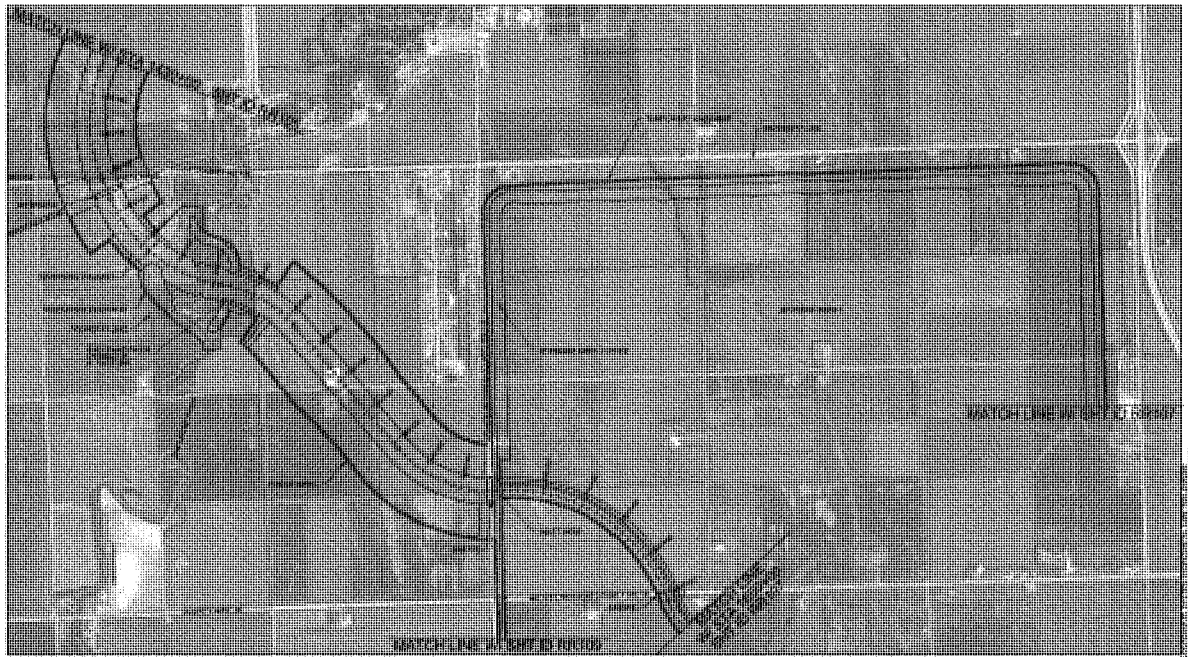
RR105



PLAN VIEW

1000' 500' 0 1000'

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CHECKED BY: DAW
SUBMITTED BY: MAW
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DATE: 11-14-2011
SOLICITATION NO.:
CONTRACT NO.:
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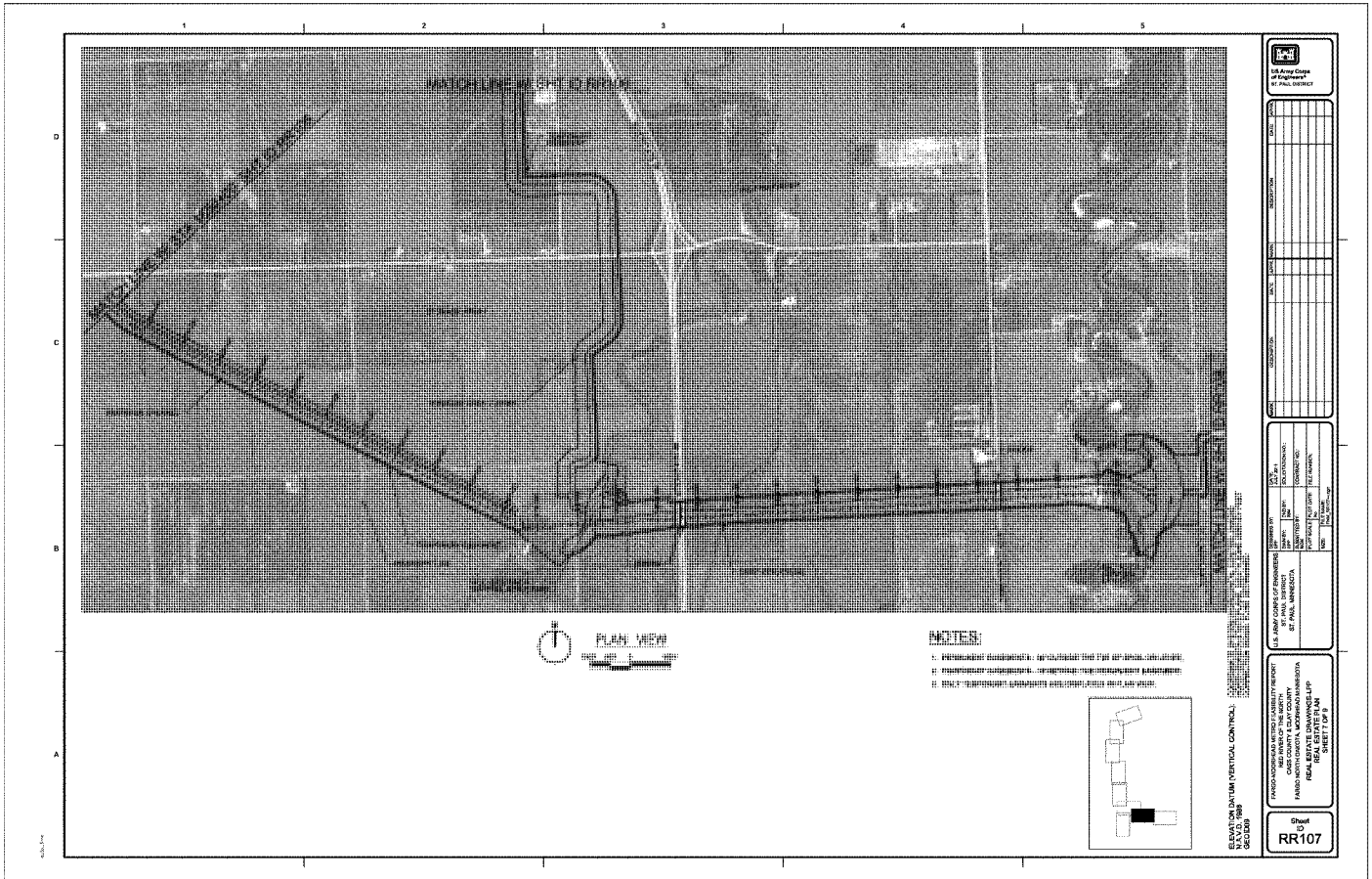
Sheet ID
RR106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Sheet ID
RR107

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RR108
FARGO-MOORHEAD METRO FEASIBILITY REPORT
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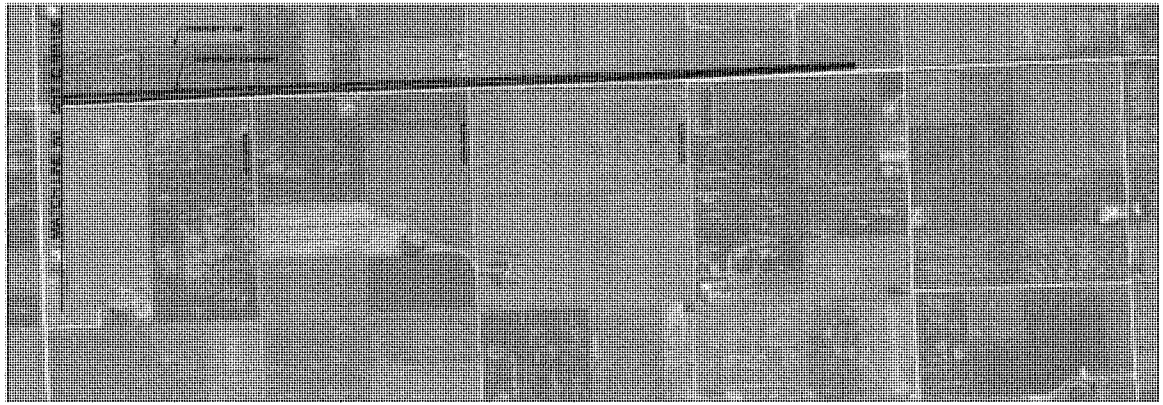
Final Fargo-Moorhead Metro Feasibility Report
August 2011



PLAN VIEW

1000' 500' 0 1000'

NOTES:

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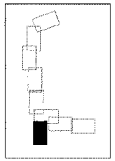
2. TEMPORARY EASEMENTS - 15' BEYOND THE PERMANENT EASEMENT.
3. ONLY TEMPORARY EASMENTS ARE DISPLAYED IN PLAN VIEW.



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N.A.V.D. 1988 NORTH DAKOTA STATE PLANE, SOUTH ZONE SURVEY FEET
GEOID09 CORRECTION SCALE: TO BE DETRMINED

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DRAWN BY: PPP
CHECKED BY: PPP
SUBMITTED BY: PPP
DATE: JUN 2011
SOLICITATION NO.:
CONTRACT NO.:
PLOT SCALE: 1:1
PLOT DATE: Feb 2011
FILE NAME: FMM-Alt-Plan-Alt-Plan
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FARGO-MOORHEAD METRO FEASIBILITY REPORT
RED RIVER OF THE NORTH
CASS COUNTY & CLAY COUNTY
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Sheet ID
RR109

Final Fargo-Moorhead Metro Feasibility Report
August 2011
Page-32

Appendix H
Geotechnical Analysis: Credit to Existing Levees

Fargo-Moorhead Metropolitan Area Flood Risk Management

Final Feasibility Report
and Environmental Impact Statement

July 2011

US Army Corps of Engineers ®

Prepared by:
U.S. Army Corps of Engineers
St. Paul District
180 Fifth Street East, Suite 700
St. Paul, Minnesota 55101-1678

Fargo – Moorhead Metro Feasibility Study
Fargo, North Dakota and Moorhead, Minnesota
Appendix H
Geotechnical Analysis: Credit to Existing Levees

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Attachment H-16: 1st Ave, Moorhead

Fargo – Moorhead Metro Feasibility Study
Fargo, North Dakota and Moorhead, Minnesota
Appendix H:
Geotechnical Analysis: Credit to Existing Levees

PURPOSE

1. Both the communities of Fargo, ND and Moorhead, MN have constructed levees that are protecting areas of their cities from the Red River of the North. These levees have been design and constructed by the communities and are not a part of the Corps' federal or non-federal levee programs. An evaluation is necessary to determine the reliability of the existing levees as required by Policy Guidance Letter No. 26, *Benefit Determination Involving Existing Levees*, dated 23 December 1991 (Reference 1).

2. The purpose of this is report is to summarize the geotechnical analysis that was completed in associated with the "credit to existing levees" study. A reliability analysis was completed to determine the probability of failure of the existing levees as a function of the floodwater elevation. The USACE ETL 1110-2-556, *Risked-Based Analysis on Geotechnical Engineering for Support of Planning Studies*, dated 28 May 1999 (Reference 2), was used a guidance. This guidance expired on 30 June 2004 and was rescinded on 4 MAR 2009. The "credit to existing levees" analysis was completed prior to the ETL being rescinded. There is no other guidance that has replaced this ETL and due to this fact it is still the most appropriate document to use as guidance.

EXISTING LEVEES

3. The levees constructed by the communities of Fargo, ND and Moorhead, MN vary in height, top width, and side slopes and are scattered throughout the metro area. The locations of the existing levees can be seen in Attachment H-1.

4. These levees were inspected during a site visit on 8 October 2008 and many again were observed during a site visit between 19 and 20 November 2008. In general, the sod cover / turf was well established on the levee. In some instances, trees and shrubs were growing at and/or beyond the toe of the levees. In a couple instances, trees and shrubs were growing on the levee. Structures, such as homes and apartment/condo buildings were adjacent to the levees. The purpose of the inspection was to assess the current conditions of the levee and not to evaluate if the levees conformed to current USACE's guidelines. Photos of the levees can be seen in Attachment H-2.

5. The project documents for the existing levees indicate that the levees were generally constructed and/or modified between 1997 and 2003; the North Broadway Addition levee reach was constructed as early as 1990 while the Southwood Drive Levee reach was constructed as recently as 2007. It is unknown exactly where the fill material was obtained for the construction of the existing levees, but clay material is readily available in the area and it is highly likely that the levees are constructed of this clay material. The exact construction method of the levees is also unknown, but the general practice is to place fill materials in lifts using a dozer and compact it either with the dozer or using a sheepsfoot or padfoot roller. It is not likely that an inspection

trench was excavated beneath the centerline of the existing levees, which is standard practice for permanent levees that are designed and constructed by the Corps' St. Paul District.

6. Most of these levees do not afford a continuous line of protection. These discontinuities range from being low spots in the existing levee, openings in the levee to maintain day-to-day traffic, or the fact that the levee does not tie into high ground. These discontinuities require that emergency measures (i.e. emergency levees, sandbags, or HESCO Bastion Concertainers) be constructed / placed to provide a continuous line of protection to the areas behind the existing levees. A summary of the elevation in which the discontinuities occur can be found in Table 1. All elevations are presented in North American Vertical Datum 1988 (NAVD 88). Some of the project as-built drawings use different vertical datums, but were converted to NAVD 88 for reporting purposes.

Table 1: Summary of Discontinuity Elevations

City	Project ID	Location	Top of Levee	Highest Flood Level Protection	Notes
Fargo	5078-2	10th St. N	898.5	896	Based on Broadway 1st Addition As-Builts that indicate top of levee at 896 FT.
Fargo	4903	Cardinal Muench Seminary	898	897.3	Based on levee as-builts that indicate top of levee at 897.3 FT
Fargo	4579-3	10th Ave S (Dike West)	905	904	Based on levee as-builts that indicate top of levee at 904 FT
Fargo	4908	Lindenwood Drive	905	901.5	Based on contours that indicate discontinuity (driveway) between 901 to 902 and ties into ground between 901 to 902 FT.
Fargo	4980	Southwood Drive	905	903.5	Based on contours that indicate discontinuity and lowest top of levee between 903 to 904 FT.
Fargo	5093	Drain 27 / Rose Coulee	909	906.3	Based on as-builts of area projects that indicate lowest top of levee at 906.3 FT.
Moorhead	97-13-15	Woodlawn Park	904	904	Based on levee as-builts that indicate top of levee at 904 FT.
Moorhead	97-13-14	Horn Park	905	899.5	Based on contours and as-builts that indicate a required closure between 899 and 900 FT.

7. Because of the varying configuration of the levees and locations, eight individual cross sections were analyzed for the "credit to existing levees". These cross sections represent the highest portion along the existing levee reaches. Six of the eight levee reaches are located in Fargo and the other two in Moorhead. Detailed information concerning the levee reaches is summarized below. The locations are summarized in Table 2 and the characteristics are summarized in Table 3. In addition, for each levee reach there is an associated attachment that indicates the specific location of the reach, contours, and drawing/plan sets for the reach.

Table 2: Summary of Location of Existing Levee Reaches

City	Project ID	Location	River Mile	HEC-RAS Section
Fargo	5078-2	10th St. N	440 to 440.5	320 to 321
Fargo	4903	Cardinal Muench Seminary	443.3 to 444.6	330 to 333
Fargo	4579-3	10th Ave S (Dike West)	452.8 to 453.1	388 to 390
Fargo	4908	Lindenwood Drive	453.4 to 453.8	391 to 392
Fargo	4980	Southwood Drive	457.3 to 457.6	407
Fargo	5093	Drain 27 / Rose Coulee	460.4	415 / 7994
Moorhead	97-13-15	Woodlawn Park	452.2	386 to 387
Moorhead	97-13-14	Horn Park	455.5 to 455.7	402 to 403

Table 3: Summary of the Characteristics of the Existing Levee Reaches

City	Project ID	Location	Top of Levee	Elevation at Dryside Toe	Max Height (feet)	Top Width (feet)	Riverside Slope (1V: XH)	Landside Slope (1V: XH)
Fargo	5078-2	10th St. N	898.5	893.5	5	10	3	3
Fargo	4903	Cardinal Muench Seminary	898	893	5	5	6	6
Fargo	4579-3	10th Ave S (Dike West)	905	890	15	10	3	3
Fargo	4908	Lindenwood Drive	905	897	8	8	4	4
Fargo	4980	Southwood Drive	905	901	4	4	3	3
Fargo	5093	Drain 27 / Rose Coulee	909	904	5	10	5	5
Moorhead	97-13-15	Woodlawn Park	904	894	10	10	3	3
Moorhead	97-13-14	Horn Park	905	888	17	10	3	3

8. The Fargo-Moorhead has experienced ten flood events that have crested over 34.5 feet since 1882, with four events occurring since 1997. The largest flood of record occurred on March 28, 2009. A summary of the historical flood crests is provided in Table 4.

Table 4: Historical Flood Crest Elevations for the Fargo-Moorhead Metro Area

Flood Crest (ft)	Year
(1) 40.82	March 28, 2009
(2) 40.1	April 7, 1897
(3) 39.57	April 17, 1997
(4) 37.8	April 11, 1882
(5) 37.34	April 15, 1969
(6) 37.13	April 5, 2006
(7) 36.69	April 14, 2001
(8) 35.39	April 9, 1989
(9) 34.93	April 19, 1979
(10) 34.65	April 16, 1952
* Gage located at approximately River Mile 453. ** Flood Elevation: Crest + 861.4 + 0.94 ft	

9. The river stage is measured at the United States Geological Survey (USGS) gage station 05054000, which is located at approximate river mile 453, near the Fargo water treatment plant and adjacent to the 10th Ave S levee reach. The flood crest or gage reading can be converted to a flood elevation by adding 866.32 feet to the gage reading. This provides a flood elevation at the gage station in NAVD 1988 vertical datum.

10. Because of the natural slope of the river and the various low head dams and bridges on the river, the river / flood elevation is not constant throughout the project area. Therefore a flood profile is required to determine the flood elevation at the existing levee locations for the various flood events. The flood elevation of the last four flood events was estimated using the flood profile that was developed during "Phase 2" of the Feasibility Study. The last four flood events were selected as these events coincide with the time that these levees would have been in place. From the estimated flood profile, the amount of flood water above the toe of the existing levees was determined and is summarized in Table 5. In addition, the table presents the percentage the flood water above the toe compared to the height of the levees.

Table 5: Summary of the Historical Crests

			Amount Historical Crest is Above Levee Toe							
			April 17, 1997		April 14, 2001		April 5, 2006		March 28, 2009	
City	Project ID	Location	39.57		36.69		37.13		40.82	
Fargo	5078-2	10th St. N	-0.1	-2%	-3.0	-59%	-2.5	-51%	1.2	23%
Fargo	4903	Cardinal Muench Seminary	1.9	37%	-1.0	-20%	-0.6	-12%	3.1	62%
Fargo	4579-3	10th Ave S (Dike West)	12.3	82%	9.4	63%	9.9	66%	13.6	90%
Fargo	4908	Lindenwood Drive	5.9	73%	3.0	38%	3.4	43%	7.1	89%
Fargo	4980	Southwood Drive	3.5	89%	0.7	17%	1.1	28%	4.8	120%
Fargo	5093	Drain 27 / Rose Coulee	2.7	54%	-0.2	-4%	0.3	5%	4.0	79%
Moorhead	97-13-15	Woodlawn Park	7.8	78%	4.9	49%	5.3	53%	9.0	90%
Moorhead	97-13-14	Horn Park	15.8	93%	12.9	76%	13.4	79%	17.1	100%

11. The existing levees have performed satisfactorily during the four major recent flood events as there have not been any reported signs of distress observed during high water. This is generally consistent with the District's experience in the Red River Valley. The District typically constructs permanent projects using homogeneous clay levees, with a 10-foot top width and 1V on 3H side slopes. These projects typically perform well during floods. During flood fights, emergency clay levees are constructed with side slopes varying between 1V on 2H to 3H side slopes and 8 to 12 foot top widths. These emergency levees generally holdup during floods, but there are instances in which additional work is required to reinforce them. By comparison, the existing levees of Fargo and Moorhead, which are similar in nature to emergency levees and permanent projects, should have similar performance and provide some reliability during similar flood events.

10th Street North

12. The 10th Street North Levee reach refers to the three levee reaches located at the north end of Fargo, near the Fargo Waste Water Treatment Plant. More specifically, these levees protect the following subdivision: Broadway 1st Addition, River Addition, Royal Oaks 2nd Addition, and the Red River Addition. The levees within this reach were constructed and/or modified 3 different times, the first in 1990, again in 1998, and finally in 2000.

13. These levees are located directly adjacent to homes. The levee cross section matches the Corps' typical section, with a 10-foot top width and 1V:3H side slopes. The levees are at most 5 feet high, or top elevation approximately 898.5 FT. The highest level of protection afforded by these levees is 896 FT, which is the top elevation of the Broadway 1st Addition, as indicated in the as-built drawings. Trees and shrubs were observed to be growing on the levee and also beyond the toe. A portion of the levee has a fence constructed on the top. These encroachments would not meet current Corps requirements.

14. Of the four recent flood events, only the 2009 flood event was high enough that water reached the levee slope. The amount of water was a little more than 1 foot, or slightly more than 20% of the levee height.

Cardinal Muench Seminary

15. The Cardinal Muench Seminary levee reach protects the area of the Cardinal Muench Seminary in the city of Fargo. The majority of this levee is less than two feet in height with the exception of the north end, which approaches 5 feet in height. The highest level of protection afforded by these levees is 897.3 FT, which is the top elevation of the levee as indicated in the

as-built drawings. The roadway that circles the seminary is the closest feature to the levee and is located beyond the dryside toe of the levee. This levee reach existed prior to 1999. In 1999, a portion of the levee was relocated closer to the river to its current location.

16. The typical section of this levee is a 5-foot top width, which is less than the Corps' standard top width of 10 feet. The levee side slopes are 1V:6H, which is flatter than the Corps' standard slope of 1V:3H.

17. Out of the four recent events, water reached this levee only twice (1997 and 2009). The height of water on the levee was approximately 2 and 3 feet for the 1997 and 2009 floods, respectively. This equates to approximate 40% and 60% of the levee height.

10th Avenue South (Dike West)

18. The 10th Avenue South levee reach refers to the levee that was constructed by the City of Fargo to extend the Corps' project "Dike West" southward to provide additional protection to the area near the Fargo water treatment plant. Houses and residential apartment/condo buildings are located adjacent to the levee.

19. The typical section of this levee features a 10-foot top width with 1V:3H side slopes, which matches the Corps' typical section. The highest level of protection afforded by these levees is 904 FT, which is the top elevation of the levee as indicated in the as-built drawings. In two instances, retaining walls were constructed into the dryside slope of the levee to accommodate the residential buildings. The highest retaining wall is approximately five feet in height and the topography slopes down and away from the walls. The lowest elevation behind the levee/wall is approximately 890, which is 15 feet below top of levee. Retaining walls are not typically incorporated into a levee cross section unless properly designed. It is unknown as to how the retaining walls and levee were designed.

20. Flood waters were high enough during the last four flood events to be on the levee. The flood waters ranged from approximately 9.4 feet to 13.6 feet above the toe, or approximately 60% to 90% of the levee height.

Lindenwood Drive

21. The Lindenwood Drive levee reach is located in the area north of the Lindenwood Park, off of Lindenwood Drive South, in Fargo. The levee reach alignment was shifted further away from the river in 1999. The current levee consists of an 8-foot top width and 1V:4H side slopes, which is similar to the Corps' typical section. At most, the levee is eight feet in height, corresponding with a top elevation of approximately 905 FT. The highest level of protection afforded by these levees is 901.5 FT, which is the elevation of the driveway that is cut through the levee. Also, the levee does not tie into high ground, but instead slopes down to an elevation between 901 and 902 FT. At one location, a retaining wall was constructed into the dryside slope of the levee in order to minimize the encroachment of an adjacent house.

22. Since the levee was modified in 1999, the last three flood events were high enough that water was on the levee. The water heights ranged from 3 to 7 feet, or approximately 40% to 90% of the levee height.

Southwood Drive

23. The Southwood Drive levee reach is associated with the area at the east end of Southwood Drive, just south of the Fargo Country Club. This levee was constructed in 2007 to a

top elevation of 905 FT. It is a small levee with a 4-foot top width and is at most approximately 4 feet high. The highest level of protection afforded by these levees is 903.5 FT, which is based on the lowest top elevation of the levee and the ground surface elevation the levee ties into. The side slopes are 1V:3H. There is approximately 130 linear feet of retaining wall constructed within the wetside slope. There are many residential homes adjacent to this levee.

24. During the 2009 flood, this levee reach was raised as the crest was predicted to overtop it. This emergency raise of this levee allowed the flood waters to reach an approximate height of 4.8 above the toe, which is 0.8 feet above the top of the permanent levee.

Drain 27 / Rose Coulee

25. The Drain 27 / Rose Coulee levee reach is associated with the drainage ditch "Drain 27" and the Rose Coulee in Fargo and is a few miles long. A portion of the drain and coulee runs through the Rose Creek Golf Course in Fargo and drains into the Red River. So when the Red River is high water, water can back up into the ditch and coulee. Therefore there are levees constructed along the ditch to confine the backwaters within the ditch, preventing homes from being flooded. In addition to providing protection from the Red River, the drain and coulee direct overland flow from the west to the Red River, prevent flooding. Drain 27 and Rose Coulee were constructed prior to the 1997 flood, and were modified afterwards in 1997, 2002, and 2003.

26. The entire drain and coulee work together as a system, the reliability of which is only as good as the most critical section. Due to the relative similarity of the area, only one section was analyzed for this reach and this was at the highest levee location along the ditch. The levee has a 10-foot top width, 1V:5H side slopes, and on the dryside, is at most 5 feet high. This section is more robust than the Corps' typical section of a 10-foot top width and 1V:3H side slopes. The top elevation of the most of the levees is 909 FT, but in some places, it is only 906.3 FT.

27. Since the modifications to the Drain 27 / Rose Coulee reach in 1997, two of the three most recent flood events have been high enough that water rose above the dryside toe. Flood waters were 0.6 feet above the toe in 2006and 4 feet in 2009. During the 2009 flood, the levees through this reach were raised due to a predicted flood crest greater than the top of levee.

Woodlawn Park

28. The Woodlawn Park levee reach is located on the southeast corner of Woodlawn Park in Moorhead. The levee was in-place during the 1997 flood, but was raised to an elevation of 904 FT and extended after the event. The existing levee is constructed with a 10-foot top width and 1V:3H side slopes, which is the Corps' typical section. At most, the levee is 10 feet tall. This levee is located a considerable distance away from the Red River so the water at this location is relatively slow moving. In addition, a lift station is constructed within the levee prism.

29. Water has been on this levee during all four recent flood events. The height of water on the levee has ranged from approximately 5 to 9 feet above the toe, or 50% to 90% of the levee height, respectfully.

Horn Park

30. The Horn Park levee reach is located in the area of Horn Park in Moorhead, just south of Interstate 94, along River Shore Drive. The levee was in-place during the 1997 flood but was reconstructed with a slight shift riverward following the flood. The top elevation of the levee is

905 FT, but the ground surface on the northeast end of the alignment is only 899.5 FT. The typical section consists of a 10-foot top width and 1V:3H side slopes. The majority of the levee is six feet in height but there is a portion in which the levee approaches a height of 17 feet.

31. Since the modifications in 1997, flood waters have been on the levee during the last three most recent events. The height of water above the toe ranged from approximately 13 to 17 feet, or 75% to 100% of the levee height, respectively.

STRATIGRAPHY

32. For the "Credit to Existing Levees" analysis, soil exploration was not completed. Due to the lake deposition environment of the area, the geology is similar throughout Fargo-Moorhead area and the stratigraphy was generalized. The generalization was based on the findings of the previous Corps Section 205 project, Fargo-Ridgewood. It was acceptable to assume this generalized stratigraphy during the "credit to existing levees" analysis as the main failure mode, slope stability, was dependent on only the configuration of the levee and the material it was immediately founded on. The range of the formations' top elevation and the selected top elevation for the "Credit to Existing Levees" analysis is summarized below in Table 6.

Table 6: Summary of Generalized Stratigraphy for Fargo-Moorhead Area

Soil Formation	Range of Top Elevation	Selected Top Elevation
Plastic Laminated Sherack / Sherack	890-891	Ground Surface
Brenna	856 - 858	857
Argusville	803 - 831	815

GEOLOGY

33. The geology of the Fargo-Moorhead area consists of 5 major formations. A summary of the formations is included below and was taken directly from the USACE "Appendix D, Geotechnical Design and Geology" for the Fargo-Ridgewood project, date 2007 (Reference 3).

34. The geology influencing the Red River of the North Valley along the North Dakota / Minnesota border is the legacy of glacial Lake Agassiz and recent fluvial/alluvial processes of the Red River and its tributaries. During the glacial period, the entire watershed of the present day Red River of the North was covered by a continental glacier. Periodically, as the glacial ice melted and retreated northward, huge ice dams were formed which blocked the natural northerly drainage pattern. Glacial Lake Agassiz, which covered approximately 200,000 square miles, resulted from the ice damming and subsequent ponding of meltwaters. The lake is believed to have existed from approximately 13,800 to 9,000 years before present (B.P.), during the Late Wisconsin Glacial Episode of the Pleistocene Epoch. At its maximum extent, Lake Agassiz is believed to have been approximately 150 feet deep in the vicinity of Fargo. As the glacier receded and advanced, fluctuations of the lake levels resulted in corresponding variations of the sediment types. After the glacial lake drained for the final time, the relatively youthful drainage pattern of the present Red River of the North established itself on top of the lake sediments. A useful analogy may be to consider the river course to be little more than a scratch in a broad table top. The basis for most of the stability analysis prepared for this report is a direct result of

the geologic setting of the present day Red River Valley. A brief history of the Pleistocene Epoch and related stratigraphy is presented, therefore, to establish background for discussions of the engineering characteristics of the various soil units. Much of this information has been previously detailed in:

North Dakota Geological Survey Bulletin No. 47 (Klausing, 1968),
North Dakota Geological Survey Miscellaneous Series 52 (Harris, Moran, & Clayton, 1974),
North Dakota Geological Survey Report of Investigation No. 60 (Arndt, 1977),
General Design Memorandum for Flood Control-East Grand Forks (Corps of Engineers, 1986).

35. The stratigraphic units will be discussed from bottom-most to ground surface.

36. Bedrock. Bedrock lies at an estimated depth greater than 300 feet beneath the glacial sediments in the region. The bedrock is likely composed of Pre-Cambrian Era, crystalline, igneous and/or metamorphic rock. The bedrock lies well below the influence of the proposed project.

37. Undifferentiated Glacial Sediment. Up to 200 feet of till overlies the bedrock surface. An unknown amount of glacial drift is included in the estimated thickness. The till surface generally slopes from south to north at a slightly greater rate than the ground surface. The till ranges from a gravelly, sandy clay to a gravelly, silty, clayey sand.

38. Argusville Formation. The lowest foundation unit of interest is the Argusville Formation. In the project location, the depositional period for this formation likely straddled the Pre-Caledonian Advance of the Lostwood Glaciation (Cass Phase) and continued throughout the early portion of the Caledonian Advance approximately 13,500 – 12,800 years BP. In contrast to the underlying glacial drift, this unit has only scattered sand and gravel. The sand and gravel in the deposit was likely derived from rafts of floating glacial ice. The Argusville Formation may be characterized as massive, soft to medium stiff, wet, highly plastic, slightly sandy or gravelly, brown to dark gray, glacio-lacustrine clay. A gritty texture is the most distinctive feature of the Argusville Formation. Along the proposed project alignment, the Argusville Formation has an approximate top elevation of 803-831 feet (+/- 5 feet), (NAVD 1988 adj.), and has an average thickness of 20-30 feet. The contact with the overlying Brenna Formation is gradational. The engineering properties are very poor and should be considered as poor as, or only slightly better than, the overlying Brenna unit.

39. Brenna Formation. The second high-water phase (or Lockhart Phase) of Lake Agassiz occurred from approximately 11,600 to 11,000 years BP and resulted in the deposition of the Brenna Formation. The Brenna Formation is characterized as a uniform, soft to very soft, wet, highly plastic, dark grey, glacio-lacustrine clay, with little or no visible structure. The major source of sediment for this formation was eroded Pierre Shale bedrock. Slickensides are commonly observed on shear planes in freshly broken samples. Soft, calcareous silty nodules are common, increasing with depth. The Brenna Formation is notoriously unstable as a foundation material throughout the Red River of the North Valley. At the project location, the top of the Brenna Formation has an approximate top elevation of 856-858 feet (+/- 5 feet), (NAVD 1988 adj.) and exhibits a gently undulating surface. In the project area, the unit has an average thickness of approximately 30-35 feet. The contact with the overlying Sherack or Poplar River Formations is an erosional unconformity. The upper 3 to 5 feet of the Brenna Formation is variably harder and more consolidated, probably due to desiccation during sub-

aerial exposure, than the bulk of the Brenna Formation. It is not thick enough, however, to substantially alter the basic weakness inherent within the formation.

40. Poplar River Formation. Between 11,000 to 9,000 years BP (the Moorhead Phase), Glacial Lake Agassiz experienced several water level fluctuations. During periods that portions of the lake bottom were exposed to sub-aerial erosion, a drainage network similar to the modern Red River system developed. The Poplar River Formation is the result of deposition of fluvial channel and overbank sediments during this phase. Along the project alignment, the formation is characterized as laminated, soft to medium stiff, wet, silty, organic rich clay with a mealy texture. Locally, peat beds up to 3 feet thick may be encountered in this unit. Where present, it typically occurs as trough shaped features from a few hundred feet to a mile in width that are incised into the top of the Brenna Formation. Though known to be more than 100 feet thick in some areas of the formation, in the proposed project area, it averages 8 feet in thickness. The contact with the overlying Sherack Formation is conformable, usually interbedded, and gradational. Although not encountered in any project related soil borings to date, locally pervious deposits of the Poplar River Formation can produce substantial amounts of water. If a significant body of this pervious material were encountered during construction, it could, potentially, pose a dewatering problem.

41. Sherack Formation. The third and final high-water phase (or Emerson Phase) of Glacial Lake Agassiz occurred from approximately 9,900 to 9,000 years BP and resulted in the deposition of the Sherack Formation. The Sherack Formation is typically characterized as laminated, medium stiff, glacio-lacustrine silty clay and clayey silt with minor amounts of sand, gypsum and calcite crystals, and /or organics. The upper portion of this unit is usually brown to yellow-brown with frequent iron oxide or calcareous concretions but the base is grey. Glacial material from the uplands, instead of shale bedrock, was the major source of sediment for the Sherack Formation. The contact with the overlying present period (Holocene Epoch) sediments is an erosional unconformity.

42. An interbedded zone of highly plastic, very wet, grey to grey-brown, silty clay and clayey silt with lower strength properties than most of the Sherack Formation was encountered in boring 01-5M. This unit was identified as the Lower Sherack Formation in the 1986 Design Memorandum for Flood Control (East Grand Forks) and is currently designated as the "plastic laminated" Sherack Formation by the St. Paul District. Typically this layer has a liquid limit greater than 80, with a plasticity index greater than 50. Most commonly, but not exclusively, this zone is located near the base of the Sherack Formation. It may also be found near the top or sandwiched throughout the unit. Often this weaker zone is not continuous from the upper to lower river banks along a given cross section. Generally, when found, the plastic, laminated zone is about 5 to 10 feet thick.

43. The Sherack Formation has been impacted more than any other unit in the project reach by erosion and flooding of the river. Often, below the secondary (upper) banks, substantial portions have been removed and replaced by relatively recent alluvial and/or fluvial sediments. Slope failures have also displaced the Sherack Formation riverward of the secondary banks. Riverward of the upper bank, average elevation and thickness of formation figures are so variable that the only practical method for evaluation is to reference a specific cross-section before any meaningful analysis may begin. On top of the secondary (upper) bank and beyond, the approximate average top of formation elevation within the project reach is 890 to 891 feet (+/- 5 feet), (NAVD 1988 adj.) with an average thickness of approximately 20 to 25 feet.

44. *Present period sediments. As the northeastern outlets for the lake opened for the final time, it is estimated that Glacial Lake Agassiz retreated from North Dakota by about 9,000 years BP, and was wholly gone as a Pleistocene phenomenon by approximately 8,500 years BP. An immature drainage system developed along the floor of the glacial lake bed with tributary streams rising in the high ground to the west and east. The present day Red River of the North watershed is the result of this post-glacial erosional activity. Flood sediments from the Red River blanket the valley ground surface now in a meander belt approximately 1 to 1.5 miles on either side of the existing river. These surface sediments may be characterized generally as soft to medium stiff, fluvial or alluvial, silty clay or clayey silt. Variably, the unit may contain sand or organic matter and range from massive to weakly laminated. Adjacent to urban development, fill and rubble are frequently components of the upper sediments. The river exhibits no well defined flood plain. The depth of these surface sediments is highly variable and may range from approximately 1 to 15 feet in thickness along the proposed project alignment.*

TOPOGRAPHY

45. The program ArcMap from ESRI, Inc. was used to display the topography of the Fargo-Moorhead area. Contours were developed from a combination of previous data. Using ArcMap to display the contours, critical cross sections were selected. Profiles of the ground surface and existing levees were developed using a combination of both the displayed contours and as-built drawings obtained from the cities of Fargo and Moorhead.

PERFORMANCE MODES

46. The ETL 1110-2-556 (Reference 2) indicates that there are five major geotechnical performance modes to consider for the "credit to existing levees" analysis. These five performance modes are summarized below with an explanation of how they were evaluated.

Underseepage

47. The performance mode "underseepage" as used in ETL 1110-2-556 (Reference 2), is related to the phenomenon known as piping. Piping is the backward erosion of materials caused by seepage forces that are large enough to move particles. As this phenomenon continues, more and more soil particles are moved out of the soil mass and a "pipe"-like cavity is formed. If not caught in time, piping can lead to catastrophic failure of the structure or levee. It is assessed by comparing the maximum exit gradient to the critical gradient.

48. In the case of the Fargo-Moorhead area, the clay levees are constructed on foundation materials that are composed of clay type materials which are relatively impermeable. The District's flood fighting experiences in the Red River Valley indicate that underseepage is not a likely concern for clay levees on clay foundations. In addition, judgment dictates that seepage should not be an expected concern for clay levees founded on clay foundations without a pervious subsurface stratum.

49. Based on the aforementioned reasons, judgment was used to estimate the probability of failure of the existing levees. The expected performance level of each levee reach with the flood water elevation at the top of the levee was selected. The selected performance level was based on the following:

- If the levee configuration was similar to the Corps' typical section (10-foot top width, 1V:3H side slopes), and 10 feet in height or less, then performance was "GOOD".

Levees greater than 10 feet in height were given An "ABOVE AVERAGE" performance level.

- If the levee configuration was less robust than the Corps' typical section meaning narrower top width, and less than 10 feet high, the performance was "ABOVE AVERAGE".
- If a retaining wall was constructed within the dryside slope, the performance level was "BELOW AVERAGE", due to the reduction of the seepage path length.

50. Using the selected performance level, the probability of failure was obtained using Table A1 of ETL 1110-2-556, which is reproduced in Table 7 (Reference 2). The probability of failure at the elevation associated with the dryside toe was taken to be zero. For elevations in between the toe and top of levee, probability of failure was assumed to be linear. The selected expected performance levee for the underseepage failure mode and associated probability of failure is indicated in Table 8.

Table 7: Target Reliability Indices (reproduction of Table A1 of ETL 1110-2-556)

Expected Performance Level	Beta	Probability of Unsatisfactory Performance	Probability of Failure (1 in X times)
High	5	3.00E-07	3.33E+06
Good	4	3.00E-05	33333
Above Average	3	1.00E-03	1000
Below Average	2.5	6.00E-03	166.7
Poor	2	0.023	43.5
Unsatisfactory	1.5	0.07	14.3
Hazardous	1	0.16	6.3

Table 8: Selected Performance Levels for Underseepage Failure Mode

City	Project ID	Location	Selected Expected Performance Level for Underseepage	Probability of Failure, P(F)
Fargo	5078-2	10th St. N	GOOD	3.00E-05
Fargo	4903	Cardinal Muench Seminary	GOOD	3.00E-05
Fargo	4579-3	10th Ave S (Dike West)	BELOW AVERAGE	6.00E-03
Fargo	4908	Lindenwood Drive	BELOW AVERAGE	6.00E-03
Fargo	4980	Southwood Drive	ABOVE AVERAGE	1.00E-03
Fargo	5093	Drain 27 / Rose Coulee	ABOVE AVERAGE	1.00E-03
Moorhead	97-13-15	Woodlawn Park	GOOD	3.00E-05
Moorhead	97-13-14	Horn Park	ABOVE AVERAGE	1.00E-03

Slope Stability for short-term conditions

51. The performance mode "short-term stability" is to assess the stability of the levee under short-term, undrained conditions which is commonly referred to as end-of-construction situation. Due to the fact that the levees have been in place for a number of years, the end-of-construction condition is no longer applicable. The riverward slope is loaded rapidly during a flood event though. This loaded situation was evaluated at the highest levee section (Horn Park in Moorhead) to check to see if this was a critical condition. The analysis was run using undrained shear strength parameters and floodwater to the top of the levee. It was found that the short-term flood loading condition was less critical than the long-term condition. Therefore, the probability of failure due to slope instability was based on the long-term conditions and not the short-term conditions.

Slope stability for long-term conditions

52. The performance mode "long-term stability" is to assess the stability of the levee under long-term, drained conditions. Drained shear strength parameters are required for this analysis along with pore pressures. A summary of the slope stability procedure used is below.

Model

53. The slope stability models were set up in the program SLIDE 5.0 from Rocscience. The stratigraphy was generalized as previously stated. The ground surface profile and levee configuration was determined using both the contours developed and displayed in ArcMap and as-built drawings.

Soil Design Parameters

54. No soil exploration or testing was completed during the "credit to existing levee" study. Instead, design parameters were selected based on the test data that was obtained for previous projects in the area. These projects were the Horace and West Fargo Diversions and the Fargo-Ridgewood Section 205 project. This test data was used to estimate moist and saturated unit weights along with drained and undrained shear strengths.

55. The failure criteria used in the selection of the effective stress shear strength parameters was ultimate or post-peak failure. This is due to the fact that large strains may occur in the soils over time. In the case of the "levee fill" material, the effective shear strength of the material was estimated based on the Sherack effective friction angle and an effective cohesion intercept from triaxial tests on compacted levee fill material for the Grand Forks and East Grand Forks projects. The total stress shear strength parameters were selected based on peak values. The selected shear strength parameters are summarized in Table 9 and the Mohr-Coulomb shear strength plots can be seen in Attachment H-4. Table 10 summarizes the selected unit weights.

56. In addition to determining the mean values for the design parameters, the coefficient of variation or standard deviation is also required when completing a reliability analyses. The coefficients of variation are only required for those parameters that are expected to have a large influence on the slope stability results. For this reliability analyses those parameters are as follows and can be found in Table 9 and Table 10.

- Levee effective friction angle and cohesion intercept,
- Sherack effective friction angle, and
- Plastic Laminated (PL) Sherack effective friction angle.

Table 9: Summary of Shear Strength Parameter

Formation	Most Likely Effective Stress Shear Strength Parameters (1)						Most Likely Total Stress Shear Strength Parameters (2)			Fargo-Ridgewood Parameters (3)	
	ϕ'	σ	Coeff. Of Var.	c'	σ	Coeff. Of Var.	c	σ	Coeff. Of Var.	ϕ'	c
Levee Fill (4)	27	3	10%	250	75	30%	assume values of PL Sherack				
Plastic Laminated Sherack	21	3	14%	0	0		1125	175	16%	19	1150
Sherack	27	3	10%	0	0		assume values of PL Sherack			26	1150
Poplar River	30	2	6%	0	0		1800	350	19%	29	1700
Brenna	15	3	20%	0	0		650	100	15%	13	650
Argusville	17	3	17%	0	0		850	100	12%	16	850

Notes:
(1) The parameters for the formations not including Levee Fill are based on the R-Bar triaxial and direct shear tests. The failure criterion is defined as ultimate deviator stress which equates to the deviator stress at 15% or 20% axial strain. It is assumed that there is no cohesion intercept for the Mohr-Coulomb shear strength envelop except for the levee fill material.
(2) These parameters are based on triaxial shear tests with the failure criterion defined at peak deviator stress.
(3) These are the parameters that were selected and used in the analyses completed for the Section 205 Fargo-Ridgewood project.
(4) The effective friction angle parameter for the Levee Fill material is based on the Sherack formation shear strength parameter and the effective cohesion intercept is based on triaxial test results from the Grand Forks/East Grand Forks projects using compacted clay specimens.

Table 10: Summary of Unit Weights

Formation	γ_m (pcf)	γ_{sat} (pcf)
Levee Fill	assume values of Sherack	
Plastic Laminated Sherack	114	114
Sherack	118	121
Poplar River	121	121
Brenna	103	103
Argusville	105	105

Groundwater

57. The groundwater conditions and the phreatic surface through the embankment were modeled using the piezometric line feature for the slope stability analyses as this is a quick and easy way to approximate the pore pressures in the embankment and foundation materials. The phreatic surface through the levee was approximated as a straight line from the flood water surface elevation and dryside toe of the levee. This assumption is thought to be conservative in the fact that the assumed phreatic surface approximates the steady-state seepage condition if it were to develop. Due to the impervious nature of the materials and the short time duration of the flood events, the seepage conditions would not reach steady-state.

Foundation Conditions

58. Soil exploration was not completed prior to the "credit to existing levees" analysis; therefore generalized stratigraphy of the Fargo-Moorhead region was used. The generalized stratigraphy indicates that the Sherack formation is the top layer and that any levees constructed would be founded on this formation. Experience also indicates that the Sherack formation can be interbedded with a lower shear strength material identified as Plastic-Laminated (PL) Sherack. The PL Sherack occurs at random and could be found throughout the Fargo-Moorhead region. Therefore it was assumed that the levees could be constructed on top of the Sherack formation 50% of the time and the PL Sherack formation 50% of the time.

59. The contact elevation of the Sherack / PL Sherack and Brenna was taken to be 857. The contact elevation of the Brenna and Argusville was taken to be 815.

Procedure

60. The Taylor's Series procedure outlined in the ETL 1110-2-556 (Reference 2) was used to determine the reliability of the existing levees. The parameters that were varied for the analysis were the effective shear strength parameters for the levee, Sherack, and PL Sherack materials. Because there was uncertainty in whether Sherack or PL Sherack would be located beneath the existing levees, the Taylor's Series procedure was conducted for each scenario and the results were combined.

61. To complete the stability analyses the software program SLIDE 5.0 from Rocscience was implemented. The program has multiple features that were set standard for all analyses and are listed below.

- Factor of Safety was calculated using Spencer's Method,
- The failure surface was broken into 50 slices,
- Circular failure searches were used,
- Groundwater was models using a "water table line",
- The grid spacing for the center of the circular failure surface grid was 1 foot by 1 foot,
- Twenty-five radius increments were used,
- Number of trial slip surfaces = 17,576,
- Tension cracks filled with water were used.

Through-seepage

62. The performance mode "through-seepage" is related to the phenomenon known as internal erosion. Internal erosion is similar to piping but is the initiation of the particle movement through/along cracks or defects. Particle movement is initiated when the tractive shear stress exerted on the soil by flow of the water is greater than the resisting tractive shear stress of the soil (ETL 11102-556, Reference 2).

63. Through-seepage can also lead to surface erosion on the landside slope if there is a large enough quantity of flow through the embankment. This often occurs with sand embankments were water can easily flow through the embankment. The levees constructed in the Red River are homogeneous clay levees and water cannot easily flow through them. Therefore through-

seepage is not likely to be an issue as the quantity of flow and velocity through the levees is low and would not cause surface erosion.

64. For clay embankments that are constructed properly, there is a low probability that internal erosion will be a concern as indicated in the ETL. The ETL also goes on to indicate that there are no analytical models to assess internal erosion and judgment or historical data be used to estimate the probability of failure due to through-seepage.

65. Based on the aforementioned reasons, judgment was used to estimate the expected level of performance of the existing levees for the failure mode of through-seepage. The criteria used to select the performance level is as follows:

- If levee configuration was similar to the Corps' typical section, the expected level of performance was taken to be "ABOVE AVERAGE".
- If the levee configuration consisted of 1V:3H side slopes, less than 5 feet in height, but the levee had a narrower top width, performance was taken to be "ABOVE AVERAGE".
- If the levee had flatter side slopes than 1V:3H and was less than 5 feet in height, the level of performance was taken to be "GOOD".
- If a retaining wall constructed within the dryside slope of the levee, the performance level was taken to be "BELOW AVERAGE" due to the reduced seepage length.

66. Using the selected performance level, the probability of failure was obtained using Table A1 of ETL 1110-2-556, which is reproduced in Table 7. The probability of failure at the elevation associated with the dryside toe was taken to be zero. For elevations in between the toe and top of levee, probability of failure was assumed to be linear. The selected expected performance levee for the through-seepage failure mode and associated probability of failure is indicated in Table 11.

Table 11: Selected Performance Levels for Through-seepage Failure Mode

City	Project ID	Location	Selected Expected Performance Level for Through-Seepage	Probability of Failure, P(F)
Fargo	5078-2	10th St. N	ABOVE AVERAGE	1.00E-03
Fargo	4903	Cardinal Muench Seminary	GOOD	3.00E-05
Fargo	4579-3	10th Ave S (Dike West)	BELOW AVERAGE	6.00E-03
Fargo	4908	Lindenwood Drive	BELOW AVERAGE	6.00E-03
Fargo	4980	Southwood Drive	ABOVE AVERAGE	1.00E-03
Fargo	5093	Drain 27 / Rose Coulee	ABOVE AVERAGE	1.00E-03
Moorhead	97-13-15	Woodlawn Park	ABOVE AVERAGE	1.00E-03
Moorhead	97-13-14	Horn Park	ABOVE AVERAGE	1.00E-03

Surface Erosion

67. The purpose of the performance mode "surface erosion" is to assess the potential for the levee to be eroded by the current flowing parallel to the slope or by the wave action against the slope. The ETL 1110-2-556 (Reference 2) outlines a procedure to estimate the probability of

failure due to erosion due to flow parallel to the slope. This procedure was followed for the "credit to existing levee" analysis.

68. Hydraulic modeling of the river indicated that the expected river velocities adjacent to the levees would be between 1 and 2 feet per second for flows associated with flood events between the 100-year and 500-year. In general, the top of the levees are around the 100-year flood elevation, or slightly higher. Therefore a conservative river velocity of 2 feet per second was used for all water elevations. In addition, the following parameters were also assumed.

- Coefficient of variation for the velocity: approximately 11%
- Critical velocity where erosion begins: 5 feet per second (this is the maximum velocity allowed by the St. Paul District before riprap is to be used as erosion protection. Table 2-5 of EM 1110-2-1601 (Reference 4) indicates that the maximum permissible mean channel velocities for silt clay and clay earth is 3.5 and 6.0 feet per second, respectfully. The existing levee material is expected to be made up of more clay than silt clay material and the value of 5 feet per second falls in between the suggested range)
- Coefficient of variation of the critical velocity: 20%

69. Based on the assumed values, a probability of failure equal to 3.18×10^{-5} (1 chance in 31,444) was calculated. This value was used for all levees at all flood elevations.

70. With the narrow river basin and "short" fetch distances, any waves that are formed are not likely to erode a grass covered, clay slope. In addition, there currently are no models to predict erosion from wave action. Therefore, probability of failure was not calculated for this situation.

RESULTS

71. The performance of the existing Fargo and Moorhead levees and the lack of reported distress for the past flood events indicates that they have provided some reliable means against flooding. In general, the results of the "credit to existing levees" analysis tend to show this, as expected. However, only four recent flood events have occurred since the existing levees were constructed. Furthermore, the existing levees, for the most part, have not been tested with flood waters to the top of the crest. Therefore, the analyses performed show a wide range of reliabilities from high to low due to uncertainties associated with performance at maximum floodwater and variations in geometry and levee height.

72. The results of the "credit to existing levees" analysis indicate a wide range of probability of failure of the levees. With the flood water at the top of the levee, the probability of failure ranges from 0.001 to 0.38. These values are summarized below in Table 12. This relates to a frequency of failure on the range of 1 chance in 913 to 1 chance in 3.

Table 12: Summary of the Probability of Failure with Flood Water at Top of Levee

City	Project ID	Location	Probability of Failure, P(F)	Frequency of Failure	Reliability, R	Expected Performance Level
Fargo	5078-2	10th St. N	0.0011	913	0.9989	ABOVE AVERAGE
Fargo	4903	Cardinal Muench Seminary	0.0062	162	0.9938	BELOW AVERAGE
Fargo	4579-3	10th Ave S (Dike West)	0.2646	3.8	0.7354	HAZARDOUS
Fargo	4908	Lindenwood Drive	0.3825	2.6	0.6175	HAZARDOUS
Fargo	4980	Southwood Drive	0.0081	123	0.9919	BELOW AVERAGE
Fargo	5093	Drain 27 / Rose Coulee	0.0021	477	0.9979	AVERAGE
Moorhead	97-13-15	Woodlawn Park	0.0120	83	0.9880	POOR
Moorhead	97-13-14	Horn Park	0.0476	21	0.9524	HAZARDOUS

73. In general, the analysis indicates that for levees that have a similar cross section to the Corps' typical section and are 5 feet or less in height, the calculated "expected performance level" is "AVERAGE" to "ABOVE AVERAGE". If the levees slightly less robust than the Corp's typical section, the calculated performance level is "BELOW AVERAGE". As the levee heights increase, the performance level decreases to "POOR" to "HAZARDOUS". If retaining walls are incorporated into the dryside slope, the performance level is "HAZARDOUS".

74. The reliability analysis indicates that the performance of the levees, in most instances, is controlled by the stability of the levee. This is what is generally thought to be the case when clay levees are constructed on clay foundations. The stability of the levee is controlled by the strength of the levee material and also the foundation material. Without soil borings being taken at the location of the levees, it was assumed that there was a 50% chance that the foundation material would be Sherack and the other 50% of the time, the foundation would be PL Sherack. The strength of the PL Sherack is 75% of the Sherack. This has a major effect on the outcome of the stability analysis. This is the main reasoning that the overall probability of failure of the existing levees can be so high.

75. During the "credit to existing levees" study the probability of failure was determined for multiple flood elevations. In Table 12 above, only the calculated probability of failure with flood water at the top of the levees are indicated. Due to the "discontinuities" of many of these levees, flood water could flank these levees through adjacent lower spots. In addition, some portions of the levees themselves are lower. These "discontinuities" were incorporated into the relationship of the probability of failure to flood elevation. If the flood water elevation was higher than the "discontinuity", then the probability of failure of the levee reach was taken to be 1.

76. The relationship of the probability of failure to flood elevation can be seen in Figure 1. Figure 2 is a similar plot to Figure 1 but shows the relationship of the probability of failure to the height of water on the levee. These plots can also be found in Attachment H-4. The solid lines on the figures indicate the probability of failure when "discontinuities" are accounted for. The dashed lines on the figures indicate the probability of failure without the discontinuities. The performance levels are also indicated on the figures.

77. When the discontinuities are accounted for, the expected performance levels for the majority of the levees are between "ABOVE AVERAGE" and "BELOW AVERAGE". For the Horn Park levee in Moorhead, the expected performance level is in the "POOR" range before the flood waters reach the discontinuities. For the Lindenwood Drive and 10th Avenue S levees in

Fargo, which have retaining walls within the dryside slope, the expected performance level prior to the flood waters reaching the discontinuities, is "UNSATISFACTORY" and "HAZARDOUS", respectively. This relationship is better shown in Figure 3, which only plots the probability of failures to 0.3.

78. Details of the slope stability and reliability calculations for the "credit to existing levees" analyses can be found in Attachment H-5.

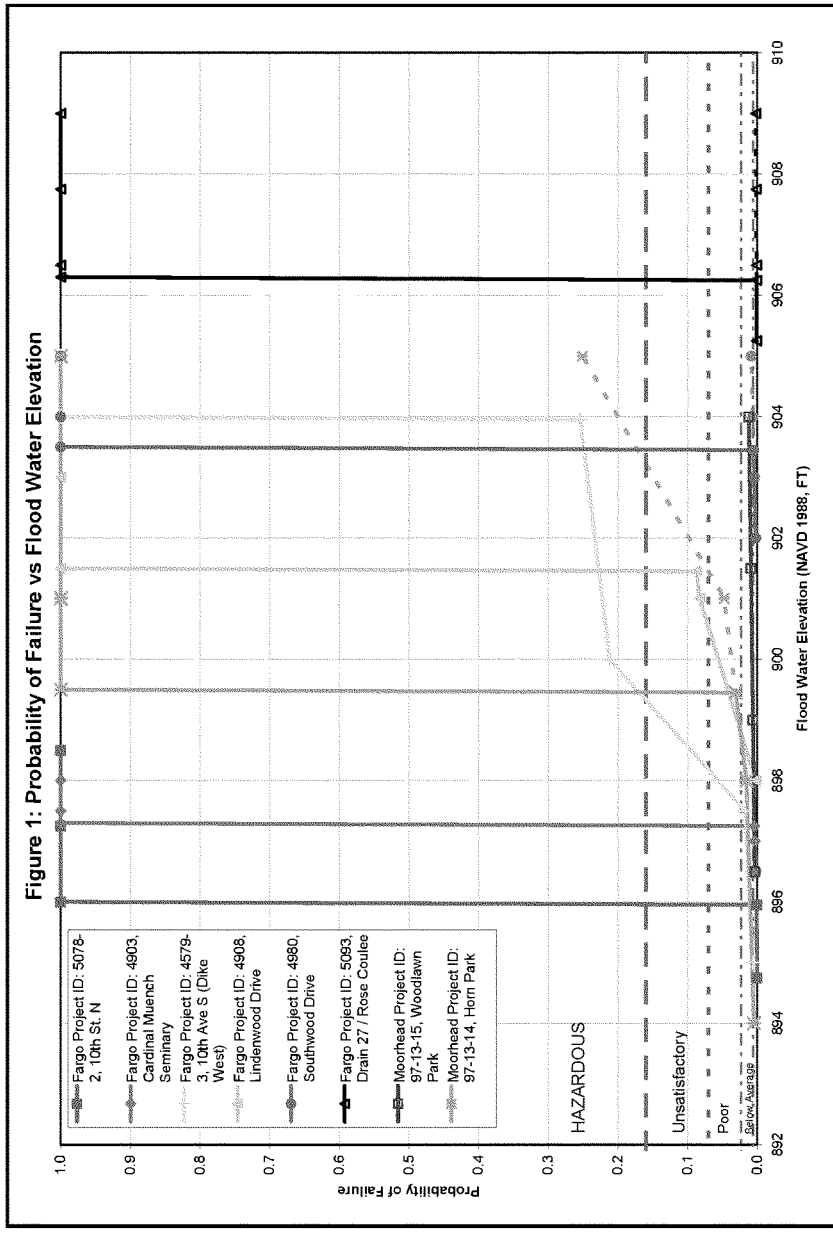
Figure 1: Probability of Failure vs Flood Water Elevation
Fargo Project ID: 5078-2, 10th St. N
Fargo Project ID: 4903, Cardinal Muench Seminary
Fargo Project ID: 4579-3, 10th Ave S (Dike West)
Fargo Project ID: 4908, Lindenwood Drive
Fargo Project ID: 4980, Southwood Drive
Fargo Project ID: 5093, Drain 27 / Rose Coulee
Moorhead Project ID: 97-13-15, Woodlawn Park
Moorhead Project ID: 97-13-14, Horn Park
HAZARDOUS
Unsatisfactory
Poor
Below Average
Probability of Failure
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
892
894
896
898
900
902
904
906
908
910
Flood Water Elevation (NAVD 1988, FT)

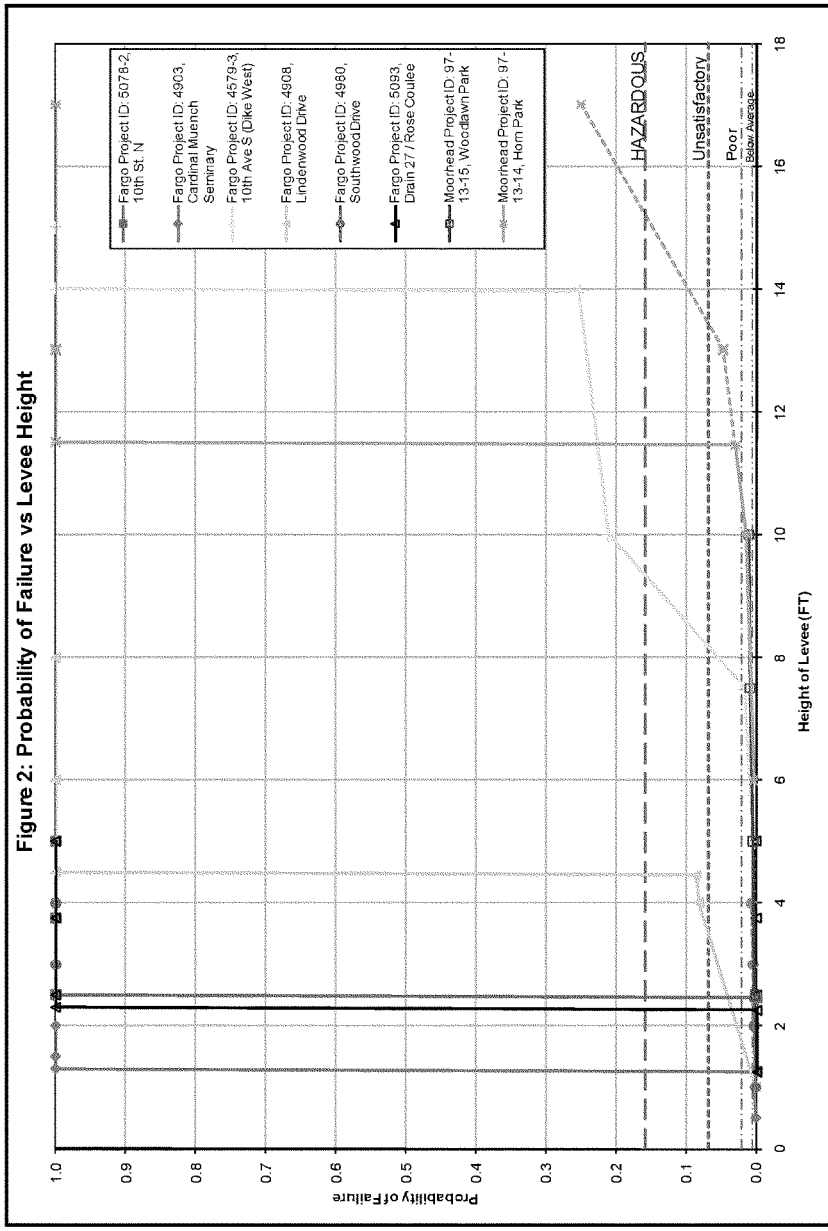

Figure 2: Probability of Failure vs Levee Height

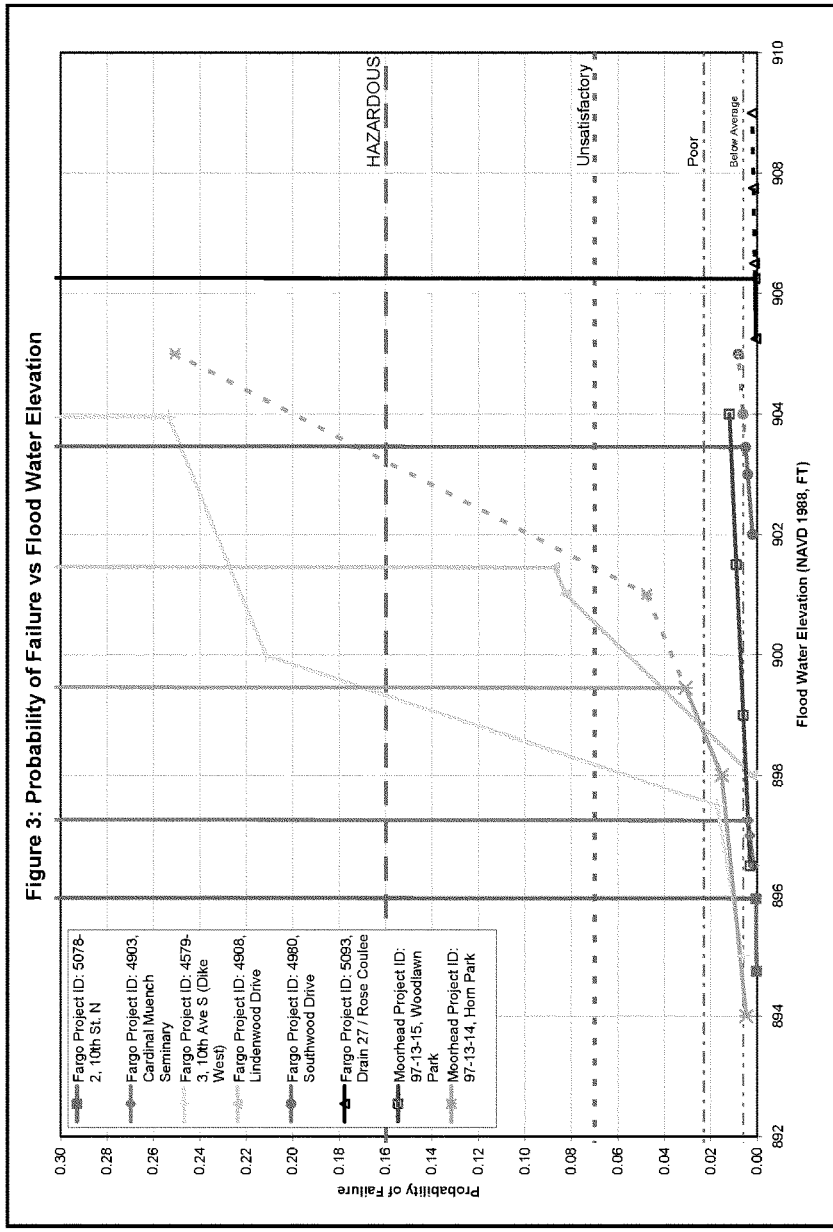
Figure 3: Probability of Failure vs Flood Water Elevation
Fargo Project ID: 5078-2, 10th St. N
Fargo Project ID: 4903, Cardinal Muench Seminary
Fargo Project ID: 4579-3, 10th Ave S (Dike West)
Fargo Project ID: 4908, Lindenwood Drive
Fargo Project ID: 4980, Southwood Drive
Fargo Project ID: 5093, Drain 27 / Rose Coulee
Moorhead Project ID: 97-13-15, Woodlawn Park
Moorhead Project ID: 97-13-14, Horn Park
HAZARDOUS
Unsatisfactory
Poor
Below Average
Probability of Failure
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
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900
902
904
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910
Flood Water Elevation (NAVD 1988, FT)

Short-Term (Undrained Conditions) Slope Stability

79. A check of the undrained (short-term) stability of the levee was completed to make certain that the long-term stability condition was most critical. An undrained stability analysis was completed on the Horn Park Levee, as this is the highest levee and has 1V:3H slopes, making it the most critical levee. Using average undrained shear strength parameters and a flood water elevation at top of the levee, a factor of safety against slide of 2.1 was computed. This is well above the factors of safety for the drained conditions of 1.3 and 1.0, using both Sherack and PL Sherack foundation materials, respectively. When a Taylor series slope stability analysis was completed using undrained shear strength parameters, the probability of failure was found to be negligible. Therefore this verifies that the assumption that the long-term (drain conditions) slope stability condition was most critical was correct.

Long-Term Slope Stability Check

80. A check of the long-term (drained) slope stability calculations was carried out to verify the results of SLIDE 5.0. To complete this check, the program Slope/W 2007 from GeoSlope, LTD was used. Two levee sections, Woodlawn Park and Horn Park, were modeled in Slope/W such that they were the same as the SLIDE 5.0 models. Taylor series slope stability runs were completed using Slope/W. For Woodlawn Park levee, only the Sherack foundation condition was modeled. The search mechanism used was a grid. The factors of safety computed by Slope/W were the same as SLIDE 5.0. For the Horn Park levee, both the Sherack and PL Sherack foundation were modeled. For both foundation conditions, the factors of safety computed by Slope/W were the same as those computed for SLIDE 5.0.

OTHER STRUCTURES

81. There are two locations in the Fargo-Moorhead area that should be noted because of their unique circumstances. These areas are summarized below.

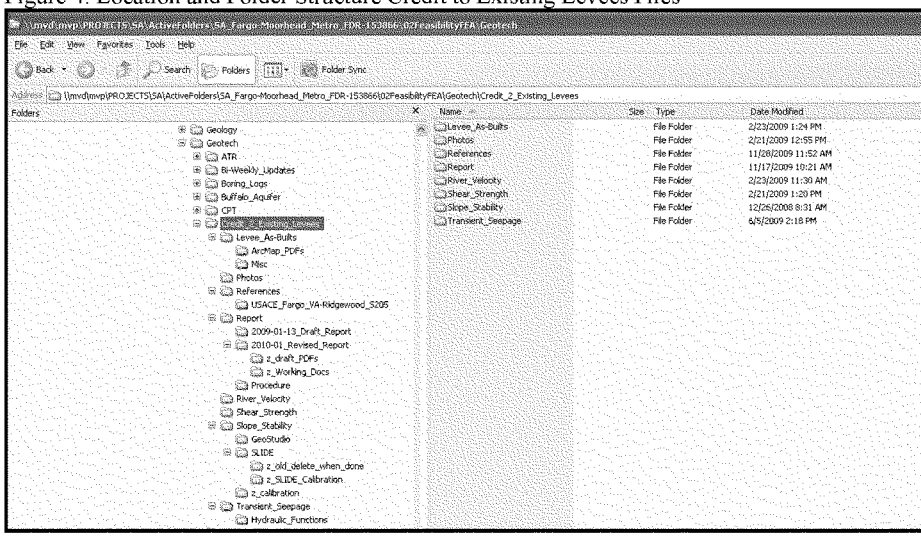
82. The first area that is unique is located at the Oak Grove Lutheran High School in Fargo. A floodwall to top elevation of 902.5 feet was constructed around the eastern portion of the high school to provide protection. This floodwall system ties into an existing levee on the north side that has an approximately elevation of 902 feet, or approximately 4 to 5 feet high. An emergency closure is required to be constructed on the south side when the flood water is expected to get above approximate elevation 897 feet. The Oak Grove levee is similar to the Fargo Southwood Drive levee. Therefore the reliability of the Oak Grove levee can be estimated based on the reliability of the Southwood Drive levee but the discontinuity if the Oak Grove levee must be accounted for.

83. The second levee is located in Moorhead along 1st Avenue, just north of the Moorhead Center Mall. The purpose of this levee is to prevent 1st Avenue from flooding during more frequent flood events. It does not protect any structures. At a flood stage of 31.0 feet, the City of Moorhead floods the underpass and traffic is rerouted. Construction of an emergency levee is also required on the west side of the underpass to protect and provide access to the apartment complex and Heritage Hjemkomst Center.

LOCATION OF FILES

84. All files associated with the "credit to existing levees" are within the project directory located on the server. The folder structure is such that each type of information is located in its own folder, which is appropriately named. The folders which can be seen in Figure 3 can be found using the link below.

Figure 4: Location and Folder Structure Credit to Existing Levees Files



Link:\\mvd\mvp\PROJECTS\SA\SA_Fargo-Moorhead_Metro_FDR-153866\02FeasibilityFEA\Geotech\Credit_2_Existing_Levees\Report\2010-03_Revision_2\z_working_docs\ \mvd\mvp\PROJECTS\SA\SA_Fargo-Moorhead_Metro_FDR-153866\02FeasibilityFEA\Geotech\Credit_2_Existing_Levees\ \\mvd\mvp\projects\sa\SA_Fargo-Moorhead_Metro_FDR-153866\02FeasibilityFEA\Geotech\Credit_2_Existing_Levees

REFERENCES

Reference 1: U.S. Army Corps of Engineers 1991 (December 23). Policy Guidance Letter No. 26, *Benefit Determination Involving Existing Levees*.

Reference 2: U.S. Army Corps of Engineers. 1999 (May 28). "Risked-Based Analysis on Geotechnical Engineering for Support of Planning Studies," *ETL 1110-2-556*.

Reference 3: U.S. Army Corps of Engineers, 2007. "Feasibility Study and Environmental Assessment, Fargo, North Dakota, Appendix D, Geotechnical Design and Geology." St. Paul District.

Reference 4: U.S. Army Corps of Engineers. 1994 (June 30). "Hydraulic Design of Flood Control Channels." *EM 1110-2-1601*

Attachment H-1: Locations of Existing Levees

Attachment H-1, pg 1
Credit to Existing Levees

St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps of Engineers®

FMMFS_P2_geotech_2009-04.mxd
Printed 13 NOV 09

Fargo-Moorhead Metro Feasibility Study
Existing Levee Locations

0 500 1,000 2,000 3,000 Feet

Fargo-Moorhead Metro Feasibility Study
Existing Levee Locations
St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps
of Engineers®
FMMFS_P2_geotech_2009-04.mxd
Printed 13 NOV 09
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500
1,000
2,000
3,000
Feet

Fargo-Moorhead Metro Feasibility Study
Existing Levee Locations
St. Paul District
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GEOTECHNICAL
US Army Corps
of Engineers®
FMMFS_P2_geotech_2009-04.mxd
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Feet

Fargo-Moorhead Metro Feasibility Study
Existing Levee Locations
St. Paul District
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3,000
Feet

St. Paul District
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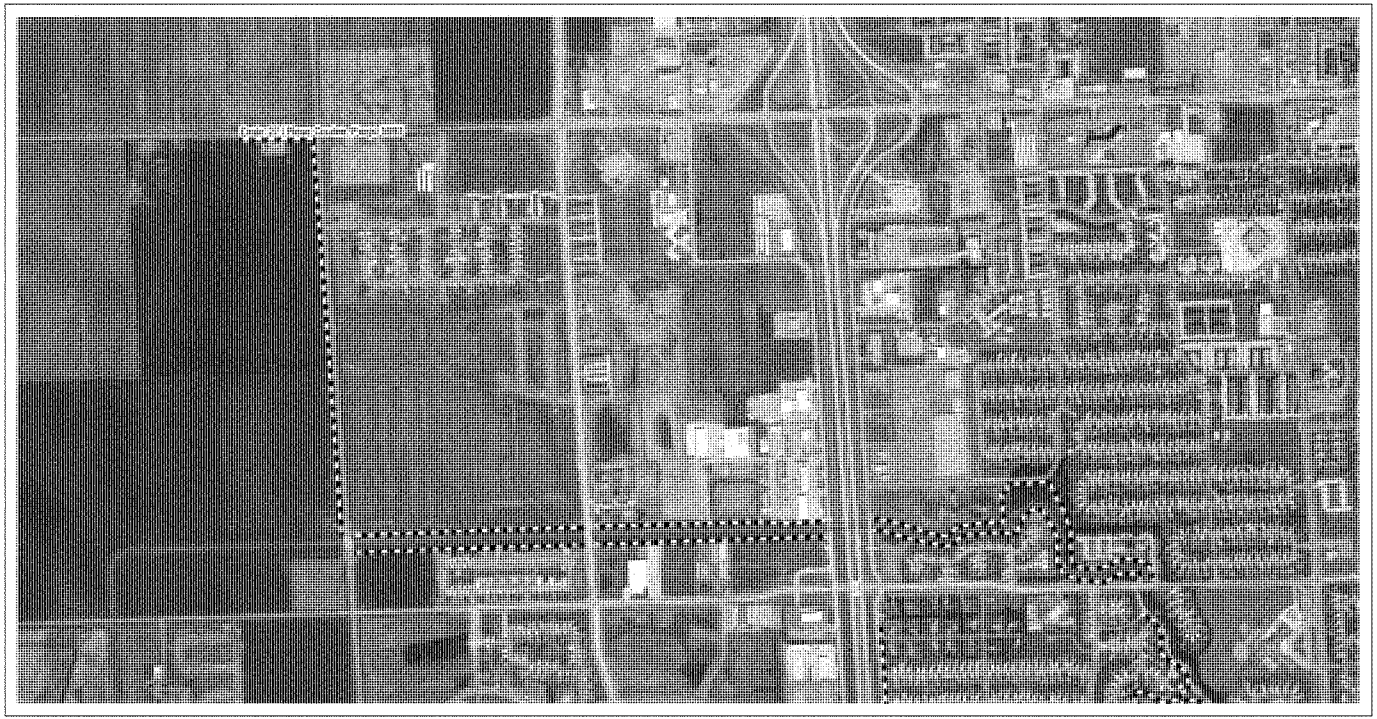
US Army Corps
of Engineers®
FMMFS_P2_geotech_2009-04.mxd
Printed 13 NOV 09
Fargo-Moorhead Metro Feasibility Study
Existing Levee Locations
0
500
1,000
2,000
3,000
Feet



St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps of Engineers®

FMMFS_P2_geotech_2009-04.mxd
Printed 13 NOV 09

Fargo-Moorhead Metro Feasibility Study
Existing Levee Locations

0 1,000 2,000 4,000 6,000 Feet

St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps of Engineers®

FMMFS_P2_geotech_2009-04.mxd
Printed 13 NOV 09

Fargo-Moorhead Metro Feasibility Study
Existing Levee Locations

0 1,000 2,000 4,000 6,000 Feet

Attachment H-2: Photos of Existing Levees

Fargo-Moorhead Metro Feasibility Study

Credit to Existing Levees

Attachment 2:

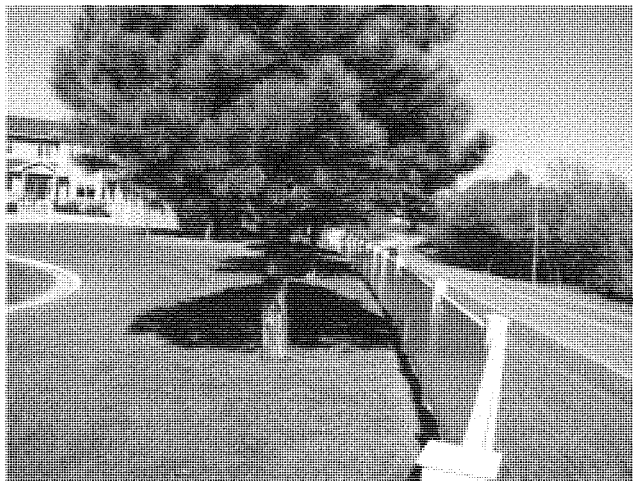
Photos of Existing Levees

Photos presented in this attachment are provided for quick reference. Additional photos are available within the project folder.

\\MVD\MVP\PROJECTS\SA\ActiveFolders\SA_Fargo-Moorhead_Metro_FDR-153866\02Feasibility(FEA)\Geotech\Credit_2_Existing_Levees\Photos

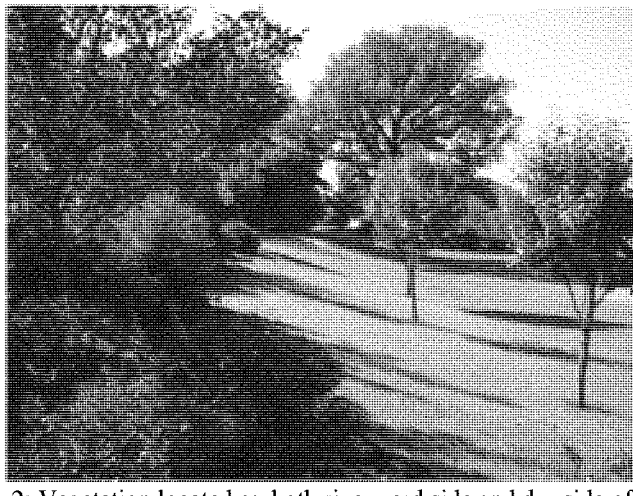
&

\\MVD\MVP\PROJECTS\SA\ActiveFolders\SA_Fargo-Moorhead_Metro_FDR-153866\02Feasibility(FEA)\Geotech\Slide_Investigation\Photos_2008-11-19_20



10th Street North

Photo 1 : Fence and trees located on top of levee.



10th Street North

Photo 2: Vegetation located on both riverward side and dry side of levee.

10th Avenue South (Dike West)

Photo 3: Riverward side of levee with road across it which provides access to water treatment plant.

10th Avenue South (Dike West)

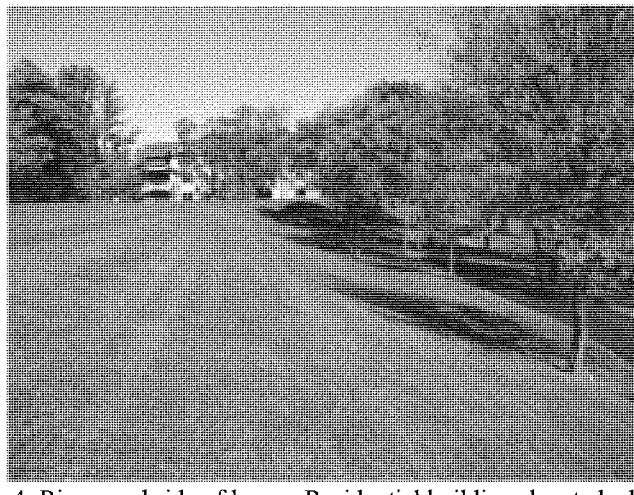


Photo 4: Riverward side of levee. Residential buildings located adjacent to dryside of levee.

10th Avenue South (Dike West)

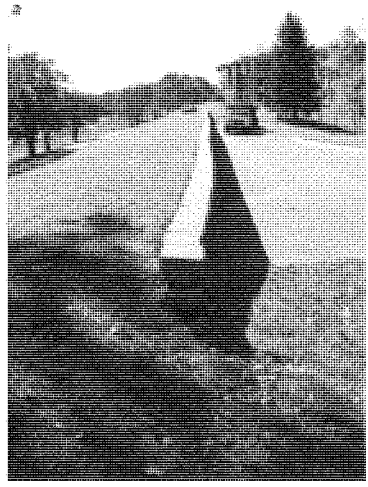


Photo 5: Retaining wall constructed in dryside of levee. Residential buildings located adjacent to dryside of levee.

10th Avenue South (Dike West)

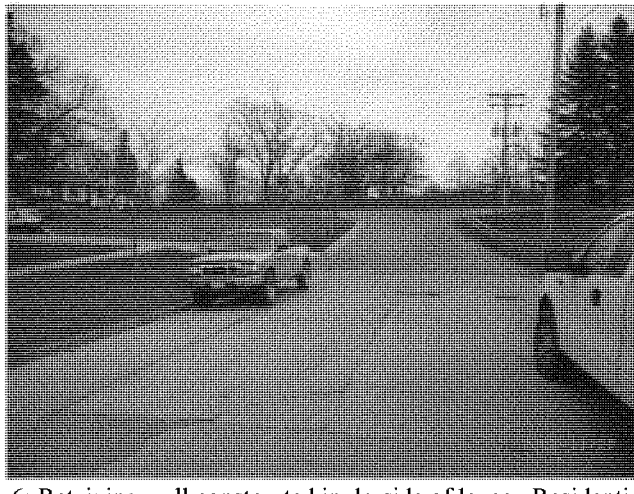


Photo 6: Retaining wall constructed in dryside of levee. Residential buildings located adjacent to dryside of levee.

Southwood Drive Levee

Photo 7: Southwood Drive Levee looking southeast. River located on left side.

Drain 27 / Rose Creek

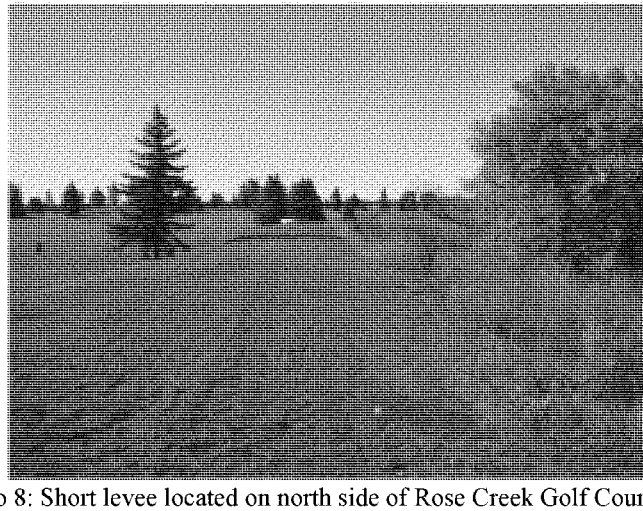


Photo 8: Short levee located on north side of Rose Creek Golf Course.

Woodlawn Park Levee

Photo 9: West end of levee tying into high ground.

Woodlawn Park Levee

Photo 10: Riverward slope of levee, taken looking northeast.

Woodlawn Park Levee

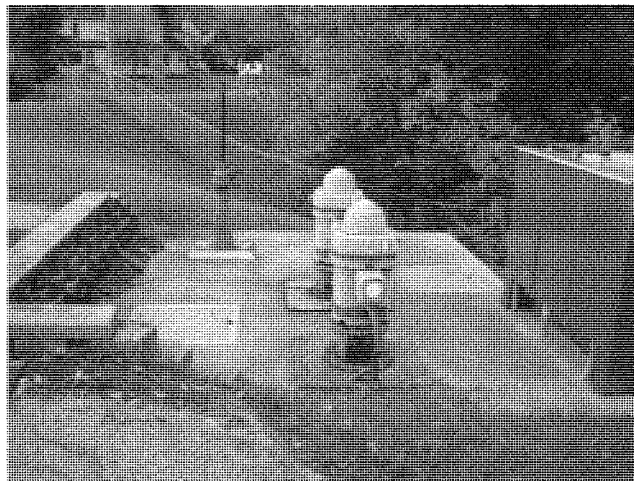


Photo 11: Pumpstation located within levee.

Woodlawn Park Levee

Photo 12: Vegetation located at toe of levee.

Woodlawn Park Levee

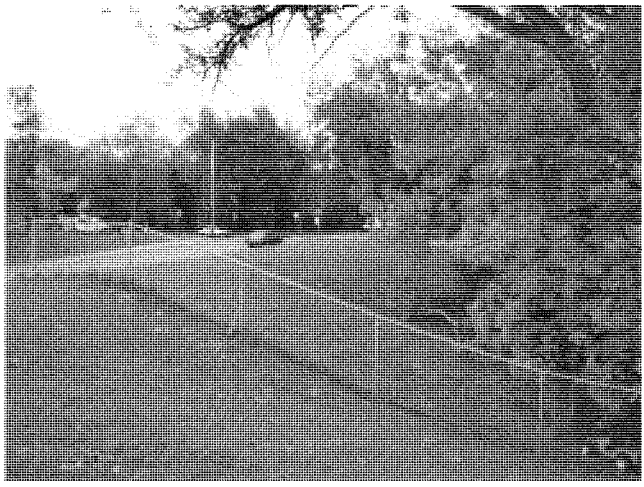


Photo 13: East end of levee tying into high ground.

Horn Park Levee

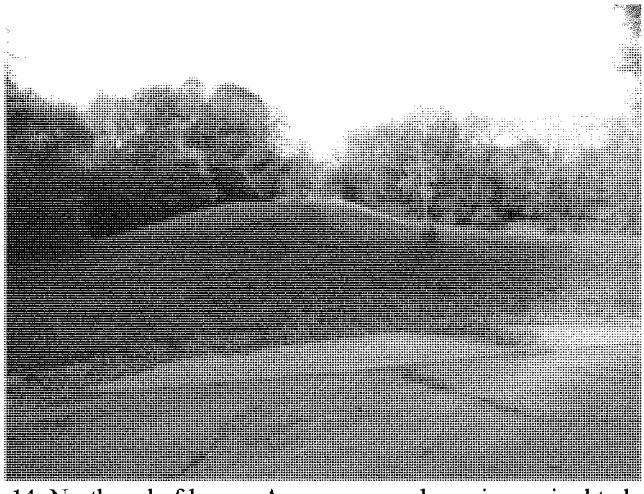
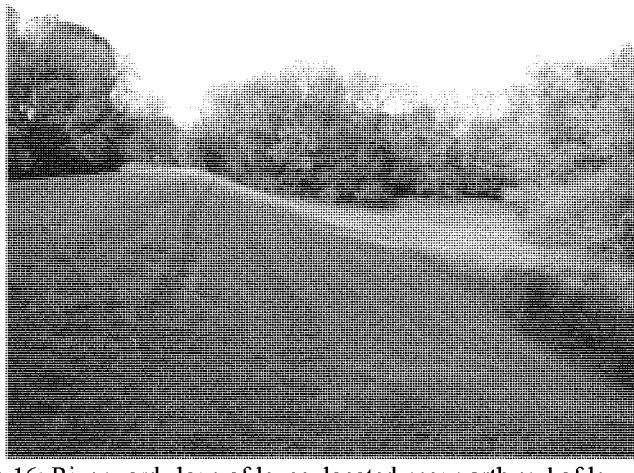


Photo 14: North end of levee. An emergency levee is required to be constructed to tie existing levee into high ground.

Horn Park Levee

Photo 15: Taken at north end of levee to indicate location where emergency levee is needed to tie into high ground at electrical substation.

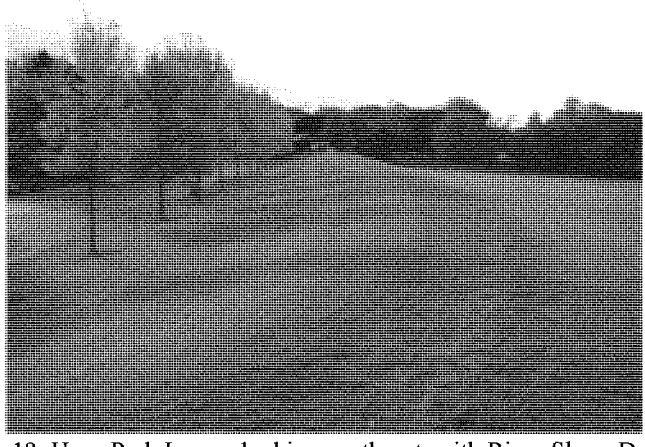


Horn Park Levee

Photo 16: Riverward slope of levee, located near north end of levee.

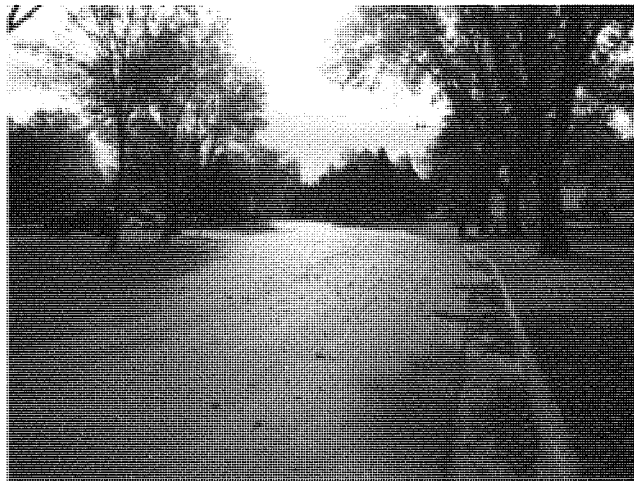
Horn Park Levee

Photo 17: Vegetation located on and beyond toe of levee, near the north end of levee.



Horn Park Levee

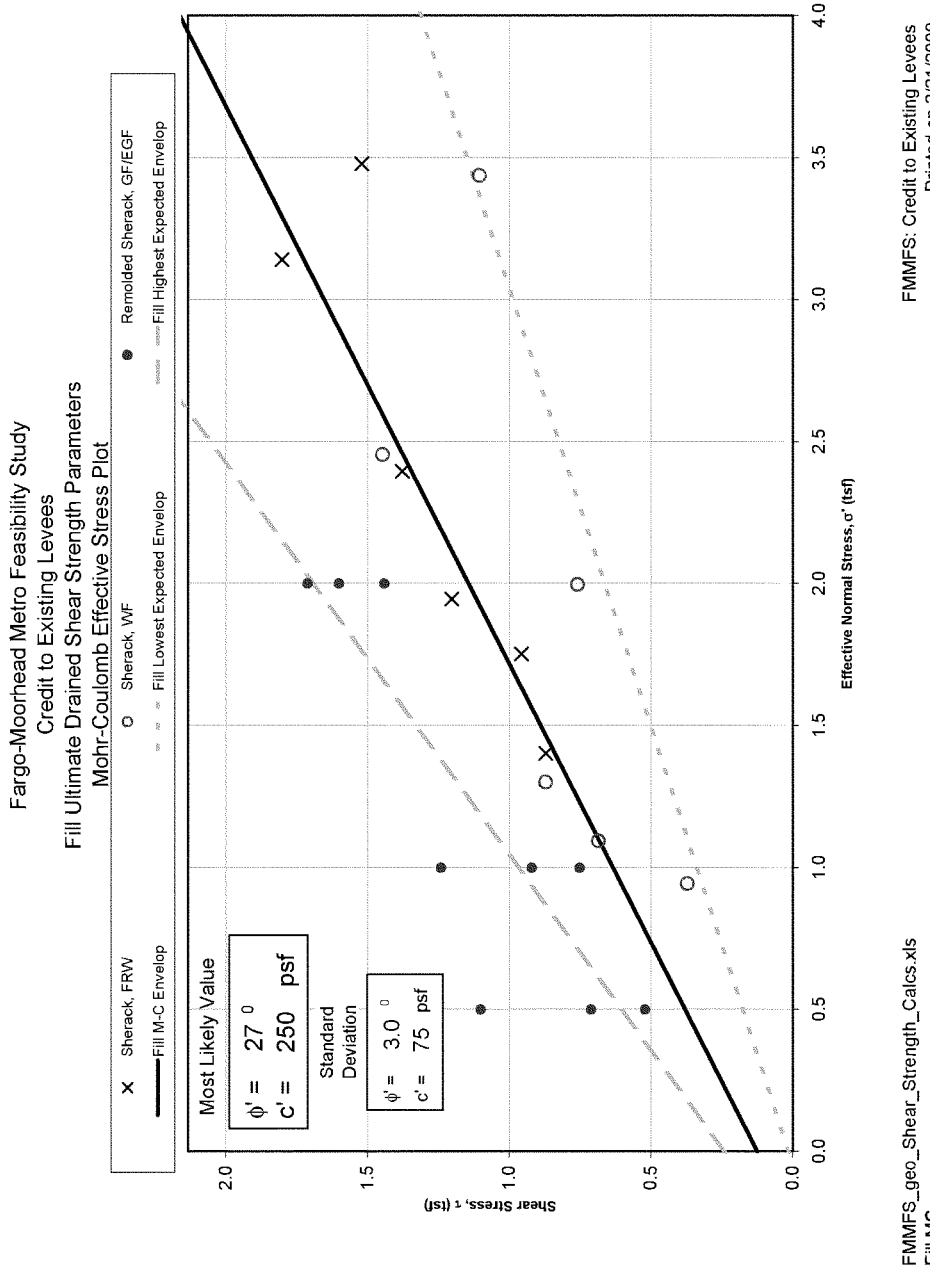
Photo 18: Horn Park Levee, looking southeast, with River Shore Drive on left.



Horn Park Levee

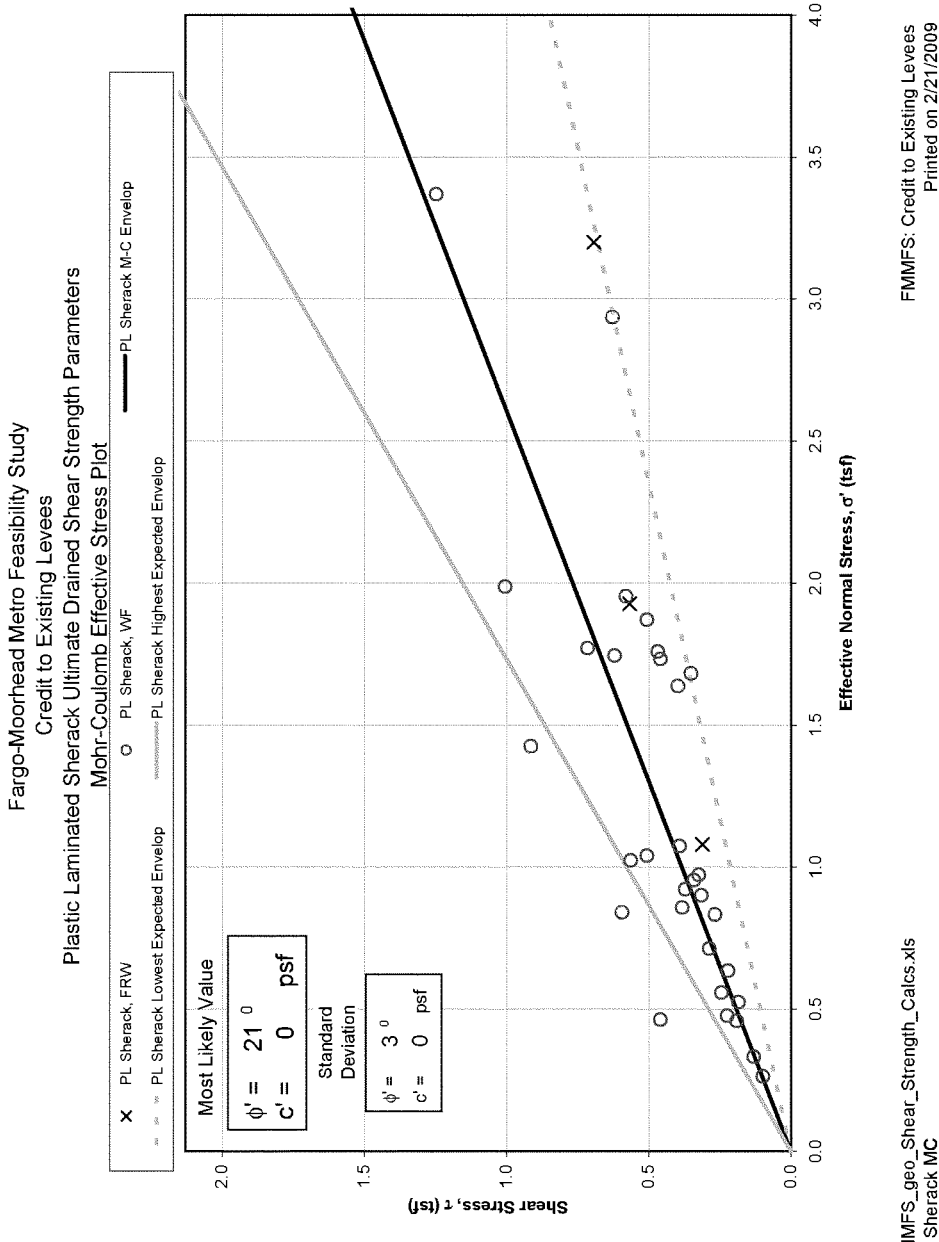
Photo 19: Southwest end of levee requires an emergency levee to be constructed to tie into high ground.

Attachment H-3: Shear Strength Plots



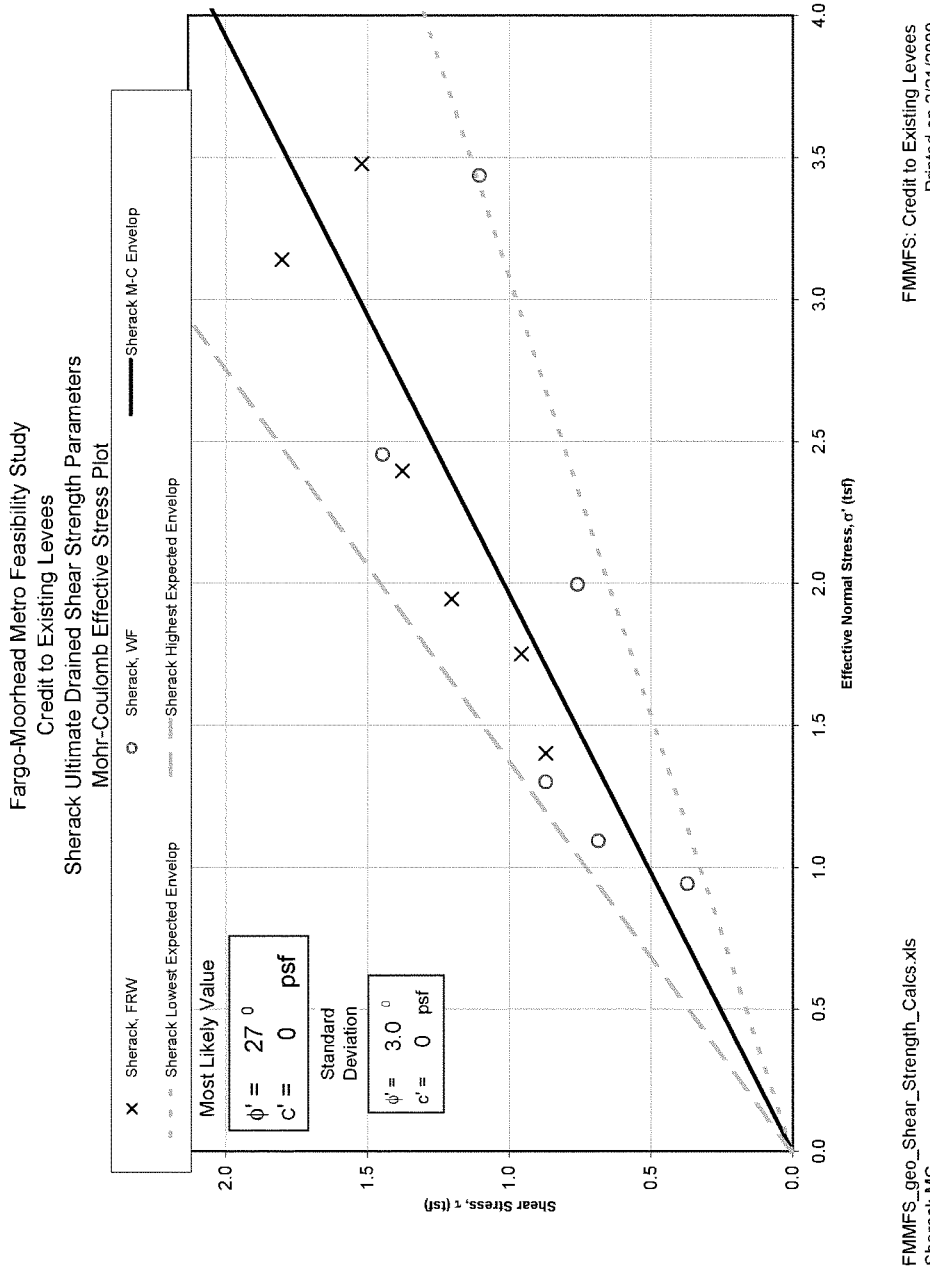
FMMFS: Credit to Existing Levees
Printed on 2/21/2009

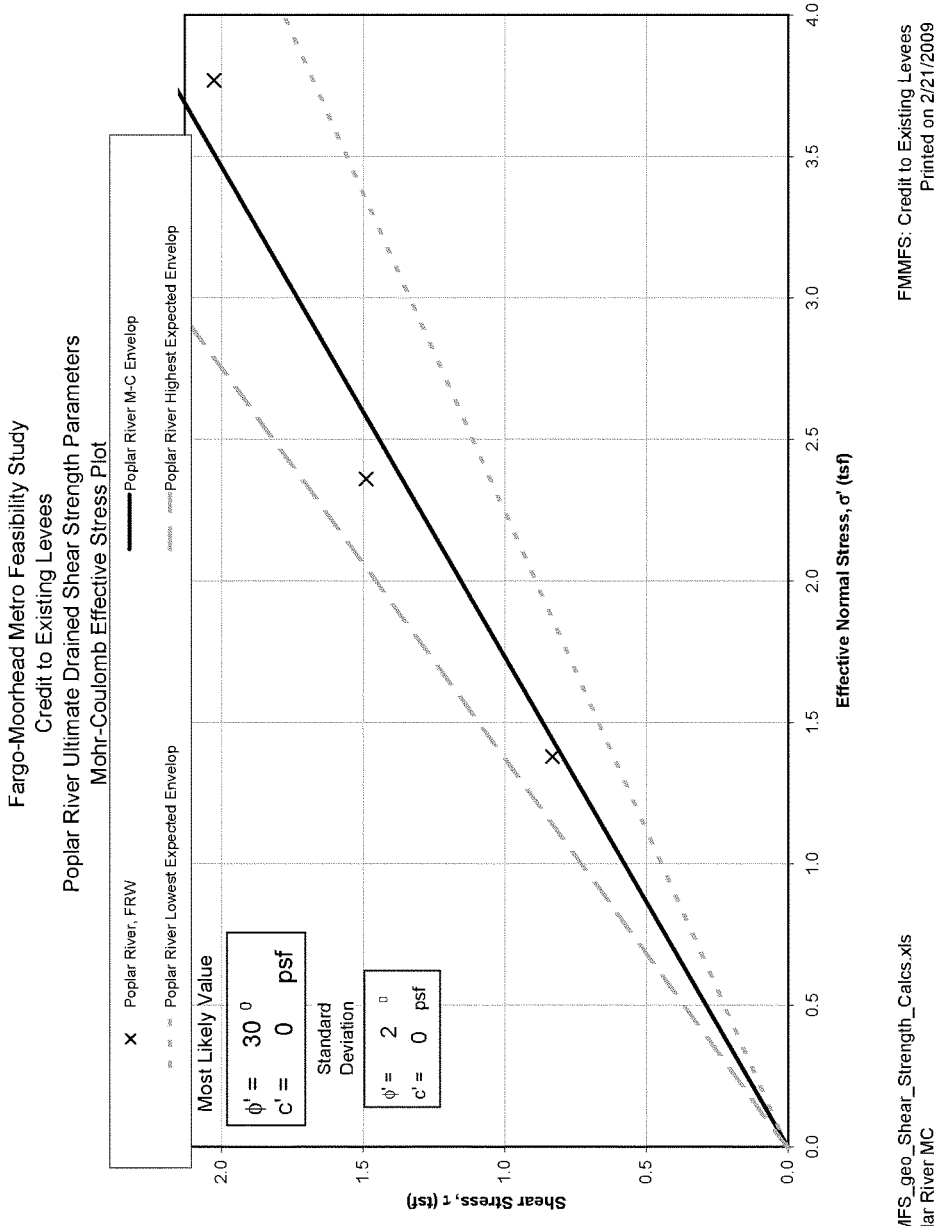
FMMFS_geo_Shear_Strength_Calcs.xls
Fill MC



FMMFS: Credit to Existing Levees
Printed on 2/21/2009

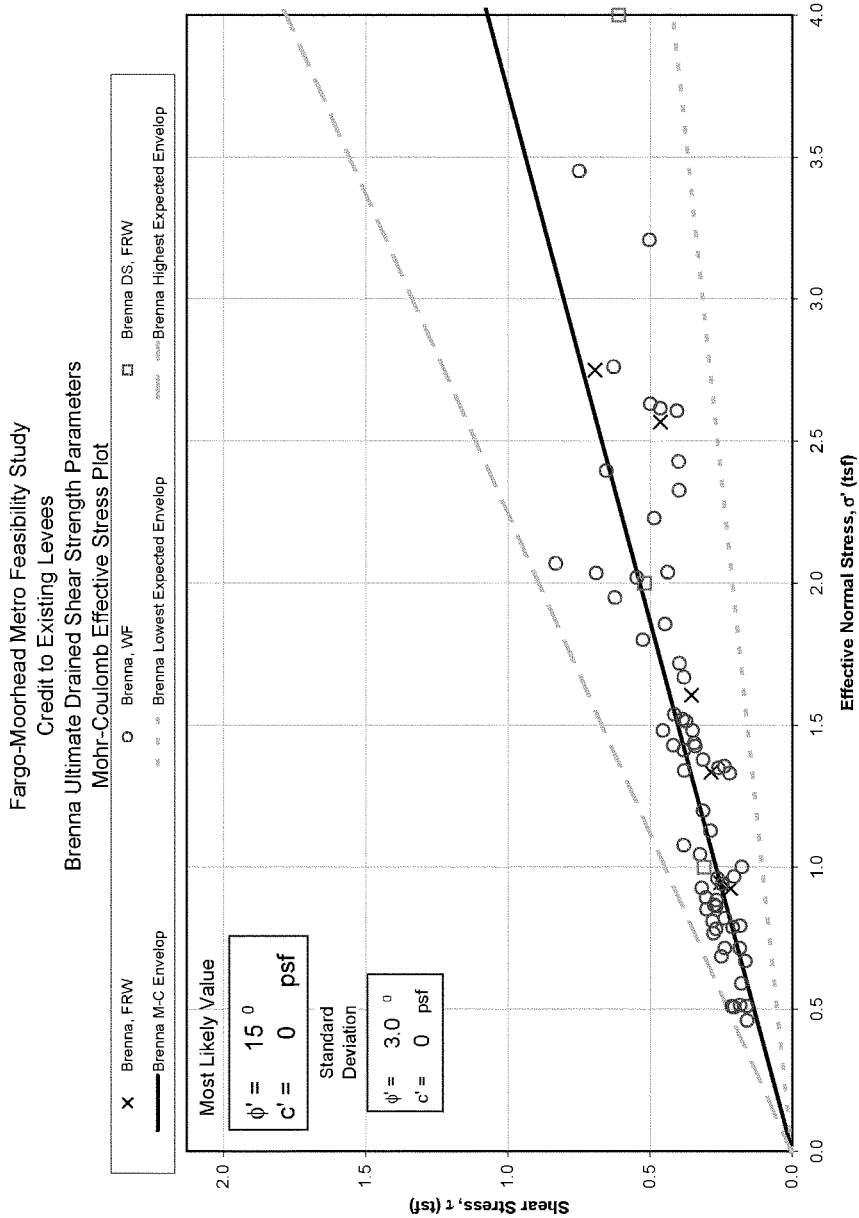
FMMFS_geo_Shear_Strength_Calcs.xls
PL Sherack MC


Fargo-Moorhead Metro Feasibility Study
Credit to Existing Levees
Sherack Ultimate Drained Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
Sherack, FRW
Sherack, WF
Sherack M-C Envelop
Sherack Lowest Expected Envelop
Sherack Highest Expected Envelop
Most Likely Value
φ' = 27 °
c' = 0 psf
Standard Deviation
φ' = 3.0 °
c' = 0 psf
Shear Stress, τ (tsf)
Effective Normal Stress, σ' (tsf)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
FMMFS: Credit to Existing Levees
Printed on 2/21/2009
FMMFS_geo_Shear_Strength_Calcs.xls
Sherack MC



FMMFS: Credit to Existing Levees
Printed on 2/21/2009

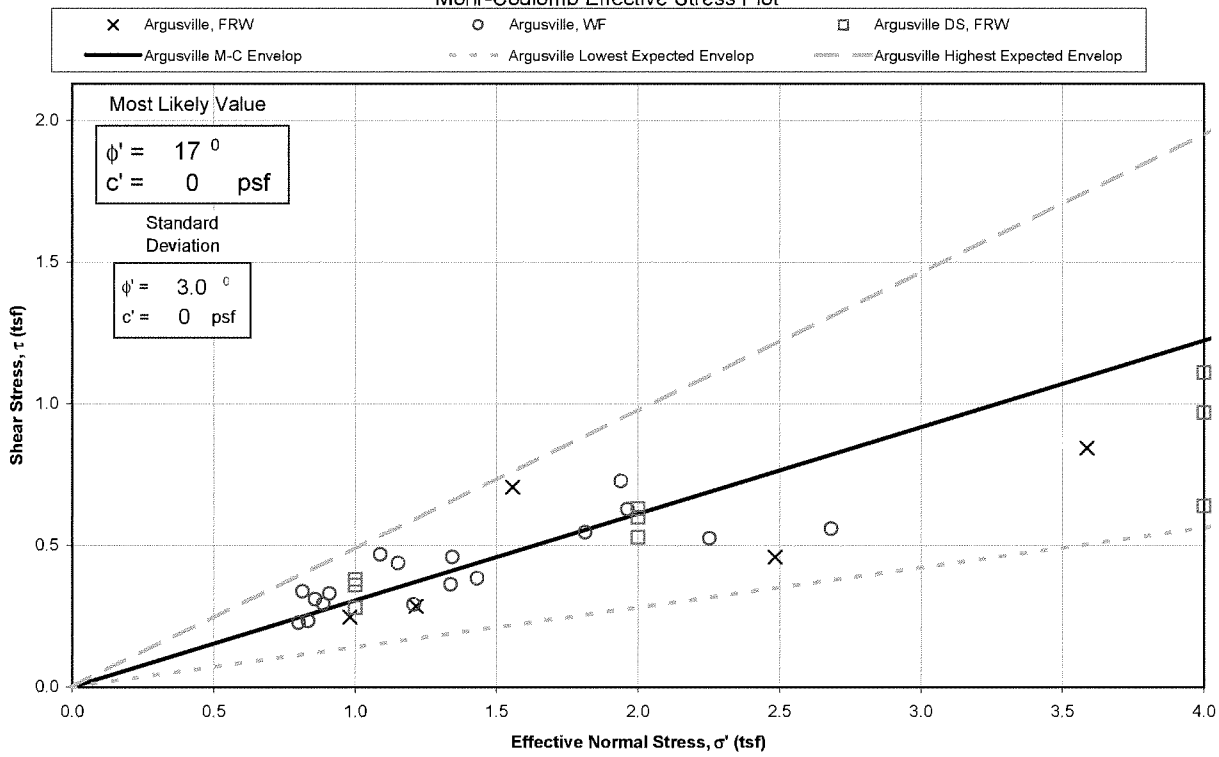
FMMFS_geo_Shear_Strength_Calcs.xls
Poplar River MC



FMMFS: Credit to Existing Levees
Printed on 2/21/2009

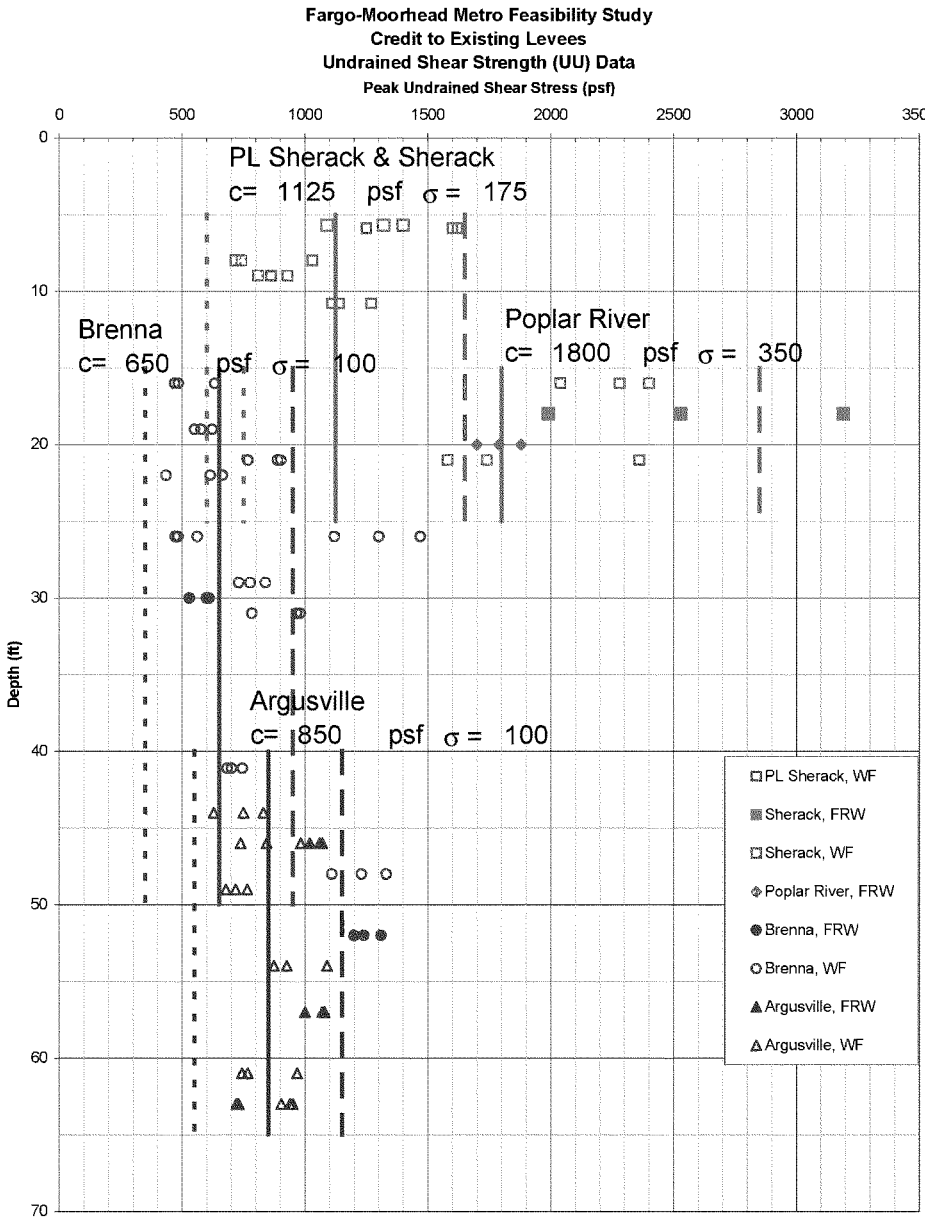
FMMFS_geo_Shear_Strength_Calcs.xls
Brenna MC

Fargo-Moorhead Metro Feasibility Study
Credit to Existing Levees
Argusville Ultimate Drained Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot



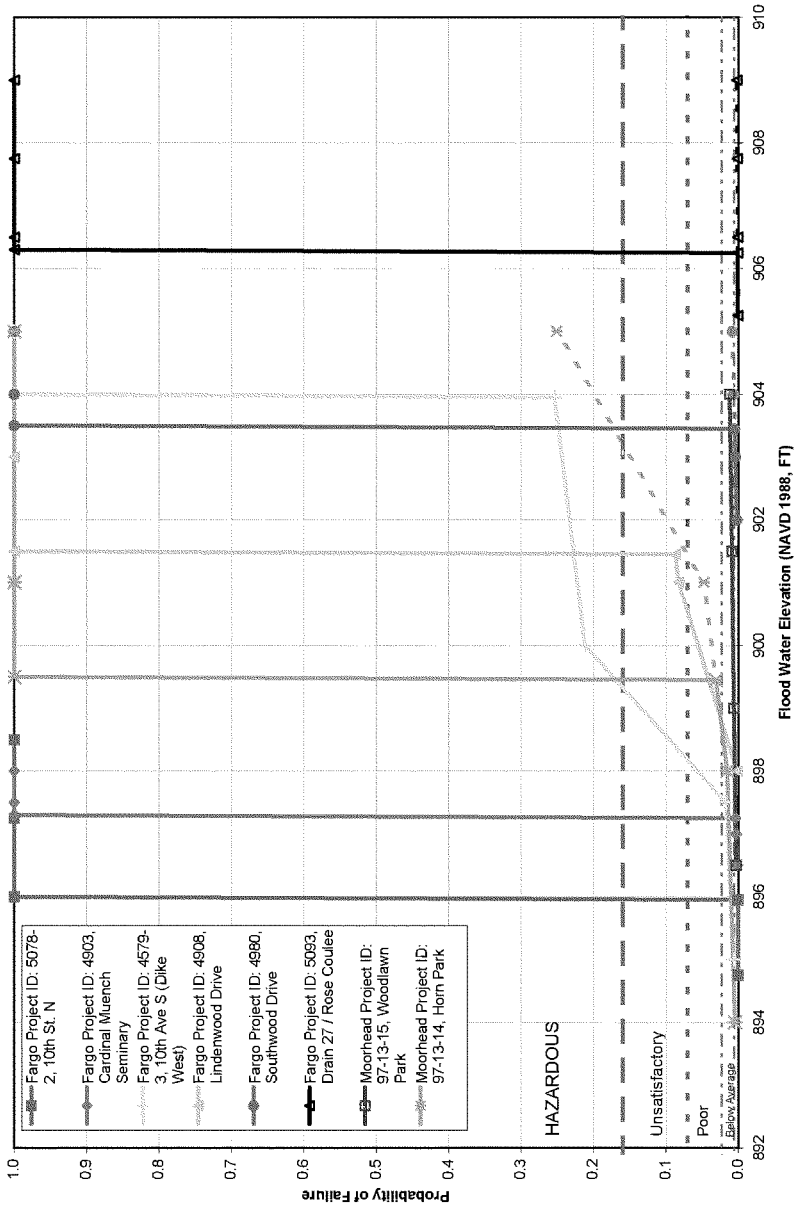
FMMFS_geo_Shear_Strength_Calcs.xls
Argusville MC

FMMFS: Credit to Existing Levees
Printed on 2/21/2009


Fargo-Moorhead Metro Feasibility Study
Credit to Existing Levees
Undrained Shear Strength (UU) Data
Peak Undrained Shear Stress (psf)
0
500
1000
1500
2000
2500
3000
3500
Depth (ft)
0
10
20
30
40
50
60
70
PL Sherack & Sherack
c= 1125 psf σ = 175
Brenna
c= 650 psf σ = 100
Poplar River
c= 1800 psf σ = 350
Argusville
c= 850 psf σ = 100
PL Sherack, WF
Sherack, FRW
Sherack, WF
Poplar River, FRW
Brenna, FRW
Brenna, WF
Argusville, FRW
Argusville, WF

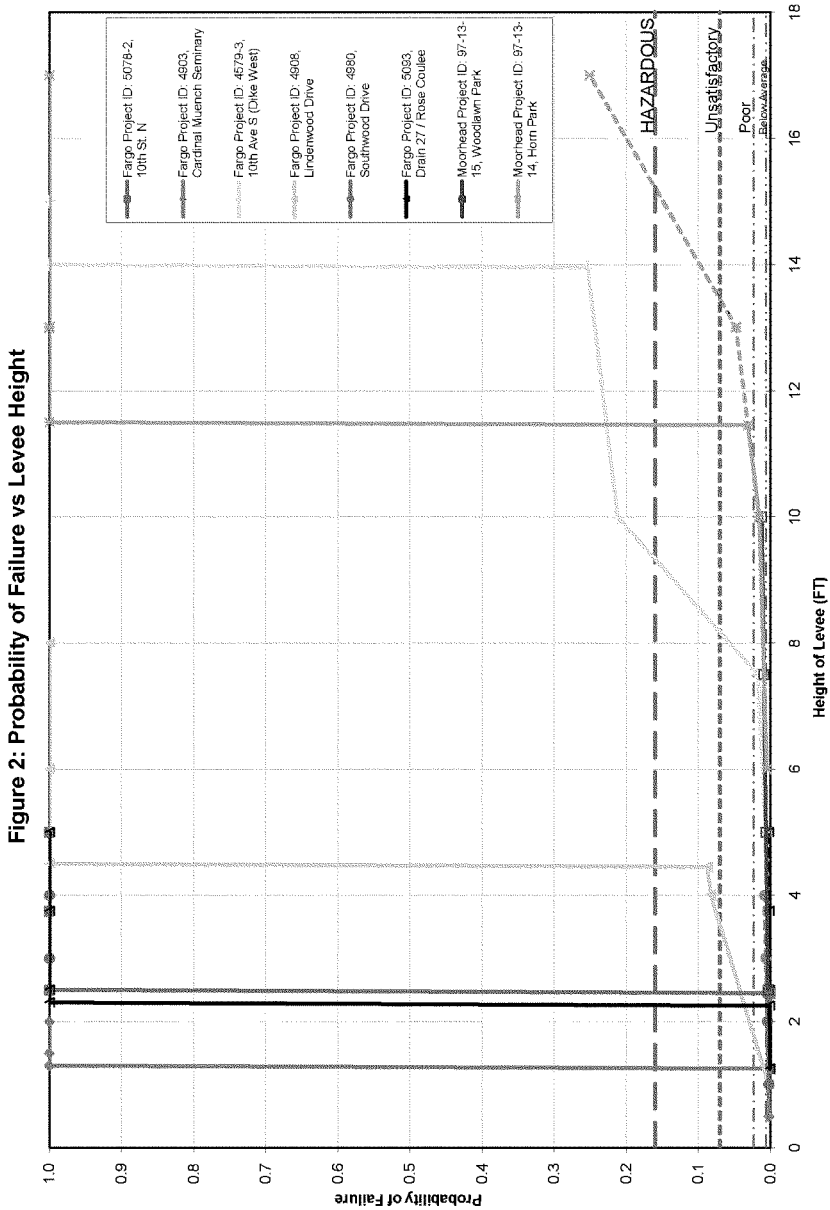
Attachment H-4: Probability of Failure Plots

Figure 1: Probability of Failure vs Flood Water Elevation



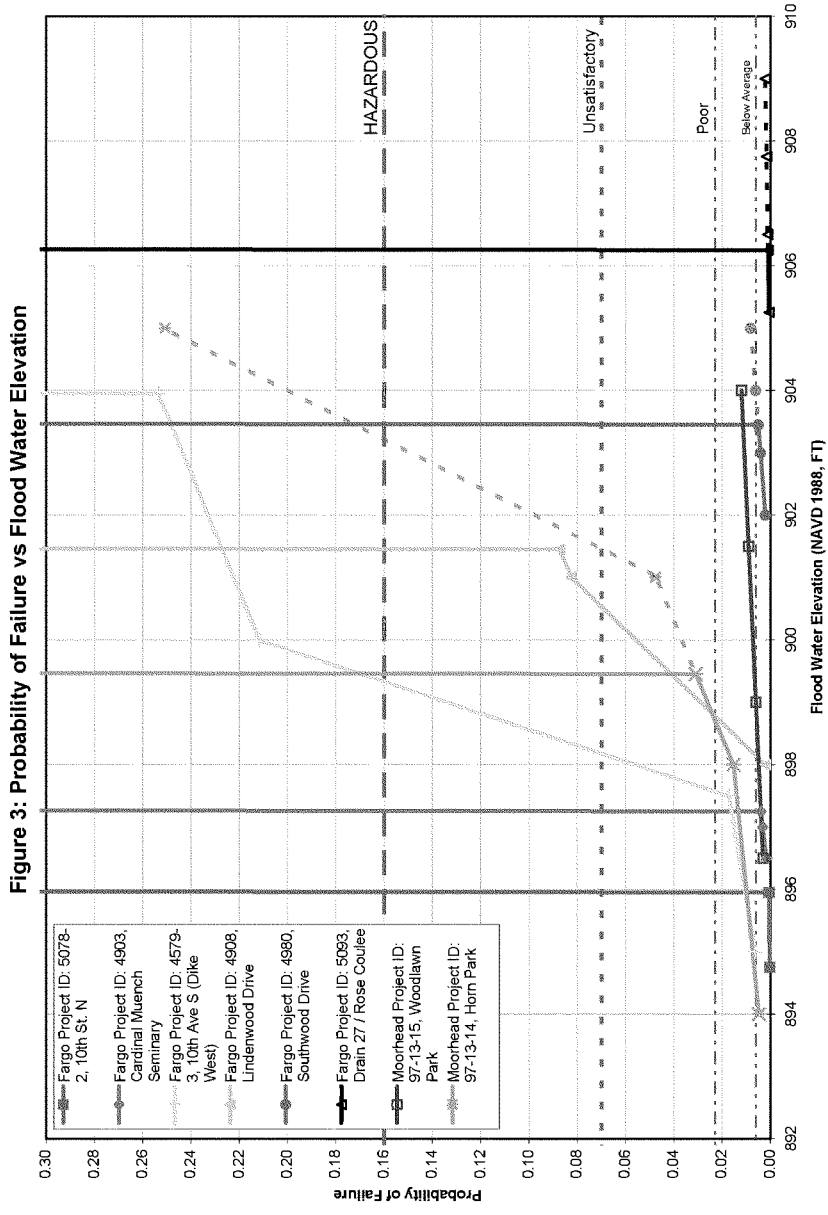
FMMFS_Geo_C2EL_Prob_Failure_rev_2010-01.xls
Report P(F) vs FWE

FMMFS: Credit to Existing Levees
Printed on 11/28/2009



FMMFS_Geo_rev2_C2EL_Prob_Failure_2010-03.xls
Report P(F) vs Height

FMMFS: Credit to Existing Levees
Printed on 3/17/2010



FMMFS_Geo_C2EL_Prob_Failure_rev_2010-01.xls
Report P(F)0.3 vs FWE

FMMFS: Credit to Existing Levees
Printed on 11/28/2009

Attachment H-5: Slope Stability and Reliability Calculations

Project: FMMFS
Subject: Stability Analysis
Computed By: KAH
Date: 19-Dec-08
Revised By: KAH
Date: 13-Jan-09

Long-Term, Drained Conditions

Fargo Project ID: 5708
Location: 10th St. N
Top of Levee: 898.5
Elevation at Dryside Toe: 893.5
Height: 5
Top Width: 10
Riverside Slope: 3
Landside Slope: 3

Fargo Project ID: 5708, 10th St. N

Run	Levee Friction	Levee Cohesion	Sherack Friction	River Stage	FS	SLIDE ΔF	(ΔF/2)^0.5
Most Likely Values	27	250	27	898.5	2.135		
2	24	250	27	898.5	2.110		
3	30	250	27	898.5	2.160	-0.05	0.0006
4	27	175	27	898.5	1.934		
5	27	325	27	898.5	2.300	-0.37	0.0335
6	27	250	24	898.5	1.953		
7	27	250	30	898.5	2.307	-0.35	0.0305
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.254095
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		11.90%

Run	Levee Friction	Levee Cohesion	PL Sherack Friction	River Stage	FS	SLIDE ΔF	(ΔF/2)^0.5
Most Likely Values	27	250	21	898.5	1.725		
2	24	250	21	898.5	1.707		
3	30	250	21	898.5	1.744	-0.04	0.0003
4	27	175	21	898.5	1.571		
5	27	325	21	898.5	1.825	-0.25	0.0161
6	27	250	18	898.5	1.547		
7	27	250	24	898.5	1.883	-0.35	0.0299
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.215407
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		12.49%

Probability of Failure (FS < 1)			
1.19E-10	or	0.000%	
1.16	chance in	1.E+10	
Reliability Index		6.34	

Probability of Failure (FS < 1)			
7.77E-06	or	0.001%	
1.00	chance in	1.3E+05	
Reliability Index		4.32	

Fargo Project ID: 4903
Location: Cardinal Muench Seminary
Top of Levee: 899
Elevation at Dryside Toe: 893
Height: 5
Top Width: 5
Riverside Slope: 8
Landside Slope: 8

Fargo Project ID: 4903, Cardinal Muench Seminary

Run	Levee Friction	Levee Cohesion	Sherack Friction	River Stage	FS	SLIDE ΔF	(ΔF/2)^0.5
Most Likely Values	27	250	27	898	2.010		
2	24	250	27	898	2.010		
3	30	250	27	898	2.010	0.00	0.0000
4	27	175	27	898	2.006		
5	27	325	27	898	2.014	-0.01	0.0000
6	27	250	24	898	1.768		
7	27	250	30	898	2.276	-0.27	0.0671
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.259030886
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		12.89%

Run	Levee Friction	Levee Cohesion	PL Sherack Friction	River Stage	FS	SLIDE ΔF	(ΔF/2)^0.5
Most Likely Values	27	250	21	898	1.439		
2	24	250	21	898	1.439		
3	30	250	21	898	1.439	0.00	0.0000
4	27	175	21	898	1.438		
5	27	325	21	898	1.439	0.00	0.0000
6	27	250	18	898	1.218		
7	27	250	24	898	1.676	-0.45	0.0511
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.298300
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		15.71%

Probability of Failure (FS < 1)			
5.83E-06	or	0.000%	
7638.00	chance in	2.0E+11	
Reliability Index		5.38	

Probability of Failure (FS < 1)			
1.21E-02	or	1.211%	
1.00	chance in	82.50	
Reliability Index		2.25	

Fargo Project ID: 4579-3
Location: 10th Ave S (Dike West)
Top of Levee: 905
Elevation at Dryside Toe: 900
Height: 15
Top Width: 10
Riverside Slope: 3
Landside Slope: 3

Fargo Project ID: 4579-3, 10th Ave S (Dike West)

Run	Levee Friction	Levee Cohesion	Sherack Friction	River Stage	FS	SLIDE ΔF	(ΔF/2)^0.5
Most Likely Values	27	250	27	905	1.329		
2	24	250	27	905	1.331		
3	30	250	27	905	1.347	-0.02	0.0001
4	27	175	27	905	1.257		
5	27	325	27	905	1.415	-0.16	0.0062
6	27	250	24	905	1.208		
7	27	250	30	905	1.499	-0.28	0.0170
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.152756797
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		11.41%

Run	Levee Friction	Levee Cohesion	Sherack Friction	River Stage	FS	SLIDE ΔF	(ΔF/2)^0.5
Most Likely Values	27	250	27	905	1.445		
2	24	250	27	905	1.427		
3	30	250	27	905	1.461	-0.03	0.0003
4	27	175	27	905	1.359		
5	27	325	27	905	1.462	-0.10	0.0027
6	27	250	24	905	1.259		
7	27	250	30	905	1.582	-0.32	0.0051
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.170362948
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		11.79%

Run	Levee Friction	Levee Cohesion	Sherack Friction	River Stage	FS	SLIDE ΔF	(ΔF/2)^0.5
Most Likely Values	27	250	27	897.5	1.761		
2	24	250	27	897.5	1.751		
3	30	250	27	897.5	1.779	-0.03	0.0002
4	27	175	27	897.5	1.666		
5	27	325	27	897.5	1.832	-0.13	0.0045
6	27	250	24	897.5	1.598		
7	27	250	30	897.5	1.964	-0.37	0.0339
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.196318610
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		11.15%

Run	Levee Friction	Levee Cohesion	Sherack Friction	River Stage	FS	SLIDE ΔF	(ΔF/2)^0.5
Most Likely Values	27	250	27	896	1.892		
2	24	250	27	896	1.889		
3	30	250	27	896	1.918	-0.05	0.0006
4	27	175	27	896	1.790		
5	27	325	27	896	1.999	-0.21	0.0109
6	27	250	24	896	1.719		
7	27	250	30	896	2.074	-0.36	0.0315
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.207439003
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		10.96%

Probability of Failure (FS < 1)			
6.02E-03	or	0.603%	
1.00	chance in	165	
Reliability Index		2.51	

Probability of Failure (FS < 1)			
1.05E-03	or	0.104%	
1.00	chance in	958	
Reliability Index		3.07	

Probability of Failure (FS < 1)			
2.39E-07	or	0.000%	
1.00	chance in	4,200,000	
Reliability Index		5.04	

Probability of Failure (FS < 1)			
3.76E-09	or	0.000%	
1.00	chance in	265,000,000	
Reliability Index		5.78	

Fargo Project ID: 4579-3
Location: 10th Ave S (Dike West)
Top of Levee: 905
Elevation at Dryside Toe: 900
Height: 15
Top Width: 10
Riverside Slope: 3
Landside Slope: 3
MSE Wall Height: 6
Toe of Slope (ft): 900
Geogrid length (ft): 4

Fargo Project ID: 4579-3, 10th Ave S (Dike West)

Run	Levee Friction	Levee Cohesion	PL Sherack Friction	River Stage	FS	SLIDE ΔF	(ΔF/2)^0.5
Most Likely Values	27	250	21	905	1.015		
2	24	250	21	905	1.012		
3	30	250	21	905	1.018	-0.01	0.0000
4	27	175	21	905	0.957		
5	27	325	21	905	0.973	-0.01	0.0000
6	27	250	18	905	0.809		
7	27	250	24	905	1.143	-0.33	0.0279
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.167153
Coefficient of Variation	10.3%	30.0%	13.7%		Coeff. Of Var. of FS		16.47%

Run	Levee Friction	Levee Cohesion	PL Sherack Friction	River Stage	FS	SLIDE ΔF	(ΔF/2)^0.5
Most Likely Values	27	250	21	900	1.047		
2	24	250	21	900	1.038		
3	30	250	21	900	1.055	-0.02	0.0001
4	27	175	21	900	0.987		
5	27	325	21	900	1.032	-0.04	0.0003
6	27	250	18	900	0.873		
7	27	250	24	900	1.175	-0.30	0.0235
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.152348
Coefficient of Variation	10.3%	30.0%	13.7%		Coeff. Of Var. of FS		14.54%

Run	Levee Friction	Levee Cohesion	PL Sherack Friction	River Stage	FS	SLIDE ΔF	(ΔF/2)^0.5
Most Likely Values	27	250	21	897.5	1.381		
2	24	250	21	897.5	1.371		
3	30	250	21	897.5	1.391	-0.02	0.0001
4	27	175	21	897.5	1.331		
5	27	325	21	897.5	1.377	-0.05	0.0006
6	27	250	18	897.5	1.161		
7	27	250	24	897.5	1.564	-0.40	0.0406
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.203958
Coefficient of Variation	10.3%	30.0%	13.7%		Coeff. Of Var. of FS		14.70%

Run	Levee Friction	Levee Cohesion	PL Sherack Friction	River Stage	FS	SLIDE ΔF	(ΔF/2)^0.5
Most Likely Values	27	250	21	895	1.545		
2	24	250	21	895	1.521		
3	30	250	21	895	1.569	-0.05	0.0006
4	27	175	21	895	1.441		
5	27	325	21	895	1.571	-0.13	0.0042
6	27	250	18	895	1.327		
7	27	250	24	895	1.795	-0.38	0.0307
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.201301
Coefficient of Variation	10.3%	30.0%	13.7%		Coeff. Of Var. of FS		13.03%

Probability of Failure (FS < 1)			
4.89E-01	or	49.032%	
1.00	chance in	2.02	
Reliability Index		0.01	

Probability of Failure (FS < 1)			
4.03E-01	or	40.316%	
1.00	chance in	2.47	
Reliability Index		0.25	

Probability of Failure (FS < 1)			
1.64E-02	or	1.642%	
1.00	chance in	61	
Reliability Index		2.13	

Probability of Failure (FS < 1)			
0.04E-04	or	0.004%	
1.00	chance in	1985	
Reliability Index		3.29	

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File: FMMFS_Geo_C2E_Prob_Failure_rev_2010-01.xls
Worksheet: F(R) Stability
Printed on 11/30/2009

Project: FMMFS
Subject: Stability Analysis
Computed By: KAH
Date: 19-Dec-08
Revised By: KAH
Date: 13-Jan-09

Long-Term, Drained Conditions

Fargo Project ID: 4908
Location: Lindenwood Drive
Top of Levee: 908
Elevation at Dryside Toe: 897
Height: 8
Top Width: 6
Riverside Slope: 4
Landside Slope: 4
MSE Wall Height: 0
Geogrid length (ft): 4

Fargo Project ID: 4908, Lindenwood Drive

Run	Levee Friction	Levee Cohesion	Sheirack Friction	River Stage	FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	**27**	**250**	**27**	**905**	**1.206**		
2	**24**	250	27	905	1.206		
3	**30**	250	27	905	1.206	0.00	0.0000
4	27	**175**	27	905	1.101		
5	27	**325**	27	905	1.292	-0.19	0.0091
6	27	250	**24**	905	1.065		
7	27	250	**30**	905	1.315	-0.23	0.0128
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.147957764
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		12.27%

Probability of Failure (FS < 1): 7.06E-02 or **7.060%**
1.00 change in 14.2
Reliability Index: 1.47

Run	Levee Friction	Levee Cohesion	Sheirack Friction	River Stage	FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	**27**	**250**	**27**	**905**	**1.075**		
2	**24**	250	27	905	1.075		
3	**30**	250	27	905	1.075	-0.05	0.0007
4	27	**175**	27	905	1.049		
5	27	**325**	27	905	1.195	-0.25	0.0153
6	27	250	**24**	905	1.059		
7	27	250	**30**	905	1.317	-0.28	0.0193
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.181678248
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		11.20%

Probability of Failure (FS < 1): 2.53E-06 or **0.000%**
1.00 change in 395,000
Reliability Index: 4.55

Run	Levee Friction	Levee Cohesion	Sheirack Friction	River Stage	FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	**27**	**250**	**27**	**901**	**1.516**		
2	**24**	250	27	901	1.479		
3	**30**	250	27	901	1.538	-0.06	0.0009
4	27	**175**	27	901	1.372		
5	27	**325**	27	901	1.620	-0.25	0.0153
6	27	250	**24**	901	1.388		
7	27	250	**30**	901	1.517	-0.13	0.0130
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.170641437
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		11.26%

Probability of Failure (FS < 1): 1.32E-04 or **0.013%**
1.00 change in 7,650
Reliability Index: 3.65

Run	Levee Friction	Levee Cohesion	Sheirack Friction	River Stage	FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	**27**	**250**	**27**	**903**	**1.498**		
2	**24**	250	27	903	1.471		
3	**30**	250	27	903	1.515	-0.04	0.0005
4	27	**175**	27	903	1.360		
5	27	**325**	27	903	1.602	-0.24	0.0146
6	27	250	**24**	903	1.368		
7	27	250	**30**	903	1.600	-0.24	0.0142
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.171131528
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		11.42%

Probability of Failure (FS < 1): 2.42E-04 or **0.024%**
1.00 change in 4,175
Reliability Index: 3.49

Fargo Project ID: 4908
Location: Lindenwood Drive
Top of Levee: 908
Elevation at Dryside Toe: 897
Height: 8
Top Width: 6
Riverside Slope: 4
Landside Slope: 4
MSE Wall Height: 0
Geogrid length (ft): 4

Fargo Project ID: 4908, Lindenwood Drive

Run	Levee Friction	Levee Cohesion	PL Sheirack Friction	River Stage	FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	**27**	**250**	**21**	**905**	**0.948**		
2	**24**	250	21	905	0.952		
3	**30**	250	21	905	0.947	0.01	0.0006
4	27	**175**	21	905	0.879		
5	27	**325**	21	905	1.013	-0.14	0.0048
6	27	250	**18**	905	0.833		
7	27	250	**24**	905	1.067	-0.23	0.0137
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.138106419
Coefficient of Variation	10.3%	30.0%	13.7%		Coeff. Of Var. of FS		14.56%

Probability of Failure (FS < 1): 6.72E-01 or **67.194%**
1.01 change in 1.6
Reliability Index: 0.45

Run	Levee Friction	Levee Cohesion	PL Sheirack Friction	River Stage	FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	**27**	**250**	**21**	**898**	**1.393**		
2	**24**	250	21	898	1.378		
3	**30**	250	21	898	1.419	-0.05	0.0006
4	27	**175**	21	898	1.273		
5	27	**325**	21	898	1.405	-0.13	0.0044
6	27	250	**18**	898	1.175		
7	27	250	**24**	898	1.486	-0.31	0.0242
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.176694171
Coefficient of Variation	10.3%	30.0%	13.7%		Coeff. Of Var. of FS		12.25%

Probability of Failure (FS < 1): 3.98E-03 or **0.398%**
1.00 change in 251
Reliability Index: 2.65

Run	Levee Friction	Levee Cohesion	PL Sheirack Friction	River Stage	FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	**27**	**250**	**21**	**901**	**1.152**		
2	**24**	250	21	901	1.140		
3	**30**	250	21	901	1.164	-0.02	0.0001
4	27	**175**	21	901	1.083		
5	27	**325**	21	901	1.230	-0.15	0.0054
6	27	250	**18**	901	1.059		
7	27	250	**24**	901	1.287	-0.23	0.0196
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.148963852
Coefficient of Variation	10.3%	30.0%	13.7%		Coeff. Of Var. of FS		12.93%

Probability of Failure (FS < 1): 1.53E-01 or **15.045%**
1.00 change in 7
Reliability Index: 1.03

Run	Levee Friction	Levee Cohesion	PL Sheirack Friction	River Stage	FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	**27**	**250**	**21**	**903**	**1.130**		
2	**24**	250	21	903	1.119		
3	**30**	250	21	903	1.147	-0.03	0.0002
4	27	**175**	21	903	1.068		
5	27	**325**	21	903	1.208	-0.14	0.0049
6	27	250	**18**	903	1.013		
7	27	250	**24**	903	1.264	-0.25	0.0158
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.144382905
Coefficient of Variation	10.3%	30.0%	13.7%		Coeff. Of Var. of FS		12.78%

Probability of Failure (FS < 1): 1.55E-01 or **18.492%**
1.00 change in 5
Reliability Index: 0.90

Fargo Project ID: 4960
Location: Southwood Drive
Top of Levee: 905
Elevation at Dryside Toe: 901
Height: 4
Top Width: 4
Riverside Slope: 3
Landside Slope: 3
Toe of Slope (ft): 900
Height at toe of slope: 5

Fargo Project ID: 4960, Southwood Drive

Run	Levee Friction	Levee Cohesion	Sheirack Friction	River Stage	FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	**27**	**250**	**27**	**905**	**1.839**		
2	**24**	250	27	905	1.833		
3	**30**	250	27	905	1.842	-0.01	0.0000
4	27	**175**	27	905	1.654		
5	27	**325**	27	905	1.972	-0.29	0.0207
6	27	250	**24**	905	1.672		
7	27	250	**30**	905	2.007	-0.34	0.0291
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.229895011
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		12.01%

Probability of Failure (FS < 1): 2.46E-07 or **0.000%**
1.00 change in 4,060,000
Reliability Index: 5.05

Run	Levee Friction	Levee Cohesion	PL Sheirack Friction	River Stage	FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	**27**	**250**	**21**	**905**	**1.395**		
2	**24**	250	21	905	1.394		
3	**30**	250	21	905	1.396	0.00	0.0000
4	27	**175**	21	905	1.359		
5	27	**325**	21	905	1.483	-0.20	0.0038
6	27	250	**18**	905	1.223		
7	27	250	**24**	905	1.569	-0.34	0.0254
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.195431574
Coefficient of Variation	10.3%	30.0%	13.7%		Coeff. Of Var. of FS		14.01%

Probability of Failure (FS < 1): 1.02E-02 or **1.022%**
1.00 change in 98
Reliability Index: 2.32

Fargo Project ID: 5093
Location: Drain 27 / Rose Coulee
Top of Levee: 909
Elevation at Dryside Toe: 904
Height: 5
Top Width: 10
Riverside Slope: 5
Landside Slope: 5

Fargo Project ID: 5093, Drain 27 / Rose Coulee

Run	Levee Friction	Levee Cohesion	Sheirack Friction	River Stage	FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	**27**	**250**	**27**	**909**	**2.291**		
2	**24**	250	27	909	2.276		
3	**30**	250	27	909	2.304	-0.03	0.0002
4	27	**175**	27	909	2.189		
5	27	**325**	27	909	2.403	-0.23	0.0133
6	27	250	**24**	909	2.089		
7	27	250	**30**	909	2.532	-0.47	0.0668
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.258517552
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		11.50%

Probability of Failure (FS < 1): 3.65E-13 or **0.000%**
1.00 change in 2,739,356,300,000
Reliability Index: 7.17

Run	Levee Friction	Levee Cohesion	PL Sheirack Friction	River Stage	FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	**27**	**250**	**21**	**905**	**1.692**		
2	**24**	250	21	905	1.685		
3	**30**	250	21	905	1.699	-0.01	0.0000
4	27	**175**	21	905	1.619		
5	27	**325**	21	905	1.763	-0.14	0.0052
6	27	250	**18**	905	1.476		
7	27	250	**24**	905	1.914	-0.44	0.0480
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.230638245
Coefficient of Variation	10.3%	30.0%	13.7%		Coeff. Of Var. of FS		13.63%

Probability of Failure (FS < 1): 7.00E-05 or **0.007%**
1.00 change in 14,250
Reliability Index: 3.81

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File: FMMFS_Geo_C2E_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) Stability
Printed on 11/30/2009

Project: FMMFS
Subject: Stability Analysis
Computed By: KAH
Date: 19-Dec-08
Revised By: KAH
Date: 13-Jan-09

Long-Term, Drained Conditions

Moorhead Project ID: 97-13-15
Location: Woodlawn Park
Top of Levee 904
Elevation at Drystole Toe 894
Height 10
Top Width 10
Riverside Slope 3
Landside Slope 3

Moorhead Project ID: 97-13-15, Woodlawn Park

Run	Levee Friction	Levee Cohesion	Sheirack Friction	River Stage	SLIDE FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	27	250	27	904	1.817		
2	24	250	27	904	1.593		
3	30	250	27	904	1.840	-0.05	0.0006
4	27	175	27	904	1.439		
5	27	325	27	904	1.795	-0.22	0.0123
6	27	250	24	904	1.477		
7	27	250	30	904	1.795	-0.28	0.0195
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.173815183
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		11.12%

Run	Levee Friction	Levee Cohesion	PL Sheirack Friction	River Stage	SLIDE FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	27	250	21	904	1.303		
2	24	250	21	904	1.287		
3	30	250	21	904	1.318	-0.03	0.0003
4	27	175	21	904	1.212		
5	27	325	21	904	1.364	-0.17	0.0074
6	27	250	18	904	1.159		
7	27	250	24	904	1.442	-0.28	0.0200
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.168355733
Coefficient of Variation	10.3%	30.0%	13.7%		Coeff. Of Var. of FS		12.77%

Probability of Failure (FS < 1)			
9.37E-06	or		0.001%
1.00	chance in		107,000
Reliability Index			4.28

Probability of Failure (FS < 1)			
2.18E-02	or		2.180%
1.00	chance in		46
2.02			

Moorhead Project ID: 97-13-14
Location: Horn Park
Top of Levee 905
Elevation at Drystole Toe 888
Height 17
Top Width 19
Riverside Slope 3
Landside Slope 3
Toe of slope (ft) 894
Height at toe of slope 21

Moorhead Project ID: 97-13-14, Horn Park

Run	Levee Friction	Levee Cohesion	Sheirack Friction	River Stage	SLIDE FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	27	250	27	905	1.278		
2	24	250	27	905	1.290		
3	30	250	27	905	1.297	-0.04	0.0003
4	27	175	27	905	1.210		
5	27	325	27	905	1.342	-0.13	0.0044
6	27	250	24	905	1.182		
7	27	250	30	905	1.398	-0.24	0.0139
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.135463365
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		10.60%

Probability of Failure (FS < 1)			
1.22E-02	or		1.221%
1.00	chance in		82
Reliability Index			2.25

Run	Levee Friction	Levee Cohesion	Sheirack Friction	River Stage	SLIDE FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	27	250	27	901	1.520		
2	24	250	27	901	1.491		
3	30	250	27	901	1.547	-0.08	0.0008
4	27	175	27	901	1.452		
5	27	325	27	901	1.562	-0.11	0.0030
6	27	250	24	901	1.378		
7	27	250	30	901	1.660	-0.28	0.0199
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.155915561
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		10.13%

Probability of Failure (FS < 1)			
2.11E-05	or		0.002%
1.00	chance in		47,500
Reliability Index			4.10

Run	Levee Friction	Levee Cohesion	Sheirack Friction	River Stage	SLIDE FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	27	250	27	898	1.625		
2	24	250	27	898	1.582		
3	30	250	27	898	1.658	-0.07	0.0011
4	27	175	27	898	1.582		
5	27	325	27	898	1.682	-0.12	0.0036
6	27	250	24	898	1.471		
7	27	250	30	898	1.779	-0.31	0.0237
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.168637157
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		10.37%

Probability of Failure (FS < 1)			
1.73E-06	or		0.000%
1.00	chance in		569,000
Reliability Index			4.84

Run	Levee Friction	Levee Cohesion	Sheirack Friction	River Stage	SLIDE FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	27	250	27	894	1.718		
2	24	250	27	894	1.660		
3	30	250	27	894	1.753	-0.07	0.0013
4	27	175	27	894	1.656		
5	27	325	27	894	1.775	-0.12	0.0038
6	27	250	24	894	1.557		
7	27	250	30	894	1.881	-0.32	0.0252
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.177583314
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		10.31%

Probability of Failure (FS < 1)			
9.31E-08	or		0.000%
1.00	chance in		10,750,000
Reliability Index			5.21

Moorhead Project ID: 97-13-14
Location: Horn Park
Top of Levee 905
Elevation at Drystole Toe 888
Height 17
Top Width 19
Riverside Slope 3
Landside Slope 3
Toe of slope (ft) 894
Height at toe of slope 21

Moorhead Project ID: 97-13-14, Horn Park

Run	Levee Friction	Levee Cohesion	PL Sheirack Friction	River Stage	SLIDE FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	27	250	21	905	1.012		
2	24	250	21	905	1.003		
3	30	250	21	905	1.023	-0.02	0.0001
4	27	175	21	905	0.961		
5	27	325	21	905	1.048	-0.09	0.0019
6	27	250	18	905	0.889		
7	27	250	24	905	1.133	-0.24	0.0145
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.128826397
Coefficient of Variation	10.3%	30.0%	12.7%		Coeff. Of Var. of FS		12.71%

Probability of Failure (FS < 1)			
4.88E-01	or		48.780%
1.00	chance in		2
Reliability Index			0.03

Run	Levee Friction	Levee Cohesion	PL Sheirack Friction	River Stage	SLIDE FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	27	250	21	901	1.187		
2	24	250	21	901	1.165		
3	30	250	21	901	1.256	-0.04	0.0004
4	27	175	21	901	1.139		
5	27	325	21	901	1.228	-0.09	0.0020
6	27	250	18	901	1.045		
7	27	250	24	901	1.324	-0.28	0.0195
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.147853513
Coefficient of Variation	10.3%	30.0%	13.7%		Coeff. Of Var. of FS		12.46%

Probability of Failure (FS < 1)			
9.35E-02	or		9.348%
1.00	chance in		11
Reliability Index			1.32

Run	Levee Friction	Levee Cohesion	PL Sheirack Friction	River Stage	SLIDE FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	27	250	21	895	1.272		
2	24	250	21	895	1.248		
3	30	250	21	895	1.294	-0.05	0.0005
4	27	175	21	895	1.227		
5	27	325	21	895	1.313	-0.09	0.0018
6	27	250	18	895	1.123		
7	27	250	24	895	1.422	-0.33	0.0224
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.157292168
Coefficient of Variation	10.3%	30.0%	13.7%		Coeff. Of Var. of FS		12.36%

Probability of Failure (FS < 1)			
2.92E-02	or		2.925%
1.00	chance in		34
Reliability Index			1.89

Run	Levee Friction	Levee Cohesion	PL Sheirack Friction	River Stage	SLIDE FS	SLIDE ΔF	(ΔF/Z)^0.5
Most Likely Values	27	250	21	894	1.352		
2	24	250	21	894	1.326		
3	30	250	21	894	1.376	-0.05	0.0006
4	27	175	21	894	1.302		
5	27	325	21	894	1.395	-0.09	0.0022
6	27	250	18	894	1.192		
7	27	250	24	894	1.510	-0.32	0.0203
8							
9						0.00	0
Standard Deviation	3	75	3			(sum)	0.167535517
Coefficient of Variation	10.3%	30.0%	13.7%		Coeff. Of Var. of FS		12.39%

Probability of Failure (FS < 1)			
6.62E-03	or		0.662%
1.00	chance in		151
Reliability Index			2.38

1196

File: FMMFS_Geo_C2S_Prob_Failure_rev_2010-01.xls
Worksheet: F(F) Stability
Printed on 11/30/2009

Project: FMMFS
Subject: Stability Analysis
Computed By: KAH
Date: 19-Dec-08
Revised By: KAH
Date: 13-Jan-09

Long-Term, Drained Conditions
Short-Term, Undrained Conditions

Moorhead Project ID:	97-13-14
Location:	Horn Park
Top of Levee	905
Elevation at Dryside Toe	889
Height	17
Top Width	10
Riverside Slope	3
Landside Slope	3
Toe of slope (ft)	884
Height at toe of slope	21

Moorhead Project ID: 97-13-14, Horn Park

Run	Levee Cohesion	Sheraick Cohesion		River Stage	SLIDE FS	SLIDE ΔF	SLIDE (ΔF/Z)^0.5
Most Likely Values	**1125**	**1125**		905	**2.138**		
2	**950**	1125		905	2.123		
3	**1300**	1125		905	2.141	-0.02	0.0001
4	1125	**950**		905	1.971		
5	1125	**1300**		905	2.311	-0.34	0.0289
6							
7						0.00	0.0000
8							
9						0.00	0
Standard Deviation	175	175				(sum)	0.170238089
Coefficient of Variation	8.7%	15.6%	#DIV/0!		Coeff. Of Var. of FS		7.96%

Probability of Failure (FS < 1)	0.00E+00	for	**0.000%**
	0.00	chance in	10,000,000,000
	Reliability Index		9.00

Check of LongTerm, Drained Conditions using GeoStudio

Moorhead Project ID:	97-13-15
Location:	Woodlawn Park
Top of Levee	904
Elevation at Dryside Toe	894
Height	10
Top Width	10
Riverside Slope	3
Landside Slope	3

Moorhead Project ID: 97-13-15, Woodlawn Park

Run	Levee Friction	Levee Cohesion	Sheraick Friction	River Stage	SLIDE FS	SLIDE ΔF	SLIDE (ΔF/Z)^0.5	Levee Friction	Levee Cohesion	Sheraick Friction	River Stage	SlopeW FS	SlopeW ΔF	SlopeW (ΔF/Z)^0.5
Most Likely Values	**27**	**250**	**27**	904	**1.617**			**27**	**250**	**27**	904	**1.619**		
2	**24**	250	27	904	1.593			**24**	250	27	904	1.595		
3	**30**	250	27	904	1.640	-0.05	0.0006	**30**	250	27	904	1.645	-0.05	0.0006
4	27	**175**	27	904	1.498			27	**175**	27	904	1.503		
5	27	**325**	27	904	1.739	-0.12	0.0123	27	**325**	27	904	1.723	-0.12	0.0121
6	27	250	**24**	904	1.477			27	250	**24**	904	1.482		
7	27	250	**30**	904	1.769	-0.28	0.0195	27	250	**30**	904	1.760	-0.28	0.0193
8														
9						0.00	0						0.00	0
Standard Deviation	3	75	3			(sum)	0.179815163	3	75	3			(sum)	0.179913968
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		11.12%	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		11.08%

Probability of Failure (FS < 1)	9.37E-06	for	**0.001%**	**Probability of Failure (FS < 1)**	7.95E-06	for	**0.001%**
	1.00	chance in	107,000		1.00	chance in	125,500
	Reliability Index		4.26		4.32		

Moorhead Project ID:	97-13-14
Location:	Horn Park
Top of Levee	905
Elevation at Dryside Toe	889
Height	17
Top Width	10
Riverside Slope	3
Landside Slope	3
Toe of slope (ft)	884
Height at toe of slope	21

Moorhead Project ID: 97-13-14, Horn Park

Run	Levee Friction	Levee Cohesion	Sheraick Friction	River Stage	SLIDE FS	SLIDE ΔF	SLIDE (ΔF/Z)^0.5	Levee Friction	Levee Cohesion	PL Sheraick Friction	River Stage	SlopeW (Entry-Exit) FS	SlopeW (Entry-Exit) ΔF	SlopeW (Entry-Exit) (ΔF/Z)^0.5
Most Likely Values	**27**	**250**	**27**	905	**1.278**			**27**	**250**	**27**	905	**1.281**		
2	**24**	250	27	905	1.260			**24**	250	27	905	1.261		
3	**30**	250	27	905	1.297	-0.04	0.0003	**30**	250	27	905	1.299	-0.04	0.0004
4	27	**175**	27	905	1.210			27	**175**	27	905	1.211		
5	27	**325**	27	905	1.342	-0.13	0.0044	27	**325**	27	905	1.342	-0.13	0.0043
6	27	250	**24**	905	1.162			27	250	**24**	905	1.161		
7	27	250	**30**	905	1.399	-0.24	0.0139	27	250	**30**	905	1.399	-0.24	0.0142
8														
9						0.00	0						0.00	0
Standard Deviation	3	75	3			(sum)	0.138463365	3	75	3			(sum)	0.137157756
Coefficient of Variation	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		10.88%	10.3%	30.0%	10.3%		Coeff. Of Var. of FS		10.71%

Probability of Failure (FS < 1)	1.22E-02	for	**1.221%**	**Probability of Failure (FS < 1)**	1.17E-02	for	**1.172%**
	1.00	chance in	82		1.00	chance in	85
	Reliability Index		2.25		Reliability Index		2.27

Moorhead Project ID:	97-13-14
Location:	Horn Park
Top of Levee	905
Elevation at Dryside Toe	889
Height	17
Top Width	10
Riverside Slope	3
Landside Slope	3
Toe of slope (ft)	884
Height at toe of slope	21

Moorhead Project ID: 97-13-14, Horn Park

Run	Levee Friction	Levee Cohesion	PL Sheraick Friction	River Stage	SLIDE FS	SLIDE ΔF	SLIDE (ΔF/Z)^0.5	Levee Friction	Levee Cohesion	PL Sheraick Friction	River Stage	SlopeW (Entry-Exit) FS	SlopeW (Entry-Exit) ΔF	SlopeW (Entry-Exit) (ΔF/Z)^0.5
Most Likely Values	**27**	**250**	**21**	905	**1.012**			**27**	**250**	**21**	901	**1.012**		
2	**24**	250	27	905	1.000			**24**	250	21	901	1.000		
3	**30**	250	27	905	1.023	-0.02	0.0001	**30**	250	21	901	1.023	-0.02	0.0001
4	27	**175**	27	905	0.961			27	**175**	21	901	0.961		
5	27	**325**	27	905	1.045	-0.09	0.0019	27	**325**	21	901	1.058	-0.10	0.0024
6	27	250	**18**	905	0.883			27	250	**18**	901	0.891		
7	27	250	**24**	905	1.130	-0.24	0.0145	27	250	**24**	901	1.131	-0.24	0.0144
8														
9						0.00	0						0.00	0
Standard Deviation	3	75	3			(sum)	0.128826397	3	75	3			(sum)	0.129940371
Coefficient of Variation	10.3%	30.0%	13.7%		Coeff. Of Var. of FS		12.71%	10.3%	30.0%	13.7%		Coeff. Of Var. of FS		12.84%

Probability of Failure (FS < 1)	4.88E-01	for	**48.766%**	**Probability of Failure (FS < 1)**	4.88E-01	for	**48.839%**
	1.00	chance in	2		1.00	chance in	2
	Reliability Index		0.03		Reliability Index		0.03

File: FMMFS_Geo_CDEL_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) Stability
Printed on: 11/30/2009

Project: FMMFS
Subject: Summary of Conditional Probability of Failure
Computed By: KAH
Date: 31-Dec-08
Revised By: KAH
Date: 8-Jan-09

Fargo Project ID: 5078-2, 10th St. N

Fargo Project ID: 5078-2
Location: 10th St. N

Overall Expected Level of Performance: ABOVE AVERAGE

Top of Levee	898.5 ft	Top Width	10 ft
Elevation at Dryside Toe	893.5 ft	Riverside Slope	1V on 3H
Height	5 ft	Landside Slope	1V on 3H

	Flood Water Elevation (NAVD 1988)	Height (ft)	Underseepage (1) P(f)	Underseepage (1) R	Slope Stability (2) P(f)	Slope Stability (2) R	Through Seepage (3) P(f)	Through Seepage (3) R	Surface Erosion (4) P(f)	Surface Erosion (4) R	Judgement (5) P(f)	Judgement (5) R	Combined P(f)	Combined R	Frequency of Failure 1 in X times
Sheraick Foundation	893.5	0	0	1	0	1.00000	0	1	0	1	0	1	0	1	
	894.75	1.25	7.50E-06	1.0000	0.0000000	1.00000	2.50E-04	0.9998	3.18E-05	1.0000	7.50E-06	1.0000	0.00030	0.99970	3369
	896	2.5	1.50E-05	1.0000	0.0000000	1.00000	5.00E-04	0.9995	3.18E-05	1.0000	1.50E-05	1.0000	0.00056	0.99944	1780
	897.25	3.75	2.25E-05	0.9999775	0.0000000	1.00000	7.50E-04	0.9993	3.18E-05	1.0000	2.25E-05	1.0000	0.00083	0.99917	1210
	898.5	5	3.00E-05	0.99997	1.18E-10	1.00000	1.00E-03	0.999	3.18E-05	0.9999682	3.00E-05	0.99997	0.00109	0.99891	916
PL Sheraick Foundation	893.5	0	0	1	0	1.00000	0	1	0	1	0	1	0	1	
	894.75	1.25	7.50E-06	1.0000	0.0000019	1.00000	2.50E-04	0.9998	3.18E-05	1.0000	7.50E-06	1.0000	0.00030	0.99970	3347
	896	2.5	1.50E-05	1.0000	0.0000039	1.00000	5.00E-04	0.9995	3.18E-05	1.0000	1.50E-05	1.0000	0.00057	0.99943	1768
	897.25	3.75	2.25E-05	0.9999775	0.0000058	0.99999	7.50E-04	0.9993	3.18E-05	1.0000	2.25E-05	1.0000	0.00083	0.99917	1201
	898.5	5	3.00E-05	0.99997	0.0000078	0.99999	1.00E-03	0.999	3.18E-05	0.9999682	3.00E-05	0.99997	0.00110	0.99890	910
Weighted	893.5	0	0	1	0	1.00000	0	1	0	1	0	1	0	1	
	894.75	1.25	7.50E-06	1.0000	9.71E-07	1.00000	2.50E-04	0.9998	3.18E-05	1.0000	7.50E-06	1.0000	0.00030	0.99970	3358
	896	2.5	1.50E-05	1.0000	1.94E-06	1.00000	5.00E-04	0.9995	3.18E-05	1.0000	1.50E-05	1.0000	0.00056	0.99944	1774
	897.25	3.75	2.25E-05	0.9999775	2.91E-06	1.00000	7.50E-04	0.9993	3.18E-05	1.0000	2.25E-05	1.0000	0.00083	0.99917	1205
	898.5	5	3.00E-05	0.99997	3.88E-06	1.00000	1.00E-03	0.999	3.18E-05	0.9999682	3.00E-05	0.99997	0.00110	0.99890	913

Sheraick Foundation Weighting 0.5

Notes:

(1) P(f) due to "underseepage" is very small to neglible for clay embankments on clay foundations. During past flood fighting activities in the Red River Valley, no serious issues associated with piping have been observed. Therefore, judgement is used to estimate a P(f) due to "underseepage" based on an expected level of performance. Because this levee is similar to the Corp's typical section, the levee is expected to have the following level of performance:

Expected Level of Perfomance: **GOOD** Beta: **4** P(F): **3.00E-05**

(2) P(f) due to "slope stability" was determined using the Taylor's Series procedure for reliability analysis as described in ETL 1110-2-556. The slope stability analyses was based on drained shear strengths and an assumed piezometeric surface similar to what would be expected to develop for steady-state seepage.

(3) P(f) due to "through seepage" (i.e. internal erosion) is very small for clay embankments on clay foundations. During past flood fighting activities in the Red River Valley, no serious issues associated with internal erosion have been observed. Therefore, judgment is used to estimate a P(f) due to "through seepage based on an expected level of performance. Because this levee is similar to the Corps' typical section, the levee is expected to have the following level of performance:

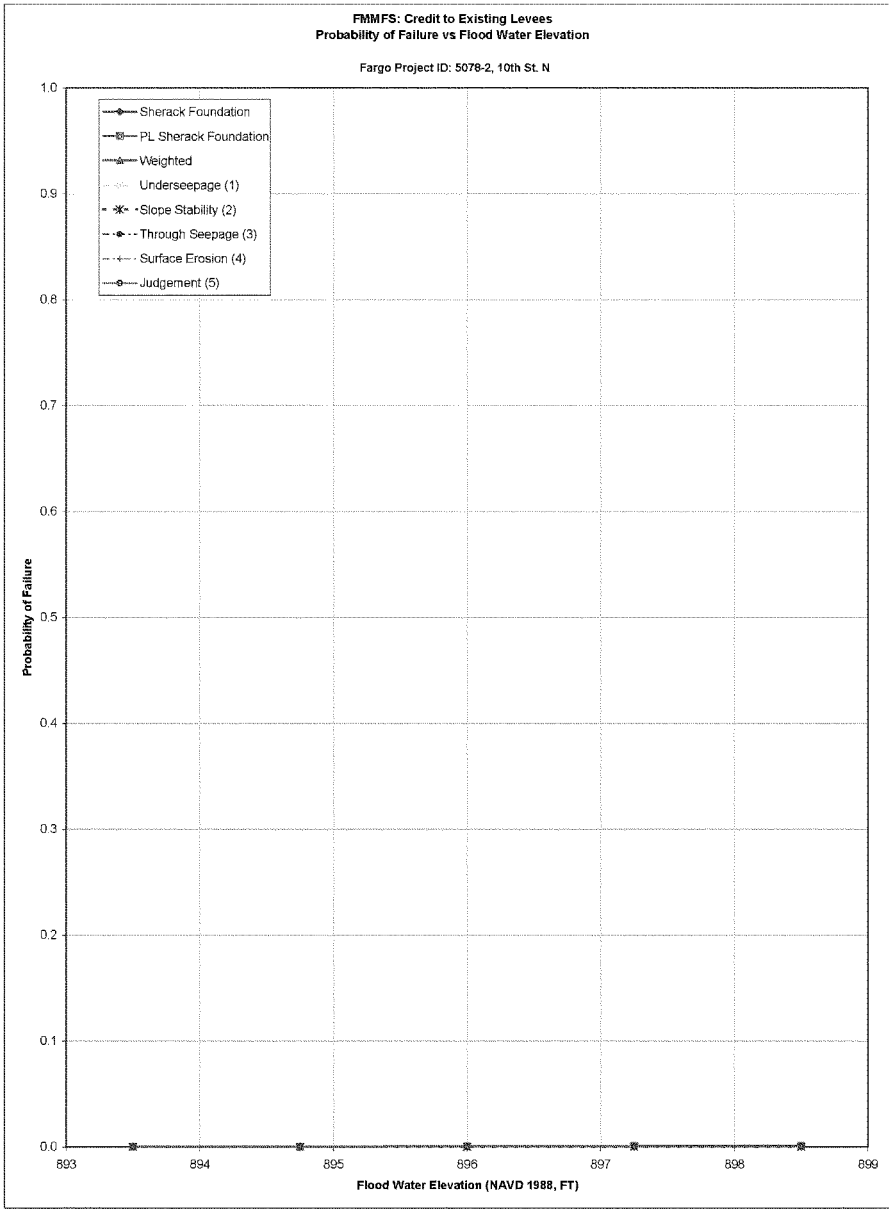
Expected Level of Performance: **ABOVE AVERAGE** Beta: **3** P(F): **1.00E-03**

(4) P(f) due to "surface erosion" was determined using the procedure described in ETL 1110-2-556. The calculations are based on a maximum velocity of 2 feet per second occuring at the location of the levee. This velocity is assumed to occur for all flood elevations.

(5) Probability of failure based on "judgement" takes into account configuration of levee, features at or near the toe that could effect the stability of the levee, and observed conditions. Because this levee is similar to the Corps' typical section and 5 feet or less in height, the levee is expected to have the following level of performance:

Expected Level of Perfomance: **GOOD** Beta: **4** P(F): **3.00E-05**

File: FMMFS_Geo_C2EL_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) 10th St N
Printed on 11/30/2009



File: FMMFS_Geo_C2EL_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) 10th St N
Printed on 11/30/2009

Project: FMMFS
Subject: Summary of Conditional Probability of Failure
Computed By: KAH
Date: 31-Dec-08
Revised By: KAH
Date: 9-Jan-09

Fargo Project ID: 4903, Cardinal Muench Seminary

Fargo Project ID: 4903
Location: Cardinal Muench Seminary

Overall Expected Level of Performance: BELOW AVERAGE

Top of Levee	898 ft	Top Width	5 ft
Elevation at Dryside Toe	893 ft	Riverside Slope	1V on 6H
Height	5 ft	Landside Slope	1V on 6H

	Flood Water Elevation (NAVD 1988)	Height (ft)	Underseepage		Slope Stability		Through Seepage		Surface Erosion		Judgement		Combined		Frequency of Failure 1 in X times
			P(f)	R	P(f)	R	P(f)	R	P(f)	R	P(f)	R	P(f)	R	
Sherack Foundation	896	0	0	1	0	1	0	1	0	1	0	1	0	1	
	896.5	0.5	7.50E-06	1.0000	0.0000000	1.00000	7.50E-06	1.0000	3.18E-05	1.0000	7.50E-06	1.0000	0.00005	0.99995	18412
	897	1	1.50E-05	1.0000	0.0000000	1.00000	1.50E-05	1.0000	3.18E-05	1.0000	1.50E-05	1.0000	0.00008	0.99992	13018
	897.5	1.5	2.25E-05	0.9999775	0.0000000	1.00000	2.25E-05	1.0000	3.18E-05	1.0000	2.25E-05	1.0000	0.00010	0.99990	10068
	898	2	3.00E-05	0.99997	3.818E-08	1.00000	3.00E-05	0.99997	3.18E-05	0.9999682	3.00E-05	0.99997	0.00012	0.99988	8208
PL Sherack Foundation	896	0	0	1	0	1	0	1	0	1	0	1	0	1	
	896.5	0.5	7.50E-06	1.0000	0.0030285	0.99697	7.50E-06	1.0000	3.18E-05	1.0000	7.50E-06	1.0000	0.00308	0.99692	324
	897	1	1.50E-05	1.0000	0.0060570	0.99394	1.50E-05	1.0000	3.18E-05	1.0000	1.50E-05	1.0000	0.00613	0.99387	163
	897.5	1.5	2.25E-05	0.9999775	0.0090855	0.99091	2.25E-05	1.0000	3.18E-05	1.0000	2.25E-05	1.0000	0.00918	0.99082	109
	898	2	3.00E-05	0.99997	0.0121141	0.98789	3.00E-05	0.99997	3.18E-05	0.9999682	3.00E-05	0.99997	0.01223	0.98777	82
Weighted	896	0	0	1	0.00E+00	1	0	1	0	1	0	1	0	1	
	896.5	0.5	7.50E-06	1.0000	1.51E-03	0.99849	7.50E-06	1.0000	3.18E-05	1.0000	7.50E-06	1.0000	0.00157	0.99843	638
	897	1	1.50E-05	1.0000	3.03E-03	0.99697	1.50E-05	1.0000	3.18E-05	1.0000	1.50E-05	1.0000	0.00311	0.99689	322
	897.5	1.5	2.25E-05	0.9999775	4.54E-03	0.99546	2.25E-05	1.0000	3.18E-05	1.0000	2.25E-05	1.0000	0.00464	0.99536	215
	898	2	3.00E-05	0.99997	6.06E-03	0.99394	3.00E-05	0.99997	3.18E-05	0.9999682	3.00E-05	0.99997	0.00618	0.99382	162

Sherack Foundation Weighting 0.5

Notes:

(1) P(f) due to "underseepage" is very small to neglible for clay embankments on clay foundations. During past flood fighting activities in the Red River Valley, no serious issues associated with piping have been observed. Therefore, judgement is used to estimate a P(f) due to "underseepage" based on an expected level of performance. The levee only has a 5-foot top width but 1V on 6H side slopes and is 5 feet or less in height, therefore the levee is expected to have the following level of performance:
Expected Level of Performance: **GOOD** Beta: **4** P(F): **3.00E-05**

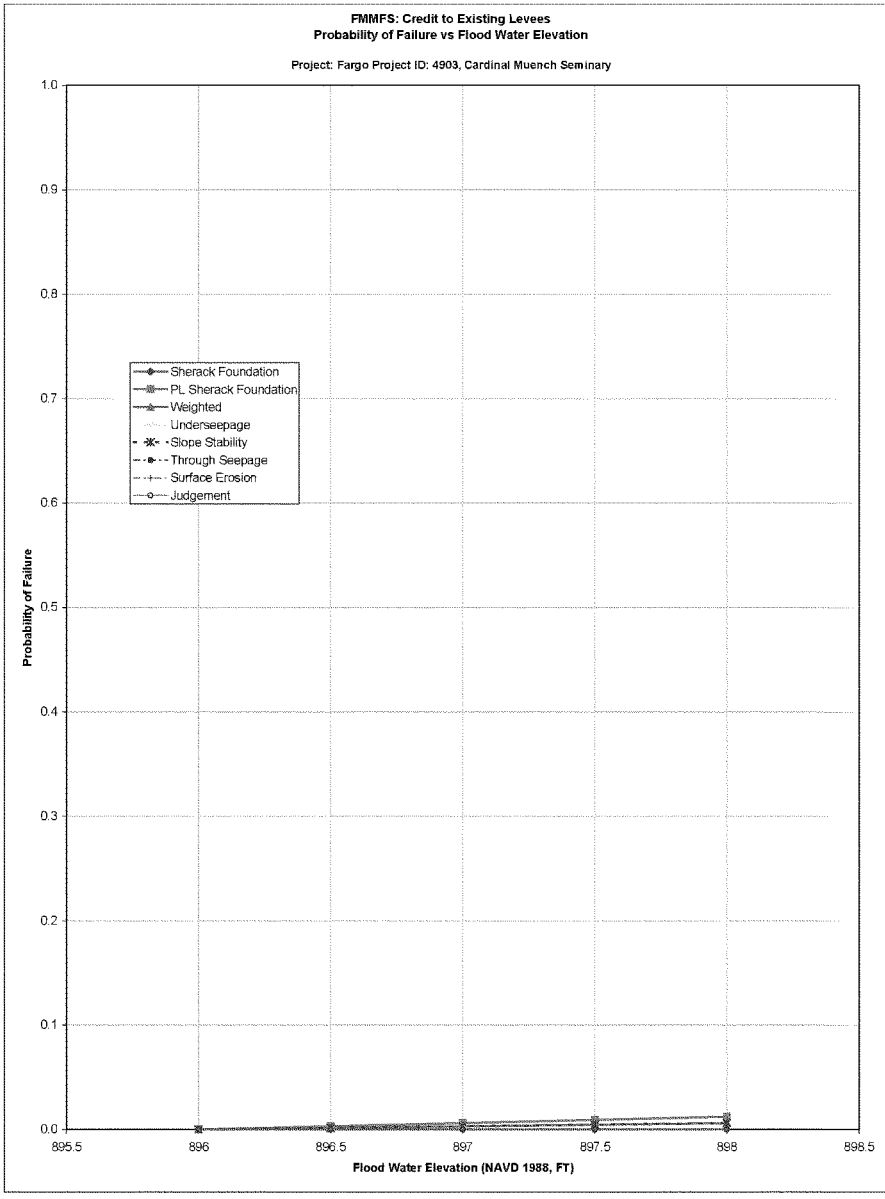
(2) P(f) due to "slope stability" was determined using the Taylor's Series procedure for reliability analysis as described in ETL 1110-2-556. The slope stability analyses was based on drained shear strengths and an assumed piezometeric surface similar to what would be expected to develop for steady-state seepage.

(3) P(f) due to "through seepage" (i.e. internal erosion) is very small for clay embankments on clay foundations. During past flood fighting activities in the Red River Valley, no serious issues associated with internal erosion have been observed. Therefore, judgment is used to estimate a P(f) due to "through seepage based on an expected level of performance. The levee only has a 5-foot top width but 1V on 6H side slopes, the levee is expected to have the following level of performance:
Expected Level of Performance: **GOOD** Beta: **4** P(F): **3.00E-05**

(4) P(f) due to "surface erosion" was determined using the procedure described in ETL 1110-2-556. The calculations are based on a maximum velocity of 2 feet per second occuring at the location of the levee. This velocity is assumed to occur for all flood elevations.

(5) Probability of failure based on "judgement" takes into account configuration of levee, features at or near the toe that could effect the stability of the levee, and observed conditions. There is only a small segment of the levee that is 5 feet in height while the rest is two feet or less. Because of this the levee system is expected to have the following level of performance:
Expected Level of Performance: **GOOD** Beta: **4** P(F): **3.00E-05**

File: FMMFS_Geo_C2EL_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) Cardinal Muench Seminary
Printed on 11/30/2009



File: FMMFS_Geo_C2EL_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) Cardinal Muench Seminary
Printed on 11/30/2009

Project: FMMFS
Subject: Summary of Conditional Probability of Failure
Computed By: KAH
Date: 5-Jan-09
Revised By: KAH
Date: 9-Jan-09

Fargo Project ID: 4579-3, 10th Ave S (Dike West)

Fargo Project ID: 4579-3
Location: 10th Ave S (Dike West)

Overall Expected Level of Performance: HAZARDOUS

Top of Levee	905 ft	Top Width	10 ft
Elevation at Dryside Toe	890 ft	Riverside Slope	1V on 3H
Height	15 ft	Landside Slope	1V on 3H

	Flood Water Elevation (NAVD 1988)	Height (ft)	Underseepage (1)		Slope Stability		Through Seepage (2)		Surface Erosion (3)		Judgement		Combined		Frequency of Failure 1 in X times
			P(f)	R	P(f)	R	P(f)	R	P(f)	R	P(f)	R	P(f)	R	
Sherack Foundation	890	0	0	1	0	1	0	1	0	1	0	1	0	1	
	895	5	2.00E-03	0.9980	0.0000000	1.00000	2.00E-03	0.9980	3.18E-05	1.0000	2.00E-03	0.9980	0.00602	0.99398	166
	897.5	7.5	3.00E-03	0.9970	0.0000002	1.00000	3.00E-03	0.9970	3.18E-05	1.0000	3.00E-03	0.9970	0.00900	0.99100	111
	900	10	4.00E-03	0.996	0.0010549	0.99895	4.00E-03	0.9960	3.18E-05	1.0000	4.00E-03	0.9960	0.01303	0.98697	77
	905	15	6.00E-03	0.994	6.032E-03	0.99397	6.00E-03	0.994	3.18E-05	0.9999682	6.00E-03	0.994	0.02385	0.97615	42
P.L. Sherack Foundation	890	0	0	1	0	1	0	1	0	1	0	1	0	1	
	895	5	2.00E-03	0.9980	0.0005044	0.99950	2.00E-03	0.9980	3.18E-05	1.0000	2.00E-03	0.9980	0.00652	0.99348	153
	897.5	7.5	3.00E-03	0.9970	0.0164164	0.98358	3.00E-03	0.9970	3.18E-05	1.0000	3.00E-03	0.9970	0.02527	0.97473	40
	900	10	4.00E-03	0.996	0.4031575	0.59684	4.00E-03	0.9960	3.18E-05	1.0000	4.00E-03	0.9960	0.41031	0.58969	2
	905	15	6.00E-03	0.994	0.4963200	0.50368	6.00E-03	0.994	3.18E-05	0.9999682	6.00E-03	0.994	0.50535	0.49465	2
Weighted	890	0	0	1	0.00E+00	1	0	1	0	1	0	1	0	1	
	895	5	2.00E-03	0.9980	2.52E-04	0.99975	2.00E-03	0.9980	3.18E-05	1.0000	2.00E-03	0.9980	0.00627	0.99373	159
	897.5	7.5	3.00E-03	0.9970	8.21E-03	0.99179	3.00E-03	0.9970	3.18E-05	1.0000	3.00E-03	0.9970	0.01714	0.98286	58
	900	10	4.00E-03	0.996	2.02E-01	0.79789	4.00E-03	0.9960	3.18E-05	1.0000	4.00E-03	0.9960	0.21167	0.78833	5
	905	15	6.00E-03	0.994	2.51E-01	0.74882	6.00E-03	0.994	3.18E-05	0.9999682	6.00E-03	0.994	0.26460	0.73540	4

Sherack Foundation Weighting 0.5

Notes:

(1) P(f) due to "underseepage" is very small to neglible for clay embankments on clay foundations. During past flood fighting activities in the Red River Valley, no serious issues associated with piping have been observed. Therefore, judgement is used to estimate a P(f) due to "underseepage" based on an expected level of performance. With a retaining wall in the dryside slope, which decreases the seepage path length, the levee is expected to have the following level of performance:

Expected Level of Performance: **BELOW AVERAGE** Beta: **2.5** P(F): **6.00E-03**

(2) P(f) due to "slope stability" was determined using the Taylor's Series procedure for reliability analysis as described in ETL 1110-2-556. The slope stability analyses was based on drained shear strengths and an assumed piezometeric surface similar to what would be expected to develop for steady-state seepage.

(3) P(f) due to "through seepage" (i.e. internal erosion) is very small for clay embankments on clay foundations. During past flood fighting activities in the Red River Valley, no serious issues associated with internal erosion have been observed. Therefore, judgment is used to estimate a P(f) due to "through seepage based on an expected level of performance. With a retaining wall in the dryside slope, the levee is expected to have the following level of performance:

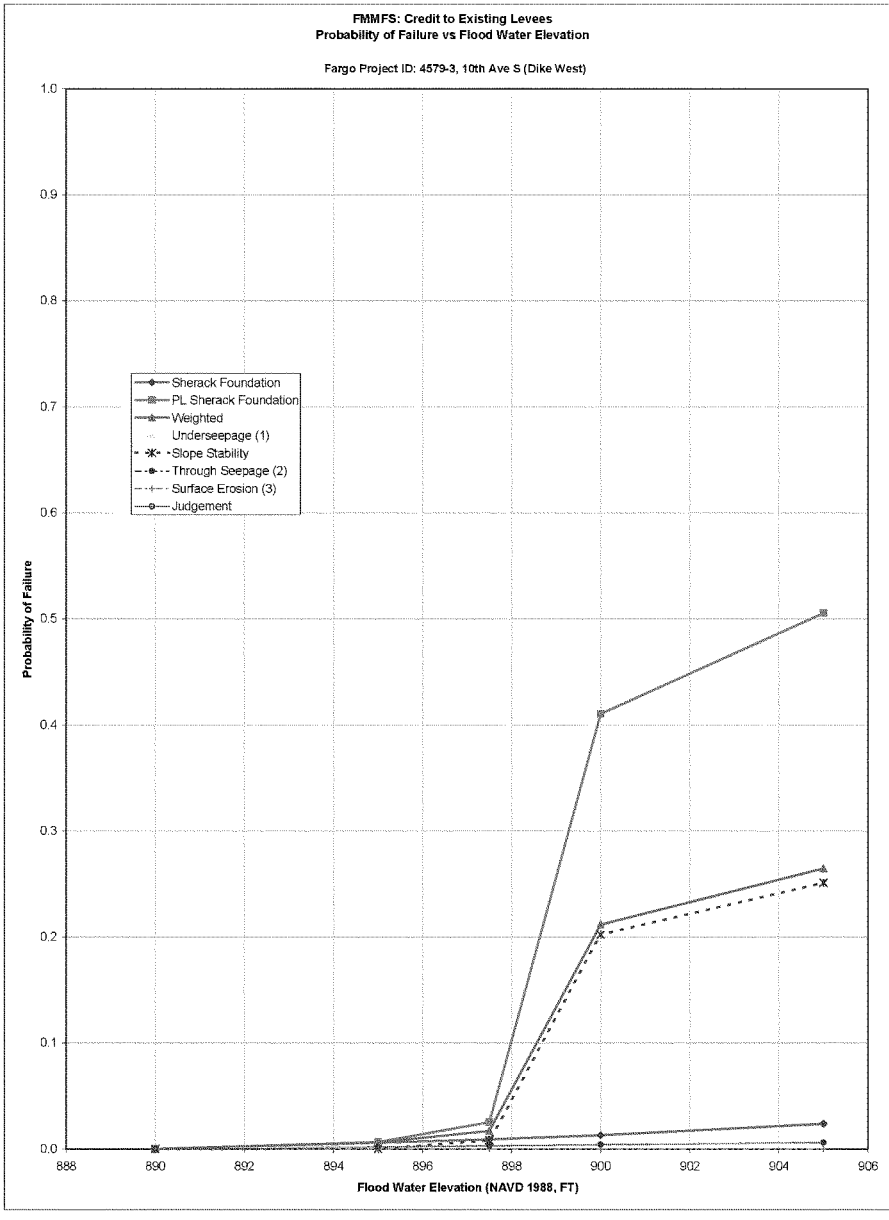
Expected Level of Performance: **BELOW AVERAGE** Beta: **2.5** P(F): **6.00E-03**

(4) P(f) due to "surface erosion" was determined using the procedure described in ETL 1110-2-556. The calculations are based on a maximum velocity of 2 feet per second occuring at the location of the levee. This velocity is assumed to occur for all flood elevations.

(5) Probability of failure based on "judgement" takes into account configuration of levee, features at or near the toe that could effect the stability of the levee, and observed conditions. With a retaining wall in the dryside slope, the levee system is expected to have the following level of performance:

Expected Level of Performance: **BELOW AVERAGE** Beta: **2.5** P(F): **6.00E-03**

File: FMMFS_Geo_C2EL_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) 10th Ave S (Dike West)
Printed on 11/30/2009



File: FMMFS_Geo_C2EL_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) 10th Ave S (Dike West)
Printed on 11/30/2009

Project: FMMFS
Subject: Summary of Conditional Probability of Failure
Computed By: KAH
Date: 31-Dec-08
Revised By: KAH
Date: 9-Jan-09

Fargo Project ID: 4908, Lindenwood Drive

Fargo Project ID: 4908
Location: Lindenwood Drive

Overall Expected Level of Performance: HAZARDOUS

Top of Levee	905 ft	Top Width	8 ft
Elevation at Dryside Toe	897 ft	Riverside Slope	1V on 4H
Height	8 ft	Landside Slope	1V on 4H

	Flood Water Elevation (NAVD 1988)	Height (ft)	Underseepage (1)		Slope Stability		Through Seepage (2)		Surface Erosion (3)		Judgement		Combined		Frequency of Failure 1 in X times
			P(f)	R	P(f)	R	P(f)	R	P(f)	R	P(f)	R	P(f)	R	
Sheraick Foundation	898	1	0	1	0.0000025	1.00000	0	1	0	1	0	1	2.532E-06	0.9999975	394866.8518
	901	4	2.57E-03	0.9974	0.0001301	0.99987	2.57E-03	0.9974	3.18E-05	1.0000	2.57E-03	0.9974	0.00786	0.99214	127
	901.01	4.01	2.58E-03	0.9974	0.0001301	0.99987	2.58E-03	0.9974	3.18E-05	1.0000	2.58E-03	0.9974	0.00788	0.99212	127
	903	6	4.29E-03	0.9957143	0.0002396	0.99976	4.29E-03	0.9957	3.18E-05	1.0000	4.29E-03	0.9957	0.01307	0.98693	77
	905	8	6.00E-03	0.994	0.0705971	0.92940	6.00E-03	0.994	3.18E-05	0.9999682	6.00E-03	0.994	0.08726	0.91274	11
Pl. Sheraick Foundation	898	1	0	1	0.0039767	0.99602	0	1	0	1	0	1	0.0039767	0.9960233	251.4663997
	901	4	2.57E-03	0.9974	0.1504469	0.84955	2.57E-03	0.9974	3.18E-05	1.0000	2.57E-03	0.9974	0.15701	0.84299	6
	901.01	4.01	2.58E-03	0.9974	0.1504469	0.84955	2.58E-03	0.9974	3.18E-05	1.0000	2.58E-03	0.9974	0.15703	0.84297	6
	903	6	4.29E-03	0.9957143	0.1849162	0.81508	4.29E-03	0.9957	3.18E-05	1.0000	4.29E-03	0.9957	0.19538	0.80462	5
	905	8	6.00E-03	0.994	0.6719359	0.32806	6.00E-03	0.994	3.18E-05	0.9999682	6.00E-03	0.994	0.67782	0.32218	1
Weighted	898	1	0	1	1.99E-03	0.99801	0	1	0	1	0	1	0.0019896	0.9980104	502.6127163
	901	4	2.57E-03	0.9974	7.53E-02	0.92471	2.57E-03	0.9974	3.18E-05	1.0000	2.57E-03	0.9974	0.08243	0.91757	12
	901.01	4.01	2.58E-03	0.9974	7.53E-02	0.92471	2.58E-03	0.9974	3.18E-05	1.0000	2.58E-03	0.9974	0.08246	0.91754	12
	903	6	4.29E-03	0.9957143	9.26E-02	0.90742	4.29E-03	0.9957	3.18E-05	1.0000	4.29E-03	0.9957	0.10422	0.89578	10
	905	8	6.00E-03	0.994	3.71E-01	0.62873	6.00E-03	0.994	3.18E-05	0.9999682	6.00E-03	0.994	0.38254	0.61746	3

Sheraick Foundation Weighting 0.5

Notes:

(1) P(f) due to "underseepage" is very small to neglible for clay embankments on clay foundations. During past flood fighting activities in the Red River Valley, no serious issues associated with piping have been observed. Therefore, judgement is used to estimate a P(f) due to "underseepage" based on an expected level of performance. With a retaining wall in the dryside slope, which decreases the seepage path length, the levee is expected to have the following level of performance:

Expected Level of Performance: **BELOW AVERAGE** Beta: **2.5** P(F): **6.00E-03**

(2) P(f) due to "slope stability" was determined using the Taylor's Series procedure for reliability analysis as described in ETL 1110-2-556. The slope stability analyses was based on drained shear strengths and an assumed piezometeric surface similar to what would be expected to develop for steady-state seepage.

(3) P(f) due to "through seepage" (i.e. internal erosion) is very small for clay embankments on clay foundations. During past flood fighting activities in the Red River Valley, no serious issues associated with internal erosion have been observed. Therefore, judgment is used to estimate a P(f) due to "through seepage based on an expected level of performance. With a retaining wall in the dryside slope, the levee is expected to have the following level of performance:

Expected Level of Performance: **BELOW AVERAGE** Beta: **2.5** P(F): **6.00E-03**

(4) P(f) due to "surface erosion" was determined using the procedure described in ETL 1110-2-556. The calculations are based on a maximum velocity of 2 feet per second occuring at the location of the levee. This velocity is assumed to occur for all flood elevations.

(5) Probability of failure based on "judgement" takes into account configuration of levee, features at or near the toe that could effect the stability of the levee, and observed conditions. With a retaining wall in the dryside slope, the levee system is expected to have the following level of performance:

Expected Level of Performance: **BELOW AVERAGE** Beta: **2.5** P(F): **6.00E-03**

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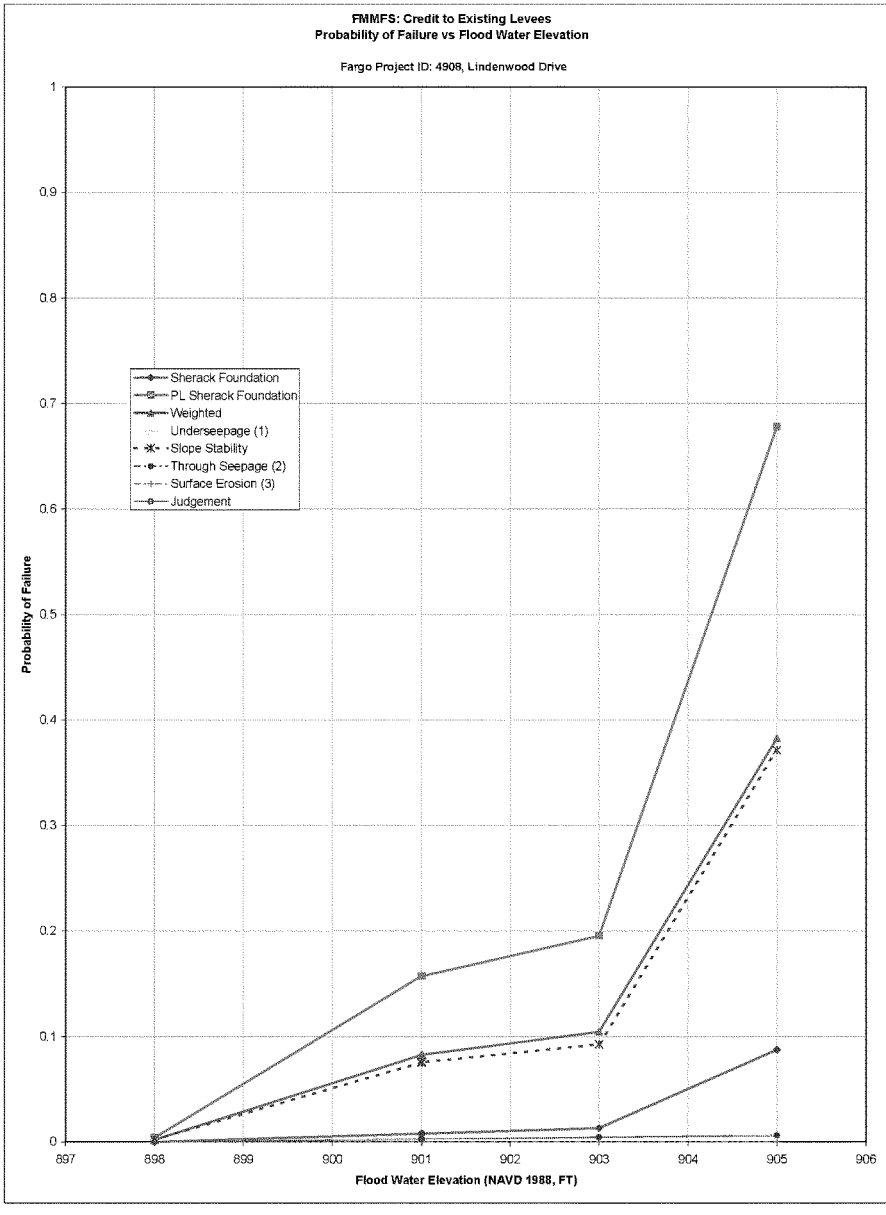
Worksheet: P(F) Lindenwood Drive
Printed on 11/30/2009



File: FMMFS_Geo_C2EL_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) Lindenwood Drive
Printed on 11/30/2009

Project: FMMFS
Subject: Summary of Conditional Probability of Failure
Computed By: KAH
Date: 31-Dec-08
Revised By: KAH
Date: 9-Jan-09

Fargo Project ID: 4980, Southwood Drive

Fargo Project ID: 4980
Location: Southwood Drive

Overall Expected Level of Performance: BELOW AVERAGE

Top of Levee	905 ft	Top Width	4 ft
Elevation at Dryside Toe	901 ft	Riverside Slope	1V on 3H
Height	4 ft	Landside Slope	1V on 3H

	Flood Water Elevation (NAVD 1988)	Height (ft)	Underseepage (1)		Slope Stability		Through Seepage (2)		Surface Erosion (3)		Judgement		Combined		Frequency of Failure 1 in X times
			P(f)	R	P(f)	R	P(f)	R	P(f)	R	P(f)	R	P(f)	R	
Sherack Foundation	901	0	0	1	0.00E+00	1.00000	0	1	0	1	0	1	0	1	
	902	1	2.50E-04	0.9998	6.15E-08	1.00000	2.50E-04	0.9998	3.18E-05	1.0000	2.50E-04	0.9998	0.00078	0.99922	1279
	903	2	5.00E-04	0.9995	1.23E-07	1.00000	5.00E-04	0.9995	3.18E-05	1.0000	5.00E-04	0.9995	0.00153	0.99847	653
	904	3	7.50E-04	0.99925	1.85E-07	1.00000	7.50E-04	0.9993	3.18E-05	1.0000	7.50E-04	0.9993	0.00228	0.99772	439
	905	4	1.00E-03	0.999	2.46E-07	1.00000	1.00E-03	0.999	3.18E-05	0.9999682	1.00E-03	0.999	0.00303	0.99697	330
P.L. Sherack Foundation	901	0	0	1	0	1.00000	0	1	0	1	0	1	0	1	
	902	1	2.50E-04	0.9998	0.0025555	0.99744	2.50E-04	0.9998	3.18E-05	1.0000	2.50E-04	0.9998	0.00334	0.99666	300
	903	2	5.00E-04	0.9995	0.0051109	0.99489	5.00E-04	0.9995	3.18E-05	1.0000	5.00E-04	0.9995	0.00663	0.99337	151
	904	3	7.50E-04	0.99925	0.0076664	0.99233	7.50E-04	0.9993	3.18E-05	1.0000	7.50E-04	0.9993	0.00993	0.99007	101
	905	4	1.00E-03	0.999	0.0102219	0.98978	1.00E-03	0.999	3.18E-05	0.9999682	1.00E-03	0.999	0.01322	0.98678	76
Weighted	901	0	0	1	0.00E+00	1	0	1	0	1	0	1	0	1	
	902	1	2.50E-04	0.9998	1.28E-03	0.99872	2.50E-04	0.9998	3.18E-05	1.0000	2.50E-04	0.9998	0.00206	0.99794	486
	903	2	5.00E-04	0.9995	2.56E-03	0.99744	5.00E-04	0.9995	3.18E-05	1.0000	5.00E-04	0.9995	0.00408	0.99592	245
	904	3	7.50E-04	0.99925	3.83E-03	0.99617	7.50E-04	0.9993	3.18E-05	1.0000	7.50E-04	0.9993	0.00610	0.99390	164
	905	4	1.00E-03	0.999	5.11E-03	0.99489	1.00E-03	0.999	3.18E-05	0.9999682	1.00E-03	0.999	0.00812	0.99188	123

Sherack Foundation Weighting 0.5

Notes:

(1) P(f) due to "underseepage" is very small to neglible for clay embankments on clay foundations. During past flood fighting activities in the Red River Valley, no serious issues associated with piping have been observed. Therefore, judgement is used to estimate a P(f) due to "underseepage" based on an expected level of performance. With only a 4-foot top width, decreasing the seepage path length, the levee is expected to have the following level of performance:
Expected Level of Perfomance: **ABOVE AVERAGE** Beta: **3** P(F): **1.00E-03**

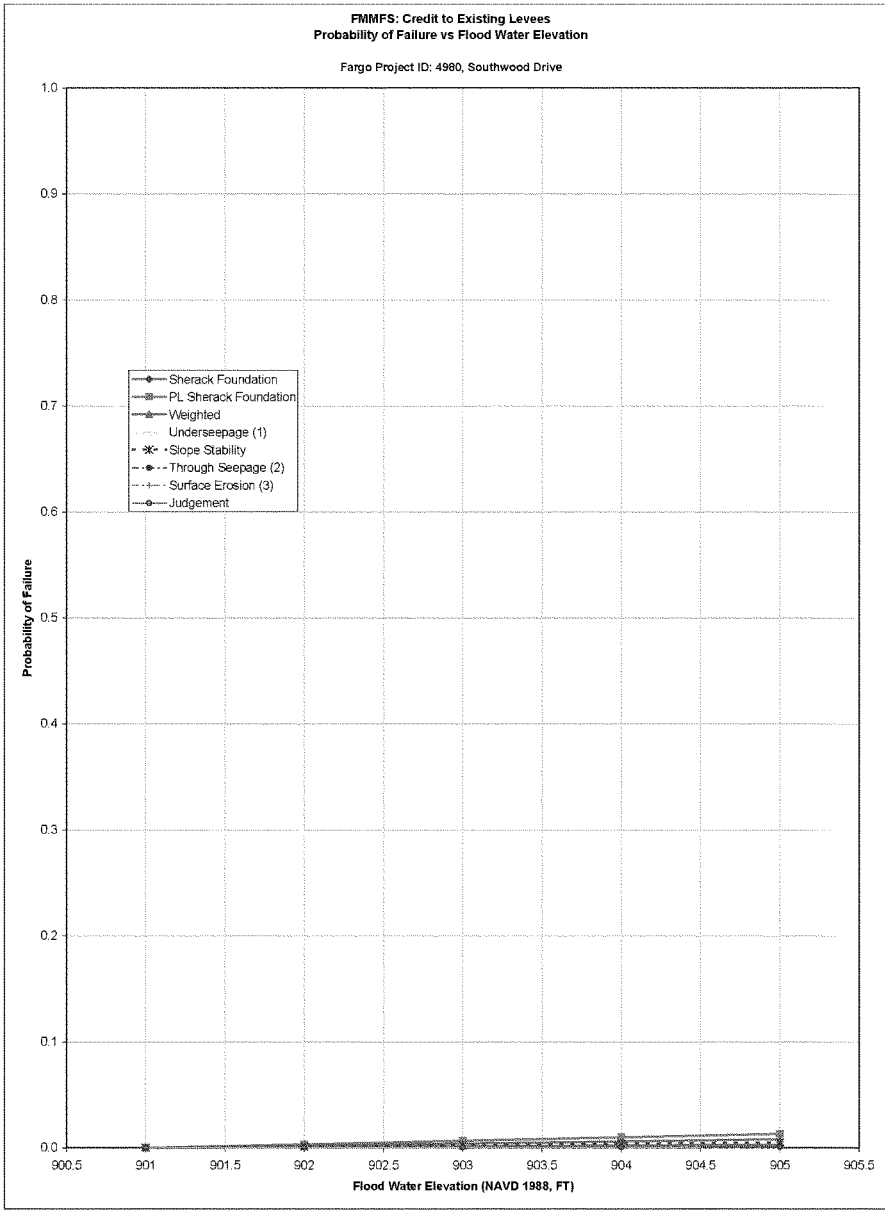
(2) P(f) due to "slope stability" was determined using the Taylor's Series procedure for reliability analysis as described in ETL 1110-2-556. The slope stability analyses was based on drained shear strengths and an assumed piezometeric surface similar to what would be expected to develop for steady-state seepage.

(3) P(f) due to "through seepage" (i.e. internal erosion) is very small for clay embankments on clay foundations. During past flood fighting activities in the Red River Valley, no serious issues associated with internal erosion have been observed. Therefore, judgment is used to estimate a P(f) due to "through seepage based on an expected level of performance. With 1V on 3H side slopes but only a 4-foot top width, the levee is expected to have the following level of performance:
Expected Level of Perfomance: **ABOVE AVERAGE** Beta: **3** P(F): **1.00E-03**

(4) P(f) due to "surface erosion" was determined using the procedure described in ETL 1110-2-556. The calculations are based on a maximum velocity of 2 feet per second occuring at the location of the levee. This velocity is assumed to occur for all flood elevations.

(5) Probability of failure based on "judgement" takes into account configuration of levee, features at or near the toe that could effect the stability of the levee, and observed conditions. With being a short levee with 1V on 3H side slopes, the levee is expected to have the following level of performance:
Expected Level of Perfomance: **ABOVE AVERAGE** Beta: **3** P(F): **1.00E-03**

File: FMMFS_Geo_C2EL_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) Southwood Drive
Printed on 11/30/2009



File: FMMFS_Geo_C2Ei_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) Southwood Drive
Printed on 11/30/2009

Project: FMMFS
Subject: Summary of Conditional Probability of Failure
Computed By: KAH
Date: 31-Dec-08
Revised By: KAH
Date: 1*9

Fargo Project ID: 5093, Drain 27 / Rose Coulee

Fargo Project ID: 5093
Location: Drain 27 / Rose Coulee

Overall Expected Level of Performance: AVERAGE

Top of Levee	909 ft	Top Width	10 ft
Elevation at Dryside Toe	904 ft	Riverside Slope	1V on 5H
Height	5 ft	Landside Slope	1V on 5H

	Flood Water Elevation (NAVD 1988)	Height (ft)	Underseepage (1)		Slope Stability		Through Seepage (2)		Surface Erosion (3)		Judgement		Combined		Frequency of Failure 1 in X times
			P(f)	R	P(f)	R	P(f)	R	P(f)	R	P(f)	R	P(f)	R	
Sherack Foundation	904	0	0	1	0	1.00000	0	1	0	1	0	1	0	1	
	905.25	1.25	2.50E-04	0.9998	0.0000000	1.00000	2.50E-04	0.9998	3.18E-05	1.0000	7.50E-06	1.0000	0.00054	0.99946	1855
	906.5	2.5	5.00E-04	0.9995	0.0000000	1.00000	5.00E-04	0.9995	3.18E-05	1.0000	1.50E-05	1.0000	0.00105	0.99895	956
	907.75	3.75	7.50E-04	0.99925	0.0000000	1.00000	7.50E-04	0.9993	3.18E-05	1.0000	2.25E-05	1.0000	0.00155	0.99845	644
	909	5	1.00E-03	0.999	0.0000000	1.00000	1.00E-03	0.999	3.18E-05	0.9999682	3.00E-05	0.99997	0.00206	0.99794	485
P.L. Sherack Foundation	904	0	0	1	0	1.00000	0	1	0	1	0	1	0	1	
	905.25	1.25	2.50E-04	0.9998	0.0000175	0.99998	2.50E-04	0.9998	3.18E-05	1.0000	7.50E-06	1.0000	0.00056	0.99944	1796
	906.5	2.5	5.00E-04	0.9995	0.0000350	0.99996	5.00E-04	0.9995	3.18E-05	1.0000	1.50E-05	1.0000	0.00108	0.99892	925
	907.75	3.75	7.50E-04	0.99925	0.0000525	0.99995	7.50E-04	0.9993	3.18E-05	1.0000	2.25E-05	1.0000	0.00161	0.99839	623
	909	5	1.00E-03	0.999	0.0000700	0.99993	1.00E-03	0.999	3.18E-05	0.9999682	3.00E-05	0.99997	0.00213	0.99787	469
Weighted	904	0	0	1	0.00E+00	1	0	1	0	1	0	1	0	1	
	905.25	1.25	2.50E-04	0.9998	8.75E-06	0.99999	2.50E-04	0.9998	3.18E-05	1.0000	7.50E-06	1.0000	0.00055	0.99945	1825
	906.5	2.5	5.00E-04	0.9995	1.75E-05	0.99998	5.00E-04	0.9995	3.18E-05	1.0000	1.50E-05	1.0000	0.00106	0.99894	940
	907.75	3.75	7.50E-04	0.99925	2.63E-05	0.99997	7.50E-04	0.9993	3.18E-05	1.0000	2.25E-05	1.0000	0.00158	0.99842	633
	909	5	1.00E-03	0.999	3.50E-05	0.99996	1.00E-03	0.999	3.18E-05	0.9999682	3.00E-05	0.99997	0.00210	0.99790	477

Sherack Foundation Weighting 0.5

Notes:

(1) P(f) due to "underseepage" is very small to neglible for clay embankments on clay foundations. During past flood fighting activities in the Red River Valley, no serious issues associated with piping have been observed. Therefore, judgement is used to estimate a P(f) due to "underseepage" based on an expected level of performance. With the levee section being more substaintial than the Corps' typical section (1V on 5H slopes), the levee is expected to have the following level of performance.

Expected Level of Perfomance: **ABOVE AVERAGE** Beta: **3** P(F): **1.00E-03**

(2) P(f) due to "slope stability" was determined using the Taylor's Series procedure for reliability analysis as described in ETL 1110-2-556. The slope stability analyses was based on drained shear strengths and an assumed piezometeric surface similar to what would be expected to develop for steady-state seepage.

(3) P(f) due to "through seepage" (i.e. internal erosion) is very small for clay embankments on clay foundations. During past flood fighting activities in the Red River Valley, no serious issues associated with internal erosion have been observed. Therefore, judgment is used to estimate a P(f) due to "through seepage based on an expected level of performance. With the levee section being more substaintial than the Corps' typical section (1V on 5H slopes), the levee is expected to have the following level of performance:

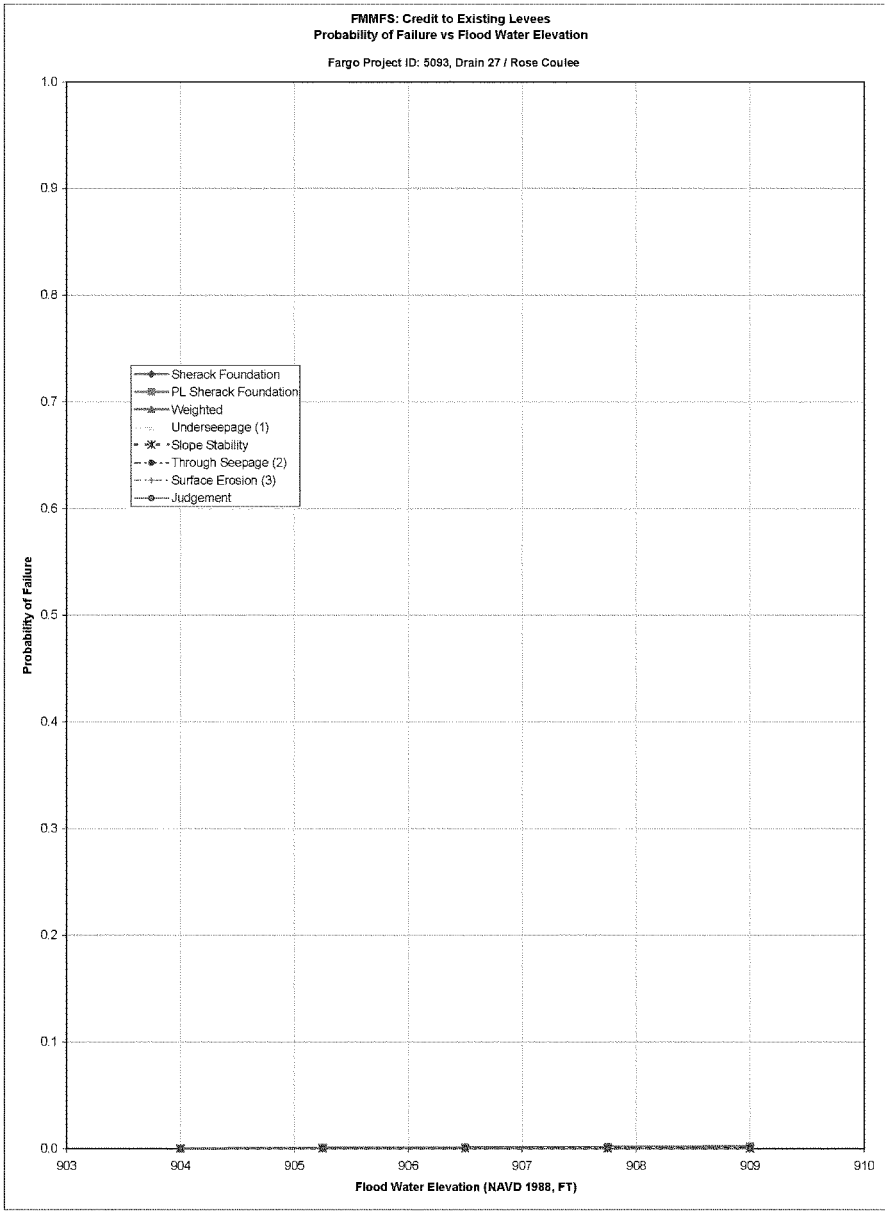
Expected Level of Perfomance: **ABOVE AVERAGE** Beta: **3** P(F): **1.00E-03**

(4) P(f) due to "surface erosion" was determined using the procedure described in ETL 1110-2-556. The calculations are based on a maximum velocity of 2 feet per second occuring at the location of the levee. This velocity is assumed to occur for all flood elevations.

(5) Probability of failure based on "judgement" takes into account configuration of levee, features at or near the toe that could effect the stability of the levee, and observed conditions. With the levee section being more substaintial than the Corps' typical section (1V on 5H slopes), the levee is expected to have the following level of performance:

Expected Level of Perfomance: **GOOD** Beta: **4** P(F): **3.00E-05**

File: FMMFS_Geo_C2EL_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) Drain 27, Rose Coulee
Printed on 11/30/2009



File: FMMFS_Geo_C2EL_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) Drain 27, Rose Coulee
Printed on 11/30/2009

Project: FMMFS
Subject: Summary of Conditional Probability of Failure
Computed By: KAH
Date: 31-Dec-08
Revised By: KAH
Date: 9-Jan-09

Moorhead Project ID: 97-13-15, Woodlawn Park

Moorhead Project ID: 97-13-15
Location: Woodlawn Park

Overall Expected Level of Performance: POOR

Top of Levee	904 ft	Top Width	10 ft
Elevation at Dryside Toe	894 ft	Riverside Slope	1V on 3H
Height	10 ft	Landside Slope	1V on 3H

	Flood Water Elevation (NAVD 1988)	Height (ft)	Underseepage (1)		Slope Stability		Through Seepage (2)		Surface Erosion (3)		Judgement		Combined		Frequency of Failure 1 in X times
			P(f)	R	P(f)	R	P(f)	R	P(f)	R	P(f)	R	P(f)	R	
Sherack Foundation	894	0	0	1	0.00E+00	1.00000	0	1	0	1	0	1	0	1	
	896.5	2.5	7.50E-06	1.0000	2.34E-06	1.00000	2.50E-04	0.9998	3.18E-05	1.0000	7.50E-06	1.0000	0.00030	0.99970	3343
	899	5	1.50E-05	1.0000	4.68E-06	1.00000	5.00E-04	0.9995	3.18E-05	1.0000	1.50E-05	1.0000	0.00057	0.99943	1765
	901.5	7.5	2.25E-05	0.9999775	7.03E-06	0.99999	7.50E-04	0.9993	3.18E-05	1.0000	2.25E-05	1.0000	0.00083	0.99917	1199
	904	10	3.00E-05	0.99997	9.37E-06	0.99999	1.00E-03	0.999	3.18E-05	0.9999682	3.00E-05	0.99997	0.00110	0.99890	908

PL Sherack Foundation	894	0	0	1	0	1	0	1	0	1	0	1	0	1	
	896.5	2.5	7.50E-06	1.0000	0.0054505	0.99455	2.50E-04	0.9998	3.18E-05	1.0000	7.50E-06	1.0000	0.00575	0.99425	174
	899	5	1.50E-05	1.0000	0.0109009	0.98910	5.00E-04	0.9995	3.18E-05	1.0000	1.50E-05	1.0000	0.01146	0.98854	87
	901.5	7.5	2.25E-05	0.9999775	0.0163514	0.98365	7.50E-04	0.9993	3.18E-05	1.0000	2.25E-05	1.0000	0.01716	0.98284	58
	904	10	3.00E-05	0.99997	0.0218018	0.97820	1.00E-03	0.999	3.18E-05	0.9999682	3.00E-05	0.99997	0.02287	0.97713	44

Weighted	894	0	0	1	0.00E+00	1	0	1	0	1	0	1	0	1	
	896.5	2.5	7.50E-06	1.0000	2.73E-03	0.99727	2.50E-04	0.9998	3.18E-05	1.0000	7.50E-06	1.0000	0.00302	0.99698	331
	899	5	1.50E-05	1.0000	5.45E-03	0.99455	5.00E-04	0.9995	3.18E-05	1.0000	1.50E-05	1.0000	0.00601	0.99399	166
	901.5	7.5	2.25E-05	0.9999775	8.18E-03	0.99182	7.50E-04	0.9993	3.18E-05	1.0000	2.25E-05	1.0000	0.00900	0.99100	111
	904	10	3.00E-05	0.99997	1.09E-02	0.98909	1.00E-03	0.999	3.18E-05	0.9999682	3.00E-05	0.99997	0.01199	0.98801	83

Sherack Foundation Weighting 0.5

Notes:

(1) P(f) due to "underseepage" is very small to neglible for clay embankments on clay foundations. During past flood fighting activities in the Red River Valley, no serious issues associated with piping have been observed. Therefore, judgement is used to estimate a P(f) due to "underseepage" based on an expected level of performance. With the levee section similar to the Corps' typical section, the levee is expected to have the following level of performance:

Expected Level of Performance: **GOOD** Beta: **4** P(F): **3.00E-05**

(2) P(f) due to "slope stability" was determined using the Taylor's Series procedure for reliability analysis as described in ETL 1110-2-556. The slope stability analyses was based on drained shear strengths and an assumed piezometeric surface similar to what would be expected to develop for steady-state seepage.

(3) P(f) due to "through seepage" (i.e. internal erosion) is very small for clay embankments on clay foundations. During past flood fighting activities in the Red River Valley, no serious issues associated with internal erosion have been observed. Therefore, judgment is used to estimate a P(f) due to "through seepage based on an expected level of performance. With the levee section similar to the Corps' typical section, the levee is expected to have the following level of performance:

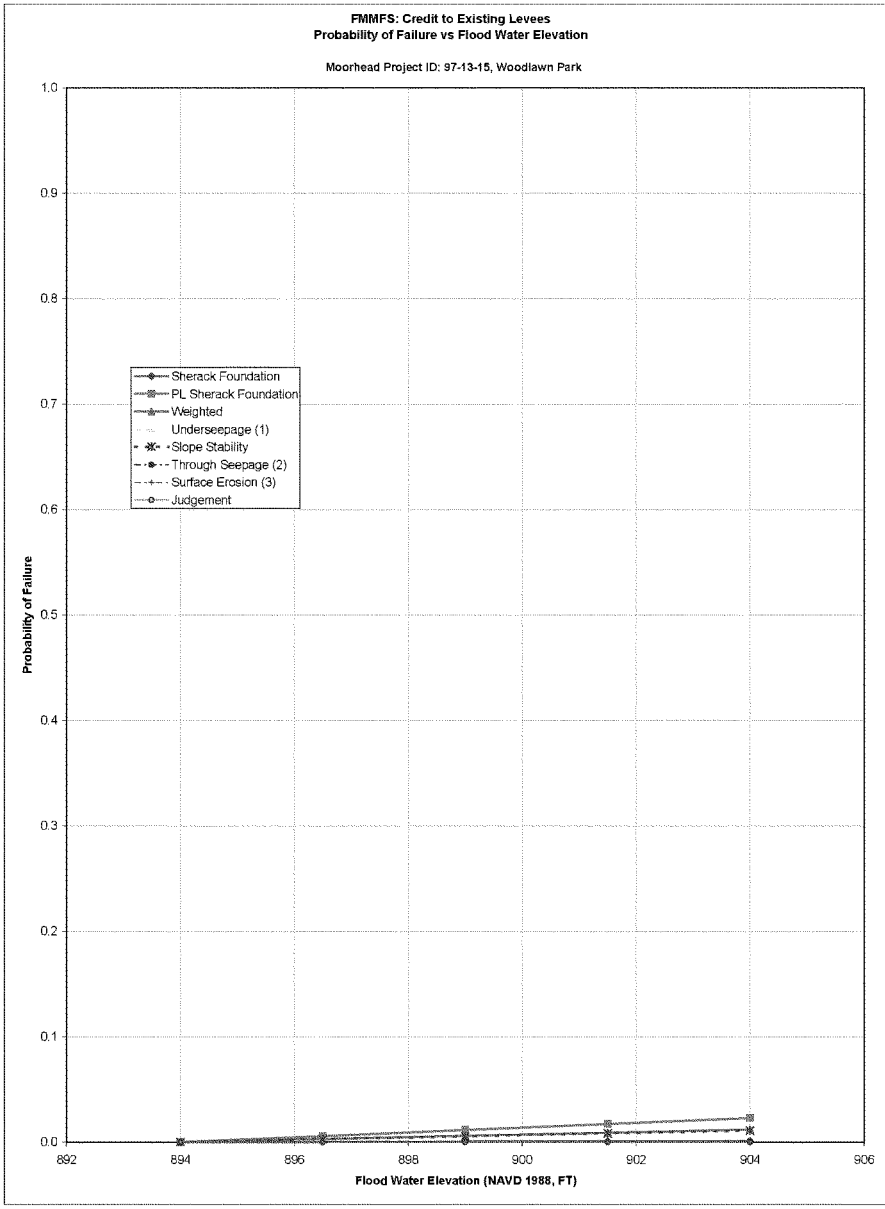
Expected Level of Performance: **ABOVE AVERAGE** Beta: **3** P(F): **1.00E-03**

(4) P(f) due to "surface erosion" was determined using the procedure described in ETL 1110-2-556. The calculations are based on a maximum velocity of 2 feet per second occuring at the location of the levee. This velocity is assumed to occur for all flood elevations.

(5) Probability of failure based on "judgement" takes into account configuration of levee, features at or near the toe that could effect the stability of the levee, and observed conditions. With the levee section similar to the Corps' typical section but having a larger height, the levee is expected to have the following level of performance:

Expected Level of Performance: **GOOD** Beta: **4** P(F): **3.00E-05**

File: FMMFS_Geo_C2EL_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) Woodlawn Park
Printed on 11/30/2009



File: FMMFS_Geo_C2EI_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) Woodlawn Park
Printed on 11/30/2009

Project: FMMFS
Subject: Summary of Conditional Probability of Failure
Computed By: KAH
Date: 31-Dec-08
Revised By: KAH
Date: 9-Jan-09

Moorhead Project ID: 97-13-14, Horn Park

Moorhead Project ID: 97-13-14
Location: Horn Park

Overall Expected Level of Performance: HAZARDOUS

Top of Levee	905 ft	Top Width	10 ft
Elevation at Dryside Toe	888 ft	Riverside Slope	1V on 3H
Height	17 ft	Landside Slope	1V on 3H

	Flood Water Elevation (NAVD 1988)	Height (ft)	Underseepage (1)		Slope Stability		Through Seepage (2)		Surface Erosion (3)		Judgement		Combined		Frequency of Failure 1 in X times
			P(f)	R	P(f)	R	P(f)	R	P(f)	R	P(f)	R	P(f)	R	
Sheriack Foundation	888	0	0	1	0	1	0	1	0	1	0	1	0	1	
	894	6	1.06E-05	0.9999894	0.0000001	1.00000	1.06E-05	0.9999894	3.18E-05	0.9999682	3.53E-04	0.9996471	0	0.999594	2463
	898	10	1.76E-05	0.999982	0.0000017	1.00000	1.76E-05	0.9999824	3.18E-05	0.9999682	5.88E-04	0.9994118	0.00066	0.99934	1522
	901	13	2.29E-05	0.999977	0.0000211	0.99998	2.29E-05	0.9999771	3.18E-05	0.9999682	7.65E-04	0.9992353	0.00086	0.99914	1158
	901.01	13.01	2.30E-05	0.999977	0.0000211	0.99998	2.30E-05	0.9999770	3.18E-05	1.0000	7.65E-04	0.9992347	0.00086	0.99914	1157
	905	17	3.00E-05	0.999970	0.0122078	0.98779	3.00E-05	0.99997	3.18E-05	0.9999682	1.00E-03	0.9990	0.01329	0.98671	75
Pt. Sheriack Foundation	888	0	0	1	0	1	0	1	0	1	0	1	0	1	
	894	6	0	0.9999894	0.0036248	1	0	0.9999894	0	0.9999682	0	0.9996471	0	0.990973	111
	898	10	1.76E-05	0.9999824	0.0292494	0.97075	1.76E-05	0.9999824	3.18E-05	0.9999682	5.88E-04	0.9994118	0.02989	0.97011	33
	901	13	2.29E-05	0.9999771	0.0934942	0.90651	2.29E-05	0.9999771	3.18E-05	0.9999682	7.65E-04	0.9992353	0.09426	0.90574	11
	901.01	13.01	2.30E-05	0.999977	0.0934942	0.90651	2.30E-05	0.9999770	3.18E-05	0.9999682	7.65E-04	0.9992347	0.09426	0.90574	11
	905	17	3.00E-05	0.999970	0.4876618	0.51234	3.00E-05	0.99997	3.18E-05	0.999968	1.00E-03	0.9990	0.48822	0.51178	2
Weighted	888	0	0	1	0	1	0	1	0	1	0	1	0	1	
	894	6	1.06E-05	0.9999894	4.31E-03	1	1.06E-05	0.9999894	3.18E-05	0.9999682	3.53E-04	0.9996471	0	0.995283	212
	898	10	1.76E-05	0.9999824	1.46E-02	0.98537	1.76E-05	0.9999824	3.18E-05	0.999968	5.88E-04	0.9994118	0.01527	0.98473	65
	901	13	2.29E-05	0.9999771	4.68E-02	0.95324	2.29E-05	0.9999771	3.18E-05	0.999968	7.65E-04	0.9992353	0.04756	0.95244	21
	901.01	13.01	2.30E-05	0.999977	4.68E-02	0.95324	2.30E-05	0.9999770	3.18E-05	0.999968	7.65E-04	0.9992347	0.04756	0.95244	21
	905	17	3.00E-05	0.999970	2.50E-01	0.75007	3.00E-05	0.999970	3.18E-05	0.999968	1.00E-03	0.999	0.25075	0.74925	4

Sheriack Foundation Weighting 0.5

Notes:

(1) P(f) due to "underseepage" is very small to neglible for clay embankments on clay foundations. During past flood fighting activities in the Red River Valley, no serious issues associated with piping have been observed. Therefore, judgement is used to estimate a P(f) due to "underseepage" based on an expected level of performance. With the levee section similar to the Corps' typical section, the levee is expected to have the following level of performance:

Expected Level of Performance: **ABOVE AVERAGE** Beta: **3** P(F): **1.00E-03**

(2) P(f) due to "slope stability" was determined using the Taylor's Series procedure for reliability analysis as described in ETL 1110-2-556. The slope stability analyses was based on drained shear strengths and an assumed piezometeric surface similar to what would be expected to develop for steady-state seepage.

(3) P(f) due to "through seepage" (i.e. internal erosion) is very small for clay embankments on clay foundations. During past flood fighting activities in the Red River Valley, no serious issues associated with internal erosion have been observed. Therefore, judgment is used to estimate a P(f) due to "through seepage based on an expected level of performance. With the levee section similar to the Corps' typical section, the levee is expected to have the following level of performance:

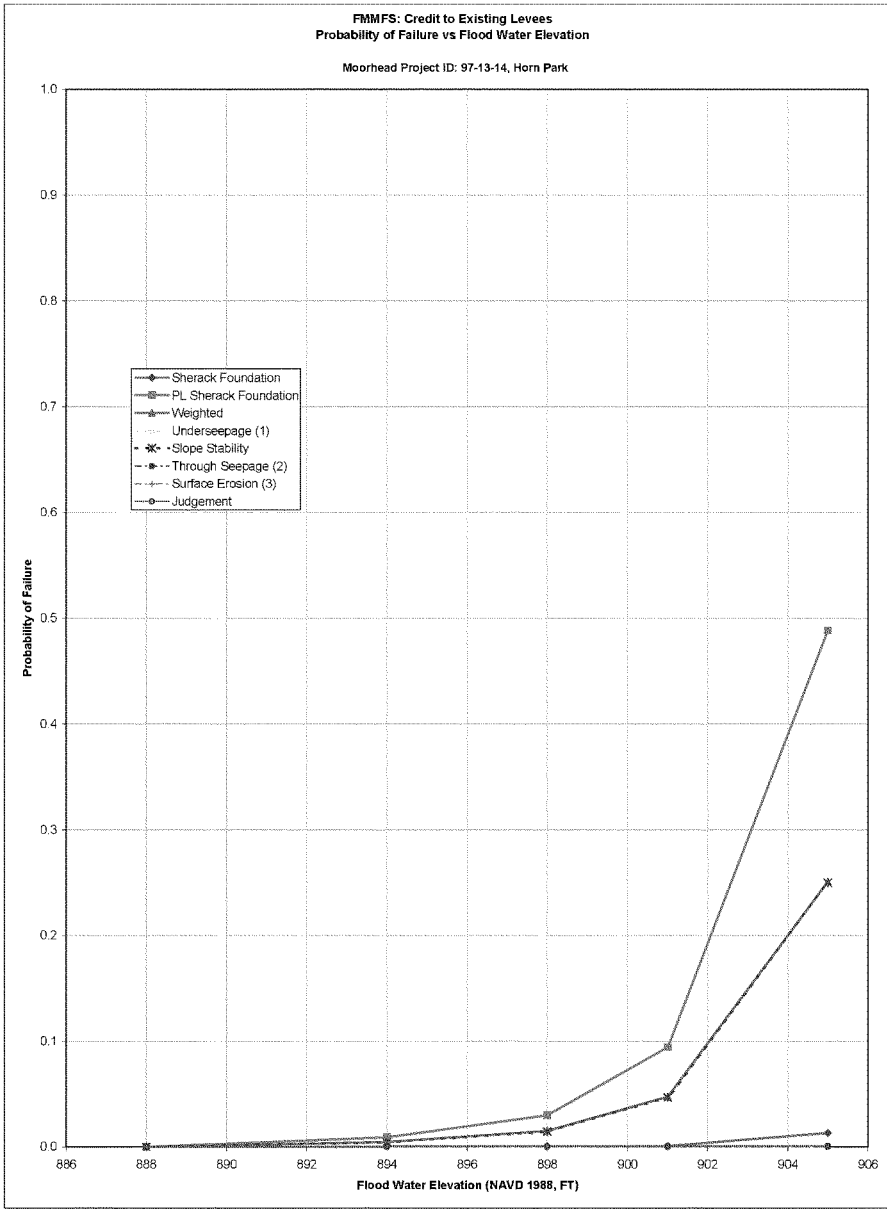
Expected Level of Performance: **ABOVE AVERAGE** Beta: **3** P(F): **1.00E-03**

(4) P(f) due to "surface erosion" was determined using the procedure described in ETL 1110-2-556. The calculations are based on a maximum velocity of 2 feet per second occuring at the location of the levee. This velocity is assumed to occur for all flood elevations.

(5) Probability of failure based on "judgement" takes into account configuration of levee, features at or near the toe that could effect the stability of the levee, and observed conditions. With the levee section similar to the Corps' typical section but with having a larger height, the levee is expected to have the following level of performance:

Expected Level of Performance: **AVERAGE** Beta: **2.75** P(F): **2.50E-03**

File: FMMFS_Geo_C2EL_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) Horn Park
Printed on 11/30/2009



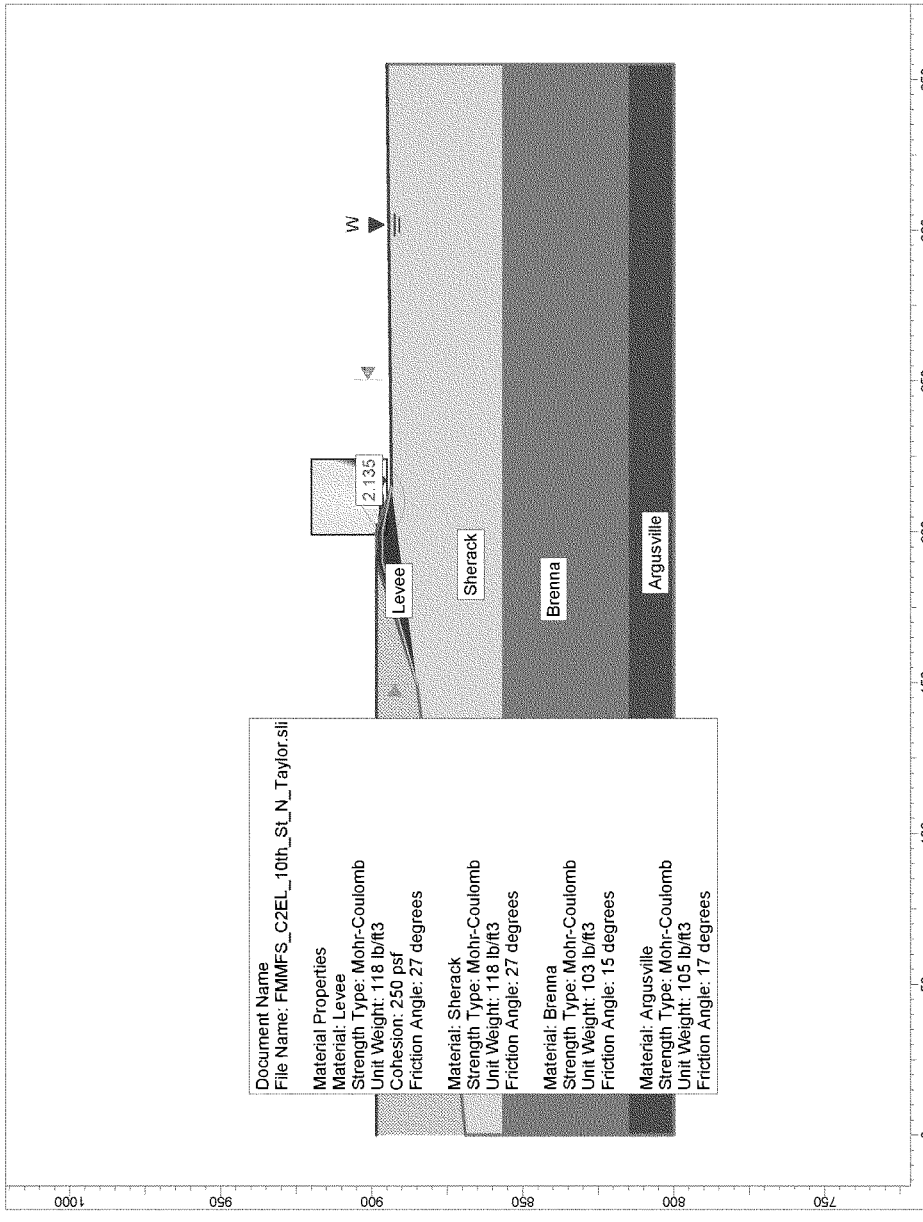
File: FMMFS_Geo_C2EL_Prob_Failure_rev_2010-01.xls
Worksheet: P(F) Horn Park
Printed on 11/30/2009

Project: FMMFS
Subject: ETL 1110-2-556 Example for Probability of Failure due to Erosion
Computed By: KAH
Date: 7-Jan-09
Revised By:
Date:

		Water Surface Elevation				Velocity near Levee		$\ln(E[Vc_{crit}]/E[V])$		Beta		P(F)	
Project ID	Location	10-year	50-year	100-yr	500-yr	100-yr	500-yr	100-yr	500-yr	100-yr	500-yr	100-yr	500-yr
4902	Riverwood 2nd Addition	887.38	893.16	894.86	897.76	2.00	2.00	0.92	0.92	4.00	4.00	3.1803E-05	3.1803E-05
5078-2	10th St. N	887.62	893.52	895.31	898.24	2.00	2.00	0.92	0.92	4.00	4.00	3.1803E-05	3.1803E-05
4903	Cardinal Muench Seminary	888.42	894.34	896.25	899.03	2.00	2.00	0.92	0.92	4.00	4.00	3.1803E-05	3.1803E-05
5036	Oak Grove Floodwall	890.48	897.10	899.49	902.90	1.00	2.00	1.61	0.92	7.02	4.00	1.0768E-12	3.1803E-05
144-115-07	1st Ave to 2nd Ave	890.88	897.57	900.00	903.51	2.00	2.00	0.92	0.92	4.00	4.00	3.1803E-05	3.1803E-05
97-13-14	Horn Park	891.85	898.87	901.55	905.58	2.00	2.00	0.92	0.92	4.00	4.00	3.1803E-05	3.1803E-05
4579-3	Dike West (10th Ave S)	892.16	899.27	902.01	906.13	2.00	2.00	0.92	0.92	4.00	4.00	3.1803E-05	3.1803E-05
4908	Lindenwood Drive	892.40	899.56	902.33	906.54	2.00	2.00	0.92	0.92	4.00	4.00	3.1803E-05	3.1803E-05
97-13-15	Woodlawn Park	893.36	900.59	903.35	907.65	1.00	1.00	1.61	1.61	7.02	7.02	1.0768E-12	1.0768E-12
4980	Southwood Drive	894.07	901.41	904.20	908.39	1.00	1.00	1.61	1.61	7.02	7.02	1.0768E-12	1.0768E-12
	General					2.00	2.00	0.92	0.92	4.00	4.00	3.1803E-05	3.1803E-05

Scouring velocity, V_{crit} = 5 $V(V_{crit})$ 0.2
V(S) 0.1
V(n) 0.1
V(V) 0.1118
$\text{sqrt}(V^2_{vcrit}+V^2_V)$ 0.22913

Attachment H-6: Slope Stability Models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File Name: FMMFS_C2EL_10th_St_N_Taylor.sli
Material Properties
Material: Levee
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 250 psf
Friction Angle: 27 degrees
Material: Sherack
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Friction Angle: 27 degrees
Material: Brenna
Strength Type: Mohr-Coulomb
Unit Weight: 103 lb/ft3
Friction Angle: 15 degrees
Material: Argusville
Strength Type: Mohr-Coulomb
Unit Weight: 105 lb/ft3
Friction Angle: 17 degrees
Levee
Sherack
Brenna
Argusville
2.135
W
0
50
100
150
200
250
300
350
750
800
850
900
950
1000

Slide Analysis Information

Document Name

File Name: FMMFS_C2EL_10th_St_N_Taylor.sli

Project Settings

Project Title: FMMFS, C2EL: Fargo - Lindenwood
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Spencer

Number of slices: 50
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 25
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Tension Crack

Tension crackWater level: filled with water

Material Properties

Material: Levee
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 250 psf
Friction Angle: 27 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Sherack
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 0 psf
Friction Angle: 27 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Brenna
Strength Type: Mohr-Coulomb
Unit Weight: 103 lb/ft3
Cohesion: 0 psf
Friction Angle: 15 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Argusville
Strength Type: Mohr-Coulomb
Unit Weight: 105 lb/ft3
Cohesion: 0 psf
Friction Angle: 17 degrees
Water Surface: Water Table
Custom Hu value: 1

List of All Coordinates

Material Boundary

0.000	857.000
355.000	857.000

Material Boundary

0.000	815.000
355.000	815.000

Material Boundary

149.500	885.000
215.000	893.500

External Boundary

0.000	800.000
355.000	800.000
355.000	815.000
355.000	857.000
355.000	895.000
215.000	893.500
200.000	898.500
190.000	898.500
149.500	885.000
90.000	878.000
0.000	869.000
0.000	857.000
0.000	815.000

Water Table

0.000	898.500
190.000	898.500

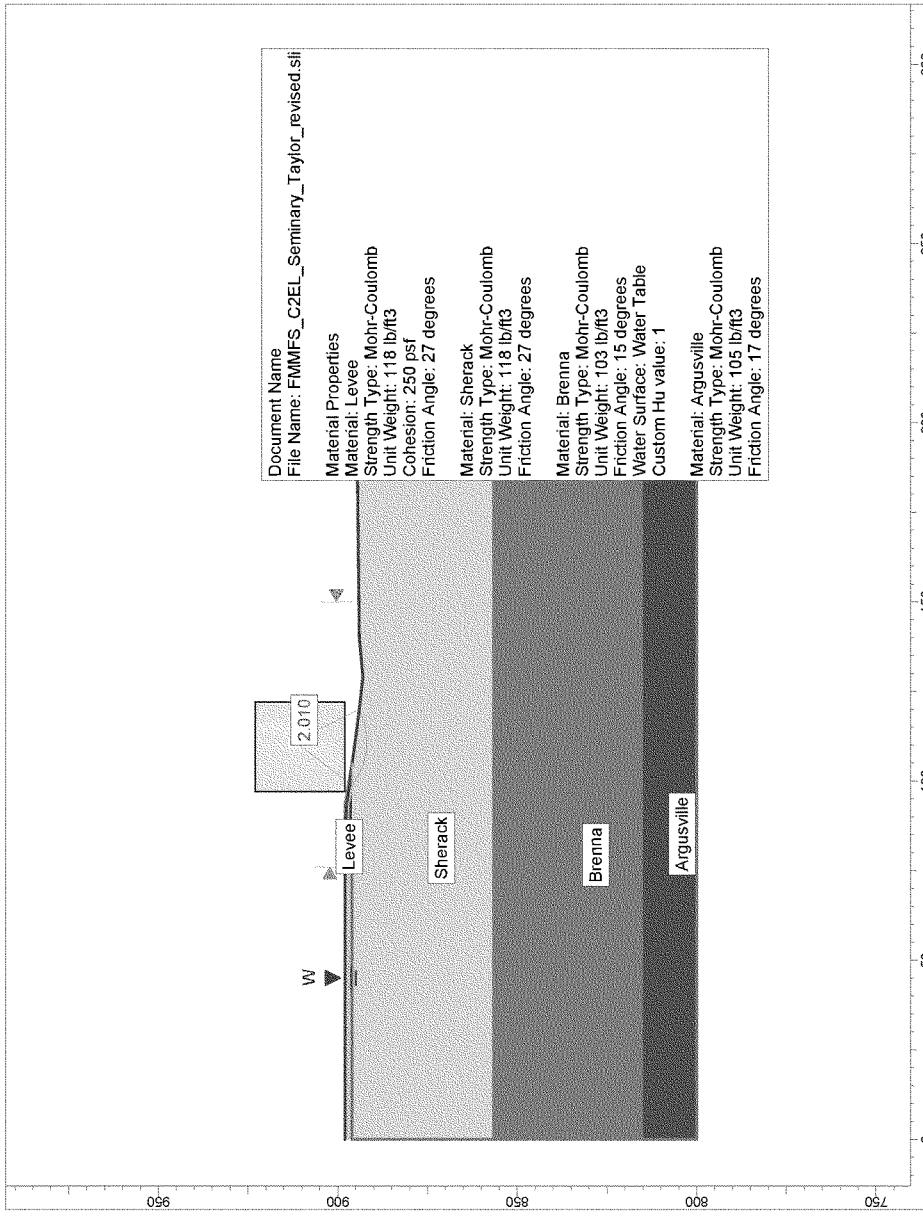
215.000	893.500
355.000	895.000

Tension Crack

149.500	885.000
190.000	896.500
200.000	896.500
215.000	893.500

Search Grid

199.000	895.000
224.000	895.000
224.000	920.000
199.000	920.000


Document Name
File Name: FMMFS_C2EL_Seminary_Taylor_revised.sli
Material Properties
Material: Levee
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 250 psf
Friction Angle: 27 degrees
Material: Sherack
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Friction Angle: 27 degrees
Material: Brenna
Strength Type: Mohr-Coulomb
Unit Weight: 103 lb/ft3
Friction Angle: 15 degrees
Water Surface: Water Table
Custom Hu value: 1
Material: Argusville
Strength Type: Mohr-Coulomb
Unit Weight: 105 lb/ft3
Friction Angle: 17 degrees
2.010
W
Levee
Sherack
Brenna
Argusville
0
50
100
150
200
250
300
750
800
850
900
950

Slide Analysis Information

Document Name

File Name: FMMFS_C2EL_Seminary_Taylor_revised.sli

Project Settings

Project Title: FMMFS, C2EL: Fargo - Lindenwood
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Spencer

Number of slices: 50
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 25
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: 3

Tension Crack

Tension crackWater level: filled with water

Material Properties

Material: Levee
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 250 psf
Friction Angle: 27 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Sherack
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 0 psf
Friction Angle: 27 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Brenna
Strength Type: Mohr-Coulomb
Unit Weight: 103 lb/ft3
Cohesion: 0 psf
Friction Angle: 15 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Argusville
Strength Type: Mohr-Coulomb
Unit Weight: 105 lb/ft3
Cohesion: 0 psf
Friction Angle: 17 degrees
Water Surface: Water Table
Custom Hu value: 1

List of All Coordinates

Material Boundary

0.000	857.000
300.000	857.000

Material Boundary

0.000	815.000
300.000	815.000

Material Boundary

76.000	896.000
105.000	896.000

External Boundary

0.000	800.000
300.000	800.000
300.000	815.000
300.000	857.000
300.000	896.000
230.000	895.000
140.000	894.000
129.000	893.000
120.000	894.000
112.000	895.000
105.000	896.000
93.000	898.000
88.000	898.000
76.000	896.000
0.000	896.000
0.000	857.000
0.000	815.000

Water Table

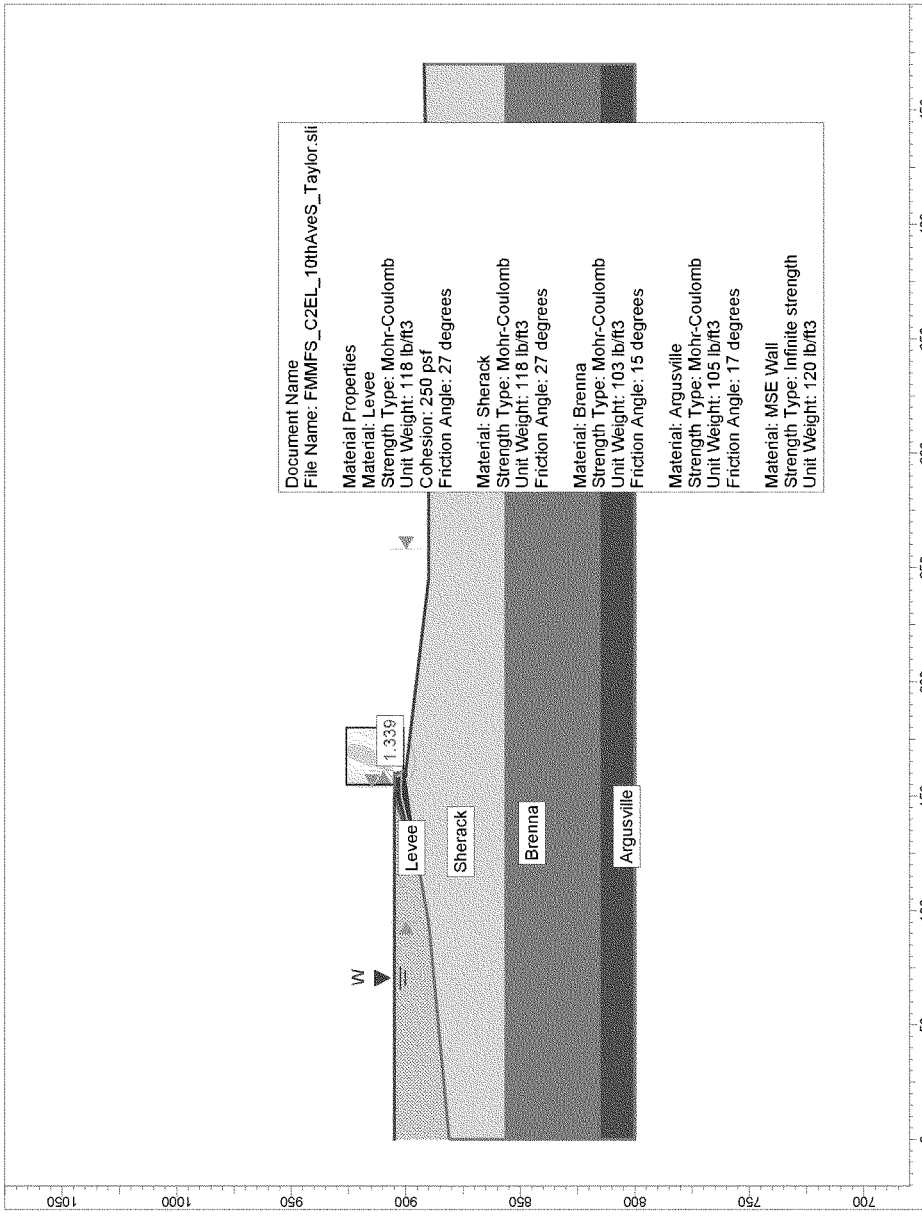
0.000	898.000
88.000	898.000
105.000	896.000
112.000	895.000
120.000	894.000
129.000	893.000
140.000	894.000
230.000	895.000
300.000	896.000

Tension Crack

76.000	896.000
88.000	897.000
93.000	897.000
99.000	896.000
105.000	896.000

Search Grid

97.000	898.000
122.000	898.000
122.000	923.000
97.000	923.000


Document Name
File Name: FMMFS_C2EL_10thAveS_Taylor.sli
Material Properties
Material: Levee
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 250 psf
Friction Angle: 27 degrees
Material: Sherack
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Friction Angle: 27 degrees
Material: Brenna
Strength Type: Mohr-Coulomb
Unit Weight: 103 lb/ft3
Friction Angle: 15 degrees
Material: Argusville
Strength Type: Mohr-Coulomb
Unit Weight: 105 lb/ft3
Friction Angle: 17 degrees
Material: MSE Wall
Strength Type: Infinite strength
Unit Weight: 120 lb/ft3
W
1.339
Levee
Sherack
Brenna
Argusville
1050
1000
950
900
850
800
750
700
0
50
100
150
200
250
300
350
400
450

Slide Analysis Information

Document Name

File Name: FMMFS_C2EL_10thAveS_Taylor.sli

Project Settings

Project Title: FMMFS, C2EL: Moorhead - Horn Park
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Spencer

Number of slices: 50
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 25
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Tension Crack

Tension crackWater level: filled with water

Material Properties

Material: Levee
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 250 psf
Friction Angle: 27 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Sherack
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 0 psf
Friction Angle: 27 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Brenna
Strength Type: Mohr-Coulomb
Unit Weight: 103 lb/ft3
Cohesion: 0 psf
Friction Angle: 15 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Argusville
Strength Type: Mohr-Coulomb
Unit Weight: 105 lb/ft3
Cohesion: 0 psf
Friction Angle: 17 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: MSE Wall
Strength Type: Infinite strength
Unit Weight: 120 lb/ft3

List of All Coordinates

Material Boundary

0.000	857.000
470.000	857.000

Material Boundary

0.000	815.000
470.000	815.000

Material Boundary

117.000	894.000
159.000	900.000

Material Boundary

158.000	905.000
159.000	900.000
161.000	900.000

External Boundary

0.000	800.000
470.000	800.000
470.000	815.000
470.000	857.000
470.000	892.000
365.000	890.000
245.000	890.000
161.000	900.000

160.000	905.000
158.000	905.000
150.000	905.000
117.000	894.000
95.000	890.000
0.000	881.000
0.000	857.000
0.000	815.000

Water Table

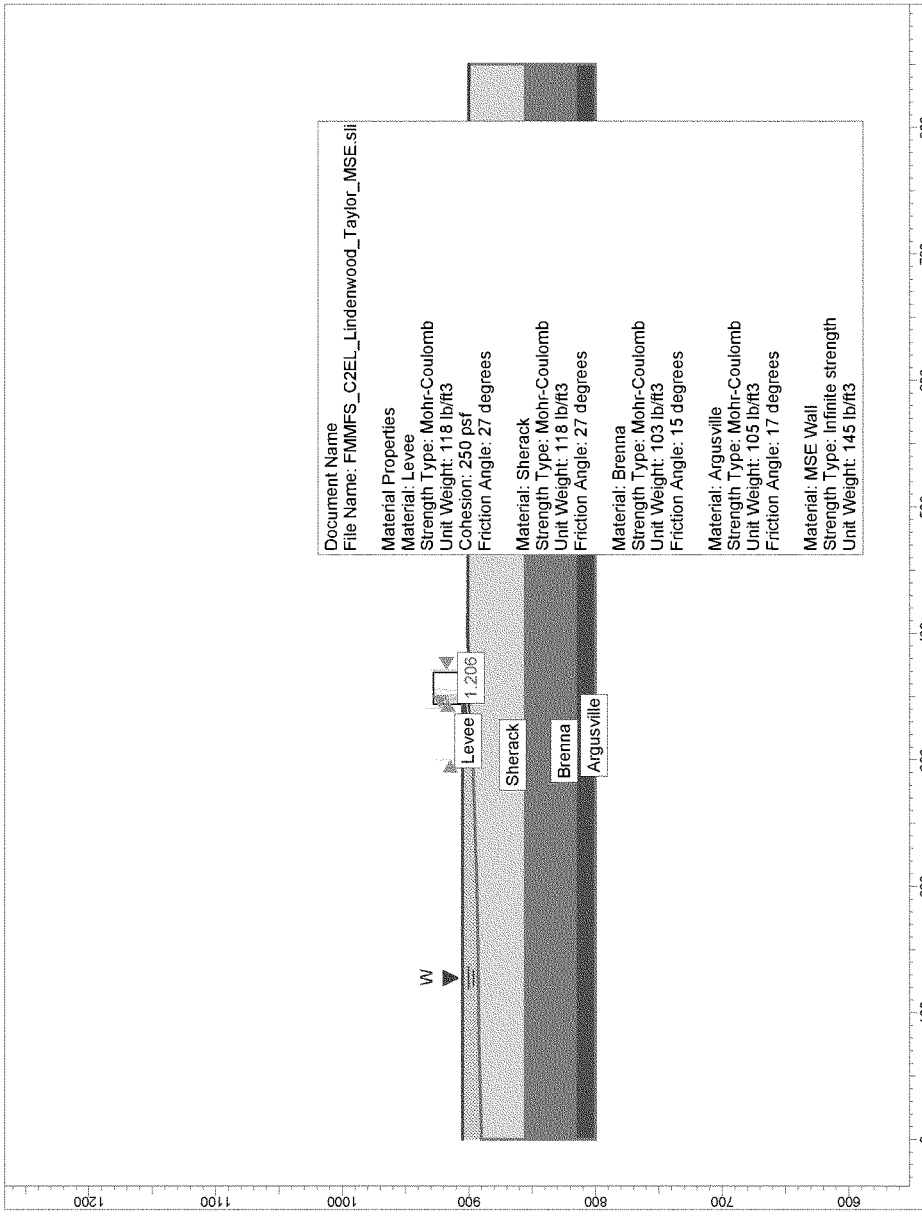
0.000	905.000
150.000	905.000
159.000	900.000
161.000	900.000
245.000	890.000
365.000	890.000
470.000	892.000

Tension Crack

117.000	894.000
150.000	902.000
160.000	902.000

Search Grid

155.000	901.000
180.000	901.000
180.000	926.000
155.000	926.000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Material Properties
Material: Levee
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 250 psf
Friction Angle: 27 degrees
Material: Sherack
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Friction Angle: 27 degrees
Material: Brenna
Strength Type: Mohr-Coulomb
Unit Weight: 103 lb/ft3
Friction Angle: 15 degrees
Material: Argusville
Strength Type: Mohr-Coulomb
Unit Weight: 105 lb/ft3
Friction Angle: 17 degrees
Material: MSE Wall
Strength Type: Infinite strength
Unit Weight: 145 lb/ft3
Levee
1.206
Sherack
Brenna
Argusville
WL
0
100
200
300
400
500
600
700
800
600
700
800
900
1000
1100
1200

Slide Analysis Information

Document Name

File Name: FMMFS_C2EL_Lindenwood_Taylor_MSE.sli

Project Settings

Project Title: FMMFS, C2EL: Fargo - Lindenwood
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Spencer

Number of slices: 50
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 25
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Tension Crack

Tension crackWater level: filled with water

Material Properties

Material: Levee
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 250 psf
Friction Angle: 27 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Sherack
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 0 psf
Friction Angle: 27 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Brenna
Strength Type: Mohr-Coulomb
Unit Weight: 103 lb/ft3
Cohesion: 0 psf
Friction Angle: 15 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Argusville
Strength Type: Mohr-Coulomb
Unit Weight: 105 lb/ft3
Cohesion: 0 psf
Friction Angle: 17 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: MSE Wall
Strength Type: Infinite strength
Unit Weight: 145 lb/ft3

List of All Coordinates

Material Boundary

0.000	857.000
850.000	857.000

Material Boundary

0.000	815.000
850.000	815.000

Material Boundary

344.500	905.000
345.500	899.000
347.000	899.000

Material Boundary

300.000	897.000
345.500	899.000

External Boundary

0.000	800.000
850.000	800.000
850.000	815.000
850.000	857.000
850.000	900.000
397.000	901.000
347.000	899.000
346.000	905.000

344.500	905.000
341.000	905.000
311.000	898.000
300.000	897.000
213.000	894.000
170.000	893.000
78.000	892.000
0.000	890.000
0.000	857.000
0.000	815.000

Water Table

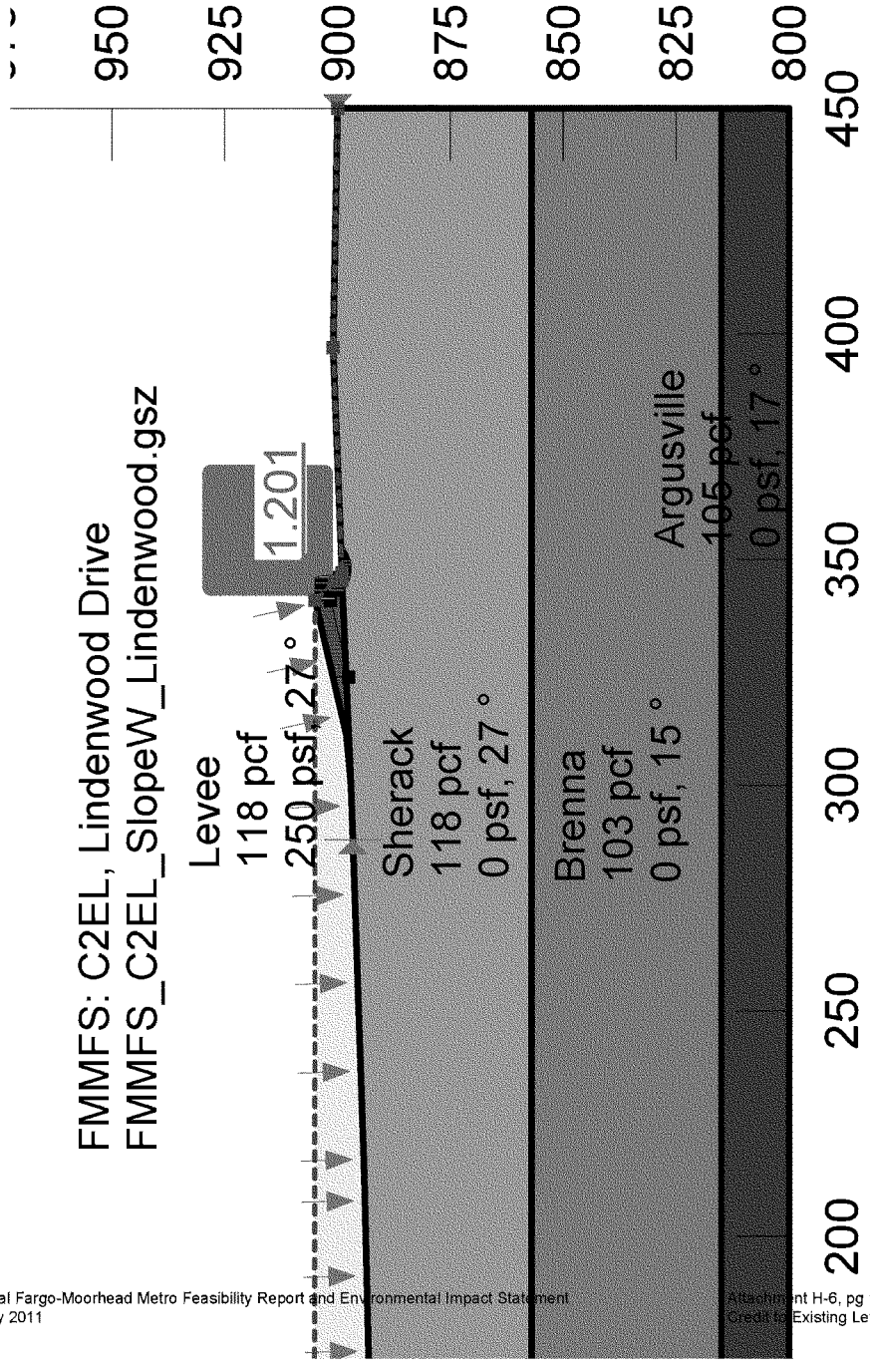
0.000	905.000
341.000	905.000
345.240	900.560
345.500	899.000
347.000	899.000
397.000	901.000
850.000	900.000

Tension Crack

324.000	897.500
341.000	901.500
346.500	901.500

Search Grid

344.000	903.000
369.000	903.000
369.000	928.000
344.000	928.000


FMMFS: C2EL, Lindenwood Drive
FMMFS_C2EL_SlopeW_Lindenwood.gsz
Levee
118 pcf
250 psf, 27 °
1.201
Sherack
118 pcf
0 psf, 27 °
Brenna
103 pcf
0 psf, 15 °
Argusville
105 pcf
0 psf, 17 °
950
925
900
875
850
825
800
450
400
350
300
250
200

Slope Stability

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File Information

Created By: Heckendorf, Kurt A MVP
Revision Number: 2
Last Edited By: Heckendorf, Kurt A MVP
Date: 1/13/2009
Time: 8:53:41 AM
File Name: FMMFS_C2EL_SlopeW_Lindenwood.gsz
Directory: Q:\02FeasibilityFEA\Geotech\Credit_2_Existing_Levees\Slope_Stability\GeoStudio\
Last Solved Date: 1/13/2009
Last Solved Time: 8:53:56 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Slope Stability

Description: FMMFS: C2EL, Lindenwood Drive
Kind: SLOPE/W
Method: Spencer
Settings
- Apply Phreatic Correction: No
- PWP Conditions Source: Piezometric Line
- Use Staged Rapid Drawdown: No

SlipSurface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack
  - Tension Crack Option: Tension Crack Line
  - Percentage Wet: 1

Tension Crack Fluid Unit Weight: 62.4 pcf
FOS Distribution
FOS Calculation Option: Constant
Advanced
Number of Slices: 50
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 2000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

Materials

Levee

Model: Mohr-Coulomb
Unit Weight: 118 pcf
Cohesion: 250 psf
Phi: 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Sherack

Model: Mohr-Coulomb
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Brenna

Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Argusville

Model: Mohr-Coulomb

Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 17 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Wall

Model: Mohr-Coulomb
Unit Weight: 145 pcf
Cohesion: 5000 psf
Phi: 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (344, 928) ft
Lower Left: (344, 903) ft
Lower Right: (369, 903) ft
Grid Horizontal Increment: 25
Grid Vertical Increment: 25
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (340, 902) ft
Upper Right Coordinate: (363, 902) ft
Lower Left Coordinate: (340, 887) ft
Lower Right Coordinate: (363, 887) ft
Number of Increments: 15
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °
UsePoints: 0

Slip Surface Limits

Left Coordinate: (287.9456, 896.58671) ft
Right Coordinate: (450, 900) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
	0	905
	341	905
	345.25	900.56
	345.5	899
	347	899
	397	901
	450	900

Tension Crack Line

	X (ft)	Y (ft)
	324	897.5
	341	901.5
	346	901.5

Regions

	Material	Points	Area (ft^2)
Region 1	Levee	5,6,7,8,19	128
Region 2	Wall	8,9,10,19	9
Region 3	Sherack	10,11,12,14,13,1,2,3,4,5,19	17222
Region 4	Brenna	13,14,16,15	18900
Region 5	Argusville	17,15,16,18	6750

Points

	X (ft)	Y (ft)
Point 1	0	890
Point 2	78	892
Point 3	170	893
Point 4	212.5	894

Point 5	300	897
Point 6	311	898
Point 7	341	905
Point 8	344.5	905
Point 9	346	905
Point 10	347	899
Point 11	397	901
Point 12	450	900
Point 13	0	857
Point 14	450	857
Point 15	0	815
Point 16	450	815
Point 17	0	800
Point 18	450	800
Point 19	345.5	899

Critical Slip Surfaces

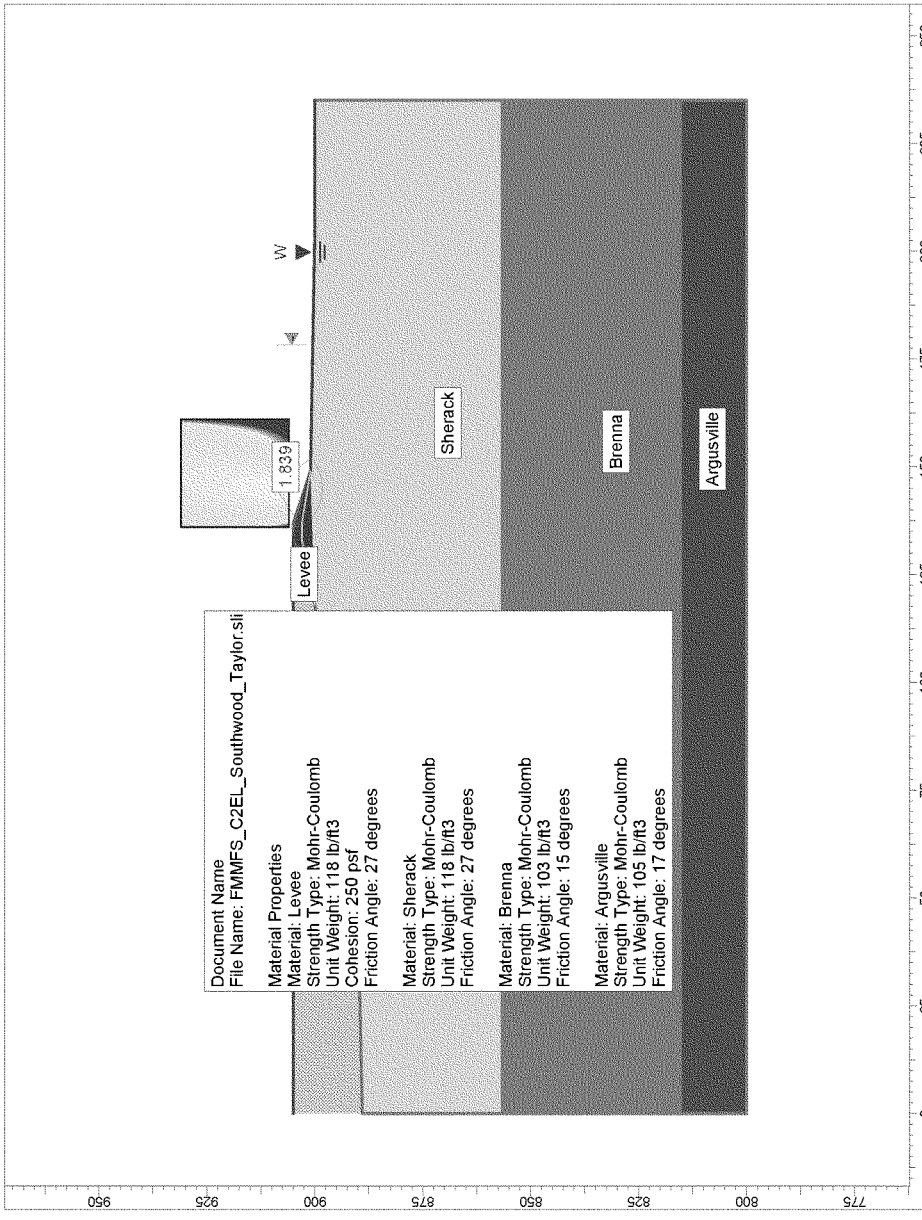
	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	902	1.201	(348, 905)	8	(340.826, 904.96)	(353.576, 899.263)

Slices of Slip Surface: 902

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	902	340.91315	901.29305	231.31114	-180.95071	-210.05791	250
2	902	341.1317	900.90605	246.8737	163.10847	-42.680517	250
3	902	341.3951	900.4921	255.52443	214.79889	-20.750701	250
4	902	341.6585	900.1277	261.10585	262.74802	0.83673002	250
5	902	341.92195	899.8023	264.24799	307.82053	22.20132	250
6	902	342.1854	899.5088	265.37042	350.62989	43.441869	250
7	902	342.4488	899.24235	264.83203	391.65647	64.620278	250
8	902	342.7122	898.9993	262.82682	431.16621	85.773203	250
9	902	342.9819	898.77205	259.42491	541.88737	143.92181	0
10	902	343.2579	898.55925	254.70995	573.17324	162.26515	0

11	902	343.53395	898.36475	248.85225	603.72901	180.81874	0
12	902	343.81	898.187	241.95318	633.66045	199.58482	0
13	902	344.086	898.02465	234.08802	663.06351	218.57393	0
14	902	344.362	897.87675	225.32471	692.02612	237.79624	0
15	902	344.623	897.749	216.28188	735.63259	264.62241	0
16	902	344.86895	897.6394	207.08774	795.12145	299.61814	0
17	902	345.12095	897.5373	197.02745	856.72597	336.13319	0
18	902	345.375	897.4441	145.76225	921.64575	395.33239	0
19	902	345.625	897.3618	102.22439	969.07486	441.68237	0
20	902	345.875	897.28845	106.79933	998.96613	454.58169	0
21	902	346.125	897.2239	110.82772	924.69851	414.68788	0
22	902	346.375	897.16785	114.32915	738.90372	318.23663	0
23	902	346.625	897.1201	117.30748	542.6407	216.7181	0
24	902	346.875	897.0805	119.77753	335.58301	109.95839	0
25	902	347.12645	897.04885	122.06563	232.14362	56.087538	0
26	902	347.37935	897.02515	124.18019	240.28301	59.157342	0
27	902	347.63225	897.00945	125.78671	247.75787	62.147411	0
28	902	347.88515	897.0018	126.89526	254.54567	65.04113	0
29	902	348.13805	897.0022	127.50223	260.64205	67.83813	0
30	902	348.39095	897.0106	127.61364	266.02072	70.521927	0
31	902	348.64385	897.027	127.2217	270.66141	73.086181	0
32	902	348.8968	897.05145	126.3243	274.54151	75.520442	0
33	902	349.14975	897.08405	124.91758	277.62506	77.808348	0
34	902	349.40265	897.12495	122.99956	279.8856	79.93743	0
35	902	349.65555	897.17425	120.55515	281.26827	81.887424	0
36	902	349.90845	897.23205	117.57966	281.7327	83.640154	0
37	902	350.16135	897.2986	114.05612	281.21534	85.171878	0
38	902	350.41425	897.37415	109.97503	279.64584	86.451594	0
39	902	350.66715	897.4589	105.31982	276.9263	87.437869	0
40	902	350.92005	897.5532	100.06424	272.94864	88.089005	0
41	902	351.17295	897.65745	94.192383	267.56865	88.339622	0
42	902	351.42585	897.772	87.674322	260.60047	88.110274	0
43	902	351.67875	897.8974	80.479492	251.78544	87.284739	0
44	902	351.93165	898.0343	72.56919	240.76787	85.70151	0
45	902	352.18455	898.1833	63.900487	227.02988	83.118575	0
46	902	352.4375	898.34525	54.428353	209.76546	79.148208	0

47	902	352.69045	898.52115	44.083466	187.63338	73.142333	0
48	902	352.94335	898.7121	32.800318	158.17947	63.883869	0
49	902	353.19625	898.91955	20.484747	116.35918	48.850464	0
50	902	353.44915	899.1453	7.028383	50.414024	22.106088	0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File Name: FMMFS_C2EL_Southwood_Taylor.sli
Material Properties
Material: Levee
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 250 psf
Friction Angle: 27 degrees
Material: Sherack
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Friction Angle: 27 degrees
Material: Brenna
Strength Type: Mohr-Coulomb
Unit Weight: 103 lb/ft3
Friction Angle: 15 degrees
Material: Argusville
Strength Type: Mohr-Coulomb
Unit Weight: 105 lb/ft3
Friction Angle: 17 degrees
Levee
1.839
W
Sherack
Brenna
Argusville
0
25
50
75
100
125
150
175
200
225
250
775
800
825
850
875
900
925
950

Slide Analysis Information

Document Name

File Name: FMMFS_C2EL_Southwood_Taylor.sli

Project Settings

Project Title: FMMFS, C2EL: Fargo - Lindenwood
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Spencer

Number of slices: 50
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 25
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Tension Crack

Tension crackWater level: filled with water

Material Properties

Material: Levee
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 250 psf
Friction Angle: 27 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Sherack
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 0 psf
Friction Angle: 27 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Brenna
Strength Type: Mohr-Coulomb
Unit Weight: 103 lb/ft3
Cohesion: 0 psf
Friction Angle: 15 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Argusville
Strength Type: Mohr-Coulomb
Unit Weight: 105 lb/ft3
Cohesion: 0 psf
Friction Angle: 17 degrees
Water Surface: Water Table
Custom Hu value: 1

List of All Coordinates

Material Boundary

0.000	857.000
235.000	857.000

Material Boundary

0.000	815.000
235.000	815.000

Material Boundary

118.000	900.000
149.000	901.000

External Boundary

0.000	800.000
235.000	800.000
235.000	815.000
235.000	857.000
235.000	900.000
205.000	900.000
149.000	901.000
137.000	905.000
133.000	905.000
118.000	900.000
48.000	890.000
0.000	889.000
0.000	857.000
0.000	815.000

Water Table

0.000	905.000

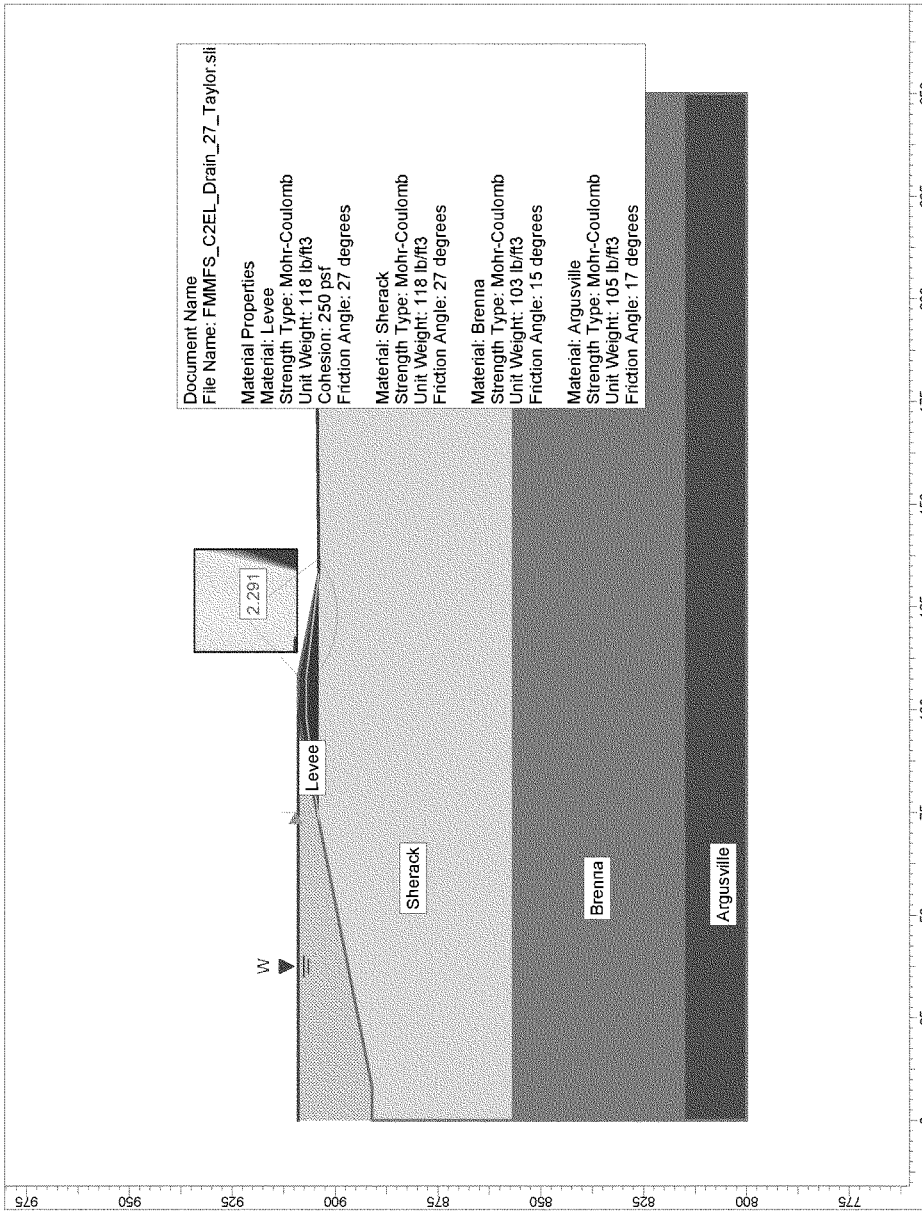
133.000	905.000
149.000	901.000
205.000	900.000
235.000	900.000

Tension Crack

118.000	900.000
133.000	903.000
137.000	903.000
149.000	901.000

Search Grid

136.000	906.000
161.000	906.000
161.000	931.000
136.000	931.000


Document Name
File Name: FMMFS_C2EL_Drain_27_Taylor.sli
Material Properties
Material: Levee
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 250 psf
Friction Angle: 27 degrees
Material: Sherack
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Friction Angle: 27 degrees
Material: Brenna
Strength Type: Mohr-Coulomb
Unit Weight: 103 lb/ft3
Friction Angle: 15 degrees
Material: Argusville
Strength Type: Mohr-Coulomb
Unit Weight: 105 lb/ft3
Friction Angle: 17 degrees
2.291
Levee
Sherack
Brenna
Argusville
W
0
25
50
75
100
125
150
175
200
225
250
975
950
925
900
875
850
825
800
775

Slide Analysis Information

Document Name

File Name: FMMFS_C2EL_Drain_27_Taylor.sli

Project Settings

Project Title: FMMFS, C2EL: Drain 27
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Spencer

Number of slices: 50
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 25
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Tension Crack

Tension crackWater level: filled with water

Material Properties

Material: Levee
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 250 psf
Friction Angle: 27 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Sherack
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 0 psf
Friction Angle: 27 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Brenna
Strength Type: Mohr-Coulomb
Unit Weight: 103 lb/ft3
Cohesion: 0 psf
Friction Angle: 15 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Argusville
Strength Type: Mohr-Coulomb
Unit Weight: 105 lb/ft3
Cohesion: 0 psf
Friction Angle: 17 degrees
Water Surface: Water Table
Custom Hu value: 1

List of All Coordinates

Material Boundary

0.000	857.000
250.000	857.000

Material Boundary

0.000	815.000
250.000	815.000

Material Boundary

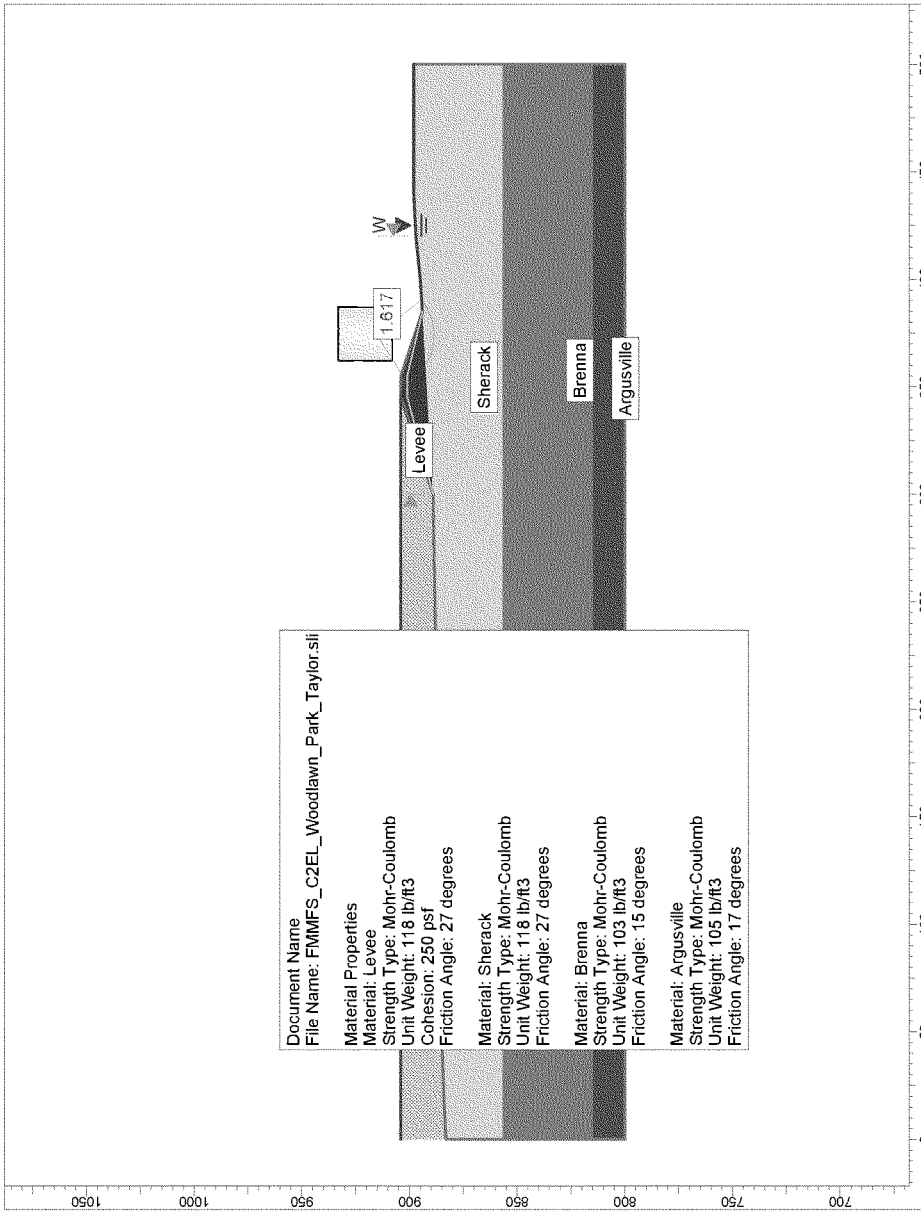
73.000	904.000
133.000	904.000

External Boundary

0.000	800.000
250.000	800.000
250.000	815.000
250.000	857.000
250.000	905.000
133.000	904.000
108.000	909.000
98.000	909.000
73.000	904.000
8.000	891.000
0.000	891.000
0.000	857.000
0.000	815.000

Water Table

0.000	909.000
98.000	909.000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File Name: FMMFS_C2EL_Woodlawn_Park_Taylor.sli
Material Properties
Material: Levee
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 250 psf
Friction Angle: 27 degrees
Material: Sherack
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Friction Angle: 27 degrees
Material: Brenna
Strength Type: Mohr-Coulomb
Unit Weight: 103 lb/ft3
Friction Angle: 15 degrees
Material: Argusville
Strength Type: Mohr-Coulomb
Unit Weight: 105 lb/ft3
Friction Angle: 17 degrees
Levee
Sherack
Brenna
Argusville
1.617
W
0
50
100
150
200
250
300
350
400
450
500
700
750
800
850
900
950
1000
1050

Slide Analysis Information

Document Name

File Name: FMMFS_C2EL_Woodlawn_Park_Taylor.sli

Project Settings

Project Title: FMMFS, C2EL: Moorhead - Woodlawn Park
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Spencer

Number of slices: 50
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 25
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Tension Crack

Tension crackWater level: filled with water

Material Properties

Material: Levee
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 250 psf
Friction Angle: 27 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Sherack
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 0 psf
Friction Angle: 27 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Brenna
Strength Type: Mohr-Coulomb
Unit Weight: 103 lb/ft3
Cohesion: 0 psf
Friction Angle: 15 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Argusville
Strength Type: Mohr-Coulomb
Unit Weight: 105 lb/ft3
Cohesion: 0 psf
Friction Angle: 17 degrees
Water Surface: Water Table
Custom Hu value: 1

List of All Coordinates

Material Boundary

0.000	857.000
500.000	857.000

Material Boundary

0.000	815.000
500.000	815.000

Material Boundary

300.000	889.000
385.000	894.000

External Boundary

0.000	800.000
500.000	800.000
500.000	815.000
500.000	857.000
500.000	898.000
440.000	898.000
420.000	897.000
400.000	895.000
385.000	894.000
355.000	904.000
345.000	904.000
300.000	889.000
180.000	887.000
80.000	886.000
20.000	884.000
0.000	883.000
0.000	857.000

0.000	815.000

Water Table

0.000	904.000
345.000	904.000
385.000	894.000
400.000	895.000
420.000	897.000
440.000	898.000
500.000	898.000

Tension Crack

300.000	889.000
345.000	901.000
355.000	901.000
385.000	894.000

Search Grid

362.000	908.000
387.000	908.000
387.000	933.000
362.000	933.000

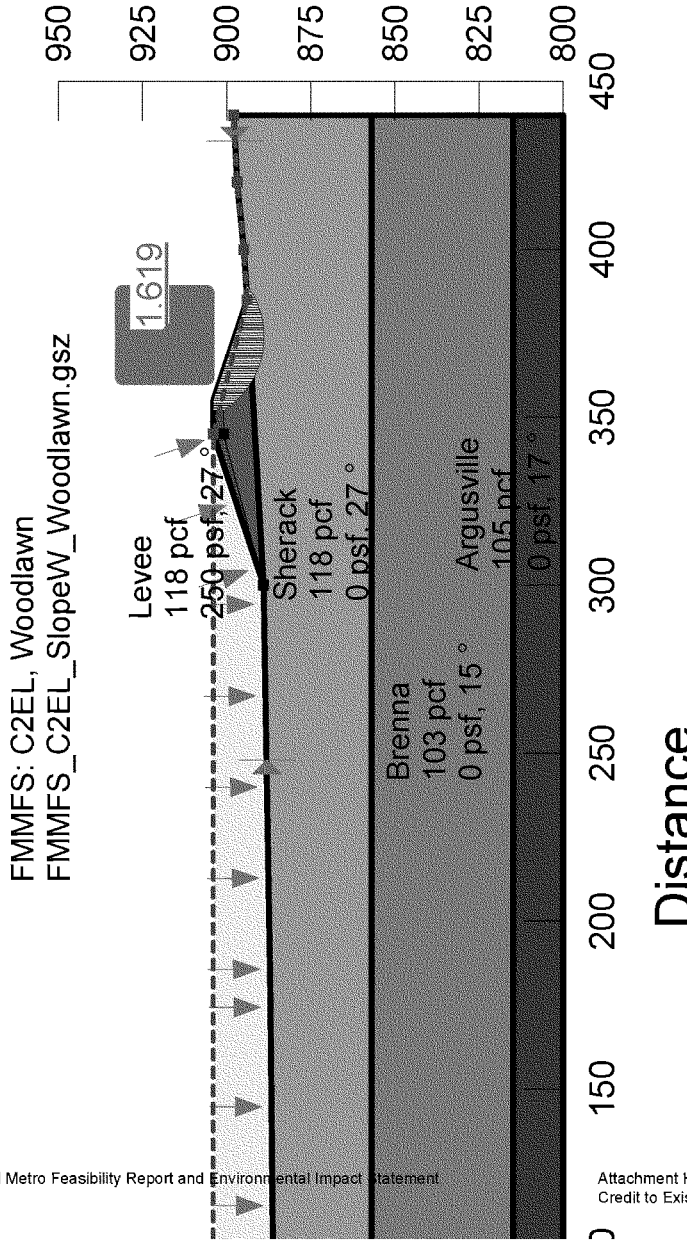
133.000	904.000
250.000	905.000

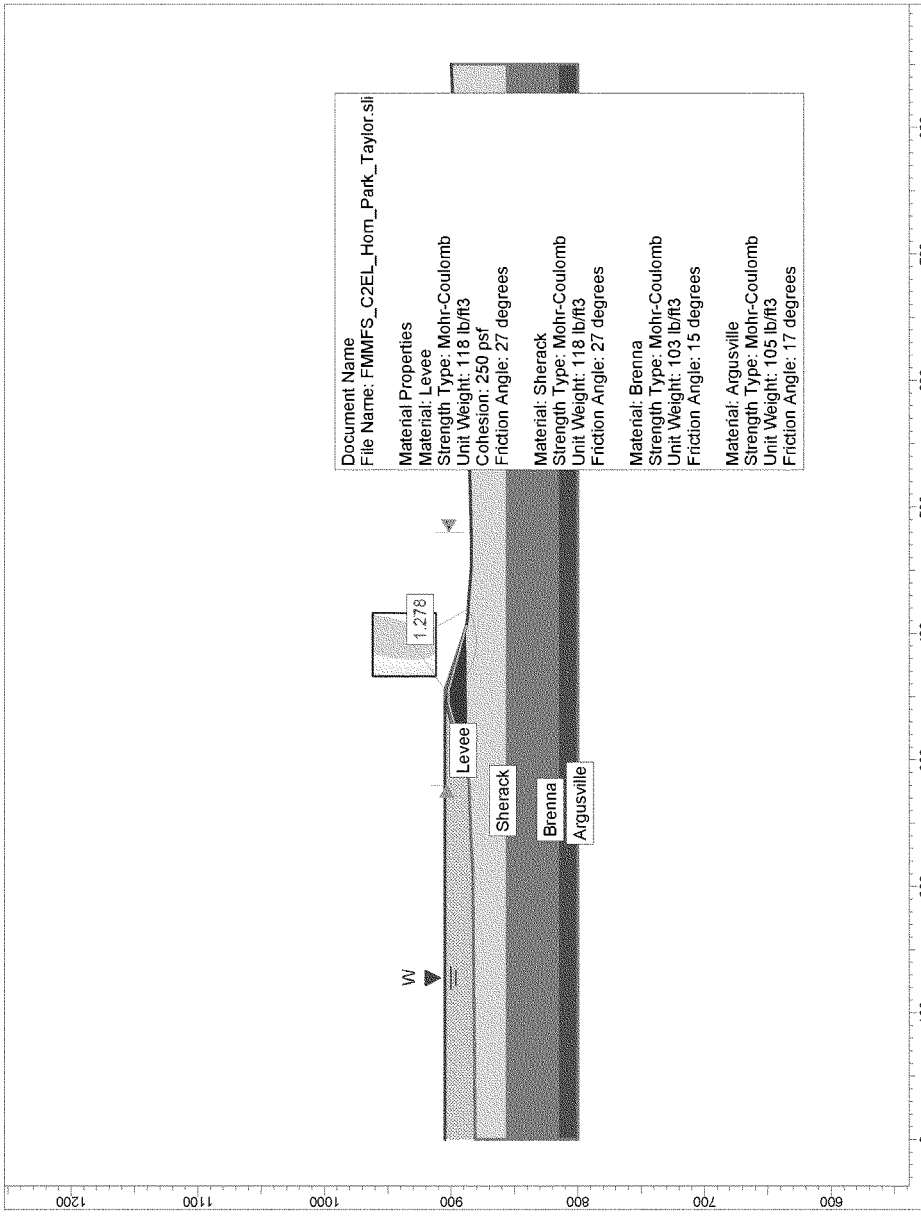
Tension Crack

73.000	904.000
98.000	907.000
108.000	907.000
133.000	904.000

Search Grid

114.000	909.234
139.000	909.234
139.000	934.234
114.000	934.234


FMMFS: C2EL, Woodlawn
FMMFS_C2EL_SlopeW_Woodlawn.gsz
1.619
Levee
118 pcf
250 psf, 27 °
Sherack
118 pcf
0 psf, 27 °
Brenna
103 pcf
0 psf, 15 °
Argusville
105 pcf
0 psf, 17 °
950
925
900
875
850
825
800
450
400
350
300
250
200
150
Distance


Document Name
File Name: FMMFS_C2EL_Horn_Park_Taylor.sli
Material Properties
Material: Levee
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 250 psf
Friction Angle: 27 degrees
Material: Sherack
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Friction Angle: 27 degrees
Material: Brenna
Strength Type: Mohr-Coulomb
Unit Weight: 103 lb/ft3
Friction Angle: 15 degrees
Material: Argusville
Strength Type: Mohr-Coulomb
Unit Weight: 105 lb/ft3
Friction Angle: 17 degrees
1.278
Levee
Sherack
Brenna
Argusville
W
0
100
200
300
400
500
600
700
800
600
700
800
900
1000
1100
1200

Slope Stability

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File Information

Created By: Heckendorf, Kurt A MVP
Revision Number: 16
Last Edited By: Heckendorf, Kurt A MVP
Date: 11/30/2009
Time: 8:56:38 AM
File Name: FMMFS_C2EL_SlopeW_Woodlawn.gsz
Directory: Q:\02FeasibilityFEA\Geotech\Credit_2_Existing_Levees\Slope_Stability\GeoStudio\
Last Solved Date: 11/30/2009
Last Solved Time: 8:56:56 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Slope Stability

Description: FMMFS: C2EL, Woodlawn
Kind: SLOPE/W
Method: Spencer
Settings
- Apply Phreatic Correction: No
- PWP Conditions Source: Piezometric Line
- Use Staged Rapid Drawdown: No

SlipSurface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack
  - Tension Crack Option: Tension Crack Line
  - Percentage Wet: 1

Tension Crack Fluid Unit Weight: 62.4 pcf
FOS Distribution
FOS Calculation Option: Constant
Advanced
Number of Slices: 50
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 2000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

Materials

Levee

Model: Mohr-Coulomb
Unit Weight: 118 pcf
Cohesion: 250 psf
Phi: 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Sherack

Model: Mohr-Coulomb
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Brenna

Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Argusville

Model: Mohr-Coulomb

Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 17 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (362, 931) ft
Lower Left: (362, 906) ft
Lower Right: (387, 906) ft
Grid Horizontal Increment: 25
Grid Vertical Increment: 25
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (351, 900) ft
Upper Right Coordinate: (391, 900) ft
Lower Left Coordinate: (351, 885) ft
Lower Right Coordinate: (391, 885) ft
Number of Increments: 15
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °
UsePoints: 0

Slip Surface Limits

Left Coordinate: (248.01444, 888.13357) ft
Right Coordinate: (432.26548, 897.61327) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
	0	904
	345	904

	385	894
	400	895
	420	897
	440	898

Tension Crack Line

	X (ft)	Y (ft)
	300	889
	345	901
	355	901
	385	894

Regions

	Material	Points	Area (ft^2)
Region 1	Levee	5,6,7,8	575
Region 2	Sherack	5,8,9,10,11,13,12,1,18,3,4	13962
Region 3	Brenna	14,12,13,15	18480
Region 4	Argusville	16,14,15,17	6600

Points

	X (ft)	Y (ft)
Point 1	0	883
Point 2	20	884
Point 3	80	886
Point 4	180	887
Point 5	300	889
Point 6	345	904
Point 7	355	904
Point 8	385	894
Point 9	400	895
Point 10	420	897
Point 11	440	898
Point 12	0	857
Point 13	440	857

Point 14	0	815
Point 15	440	815
Point 16	0	800
Point 17	440	800
Point 18	22	884

Critical Slip Surfaces

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	3948	1.619	(374, 915)	26	(352.091, 904)	(389.755, 894.317)

Slices of Slip Surface: 3948

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	3948	352.4547	900.46115	104.53042	111.35297	3.4762639	250
2	3948	353.1819	899.43595	157.1579	259.01783	51.900224	250
3	3948	353.90915	898.50665	203.80136	357.45073	78.288264	250
4	3948	354.6364	897.65775	245.43181	450.50723	104.49115	250
5	3948	355.36475	896.8767	282.8061	529.06807	125.47674	250
6	3948	356.0943	896.155	316.45085	592.81621	140.81518	250
7	3948	356.82385	895.4873	346.73411	651.63377	155.35414	250
8	3948	357.5534	894.8682	373.99384	705.90913	169.11929	250
9	3948	358.28295	894.29335	398.48154	755.98708	182.15817	250
10	3948	359.0125	893.7591	420.44115	802.13092	194.48066	250
11	3948	359.74205	893.26245	440.04553	844.583	206.12213	250
12	3948	360.4716	892.8009	457.4629	883.52154	217.08772	250
13	3948	361.21395	892.36535	473.06269	967.20316	251.77715	0
14	3948	361.96905	891.95495	486.89664	995.96924	259.38544	0
15	3948	362.72415	891.57605	498.75324	1021.5385	266.37238	0
16	3948	363.47925	891.22725	508.74629	1043.9774	272.71388	0
17	3948	364.23435	890.90715	516.93315	1063.371	278.42398	0
18	3948	364.98945	890.6146	523.4196	1079.7952	283.4875	0
19	3948	365.7446	890.34865	528.23505	1093.3141	287.92214	0
20	3948	366.49975	890.10845	531.44095	1103.9522	291.70904	0
21	3948	367.25485	889.89325	533.09282	1111.7547	294.84296	0

22	3948	368.00995	889.7024	533.21344	1116.7366	297.3199	0
23	3948	368.76505	889.5354	531.85562	1118.9191	299.12379	0
24	3948	369.52015	889.39175	529.03751	1118.3035	300.24602	0
25	3948	370.27525	889.27105	524.79393	1114.884	300.66591	0
26	3948	371.0304	889.17295	519.13685	1108.6339	300.36376	0
27	3948	371.78555	889.09725	512.08119	1099.5581	299.33443	0
28	3948	372.54065	889.04375	503.63206	1087.6152	297.55426	0
29	3948	373.29575	889.0123	493.82386	1072.7427	294.97391	0
30	3948	374.05085	889.0028	482.62847	1054.9122	291.59311	0
31	3948	374.80595	889.01525	470.07406	1034.0359	287.35289	0
32	3948	375.56105	889.0497	456.15302	1010.0484	282.22379	0
33	3948	376.3162	889.10615	440.84875	982.85449	276.16572	0
34	3948	377.07135	889.18485	424.14979	952.33161	269.12208	0
35	3948	377.82645	889.28595	406.06307	918.37058	261.03371	0
36	3948	378.58155	889.4097	386.56273	880.80092	251.82694	0
37	3948	379.33665	889.5565	365.61718	839.44585	241.42777	0
38	3948	380.09175	889.7267	343.21687	794.11468	229.74391	0
39	3948	380.84685	889.9208	319.33617	744.5556	216.66012	0
40	3948	381.60195	890.13935	293.91066	690.4773	202.06079	0
41	3948	382.3571	890.38295	266.92901	631.54555	185.78141	0
42	3948	383.11225	890.6524	238.33373	567.34491	167.63957	0
43	3948	383.86735	890.9486	208.07622	497.39565	147.41561	0
44	3948	384.62245	891.27255	176.0843	421.08902	124.83614	0
45	3948	385.39625	891.63485	149.23459	359.97542	107.37782	0
46	3948	386.1887	892.0384	127.35291	314.48122	95.346634	0
47	3948	386.98115	892.4771	103.26983	261.69227	80.720264	0
48	3948	387.7736	892.95305	76.869665	200.47093	62.977992	0
49	3948	388.56605	893.46865	47.992846	129.26859	41.412061	0
50	3948	389.35855	894.02685	16.457559	45.999719	15.052482	0

Slide Analysis Information

Document Name

File Name: FMMFS_C2EL_Horn_Park_Taylor.sli

Project Settings

Project Title: FMMFS, C2EL: Moorhead - Horn Park
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Spencer

Number of slices: 50
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 25
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Tension Crack

Tension crackWater level: filled with water

Material Properties

Material: Levee
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 250 psf
Friction Angle: 27 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Sherack
Strength Type: Mohr-Coulomb
Unit Weight: 118 lb/ft3
Cohesion: 0 psf
Friction Angle: 27 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Brenna
Strength Type: Mohr-Coulomb
Unit Weight: 103 lb/ft3
Cohesion: 0 psf
Friction Angle: 15 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Argusville
Strength Type: Mohr-Coulomb
Unit Weight: 105 lb/ft3
Cohesion: 0 psf
Friction Angle: 17 degrees
Water Surface: Water Table
Custom Hu value: 1

List of All Coordinates

Material Boundary

0.000	857.000
850.000	857.000

Material Boundary

0.000	815.000
850.000	815.000

Material Boundary

291.000	887.000
406.000	888.000

External Boundary

0.000	800.000
850.000	800.000
850.000	815.000
850.000	857.000
850.000	900.000
540.000	886.000
515.000	885.000
470.000	884.000
455.000	884.000
440.000	885.000
430.000	886.000
412.500	887.000
406.000	888.000
355.000	905.000
345.000	905.000
291.000	887.000
282.500	886.000

255.000	885.000
230.000	884.000
215.000	883.000
0.000	881.000
0.000	857.000
0.000	815.000

Water Table

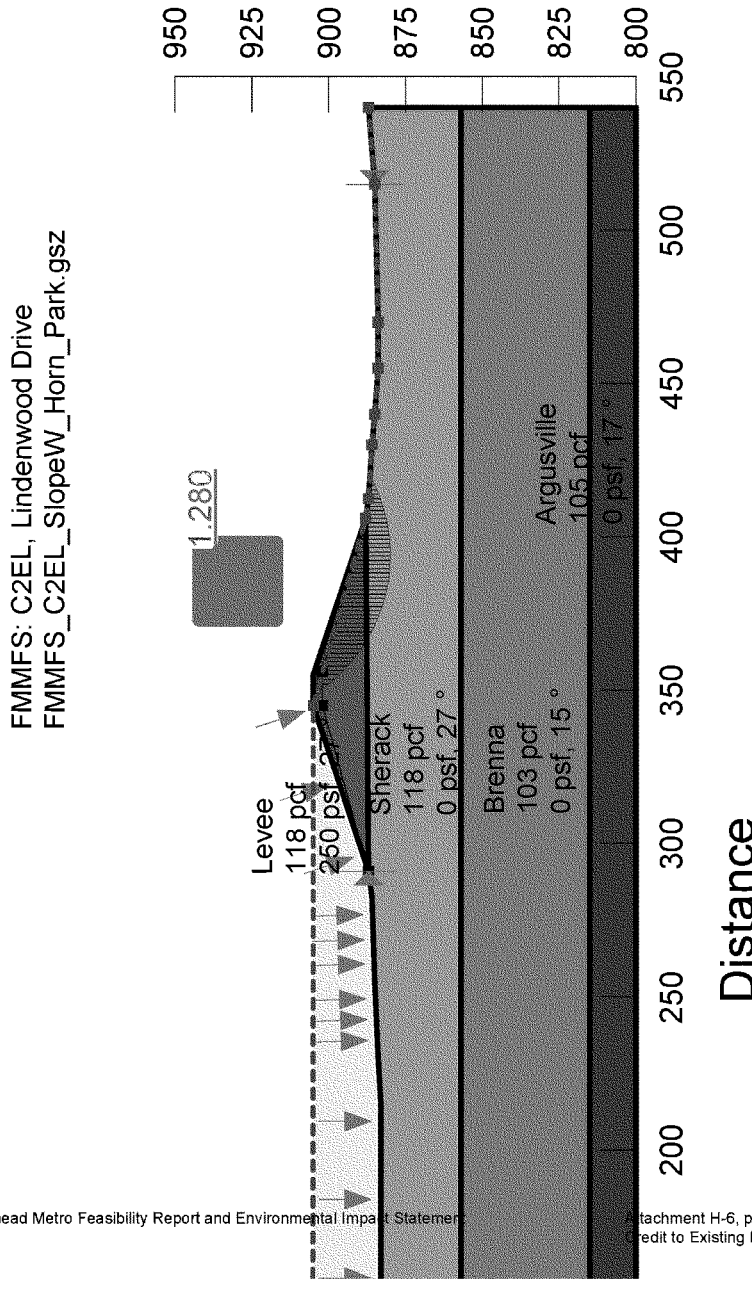
0.000	905.000
345.000	905.000
406.000	888.000
412.500	887.000
430.000	886.000
440.000	885.000
455.000	884.000
470.000	884.000
515.000	885.000
540.000	886.000
850.000	900.000

Tension Crack

291.000	887.000
345.000	902.000
355.000	902.000
406.000	888.000

Search Grid

366.000	912.000
416.000	912.000
416.000	962.000
366.000	962.000


FMMFS: C2EL, Lindenwood Drive
FMMFS_C2EL_SlopeW_Horn_Park.gsz
1.280
Levee
118 pcf
250 psf, 27 °
Sherack
118 pcf
0 psf, 27 °
Brenna
103 pcf
0 psf, 15 °
Argusville
105 pcf
0 psf, 17 °
950
925
900
875
850
825
800
550
500
450
400
350
300
250
200
Distance

Slope Stability

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File Information

Created By: Heckendorf, Kurt A MVP
Revision Number: 17
Last Edited By: Heckendorf, Kurt A MVP
Date: 1/13/2009
Time: 9:38:35 AM
File Name: FMMFS_C2EL_SlopeW_Horn_Park.gsz
Directory: Q:\02FeasibilityFEA\Geotech\Credit_2_Existing_Levees\Slope_Stability\GeoStudio\
Last Solved Date: 1/13/2009
Last Solved Time: 9:38:52 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Slope Stability

Description: FMMFS: C2EL, Lindenwood Drive
Kind: SLOPE/W
Method: Spencer
Settings
- Apply Phreatic Correction: No
- PWP Conditions Source: Piezometric Line
- Use Staged Rapid Drawdown: No

SlipSurface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack
  - Tension Crack Option: Tension Crack Line
  - Percentage Wet: 1

Tension Crack Fluid Unit Weight: 62.4 pcf
FOS Distribution
FOS Calculation Option: Constant
Advanced
Number of Slices: 50
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 2000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

Materials

Levee

Model: Mohr-Coulomb
Unit Weight: 118 pcf
Cohesion: 250 psf
Phi: 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Sherack

Model: Mohr-Coulomb
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Brenna

Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Argusville

Model: Mohr-Coulomb

Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 17 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (373, 942) ft
Lower Left: (373, 917) ft
Lower Right: (398, 917) ft
Grid Horizontal Increment: 25
Grid Vertical Increment: 25
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (358, 894) ft
Upper Right Coordinate: (398, 894) ft
Lower Left Coordinate: (358, 879) ft
Lower Right Coordinate: (398, 879) ft
Number of Increments: 15
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °
UsePoints: 0

Slip Surface Limits

Left Coordinate: (291, 887) ft
Right Coordinate: (514.86673, 884.99704) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
	0	905
	345	905

	406	888
	412.5	887
	430	886
	440	885
	455	884
	470	884
	515	885
	540	887

Tension Crack Line

	X (ft)	Y (ft)
	291	887
	345	902
	356	902
	406	888

Regions

	Material	Points	Area (ft^2)
Region 1	Levee	6,7,8,9	1093
Region 2	Sherack	5,6,9,10,11,12,13,14,15,18,16,17,1,2,3,4	14996.5
Region 3	Brenna	17,16,20,19	22680
Region 4	Argusville	21,19,20,22	8100

Points

	X (ft)	Y (ft)
Point 1	0	883
Point 2	215	883
Point 3	230	884
Point 4	255	885
Point 5	282.5	886
Point 6	291	887
Point 7	345	905
Point 8	355	905
Point 9	406	888

Point 10	412.5	887
Point 11	430	886
Point 12	440	885
Point 13	455	884
Point 14	470	884
Point 15	515	885
Point 16	540	857
Point 17	0	857
Point 18	540	887
Point 19	0	815
Point 20	540	815
Point 21	0	800
Point 22	540	800

Critical Slip Surfaces

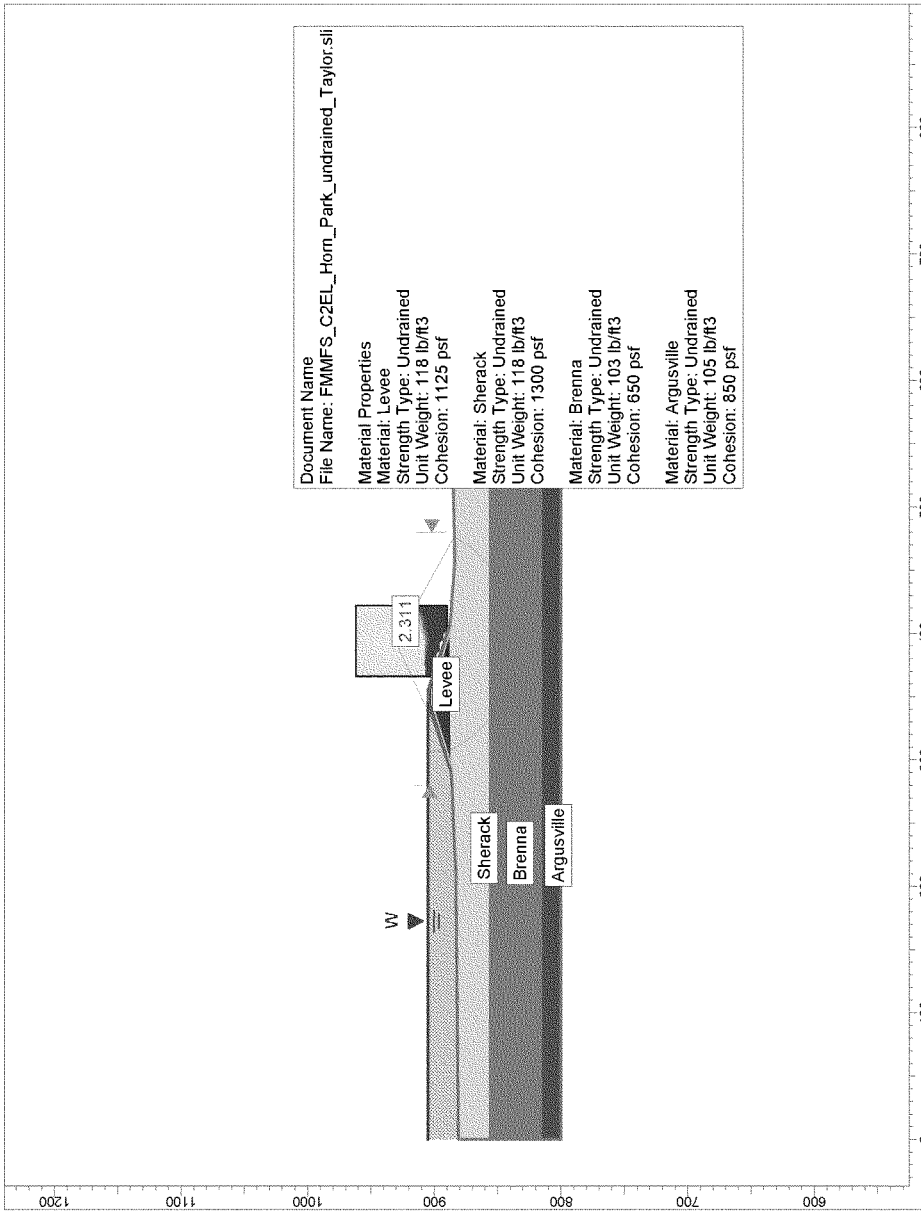
	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	7423	1.280	(394, 934)	54	(350.503, 905)	(419.835, 886.581)

Slices of Slip Surface: 7423

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	7423	351.2524	901.02825	139.10675	162.3951	11.866008	250
2	7423	352.75145	899.1689	229.06119	358.20776	65.803467	250
3	7423	354.2505	897.4658	309.26979	522.83793	108.81841	250
4	7423	355.70535	895.9406	379.13889	657.77507	141.97222	250
5	7423	357.116	894.5711	440.0626	762.19536	164.13484	250
6	7423	358.52665	893.2966	495.05876	859.18495	185.53156	250
7	7423	359.9373	892.1084	544.67442	949.27101	206.15226	250
8	7423	361.34795	890.9993	589.35747	1032.7164	225.90267	250
9	7423	362.7586	889.96335	629.45444	1109.9721	244.83598	250
10	7423	364.16925	888.99545	665.32577	1181.2782	262.89091	250
11	7423	365.5799	888.0913	697.19321	1246.8951	280.08711	250
12	7423	366.96995	887.2587	724.97848	1362.7876	324.97998	0
13	7423	368.33945	886.49285	748.99726	1411.1962	337.40719	0

14	7423	369.7089	885.77805	769.78559	1454.8582	349.06195	0
15	7423	371.07835	885.11205	787.48903	1493.7895	359.87808	0
16	7423	372.44785	884.49295	802.34759	1528.1026	369.79064	0
17	7423	373.81735	883.91895	814.29055	1557.8733	378.87436	0
18	7423	375.1868	883.38845	823.59818	1583.1319	387.00175	0
19	7423	376.55625	882.90015	830.22936	1603.9998	394.25573	0
20	7423	377.92575	882.4529	834.35807	1620.4769	400.54754	0
21	7423	379.29525	882.0456	835.96167	1632.5071	405.86016	0
22	7423	380.6647	881.67725	835.09405	1640.1864	410.21505	0
23	7423	382.03415	881.3471	831.88906	1643.4847	413.52862	0
24	7423	383.40365	881.05445	826.3445	1642.4501	415.82657	0
25	7423	384.77315	880.79865	818.53691	1636.9299	416.99207	0
26	7423	386.1426	880.5792	808.40393	1626.9942	417.09257	0
27	7423	387.51205	880.3956	796.03094	1612.5045	416.01407	0
28	7423	388.88155	880.2475	781.43741	1593.4781	413.75539	0
29	7423	390.25105	880.13465	764.64829	1569.7981	410.24432	0
30	7423	391.6205	880.0568	745.69214	1541.4278	405.44757	0
31	7423	392.98995	880.0138	724.58869	1508.124	399.23116	0
32	7423	394.35945	880.00555	701.28258	1469.8742	391.61697	0
33	7423	395.72895	880.03205	675.8173	1426.53	382.50722	0
34	7423	397.0984	880.09335	648.17913	1377.89	371.80628	0
35	7423	398.46785	880.18955	618.3579	1323.6908	359.38506	0
36	7423	399.83735	880.32085	586.34575	1263.8389	345.2	0
37	7423	401.20685	880.48755	552.13379	1198.0412	329.10625	0
38	7423	402.5763	880.68995	515.68614	1125.8871	310.91292	0
39	7423	403.94575	880.9284	476.99158	1047.1422	290.50626	0
40	7423	405.31525	881.20345	436.01409	961.46294	267.72956	0
41	7423	406.65	881.50685	398.9336	887.51622	248.94528	0
42	7423	407.95	881.83735	365.82856	826.19632	234.56909	0
43	7423	409.25	882.20255	330.56321	758.35392	217.97026	0
44	7423	410.55	882.6032	293.08028	683.58796	198.9736	0
45	7423	411.85	883.0402	253.33153	601.29486	177.29617	0
46	7423	413.23345	883.5475	212.82247	515.2239	154.08122	0
47	7423	414.70035	884.13155	171.14708	423.72801	128.69641	0
48	7423	416.1673	884.76625	126.30901	320.39101	98.889718	0
49	7423	417.63425	885.45355	78.19065	203.61931	63.909096	0

50	7423	419.10115	886.19575	26.646951	71.418656	22.812323	0


Document Name
File Name: FMMFS_C2EL_Horn_Park_undrained_Taylor.sli
Material Properties
Material: Levee
Strength Type: Undrained
Unit Weight: 118 lb/ft3
Cohesion: 1125 psf
Material: Sherack
Strength Type: Undrained
Unit Weight: 118 lb/ft3
Cohesion: 1300 psf
Material: Brenna
Strength Type: Undrained
Unit Weight: 103 lb/ft3
Cohesion: 650 psf
Material: Argusville
Strength Type: Undrained
Unit Weight: 105 lb/ft3
Cohesion: 850 psf
2.311
Levee
Sherack
Brenna
Argusville
W
0
100
200
300
400
500
600
700
800
600
700
800
900
1000
1100
1200

Slide Analysis Information

Document Name

File Name: FMMFS_C2EL_Horn_Park_undrained_Taylor.sli

Project Settings

Project Title: FMMFS, C2EL: Moorhead - Horn Park
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Spencer

Number of slices: 50
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 25
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Tension Crack

Tension crackWater level: filled with water

Material Properties

Material: Levee
Strength Type: Undrained
Unit Weight: 118 lb/ft3
Cohesion Type: Constant
Cohesion: 1125 psf
Water Surface: None

Material: Sherack

Strength Type: Undrained
Unit Weight: 118 lb/ft3
Cohesion Type: Constant
Cohesion: 1300 psf
Water Surface: None

Material: Brenna
Strength Type: Undrained
Unit Weight: 103 lb/ft3
Cohesion Type: Constant
Cohesion: 650 psf
Water Surface: None

Material: Argusville
Strength Type: Undrained
Unit Weight: 105 lb/ft3
Cohesion Type: Constant
Cohesion: 850 psf
Water Surface: None

List of All Coordinates

Material Boundary

0.000	857.000
850.000	857.000

Material Boundary

0.000	815.000
850.000	815.000

Material Boundary

291.000	887.000
406.000	888.000

External Boundary

0.000	800.000
850.000	800.000
850.000	815.000
850.000	857.000
850.000	900.000
540.000	886.000
515.000	885.000
470.000	884.000
455.000	884.000
440.000	885.000
430.000	886.000
412.500	887.000
406.000	888.000
355.000	905.000
345.000	905.000
291.000	887.000
282.500	886.000
255.000	885.000
230.000	884.000
215.000	883.000
0.000	881.000

0.000	857.000
0.000	815.000

Water Table

0.000	905.000
345.000	905.000

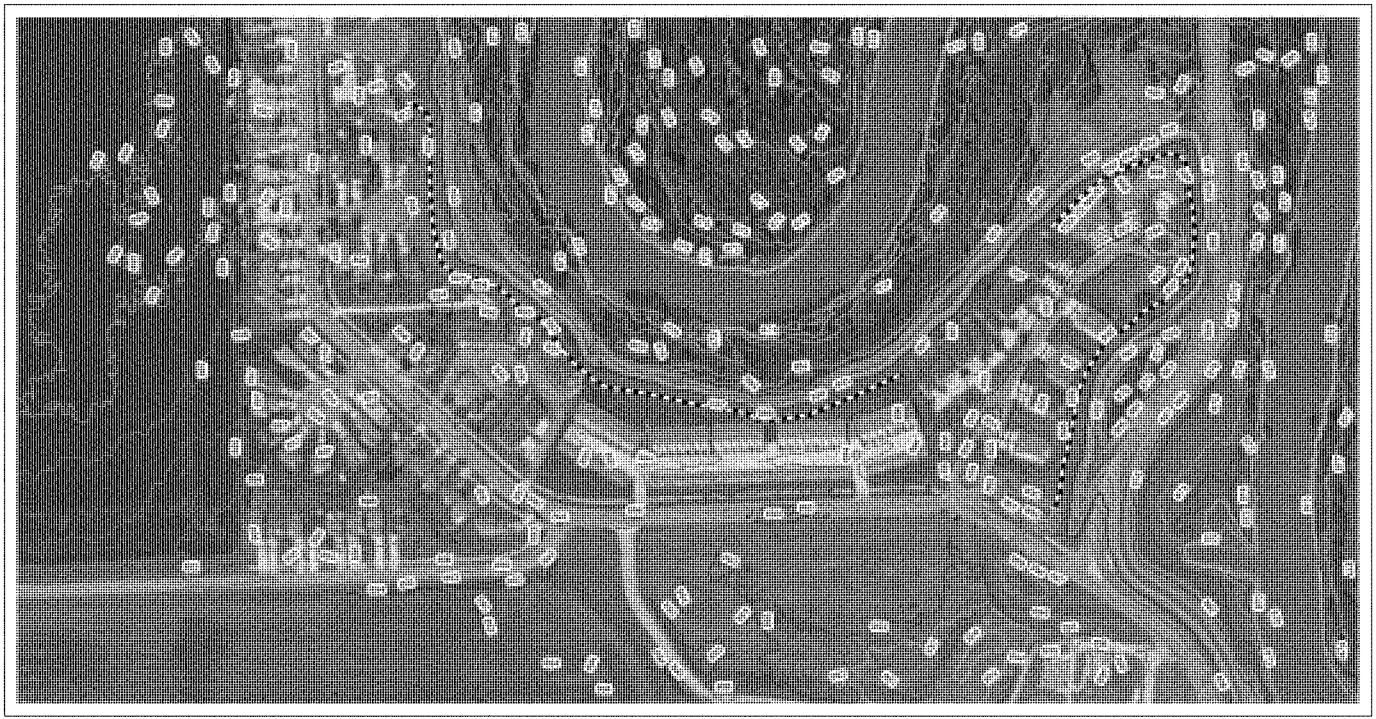
Tension Crack

291.000	885.000
345.000	902.000
355.000	902.000
406.000	886.000

Search Grid

366.000	890.000
422.000	890.000
422.000	962.000
366.000	962.000

Attachment H-7: 10th Street North Levee Information

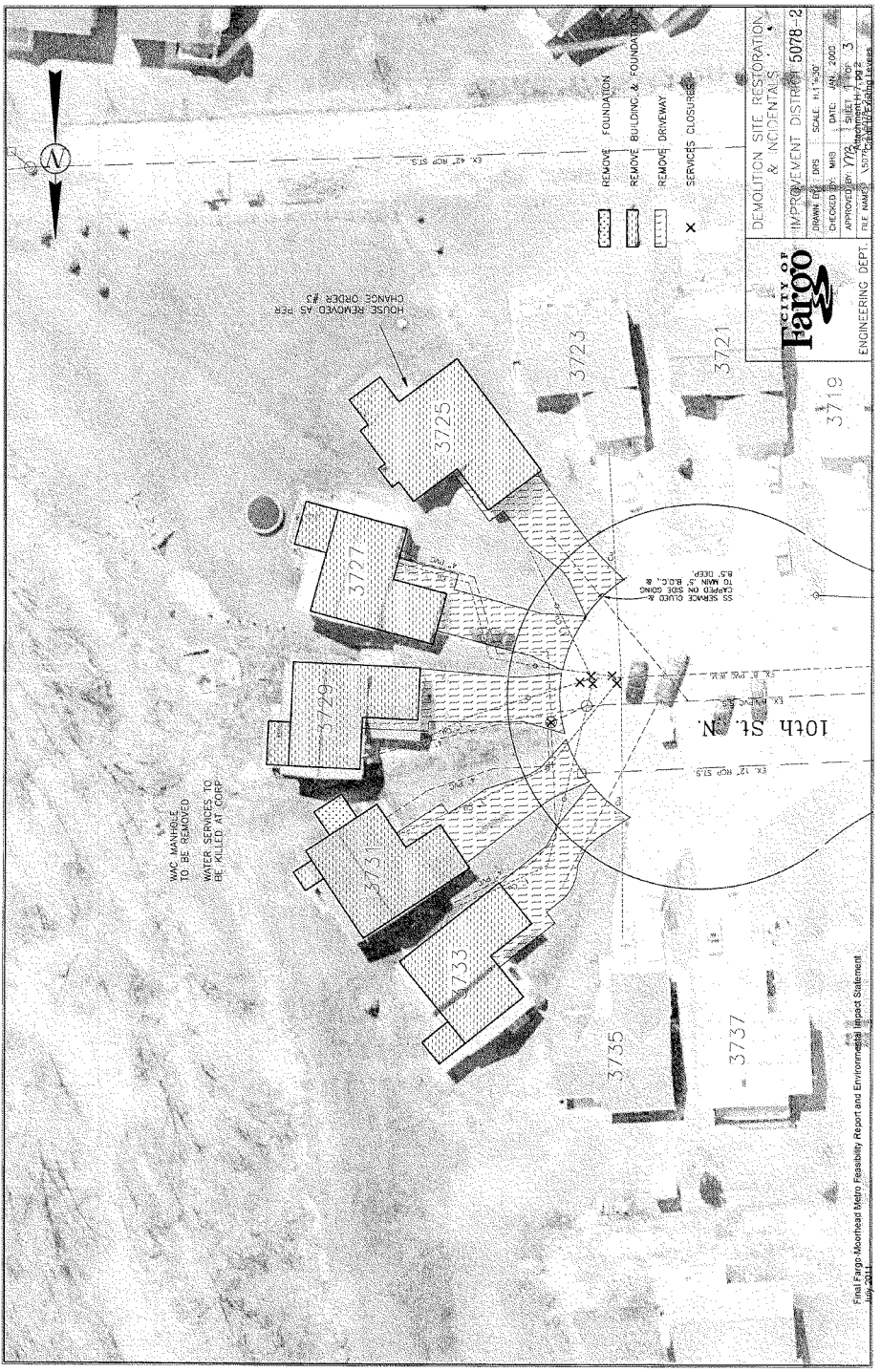


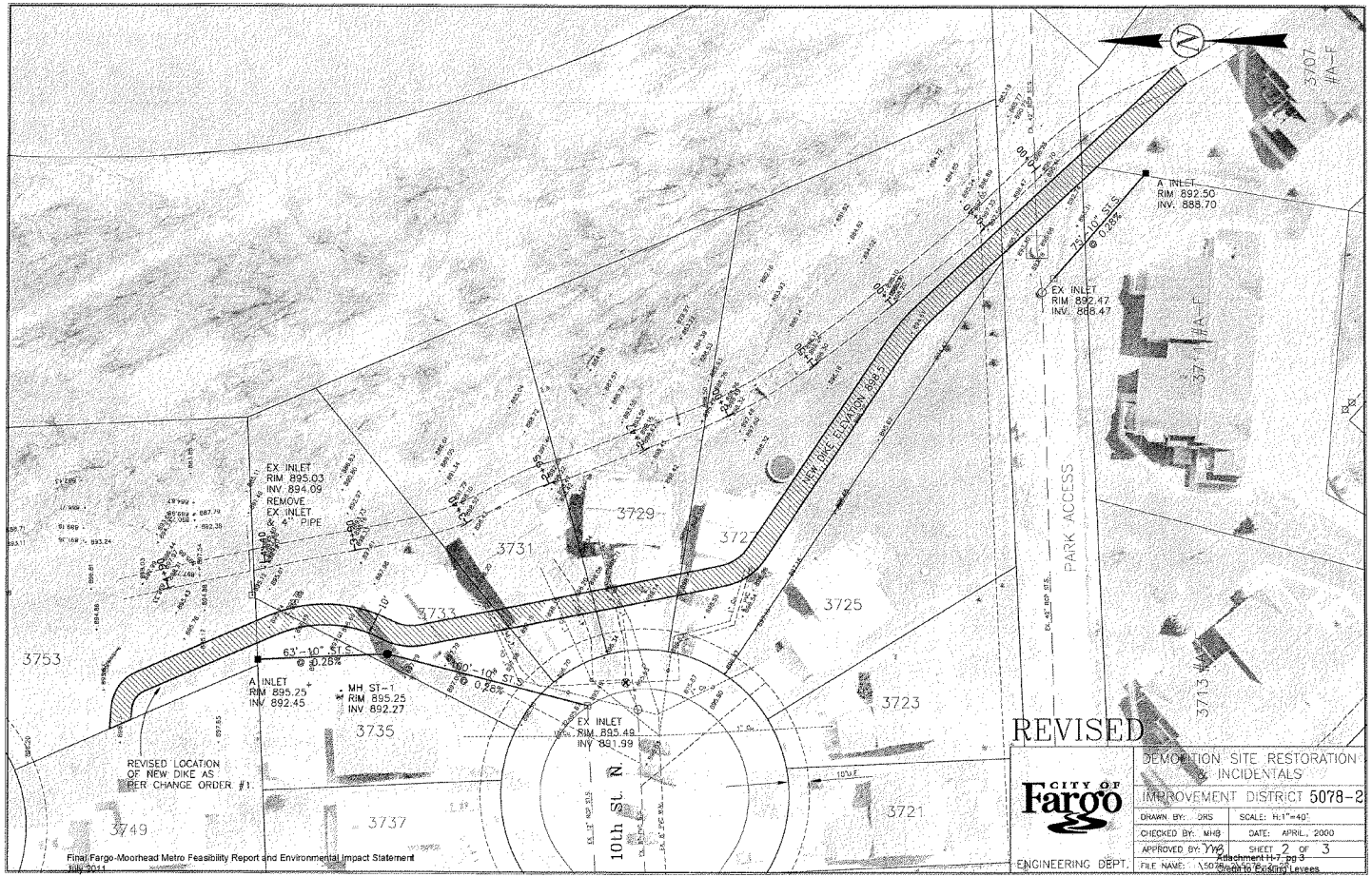
St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps of Engineers®

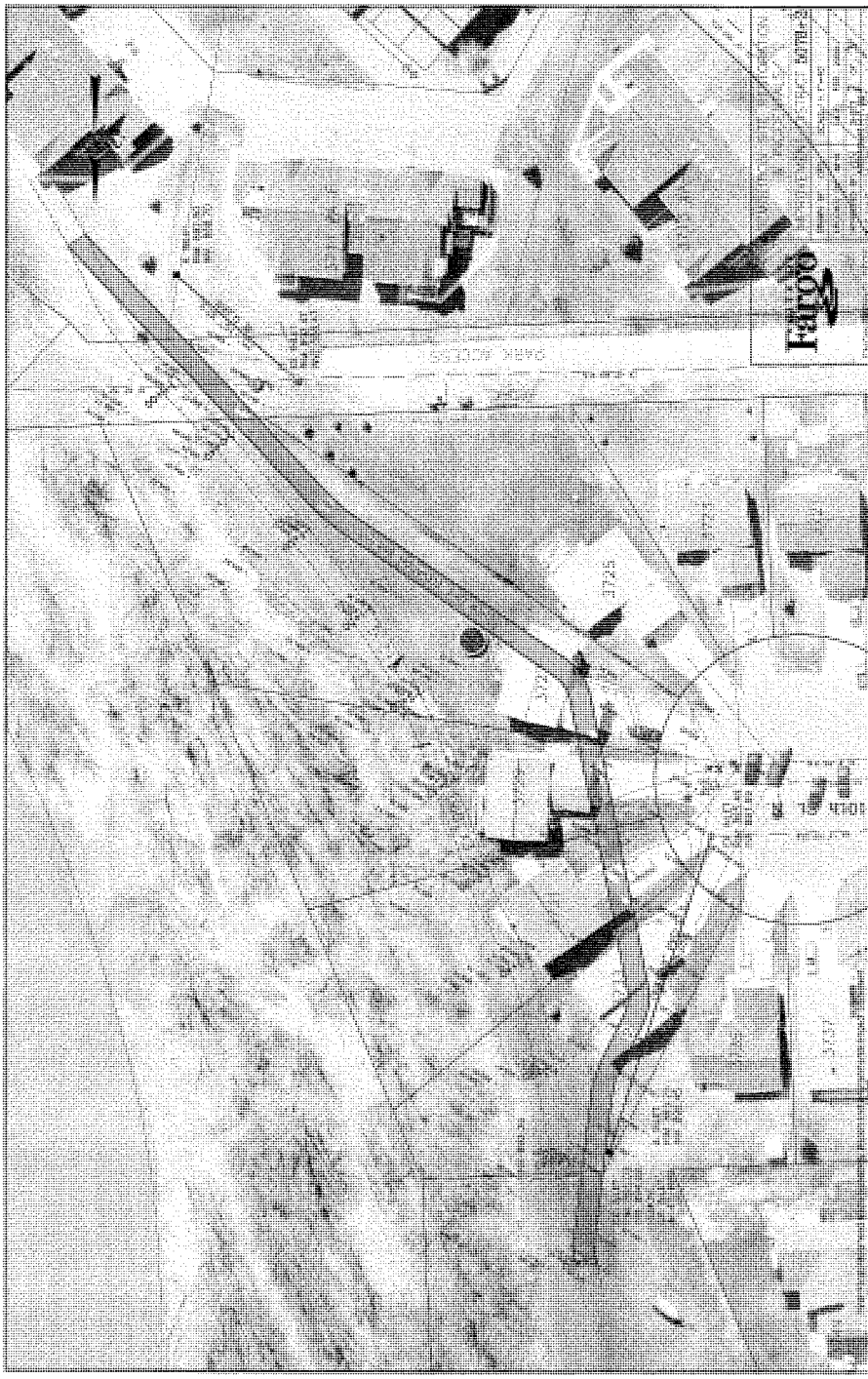
FMMFS_P2_geotech_2009-04.mxd
Printed 20 NOV 09

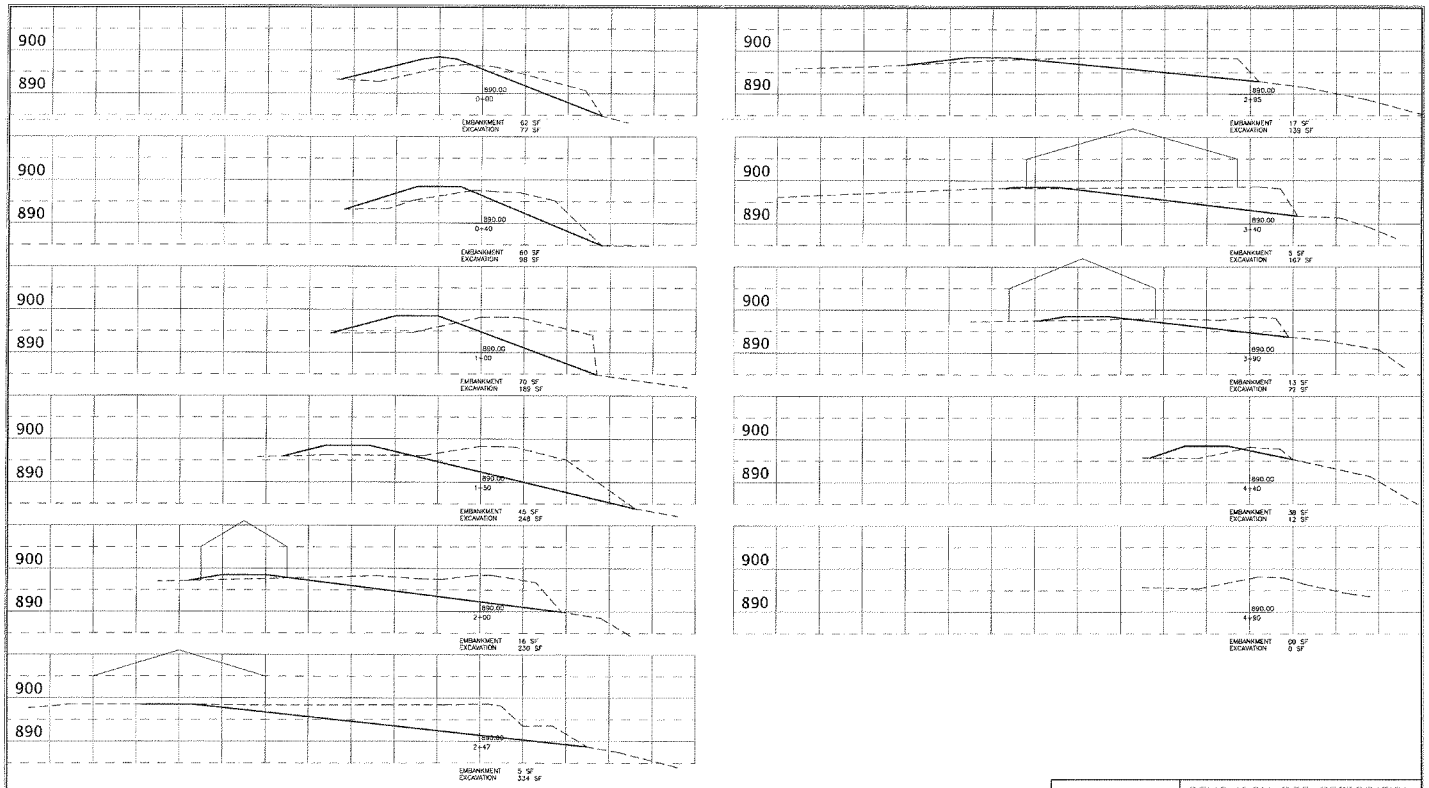
FMMFS: Credit to Existing Levees
10th St. North, 5078-2 (Fargo)

0 100 200 400 600 Feet


REMOVE FOUNDATION
REMOVE BUILDING & FOUNDATION
REMOVE DRIVEWAY
SERVICES CLOSURES
DEMOLITION SITE RESTORATION & INCIDENTALS
IMPROVEMENT DISTRICT 5078-2
CITY OF Fargo
ENGINEERING DEPT.
HOUSE REMOVED AS PER CHANGE ORDER #3
WAC MANHOLE TO BE REMOVED
WATER SERVICES TO BE KILLED AT CORP
10th St. N.
3719
3721
3723
3725
3727
3729
3731
3733
3735
3737
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011


EX INLET
RIM 895.03
INV. 894.09
REMOVE
EX. INLET
& 4" PIPE
A INLET
RIM 892.50
INV. 888.70
EX INLET
RIM 892.47
INV. 888.47
75'-10" ST.S.
@ 0.28%
NEW DIKE ELEVATION 898.5
63'-10" ST.S.
@ 0.28%
60'-10" ST.S.
@ 0.28%
A INLET
RIM 895.25
INV. 892.45
MH ST-1
RIM 895.25
INV. 892.27
EX INLET
RIM 893.49
INV. 891.99
REVISED LOCATION
OF NEW DIKE AS
PER CHANGE ORDER #1.
PARK ACCESS
10th St. N.
3753
3749
3735
3737
3733
3731
3729
3727
3725
3723
3721
3707
3713
REVISED
CITY OF
Fargo
ENGINEERING DEPT.
DEMOLITION SITE RESTORATION
& INCIDENTALS
IMPROVEMENT DISTRICT 5078-2
DRAWN BY: DRS
SCALE: H:1"=40'
CHECKED BY: MHB
DATE: APRIL, 2000
APPROVED BY:
SHEET 2 OF 3
FILE NAME: \5078\Right to Existing Levees





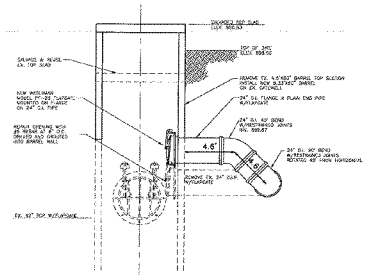
CITY OF Fargo

ENGINEERING DEPT.

DEMOLITION SITE RESTORATION & INCIDENTALS

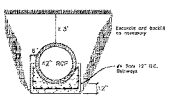
IMPROVEMENT DISTRICT 5078-2

DRAWN BY: DRS	SCALE: H.1"=20'
CHECKED BY: MHB	DATE: FEB., 2000
APPROVED BY: [illegible]	SHEET 3 OF 3
FILE NAME: [illegible]	



STORM SEWER GATEWELL MODIFICATIONS

(CHANGE ORDER NO. 2)

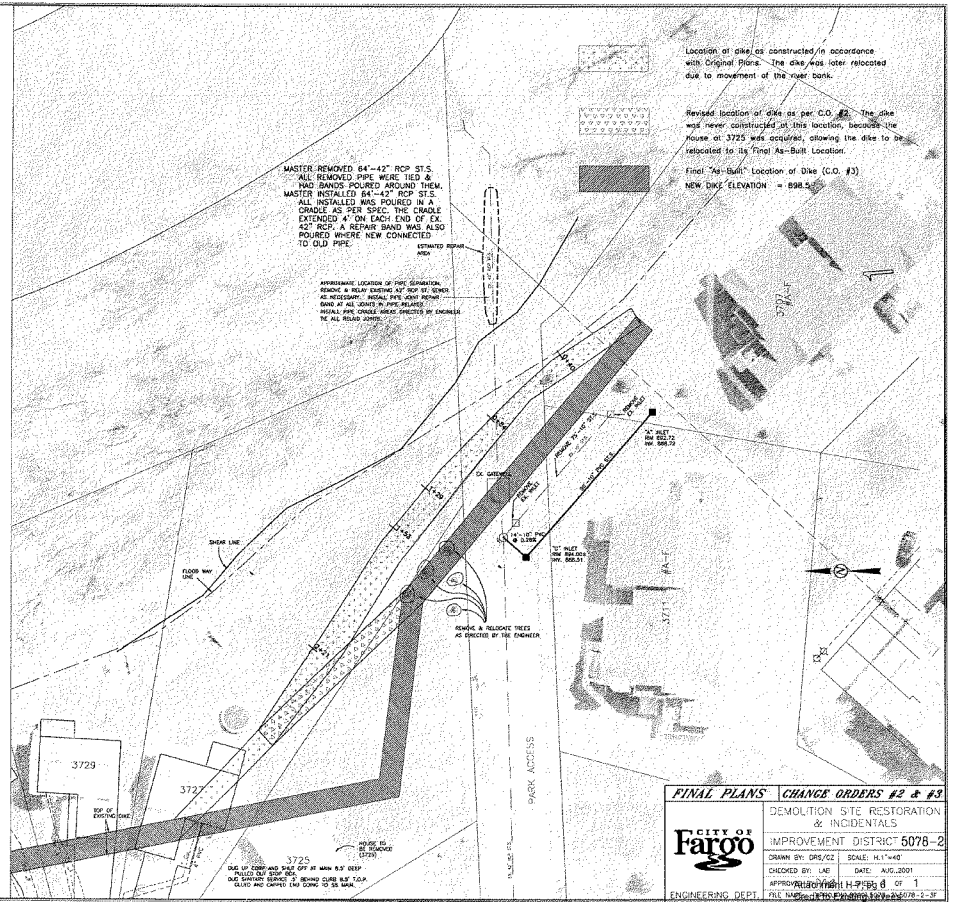


CONCRETE PIPE CRADLE DETAIL

(CHANGE ORDER #3)

PIPE JOINT REPAIR BAND DETAIL

(CHANGE ORDER #3)



CITY OF FARGO
ENGINEERING DEPARTMENT

PLANS

DIKE CONSTRUCTION & INCIDENTALS

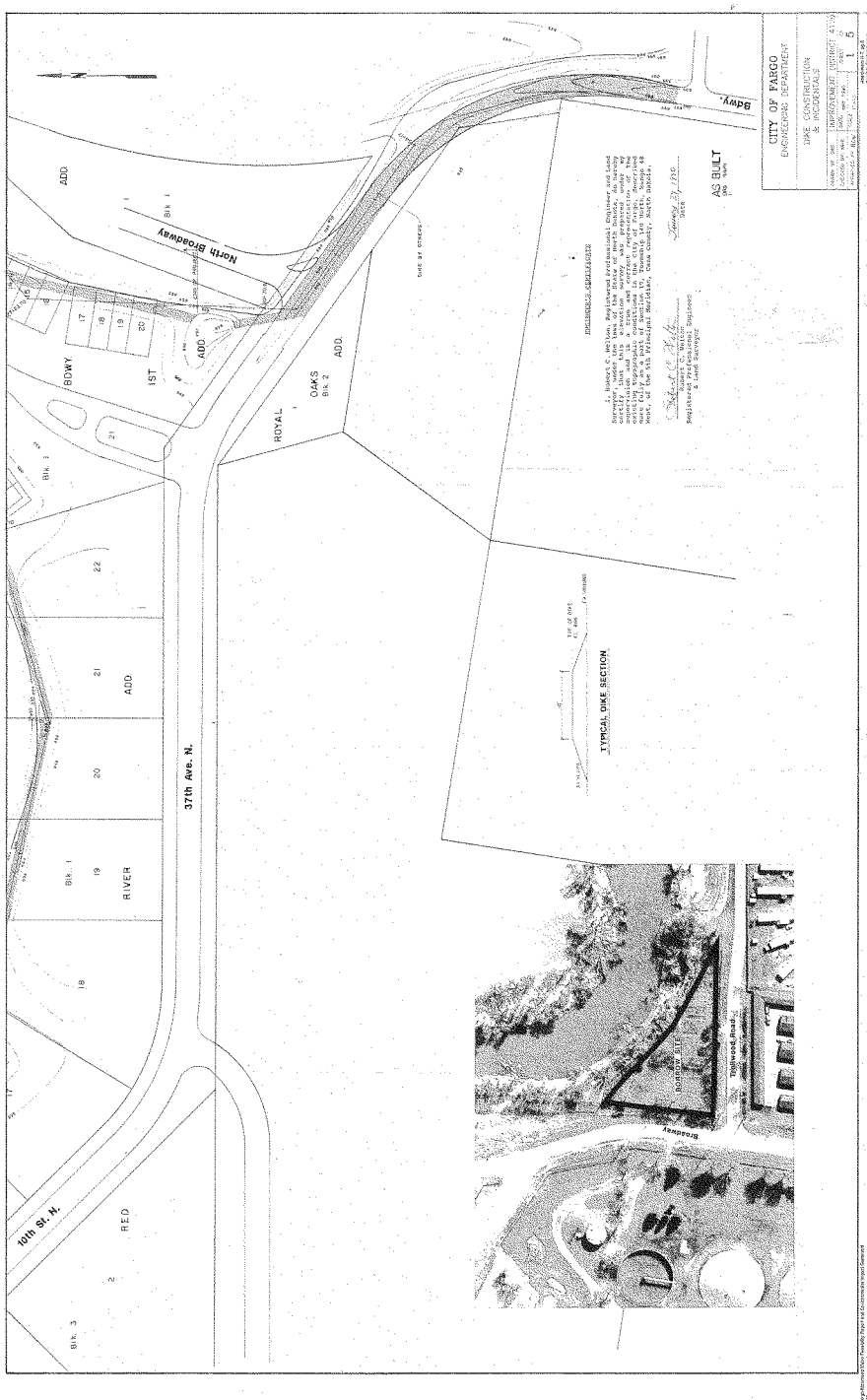
IMPROVEMENT DISTRICT NO. 4129

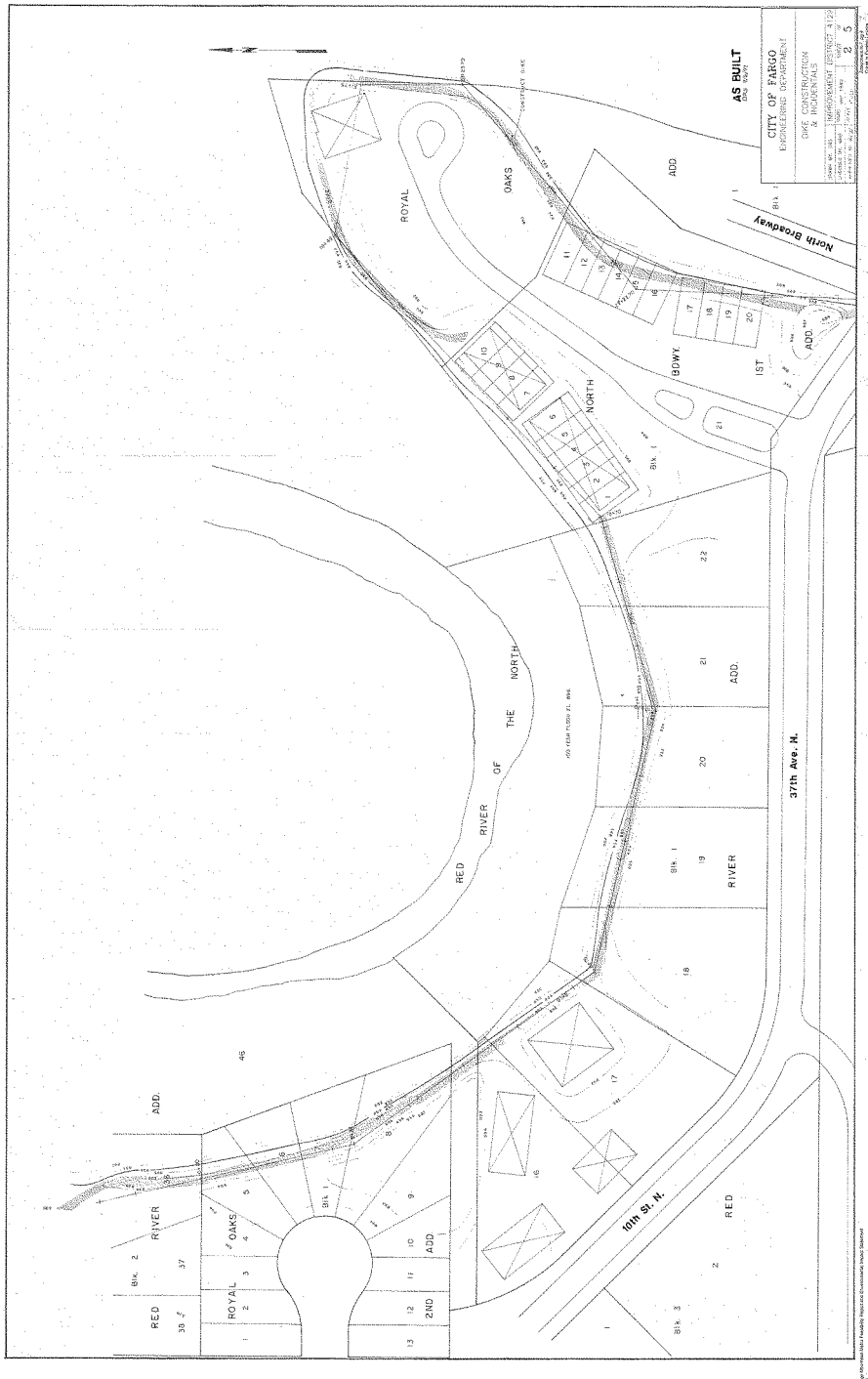
Final Plans

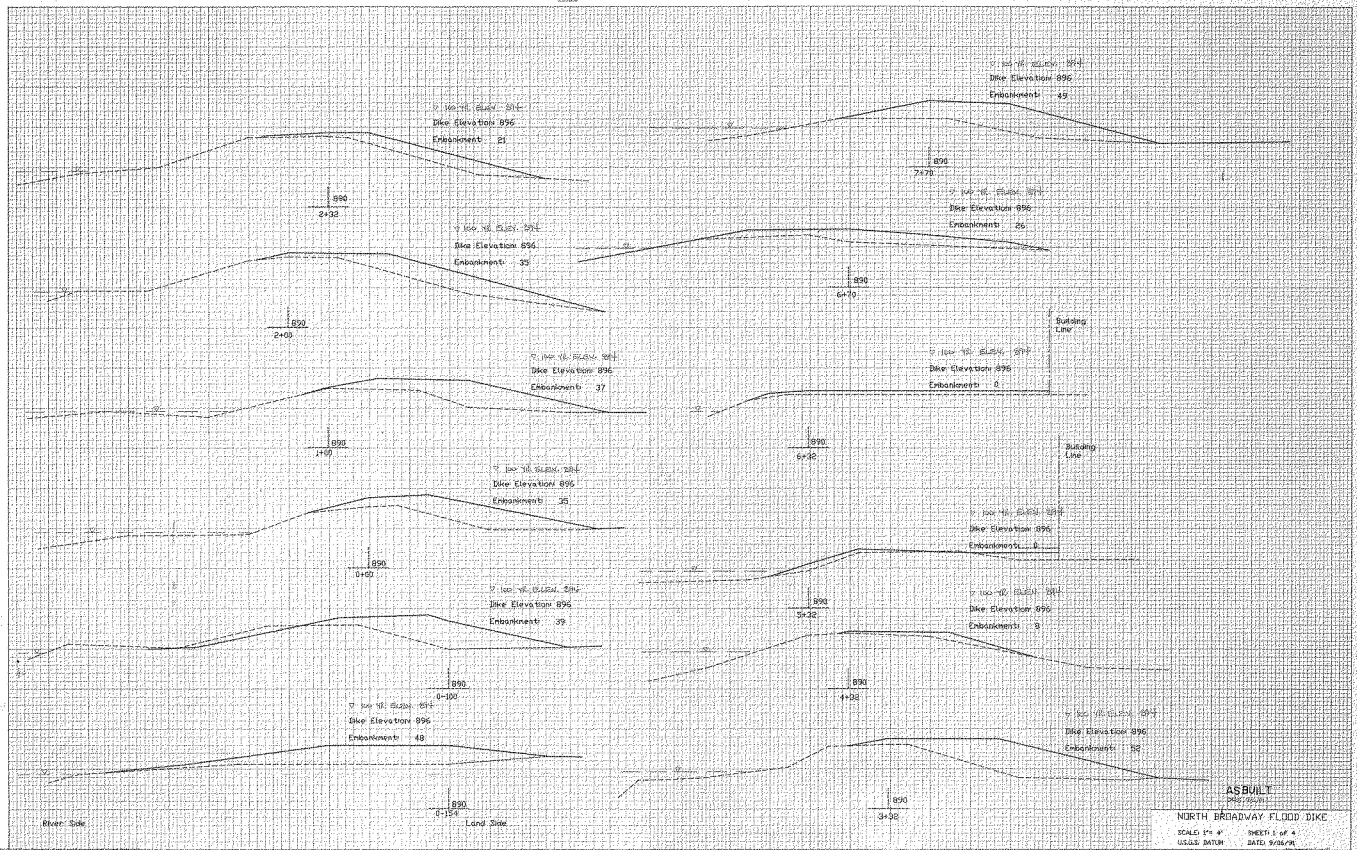
1990

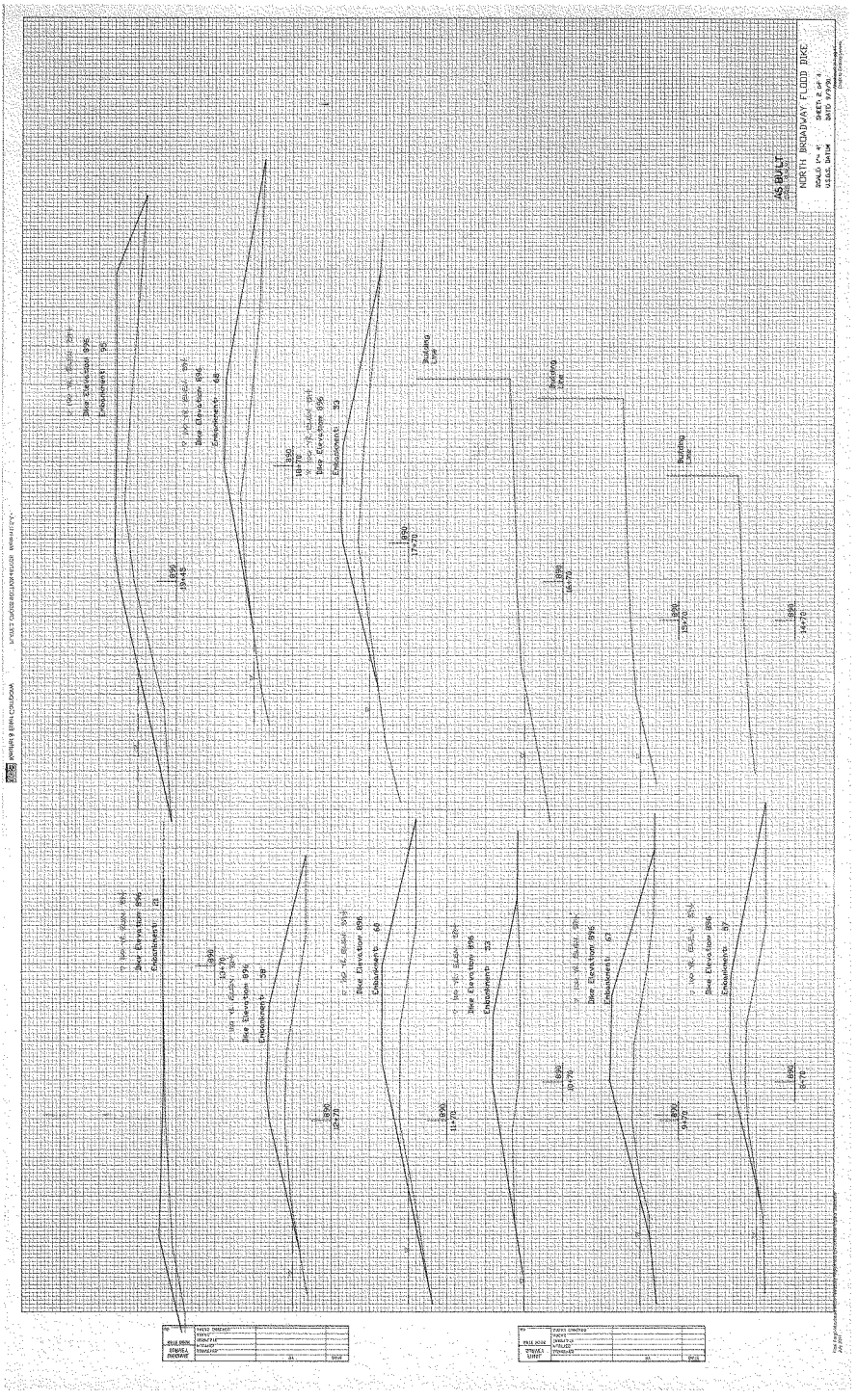
CONTRACTOR: NORTHERN IMPROVEMENT COMPANY
ENGINEER: MARK BITTNER

1282


CITY OF FARGO
ENGINEERING DEPARTMENT
DIKE CONSTRUCTION
& INCIDENTALS
AS BUILT
North Broadway
37th Ave. N.
10th St. N.
Bdwy.
ADD.
BDWY.
1ST
ADD.
ROYAL
OAKS
ADD.
RIVER
ADD
RED
Blk. 1
Blk. 2
Blk. 3
TYPICAL DIKE SECTION
BORROW SITE
Broadway
Tollwood Road


AS BUILT
CITY OF FARGO
ENGINEERING DEPARTMENT
DIKE CONSTRUCTION & INCIDENTALS
IMPROVEMENT DISTRICT
North Broadway
37th Ave. N.
10th St. N.
RED RIVER OF THE NORTH
ROYAL OAKS ADD.
NORTH BDWY. 1ST ADD.
RED RIVER ADD.
ROYAL OAKS 2ND ADD.
Blk. 1
Blk. 2
Blk. 3


Dike Elevation 896
Embankment 21
890
2+32
Dike Elevation 896
Embankment 33
890
2+00
Dike Elevation 896
Embankment 37
890
1+00
Dike Elevation 896
Embankment 35
890
0+00
Dike Elevation 896
Embankment 39
890
0-100
Dike Elevation 896
Embankment 48
890
0-154
River Side
Land Side
Dike Elevation 896
Embankment 49
896
7+70
Dike Elevation 896
Embankment 26
890
6+70
Building Line
Dike Elevation 896
Embankment 0
890
6+32
Building Line
Dike Elevation 896
Embankment 0
893
5+32
Dike Elevation 896
Embankment 8
890
4+32
Dike Elevation 896
Embankment 32
890
3+32
AS BUILT
NORTH BROADWAY FLOOD DIKE
SCALE: 1" = 4'
SHEET: 1 of 4
U.S.G.S. DATUM
DATE: 9/26/08


NORTH BROADWAY FLOOD DIKE
AS BUILT
Dike Elevation 896
Embankment 95
Dike Elevation 896
Embankment 68
Dike Elevation 896
Embankment 53
Dike Elevation 896
Embankment 58
Dike Elevation 896
Embankment 60
Dike Elevation 896
Embankment 53
Dike Elevation 896
Embankment 62
Dike Elevation 896
Embankment 57
Building Line
Building Line
Building Line
Building Line
890
19+45
890
18+70
890
17+70
890
16+70
890
15+70
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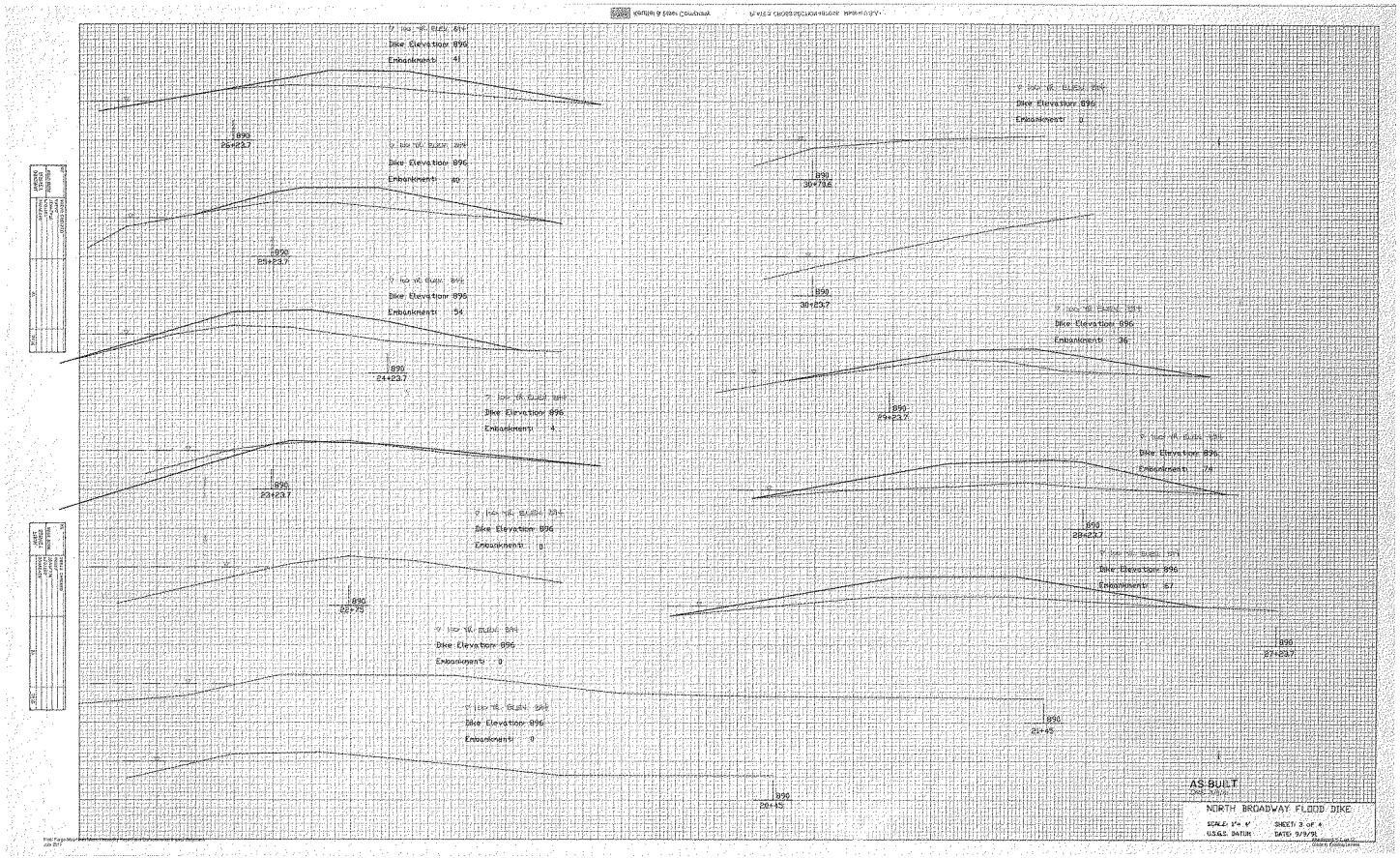
890
9+70
890
8+70

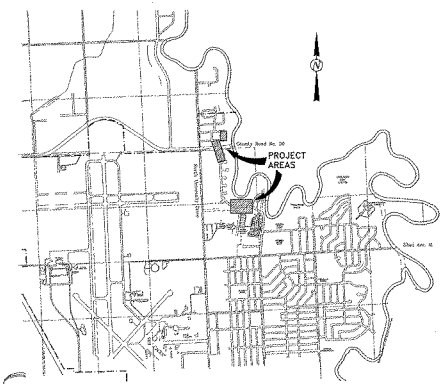

Dike Elevation 896
Embankment: 41
Dike Elevation 896
Embankment: 40
Dike Elevation 896
Embankment: 54
Dike Elevation 896
Embankment: 4
Dike Elevation 896
Embankment: 0
Dike Elevation 896
Embankment: 0
Dike Elevation 896
Embankment: 0
Dike Elevation 896
Embankment: 36
Dike Elevation 896
Embankment: 78
Dike Elevation 896
Embankment: 57
896
26+23.7
896
25+23.7
896
24+23.7
896
23+23.7
896
22+75
896
30+73.6
896
30+23.7
896
29+23.7
896
28+23.7
896
27+23.7
896
21+45
896
20+45
AS-BUILT
NORTH BROADWAY FLOOD DIKE
SCALE: 1" = 4'
U.S.G.S. DATUM
SHEET: 3 of 4
DATE: 9/9/91

PLANS FOR

STORM WATER LIFT STATION & INCIDENTALS

ENGINEERING DEPARTMENT

CITY OF Fargo



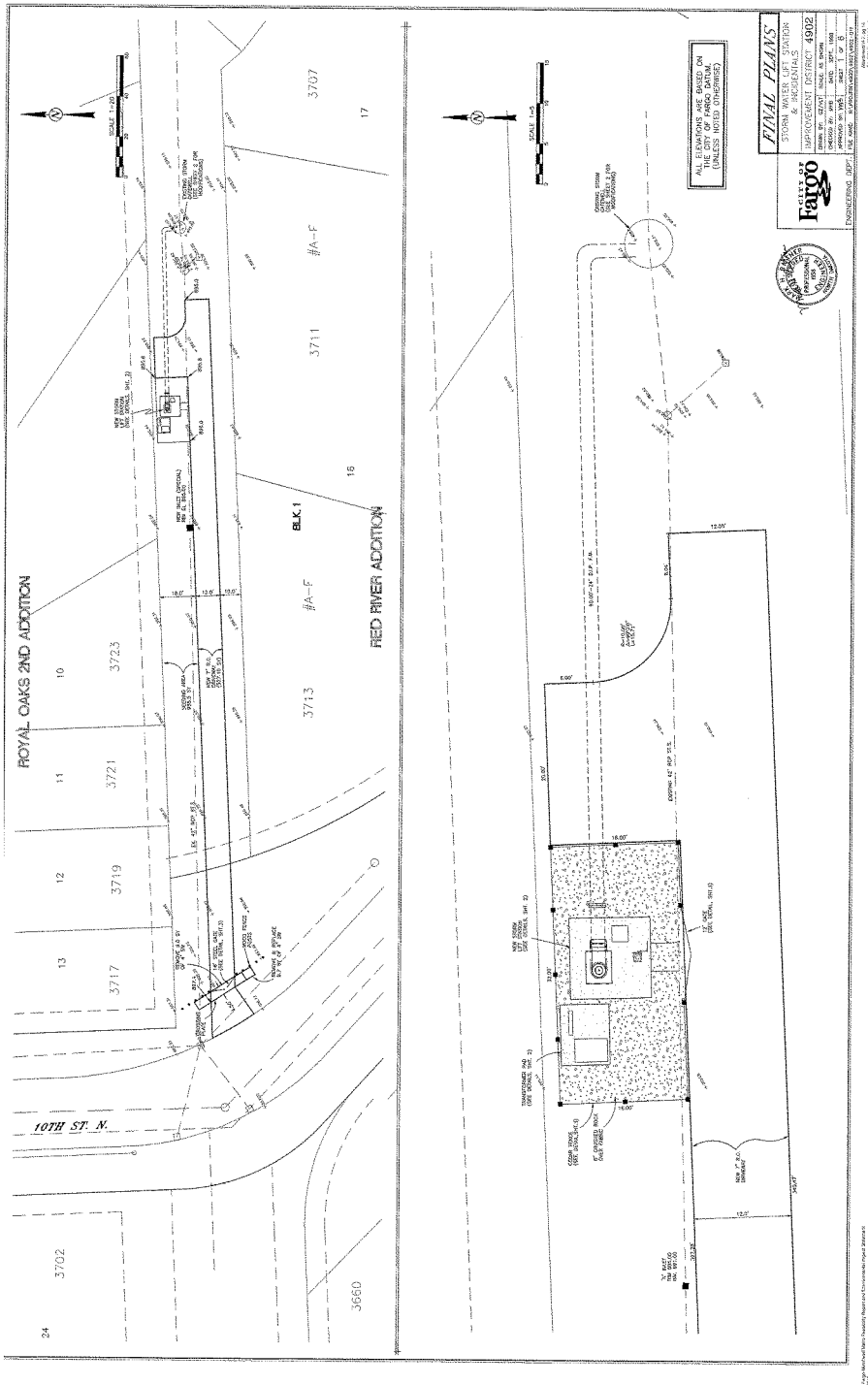
FINAL PLANS

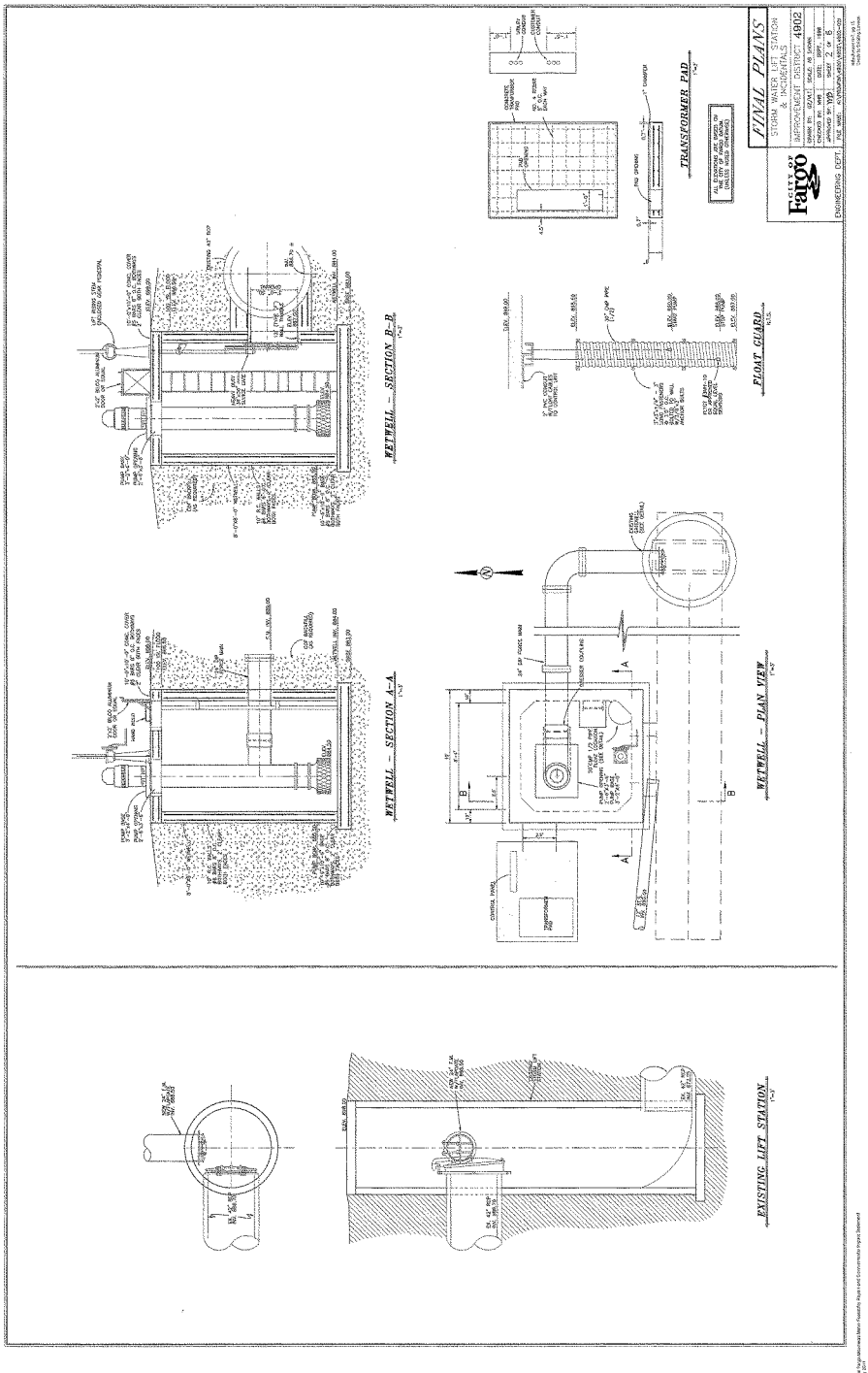
IMPROVEMENT DIST. 4902

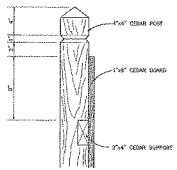
1998

FINAL AMOUNT: $200,730.36
PROJECT ENGINEER: VERN L. TOMANEK
INSPECTOR: DON HILLMAN
CONTRACTOR: MUNICIPAL INDUSTRIAL CONTRACTING, INC.

1288


ROYAL OAKS 2ND ADDITION
RED RIVER ADDITION
BLK 1
10TH ST. N.
3707
3711
3713
3723
3721
3719
3717
3702
3660
#A-F
#A-F
ALL ELEVATIONS ARE BASED ON THE CITY OF FARGO DATUM. (UNLESS NOTED OTHERWISE)
FINAL PLANS
STORM WATER LIFT STATION & INCIDENTALS
IMPROVEMENT DISTRICT 4902
CITY OF Fargo
ENGINEERING DEPT.


FINAL PLANS
STORM WATER LIFT STATION & INCIDENTALS
IMPROVEMENT DISTRICT 4902
CITY OF Fargo
ENGINEERING DEPT.
WETWELL - SECTION B-B
WETWELL - SECTION A-A
WETWELL - PLAN VIEW
TRANSFORMER PAD
FLOAT GUARD
EXISTING LIFT STATION



FENCE POST DETAIL
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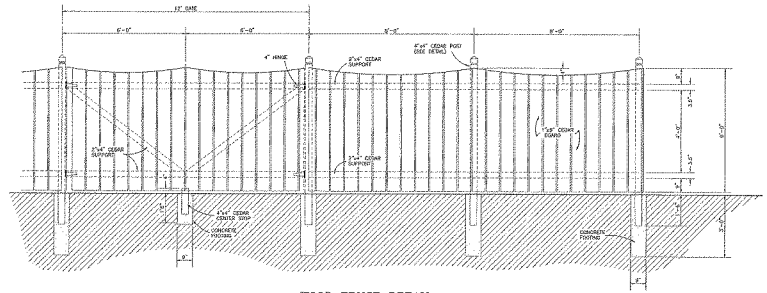
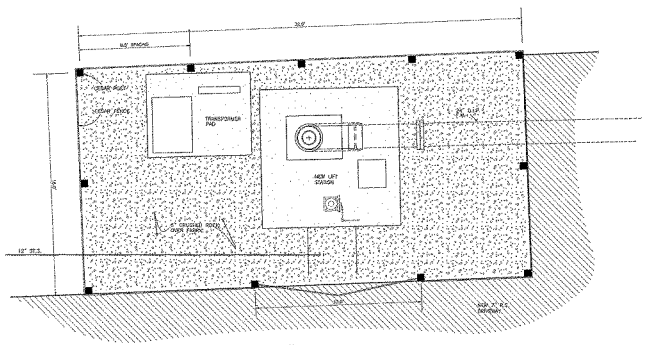
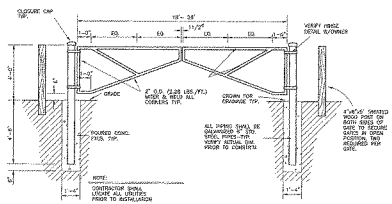


WOOD FENCE DETAIL
1"=5'

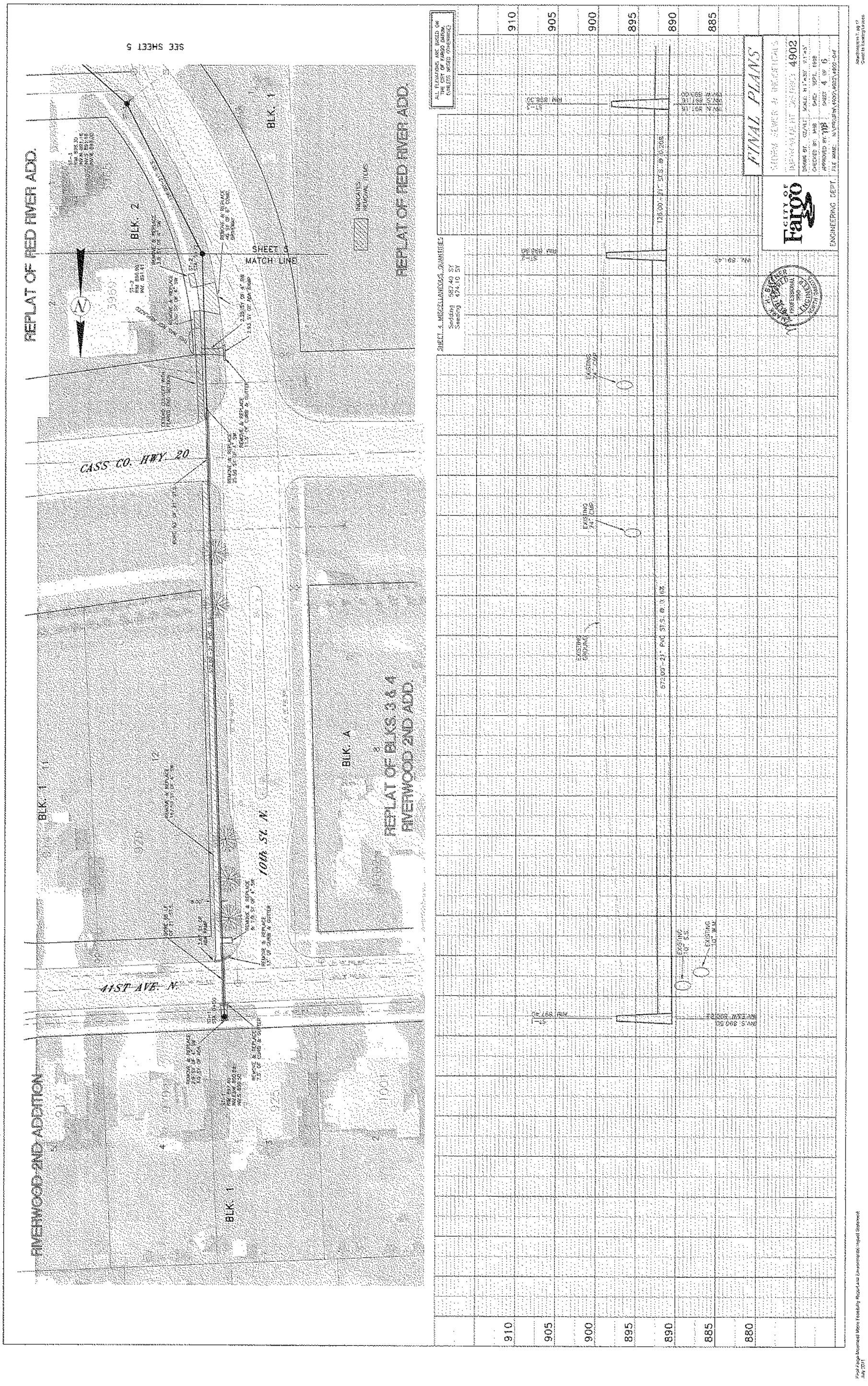


FENCE LAYOUT
1"=5'



ENTRANCE GATE DETAIL
1"=3'

FINAL PLANS	
CITY OF Fargo	STORM WATER LIFT STATION & INCIDENTALS
	IMPROVEMENT DISTRICT 4902
DRAWN BY: GZ/VLT	SCALE: AS SHOWN
CHECKED BY: MHB	DATE: SEPT. 1994
APPROVED BY: TJB	SHEET 3 OF 6
ENGINEERING DEPT.	FILE NAME: N:\PROJECTS\4902\4902-03.DGN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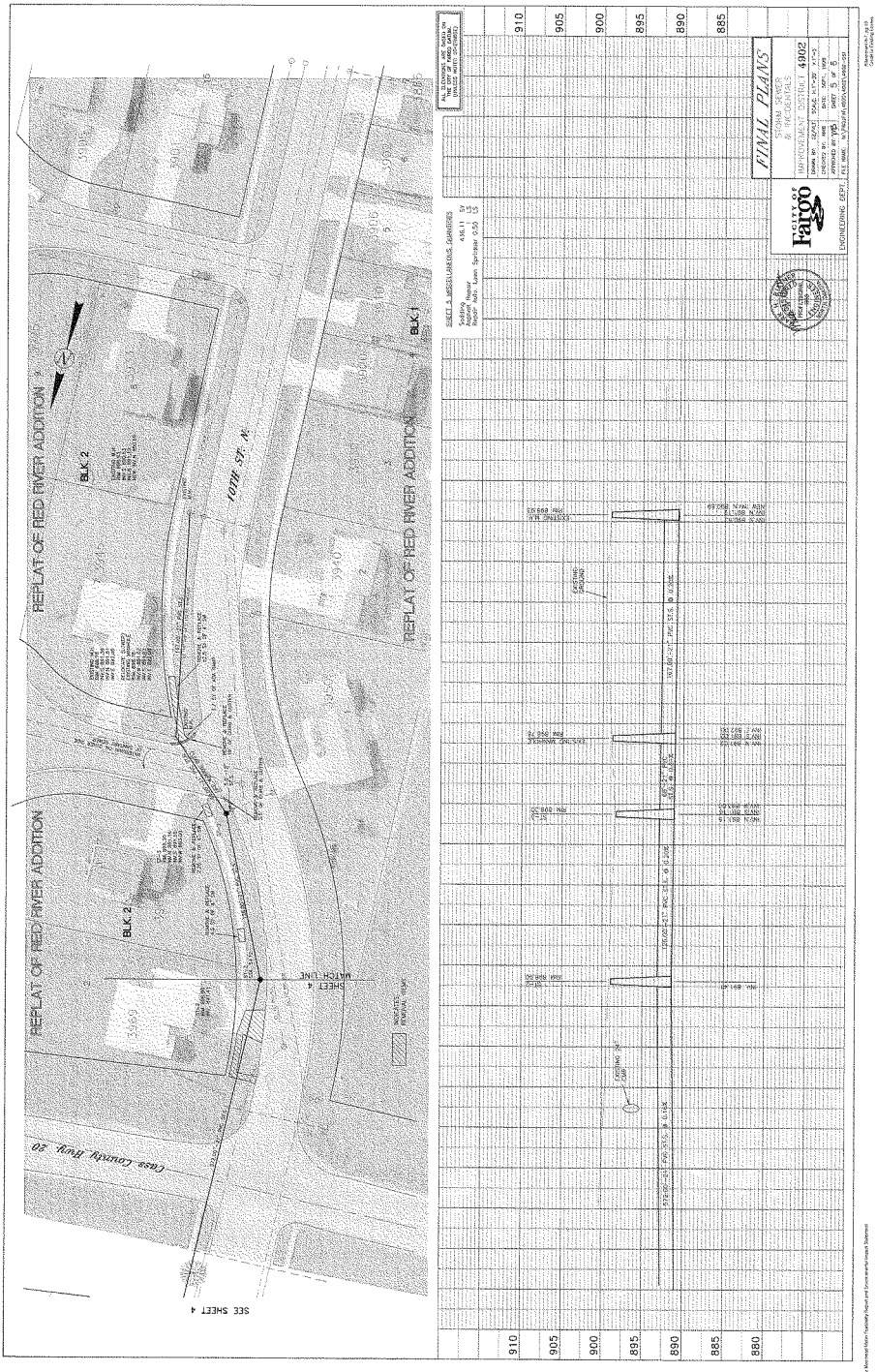
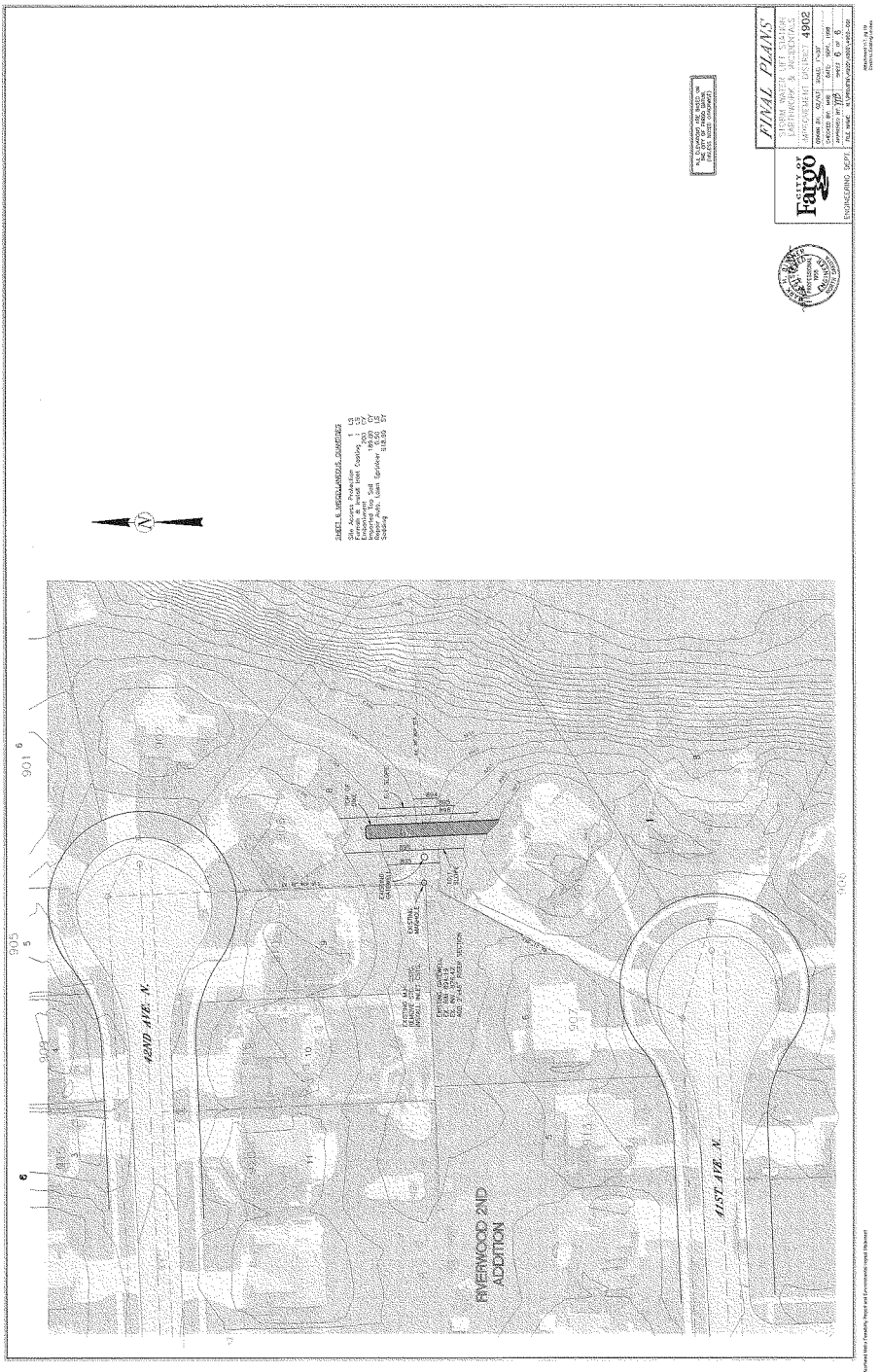
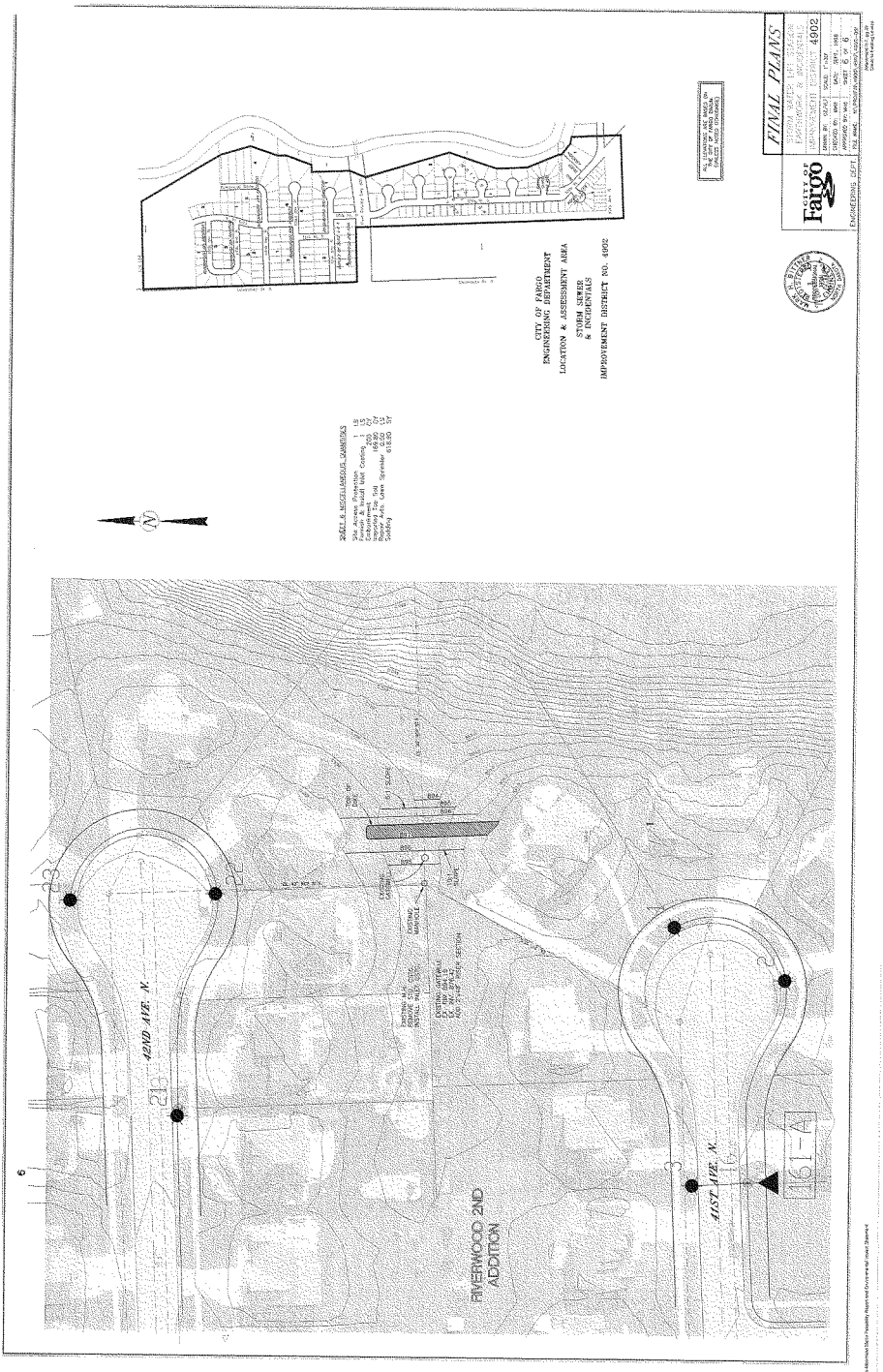
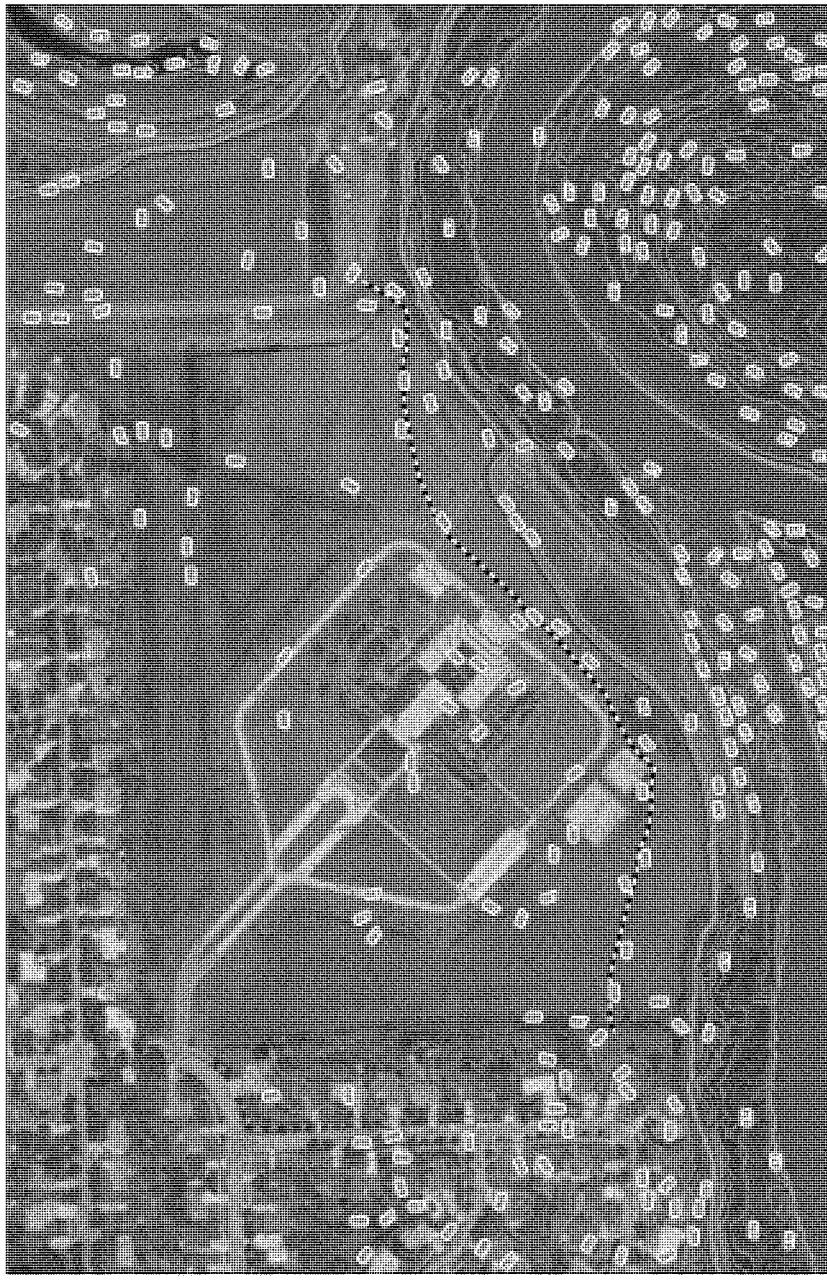
REPLAT OF RED RIVER ADD.
BLK. 2
BLK. 1
SHEET 5
MATCH LINE
INDICATES REMOVAL ITEMS
REPLAT OF RED RIVER ADD.
CASS CO. HWY. 20
10th St. N.
41ST AVE. N.
BLK. 1
BLK. A
REPLAT OF BLKS. 3 & 4
RIVERWOOD 2ND ADD.
RIVERWOOD 2ND ADDITION
ALL ELEVATIONS ARE BASED ON THE CITY OF FARGO DATUM, (UNLESS NOTED OTHERWISE)
SHEET 4 MISCELLANEOUS QUANTITIES
Sodding 587.40 SY
Seeding 474.10 SY
EXISTING 24" CMP
EXISTING GROUND
EXISTING 10" S.S.
FINAL PLANS
4902
CITY OF Fargo
ENGINEERING DEPT.
910
905
900
895
890
885
880


REPLAT OF RED RIVER ADDITION
REPLAT OF RED RIVER ADDITION
REPLAT OF RED RIVER ADDITION
BLK. 2
BLK. 2
BLK. 1
10TH ST. N.
Cass County Hwy. 20
SHEET 4
MATCH LINE
SEE SHEET 4
FINAL PLANS
STORM SEWER & INCIDENTALS
IMPROVEMENT DISTRICT 4902
CITY OF Fargo
ENGINEERING DEPT.
910
905
900
895
890
885
880


FINAL PLANS
STORM WATER LIFT STATION
EARTHWORK & INCIDENTALS
IMPROVEMENT DISTRICT 4902
CITY OF Fargo
ENGINEERING DEPT.
42ND AVE. N.
41ST AVE. N.
RIVERWOOD 2ND ADDITION
EXISTING MANHOLE
EXISTING GATEWELL
TOP OF DIKE
SHEET 6 MISCELLANEOUS QUANTITIES
Site Access Protection 1 LS
Furnish & Install Inlet Casting 1 LS
Embankment 200 CY
Imported Top Soil 189.00 CY
Repair Auto. Lawn Sprinkler 0.50 LS
Sodding 518.00 SY


FINAL PLANS
CITY OF Fargo
ENGINEERING DEPT.
CITY OF FARGO
ENGINEERING DEPARTMENT
LOCATION & ASSESSMENT AREA
STORM SEWER
& INCIDENTALS
IMPROVEMENT DISTRICT NO. 4902
42ND AVE. N.
41ST AVE. N.
RIVERWOOD 2ND
ADDITION
161-A

Attachment H-8: Cardinal Muench Seminary Information



St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps of Engineers®

FMMFS: Credit to Existing Levees
Cardinal Muench Seminary, 4903 (Fargo)

0 100 200 400 600
Feet

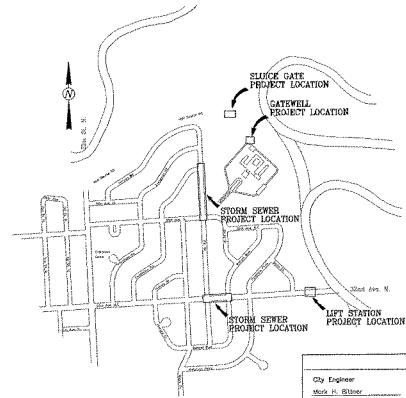
FMMFS_P2_geotech_2009-04.mxd
Printed 20 NOV 09

PLANS FOR

STORM SEWER, LIFT STATION & INCIDENTALS

ENGINEERING DEPARTMENT

CITY OF Fargo



FINAL PLANS

IMPROVEMENT DIST. 4903

1999

FINAL AMOUNT: $219,315.02
PROJECT ENGINEER: SCOTT W. SATERMO
INSPECTOR: STEVE MOSS/DONLON HILLMAN
CONTRACTOR: DAKOTA UNDERGROUND

APPROVAL SIGNATURES

City Engineer
Mark H. Bittner
Name
Mark H. Bittner 11/16/99
Signature Date

Project Engineer/Manager
Scott W. Satermo
Name
Scott W. Satermo 11/15/99
Signature Date

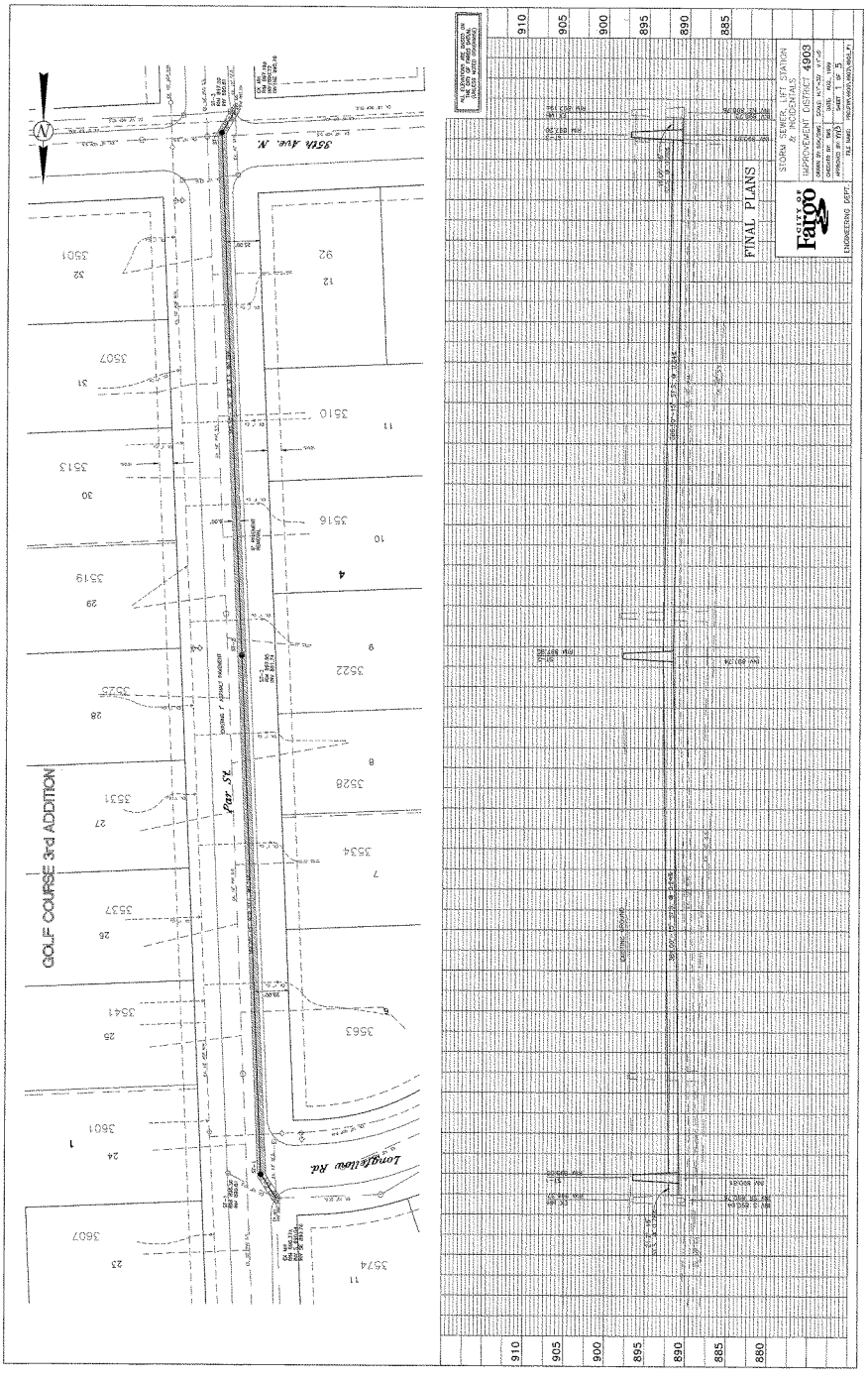
Senior Engineer
David W. Johnson
Name
David W. Johnson 11-16-99
Signature Date

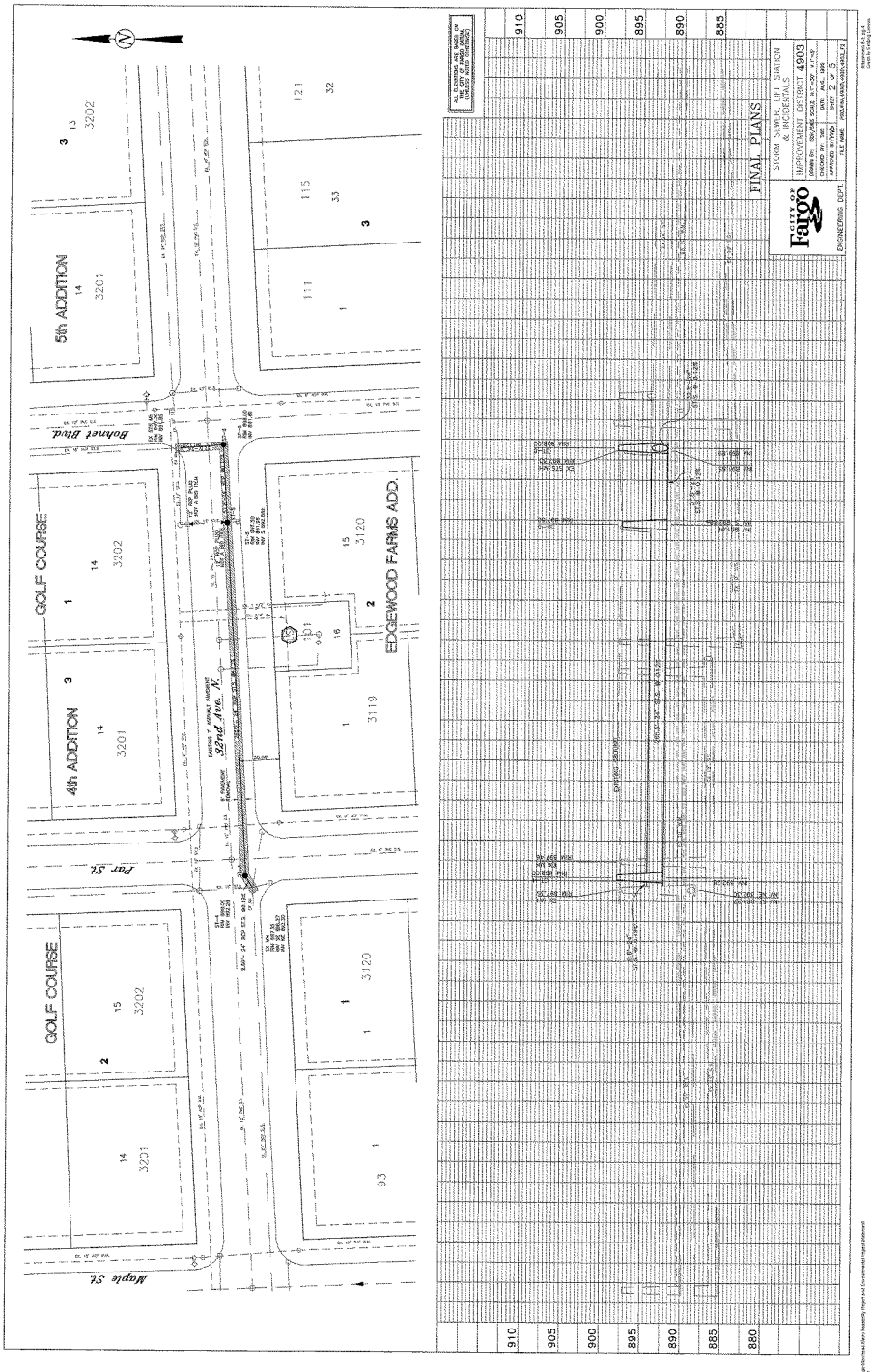
I hereby certify that the attached plan, specification, or report was prepared by me or under my direct supervision and that I am a duly registered Professional Engineer under the laws of the State of North Dakota.

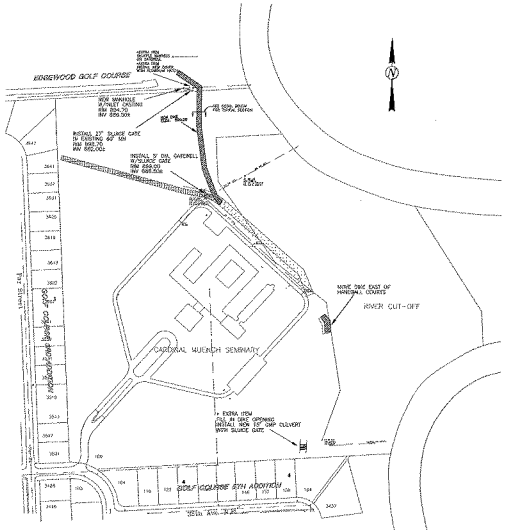
DAVID W. JOHNSON REGISTERED PROFESSIONAL ENGINEER 3200 NORTH DAKOTA

File: Fargo-Horizontal Mains Feasibility Report and Environmental Impact Statement
July 2001

Reorganized July 2001
Grant to Existing Licence


GOLF COURSE 3rd ADDITION
35th Ave. N.
Par St.
Longfellow Rd.
FINAL PLANS
STORM SEWER, LIFT STATION & INCIDENTAL
IMPROVEMENT DISTRICT 4903
Fargo
ENGINEERING DEPT.
910
905
900
895
890
885
880


5th ADDITION
4th ADDITION
GOLF COURSE
GOLF COURSE
EDGEWOOD FARMS ADD.
Bohnet Blvd.
Par St.
Maple St.
32nd Ave. N.
FINAL PLANS
STORM SEWER, LIFT STATION & INCIDENTALS
IMPROVEMENT DISTRICT 4903
CITY OF Fargo
ENGINEERING DEPT.
910
905
900
895
890
885
880

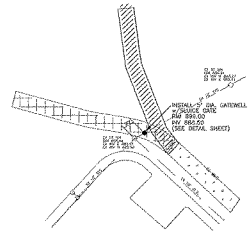


DIKE TO BE RELOCATED

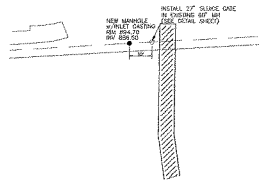
DIKE TO STAY

NEW DIKE

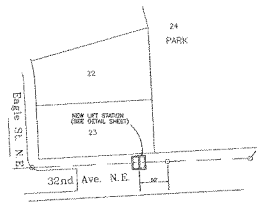
DIKE RELOCATION



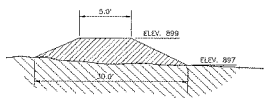
SITE 1: NEW GATEWELL



SITE 2: STORM SEWER GATEWELL MODIFICATIONS



SITE 3: NEW LIFT STATION

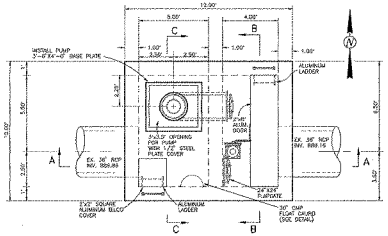


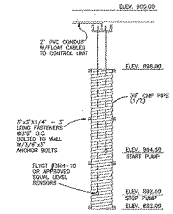
TYPICAL SECTION

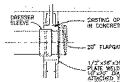
LIFT STATION LOCATION

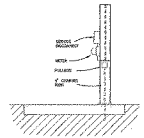
FINAL PLANS

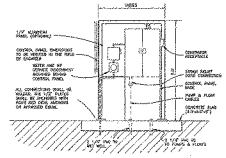
CITY OF Fargo ENGINEERING DEPT.	STORM SEWER, LIFT STATION & INCIDENTALS
	IMPROVEMENT DISTRICT 4903
	DRAWN BY: SEK/SWS SCALE: NO SCALE
	CHECKED BY: SAS DATE: AUG., 1997
	APPROVED BY: WB SHEET 3 of 5
	FILE NAME: PROJPRO_6903P_6937_(1001_F2)

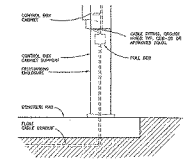


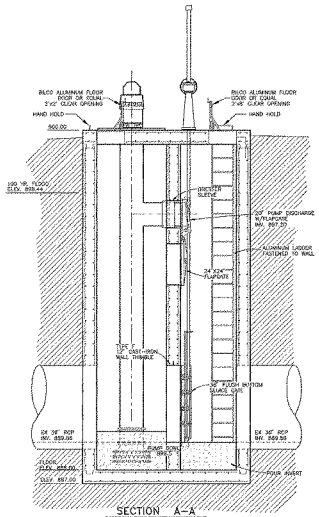


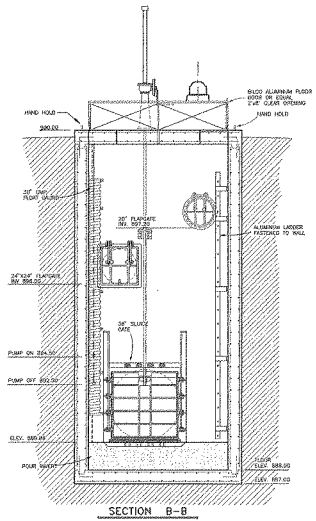


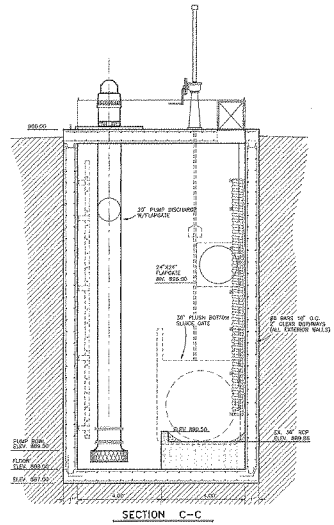










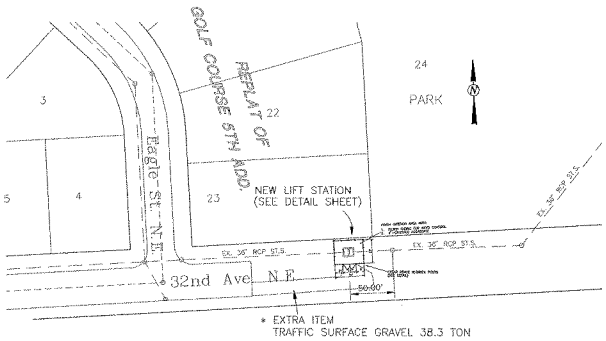


ALL ELEVATIONS ARE BASED ON THE CITY OF FARGO DATUM. (UNLESS NOTED OTHERWISE)

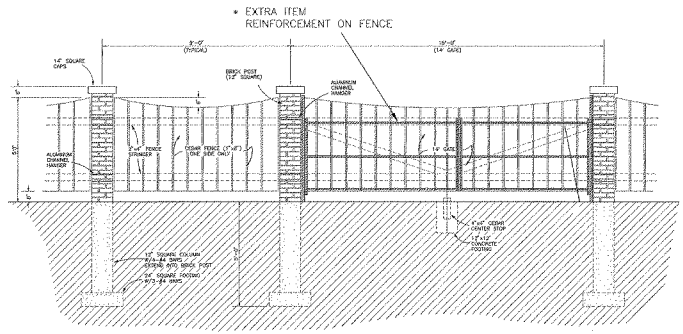
FINAL PLANS

CITY OF Fargo ENGINEERING DEPT.	STORM SEWER, LIFT STATION & INCIDENTALS	
	IMPROVEMENT DISTRICT 4903	
	DRAWN BY: SJM/SWS	SCALE: NOT TO SCALE
	CHECKED BY: SWS	DATE: AUG., 1996
	APPROVED BY: TRB	SHEET 4 OF 5
	FILE NAME: PROJFILE\4903\4903-4.F4	

1302

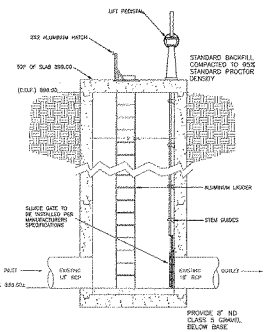


LIFT STATION FENCE LOCATION

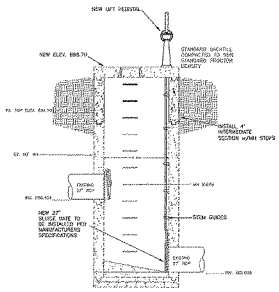


NOTES:
1. POSTS ARE 12"x12" SQUARE W/1.6" SQUARE CAPS FILL ALL CAVITIES WITH CONCRETE
2. EXTEND FOOTING STEEL TO TOP OF BRICK POSTS, TIE VERTICAL REINFORCING HANGERS THROUGH BRICK POSTS TO ATTACH TO FOOTING
3. HORIZONTAL STRANGERS ARE 2"x6" FASTENED TO ALUMINUM HANGERS, VERTICALS SPANNING ARE 1"x8" CEDAR
4. DOUBLE SWING 14' GATE WITH HORIZONTAL AND VERTICAL BOLT LATCHES
5. WOOD FENCE TO BE SEALED WITH NATURAL CEDAR SEALER FINISH

FENCE DETAIL



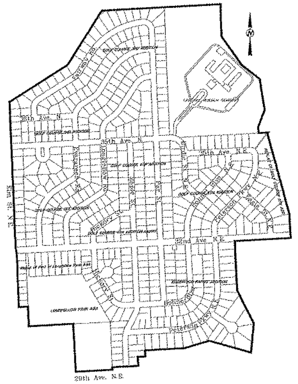
GATEWELL DETAIL
(NO SCALE)



STORM SEWER GATEWELL MODIFICATIONS DETAIL
(NO SCALE)

FINAL PLANS

CITY OF Fargo	STORM SEWER, LIFT STATION & INCIDENTALS IMPROVEMENT DISTRICT 4903
	DRAWN BY: SDK/TSRS — SCALE: NOT TO SCALE
	CHECKED BY: SMS — DATE: AUG. 1999
	APPROVED BY: WEP — SHEET 5 OF 5
ENGINEERING DEPT.	FILE NAME: \4903\4903_02



IMPROVEMENT DISTRICT NO. 4903

FINAL PLANS

Materials List

Improvement District # 4903

Item #	Item Description	Quantity / Unit	
Storm Sewer			
2084	Rem. & Repl. 7" Asph. Pvmt.	1100.00	SY
2945	Traffic Control	1.00	LS
3101	15" Storm Sewer w/Gravel Backfill	810.00	LF
3104	24" Storm Swr w/Gravel Backfill	379.00	LF
3450	A Inlet	1.00	EA
3509	Std. Storm Sewer MH	7.00	EA
3654	Rem. & Repl. Curb & Gutter	100.00	LF
4803	Hydroseed with Mulch	1.00	ACRE
3752	Sodding	200.00	SY
3800	Storm Sewer Lift Station	1.00	LS
3802	Storm Sewer Gatewell	1.00	EA
3803	Storm Sewer Gatewell Modifications	1.00	LS
4004	Embankment	500.00	CY

SPECIAL INSTRUCTIONS FOR BIDDERS
IMPROVEMENT DISTRICT NO. 4903

1. SPECIFICATION

The City of Fargo Standard Specifications for Construction of Public Utilities (revised 4-87) along with these Special Instructions shall govern the construction of the project.

2. COMPLETION

Functional completion of the lift station and sluice gate vaults will be March 15, 1999. All work shall be complete by June 15, 1999.

3. PROJECT COORDINATION

The Contractor with the aid of the engineer shall coordinate and schedule with other contractors, utilities companies, and City of Fargo personnel that may be working during the same time period. Co-operation is required to ensure timely accomplishment of all phases of construction.

The City of Fargo will not be responsible for additional cost resulting from delays caused by work on adjacent projects. The engineer shall be the sole judge if any problems or disputes evolve between contractors.

4. MANHOLE & INLET CASTING TYPES

A. Storm Manholes

1) Regular manhole castings required – 6

2) Inlet castings required – 1

Total – 7

B. Approved Casting Types

1) Regular manhole castings – Municipal #304 or equal.

2) Inlet castings – Municipal #413 or equal.

5. BID PURPOSE ITEMS

The following items are listed for bid purposes to be used only as directed by the engineer.

A. A Inlet

B. Remove and Replace Concrete Curb & Gutter

C. Sodding

6. STORM SEWER PIPE

All storm sewer pipe shall be RCP. All costs associated with tapping into existing storm manholes shall be incidental to the project. RCP pipe shall be provided with a Hamilton Kent Super Seal Gasket or approved equal.

7. TRENCH BACKFILL

The trench backfill under paving or driveways will be N.D. Class 5 or equal. Hydraulic plate compactors will be used to compact the material to 90% of proctor density from pipe elevation to 3 feet below subgrade and 95% in the last 3 feet. The backfill material will be incidental to the price bid for the storm sewer. A box or shoring will be used to protect the storm sewer pipe installers. Standard earth backfill compacted to 90% Standard Proctor Density is required for boulevard trenches.

8. EXCESS EXCAVATION

All clean excess excavation will be used as embankment for the seminary dike. All costs of this item to be incidental to other items. Unsuitable backfill shall be disposed of by the contractor.

9. PAVEMENT REMOVAL & REPLACEMENT

Approximate pavement removal is shown on the plans. In general, the trench width will be limited to six feet. Concrete curb & gutter will be removed only as directed by the engineer. The remaining curb shall be preserved during storm sewer installation.

Payment will be on a square yard price for pavement removal and replacement.

10. STORM SEWER/PAVING CONSTRUCTION

The contractor shall have a period of thirty calendar days per block to complete the installation of the storm sewer, street section, driveways and sidewalks. In the event the contractor fails to meet this condition, he shall be subject to a $500 per calendar day penalty until such time as access is provided to the affected block.

11. TRAFFIC CONTROL

Traffic control shall conform to Part VI of the MUTCD – Standards for Work Zone Traffic Control, latest edition. All signs and barricades are to have amber flashing lights.

Traffic control devices shall be installed at the inception of construction operations. These control devices shall be properly maintained during the time such special conditions exist. They shall remain in place only as long as they are needed and shall be immediately removed thereafter. The lump sum bid for traffic control shall include all costs for signs and barricades and lights, and all traffic maintenance costs.

Proposed detour signing shall be submitted to the engineer for approval prior to the closing of a particular street.

The contractor shall provide a qualified watch person who is knowledgeable in traffic control operations.

A. Watch persons shall be provided to patrol the project to assure that the traffic control devices are properly placed in accordance with the traffic control plans and standards. The project shall be patrolled daily at least once during daylight before 10 AM and at least once during darkness after 10 PM, including weekends and days when no work is in progress.

The watch person shall complete the traffic control devices daily checklist for every patrol and turn it in to the project inspector or engineer. A check list form is attached as part of these specifications.

The contractor shall provide written documentation to the engineer of the watch person's hours and activities.

The contractor shall immediately assist the watch person, whenever needed, to correct conditions that cause erratic traffic movement, unexpected braking, etc., and erect, repair, replace, or relocate the required traffic control devices. Emergency assistance shall be provided to motorists, when needed, due to roadway conditions. Suspension of watch person service may be permitted during periods of authorized suspension or after substantial completion of the work, provided the job site is in safe condition.

B. All costs associated with the above requirements shall be included in the price bid for the traffic control items.

12. EMBANKMENT

Relocation of the flood protective earthen dike in Cardinal Muench Seminary will be paid for on a cubic yard basis for embankment. Existing topsoil shall be stripped prior to construction and replaced after completion of embankment work. The cost bid for embankment shall include all costs associated with topsoil handling, hauling, placement, compaction (in 6" lifts) to 95% Standard Proctor Density, grading, etc.

13. HYDROSEEDING WITH MULCH

Part 1
Description of work

This work shall consist of the placing of topsoil and seeding the boulevards and yards after demolition and backfill are completed as designated by the engineer.

Part 2
Material

2.1. Topsoil

All topsoil shall be natural, friable soil which has produced heavy growths of crops, grass, or other vegetation and shall be reasonably free from subsoil, brush, objectionable weeds, or other litter, and shall be free from clay lumps, stones or other objects larger than one inch diameter, stumps, roots, any toxic substance, or any other material which may be harmful to plant growth or may be a hindrance to grading, planting and maintenance operations.

2.2. Seed

All seed shall be labeled in accordance with U.S. Department of Agriculture rules and regulations under the federal seed act in effect on the date of the invitation to bids. Seed shall be furnished in sealed containers unless exception is granted by the engineer. Damaged, wet, or moldy seed will not be accepted. All seed shall meet the minimum requirements for purity and germination. No purity or germination tolerance will be allowed. Weed seed shall not exceed 0.5% of the total mixture, and seed shall contain no noxious weed seed of the state from which seed is to be shipped. The seed mixture shall conform to the following:

A. Ditches and side slopes:

Kind of Seed	Percentage by Weight	Purity	Germination
Brome Grass	40%	85%	85%
Western Wheat	20%	90%	75%
Crested Wheat	20%	90%	85%
Rye Grass	20%	95%	90%

Rate of seeding = 70 pounds per acre

B. Parks, boulevards, private property, built-up areas:

Kind of Seed	Percentage by Weight	Purity	Germination
Glade Kentucky Blue	30%	90%	80%
Park Kentucky Blue	30%	90%	80%
Creeping Red Fescue	30%	90%	80%
Annual Rye	10%	95%	90%

Rate of seeding = 220 pounds per acre (5 pounds per 1,000 sq. ft.)

2.3. Fertilizer

Fertilizer shall be a commercial product and shall be 10-10-10 at an application rate of 220 pounds per acre (5 pounds per 1,000 sq. ft.). Fertilizer shall be free flowing and suitable for application with mechanical equipment, delivered in sealed containers, fully labeled, and bearing the name, trade name or trade mark and warranty of the producer.

2.4. Mulch (if specified)

A. Hydro Mulch

Hydro mulch shall be a wood cellulose fiber (not sawdust) and be applied at a rate of 2000 pounds per acre (45 pounds per 1,000 sq. ft.). The mulch shall have an approved tacking and bonding agent to ensure long lasting stabilization and reduce erosion potential. The tackifier shall be installed as per the manufacturer's recommendation.

Part 3
Construction

3.1 Preparation of Areas to be Seeded

Prior to or during grading and tillage operations, the ground surface shall be cleared of all stumps, brush, roots, stones larger than 2 inches in diameter, wire or other material that may hinder seeding and maintenance operations.

Any accumulated material shall be disposed of by the contractor at no additional cost to the city.

3.2. Placing Topsoil

Immediately prior to placing the topsoil, the subgrade shall be loosened by discing or scarifying to a depth of two inches to provide for the bonding of the topsoil to the subgrade. Topsoil shall be placed on all areas to meet prescribed grades or to provide soil capable of supporting grass growth. Topsoil shall be dumped in uniformly spaced piles and spread evenly to a minimum depth of six inches over the prescribed area. Topsoil shall be graded as shown on the plans or as directed by the engineer. Irregularities or low spots resulting from the topsoiling or other operations shall be corrected in order to prevent pockets where water may stand. Topsoil will not be placed when the subgrade is frozen, excessively wet, extremely dry, or in a condition otherwise detrimental to the proposed plantings or the grading operation.

3.3. Planting Seed

Prior to planting of the seed, fertilizer will be applied at the specified rate. All seeding shall be done when the ground is open, not frozen or covered with snow, except as otherwise directed in writing by the engineer. Seed shall be mechanically sown using approved equipment. Application rates shall be checked periodically using approved methods. When drill seeding, provisions shall be made to assure overlap. If inspection shows strips have been missed or skipped, these areas will be reseeded at no additional cost. When delays in operation or unfavorable weather conditions indicate that seeding will not have satisfactory results, the work will be stopped by the engineer.

A. Broadcast seeding

Seed shall be broadcast by approved sowing equipment or by hand for small areas. Seed shall be uniformly distributed with half the seed being sown with the sower moving in one direction, and the remaining half sown at right angles to the first sowing. Seed shall be covered to an average depth of 1/2 inch by a harrow or approved device. Broadcast seeding will not be allowed in windy conditions.

B. Drill seeding

Drill seeding shall be done with grass drills not more than 8 inches apart and shall be sown uniformly over the designated area. Seed shall be sown to an average depth of 1/2 inch.

C. Slurry seeding

The seed, water and mulch (if specified) shall be combined and kept under constant agitation so that a slurry of seed, mulch (if required) and fertilizer and water can be applied hydraulically to the areas to be seed. The equipment used will provide sufficient agitation to insure a uniform mixture of the ingredients throughout the application of each given quantity of slurry mixture. Uniform coverage and seeding rates shall be obtained and spot checks of seed distribution may be made by random placing of paper plates on areas to be seeded. After seeding, comparison of actual count of seed on the plates will verify the uniformity and application rate of the seeding distribution. No hydroseeding will be allowed after September 15th.

3.4. Mulching (if required)

3.4.1. Hydro Mulch

Hydro mulch will be applied with the slurry seed application and when completed shall provide uniform coverage while allowing percolation of water to the seedbed.

3.5. Cleanup

All areas shall be cleaned of items that may hinder maintenance operations and all paved areas over which hauling operations were conducted shall be cleaned of soil or other material which may have been brought upon the surface.

3.6. Protection of Seeded Area

The contractor shall protect all planted areas from traffic or other use by placing warning signs or erecting barricades immediately after seeding is complete. Any damage that may occur prior to final acceptance by the engineer shall be repaired to re-establish the conditions or grade of the soil prior to the damage and shall then be re-planted by the contractor at no additional cost.

3.7. Watering of Seeded Area

Immediately upon completion of the seeding, the seeded areas shall be given one watering. Sufficient water to moisten the seedbed to a depth of 2 inches shall be applied. Water shall be applied in a manner that provides uniform coverage and prevents erosion and damage to the final surface. The contractor shall provide additional watering as necessary for a two week period to insure germination of the seed unless dormant seeding after October 15 is approved by the Engineer.

14. SOD

Areas requiring sod shall have a minimum of 4-inches of black dirt installed prior to the placing of the sod. The existing sod shall be removed using a method that provides a straight edge of sufficient depth to allow the new sod to be placed abutting that edge, without the presence of an unsightly ridge, and provide a smooth continuous appearance. In areas where excessive settlement has occurred or the existing boulevard is blocking drainage, the contractor will be required to remove the existing sod and level the area by filling with black dirt, or by removing excess dirt prior to placing the new sod. The contractor shall water the sod daily for a period of two weeks from the date of installation.

15. CONDITIONS AT SITE

Bidders must satisfy themselves by personal investigation and by such other means as they may think necessary or desirable as to the location of and the conditions affecting the proposed work and as to the cost thereof. No information derived from maps, plans, specifications, profiles, or drawings, or from the engineer or his own assistants, or any other official, employee, or agent of the owner will relieve the contractor from any risk or from fulfilling all of the terms of the contract.

The accuracy of the contractor's interpretation of the facts disclosed by any preliminary investigation that may have been made by the engineer is not guaranteed. The engineer's estimate of quantities given in the statement of work is to be considered as preliminary and approximate only, and to be used only for the purpose of canvassing and comparing bids. The contractor shall not, at any time, make claims to additional payments of considerations on account of any misunderstanding regarding the nature or amount of the work to be done.

16. TEMPORARY BARRICADES

The contractor shall provide temporary barricades where required around his excavations to ensure against anyone accidentally falling into the excavation. Each contractor shall be responsible for his own excavations.

17. LOCATION OF EXISTING UTILITIES

Existing utilities have been shown to direct the contractor's attention to their existence. Such utilities have been plotted from record drawings.
THE CONTRACTOR IS CAUTIONED THAT ALL EXISTING UTILITIES MAY NOT BE SHOWN. THE LOCATION OF EXISTING UTILITIES IS NOT GUARANTEED, AND THE CONTRACTOR WILL BE RESPONSIBLE FOR DETERMINING THE EXACT LOCATION AND PROTECTION OF THE EXISTING UTILITIES.

THE CONTRACTOR, BEFORE COMMENCING ANY EXCAVATION OR CONSTRUCTION, SHALL FIND OUT THE LOCATION AND SEEK AID IN LOCATING ALL PUBLIC AND PRIVATE UTILITIES.

18. STREETS TO BE KEPT CLEAN

Streets and highways that are being used by the contractor and his forces to and from, as well as in the project site, shall be kept clean and dust-free at all times for the duration of the project and at project completion. Only methods approved by the engineer shall be used to keep the streets clean.

19. FINAL CLEANING UP

Before final acceptance, the streets, right-of-ways, and all areas occupied or used by the contractor in connection with the work, shall be cleaned of all rubbish, excess materials, temporary structures and equipment; and all parts of the work shall be left in an acceptable condition.

20. LIQUIDATED DAMAGES

The contractor should note that new liquidated damages schedule has been adopted by the City Commission. Listed below is the new schedule, and an explanation of requests for time extension that shall be followed on this project.

ORIGINAL CONTRACT AMOUNT		SUBSTANTIAL COMPLETION	FINAL COMPLETION
From	To	Calendar Day	30%
$0	$50,000	$150	$45
$50,000	$100,000	$250	$75
$100,000	$500,000	$400	$120
$500,000	$1,000,000	$500	$150
$1,000,000	$2,000,000	$600	$180
$2,000,000	---	$900	$270

The designated completion date will be strictly enforced. Changes in project scope or conditions may warrant time extension.

Substantial completion is defined as completion of all pay items by designated completion date. Final completion is defined as completion of all clean-up items of final inspection. Final completion must be within 30 days of specified completion date. Liquidated damages of 30% will be charged per calendar day for failure to complete all clean-up items within specified period.

Request for Additional Time

At any time before expiration of the original or extended contract time, a written request may be made to the engineer for additional time to complete the contract. The request shall be supported by adequate documentation stating the reasons and basis for the request. The engineer's determination will consider to what extent the delays were caused by conditions beyond the contractor's control that may be offset by time lost due to the failure to diligently prosecute the work or to other conditions within the contractor's control. A plea that insufficient time was specified is not valid reason for a time extension. A time extension will not be considered for inclement weather or for the time period from November 15 to April 15.

21. FINAL INSPECTION

After the contractor has completed the installation of the public facility and any clean-up items, he shall make a written request to the engineer for a final inspection. Upon receipt of this request, the engineer will set a date and time for the final inspection. The final inspection request form is attached as part of these specifications.

22. STORM SEWER GATEWELL

The new gatewell will be installed on an existing 18" RCP storm sewer. The storm sewer gatewell will be paid for at the unit price bid and shall include connecting the existing storm sewer to the new gatewell and all labor, materials and incidentals necessary to make a complete connection as well as the access cover, sluicegate, lift assembly, stem, aluminum ladder and other incidentals necessary for a complete operational gatewell.

23. SLUICE GATES

A. Sluice Gate 18", 27" and 36"

The sluice gates shall be a cast iron, heavy-duty Waterman Series 3000 sluice gate as manufactured by Waterman Industries of Texas or approved equal. The gate shall be a rising stem spigot back sluice gate with guiderail mounted to the frame to form a guide slot.

The guiderail and head piece, whether it be separate or integrally cast with frame, shall be designed to withstand the total thrust of the gate slide due to water pressure and wedging action.

The frame, slide, and guide rails shall be cast iron. Seating faces shall be naval bronze. Wedges and stem block shall be manganese bronze. All fasteners shall be stainless steel.

At the contractor's option, a stainless steel sluice gate equal to a Fontaine Series 50 may be installed.

B. Lift Assembly

The lift assembly shall be of the hand-operated pedestal type. The hand crank shall be sized to lift the gate against 25-feet of head with a maximum of 40 pounds of effort. The pedestal shall have a bronze lifting nut, ball bearings, or tempered roller bearings above the below the flange and shall have machined friction surfaces. The hand crank shall be provided with a free turning bronze sleeve on the handle and shall be readily removable from the pedestal. A steel pipe stem cover and the lift assembly shall be firmly attached to the intake structure during all modes of operation.

C. Stem

The gates shall be equipped with a self-contained stainless steel rising stem capable of safely withstanding the stresses induced by the lift mechanism without buckling or permanent distortion. Fully adjustable stem guides shall be installed as necessary to maintain stem alignment, yet free enough to permit easy operation. They shall be spaced in accordance with the manufacturer's recommendations.

D. The cost for the 15" sluice gate and appurtenances shall be incidental to the bid price for storm sewer gatewell. The cost for the 27" gate and appurtenances shall be incidental to the bid price for storm sewer gatewell modifications. The cost for the 36" sluice gate and appurtenances shall be incidental to the bid price for the storm lift station.

24. ALUMINUM HATCH

Floor access doors shall be Type K as manufactured by the Bilco Co., New Haven, Connecticut or approved equal.

The clear opening shall be: 2' x 2' for gatewell
2' x 8' for lift station

Frame shall be 1/4" extruded aluminum with built-in neoprene cushion and with strap anchors bolted to exterior and locking lug for padlock. Door leaf shall be 1/4" aluminum diamond plate reinforced with aluminum stiffeners as required. Cast steel hinges shall be bolted to underside and pivot on torsion bars that counterbalance the door for easy operation. The door shall open to 90? and lock automatically in that position. A vinyl grip handle shall be provided to release the cover for closing. Doors shall be mill finish, with bituminous coating to be applied to frame exterior by manufacturer. Installation shall be in accordance with manufacturer's instructions. Manufacturer shall guarantee against defects in material or workmanship for a period of five years.

The cost for the 2' x 2' aluminum hatch shall be incidental to the bid price for storm sewer gatewell. The cost for the 2' x 8' aluminum hatch shall be incidental to the bid price for the storm lift station.

25. STORM SEWER GATEWELL MODIFICATIONS

The modifications to the existing gatewell shall consist of installing a 27-inch sluicegate and removing the existing gatewell cover, installing a 4 foot riser extension (60" barrel) and replacing the cover.

26. SHOP DRAWINGS & PRODUCT DATA

Four sets of shop drawings and product data, checked and stamped approved by the contractor, shall be submitted to the engineer for his evaluation and approval of all pipe, pumps, motors, valves, controls, appurtenances and other materials and equipment required in the specifications prior to installation and construction. Any unique construction techniques shall be submitted, along with drawings, to the engineer for approval.

Shop drawings and product data shall include manufacturer's or fabricator's drawings, diagrams, schedules, operational curves, test reports, catalog cuts, or descriptive data showing model, size, type, weight, ratings, and other information as may be considered necessary to determine compliance with the contract documents and to enable proper installation of the material or equipment being proposed.

In submitting shop drawings, product data, and samples, the contractor represents that he has determined and verified all materials, field measurements, and field construction criteria related thereto, or will do so, and that he has checked and coordinated the information contained within such submittals with the work and the contract documents.

27. SCOPE OF WORK

The contractor shall include in his proposal all of the work outlined on the drawings and/or included in the specifications, and shall include the cost of all the work and any and all trades whether or not indicated on the drawings or mentioned in the specifications, but which may be required to complete the project, ready for operations in a satisfactory manner.

28. MATERIAL STORAGE

The contractor shall store his materials and equipment in such a place and in such a manner that a minimum of congestion will result. The placing of said equipment shall be subject to the approval of the engineer.

29. INTERPRETATION OF DOCUMENTS

The contractor shall carefully read the specifications before submitting bids on the work to be done. If any contractor contemplating submitting a bid for the proposed contract documents is in doubt as to the true meaning of any part of the specifications, he may submit to the engineer a written request for an interpretation thereof. The person submitting the request will be responsible for its prompt delivery. Any interpretation of the proposed documents will be made only in writing duly issued, a copy of which will be mailed or delivered to each bidder receiving a copy of the plans and specifications and to such other prospective bidders as have requested that they be furnished with a copy of each.

30. DRAWINGS & SPECIFICATIONS OF THE WORK

The contractor shall keep one copy of all drawings and specifications on the work, in good order, available to the engineer and to his representatives. All drawings on the work shall bear the engineer's approval.

31. INSPECTION OF WORK

The engineer and his representatives shall at all times have access to the work wherever it is in preparation or progress, and the contractor shall provide proper facilities for such access and for inspection.

In the specifications, the engineer's instructions, laws, ordinances or any public authority requiring any work to be specially tested or approved, the contractor shall give the engineer timely notice of its readiness for inspection, and if the inspection is by another authority than the engineer, of the date fixed for such inspection. Inspections by the engineer shall be promptly made, and where practicable, at the source of supply. If any work should be covered up without approval or consent of the engineer, it must, if required by the engineer, be uncovered for examination at the contractor's expense.

Re-examination of questioned work may be ordered by the engineer and if so ordered, the work must be uncovered by the contractor. If such work be found in accordance with the contract documents, the City shall pay the cost of re-examination and replacement. If such work be found not in accordance with the contract documents, the contractor shall pay such cost, unless he shall show that the defect in the work was caused by another contractor, and in that event the City shall pay such cost.

32. NOTICE TO SURETIES

The final inspection and acceptance of the work shall not be binding or conclusive upon the City if it shall subsequently appear that the contractor has willfully or fraudulently supplied inferior apparatus, equipment, materials, or workmanship, or has departed from the terms of the contract documents. In such case, the City shall have the right notwithstanding such final acceptance and payment, to cause the work to be properly performed and satisfactory apparatus, equipment and materials supplied to such extent as in the opinion of the engineer, may be necessary to finish the work in accordance with the plans and specifications therefore at cost and expense of the contractor and the sureties on his bond, and shall have the right to recover against the contractor and his sureties the cost of such work together with such other damages as the owner may suffer because of the default of the contractor, the same as though such final acceptance and final payment had not been made.

33. ENGINEER'S STATUS

The engineer shall determine if the work is proceeding in accordance with the contract documents. He is the agent of the City. He has authority to stop the work whenever such stoppage may be necessary to ensure the proper execution of the contract.

The engineer is, in the first instance the interpreter of the conditions of the contract, and the judge of their performance.

34. ENGINEER'S DECISIONS

The engineer shall, within a reasonable time, make decisions on all claims of the City or contractor, and on all other matters relating to the execution and progress of the work or the interpretation of the contract documents. The engineer's decision in matters relating to material and workmanship shall be final if within the terms of

35. PRIME CONTRACTOR SUPERVISION

The prime contractor shall furnish a full-time superintendent who is acceptable to the engineer. The superintendent shall have authority to make decisions on behalf of the contractor and shall coordinate and control all subcontractors.

36. TESTING

The City shall provide all testing as called for in the specifications. The amount of testing shall be as called for in the specifications or as judged to be necessary by the engineer.

37. UTILITIES

All utilities used by the contractor in the prosecution of the work shall be paid for by the contractor.

38. MANUFACTURED EQUIPMENT – PRIOR APPROVAL

In these specifications and on accompanying drawings, there are specified and shown certain equipment and materials deemed most suitable for the service anticipated. This is not done, however, to eliminate others equally as good and efficient. REQUESTS FOR SUBSTITUTION OF EQUIPMENT AND MATERIALS MUST BE RECEIVED BY THE ENGINEER TEN DAYS PRIOR TO BIDDING. Request shall include all product data and performance data indicating compliance with the appropriate specification. An addendum will be issued listing approved substitutions ten days prior to the bid opening. The awarding of the contract shall constitute a contractual obligation to furnish approved materials and equipment suitable for the specified service.

39. MATERIAL & EQUIPMENT APPROVAL

Approval for items of material and equipment proposed to be furnished by the contractor shall be based on the engineer's review of shop drawings, product data, and other submittals required in the specifications. Any material or equipment determined not to be in accordance with the specification requirements may be rejected during the review process. Once approval has been granted, changes such as model, type, manufacturer, etc. shall not be allowed except where considered beneficial to the City by the engineer.

The review of submittal will be general, and shall not be construed:

A. As permitting any departure from the contract requirements; or

B. As relieving the contractor of the responsibility for any errors or omissions in the submittals or the materials or equipment including details, dimensions, functions, quantities, ratings, etc.

C. As disallowing subsequent rejections upon the finding of defects of departures from the contract documents after the material or equipment has been installed.

Submittals covering any equipment or material which, because of standard shop practice or for other reasons, is not in accordance with the specification requirements, shall be specifically noted with regard to the points or features of variance. If requested, the contractor shall provide samples of materials or equipment that he proposes to furnish to assist in determining compliance with the specifications.

The contractor shall make all submittals sufficiently in advance of construction requirements to allow ample time for checking, resubmitting, and rechecking without delaying the project. No work shall be fabricated and no material or equipment shall be purchased, except at the contractor's risk, until the submittal has been reviewed and returned.

40. PROJECT CLOSEOUT

All mechanical, electrical, and process equipment shall be operated and tested by the contractor to the satisfaction of the engineer before the facilities are put into operation.

During the testing, the contractor shall arrange for the presence of qualified representatives of the manufacturer of all of the various pieces of equipment who shall instruct the owner's personnel in the operation and maintenance of the equipment at no additional cost to the owner.

41. RECORD DRAWINGS & MANUALS

Prior to final acceptance, the contractor shall provide the engineer with three copies of the descriptive materials, operating and maintenance instructions, spare parts lists, manufacturer's as-built drawings, installation drawings, and the name and location of the nearest supply house stocking spare parts for all equipment provided or installed on the project.

42. LIST OF SUPPLIERS & SUBCONTRACTORS

The successful bidder shall submit to the engineer a list of equipment suppliers and subcontractors. This list shall be submitted within two weeks after the award of the bids.

43. STORM SEWER LIFT STATION

A. General

The contractor shall furnish and install the storm sewer lift station as described herein and as shown on the plans. The equipment shall form a storm water pump system complete with wetwell structure, ladder, fence enclosure, pump, controls, sluicegates, flapgates, covers and miscellaneous items as contained in the contract documents.

B. Flapgates 20"; 24" x 24"

1) Scope

The work to be done under this specification shall include all labor, tools, materials, and equipment necessary to install the flapgates as shown on the plans.

2) Flapgates

The flapgates shall be Waterman F-20 or approved equal with bronze hinge bushings. Hinge pins, washers, and keepers shall be stainless steel. Neoprene dovetail seat faces shall be recessed in the covers.

C. Storm Water Pump

1) Pump and Motor

a) Operating Conditions

The contractor shall furnish and install one new electric motor driven mixed flow/propeller pump and motor as shown on the plans. The pump must have the necessary characteristics and be properly selected to pump the following capacities and head conditions:

Size & Type – 20 inch mixed flow or propeller.

Horsepower – 20 Horsepower.

RPM – 900

Capacity Each – 6800 GPM at 7 feet. TDH.

Maximum Head – 10 feet TDH.

The motor shall be capable of driving the pump through the full operating range without overloading at any point on the impeller curve. All pumps and motors must receive written approval by the engineer.

b) Approved Models

1) Simmons P16A or approved equal

c) Bowl Assembly

The suction bell shall have a flared inlet designed to reduce entrance losses and sufficient number of vanes to support the bearing housing. Both the suction bell and the pump bowl shall have sleeve type bronze bearings. An oil seal shall be furnished just below the top discharge bowl bearing to keep the shaft enclosing tube flooded with oil at all times. The suction bell bearing shall be grease packed and be protected by a sand collar. The impeller shall be made of ASTM B584 Alloy 836 bronze and shall be fastened to the pump shaft in such a manner as to be readily removable and to be able to prevent damage from reverse rotation. The pump shaft shall be stainless steel and be of sufficient diameter to transmit the required horsepower. The pump bowl is used with oil lubricated column and shall have a drain port to drain the water that passes through the pump bowl bearing. The stator shall be stainless steel lined to improve wearability.

d) Column Assembly

The column and discharge elbow shall support the driver and direct the flow of water from the pump bowl to the horizontal (underground) discharge pipe located as specified. It should consist of elbow, stuffing box assembly, column sections, line shaft and couplings, bearings, shaft enclosing tube, and tube tension device.

The discharge elbow shall be connected to the discharge force main with a dresser coupling and the discharge elbow and force main shall be adequately tied across the dresser coupling with tie bolts to prevent separation.

e) Line Shaft

The line shaft shall be ASTM A108 grade 1045 steel ground and polished. It shall be of ample size to operate the without distortion or vibration and shall be capable of carrying the maximum horsepower that may be generated by the motor. Shaft couplings shall have left handed threads to tighten during pump operation.

The shaft enclosing tube shall be of sufficient diameter to provide adequate lubrication under any operating conditions.

The line shaft bearings which serve as couplings for the shaft tubing shall be spaced at each tubing length to maintain alignment of pump shaft and prevent excessive vibration. They shall be of bronze alloy, machined, threaded, and grooved for proper lubrication.

f) Non-Reverse Ratches

Non-reverse ratches shall be required to prevent damage to the pump and motor in event of reverse flow.

g) Motor

Electric motor as required for the pump. The motor must conform in every respect to the standard specification of NEMA and bear nameplate of manufacturer, with current and operating characteristics noted thereon.

The motor must be guaranteed to operate continuously at full-rated load and speed. The motor shall be quiet operating under all load conditions. The electric motor shall be 20 horsepower, 900 RPM to operate on 480-volt, 3 phase, 60-cycle alternating current adequate for operating the connected loads continuously in an ambient temperature of 40° C without exceeding the NEMA standard temperature rises for the motor insulations. The pump shall not overload the motor at any operating range of head on pump curve. The motor windings shall have moisture resistant insulation.

Motor enclosures shall be totally enclosed weather-proof with grease lubricated ball bearings.

h) Suitability & Approval

All parts of the pumping unit shall be suitably designed for the service required. It shall operate without excessive vibration or cavitation of the impeller. The pump and motor shall be new and the standard product of a reputable manufacturer with component parts fabricated on a principal of interchangeability to facilitate ready replacement. The pump, as assembled, shall have substantially the clearances shown on the plans when installed in the space provided. The manufacturer shall submit to the contractor certified dimension drawings, performance curves, and detailed specifications of the equipment he proposes to furnish which all shall be submitted to the engineer for approval ten days prior to the opening of bids. There shall be furnished all necessary wrenches or specially needed tools.

i) Pump Lubrication

The pump shall be equipped with a two quart oiler which shall be attached to the motor base with a bracket. The oiler shall be solenoid controlled to provide automatic lubrication when the pump starts operating. The pump manufacturer shall furnish the solenoid controls for the pump, and the solenoid controls and pump motor shall be wired in accordance with the wiring diagrams furnished by the pump manufacturer. The suction bell bearing shall be connected with a grease line and Alemite fitting at the base plate.

j) Strainer/Vortex Suppressor

The pump shall be provided with a stainless steel strainer/vortex suppressor of size and design as recommended by the manufacturer.

k) Testing

Contractor shall prepare certified, guaranteed performance curves based on shop tests of pumps or of scale models in accordance with procedures as specified by Hydraulic Institute Standards. Performance curves must be certified by a registered professional engineer. Curves shall be submitted for approval twenty days before shipment of equipment.

Field Testing – The pump shall be fully tested on water at the site after installation, and at the contractor's expense before acceptance. The driving motor, pump and motor shall be assembled and tested as a unit.

l) Pump Warranty

The pump manufacturer shall warrant the pump being supplied to the owner against defects in workmanship and materials for a period of one year under normal use, operation and service from the start-up date of the pumping station. The warranty shall be in published form and apply to all similar units. A copy of this warranty shall be placed on file with the owner and engineer prior to approval of the pump.

m) Maintenance & Service

The local authorized representative shall have his own full time repair service available on 24-hour call. A factory serviceman and service vehicle equipped with tools to make all necessary repairs, as well as component parts required to maintain satisfactory operation of the equipment outlined in these specifications, shall be available if needed without undue delay.

n) Start-Up

A factory-trained serviceman shall be present at the time when the station is to be put into service and turned over to the owner. He shall instruct the owner in the proper operation and maintenance of the equipment, and submit a written report to the engineer and owner. The factory-trained serviceman shall return to the job site at least once after official start-up to review instructions given previously.

o) Painting

1) Pump and motor
i) Manufacturer's standard surface preparation and high solids epoxy finish and color.
ii) Provide one quart of touch-up paint – each color.

D. Electrical & Controls

1) General

The contractor shall furnish and install a complete electrical control system. This electrical control system shall be the property combined product of motor control units, automatic level controls and other related electrical components required to constitute a complete coordinated panel. This system shall be the product of a manufacturer skilled and experienced in systems of this type. A complete wiring diagram, dimensional drawings and description of operation and panel layout shall be furnished by the successful manufacturer for approval by the engineer prior to producing said controls.

The manufacturer shall provide the services of a qualified engineer to inspect installation, supervise final adjustment and instruct the operator in the use and maintenance of this equipment.

The manufacturer shall warrant the control system to be free of defective material and workmanship for a period of one year from the date of final acceptance. Any service necessary to replace material shall be performed without cost of the owner during this one year period.

2) Electrical Service

Northern States Power Company will supply power to the main circuit breaker and supply the current transformers for metering. The meter socket shall be supplied by the contractor, as approved by NSP. The contractor shall supply a complete 200 amp, 480-volt, 3-phase, 4-wire electrical service. Rigid steel conduit will be required from the transformer. The pump electrical power and house electrical shall be separated out of the main breaker to allow work on one without affecting the other.

3) Level Regulators

Furnish a complete level control system consisting of three (one spare) Flygt Model ENH-10 liquid level regulators or equal. Each regulator shall consist of a conical part and a hemispherical bottom covered with a chemical and sewage resistance hard PVC casing, all enclosing an eccentrically fitted lead weight to keep the regulator in the correct attitude and a shockproof mercury switch. Consolidated Electric Model LS float with weight kit is an approved float alternate.

4) Controls

Furnish and install one automatic control center as manufactured by "Consolidated Electric" or equal. Panel shall be 240/480 volts, 3 phase, 60 cycle, NEMA 3R construction equipment totally self contained on a free standing pedestal with the following:

a) Circuit breaker for pump – E frame or better.

b) NEMA rated magnetic-x-line starter for the pump, with proper size replaceable quick trip heater element and overload protection. G.E. Square D or Westinghouse.

c) Overload reset pushbutton extended through the dead front door. (Heavy Duty).

d) Oil tight hand-off-automatic selector switch for pump, operable through the dead front door.

e) Solid State liquid level regulator controller assembly with automatic pump operation, with float test switches and LED's. Electro-mechanical devices are not acceptable.

f) One 24-volt control circuit transformer with circuit breaker primary connection and fused secondary circuit. Switch unit shall have transient protection built into module. Unit shall be U.L. approved.

g) Box clamp type terminals shall be provided for connection for the electric power supply wires, pump circuit wires, and liquid level regulator cables, and shall be coded.

h) Condensation protective heater, (element to be replaceable without tools).

i) GFI Type Simplex receptacle, 120 volts, A.C., 15 Amps.

j) Pump running time meter, reading in hours of operation.

k) Plastic coated wiring diagram on inner door.

l) Control center shall be mounted as shown on the plans.

m) Transfer switch for emergency generator shall be supplied by the control panel manufacturer and installed in panel. Receptacle shall be Appelton ACR 6044 RS and mounted on side of panel.

E. Measurement and Payment

The total price bid for construction of the storm lift station complete, shall cover all work and materials including wetwell, covers, gates, ladders, pumps, controls, fence enclosure and miscellaneous, and as shown on the contract drawings and/or required by the specifications and other contract documents, or reasonably inferred thereby. All costs in connection with the work, including the furnishing of materials, machinery, supplies and appurtenances; providing all construction plant, equipment and tools; and performing all necessary labor, coordination, supervision and management to fully complete the work shall be included in the lump sum and unit prices named in the Bid Proposal. No item that is required by the contract documents for the proper and successful completion of the work will be paid for outside of, or in addition to, the amounts and prices submitted in the Bid Proposal. All work not specifically set forth as a pay item in the Bid Proposal shall be considered included in the lump sum bid.

F. Topsoil Spreading

Topsoil strippings from the project area shall be used as directed by the engineer to finish grade the area upon completion of the lift station installation. Topsoil spreading shall be considered incidental to the work.

G. Seeding

The area impacted by lift station construction shall be seeded after topsoil spreading has been completed.

44. CEDAR FENCE

A. General

A cedar fence shall be installed between brick posts around the site as shown on the plans.

B. Materials

All rough cedar
2 x 4 horizontal stringers
1 x 8 vertical boards

C. Installation

Attach stringers using carriage bolts to aluminum channel hangers extending from brick posts. Fence boards shall be attached to framing members with aluminum rib-shanked nails or approved equal. Finish fence with a natural cedar tone sealer.

D. Gate

14-foot wide double swing. Horizontal bolt latch suitable for padlock. Vertical bolt latch into concrete base to fix one gate.

E. Payment

Payment shall be incidental to lift station costs.

45. BRICK POST WITH FOOTINGS

A. General

Scope: This section covers the furnishing of all labor, equipment, and materials to complete the unit masonry work as shown on the drawings and herein specified.

B. Products

1) Type #1 Face Brick

a) Hollow units of burned clay or shale, ASTM C216 grade SW, Type FBS; modular size. The contractor shall provide brick sample to the engineer prior to ordering materials.

2) Provide solids at corners of soldier courses and rowlock ends.

3) Mortar Materials

a) Aggregate: ASTM C-144.

b) Water shall be clean and free from injurious amounts of acids, alkalis, organic materials, or other deleterious substances.

c) Portland cement: ASTM C-150, Type 1.

d) Hydrated lime: ASTM C-207, Type S.

e) Water proofing admixtures: "Hydrolite Plus" by A.C. Horn Company, "Hydrocide Powder" by Sonneborn or approved equal.

4) Masonry cleaner "Surekleen" by Process Solvent Co., Inc., Kansas City, Kansas, or "S-C Clean No. 86" by S-C Industries, Minneapolis, Minnesota or approved equal.

C. Execution

1) Protect all masonry work from the elements and from staining or damage of every description during the progress of the work.

2) All workmanship shall be first class.

3) All masonry work damaged or disfigured during the progress of the work shall be replaced in the entirety at the expense of the contractor.

4) Mortar and Mortar Mixing

a) Prepare mortar only with materials specified and in conformance with ASTM C-270. Type M, S, or N mortar may be used in masonry work.

b) Aggregates: 2 1/4 to 3 times the volume of cement and lime used; measured in damp, loose condition.

c) Use waterproofing admixture as per manufacturer's recommendations.

d) Materials that have partially set shall not be retempered or used. Frozen, caked or lumpy materials shall not be used. Mixers and boxes shall be thoroughly cleaned of all set or hardened mortar before the materials for a new batch are loaded.

e) All sand and water for mixing shall be heated to at least 80° F. when daily temperatures are below 50° F. Antifreeze admixtures shall not be used.

5) Laying up Masonry

a) All masonry shall be laid up by skilled mechanics and in accordance with the following specifications and applicable trade practices and as indicated on the drawings.

b) Masonry joints: All concrete block shall have concave joints. Joints shall be tooled concave at exposed masonry. All face brick joints shall have tooled joint.

c) The horizontal and vertical joints shall be filled solid without any voids in the walls. All masonry shall be laid in a full bed of mortar.

d) Cold weather requirements

i) When air temperatures fall below 40° F., provide suitable work area enclosures; heat to raise temperatures above 40° F., for minimum of 48 hours. Temperatures of masonry materials when laid shall be above 40° F.

ii) Temperature of mortar when heated shall be between 70° F. minimum to 120° F. maximum.

iii) Temperature of sand and mixing water shall be 70° F. minimum to 180° F. maximum.

6) Clean as required, the exterior masonry. Mixing and application of cleaner shall be in accordance with the block manufacturer's recommendations. Under no circumstances shall muriatic acid be allowed on the site without the written approval of the architect/engineer.

D. Concrete Footings

The concrete footings shall be of the size shown on the plans and reinforced as indicated. The concrete for the footings shall have a minimum compression strength of 3000 psi at 28 days.

E. Payment

Payment shall be incidental to lift station costs.

MARK H. BITTNER REGISTERED PROFESSIONAL ENGINEER NORTH DAKOTA

CITY OF FARGO
ASSESSMENT PLAT

STORM SEWER, LIFT STATION
AND INCIDENTALS

IMPROVEMENT DISTRICT NO. 4903

FINAL PLANS

Mark H. Bittner
MARK H. BITTNER
CITY ENGINEER
NOV., 1989

Attachment H-9: 10th Avenue South (Dike West) Information

St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps
of Engineers®
FMMFS_P2_geotech_2008-04.mxd
Printed 20 NOV 09
FMMFS: Credit to Existing Levees
10th Avenue South, 4579-3 (Fargo)
0 100 200 400 600
Feet

4TH STREET DIKE IMPROVEMENTS

IMPROVEMENT DISTRICT #4579-3

FARGO, NORTH DAKOTA
1998

moore engineering inc.

fargo – west fargo, north dakota

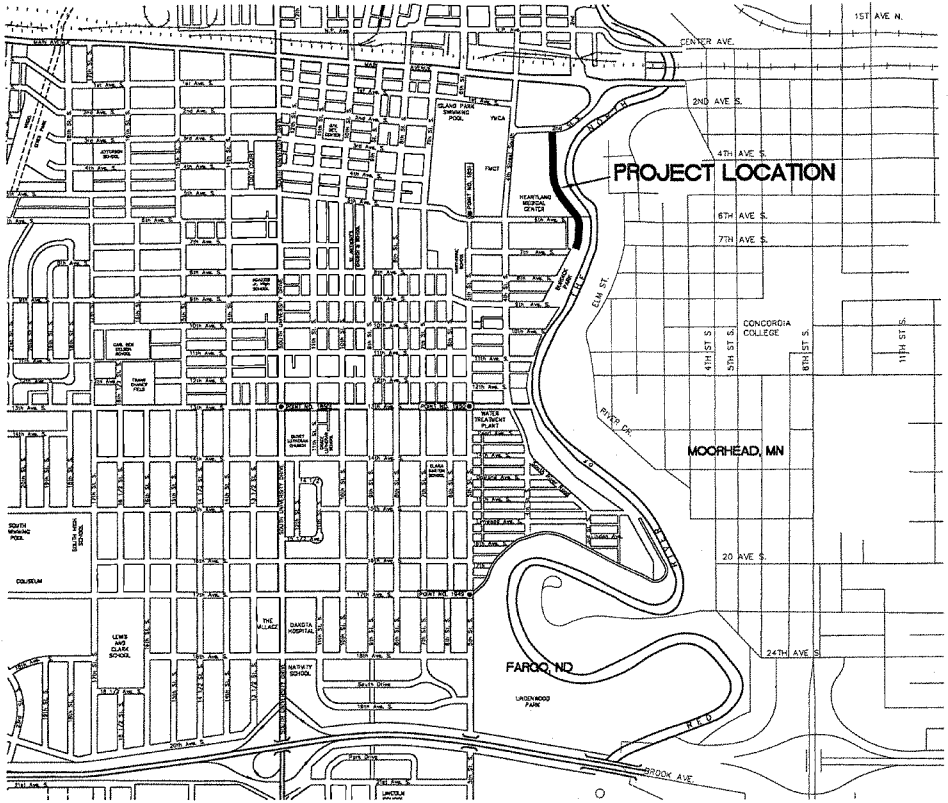
TABLE OF CONTENTS

COVER SHEET	SHEET 1
GENERAL SITE MAP & LEGEND	SHEET 2
PLAN & PROFILE	SHEET 3
PLAN & PROFILE	SHEET 4
CROSS SECTIONS	SHEET 5
TYPICAL DETAILS	SHEET 6

Final Plans
RECORD DRAWING – 12/7/98
PROJECT NO. 8948-10
SHEET 1 OF 6 03/12/98

Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011

Attachment H-9, pg 2
Credit to Existing Levees



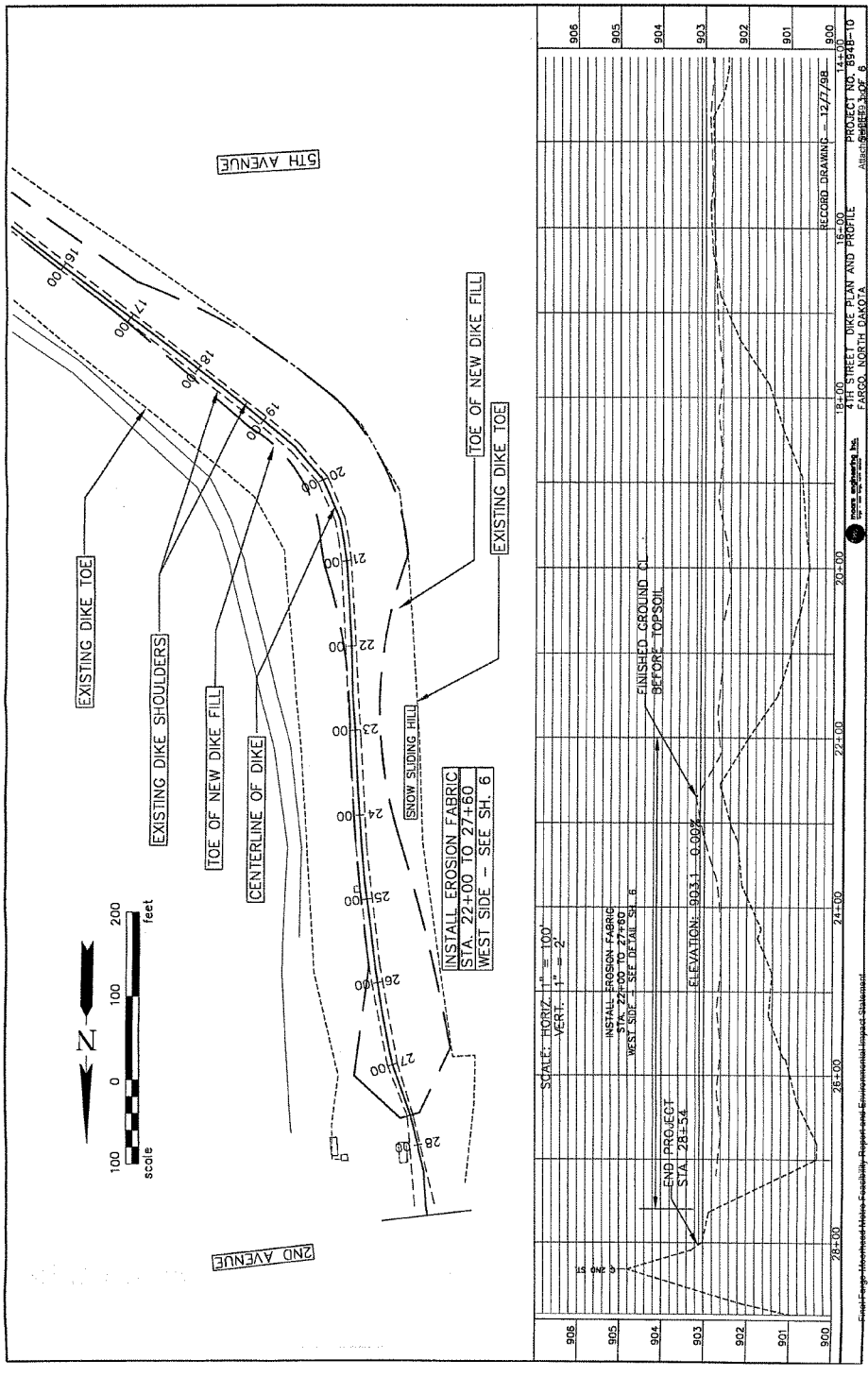
BENCHMARK			
NO.	DESCRIPTION	LOCATION	ELEV.
1	BRASS CAP - 043-74 U.S.C.S.-1929 DATUM	CORNER OF 4TH ST. S. & 10TH AVE. S.	891.59
2	BRASS CAP - 044-74 U.S.C.S.-1929 DATUM	CORNER OF 4TH ST. S. & 12TH AVE. S.	894.26

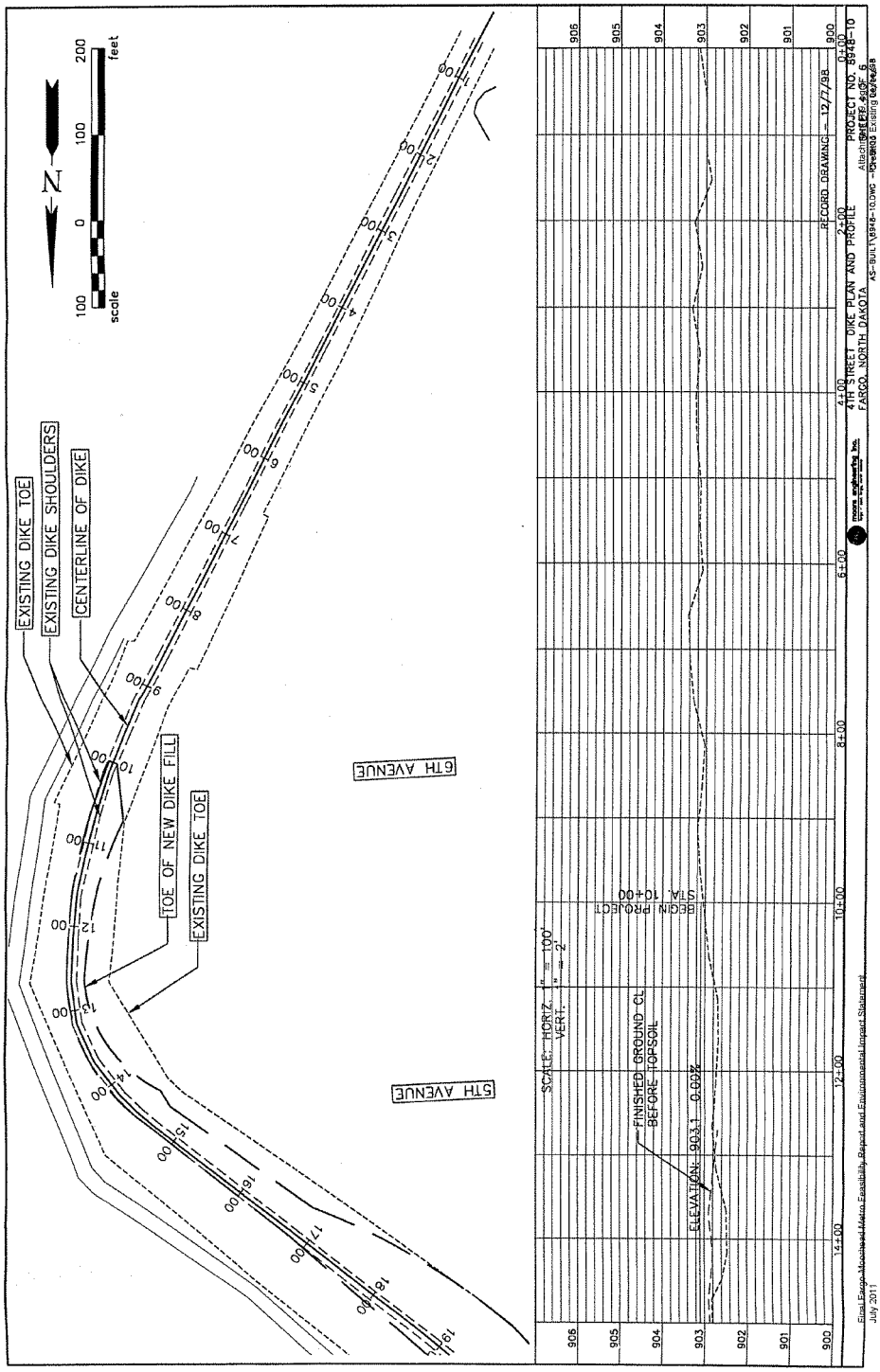
RECORD DRAWING - 12/7/98

GENERAL LAYOUT 4TH STREET DIKE IMPROVEMENTS FARGO, NORTH DAKOTA	DATE 03/12/98	REVISED
	DRAWN BY SDN	PROJ. NO. 8948
moore engineering inc. fargo - west fargo, north dakota	CH'D BY	DRAWING 2 OF 6
	SCALE 1" = 600'	

T:\DWGS\85-89\8948-10\AS-BUILT\8948-CPV.DWG RS-GL 03/12/98

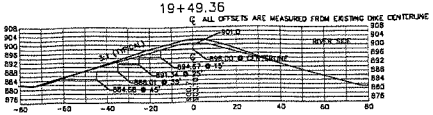
Attachment H-9, pg 5
Credit to Existing Levees


5TH AVENUE
2ND AVENUE
EXISTING DIKE TOE
EXISTING DIKE SHOULDERS
TOE OF NEW DIKE FILL
CENTERLINE OF DIKE
SNOW SLIDING HILL
TOE OF NEW DIKE FILL
EXISTING DIKE TOE
INSTALL EROSION FABRIC
STA. 22+00 TO 27+60
WEST SIDE - SEE SH. 6
N
scale
feet
SCALE: HORIZ. 1" = 100'
VERT. 1" = 2'
INSTALL EROSION FABRIC
STA. 22+00 TO 27+60
WEST SIDE - SEE DETAIL SH. 6
FINISHED GROUND CL
BEFORE TOPSOIL
ELEVATION: 903.1 0.00%
END PROJECT
STA. 28+54
RECORD DRAWING - 12/7/98
4TH STREET DIKE PLAN AND PROFILE
FARGO, NORTH DAKOTA
PROJECT NO. 8948-10
Final Fargo Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011


EXISTING DIKE TOE
EXISTING DIKE SHOULDERS
CENTERLINE OF DIKE
TOE OF NEW DIKE FILL
EXISTING DIKE TOE
6TH AVENUE
5TH AVENUE
N
scale
feet
SCALE: HORIZ. 1" = 100'
VERT. 1" = 2'
FINISHED GROUND CL
BEFORE TOPSOIL
ELEVATION: 903.1 0.00%
BEGIN PROJECT
STA. 10+00
RECORD DRAWING - 12/7/98
4TH STREET DIKE PLAN AND PROFILE
FARGO, NORTH DAKOTA
PROJECT NO. 5948-10
Final Fargo Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011

FINISHED DIRT GRADE IS BEFORE TOPSOIL PLACEMENT

19+49.36



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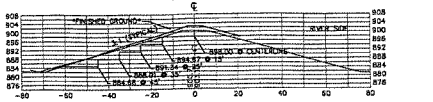

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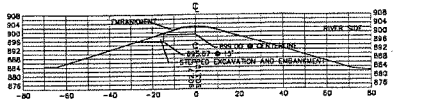

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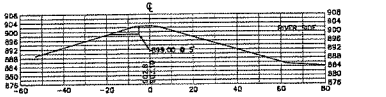

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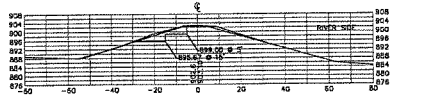

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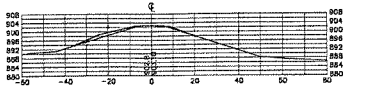

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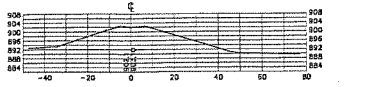


FARGO FLOOD PROTECTION
4TH STREET DIKE

Restore Dike To Elevation 903

EXCAVATION & EMBANKMENT STEPPED

Station	Dist.	Area Ave.	Area	Cu. Ft.	Cumm. Cu. Ft.
	201.06		0.0	0.0	0.0
106.83		0			
	102.49		0.0	0.0	0.0
1265.32		0			
	182.22		19.8	4,096.7	4,096.7
1447.54		53.69			
	22.9		41.7	955.3	5,052.0
1470.44		27.75			
	209.67		44.8	9,389.4	14,441.4
1680.11		61.81			
	212.28		127.4	27,047.4	41,488.8
1892.39		192.99			
	56.97		150.5	8,571.7	50,060.5
1949.36		107.83			
	124.87		157.0	19,594.6	69,655.1
2074.23		166.27			
	26.31		161.4	4,246.0	73,901.1
2100.54		156.7			
	206.06		133.8	27,577.3	101,478.4
2306.60		145.31			
	119.55		59.6	7,120.8	108,599.2
2426.15		49.93			
	153.29		67.94	10,415.7	119,014.9
2579.44		86.62			
	120.45		109.8	13,227.3	132,242.2
2699.89		133.03			
	63.78		128.3	8,175.9	140,418.1
2763.67		122.6			
	122.2		0	0.0	140,418.1
2885.87		0			

Excavation & Embankment Material	Cu. Ft.	140,418.1
	Cu. Yds.	5,201.1

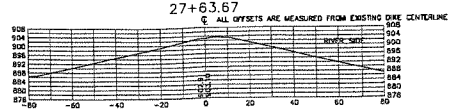
Station	Dist.	Width Ave.	Width	Stripping 10' Top – 3:1 Sq. Ft.	Cumm. Sq. Ft.
852.77		0			
	201.06		20.5	4,121.7	4,121.7
1063.83		41			
	201.49		31.0	6,246.2	10,367.9
1265.32		21			
	182.22		32.5	5,922.2	16,290.1
1447.54		44			
	22.9		39.5	904.6	17,194.6
1470.44		35			
	209.67		40.5	8,491.6	25,686.3
1680.11		46			
	212.28		64.0	13,585.9	39,272.2
1892.39		82			
	56.97		83.0	4,728.5	44,000.7
1949.36		84			
	124.87		94.5	11,800.2	55,800.9
2074.23		105			
	26.31		105.0	2,762.5	58,563.5
2100.54		105			
	206.06		71.5	14,733.3	73,296.7
2306.60		38			
	119.55		45.0	5,379.8	78,676.5
2426.15		52			
	153.29		63.0	9,653.9	88,640.3
2579.44		78			
	120.45		100.0	12,043.0	100,683.3
2699.89		122			
	63.78		71.0	4,528.4	105,213.7
2763.67		20			
	122.2		10.0	1,222.0	106,435.7
2885.87		0			

	Sq. Ft. Stripping	106,435.7
	Sq. Yds. Stripping	11,826.2

Station	Dist.	Embankment 10' TOP – 3 : 1 Area Ave.	Area	Cu. Ft.	Cumm. Cu. Ft.
852.77		0			
	201.06		6.4	1,282.8	1,282.8
1063.83		20.49			
	201.49		12.76	9.3	1,868.6	3,151.6
1265.32		3.79			
	182.22		12.7	2,306.9	5,458.5
1447.54		19.53			
	22.9		17.6	403.5	5,862.0
1470.44		15.71			
	209.67		18.1	3,790.8	9,652.8
1680.11		20.45			
	212.28		83.0	18,438.9	28,112.7
1892.39		153.47			
	56.97		155.7	8,867.4	36,980.1
1949.36		157.83			
	124.87		150.8	18,830.4	55,810.5
2074.23		143.77			
	26.31		142.2	3,781.9	59,592.0
2100.54		140.69			
	206.06		84.2	17,358.5	76,950.5
2306.60		24.79			
	119.55		39.8	4,755.1	81,705.6
2426.15		54.76			
	153.29		85.9	13,162.9	94,875.5
2579.44		117.07			
	120.45		146.8	17,683.9	112,559.5
2699.89		176.22			
	63.78		86.1	5,491.8	118,220.7
2763.67		1.95			
	122.2		1.0	119.1	118,339.8
2885.87		0			

	Cu. Ft. Fill	118,339.8
	Cu. Yds. Fill	4,383.0

27+63.67



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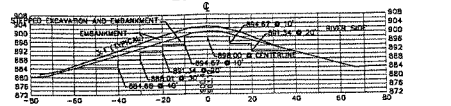

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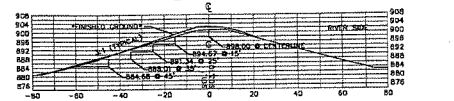

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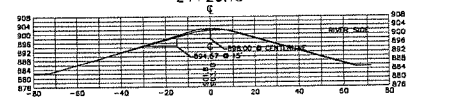

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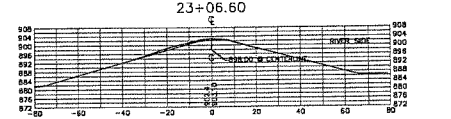

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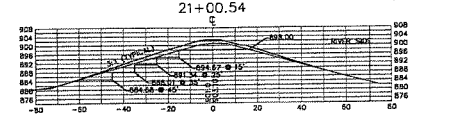
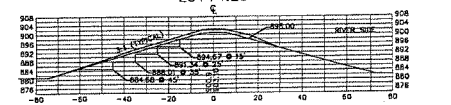


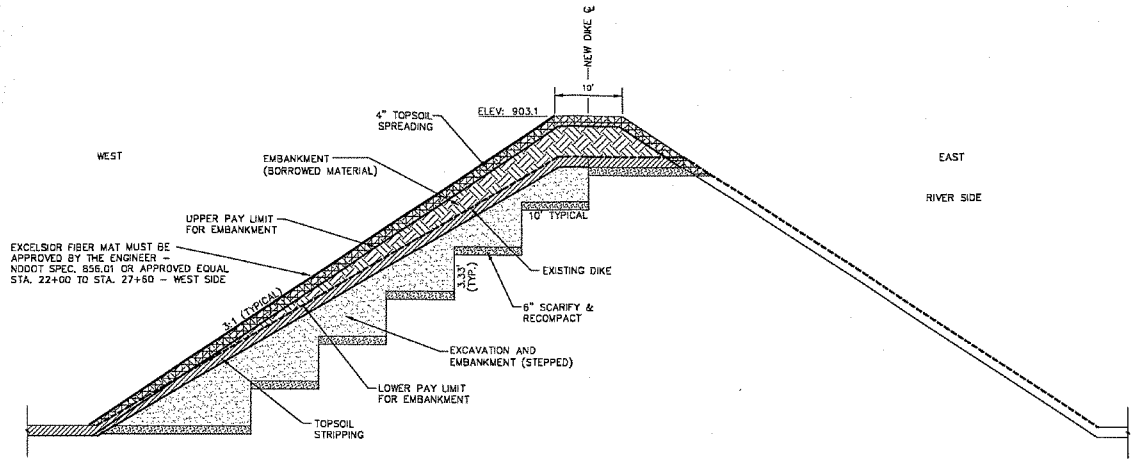
20+74.23



moore engineering inc.

4TH STREET DIKE — RECORD DRAWING – 12/7/98
CROSS SECTIONS — PROJECT NO. 8948-10
FARGO, NORTH DAKOTA — SHEET 5 OF 6
AS-BUILT DATE 12/7/98 — AS-BUILT BY MS — 3/20/98

1312



TYPICAL STEPPED EXCAVATION AND EMBANKMENT DETAIL

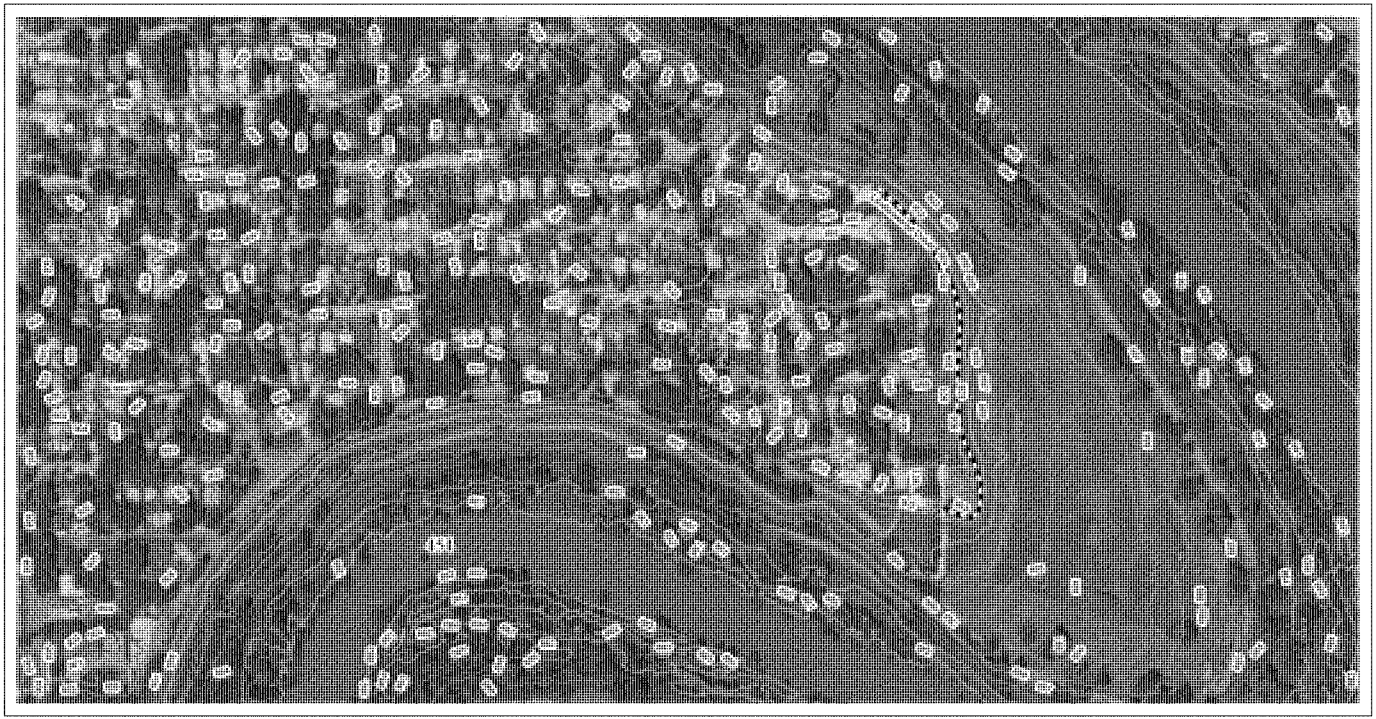
NO SCALE

RECORD DRAWING - 12/7/98

TYPICAL DETAILS 4TH STREET DIKE IMPROVEMENTS FARGO, NORTH DAKOTA	DATE 03/12/98	REVISED
	DRAWN BY SGN	PROJ. NO. 8948-10
moore engineering inc. fargo - west fargo, north dakota	CH'D BY	DRAWING 6
	SCALE NONE	OF 6

T:\DWGS\85-89\8948-10\AS-BUILT\[illegible] 03/12/98

Attachment H-10: Lindenwood Drive Levee Information



St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps of Engineers®

FMMFS_P2_geotech_2009-04.mxd
Printed 20 NOV 09

FMMFS: Credit to Existing Levees
Lindenwood Drive, 4908 (Fargo)

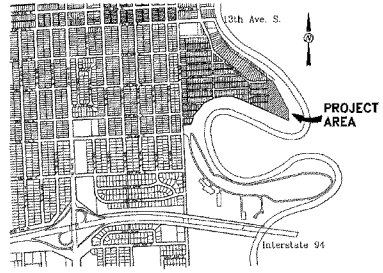
0 100 200 400 600 Feet

PLANS FOR

DIKE CONSTRUCTION & INCIDENTALS

ENGINEERING DEPARTMENT

CITY OF Fargo



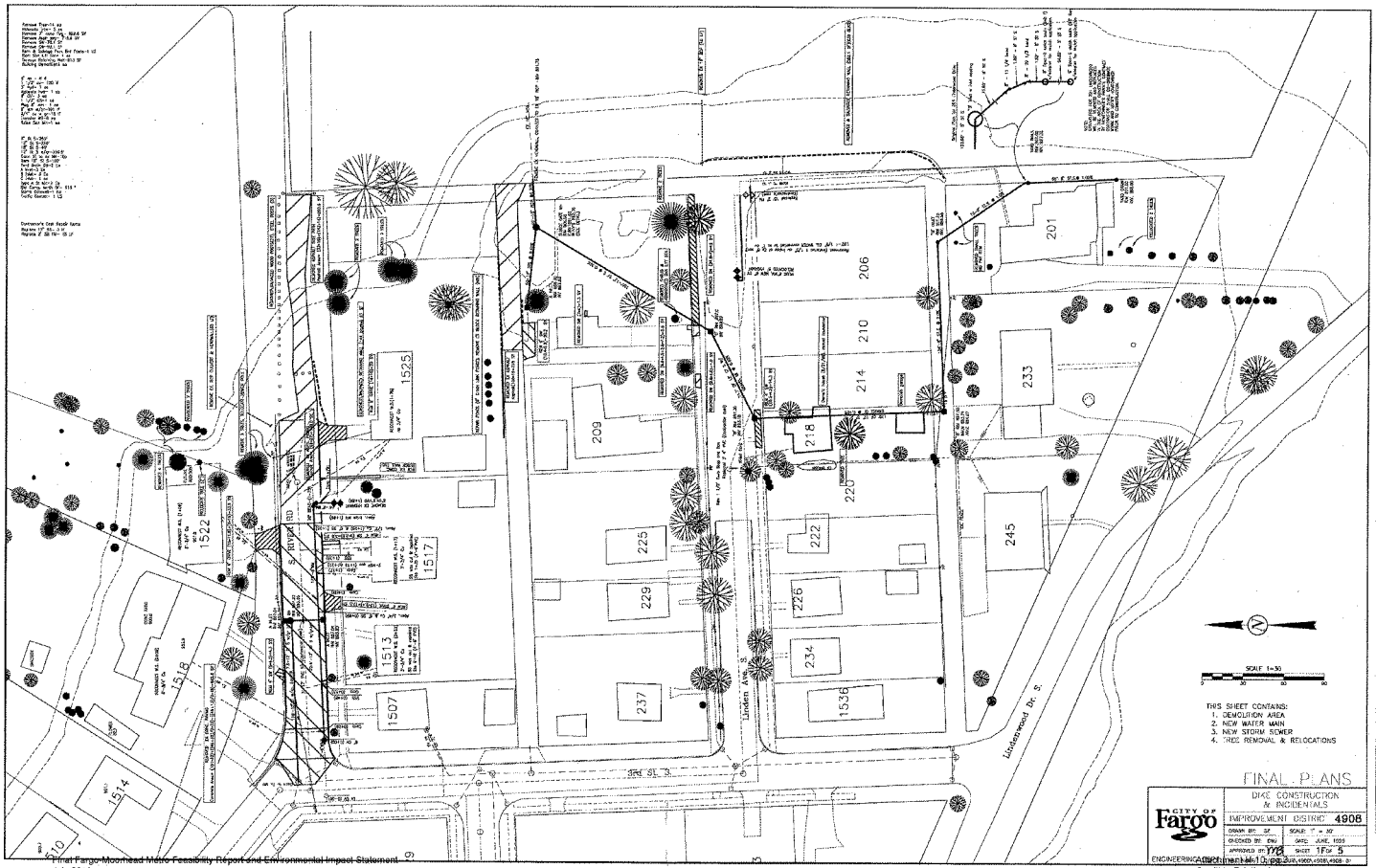
FINAL PLANS

IMPROVEMENT DIST. 4908

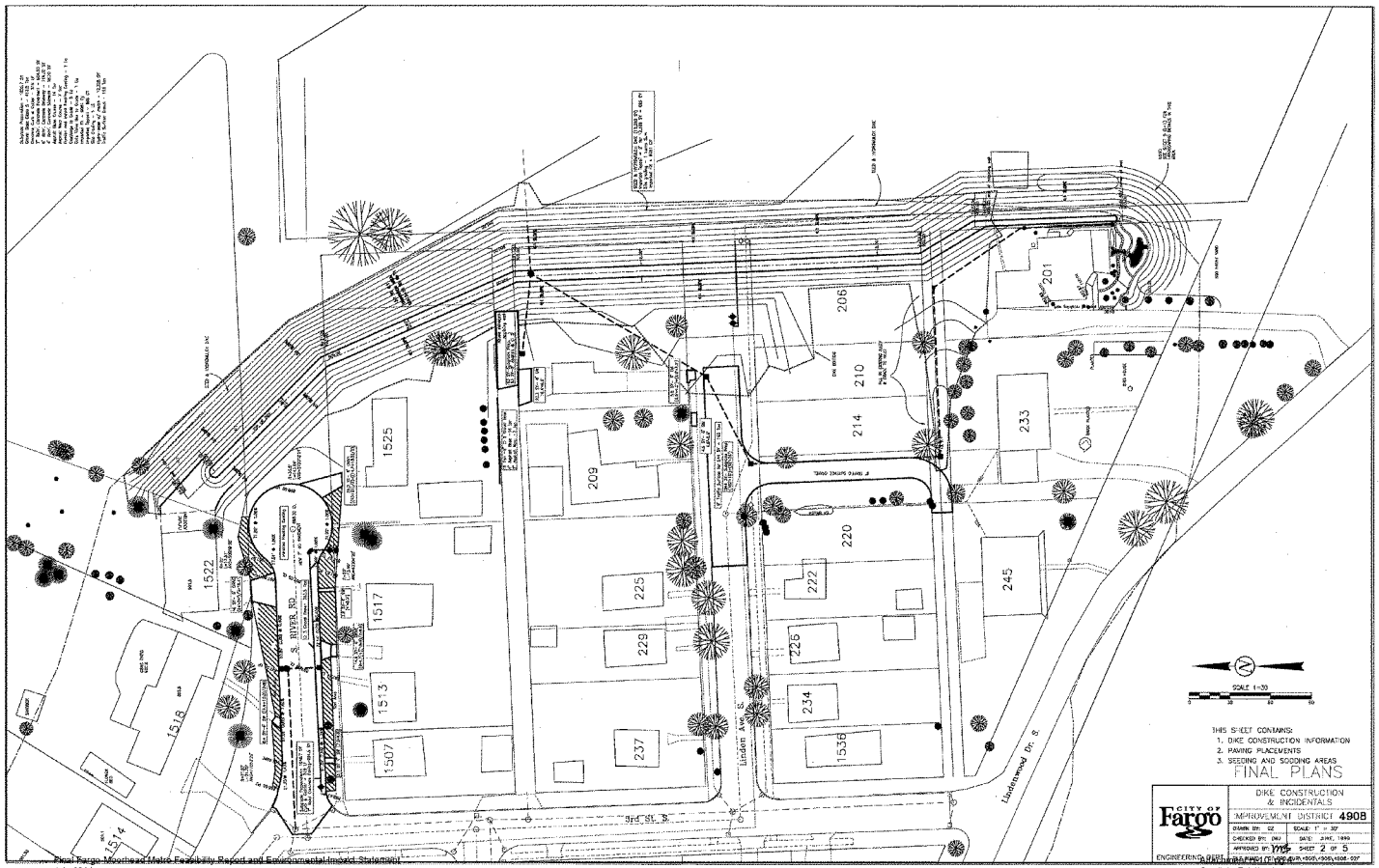
1999

FINAL AMOUNT: $337,084.00
PROJECT ENGINEER: DAVID W. JOHNSON
INSPECTOR: VARIOUS
CONTRACTOR: MASTER CONSTRUCTION CO., INC.

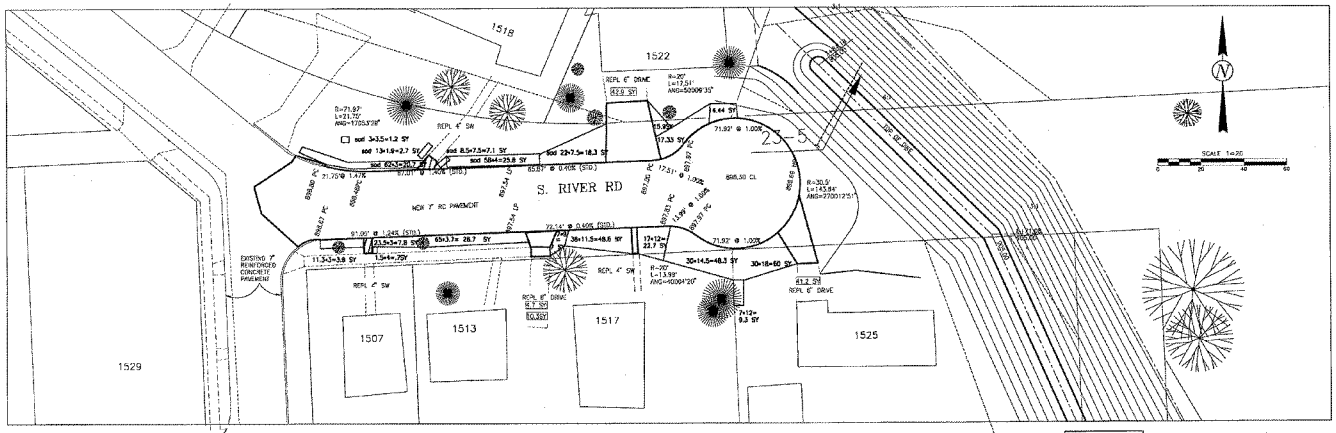
APPROVAL SIGNATURES	
City Engineer Signature ____ Date ____	Senior Engineer Signature ____ Date ____
Project Engineer/Manager Signature ____ Date ____	*I hereby certify that the attached plan, specification, or report was prepared by me or under my direct supervision and that I am a duly registered Professional Engineer under the laws of the State of North Dakota.*
Traffic Control Engineer Signature ____ Date ____	



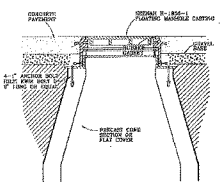
Credit to Existing Levees

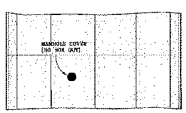


Credit to Existing Levees

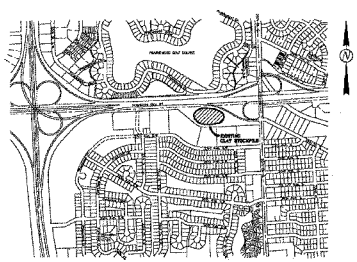


SOD-351.4



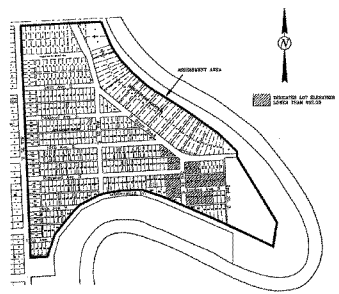


FLOATING MANHOLE COVER
N.T.S.



STOCKPILE LOCATION
N.T.S.

Note: Dakota Construction obtained the clay from their Moorhead Underground projects and did not use this stockpile.



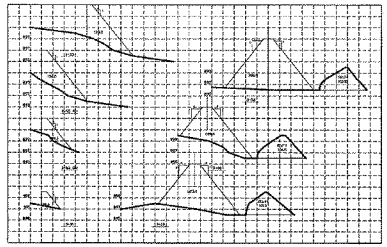
CITY OF FARGO
ENGINEERING DEPARTMENT
LOCATION & ASSESSMENT
DIKE CONSTRUCTION
& INCIDENTALS
IMPROVEMENT DISTRICT NO.4908

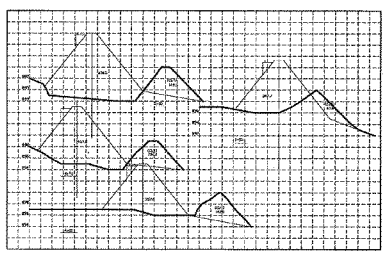
NOTE - THIS SHEET CONTAINS
1. PAVING IN SOUTH RIVER ROAD
2. ASSESSMENT DISTRICT
3. EXISTING CLAY STOCKPILE SITE
4. FLOATING CASTING DETAIL

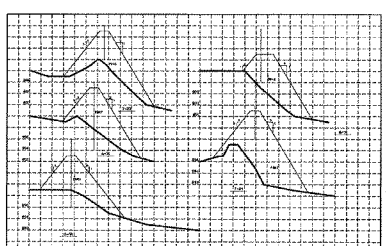
FINAL PLANS

CITY OF Fargo	DIKE CONSTRUCTION & INCIDENTALS
	IMPROVEMENT DISTRICT 4908
	DRAWN BY: CZ / SCALE: AS SHOWN
	CHECKED BY: DKU / DATE: JUNE, 1999
ENGINEERING DEPT.	SHEET 3 OF 5

Attachment 10 of 5
Ok-Mn to Existing Levees





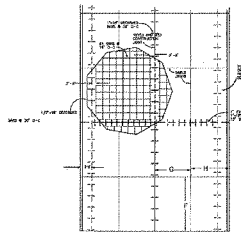


TYPICAL SECTIONS

N.T.S.

CONCRETE PAVEMENT WIDTH	BACK-BACK WIDTH	GRAVEL BASE WIDTH	SLAB THICKNESS	GRAVEL THICKNESS	PE CROSS SLOPE	DROWN HEIGHT ABOVE OR BELOW TOP OF CURB	PANEL HEIGHT	CENTER PANEL	OUTSIDE PANEL	UNDERLAYING FABRIC
(W/CROSS SLOPE)	(BUT GRAV)									
12'	31	30	5	6	3.0%	1/2" BELOW 1/2" ABOVE	12'	8'	7.5'	CNG, FABRIC
13'	33	30	5	6	3.0%	1/2" BELOW 1/2" ABOVE	12'	8'	8.0'	CNG, FABRIC
14'	35	30	5	6	3.0%	1/2" BELOW 1/2" ABOVE	12'	8'	8.5'	CNG, FABRIC
15'	37	30	5	6	3.0%	1/2" BELOW 1/2" ABOVE	12'	8'	9.0'	CNG, FABRIC
16'	39	30	5	6	3.0%	1/2" BELOW 1/2" ABOVE	12'	8'	9.5'	CNG, FABRIC
17'	41	30	5	6	3.0%	1/2" BELOW 1/2" ABOVE	12'	8'	10.0'	CNG, FABRIC
18'	43	30	5	6	3.0%	1/2" BELOW 1/2" ABOVE	12'	8'	10.5'	CNG, FABRIC

*NOTE: CENTER PANEL IS CENTERED ON 3/4, TOTAL OF 4-13' AND 1-11' PANELS

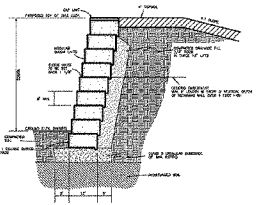


PLAN VIEW

PAVEMENT PROFILE

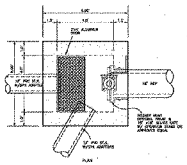
SOUTH RIVER ROAD
CONCRETE PAVEMENT SECTION

N.T.S.

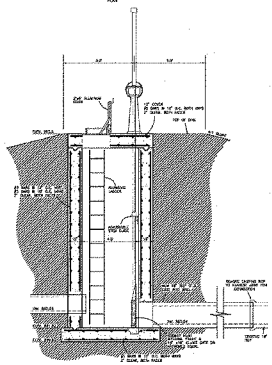


RETAINING WALL DETAIL

N.T.S.



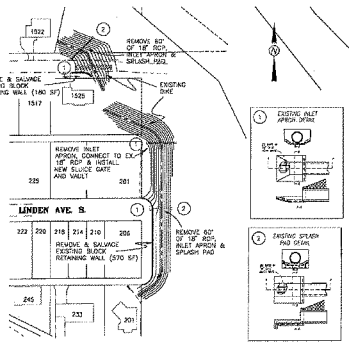
PLAN



PROFILE

SLUICE GATE VAULT DETAIL

N.T.S.



18" ST. S. AND RETAINING
WALL REMOVAL LOCATION MAP

N.T.S.

FINAL PLANS

DIKE CONSTRUCTION & INCIDENTALS

IMPROVEMENT DISTRICT 4908

CITY OF Fargo

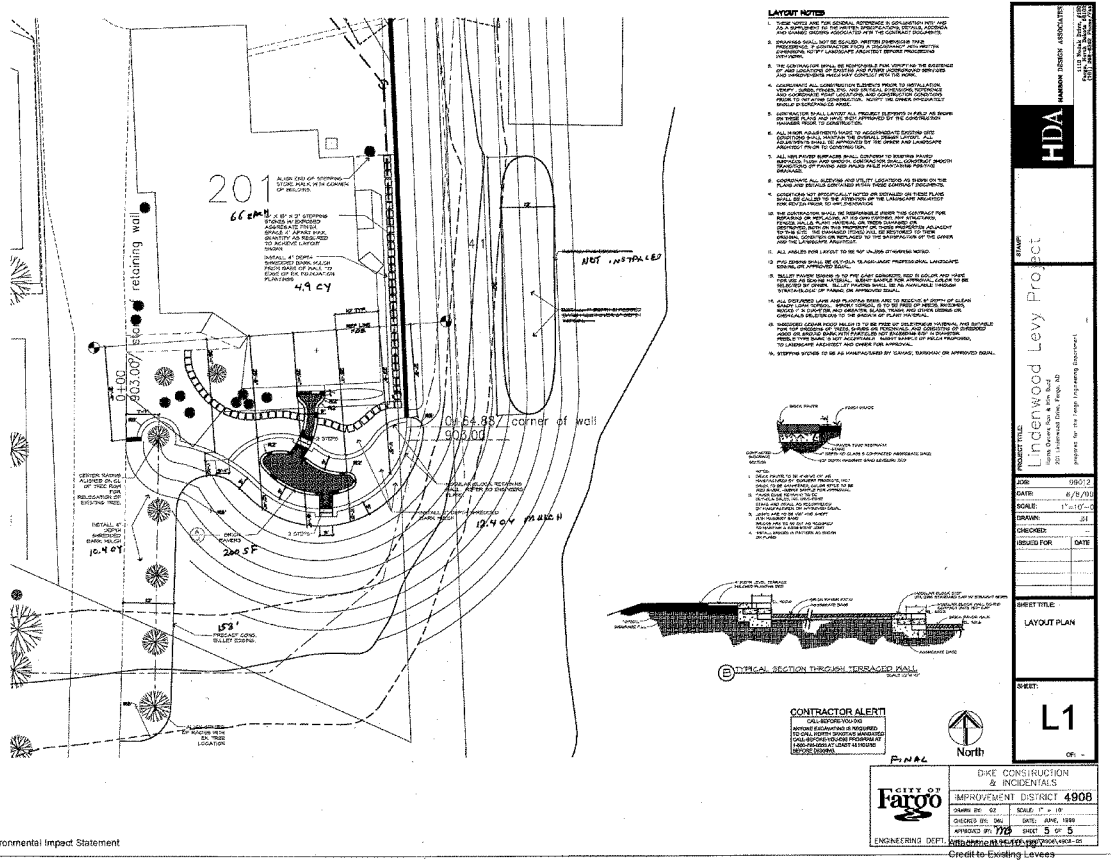
DRAWN: CC/SG/MJ | SCALE: AS SHOWN

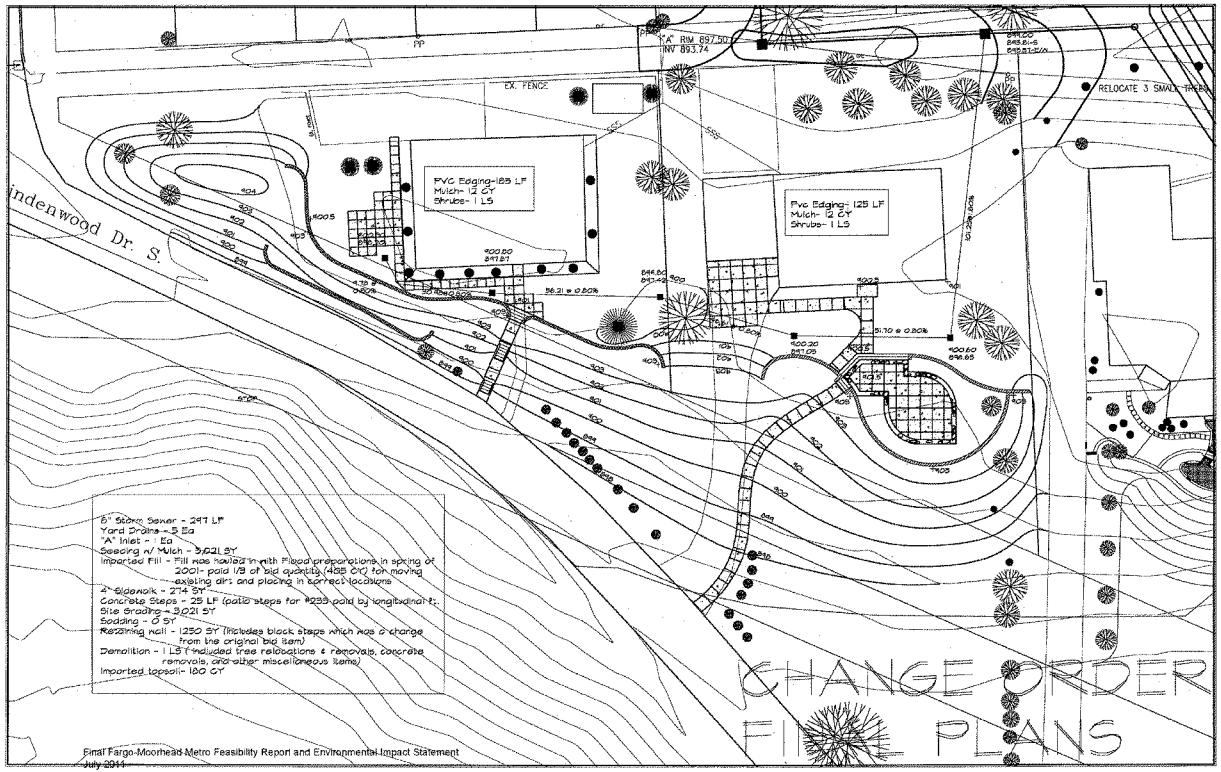
CHECKED BY: DWJ | DATE: JUNE, 1999

APPROVED BY: DWJ | SHEET 4 OF 5

ENGINEERING DEPARTMENT

Attachment 1320 pg 5


201
66 EACH
4.9 CY
NOT INSTALLED
0+00
903.00
stone retaining wall
0+64.88 corner of wall
903.00
12.4 CY MULCH
200 SF
10.4 CY
153'
LAYOUT NOTES
TYPICAL SECTION THROUGH TERRACED WALL
CONTRACTOR ALERT!
North
FINAL
HDA
HARMON DIESEN ASSOCIATES
Lindenwood Levy Project
JOB: 99012
DATE: 8/8/00
SCALE: 1"=10'-0
DRAWN: JH
CHECKED:
ISSUED FOR
DATE
SHEET TITLE
LAYOUT PLAN
SHEET:
L1
OF: -
DIKE CONSTRUCTION & INCIDENTALS
IMPROVEMENT DISTRICT 4908
CITY OF Fargo
ENGINEERING DEPT.
SCALE: 1" = 10'
DATE: JUNE, 1999
SHEET 5 OF 5


"A" RIM 897.50
INV 893.74
EX. FENCE
RELOCATE 3 SMALL TREES
PVC Edging-183 LF
Mulch- 12 CY
Shrubs- 1 LS
Pvc Edging- 125 LF
Mulch- 12 CY
Shrubs- 1 LS
indenwood Dr. S.
8" Storm Sewer - 297 LF
Yard Drains - 5 Ea
"A" Inlet - 1 Ea
Seeding w/ Mulch - 3,021 SY
Imported Fill - Fill was hauled in with Flood preparations in spring of 2001- paid 1/3 of bid quantity (408 CY) for moving existing dirt and placing in correct locations
2" Sidewalk - 274 SY
Concrete Steps - 25 LF (patio steps for #233 paid by longitudinal ft.)
Site Grading - 3,021 SY
Sodding - 0 SY
Retaining wall - 1250 SY (includes block steps which was a change from the original bid item)
Demolition - 1 LS (included tree relocations & removals, concrete removals, and other miscellaneous items)
Imported topsoil- 180 CY
CHANGE ORDER
FINAL PLANS

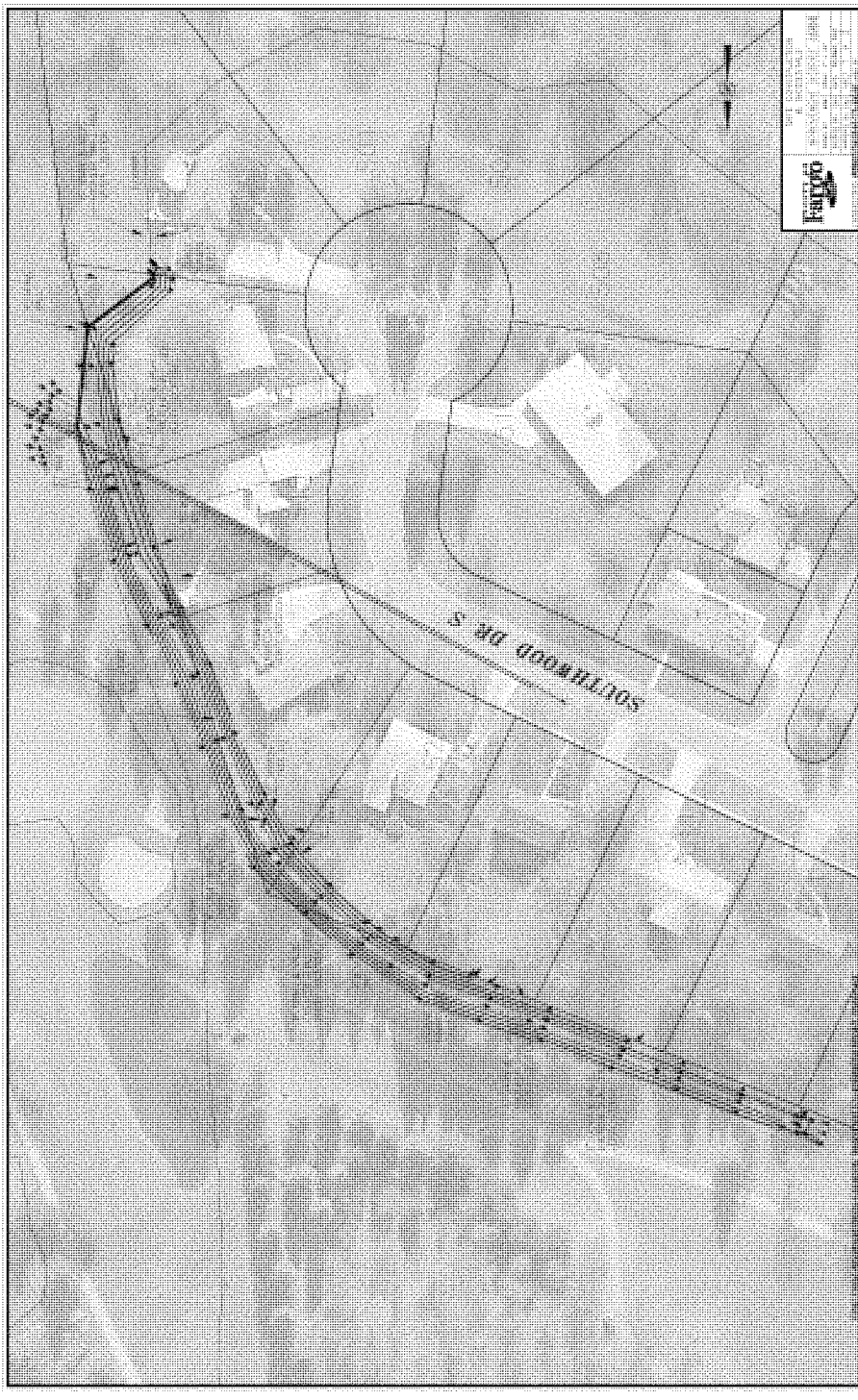
Attachment H-11: Southwood Drive Levee Information

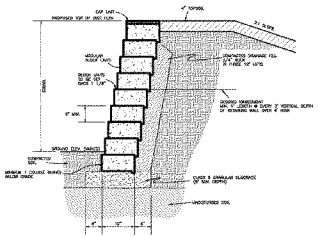
St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps of Engineers®

FMMFS_P2_geotech_2009-04.mxd
Printed 20 NOV 09

FMMFS: Credit to Existing Levees
Southwood Dirve, 4980 (Fargo)

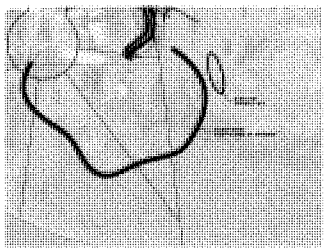
0 100 200 400 600 Feet





RETAINING WALL DETAIL
N.T.S.

BERM DETAIL
N.T.S.



SPECIAL INSTRUCTIONS FOR BIDDERS

DIKE CONSTRUCTION & INCIDENTALS

IMPROVEMENT DISTRICT NO. 4980

1. GENERAL

The City of Fargo Standard Specifications for Construction of Public Utilities (revised 3-2007) along with these Special Instructions shall govern the construction of the project.

2. CLEAR AND GRUB

This bid item provides for removal of small trees and brush along the dike location and the access route to the site. The bid item also includes trimming of any tree branches necessary for the earth dike installation. Specific small tree/bush removals are as follows:

A. 3 small trees/bushes at approx stationing 0+00.
B. 3 small trees/ bushes at approx station 6+50.
C. All or any bushes and small trees along the access route behind 503 Southwood Drive.

All material and debris shall become the property of the contractor and removed from the site.

3. REMOVE TREE

This bid item provides for removal of the larger trees identified on the plan sheet. Trees shall be removed to at least 6" below ground level and shall become the property of the contractor and removed from the site. Specifically these trees are as follows:

A. 1 tree at approx stationing 0+50.
B. 1 tree at approx stationing 2+50.
C. 3 trees at approx stationing 4+75.
D. 3 trees at approx stationing 5+00.
E. 1 tree at approx stationing 6+00.

4. RELOCATE TREE

This bid item provides for relocation of 3 smaller trees identified on the plan sheet (approx stationing 2+00). The trees shall be relocated to locations in the immediate area as designated by the engineer. Contractor shall use care in removal of these trees as they are close to the Magellan petroleum pipelines. Contractor shall notify Magellan Pipeline of this work prior to removal of these trees (Paul Klabunde – Magellan Pipeline 282-7134).

5. STRIP BLACK DIRT

6 inches of black dirt shall be stripped from the future dike location, temporarily stockpiled at the designated location shown on the plan sheet and a minimum of 4" of topsoil replaced on the dike following installation of the clay fill.

6. IMPORTED BLACK DIRT

This bid item is not a planned quantity but provides for additional topsoil in the event that not enough topsoil is salvaged during the stripping process. The imported topsoil will only be used when ordered by the Engineer.

7. IMPORTED FILL

The contractor shall obtain and provide clean clay fill suitable for dike construction. The material shall be clean fill, free of rocks and concrete debris and organic material. Material shall be compacted to 95% Proctor density. Bid quantities are based on the actual plan cross sections to construct the basic dike (1,755 CY) with no allowance for shrinkage and an additional 300 CY are included based on input from individual property owners. Some owners have indicated they would like additional clay installed on the dike adjacent to their properties to soften the dike appearance. Payment will be based on plan quantity for the base dike and actual calculated volumes based on the final landscaping selected for these properties.

8. BLOCK RETAINING WALL

The contractor shall install a modular block retaining wall at the location(s) designated on the plans or as directed by the engineer. Retaining walls higher than 4 feet shall have a geogrid anchoring system as per the detail shown on the plans. Block shall be approximately 16–18" wide, 6–8" tall and 12–18" deep. Wall caps shall be installed and included in the bid price. Approved manufacturers are Rockwood, Versa-Lok and Keystone. Contractor shall submit sample for approval prior to installation. Payment will be based on actual square feet of block installed.

9. 8" GATE VALVE

The shutoff valves shall be resilient wedge gate valve with an epoxy coating. The valve box shall be included and extended to the surface of the dike at the locations shown.

10. 8" DRAIN PIPE

8" drain pipe shall be schedule 40 or DR 26 PVC

11. REMOVE AND REPLACE FENCE

The existing 4' chain link fence shall be removed as shown on the plans. Existing fence posts shall be removed and the chain link fencing rolled back to allow for the dike construction. Following the dike installation, the fence posts shall be reinstalled and/or the fence shall be shortened as necessary and reinstalled on the existing fence poles.

12. ACCESS TO SITE

The route is shown on the detail sheet of the plans. Access to the site shall be off Southwood Drive, through lot 40, Southwood Addition and across the very rear of 503 Southwood Drive, and onto the Fargo Country Club. Any tree clearing and/or shrub removal necessary for this access route shall be included as part of the clear and grub bid item.

13. SEEDING WITH HYDRO-MULCH

This item provides for drill seeding followed by hydro-mulching to prevent soil erosion. Seeding shall be in accordance with Section 3100 of the City of Fargo Standard Specifications. Seed shall be Type B. It is anticipated that the seeding would be dormant seeded with no watering required. If seeding is not installed until next spring, seed would need to be watered in accordance with the Standard Specifications.

Quantities are estimated for the actual dike area and restoration of the access route (estimated to be approximately the same area as the actual dike). Payment will be based on actual field measurements. Access roads and other disturbed areas shall be tilled and leveled prior to seeding.

14. STORM WATER MANAGEMENT

Classification – The engineer has estimated that this project will result in a land disturbance or total amount of exposed erodible surface of less than 1 acre. Therefore, no NDPDES Permit is required. If the contractor feels that a disturbance of 1 acre or greater will be necessary to facilitate construction of the project, he must notify the engineer prior to commencing work, so that appropriate permit procedures may be followed (see Section 3300).

15. MAGELLAN GAS LINE

The Magellan Gas pipelines cross the construction site and is shown on the plan. Contractor shall exercise caution when excavating of crossing the pipelines. Contractor may be required to install temporary fill material over the pipelines to avoid any damage to the pipelines. Coordinate crossing with Magellan Pipelines.

16. XCEL POWER

Several power poles are currently located in the dike alignment. Xcel is evaluating options for removal of the poles and abandonment of a portion of this overhead line with underground installation of services an option. Contractor shall work with Xcel and coordinate their construction activity to ensure compaction around the poles. The poles will be removed following the dike construction under a separate agreement with Xcel.

17. COMPLETION

Dike construction shall be completed by December 15, 2007. Seeding and final cleanup shall be completed by May 15, 2008.

18. TRACKING MANAGEMENT

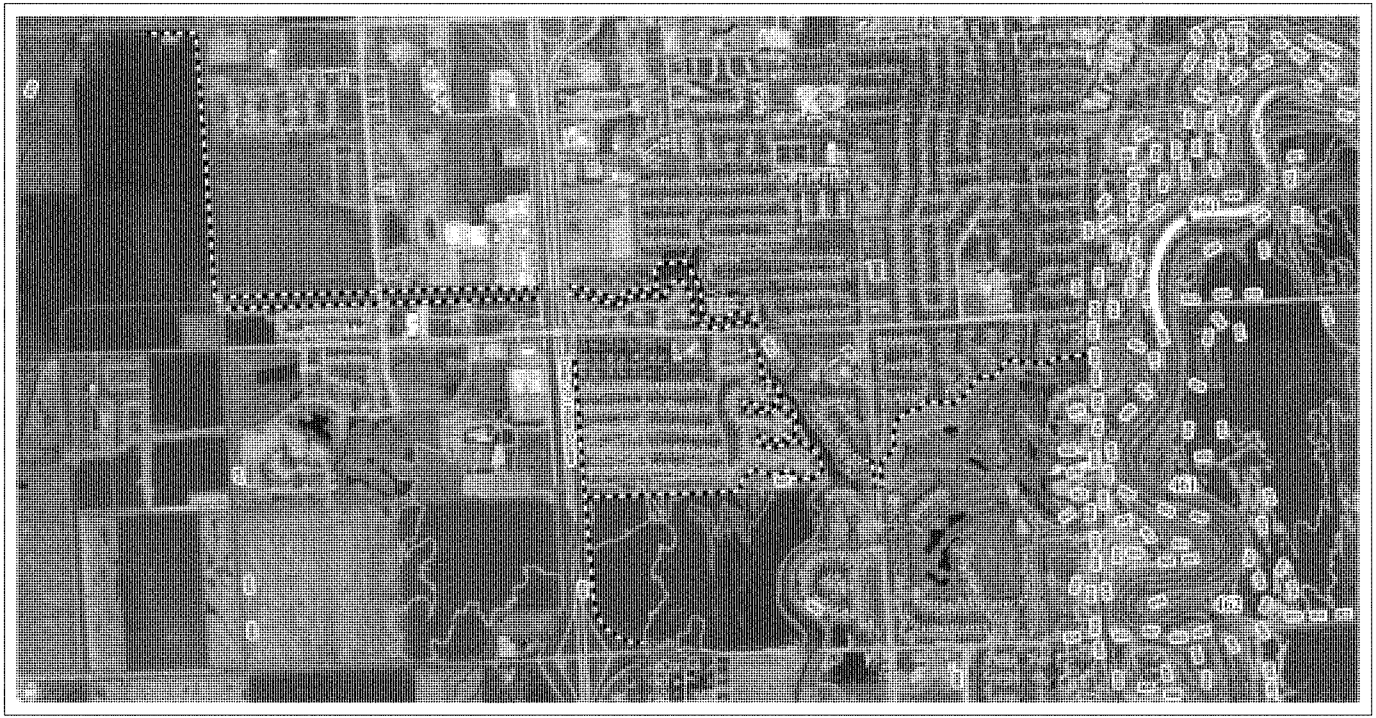
Streets and highways that are being used by the contractor and his forces to and from, as well as in the project site, shall be kept clean at all times for the duration of the project and at project completion. Only methods approved by the engineer shall be used to keep the streets clean.

19. FINAL INSPECTION

After the contractor has completed the installation of the public facility and any clean-up items, he shall make a written request to the engineer for a final inspection. Upon receipt of this request, the engineer will set a date and time for the final inspection. The final inspection request form is attached as part of these specifications.

CITY OF Fargo	DIKE CONSTRUCTION & INCIDENTALS
	IMPROVEMENT DISTRICT 4980
	DRAWN BY: DNN / SCALE: N.T.S.
	CHECKED BY: DAJ / DATE: OCTOBER, 2007
ENGINEERING DEPT.	APPROVED BY: DAJ / SHEET 2 OF 2
	FILE NAME: 1-4980-DIKE 8"

Attachment H-12: Drain 27 / Rose Coulee Levee Information



St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps of Engineers®

FMMFS_P2_geotech_2009-04.mxd
Printed 20 NOV 09

FMMFS: Credit to Existing Levees
Drain 27 / Rose Coulee, 5093 (Fargo)

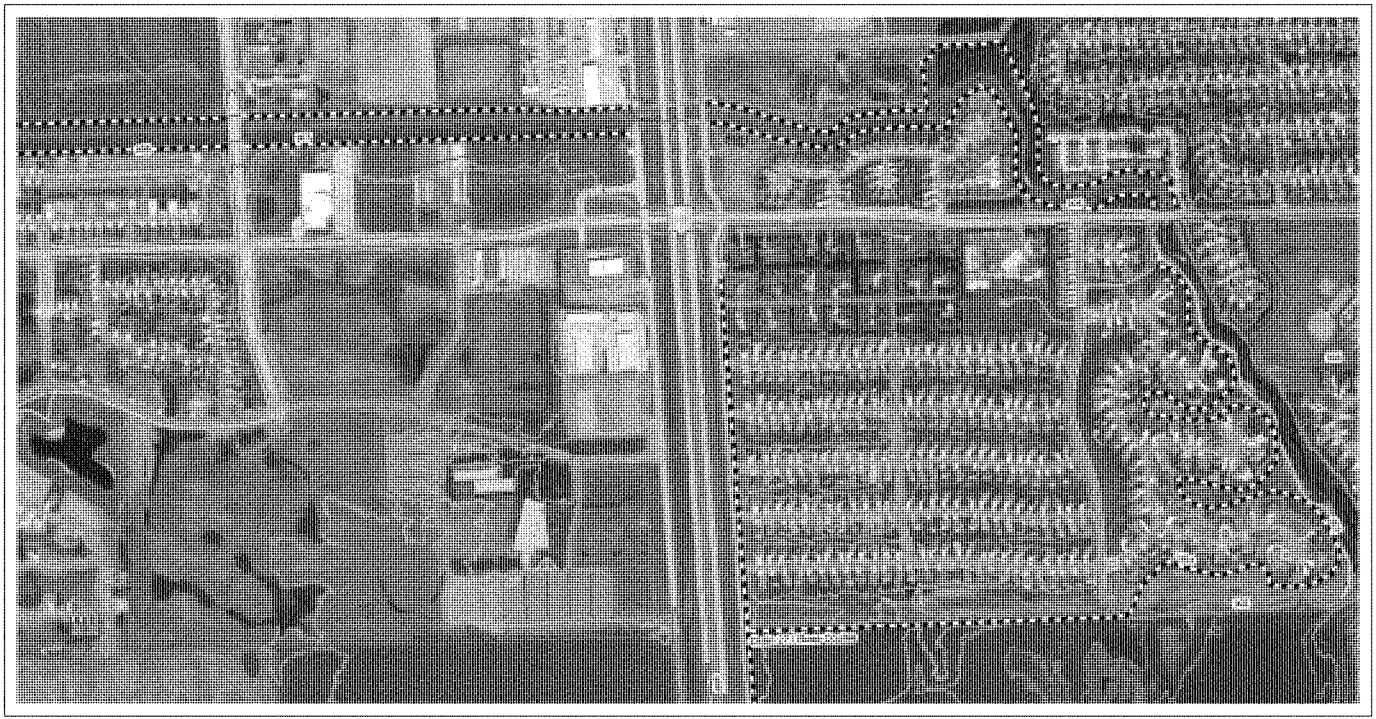
0 1,000 2,000 4,000 6,000 Feet

St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps of Engineers®

FMMFS_P2_geotech_2009-04.mxd
Printed 20 NOV 09

FMMFS: Credit to Existing Levees
Drain 27 / Rose Coulee, 5093 (Fargo)

0 250 500 1,000 1,500
Feet



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FMMFS_P2_geotech_2009-04.mxd
Printed 20 NOV 09

FMMFS: Credit to Existing Levees
Drain 27 / Rose Coulee, 5093 (Fargo)

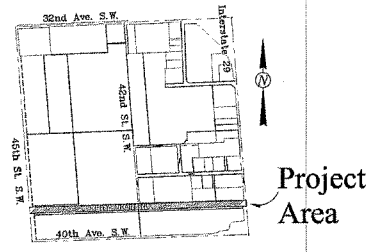
0 250 500 1,000 1,500
Feet

PLANS FOR

DRAIN IMPROVEMENTS & INCIDENTALS

ENGINEERING DEPARTMENT

CITY OF Fargo

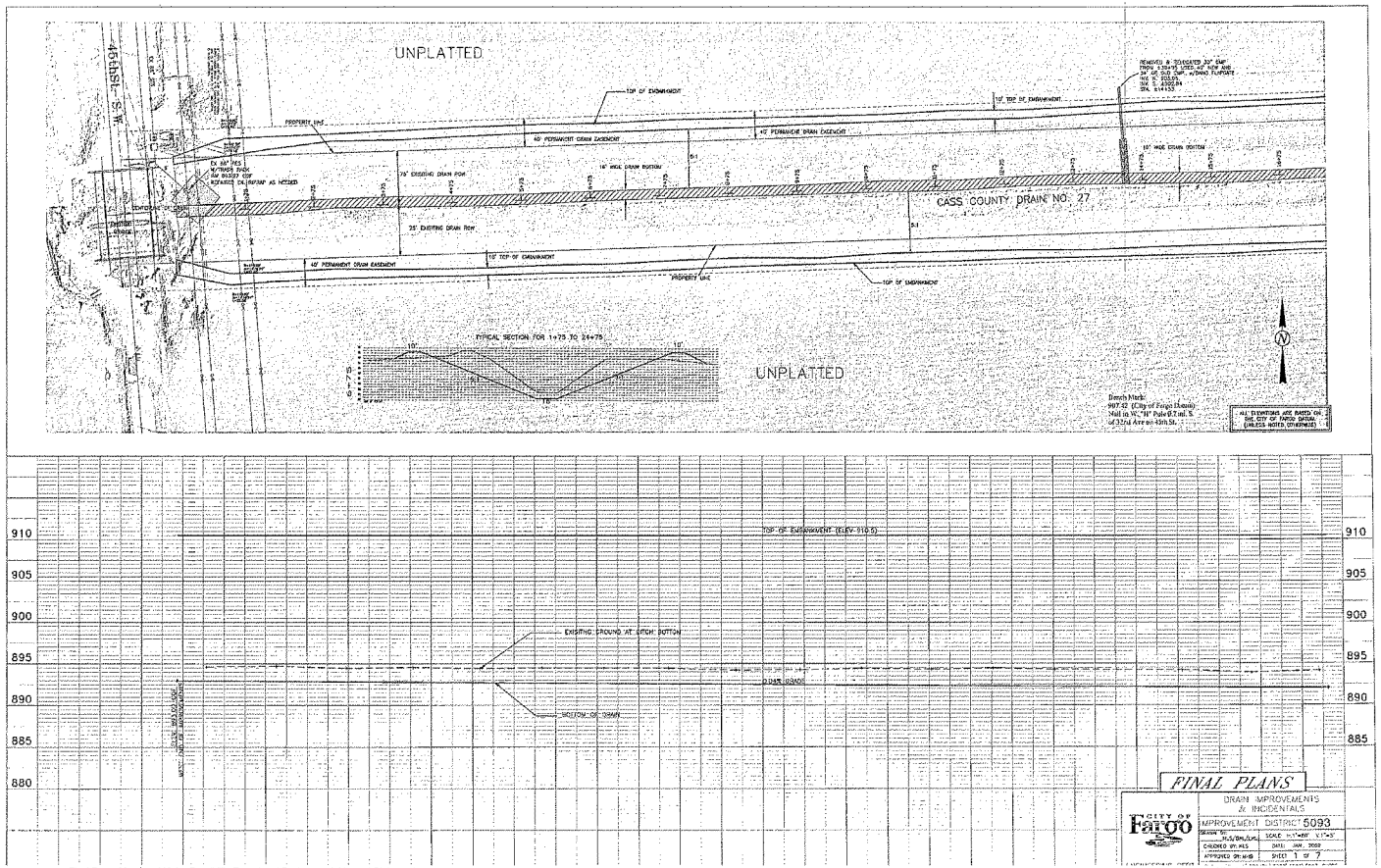


FINAL PLANS

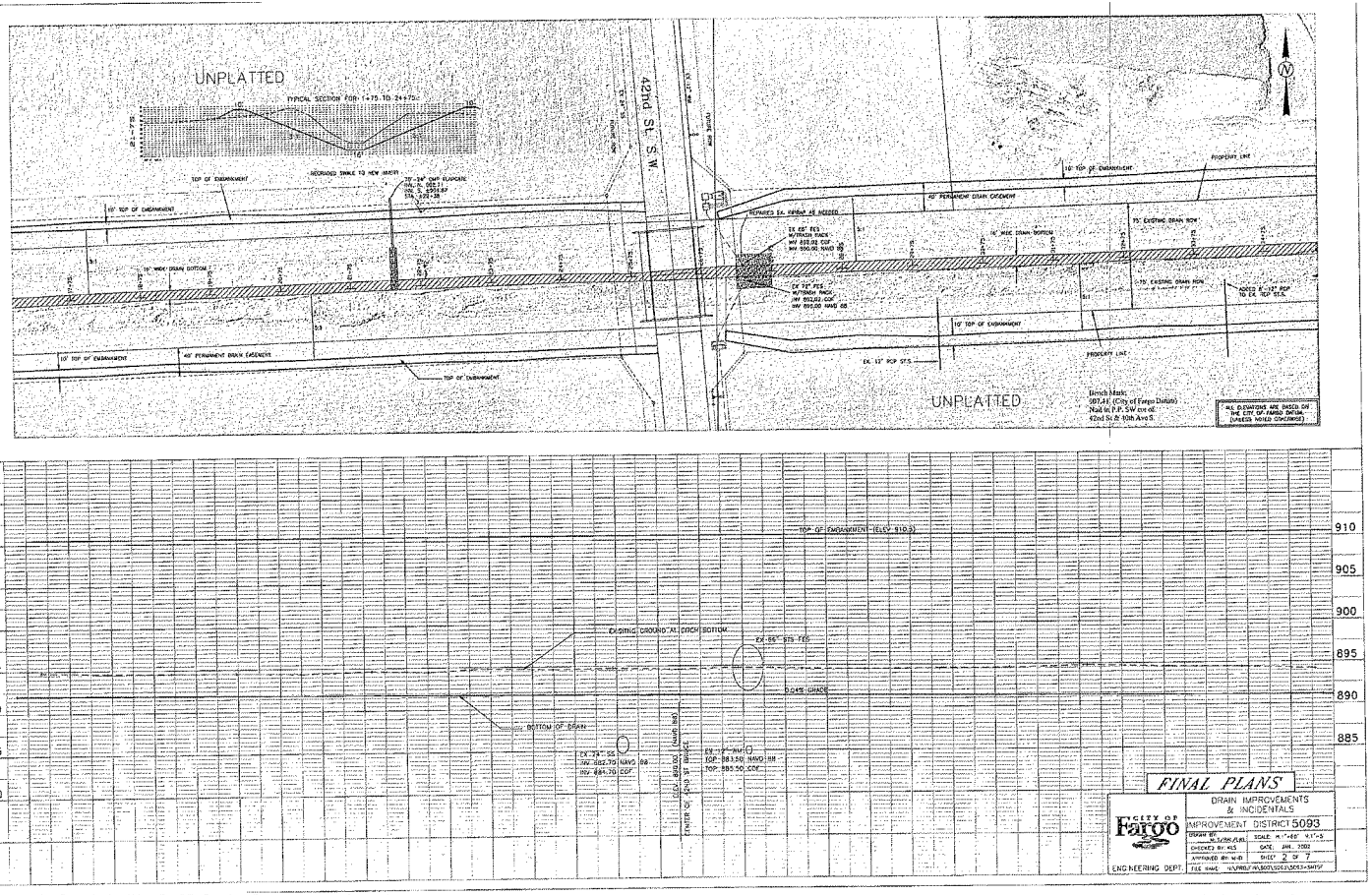
IMPROVEMENT DIST. 5093

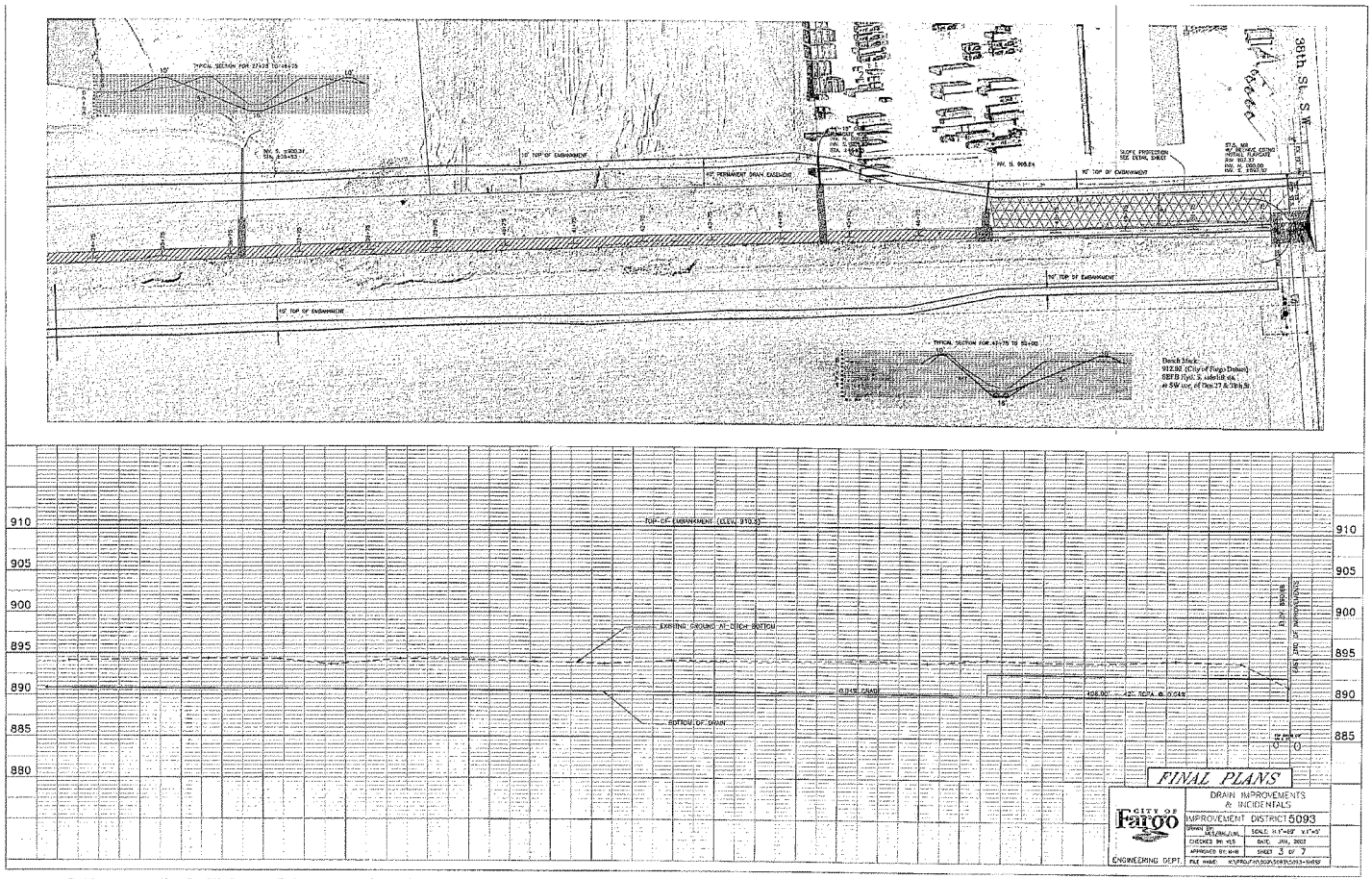
FINAL AMOUNT: $542,762.85
PROJECT ENGINEER: KRISTY L. SCHMIDT
INSPECTOR: LEE LUDWIG
CONTRACTOR: WANZEK

2002



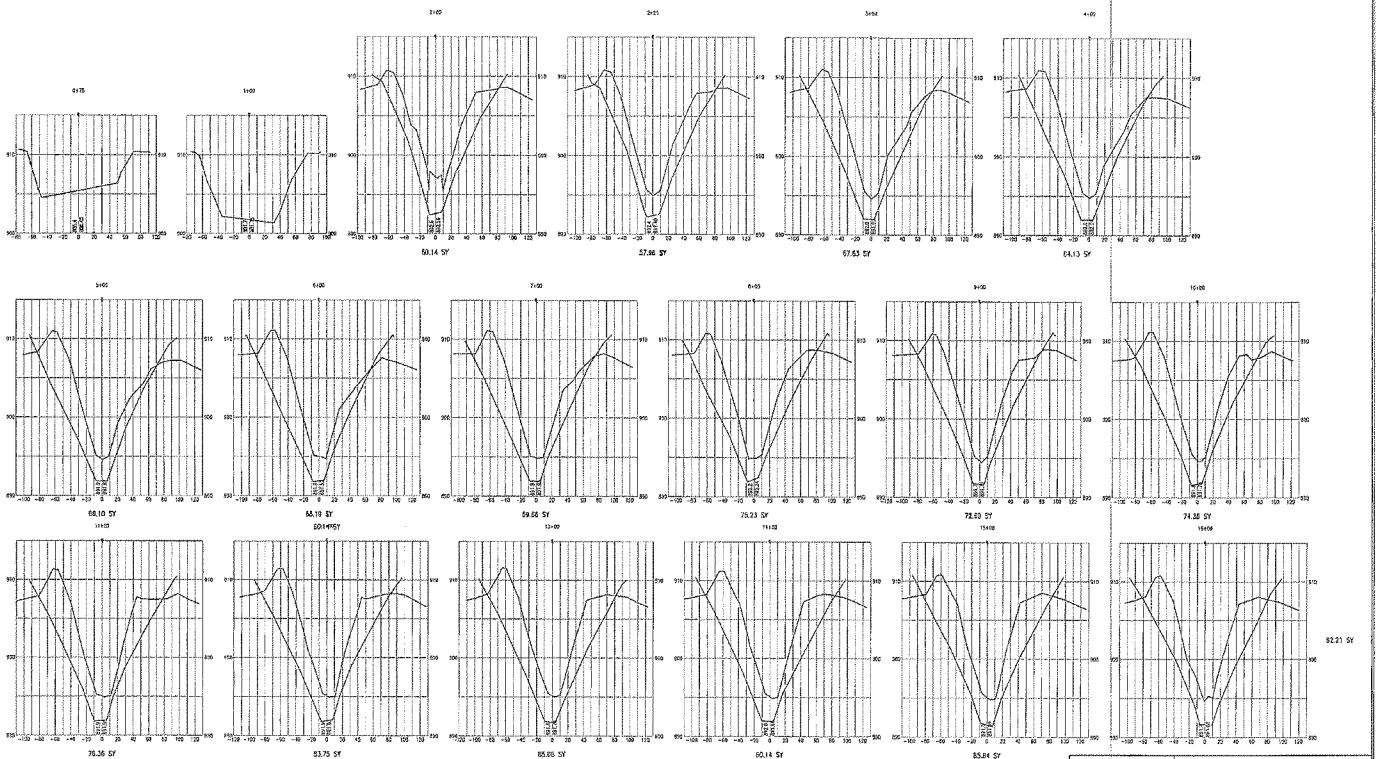
Attachment H-12, pg 5
Credit to Existing Levees


UNPLATTED
TYPICAL SECTION FOR: 1+75 TO 24+75
42nd St. S.W.
TOP OF EMBANKMENT
10' TOP OF EMBANKMENT
40' PERMANENT DRAIN EASEMENT
10' WIDE DRAIN BOTTOM
PROPERTY LINE
UNPLATTED
Bench Mark:
907.41 (City of Fargo Datum)
Nail in P.P. SW cor of
42nd St & 40th Ave S
ALL ELEVATIONS ARE BASED ON THE CITY OF FARGO DATUM (UNLESS NOTED OTHERWISE)
910
905
900
895
890
885
880
TOP OF EMBANKMENT (ELEV 910.5)
EXISTING GROUND AT DITCH BOTTOM
EX 66" STS FES
0.04% GRADE
BOTTOM OF DRAIN
EX 24" SS
INV 882.70 NAVD 88
INV 884.70 CCF
EX 12" WM
TOP 883.50 NAVD 88
TOP 885.50 CCF
FINAL PLANS
DRAIN IMPROVEMENTS & INCIDENTALS
IMPROVEMENT DISTRICT 5093
CITY OF Fargo
ENGINEERING DEPT.
SHEET 2 OF 7



Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011

Attachment H-12, pg 7
Credit to Existing Levees



FINAL DRAFT

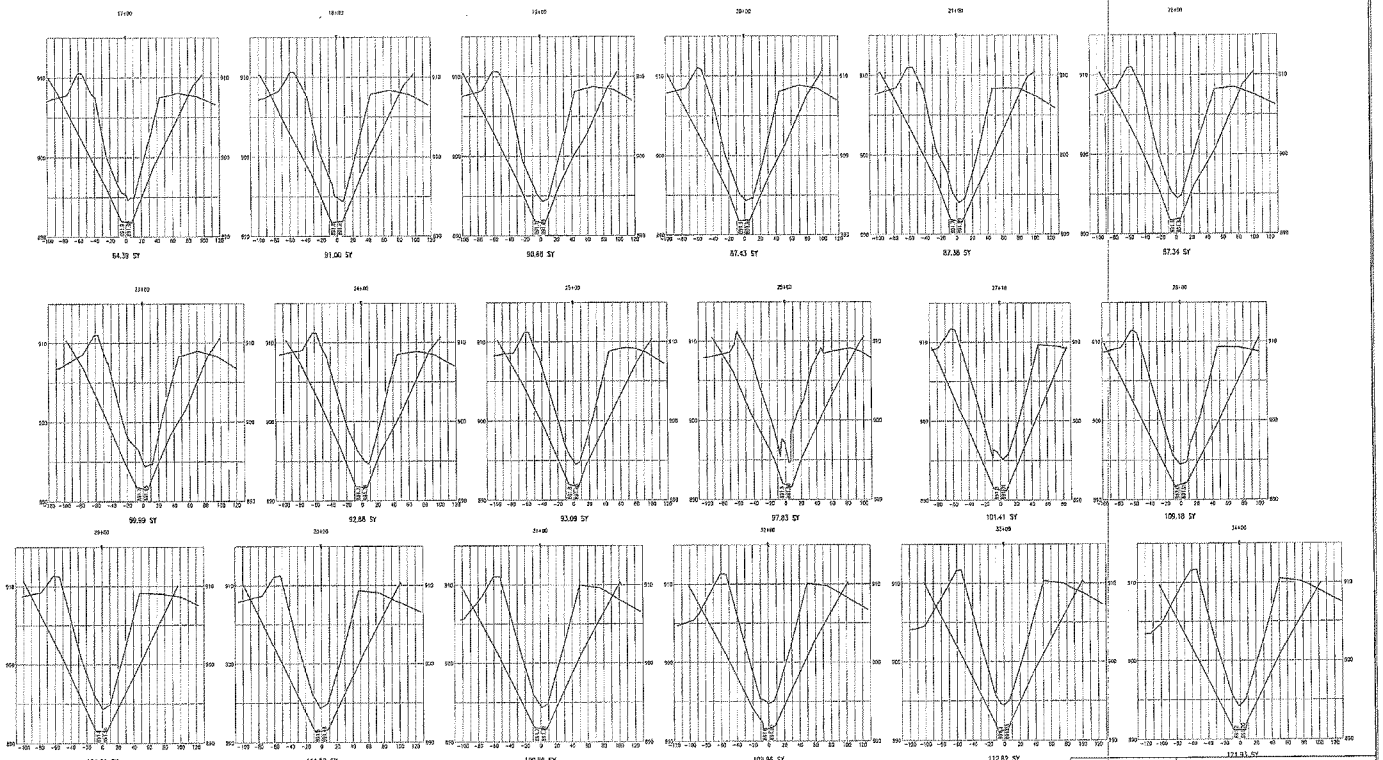
CITY OF Fargo

DRAIN IMPROVEMENTS & INCIDENTALS

IMPROVEMENT DISTRICT 5093

DRAWN BY: LWL	SCALE: NTS
CHECKED BY: KLS	DATE: JAN., 2002
APPROVED BY: MHD	SHEET 4 OF 7

Attachment H-12, pg 8
Credit to Existing Levees

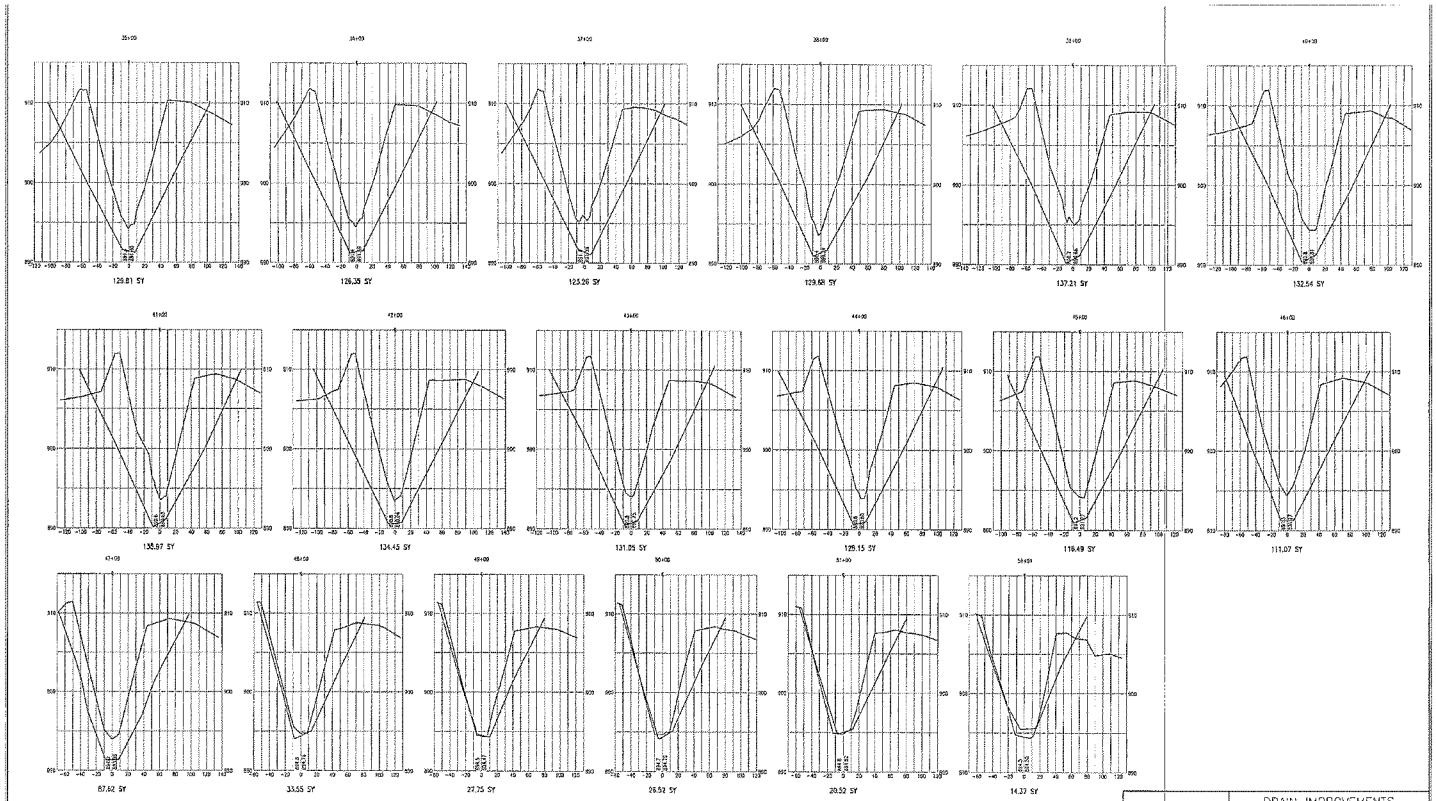


FINAL PLANS

CITY OF Fargo

DRAIN IMPROVEMENTS & INCIDENTALS	
IMPROVEMENT DISTRICT 5093	
DRAWN BY: LWL	SCALE: NTS
CHECKED BY: RLS	DATE: JAN. 2002
APPROVED BY: MHB	SHEET 5 OF 7

Attachment H-12, pg 9
Credit to Existing Levees



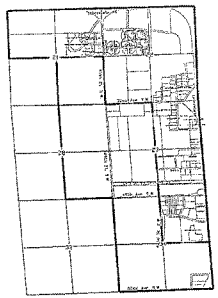
FINAL PLANS

CITY OF Fargo
ENGINEERING DEPT.

DRAIN IMPROVEMENTS & INCIDENTALS

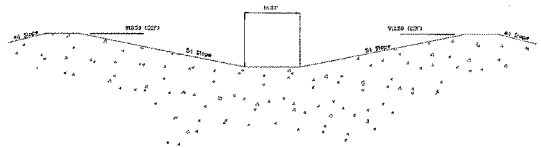
IMPROVEMENT DISTRICT 5093

DRAWN BY: LML	SCALE: NTS
CHECKED BY: KLS	DATE: JAN. 2002
APPROVED BY: MHB	SHEET 6 OF 7
FILE NAME: N:\PROJFIN\5000\5093\5093-XSECT	

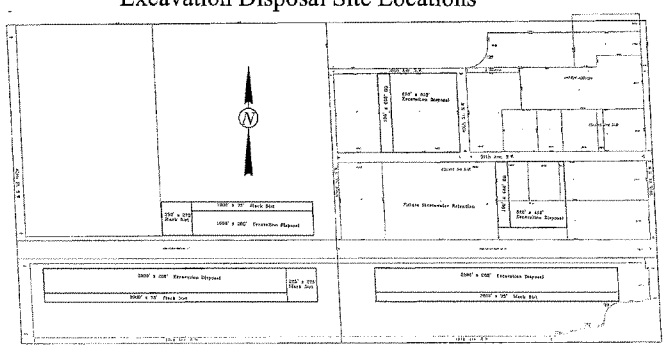


CITY OF FARGO
ENGINEERING DEPARTMENT
LOCATION AND ASSESSMENT
DRAIN IMPROVEMENTS & INCIDENTALS
IMPROVEMENT DISTRICT NO. 5093

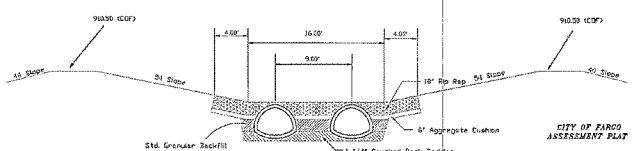
Open Channel



Excavation Disposal Site Locations



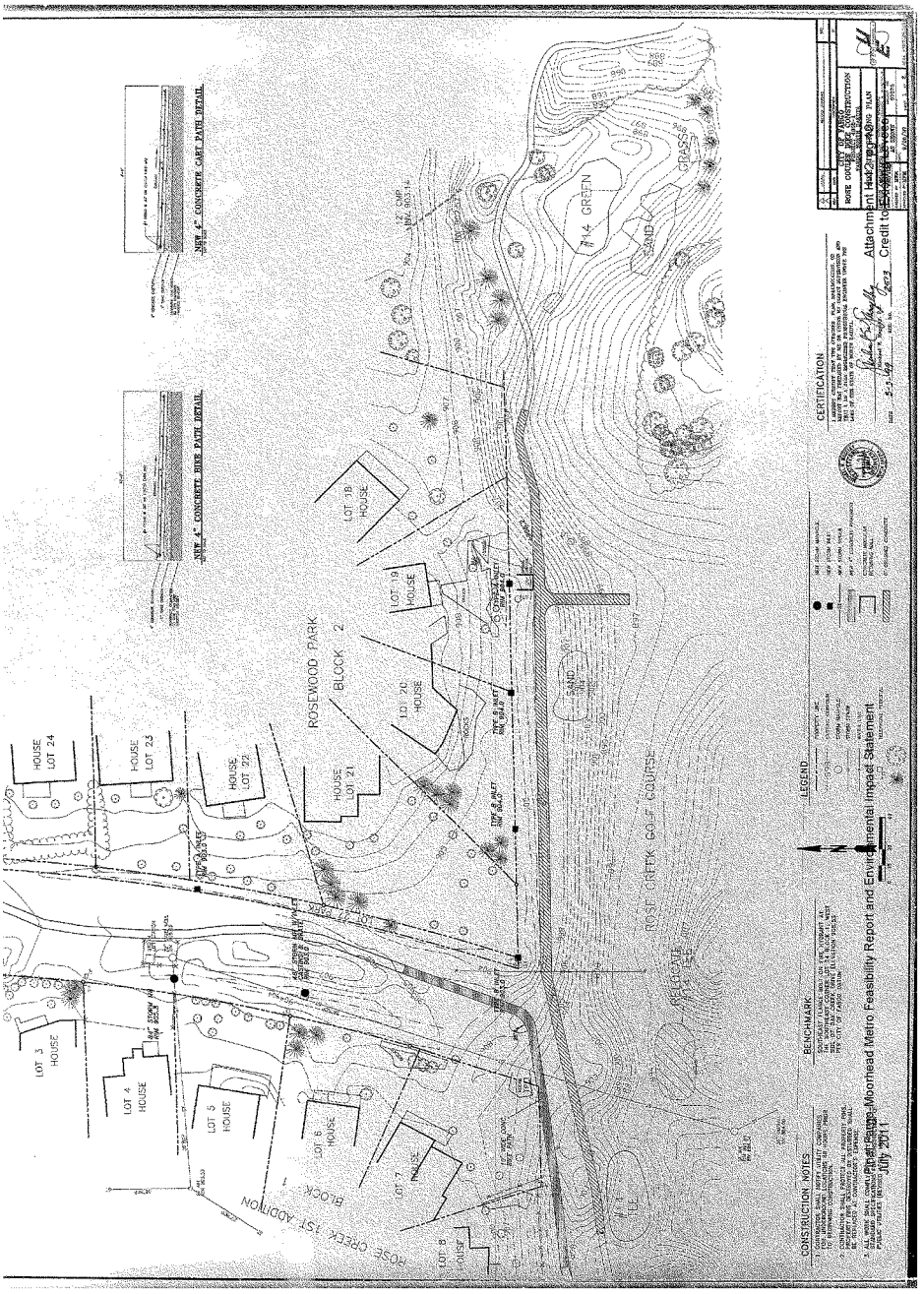
Open Channel w/ Double Pipe

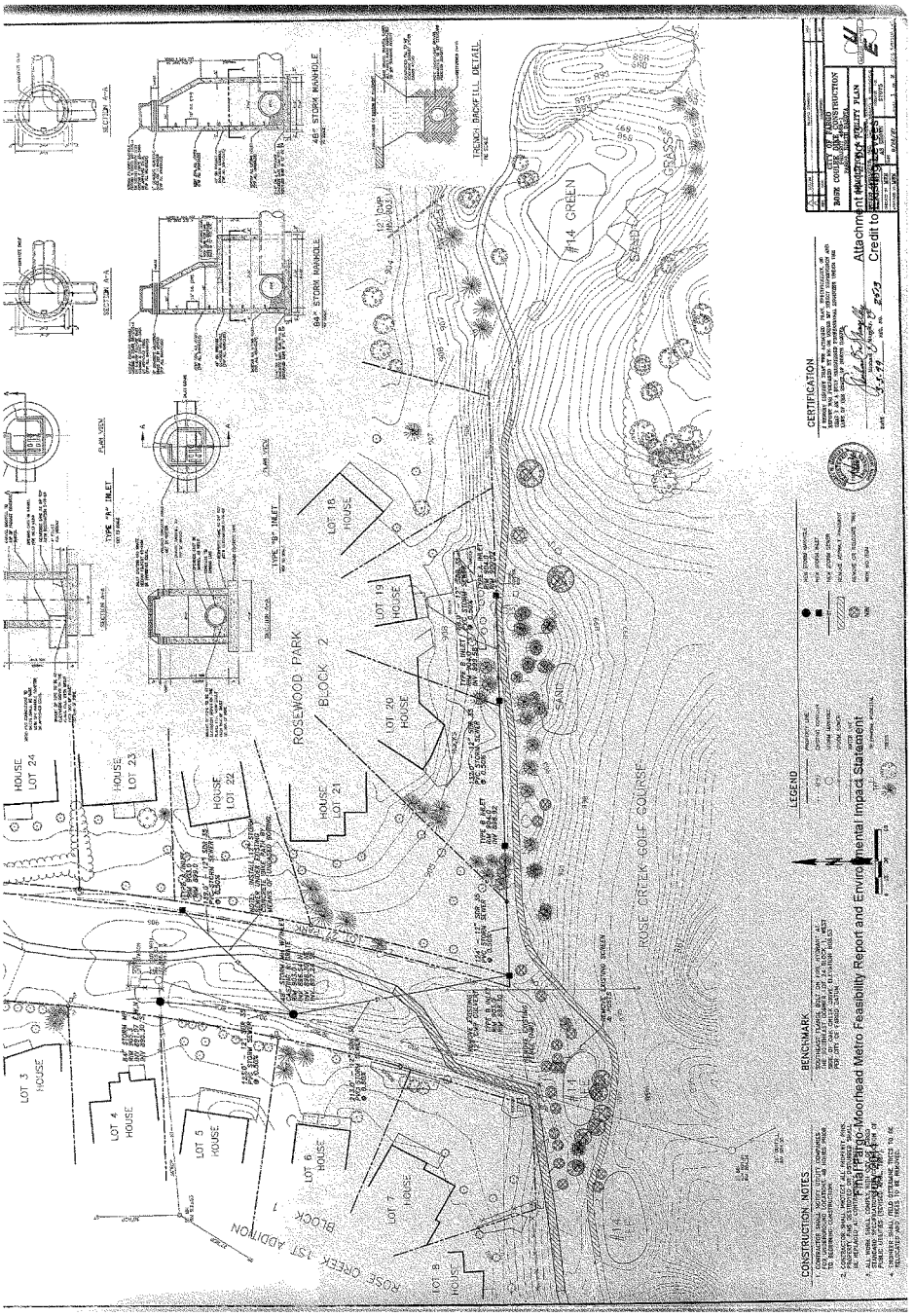


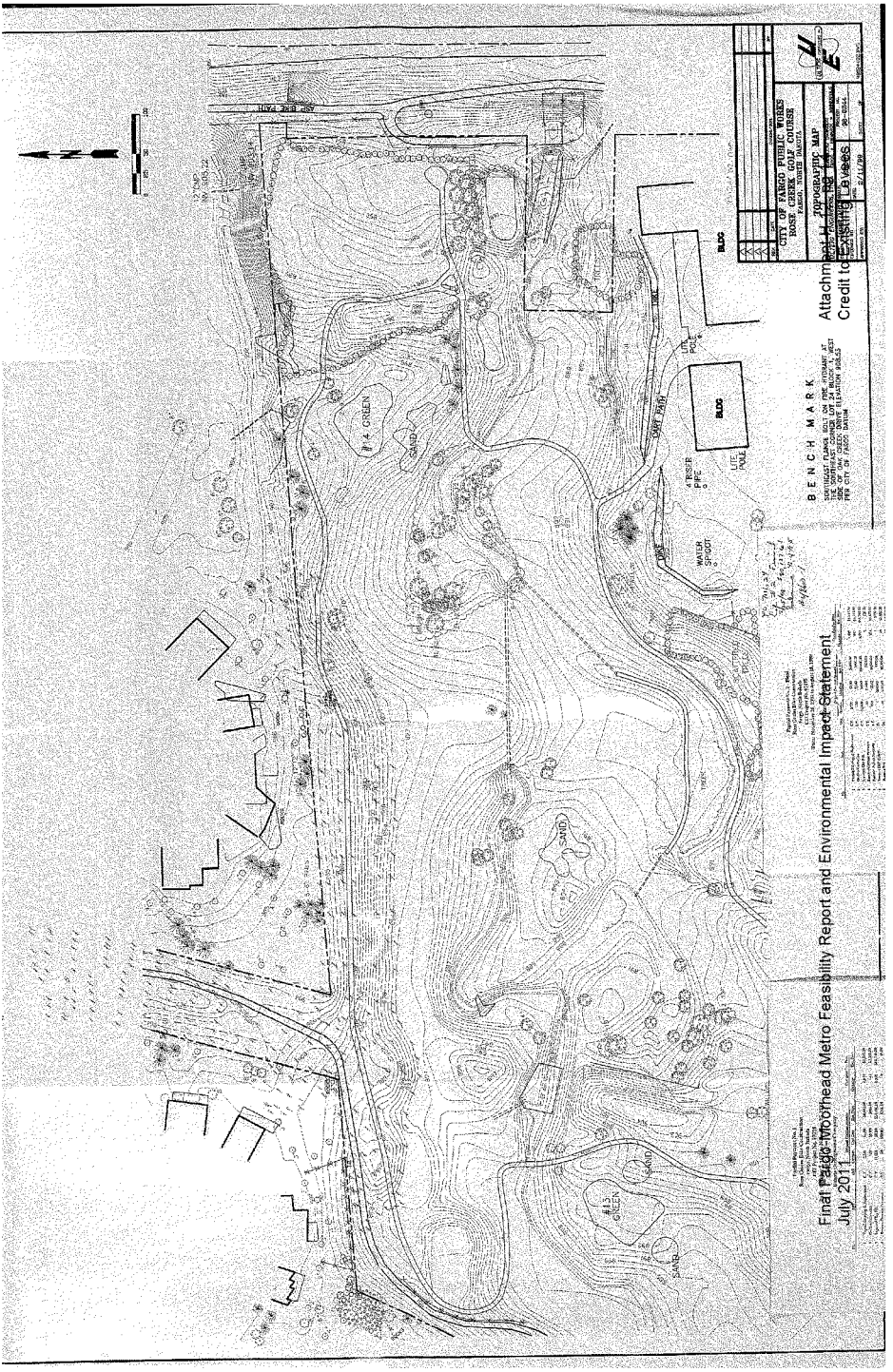
CITY OF FARGO
ASSESSMENT PLAT

DRAIN IMPROVEMENTS
AND INCIDENTALS

IMPROVEMENT DISTRICT NO. 5093


NEW 4" CONCRETE CART PATH DETAIL
NEW 4" CONCRETE BIKE PATH DETAIL
ROSEWOOD PARK
BLOCK 2
ROSE CREEK GOLF COURSE
ROSE CREEK 1ST ADDITION
BLOCK 1
LOT 3 HOUSE
LOT 4 HOUSE
LOT 5 HOUSE
LOT 6 HOUSE
LOT 7 HOUSE
LOT 8 HOUSE
LOT 18 HOUSE
LOT 19 HOUSE
LOT 20 HOUSE
HOUSE LOT 21
HOUSE LOT 22
HOUSE LOT 23
HOUSE LOT 24
#14 GREEN
SAND
GRASS
CONSTRUCTION NOTES
BENCHMARK
LEGEND
CERTIFICATION
Final Range-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Attachment Hwy 2 Grading Plan
Credit to Existing Levees


ROSE CREEK 1ST ADDITION
BLOCK 1
ROSEWOOD PARK
BLOCK 2
ROSE CREEK GOLF COURSE
LOT 3 HOUSE
LOT 4 HOUSE
LOT 5 HOUSE
LOT 6 HOUSE
LOT 7 HOUSE
LOT 8 HOUSE
LOT 18 HOUSE
LOT 19 HOUSE
LOT 20 HOUSE
HOUSE LOT 21
HOUSE LOT 22
HOUSE LOT 23
HOUSE LOT 24
#14 GREEN
SAND
GRASS
TYPE "A" INLET
TYPE "B" INLET
48" STORM MANHOLE
84" STORM MANHOLE
TRENCH BACKFILL DETAIL
SECTION A-A
PLAN VIEW
CONSTRUCTION NOTES
BENCHMARK
LEGEND
CERTIFICATION
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
Attachment
Credit to Existing Levees


Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Attachment H-17-Rg-14
Credit to Existing Levees
CITY OF FARGO PUBLIC WORKS
ROSE CREEK GOLF COURSE
FARGO, NORTH DAKOTA
TOPOGRAPHIC MAP
BENCH MARK
SOUTHEAST FLANGE BOLT ON FIRE HYDRANT AT THE SOUTHEAST CORNER LOT 24 BLOCK 1, WEST SIDE OF OAK CREEK DRIVE ELEVATION 908.53 PER CITY OF FARGO DATUM
#14 GREEN
#15 GREEN
SAND
BLDG
CART PATH
LITE POLE
4" RISER PIPE
WATER SPIGOT
DIKE
ASP BIKE PATH

RECORD DRAWINGS
FOR
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS

FARGO, NORTH DAKOTA
IMPROVEMENT DISTRICT NO. 4556-1
UEI PROJECT NO. 00-0093

LOCATION MAP

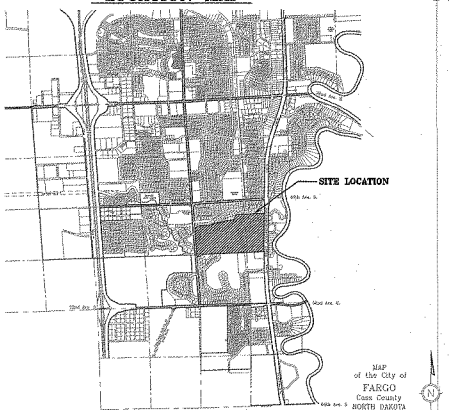


TABLE OF CONTENTS

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1	OVERALL LAYOUT EXISTING CONDITIONS
2	OVERALL LAYOUT PROPOSED IMPROVEMENTS
3	EXISTING CONDITIONS/DEMOLITION PLAN
4	EXISTING CONDITIONS/DEMOLITION PLAN
5	EXISTING CONDITIONS/DEMOLITION PLAN
6	EXISTING CONDITIONS/DEMOLITION PLAN
7	EXISTING CONDITIONS/DEMOLITION PLAN
8	EXISTING CONDITIONS/DEMOLITION PLAN
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10	PROPOSED IMPROVEMENTS
11	PROPOSED IMPROVEMENTS
12	PROPOSED IMPROVEMENTS
13	PROPOSED IMPROVEMENTS
14	PROPOSED IMPROVEMENTS
15	PROPOSED IMPROVEMENTS
16	PROPOSED IMPROVEMENTS
17	CART PATH BRIDGE PLAN & DETAILS
18	DETAILS
19	DETAILS
20	DETAILS
21	TURF REINFORCEMENT, SEEDING & SODDING PLAN
22	IRRIGATION SYSTEM REVISIONS

CITY OF Fargo

I HEREBY CERTIFY THAT THE ATTACHED PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF NORTH DAKOTA.

DATE _____ REG. NO. _____

APPROVAL OF CITY ENGINEER

I MARK BETTNER, P.E., CITY ENGINEER FOR THE CITY OF FARGO, NORTH DAKOTA, HEREBY APPROVE THESE PLANS FOR DRAIN 27/ROSE COULEE IMPROVEMENTS AND INCIDENTALS IMPROVEMENT DISTRICT NO. 4556-1, FARGO, NORTH DAKOTA AS SHOWN ON THE ACCOMPANYING PLANS.

MARK BETTNER, P.E.
CITY ENGINEER
FARGO, NORTH DAKOTA

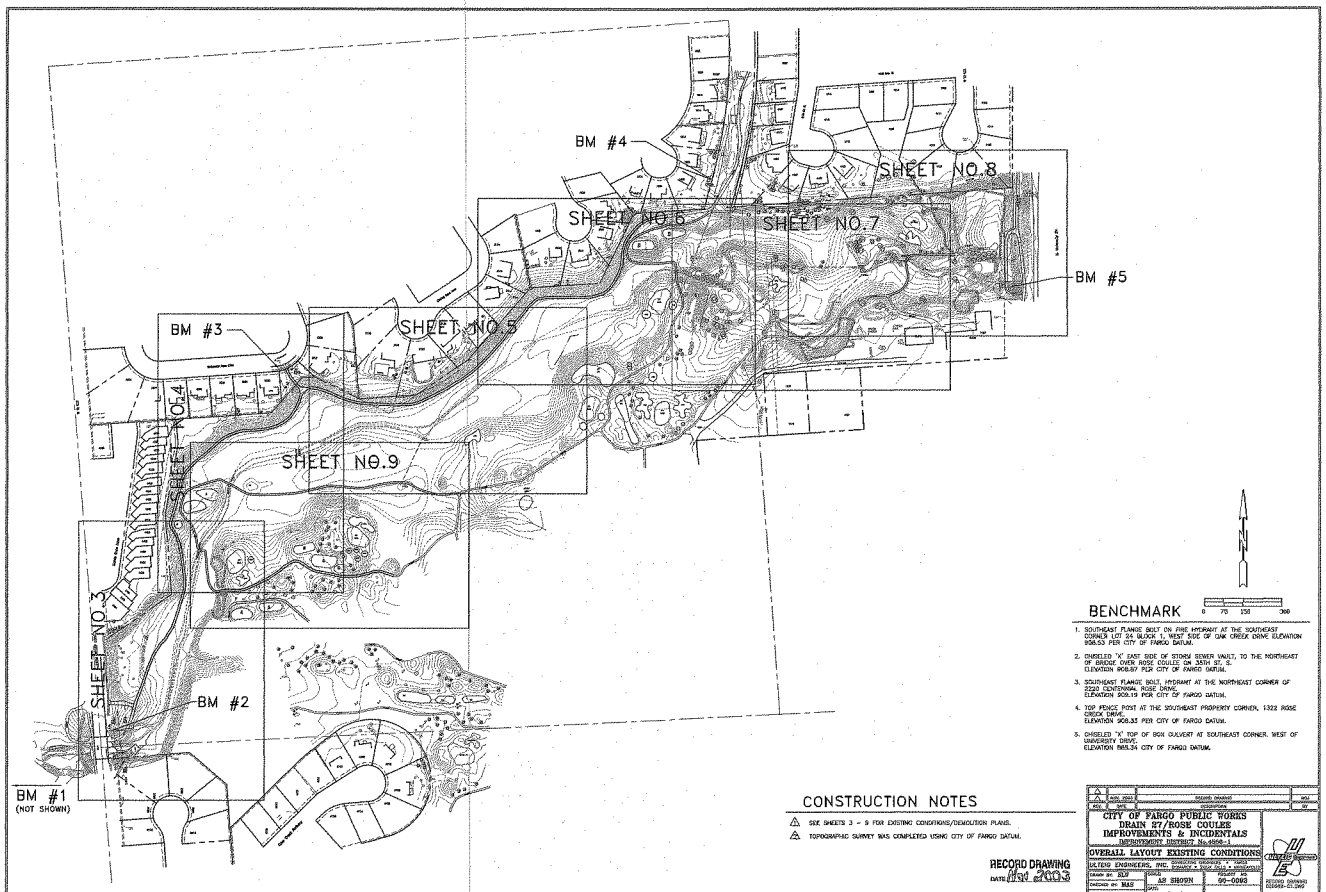
DATE _____ REG. NO. _____

ULTEIG ENGINEERS INC. FARGO * BISMARCK * MINNEAPOLIS * SIOUX FALLS

RECORD DRAWING
DATE Mar 2003

1342

1-35.54



BENCHMARK

0 75 150 300

1. SOUTHEAST FLANGE BOLT ON FIRE HYDRANT AT THE SOUTHEAST CORNER LOT 24 BLOCK 1, WEST SIDE OF OAK CREEK DRIVE ELEVATION 898.53 PER CITY OF FARGO DATUM.
2. CHISELED "V" EAST SIDE OF STORM SEWER VAULT, TO THE NORTHEAST OF BRIDGE OVER ROSE COULEE ON 35TH ST. S. ELEVATION 908.87 PER CITY OF FARGO DATUM.
3. SOUTHEAST FLANGE BOLT, HYDRANT AT THE NORTHEAST CORNER OF 2220 CENTENNIAL ROSE DRIVE. ELEVATION 908.19 PER CITY OF FARGO DATUM.
4. TOP FENCE POST AT THE SOUTHEAST PROPERTY CORNER, 1322 ROSE CREEK DRIVE. ELEVATION 908.33 PER CITY OF FARGO DATUM.
5. CHISELED "X" TOP OF BOX CULVERT AT SOUTHEAST CORNER, WEST OF UNIVERSITY DRIVE. ELEVATION 885.54 CITY OF FARGO DATUM.

CONSTRUCTION NOTES

1. SEE SHEETS 3 - 9 FOR EXISTING CONDITIONS/DEMOLITION PLANS.
2. TOPOGRAPHIC SURVEY WAS COMPLETED USING CITY OF FARGO DATUM.

RECORD DRAWING
DATE: MAY 2003

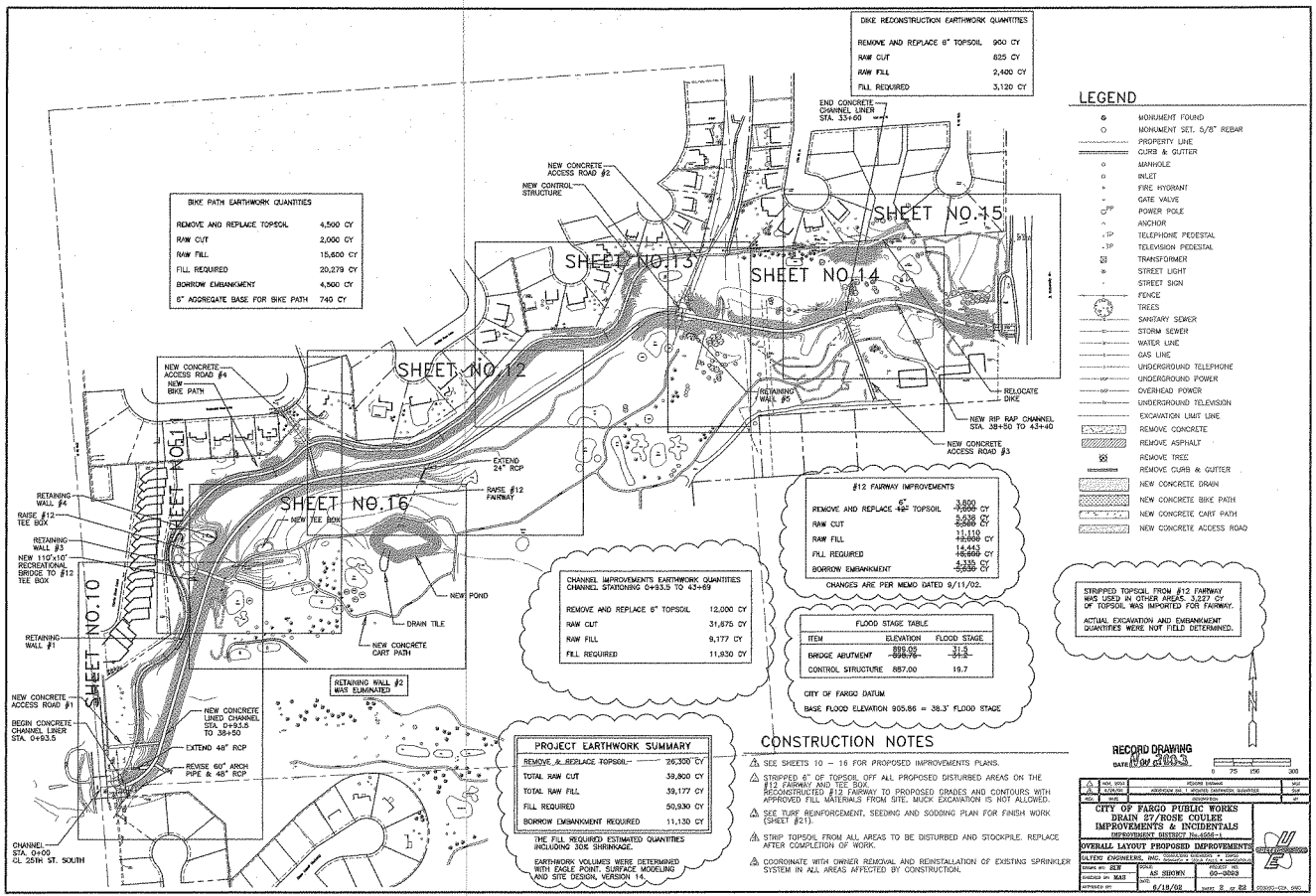
1	APR. 2003	RECORD DRAWING	WSJ
REV.	DATE	DESCRIPTION	BY

CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
IMPROVEMENT DISTRICT No.4998-1

OVERALL LAYOUT EXISTING CONDITIONS

ULTEIG ENGINEERS, INC. CONSULTING ENGINEERS • SURVEYORS • PLANNERS
1701 SOUTH UNIVERSITY DRIVE, FARGO, NORTH DAKOTA 58103 (701) 232-7301

DRAWN BY: JLW	DATE: 6/10/02	PROJECT NO: 99-0093	RECORD DRAWING 4998-1-01.DWG
CHECKED BY: MAS			
APPROVED BY:		SHEET 1 OF 23	



BIKE PATH EARTHWORK QUANTITIES

REMOVE AND REPLACE TOPSOIL	4,500 CY
RAW CUT	2,000 CY
RAW FILL	15,600 CY
FILL REQUIRED	20,279 CY
BORROW EMBANKMENT	4,500 CY
6" AGGREGATE BASE FOR BIKE PATH	740 CY

DIKE RECONSTRUCTION EARTHWORK QUANTITIES

REMOVE AND REPLACE 6" TOPSOIL	900 CY
RAW CUT	825 CY
RAW FILL	2,400 CY
FILL REQUIRED	3,120 CY

#12 FAIRWAY IMPROVEMENTS

REMOVE AND REPLACE ~~4"~~ 6" TOPSOIL	3,800 ~~7,000~~ CY
RAW CUT	3,538 CY ~~6,588~~
RAW FILL	11,110 ~~12,008~~ CY
FILL REQUIRED	14,443 ~~18,596~~ CY
BORROW EMBANKMENT	4,335 CY ~~5,939~~ CY

CHANGES ARE PER MEMO DATED 9/11/02.

CHANNEL IMPROVEMENTS EARTHWORK QUANTITIES
CHANNEL STATIONING 0+93.5 TO 43+69

REMOVE AND REPLACE 6" TOPSOIL	12,000 CY
RAW CUT	31,675 CY
RAW FILL	9,177 CY
FILL REQUIRED	11,830 CY

FLOOD STAGE TABLE

ITEM	ELEVATION	FLOOD STAGE
BRIDGE ABUTMENT	899.09 ~~898.76~~	31.3 ~~31.2~~
CONTROL STRUCTURE	887.00	19.7

CITY OF FARGO DATUM

BASE FLOOD ELEVATION 905.86 = 38.3' FLOOD STAGE

STRIPPED TOPSOIL FROM #12 FAIRWAY WAS USED IN OTHER AREAS. 3,227 CY OF TOPSOIL WAS IMPORTED FOR FAIRWAY.

ACTUAL EXCAVATION AND EMBANKMENT QUANTITIES WERE NOT FIELD DETERMINED.

PROJECT EARTHWORK SUMMARY

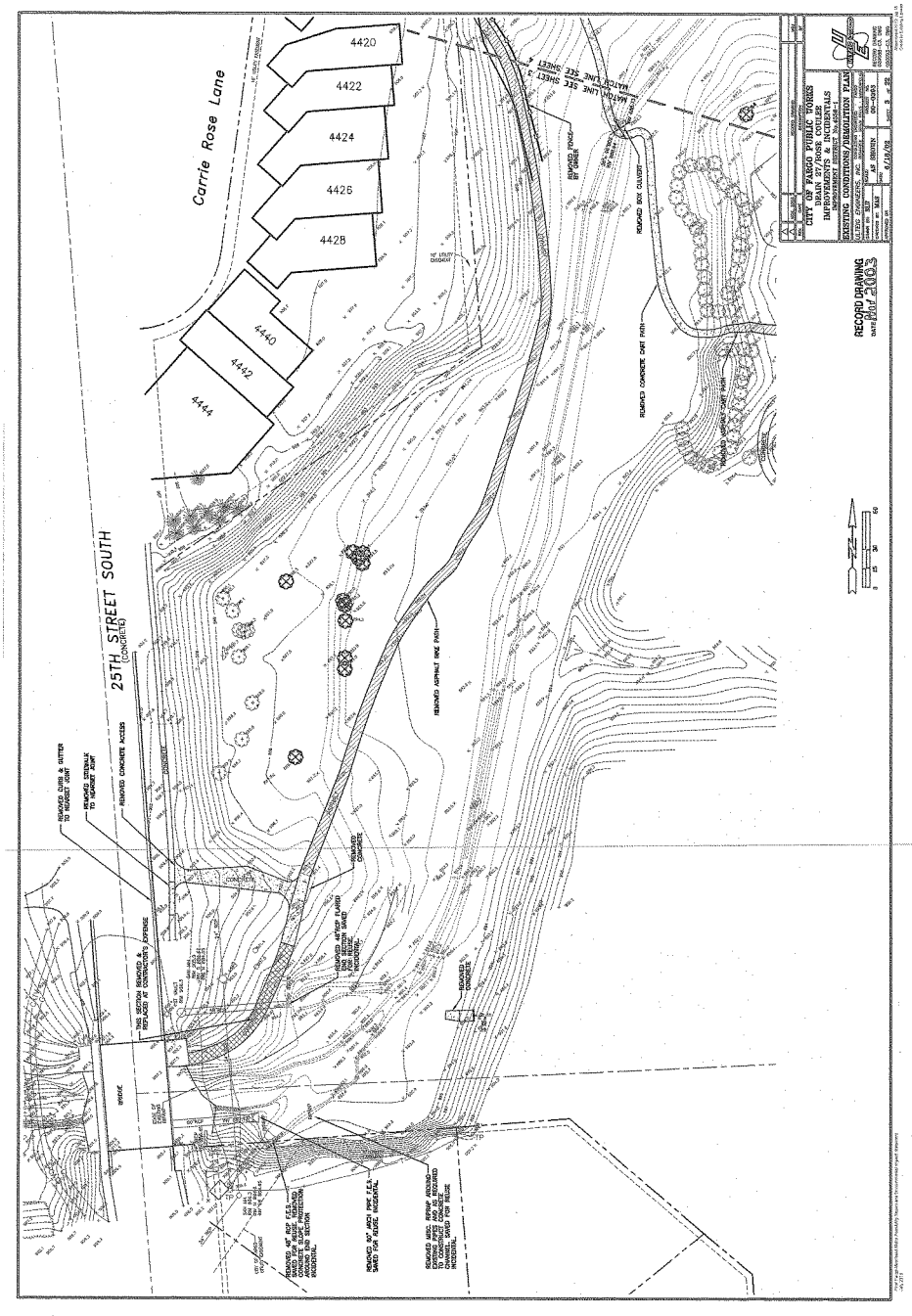
REMOVE & REPLACE TOPSOIL	26,300 CY
TOTAL RAW CUT	39,800 CY
TOTAL RAW FILL	39,177 CY
FILL REQUIRED	50,930 CY
BORROW EMBANKMENT REQUIRED	11,130 CY

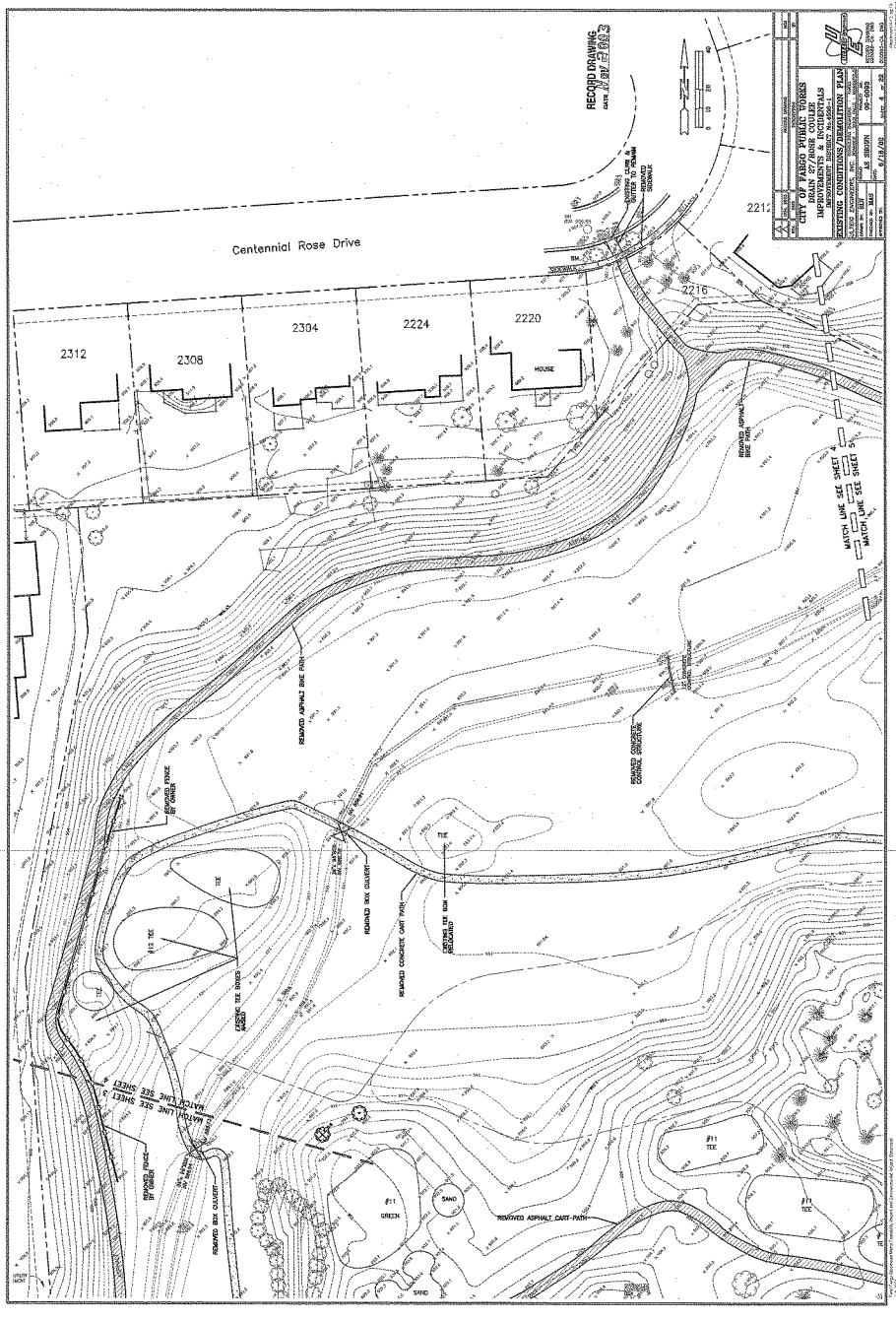
THE FILL REQUIRED ESTIMATED QUANTITIES INCLUDING 30% SHRINKAGE.

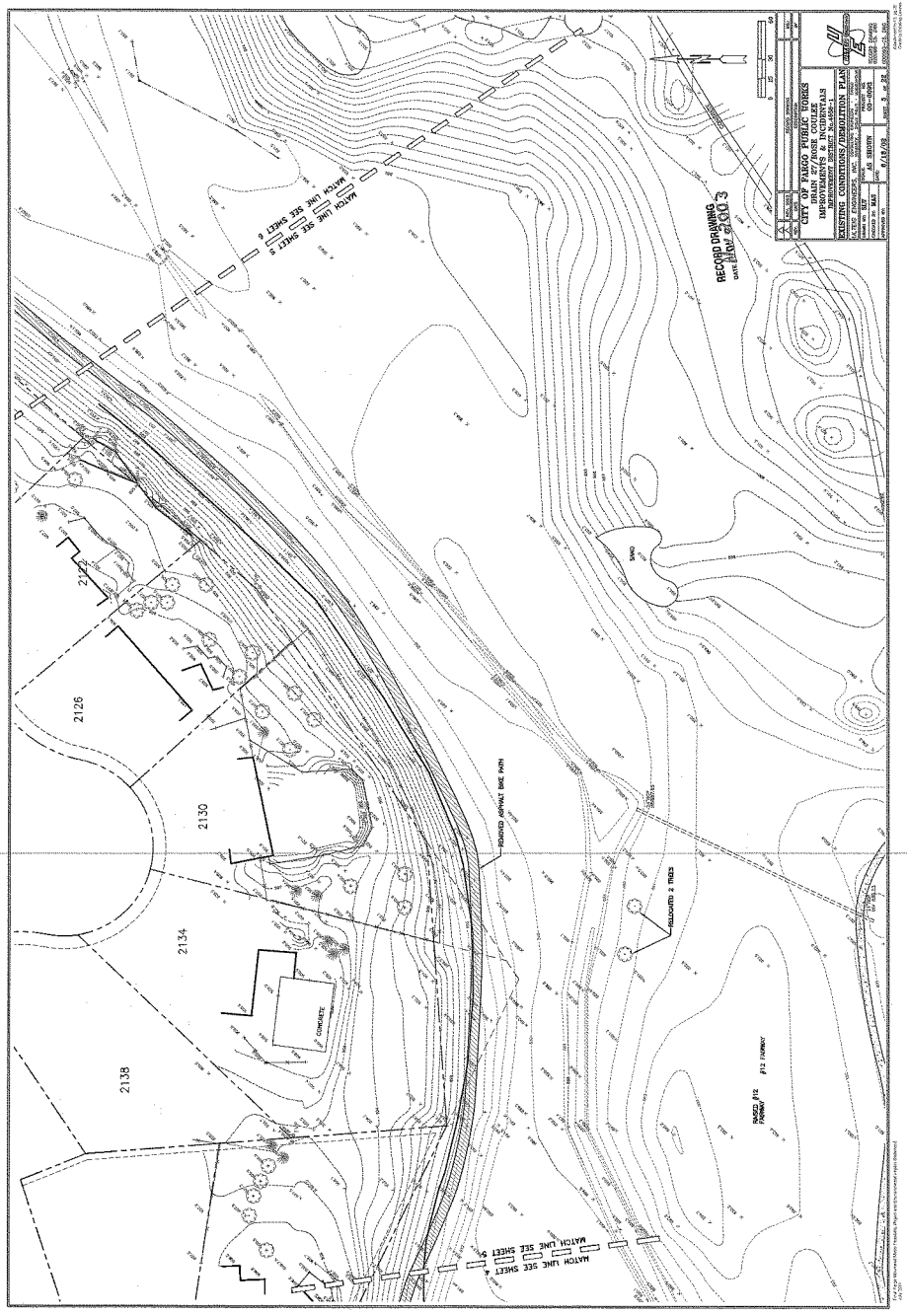
EARTHWORK VOLUMES WERE DETERMINED WITH EAGLE POINT, SURFACE MODELING AND SITE DESIGN, VERSION 14.

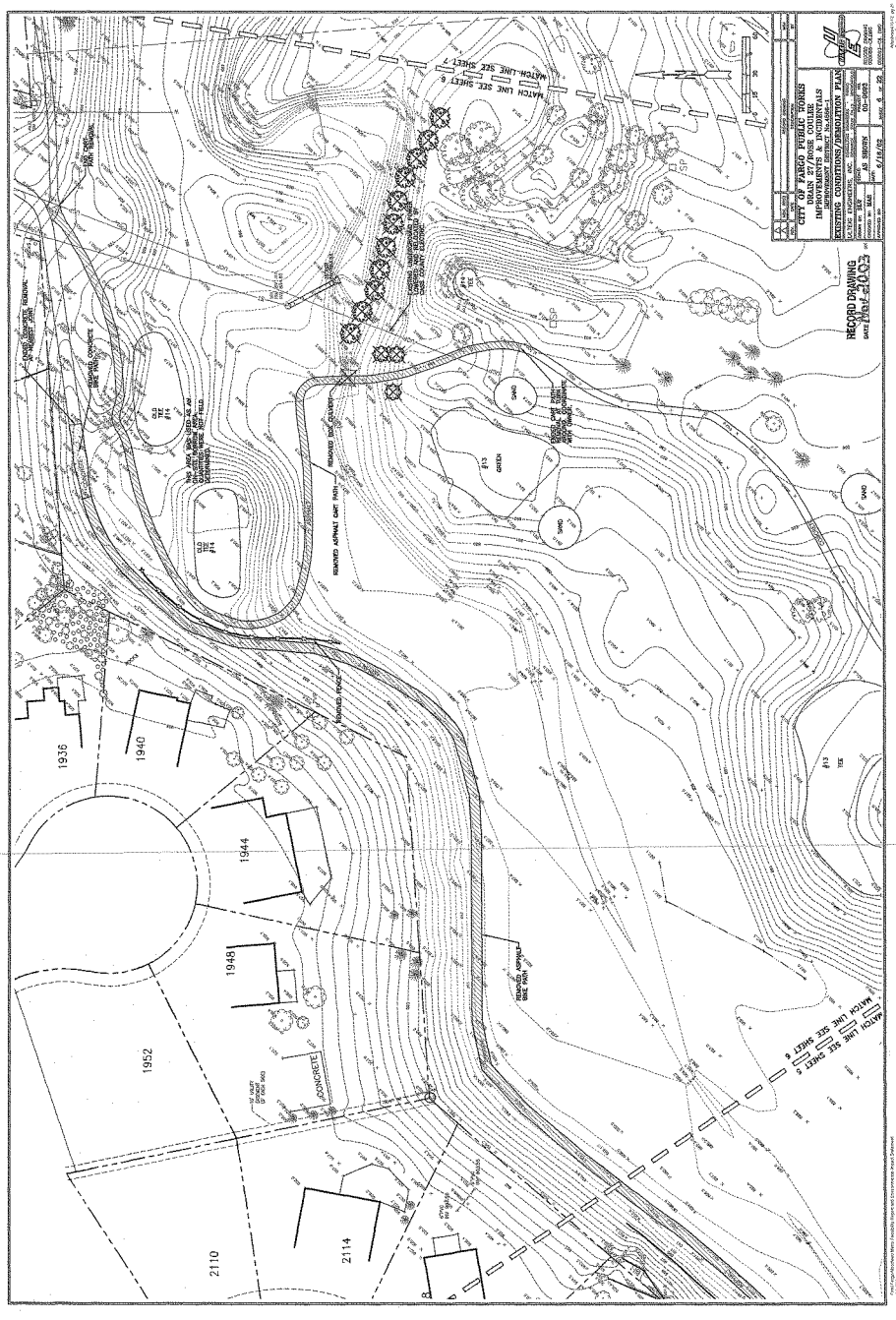
CONSTRUCTION NOTES

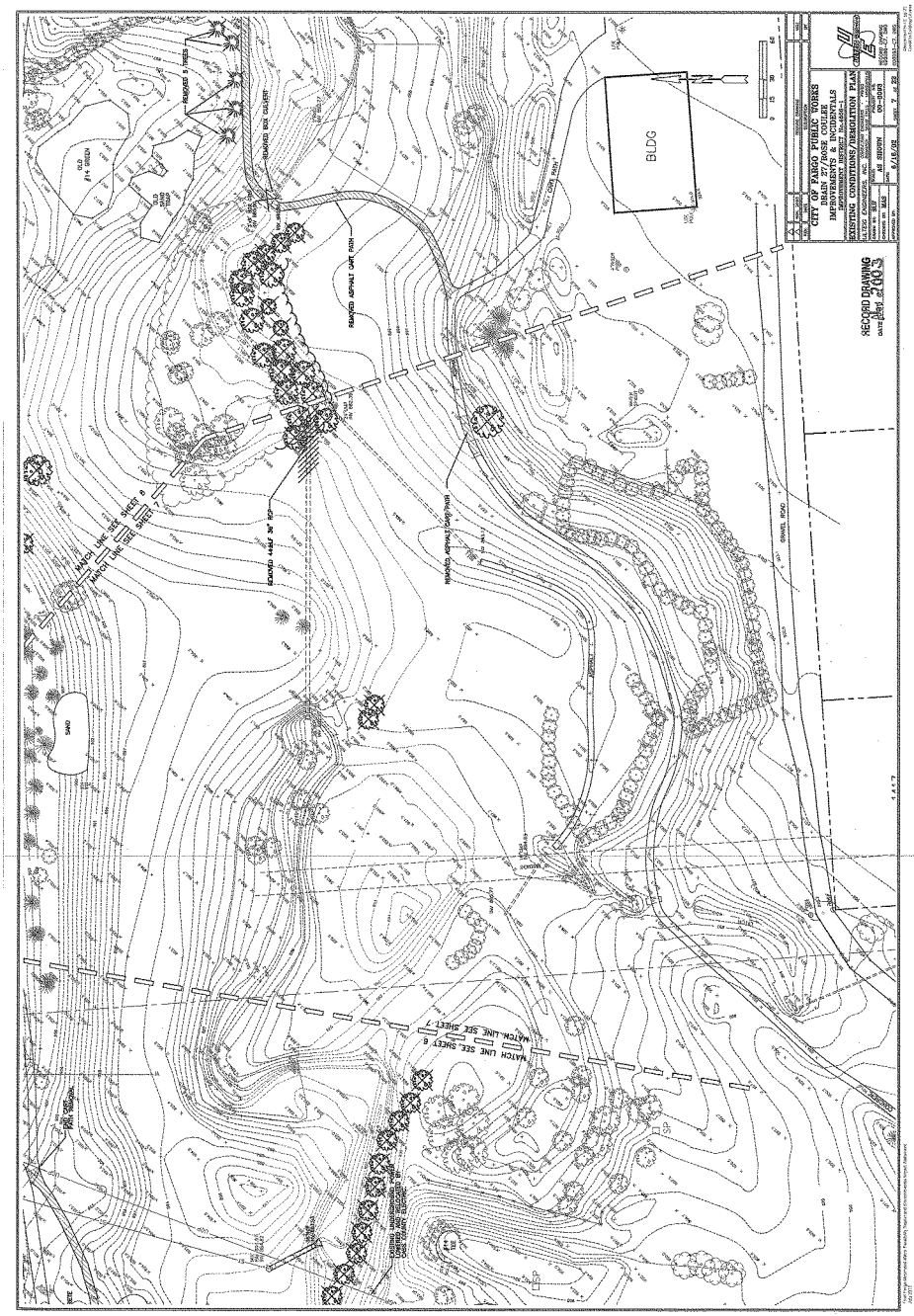
1. SEE SHEETS 10 – 16 FOR PROPOSED IMPROVEMENTS PLANS.
2. STRIPPED 6" OF TOPSOIL OFF ALL PROPOSED DISTURBED AREAS ON THE #12 FAIRWAY AND TEE BOX. RECONSTRUCTED #12 FAIRWAY TO PROPOSED GRADES AND CONTOURS WITH APPROVED FILL MATERIALS FROM SITE. MUCK EXCAVATION IS NOT ALLOWED.
3. SEE TURF REINFORCEMENT, SEEDING AND SODDING PLAN FOR FINISH WORK (SHEET #21).
4. STRIP TOPSOIL FROM ALL AREAS TO BE DISTURBED AND STOCKPILE. REPLACE AFTER COMPLETION OF WORK.
5. COORDINATE WITH OWNER REMOVAL AND REINSTALLATION OF EXISTING SPRINKLER SYSTEM IN ALL AREAS AFFECTED BY CONSTRUCTION.

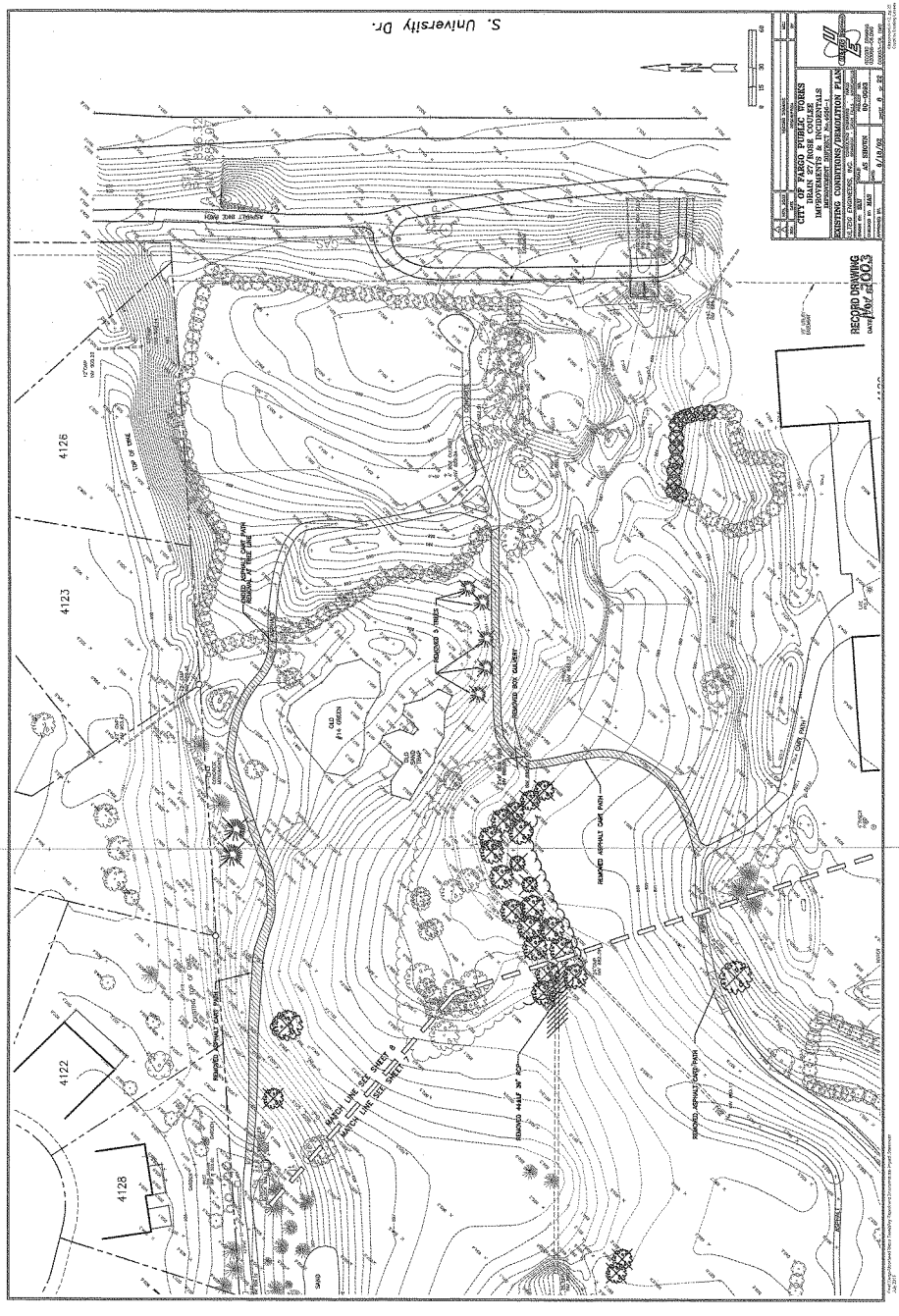

Carrie Rose Lane
4420
4422
4424
4426
4428
4440
4442
4444
25TH STREET SOUTH
(CONCRETE)
REMOVED CONCRETE ACCESS
REMOVED CURB & GUTTER TO NEAREST JOINT
REMOVED SIDEWALK TO NEAREST JOINT
THIS SECTION REMOVED & REPLACED AT CONTRACTOR'S EXPENSE
REMOVED CONCRETE
REMOVED 48" RCP FLARED END SECTION SAVED FOR REUSE INCIDENTAL
REMOVED 48" RCP F.E.S. SAVED FOR REUSE INCIDENTAL
REMOVED 60" ARCH PIPE F.E.S. SAVED FOR REUSE INCIDENTAL
REMOVED MISC. RIPRAP AROUND EXISTING PIPES AND AS REQUIRED TO CONSTRUCT CONCRETE CHANNEL SAVED FOR REUSE INCIDENTAL
REMOVED CONCRETE CAST PATH
REMOVED ASPHALT BIKE PATH
REMOVED BOX CULVERT
REMOVED FENCE BY OWNER
MATCH LINE SEE SHEET 3
MATCH LINE SEE SHEET 4
CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
IMPROVEMENT DISTRICT No.4584-1
EXISTING CONDITIONS/DEMOLITION PLAN
RECORD DRAWING
DATE 8/01/2003

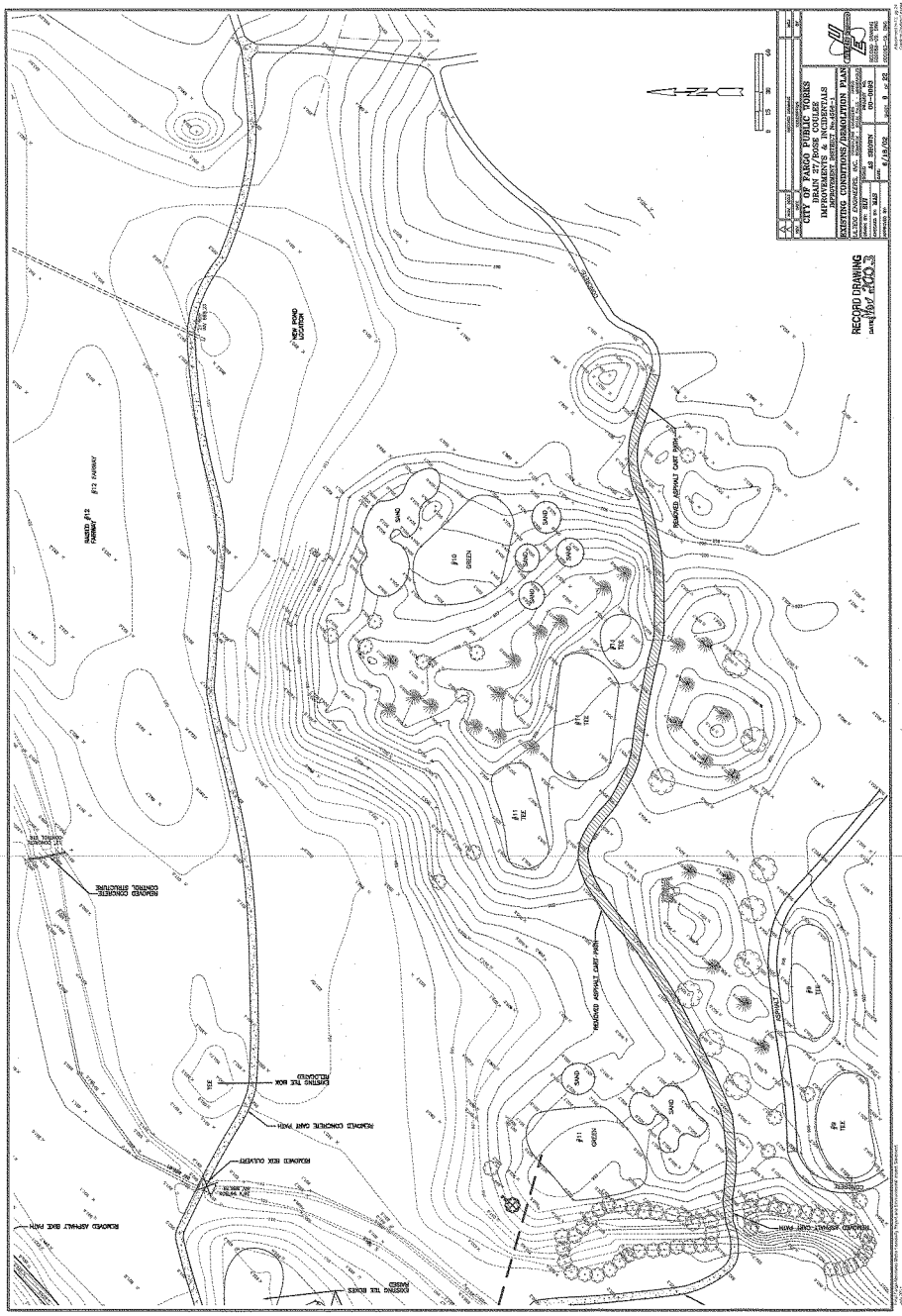

Centennial Rose Drive
2312
2308
2304
2224
2220
2216
HOUSE
RECORD DRAWING
CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
EXISTING CONDITIONS/DEMOLITION PLAN
REMOVED ASPHALT BIKE PATH
REMOVED CONCRETE CONTROL STRUCTURE
REMOVED BOX CULVERT
REMOVED CONCRETE CART PATH
EXISTING TEE BOXES
REMOVED FENCE BY OWNER
REMOVED ASPHALT CART PATH
MATCH LINE SEE SHEET 4
MATCH LINE SEE SHEET 5
MATCH LINE SEE SHEET 3
#12 TEE
#11 TEE
#11 GREEN
SAND

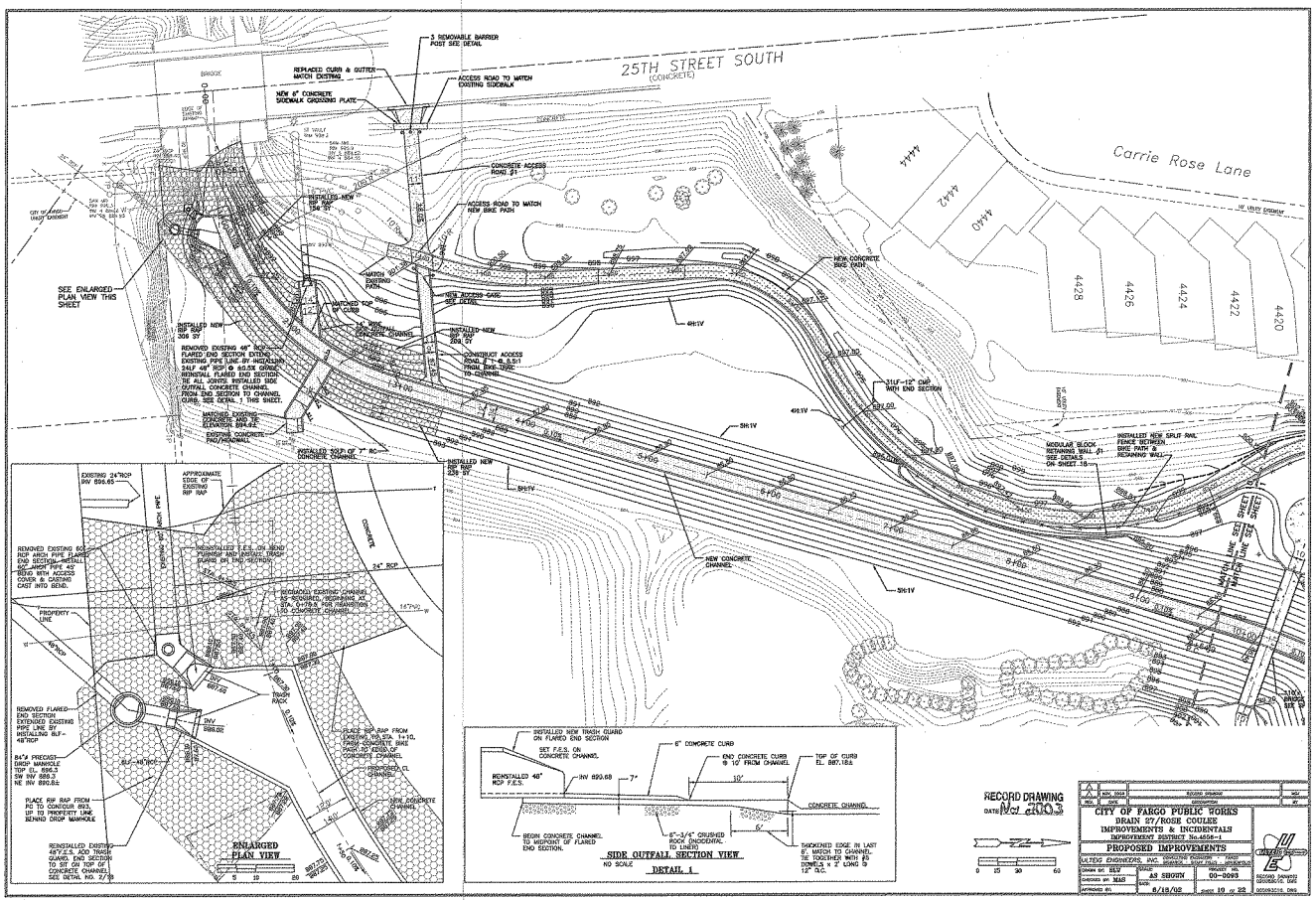

CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
EXISTING CONDITIONS/DEMOLITION PLAN
RECORD DRAWING
MATCH LINE SEE SHEET 5
MATCH LINE SEE SHEET 6
MATCH LINE SEE SHEET 4
2122
2126
2130
2134
2138
CONCRETE
SAND
REMOVED ASPHALT BIKE PATH
RELOCATED 2 TREES
RAISED #12 FAIRWAY
#12 FAIRWAY

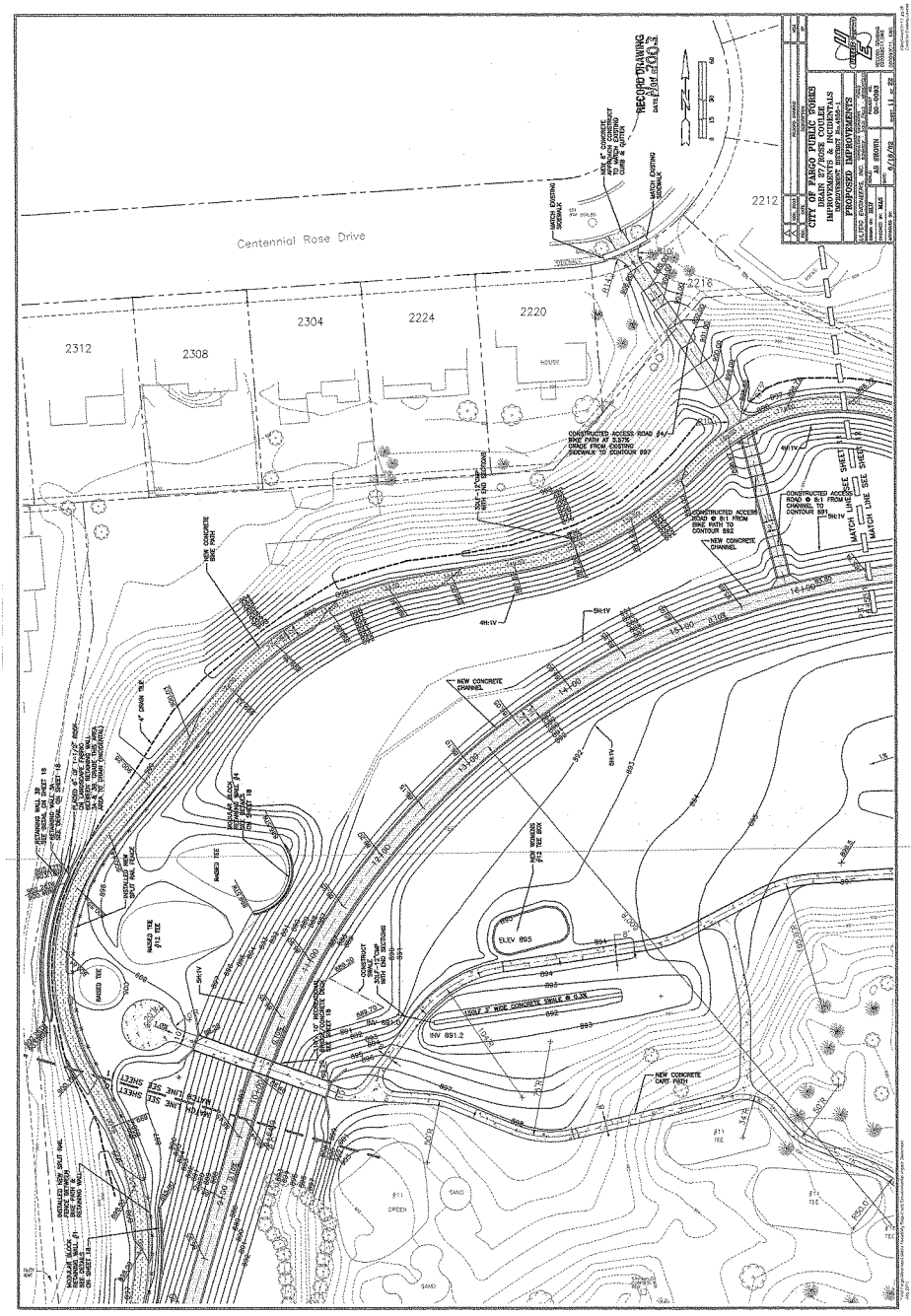

CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
EXISTING CONDITIONS/DEMOLITION PLAN
RECORD DRAWING
MATCH LINE SEE SHEET 6
MATCH LINE SEE SHEET 7
MATCH LINE SEE SHEET 5
REMOVED ASPHALT CART PATH
REMOVED FENCE
REMOVED ASPHALT BIKE PATH
CONCRETE
1936
1940
1944
1948
1952
2110
2114

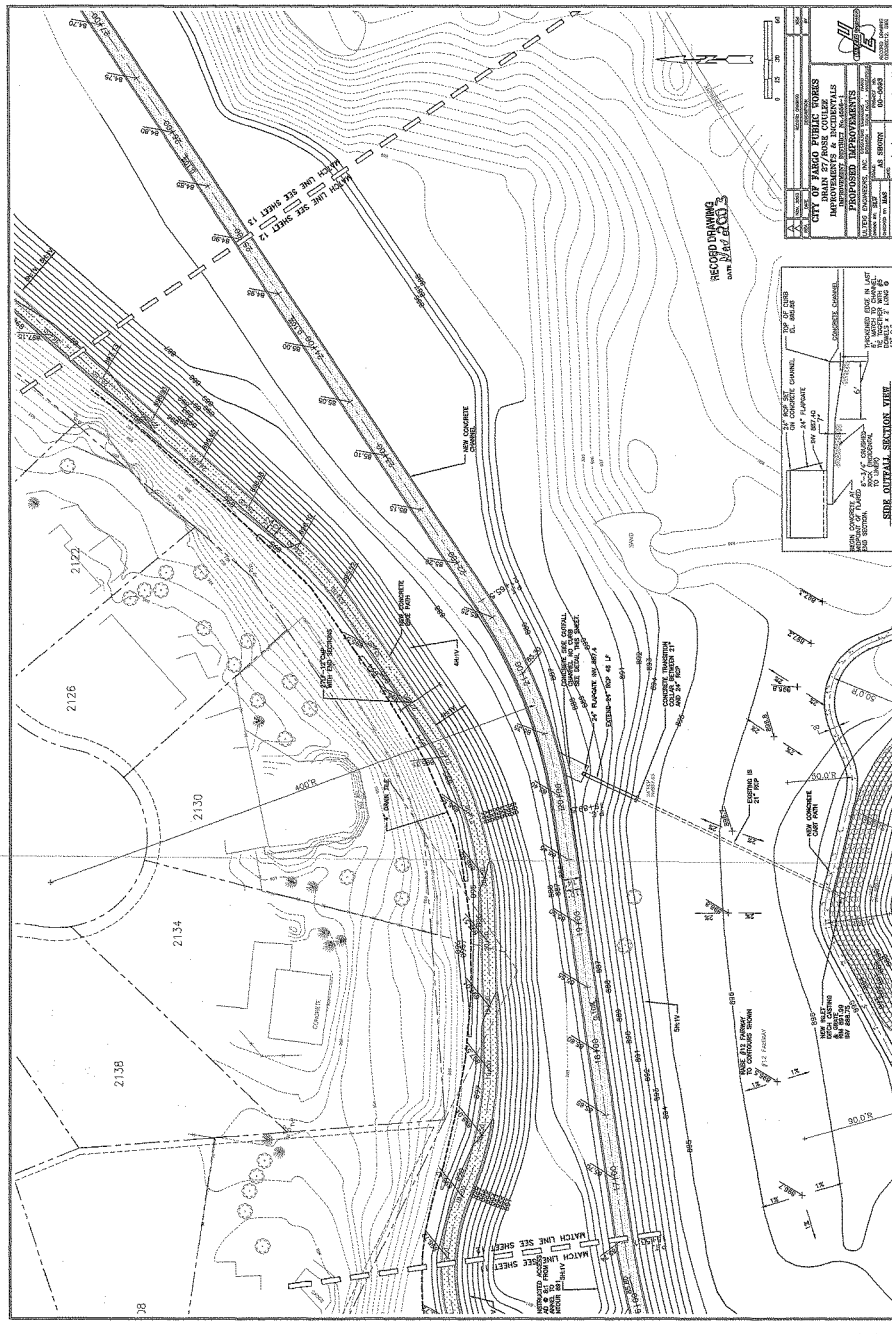

CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
EXISTING CONDITIONS/DEMOLITION PLAN
AS SHOWN
00-0001
6/16/02
RECORD DRAWING
BLDG
MATCH LINE SEE SHEET 8
MATCH LINE SEE SHEET 7
REMOVED ASPHALT CART PATH
REMOVED BOX CULVERT
GRAVEL ROAD
SAND

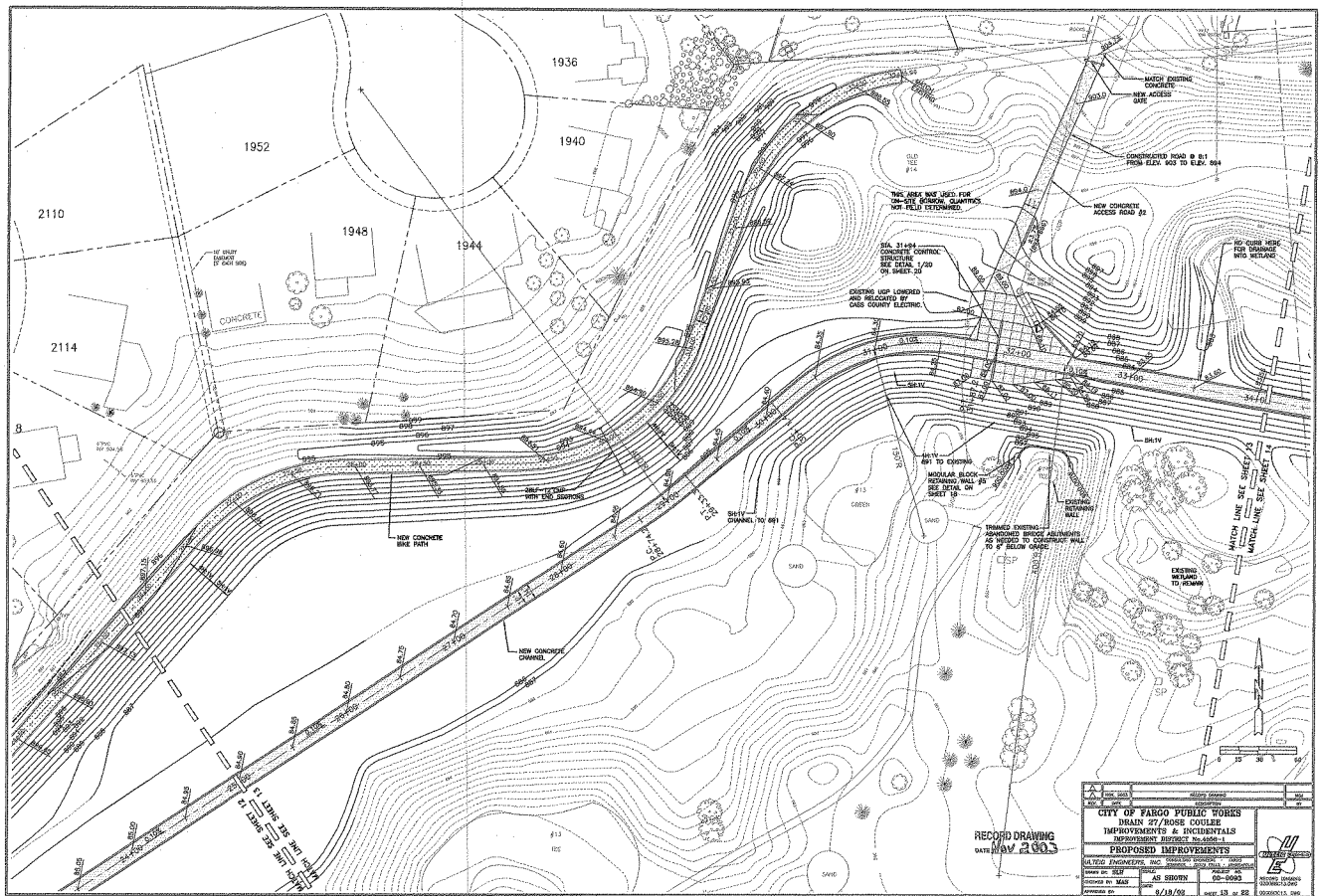

S. University Dr.
CITY OF FARGO PUBLIC WORKS
DRAIN 27/NOBLE COULEE
IMPROVEMENTS & INCIDENTALS
EXISTING CONDITIONS/DEMOLITION PLAN
RECORD DRAWING
4126
4123
4122
4128
REMOVED ASPHALT CART PATH
MATCH LINE SEE SHEET 8
MATCH LINE SEE SHEET 7
REMOVED 5 TREES
REMOVED BOX CULVERT
REMOVED 44 LF 36" RCP
TOP OF DIKE
SAND


CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
EXISTING CONDITIONS/DEMOLITION PLAN
RECORD DRAWING
NEW POND LOCATION
REMOVED ASPHALT CART PATH
REMOVED CONCRETE CONTROL STRUCTURE
EXISTING TEE BOX RELOCATED
REMOVED CONCRETE CART PATH
REMOVED BOX CULVERT
REMOVED ASPHALT BIKE PATH
EXISTING TEE BOXES RAISED
#10 GREEN
#11 GREEN
#11 TEE
#9 TEE
SAND
TEE

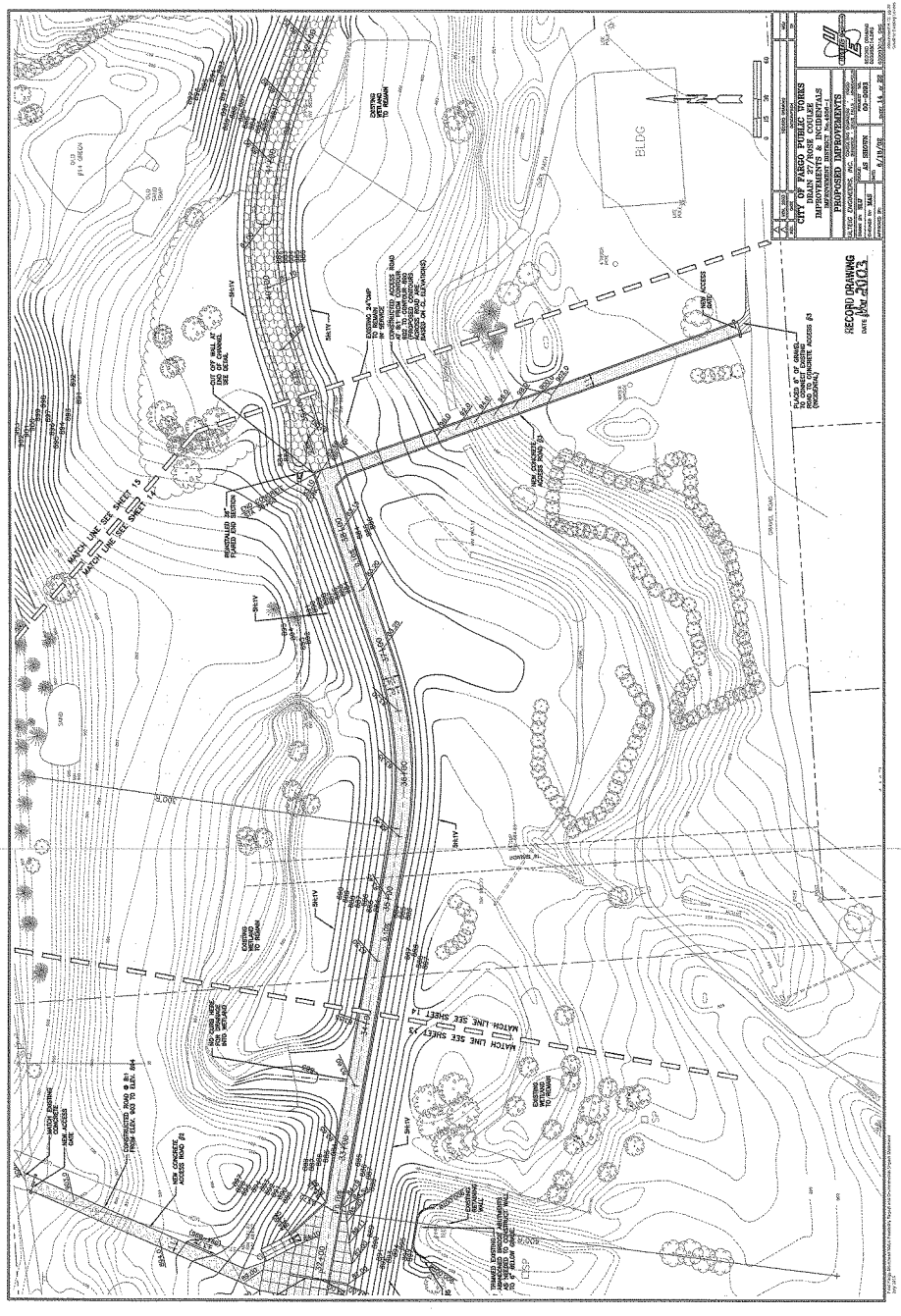

25TH STREET SOUTH
(CONCRETE)
Carrie Rose Lane
3 REMOVABLE BARRIER POST SEE DETAIL
REPLACED CURB & GUTTER MATCH EXISTING
ACCESS ROAD TO MATCH EXISTING SIDEWALK
NEW 8" CONCRETE SIDEWALK GROUND PLATE
CONCRETE ACCESS ROAD #1
ACCESS ROAD TO MATCH NEW BIKE PATH
INSTALLED NEW RIP RAP 154 SY
SEE ENLARGED PLAN VIEW THIS SHEET
MATCH EXISTING PATH
MATCHED ICP & CURB
INSTALLED NEW RIP RAP 206 SY
REMOVED EXISTING 48" RCP FLARED END SECTION EXTEND EXISTING PIPE LINE BY INSTALLING 24LF 48" RCP @ 40.5% GRADE INSTALL FLARED END SECTION TIE ALL JOINTS INSTALLED SIDE OUTFALL CONCRETE CHANNEL FROM END SECTION TO CHANNEL (CURB) SEE DETAIL 1 THIS SHEET
MATCHED EXISTING CONCRETE CURB ELEVATION 894.42±
EXISTING CONCRETE PADS/SIDEWALK
INSTALLED NEW RIP RAP 239 SY
INSTALLED 900LF OF 7' RC CONCRETE CHANNEL
NEW ACCESS GATE SEE DETAIL
INSTALLED NEW RIP RAP 209 SY
CONSTRUCT ACCESS ROAD 7' T-6, 8.5:1 FROM BIKE TRAIL TO CHANNEL
NEW CONCRETE BIKE PATH
48:1V
49:1V
51:1V
56:1V
31LF-12" CMP WITH END SECTION
MODULAR BLOCK RETAINING WALL (1) SEE DETAILS ON SHEET 18
INSTALLED NEW SPLIT RAIL FENCE BETWEEN BIKE PATH & RETAINING WALL
NEW CONCRETE CHANNEL
4428
4426
4424
4422
4420
4442
4440
EXISTING 24"RCP INV 890.65
APPROXIMATE EDGE OF EXISTING RIP RAP
REMOVED EXISTING 60" RCP FLARED END SECTION INSTALL 60" CAP PIPE 42' 60" RCP WITH FLARED ENDS & CONCRETE CAST INTO BEND.
REINSTALLED F.E.S. ON BEND PUMPED AND INSTALL TRASH GUARD ON END SECTION
REMOVED EXISTING CHANNEL AS REQUIRED, RECHANNEL AT STA. 0+79.5 FOR INSTALLATION OF CONCRETE CHANNEL
PROPERTY LINE
REMOVED FLARED END SECTION EXTENDED EXISTING PIPE LINE BY INSTALLING 8LF-48"RCP
84"± PRECAST DROP MANHOLE TOP EL. 896.3 SW INV 888.3 NE INV 890.8±
PLACE RIP RAP FROM PC TO CONTOUR 893, UP TO PROPERTY LINE, BEHIND DROP MANHOLE
REINSTALLED EXISTING 60"F.E.S. AND TRASH GUARD, END SECTION TO SIT ON TOP OF CONCRETE CHANNEL SEE DETAIL NO. 2/18
PLACE RIP RAP FROM EXISTING, NO. STA. 1+10, FROM CONCRETE BIKE TRAIL TO BEND OF CONCRETE CHANNEL
NEW CONCRETE CHANNEL
ENLARGED PLAN VIEW
INSTALLED NEW TRASH GUARD ON FLARED END SECTION
SET F.E.S. ON CONCRETE CHANNEL
REINSTALLED 48" RCP F.E.S.
INV 890.68
7"
6" CONCRETE CURB
END CONCRETE CURB 8' 10' FROM CHANNEL
TOP OF CURB EL. 887.18±
10'
CONCRETE CHANNEL
BEGIN CONCRETE CHANNEL TO MIDPOINT OF FLARED END SECTION.
6"-3/4" CRUSHED ROCK (INCIDENTAL TO LINER)
6'
THICKENED EDGE IN LAST 8' MATCH TO CHANNEL, TIE TOGETHER WITH #5 DOWELS x 2' LONG @ 12" O.C.
SIDE OUTFALL SECTION VIEW
NO SCALE
DETAIL 1
RECORD DRAWING
DATE NOV 2003
CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
IMPROVEMENT DISTRICT No.4656-1
PROPOSED IMPROVEMENTS
MILTEX ENGINEERS, INC.
DRAWN BY: ELV
CHECKED BY: MAS
APPROVED BY:
SCALE: AS SHOWN
DATE: 6/19/02
PROJECT: 01-0093
SHEET 10 of 22
RECORD DRAWING CERTIFICATION DATE
AUTHORIZATION DATE

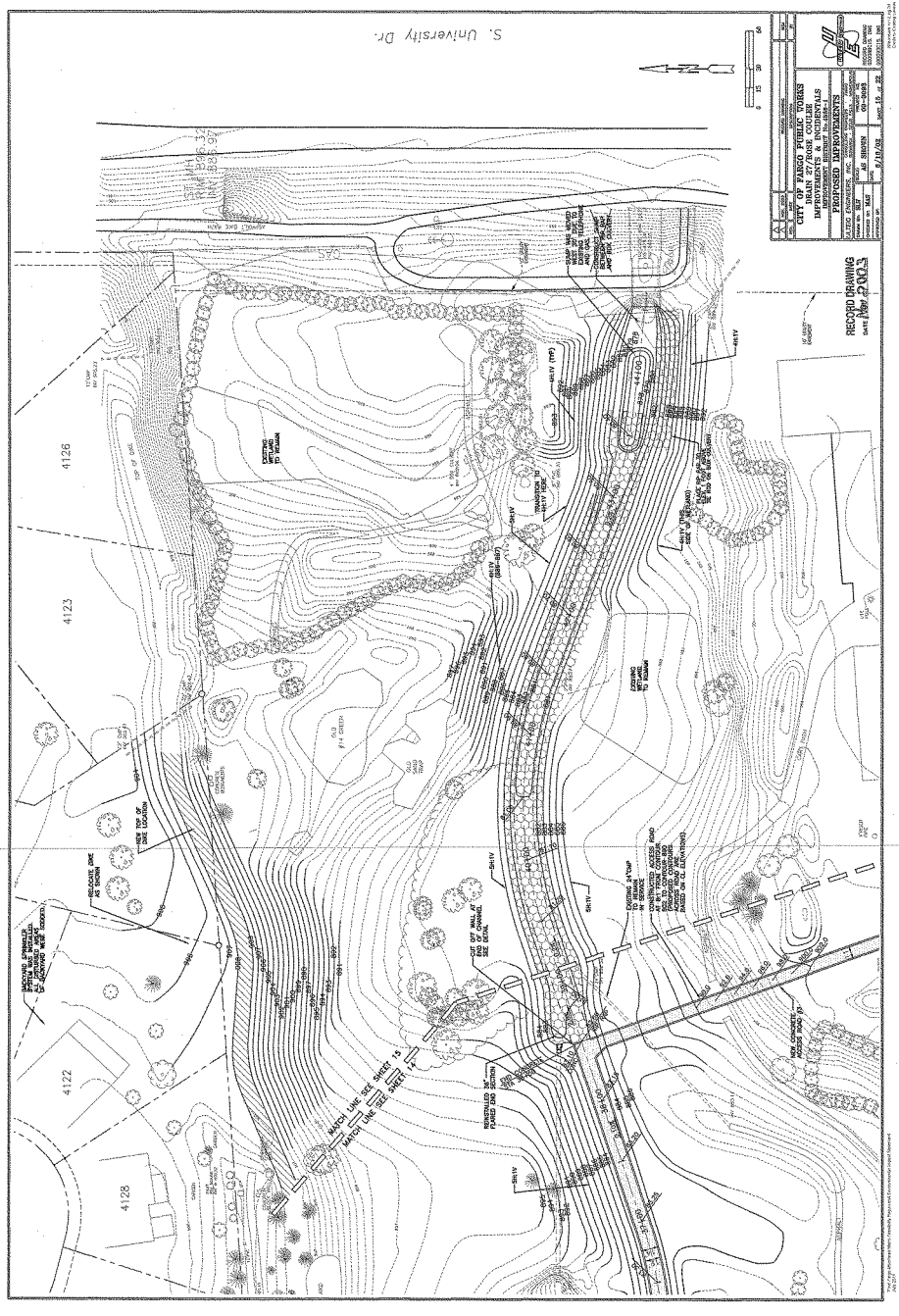

Centennial Rose Drive
2312
2308
2304
2224
2220
2212
2216
HOUSE
RECORD DRAWING
CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
PROPOSED IMPROVEMENTS
AS SHOWN
NEW CONCRETE CHANNEL
NEW CONCRETE BIKE PATH
NEW CONCRETE CART PATH
ELEV 895
INV 891.2
MATCH LINE SEE SHEET
MATCH LINE SEE SHEET
MATCH LINE SEE SHEET
MATCH LINE SEE SHEET
RAISED TEE
RAISED TEE
RAISED TEE
SAND
GREEN
SAND

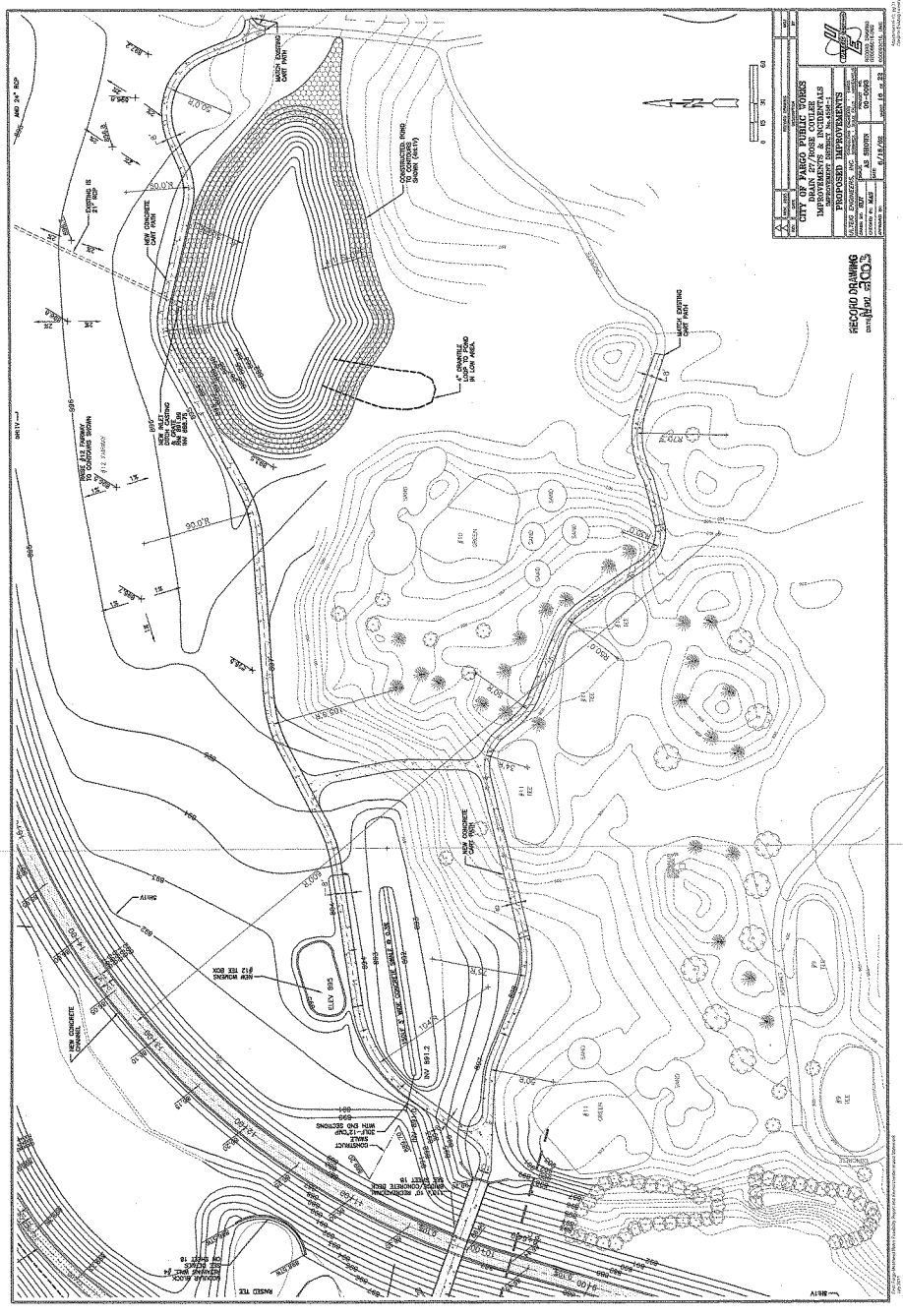

CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
PROPOSED IMPROVEMENTS
AS SHOWN
SIDE OUTFALL SECTION VIEW
RECORD DRAWING
MATCH LINE SEE SHEET 12
MATCH LINE SEE SHEET 13
NEW CONCRETE CHANNEL
NEW CONCRETE CUT PATH
2122
2126
2130
2134
2138
400'R
90.0'R
50.0'R
CONCRETE



Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011

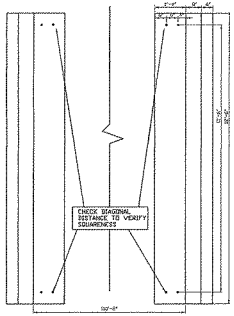

CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
IMPROVEMENT PROJECT No. 4504-1
PROPOSED IMPROVEMENTS
RECORD DRAWING
DATE May 2003
BLDG
MATCH LINE SEE SHEET 15
MATCH LINE SEE SHEET 14
MATCH LINE SEE SHEET 13
MATCH LINE SEE SHEET 14
NEW CONCRETE ACCESS ROAD #3
NEW CONCRETE ACCESS ROAD #2
NEW ACCESS GATE
EXISTING WETLAND TO REMAIN
EXISTING WETLAND TO REMAIN
EXISTING WETLAND TO REMAIN
CUT OFF WALL AT END OF CHANNEL SEE DETAIL
REINSTALLED 24" FLARED END SECTION
EXISTING 24" CMP TO REMAIN IN SERVICE
CONSTRUCTED ACCESS ROAD AT 8:1 FROM CONTOUR 802 TO CONTOUR 800 PROPOSED CONTOURS ACCESS ROAD ARE BASED ON CL. ELEVATIONS
PLACED 6" OF GRAVEL TO CONNECT EXISTING ROAD TO CONCRETE ACCESS #3 (INCIDENTAL)
MATCH EXISTING CONCRETE
NEW ACCESS GATE
CONSTRUCTED ROAD @ 8:1 FROM ELEV. 803 TO ELEV. 804
NEW CONCRETE ACCESS ROAD #2
EXISTING RETAINING WALL
TRAILED EXISTING REINFORCED BRIDGE ABUTMENTS AS NEEDED TO CONSTRUCT WALL TO 6" BELOW GRADE
SAND
GRAVEL ROAD
DRAIN 27
CSP

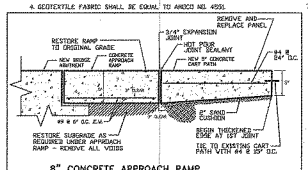

S. University Dr.
CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
PROPOSED IMPROVEMENTS
RECORD DRAWING
4126
4123
4122
4128
MATCH LINE SEE SHEET 15
MATCH LINE SEE SHEET 14


CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
PROPOSED IMPROVEMENTS
RECORD DRAWING
MATCH EXISTING CART PATH
NEW CONCRETE CART PATH
CONSTRUCTED POND TO CONTOURS SHOWN (ELEV 1)
4" GRANULE LOOP TO POND IN LOW AREA
EXISTING IS 21" RCP
NEW INLET DITCH CASTING & GRATE
NEW CONCRETE CHANNEL
NEW MOWING
ELEV 895
INV 891.2
RAISED TEE
SHEET 18

CONSTRUCTION NOTES

1. REFER TO SPECIFICATION SECTION 02891- CART PATH BRIDGE FOR BRIDGE SPECIFICATIONS.
2. REFER TO SPECIFICATION SECTIONS 03200- CONCRETE REINFORCEMENT AND 03300- CAST-IN-PLACE CONCRETE FOR FOUNDATION REINFORCING AND CONCRETE SPECIFICATIONS.
3. CONTRACTOR SHALL FIELD VERIFY ALL BRIDGE SETTING DIMENSIONS WITH FINAL BRIDGE SHOP DRAWINGS.
4. GEOTEXTILE FABRIC SHALL BE EQUAL TO AMOCO NO. 4551.





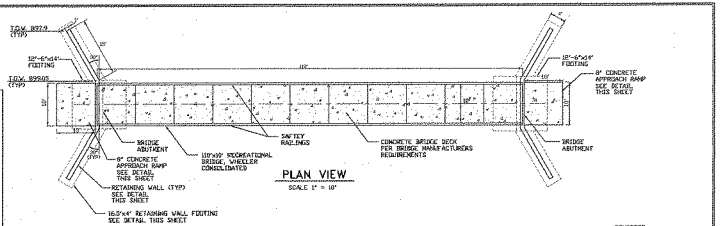
8" CONCRETE APPROACH RAMP

(TYPICAL BOTH SIDES)

NO SCALE

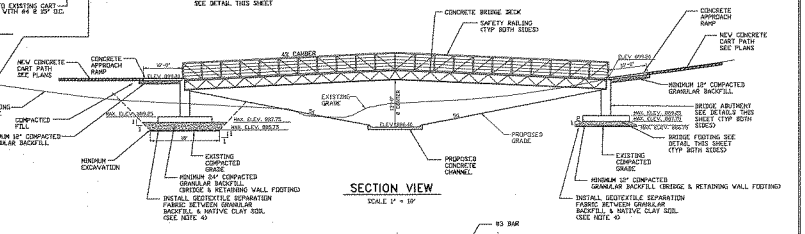
NOTES:

1. IF APPROACH RAMP IS REPLACED, PUT EXPANSION MATERIAL AT BRIDGE ABUTMENT. TIE APPROACH SLAB TO CART PATH WITH #6 REBAR AT 15" O.C.
2. ON WEST APPROACH RAMP, REPLACE DAMAGED CONCRETE.
3. RECONSTRUCT SUBGRADE AS REQUIRED TO ACHIEVE COMPACTION.



PLAN VIEW

SCALE 1" = 10'

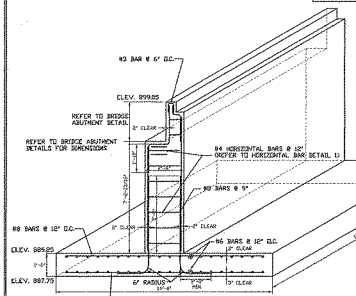


SECTION VIEW

SCALE 1" = 10'

HORZ. BAR DETAIL 1

NO SCALE



BRIDGE FOUNDATION

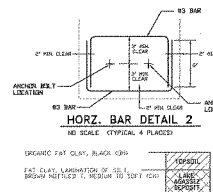
NO SCALE

FOUNDATION DESIGN LOADS

BRIDGE LOADS (PER BRIDGE DESIGN LOADS)

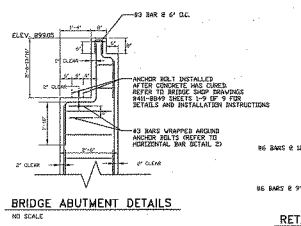
LOAD	P*	H**	L*
DEAD LOAD	27,000	-----	-----
UNITED LIVE	23,400	-----	-----
VEHICLE	4,000	-----	-----
WIND - WINDWARD	-12,300	12,200	0,550
WIND - LEEWARD	1,300	-----	-----
STREAM FLOW	-5,000	-----	-----
THERMAL	-----	-----	5,600

* - LOAD AT EACH BASEPLATE (4 PER BRIDGE)
** - LOAD AT EACH FOOTING (2 PER BRIDGE)
+ DOWNWARD LOAD
- UPWARD LOAD



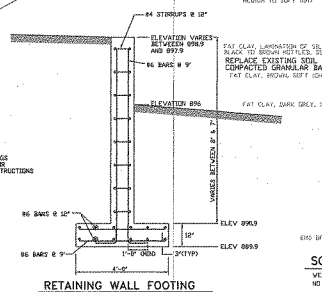
HORZ. BAR DETAIL 2

NO SCALE (TYPICAL 4 PLACES)



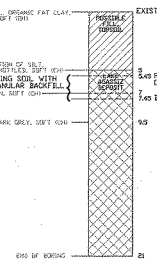
BRIDGE ABUTMENT DETAILS

NO SCALE



RETAINING WALL FOOTING

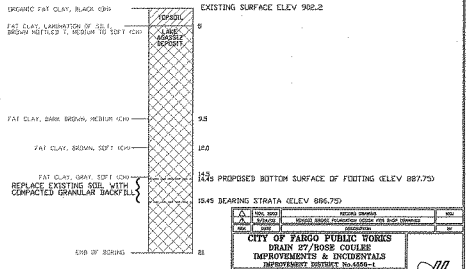
NO SCALE



SOIL BORING SB-2

WEST SIDE (SEE PLAN FOR LOCATION)

NO SCALE



SOIL BORING SB-1

EAST SIDE (SEE PLAN FOR LOCATION)

NO SCALE

1	NOV. 2002	REVISED DRAWING	NDI
0	6/18/02	REVISED BRIDGE FOUNDATION DESIGN PER BID# DRAWINGS	
NO.	DATE	DESCRIPTION	BY

CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
IMPROVEMENT DISTRICT No.4556-1

CART PATH BRIDGE PLAN & DETAILS

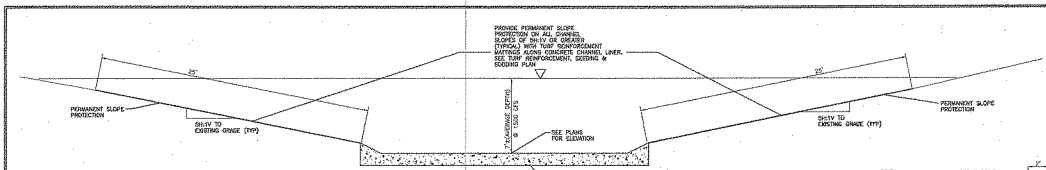
ULTERIG ENGINEERS, INC. CONSULTING ENGINEERS FARGO

DRAWN BY: NLV	SCALE: AS SHOWN	PROJECT NO. 02-0088	
CHECKED BY: MAH	DATE: 6/18/02	SHEET 17 OF 22	20228-217.DWG
APPROVED BY: EPT			

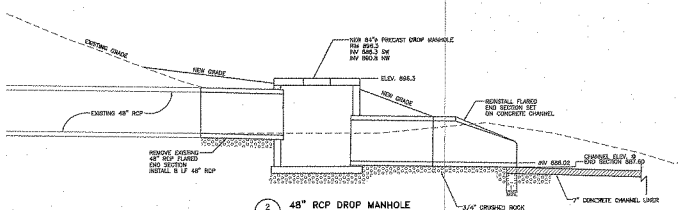
RECORD DRAWING
DATE: May 27 2003

Attachment 1-17 (p.22)
Cover to Cover Limited

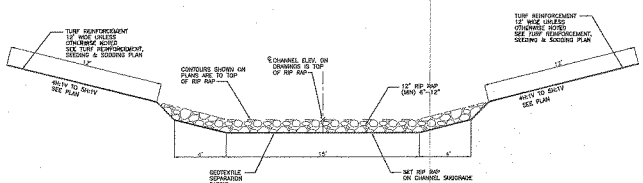
Final Fargo-Moorhead Metro Feasibility Phase II and Environmental Impact Statement
July 2011



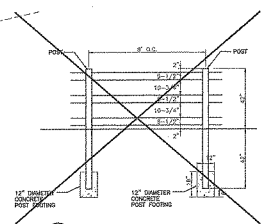
1 / 18 TYPICAL CONCRETE CHANNEL SECTION
NO SCALE



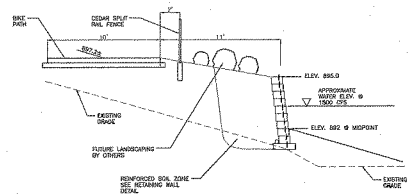
2 / 18 48" RCP DROP MANHOLE
NO SCALE
SECTION VIEW



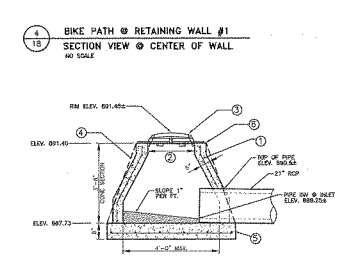
3 / 18 RIP RAP CHANNEL SECTION
NO SCALE



5 / 18 3 RAIL VINYL FENCE DETAIL
NO SCALE



4 / 18 BIKE PATH @ RETAINING WALL #1
SECTION VIEW @ CENTER OF WALL
NO SCALE



1. REINFORCING: SINGLE LINE STEEL WIRE FABRIC HAVING AN AREA OF NOT LESS THAN 0.12 SQ. IN. PER FOOT OF HEIGHT.
2. 2'-3" NOM. OPENING.
3. INLET CASTING AND GRATE NEENAH FOUNDRY #R2560-E2, HIGH BEEHIVE GRATE OR APPROVED EQUAL.
4. A STRAIGHT TAPERED WALL IS ACCEPTABLE.
5. 8 IN. POURED CONCRETE BASE. BASE REINFORCEMENT: 0.12 SQ. IN. PER FT. IN EACH DIRECTION. AN APPROVED ALTERNATE PRECAST CONCRETE BASE MAY BE USED.
6. ADJUSTING RINGS NOT REQUIRED. SECURE FRAME TO TOP OF STRUCTURE. SEAL JOINTS BETWEEN FRAME AND PRECAST CONCRETE.

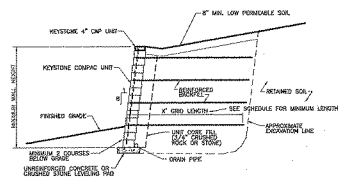
POND INLET DETAIL
NO SCALE

RETAINING WALL SCHEDULE

RETAINING WALL #	TOP OF WALL ELEVATION	TOE (GRADE) ELEVATION	MINIMUM WALL HEIGHT(Ft)	LENGTH OF WALL @ TOP (Ft)	GEOGRID PLACEMENT & MINIMUM LENGTH	COMMENTS
1	~~895~~	892	3.67	197	2 LAYERS @ 7' LONG	TERRACE TOP TWO FEET INTO GRADE @ SOUTH END
2	~~895~~	893	1.67	115.6	2 LAYERS @ 5' LONG	
3a	903.36	900.4	3.84	124	2 LAYERS @ 6' LONG	RETAINING WALL 3 IS TWO SEPARATE WALLS 5 FEET APART. 3A IS THE LOWER WALL. 3B IS THE UPPER WALL. 3B IS THE UPPER WALL PLACE 6" OF 1-1/2" ROCK ON LANDSCAPE FABRIC BETWEEN WALLS 3A & 3B. PLACE EDGING FROM EACH END OF WALL 3A TO FACE OF WALL 3B TO SEPARATE ROCK FROM GRASS.
3b	906.72	903	3.84	128	2 LAYERS @ 6' LONG	
4	896.5	884	3.84	73	2 LAYERS @ 6' LONG	–
5	903	897	4.67	58	2 LAYERS @ 8' LONG	

RETAINING WALL #2 WAS ELIMINATED

SEE SHOP DRAWINGS FOR FINAL WALL DESIGN



7 / 18 TYPICAL REINFORCED SECTION
COMPAC UNIT – 1" MINIMUM SETBACK
NO SCALE

RECORD DRAWING
DATE: MAY 2003

A	MAN. 2003	REVISED DRAWING	MAY
ADD	DATE	DESCRIPTION	BY

CITY OF FARGO PUBLIC WORKS
DRAIN 27/BOSE COULEE
IMPROVEMENTS & INCIDENTALS
IMPROVEMENT DISTRICT No.4866-1

DETAILS

DALTEKG ENGINEERS, INC. — CONSULTING ENGINEERS — FARGO, NORTH DAKOTA — WEST FARGO, NORTH DAKOTA

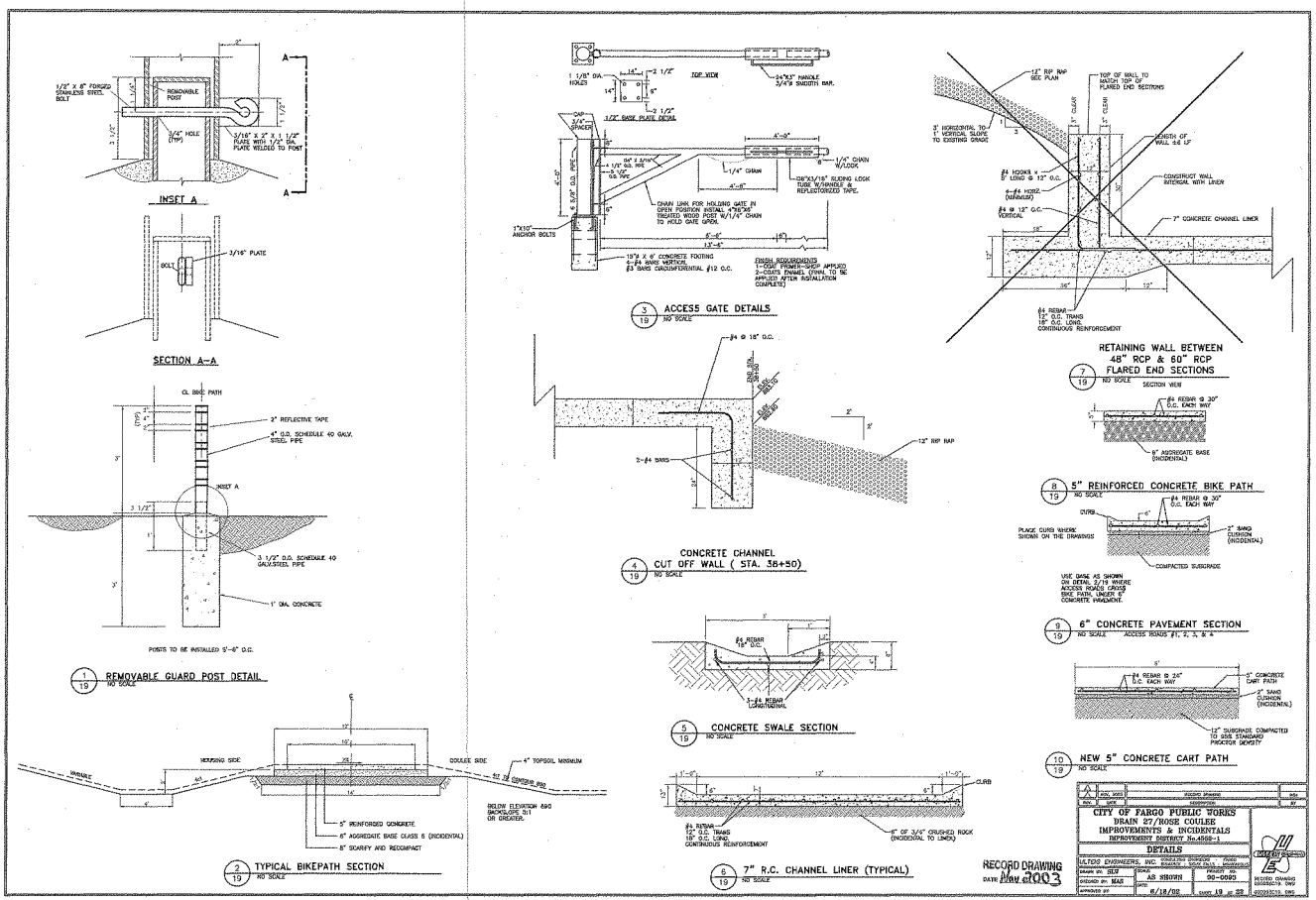
DRAWN BY: BCW	DATE: 6/18/03	AS SHOWN	PROJECT NO. 00-0093
DESIGNED BY: MAS	DATE:		
APPROVED BY:	DATE: 6/18/03	SHEET 18 OF 22	RECORD DRAWING 03/06/06

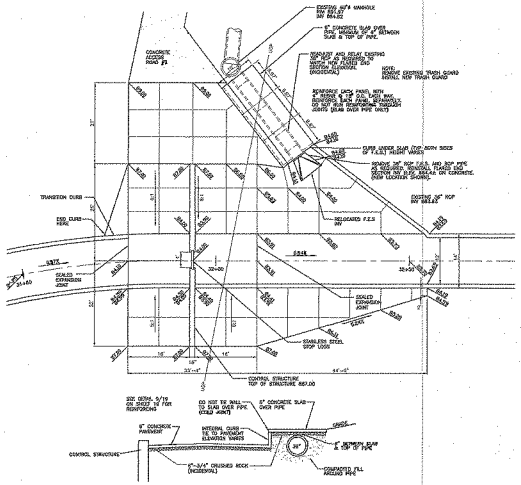
DRAWING NO. 03-0093-18.DWG

Microstation V.7.1 Jul 10
Created by Dalteking Groups

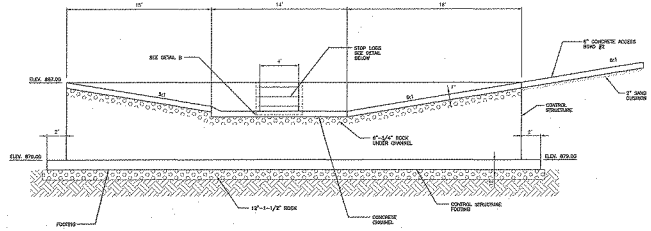
1360

Fargo Standard Water Specific Notes and Details
July 2012

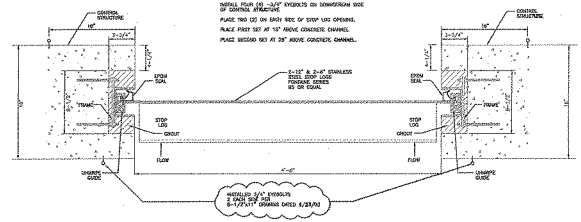

1/2" X 8" FORGED STAINLESS STEEL BOLT
REMOVABLE POST
3/4" HOLE (TYP)
3/16" X 2" X 1 1/2" PLATE WIDH 1/2" DIA. PLATE WELDED TO POST
INSET A
3/16" PLATE
BOLT
SECTION A-A
CL BIKE PATH
2" REFLECTIVE TAPE
4" O.D. SCHEDULE 40 GALV. STEEL PIPE
INSET A
3 1/2" O.D. SCHEDULE 40 GALV.STEEL PIPE
1" DIA. CONCRETE
POSTS TO BE INSTALLED 5'-6" O.C.
1 REMOVABLE GUARD POST DETAIL
NO SCALE
HOUSING SIDE
COULEE SIDE
4" TOPSOIL MINIMUM
5" REINFORCED CONCRETE
6" AGGREGATE BASE CLASS 6 (INCIDENTAL)
8" SCARIFY AND RECOMPACT
BELOW ELEVATION 890 BACKSLOPE 3:1 OR GREATER.
2 TYPICAL BIKEPATH SECTION
NO SCALE
1 1/8" DIA. HOLES
TOP VIEW
3/4"X3" HANDLE 3/4"Ø SMOOTH BAR.
1/2" BASE PLATE DETAIL
CAP 3/4" SPACER
1/4" CHAIN
1/4" CHAIN W/LOOK
DIE"X3/16" SLIDING LOCK TUBE W/HANDLE & REFLECTORIZED TAPE.
CHAIN LINK FOR HOLDING GATE IN OPEN POSITION INSTALL 4"X6"X8' TREATED WOOD POST W/1/4" CHAIN TO HOLD GATE OPEN.
1"X10" ANCHOR BOLTS
18"Ø X 6' CONCRETE FOOTING 4-#4 BARS VERTICAL #3 BARS CIRCUMFERENTIAL #12 O.C.
FINISH REQUIREMENTS 1-COAT PRIMER-SHOP APPLIED 2-COATS ENAMEL (PAINT TO BE APPLIED AFTER INSTALLATION COMPLETE)
3 ACCESS GATE DETAILS
NO SCALE
#4 @ 18" O.C.
2-#4 BARS
12" RIP RAP
4 CONCRETE CHANNEL CUT OFF WALL (STA. 38+50)
NO SCALE
#4 REBAR 18" O.C.
3-#4 REBAR LONGITUDINAL
5 CONCRETE SWALE SECTION
NO SCALE
#4 REBAR 12" O.C. TRANS 18" O.C. LONG CONTINUOUS REINFORCEMENT
6" OF 3/4" CRUSHED ROCK (INCIDENTAL TO LINER)
CURB
6 7" R.C. CHANNEL LINER (TYPICAL)
NO SCALE
12" RIP RAP SEE PLAN
TOP OF WALL TO MATCH TOP OF FLARED END SECTIONS
3" HORIZONTAL TO 1" VERTICAL SLOPE TO EXISTING GRADE
LENGTH OF WALL 44 LF
#4 HOOKS x 8' LONG @ 12" O.C.
6-#4 HORIZ. (MINIMUM)
#4 @ 12" O.C. VERTICAL
CONSTRUCT WALL MATERIAL WITH LINER
7" CONCRETE CHANNEL LINER
#4 REBAR 12" O.C. TRANS 18" O.C. LONG CONTINUOUS REINFORCEMENT
RETAINING WALL BETWEEN 48" RCP & 60" RCP FLARED END SECTIONS
7 NO SCALE
SECTION VIEW
#4 REBAR @ 30" O.C. EACH WAY
6" AGGREGATE BASE (INCIDENTAL)
8 5" REINFORCED CONCRETE BIKE PATH
NO SCALE
#4 REBAR @ 30" O.C. EACH WAY
CURB
PLACE CURB WHERE SHOWN ON THE DRAWINGS
3" SAND CUSHION (INCIDENTAL)
COMPACTED SUBGRADE
USE DASH AS SHOWN ON DETAIL 2/19 WHERE ACCESS ROADS CROSS BIKE PATH UNDER 8" CONCRETE PAVEMENT.
9 6" CONCRETE PAVEMENT SECTION
NO SCALE
ACCESS ROADS #1, 2, 3, & 4
#4 REBAR @ 24" O.C. EACH WAY
5" CONCRETE CART PATH
3" SAND CUSHION (INCIDENTAL)
12" SUBGRADE COMPACTED TO 95% STANDARD PROCTOR DENSITY
10 NEW 5" CONCRETE CART PATH
NO SCALE
CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE IMPROVEMENTS & INCIDENTALS
IMPROVEMENT DISTRICT No.4558-1
DETAILS
ULTEIG ENGINEERS, INC.
DRAWN BY: DLW
DESIGNED BY: MAR
SCALE: AS SHOWN
PROJECT NO: 90-0093
APPROVED BY
DATE: 6/18/02
SHEET 19 of 28
RECORD DRAWING
DATE May 2003
RECORD DRAWING 02/08/2016 DWG
92009.DG.DWG
Final Fargo Minimum Meets Feasibility Report and Environmental Impact Statement
July 2007
Microstation V8.11.9.2 64
Units to Existing Levees



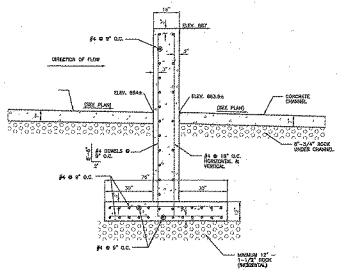
1 / 20 CONTROL STRUCTURE ENLARGED PLAN VIEW
SCALE 1"=10'



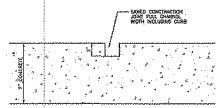
5 / 20 CONCRETE CONTROL STRUCTURE FRONT VIEW (LOOKING WEST)
1"=4'



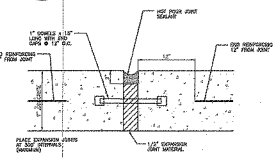
5 / 20 CONTROL STRUCTURE DETAIL PLAN VIEW
NO SCALE



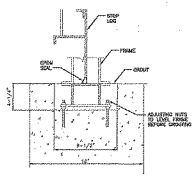
2 / 20 CONTROL STRUCTURE DETAIL SECTION VIEW
1"=2'



3 / 20 UNDOWELED CONTRACTION JOINT
NO SCALE



4 / 20 EXPANSION JOINT DETAIL
NO SCALE



7 / 20 EMBEDDED FRAME DETAIL B
NO SCALE SECTION VIEW

RECORD DRAWING
DATE May 2003

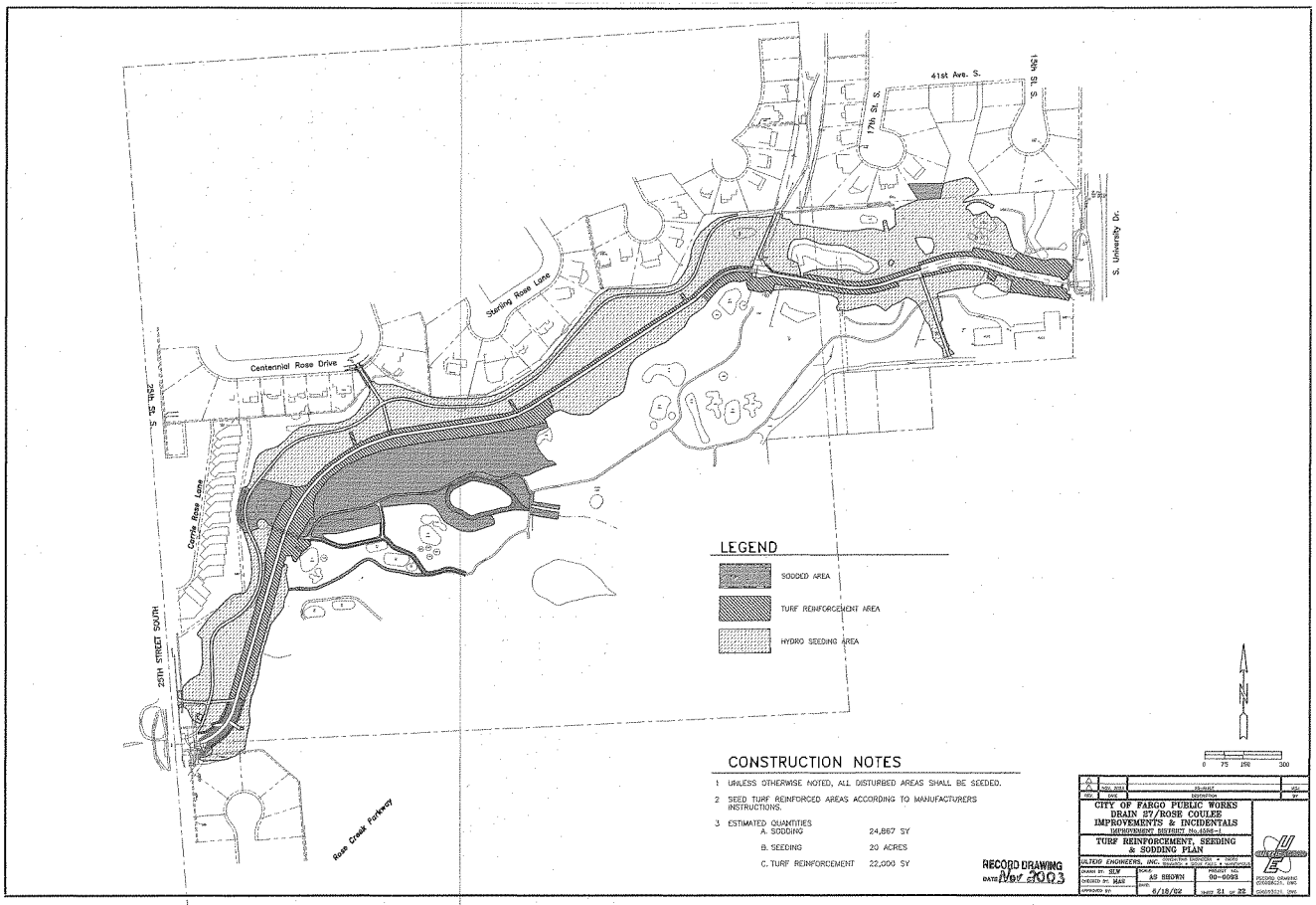
A			
REV.	DATE	RECORD DRAWING DESCRIPTION	BY
REV.	DATE	DESCRIPTION	BY

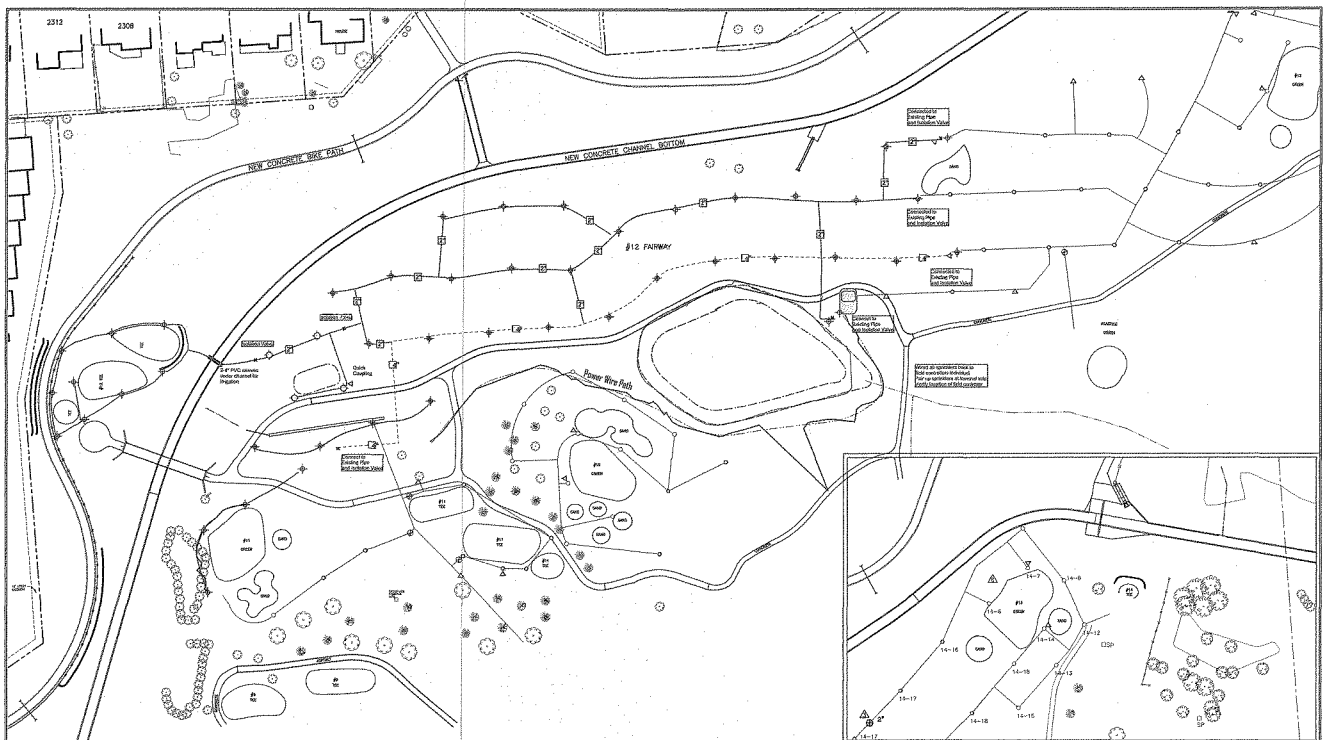
CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
IMPROVEMENT DISTRICT No.4868-1

DETAILS

ULTEAM ENGINEERS, INC. ENGINEERS ARCHITECTS PLANNERS SURVEYORS 3202 13th AVENUE SOUTH FARGO, NORTH DAKOTA

DRAWN BY: SLCT	AS SHOWN	PROJECT NO. 06-0093	RECORD DRAWING DESIGNATION DATE
CHECKED BY: MAR	DATE: 6/16/06	SHEET 20 OF 20	REVISED 8/22 DWG.
APPROVED BY:			


41st Ave. S.
15th St. S.
17th St. S.
S. University Dr.
Sterling Rose Lane
Centennial Rose Drive
25th St. S.
Carrie Rose Lane
25TH STREET SOUTH
Rose Creek Parkway
LEGEND
SODDED AREA
TURF REINFORCEMENT AREA
HYDRO SEEDING AREA
N
0 75 150 300
CONSTRUCTION NOTES
1 UNLESS OTHERWISE NOTED, ALL DISTURBED AREAS SHALL BE SEEDED.
2 SEED TURF REINFORCED AREAS ACCORDING TO MANUFACTURERS INSTRUCTIONS.
3 ESTIMATED QUANTITIES
A. SODDING 24,867 SY
B. SEEDING 20 ACRES
C. TURF REINFORCEMENT 22,000 SY
RECORD DRAWING
DATE Nov 2003
CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
IMPROVEMENT DISTRICT No.4556-1
TURF REINFORCEMENT, SEEDING & SODDING PLAN
ULTEIG ENGINEERS, INC.
DRAWN BY: SLW
CHECKED BY: MAR
APPROVED BY:
SCALE: AS SHOWN
DATE: 6/18/02
PROJECT NO. 00-0093
SHEET 21 OF 22
PROJECT NO. 00-0093
DWG. NO. 2001
REVISION
REV. DATE DESCRIPTION BY
Attachment H-12 pg 34
Creative Catalog Lenses



CONSTRUCTION NOTES

1. ~~SHOWN IS THE APPROXIMATE LOCATION (DIMENSIONATED) OF EXISTING SPRINKLER SYSTEM OVERLAID ON PROPOSED IMPROVEMENTS OF THE #13 TEE BOX AREA, #12 FAIRWAY AND THE #14 GREEN. FIELD VERIFY AND TIE IN THE LOCATIONS OF ALL EXISTING SPRINKLERS, QUICK COUPLERS, AND SWING JOINTS PRIOR TO CONSTRUCTION.~~
2. REMOVED AND SALVAGED ALL SPRINKLER HEADS, QUICK COUPLERS, AND SWING JOINTS PRIOR TO CONSTRUCTION. ABANDON SPRINKLER LINES IN PLACE.
3. INSTALLED AN ISOLATION VALVE AT ALL RECONNECTION POINTS TO EXISTING SYSTEM. EXISTING SYSTEM OUTAGE OF CONSTRUCTION LIGHTS TO REMAIN IN SERVICE. TIE IN LOCATIONS TO BE FIELD DETERMINED.
4. EXISTING CONTROL STATION TO REMAIN.
5. DISCONNECTED EXISTING SPRINKLER SYSTEM AT PROPOSED CHANNEL CROSSING. PLUG LINE NORTH OF CHANNEL AND ABANDON IN PLACE.
6. MODIFIED EXISTING SPRINKLER SYSTEM AS NEEDED ALONG #13 GREEN. CONSTRUCTION LIMIT IS ALONG EDGE OF GREEN. SLOPE FROM GREEN TO CHANNEL WILL BE COVERED WITH TURF REINFORCEMENT.
7. ALL NEW IRRIGATION PIPING TO BE INSTALLED UNDER PAVED AREAS OR ACROSS THE CONCRETE CHANNEL LINER SHALL BE SLEEVED.
8. ABANDONED EXISTING COMMUNICATION AND CONTROL CABLES IN PLACE. REPLACE AFTER COMPLETION OF FAIRWAY IMPROVEMENTS.
9. REINSTALLED ALL REMOVED SPRINKLER HEADS ON #12 TEE BOX AND FAIRWAY. INSTALLED NEW IRRIGATION LINES TO EACH HEAD.
10. MODIFIED IRRIGATION SYSTEM AS REQUIRED AROUND #10 GREEN AND #11 FAIRWAY TO ACCOMMODATE NEW CART PATH.

LEGEND

- SPRINKLER VALVE
- QUICK COUPLER
- SPRINKLER HEAD TORO 674
- SPRINKLER HEAD TORO 890
- 4" IRRIGATION LINE
- 2-1/2" LATERAL IRRIGATION LINE
- 2" IRRIGATION LINE
- COMMUNICATION & CONTROL WIRING FROM EXISTING CONTROL STATION
- NEW ISOLATION VALVE

0 25 50 100

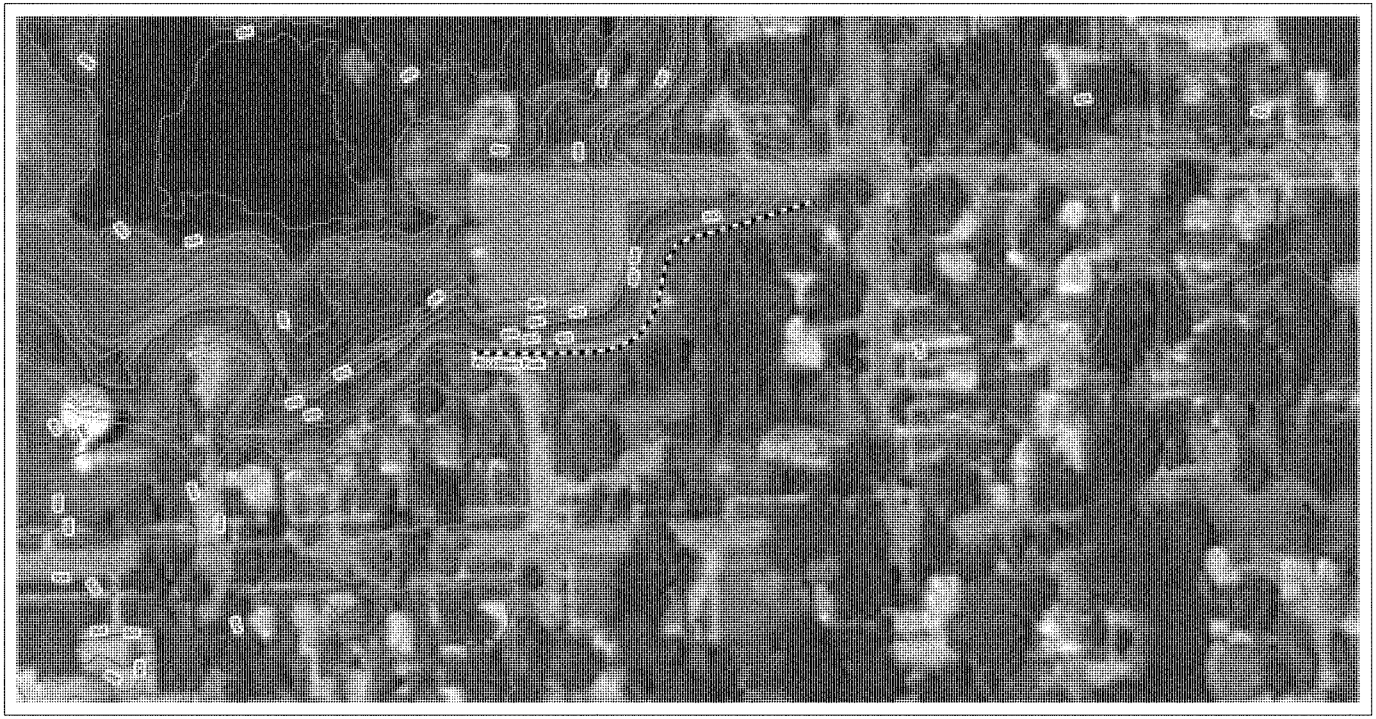
RECORD DRAWING
DATE Nov 2003

A			
B			
C			
REV.	DATE	REVISED DRAWING	MAP
REV.	DATE	DESCRIPTION	BY

CITY OF FARGO PUBLIC WORKS
DRAIN 27/ROSE COULEE
IMPROVEMENTS & INCIDENTALS
IMPROVEMENT DISTRICT No.4956-1
IRRIGATION SYSTEM REVISIONS

ULTERG ENGINEERS, INC. CONSULTING ENGINEERS • SURVEYORS • PLANNERS
DRAWN BY: BLD SCALE: AS SHOWN DATE: 9/19/02 PROJECT NO. 02-5083 RECORD DRAWING DESIGNED BY: DATE
CHECKED BY: MAS
APPROVED BY: SHEET 22 of 22 DOCUMENT/FILE: 02083-22-22.DWG

Attachment H-13: Woodlawn Park Levee Information



St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps of Engineers®

FMMFS_P2_geotech_2009-04.mxd
Printed 20 NOV 09

FMMFS: Credit to Existing Levees
Woodlawn Park, 97-13-15 (Moorhead)

0 50 100 200 300 Feet

column - 29
change to 88 in 020.03

CITY OF MOORHEAD MINNESOTA

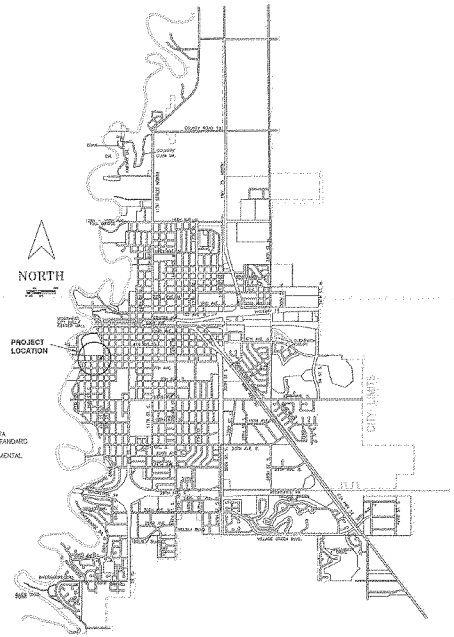
ENGINEERING DEPARTMENT
CONSTRUCTION PLANS FOR

WOODLAWN PARK DIKE IMPROVEMENTS

ENGR. NO. 97-13-15

LEGEND

- PROPOSED OR EXISTING C&G
- NEW CURB AND GUTTER
- EXISTING SEWER
- NEW SEWER
- W — WATERMAIN
- G — GAS MAIN
- T — TELEPHONE -OH OR BURIED
- E — ELECTRICAL -OH OR BURIED
- FENCE
- DRIVEWAY APPROACH
- PAVEMENT REMOVAL
- HEDGE
- TREE
- EXISTING MANHOLE
- NEW MANHOLE
- EXISTING CATCH BASIN
- NEW CATCH BASIN
- HYDRANT
- GATE VALVE
- UTILITY POLE



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SHEET NO. 1 TITLE SHEET AND LOCATION
SHEET NO. 2 DIKE CONSTRUCTION PLAN
SHEET NO. 3-4 CROSS SECTIONS

SPECIFICATION REFERENCE
THE 1988 EDITION OF THE MINNESOTA DEPARTMENT OF TRANSPORTATION "STANDARD SPECIFICATIONS FOR CONSTRUCTION" SHALL GOVERN ALONG WITH SUPPLEMENTAL SPECIFICATIONS DATED MAY 2,1994

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

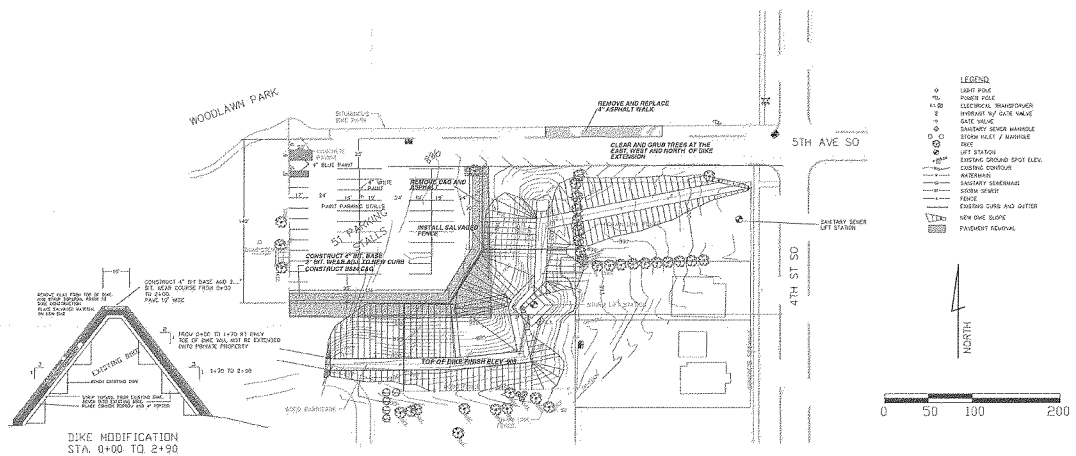
DATE
CITY ENGINEER REG. NO 8835

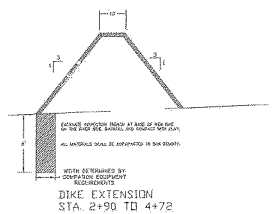
RECOMMENDED FOR APPROVAL DATE
DISTRICT STATE AID ENGINEER

RECOMMENDED FOR APPROVAL DATE
STATE AID PLANS & SPECS ENGINEER

APPROVED DATE
STATE AID ENGINEER

DRAWN BY	CHECKED BY	REVISION	REVISION	REVISION	INSPECTOR	CONTRACTOR	SUBCONTRACTOR	SUBCONTRACTOR	LEGAL NO.	ENGINEERING NO.	
									13-15-1997	97-13-15	SHT. 1 OF 4

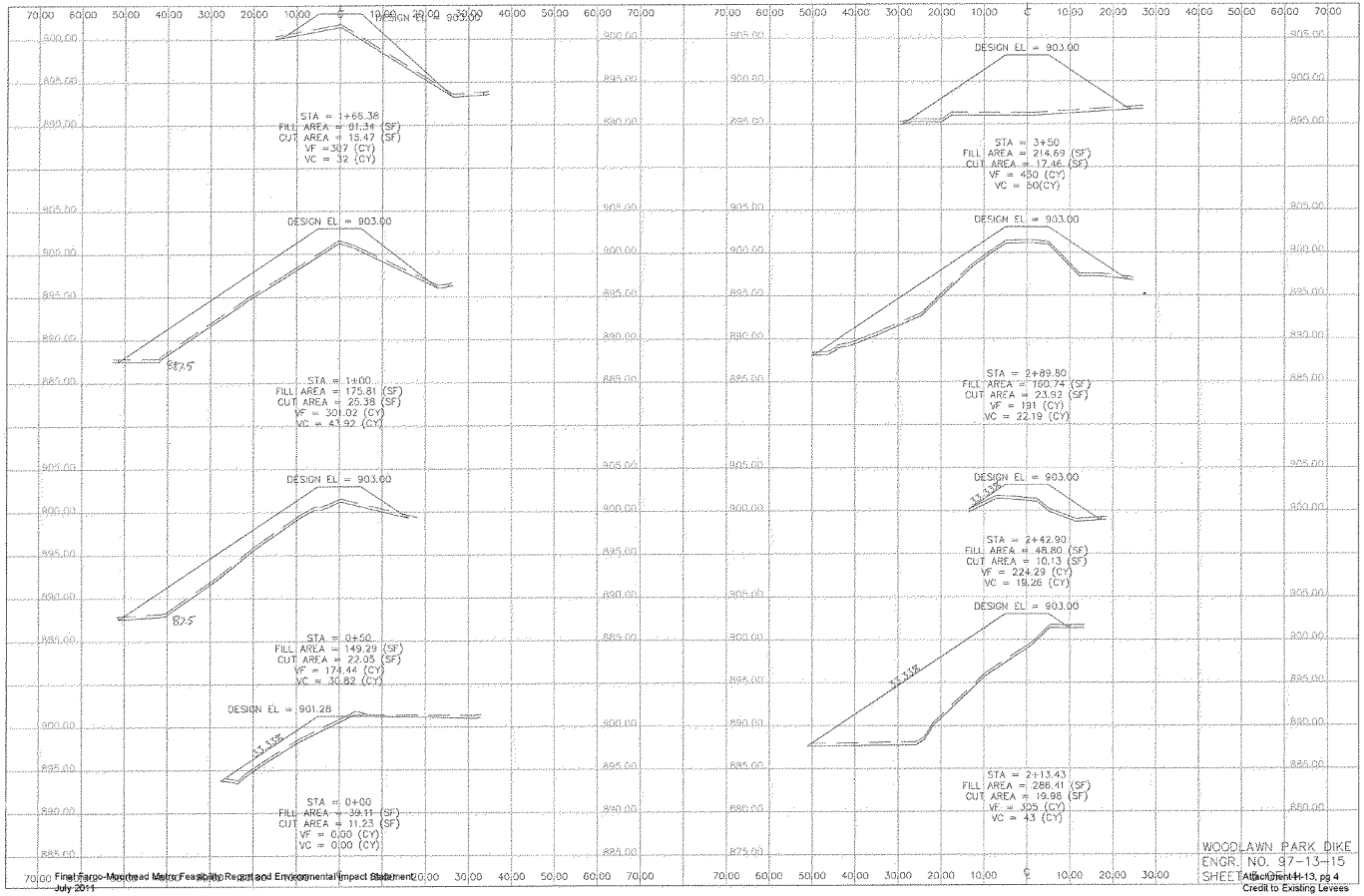




WOODLAWN PARK DIKE EXTENTION

CITY ENGR. PROJECT 97-12-15

SHEET 2 OF 4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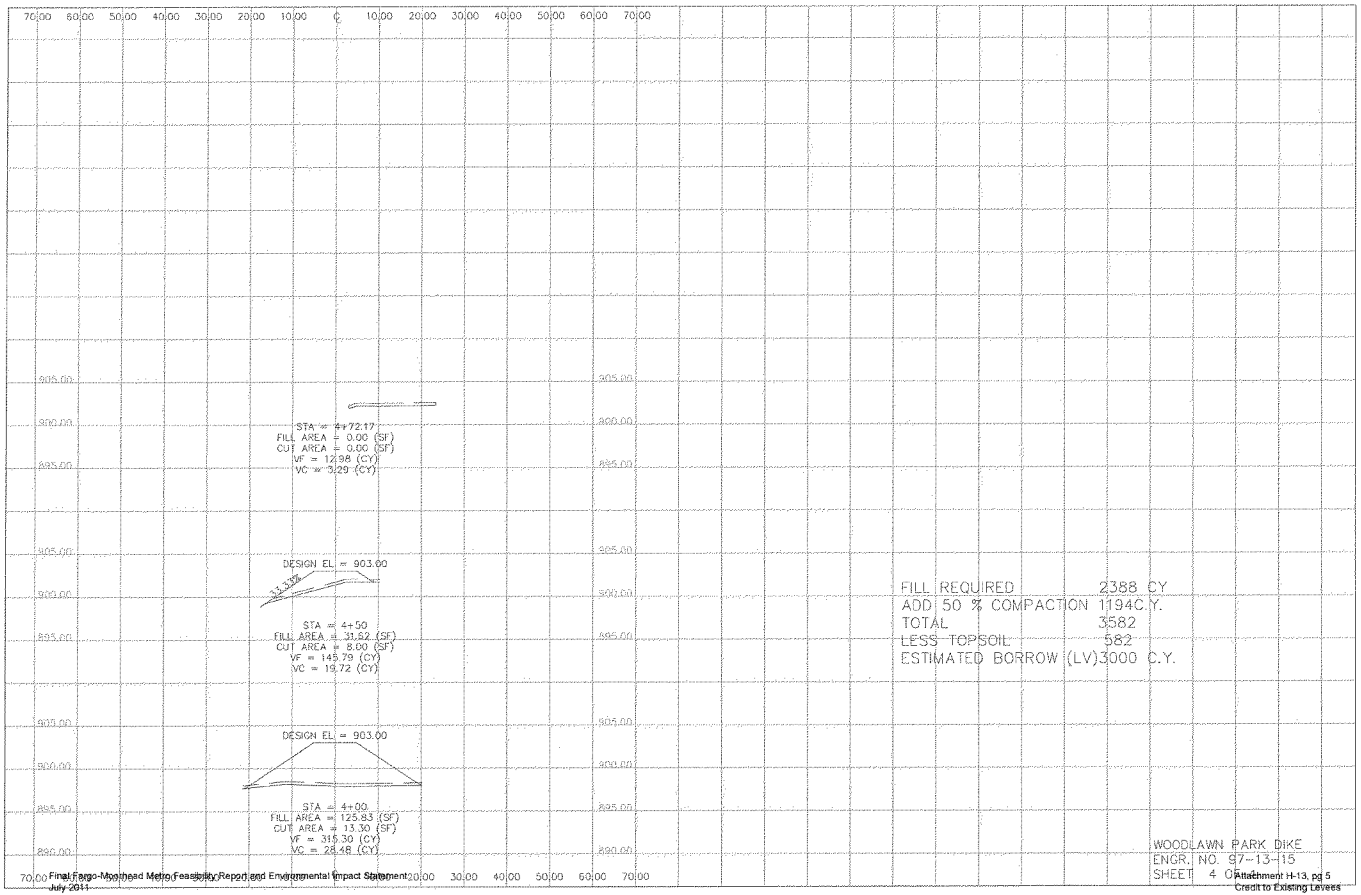
WOODLAWN PARK DIKE
ENGR. NO. 97-13-15
SHEET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895.00
890.00
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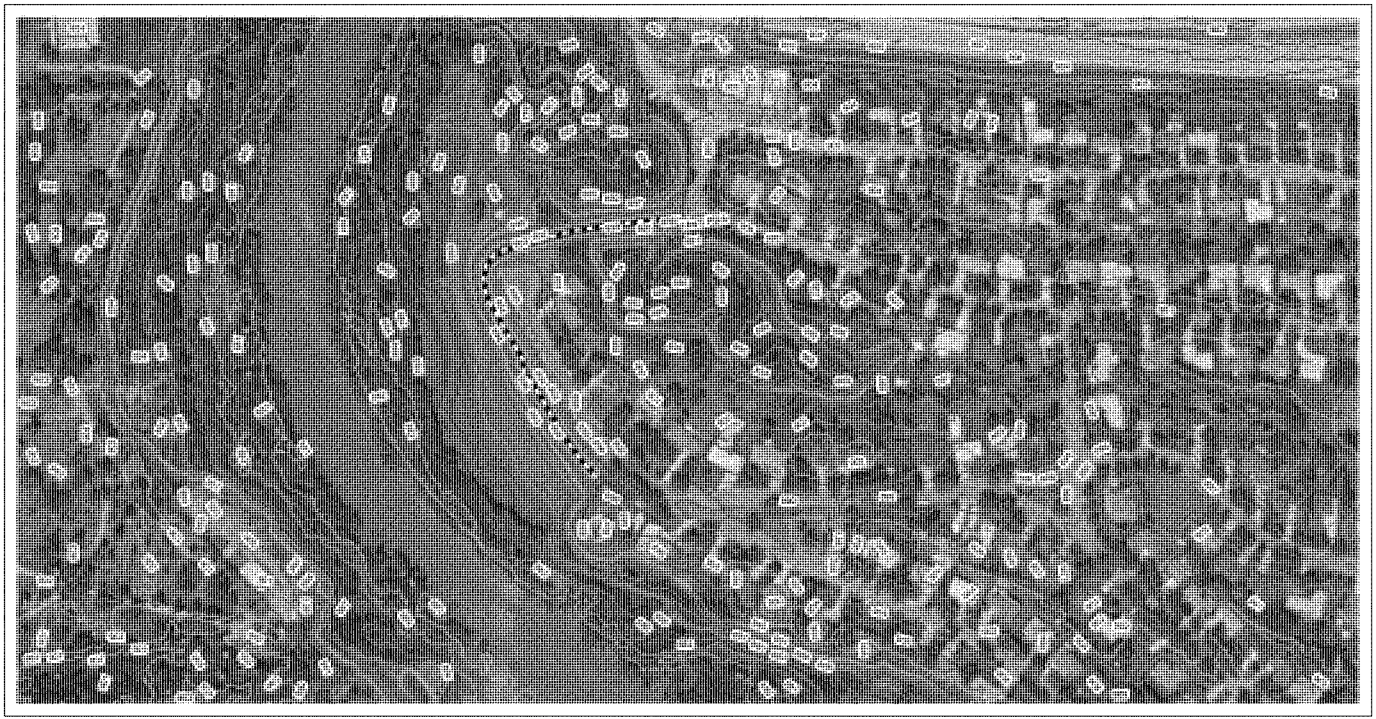
FILL REQUIRED 2388 CY
ADD 50 % COMPACTION 1194C.Y.
TOTAL 3582
LESS TOPSOIL 582
ESTIMATED BORROW (LV)3000 C.Y.
WOODLAWN PARK DIKE
ENGR. NO. 97-13-15
SHEET 4 OF

Attachment H-14: Horn Park Levee Information



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US Army Corps of Engineers®

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Printed 20 NOV 09

FMMFS: Credit to Existing Levees
Horn Park, 97-13-14 (Moorhead)

0 100 200 400 600 Feet

CITY OF MOORHEAD MINNESOTA

ENGINEERING DEPARTMENT
CONSTRUCTION PLANS FOR
HORN PARK DIKE IMPROVEMENTS
ENGR. NO. 97-13-14

LEGEND

- PROPOSED OR EXISTING C&G
- NEW CURB AND GUTTER
- EXISTING SEWER
- NEW SEWER
- W — WATERMAIN
- G — GAS MAIN
- T — TELEPHONE –OH OR BURIED
- E — ELECTRICAL –OH OR BURIED
- FENCE
- DRIVEWAY APPROACH
- PAVEMENT REMOVAL
- HEDGE
- TREE
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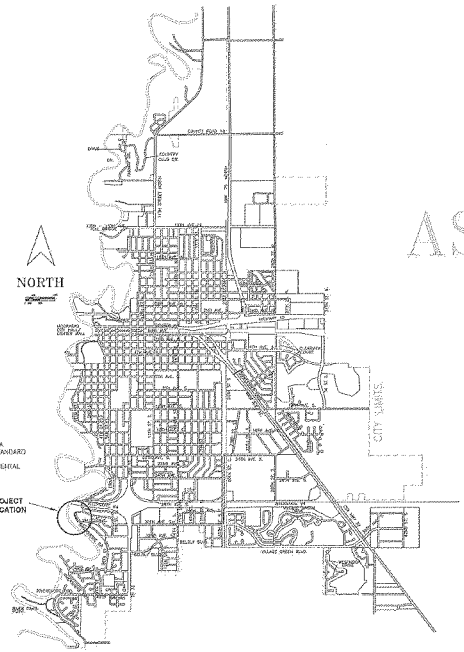
- EXISTING CATCH BASIN
- NEW CATCH BASIN
- HYDRANT
- GATE VALVE
- UTILITY POLE



AS-BUILT

AS-BUILT

SPECIFICATION REFERENCE
THE 1988 EDITION OF THE MINNESOTA DEPARTMENT OF TRANSPORTATION "STANDARD SPECIFICATIONS FOR CONSTRUCTION" SHALL GOVERN ALONG WITH SUPPLEMENTAL SPECIFICATIONS DATED MAY 2, 1994

INDEX

SHEET NO. 1 TITLE SHEET AND LOCATION
SHEET NO. 2 DIKE CONSTRUCTION PLAN
SHEET NO. 3-6 CROSS SECTIONS

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

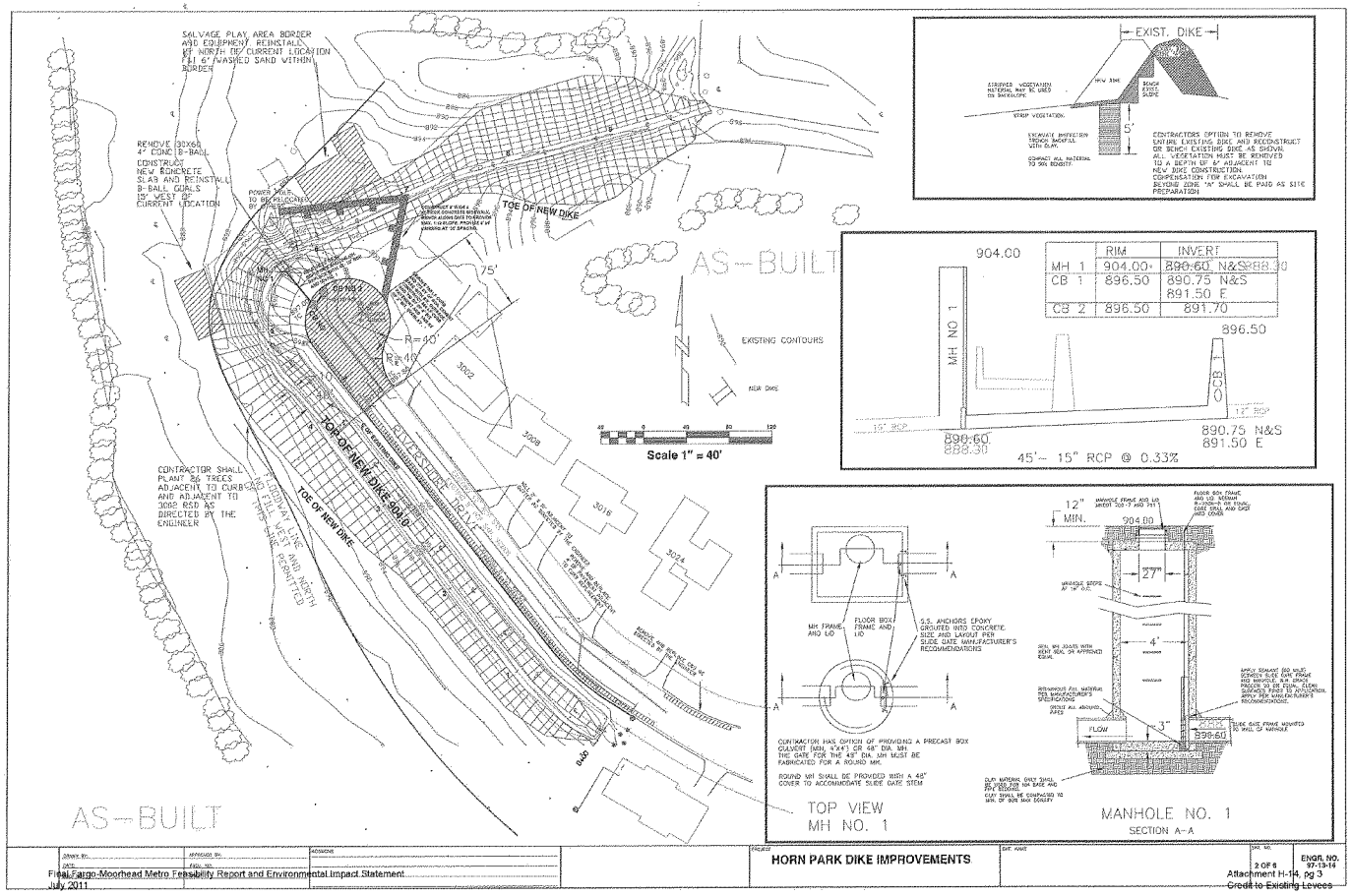
CITY ENGINEER — DATE — REG. NO 8835

RECOMMENDED FOR APPROVAL — DISTRICT STATE AID ENGINEER — DATE

RECOMMENDED FOR APPROVAL — STATE AID PLANS & SPECS. ENGINEER — DATE

APPROVED — STATE AID ENGINEER — DATE

DRAWN BY	CHECKED BY	REVISION	REVISION	REVISION	INSPECTOR	CONTRACTOR	SUBCONTRACTOR	SUBCONTRACTOR	LEGAL NO.	ENGINEERING NO.
					BROOKS	SCHIPPER CONST.			13-14-1997	97-13-14



DRAWN BY:	APPROVED BY:	REVISIONS
DATE:	FED. NO.	

PROJECT: **HORN PARK DIKE IMPROVEMENTS**

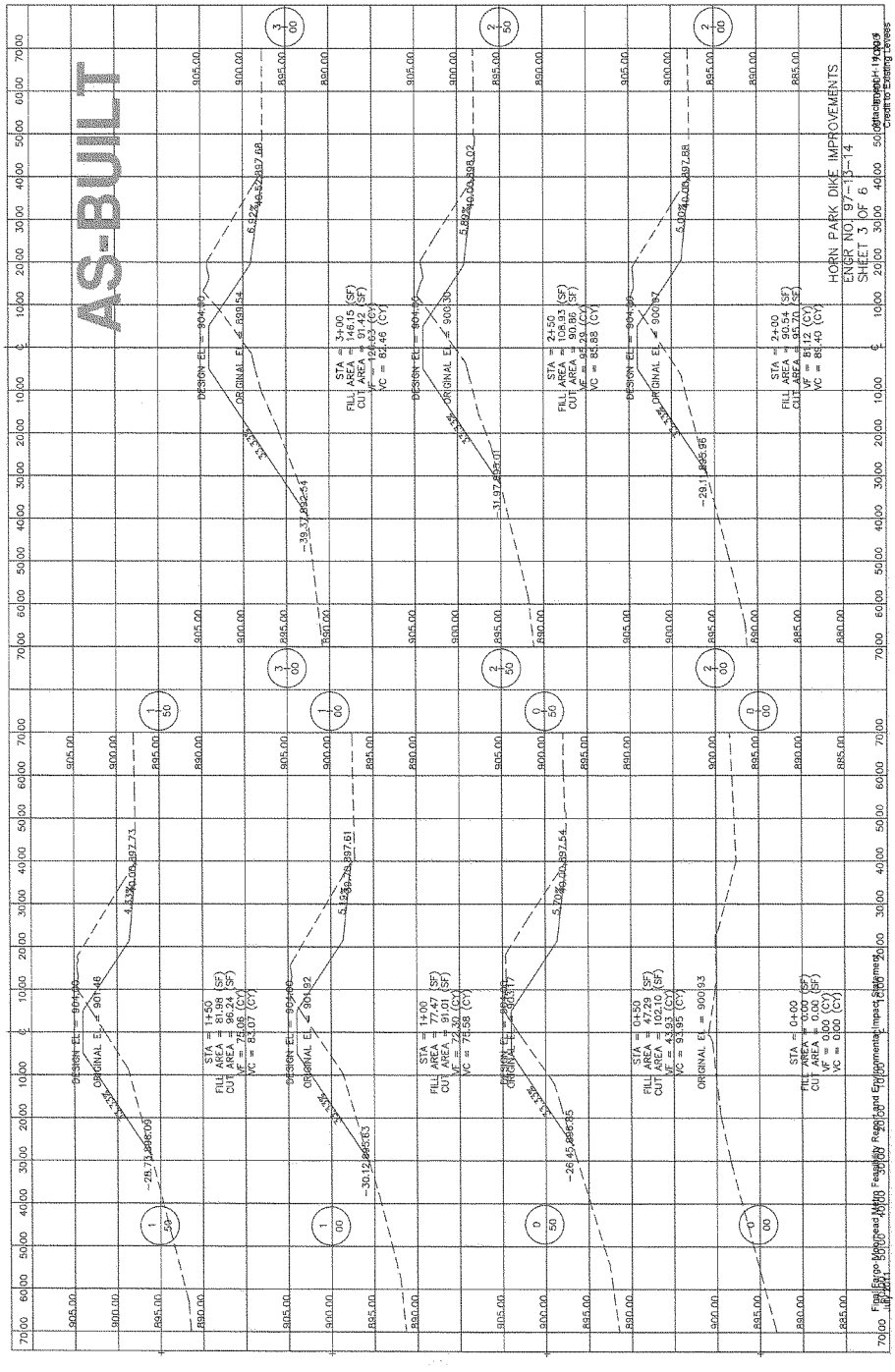
DATE: MAR

SHT. NO. 2 OF 6

ENGR. NO. 97-13-14

Attachment H-14, pg 3

Credit to Existing Levees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HORN PARK DIKE IMPROVEMENTS
ENGR NO. 97-13-14
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6.52%
4.33%
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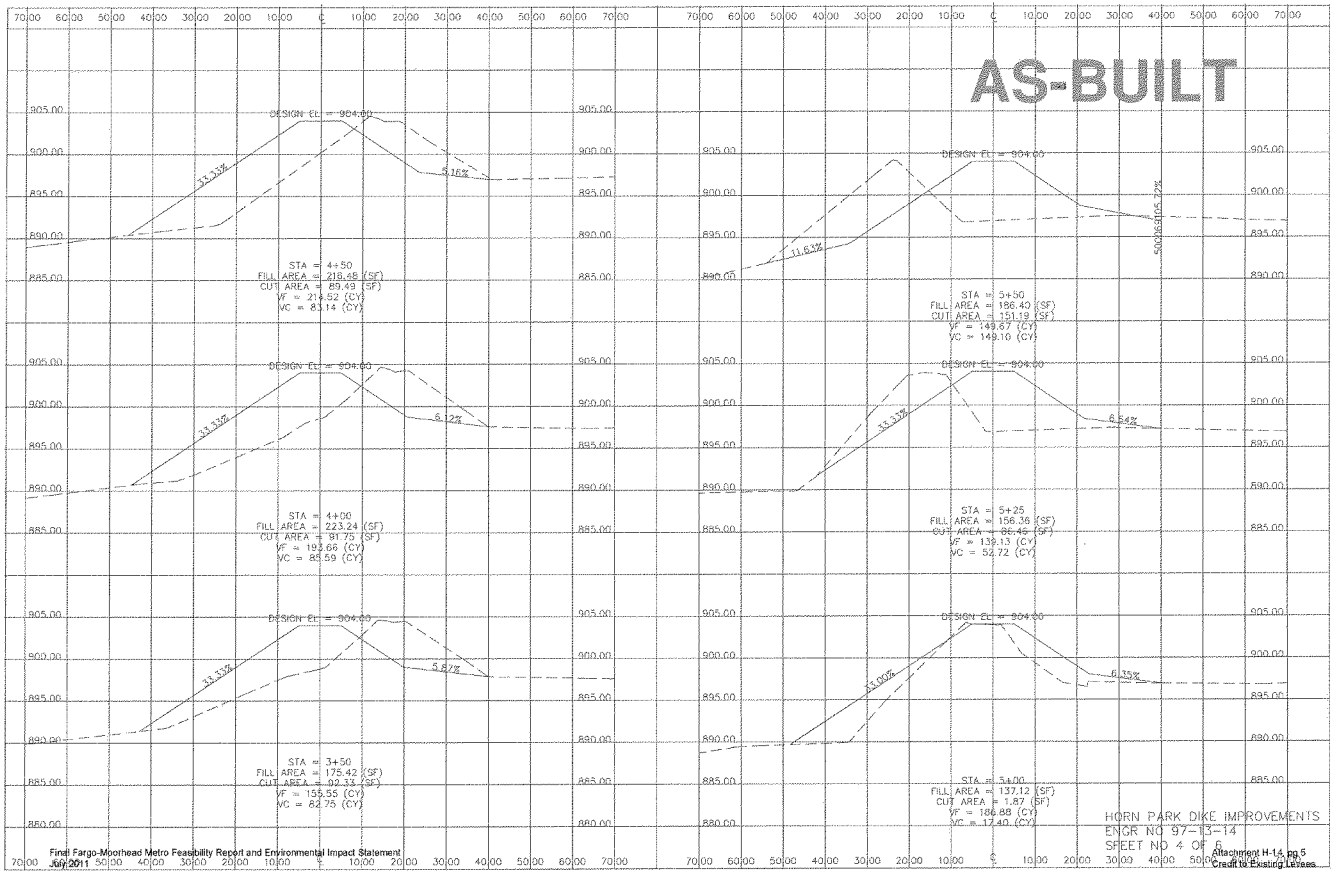
Final Engro-Kopcrowd Metro Feasibility Report and Environmental Impact Statement
Figure 3.2-11
Credit to Existing Levees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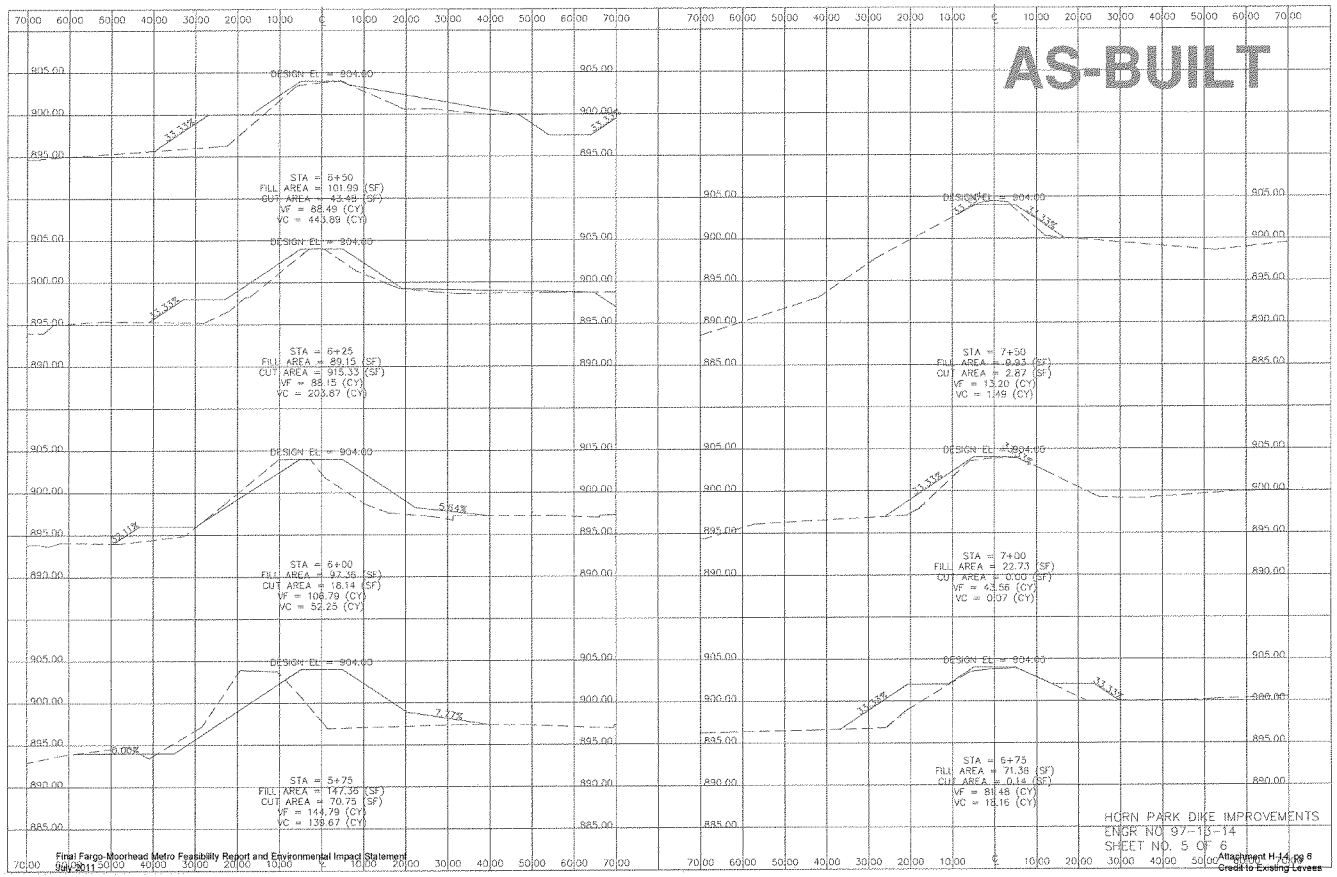
HORN PARK DIKE IMPROVEMENTS
ENGR NO 97-13-14
SHEET NO 4 OF 6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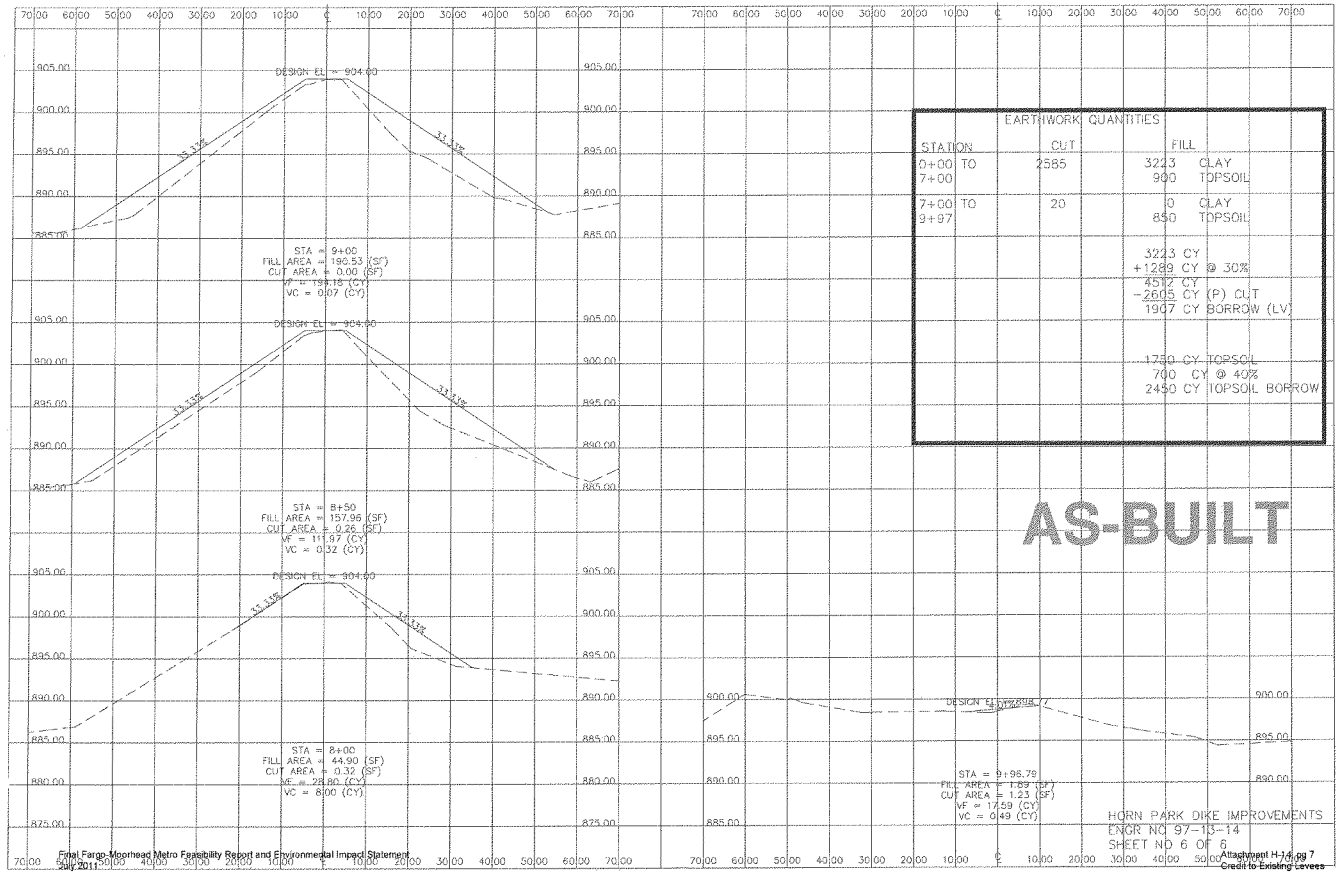
HORN PARK DIKE IMPROVEMENTS
ENGR NO 97-13-14
SHEET NO. 5 OF 6



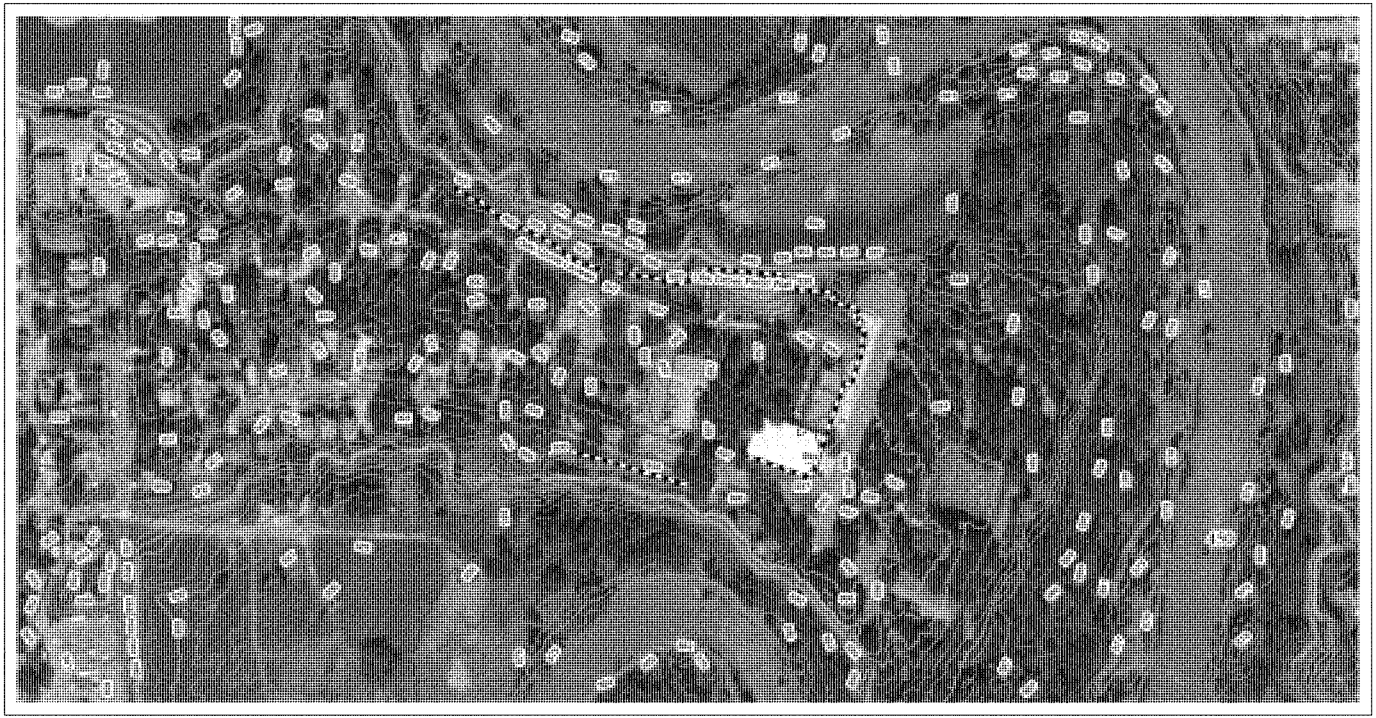
EARTHWORK QUANTITIES

STATION	CUT	FILL	
0+00 TO 7+00	2585	3223	CLAY
		900	TOPSOIL
7+00 TO 9+97	20	0	CLAY
		850	TOPSOIL

3223 CY
+1289 CY @ 30%
4512 CY
-2605 CY (P) CUT
1907 CY BORROW (LV)

1750 CY TOPSOIL
700 CY @ 40%
2450 CY TOPSOIL BORROW

Attachment H-15: Oak Grove Floodwall Information

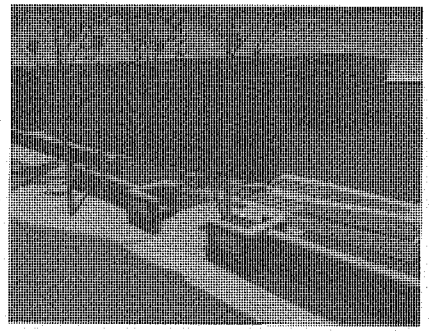


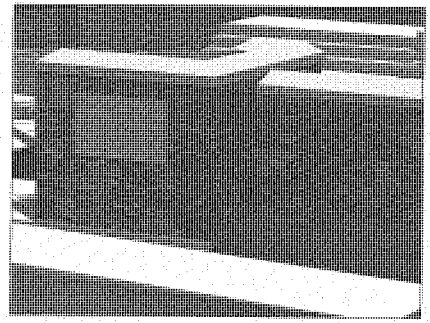
St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps of Engineers®

FMMFS_P2_geotech_2009-04.mxd
Printed 20 NOV 09

FMMFS: Credit to Existing Levees
Oak Grove (Fargo)

0 100 200 400 600 Feet





OAK GROVE FLOODWALL IMPROVEMENT PROJECT

HAZARD MITIGATION GRANT PROGRAM
DR 1174 - ND PROJECT NO. 0027

CITY OF FARGO
SPECIAL IMPROVEMENT DISTRICT #5036

OAK GROVE LUTHERAN HIGH SCHOOL
FARGO, NORTH DAKOTA

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A1.0 ARCHITECTURAL SITE PLAN
A1.1 MASTER LANDSCAPING PLAN
A1.2 PHASE 1 LANDSCAPING PLAN
A2.0 ELEVATIONS
A3.0 ELEVATION DETAILS
A4.0 WALL SECTIONS
A5.0 ENLARGED PLANS/DETAILS
A6.0 REMOVABLE FLOODWALL
A7.0 ALTERNATE 4 - STORAGE BLDG.

CIVIL

C1.0 SURVEY
C2.0 SITE DEMOLITION PLAN
C3.0 GRADING SITE PLAN
C4.0 PAVING & UTILITY PLAN
C5.0 DETAILS

STRUCTURAL

S1.0 PLAN
S2.0 SECTIONS
S3.0 SECTIONS/DETAILS

OAK GROVE LUTHERAN HIGH SCHOOL

ARCHITECT

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF NORTH DAKOTA

DATE 4-24-2000 REG NO 740

STRUCTURAL ENGINEERING CONSULTANT

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF NORTH DAKOTA

STEVE T. LOWE
APRIL 24, 2000
DATE 4-24-2000 REG NO 1835

CIVIL ENGINEERING CONSULTANT

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF NORTH DAKOTA

STEVE T. LOWE
APRIL 24, 2000
DATE 4-24-2000 REG NO 4852

OAK GROVE FLOODWALL IMPROVEMENT PROJECT

FARGO
NORTH DAKOTA

HAZARD MITIGATION GRANT PROGRAM
DR 1174-ND Project No. 0027

City of Fargo
Special Improvement District #5036

#OA

TRIEBWASSER HELENSKE & ASSOCIATES, Ltd.

ARCHITECTS AND CONSTRUCTION MANAGEMENT

11 RIVER OAKS POINT
P.O. BOX 547
MOORHEAD, MINNESOTA

444 MAIN AVENUE
FARGO, NORTH DAKOTA

(218) 236-8995 (Voice)
(701) 232-3273 (Voice)
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CADD NAME / SCALE
COVER
PROJECT NO.
THA - 40678
DATE
April 24, 2000
COVER SHEET

ACOVER

Adobe Acrobat 5.0 Pg 2
Created by Stocking Cameron

G:\ACTIVE\R8670\DWGS\ND\COVER

LEGEND	EXISTING
STORM SEWER MAIN	
SANITARY SEWER MAIN	
WATER MAIN	
GAS MAIN	
STORM INLET	
CURB STOP	
MANHOLE	
FIRE HYDRANT	
GATE VALVE	
UTILITY POLE	
W / GUY WIRE	
LIGHT POLE	
SIGN	
OVERHEAD POWER LINE	
UNDERGROUND TELEPHONE	
UNDERGROUND ELECTRIC	
UNDERGROUND GAS	
FIBER OPTIC	
TELEPHONE RISER	
FENCE	
DECIDUOUS TREE	
CONFEROUS TREE	
MISC. SHRUBBERY	
IRON MONUMENT FOUND	
1/2" I.D. IRON PIPE SET	
FIELD DISTANCE	523.24'
PLAT OR RECORDED DISTANCE	(523.13')
FIELD BEARING	N89°53'30"E
PLAT OR RECORDED BEARING	(N89°53'30"E)
CONCRETE	
ASPHALT	
BUILDING	

C 1.0

TOPOGRAPHIC SURVEY
OAK GROVE SCHOOL
FARGO, NORTH DAKOTA

Scale	Drawn by	Checked by	Project No.	Date	Sheet
AS SHOWN	DKB	BCH	3850-002	12-30-99	1 of 1

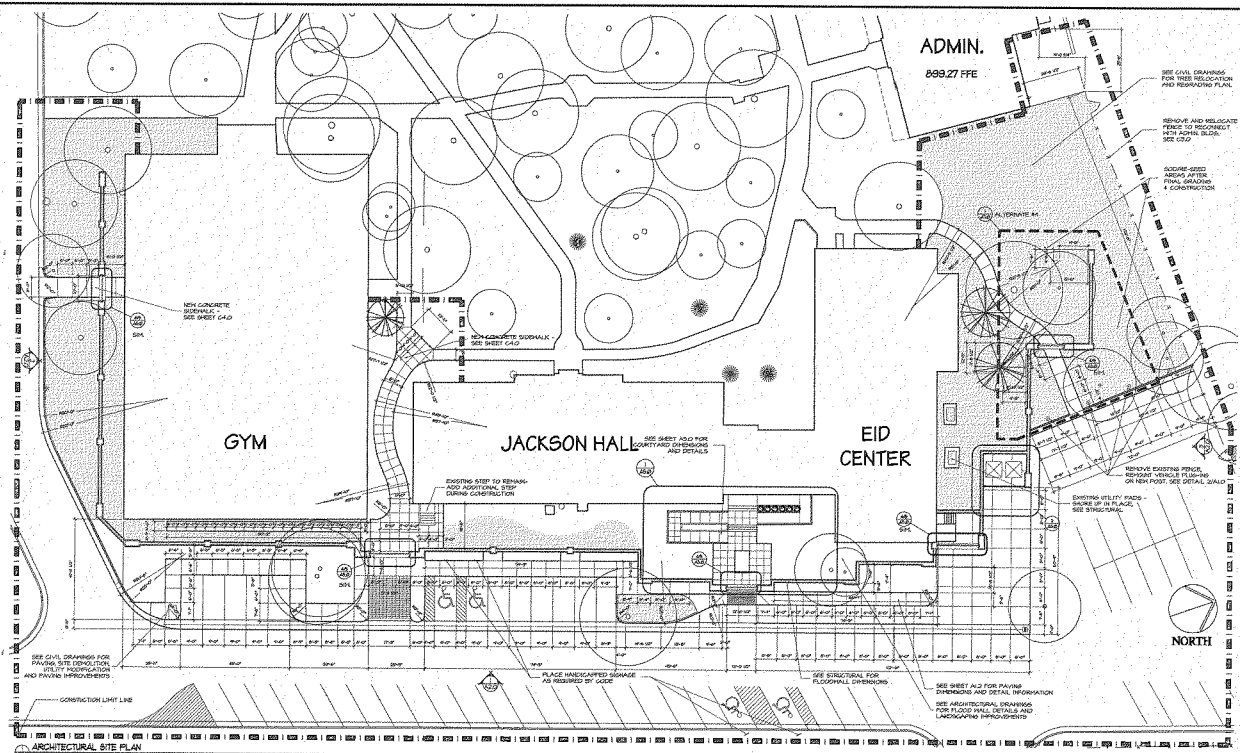
No.	Revision	Date	By

PREPARED BY
HOUSTON ENGINEERING, INC.
P.O. BOX 5054 FARGO, NORTH DAKOTA 58105
PHONE: (701) 237-5065 FAX: (701) 237-5101

CAD: REF-OAK-GROVE_ELEV

Fargo Schools Facility Master Plan
Feb 2011

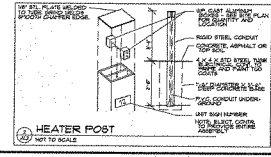
1382



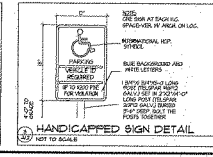
1 ARCHITECTURAL SITE PLAN
SCALE: 1" = 10'-0"

GENERAL PLAN NOTES

1. HEAVY DASHED LINE INDICATES PROJECT CONSTRUCTION LIMIT.
2. PROTECT ADJOINING PROPERTIES FROM CONSTRUCTION ACTIVITIES ACCORDING TO CITY OF FARGO SPECS.
3. COORDINATE CONSTRUCTION VEHICLE TRAFFIC AND CONSTRUCTION VEHICLE AND CREW PARKING WITH OWNER AND CITY TRAFFIC ENGINEER.
4. ALTERNATE BID #1 - RESURFACING OF EXISTING LOT. COORDINATE WITH CIVIL DOCUMENTS.
5. ALTERNATE BID #2 - REPLACEMENT OF REMAINDER OF ASPHALT ON ASH STREET IN AREA OF CONSTRUCTION LIMITS. COORDINATE WITH CIVIL.



2 HEATER POST
NOT TO SCALE



2 HANDICAPPED SIGN DETAIL
NOT TO SCALE

OAK GROVE FLOODWALL IMPROVEMENT PROJECT

FARGO
NORTH DAKOTA

HAZARD MITIGATION GRANT PROGRAM
DR 1176-ND Project No. 0027

City of Fargo
Special Improvement District #5856

TRIEBWASSER HELENSKE & ASSOCIATES, Ltd.

ARCHITECTS AND CONSTRUCTION MANAGEMENT

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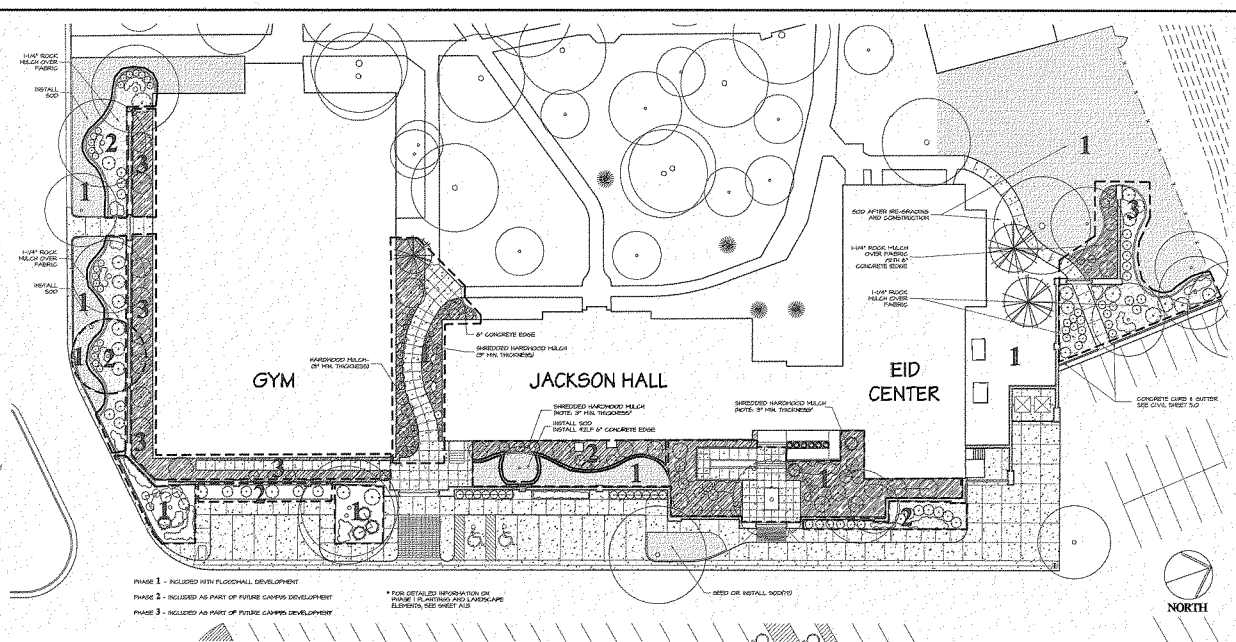
CADD NAME / SCALE
AI-0.dwg
PROJECT NO.
THA - 1516/10
DATE:
April 24, 2010
ARCHITECTURAL SITE PLAN

A1.0

1 OF 8
Sheet 1 of 8 Sheets
Certificate Number 1 Licensed

1383

VOMCS0CD\DWG\A1.0.DWG
July 2011



PHASE 1 - INCLUDED WITH FLOODWALL DEVELOPMENT

PHASE 2 - INCLUDED AS PART OF FUTURE CAMPUS DEVELOPMENT

PHASE 3 - INCLUDED AS PART OF FUTURE CAMPUS DEVELOPMENT

* FOR DETAILED INFORMATION ON PHASE 1 PLANTINGS AND LANDSCAPE ELEMENTS, SEE SHEET A1.3

LANDSCAPE MASTER PLAN
(A1.2) 1" = 20'-0"

GENERAL LANDSCAPE NOTES

1. ALL TREES TO BE STAKED WITH MIN. 2) 6'-0 LONG T-POSTS WITH NYLON STRAPS.
2. ALL TREES AND SHRUBS PLANTED IN BEDS TO CONTAIN 75% COMPOST SOIL SHADED BEND WITH 4" MIN. SHREDDED HARDWOOD MULCH PLACED AROUND.
3. ALL PERENNIAL/ORNAMENTAL GRASS PLANTING BEDS SHALL HAVE A MIN. OF 12" SANDY LOAM WITH PEAT HUMA (RATIO 3:1) TILLED IN AND RAKED UP.
4. SHREDDED HARDWOOD MULCH WHERE DESIGNATED SHALL HAVE A MIN. THICKNESS OF 3" IN ALL PLANT BEDS.
5. 2-6" RIVER ROCK MULCH WHERE DESIGNED SHALL HAVE 1-1/4" AGGREGATE PLACED BENEATH AT MIN. DEPTH OF 2".
6. ALL PLANTING BEDS SHALL HAVE WEED BARRIER FABRIC INSTALLED WITHIN THE EDGE OF MULCH.
7. ALL QUANTITIES SHOWN ON PLAN ARE ESTIMATED QUANTITIES ONLY. CONTRACTOR IS RESPONSIBLE FOR ALL MATERIAL REQUIRED TO COMPLETED THE PROJECT AS SHOWN ON THE DRAWINGS.
8. ALL TREES AND SHRUBS SHALL BE WARRANTED FOR A PERIOD OF ONE (1) YEAR FROM DATE OF INSTALLATION.
9. ALL PERENNIALS AND ORNAMENTAL GRASSES SHALL BE WARRANTED FOR A PERIOD OF AT LEAST 90 DAYS.
10. LANDSCAPE CONTRACTOR IS RESPONSIBLE FOR ANY DAMAGE INCURRED TO EXISTING IRRIGATION HEADS PRIOR TO LANDSCAPE INSTALLATION.
11. LANDSCAPE CONTRACTOR IS RESPONSIBLE FOR ENSURING PROPER COVERAGE OF IRRIGATED AREAS FOR SOD AND PLANT BEDS AND TO REPORT ANY PROBLEMS TO THE LANDSCAPE DESIGNER FOR IMMEDIATE REQUIRED ALTERATIONS BY THE IRRIGATION CONTRACTOR.
12. LANDSCAPE CONTRACTOR SHALL NOTIFY THE LANDSCAPE DESIGNER 72 HRS. IN ADVANCE FOR CORRECT PLACEMENT OF PLANTS.
13. LANDSCAPE CONTRACTOR SHALL NOTIFY THE LANDSCAPE DESIGNER 72 HRS. IN ADVANCE FOR MAKING EDGE LINES TO ENSURE PROPER PLACEMENT OF EDGING.
14. OWNER/LANDSCAPE DESIGNER SHALL HAVE THE RIGHT TO ACCEPT OR REJECT ANY PLANT MATERIALS NOT CONSIDERED TO BE QUALITY NURSERY STOCK.
15. ALL PLANT MATERIAL SHALL CONFORM TO THE GUIDELINES ESTABLISHED BY THE CURRENT AMERICAN STANDARD FOR NURSERY STOCK, PUBLISHED BY THE AMERICAN ASSOCIATION FOR NURSERYMEN OR EQUIVALENT.
16. BARE ROOT STOCK SHALL NOT BE ALLOWED.
17. THE CONTRACTOR SHALL BE RESPONSIBLE FOR INSTALLING TREE WRAP IN THE FALL OF THE YEAR, IN WHICH PLANT MATERIAL IS INSTALLED FOLLOWED BY REMOVAL THE FOLLOWING SPRING.
18. SEED MIX SHALL BE MIN 60.0% KENTUCKY BLUE (60%) CREEPING RED FESCUE (25%) PERENNIAL RYE (10%). METHOD OF SEED APPLICATION SHALL BE BY DRILL; MIX IN PLANT FOOD STARTER FERTILIZER (CONSULT SPECIFICATION) BY SUPPLYING INCLUDED AS PART OF THE SEED MIX DESIGN. SEEDING MAY TAKE PLACE WHEN SOIL CONDITIONS SUPPORT EQUIPMENT NEEDED TO SUCCESSFULLY PREPARE THE SEED BED AND WHEN THE SOIL TEMPERATURE REMAINS AT FORTY DEGREES OR HIGHER.
19. SOD SHALL BE PLACED ON SITE WITHIN 24 HOURS. SOD MAY BE ALLOWED UNLESS PRIOR APPROVAL HAS BEEN GIVEN BY THE OWNER/LANDSCAPE DESIGNER.
20. ALL CONTRACTORS SHALL BE RESPONSIBLE TO LOCATE AND VERIFY THE EXISTENCE OF ALL UTILITIES PRIOR TO STARTING WORK.

LEGEND

TURFGRASS	HARDWOOD MULCH
1-1/4" ROCK MULCH	NEW CONCRETE PAVERS

MASTER PLANTING SCHEDULE

DECIDUOUS TREES

Symbol	Quant.	Common Name	Scientific Name	Size/Cond.
SGC	2	Spring Snow Crab	Malus "Spring Snow"	2" B & B
OS	1	Ohio Buckeye	Aesculus glabra	2" B & B
CEA	18	Swedish Columnar Aspen	Populus tremula 'Erecta'	6-8' Pot
JTC	1	Japanese Tree Lilac Cloud	Syringa x pekinensis	2" B & B

DECIDUOUS SHRUBS

Symbol	Quant.	Common Name	Scientific Name	Size/Cond.
DD	26	Ivory Dogwood	Cornus sericea 'Isanti'	#5 Cont.
TBL	10	Thunderbolt Lilac	Syringa 'Bailbelle'	#5 Cont.
DKL	1	Dwarf Korean Lilac	Syringa meyeri 'Palibin'	#5 Cont.
DV	9	Onondaga Viburnum	Viburnum sargentii 'Onondaga'	#5 Cont.
MV	5	Mariesii Viburnum	Viburnum plicatum 'Mariesii'	#5 Cont.
CAC	4	Compact American Cranberrybush	Viburnum trilobum 'Alfredo'	#5 Cont.
WV	3	Nanaberry	Viburnum lentago	3' Pot
BGH	3	Blackhills Gold Honeysuckle	Weigelia florida x 'Bokalo's Gold'	#5 Cont.
RDD	35	Dwarf Red Tipped Dogwood	Cornus pumila	#3 Cont.
CLS	22	Crisp Leaf Spirea	Spiraea x bumalda 'Crispa'	#3 Cont.
MGS	8	Magic Carpet Spirea	Spiraea japonica 'Magic Carpet'	#2 Cont.
FS	15	Froebel Spirea	Spiraea x bumalda 'Froebelii'	#2 Cont.
JRH	6	Java Red Weigela	Weigela florida 'Java Red'	#5 Cont.
AH	16	Annabelle Hydrangea	Hydrangea arborescens 'Annabelle'	#5 Cont.

MASTER PLANTING SCHEDULE

EVERGREEN SHRUBS

Symbol	Quant.	Common Name	Scientific Name	Size/Cond.
GBS	4	Globe Blue Spruce	Picea pungens glauca 'Glauca Globosa'	#5 Cont.

PERENNIALS

Symbol	Quant.	Common Name	Scientific Name	Size/Cond.
PDL	84	Daylily	Hemerocallis 'Stella-de-Oro'	6" Pot
AUS	13	Aster	Aster 'Autumn Joy'	6" Pot
PSH	46	Sedum	Sedum 'Matrona'	6" Pot
PLK	34	Liatris	Liatris spicata 'Kobold'	6" Pot
PYR	30	Yarrow	Achillea 'Moonshine'	6" Pot
PLU	11	Lupine	Lupine 'Gallery Mix'	6" Pot
PP	13	Phlox	Phlox 'Peony'	6" Pot
4"	1	Hosta	Hosta 'Frances'	4" Cont.
HFR	1	Hosta	Hosta 'Fragrant'	4" Cont.

ORNAMENTAL CLUMP GRASS

Symbol	Quant.	Common Name	Scientific Name	
OSF	4	Silver Feather Miscanthus	Miscanthus sinensis 'Silberfeather'	#5 Cont.

ESTIMATED HARDSCAPE QUANTITIES

Quant.	Unit	Material
HGO	SF	1-1/4" Rock Mulch w/ Fabric
SOBO	SY	Shredded Hardwood Mulch (Note: 3" Min. Thickness)
BCR	LF	8" Concrete Edge
VS	SY	Sod/Seed

OAK GROVE FLOODWALL IMPROVEMENT PROJECT

FARGO
NORTH DAKOTA

HAZARD MITIGATION GRANT PROGRAM
DR 1174-ND Project No. 0027

City of Fargo
Special Improvement District #5006

TRIEBWASSER HELENSKE & ASSOCIATES, Ltd.

ARCHITECTS AND CONSTRUCTION MANAGEMENT

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FARGO, NORTH DAKOTA

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(218) 233-5272 (Voice)
(701) 293-0272 (Fax)

FOR REFERENCE ONLY

CADD NAME / SCALE
A1-2.dwg

PROJECT NO.
TGA - 4867.0

DATE:
April 24, 2006

MASTER PLAN

A1.1

2 OF 8

1384

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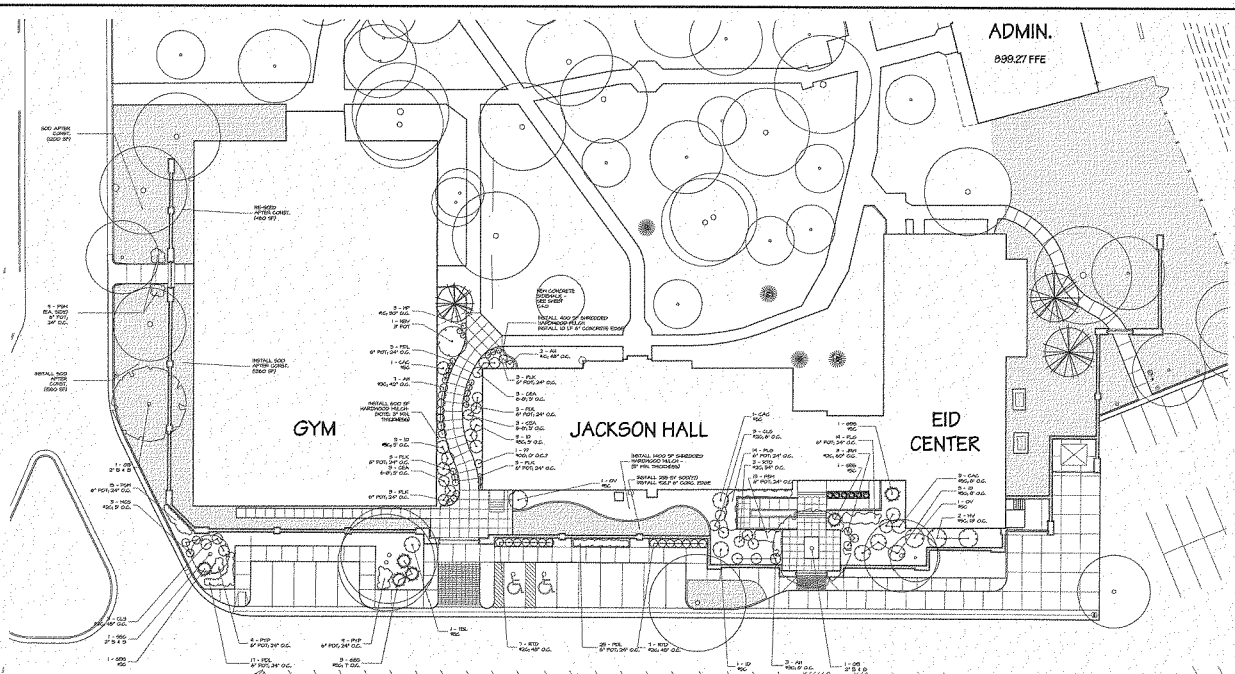

PHASE I LANDSCAPE PLAN
1" = 20'-0"

GENERAL LANDSCAPE NOTES

1. ALL TREES TO BE STAKED WITH MIN. (2 GA.) STEEL T-POSTS WITH NYLON STRAPS.
2. ALL TREES OUTSIDE PLANT BEDS TO HAVE 4' MIN. DIAMETER SOIL SAUCER RING WITH 6" MIN. SHREDDED HARDWOOD MULCH PLACED AROUND.
3. ALL PERENNIAL/ORNAMENTAL GRASS PLANTING BEDS SHALL HAVE A MIN. OF 12" SANDY LOAM WITH PEAT MOSS (RATIO 2:1) TILLED IN AND RAKED UP.
4. SHREDDED HARDWOOD MULCH WHERE DESIGNATED SHALL HAVE A MIN. THICKNESS OF 3" AFTER SETTLEMENT.
5. 2-4" RIVER ROCK MULCH WHERE DESIGNED SHALL HAVE 1-1/4" AGGREGATE PLACED BENEATH AT MIN. DEPTH OF 2".
6. ALL PLANTING BEDS SHALL HAVE WEED BARRIER FABRIC INSTALLED WITHIN THE ZONE REMOVED.
7. ALL QUANTITIES SHOWN ON PLAN ARE ESTIMATED QUANTITIES ONLY. CONTRACTOR IS RESPONSIBLE FOR ALL MATERIAL REQUIRED TO COMPLETED THE PROJECT AS SHOWN ON THE DRAWINGS.
8. ALL TREES AND SHRUBS SHALL BE WARRANTED FOR A PERIOD OF ONE (1) YEAR FROM DATE OF FINAL ACCEPTANCE.
9. ALL PERENNIALS AND ORNAMENTAL GRASSES SHALL BE WARRANTED FOR A PERIOD OF AT LEAST 90 DAYS.
10. LANDSCAPE CONTRACTOR IS RESPONSIBLE FOR ANY DAMAGE INCURRED TO EXISTING IRRIGATION HEADS PRIOR TO LANDSCAPE INSTALLATION.
11. LANDSCAPE CONTRACTOR IS RESPONSIBLE FOR ENSURING PROPER COVERAGE OF IRRIGATED AREAS FOR SOD AND PLANT BEDS AND TO REPORT ANY PROBLEMS TO THE LANDSCAPE ARCHITECT OR IMMEDIATE REQUIRED ALTERATIONS BY THE IRRIGATION CONTRACTOR.
12. LANDSCAPE CONTRACTOR SHALL NOTIFY THE LANDSCAPE DESIGNER 72 HRS. IN ADVANCE FOR CORRECT PLACEMENT OF PLANTS.
13. LANDSCAPE CONTRACTOR SHALL NOTIFY THE LANDSCAPE DESIGNER 72 HRS. IN ADVANCE FOR MARKING EDGE LINES TO ENSURE PROPER PLACEMENT OF EDGING.
14. OWNER/LANDSCAPE DESIGNER SHALL HAVE THE RIGHT TO ACCEPT OR REJECT ANY PLANT MATERIALS NOT CONSIDERED TO BE QUALITY NURSERY STOCK.
15. ALL PLANT MATERIAL SHALL CONFORM TO THE GUIDELINES ESTABLISHED BY THE CURRENT AMERICAN STANDARD FOR NURSERY STOCK, PUBLISHED BY THE AMERICAN ASSOCIATION OF NURSERYMEN, INCORPORATED.
16. BARE ROOT STOCK SHALL NOT BE ALLOWED.
17. LANDSCAPE CONTRACTOR SHALL BE RESPONSIBLE FOR INSTALLING TREE WRAP IN THE FALL OF THE YEAR, IN HIGH PLANT MATERIAL IS INSTALLED FOLLOWED BY REMOVAL THE FOLLOWING SPRING.
18. SEED MIX SHALL BE NEW GLADE KENTUCKY BLUE (65%) CREEPING RED FESCUE (25%), PERENNIAL RYE (10%). METHOD OF SEED APPLICATION SHALL BE BY DRILL WITH A PLANT FOOD STARTER POSTS (LOW) (SUBJECT SPECIFICATIONS BY SUPPLIER) INCLUDED AS PART OF THE SEED MIX DESIGN. SEEDING MAY TAKE PLACE WHEN SOIL CONDITIONS ARE SUITABLE AS DETERMINED BY THE OWNER'S REPRESENTATIVE. THE SEED BED AND WHEN THE SOIL TEMPERATURE REMAINS AT FORTY DEGREES OR HIGHER.
19. NO CHANGES OR DEVIATIONS FROM THE DRAWINGS SHALL BE ALLOWED UNLESS PRIOR APPROVAL HAS BEEN GIVEN BY THE OWNER/ LANDSCAPE DESIGNER.
20. ALL CONTRACTORS SHALL BE RESPONSIBLE TO LOCATE AND VERIFY THE EXISTENCE OF ALL UTILITIES PRIOR TO STARTING WORK.
21. LANDSCAPE CONCRETE EDGING SHOWN SHALL BE 6" WIDE/4" DEEP LOW-SLUMP EXTRUDED CONCRETE EDGING BY CURB MASTERS OR EQUAL. PORTLAND CEMENT/SAND MIXTURE WITH FIBER-MESH REINFORCING. CONTROL JOINT IS CUT @ 4'-0" CENTER.

PHASE I PLANTING SCHEDULE

DECIDUOUS TREES

Symbol	Quant.	Common Name	Scientific Name	Size/Cond.
SPG	1	Spring Snow Crab	Malus "Spring Snow"	2" B & B
OS	2	Ohio Buckeye	Aesculus glabra	2" B & B
JEA	4	Swedish Columnar Aspen	Populus tremula "Erecta"	6-8' Pot
JTC	0	Japanese Tree Lilac, Clump	Syringa reticulata	2" B & B

DECIDUOUS SHRUBS

Symbol	Quant.	Common Name	Scientific Name	Size/Cond.
D	10	Ivory Dogwood	Cornus sericea 'Ivory'	#5 Cont.
TBL	1	Tinkerbelle Lilac	Syringa "Bloomerang"	#5 Cont.
DBL	0	Dwarf Korean Lilac	Syringa meyeri 'Palibin'	#5 Cont.
OV	2	Onondaga Viburnum	Viburnum sargentii 'Onondaga'	#5 Cont.
PV	2	Mohican Viburnum	Viburnum lentago 'Mohican'	#5 Cont.
CAV	5	Compact American Cranberrybush	Viburnum trilobum 'Wilhelm'	#5 Cont.
NEV	1	Nanapanny	Viburnum rufidulum	3' Pot
BGH	0	Buckeye's Gold Hydrangea	Hydrangea x "Buckeye's Gold"	#5 Cont.
DRD	11	Dwarf Red Tipped Dogwood	Cornus alba	#2 Cont.
GLS	6	Gold Leaf Spirea	Spiraea x bumalda 'Gold'	#2 Cont.
HGS	3	Magic Carpet Spirea	Spiraea japonica 'Magic Carpet'	#2 Cont.
FS	0	Firestone Spirea	Spiraea x bumalda "Firedance"	#2 Cont.
JRH	5	Java Red Hydrangea	Hydrangea Florida 'Java Red'	#5 Cont.
AN	12	Annabelle Hydrangea	Hydrangea arborescens 'Annabelle'	#5 Cont.

PHASE I PLANTING SCHEDULE

EVERGREEN SHRUBS

Symbol	Quant.	Common Name	Scientific Name	Size/Cond.
GSG	6	Globe Blue Spruce	Picea Pungens glauca 'Maxwell Globe'	#5 Cont.

PERENNIALS

Symbol	Quant.	Common Name	Scientific Name	Size/Cond.
HSL	52	Stella	Hemerocallis "Stella-de-Oro"	#1 Pot
HSA	7	Seafoam	Seafoam "Autumn Joy"	#1 Pot
HSH	46	Seafoam	Seafoam "Halmond"	#1 Pot
PLE	12	Liatris	Liatris spicata 'Kobold'	#1 Pot
PYP	15	Yarrow	Achillea 'Paprika'	#1 Pot
PLG	16/50	Lupine	Lupine 'Gallery Mixture'	#1 Pot
HF	3	Hosta	Hosta 'Fortune'	#1 Cont.
HP	2	Hosta	Hosta 'Patriot'	#1 Cont.
HPH	0	Hosta	Hosta 'Elegans'	#1 Cont.

OAK GROVE FLOODWALL IMPROVEMENT PROJECT

FARGO
NORTH DAKOTA

HAZARD MITIGATION GRANT PROGRAM
DR 1174-ND Project No. 0027

City of Fargo
Special Improvement District #5081

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CARD NAME / SCALE
A-Sizes
PROJECT NO.
THA - 165718
DATE:
April 24, 2020
PHASE I LANDSCAPE PLAN

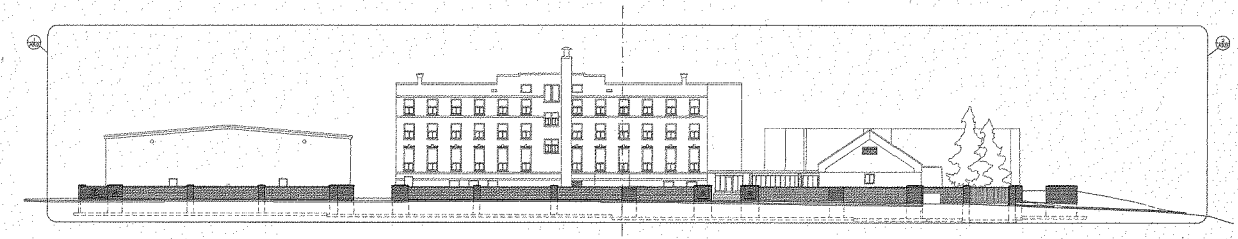
A1.2

NORTH

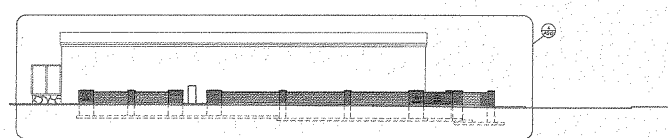
3 OF 8

July 2011

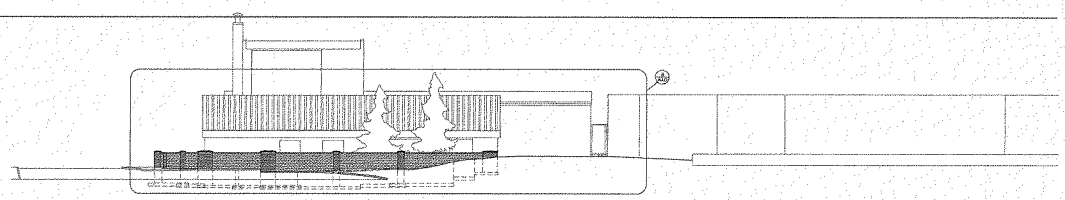
1385



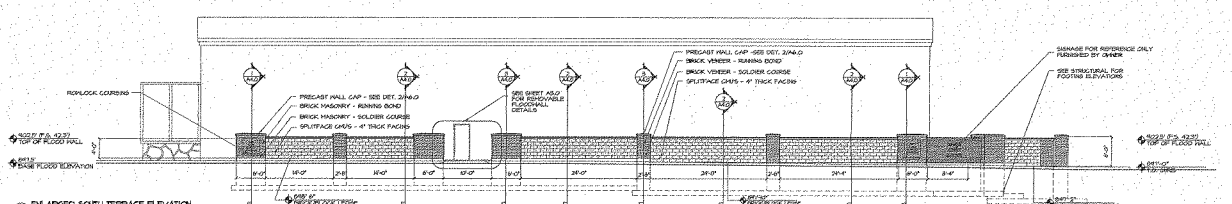
4TH STREET ELEVATION
1/8" = 1'-0"



SOUTH TERRACE ELEVATION
1/8"=1'-0"



NORTH EID CENTER ELEVATION
1/8"=1'-0"



ENLARGED SOUTH TERRACE ELEVATION
1/8"=1'-0"

OAK GROVE FLOODWALL IMPROVEMENT PROJECT

FARGO
NORTH DAKOTA

HAZARD MITIGATION
GRANT PROGRAM
DR 1170-ND Project No. 0027

City of Fargo
Special Improvement District #2034

TRIEBWASSER
HELENSKE &
ASSOCIATES, Ltd.

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CADD NAME	/ SCALE
A2.dwg	
PROJECT NO.	
THA - 4045-10	
DATE:	
April 24, 2000	

1/4" & 1/8" ELEVATIONS

A2.0

4 OF 8

Approved: H.T.S. 04/7

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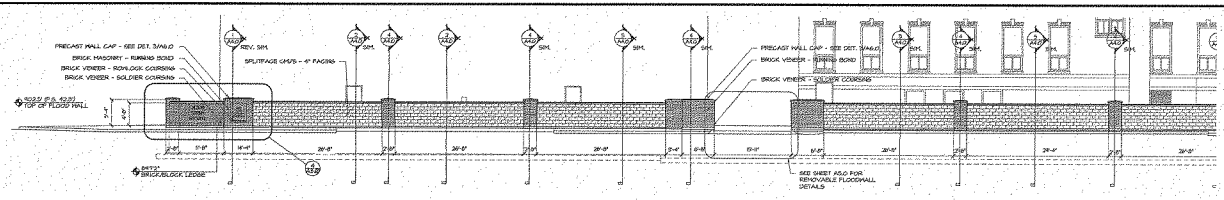
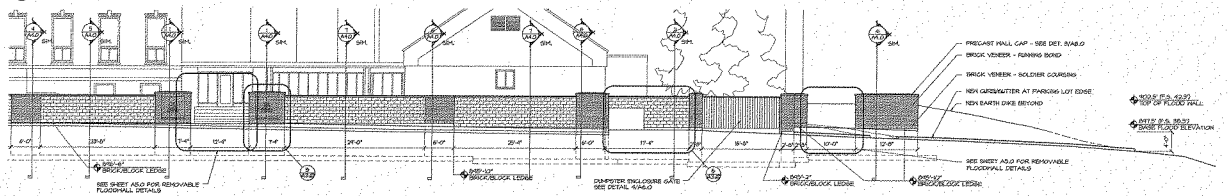
Fargo Flood Wall Alternative Feasibility Report and Environmental Impact Statement
July 2011

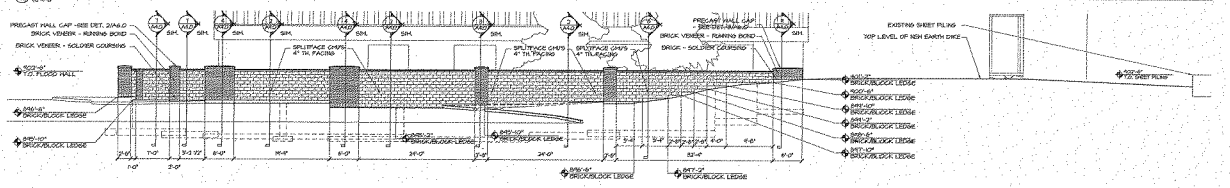
1386



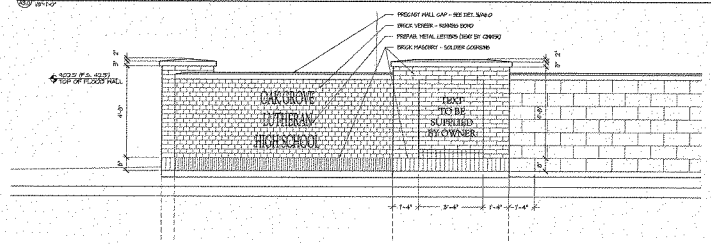
1 ENLARGED ASH STREET ELEVATION A
1/8" = 1'-0"



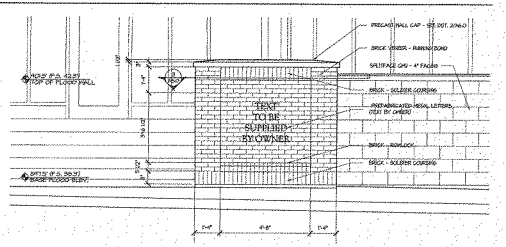
2 ENLARGED ASH STREET ELEVATION A
1/8" = 1'-0"



3 ENLARGED NORTH ELEVATION
1/8" = 1'-0"



4 ELEVATION DETAIL
1/2" = 1'-0"



5 ELEVATION DETAIL
1/2" = 1'-0"

OAK GROVE FLOODWALL IMPROVEMENT PROJECT

FARGO
NORTH DAKOTA

HAZARD MITIGATION GRANT PROGRAM
DR-1174-ND Project No. 8027

City of Fargo
Special Improvement District #5201

TRIEBWASSER HELENSKE & ASSOCIATES, Ltd.

ARCHITECTS AND CONSTRUCTION MANAGEMENT

11 RIVER OAKS POINT
P.O. BOX 547
MOORHEAD, MINNESOTA

416 MAIN AVENUE
FARGO, NORTH DAKOTA

(218) 233-6523 (Voice)
(701) 232-2171 (Voice)
(701) 232-2171 (Fax)

CADD NAME / SCALE	A3.dwg
PROJECT NO.	THA - 1068.16
DATE	April 24, 2000

1/8" ELEVATIONS
ELEVATION DETAILS

A3.0

5 OF 8

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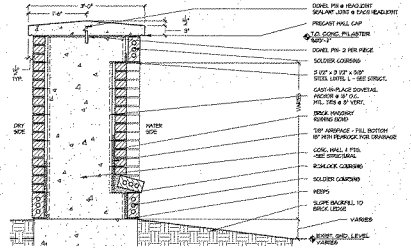
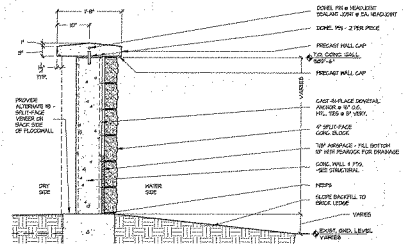
G:\ACTIVE\1068\16\DWG\OAK\



1 WALL SECTION
1" = 1'-0"



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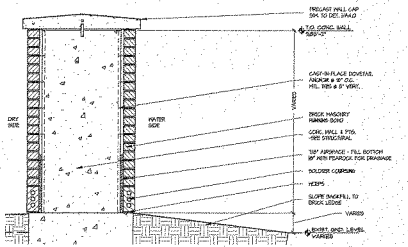

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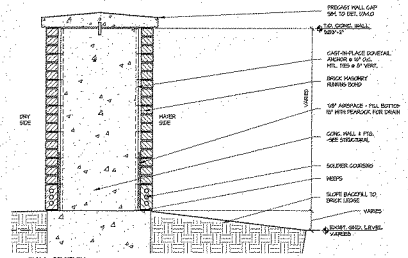

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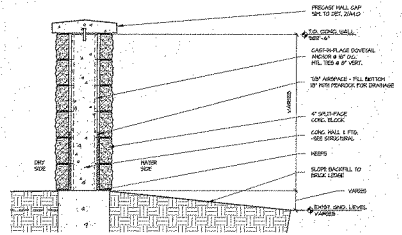

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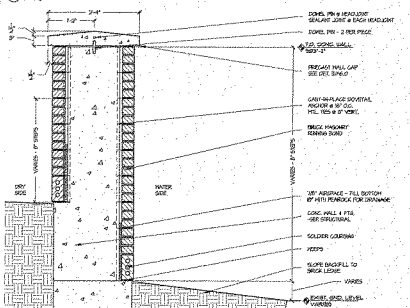
1" = 1'-0"



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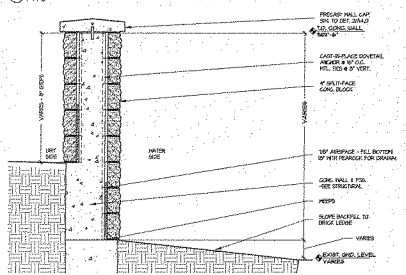
1" = 1'-0"



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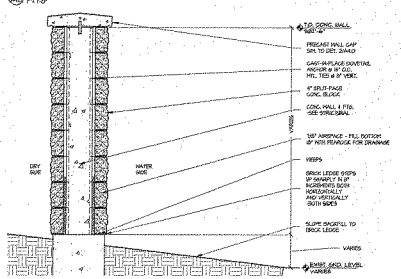
1" = 1'-0"



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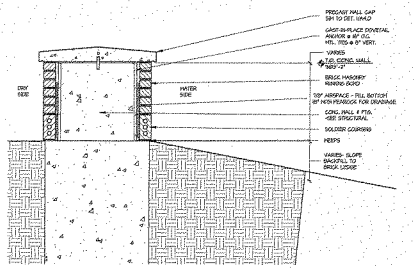

9 WALL SECTION
1" = 1'-0"

OAK GROVE FLOODWALL IMPROVEMENT PROJECT

FARGO
NORTH DAKOTA

HAZARD MITIGATION GRANT PROGRAM
DR. 1174-ND Project No. 9027

City of Fargo
Special Improvement District #9204

TRIEBWASSER HELENSKE & ASSOCIATES, Ltd.

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(218) 233-2271 (Voice)
(701) 293-0171 (Fax)

CAD NAME / SCALE
A4.0wg

PROJECT NO.
THA - 4867B

DATE:
April 24, 2000

WALL SECTIONS

A4.0

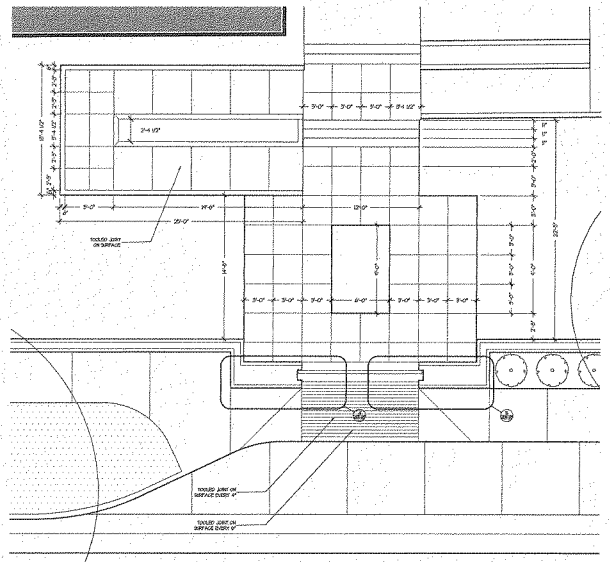
6 OF 8

Modified 4/19/00

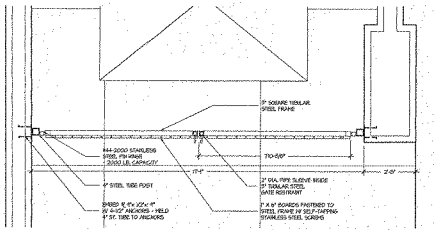
1388

G:\ACTIVE\4867B\DWG\SIM\SIM-M4

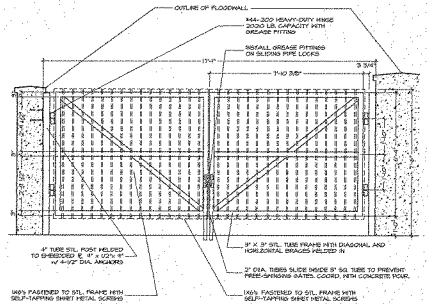
Final Fargo Municipal Airport Feasibility Project Land Appropriation Impact Statement



ENLARGED COURTYARD PLAN
1/8" = 1'-0"



ENLARGED DUMPSTER ENCLOSURE PLAN
1/2" = 1'-0"



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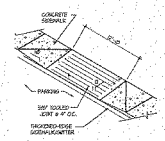
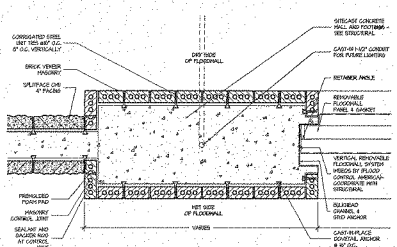
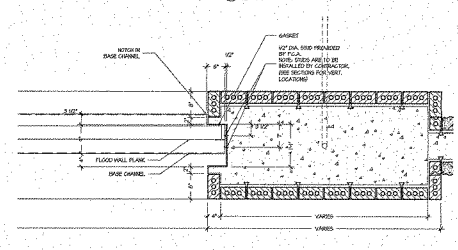
1/2" = 1'-0"



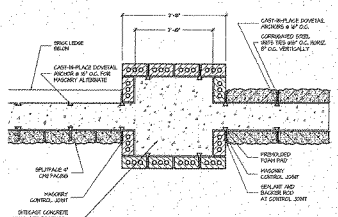
HANDICAPPED RAMP DETAIL
NOT TO SCALE



FLOODWALL PILASTER DETAIL
1" = 1'-0"



FLOODWALL PILASTER DETAIL
1" = 1'-0"



PILASTER DETAIL
1" = 1'-0"

OAK GROVE FLOODWALL IMPROVEMENT PROJECT

FARGO
NORTH DAKOTA

HAZARD MITIGATION GRANT PROGRAM
DR-1174-ND Project No. 0027

City of Fargo
Special Improvement District #6036

TRIEBWASSER HELENSKE & ASSOCIATES, Ltd.

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14 MAIN AVENUE
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(701) 232-2171 (Voice)
(701) 232-2177 (Fax)

CADD NAME / SCALE	
FCJ.dwg	
PROJECT NO.	
THA - 4267.10	
DATE:	
APRIL 24, 2002	
DETAILS/PLANS	

A5.0

1 OF 8

1389

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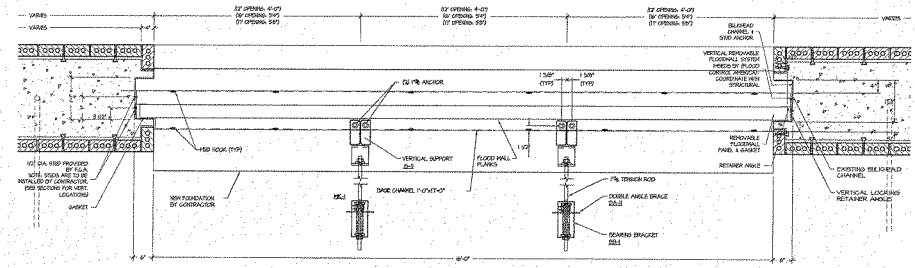
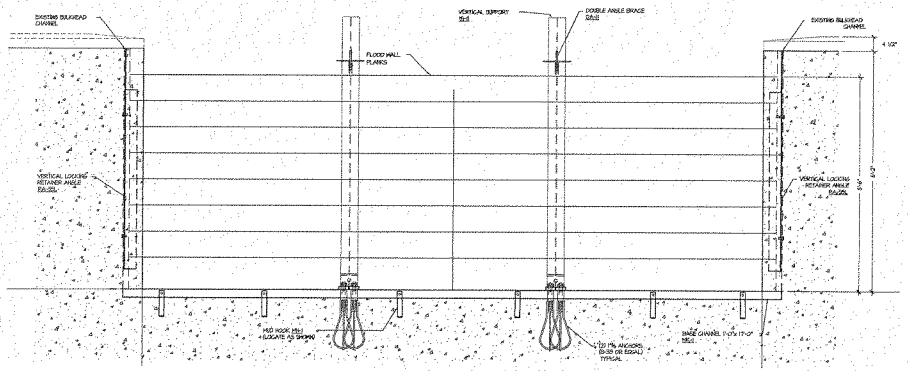
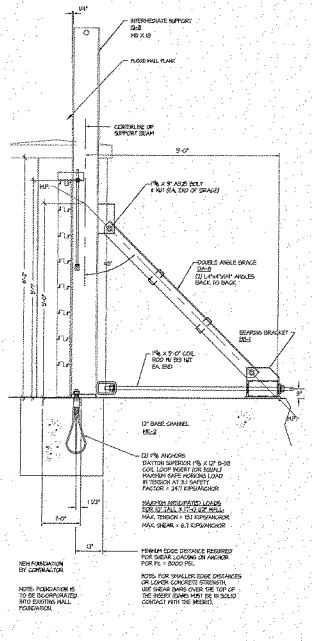
Fargo Moorhead Metro Feasibility Report and Environmental Impact Statement



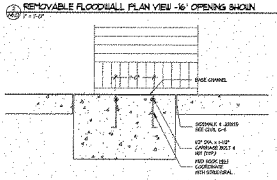
REMOVABLE FLOODWALL ELEVATION - 16' OPENING SHOWN
SCALE 1" = 1'-0"



REMOVABLE FLOODWALL PLAN VIEW -16' OPENING SHOWN
SCALE 1" = 1'-0"



SECTION AT CENTER SUPPORT
SCALE 1" = 1'-0"



MID HOOK DETAIL
SCALE 1" = 1'-0"

OAK GROVE FLOODWALL IMPROVEMENT PROJECT

FARGO
NORTH DAKOTA

HAZARD MITIGATION GRANT PROGRAM
DR 1176-ND Project No. 0027

City of Fargo
Special Improvement District #5026

TRIEBWASSER HELENSKE & ASSOCIATES, Ltd.

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FARGO, NORTH DAKOTA

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(701) 232-2071 (Voice)
(701) 232-2072 (Fax)

CADD NAME / SCALE
A6.dwg

PROJECT NO.
TWA - 1550.70

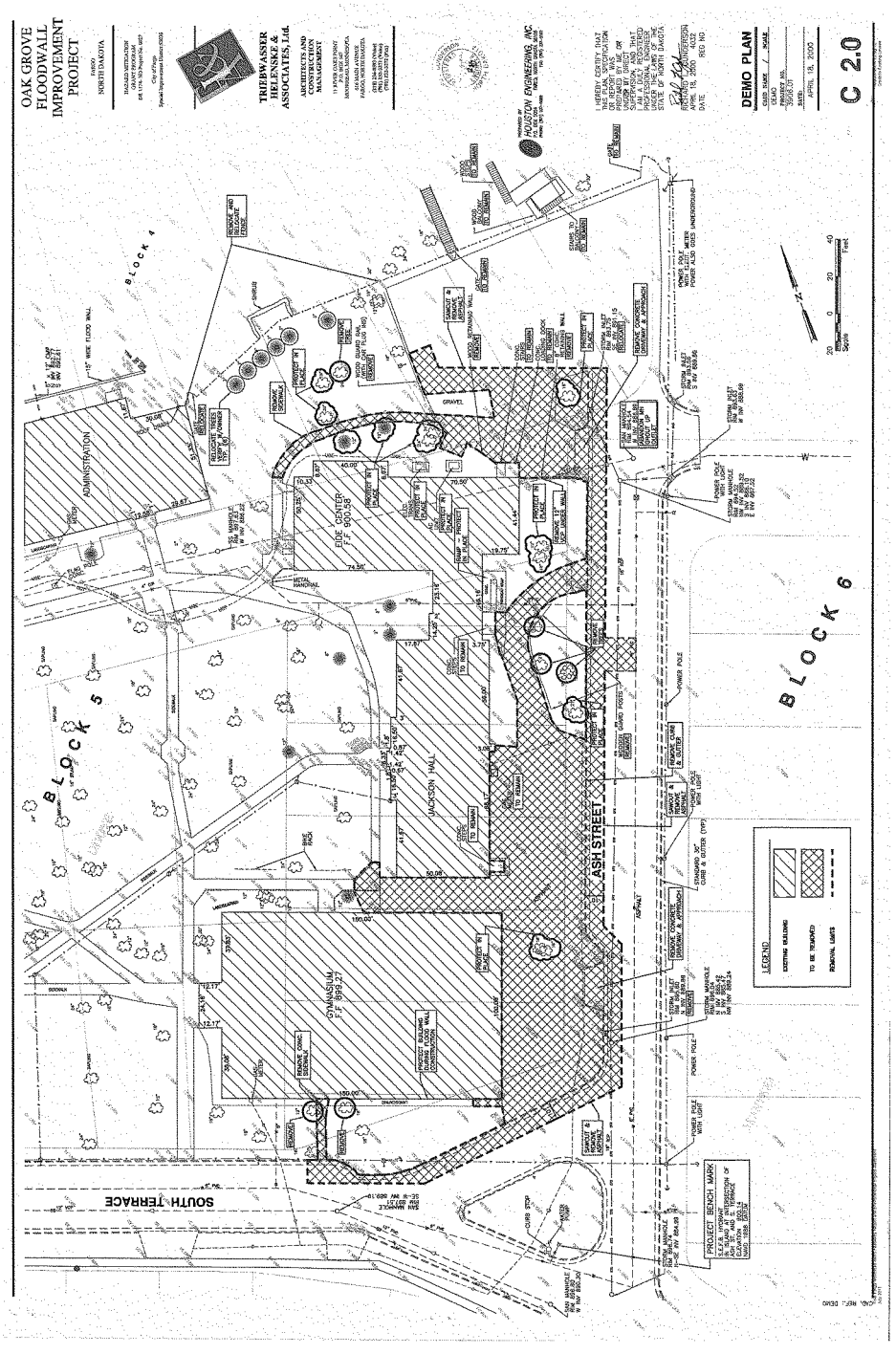
DATE
April 24, 2000

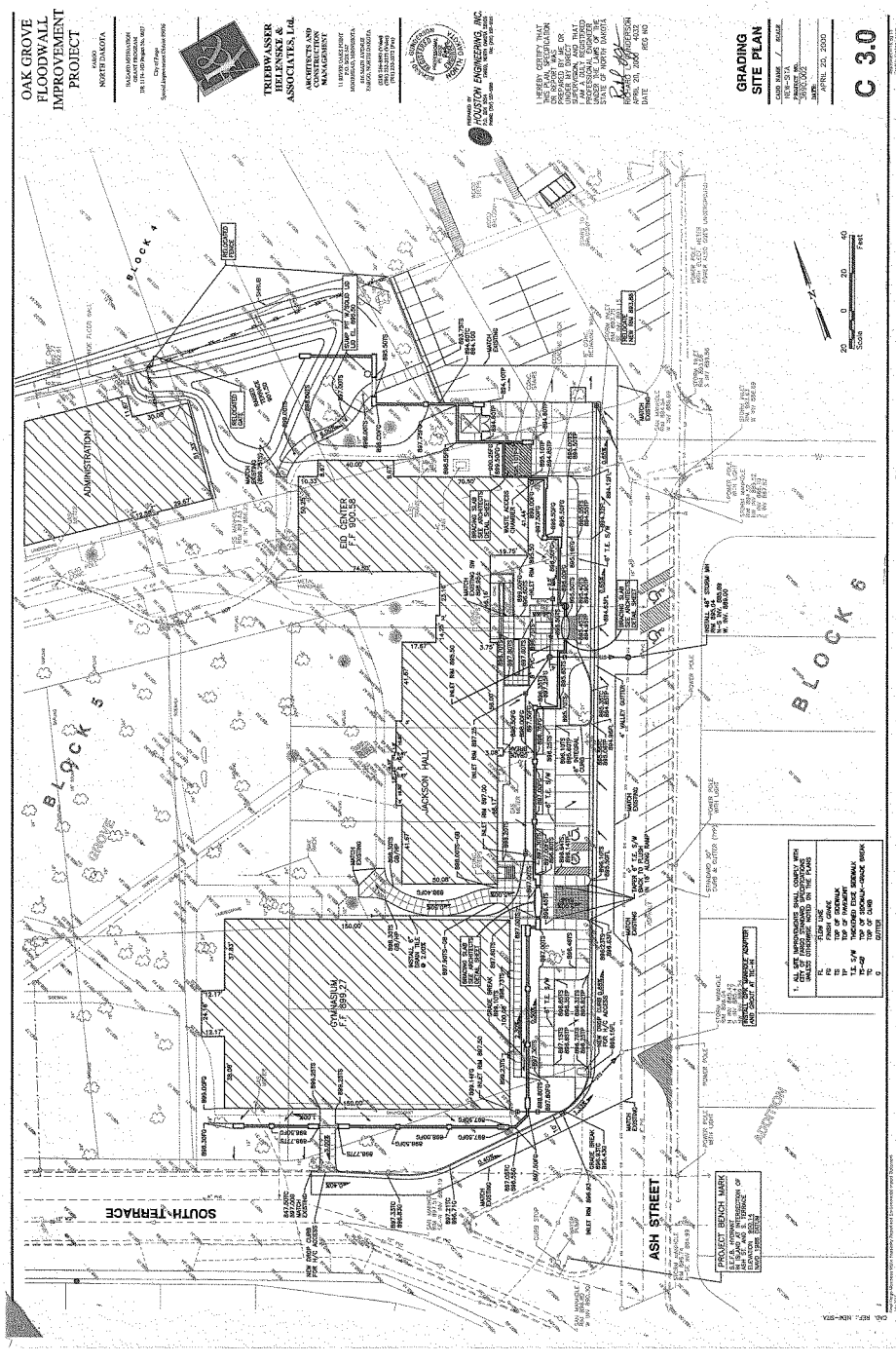
REMOVABLE FLOODWALL DETAIL

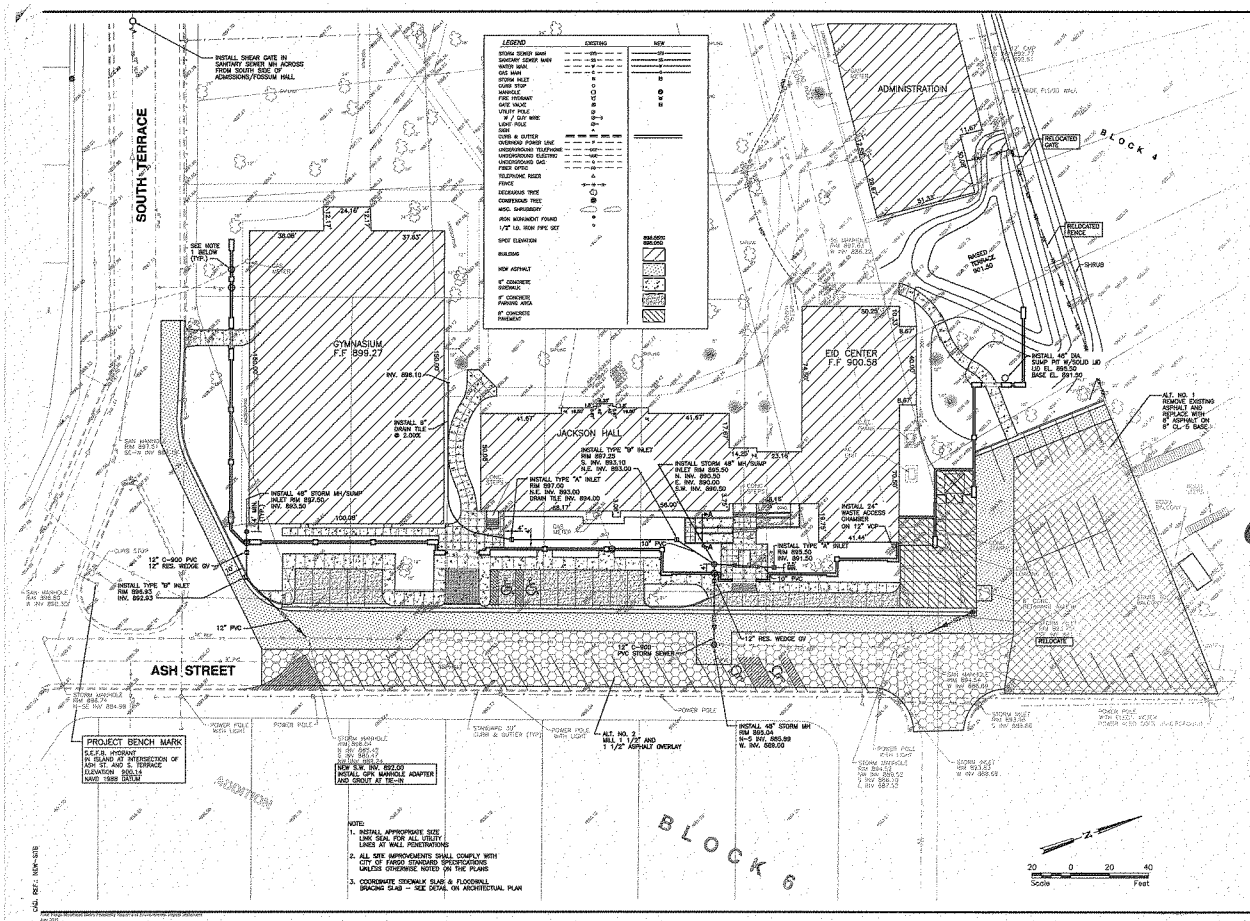
A6.0

S CF 3
Reserved for F.C. sig.1

1390


OAK GROVE FLOODWALL IMPROVEMENT PROJECT
FARGO NORTH DAKOTA
TRIEBWASSER HELENSKE & ASSOCIATES, Ltd.
ARCHITECTS AND CONSTRUCTION MANAGEMENT
HOUSTON ENGINEERING, INC.
DEMO PLAN
C 2.0
BLOCK 4
BLOCK 5
BLOCK 6
ADMINISTRATION
EIDE CENTER F.F. 900.58
JACKSON HALL
GYMNASIUM F.F. 899.27
ASH STREET
SOUTH TERRACE
GRAVEL
LEGEND
EXISTING BUILDING
TO BE REMOVED
REMOVAL LIMITS
PROJECT BENCH MARK
POWER POLE
Scale
Feet


OAK GROVE FLOODWALL IMPROVEMENT PROJECT
FARGO NORTH DAKOTA
TRIEBWASSER HELLENSKE & ASSOCIATES, Ltd.
ARCHITECTS AND CONSTRUCTION MANAGEMENT
HOUSTON ENGINEERING, INC.
GRADING SITE PLAN
C 3.0
BLOCK 4
BLOCK 5
BLOCK 6
ADMINISTRATION
EID CENTER F.F. 900.58
JACKSON HALL
GYMNASIUM F.F. 899.27
SOUTH TERRACE
ASH STREET
PROJECT BENCH MARK



OAK GROVE FLOODWALL IMPROVEMENT PROJECT

FARGO
NORTH DAKOTA

HAZARD MITIGATION GRANT PROGRAM
DR-1718-ND Project No. 0022

City of Fargo
Special Improvement District #9356

TRIEBWASSER HELENSKE & ASSOCIATES, Ltd.

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(701) 232-2172 (Fax)

PREPARED BY
HOUSTON ENGINEERING, INC.
(NDCL NORTH DAKOTA 3819)
PHONE: (701) 237-5065 FAX: (701) 237-1907

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION, AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF NORTH DAKOTA

RICHARD L. ANDERSON
APRIL 20, 2000 4032
DATE REG NO

PAVING & UTILITY PLAN

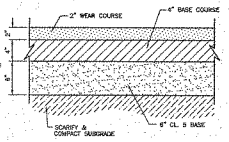
CADD NAME / SCALE
NEW-STG

PROJECT NO.
3890.002

DATE:
APRIL 20, 2000

C 4.0

1393



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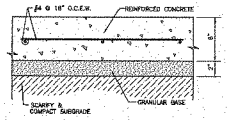

8" CONCRETE SECTION
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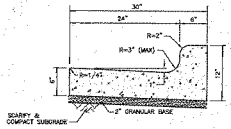

STANDARD CURB & GUTTER DETAIL
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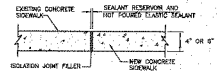
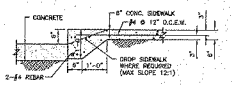
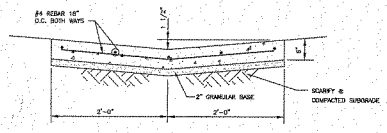


ISOLATION JOINT TO JOIN EXISTING SIDEWALK
NOT TO SCALE



TYPICAL SIDEWALK WITH THICKENED EDGE
NOT TO SCALE



VALLEY GUTTER DETAIL
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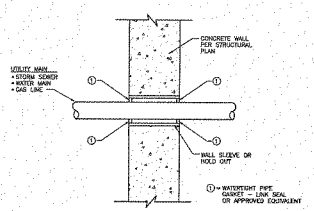
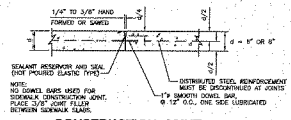
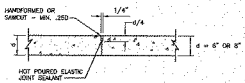


WALL PENETRATION SEAL DETAIL
NOT TO SCALE

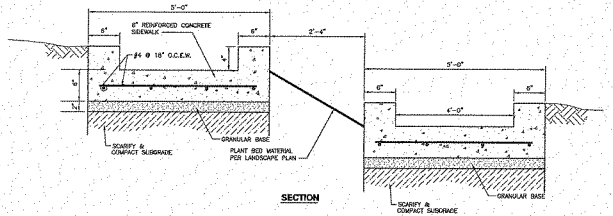


CONSTRUCTION JOINT
NOT TO SCALE

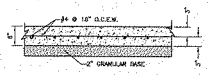


CONTRACTION JOINT DETAIL (LONGITUDINAL OR TRANSVERSE)
NOT TO SCALE

ISOLATION JOINT
NOT TO SCALE



RAMP DETAIL
NOT TO SCALE



6" CONCRETE SIDEWALK
NOT TO SCALE

OAK GROVE FLOODWALL IMPROVEMENT PROJECT

FARGO
NORTH DAKOTA

HAZARD MITIGATION GRANT PROGRAM
DR-1174-ND Project No. 0027

City of Fargo
Special Improvement Districts 6/5/01

TRIEBWASSER HELENSKE & ASSOCIATES, Ltd.

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(701) 235-5373 (Voice)
(701) 235-5719 (Fax)

REGISTERED PROFESSIONAL ENGINEER
RICHARD L. SUNDERSON
NORTH DAKOTA

PREPARED BY
HOUSTON ENGINEERING, INC.
P.O. BOX 5264 FARGO, NORTH DAKOTA 58103
PHONE: (701) 237-5065 fax: (701) 237-5814

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION, AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF NORTH DAKOTA

RICHARD L. SUNDERSON
APRIL 20, 2000 4032
DATE REG NO

DETAILS

CADD FRAME	SCALE
DETAILS	NONE

PROJECT NO.
3690.002

DATE:
APRIL 20, 2000

C 5.0

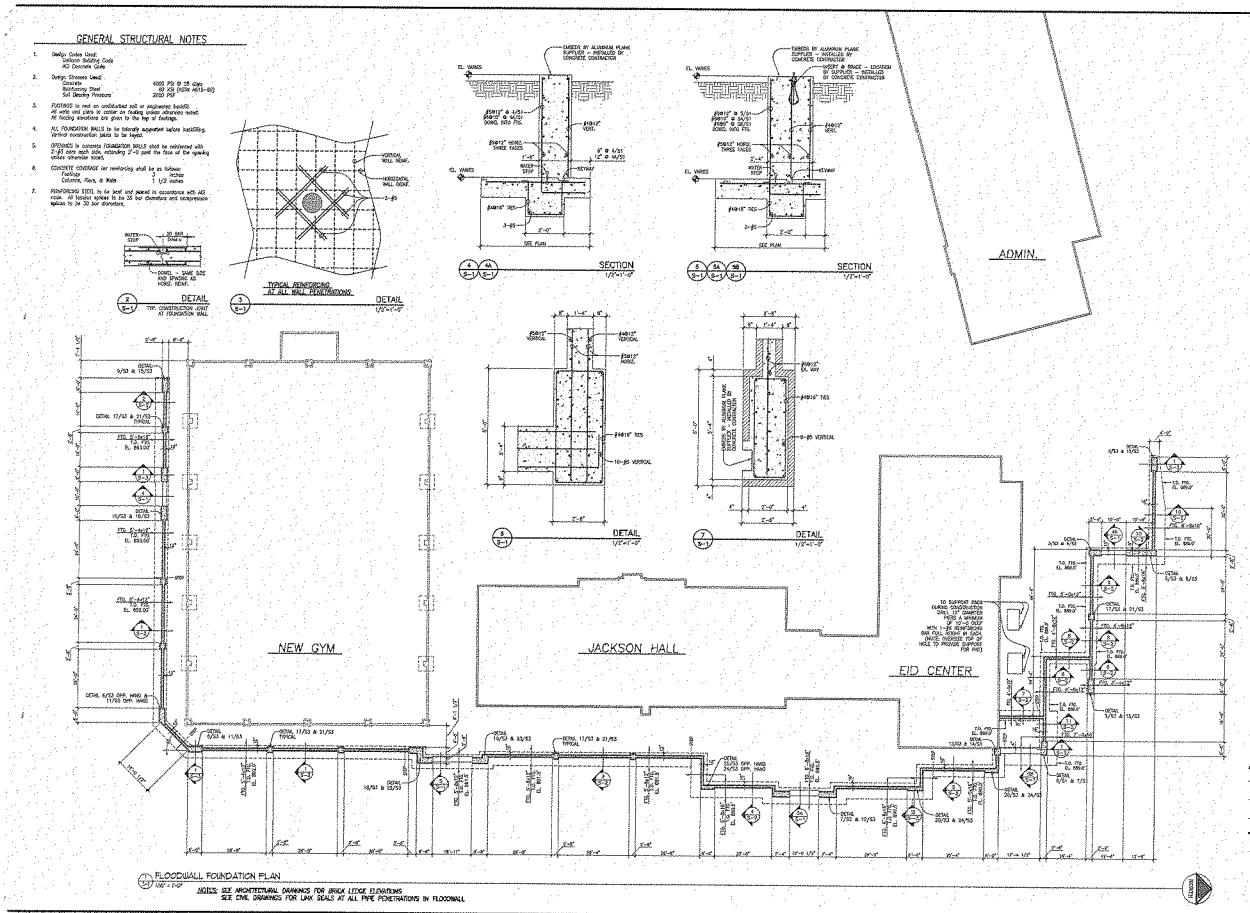
1394

CAD: RICE-JOCHALE

Fargo Hazard Mitigation Feasibility Report and Environmental Impact Document
10/2/01

GENERAL STRUCTURAL NOTES

1. Design Codes Used:
   Uniform Building Code
   ACI Concrete Code
2. Design Stresses Used:
   Concrete 4000 PSI @ 28 days
   Reinforcing Steel 60 KSI (ASTM A615-60)
   Soil Bearing Pressure 2000 PSF
3. FOOTINGS to rest on undisturbed soil or engineered backfill. All walls and piers to center on footing unless otherwise noted. All footing elevations are given to the top of footings.
4. ALL FOUNDATION WALLS to be laterally supported before backfilling. Vertical construction joints to be keyed.
5. OPENINGS in concrete FOUNDATION WALLS shall be reinforced with 2-#5 bars each side, extending 2'-0 past the face of the opening unless otherwise noted.
6. CONCRETE COVERAGE for reinforcing shall be as follows:
   Footings 3 inches
   Columns, Piers, & Walls 1 1/2 inches
7. REINFORCING STEEL to be bent and placed in accordance with ACI code. All tension splices to be 35 bar diameters and compression splices to be 30 bar diameters.



OAK GROVE FLOODWALL IMPROVEMENT PROJECT

FARGO NORTH DAKOTA

THA

TRIEBWASSER HELENSKE AND ASSOCIATES, LTD.

ARCHITECTS AND CONSTRUCTION MANAGEMENT

11 RIVER OAKS POINT
MOORHEAD, MINNESOTA

616 MAIN AVENUE
FARGO, NORTH DAKOTA

701 232-2271 (P)
701 232-2272 (F)

REGISTERED PROFESSIONAL ENGINEER
WAYNE E. LARSON
1835
NORTH DAKOTA

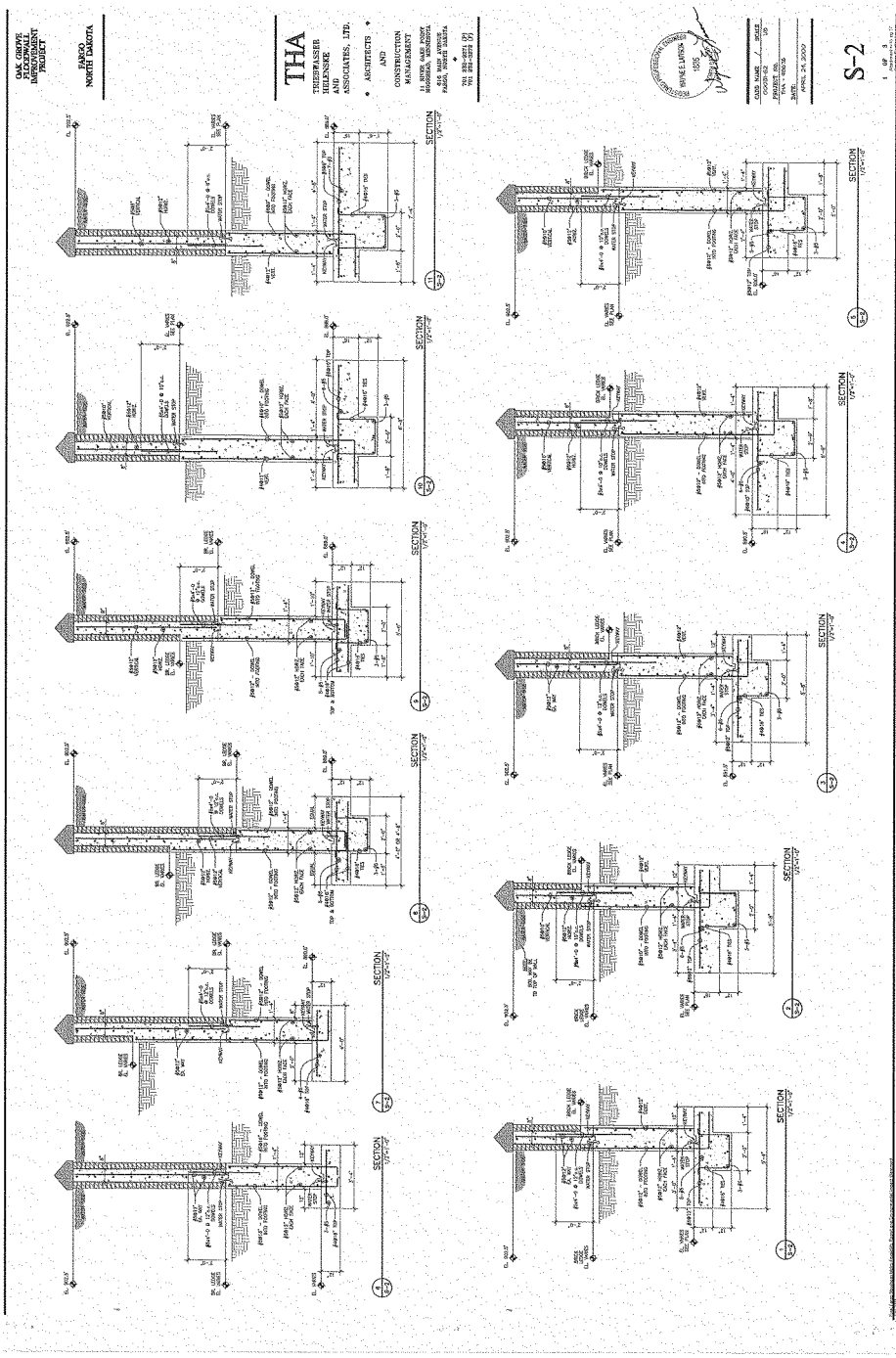
CADD NAME / SCALE
00C031-21 1/8

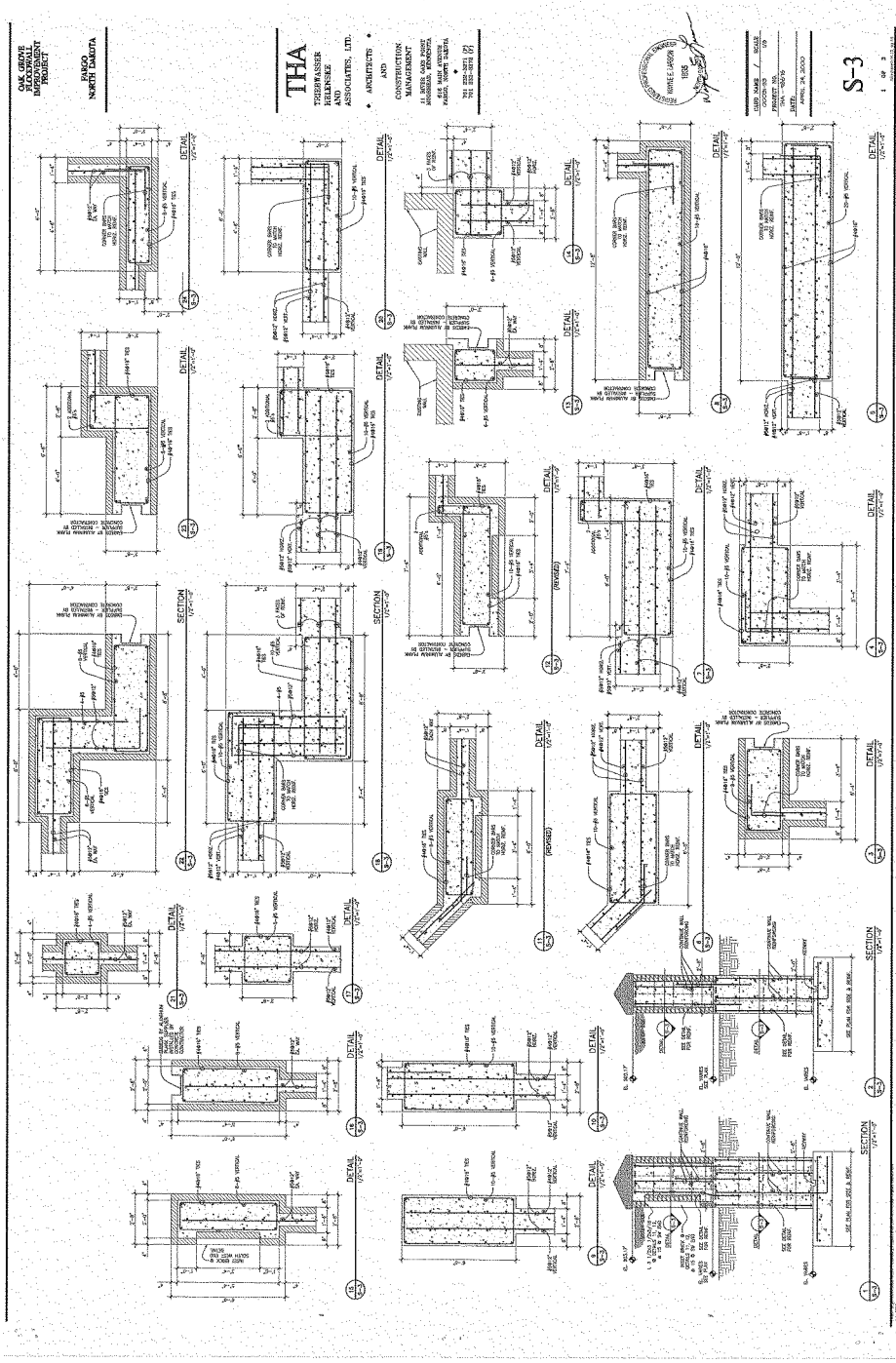
PROJECT NO.
THA - 48679

DATE:
APRIL 24, 2000

S-1

1 OF 5


OAK GROVE FLOODWALL IMPROVEMENT PROJECT
FARGO NORTH DAKOTA
THA
TRIESTRASSER HELENSKE AND ASSOCIATES, LTD.
ARCHITECTS AND CONSTRUCTION MANAGEMENT
S-2
SECTION


OAK GROVE FLOODWALL IMPROVEMENT PROJECT
FARGO NORTH DAKOTA
THA
TRIEBWASSER HELENSKE AND ASSOCIATES, LTD.
ARCHITECTS AND CONSTRUCTION MANAGEMENT
S-3
DETAIL
SECTION

Attachment H-16: 1st Ave, Moorhead

St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps of Engineers®

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FMMFS: Credit to Existing Levees
1st Avenue (Moorhead)

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Feet

Appendix I
Geotechnical Design and Geology

Fargo-Moorhead Metropolitan Area Flood Risk Management

Final Feasibility Report and Environmental Impact Statement

July 2011

US Army Corps of Engineers ®

Prepared by:
U.S. Army Corps of Engineers
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Fargo – Moorhead Metro Feasibility Study
Fargo, North Dakota and Moorhead, Minnesota
Appendix I
Geotechnical Design and Geology

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Fargo – Moorhead Metro Feasibility Study
Fargo, North Dakota and Moorhead, Minnesota
Appendix I
Geotechnical Design and Geology

I.1.0. PROJECT DESCRIPTION

I.1.0.1. The Fargo-Moorhead Metro Feasibility Study (FMMFS) was initiated in the fall of 2008. The purpose of this study is to identify measures to reduce the flood risk in the Fargo-Moorhead (FM) metro area. The study consists of six major steps that include:

(1) Specification of water and related land resources problems and opportunities;

(2) Inventory, forecast and analysis of water and related land resources conditions within the study area;

(3) Formulation of alternative plans;

(4) Evaluation of the effects of the alternative plans;

(5) Comparison of the alternative plans; and

(6) Selection of the recommended plan based upon the comparison of the alternative plans.

I.1.0.2. The feasibility study was initially broken into three major phases. In September 2010, it was determined that the study would be extended to allow for additional analysis to be completed, creating a fourth phase. The first phase, Phase 1 (September 2008 – May 2009), was to develop low level of detail assessments of the alternatives to determine which concepts seemed feasible. This phase was dominated by hydrologic, hydraulic, and economic analyses. The major geotechnical design effort during this phase was to evaluate the reliability of the existing levees that the cities of Fargo and Moorhead have in place. This effort is documented in Appendix H, Geotechnical Analysis: Credit to Existing Levees and the results used in the economic analyses. The assessment of the alternatives in Phase 1 indicated that the in-town levee alternative had a benefit/cost ratio (BCR) of 1.0 while the preliminary diversion concept had a BCR of 0.65. It was decided that further evaluation of these alternatives was needed.

I.1.0.3. The second phase of the study, Phase 2 (May 2009 – November 2009), required that further evaluation and technical analyses be completed on the most implementable projects. Three alternatives that were likely to be implementable were selected:

(1) In-Town Levee Alternatives

(2) Minnesota Diversion Alternatives

(3) North Dakota Diversion Alternatives

I.1.0.4. During Phase 2, the geotechnical design became a major effort. Initially, a soil exploration and testing program was developed and implemented for the In-Town Levee alternative and the Minnesota (MN) Diversion alternative. This data was used in the geotechnical analyses completed to determine the required setback distances for the In-Town Levee alternatives and complete the preliminary evaluation of slope stability for the MN Diversion channel.

I.1.0.5. During Phase 2, the hydrologic, hydraulic, and economic analyses were refined and preliminary cost estimates developed for the different alternatives. By the end of November 2009, the initial results indicated that the most viable alternatives were the MN and ND Diversion channels. The In-Town Levee alternative was not recommended for further evaluation for a number of reasons, listed below:

(1) Top elevation is limited to highest natural ground, which nearly corresponds with the 1% chance event,

(2) Due to the constraints of the maximum height there would be unacceptably high residual risks,

(3) Many structures would need to be removed, which would have social impacts.

I.1.0.6. Refinements to both the MN and ND Diversion alternatives were made during the third phase of the study, Phase 3 (December 2009 – August 2010). These refinements were made to the hydrology, hydraulics, geotechnical, and economic analyses in order to determine the National Economic Development (NED) plan.

I.1.0.7. The major geotechnical task for Phase 3 was completing the evaluation of the slope stability for the MN and ND Diversion alternatives. In December 2009, a soil exploration and testing program was initiated and completed along the North Dakota (ND) Diversion alternative. Additional soil exploration was conducted along both alignments from May to July 2010.

I.1.0.8. The fourth phase (September 2010 – February 2011) consisted of completing additional analysis on alternatives and impacts. The majority of the additional analysis involved refinement to the hydrology and hydraulics. The design of the MN Diversion alternative remained unchanged from Phase 3 during this phase. Revisions to the ND Diversion alternative were done which consisted of changing the configuration of the channel, including a large storage cell, and staging water upstream of the project.

I.1.0.9. The geotechnical analyses completed and geological interpretation for the Fargo-Moorhead Metro Feasibility Study are presented in this appendix.

I.2.0. REGIONAL GEOLOGY

I.2.0. Physiography

I.2.0.1. The adjacent cities of Fargo, North Dakota and Moorhead, Minnesota are located within the Red River Valley Division of the Central Lowlands Physiographic Province. The watershed of the Red River of the North encompasses the northeastern corner of South Dakota, much of eastern North Dakota, northwestern Minnesota, and a small portion of the province of Manitoba, Canada. The river is formed by the confluence of the Bois de Sioux and Ottertail rivers at the cities of Breckenridge, Minnesota and Wahpeton, North Dakota. Flowing northward, the Red River of the North forms most of the boundary between North Dakota and Minnesota. Upstream of the proposed project, the river drains an area of about 30,100 square miles including the Devils Lake sub-basin.

I.2.0.2. The river valley consists of a broad, nearly flat plain flanked on either side by gradual hills or higher ground. This plain is not derived from river erosion, but is an ancient glacial lake bed. North-south trending, the plain extends approximately 245 miles within the United States, and is about 15 miles in width on the extreme southern end before rapidly widening to 60-70 miles. The plain is generally inclined northward with an average slope of less than 1 foot per mile. The Red River of the North flows in a tightly meandering course within this plain for about 400 river miles before arriving at the Canadian border, with a river surface elevation drop from approximately 945 feet (msl) to 740 feet. The Red River meander belt may be up to 1.5 miles wide. Ultimately the river flows into Lake Winnipeg, Manitoba, Canada. Some of the principal tributaries of the Red River of the North in the project vicinity include the Sheyenne River, Wild Rice River of ND, Maple River, Rush River, and the Buffalo River.

I.2.1. Topography

I.2.1.1. The upper reaches of the Red River of the North watershed lie in drift prairie plateaus, while the river's main stem flows through an ancient glacial lake bed. The uplands vary in elevation from approximately 2,150 to 1,200 feet (msl), while the elevation of the valley plain varies from about 980 feet near Lake Traverse, Minnesota to 800 feet at the Canadian border. Westward the plain slopes gently nearly to the elevation of the upland. Eastward of the valley plain lies a relatively hilly area that merges into lakes and swamps of the uplands area. Perpendicular to the trend of the main stem of the Red River the valley has an average slope of 2 to 3 feet per mile. The slope of the main stem between Fargo, North Dakota and Grand Forks (154 river miles) averages slightly more than one-half foot per mile. The pools of three low head dams at Fargo/Moorhead on the Red River extend for several miles upstream at each location.

I.2.1.2. Previously proposed in-town levee alignments would have been confined to an area approximately 300-500 feet wide, along the banks of the Red River of the North. Due to modern erosional processes, topographic relief is more pronounced along this narrow zone, than is typical for most of the present day Red River Valley. Nearest the river primary banks exist some 5 to 15 feet above the normal water surface. Above the

primary banks the ground slopes in either a gentle, flat or somewhat hummocky fashion to the foot of a secondary bank. The secondary bank usually rises relatively steeply 20 to 25 feet above the primary bank, before flattening out into the ancient glacial lake bottom that forms a majority of the modern watershed. Most of the present-day human activity begins within tens of feet of the top of the secondary bank.

I.2.1.3. Scarps from riverbank slides are typically located in the secondary bank, 100 to 400 feet from the edge of the river. Often the slides progress up slope thereby leading to a hummocky appearance between the tops of the primary and secondary banks. The slides may extend for several hundred feet along the river bank.

I.2.1.4. It has been noted that slides in the Red River Valley are most typically found to exist on the outside of river bends. These slides are likely initiated, in part, by the scouring action of the river on the toe of the primary or lower river bank. In addition to slides in the upper or secondary banks, smaller scale sloughing of the lower river banks is frequently observed.

I.2.1.5. Topography of the Red River Valley, outside of the river channel, is predominately flat. The proposed North Dakota Diversion alternative follows a topographical route that progresses from the south, just north of Oxbow, ND, to the north end of the project where the project channel rejoins the natural channel north of Argusville, ND, and Georgetown, MN. The elevation from south to north drops from about 915 feet to 880 (NAVD 1988 adj). This relatively steady slope to the north falters very little, but is cut by 5 different river channels. The Wild Rice and Sheyenne are the most influential, though their river bottoms drop beneath their banks by only about 20 feet, to elevations of 893 and 902 feet at their respective proposed diversion channel crossings.

I.2.1.6. The proposed Minnesota Diversion alternative follows a topographical route that drops from about 910 feet at the south, where the river is proposed to divert the Red River, just north of confluence of the Wild Rice River, to approximately 885 feet (NAVD 1988 adj) at the north end of the project where the diversion rejoins the natural channel north of Oakport, MN. This relatively steady slope to the north falters very little, but crosses a few eskers that create low-lying ridges. The largest of these, at the north end of the proposed channel, is about 150 feet wide with a relief of approximately 4 feet.

I.2.2. Geology

I.2.2.1. Most of the observed conditions that are the basis of this report are closely related to the geologic setting within the proposed project site. Soil borings were obtained along the river course and diversion alignments in order to more closely define the site specific subsurface conditions.

I.2.2.2. The geology influencing the Red River of the North Valley along the North Dakota / Minnesota border is the legacy of glacial Lake Agassiz and recent fluvial/alluvial processes of the Red River and its tributaries. During the glacial period, the entire watershed of the present day Red River of the North was covered by a

continental glacier. Periodically, as the glacial ice melted and retreated northward, huge ice dams were formed which blocked the natural northerly drainage pattern. Glacial Lake Agassiz, which covered approximately 200,000 square miles, resulted from the ice damming and subsequent ponding of meltwaters. The lake is believed to have existed from approximately 13,800 to 9,000 years before present (B.P.), during the Late Wisconsin Glacial Episode of the Pleistocene Epoch. At its maximum extent, Lake Agassiz is believed to have been approximately 150 feet deep in the vicinity of Fargo. As the glacier receded and advanced, fluctuations of the lake levels resulted in corresponding variations of the sediment types. After the glacial lake drained for the final time, the relatively youthful drainage pattern of the present Red River of the North established itself on top of the lake sediments. A useful analogy may be to consider the river course to be little more than a scratch in a broad table top. The basis for most of the stability analysis prepared for this report is a direct result of the geologic setting of the present day Red River Valley. This brief history of the Pleistocene Epoch and related stratigraphy is presented to establish background for discussions of the engineering characteristics of the various soil units. Much of this information has been previously detailed in:

- North Dakota Geological Survey Bulletin No. 47 (Klausing, 1968),
- North Dakota Geological Survey Miscellaneous Series 52 (Harris, Moran, & Clayton, 1974),
- North Dakota Geological Survey Report of Investigation No. 60 (Arndt, 1977),
- General Design Memorandum for Flood Control-East Grand Forks (Corps of Engineers, 1986).

I.2.2.3. The stratigraphic units will be discussed from bottom-most to ground surface.

I.2.2.4. **Bedrock**. Bedrock lies at an estimated depth greater than 300 feet beneath the glacial sediments in the region. The bedrock is likely composed of Cretaceous Period, shales and sandstones. The bedrock lies well below the influence of the proposed project.

I.2.2.5. **Undifferentiated Glacial Sediment**. Up to 400 feet of till may overlie the bedrock surface. An unknown amount of glacial drift is included in the estimated thickness. The till surface generally slopes from south to north at a slightly greater rate than the ground surface. The till ranges from a gravelly, sandy clay to a gravelly, silty, clayey sand.

I.2.2.6. **Argusville Formation (Unit A)**. The lowest foundation unit of interest is the Argusville Formation (Unit A). In the project location, the depositional period for this formation likely straddled the Pre-Caledonian Advance of the Lostwood Glaciation (Cass Phase) and continued throughout the early portion of the Caledonian Advance approximately 13,500 – 12,800 years BP. This unit provides suitable foundation for nearly all types of pile-founded construction in the Fargo-Moorhead area. 'Unit A" is composed mostly of gray to dark gray silty, sandy, pebble-loam (till). Locally the uppermost portion of this formation may be made up of sand and gravel. The Argusville Formation (Unit A) may be characterized as stiff to hard, moist, low plasticity, variably sandy, silty, gray, glacial clay, with a liquid limit generally less than 40. A gritty texture

and high SPT values are the distinguishing features of "Unit A". The contact with the overlying Argusville Formation is gradational. The engineering properties are the best of any unit in the project vicinity.

I.2.2.7. **Argusville Formation**. In the project location, the depositional period for this formation likely straddled the Pre-Caledonian Advance of the Lostwood Glaciation (Cass Phase) and continued throughout the early portion of the Caledonian Advance approximately 13,500 – 12,800 years BP. In contrast to the underlying glacial till, this unit has only scattered sand and gravel, and occasional small till inclusions up to 3 inches in diameter. The sand, gravel and till inclusions in the deposit may have been derived from rafts of floating glacial ice. The Argusville Formation may be characterized as massive, soft to medium stiff, wet, highly plastic, slightly sandy or gravelly, dark gray, glacio-lacustrine clay, with a liquid limit generally less than 80. A slightly gritty texture is the most distinctive feature of the Argusville Formation. Along the proposed project alignment, the Argusville Formation has an average thickness of 20-40 feet. The contact with the overlying Brenna Formation is gradational. The engineering properties are very poor and should be considered as poor as, or only slightly better than, the overlying Brenna unit.

I.2.2.8. **Brenna Formation**. The second high-water phase (or Lockhart Phase) of Lake Agassiz occurred from approximately 11,600 to 11,000 years BP and resulted in the deposition of the Brenna Formation. The Brenna Formation is characterized as a uniform, soft to very soft, wet, highly plastic, dark grey, glacio-lacustrine clay, with little or no visible structure and a liquid limit generally greater than 80. The major source of sediment for this formation was eroded Pierre Shale bedrock. Slickensides are commonly observed on shear planes in freshly broken samples. Soft, calcareous silty nodules are common, increasing with depth, and silty laminae are occasionally present in the lower zone of the formation. The Brenna Formation is notoriously unstable as a foundation material throughout the Red River of the North Valley. In the project area, the unit has an average thickness of approximately 20-40 feet. The contact with the overlying Sherack or Poplar River Formations is an erosional unconformity. The upper 3 to 10 feet of the Brenna Formation is variably harder, occasionally oxidized, and more consolidated than the bulk of the Brenna Formation, probably due to desiccation during sub-aerial exposure. It is not thick enough, however, to substantially alter the basic weakness inherent within the formation.

I.2.2.9. **Poplar River Formation**. Between 11,000 to 9,000 years BP (the Moorhead Phase), Glacial Lake Agassiz experienced several water level fluctuations. During periods that portions of the lake bottom were exposed to sub-aerial erosion, a drainage network similar to the modern Red River system developed. The Poplar River Formation is the result of deposition of fluvial channel and overbank sediments during this phase. Along the project alignment the formation is found as two members- the West Fargo member is characterized as a laminated, soft to medium stiff, wet, silty, organic rich clay with sand and silt seams. The Harwood member of the Poplar River unit is a medium stiff, moist, silty clay, brownish gray with a mealy texture. Locally, peat beds up to 3 feet thick may be encountered in this unit. Where present, it typically occurs as trough-shaped features from a few hundred feet to a mile in width that are incised into the top of

the Brenna Formation. In the proposed project area, it averages 8 feet in thickness, and is found more abundantly towards the northwest in the project area. The contact with the overlying Sherack Formation is conformable, usually interbedded, and gradational. Locally pervious deposits of the Poplar River Formation can produce substantial amounts of water. If a significant body of this pervious material were encountered during construction, it could, potentially, pose a dewatering problem.

I.2.2.10. **Sherack Formation**. The third and final high-water phase (or Emerson Phase) of Glacial Lake Agassiz occurred from approximately 9,900 to 9,000 years BP and resulted in the deposition of the Sherack Formation. The Sherack Formation is typically characterized as laminated, medium stiff, glacio-lacustrine silty clay and clayey silt with minor amounts of sand, gypsum and calcite crystals, and /or organics. The upper portion of this unit is usually brown to yellow-brown with frequent iron oxide or calcareous concretions but the base is grey. Glacial material from the uplands, instead of shale bedrock, was the major source of sediment for the Sherack Formation. The contact with the overlying present period (Holocene Epoch) sediments is an erosional unconformity.

I.2.2.11. The Sherack Formation has been impacted more than any other unit in the project reach by erosion and flooding near the banks of the Red River. Often, below the secondary (upper) banks, substantial portions have been removed and replaced by relatively recent alluvial and/or fluvial sediments. Slope failures have also displaced the Sherack Formation riverward of the secondary banks. Riverward of the upper bank, average elevation and thickness of formation figures are so variable that the only practical method for evaluation is to reference a specific cross-section before any meaningful analysis may begin. In the project vicinity the formation averages approximately 10 to 20 feet in thickness. The engineering properties are the best of any glacio-lacustrine unit in the project area.

I.2.2.12. **Present period sediments**. As the northeastern outlets for the lake opened for the final time, it is estimated that Glacial Lake Agassiz retreated from North Dakota by about 9,000 years BP, and was wholly gone as a Pleistocene phenomenon by approximately 8,500 years BP. An immature drainage system developed along the floor of the glacial lake bed with tributary streams rising in the high ground to the west and east. The present day Red River of the North watershed is the result of this post-glacial erosional activity. Flood sediments from the Red River blanket the valley ground surface now in a meander belt approximately 1 to 1.5 miles on either side of the existing river. These surface sediments may be characterized generally as soft to medium stiff, fluvial or alluvial, silty clay or clayey silt. Variably, the unit may contain sand or organic matter, including shells, and range from massive to weakly laminated. Adjacent to urban development, fill and rubble are frequently components of the upper sediments. The river exhibits no well defined flood plain. The depth of these surface sediments is highly variable and may range from approximately 1 up to 15 feet in thickness along the proposed project alignment.

I.2.3. Structure

I.2.3.1. Jointing within the glacio-lacustrine deposits at the site has been observed in the boreholes infrequently. These joints had a short vertical magnitude and no attempts were made to determine their orientation. Evidence of sliding is usually most noticeable near the main-stem valley of the Red River or its major tributaries. Obvious surficial evidence of slide activity noted includes crack development in the ground surface, cracking of walls, foundations, and drainage utilities, scarps and hummocky topography within and below the secondary (upper) river bank, leaning trees, utility poles, and structures. The borings revealed evidence of slide activity also. Jumbled, high angle or displaced bedding, soil units out of stratigraphic sequence or at displaced elevations, and older or pre-existing slickensides were all used to identify areas where sliding is occurring now or has occurred within the relatively recent past. Typically, but not exclusively, these areas were also located on the outside of river bends. All of the evidence gathered was used to determine which criteria was appropriate for any slope stability analysis in the project reach. Sliding, as observed in numerous exposures along the Red River of the North, is generally oriented so that the major plane of movement is perpendicular to the trend of the river.

I.2.4. Site Hydrogeology

I.2.4.1. The generally low permeability of the soils within the proposed project boundaries makes determination and prediction of groundwater levels challenging. Occasionally some coarse sediment seams are sufficiently pervious to allow a confident measurement. Earlier efforts to correlate soil color with groundwater conditions are now thought to be unreliable. In an attempt to obtain more useful groundwater information, the drilling method was modified. An offset hole was drilled and allowed to stand open as long as practical so that a water level could be obtained. In essence, 2 holes were drilled at many locations so that little time was wasted waiting on a single borehole to develop a stable water level. Several water level holes were allowed to stand open overnight, although all the water levels obtained by this method were not definitively known to be stable. The information gathered has helped to shed light on this problem; however the results are still not entirely definitive.

I.2.4.2. Groundwater levels in the Fargo area are high. Soil borings taken for this study revealed groundwater to be within an approximate range of 5 to 20 feet below the ground surface. Experience indicates that water levels fluctuate seasonally, with fall /winter conditions exhibiting the lowest measured water levels as might be expected. The water surface profile from the secondary bank riverward varies also, with the flattest profile occurring during the fall/winter months. It is reasonable to expect these same conditions to be reflected in Fargo. Water levels in the banks do fluctuate with the level in the river. Data is not available to ascertain the rate at which the banks become saturated with river water. River banks observed weeks after a high water event reveal that there is usually a seepage point 2 to 3 feet above the river water surface at approximately the same level as the measured water level in the borehole adjacent to the lowest or primary river bank. Water levels are most frequently, but not exclusively, measured in the alluvial and/or fluvial surface deposits. Levels not obtained in the

alluvial/fluvial soils (or fill) are found in permeable zones of the upper portions of the Sherack Formation. Dry holes are occasionally encountered, but are the exception rather than the rule.

I.2.5. Seismic Risk and Earthquake History

I.2.5.1. The Fargo-Moorhead metro area in the Red River of the North Valley is one of the least seismically active places in the United States. According to Figure C-1, Seismic Zone Map of the United State from ER 1110-2-1806 (Reference I.13.7), the Fargo-Moorhead metro area is located within earthquake Seismic Zone 0. The Seismic Zone of 0 is associated with the least risk area while a Seismic Zone 4 is associated with the greatest risk. A reproduction of Figure C-1 with the Fargo-Moorhead metro location indicated is included in Attachment I-1.

I.2.5.2. The nearest continental basement fault to the west is the Thompson Boundary fault, which extends from the approximate Saskatchewan - Manitoba boundary southward through North Dakota, about 200 miles west of the Red River Valley. The fault separates the stable Wyoming and Superior Cratons of the tectonically-inactive Canadian Shield. An earthquake occurred along this fault near Huff, North Dakota, south of Bismarck, in 1968. It had a magnitude of 4.4 on the Richter Scale (IV-V Mercalli Intensity). This has been the largest and also the nearest (less than 200 miles west) recorded earthquake in North Dakota (Reference I.13.2). Northwest of the Fargo-Moorhead metro area, an earthquake with an epicenter located in southeast Saskatchewan, Canada had a Mercalli Intensity of VI. No known reports of disturbances near the proposed project area resulted from either of these events. Additional earthquakes have been recorded west and northwest of the Fargo-Moorhead area near Goodrich, Hebron, Williston, and Grenora, North Dakota. These earthquakes have recorded or estimated to be between 1.5 to 3.7 magnitude. Included in Attachment I-1 is a map indicated the "Earthquakes in North Dakota", and was obtained from the North Dakota Geological Survey, *Geologic Investigation No. 94* (Reference I.13.2).

I.2.5.3. To the east, two faults exist in Minnesota that could possibly affect the project. The first is known as the Vermillion fault, which is an inactive Precambrian fault that extends eastward from Northwestern Minnesota near the Twin Lakes area in the Glacial Lake Agassiz plain. The westernmost extent of the fault is approximately 30 miles east of the Red River. It bends southeastward in an arcuate path through the northern part of Minnesota and enters Canada north of Ely, Minnesota. It is approximately 250 miles long. Its surface expression is defined by a narrow, linear topographic depression, which is occasionally occupied by deep, elongate lakes. The second fault, known as the Morris fault, extends diagonally from the town of Morris, Minnesota to the Brainerd area in west-central Minnesota, roughly 100-130 miles east/southeast of Fargo. Like the Vermillion fault, it is confined to the Precambrian bedrock and is not considered tectonically active, although some seismic activity has been associated with the Morris fault. In 1975, an earthquake with a Modified Mercalli Intensity of VI occurred near the town of Morris. This earthquake occurred about 10 miles west-northwest of Morris at a depth of 3-5 miles. It is one of the best documented earthquakes in Minnesota history, and possibly the largest. In Fargo and in Valley City, North Dakota, a Modified Mercalli

Intensity of II (felt by persons at rest, on upper floors, or favorably placed) was assigned for this event. The Modified Mercalli Intensity Scale ranges from I (not felt) to XII (damage nearly total). Five other earthquakes have been linked to the Morris fault since the year 1860. The most recent earthquake in Minnesota occurred along the western edge of the Morris fault in 1993 near the town of Graceville. It had a magnitude of 4.1 on the Richter Scale and a Mercalli Intensity of V. The Graceville earthquake occurred at an estimated depth of 7 miles.

I.2.5.4. Eighteen recorded earthquakes have occurred in Minnesota since 1860. Some are associated with glacial isostatic rebound, particularly in the northeast region of the state near Duluth. No earthquake has exceeded the magnitude or intensity of the Morris event in 1975. An approximate frequency of between 10 and 30 years has been established for minor earthquakes in Minnesota.

I.2.5.5. The peak horizontal ground accelerations (PGA) for various annual exceedance rates were determined using the 2008 NSHMP PSHA Interactive Deaggregation web site (http://eqint.cr.usgs.gov/deaggint/2008/) from the U.S. Geological Survey (USGS). The estimated PGA for the mean return time of 475 years, 2475 years, and 4975 years, was 0.007g, 0.025g, and 0.04g, respectively, which are very small. The PSH deaggregation charts are presented in Attachment I-1.

I.2.5.6. The probability of a magnitude 5 or larger earthquake occurring within 50 km of the Fargo-Moorhead was also determined using the USGS 2009 Earthquake Probability Mapping tool (http://geohazards.usgs.gov/eqprob/2009/index.php). Maps indicating the probability of earthquakes of magnitude 5 or larger occurring within "50 year and 50 KM" and "250 years and 50 KM" are also included in Attachment I-1. For both scenarios, the probability of a magnitude 5 earthquake or larger is between 0.0 and 0.01.

I.2.5.7. A search for earthquakes within a 1000 kilometer circular area of the Fargo-Moorhead metro area was also conducted. Again, the U.S. Geological Survey's "Circular Area Earthquake Search" tool found on their website (http://earthquake.usgs.gov/earthquakes/eqarchives/epic/epic_circ.php) was used. The search resulted in finding 219 earthquakes that have occurred between 1804 and 2010. The earthquakes ranged in magnitude from 2.3 to 6.2. The 6.2 magnitude occurred on November 8, 1882 at a distance of 620 miles from Fargo-Moorhead, near Fort Collins, Colorado. A table that summarizes these earthquakes is presented in Attachment I-1 along with a map that indicates the locations and magnitudes.

I.2.5.8. The seismic risk assessment for the Red River Valley region relies largely on earthquake history. The absence of major or catastrophic earthquakes, coupled with the infrequency of these earthquakes in general, implies an extremely low risk level for seismic activity in the vicinity of Fargo-Moorhead metro area. Based on this low risk, the performance of project features were not assessed using earthquake loading cases.

I.3.0. SUBSURFACE INVESTIGATION

I.3.0.1. The subsurface investigation for the FMMFS was completed at different phases of the study. The first subsurface investigation program was developed and initiated in the Spring/Summer 2009. This program was developed to obtain subsurface information for the In-Town Levee alternative and also the Minnesota Diversion alternative. This program consisted of machine borings and the use of the cone penetration test (CPT). A subsequent subsurface investigation program consisting of only machine borings was completed in December 2009. This program was developed to obtain subsurface information along the North Dakota Diversion alternative. A third subsurface investigation, consisting again of only machine borings, was completed between May and July 2010. This program was used to obtain additional subsurface information along the MN Diversion alignment, especially in the area near Dilworth, MN and at the structure locations. Exploration was also conducted along the ND Diversion alignment, with most being taken near the proposed locations of the structures. The final subsurface investigation was conducted between November 2010 and March 2011. The program was used to gather additional subsurface information along the ND Diversion alignment and at structural locations. Both machine borings and CPTs were used.

I.3.0.2. The entire soil exploration program consisted of 123 machine borings, 22 off-set undisturbed borings, and 101 cone penetration test (CPT) soundings. The off-set undisturbed borings were completed in order to obtain 5-inch undisturbed samples to conduct shear strength and consolidation testing. To better understand the CPT sounding results, 25 soundings were off-set from machine borings. In addition, at 15 of these locations, undisturbed samples were obtained.

I.3.0.3. The number and type of exploratory holes completed for the different alignments varied. Table I - 1 below indicated the type and number of explorations completed for each alignment. For the In-Town Levee alternatives, the exploratory holes were typically located on the outside bends of the river, where stability of the natural bank is of greatest concern. In general, a machine boring was completed near the river's edge on the primary bank while a second exploratory hole was conducted on the secondary bank. The secondary bank hole was generally a CPT sounding, but some were machine borings. For the MN Diversion alignment, the exploratory holes were generally located in a checker board pattern, with exploratory holes being located on alternate sides of the diversion channel alignment. In the area of Dilworth, MN, the exploratory holes were completed along sections running east-west in order to determine the trend of the Buffalo Aquifer. For the ND Diversion alignment, the exploratory holes were generally done near the centerline.

Table I - 1: Summary of Soil Exploration and Instrumentation

Location	Machine Borings	Undisturbed Borings	CPT	Piezometer	Slope Inclinometer
Fargo - In-Town Levees	22	4	19	0	1
Moorhead - In-Town Levees	21	3	16	1	1
ND Diversion Channel	40	12	34	2	0
MN Diversion Channel	40	3	32	5	0
Total	**123**	**22**	**101**	**8**	**2**

I.3.0.4. The locations of the exploratory holes are shown on the figures presented in Attachment I-2. The exploratory holes are numbered in sequential order as they were obtained. Each side of the river has its own sequential order, with the FMMFS exploratory holes for the Fargo side starting at 21 and for the Moorhead side, 11. This is due to the fact that the St. Paul District had previously obtained borings in the area. The exploratory holes are labeled to indicate the year in which the hole was obtained, the sequential order of the hole, and the type (i.e. 09-21M). Machine borings are indicated by "M" (i.e. 09-21M) while off-set undisturbed machine borings are indicated by "MU" (i.e. 09-32MU). CPT soundings are indicated by "C" (i.e. 09-23C). For locations in which multiple types of exploratory holes are off-set from each other, each type of hole will have the same year and sequential order, with the type varying in the name.

I.3.1. Borings

I.3.1.1. Many of the machine borings were conducted using an all-terrain vehicle (ATV) rig. The ATV rig was more maneuverable and minimized the disturbance of the area when compared to a truck mounted rig or the CPT truck mounted rig. Therefore, the ATV rig was used to complete the borings located on the primary bank, near the river's edge. The truck mounted rig was utilized at locations along the diversion channel alternatives where access and disturbance were not issues.

I.3.1.2. The machine borings were conducted using a continuous sampling method which allowed the soils to be classified in the field by a geologist. The sampling was done in 5 foot flights. The first 3 feet were sampled with a modified 2"x2 ½" split spoon, followed by the 2" standard penetration spoon for the remaining 2 feet. The already sampled 5 feet was then cleaned out with the noted drilling method, and sampling continued. The larger spoon above the standard spoon cleaned the hole out large enough to not affect the SPT blow counts of the standard spoon. The drive of the modified 2"x2 ½" spoon was recorded on the field logs, but not digitally recorded. The standard SPT blows were recorded in the field with a hand held device into PLog software and are the blow counts presented on the drafted logs. SPT blows were performed dropping a 140 pound hammer 30", unless otherwise stated, with the auto-hammer corresponding to the drill rig performing the boring; either the CME-750, or the Diedrich 120. Disturbed samples were also collected and tested for moisture content, Atterberg limits, and in some cases, grain size distribution.

I.3.1.3. The undisturbed soil borings were located off-set to the machine borings in order to obtain 5-inch undisturbed samples. Generally at each undisturbed machine boring, one undisturbed sample was obtained from each formation. A total of 16 undisturbed borings were completed, obtaining 63 undisturbed samples. These undisturbed borings were distributed throughout the project, with four completed for the in-town levee alignment in Fargo, three for the in-town levee alignment in Moorhead, three along the Minnesota Diversion alternative, and six along the North Dakota Diversion alternative.

I.3.1.4. The boring logs are presented in Attachment I-3.

I.3.2. Cone Penetration Tests

I.3.2.1. The CPT method of soil exploration was implemented during the first and fourth exploration programs. For the first exploration program in the Spring/Summer 2009, the CPT soundings were conducted by the USACE Savannah District using a 20-ton CPT truck mounted rig. The CPT cone was a Hogentogler piezocone that measured U2 pore pressure located at the shoulder of the cone. Due to the large size and weight of the CPT rig, CPT soundings were conducted on the secondary bank at locations which would minimize the disturbance of the area. This typically meant that the CPT soundings were conducted on or near a paved street. USACE Savannah District again conducted the CPT soundings during the fourth exploration, November 2010 through January 2011. For this program, a 20-ton track rig was implemented. With the track rig, a Hogentogler seismic piezocone was used to obtain the shear wave velocity of the soils.

I.3.2.2. As mentioned previously, 16 of the CPT soundings were conducted off-set from machine boring locations during the first exploration program. This was completed in order to correlate the CPT sounding and resulting "soil behavior type" (SBT) with the geologic formations indicated in the machine boring. It was found that the results of the SBT could not readily distinguish the contacts between the different upper foundation materials such as the Alluvium, Sherack, and Poplar River formations. It was discovered that there was a distinct change between the upper foundation materials and the Brenna formation and was readily apparent. It was also found that the CPT data and SBT could not be used to distinguish between the Brenna and Argusville materials, nor was there a parameter that could be used to distinguish between the two formations.

I.3.2.3. For the fourth exploration program, the seismic cone was used implemented in order to obtain the shear wave velocity of the soils. It was thought that the shear wave velocity could help distinguish between the Brenna and Argusville formations. It was found that there is a general trend in the shear wave velocity that can be used to help distinguish between the Brenna/Argusville contact. The trend is that the shear wave velocity increases in the Argusville compared to the Brenna formation. This trend is based on only two CPTs off-set from the machine borings. Additional machine borings should be completed adjacent to CPT sounding locations to verify this trend.

I.3.2.4. The CPT soundings are presented in Attachment I-3.

I.3.3. Testing

I.3.3.1. Testing was done on disturbed samples (jar samples) to determine in-situ moisture contents, Atterberg limits, and in some cases grain size distributions. The results of this testing helped to identify the soil characteristics and define the stratigraphy. A summary of the disturbed sample results is in Attachment I-4.

I.3.3.2. Undisturbed testing was requested on 79 of the 81 undisturbed samples. The majority of the laboratory testing performed was done to determine the shear strengths of the soils. The shear strength tests included isotropically consolidated-undrained triaxial compression tests with pore-water pressure measurements (R-Bar), direct shear tests (DS), and unconsolidated-undrained (Q tests). Residual direct shear tests were also run to determine the effective residual shear strength of the soil. In addition, consolidation tests were performed on the samples. Other testing performed on undisturbed samples included: moisture content, unit weight, specific gravity, Atterberg limits, and grain size distributions. These tests helped identify the soil characteristics and define stratigraphy. Table I - 2 shows the undisturbed testing request for Phases 2, 3, and 4 while Table I - 3 shows testing completed on each soil unit. The laboratory test results are presented in Attachment I-4.

Table I - 2: Summary of Undisturbed Testing By Phase

Test	Phase 2	Phase 3	Phase 4	Total
DS	13	4	0	17
Residual	12	0	0	12
UU, Undisturbed	12	12	24	48
R-bar, Undisturbed	28	12	25	65
Consolidation	10	5	19	34
Constant Rate of Strain Consolidation	0	7	2	9
Atterberg Limits	30	15	26	71
Spec. Gravity	5	0	26	31
Hydro & Sieve	10	13	26	49
Sample Extrusion	38	15	26	79

Table I - 3: Summary of Undisturbed Testing by Formation

	Test								
	DS	Residual	UU, Undisturbed	R-bar, Undisturbed	Consolidation	Constant Rate of Strain Consolidation	Atterberg Limits	Spec. Gravity	Hydro & Sieve
Alluvium	0	2	2	7	2	2	5	1	3
Sherack	0	3	2	7	1	0	6	1	0
PL Sherack	0	0	0	0	0	0	0	0	0
Poplar River	0	0	0	1	0	0	1	0	0
PR - Harwood	0	0	2	2	1	0	2	0	2
PR - WF	1	0	2	2	1	0	2	0	2
OX Brenna	0	1	7	9	6	0	8	4	6
Brenna	10	3	16	18	11	3	22	9	15
B/A Trans	1	1	1	2	2	0	2	0	1
Argusville	5	2	14	13	9	4	18	12	15
Till	0	0	2	4	1	0	5	4	5
TOTAL	**17**	**12**	**48**	**65**	**34**	**9**	**71**	**31**	**49**

I.3.4. Selection of Design Parameters

I.3.4.1. The effective shear strength parameters used for the FMMFS are based on the ultimate (post-peak) strength failure criteria that equated to a strain of 15%. There are a number of reasons for this. First, ultimate strengths have been used for previous St. Paul District (MVP) projects within the Red River Valley. In addition, experience within the Red River Valley indicates that clays within this region are fissured and the weakest of these clays exhibit brittle stress-strain behavior. This can lead to progressive failure of the riverbanks and cut slopes, which is commonly seen. As a result of the brittle stress-strain behavior and progressive failure mechanism, the peak shear strength can not be mobilized along the potential shear surfaces simultaneously. Also, experience indicates that large amount of strain (more than 10%) may occur in natural or cut slopes during the life time of the project. The effective stress shear strength test data indicates that if the materials exhibit brittle stress-strain response, the peak strength occurs typically between 3 and 8 percent strain. For those materials that do not exhibit a brittle stress-strain response, the maximum stress typically remains constant beyond 10% strain For these reasons, the effective stress shear strength parameters were based on the ultimate (post-peak) strength failure criteria for both the In-town Levee alternative and the Diversion Channel alternatives. Both R-bar and DS test results were used in the determination of the effective stress shear strength parameters.

I.3.4.2. In the case of the total stress analyses, different criteria were used for the In-Town Levee alternative then for the Diversion Channel alternatives. The peak undrained shear strength parameters were used when analyzing the end-of-levee construction condition. At the end-of-levee-construction, the clay soils will start to consolidate and dissipate excess pore pressures generated from the embankment loading. The clay will drain, but very slowly, due to the low hydraulic conductivity associated with clay minerals. In time, the clay soils will drain and all excess pore water pressures will have dissipated. At this time, the soil mass is said to be in a drained condition. During the process of draining, it is thought that the soils will experience strain of less than what is required to reach the peak undrained shear strengths.

I.3.4.3. In the case of analyzing the excavated slopes for the diversion channels, ultimate undrained shear strength parameters were used when analyzing the end-of-excavation condition of the diversion channel excavated slopes during Phase 3. The preliminary analyses completed during Phase 2 used peak undrained shear strength parameters. There are a few reasons why the use of ultimate, undrained shear strength parameters were used during Phase 3: 1) The excavation of the channel and the placement of the spoil piles, which are substantially higher than the levees (15 feet high) and extend for a considerable distance, influences the pore pressures over a larger area than just the placement of a levee; 2) The clays in the area are fissured and localized softening can occur along the fissures; the sample size does not capture a representative sampling of the fissure, therefore possibly indicating higher strengths then what would occur in the field; the use of the ultimate undrained strength is an reasonable way to address these differences; 3) An independent external peer review (IEPR) suggested that ultimate undrained shear strength parameters be used; review of the undrained shear strengths indicated a 10% to 30% reduction in strength from peak strengths to ultimate;

selection of ultimate undrained shear strengths adds conservatism into the stability model and decreases the potential of failure during construction which would result in a difficult and expensive fix. For either the peak or ultimate criteria, the selection of the undrained shear strength (c_u) was based on the results of the Q tests.

I.3.4.4. The test results from the Fargo-Moorhead samples were entered into the St. Paul District's shear strength calculation spreadsheet. Since the Lake Agassiz soil deposits generally do not vary much, test results from other projects were also all incorporated into the spreadsheet. The other projects included three other MVP projects and consisting of: 1) Fargo Section 205 for the VA Hospital and Ridgewood Area; 2) the Sheyenne River and West Fargo Diversion project; and 3) Oakport Section 205. Data from the City of Fargo Southside Flood Control was also incorporated. It was found that the data from the different projects compared favorably to each other.

I.3.4.5. The shear strength parameters were selected using the 1/3: 2/3 rule, meaning that approximately 1/3 of the data points fell below the failure envelope and 2/3 of the data plotted above it. In the case of the Oxidized Brenna, Brenna, and Argusville formations, a curvilinear shear strength envelope was developed for the effective stress analysis of the diversion channel excavated slope. The curvilinear envelope is one standard deviation less than the most likely value. The most likely value (MLV) was determined by estimating lines that represented the highest and lowest conceivable values for shear strength. It was assumed that there were six standard deviations between the highest and lowest conceivable values, with the MLV envelope being located three standard deviations from either one. The selection of unit weights was based on the average value of the laboratory test results. The selected design parameters can be found in Table I - 4 and the data points for the curvilinear shear strength parameters in Table I - 5. In addition, the Mohr-Coulomb and curvilinear shear strength plots and undrained strength versus elevation plots are presented in Attachment I-5.

Table I - 4: Summary of Selected Soil Parameters

Formation	Unit Weight (1) γ_{sat} (pcf)	Shear Strength Parameters: Effective Stress (2) ϕ'	Effective Stress (2) c' (psf)	Total Stress, c (psf) Peak (3)	Total Stress, c (psf) Ultimate (4)	Residual $\phi'_{residual}$
Alluvium (5)	119	31	0	assume values of Sherack		20
Sherack	118	28	0	1400	900	13.0
Plastic Laminated Sherack	112	19	0	1150	N/D	6.8
Poplar River - West Fargo	123	34	0	1900	1900	25
Poplar River - Harwood	116	26	0	1450	1200	assume values of West Fargo
Poplar River, All (6)	119	assume values of Harwood		assume values of Harwood		assume values of West Fargo
Oxidized Brenna (7)	111	19	0	1000	900	5.5
Brenna (7)	104	13	0	650	525	9.0
Argusville (7)	106	15	0	825	600	10.5
Till (8)	122	31	0	1900	1900	N/A
Sand (9)	125	32	0	N/A		N/A
Riprap (9)	125	30	0	N/A		N/A

Notes:

(1) The unit weights are taken as the average value of all laboratory test results.

(2) The effective stress parameters are based on the R-Bar triaxial and direct shear tests. The failure criterion is defined as ultimate deviator stress which equates to the deviator stress at 15% or 20% axial strain.

(3) The peak total stress parameters are based on unconsolidated-undrained triaxial shear tests with the failure criterion defined at peak deviator stress. The peak undrained shear strength parameters were used for the end-of-levee-construction condition.

(4) The ultimate total stress parameters are based on unconsolidated-undrained triaxial shear tests with the failure criterion defined at ultimate deviator stress which equates to the deviator stress at 15% axial strain. The ultimate undrained shear strength parameters were used of the end-of-excavation condition when analyzing the diversion channel excavated slopes.

(5) Alluviun undrained shear strength parameters are assumed to be that of Sherack.

(6) Poplar River formation parameters are assumed to be that of the Harwood member.

(7) For the Oxidized Brenna, Brenna, and Argusville formations, a curvilinear shear strength envelope was developed for the effective stress analysis of the diversion channel excavated slope. The curvilinear envelop is one standard deviation less than the most likely value.

(8) Assumed values based on literature review.

(9) Assumed values based judgment.

Table I - 5: Summary of Curvilinear Shear Strength Envelope Points

Oxidized Brenna		Brenna		Argusville	
Effective Normal Stress σ' (psf)	Effective Shear Stress τ' (psf)	Effective Normal Stress σ' (psf)	Effective Shear Stress τ' (psf)	Effective Normal Stress σ' (psf)	Effective Shear Stress τ' (psf)
0	25	0	50	0	50
200	113	200	120	200	127
1000	420	1000	333	1000	413
2000	760	2000	540	2000	653
3000	933	3000	673	3000	893
4000	1073	4000	807	4000	1093
7000	1493	6000	1033	6000	1460

I.4.0. GEOTECHNICAL DESIGN OF ALTERNATIVE

I.4.0.1. The geotechnical design of the alternatives was completed in phases that followed the direction of the feasibility study. As mentioned earlier, the "Credit to Existing Levees" analysis was completed during Phase 1 and is documented in Appendix H. During Phase 2 geotechnical analyses of the most promising alternatives was completed. The alternatives were the In-Town Levee option and the diversion channel options. One major task during Phase 2 was to collect and interpret subsurface information and laboratory test data – the basis for the design analyses. For the In-Town Levee alternative, the minimum setback distances had to be determined. In addition, the MN Diversion channel was analyzed to determine what side slopes would be appropriate and how deep the channel could be excavated. The major geotechnical task for Phase 3 was completing the evaluation of the slope stability for the MN and ND Diversion alternatives. Additional soil exploration was also completed along the MN and ND Diversion channel alignments during Phase 3. For Phase 4, the major task was to reanalyze the ND Diversion channel incorporating the changes that were determined during the Phase 4 hydraulic analysis. The analyses completed for the alternatives during Phase 2, 3, and 4 are presented in the following respective sections.

I.5.0. IN-TOWN LEVEE ALTERNATIVE

I.5.0.1. The In-Town Levee alternative was evaluated in detail during Phase 2. The evaluation was completed to determine the required setback distance for levees such that stability of the natural banks and levees were adequate. At the end of Phase 2, it was recommended not to evaluate the In-Town Levee alternative due to the limitation in the top elevation of the levee that could be tied into high ground, high residual risks due to maximum height constraint, and the requirement to remove a large number of structures. Therefore, no refinement to the In-Town Levee alternative was completed during Phase 3. The following section describes the In-Town Levee Alternative and the analyses completed during Phase 2.

I.5.1. Features

I.5.1.1. Levees

I.5.1.1.1. Levees have been used as the primary feature for many of the projects designed and constructed by the St. Paul District in the Red River Valley. The levees are constructed of clay that is readily available within the valley. The typical configuration of the clay levees includes a 10-foot wide top and 1 vertical on 3 horizontal side slopes. With the foundation being composed of various clay formations, minimal foundation preparation is required. Typically, stripping of the topsoil and clearing and grubbing areas within the footprint of the levees is all that is required. Special seepage control measures are not typically required due to the impermeable nature of the foundation and levee. The only seepage control measure generally required is an inspection trench that is excavated 6 feet below the ground surface along the centerline. This is done to investigate the foundation conditions and intercept any unsuitable materials near the surface. The construction of the levees is straightforward and major constructability issues are rarely encountered.

I.5.1.2. Floodwalls

I.5.1.2.1. Floodwalls have also been incorporated into St. Paul District projects and are generally inverted T-walls. They are used when project constraints limit the location and size of the project footprint. Typically it is where residential homes and other buildings are required to stay in place. The construction cost of floodwalls is generally higher than that of levees, but the real estate cost can be less. Typically, the St. Paul District compares the cost of levees versus floodwalls and makes a determination as to which is the most cost effective solution. In the case of the FMMFS, it was decided that during Phase 2, only levees would be considered for design and cost purposes. It was understood that refinement of this assumption would be required if the In-Town Levee alternative proved to be the best implementable plan.

I.5.1.2.2. For floodwalls, there generally are not many special geotechnical considerations. The floodwall foundations are constructed and bear directly on the impervious foundation to minimize seepage. The depth of the foundation is below the frost line, approximately 6 to 7 feet below the ground surface. Piling is normally not required to support the floodwall. Sheetpile is typically only included on closure structure foundations.

I.5.1.3. Pump Stations and Drainage Structures

I.5.1.3.1. In addition to the levees and floodwalls, pump stations and drainage structures are required. The foundation elevations for these structures are normally deep because the storm sewer outlets at the river are deep because of the flat topography. Deep foundations allow drainage structures to be designed and constructed to bear on the natural clay deposits without piles or foundation treatments.

I.5.2. Design Methodology

I.5.2.1. Background

I.5.2.1.1. Experience and observation within the Red River Basin have shown that the riverbanks are unstable or only marginally stable in many areas. This is mainly the result of having a weak soil formation (Brenna) at depth. Continued erosion of the bank and lower than normal water elevations in the river also lends the natural banks to becoming unstable. Failure of the natural bank has been repeatedly observed during low water conditions, when the stabilizing force of the water on the bank is the lowest, even without an additional load being placed. Construction activities which place loads on the natural banks may also induce slope failures in areas that are unstable or only marginally stable. The fact that the riverbanks are unstable or only marginally stable leads to a critical geotechnical problem when trying to design and construct a flood barrier (i.e. levee or floodwall).

I.5.2.1.2. The flood barrier (levee, wall, or combination of both) represents a large capital investment by the local sponsors and the federal government. The flood barrier needs to perform its intended function (keep water out of the cities) over the life of the project, under both undrained and drained conditions. Foundation movements of the flood barrier resulting from the natural slope failing and sliding towards the river have the potential to render the flood barrier ineffective. Given the overall cost of the flood barrier, the importance of its intended function, and the potential to impact other structures by initiating foundation movements, a proper analysis and design is required that results in construction of a flood barrier in a stable and reliable zone.

I.5.2.1.3. The slope stability criteria and guide, EM 1110-2-1913, "Design and Construction of Levees," (Reference I.13.5) does not cover the aspects of an effective stress analysis analyzing using low water conditions to establish a stable and reliable location of a flood barrier. The St. Paul District, through discussions with HQUSACE, established a design methodology for the Grand Forks, North Dakota and the East Grand Forks, Minnesota flood control projects in the late 1990s (Reference I.13.9). This design methodology has been used on projects within the Red River Basin following the Grand Forks/East Grand Forks projects and is the basis of the geotechnical analyses completed for the FMMFS In-Town Levee alternative.

I.5.2.2. Method of Analysis

I.5.2.2.1. The geotechnical analysis completed for the FMMFS requires that slope stability analyses be completed to determine appropriate setback distances for the In-Town Levee alignments. This analysis is intended to determine the location of the levee such that it is outside a zone that is unstable, marginally stable, or may become unstable. Like traditional stability analyses, a computer program was implemented to calculate the factors of safety against slope stability. The St. Paul District elected to use Slope/W 2007 from Geo-Slope International LTD.

I.5.2.2.2. The St. Paul District's experience in analyzing setback distances for projects within the Red River Basin indicates that non-circular type failures are the most critical. The "Entry and Exit" slip surface option in Slope/W was utilized along with the

"optimize" feature. The "Entry and Exit" search routine requires that the ranges for the entry and exit points of potential circular slip surfaces be indicated in the model. The circular surfaces along which the factor of safety (FS) is computed are determined by the entry and exit points, as well as a specified number of radius increments. The search yields a critical slip surface with the lowest factor of safety. With the optimization feature enabled, Slope/W proceeds to divide the critical slip surface into multiple segments and adjusts the location of these segments for the number of iterations specified, while calculating the FS for each iteration. Finally, the most critical "optimized" slip surface, now non-circular in shape, is reported. All stability analyses were completed using the Spencer's Method. In addition, an independent check of the Slope/W results was completed using UTexas4.

I.5.2.2.3. A range of entry points for the slip surface search was placed along the levee, from the wetside toe to the dryside toe. This allows a search to be conducted along the entire footprint of the levee. The rationale used to select the extents of the "entry" search limits within the footprint of the levee was to determine the slope stability factor of safety for the levee and natural bank with respect to sliding down towards the river. The slope stability analysis required that minimum FS be obtained within the footprint of the levee to ensure that the levee could be constructed in a location that remained stable both during construction and also long term. In the case of Fargo-Moorhead, the most critical slip surfaces initiated at the wetside toe of the levee. If the entry points were extended towards the river, lower factors of safety would be determined. Shear surfaces riverward of the wet-side toe with lower factors of safety was deemed acceptable for the required level of effort for the Phase 2 analysis and design.

I.5.2.3. Long-Term (Drained/Effective Stress) Design Condition

I.5.2.3.1. The long-term, low water, drained/effective stress design condition has been in most instances, the critical design condition in determining setback distances. The long-term design condition represents a drained slope stability case where the changes in water table and lowering of the river water surface elevation, occur gradually over periods of time which allow for dissipation of excess pore pressures. Therefore, effective stress shear strength parameters are used for all of the soil units in the slope stability analyses. Due to the fact that many of the soil formations exhibit a brittle stress-strain behavior and slope movements are progressive failures, the ultimate (post-peak) shear strength parameters are selected for design.

I.5.2.3.2. The long-term design condition also requires that the groundwater table and river elevation be defined in the model. The groundwater table is known to fluctuate seasonally. The groundwater table was conservatively set at ten feet below the ground surface above the secondary bank, which is similar to the groundwater conditions used for the analysis of the Fargo-Ridgewood project. A low river stage was used in the long-term analysis since this provides for a small stabilizing force at the toe of the slope.

I.5.2.4. End-of-Construction (Undrained/Total Stress) Design Condition

I.5.2.4.1. The end-of-construction, undrained, total stress design condition has generally not been the controlling design condition. Even so, this condition is analyzed as a check. The end-of-construction condition represents the short-term slope stability case where excess pore water pressures develop due to foundation loading (normally from embankment construction). A total stress analysis is assumed, where undrained shear strength parameters are used to characterize the soil formations. For undrained analyses, pore water pressures are assumed to be unknown in clays, so a piezometric line was not used. The hydrostatic pressure due to river loading corresponds with the low river stage used in the long-term design condition.

I.5.2.5. Sudden Drawdown Design Condition

I.5.2.5.1. The sudden drawdown design condition is not considered to be a critical design condition. The low permeability soils and the relatively slow rise/fall of the river should not result in development of a Sudden Drawdown Condition. While a lag between the river level and the adjacent groundwater level is likely as the flood waters recede, a rapid river drawdown to a normal level leaving the levee and river bank saturated is not physically possible.

I.5.3. Preliminary Geotechnical Analysis

I.5.3.1. The geotechnical analysis for the In-Town Levee alternative was started in Phase 2. The purpose of the analysis was to determine the setback distances from the centerline of the Red River for the In-Town Levee alternative. Given the schedule of the project, the alignment for the In-Town Levee alternative was required prior to finishing the collection and interpretation of the subsurface information (i.e. soil exploration and testing) in order to provide enough time to complete the layout of the project and cost estimate. Because of this, many assumptions had to be made in order to perform the preliminary geotechnical analyses. For these preliminary analyses, the stratigraphy of the Fargo-Moorhead area was generalized based on the findings of the St. Paul District's 2007 feasibility study for the Fargo Section 205 Project (Reference I.13.8). Also, the design parameters were selected based on data available at that time.

I.5.3.2. The preliminary geotechnical analyses were completed for two different flood event scenarios. The hydrologic and hydraulic (H&H) analyses had not been completed prior to starting the preliminary geotechnical analyses. Therefore, the first event was based on the top of levee profile for the 1-percent annual chance event plus 4 feet of freeboard as presented in the "North Side Flood Control Evaluation" report dated April 30, 2008, and prepared by Houston Engineering, Inc. for the City of Fargo (Reference I.13.0). During this time, the H&H analyses were completed for the 0.5-percent and 0.2-percent annual chance events and the top of levee profiles were determined. The levee profile developed by Houston Engineering was compared to the St. Paul District's 0.5-percent annual chance event and found to be similar. The top of levee profile the St. Paul District determined for the 0.2-percent annual chance event was found to increase the levee heights between 2 and 4 feet. Geotechnical analyses were completed for this second flood event scenario.

I.5.4. Revised Geotechnical Analysis

I.5.4.1. Typically, interpretation of the soil exploration program and testing results would be completed prior to starting any geotechnical analyses. In this case, due to the project schedule, geotechnical analyses had to be started prior to completion of exploration and testing. When time allowed, the stratigraphy was revised based on site specific data. Also, the additional test data was incorporated and the design parameters were reevaluated. Once this was completed, the initial slope stability models used in the preliminary geotechnical analyses were revised using the site specific stratigraphy and revised design parameters. The long-term and end-of-construction conditions were analyzed for the 0.2-percent annual chance event. The more frequent flood event was not analyzed as the results of the preliminary analysis indicated similar setback distances for the two flood events.

I.5.5. Design Sections

I.5.5.1. There were many design sections selected for analysis of the In-Town Levee alternative. A total of 40 cross sections were analyzed, 20 sections a piece for the Fargo side and Moorhead side. These sections were developed in locations on the outside bend of the river or slightly downstream of the apex of the bend as these areas are the most susceptible to destabilizing toe erosion. The locations of the design sections are shown in Attachment I-2.

I.5.5.2. The ground surface profiles for the design sections were based on LiDAR data gathered in 2008. The LiDAR data was gathered as part of the Red River Basin Mapping Initiative. In addition, hydrographic surveys of the Red River were completed in October 2008 by St. Paul District's Channels and Harbors crew. From this survey, the channel bathymetry was developed and merged with the LiDAR data. The ground surface profile and channel bathymetry for the design sections are based on this merged data. All elevation data is presented in North American Vertical Datum 1988 (NAVD 88).

I.5.6. Slope Stability

I.5.6.1. Stratigraphy

I.5.6.1.1. The slope stability design sections were developed in Slope/W. The ground surface profile was generalized for the design cross sections. For the preliminary geotechnical analysis, the stratigraphy was also generalized based on the findings of the St. Paul District's 2007 feasibility study for the Fargo Section 205 Project (Reference I.13.8). An assumed stratigraphy as indicated below in Figure I - 1 was used. The stratigraphy of the design sections was revised to reflect the foundation conditions as indicated by the soil exploration program. The stratigraphy developed and used for the revised geotechnical analyses is presented in Attachment I-6.

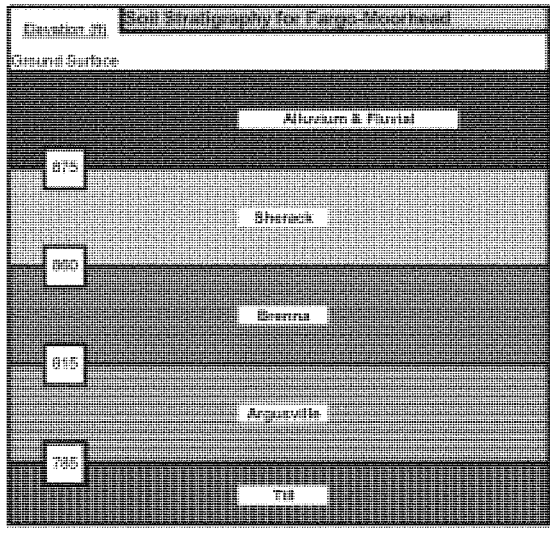


Figure I - 1: Assumed Stratigraphy for the Preliminary Geotechnical Analysis

I.5.6.2. Past Slides

I.5.6.2.1. There is evidence that earth movements (slides) have occurred within the Fargo-Moorhead metro area. Some of these slides have been initiated by human activities such as placing fill on the natural bank. One such occurrence has been documented in the area of the Veterans Administration Hospital in Fargo, ND in which a levee was constructed that caused a slide to form. In Moorhead, MN at Gooseberry Mound Park, there is physical evidence of a slide - a crack has formed in the pavement and there is differential vertical movement on either side of the crack.

I.5.6.2.2. Experience dictates that excess loading in areas of these slides, even if dormant, could cause existing slides to reactivate. For the revised geotechnical analysis, a residual shear strength zone, or failed soil zone, was assumed in the stability models to account for this. The residual shear strength zone was assumed to coincide with the location of the secondary bank slope and extend through the upper materials of alluvium and Sherack into and through the Brenna formation. The location of the residual shear strength zone coinciding with the secondary bank slope is a conservative assumption. It was assumed that no failure of the Argusville formation has occurred and that the formation was intact. The shear strength parameters of the failed soil were based on the results of the residual direct shear tests performed on samples of the respective formations.

I.5.6.3. Groundwater Table and River Elevation

I.5.6.3.1. The groundwater table was input into the stability model using the piezometric line feature in Slope/W. The groundwater table was assumed to be

approximately 10 feet below the ground surface. At a location approximately 100 feet back from the start of the secondary bank, the groundwater table sloped linearly down to the assumed river surface elevation. For the preliminary analyses, the river surface elevation that was assumed to be 5 feet above the river bottom. This was based on the low river flow depth used for the of the St. Paul District's Fargo Section 205 project (Reference I.13.8).

I.5.6.3.2. For the revised analyses, a low river surface profile was determined using the Red River HEC-RAS model for a flow of 220 cubic feet per sec (CFS). The 220 CFS flow is the 50-percentile flow for the month of September. The month of September was chosen because the average flow is the lowest of any given month. This resulted in an increase to the river surface elevation between 2 and 11 feet from the originally assumed 5-foot depth used in the preliminary analyses.

I.5.6.4. Required Minimum Factors of Safety

I.5.6.4.1. The goal of the geotechnical analyses was to determine the required setback distance of the levee from the centerline of the Red River. The position of the centerline of the levee on the slope that produced the required factor of safety (FS) was used as the minimum setback distance from the river's edge. There were three minimum FS criteria for slope stability used when determining the minimum setback distance for the in-town levees, depending on existing conditions and loading conditions.

I.5.6.4.2. A minimum FS = 1.4 was required for the preliminary analyses of the effective stress (drained) condition. The preliminary analyses were based on generalized stratigraphy with all soil being intact, an assumed ground water surface, and a river depth of 5 feet.

I.5.6.4.3. The revised geotechnical analyses included both residual shear strength zones and intact soil formations. The shear strength parameters used for the failed soils were based on residual direct shear test results, which is the lowest expected value for the soil. In addition, the failed/intact interface was assumed to coincide with the secondary bank slope and also assumed to be a vertical line. This is a conservative assumption, as it creates the largest extents for the failed soils. Also, ultimate or "fully-softened" shear strength parameters were used for the intact soil formations. Based on this, a minimum FS = 1.2 was required for revised effective stress (drained) conditions with residual shear strengths incorporated into the model. This factor of safety is similar to that used in the design procedure established by the St. Paul District for the Grand Forks / East Grand Forks Flood Control Projects (Reference I.13.9) in which back analysis was used to calculate the residual shear strength parameters.

I.5.6.4.4. The end-of-construction (undrained/total stress) conditions were also analyzed and required a minimum FS of 1.3. The undrained analysis used only intact peak undrained shear strengths. Experience in the Red River Valley indicates that undrained conditions typically do not control the required setback distances. This held true for the preliminary geotechnical analyses, in which the FS determined for end-of-construction condition were greater than the effective stress cases. Following revision and reanalysis

of the design sections, two of the forty sections were found to be controlled by the undrained condition. Therefore, in those two sections the setback distance was greater than what was required for the drained condition. A summary of the required FS is presented below in Table I - 6.

Table I - 6: Summary of Requirement Minimum Factors of Safety for Slope Stability

Design Condition	Required FS
Long-Term (Drained/Effective Stress)	1.4
Long-Term (Drained/Effective Stress) with Residual Soil	1.2
End-of-Construction (Undrained/Total Stress)	1.3

I.5.6.5. Results of the Geotechnical Analyses

I.5.6.5.1. The preliminary geotechnical analyses indicated that the required setback distances were similar for both the Houston Engineering 0.1-percent annual chance event plus 4 feet freeboard (St. Paul District's 0.5-percent annual chance event) and the 0.2-percent annual chance event. The required setback distances ranged from 345 feet to 555 feet.

I.5.6.5.2. Because the preliminary analyses indicated that the setback distances were similar for the two different scenarios, only the 0.2-percent annual chance event analyses were revised. The revised geotechnical setback distances varied from the preliminary setback distances. Sixty-five percent (26 out of 40) of the revised setback distances were within 50 feet (plus or minus) the preliminary setback distances. Approximately 28% (11 out of 40) of revised setback distance changed 50 to 100 feet (plus or minus). Only 8% (3 out of 40) of the revised setback distances changed more than 100 feet.

I.5.6.5.3. The setback distances determined during the preliminary and revised geotechnical analyses are summarized in Table I - 7. The levee setback distances that were used in the layout of the In-Town Levee alternative are also indicated, which were based primarily on "preliminary analysis" using Houston Engineering's 0.1% annual chance event. The layout of the project proceeded faster than the geotechnical analyses could be revised. Therefore there are some reaches in which the layout setback distances are less than the required setback distances. These discrepancies are not considered to be substantially and would have a small effect on the evaluation of the In-Town Levee as an implementable plan. A summary of the results of the preliminary analyses is presented in Attachment I-7 and the revised geotechnical analyses in Attachment I-8.

Table I - 7: Summary of In-Town Levee Alignment Setback Distances

Fargo, North Dakota					Moorhead, Minnesota				
	Setback Distance [ft]					Setback Distance [ft]			
	Preliminary Analysis		Revised Analysis			Preliminary Analysis		Revised Analysis	
Cross-Section	Houston 0.1% Annual Chance	USACE 0.2% Annual Chance	USACE 0.2% Annual Chance	Setback Used	Cross-Section	Houston 0.1% Annual Chance	USACE 0.2% Annual Chance	USACE 0.2% Annual Chance	Setback Used
FAR-01	520	520	415	520	MOOR-01	470	470	431	415
FAR-02	555	555	545	555	MOOR-02	435	435	442	430
FAR-03	480	480	443	480	MOOR-03	435	435	476	425
FAR-04	495	490	487	495	MOOR-04	445	445	458	450
FAR-05	510	510	454	500	MOOR-05	495	495	442	485
FAR-06	380	385	362	660	MOOR-06	400	415	336	400
FAR-07	345	355	345	380	MOOR-07	480	485	483	660
FAR-08	410	410	415	420	MOOR-08	455	465	462	455
FAR-09	435	450	360	N/A	MOOR-09	435	435	488	430
FAR-10	460	470	453	450	MOOR-10	460	470	498	470
FAR-11	370	365	263	520	MOOR-11	470	485	540	475
FAR-12	475	485	489	485	MOOR-12	415	440	472	570
FAR-13	340	380	516	340	MOOR-13	380	395	475	385
FAR-14	365	410	483	365	MOOR-14	405	420	466	415
FAR-15	410	425	448	420	MOOR-15	320	370	470	380
FAR-16	360	400	440	430	MOOR-16	385	410	471	405
FAR-17	N/D	385	405	505	MOOR-17	430	440	492	435
FAR-18	N/D	445	453	410	MOOR-18	500	515	502	530
FAR-19	N/D	500	458	470	MOOR-19	385	405	446	435
FAR-20	N/D	450	406	415	MOOR-20	425	N/D	N/D	495

I.5.7. Settlement

I.5.7.1. The levee heights for the In-Town Levee alignments ranged from a couple feet to approximately 12 feet in height. No settlement analysis was completed during Phase 2. Based on the St. Paul District's experience in the Red River Valley, expected settlement could be in the range from a few inches to approximately 1 foot. For previous projects, the levees have been constructed higher than the required H&H top of levee profile to account for anticipated settlement. This is typically referred to as overbuild. For the Phase 2 In-Town Levee layout and cost estimate, the overbuild was neglected considering it was a minor amount. It was understood that refinement of this assumption would be required if the In-Town Levee alternative is selected as an implementable plan.

I.5.8. Revetments

I.5.8.1. It is expected that the erosion of the primary bank will continue throughout the lifetime of the project. The erosion process decreases the stability of the bank. It is most prevalent on the outside bends in the river. An evaluation was done and eighteen locations were identified to be critical due to the tightness of the bend and the proximity of structures to the river. It was thought that riprap would likely be required in these critical locations in order to maintain stability over time. A rough estimate of riprap quantities was completed using a generalized cross section that was 3 feet wide at the top and had a 1V on 3H slope. The generalized cross section is shown below in Figure I - 2. It was determined that approximately 125,000 cubic yards could be placed and was included in the cost estimate for the In-Town Levee alternative.

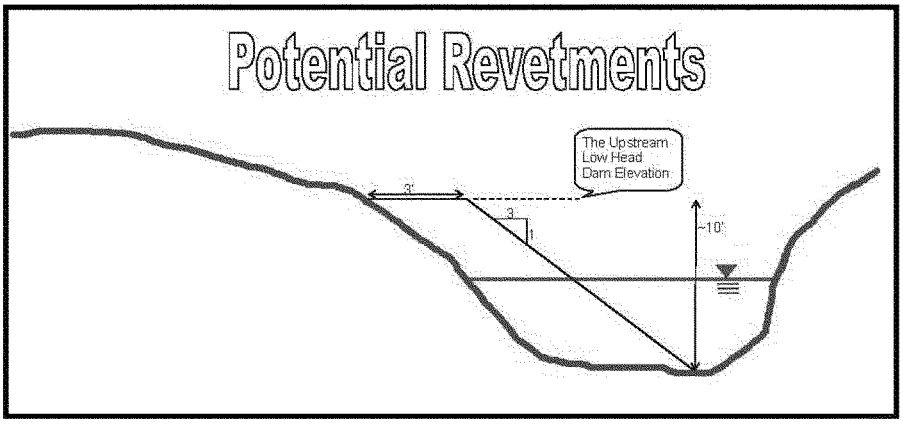


Figure I - 2: Conceptual Revetment Typical Section

I.5.9. Conclusions

I.5.9.1. The stability analyses followed the methodology that has been developed by the St. Paul District for projects within the Red River Basin. These analyses are considered conservative, but still appropriate to determine the costs associated with the In-Town Levee alternative. The level of the geotechnical analysis is comparable to the level of detail used to determine the cost estimates during Phase 2. It is acknowledged that further refinement of the models is required if the In-Town Levee alternative were to be carried forward at any point in the future.

I.5.9.2. The recommendation made at the end of Phase 2 was that no further evaluation of the In-Town Levee alternative would be completed. There were a number of reasons why the In-Town Levee alternative was not considered to be the best implementable plan, as outlined below. No further evaluation of the In-Town Levee alternative is expected at this time.

(1) The top elevation of the levees is limited to highest natural ground, which is only to an elevation close to the 1% chance event,

(2) Due to the constraints of the maximum height there would be unacceptably high residual risks, and

(3) Many structures along the river would be impacted by the levee alternative. These impacts would range from reduction of the size of the back yards and obstruction of the view of the river to complete removal of the structure. This would have a social impact to the communities.

I.6.0. DIVERSION CHANNEL ALTERNATIVES

I.6.0.1. The evaluation of the Diversion Channel alternatives began during Phase 2 in which preliminary analyses were completed for the MN Diversion channel. During Phase 3, the MN Diversion channel analyses were refined and a more robust evaluation completed. In addition, the ND Diversion channel alternative was evaluated in similar detail. For Phase 4, the ND Diversion alternative was reanalyzed incorporating the required hydraulic changes. The following section describes the evaluation completed for the Diversion Channel Alternatives.

I.6.1. Features

I.6.1.1. Diversion Channel

I.6.1.2. The major feature of the diversion channel alternatives, as the name implies, is an excavated channel. The diversion is used to intercept the Red River at flood events higher than the 20-percent annual chance event and divert the water around the Fargo-Moorhead Metro area, reducing the flood stage within the city limits. The depth of the channel and bottom width varies depending on the capacity of the diversion channel. The side slope of the channel is dependent on the depth of excavation and the strength of the foundation materials.

I.6.1.3. Red River Control Structure

I.6.1.4. A control structure is required on the Red River downstream of the diversion channel inlet for either diversion channel alternative. The purpose of this control structure is to divert the flood waters into the diversion channel and reduce the amount of water that remains in the natural channel during flood events.

I.6.1.5. Inlet Weir

I.6.1.5.1. For the MN Diversion, an inlet weir is required in the diversion channel near the Red River. The purpose of the inlet weir is to limit the flow into the diversion channel until a flood event greater than the 3.6-yr is reached on the Red River. The inlet weir consists of a sheetpile-rockfill weir.

I.6.1.5.2. For the ND Diversion channel, an inlet weir is required. The location of the inlet weir is west of the Wild Rice River and downstream of the Storage Area 1. The purpose is to limit flow into the diversion channel until a flood event greater than the 3.6-

yr is reached. The inlet weir for the ND Diversion channel is an ogee-type concrete spillway.

I.6.1.6. Outlet

I.6.1.6.1. The outlet of the diversion channel to the Red River is simply riprap placed on the excavated channel to reduce the potential for erosion for both the MN and ND Diversion.

I.6.1.7. Wild Rice River Control Structure

I.6.1.7.1. For the ND Diversion channel, there is a control structure required on the Wild Rice River. This control structure is similar in design and purpose of the Red River control structure.

I.6.1.8. Sheyenne River and Maple River Hydraulic Structures

I.6.1.8.1. For the ND Diversion channel, hydraulic structures are required at locations where the diversion channel crosses the Sheyenne and Maple Rivers. These hydraulic structures are similar in design and purpose at both crosses. At the crosses, an aqueduct will be used to pass the flow of water through the diversion channel at the same time the tributary rivers are flowing over top of the diversion channel.

I.6.1.9. Lower Rush and Rush River Drop Structures

I.6.1.9.1. For the ND Diversion, drop structures are required to divert the Lower Rush and Rush Rivers into the diversion channel. These drop structures are stepped, concrete spillways.

I.6.1.10. Tie-Back Levees

I.6.1.10.1. The tie-back levees are needed for either diversion channel alternative. The tie-back levees extend away from the inlet structure to high ground to prevent the flood water from getting into the protected area.

I.6.1.10.2. In the case of the MN Diversion channel alternative, the tie-back levee extends west from the control structure to high ground on the North Dakota side. The ND Diversion channel alternative requires two different tie-back levee alignments. The first alignment extends east from the control structure to high ground on the Minnesota side. The second tie-back levee alignment extends south from the diversion channel and western edge of Storage Area 1 to high ground on the North Dakota side. This tie-back levee contains the flows within the designated staging area.

I.6.1.11. Storage Area 1

I.6.1.11.1. For the ND Diversion alternative, a large storage area is required. The storage area encompasses 4,360 acres and is located on the north side of the ND diversion alternative between the Wild Rice River and the Sheyenne River. The storage area will

be formed by constructing approxamtely 12 miles of embankments around the area. The purpose of the storage area is to store water in order to eliminate downstream flood level impacts.

I.6.1.12. The features described above, excluding the diversion channel, were analyzed and designed under an in-kind services contract through the local sponsors. There were four engineering firms that completed this in-kind work: Moore Engineering, Inc; Houston Engineering, Inc; Barr Engineering Company; and HDR, Inc. The work completed by these A/E firms is documented in the "Red River Diversion, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 3" report (Reference I.13.1). The report will be referred to as the "RRD Report". Appendix F of the RRD Report further explains the function and design of each of the features.

I.6.2. Geotechnical Design Process

I.6.2.1. As with the analysis conducted for the In-Town Levee alternative, the analyses completed for the Diversion Channel alternatives evolved throughout the feasibility study. A description of the evolution of the Diversion Channel alternative analyses is included below.

I.6.2.2. At the beginning of Phase 2, the hydraulic modeling of the MN Diversion Channel alignment was to be completed. Initially, the side slopes of the diversion channel were set at 1V on 7H except at locations of bridge crossings. At these locations, the channel side slopes were steepened up to 1V on 5H. This was provided as input to the A/E firms so the hydraulic modeling of the diversion channels could be started. The selection of the initial side slopes was based on judgment and would be verified and/or modified through geotechnical analyses.

I.6.2.3. The selection of the 1V on 7H side slopes was based on the experience of the St. Paul District in construction of previous diversion channels and most specifically the West Fargo / Horace Diversion (WFHD) project that the St. Paul District had constructed in 1992. The depth of the WFHD was on the order of 10 feet, placing the bottom of the excavation in the Sherack formation or just into the Brenna formation. Stability analyses for the WFHD indicated that slopes as steep as 1V on 5H would be acceptable. The side slopes selected for the WFHD were 1V on 7H to allow the side slopes to be mowed with standard farming equipment. Erosion of the WFHD at the toe of the slopes has led to slope instability that had to be fixed. The design and performance of the WFHD was used as the basis of the initially selected side slopes.

I.6.2.4. The initial hydraulic modeling effort for the MN Diversion channel by Moore Engineering indicated that for a given channel capacity, the quantity of excavated material decreased with increasing depth. This meant that for a given channel capacity, the deeper the excavated channel, the more cost effective it was. The initial recommendation was therefore to use these deep excavated channels. Since the St. Paul District had not expected that deep excavations would be recommended, four sections were analyzed for seepage and stability to verify that these deep excavations would be stable and meet the required design criteria. The initial geotechnical analyses found that

the deep excavations would not meet the design criteria. Based on the initial geotechnical findings, the maximum excavation depth was limited to approximately 30 feet below the ground surface.

I.6.2.5. Using the maximum excavation depth restriction as the bottom of the channel, Moore Engineering revised the hydraulic models and optimized the MN Diversion channel width for the 3 different channel capacities. With the revised hydraulic modeling completed, the geotechnical analyses were revised for the MN Diversion channel. The results indicated that modifications to the channel slope were required for approximately 2/3 of the length of the diversion channel. The modification of the slope included the addition of a bench and flattening the bench slope to 1V on 10H.

I.6.2.6. During Phase 2, the majority of the hydraulic modeling effort was placed on the MN Diversion channel. The hydraulic modeling effort of the ND Diversion channel was kept to a minimum, as at the time the likelihood that the ND Diversion channel alternative would be selected was small. Therefore, no geotechnical effort was put forth on the ND Diversion channel. It was acknowledged that geotechnical evaluation would be required of the ND Diversion channel if this alternative was to be refined in Phase 3.

I.6.2.7. At the end of Phase 2 and the start of Phase 3, it was known that the In-Town Levee alternative was not likely to be an implementable plan. The results of Phase 2 indicated that the MN Diversion channel alternative would be the most cost effective alternative, but it was still unknown what channel capacity would provide the largest benefit/cost ratio. The local sponsors were also interested in the ND Diversion channel alternative. Therefore it was decided that for Phase 3, both the MN Diversion channel and ND Diversion channels be refined and evaluated in similar detail. From a geotechnical perspective, this meant reevaluating the stability of the MN Diversion channel and evaluating the stability of the ND Diversion channel. It also meant evaluating all the associated structures with the diversion channels.

I.6.2.8. During Phase 4, the MN Diversion alternative did not change, but changes were made to the ND Diversion alternative. The changes to the ND Diversion alternative involved raising the invert and widening the channel bottom. These changes required that the ND Diversion channel be reevaluated for seepage and slope stability along with reevaluating all the associated structures.

I.6.2.9. During both Phase 3 and Phase 4, there was an iterative process for the design of the diversion channel. Initially, the hydraulic analysis was completed based on an invert raise to determine the required cross sectional area of the channel. The seepage and stability analyses were then completed based on the preliminary hydraulic analysis results. The geotechnical analysis typically resulted in changes to the configuration of the channel to include benches, and in some instances the channel invert was raised. The geotechnical requirements were then incorporated into the hydraulic model and reanalyzed.

I.6.2.10. The seepage and slope stability analyses for the diversion channel were completed by the St. Paul District and are detailed below in the appendix. The

geotechnical analyses for the other various components of the diversion channel were completed by Barr Engineering Company and are detailed in the RRD Report (Reference I.13.1).

I.6.3. Seepage

I.6.3.1. The steady-state-seepage modeling of the diversion channels was completed using Seep/W 2007 from GeoSlope International Ltd. The reason the seepage analysis of the diversion channel was completed was to couple the seepage results with the slope stability analyses. The coupled results would provide more realistic pore pressures that could be used in the effective stress stability analyses instead of a piezometric line.

I.6.3.2. Initially in Phase 2, the seepage models represented the "full cross-section" of the channel. However, since the sections were essentially symmetric about the channel centerline, "half-space" models were used to reduce the required work and computation time. The results obtained using the "half-space" models were found to be the same as those models using the full section. During Phase 3, there were three sections along the MN Diversion channel in which the stratigraphy changed dramatically perpendicular to the centerline of the channel. In these instances, the "full cross-section" was used and the stratigraphy was varied as needed throughout the section. The "full cross sections were also used for the ND Diversion channel as the channel bottom width was initially only 100 feet wide and this could have constrained the failure surface.

I.6.3.3. Seep/W has the capability of modeling both saturated and unsaturated materials and this feature was used for the seepage analysis. Materials that were expected to be above the piezometer line (groundwater table) were modeling using the "Saturated / Unsaturated" material model type. This requires that a hydraulic conductivity function be keyed in. For the FMMFS, Seep/W's built-in tools were used to estimate the volumetric water content functions which in turn were used to estimate the hydraulic conductivity functions. The input for the materials expected to stay saturated, or below the groundwater table, was less complicated. It only required the key in of the saturated permeability (K_{sat} in Seep/W), volumetric water content, and coefficient of volumetric compressibility, M_v.

I.6.3.4. The required parameters needed for the seepage analysis are summarized below in Table I - 8. The parameters were based on tests results in as much as practical. For materials in which testing was not available, the parameters were estimated. In the case of the saturated permeability of the formations, this was based on the typical ranges of permeability for different types of soils that are published in many geotechnical engineering books. Many of the foundation materials are massive and very likely homogenous so the ratio of the vertical (k_y) to horizontal (k_x) permeability was set to unity for simplification. The permeability of the Till formation was varied until a phreatic surface that seemed reasonable was obtained. It was found that increasing the permeability of the Till formation by 2 orders of magnitude above the Brenna and Argusville formations and using a k_y/k_x ratio of 0.25 resulted in a reasonable looking phreatic surface.

Table I - 8: Summary of Selected Permeability Parameters

Material	Material Model Type (1)	Sample Material (2)	Vertical Permeability		Horizontal Permeability		Volumetric Water Content (3)	M_v (4)	Residual Water Content (5)
			k_y (cm/sec)	k_y (ft/day)	k_y/k_x ratio	k_x (ft/day)	(ft3/ft3)	(1/psf)	(ft3/ft3)
Alluvium	Sat / Unsaturated	Silty Clay	1.0E-06	2.8E-03	1	2.8E-03	0.5	9.0E-06	0.050
Sherack	Sat / Unsaturated	Silty Clay	1.0E-06	2.8E-03	1	2.8E-03	0.5	9.0E-06	0.050
PL Sherack	Sat / Unsaturated	Silty Clay	1.0E-04	2.8E-01	1	2.8E-01	0.5	9.0E-06	0.050
West Fargo	Sat / Unsaturated	Silt	1.0E-04	2.8E-01	1	2.8E-01	0.4	3.0E-06	0.040
Harwood	Sat / Unsaturated	Silt	1.0E-05	2.8E-02	1	2.8E-02	0.5	9.0E-06	0.050
OX Brenna	Sat / Unsaturated	Silty Clay	5.0E-07	1.4E-03	1	1.4E-03	0.55	1.0E-05	0.055
Brenna	Saturated Only	N/A	1.0E-07	2.8E-04	1	2.8E-04	0.63	3.0E-05	0.063
Argusville	Saturated Only	N/A	1.0E-07	2.8E-04	1	2.8E-04	0.6	3.0E-05	0.060
Silts	Saturated Only	N/A	1.0E-06	2.8E-03	1	2.8E-03	0.4	3.0E-06	0.040
Silty Sands	Saturated Only	N/A	1.0E-04	2.8E-01	1	2.8E-01	0.4	3.0E-06	0.040
Till	Saturated Only	N/A	5.0E-06	1.4E-02	0.25	5.7E-02	0.45	3.0E-05	0.045
Sand	Sat / Unsaturated	Fine Sand	1.0E-02	2.8E+01	1	2.8E+01	0.4	3.0E-05	0.040

Notes:
(1) Indicates how the material was model in Seep/W. If material above expected groundwater table, Sat/Unsaturaded. If below the groundwater table, Saturated Only.
(2) Indicates what sample material type was used when estimating the volumetric water content function in Seep/W.
(3) Volumetric Water Content Based on Porosity taken from testing except for PL Sherack, Sand, and Till which are estimated values.
(4) M_v for Alluvium, Sherack, OX Brenna, and Brenna based on consolidation data. All other materials estimated.
(5) The residual water conent was estimated to be 10% of the saturated water content.

I.6.3.5. The boundary conditions used in the "half-space" and "full cross section" seepage models consisted of total head, potential seepage, and no flow boundaries. The total head boundary conditions were used to represent the ground water elevation, which was assumed to be 5 feet below the ground surface. The total head boundary conditions were placed along the vertical side(s) of the model, opposite the centerline of the channel. Potential seepage boundary conditions were placed within the diversion channel to allow Seep/W to calculate the location where water would exit the slope. No-flow boundary conditions were placed on the bottom of the model and at the centerline of the diversion channel for the "half-space" models.

I.6.3.6. A sensitivity analysis was performed during Phase 2 in order to determine the appropriate distance between the total head boundary condition and the channel. The sensitivity analyses varied the distance of the total head boundary conditions from 1000 feet to infinity from the centerline of the channel. It was found that increasing the distance the total head boundary conditions were from the centerline of the channel decreased the exit gradients along the channel bottom, the quantity of flow into the channel, and also the phreatic surface near the channel. From these results and discussion amongst the St. Paul District geotechnical engineers, it was thought that that the diversion channel excavation would influence the groundwater table near the excavation. It was decided that a distance of 2,000 feet (approximately ½ mile) from the centerline of the diversion channel would be used in the modeling as it seemed to be a reasonable distance that the diversion channel would influence the groundwater table. If the diversion influences the groundwater table at distances greater than 2,000 feet, then the exit gradients, quantity of flow, and phreatic surface would be less that those computed using the 2,000 foot distance.

I.6.3.7. During Phase 4, a sensitivity analysis was conducted to see what affect the k_y:k_x ratio would have on the piezometric line and the slope stability results. The three sections for each diversion alternative with the lowest FSs were checked. The sensitivity analysis compared the results for k_y:k_x ratios of 1/5 and 1/10 against the original analysis using a k-ratio of unity. The results indicated that the slope stability FSs were slightly

reduced, generally by less than 1%, when a k-ratio of 1/5 was used instead of a k-ratio of unity. Even with the reduction, the minimum calculated FS remained at or above the required FS. When a k-ratio of 1/10 was used, the FSs increased above those found using a k_y:k_x ratio of 1.

I.6.4. Slope Stability

I.6.4.1. Conditions

I.6.4.1.1. The slope stability analyses for the diversion channel were completed using Slope/W 2007. The use of Slope/W allowed the pore pressures determined by Seep/W to be used in the stability analyses rather than a piezometric line. Following the guidance indicated in EM 1110-2-1902, Slope Stability (Reference I.13.4), the diversion channel excavated slopes were analyzed for the end-of-construction case and the long-term case. The end-of-construction case is the condition in which the excavated slope is undrained and total stress shear strength parameters are used in the slope stability analysis without any pore pressures. The long-term case is the drained condition of the excavated slope after the pore pressures have reached equilibrium. In this case, steady-state-seepage analyses were used in estimating the long-term pore water pressures. The long-term condition uses effective stress shear strength parameters.

I.6.4.1.2. For Phase 2, the global (failure surface encompassing the entire excavated slope) stability of the MN Diversion channel slope was evaluated based on the long-term (drained) condition and the undrained (short-term or end-of-construction) condition.

I.6.4.1.3. During Phase 3, the stability of the diversion channels were further evaluated. As in Phase 2, the long-term (drained) and undrained (short-term) conditions evaluating the global stability of the excavated channel were deemed necessary. In addition, localized, drained failure of the slope was also determined to evaluate the shallow sloughing failures that could lead to maintenance issues. The localized failures were evaluated on the lower portion of the slope and also the upper portion of the slope. This same methodology was used when reanalyzing the ND Diversion alternative during Phase 4.

I.6.4.1.4. The undrained and long-term conditions provide a range of expected performance of the excavated slope and it was reasoned that if the stability analyses resulted in meeting the required minimum factors of safety for both conditions, the channel configuration and selected slopes were adequately stable. Completing these two analyses was deemed adequate for the design of the diversion channel excavation but consideration was also given to other analyses that could be completed.

I.6.4.1.5. The classic rapid-draw-down analysis in which the water that has been on a slope for a considerable duration, allowing steady-state-seepage condition to be establish, and then suddenly drop was deemed not applicable for the excavated slope. The increase/decrease of the flood water on the slope was short enough that the pore pressures at and near the face of the excavated slope would not be dramatically changed.

I.6.4.1.6. In addition, a staged excavation type analysis was contemplated. This type analysis would require the use of a finite-element/finite-difference procedure to model the changes in stress and pore pressures throughout the excavation process. The procedure would use effective stress shear strength parameters, as the pore pressures are calculated. The excavation would cause the stresses and pore pressures adjacent to the slope to decrease due to the unloading of the materials. The most drastic changes in pore pressure would occur at the face of the slope, and decrease with distance from the slope. In the vicinity of the spoil pile, there would be an increase in stress and pore pressures. This type of analysis was considered to be more complex than required for the feasibility study and not completed for the feasibility study for a number of reasons, listed below. It is recommended that this type of analysis be completed during the planning phase as it may reveal additional information.

(1) It was not felt that slope failures during construction would be an issue due to the flat slopes required based on the undrained and long-term analyses.

(2) The spoil pile is located 50 feet from the top of the slope and there would be minimal effect on the pore pressures adjacent to the slope due to the spoil pile.

(3) The factors of safety required for levee design were used as the target FSs in the design of the channel in order to obtain a higher degree of certainty in maintaining stability.

(4) The side slopes on the diversions are considerably flat, being 1V on 7H.

I.6.4.2. Target Factors of Safety

I.6.4.2.1. The Corps Engineering Manual (EM) 1110-2-1902, Slope Stability (Reference I.13.4) identifies the minimum required factors of safety (FS) for dams while EM 1110-2-1913, Design and Construction of Levees (Reference I.13.5) identifies the minimum FS for levees. Neither of these manuals specifically identifies the minimum required FS for excavated slopes associated with a diversion channel. EM 1110-2-1902 recommends that for slopes other than dams the minimum FS be selected based on uncertainty of the shear strength parameters and the consequences of failure.

I.6.4.2.2. The St. Paul District assessed what target factors of safety should be used for evaluation of the stability of the diversion channels. The St. Paul District's experience in the Red River Valley indicates that the long-term, drained condition typically controls the design of a project due to the low drained shear strength of the Brenna formation. Once a failure has occurred, the drained shear strength is further reduced, which creates a situation that is often times difficult and expensive to repair. Therefore, the St. Paul District selected the target FSs of 1.4 and 1.3 for the long-term and undrained conditions, respectively, to coincide with the required minimum FS for levee stability. The reasoning for selecting these target FSs was to reduce the potential that the diversion channel slopes would fail and result in the implementation of a difficult and expensive fix.

I.6.4.2.3. The St. Paul District also considered the possibility of localized failures. These failures are associated with smaller potential failure surfaces which do not

encompass the entire diversion channel slope. The potential failure along these surfaces could lead to difficulty in maintenance and mowing, but would not affect the overall stability of the slope. Therefore a target FS of 1.2 was selected when analyzing the localized, drained (long-term) failures.

I.6.4.3. Critical Slip Surface Search Procedure

I.6.4.3.1. The St. Paul District's experience in riverbank slope stability in the Red River Basin indicates that non-circular type failures are the most critical, resulting in lower FS than circular failure surfaces. This is due to the fact that the failure surfaces extend over a considerable length (in effect, have long neutral blocks) through a weak soil layer that is at depth. The configuration of the diversion channel alternatives is approaching that of the riverbanks and a similar situation occurs in which the failure surfaces have long neutral blocks through a weak soil layer. In these situations, a circular failure surface does not adequately represent the most critical failure mechanism. In order to capture these critical non-circular type failures the "optimize" feature in Slope/W was enabled, as was the case when analyzing the levee setback distances for the In-Town Levee alternative. All stability analyses were completed using the Spencer's Method.

I.6.4.3.2. Slope/W has a number of ways in which to search for the critical failure surface. The "Entry and Exit" slip surface option was the search mechanism used. The "Wedge" slip surface option was also used for the global, long-term condition to verify that the "Entry and Exit" search found the critical failure surface.

I.6.4.3.3. For all searches and conditions, the range of entry points of the failure surface search were based on set criteria. In the case of the global, long-term condition, the "entry" of the failure surface search extents were set 50 feet from the top of slope to ¼ of the excavation depth below the existing ground surface. The "exit" extents were from 5 feet above the bottom of the channel to a point near the centerline of the diversion. The global, undrained condition was placed from the top of the slope and extending 250 feet away from the slope. The exit extents were the same as the global, long-term condition.

I.6.4.3.4. During Phase 2, there was no effort made in maintaining consistency of the extents for the localized drain slope condition but for Phase 3 and Phase 4 the effort was made. The localized lower drained slope condition extents for the "entry" portion were positioned on top of the bench to 5 feet above the bottom of the diversion channel. The "exit" extents were those used for the global, long-term condition. The "entry" extents for the localized upper drained slope conditions extended 50 feet from the top of slope to 5 feet above the bench. The "exit" extents started 5 feet above the bench and extended along the bench. These "entry" and "exit" extents are illustrated in the figures below.

I.6.4.3.5. During Phase 3 and Phase 4, the critical circular failure surface location was checked. If the failure surface started or exited at the limits of the extents, the "Entry and Exit" search was refined by moving the extents such that the critical failure surface started and exited within the limits and not at the edges.

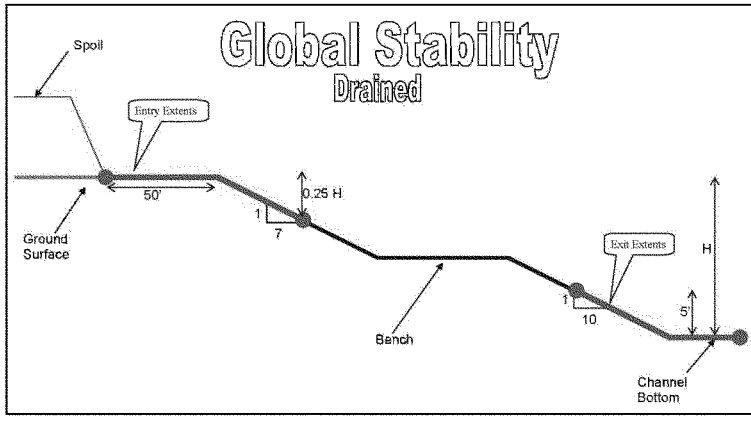


Figure I - 3: Global, Long-Term Condition Search Extents

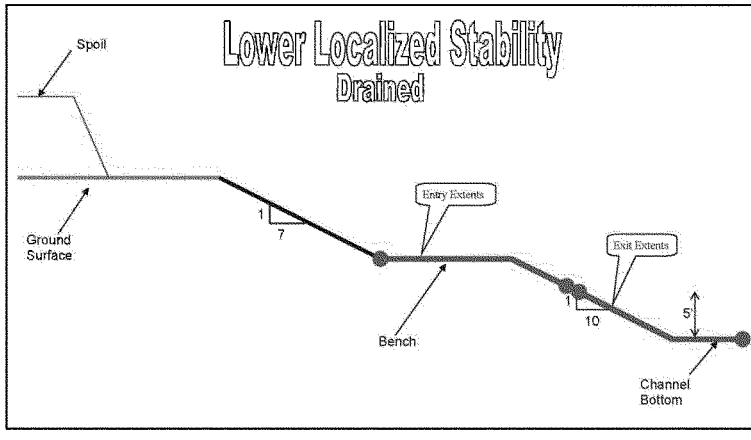


Figure I - 4: Localized Lower Slope, Long-Term Condition Search Extents

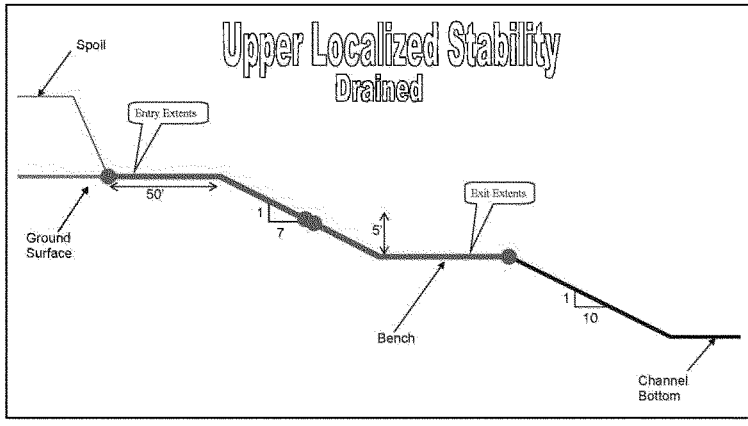


Figure I - 5: Localized Upper Slope, Long-Term Condition Search Extents

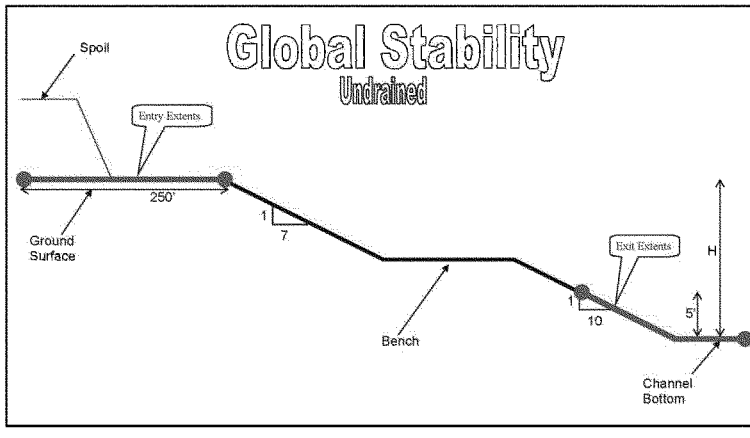


Figure I - 6: Global, Undrained Condition Search Extents

I.6.4.4. Low Flow Channel

I.6.4.4.1. The design of the diversion channels include a low flow channel located at the centerline of the diversion. The low flow channel is 3 feet deep with a bottom width of 10 feet. The side slopes are 1V:4H. During the initial part of Phase 3 it was recommended that the low flow channel be lined with riprap to minimize erosion of the low flow and channel bottom. The Phase 3 seepage and stability models included the riprap lined low flow channel.

I.6.4.4.2. Alternatives to using a riprap lined low flow channel were investigated during Phase 3. A recommended alternative included placement of riprap along the lower portion of the slope and constructing grade control structures every 5,000 feet. The revisions to the ND Diversion alternative during Phase 4 to the seepage and stability models removed the riprap from the low flow. In addition, no riprap was included along the lower portion of the slope.

I.6.4.5. Spoil Piles

I.6.4.5.1. The excavation for the diversion channel alternatives result in a large quantity of material that needs to be disposed of. The most economic way to excavate the channel is to place the spoil adjacent to the diversion channel. The spoil pile height was selected to be 15 feet based on consideration of the following issues:

- Real Estate: The higher the spoil pile height, the less real estate that is required in order to spoil excavated materials.
- Stability of Excavated Slope: The higher the spoil pile height, the increased potential to induce higher destabilizing forces on the excavation slope.
- Settlement of Spoil Pile: There will not be much compactive effort nor any moisture control when placing the spoil material, therefore the higher the spoil pile, the greater the potential for settlement of the spoil and also differential settlement.
- Consolidation of Foundation Materials: The higher the spoil pile, the more the foundation is likely to consolidate and settle.
- Bearing of the Spoil Pile: With lack of compactive effort and moisture control of the spoil pile, along with the natural consistency of the excavated materials, the strength of the spoil pile in reference to supporting farm equipment on top, could potential decrease with increasing spoil pile height.

I.6.4.5.2. For Phase 2, the assumption was made that the spoil would be placed immediately adjacent to the excavated slope at a 1V:7H slope, which was an extension to the excavated slope grade. The height of the spoil pile was limited to 15 feet. In the seepage and stability analyses, the spoil pile was modeled as a material with permeability and shear strength assigned to it.

I.6.4.5.3. During Phase 3, the way the spoil pile was modeled was reevaluated. It was decided that the spoil pile would be modeled as a surcharge with a unit weight of 125 pcf and a maximum height of 15 feet. The slope of the spoil was maintained at 1V:7H, but it was set back 50 feet from the top of the excavated channel. The spoil piles were evaluated the same way during Phase 4.

I.6.4.6. Bridge Crossing

I.6.4.6.1. At the beginning of Phase 2, it was recommended to use a channel slope of 1V:5H at the location of bridge crossings in order to minimize the length of the bridges. Based on the results of the seepage and stability analysis completed during Phase 3, it

was determined that the steeper slopes would be unstable and would require some form of reinforcement and/or stabilization techniques. Due to this, it was recommended that the slope configuration at the location of the bridges be the same as the configuration of the diversion channel, resulting in an increase to bridge lengths.

I.6.5. Phase 2 Results for the MN Diversion

I.6.5.1. The initial analyses on the four MN Diversion channel sections were completed for various channel bottom widths and depths. In the case of Section 4, it was found that the minimum FS was met for any excavated channel depths. For Section 1, only a shallow excavated channel met the required FS for long-term slope stability. It was found for Section 2 and 3 that the minimum FS for long-term slope stability could not be met for any of the excavated channel depths. These findings led to the recommendation that the maximum channel excavation depth allowed would be approximately 30 feet and that benching of the slope or other means to increase stability may be required in certain locations. A summary of these results are presented below in Table I - 9.

Table I - 9: Summary of Initial MN Diversion Stability Results

						Factor of Safety Global Slope Stability	
Cross-Section	Channel Bottom Width [ft]	Ground Surface Elevatioin [ft]	Water Table Depth [ft]	Channel Elevation [ft]	Channel Depth [ft]	Long-Term (Drained)	Short-Term (Undrained)
1	50	886	881.5	860	26	1.103	N/D
	225		881.5	868	18	1.293	N/D
	500		881.5	876	10	1.706	1.787
2	50	911	906.1	866	45	0.710	N/D
	225		906.1	874	37	0.833	N/D
	500		906.1	882	29	1.277	1.674
3	50	913	906.9	870	43	1.121	N/D
	225		906.9	878	35	1.116	N/D
	500		906.9	886	27	1.246	1.351
4	50	910	906.6	875	35	2.086	N/D
	225		906.6	884	26	2.542	N/D
	500		906.6	892	18	3.080	3.278

I.6.5.2. The initial geotechnical analyses were revised using the revised design parameters. In addition, the revised geotechnical analyses were only completed for a 500-foot wide bottom and the associated excavation profile. The results of the revised analyses were similar to the initial analyses in the fact that Sections 1 and 4 met the minimum required FS for slope stability and Sections 2 and 3 did not. A summary of the revised results is presented below in Table I - 10.

Table I - 10: Summary of Revised MN Diversion Stability Results

						Factor of Safety							
						Long-Term (Drained)						Short-Term (Undrained)	
Cross-Section	Channel Bottom Width [ft]	Ground Surface Elevatioin [ft]	Water Table Depth [ft]	Channel Elevation [ft]	Channel Depth [ft]	Global - Circular Opt	Global - Circular	Global Wedge Opt	Global Wedge	Localized Circular Opt	Localized Circular	Global Circular Opt	Global Circular
1	500	886	881.5	876	10	1.722	1.746	N/D	N/D	1.887	N/D	1.935	1.967
2	500	911	906.1	882	29	0.886	0.928	N/D	N/D	0.386	0.408	1.607	1.693
3	500	913	906.9	886	27	1.201	1.206	1.204	1.321	1.083	1.098	1.325	1.350
4	500	910	906.6	892	18	2.689	2.705	N/D	N/D	2.484	2.536	2.874	3.142

I.6.5.3. The revised geotechnical analyses required that modifications be made to the diversion channel slopes for Sections 2 and 3. The modifications to Section 2 included adding a 25-foot wide riprap berm on the slope, flattening the slope in the Brenna formation to 1V on 10H, and including a 118-foot wide bench in the channel slope. In the case of Section 3, the slope in the Brenna formation was flattened to 1V on 12H. These modifications to the channel slope increased the FS to the required value. A summary of the results of modified channel are presented below in Table I - 11.

Table I - 11: Summary of Stability Results for the Modified MN Diversion Sections

						Factor of Safety							
						Long-Term (Drained)						Short-Term (Undrained)	
Cross-Section	Channel Bottom Width [ft]	Ground Surface Elevatioin [ft]	Water Table Depth [ft]	Channel Elevation [ft]	Channel Depth [ft]	Global - Circular Opt	Global - Circular	Global Wedge Opt	Global Wedge	Localized Circular Opt	Localized Circular	Global Circular Opt	Global Circular
2	500	911	906.1	882	29	1.390	1.577	N/D	N/D	1.041	1.138	2.189	2.662
3	500	913	906.9	886	27	1.370	1.463	1.434	1.581	1.452	1.503	1.467	1.511

I.6.5.4. The modifications to Section 2 and 3 increased the required amount of excavation and real estate. In addition, riprap is required for Section 2 only. These modifications were not required along the entire Minnesota Diversion channel alternative, only in the areas associated with the two sections. A review of the soil explorations indicated that approximate 16,000 LF of diversion channel had stratigraphy similar to Section 2 while the stratigraphy along approximately 73,500 LF of diversion channel was similar to Section 3. As such, the various modifications are required along approximately 89,500 LF, or 67% of the total diversion channel length. Calculations were performed to determine what the overall affect is on the estimated excavation and real estate needs. Using a weighted average for the modifications, it was determined that overall, excavation would need to be increased by approximately 5% to account for the flatter slopes and bench and real estate would also increase by approximately 5%. A summary of the increased quantities is presented below in Table I - 12.

Table I - 12: Summary of Increased Quantities Due to Channel Modifications

Weighted Average for Increased Quantities				
	Length	Increased Excavation	Increased Real Estate	Required Riprap (CY)
No Mod	44,245	0	0	0
Mod 2	16,000	25.4%	24.8%	266,667
Mod 3	73,500	2.9%	4.0%	0
Total Length	133,745			
Weighted Average Increase		**4.6%**	**5.1%**	266,667

I.6.5.5. All analysis results for the Minnesota Diversion alternative are presented in Attachment I-9.

I.6.6. Phase 3 and 4 Design Sections

I.6.6.1. The geology in the Fargo-Moorhead metro area is consistent over a fairly large extent. With this in mind, the design sections were selected where there were noticeable changes in stratigraphy or depth of the excavated channel. In all, eleven sections were selected along the MN Diversion channel alignment and two along the MN Extension channel. On the ND side, ten sections were selected. The locations of the sections along with the reach they represent are summarized below in Table I - 13 and Table I - 14. The locations are also graphically represented on the maps contained within Attachment I-2.

Table I - 13: MN Diversion Section Locations and Extents

		Reach		Distance		
Section	Location	Start	End	(feet)	(miles)	Percent
MN 1	STA 20+00	0+00	70+00	7,000	1.3	5%
MN 2	STA 175+00	70+00	220+00	15,000	2.8	11%
MN 2B	STA 350+00	220+00	420+00	20,000	3.8	15%
MN 3	STA 510+00	420+00	570+00	15,000	2.8	11%
MN 4A	STA 582+00	570+00	640+00	7,000	1.3	5%
MN 4B	STA 688+00	640+00	730+00	9,000	1.7	7%
MN 5B	STA 796+00	730+00	850+00	12,000	2.3	9%
MN 6	STA 930+00	850+00	1055+00	20,500	3.9	16%
MN 7	STA 1100+00	1055+00	1155+00	10,000	1.9	8%
MN 7B	STA 1185+00	1155+00	1235+00	8,000	1.5	6%
MN 8	STA 1270+00	1235+00	1309+80	7,400	1.4	6%
				130,900	25.9	
MN 9A	EXT CH STA 80+00	0+00	105+00	10,500	2.0	64%
MN 9B	EXT CH STA 130+00	105+00	164+84	5,900	1.1	36%
				16,400	3.1	

Table I - 14: ND Diversion Section Locations and Extents

		Reach		Distance		
Section	Location	Start	End	(feet)	(miles)	Percent
ND 1	STA 120+00	0+00	390+00	39,000	7.4	20%
ND 2	STA 545+00	390+00	660+00	27,000	5.1	14%
ND 3	STA 940+00	660+00	1000+00	34,000	6.4	18%
ND 4	STA 1080+00	1000+00	1150+00	15,000	2.8	8%
ND 5	STA 1225+00	1150+00	1300+00	15,000	2.8	8%
ND 5B	STA 1445+00	1300+00	1490+00	19,000	3.6	10%
ND 6B	STA 1550+00	1490+00	1550+00	6,000	1.1	3%
ND 6B U/S	STA 1550+00	1550+00	1670+00	12,000	2.3	6%
ND 6C	STA 1720+00	1670+00	1770+00	10,000	1.9	5%
ND 7	STA 1810+00	1770+00	1922+00	15,200	2.9	8%
				192,200	36.4	

I.6.6.2. When developing the seepage and stability models for these sections, the ground surface was generally set at the highest elevation (rounded up to the nearest foot) within plus or minus 3,000 feet of the section location. For the channel invert, the lowest elevation (rounded down to the nearest foot) within 3,000 feet was selected. The stratigraphy in the seepage and stability models was generally depicted as the most conservative representation encountered between the limits of the section. A summary of the ground surface, diversion channel invert, and stratigraphy are shown in Attachment I-10.

I.6.6.3. There were many changes made in the way the stability of the diversion channel excavated slopes was evaluated after Phase 2. First, additional soil information was gathered along the MN Diversion channel alignment that required refinement to the stratigraphy. Secondly, the number of cross sections analyzed increased from four to eleven along the MN Diversion channel and two for the MN Extension channel. Thirdly, soil borings were obtained along the ND Diversion alignment and stratigraphy was developed for ten cross sections. Previously in Phase 2, no analyses were completed for the ND Diversion alternative. Fourthly, the shear strength tests results were reevaluated and curvilinear shear strength parameters were developed for use in the stability analyses for the diversion channels. These changes resulted in a major change in the configuration of the diversion channel slopes.

I.6.6.4. The initial seepage and stability analyses completed at the beginning of Phase 3 were done for the ND Diversion channel. The results of the analyses indicated that the 1V:7H excavated slope did not meet the target slope stability FS. In order to meet the target FS, the invert of ND Diversion channel was raised 3 feet from the elevation analyzed in Phase 2. In addition, a bench was added. The bench height and width were set at 7 and 70 feet, respectively, and were kept constant along the length of the diversion channel to simplify the hydraulic modeling. The flatter bench slope, 1V:10H was required to increase drained stability of the lower slope. The bottom width

of the ND Diversion channel was 100 feet for the majority of the alignment for both Phase 2 and Phase 3.

I.6.6.5. During Phase 4, the ND Diversion channel was redesigned to meet revised hydraulic requirements. The changes included raising the invert again, generally between 2 and 8 feet. In addition, the riprap was removed from the low flow channel. The decrease in depth resulted in slopes being more stable, reducing the benching requirements and allowing the bottom portion of the channel slope to be steepened to a slope of 1V:7H.

I.6.6.6. Upon completion of the initial analyses for the ND Diversion, the MN Diversion was reanalyzed. The previous results in Phase 2 had indicated that the 1V:7H slope did not meet the target FS for the majority of the MN alignment. Taking what was learned from the ND Diversion channel analyses, a bench was also added to the MN Diversion channel. The benching requirement was a 7-foot high, 70-foot wide bench with the slope flattened to 1V:10H below the bench, and kept constant along the entire length of the diversion channel.

I.6.6.7. The soil exploration was being completed at the same time as the seepage and stability analyses were being done for the MN Diversion alternative. The soil data was incorporated into the models as it was received. The additional exploration completed around the Dilworth area indicated that there was a sand layer starting at a depth between 60 to 90 feet below the ground surface. The sand layer encountered along the MN Diversion alignment was assumed to be part of the Buffalo aquifer formation. The elevation of this sand layer with respect to the invert of the diversion channel had a significant effect on the stability and the uplift on the impervious blanket. Due to these concerns, the portion of the MN Diversion alignment just north of Dilworth was shifted to the west in addition to raising the invert 4 feet from the inlet structure through this area. The same benching requirements as that of the ND Diversion channel in Phase 3 (7-foot high, 70-foot wide bench with the slope flattened to 1V:10H below the bench) were used for the MN Diversion alignment.

I.6.6.8. During the Phase 3 and 4 analyses, it was found that certain diversion channel sections did not meet the target FS for the global undrained condition with the spoil pile at its maximum height of 15 feet. At these sections, the spoil pile height was reduced for a set length near the diversion channel and then stepped up to the maximum height. For the MN Diversion, the spoil pile stepped length was 100 feet while for the ND Diversion, it was 50 feet. The reduction of the spoil pile height resulted in an increase to the global undrained FSs. The modified configuration of the spoil pile is illustrated in Figure I - 7 below.

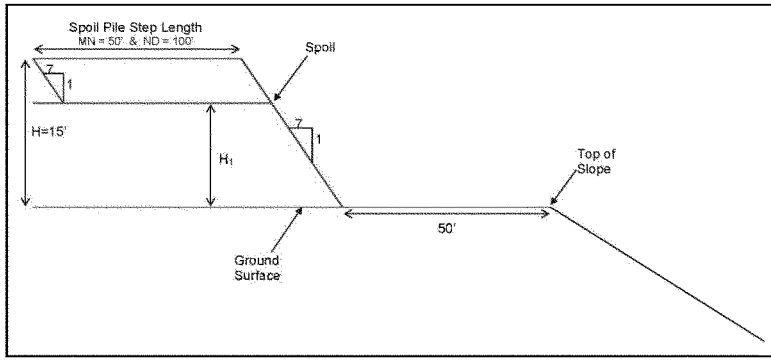


Figure I - 7: Spoil Pile Configuration With Step

I.6.6.9. The changes made to the configuration of the diversion channel slopes, the invert elevations of the channels, and spoil pile height and step lengths were coordinated with the required disciplines (i.e. hydraulics, civil layout, cost estimating). The final configuration of the sections for the MN Diversion channel and ND Diversion channel are summarized below in Table I - 15 and Table I - 16, respectively.

Table I - 15: MN Diversion Channel Configuration – Phase 3

	Channel Configuration				Bench Configuration				
Section	Ground Surface (ft)	Bottom Elev. (ft)	Depth (ft)	Bottom Width (ft)	Bench Width (ft)	Bench Height (ft)	Bench Slope (1V:_H)	Channel Slope (1V:_H	Spoil Pile Height, H_1 (ft)
MN Section 1	895	875	20	225	70	7	10	7	11
MN Section 2	894	876	18	225	70	7	10	7	15
MN Section 2B	896	878	18	225	70	7	10	7	15
MN Section 3	906	880	26	225	70	7	10	7	11
MN Section 4A	910	884	26	400	70	7	10	10	13
MN Section 4B	912	885	27	400	70	7	10	10	15
MN Section 5B	912	888	24	400	70	7	10	7	15
MN Section 6	914	890	24	400	70	7	10	7	15
MN Section 7	914	894	20	400	70	7	10	7	15
MN Section 7B	910	895	15	400	70	7	10	7	15
MN Section 8	912	897	15	400	70	7	10	7	15
MN Section 9A	911	897	14	215				7	15
MN Section 9B	914	900	14	215				7	15

Table I - 16: ND Diversion Channel Configuration – Phase 4

Section	Channel Configuration				Bench Configuration				Spoil Pile Height, H_1 (ft)
	Ground Surface (ft)	Bottom Elev. (ft)	Depth (ft)	Bottom Width (ft)	Bench Width (ft)	Bench Height (ft)	Bench Slope (1V: H)	Channel Slope (1V: H	
ND Section 1	882	865	17	250				7	8
ND Section 2	890	868	22	250	15	8	7	7	11
ND Section 3	900	877	23	250	25	8	7	7	15
ND Section 4	900	879	21	250	20	8	7	7	15
ND Section 5	903	881	22	250	40	8	7	7	12
ND Section 5B	913	885	28	250	40	8	7	7	
ND Section 6B	920	903	17	250				7	
ND Section 6C	913	905	8	250				7	
ND Section 7	912	901	11	250				7	

I.6.7. Phase 3 and 4 Results for the Diversion Channel Alternatives

I.6.7.1. The slope stability results for the MN and ND Diversion channel alternatives are presented below in Table I - 17 and Table I - 18, respectively. The tables indicate the minimum FS determined for the five slope stability conditions analyzed. Table I - 17, for the MN Diversion channel has an additional column which indicates the side of the channel that the FS corresponds to, as the stratigraphy for MN Sections 4A, 4B, and 5B could not be assumed uniform laterally across the section. The side of the channel is identified by looking downstream.

Table I - 17: MN Diversion Channel Results – Phase 3

Section	Stability Analysis: Min FS					Side of Channel
	Effective Stress				Total Stress (2) Undrained Global	
	(A) Global Entry/Exit	(B) Wedge (Global)	(C) Lower Localized	(D) Upper Localized		
MN Section 1	1.701	1.826	2.604	2.230	1.331	Left Side
MN Section 2	1.911	1.899	3.647	3.245	1.358	Left Side
MN Section 2B	2.041	1.834	2.642	2.682	1.476	Left Side
MN Section 3	1.657	1.634	2.029	1.703	1.442	Left Side
MN Section 4A	1.474	1.478	1.662	1.502	1.306	Left Side
	1.475	ND	ND	ND	1.305	Right
MN Section 4B	1.457	1.456	1.571	1.447	1.357	Left Side
	1.447	1.419	1.484	1.420	1.355	Right
MN Section 5B	1.496	1.483	1.722	1.488	1.496	Left Side
	1.558	ND	ND	ND	1.402	Right
MN Section 6	1.611	1.592	1.952	1.476	1.300	Left Side
MN Section 7	1.839	1.839	2.048	1.819	1.533	Left Side
MN Section 7B	2.191	2.195	2.127	2.115	1.683	Left Side
MN Section 8	2.080	2.080	1.875	2.189	1.728	Left Side
MN Section 9A	2.026	2.029	2.156	2.025	1.872	Left Side
MN Section 9B	1.616	1.620	1.996	1.615	1.600	Left Side

Table I - 18: ND Diversion Channel Results – Phase 4

Section	Stability Analysis: Min FS				
	Effective Stress				Total Stress
	(A) Global Entry/Exit	(B) Wedge (Global)	(C) Lower Localized	(D) Upper Localized	(2) Undrained Global
ND Section 1	1.554	1.558	1.702	2.206	1.345
ND Section 2	1.431	1.437	1.508	1.957	1.315
ND Section 3	1.421	1.411	1.710	1.791	1.332
ND Section 4	1.429	1.425	1.611	1.890	1.364
ND Section 5	1.411	1.412	1.416	1.690	1.306
ND Section 5B	1.416	1.415	1.208	1.409	1.507
ND Section 6B	1.512	1.513	1.636	2.146	1.582
ND Section 6C	2.553	2.550	2.545	2.330	2.092
ND Section 7	2.201	2.173	2.274	3.116	2.000

I.6.7.2. The Phase 3 results for the MN Diversion channel and the Phase 4 results for the ND Diversion channel indicate that the channels meet the target FSs for all

conditions. The results from the seepage and stability for the MN Diversion channel are located in Attachment I-11 and the results for ND Diversion channel are in Attachment I-12.

I.6.7.3. A check of the stability analysis was completed during Phase 3 using Slide 5.0 from Rocscience. Slide 5.0 is a limit equilibrium slope stability program which is also capable of coupling the results of the steady state seepage calculations into the stability analysis. The sections checked were MN Diversion Section 6 and ND Diversion Section 2, as these sections had the lowest long-term global stability FS for the sections with assumed symmetric about the channel centerline. The results from Slide 5.0 indicated similar factors of safety as that which were determined by GeoStudio. For MN Diversion Section 6, Slide 5.0 calculated a slightly different failure surface with a FS of 1.564, slightly lower than the Slope/W FS of 1.611. For ND Diversion Section 2, Slide 5.0 calculated a FS of 1.433 while Slope/W FS was 1.411. In this instance, the failure surfaces between the two programs were similar. These results are included at the end of the respective diversion analysis result attachments.

I.6.8. Uplift Analysis and Results

I.6.8.1. In addition to evaluating the diversion channel excavated slopes for stability, uplift on the bottom of the channel was also evaluated in areas where impervious foundation materials were overlaying a pervious substratum. One area in which this condition existed was along the MN Diversion channel alignment near and around Dilworth, MN. The extent of this area runs from approximately STA 440+00 to STA 880+00.

I.6.8.2. The calculation of the uplift factor of safety can be expressed as the critical exit gradient divided by the average gradient through the impervious foundation. This expression is shown in the below equation. The target FS for uplift of 1.5 was selected. The FS value of 1.5 is similar to the FS suggested in Engineering Manuals that deal with seepage [i.e. EM 1110-2-1914, Relief Wells (Reference I.13.6); EM 1110-2-1913, Levee Design (Reference I.13.5; EM 1110-2-1901, Seepage for Dams Reference I.13.3)].

$$FS = \frac{i_c}{i_o} = \frac{\left(\frac{\gamma_{sat} - \gamma_w}{\gamma_w}\right)}{\left(\frac{\Delta h}{Z_T}\right)} = \frac{(\gamma_{sat} - \gamma_w) \times Z_T}{\gamma_w \times \Delta h}$$

Where:
- i_c = the critical exit gradient
- I_o = the average gradient through the impervious foundation
- Δh = the difference in head between the pervious substratum and the head at the top of the impervious foundation
- Z_T = the transformed thickness of the impervious foundation
- γ_{sat} = saturated soil unit weight
- γ_w = unit weight of water

I.6.8.3. The piezometric head in the previous substratum used to calculate the uplift FSs was assumed to be 7.5 feet below the ground surface. This value was decided upon after review of the observed piezometric levels from the surrounding wells monitored by the Minnesota Department of Natural Resources (MN DNR) and the vibrating wire piezometers installed by the St. Paul District for the feasibility study. The observed piezometric levels in the MN DNR observation wells range from 7.5 feet below ground surface (BGS) to 17 feet BGS. There is a chart in Attachment I-13 that shows these observed levels along with a map indicating the well locations. The USACE's vibrating wire piezometers have been observing piezometric levels in the range of 10 to 14 feet BGS. The value of 7.5 feet BGS represents the highest elevation that has been observed in the area.

I.6.8.4. The stratigraphy used to calculate the uplift FSs was taken directly from the boring logs. The borings indicated that the impervious foundation materials were composed of the Brenna and Argusville formations. There were many instances in which silt (semi-impervious) and silty sand (semi-pervious) formations were encountered beneath the impervious material. The pervious substratum, composed of clean sands (SP) was found beneath the impervious, semi-impervious, and semi-pervious formations.

I.6.8.5. The uplift FSs were calculated at all the borings locations throughout this area. These borings were not always located at or near the centerline of the diversion channel. The general trend was that the uplift FS decreased as the boring locations moved east of the alignment. This was due to the pervious substratum thickness increasing toward the east and rising upward in the stratigraphy. The uplift FSs calculated along the centerline are summarized in Table I - 19. The results indicate that the target FS of 1.5 is obtained for all locations along the centerline with the exception of the location at 12th Ave S. At this location, the two borings were taken on either side of the alignment centerline because access to the centerline was an issue. The results indicate boring 10-102M, located west of the centerline had a FS of 0.9 while boring 10-103M, located to the east, was 1.6. There were no clean sands (SP) encountered in boring 10-102M, only a silty sand (SP-SM) at a depth of 54 feet BGS and the uplift FS reported was calculated based on this elevation. This low FS is considered to represent the worst case and that the actual uplift condition along the MN Diversion channel in this location would be acceptable. Further soil exploration is needed in this area to verify this assumption.

Table I - 19: Uplift Factor of Safety Along MN Diversion Channel Centerline

Area	STA	Offset		Boring	FS (gradient)
70th Ave NW	~440+00	400	Right	10-87M	**5.28**
57th Ave N	~510+00	400	Left	10-82M	**3.59**
43rd Ave N	~585+00	900	Right	10-93M	**2.07**
28th Ave N	~636+00	400	Left	10-104M	**1.74**
15th Ave N	~688+00	50	Right	10-83M	**1.87**
HWY 10	~741+00	150	Right	10-103M	**1.46**
12th Ave S	~795+00	805	Left	10-102M	0.86
	~795+00	2800	Right	10-101M	1.61
I-94	~850+00	4300	Right	09-43C	**2.63**
40th Ave S	~-910+00	3100	Right	09-15M	**2.74**

I.6.9. Geotechnical Considerations for Structures

I.6.9.1. As previously stated, Barr Engineering Company completed the geotechnical analyses and design for the various structural components of the diversion channel alternatives. These analyses are detailed in Appendix F of the RRD Report (Reference I.13.1) and can be found in the main report's Attachment 5. The various geotechnical analyses completed by Barr Engineering Company for the various components along with the location within Appendix F further details can be found is detailed below in Table I - 20.

Table I - 20: Location of Barr's Geotechnical Analyses

Geotechnical Analysis	Location
General Geotechncial Engineering Discussion	RRD, Appendix F, pg F-47
General Pile Design Discussion	RRD, Appendix F, Section F4.1.1, pg F-56
Erosion Control Methods for Low Flow Channel	RRD, Appendix F, Exhibit K
Review of Geotechnical Data	RRD, Appendix F, Exhibit L
Seepage Analysis for the Hydraulic Structures	RRD, Appendix F, Exhibit M
Slope Stability Analysis for the Storage Area 1 Levees	RRD, Appendix F, Exhibit N
Slope Stability Analysis for the radial walls associated with the Sheyenne and Maple River hydraulic structures	RRD, Appendix F, Exhibit N
Slope Stability Analysis for the radial walls associated with the Sheyenne and Maple River hydraulic structures	RRD, Appendix F, Exhibit N
Pile Capacity	RRD, Appendix F, Exhibit O

I.6.10. Conclusion

I.6.10.1. Overall, the geotechnical design of the MN and ND Diversion channel is considered to meet the intent of the feasibility study, which is to provide a preliminary design and cost estimate for an implementable project. The results of the geotechnical

analyses presented above support this conclusion. It is also recognized that additional work will be required during the Plans and Specification phase. Some of the tasks and issues to be further evaluated are summarized below in Section I.12.0.

I.7.0. GROUND WATER CONSIDERATIONS

I.7.0.1. For the proposed Minnesota alignment alternatives the Buffalo Aquifer was identified as a planning constraint early in the feasibility study. Water usage from the aquifer has declined in recent years but is still tapped for individual, irrigation, and municipal water wells. The Buffalo Aquifer may be characterized as a north-south trending, complex, heterogeneous outwash deposit composed of primarily of sand and gravel placed during the last glacial epoch. Studies have shown that along its east-west boundaries the Buffalo aquifer becomes increasingly fine-grained and can include silt and clay beds. Located five to seven miles east of Moorhead, the deposit is interpreted to have been formed in a tunnel valley by glacial meltwater exiting the southern end, or snout, of a glacier. The exiting meltwater was under pressure and occurred in multiple events which are indicated by the vertical and horizontal meandering of the deposit. In Clay County the Buffalo Aquifer is 1 to 2 miles wide, and up to 250-feet thick. The top of the aquifer is at, or very near, ground surface adjacent to the Buffalo River but is buried in glacial lake clays along diversion alignments proposed to date.

I.7.0.2. The Buffalo River, located approximately 5-miles east of Moorhead, runs parallel to and along the east side of the aquifer and contributes significant recharge; especially in the northern reach of the aquifer near the City of Moorhead's north well field. Regional aquifer flow in the clayey lake plain soils adjacent is generally westward or toward the Red River of the North; variations due to local hydrology, such as over-pumping, drought conditions, and adjacent wetlands can alter local groundwater flow directions.

I.7.0.3. In 1994 the City of Moorhead opened a new water treatment plant and began taking more water from the Red River of the North. Water levels in the aquifer have risen approximately 15 feet in the succeeding 10 years. Over the last 30 years, many studies have been conducted on the Buffalo Aquifer and additional groundwater management initiatives and studies are ongoing.

I.7.0.4. For the proposed North Dakota alignment alternatives the West Fargo Aquifer is the primary water source of concern. It is possible to divide the West Fargo Aquifer into several separate sub-units but, for the purposes of this report it shall be treated as one. Water from the aquifer is tapped for individual, irrigation, and municipal water wells. The West Fargo Aquifer is a buried glacio-fluvial deposit placed during the last glacial epoch that extends generally in a north-south direction for about 30 miles in Cass County. The modern day Sheyenne River traverses the same general trend of the West Fargo Aquifer from about 6 miles south of Horace, ND to about 2 miles south of Argusville, ND. The aquifer ranges in width from about 2 ½ to 8-miles and underlies an area of approximately 110 miles. Typically the aquifer is overlain by deposits of glacial till and glacio-lacustrine lake clay at depths of approximately 70 to 170 feet below ground surface. The aquifer is composed of material ranging in size from fine sand to

boulders but is primarily fine to medium sand. In places these coarse grained deposits may be interbedded with silt or clay, especially near the top of the aquifer. The deposit is interpreted to have been formed in a tunnel valley by glacial meltwater exiting the southern end, or snout, of a glacier, in the same manner as the Buffalo aquifer.

I.7.0.5. Recharge to the West Fargo Aquifer probably occurs primarily through lateral movement of water through the till and associated deposits and by downward percolation of shallow groundwater through the glacio-lacustrine deposits. Due to the relatively tight nature of the surrounding soils it is likely that the recharge rate of the aquifer is not able to keep pace with the withdrawal rate and this is reflected in declining water levels. Regional aquifer flow appears to be influenced by areas of heavy pumping but generally the piezometric surface slopes from east to west. The average depth of the water level in the West Fargo Aquifer is not defined but it is known that the decline is such that unconfined (non-artesian) conditions now exist.

I.7.0.6. The city of West Fargo draws its municipal water supply entirely from 8 production wells located in the West Fargo Aquifer. Until alternate water sources are located it is reasonable to assume that water levels will continue to decline in the aquifer.

I.7.0.7. Other, unnamed aquifers occur at various depths within the tills and glacio-lacustrine clays adjacent to the proposed diversion alignments. These buried aquifers may generally be characterized as elongate, discontinuous, lenses composed primarily of sand and gravel. Accurately locating and delineating these aquifers is difficult due to their scattered nature and relatively small aerial extent. On-going studies by the Corps of Engineers and others will aid in better defining these types of aquifers.

I.7.1. Shallow Groundwater

I.7.1.1. All of the diversion channel alternatives would have a similar effect on shallow groundwater. The shallow groundwater table is defined as the locally observed groundwater table near the ground surface; typically located within the first 15 feet below the ground surface. The groundwater table fluctuates seasonally, depending on the soil type, precipitation and climatic conditions experienced throughout the year or years. Periodic fluctuation of the groundwater table is assumed to occur even without the construction of a diversion channel. Groundwater is not considered a significant source for water in the area due to the relatively low permeability of soils and the low volume of water expected to flow through these soils.

I.7.1.2. Under the conditions reasonably anticipated, the flow of the shallow groundwater should be "downhill" or toward the area of lower hydraulic potential. After the excavation of a diversion channel is completed, the "downhill" or lowest potential area should be the bottom of the diversion channel. This may lower the groundwater table near the diversion channel but, at most, only to the depth of the excavated diversion channel. The lateral extent of the lowered groundwater table would likely be confined to areas immediately adjacent to the diversion channel including the spoil banks. Areas outside the extent of this would likely see very little to no change. The natural

groundwater flow quantities through tight clayey soils would reasonably be expected to be relatively small.

I.7.1.3. A lowered shallow groundwater table could potentially reduce the capacity of shallow local wells that are recharged by the groundwater table. The risk to the shallow groundwater table as related to the proposed diversion is low because the anticipated area effects would be concentrated adjacent to the diversion channel. The lowering of the shallow groundwater table may cause consolidation of the surrounding soils and settlement of structures within the area affected. Only structures immediately adjacent to the proposed diversion channel would have the potential to settle. Since the area affected is not expected to extend beyond the channel and spoil piles it is unlikely that any structures remaining after construction would be impacted. If local shallow wells experience reduction in capacity, the depth of the well could be increased or an additional well be installed to mitigate for the reduced capacity. Wells and structures that are within the proposed footprint of the diversion would be removed or abandoned, while those immediately adjacent would be identified and monitored to quantify any impacts.

I.8.0. PHASE I ENVIRONMENTAL SITE ASSESSMENT

I.8.0.1. A Phase I Environmental Site Assessment (ESA) was completed for both the MN and ND Diversion channel alternatives in December 2010. It conformed to ASTM Standard Practice E1527-00. The ESA recommended a limited Phase II Environmental Site Assessment depending upon the ultimate selected diversion alternative.

I.9.0. SOURCES OF CONSTRUCTION MATERIALS

I.9.1. Borrow Sources

I.9.1.1. The In-Town Levee alternative is the only alternative in which borrow materials would need to be identified for the construction of levees. This material is readily available. The local sponsor is responsible for identifying sites to be used as borrow sources. Any locations proposed will need to be evaluated from a geotechnical and cultural/archeological perspective prior to any use on the proposed project. Geotechnical parameters to be defined prior to approval include the thickness of topsoil, presence or absence of saline soils, thickness and suitability of alluvial/fluvial soils, water bearing seams and water table conditions, natural moisture content, determination of plasticity indices, gradation, and Proctor density. Soil cracking within the top 5 feet (freeboard zone) of earthen levees is a common occurrence throughout the Red River Valley. This problem may be alleviated by the application of a specific type of clayey soil to cap the levee. If determined necessary, these soils shall be identified and designated as "select" prior to completion of plans and specifications.

I.9.1.2. The borrow materials for the diversion channel alternatives will come from the excavation itself. There will be a surplus of excavated material that will require it to be spoiled adjacent to the diversion channel.

I.9.2. Concrete Aggregate, Riprap, and Bedding

I.9.2.1. Sources for fine and coarse concrete aggregate, bedding, and riprap should be available locally. Acceptable quality commercial aggregates in the Fargo/Moorhead vicinity are obtained from the beach ridges of glacial Lake Agassiz east of the Red River. Additional material may be available from field stone piles in farm fields. Most of the material consists of rounded, wave-washed boulders, cobbles, and sand. If large quantities of riprap size material are required, producers will need adequate lead time in order to stockpile material. Outside sources of quarried, angular, stone should also be available approximately 200 miles east of the proposed project in western and central Minnesota. Additional investigations will be necessary prior to plans and specifications in order to accurately quantify the amount of stone product available within a reasonable radius of the area.

I.10.0. INSTRUMENTATION

I.10.0.1. Instrumentation was installed during Phase 2 and Phase 3 that consisted of nested sets of vibratory wire piezometers and slope inclinometers. The purpose of the vibratory wire piezometers was to determine the groundwater table and piezometric levels in the different foundation materials. The purpose of the slope inclinometers was to determine the elevation of the slip surface in an active slide area along the Red River.

I.10.0.2. A total of seven nested sets of vibratory wire piezometers were installed. The piezometers were located in areas of interest, such as near the Buffalo Aquifer and locations of major structures along the diversion alignments. In addition, one piezometer was installed in the Buffalo aquifer. Piezometers P1 through P6 were installed in August 2009, P7 though P15 were installed in June 2010, and P16 through P23 were installed in July 2010. A summary of the piezometers installed and their locations is included in Table I-21 below. These locations are illustrated by the figures in Attachment I-14.

Table I - 21: Piezometer Locations and Associated Boring

Piezmeters	Location	Boring	Ground Surface Elevation	Depth	Elevation
P1	Gooseberry Park, Moorhead	Moorhead 09-21M/P	886.2	16.3	869.9
P2				48.3	837.9
P3				75.3	810.9
P4	28th Ave N & 60th St N	Moorhead 09-14M/P	913.1	20.0	893.1
P5				50.0	863.1
P6				75.0	838.1
P7	MN Diversion Red River Control Structure	Moorhead 10-81M/P	907.8	30.0	877.8
P8				60.0	847.8
P9				90.0	817.8
P10	93rd Ave N & 60th St N	Moorhead 10-88M/P	911.3	35.0	876.3
P11				70.0	841.3
P12				105.0	806.3
P13	Wild Rice River, Brodshaug Farmyard	Fargo 10-77M/P	905.7	30.0	875.7
P14				50.0	855.7
P15				100.0	805.7
P16	ND Diversion Red River Control Structure	Fargo 10-79M/P	905.3	80.0	825.3
P17				20.0	885.3
P18				40.0	865.3
P19	MN Diversion, HWY 10	Moorhead 10-106M/P	913.3	19.4	893.9
P20				64.4	848.9
P21				81.4	831.9
P22				101.4	811.9
P23	Buffalo Aquifer, 28th Ave N	Moorhead 10-105M/P	916.6	43.0	873.6

I.10.0.3. The observed piezometric levels are illustrated by the figures in Attachment I-14. A discussion on the observed readings for each instrumentation cluster is provided below.

I.10.0.4. Piezometers P1, P2, and P3 are located at Gooseberry Park in Moorhead, MN, adjacent to the Red River. During the fall of 2009, the piezometric level of P3 (deepest) was the highest, just slightly above P1 (shallowest), while P2 (middle) was approximately 10 feet lower. During the spring flood in 2010, all instruments indicated an increase in piezometric levels, with P1 (shallowest) piezometric levels essentially following the river stage. P2 (middle) and P3 (deepest) piezometric levels returned to fall 2009 levels and are remaining fairly constant. P1 (shallowest) levels continued to fall during the summer of 2011 but showed an increase in the fall to a level similar to P3 (deepest). These trends would indicate that there is a higher pressure at depth.

I.10.0.5. Piezometers P4, P5, and P6 are located east of the MN Diversion channel alternative at the corner of 28th Ave N and 60th St N. These piezometers were installed in August 2009. The trend is showing that the piezometric levels of all piezometers have increased since their installation. P6 (deepest) has shown the greatest increase, approximately 5.5 feet, while P-5 (middle) and P4 (shallowest) has shown approximate 4 foot and 3 foot increases, respectfully. Still P6 (deepest), which is located in a sand formation, is reading the lowest piezometric levels, approximately 7 feet below ground surface (BGS).

I.10.0.6. Piezometers P7, P8, and P9 were installed at the proposed location of the Red River Control Structure for the MN Diversion channel alternative. These instruments are reading piezometric levels between 30 and 34 feet BGS. The readings also indicate that P7 (shallowest) is indicating the highest piezometric level while P8 (middle) is showing the lowest levels. In April 2011, the piezometer levels P8 and P9 increased 4 to 5 feet in and then decreased back to previous levels, which is in conjunction with the Spring 2011 flood.

I.10.0.7. Piezometers P10, P11, and P12 are located east of the MN Diversion channel alternative and 1 mile north of P4, P5, and P6, at the corner of 936rd Ave N and 60th St N. Piezometers P10 and P11 are showing a slight increase in piezometric levels since their installation, at approximately 2.5 feet. P10 (shallowest) is indicating piezometric levels approximately 8 feet BGS. P11 (middle) and P12 (deepest and installed in a sand formation) are indicating piezometric levels approximately 10.5 to 14 feet BGS, lower than P10 (shallowest), respectively. In April 2011, the piezometer levels for increased slightly and then decreased, which is in conjunction with Spring 2011 flood.

I.10.0.8. Piezometers P13, P14, and P15 were installed at the proposed location of the Wild Rice River hydraulic structure on the ND Diversion channel. The piezometric levels for these piezometers are very different from all other instruments.
P13 (shallowest) indicated a decreasing piezometric level between July 2010 through February 2011, but then started increasing at a small rate. In May 2012, P13 indicated a piezometric level approximately 30 feet BGS. P14 (middle) is indicating a piezometric level decrease of about 18 feet, between July 2010 till May 2012. The May 2012 level for P14 is 52 feet BGS. The piezometric level for P15 (deepest) was fairly constant at a level between 78 and 80 feet BGS between July 2010 and October 2010. At the beginning of October 2010, there was a rapid increase in piezometric levels other one month time period, increasing approximately 5 feet to a level 75 feet BGS. Since November 2010, P15 has shown a small but steady increasing trend and as of May 2010 indicated a level 74 feet BGS.

I.10.0.9. Piezometers P16, P17, and P18 were installed near the proposed location of the Red River Control Structure for the ND Diversion channel alternative. These piezometers have shown a slight decrease in piezometric levels initially after installation but started increase in levels after about 2 months. P17 (shallowest) is indicating piezometric levels approximately 11 feet below ground surface. P18 (middle) and P16 (deepest) are indicating piezometric levels approximately 0.5 foot and 1 feet lower than P17, respectively.

I.10.0.10. Piezometers P19 through P22 were installed east of the MN Diversion channel along HWY 10, at Dilworth. This instrumentation cluster was installed in July 2010. The data collector that was connected to these instruments was inundated with water so readings were not available for this cluster between July and November 2011. In December 2011, a new data collector was connected to these instruments and started logging. P19 (shallowest) is indicating piezometric levels 3 to 4 feet BGS. Data for piezometers P21 (lower middle) P22 (deepest) has only been collected for a short period of time, since April 2011. Over a two month period, these piezometers have increased 1 to 2 foot to a May 2012 level which is approximately 5 feet BGS. Between November 2011 and May 2010, P20 (upper middle) has shown approximately a 1-foot increase, with the piezometric level being 11 feet BGS.

I.10.0.11. Piezometer P23 was installed at a depth of 43 feet BGS, in a sand formation east of the MN Diversion channel alignment. This piezometer was installed to observe the piezometric levels in the Buffalo aquifer and compare it to other readings in sand formations which are at greater depth. For P23, the piezometric level is approximately 14 feet BGS, which is similar to the readings of the other piezometers in the sand formations. Like P19 through P22, this data collector was also inundated with water. Due to its location, it has been difficult to relocate the data collector. It is anticipated that the data collector will be relocated in the Summer of 2011.

I.11.0. REVIEWS

I.11.0.1. There have been a number of reviews completed during the feasibility study. The reviews included internal district peer reviews, agency technical reviews, and also an independent external peer review. Comments and questions have come up during these reviews that have prompted changes to the analyses and report. It was considered important to include these comments and questions and the associated responses in the report. It is a way to illustrate the changes made throughout the feasibility study and how comments and questions were considered. The different reviews can be found in Attachment I-15.

I.12.0. ADDITIONAL WORK

I.12.0.1. The geotechnical analysis and geology interpretation for the feasibility study was completed in enough detail to evaluate the different alternatives and estimate their costs. It is acknowledged that additional work will be required for the Plans and Specifications stage. A summary of the additional work that is anticipated is listed below.

(1) Soil Exploration: Additional soil exploration will be required to refine the stratigraphy along the selected project. This is especially true for the MN Diversion channel alignment in the area near Dilworth.

(2) Undisturbed Testing: Additional undisturbed testing should be completed to verify the drained and undrained strengths of the critical formations (i.e. Oxidized Brenna, Brenna, and Argusville). In addition, sampling and testing of the till formation is needed.

(3) Test Excavation: A test excavation could be completed that is instrumented to try and capture the changes in pore pressure and any movements that occur. Observation of the test excavation could help in refining the method(s) used to excavate the diversion channel.

(4) Diversion Channel Analysis: Additional analyses to evaluate the stability of the diversion channel are required. These analyses should account for any changes in stratigraphy or shear strength parameters determined because of additional exploration and testing. In addition, the configuration of the diversion channel and spoil piles should be refined to minimize volume and cost of excavation. Analyses that incorporate the construction staging should be performed to supplement the results of the traditional analyses completed to date.

(5) Diversion Channel Slopes at Bridges: Investigate techniques that would improve stability at bridge locations so steeper slopes could be used and determine the cost of these alternatives.

(6) Pile Load Tests: A pile load test was developed in Spring 2011 and will be conducted between July 2011 and November 2011. The results of the pile load test will help in the understanding of pile behavior under load and pile capacity.

(7) Limited Phase II Environmental Site Assessment depending upon the final selected alternative.

(8) Final Borrow site evaluation and concrete aggregate testing.

I.13.0. REFERENCES

I.13.0. Houston Engineering, Inc. 2008 (April 30). "Project No. 5031-2, City of Fargo Flood Insurance Study, North Side Flood Control Evaluation, Fargo, ND and Moorhead, MN,", Houston Engineering, Inc., Fargo, ND.

I.13.1. Moore Engineering, Inc; Houston Engineering, Inc; Barr Engineering Company;, 2011 (FEB 2011). "Red River Diversion, Fargo-Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 4," Moore Engineering, Inc; Houston Engineering, Inc; Barr Engineering Company; and HDR, Inc., West Fargo, ND.

I.13.2. North Dakota Geological Survey. 2010 (March). "Geologic Investigation No. 94, Earthquakes in North Dakota," North Dakota Geological Survey, Bismarck, ND.

I.13.3. U.S. Army Corps of Engineers. EM 1110-2-1901. 1993. "Seepage Analysis and Control for Dams," U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

I.13.4. U.S. Army Corps of Engineers. EM 1110-2-1902. 2003. "Slope Stability," U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

I.13.5. U.S. Army Corps of Engineers. EM 1110-2-1913, 2000. "Design and Construction of Levees," U.S. Army Engineering Waterways Experiment Station, Vicksburg, MS.

I.13.6. U.S. Army Corps of Engineers. EM 1110-2-1914, 1992. "Design, Construction, and Maintenance of Relief Wells," U.S. Army Engineering Waterways Experiment Station, Vicksburg, MS.

I.13.7. U.S. Army Corps of Engineers. ER 1110-2-1806. 1995. "Earthquake Design and Evaluation for Civil Works Projects," U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

I.13.8. U.S. Army Corps of Engineers. 2007. "Feasibility Study and Environmental Assessment, Fargo, North Dakota, Appendix D, Geotechnical Design and Geology," St. Paul District, Corps of Engineers, St. Paul, MN.

I.13.9. U.S. Army Corps of Engineers. 1998. "General Reevaluation Report and Environmental Impact Statement, East Grand Forks, Minnesota and Grand Forks, North Dakota, Appendix B, Geotechnical Design and Geology," St. Paul District, Corps of Engineers, St. Paul, MN.

Attachment I-1: Seismic Information

APPENDIX C
UNIFORM BUILDING CODE SEISMIC ZONE MAP

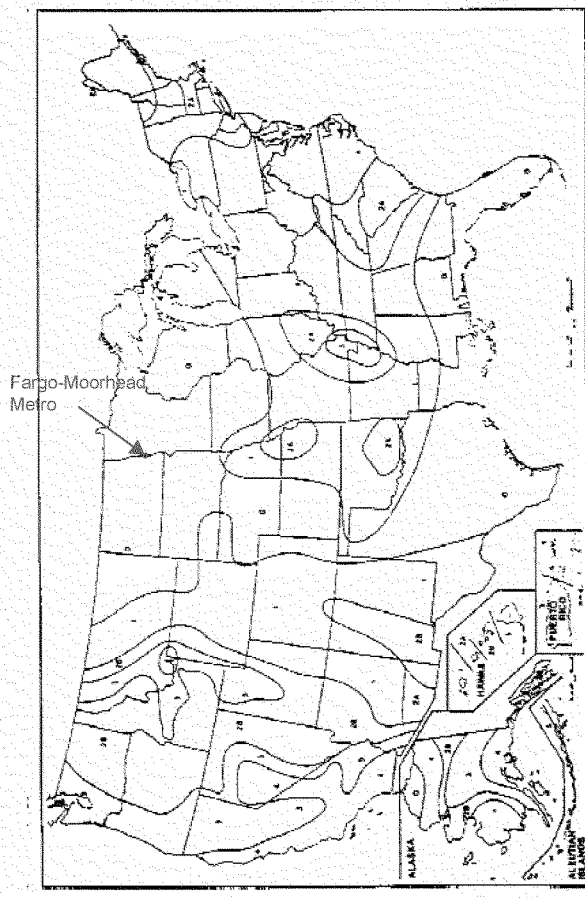
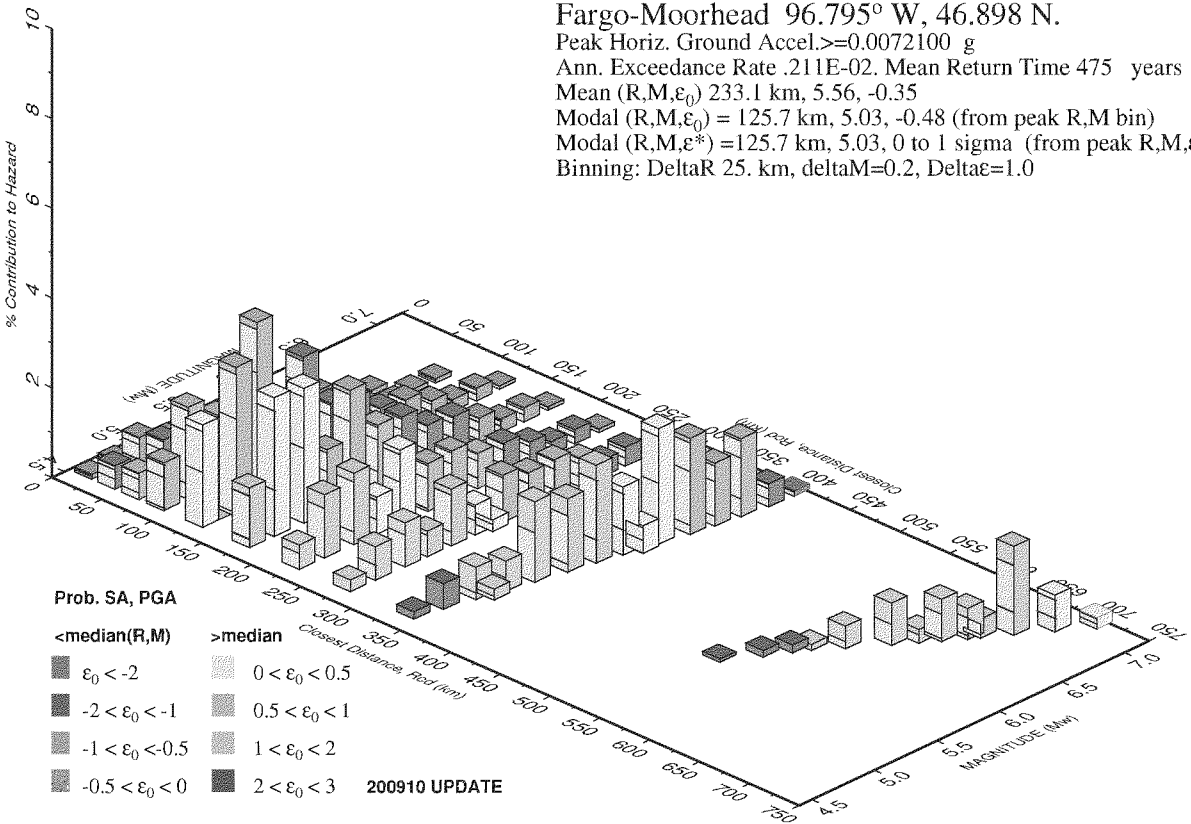


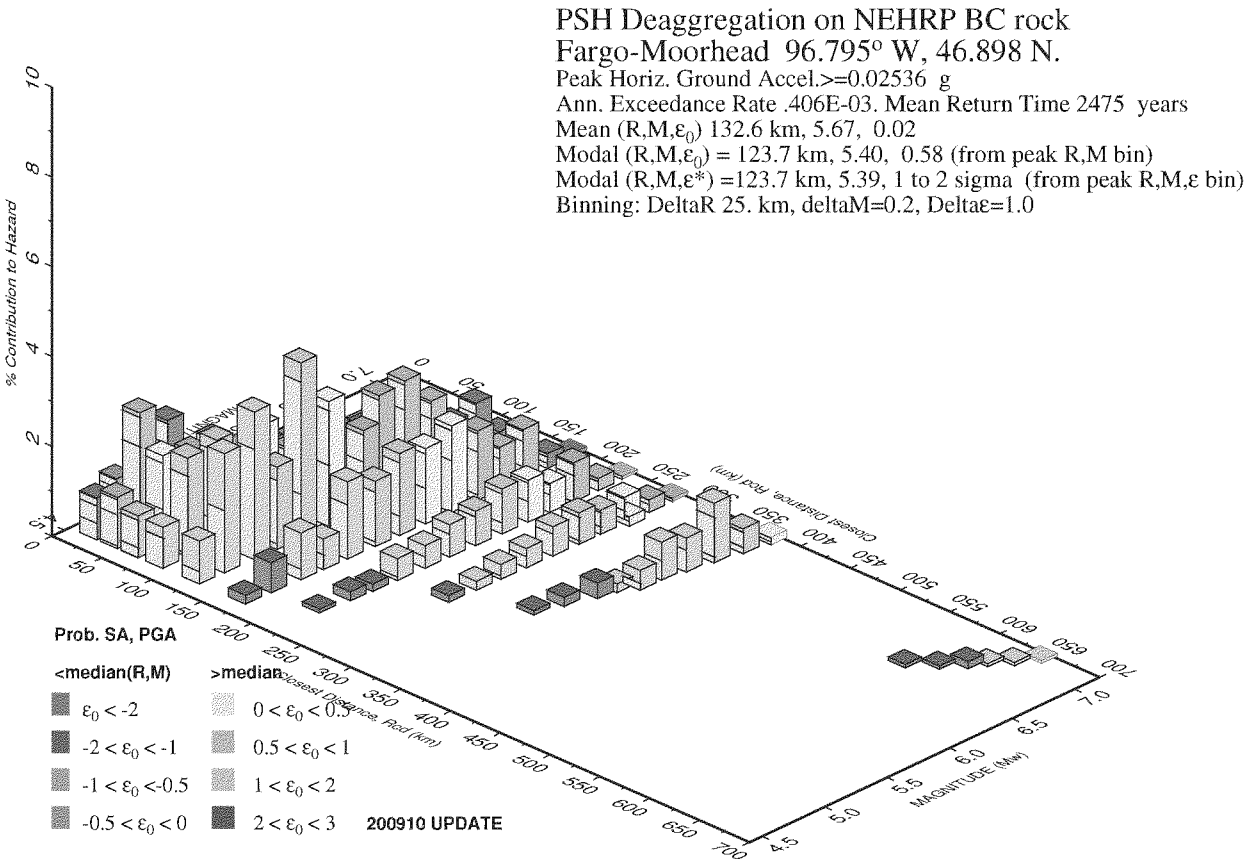
Figure C-1. Seismic zone map of the United States

PSH Deaggregation on NEHRP BC rock
Fargo-Moorhead 96.795° W, 46.898 N.

Peak Horiz. Ground Accel.>=0.0072100 g
Ann. Exceedance Rate .211E-02. Mean Return Time 475 years
Mean (R,M,ε_0) 233.1 km, 5.56, -0.35
Modal (R,M,ε_0) = 125.7 km, 5.03, -0.48 (from peak R,M bin)
Modal (R,M,ε*) =125.7 km, 5.03, 0 to 1 sigma (from peak R,M,ε bin)
Binning: DeltaR 25. km, deltaM=0.2, Deltaε=1.0



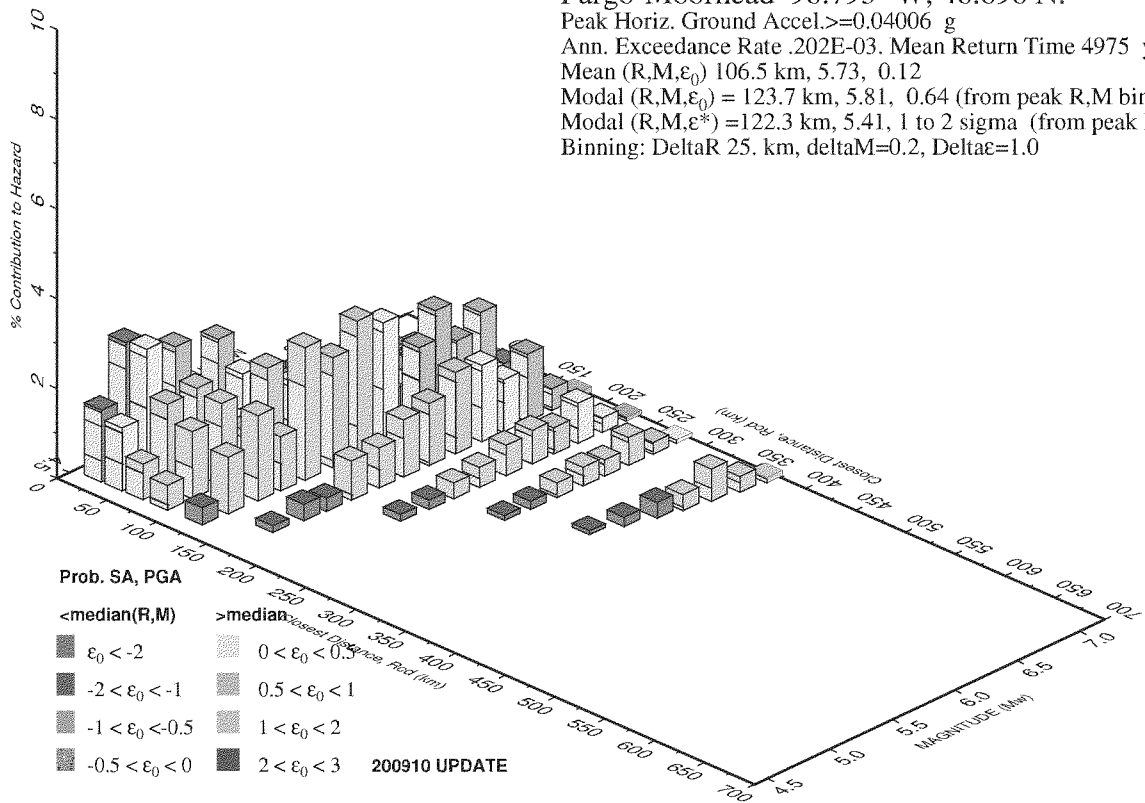
GMT 2010 May 28 17:45:41 Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on rock with average vs= 760. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted



GMT 2010 May 28 17:41:44 Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on rock with average vs= 760. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

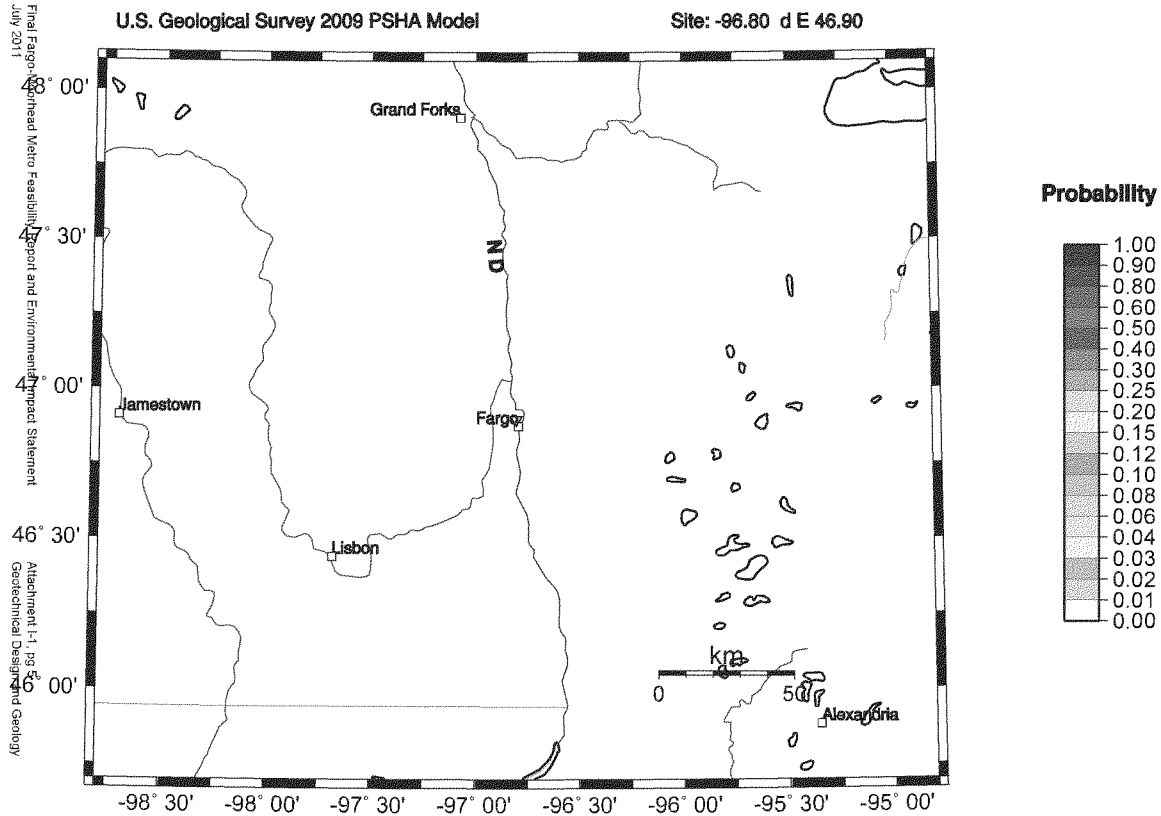
PSH Deaggregation on NEHRP BC rock
Fargo-Moorhead 96.795° W, 46.898 N.

Peak Horiz. Ground Accel.>=0.04006 g
Ann. Exceedance Rate .202E-03. Mean Return Time 4975 years
Mean (R,M,ε_0) 106.5 km, 5.73, 0.12
Modal (R,M,ε_0) = 123.7 km, 5.81, 0.64 (from peak R,M bin)
Modal (R,M,ε^*) =122.3 km, 5.41, 1 to 2 sigma (from peak R,M,ε bin)
Binning: DeltaR 25. km, deltaM=0.2, Deltaε=1.0



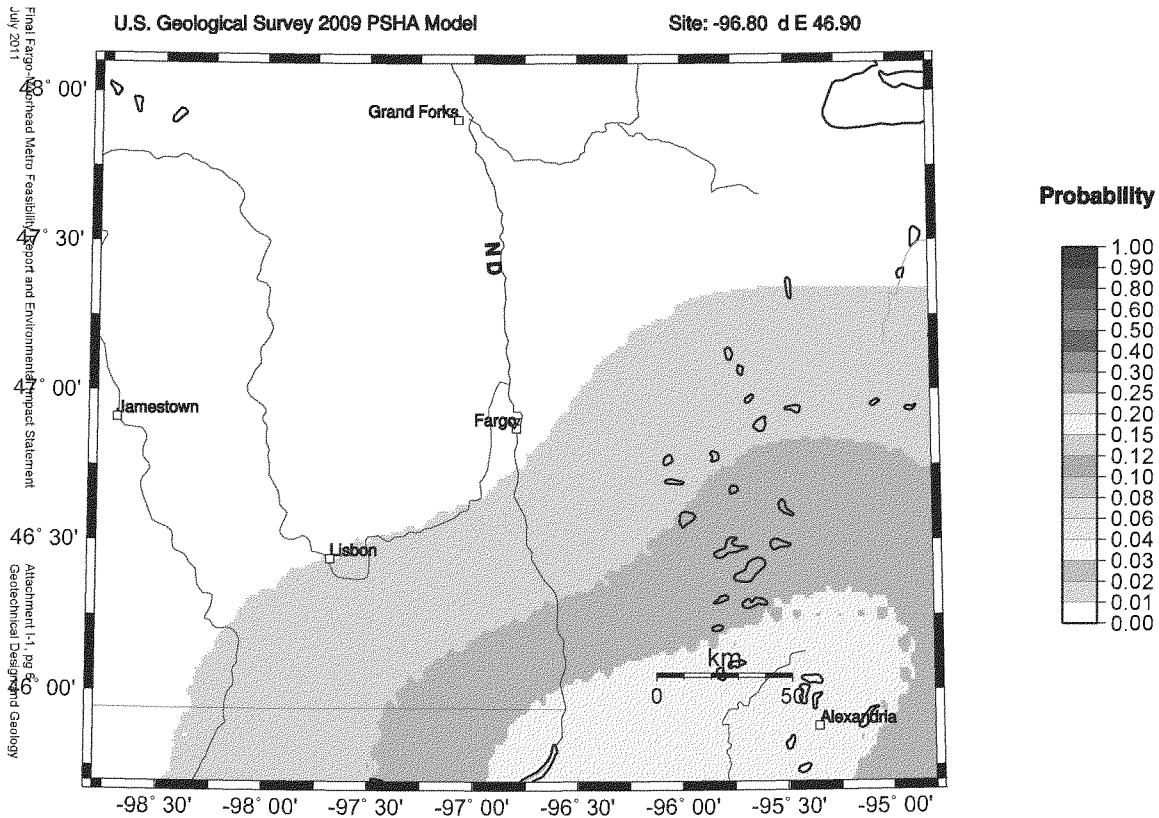
GMT 2010 May 28 17:44:34 Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on rock with average vs= 760. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Probability of earthquake with M > 5.0 within 50 years & 50 km



GMT 2010 May 28 17:49:16 Earthquake probabilities from USGS OFR 08-1128 PSHA. 50 km maximum horizontal distance. Site of interest: triangle. Epicenters mb>5 black circles; rivers blue.

Probability of earthquake with M > 5.0 within 250 years & 50 km



GMT 2010 May 28 17:50:27 Earthquake probabilities from USGS OFR 08-1128 PSHA. 50 km maximum horizontal distance. Site of interest: triangle. Epicenters mb>5 black circles; rivers blue.

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Significant Earthquake Events within 1000 Kilometers of Fargo-Moorhead
Compiled By: KAH Revised By: KAH
Date: 13-Aug Date Revised: 16-Aug

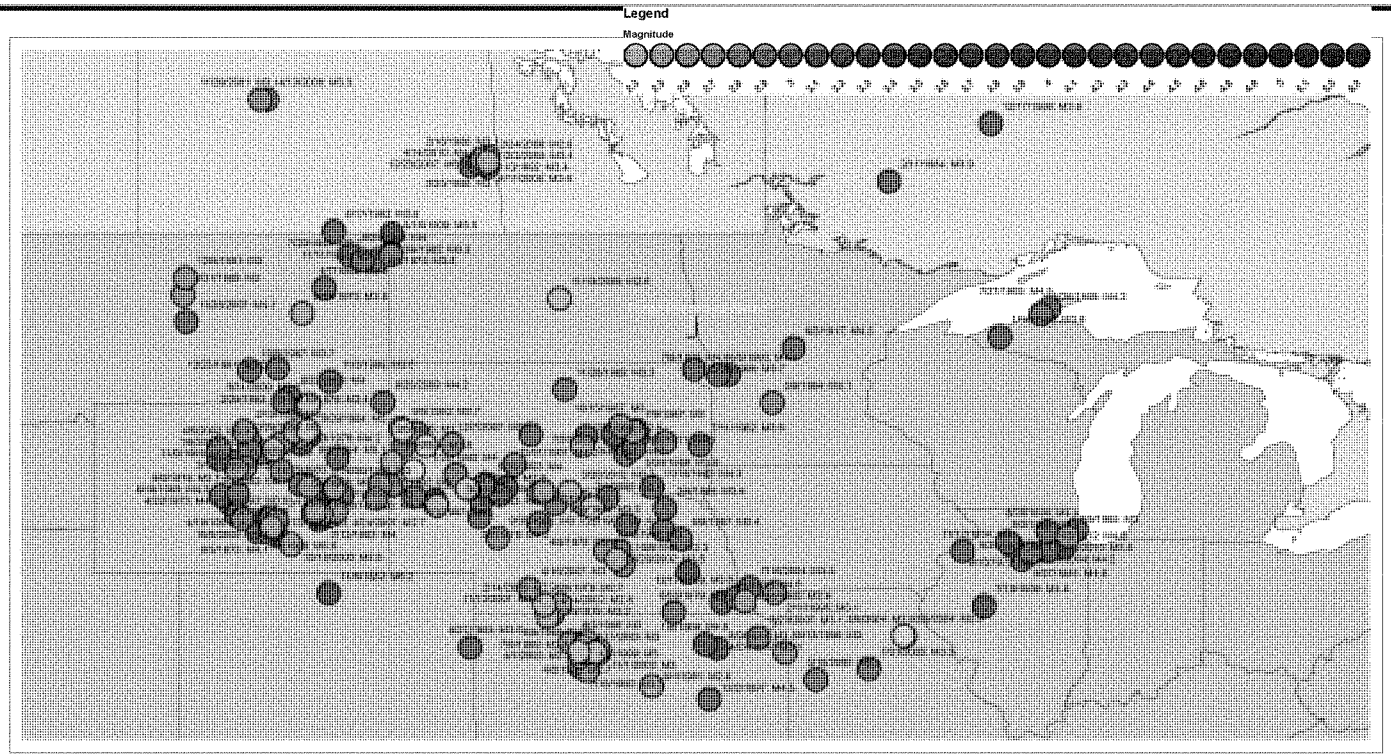
NEIC: Earthquake Search Results
U. S. GEOLOGICAL SURVEY
EARTHQUAKE DATA BASE
FILE CREATED: Fri Aug 13 15:37:41 2010
Circle Search
Circle Center Point Latitude: 46.898N Longitude: 96.795W
Radius: 1000.000 km
Catalog Used: USHIS & PED
Data Selection: Significant U.S. Earthquakes (USHIS) & Historical & Preliminary Data (PED)
Website: http://earthquake.usgs.gov/earthquakes/eqarchives/epic/epic_circ.php

**** Table sorted by largest earthquake to smallest**

		Date				Coordinates		Depth			Radial Dist	
No.	Catalog Source	Year	Month	Day	Time	Lat	Long	(km)	Magnitudes	Type	(km)	(miles)
5	USHIS	1882	11	8	130	40.5	-105.5		6.2	FAKRK	997	620
12	USHIS	1909	5	16	415	49	-104		5.5	LgEPB	586	364
62	PDE	1984	10	18	153023.1	42.38	-105.72	33	5.5	MLGOL	867	539
2	USHIS	1867	4	24	2022	39.2	-96.3		5.1	FABAR	855	531
3	USHIS	1877	11	15	1745	41	-97		5.1	FASC	655	407
13	USHIS	1909	5	26	1442	41.6	-88.1		5.1	FASC	909	565
61	PDE	1984	9	8	5931.1	44.24	-106.02	20	5.1	mbGS	777	483
60	PDE	1984	5	29	201832.7	44.23	-105.96	18	5	mbGS	774	481
9	USHIS	1906	1	8	15	39.3	-96.6		4.9	FABAR	844	524
14	USHIS	1909	7	19	434	40.2	-90		4.8	FASC	923	574
28	PDE	1973	4	22	60712.4	42.63	-107.85	33	4.8	mbGS	993	617
4	USHIS	1881	5	27		41.3	-89.1		4.6	FASC	874	543
21	USHIS	1935	3	1	11	40.3	-96.2		4.6	FASC	734	456
34	PDE	1975	7	9	145415.1	45.67	-96.04	10	4.6	mbGS	148	92
55	PDE	1983	3	4	63218.69	44.21	-99.41	5	4.6	LgTUL	361	224
6	USHIS	1897	12	2	710	38	-96.5		4.5	FABAR	988	614
8	USHIS	1905	7	27	20	47.24	-88.45		4.5	FASC	634	394
15	USHIS	1911	6	2	2234	44.2	-98.2		4.5	FABAR	319	198
16	USHIS	1912	1	2	1621	41.5	-88.5		4.5	FASC	893	555
25	USHIS	1964	3	28	100846.5	43	-101.8	30	4.5	LgDG	586	364
27	USHIS	1972	9	15	52215.9	41.65	-89.37	11	4.5	LgDG	831	516
1	USHIS	1804	8	20	2010	42	-87.8		4.4	FASC	898	558
7	USHIS	1902	7	28	18	42	-97.6		4.4	FASC	547	340
32	PDE	1974	9	19	153611.4	44.11	-107.38	10	4.4	mbGS	882	548
219	PDE-W	2010	4	14	165346.6	50.83	-101.74	1	4.4	MLPGC	568	353
17	USHIS	1917	9	3	2130	46.3	-94.5		4.3	FASC	187	116
19	USHIS	1934	7	30	720	42.7	-103		4.3	FASC	676	420
40	PDE	1978	5	7	160619.6	42.3	-101.93	15	4.3	MLGS	652	405
53	PDE	1982	11	15	25822.93	43.01	-97.85	5	4.3	LgTUL	440	273
73	PDE	1985	8	16	60522.67	42.81	-108.06	10	4.3	MLGS	998	620
168	PDE	2002	11	3	204156.9	42.77	-98.9	5	4.3	LgGS	487	303
11	USHIS	1906	5	26	1442	47.1	-88.64		4.2	FASC	620	385
24	USHIS	1961	12	31	163605.8	44.25	-100.72	23	4.2	FASC	424	263
38	PDE	1976	9	3	41816.2	44.04	-106.15	10	4.2	MLGS	797	495
63	PDE	1984	10	18	155737.4	42.37	-105.81	33	4.2	MLGOL	873	542
141	PDE	1996	10	19	132758	43.09	-106.06	5	4.2	MLGS	843	524
181	PDE	2004	6	28	61052.17	41.46	-88.9	10	4.2	MwSLM	872	542
212	PDE-W	2009	9	25	151134.1	45.02	-104.21	4	4.2	MLBUT	611	380
23	USHIS	1946	7	23	645	44.1	-98.6		4.1	FASC	341	212
29	PDE	1973	8	3	214752	41.95	-106.8	0	4.1	mbGS	966	600
122	PDE	1993	6	5	12453	45.67	-96.29	10	4.1	LgOTT	141	88
202	PDE	2007	11	26	62732	46.92	-108.87	1	4.1	MLBUT	919	571

		Date				Coordinates		Depth			Radial Dist	
No.	Catalog Source	Year	Month	Day	Time	Lat	Long	(km)	Magnitudes	Type	(km)	(miles)
20	USHIS	1934	11	12	1445	41.5	-90.5		4	FASC	782	486
22	USHIS	1943	6	25	425	48.5	-105		4	LgEPB	640	398
54	PDE	1983	2	13	134444.1	42.23	-105.73	5	4	MLGS	877	545
91	PDE	1989	6	8	181843.4	39.17	-99.48	5	4	LgGS	886	551
97	PDE	1990	1	28	45959.19	43.31	-102.5	5	4	LgTUL	600	373
174	PDE	2003	5	25	73233.39	43.09	-101.79	5	4	LgGS	578	359
211	PDE-W	2009	8	22	154852	45.14	-106.45	13	4	MLBUT	772	480
52	PDE	1982	8	17	44925	49.06	-105.38	18	3.9	LgPGC	684	425
58	PDE	1984	2	11	112641	50.23	-92.24	18	3.9	LgOTT	500	311
90	PDE	1989	4	7	82648.91	47.72	-105.6	5	3.9	MLBUT	671	417
101	PDE	1990	10	25	62525.54	43.79	-98.47	5	3.9	LgTUL	369	229
118	PDE	1993	2	25	34415.54	44.93	-106.06	5	3.9	MLBUT	750	466
155	PDE	1999	12	17	210000.1	51.6	-89.84	18	3.9	LgOTT	727	452
18	USHIS	1931	8	9	61837	39.1	-94.7		3.8	FABAR	882	548
35	PDE	1975	9	5	204740.7	48.37	-104.38	5	3.8	MLLAO	593	368
64	PDE	1984	10	18	173827.4	42.41	-105.77	33	3.8	MLGOL	867	539
89	PDE	1989	2	9	51545.8	42.69	-101.9	5	3.8	LgGS	617	383
92	PDE	1989	6	16	145353.1	39.14	-99.46	5	3.8	LgGS	888	552
121	PDE	1993	6	1	213322.9	42.3	-107.57	5	3.8	MLGS	995	618
184	PDE	2004	8	29	184944.3	42.89	-105.49	5	3.8	MLGS	817	508
217	PDE-W	2010	2	10	95935.14	41.97	-88.5	10	3.8	MwSLM	857	533
10	USHIS	1906	5	10	27	43	-101.3		3.7	FASC	560	348
41	PDE	1978	6	6	212334.7	43.63	-107.83	5	3.7	MLGS	937	582
80	PDE	1987	10	5	185449.3	45.77	-107.38	5	3.7	MLBUT	824	512
84	PDE	1988	3	25	221400.6	50.6	-102.14	1	3.7	LgOTT	568	353
124	PDE	1993	7	23	63023.84	42.48	-105.7	5	3.7	MLGS	859	534
127	PDE	1993	10	10	41746.76	42.42	-105.87	5	3.7	MLGS	873	542
136	PDE	1995	10	20	155718.7	45.79	-96.86	5	3.7	LgOTT	123	76
138	PDE	1996	2	6	160836.8	43.98	-103.73	5	3.7	LgGS	631	392
139	PDE	1996	4	9	24808.19	43.07	-104.1	5	3.7	LgGS	715	444
147	PDE	1998	7	29	33158.93	48.37	-104.71	5	3.7	LgGS	616	383
170	PDE	2003	2	1	184411.5	43.08	-106.18	5	3.7	MLGS	852	529
30	PDE	1973	8	10	204728.6	41.89	-106.74	0	3.6	mbGS	966	600
51	PDE	1982	7	11	194228.5	44.01	-96.72	5	3.6	LgTUL	321	199
59	PDE	1984	5	27	233019.3	39.22	-102.15	5	3.6	MLGOL	957	595
75	PDE	1986	5	25	71322.13	43.94	-98.29	5	3.6	LgTUL	349	217
82	PDE	1988	1	14	172336.6	46.56	-89.62	5	3.6	LgGS	549	341
85	PDE	1988	4	14	93931.47	39.09	-99.15	5	3.6	LgGS	887	551
109	PDE	1991	12	23	203227.3	45.82	-106.71	5	3.6	MLBUT	772	480
114	PDE	1992	8	31	14014.21	43.83	-107.04	5	3.6	MLGS	871	541
117	PDE	1993	2	24	235217.6	43.71	-105.29	0	3.6	MLGS	753	468
137	PDE	1996	2	6	151028.3	42.51	-97.54	5	3.6	LgGS	490	304
148	PDE	1998	8	6	182207.1	41.95	-107.19	10	3.6	MLGS	992	616
204	PDE	2008	4	11	20029.68	50.58	-101.74	1	3.6	LgOTT	547	340
216	PDE-W	2009	12	17	25342.52	40.41	-95.86	5	3.6	LgGS	725	450
33	PDE	1975	5	13	75338.5	42.12	-98.45	10	3.5	LgSLM	547	340
36	PDE	1975	12	19	232619.5	42.85	-107.65	0	3.5	MLERDA	967	601
66	PDE	1984	10	20	115108.6	42.4	-105.87	33	3.5	MLGS	875	544
78	PDE	1987	1	1	80224.07	42.79	-103.48	5	3.5	LgGS	698	434
104	PDE	1991	5	30	220744	39.2	-99.4	5	3.5	LgTUL	880	547
116	PDE	1993	2	20	130810.2	42.83	-101.46	5	3.5	LgGS	583	362
128	PDE	1993	11	16	72604.03	43.88	-107.38	5	3.5	MLGS	893	555
129	PDE	1993	12	13	145103.1	42.33	-105.5	5	3.5	MLGS	856	532
149	PDE	1998	11	11	115937.6	48.55	-104.03	5	3.5	LgPGC	572	355
152	PDE	1999	9	2	161729.7	41.72	-89.43	5	3.5	LgGS	821	510
153	PDE	1999	11	3	132852	45.51	-105.47	10	3.5	MLGS	686	426
164	PDE	2002	6	20	42940.32	41.51	-98.62	5	3.5	LgGS	616	383
175	PDE	2003	11	21	10911.63	44.26	-98.78	5	3.5	LgGS	331	206
180	PDE	2004	2	15	31818.02	42.94	-105.4	10	3.5	MLGS	809	503
182	PDE	2004	7	16	121730.7	40.63	-95.55	5	3.5	MwSLM	703	437

		Date				Coordinates		Depth			Radial Dist	
No.	Catalog Source	Year	Month	Day	Time	Lat	Long	(km)	Magnitudes	Type	(km)	(miles)
183	PDE	2004	8	13	11924.36	42.29	-106.96	5	3.5	MLGS	954	593
197	PDE	2007	1	9	101040.1	43.67	-108.11	5	3.5	MLGS	956	594
207	PDE	2008	11	3	131412.5	42.83	-105.18	5	3.5	MwRMT	801	498
37	PDE	1976	8	10	135457.5	45.03	-106.57	5	3.4	MLGS	785	488
48	PDE	1981	9	13	221629.7	43.04	-101.85	5	3.4	LgTUL	585	364
94	PDE	1989	7	13	183522.9	39.17	-99.47	5	3.4	LgGS	885	550
105	PDE	1991	8	26	114915.4	42.16	-100.53	5	3.4	LgTUL	604	375
112	PDE	1992	7	10	144443	50.64	-101.84	1	3.4	LgPGC	557	346
142	PDE	1996	12	11	35544	42.37	-107.69	5	3.4	MLGS	999	621
143	PDE	1997	8	9	174604	41.79	-97.18	5	3.4	LgGS	567	352
145	PDE	1998	6	18	162638.3	42.62	-103	5	3.4	LgGS	683	424
209	PDE	2008	12	2	102214.7	50.84	-101.73	1	3.4	LgPGC	568	353
213	PDE-W	2009	10	8	225558.1	42.3	-106.89	5	3.4	MLGS	948	589
44	PDE	1979	6	30	204639.3	40.05	-97.34	5	3.3	UKGS	762	473
49	PDE	1981	10	9	215427.9	41.17	-98.54	5	3.3	LgTUL	651	405
50	PDE	1982	3	9	131050.1	48.51	-104.03	18	3.3	LgPGC	571	355
56	PDE	1983	5	6	61446.95	42.96	-102.2	5	3.3	MLGS	611	380
65	PDE	1984	10	19	162904.4	42.41	-105.77	33	3.3	MLGS	868	539
70	PDE	1984	11	6	113852.5	42.31	-105.71	33	3.3	MLGS	871	541
72	PDE	1984	12	17	93132.24	42.36	-105.73	33	3.3	MLGS	869	540
96	PDE	1989	11	26	10614.67	45.32	-99.91	5	3.3	LgGS	297	185
113	PDE	1992	7	15	25640.75	38.76	-99.55	5	3.3	LgTUL	931	578
130	PDE	1994	1	25	24439.83	42.63	-100.14	5	3.3	LgGS	543	337
158	PDE	2000	4	13	181731.7	42.41	-105.81	5	3.3	MLGS	871	541
160	PDE	2001	11	13	15613.13	40	-100.21	5	3.3	LgGS	814	506
162	PDE	2002	4	5	11848.2	43.94	-108.1	5	3.3	MLGS	942	585
185	PDE	2005	5	18	195942.9	38.46	-93.97	5	3.3	LgGS	965	600
186	PDE	2005	7	31	70707.97	38.72	-92.72	5	3.3	LgSLM	967	601
205	PDE	2008	4	13	21028.1	52.17	-106.96	1	3.3	MLPGC	939	583
45	PDE	1979	7	16	347.3	40.18	-100.38	5	3.2	UKTUL	799	496
68	PDE	1984	10	24	90354.78	42.32	-105.72	21	3.2	MLGS	870	541
98	PDE	1990	3	2	41527	43.3	-102.5	5	3.2	MLGS	600	373
119	PDE	1993	3	10	35431.17	43.4	-106.62	5	3.2	MLGS	863	536
194	PDE	2006	8	29	114653.7	44.22	-106.29	5	3.2	MLGS	798	496
203	PDE	2007	12	23	155441.1	50.69	-101.95	1	3.2	LgPGC	566	352
26	USHIS	1966	6	26	115943.1	44.3	-103.43	2	3.1	LgBAR	592	368
47	PDE	1981	9	7	3809.12	42.89	-100.52	5	3.1	LgTUL	533	331
67	PDE	1984	10	22	111756.3	42.4	-105.88	33	3.1	MLGS	876	544
83	PDE	1988	2	18	52705.5	50.77	-101.89	0	3.1	LgOTT	570	354
108	PDE	1991	12	18	213647.9	41.94	-106.92	5	3.1	MLGS	975	606
131	PDE	1994	2	9	84535.58	45	-95	5	3.1	LgGS	252	157
134	PDE	1995	2	11	55410.16	40.51	-94.95	5	3.1	LgGS	725	450
140	PDE	1996	5	3	74751.53	43.04	-104.02	5	3.1	LgGS	712	442
146	PDE	1998	7	12	162849.6	43.55	-101.11	5	3.1	LgGS	502	312
154	PDE	1999	11	9	81741.19	43.48	-107.48	5	3.1	MLGS	920	572
161	PDE	2001	11	29	73526.36	52.17	-107.12	5	3.1	LgPGC	948	589
165	PDE	2002	7	26	83217.21	44.36	-98.22	5	3.1	LgOTT	302	188
187	PDE	2005	10	19	24346.14	44.08	-97.54	5	3.1	LgGS	318	198
190	PDE	2005	12	25	141508.7	42.27	-107.55	5	3.1	MLGS	995	618
193	PDE	2006	8	17	164058.3	44.22	-106.17	5	3.1	LgGS	789	490
198	PDE	2007	2	7	103558.7	44.03	-102.58	5	3.1	LgGS	552	343
199	PDE	2007	3	23	81549.84	39.46	-95.34	5	3.1	LgGS	834	518
206	PDE	2008	8	22	230131.8	43.08	-104.29	5	3.1	MLGS	727	452
39	PDE	1978	1	16	35001.7	42.44	-105.32	5	3	MLGS	837	520
57	PDE	1983	11	15	123312.2	43.02	-105.96	5	3	MLGS	840	522
74	PDE	1985	9	9	220631	41.85	-88.01	5	3	LgGS	896	557
76	PDE	1986	6	2	40405.2	39.34	-99.78	5	3	LgGS	873	542
77	PDE	1986	6	12	151434	42.4	-105.69	20	3	MLGS	864	537
79	PDE	1987	7	9	220645.5	44.33	-98.29	10	3	LgGS	308	191
81	PDE	1987	10	15	105433.8	44.47	-98.6	5	3	MLGS	304	189



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FMMFS_P3_seismic_2010-08.mxd
Printed on 16 AUG 2010

Fargo-Moorhead Metro Feasibility Study
Seimsic Events Located with 1000 kilometers of Fargo-Moorhead

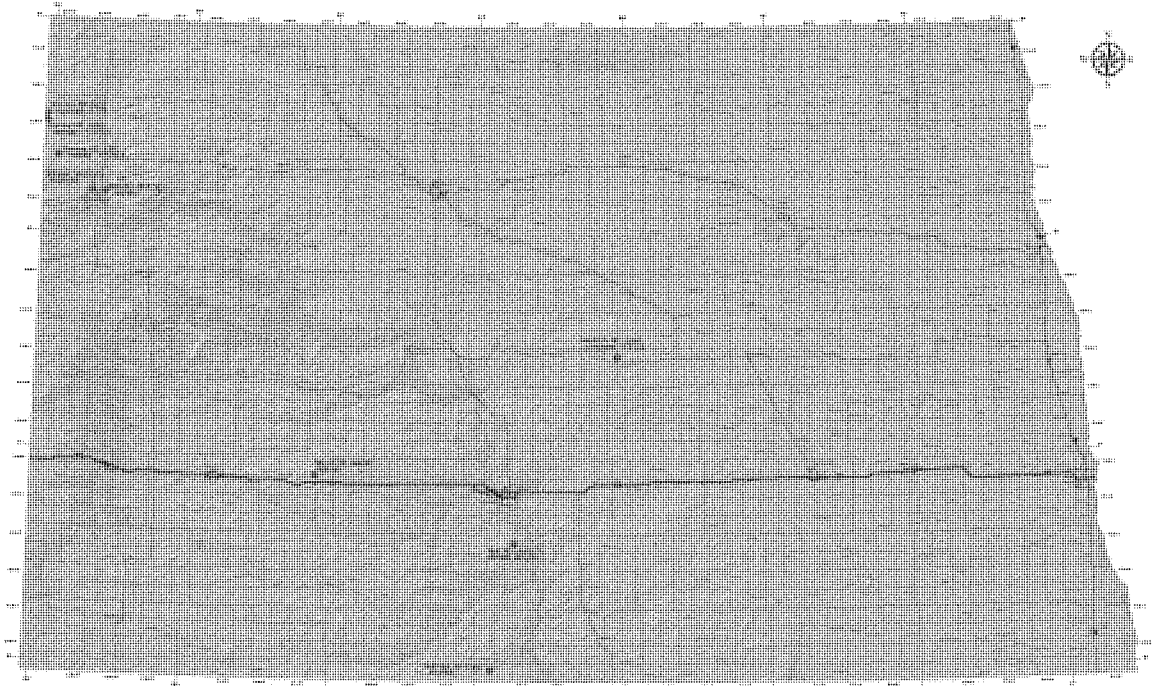
0 45 90 180 270 360 450
Miles

1:9,504,000

North Dakota Geological Survey
Geologic Investigations No. 14

Edward C. Murphy, State Geologist
Lynn D. Wilson, Director Dept. of Mineral Resources

EARTHQUAKES IN NORTH DAKOTA



EXPLANATION

Map Symbols

- Water
- Selected Major Rivers or Creeks
- County Boundaries
- Township Boundaries
- City/Town Boundaries
- City/Town Location
- Interstate Highway
- US Highway
- Selected State Highway

EARTHQUAKE INFORMATION

Nearest City or Town

Date of Earthquake — Galesburgh, ND 11/05/2000 — Magnitude 3.1 (4.2 [2])

Earthquake Magnitude Reported
++ = epicenter uncertain to regional
Middle Central Uncertainty

Modified Mercalli Earthquake Intensity
Value Reported

Approximate Location of Earthquake Epicenter

Calculated Depth of Earthquake
reported in miles (not determined for Unknown)

Scale 1:750,000

0 10 20 30 40

Miles

0 20 30 40

Kilometers

Projection: North American Datum 1983 — Lambert Conformal Conic

REFERENCES

Anderson, F.J., 2000, Earthquakes in North Dakota and surrounding United States, North Dakota Geological Survey Geologic Investigations No. 14, 1 sheet, scale 1:750,000.
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Hansen, W.R., 1965, Geology of the Zion Quadrangle, Utah: Geologic Map of the Zion National Park, U.S. Geological Survey, Miscellaneous Field Studies Map MF-244, 1 sheet, 1:62,500.
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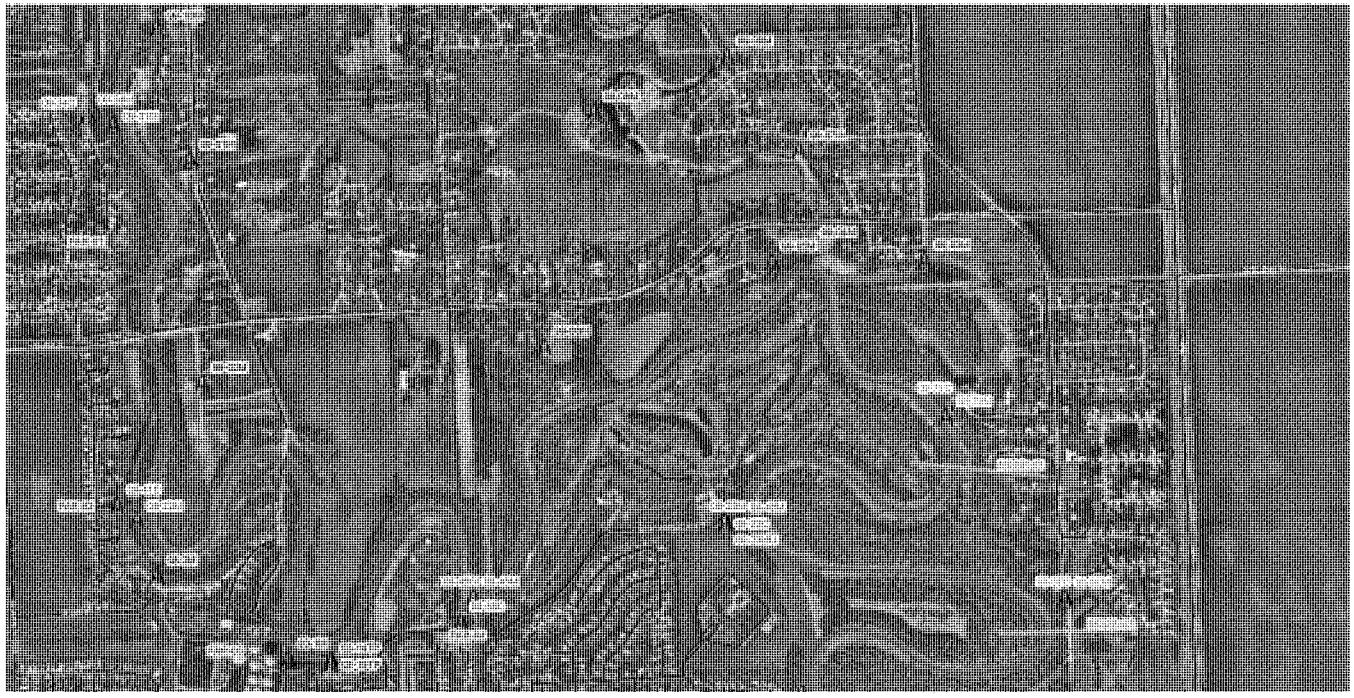
Stover, C.W., U.S. Geological Survey Earthquake Data Base, North Dakota Seismicity Database Search, July-November, 2000.

Compiled by Fred J. Anderson, March, 2000

Cartographic Compilation by Gary L. Rushkevich
Geographic Information Services
Geological Survey, Bismarck

Attachment I-2: Soil Exploration and Section Locations



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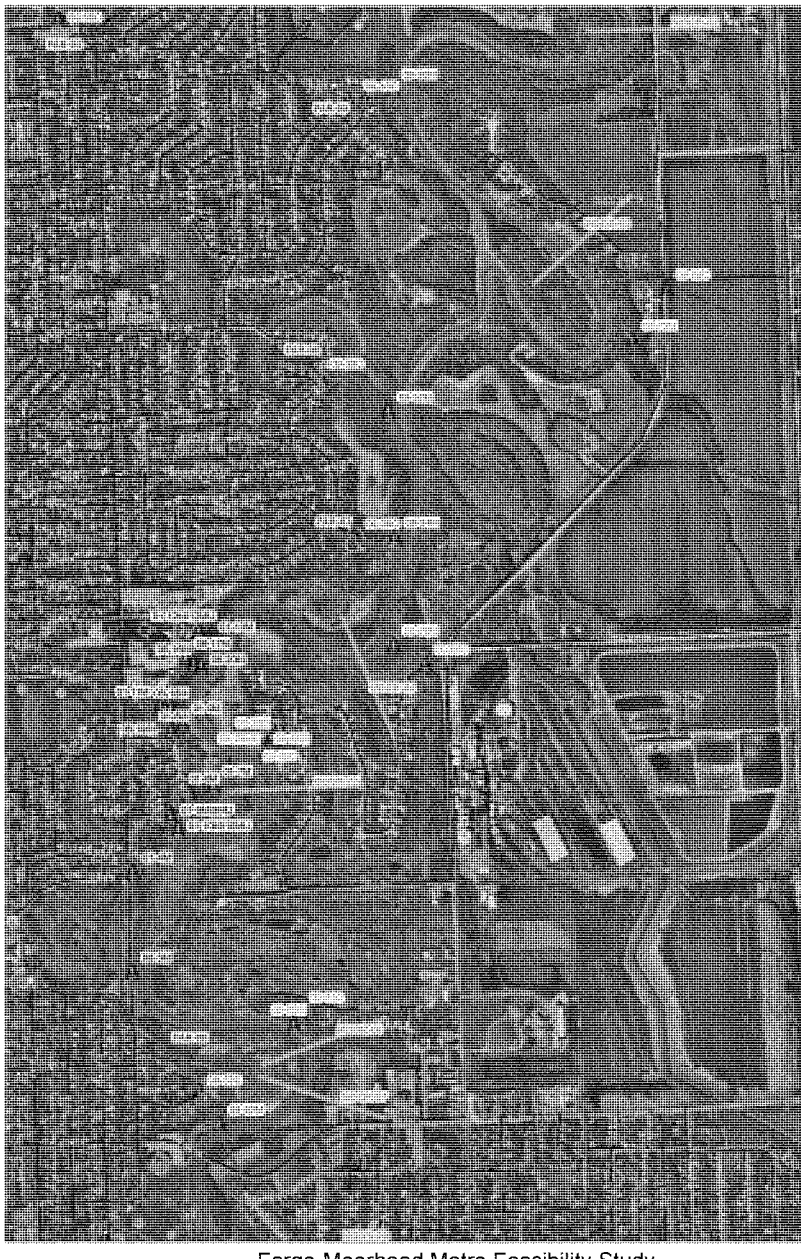
Printed 22 DEC 09

Fargo-Moorhead Metro Feasibility Study
In-Town Soil Exploration and Geotechnical Section Locations

0 500 1,000 2,000 3,000 Feet



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0 500 1,000 2,000 3,000
Feet

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0 500 1,000 2,000 3,000
Feet

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In-Town Soil Exploration and Geotechnical Section Locations

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Feet

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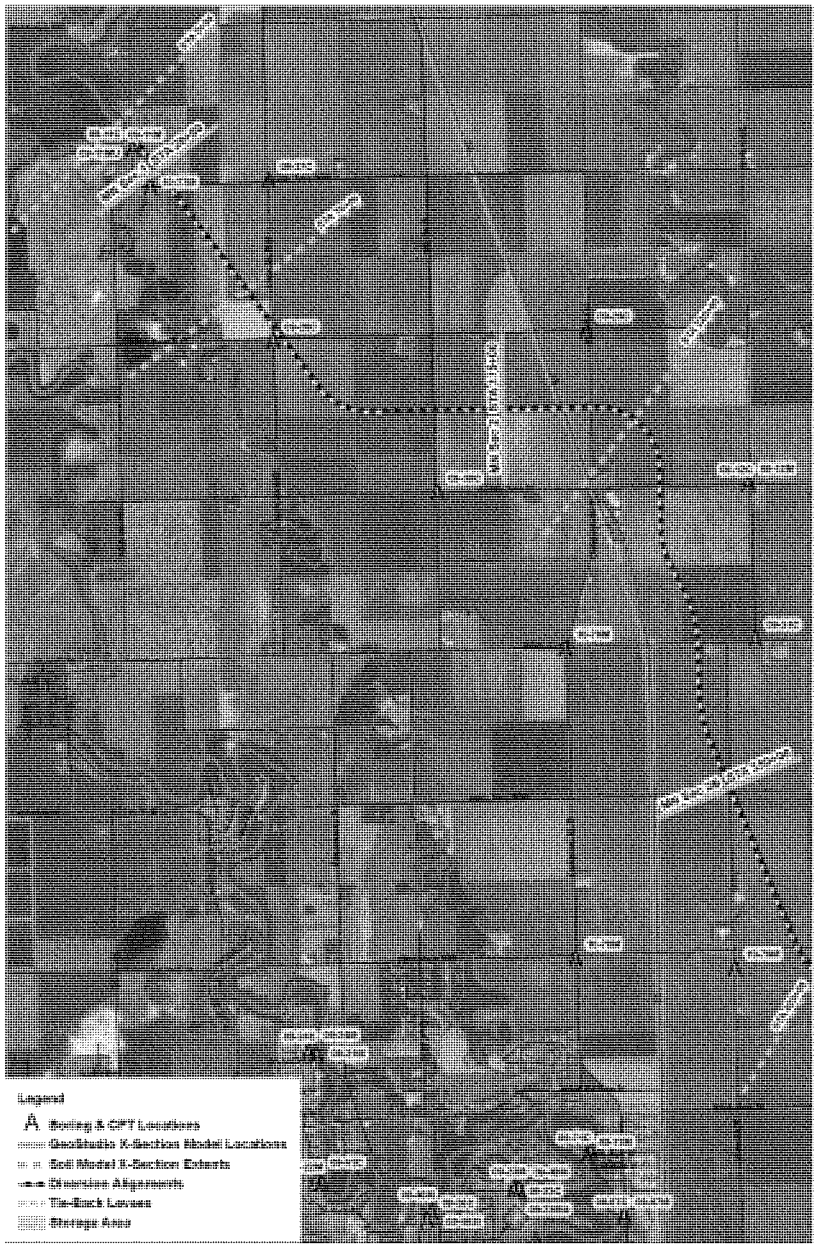
In-Town Soil Exploration and Geotechnical Section Locations

0 500 1,000 2,000 3,000 Feet



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Fargo-Moorhead Metro Feasibility Study
MN Diversion Soil Exploration & Geotechnical Section Locations

0 1,500 3,000 6,000 9,000 12,000 Feet

1 inch = 3,000 feet

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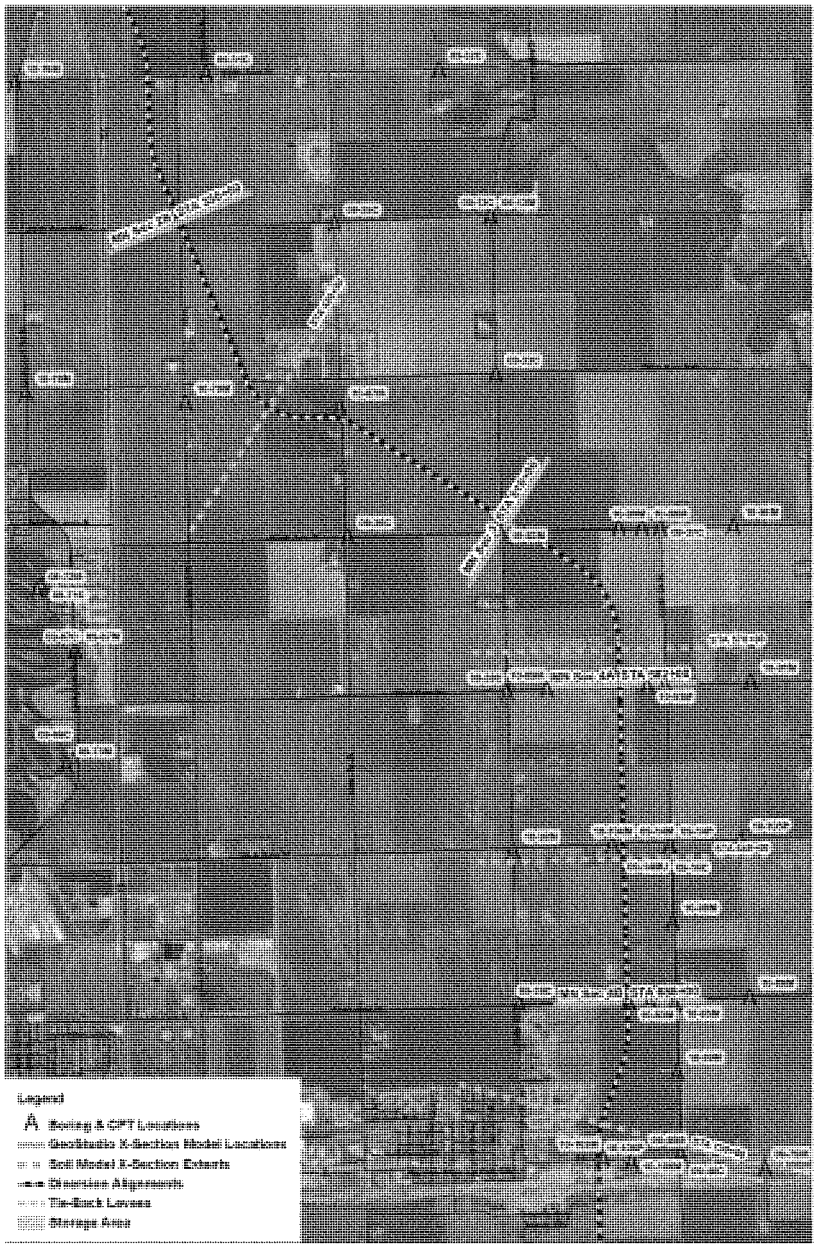
Printed 13 JUL 2011



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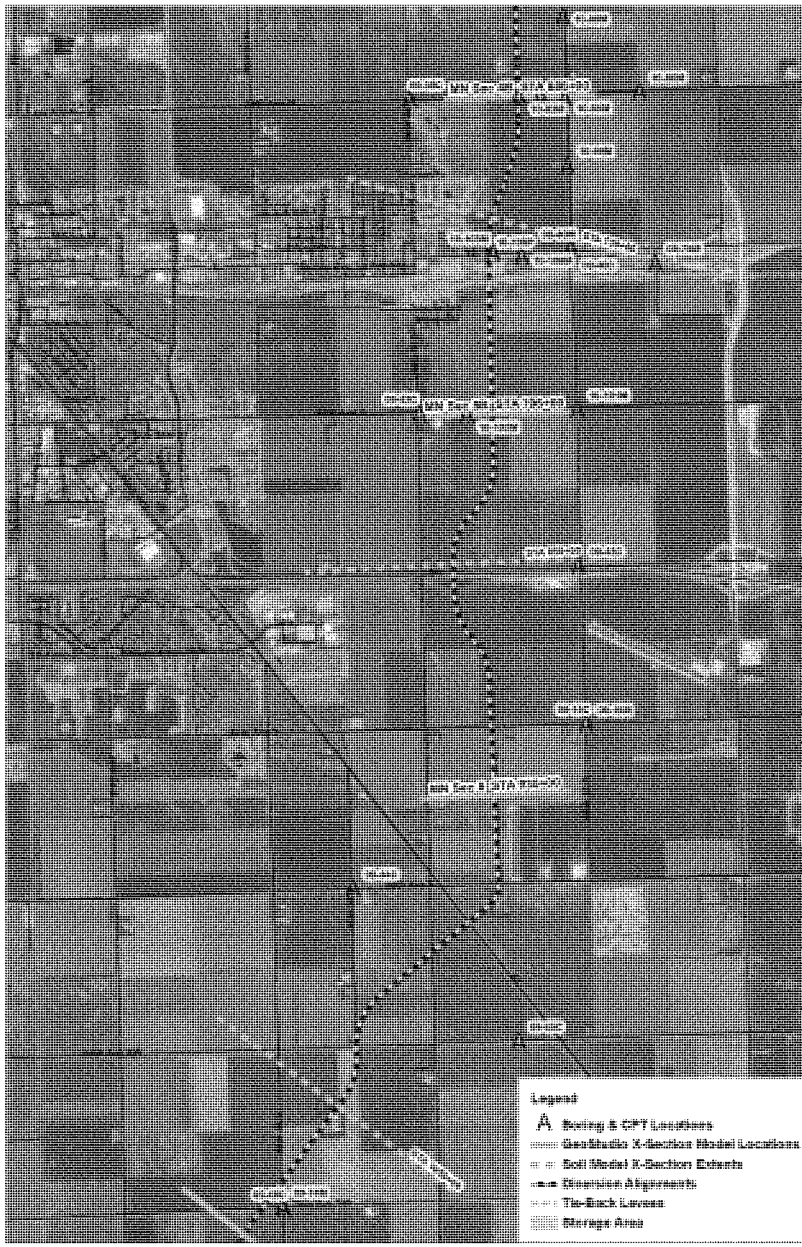

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1 inch = 3,000 feet

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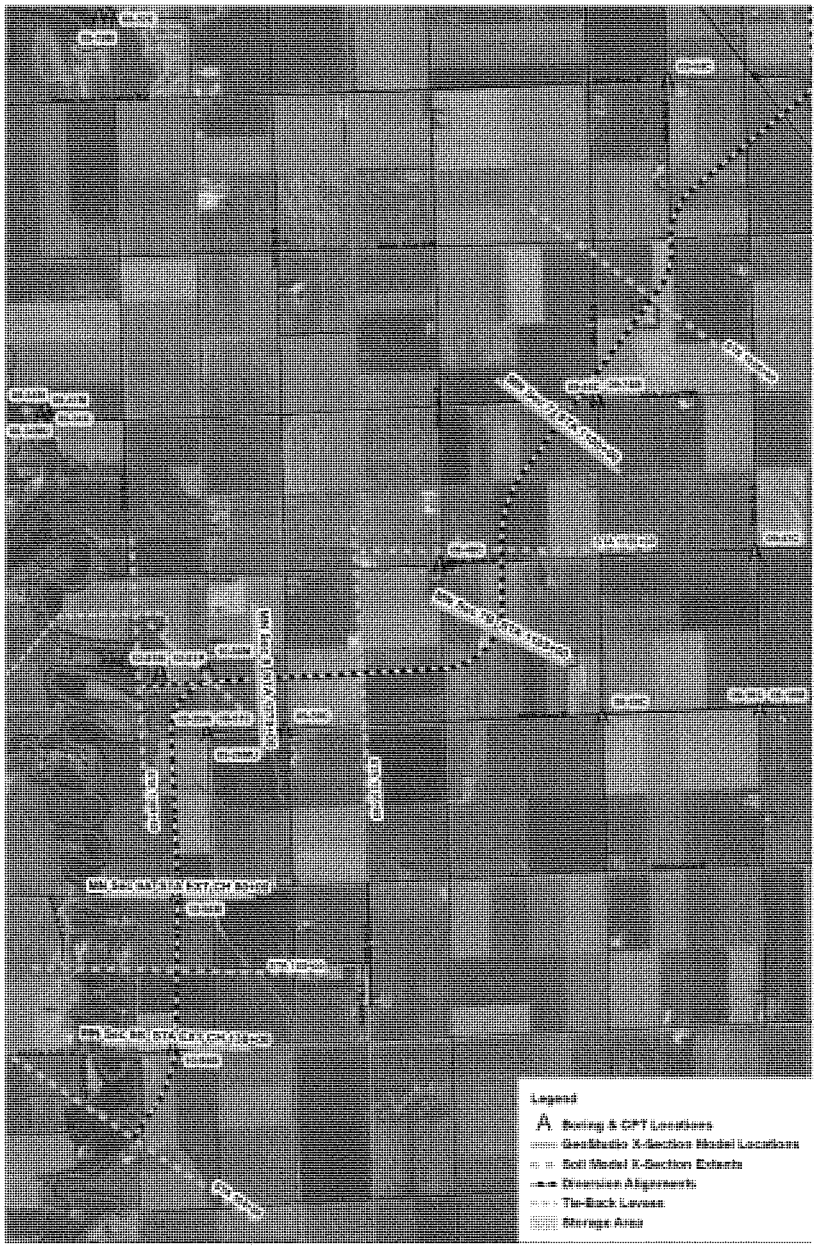
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Fargo-Moorhead Metro Feasibility Study
MN Diversion Soil Exploration & Geotechnical Section Locations
0 1,500 3,000 6,000 9,000 12,000
Feet
1 inch = 3,000 feet
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0 1,500 3,000 6,000 9,000 12,000 Feet

1 inch = 3,000 feet

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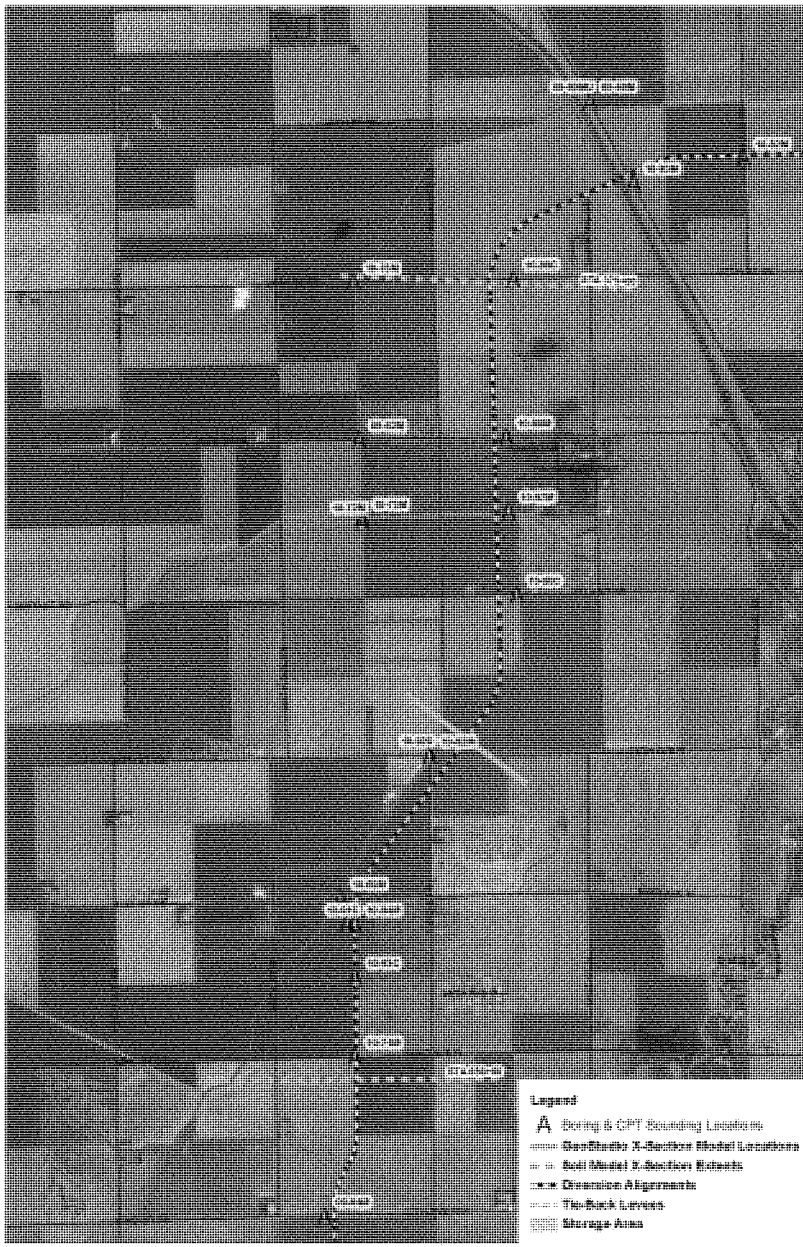

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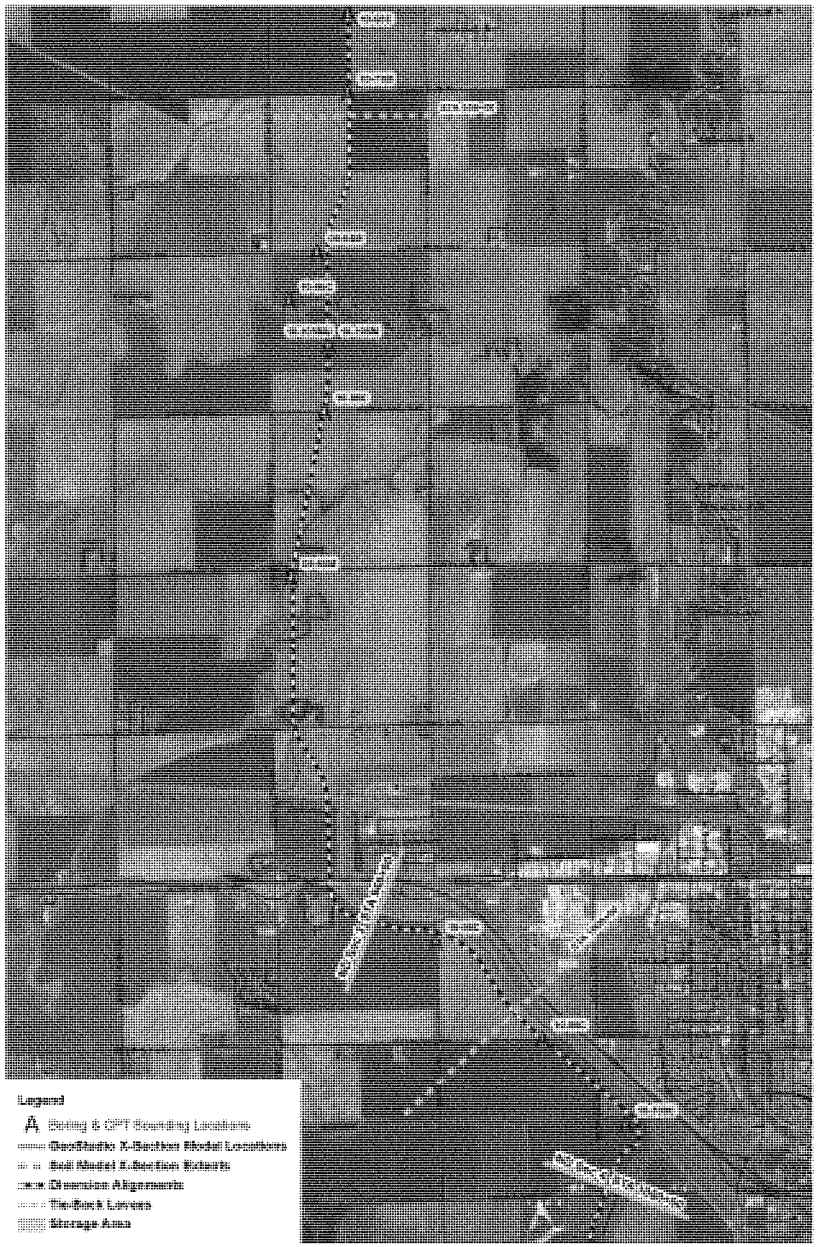

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0 1,500 3,000 6,000 9,000 12,000 Feet

1 inch = 3,000 feet

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1 inch = 3,000 feet

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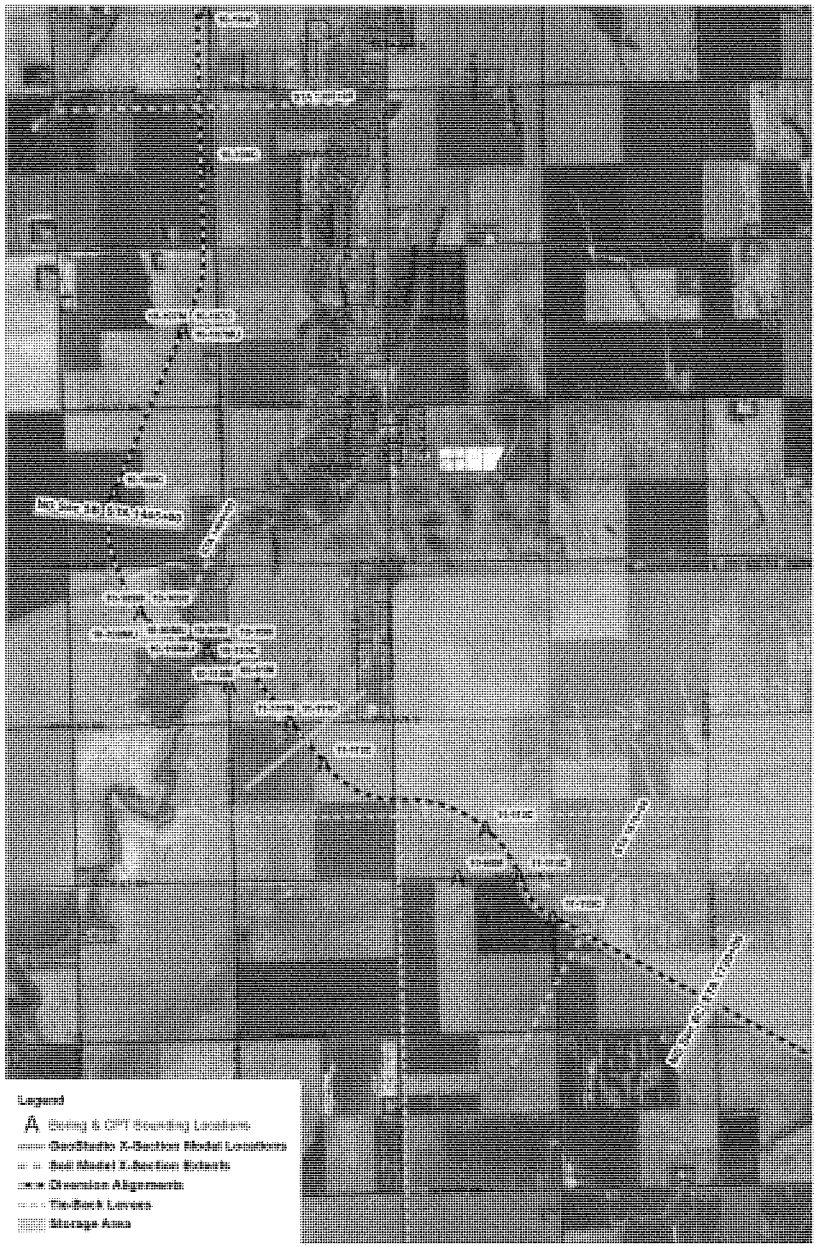

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0 1,500 3,000 6,000 9,000 12,000 Feet

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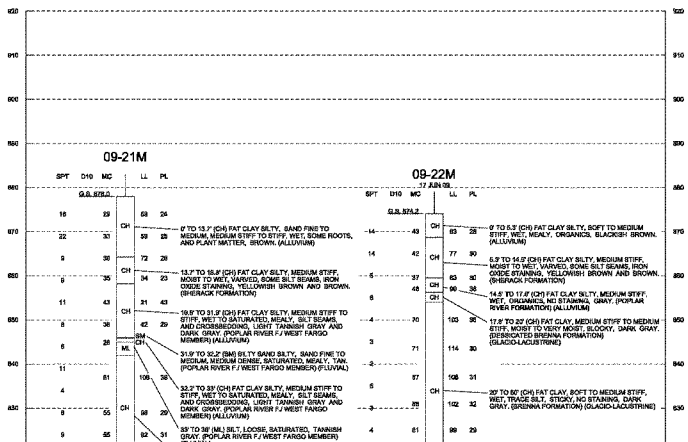
Attachment I-3: Boring Log Plates and CPT Sounding Reports



GENERAL BORING LEGEND

84-1M — YEAR OF BORING-BORING NUMBER, BORING TYPE (ED: M=MACHINE, A=AUGER, TP=TEST PIT, P=PIEZOMETER).

1 MAY 1984 — DATE OF BORING

W.S. 1026.7	WATER SURFACE ELEVATION ON DAY OF BORING
G.S. 1020.2	GROUND SURFACE ELEVATION AT BORING
GW	WELL GRADED GRAVELS, GRAVEL - SAND MIXTURE, LITTLE OR NO FINES
GP	POORLY GRADED GRAVELS, LITTLE OR NO FINES
GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SM	SILTY SANDS, SAND - SILT MIXTURES
SC	CLAYEY SANDS, SAND - CLAY MIXTURES
ML	INORGANIC SILTS, LIQUID LIMIT LESS THAN 50
MH	INORGANIC SILTS, LIQUID LIMIT GREATER THAN 50
CL	INORGANIC CLAYS, LOW TO MEDIUM PLASTICITY, LIQUID LIMIT LESS THAN 50
CH	INORGANIC CLAYS, HIGH PLASTICITY, LIQUID LIMIT GREATER THAN 50
OL	ORGANIC SILTS OR CLAYS, LOW PLASTICITY, LIQUID LIMIT LESS THAN 50
OH	ORGANIC SILTS OR CLAYS, MEDIUM TO HIGH PLASTICITY, LIQUID LIMIT GREATER THAN 50
PT	PEAT
SP-SM	BORDERLINE MATERIAL
SP/SM	STRATIFIED MATERIAL
1	LOCATION AND SAMPLE NUMBER FOR UNDISTURBED SAMPLE
	NO RECOVERY
W.L. 726.7	WATER LEVEL ON DATE OF BORING
700.1	ELEVATION AT BOTTOM OF BORING
(239.66)	ELEVATION IN METERS

GENERAL BORING NOTES

1. GENERAL: THE UNIFIED SOIL CLASSIFICATION SYSTEM IS USED TO IDENTIFY BASIC SOIL TYPE. THE LEGEND REPRESENTS ONLY THE BASIC SOILS. TO COMPLETE THE CLASSIFICATION, PERTINENT INFORMATION IS ADDED TO THE RIGHT OF THE BORING STAFF. NOTES PERTAINING TO A SPECIFIC BORING ARE SHOWN BELOW THE BORING STAFF.

2. MOISTURE CONTENT: THE NATURAL MOISTURE CONTENT IN PERCENT OF DRY WEIGHT (MC) IS SHOWN TO THE LEFT OF THE BORING STAFF.

3. BLOW COUNT (SPT): BLOW COUNTS ARE SHOWN TO THE LEFT OF THE BORING STAFF AND, EXCEPT AS NOTED, ARE THE NUMBER OF BLOWS NECESSARY TO DRIVE THE SAMPLER USED A DISTANCE OF 12-INCHES. STANDARD BLOW COUNTS ARE FOR A STANDARD PENETRATION TEST (SPT) USING A 1... X 2-INCH SAMPLER, ¾ X 2-INCH SAMPLER, 140 LB. HAMMER, AND A 30-INCH DROP. FOR NON-STANDARD BLOW COUNTS SAMPLER SIZE, HAMMER WEIGHT, AND HEIGHT OF DROP ARE AS SHOWN.

4. ATTERBERG LIMITS: LIQUID LIMIT (LL) AND PLASTIC LIMIT (PL) ARE SHOWN TO THE RIGHT OF THE BORING STAFF.

5. D10 SIZE: THE GRAIN SIZE IN MILLIMETERS OF WHICH 10% OF THE SAMPLE IS FINER IS SHOWN TO THE LEFT OF THE BORING STAFF.

6. RQD: ROCK QUALITY DESIGNATION (RQD) IS SHOWN TO THE LEFT OF THE PERCENT RECOVERY COLUMN. RQD IS THE PERCENT RECOVERY CONSISTING OF UNBROKEN PIECES LONGER THAN 4-INCHES.

7. % RECOVERY: PERCENT CORE RECOVERY IS SHOWN TO THE LEFT OF THE BORING STAFF. PERCENT RECOVERY IS LENGTH OF CORE RECOVERED/LENGTH OF CORE CUT X 100. UNLESS SPECIFIED OTHERWISE, ALL CORE IS 4-INCH DIAMETER.

8. ELEVATIONS REFERENCED TO N.A.V.D. 1988 ADJ. UNLESS SPECIFIED OTHERWISE.

9. THE BORINGS SHOW SUMMARIES OF INFORMATION RECORDED ON THE ORIGINAL FIELD LOGS. THESE LOGS ARE AVAILABLE FOR INSPECTION AT THE ST. PAUL DISTRICT OFFICE. ARRANGEMENTS TO INSPECT LOGS CAN BE MADE BY CALLING (651) 290-5599.

US Army Corps of Engineers
ST. PAUL DISTRICT

MARK	DESCRIPTION	DATE	APVD

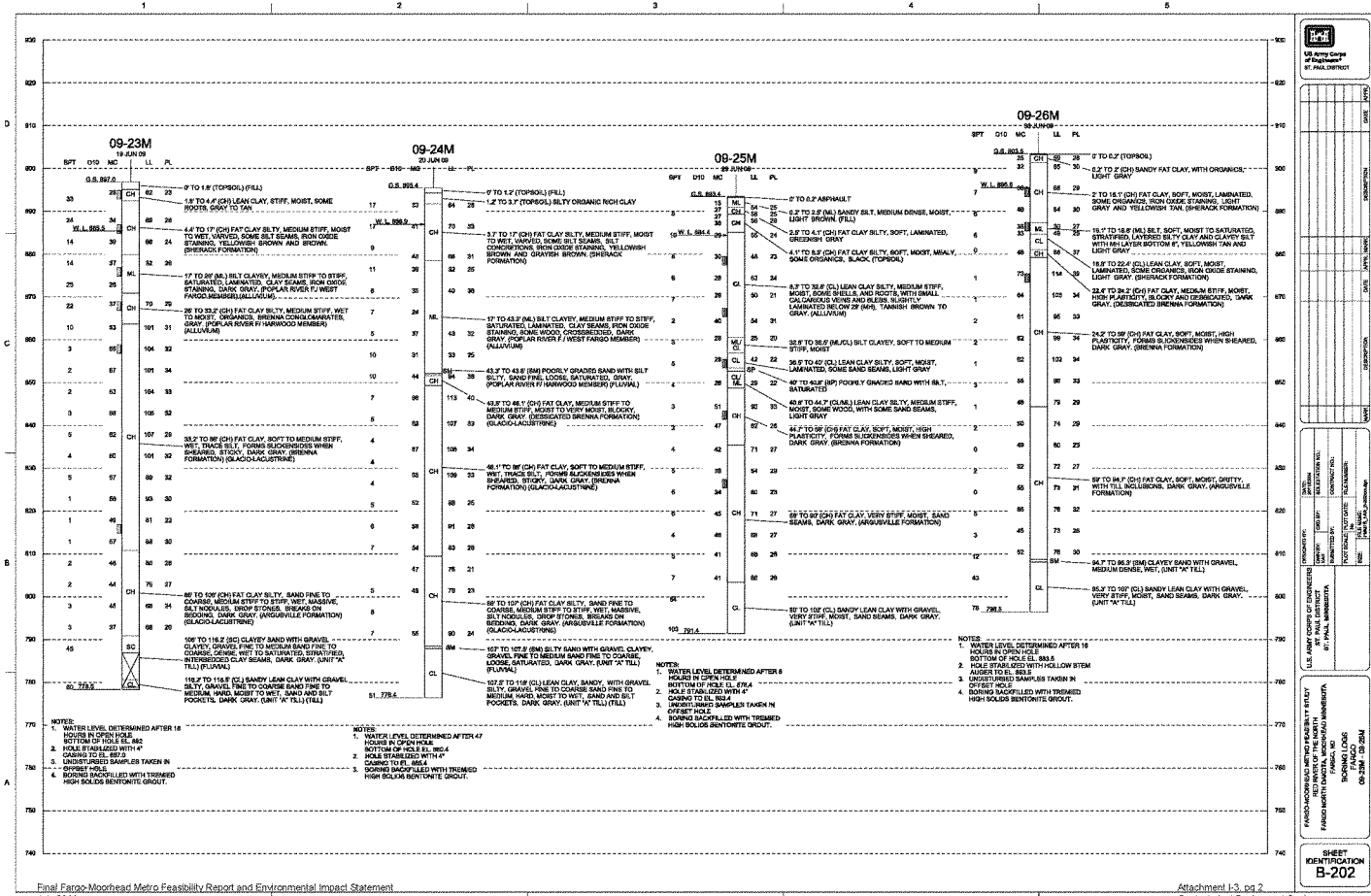
DESIGNED BY: | DATE: 10/11/2004 | DRAWN BY: | SOLICITATION NO.: | CHECKED BY: | CONTRACT NO.: | SUBMITTED BY: | FILE NUMBER: | TEST PLACE: | TEST DATE: | FIELD BOOK: | PAGE: | SIZE: 1/2 BOARD | FORMAT: 8.5X11 | SCALE: NONE

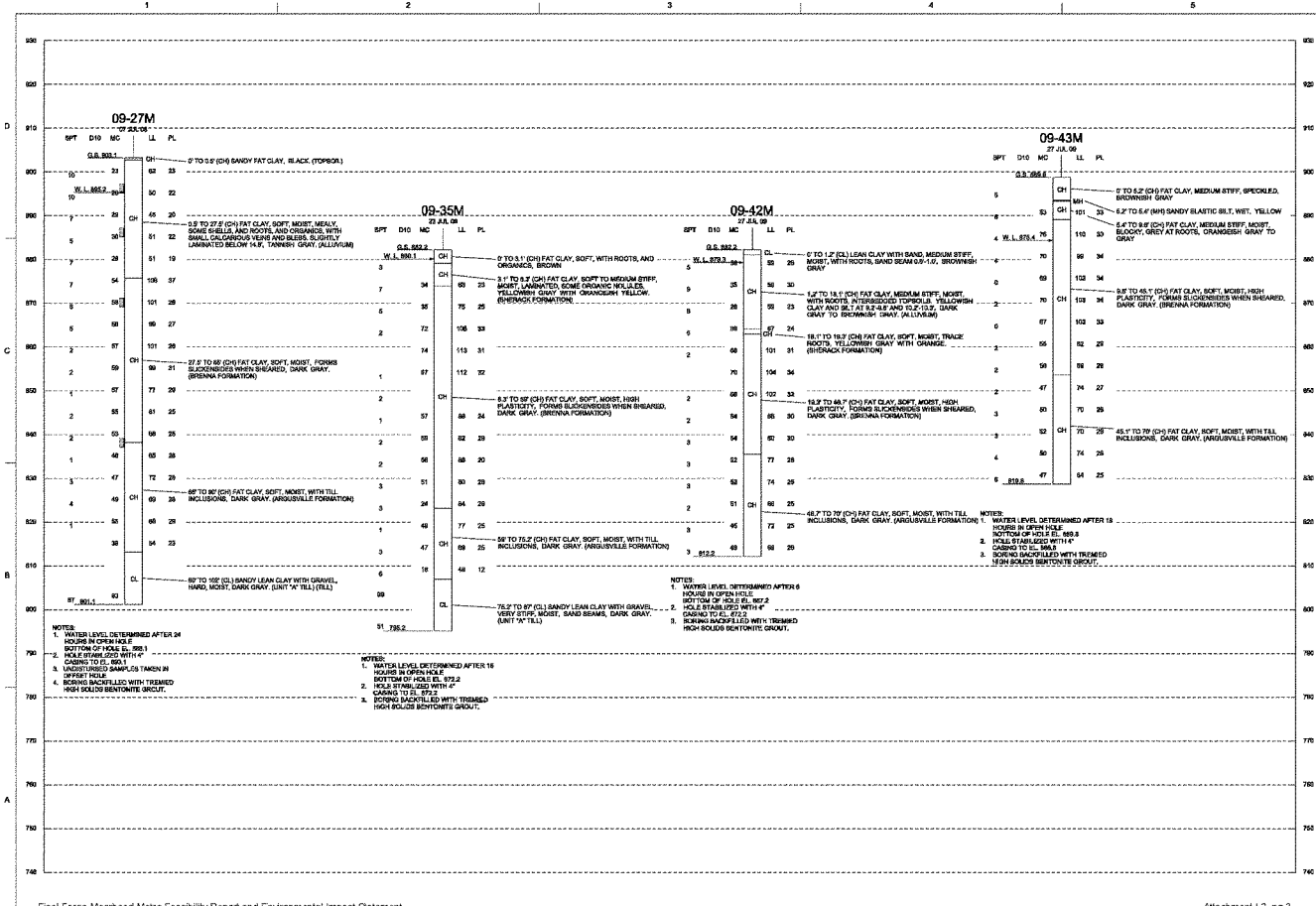
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

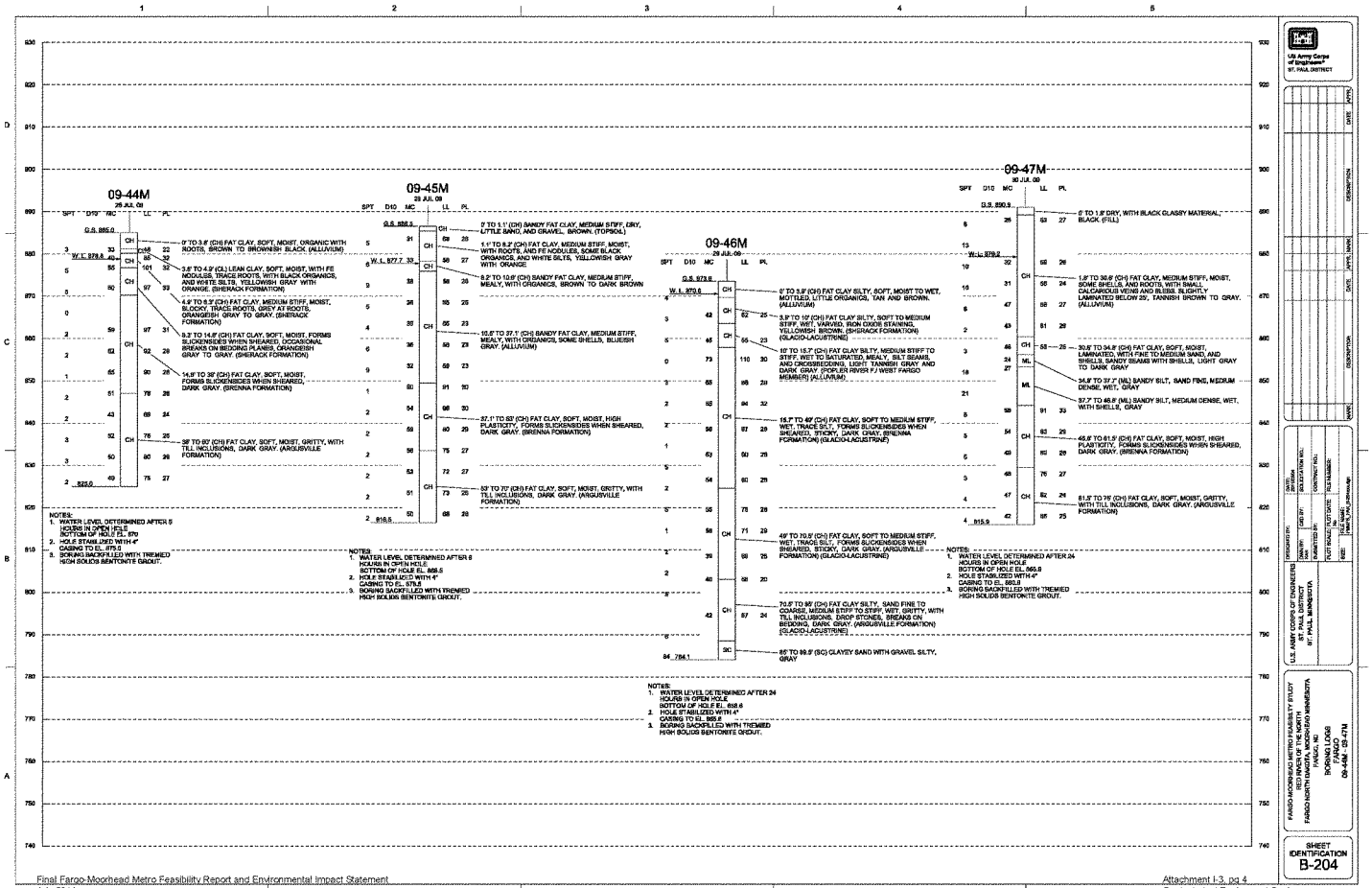
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO NORTH DAKOTA AND MOORHEAD MINNESOTA
FARGO, ND
BORING LOGS AND LEGEND
SHEET 1 OF 1
CONTRACT NO.
02-2-0000

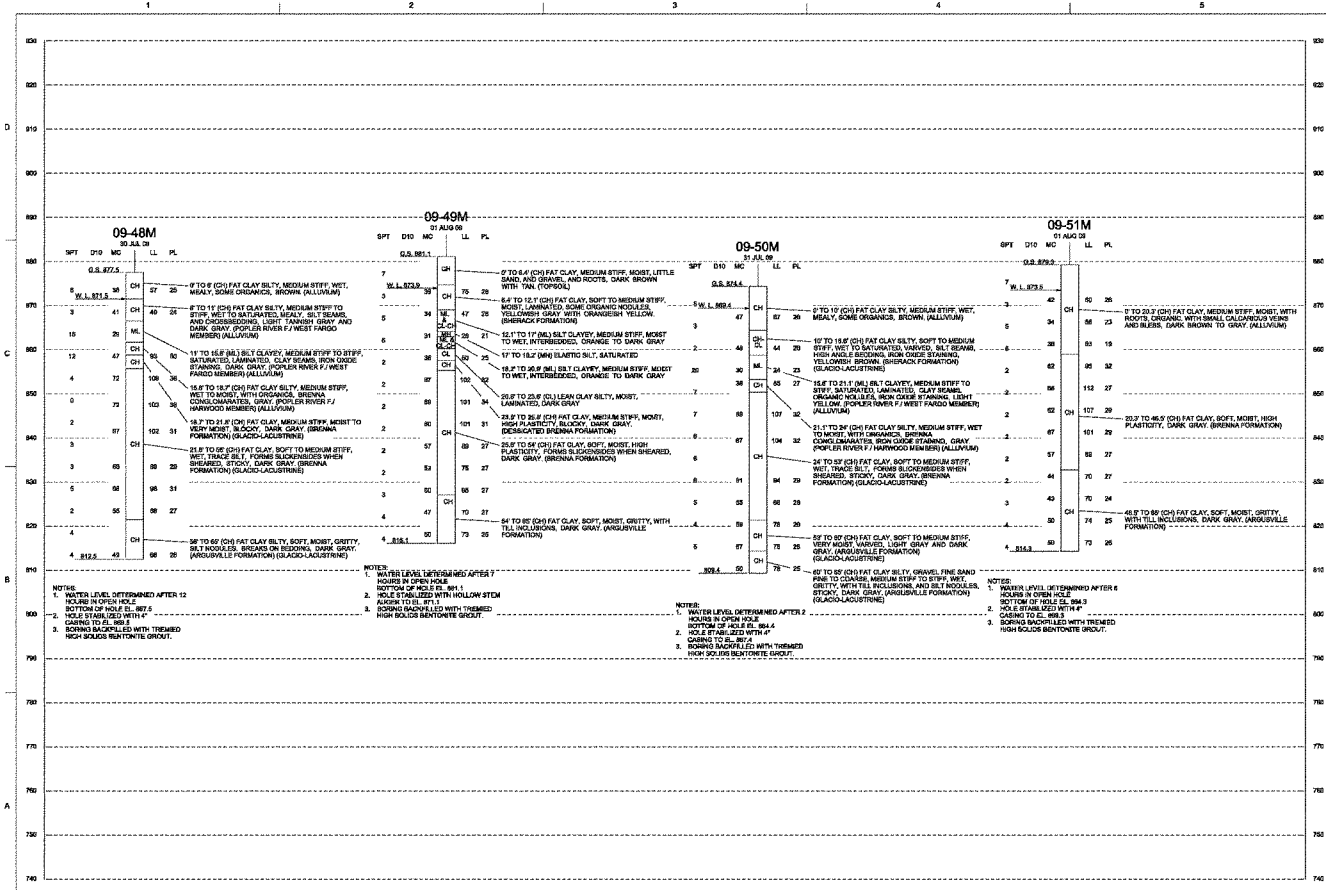
SHEET IDENTIFICATION
B-201

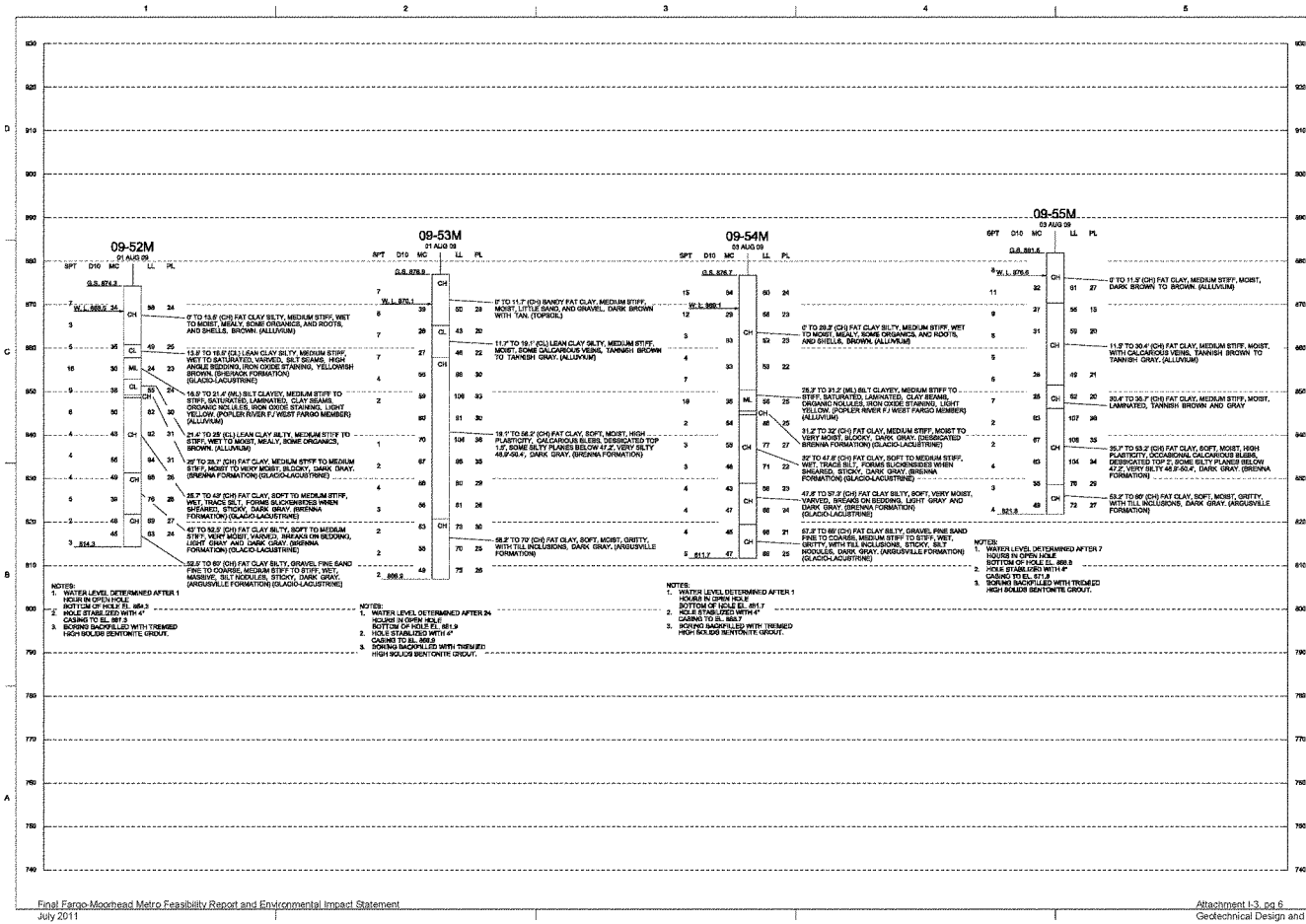
1493


09-23M
19 JUN 09
09-24M
20 JUN 09
09-25M
09-26M
30 JUN 09
0 TO 1.8' (TOPSOIL) (FILL)
1.8' TO 4.4' (CH) LEAN CLAY, STIFF, MOIST, SOME ROOTS, GRAY TO TAN
4.4' TO 17' (CH) FAT CLAY SILTY, MEDIUM STIFF, MOIST TO WET, VARVED, SOME SILT SEAMS, IRON OXIDE STAINING, YELLOWISH BROWN AND BROWN. (SHERACK FORMATION)
17' TO 26' (ML) SILT CLAYEY, MEDIUM STIFF TO STIFF, SATURATED, LAMINATED, CLAY SEAMS, IRON OXIDE STAINING, DARK GRAY. (POPLAR RIVER F / WEST FARGO MEMBER) (ALLUVIUM)
26' TO 33.2' (CH) FAT CLAY SILTY, MEDIUM STIFF, WET TO MOIST, ORGANICS, BRENNA CONGLOMERATES, GRAY. (POPLAR RIVER F/ HARWOOD MEMBER) (ALLUVIUM)
33.2' TO 56' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, WET, TRACE SILT, FORMS SLICKENSIDES WHEN SHEARED, STICKY, DARK GRAY. (BRENNA FORMATION) (GLACIO-LACUSTRINE)
56' TO 109' (CH) FAT CLAY SILTY, SAND FINE TO COARSE, MEDIUM STIFF TO STIFF, WET, MASSIVE, SILT NODULES, DROP STONES, BREAKS ON BEDDING, DARK GRAY. (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
109' TO 116.2' (SC) CLAYEY SAND WITH GRAVEL, CLAYEY, GRAVEL FINE TO MEDIUM SAND FINE TO COARSE, DENSE, WET TO SATURATED, STRATIFIED, INTERBEDDED CLAY SEAMS, DARK GRAY. (UNIT "A" TILL) (FLUVIAL)
116.2' TO 118.8' (CL) SANDY LEAN CLAY WITH GRAVEL SILTY, GRAVEL FINE TO COARSE SAND FINE TO MEDIUM, HARD, MOIST TO WET, SAND AND SILT POCKETS, DARK GRAY. (UNIT "A" TILL) (TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 18 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 882
2. HOLE STABILIZED WITH 4" CASING TO EL. 897.0
3. UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
0 TO 1.2' (TOPSOIL) (FILL)
1.2' TO 3.7' (TOPSOIL) SILTY ORGANIC RICH CLAY
3.7' TO 17' (CH) FAT CLAY SILTY, MEDIUM STIFF, MOIST TO WET, VARVED, SOME SILT SEAMS, SILT CONCRETIONS, IRON OXIDE STAINING, YELLOWISH BROWN AND GRAYISH BROWN. (SHERACK FORMATION)
17' TO 43.3' (ML) SILT CLAYEY, MEDIUM STIFF TO STIFF, SATURATED, LAMINATED, CLAY SEAMS, IRON OXIDE STAINING, SOME WOOD, CROSSBEDDED, DARK GRAY. (POPLAR RIVER F / WEST FARGO MEMBER) (ALLUVIUM)
43.3' TO 43.8' (SM) POORLY GRADED SAND WITH SILT SILTY, SAND FINE, LOOSE, SATURATED, GRAY. (POPLAR RIVER F/ HARWOOD MEMBER) (FLUVIAL)
43.8' TO 46.1' (CH) FAT CLAY, MEDIUM STIFF TO MEDIUM STIFF, MOIST TO VERY MOIST, BLOCKY, DARK GRAY. (DESICCATED BRENNA FORMATION) (GLACIO-LACUSTRINE)
46.1' TO 88' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, WET, TRACE SILT, FORMS SLICKENSIDES WHEN SHEARED, STICKY, DARK GRAY. (BRENNA FORMATION) (GLACIO-LACUSTRINE)
88' TO 107' (CH) FAT CLAY SILTY, SAND FINE TO COARSE, MEDIUM STIFF TO STIFF, WET, MASSIVE, SILT NODULES, DROP STONES, BREAKS ON BEDDING, DARK GRAY. (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
107' TO 107.5' (SM) SILTY SAND WITH GRAVEL CLAYEY, GRAVEL FINE TO MEDIUM SAND FINE TO COARSE, LOOSE, SATURATED, DARK GRAY. (UNIT "A" TILL) (FLUVIAL)
107.5' TO 118' (CL) LEAN CLAY, SANDY, WITH GRAVEL SILTY, GRAVEL FINE TO COARSE SAND FINE TO MEDIUM, HARD, MOIST TO WET, SAND AND SILT POCKETS, DARK GRAY. (UNIT "A" TILL) (TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 47 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 882.4
2. HOLE STABILIZED WITH 4" CASING TO EL. 885.4
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
0' TO 0.2' ASPHALT
0.2' TO 2.5' (ML) SANDY SILT, MEDIUM DENSE, MOIST, LIGHT BROWN. (FILL)
2.5' TO 4.1' (CH) FAT CLAY SILTY, SOFT, LAMINATED, GREENISH GRAY
4.1' TO 8.3' (CH) FAT CLAY SILTY, SOFT, MOIST, MEALY, SOME ORGANICS, BLACK. (TOPSOIL)
8.3' TO 32.6' (CL) LEAN CLAY SILTY, MEDIUM STIFF, MOIST, SOME SHELLS, AND ROOTS, WITH SMALL CALCAREOUS VEINS AND BLEBS, SLIGHTLY LAMINATED BELOW 28' (MH), TANNISH BROWN TO GRAY. (ALLUVIUM)
32.6' TO 36.0' (MI/CL) SILT CLAYEY, SOFT TO MEDIUM STIFF, MOIST
36.0' TO 40' (CL) LEAN CLAY SILTY, SOFT, MOIST, LAMINATED, SOME SAND SEAMS, LIGHT GRAY
40' TO 40.8' (SP) POORLY GRADED SAND WITH SILT, SATURATED
40.8' TO 44.7' (CL/ML) LEAN CLAY SILTY, MEDIUM STIFF, MOIST, SOME WOOD, WITH SOME SAND SEAMS, LIGHT GRAY
44.7' TO 58' (CH) FAT CLAY, SOFT, MOIST, HIGH PLASTICITY, FORMS SLICKENSIDES WHEN SHEARED, DARK GRAY. (BRENNA FORMATION)
58' TO 97' (CH) FAT CLAY, VERY STIFF, MOIST, SAND SEAMS, DARK GRAY. (ARGUSVILLE FORMATION)
97' TO 102' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, SAND SEAMS, DARK GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 8 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 878.4
2. HOLE STABILIZED WITH 4" CASING TO EL. 893.4
3. UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
0 TO 0.2' (TOPSOIL)
0.2' TO 2' (CH) SANDY FAT CLAY, WITH ORGANICS, LIGHT GRAY
2' TO 16.1' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, SOME ORGANICS, IRON OXIDE STAINING, LIGHT GRAY AND YELLOWISH TAN. (SHERACK FORMATION)
16.1' TO 18.8' (ML) SILT, SOFT, MOIST TO SATURATED, STRATIFIED, LAYERED SILTY CLAY AND CLAYEY SILT WITH MH LAYER BOTTOM 8", YELLOWISH TAN AND LIGHT GRAY
18.8' TO 22.4' (CL) LEAN CLAY, SOFT, MOIST, LAMINATED, SOME ORGANICS, IRON OXIDE STAINING, LIGHT GRAY. (SHERACK FORMATION)
22.4' TO 24.2' (CH) FAT CLAY, MEDIUM STIFF, MOIST, HIGH PLASTICITY, BLOCKY AND DESICCATED, DARK GRAY. (DESICCATED BRENNA FORMATION)
24.2' TO 59' (CH) FAT CLAY, SOFT, MOIST, HIGH PLASTICITY, FORMS SLICKENSIDES WHEN SHEARED, DARK GRAY. (BRENNA FORMATION)
59' TO 94.7' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY. (ARGUSVILLE FORMATION)
94.7' TO 96.3' (SM) CLAYEY SAND WITH GRAVEL, MEDIUM DENSE, WET, (UNIT "A" TILL)
96.3' TO 107' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, SAND SEAMS, DARK GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 16 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 883.5
2. HOLE STABILIZED WITH HOLLOW STEM AUGER TO EL. 883.5
3. UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers
ST. PAUL DISTRICT
SHEET IDENTIFICATION
B-202

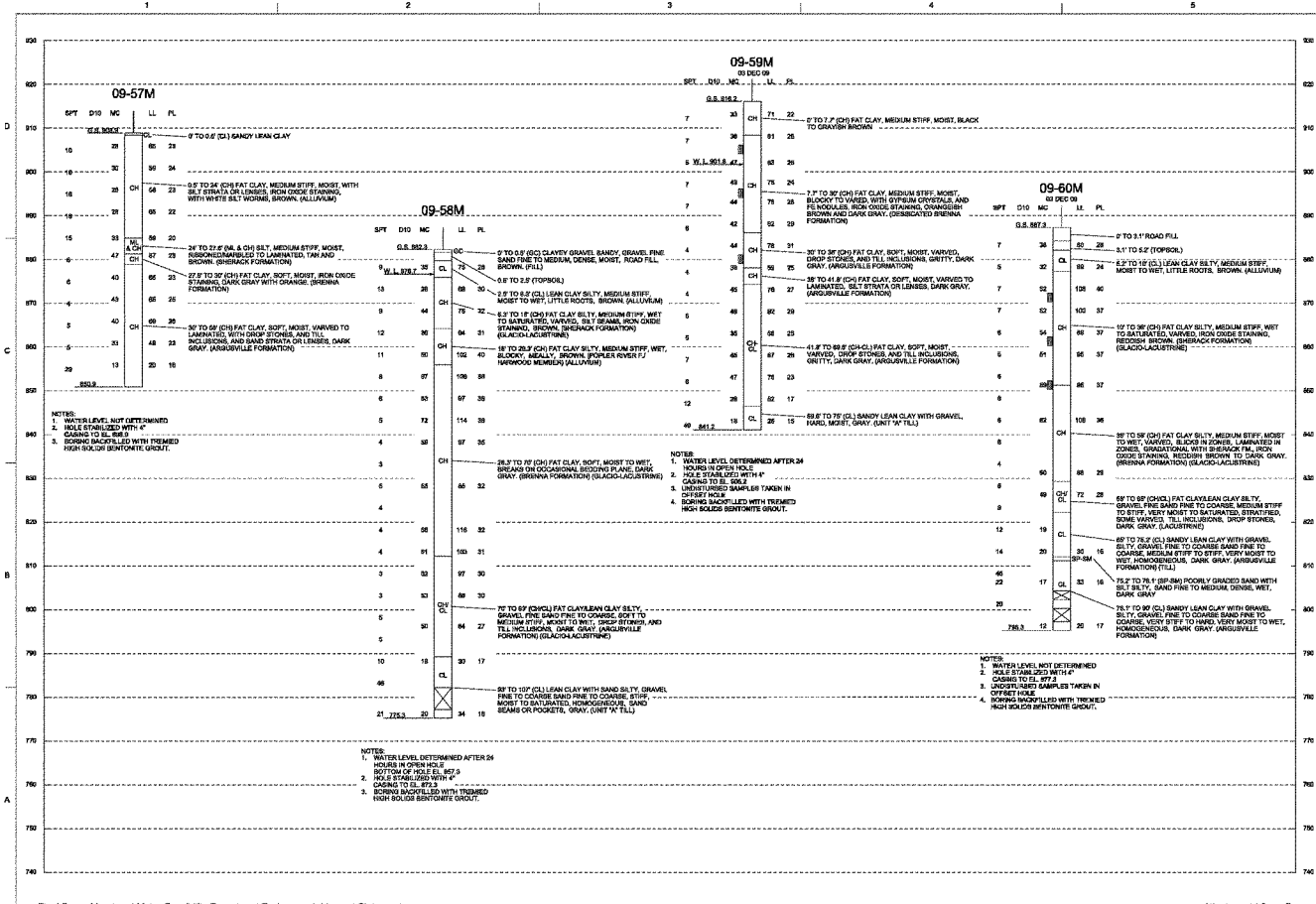

09-27M
22 JUL 09
G.S. 903.1
W.L. 895.2
ST. 891.1
0' TO 0.5' (CH) SANDY FAT CLAY, BLACK. (TOPSOIL)
0.5' TO 27.5' (CH) FAT CLAY, SOFT, MOIST, MEALY, SOME SHELLS, AND ROOTS, AND ORGANICS, WITH SMALL, CALCAREOUS VEINS AND SLESS, SLIGHTLY LAMINATED BELOW 14.8', TANNISH GRAY. (ALLUVIUM)
27.5' TO 66' (CH) FAT CLAY, SOFT, MOIST, FORMS SLICKENSIDES WHEN SHEARED, DARK GRAY. (BRENNA FORMATION)
66' TO 82' (CH) FAT CLAY, SOFT, MOIST, WITH TILL INCLUSIONS, DARK GRAY. (ARGUSVILLE FORMATION)
82' TO 102' (CL) SANDY LEAN CLAY WITH GRAVEL, HARD, MOIST, DARK GRAY. (UNIT "A" TILL) (TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 892.1
2. HOLE STABILIZED WITH 4" CASING TO EL. 890.1
3. UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-35M
23 JUL 09
G.S. 892.2
W.L. 890.1
51 795.2
0' TO 3.1' (CH) FAT CLAY, SOFT, WITH ROOTS, AND ORGANICS, BROWN
3.1' TO 8.3' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, MOIST, LAMINATED, SOME ORGANIC NODULES, YELLOWISH GRAY WITH ORANGISH YELLOW. (SHERACK FORMATION)
8.3' TO 58' (CH) FAT CLAY, SOFT, MOIST, HIGH PLASTICITY, FORMS SLICKENSIDES WHEN SHEARED, DARK GRAY. (BRENNA FORMATION)
58' TO 75.2' (CH) FAT CLAY, SOFT, MOIST, WITH TILL INCLUSIONS, DARK GRAY. (ARGUSVILLE FORMATION)
75.2' TO 87' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, SAND SEAMS, DARK GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 16 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 872.2
2. HOLE STABILIZED WITH 4" CASING TO EL. 872.2
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-42M
27 JUL 09
G.S. 892.2
W.L. 879.3
0' TO 1.2' (CL) LEAN CLAY WITH SAND, MEDIUM STIFF, MOIST, WITH ROOTS, SAND SEAM 0.9'-1.0', BROWNISH GRAY
1.2' TO 18.1' (CH) FAT CLAY, MEDIUM STIFF, MOIST, WITH ROOTS, INTERBEDDED TOPSOILS, YELLOWISH CLAY AND SILT AT 9.2'-9.5' AND 10.2'-10.3', DARK GRAY TO BROWNISH GRAY. (ALLUVIUM)
18.1' TO 19.7' (CH) FAT CLAY, SOFT, MOIST, TRACE ROOTS, YELLOWISH GRAY WITH ORANGE. (SHERACK FORMATION)
19.7' TO 48.7' (CH) FAT CLAY, SOFT, MOIST, HIGH PLASTICITY, FORMS SLICKENSIDES WHEN SHEARED, DARK GRAY. (BRENNA FORMATION)
48.7' TO 70' (CH) FAT CLAY, SOFT, MOIST, WITH TILL INCLUSIONS, DARK GRAY. (ARGUSVILLE FORMATION)
NOTES:
1. WATER LEVEL DETERMINED AFTER 6 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 867.2
2. HOLE STABILIZED WITH 4" CASING TO EL. 872.2
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-43M
27 JUL 09
0.3' 896.6
W.L. 879.4
810.6
0' TO 5.2' (CH) FAT CLAY, MEDIUM STIFF, SPECKLED, BROWNISH GRAY
5.2' TO 5.4' (MH) SANDY ELASTIC SILT, WET, YELLOW
5.4' TO 9.8' (CH) FAT CLAY, MEDIUM STIFF, MOIST, BLOCKY, GREY AT ROOTS, ORANGEISH GRAY TO GRAY
9.8' TO 45.1' (CH) FAT CLAY, SOFT, MOIST, HIGH PLASTICITY, FORMS SLICKENSIDES WHEN SHEARED, DARK GRAY. (BRENNA FORMATION)
45.1' TO 70' (CH) FAT CLAY, SOFT, MOIST, WITH TILL INCLUSIONS, DARK GRAY. (ARGUSVILLE FORMATION)
NOTES:
1. WATER LEVEL DETERMINED AFTER 18 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 869.8
2. HOLE STABILIZED WITH 4" CASING TO EL. 869.8
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers
ST. PAUL DISTRICT
DESIGNED BY:
DRAWN BY:
SUBMITTED BY:
DATE:
SOLICITATION NO.:
CONTRACT NO.:
FILE NUMBER:
LEAD EP:
PLOT DATE:
PLOT SCALE:
SIZE:
FILE NAME:
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO NORTH DAKOTA, MOORHEAD MINNESOTA
FARGO, ND
BORING LOGS
09-27M, 09-35M, 09-42M & 09-43M
SHEET IDENTIFICATION
B-203


09-44M
25 JUL 09
G.S. 885.0
W.L. 878.8
0' TO 3.8' (CH) FAT CLAY, SOFT, MOIST, ORGANIC WITH ROOTS, BROWN TO BROWNISH BLACK, (ALLUVIUM)
3.8' TO 4.2' (CL) LEAN CLAY, SOFT, MOIST, WITH FE NODULES, TRACE ROOTS, WITH BLACK ORGANICS, AND WHITE SILTS, YELLOWISH GRAY WITH ORANGE, (SHERACK FORMATION)
4.2' TO 6.3' (CH) FAT CLAY, MEDIUM STIFF, MOIST, BLOCKY, TRACE ROOTS, GREY AT ROOTS, ORANGEISH GRAY TO GRAY, (SHERACK FORMATION)
6.3' TO 14.8' (CH) FAT CLAY, SOFT, MOIST, FORMS SLICKENSIDES WHEN SHEARED, OCCASIONAL BREAKS ON BEDDING PLANES, ORANGEISH GRAY TO GRAY, (SHERACK FORMATION)
14.8' TO 32' (CH) FAT CLAY, SOFT, MOIST, FORMS SLICKENSIDES WHEN SHEARED, DARK GRAY, (BRENNA FORMATION)
32' TO 82' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY, (ARGUSVILLE FORMATION)
NOTES:
1. WATER LEVEL DETERMINED AFTER 8 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 870
2. HOLE STABILIZED WITH 4" CASING TO EL. 875.0
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-45M
23 JUL 09
G.S. 882.5
W.L. 877.7
0' TO 1.1' (CH) SANDY FAT CLAY, MEDIUM STIFF, DRY, LITTLE SAND, AND GRAVEL, BROWN, (TOPSOIL)
1.1' TO 8.2' (CH) FAT CLAY, MEDIUM STIFF, MOIST, WITH ROOTS, AND FE NODULES, SOME BLACK ORGANICS, AND WHITE SILTS, YELLOWISH GRAY WITH ORANGE
8.2' TO 10.6' (CH) SANDY FAT CLAY, MEDIUM STIFF, MEALY, WITH ORGANICS, BROWN TO DARK BROWN
10.6' TO 37.1' (CH) SANDY FAT CLAY, MEDIUM STIFF, MEALY, WITH ORGANICS, SOME SHELLS, BLUEISH GRAY, (ALLUVIUM)
37.1' TO 53' (CH) FAT CLAY, SOFT, MOIST, HIGH PLASTICITY, FORMS SLICKENSIDES WHEN SHEARED, DARK GRAY, (BRENNA FORMATION)
53' TO 70' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY, (ARGUSVILLE FORMATION)
NOTES:
1. WATER LEVEL DETERMINED AFTER 8 HOURS IN OPEN HOLE
2. HOLE STABILIZED WITH 4" CASING TO EL. 875.5
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-46M
29 JUL 09
G.S. 873.6
W.L. 870.6
0' TO 3.8' (CH) FAT CLAY SILTY, SOFT, MOIST TO WET, MOTTLED, LITTLE ORGANICS, TAN AND BROWN, (ALLUVIUM)
3.8' TO 10' (CH) FAT CLAY SILTY, SOFT TO MEDIUM STIFF, WET, VARVED, IRON OXIDE STAINING, YELLOWISH BROWN, (SHERACK FORMATION) (GLACIO-LACUSTRINE)
10' TO 15.7' (CH) FAT CLAY SILTY, MEDIUM STIFF TO STIFF, WET TO SATURATED, MEALY, SILT SEAMS, AND CROSSBEDDING, LIGHT TANNISH GRAY AND DARK GRAY (POPLER RIVER F/ WEST FARGO MEMBER) (ALLUVIUM)
15.7' TO 49' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, WET, TRACE SILT, FORMS SLICKENSIDES WHEN SHEARED, STICKY, DARK GRAY, (BRENNA FORMATION) (GLACIO-LACUSTRINE)
49' TO 70.5' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, WET, TRACE SILT, FORMS SLICKENSIDES WHEN SHEARED, STICKY, DARK GRAY, (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
70.5' TO 85' (CH) FAT CLAY SILTY, SAND FINE TO COARSE, MEDIUM STIFF TO STIFF, WET, GRITTY, WITH TILL INCLUSIONS, DROP STONES, BREAKS ON BEDDING, DARK GRAY, (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
85' TO 99.5' (SC) CLAYEY SAND WITH GRAVEL SILTY, GRAY
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 868.6
2. HOLE STABILIZED WITH 4" CASING TO EL. 865.8
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-47M
30 JUL 09
G.S. 890.9
W.L. 879.2
0 TO 1.8' DRY, WITH BLACK GLASSY MATERIAL, BLACK (FILL)
1.8' TO 30.6' (CH) FAT CLAY, MEDIUM STIFF, MOIST, SOME SHELLS, AND ROOTS, WITH SMALL CALCAROUS VEINS AND BLISS, SLIGHTLY LAMINATED BELOW 25', TANNISH BROWN TO GRAY, (ALLUVIUM)
30.6' TO 34.8' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH FINE TO MEDIUM SAND, AND SHELLS, SANDY SEAMS WITH SHELLS, LIGHT GRAY TO DARK GRAY
34.8' TO 37.7' (ML) SANDY SILT, SAND FINE, MEDIUM DENSE, WET, GRAY
37.7' TO 46.8' (ML) SANDY SILT, MEDIUM DENSE, WET, WITH SHELLS, GRAY
46.8' TO 61.5' (CH) FAT CLAY, SOFT, MOIST, HIGH PLASTICITY, FORMS SLICKENSIDES WHEN SHEARED, DARK GRAY, (BRENNA FORMATION)
61.5' TO 76' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY, (ARGUSVILLE FORMATION)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 865.8
2. HOLE STABILIZED WITH 4" CASING TO EL. 865.8
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers
ST. PAUL DISTRICT
DATE
DESCRIPTION
DATE
DESCRIPTION
DATE
DESIGNED BY:
DRAWN BY:
CHECKED BY:
PLOT SCALE:
PLOT DATE:
DATE:
CONTRACT NO.:
FILE NUMBER:
FILE:
FILE NAME:
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO NORTH DAKOTA AND MOORHEAD MINNESOTA
FARGO, ND
BORING LOGS
PLATE 2
09-44M, 45, 46, 47M
SHEET IDENTIFICATION
B-204

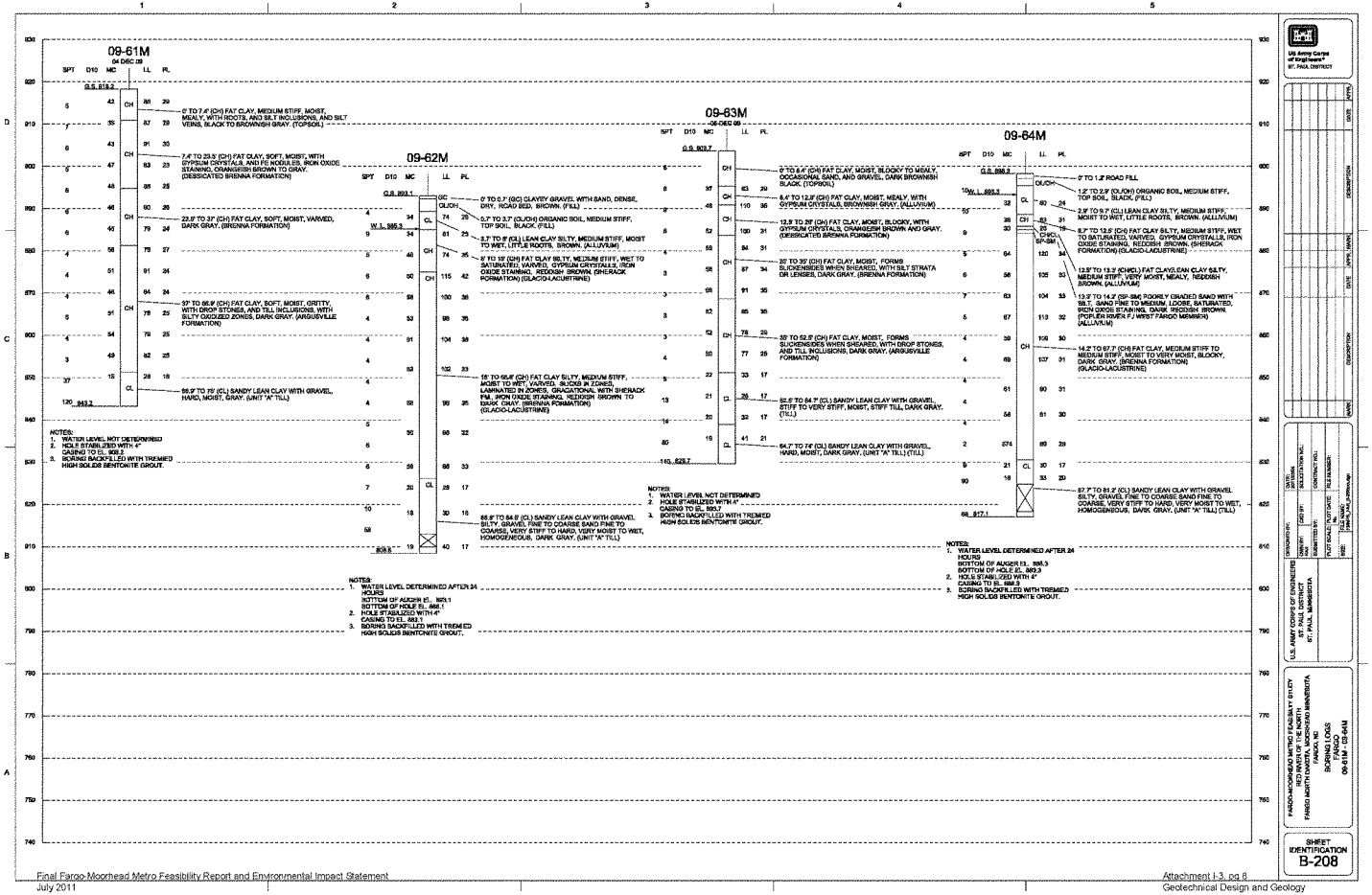

09-48M
30 JUL 09
G.S. 877.5
W.L. 871.5
0' TO 6' (CH) FAT CLAY SILTY, MEDIUM STIFF, WET, MEALY, SOME ORGANICS, BROWN (ALLUVIUM)
6' TO 11' (CH) FAT CLAY SILTY, MEDIUM STIFF TO STIFF, WET TO SATURATED, MEALY, SILT SEAMS, AND CROSSBEDDING, LIGHT TANNISH GRAY AND DARK GRAY, (POPLER RIVER F/ WEST FARGO MEMBER) (ALLUVIUM)
11' TO 15.6' (ML) SILT CLAYEY, MEDIUM STIFF TO STIFF, SATURATED, LAMINATED, CLAY SEAMS, IRON OXIDE STAINING, DARK GRAY, (POPLER RIVER F/ WEST FARGO MEMBER) (ALLUVIUM)
15.6' TO 18.3' (CH) FAT CLAY SILTY, MEDIUM STIFF, WET TO MOIST, WITH ORGANICS, BRENNA CONGLOMARATES, GRAY, (POPLER RIVER F/ HARWOOD MEMBER) (ALLUVIUM)
18.3' TO 21.8' (CH) FAT CLAY, MEDIUM STIFF, MOIST TO VERY MOIST, BLOCKY, DARK GRAY, (BRENNA FORMATION) (GLACIO-LACUSTRINE)
21.8' TO 56' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, WET, TRACE SILT, FORMS SLICKENSIDES WHEN SHEARED, STICKY, DARK GRAY, (BRENNA FORMATION) (GLACIO-LACUSTRINE)
56' TO 65' (CH) FAT CLAY SILTY, SOFT, MOIST, GRITTY, SILT NODULES, BREAKS ON BEDDING, DARK GRAY, (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
NOTES:
1. WATER LEVEL DETERMINED AFTER 12 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 867.5
2. HOLE STABILIZED WITH 4" CASING TO EL. 869.5
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-49M
31 AUG 09
G.S. 881.1
W.L. 873.9
0' TO 5.4' (CH) FAT CLAY, MEDIUM STIFF, MOIST, LITTLE SAND, AND GRAVEL, AND ROOTS, DARK BROWN WITH TAN, (TOPSOIL)
5.4' TO 12.1' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, MOIST, LAMINATED, SOME ORGANIC NODULES, YELLOWISH GRAY WITH ORANGISH YELLOW, (SHERACK FORMATION)
12.1' TO 17' (ML) SILT CLAYEY, MEDIUM STIFF, MOIST TO WET, INTERBEDDED, ORANGE TO DARK GRAY
17' TO 18.2' (MH) ELASTIC SILT, SATURATED
18.2' TO 20.8' (ML) SILT CLAYEY, MEDIUM STIFF, MOIST TO WET, INTERBEDDED, ORANGE TO DARK GRAY
20.8' TO 23.6' (CL) LEAN CLAY SILTY, MOIST, LAMINATED, DARK GRAY
23.6' TO 26.4' (CH) FAT CLAY, MEDIUM STIFF, MOIST, HIGH PLASTICITY, BLOCKY, DARK GRAY, (DESSICATED BRENNA FORMATION)
26.4' TO 54' (CH) FAT CLAY, SOFT, MOIST, HIGH PLASTICITY, FORMS SLICKENSIDES WHEN SHEARED, DARK GRAY, (BRENNA FORMATION)
54' TO 65' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY, (ARGUSVILLE FORMATION)
NOTES:
1. WATER LEVEL DETERMINED AFTER 7 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 861.1
2. HOLE STABILIZED WITH HOLLOW STEM AUGER TO EL. 871.1
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-50M
31 JUL 09
G.S. 874.4
W.L. 869.4
0' TO 10' (CH) FAT CLAY SILTY, MEDIUM STIFF, WET, MEALY, SOME ORGANICS, BROWN, (ALLUVIUM)
10' TO 15.6' (CH) FAT CLAY SILTY, SOFT TO MEDIUM STIFF, WET TO SATURATED, VARVED, SILT SEAMS, HIGH ANGLE BEDDING, IRON OXIDE STAINING, YELLOWISH BROWN, (SHERACK FORMATION) (GLACIO-LACUSTRINE)
15.6' TO 21.1' (ML) SILT CLAYEY, MEDIUM STIFF TO STIFF, SATURATED, LAMINATED, CLAY SEAMS, ORGANIC NODULES, IRON OXIDE STAINING, LIGHT YELLOW, (POPLER RIVER F/ WEST FARGO MEMBER) (ALLUVIUM)
21.1' TO 34' (CH) FAT CLAY SILTY, MEDIUM STIFF, WET TO MOIST, WITH ORGANICS, BRENNA CONGLOMARATES, IRON OXIDE STAINING, GRAY (POPLER RIVER F/ HARWOOD MEMBER) (ALLUVIUM)
34' TO 57' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, WET, TRACE SILT, FORMS SLICKENSIDES WHEN SHEARED, STICKY, DARK GRAY, (BRENNA FORMATION) (GLACIO-LACUSTRINE)
57' TO 67' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, VERY MOIST, VARVED, LIGHT GRAY AND DARK GRAY, (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
67' TO 85' (CH) FAT CLAY SILTY, GRAVEL FINE SAND FINE TO COARSE, MEDIUM STIFF TO STIFF, WET, GRITTY, WITH TILL INCLUSIONS, AND SILT NODULES, STICKY, DARK GRAY, (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
NOTES:
1. WATER LEVEL DETERMINED AFTER 2 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 864.4
2. HOLE STABILIZED WITH 4" CASING TO EL. 867.4
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-51M
01 AUG 09
G.S. 879.0
W.L. 873.5
0' TO 20.3' (CH) FAT CLAY, MEDIUM STIFF, MOIST, WITH ROOTS, ORGANIC, WITH SMALL CALCAREOUS VEINS AND BLEBS, DARK BROWN TO GRAY, (ALLUVIUM)
20.3' TO 46.5' (CH) FAT CLAY, SOFT, MOIST, HIGH PLASTICITY, DARK GRAY, (BRENNA FORMATION)
46.5' TO 85' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY, (ARGUSVILLE FORMATION)
NOTES:
1. WATER LEVEL DETERMINED AFTER 6 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 864.3
2. HOLE STABILIZED WITH 4" CASING TO EL. 869.3
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers
ST. PAUL DISTRICT
DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:
DATE:
SOLICITATION NO.:
CONTRACT NO.:
FILE NUMBER:
PLOT DATE:
PLOT SCALE:
SIZE:
FILE NAME:
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO, NORTH DAKOTA AND MOORHEAD, MINNESOTA
BORING LOGS
SHEET 1 OF 3
09-48M - 09-51M
SHEET IDENTIFICATION
B-205


09-52M
01 AUG 09
G.S. 874.3
W.L. 869.3
0' TO 13.5' (CH) FAT CLAY SILTY, MEDIUM STIFF, WET TO MOIST, MEALY, SOME ORGANICS, AND ROOTS, AND SHELLS, BROWN, (ALLUVIUM)
13.5' TO 16.5' (CL) LEAN CLAY SILTY, MEDIUM STIFF, WET TO SATURATED, VARVED, SILT SEAMS, HIGH ANGLE BEDDING, IRON OXIDE STAINING, YELLOWISH BROWN, (BHEMAK FORMATION) (GLACIO-LACUSTRINE)
16.5' TO 21.4' (ML) SILT CLAYEY, MEDIUM STIFF TO STIFF, SATURATED, LAMINATED, CLAY SEAMS, ORGANIC NODULES, IRON OXIDE STAINING, LIGHT YELLOW, (POPLER RIVER F/ WEST FARGO MEMBER) (ALLUVIUM)
21.4' TO 25' (CL) LEAN CLAY SILTY, MEDIUM STIFF TO STIFF, WET TO MOIST, MEALY, SOME ORGANICS, BROWN, (ALLUVIUM)
25' TO 28.7' (CH) FAT CLAY, MEDIUM STIFF TO MEDIUM STIFF, MOIST TO VERY MOIST, BLOCKY, DARK GRAY, (BRENNA FORMATION) (GLACIO-LACUSTRINE)
28.7' TO 42' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, WET, TRACE SILT, FORMS SLICKENSIDES WHEN SHEARED, STICKY, DARK GRAY, (BRENNA FORMATION) (GLACIO-LACUSTRINE)
42' TO 52.5' (CH) FAT CLAY SILTY, SOFT TO MEDIUM STIFF, VERY MOIST, VARVED, BREAKS ON BEDDING, LIGHT GRAY AND DARK GRAY, (BRENNA FORMATION) (GLACIO-LACUSTRINE)
52.5' TO 62' (CH) FAT CLAY SILTY, GRAVEL, FINE SAND FINE TO COARSE, MEDIUM STIFF TO STIFF, WET, MASSIVE, SILT NODULES, STICKY, DARK GRAY, (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
NOTES:
1. WATER LEVEL DETERMINED AFTER 1 HOUR IN OPEN HOLE BOTTOM OF HOLE EL. 864.3
2. HOLE STABILIZED WITH 4" CASING TO EL. 867.9
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-53M
21 AUG 09
G.S. 876.9
W.L. 870.1
0' TO 11.7' (CH) SANDY FAT CLAY, MEDIUM STIFF, MOIST, LITTLE SAND, AND GRAVEL, DARK BROWN WITH TAN, (TOPSOIL)
11.7' TO 19.1' (CL) LEAN CLAY SILTY, MEDIUM STIFF, MOIST, SOME CALCAREOUS VEINS, TANNISH BROWN TO TANNISH GRAY, (ALLUVIUM)
19.1' TO 58.2' (CH) FAT CLAY, SOFT, MOIST, HIGH PLASTICITY, CALCAREOUS BLEBS, DESIGNATED TOP 1.3', SOME SILTY PLANES BELOW 47.2', VERY SILTY 48.9'-50.4', DARK GRAY, (BRENNA FORMATION)
58.2' TO 79' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY, (ARGUSVILLE FORMATION)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 861.9
2. HOLE STABILIZED WITH 4" CASING TO EL. 866.9
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-54M
03 AUG 09
G.S. 876.7
W.L. 869.1
0' TO 20.3' (CH) FAT CLAY SILTY, MEDIUM STIFF, WET TO MOIST, MEALY, SOME ORGANICS, AND ROOTS, AND SHELLS, BROWN, (ALLUVIUM)
28.3' TO 31.2' (ML) SILT CLAYEY, MEDIUM STIFF TO STIFF, SATURATED, LAMINATED, CLAY SEAMS, ORGANIC NODULES, IRON OXIDE STAINING, LIGHT YELLOW, (POPLER RIVER F/ WEST FARGO MEMBER) (ALLUVIUM)
31.2' TO 32' (CH) FAT CLAY, MEDIUM STIFF, MOIST TO VERY MOIST, BLOCKY, DARK GRAY, (DESIGCATED BRENNA FORMATION) (GLACIO-LACUSTRINE)
32' TO 47.8' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, WET, TRACE SILT, FORMS SLICKENSIDES WHEN SHEARED, STICKY, DARK GRAY, (BRENNA FORMATION) (GLACIO-LACUSTRINE)
47.8' TO 57.3' (CH) FAT CLAY SILTY, SOFT, VERY MOIST, VARVED, BREAKS ON BEDDING, LIGHT GRAY AND DARK GRAY, (BRENNA FORMATION) (GLACIO-LACUSTRINE)
57.3' TO 69' (CH) FAT CLAY SILTY, GRAVEL, FINE SAND FINE TO COARSE, MEDIUM STIFF TO STIFF, WET, GRITTY, WITH TILL INCLUSIONS, STICKY, SILT NODULES, DARK GRAY, (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
NOTES:
1. WATER LEVEL DETERMINED AFTER 1 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 869.1
2. HOLE STABILIZED WITH 4" CASING TO EL. 871.8
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-55M
03 AUG 09
G.S. 881.6
W.L. 876.6
0' TO 11.3' (CH) FAT CLAY, MEDIUM STIFF, MOIST, DARK BROWN TO BROWN, (ALLUVIUM)
11.3' TO 30.4' (CH) FAT CLAY, MEDIUM STIFF, MOIST, WITH CALCAREOUS VEINS, TANNISH BROWN TO TANNISH GRAY, (ALLUVIUM)
30.4' TO 35.7' (CH) FAT CLAY, MEDIUM STIFF, MOIST, LAMINATED, TANNISH BROWN AND GRAY
35.7' TO 53.2' (CH) FAT CLAY, SOFT, MOIST, HIGH PLASTICITY, OCCASIONAL CALCAREOUS BLEBS, DESIGNATED TOP 2', SOME SILTY PLANES BELOW 47.2', VERY SILTY 48.8'-50.4', DARK GRAY, (BRENNA FORMATION)
53.2' TO 65' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY, (ARGUSVILLE FORMATION)
NOTES:
1. WATER LEVEL DETERMINED AFTER 7 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 869.8
2. HOLE STABILIZED WITH 4" CASING TO EL. 871.8
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers St. Paul District
LIST OF DRAWINGS
DESCRIPTION
DATE
APPR. BY
DRAWN BY:
CHKD BY:
DESIGNED BY:
CONTRACT NO.:
PLOT SCALE:
PLOT DATE:
FILE NAME:
NO.
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO-MOORHEAD, NORTH DAKOTA AND MINNESOTA
FARGO, ND
BORING LOGS
FA-02
09-52M - 09-55M
SHEET IDENTIFICATION
B-206

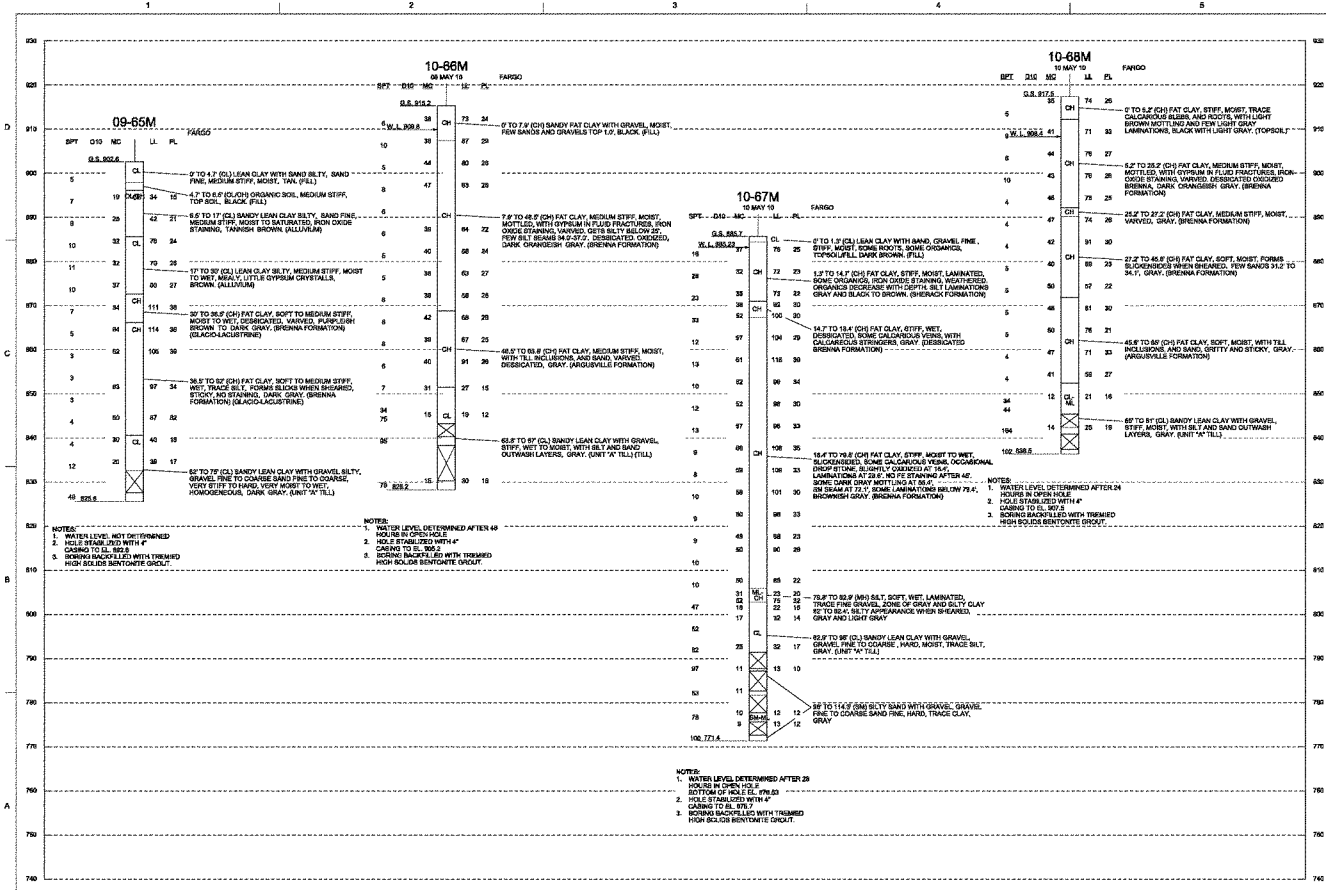
1498



Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Attachment I-3, pg 7
Geotechnical Design and Geology
1499


09-61M
04 DEC 09
G.S. 919.2
0' TO 7.4' (CH) FAT CLAY, MEDIUM STIFF, MOIST, MEALY, WITH ROOTS, AND SILT INCLUSIONS, AND SILT VEINS, BLACK TO BROWNISH GRAY. (TOPSOIL)
7.4' TO 23.5' (CH) FAT CLAY, SOFT, MOIST, WITH GYPSUM CRYSTALS, AND FE NODULES, IRON OXIDE STAINING, ORANGISH BROWN TO GRAY. (DESSICATED BRENNA FORMATION)
23.5' TO 37' (CH) FAT CLAY, SOFT, MOIST, VARVED, DARK GRAY. (BRENNA FORMATION)
37' TO 66.9' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH DROP STONES, AND TILL INCLUSIONS, WITH SILTY OXIDIZED ZONES, DARK GRAY. (ARGUSVILLE FORMATION)
66.9' TO 79' (CL) SANDY LEAN CLAY WITH GRAVEL, HARD, MOIST, GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL NOT DETERMINED
2. HOLE STABILZED WITH 4" CASING TO EL. 859.2
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-62M
G.S. 893.1
0' TO 0.7' (GC) CLAYEY GRAVEL WITH SAND, DENSE, DRY, ROAD BASE, BROWN. (FILL)
0.7' TO 3.7' (OL/CH) ORGANIC SOIL, MEDIUM STIFF, TOP SOIL, BLACK. (FILL)
3.7' TO 8' (CL) LEAN CLAY SILTY, MEDIUM STIFF, MOIST TO WET, LITTLE ROOTS, BROWN. (ALLUVIUM)
8' TO 10' (CH) FAT CLAY SILTY, MEDIUM STIFF, WET TO SATURATED, VARVED, GYPSUM CRYSTALS, IRON OXIDE STAINING, REDDISH BROWN. (SHERACK FORMATION) (GLACIO-LACUSTRINE)
10' TO 66.9' (CH) FAT CLAY SILTY, MEDIUM STIFF, MOIST TO WET, VARVED, SLICKS IN ZONES, LAMINATED IN ZONES, GRADATIONAL WITH SHERACK FM., IRON OXIDE STAINING, REDDISH BROWN TO DARK GRAY. (BRENNA FORMATION) (GLACIO-LACUSTRINE)
66.9' TO 84.8' (CL) SANDY LEAN CLAY WITH GRAVEL, SILTY, GRAVEL FINE TO COARSE SAND FINE TO COARSE, VERY STIFF TO HARD, VERY MOIST TO WET, HOMOGENEOUS, DARK GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS
BOTTOM OF AUGER EL. 875.1
BOTTOM OF HOLE EL. 866.1
2. HOLE STABILIZED WITH 4" CASING TO EL. 863.1
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-63M
-05 DEC 09
G.S. 923.7
0' TO 8.4' (CH) FAT CLAY, MOIST, BLOCKY TO MEALY, OCCASIONAL SAND, AND GRAVEL, DARK BROWNISH BLACK. (TOPSOIL)
8.4' TO 12.8' (CH) FAT CLAY, MOIST, MEALY, WITH GYPSUM CRYSTALS, BROWNISH GRAY. (ALLUVIUM)
12.8' TO 20' (CH) FAT CLAY, MOIST, BLOCKY, WITH GYPSUM CRYSTALS, ORANGERSH BROWN AND GRAY. (DESSICATED BRENNA FORMATION)
20' TO 35' (CH) FAT CLAY, MOIST, FORMS SLICKENSIDES WHEN SHEARED, WITH SILT STRATA OR LENSES, DARK GRAY. (BRENNA FORMATION)
35' TO 52.5' (CH) FAT CLAY, MOIST, FORMS SLICKENSIDES WHEN SHEARED, WITH DROP STONES, AND TILL INCLUSIONS, DARK GRAY. (ARGUSVILLE FORMATION)
52.5' TO 64.7' (CL) SANDY LEAN CLAY WITH GRAVEL, STIFF TO VERY STIFF, MOIST, STIFF TILL, DARK GRAY. (TILL)
64.7' TO 74' (CL) SANDY LEAN CLAY WITH GRAVEL, HARD, MOIST, DARK GRAY. (UNIT "A" TILL) (TILL)
NOTES:
1. WATER LEVEL NOT DETERMINED
2. HOLE STABILIZED WITH 4" CASING TO EL. 850.7
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-64M
G.S. 898.3
0' TO 1.2' ROAD FILL
1.2' TO 2.9' (OL/CH) ORGANIC SOIL, MEDIUM STIFF, TOP SOIL, BLACK. (FILL)
2.9' TO 9.7' (CL) LEAN CLAY SILTY, MEDIUM STIFF, MOIST TO WET, LITTLE ROOTS, BROWN. (ALLUVIUM)
9.7' TO 12.5' (CH) FAT CLAY SILTY, MEDIUM STIFF, WET TO SATURATED, VARVED, GYPSUM CRYSTALS, IRON OXIDE STAINING, REDDISH BROWN. (SHERACK FORMATION) (GLACIO-LACUSTRINE)
12.5' TO 13.3' (CH/CL) FAT CLAY/LEAN CLAY SILTY, MEDIUM STIFF, VERY MOIST, MEALY, REDDISH BROWN. (ALLUVIUM)
13.3' TO 14.2' (SP-SM) POORLY GRADED SAND WITH SILT, SAND FINE TO MEDIUM, LOOSE, SATURATED, IRON OXIDE STAINING, DARK REDDISH BROWN. (POPLAR RIVER F / WEST FARGO MEMBER) (ALLUVIUM)
14.2' TO 67.7' (CH) FAT CLAY, MEDIUM STIFF TO MEDIUM STIFF, MOIST TO VERY MOIST, BLOCKY, DARK GRAY. (BRENNA FORMATION) (GLACIO-LACUSTRINE)
67.7' TO 81.2' (CL) SANDY LEAN CLAY WITH GRAVEL, SILTY, GRAVEL FINE TO COARSE SAND FINE TO COARSE, VERY STIFF TO HARD, VERY MOIST TO WET, HOMOGENEOUS, DARK GRAY. (UNIT "A" TILL) (TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS
BOTTOM OF AUGER EL. 895.3
BOTTOM OF HOLE EL. 889.3
2. HOLE STABILIZED WITH 4" CASING TO EL. 894.3
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers
ST. PAUL DISTRICT
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO NORTH DAKOTA AND MOORHEAD MINNESOTA
FARGO, ND
BORING LOGS
TH-09-01
09-61M, 09-62M, 09-63M, 09-64M
SHEET IDENTIFICATION
B-208

1500



US Army Corps of Engineers
ST. PAUL DISTRICT

LEVEL	DESCRIPTION	DATE	APVD	DESCRIPTION	DATE	APVD

DESIGNED BY: | DATE: 08 May 19
DRAWN BY: | CHKD BY: | SOLICITATION NO.:
SUBMITTED BY: | CONTRACT NO.:
PLOT SCALE: | PLOT DATE: | FILE NAME:
SIZE: 22 x 34 ANSI
SHEET NAME: 09-65M_10-86M_10-67M_10-68M

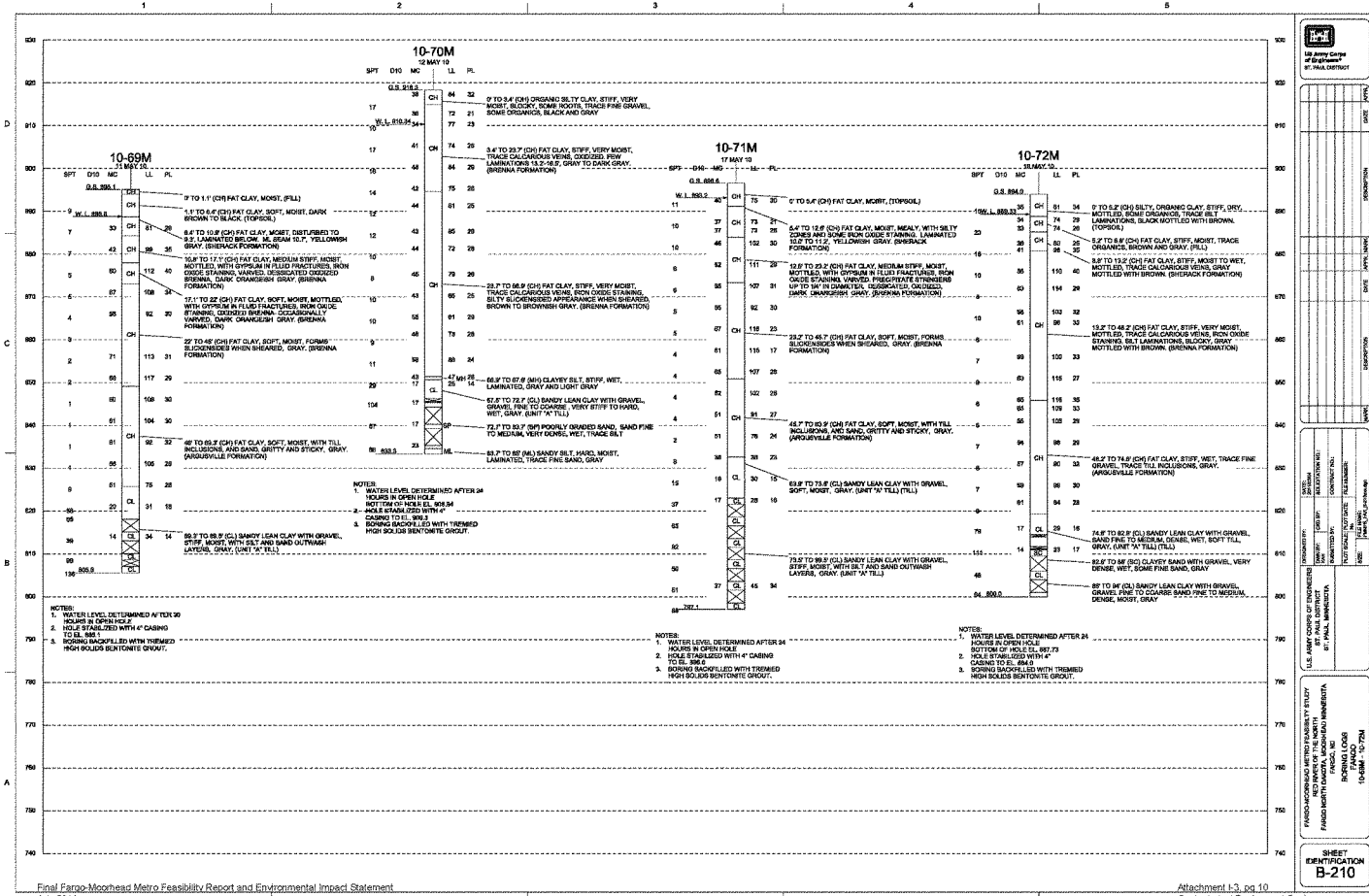
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

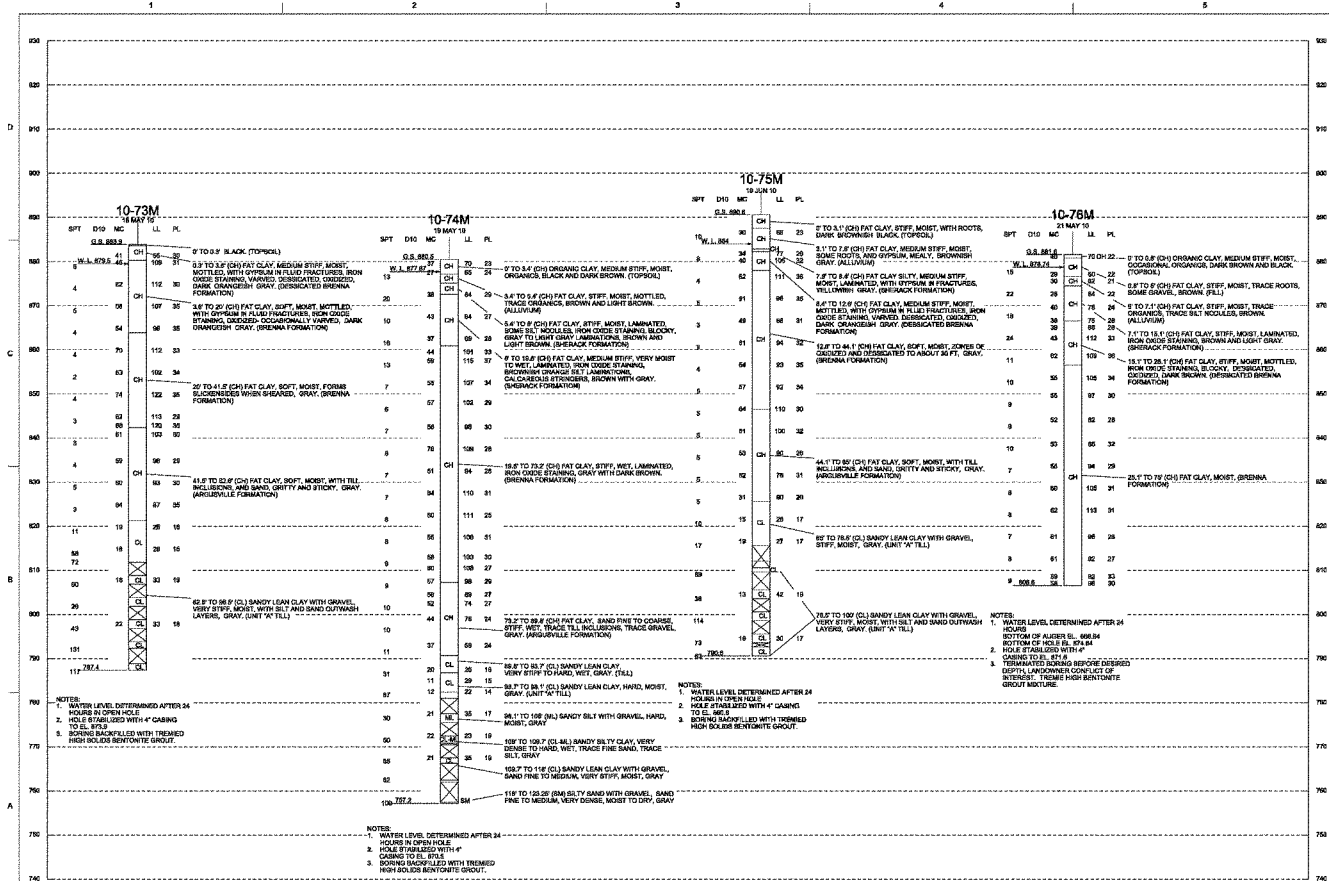
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO-NORTH DAKOTA & MOORHEAD-MINNESOTA
FARGO, ND

BORING LOGS
09-65M, 10-86M
10-67M, 10-68M

SHEET IDENTIFICATION
B-209

1501


10-69M
11 MAY 10
10-70M
12 MAY 10
10-71M
17 MAY 10
10-72M
11 MAY 10
SPT D10 MC LL PL
0 TO 1.1' (CH) FAT CLAY, MOIST, (FILL)
1.1' TO 6.4' (CH) FAT CLAY, SOFT, MOIST, DARK BROWN TO BLACK, (TOPSOIL)
6.4' TO 10.8' (CH) FAT CLAY, MOIST, DISTURBED TO 9.2', LAMINATED BELOW, ML SEAM 10.7', YELLOWISH GRAY, (SHERACK FORMATION)
10.8' TO 17.1' (CH) FAT CLAY, MEDIUM STIFF, MOIST, MOTTLED, WITH GYPSUM IN FLUID FRACTURES, IRON OXIDE STAINING, VARVED, DESSICATED OXIDIZED BRIENNA, DARK ORANGEISH GRAY, (BRIENNA FORMATION)
17.1' TO 22' (CH) FAT CLAY, SOFT, MOIST, MOTTLED, WITH GYPSUM IN FLUID FRACTURES, IRON OXIDE STAINING, OXIDIZED BRIENNA, OCCASIONALLY VARVED, DARK ORANGEISH GRAY, (BRIENNA FORMATION)
22' TO 49' (CH) FAT CLAY, SOFT, MOIST, FORMS SLICKENSIDES WHEN SHEARED, GRAY, (BRIENNA FORMATION)
49' TO 59.3' (CH) FAT CLAY, SOFT, MOIST, WITH TILL INCLUSIONS, AND SAND, GRITTY AND STICKY, GRAY, (ARGUSVILLE FORMATION)
59.3' TO 68.9' (CL) SANDY LEAN CLAY WITH GRAVEL, STIFF, MOIST, WITH SILT AND SAND OUTWASH LAYERS, GRAY, (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE
2. HOLE STABILIZED WITH 4" CASING TO EL. 888.1
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
0' TO 3.4' (CH) ORGANIC SILTY CLAY, STIFF, VERY MOIST, BLOCKY, SOME ROOTS, TRACE FINE GRAVEL, SOME ORGANICS, BLACK AND GRAY
3.4' TO 23.7' (CH) FAT CLAY, STIFF, VERY MOIST, TRACE CALCAROUS VEINS, OXIDIZED, FEW LAMINATIONS 13.2'-16.5', GRAY TO DARK GRAY, (BRIENNA FORMATION)
23.7' TO 56.9' (CH) FAT CLAY, STIFF, VERY MOIST, TRACE CALCAROUS VEINS, IRON OXIDE STAINING, SILTY SLICKENSIDED APPEARANCE WHEN SHEARED, BROWN TO BROWNISH GRAY, (BRIENNA FORMATION)
56.9' TO 67.9' (MH) CLAYEY SILT, STIFF, WET, LAMINATED, GRAY AND LIGHT GRAY
67.9' TO 72.7' (CL) SANDY LEAN CLAY WITH GRAVEL, GRAVEL FINE TO COARSE, VERY STIFF TO HARD, WET, GRAY, (UNIT "A" TILL)
72.7' TO 83.7' (SP) POORLY GRADED SAND, SAND FINE TO MEDIUM, VERY DENSE, WET, TRACE SILT
83.7' TO 87' (ML) SANDY SILT, HARD, MOIST, LAMINATED, TRACE FINE SAND, GRAY
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE
BOTTOM OF HOLE EL. 908.94
2. HOLE STABILIZED WITH 4" CASING TO EL. 909.3
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
0' TO 5.4' (CH) FAT CLAY, MOIST, (TOPSOIL)
5.4' TO 12.8' (CH) FAT CLAY, MOIST, MEALY, WITH SILTY ZONES AND SOME IRON OXIDE STAINING, LAMINATED 10.2' TO 11.3', YELLOWISH GRAY, (SHERACK FORMATION)
12.8' TO 23.2' (CH) FAT CLAY, MEDIUM STIFF, MOIST, MOTTLED, WITH GYPSUM IN FLUID FRACTURES, IRON OXIDE STAINING, VARVED, PRECIPITATE STRINGERS UP TO 1/4" IN DIAMETER, DESSICATED, OXIDIZED, DARK ORANGEISH GRAY, (BRIENNA FORMATION)
23.2' TO 45.7' (CH) FAT CLAY, SOFT, MOIST, FORMS SLICKENSIDES WHEN SHEARED, GRAY, (BRIENNA FORMATION)
45.7' TO 63.9' (CH) FAT CLAY, SOFT, MOIST, WITH TILL INCLUSIONS, AND SAND, GRITTY AND STICKY, GRAY, (ARGUSVILLE FORMATION)
63.9' TO 73.8' (CL) SANDY LEAN CLAY WITH GRAVEL, SOFT, MOIST, GRAY, (UNIT "A" TILL) (TILL)
73.8' TO 99.3' (CL) SANDY LEAN CLAY WITH GRAVEL, STIFF, MOIST, WITH SILT AND SAND OUTWASH LAYERS, GRAY, (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE
BOTTOM OF HOLE EL. 897.73
2. HOLE STABILIZED WITH 4" CASING TO EL. 894.0
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
0' TO 5.2' (CH) SILTY, ORGANIC CLAY, STIFF, DRY, MOTTLED, SOME ORGANICS, TRACE SILT LAMINATIONS, BLACK MOTTLED WITH BROWN, (TOPSOIL)
5.2' TO 8.8' (CH) FAT CLAY, STIFF, MOIST, TRACE ORGANICS, BROWN AND GRAY, (FILL)
8.8' TO 13.2' (CH) FAT CLAY, STIFF, MOIST TO WET, MOTTLED, TRACE CALCAROUS VEINS, GRAY MOTTLED WITH BROWN, (SHERACK FORMATION)
13.2' TO 48.2' (CH) FAT CLAY, STIFF, VERY MOIST, MOTTLED, TRACE CALCAROUS VEINS, IRON OXIDE STAINING, SILT LAMINATIONS, BLOCKY, GRAY MOTTLED WITH BROWN, (BRIENNA FORMATION)
48.2' TO 74.8' (CH) FAT CLAY, STIFF, WET, TRACE FINE GRAVEL, TRACE TILL INCLUSIONS, GRAY, (ARGUSVILLE FORMATION)
74.8' TO 82.8' (CL) SANDY LEAN CLAY WITH GRAVEL, SAND FINE TO MEDIUM, DENSE, WET, SOFT TILL, GRAY, (UNIT "A" TILL) (TILL)
82.8' TO 88' (SC) CLAYEY SAND WITH GRAVEL, VERY DENSE, WET, SOME FINE SAND, GRAY
88' TO 94' (CL) SANDY LEAN CLAY WITH GRAVEL, GRAVEL FINE TO COARSE SAND FINE TO MEDIUM, DENSE, MOIST, GRAY
US Army Corps of Engineers
ST. PAUL DISTRICT
DATE
DESCRIPTION
DATE
DESCRIPTION
DATE
DESCRIPTION
SYSTEM
SOLICITATION NO.:
CONTRACT NO.:
FILE NUMBER:
DRAWN BY:
CHK BY:
DATE:
DESIGNED BY:
PLOT SCALE:
PLOT DATE:
MED
FILE NAME:
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO, ND
FARGO NORTH DAKOTA AND MOORHEAD MINNESOTA
BORING LOGS
FM
10-69M, 10-70M
10-71M, 10-72M
SHEET IDENTIFICATION
B-210


10-73M
16 MAY 10
10-74M
19 MAY 10
10-75M
19 JUN 10
10-76M
21 MAY 10
SPT D10 MC LL PL
0' TO 0.3' BLACK. (TOPSOIL)
0.3' TO 3.0' (CH) FAT CLAY, MEDIUM STIFF, MOIST, MOTTLED, WITH GYPSUM IN FLUID FRACTURES, IRON OXIDE STAINING, VARVED, DESSICATED, OXIDIZED, DARK ORANGEISH GRAY. (DESSICATED BRENNA FORMATION)
3.0' TO 20' (CH) FAT CLAY, SOFT, MOIST, MOTTLED, WITH GYPSUM IN FLUID FRACTURES, IRON OXIDE STAINING, OXIDIZED- OCCASIONALLY VARVED, DARK ORANGEISH GRAY. (BRENNA FORMATION)
20' TO 41.5' (CH) FAT CLAY, SOFT, MOIST, FORMS SLICKENSIDES WHEN SHEARED, GRAY. (BRENNA FORMATION)
41.5' TO 62.9' (CH) FAT CLAY, SOFT, MOIST, WITH TILL INCLUSIONS, AND SAND, GRITTY AND STICKY. GRAY. (ARGUSVILLE FORMATION)
62.9' TO 66.5' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, WITH SILT AND SAND OUTWASH LAYERS, GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE
2. HOLE STABILIZED WITH 4" CASING TO EL. 873.3
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
0' TO 3.4' (CH) ORGANIC CLAY, MEDIUM STIFF, MOIST, ORGANICS, BLACK AND DARK BROWN. (TOPSOIL)
3.4' TO 9.4' (CH) FAT CLAY, STIFF, MOIST, MOTTLED, TRACE ORGANICS, BROWN AND LIGHT BROWN. (ALLUVIUM)
9.4' TO 9' (CH) FAT CLAY, STIFF, MOIST, LAMINATED, SOME SILT NODULES, IRON OXIDE STAINING, BLOCKY, GRAY TO LIGHT GRAY LAMINATIONS, BROWN AND LIGHT BROWN. (SHERACK FORMATION)
9' TO 15.8' (CH) FAT CLAY, MEDIUM STIFF, VERY MOIST TO WET, LAMINATED, IRON OXIDE STAINING, BROWNISH ORANGE SILT LAMINATIONS, CALCAREOUS STRINGERS, BROWN WITH GRAY. (SHERACK FORMATION)
15.8' TO 73.2' (CH) FAT CLAY, STIFF, WET, LAMINATED, IRON OXIDE STAINING, GRAY WITH DARK BROWN. (BRENNA FORMATION)
73.2' TO 89.8' (CH) FAT CLAY, SAND FINE TO COARSE, STIFF, WET, TRACE TILL INCLUSIONS, TRACE GRAVEL, GRAY. (ARGUSVILLE FORMATION)
89.8' TO 93.7' (CL) SANDY LEAN CLAY, VERY STIFF TO HARD, WET, GRAY. (TILL)
93.7' TO 99.1' (CL) SANDY LEAN CLAY, HARD, MOIST, GRAY. (UNIT "A" TILL)
99.1' TO 109' (ML) SANDY SILT WITH GRAVEL, HARD, MOIST, GRAY
109' TO 109.7' (CL-ML) SANDY SILTY CLAY, VERY DENSE TO HARD, WET, TRACE FINE SAND, TRACE SILT, GRAY
109.7' TO 118' (CL) SANDY LEAN CLAY WITH GRAVEL, SAND FINE TO MEDIUM, VERY STIFF, MOIST, GRAY
118' TO 123.25' (SM) SILTY SAND WITH GRAVEL, SAND FINE TO MEDIUM, VERY DENSE, MOIST TO DRY, GRAY
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE
2. HOLE STABILIZED WITH 4" CASING TO EL. 865.8
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
0' TO 3.1' (CH) FAT CLAY, STIFF, MOIST, WITH ROOTS, DARK BROWNISH BLACK. (TOPSOIL)
3.1' TO 7.8' (CH) FAT CLAY, MEDIUM STIFF, MOIST, SOME ROOTS, AND GYPSUM, MEALY, BROWNISH GRAY. (ALLUVIUM)
7.8' TO 8.4' (CH) FAT CLAY SILTY, MEDIUM STIFF, MOIST, LAMINATED, WITH GYPSUM IN FRACTURES, YELLOWISH GRAY. (SHERACK FORMATION)
8.4' TO 12.6' (CH) FAT CLAY, MEDIUM STIFF, MOIST, MOTTLED, WITH GYPSUM IN FLUID FRACTURES, IRON OXIDE STAINING, VARVED, DESSICATED, OXIDIZED, DARK ORANGEISH GRAY. (DESSICATED BRENNA FORMATION)
12.6' TO 44.1' (CH) FAT CLAY, SOFT, MOIST, ZONES OF OXIDIZED AND DESSICATED TO ABOUT 30 FT. GRAY. (BRENNA FORMATION)
44.1' TO 65' (CH) FAT CLAY, SOFT, MOIST, WITH TILL INCLUSIONS, AND SAND, GRITTY AND STICKY. GRAY. (ARGUSVILLE FORMATION)
65' TO 78.6' (CL) SANDY LEAN CLAY WITH GRAVEL, STIFF, MOIST, GRAY. (UNIT "A" TILL)
78.6' TO 100' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, WITH SILT AND SAND OUTWASH LAYERS, GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS
BOTTOM OF AUGER EL. 868.84
BOTTOM OF HOLE EL. 874.84
2. HOLE STABILIZED WITH 4" CASING TO EL. 871.6
3. TERMINATED BORING BEFORE DESIRED DEPTH, LANDOWNER CONFLICT OF INTEREST. TREMIE HIGH BENTONITE GROUT MIXTURE.
0' TO 0.8' (CH) ORGANIC CLAY, MEDIUM STIFF, MOIST, OCCASIONAL ORGANICS, DARK BROWN AND BLACK. (TOPSOIL)
0.8' TO 8' (CH) FAT CLAY, STIFF, MOIST, TRACE ROOTS, SOME GRAVEL, BROWN. (FILL)
8' TO 7.1' (CH) FAT CLAY, STIFF, MOIST, TRACE ORGANICS, TRACE SILT NODULES, BROWN. (ALLUVIUM)
7.1' TO 15.1' (CH) FAT CLAY, STIFF, MOIST, LAMINATED, IRON OXIDE STAINING, BROWN AND LIGHT GRAY. (SHERACK FORMATION)
15.1' TO 25.1' (CH) FAT CLAY, STIFF, MOIST, MOTTLED, IRON OXIDE STAINING, BLOCKY, DESSICATED, OXIDIZED, DARK BROWN. (DESSICATED BRENNA FORMATION)
25.1' TO 79' (CH) FAT CLAY, MOIST, (BRENNA FORMATION)
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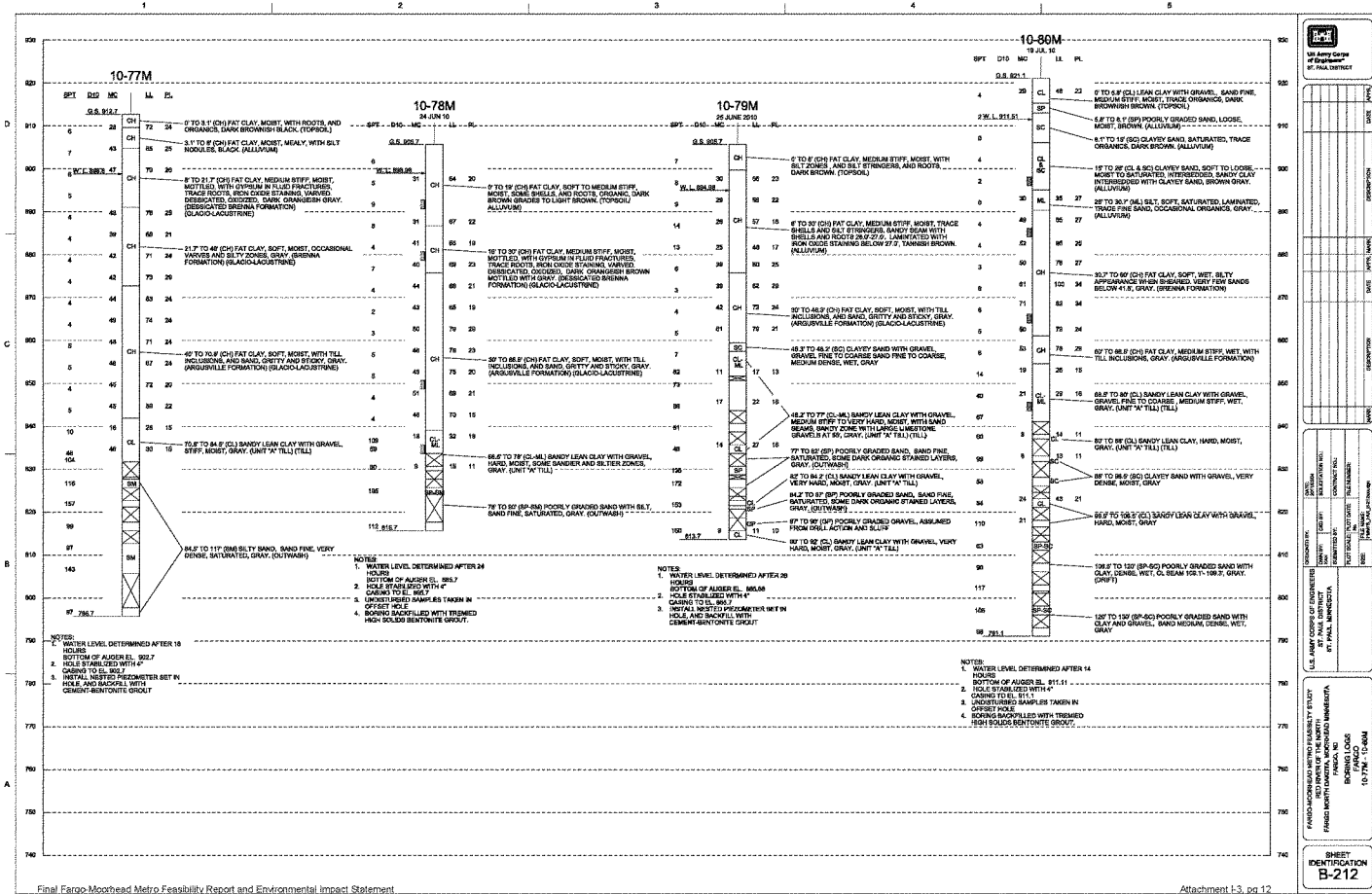
ST. PAUL DISTRICT
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO-NORTH MOORHEAD, NORTH DAKOTA/MINNESOTA
FARGO, ND
BORING LOGS
SHEET 1 OF 2
10-73M, 10-74M
SHEET IDENTIFICATION
B-211


10-77M
G.S. 912.7
0' TO 3.1' (CH) FAT CLAY, MOIST, WITH ROOTS, AND ORGANICS, DARK BROWNISH BLACK, (TOPSOIL)
3.1' TO 8' (CH) FAT CLAY, MOIST, MEALY, WITH SILT NODULES, BLACK, (ALLUVIUM)
8' TO 21.7' (CH) FAT CLAY, MEDIUM STIFF, MOIST, MOTTLED, WITH GYPSUM IN FLUID FRACTURES, TRACE ROOTS, IRON OXIDE STAINING, VARVED, DESSICATED, OXIDIZED, DARK ORANGEISH GRAY, (DESSICATED BRENNA FORMATION) (GLACIO-LACUSTRINE)
21.7' TO 46' (CH) FAT CLAY, SOFT, MOIST, OCCASIONAL VARVES AND SILTY ZONES, GRAY (BRENNA FORMATION) (GLACIO-LACUSTRINE)
46' TO 70.8' (CH) FAT CLAY, SOFT, MOIST, WITH TILL INCLUSIONS, AND SAND, GRITTY AND STICKY, GRAY, (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
70.8' TO 84.5' (CL) SANDY LEAN CLAY WITH GRAVEL, STIFF, MOIST, GRAY, (UNIT "A" TILL) (TILL)
84.5' TO 117' (SM) SILTY SAND, SAND FINE, VERY DENSE, SATURATED, GRAY, (OUTWASH)
NOTES:
1. WATER LEVEL DETERMINED AFTER 18 HOURS
BOTTOM OF AUGER EL. 902.7
2. HOLE STABILIZED WITH 4" CASING TO EL. 902.7
3. INSTALL NESTED PIEZOMETER SET IN HOLE, AND BACKFILL WITH CEMENT-BENTONITE GROUT
10-78M
24 JUN 10
G.S. 925.7
W.L. 898.98
0' TO 19' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, MOIST, SOME SHELLS, AND ROOTS, ORGANIC, DARK BROWN GRADED TO LIGHT BROWN, (TOPSOIL/ ALLUVIUM)
19' TO 30' (CH) FAT CLAY, MEDIUM STIFF, MOIST, MOTTLED, WITH GYPSUM IN FLUID FRACTURES, TRACE ROOTS, IRON OXIDE STAINING, VARVED, DESSICATED, OXIDIZED, DARK ORANGEISH BROWN MOTTLED WITH GRAY, (DESSICATED BRENNA FORMATION) (GLACIO-LACUSTRINE)
30' TO 55.5' (CH) FAT CLAY, SOFT, MOIST, WITH TILL INCLUSIONS, AND SAND, GRITTY AND STICKY, GRAY, (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
55.5' TO 78' (CL-ML) SANDY LEAN CLAY WITH GRAVEL, HARD, MOIST, SOME SANDIER AND SILTIER ZONES, GRAY, (UNIT "A" TILL)
78' TO 92' (SP-SM) POORLY GRADED SAND WITH SILT, SAND FINE, SATURATED, GRAY, (OUTWASH)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS
BOTTOM OF AUGER EL. 895.7
2. HOLE STABILIZED WITH 4" CASING TO EL. 895.7
3. UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-79M
25 JUNE 2010
G.S. 915.7
W.L. 894.28
0' TO 8' (CH) FAT CLAY, MEDIUM STIFF, MOIST, WITH SILT JONES , AND SILT STRINGERS, AND ROOTS , DARK BROWN, (TOPSOIL)
8' TO 30' (CH) FAT CLAY, MEDIUM STIFF, MOIST, TRACE SHELLS AND SILT STRINGERS, SANDY SEAM WITH SHELLS AND ROOTS 26.0'-27.0', LAMINATED WITH IRON OXIDE STAINING BELOW 27.0', TARNISH BROWN, (ALLUVIUM)
30' TO 46.2' (CH) FAT CLAY, SOFT, MOIST, WITH TILL INCLUSIONS, AND SAND, GRITTY AND STICKY, GRAY, (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
46.2' TO 48.2' (SC) CLAYEY SAND WITH GRAVEL, GRAVEL FINE TO COARSE SAND FINE TO COARSE, MEDIUM DENSE, WET, GRAY
48.2' TO 77' (CL-ML) SANDY LEAN CLAY WITH GRAVEL, MEDIUM STIFF TO VERY HARD, MOIST, WITH SAND SEAMS, SANDY ZONE WITH LARGE LIMESTONE GRAVELS AT 55', GRAY, (UNIT "A" TILL) (TILL)
77' TO 82' (SP) POORLY GRADED SAND, SAND FINE, SATURATED, SOME DARK ORGANIC STAINED LAYERS, GRAY, (OUTWASH)
82' TO 84.2' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY HARD, MOIST, GRAY, (UNIT "A" TILL)
84.2' TO 87' (SP) POORLY GRADED SAND, SAND FINE, SATURATED, SOME DARK ORGANIC STAINED LAYERS, GRAY, (OUTWASH)
87' TO 90' (SP) POORLY GRADED GRAVEL, ASSUMED FROM DRILL ACTION AND SLUFF
90' TO 92' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY HARD, MOIST, GRAY, (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 28 HOURS
BOTTOM OF AUGER EL. 865.68
2. HOLE STABILIZED WITH 4" CASING TO EL. 865.7
3. INSTALL 1/2"STEEL PIEZOMETER SET IN HOLE, AND BACKFILL WITH CEMENT-BENTONITE GROUT
10-80M
19 JUL 10
G.S. 921.1
2' W.L. 911.51
0' TO 5.8' (CL) LEAN CLAY WITH GRAVEL, SAND FINE, MEDIUM STIFF, MOIST, TRACE ORGANICS, DARK BROWNISH BROWN, (TOPSOIL)
5.8' TO 8.1' (SP) POORLY GRADED SAND, LOOSE, MOIST, BROWN, (ALLUVIUM)
8.1' TO 19' (SC) CLAYEY SAND, SATURATED, TRACE ORGANICS, DARK BROWN, (ALLUVIUM)
19' TO 28' (CL & SC) CLAYEY SAND, SOFT TO LOOSE, MOIST TO SATURATED, INTERBEDDED, SANDY CLAY INTERBEDDED WITH CLAYEY SAND, BROWN GRAY, (ALLUVIUM)
28' TO 30.7' (ML) SILT, SOFT, SATURATED, LAMINATED, TRACE FINE SAND, OCCASIONAL ORGANICS, GRAY , (ALLUVIUM)
30.7' TO 66' (CH) FAT CLAY, SOFT, WET, SILTY APPEARANCE WHEN SHEARED, VERY FEW SANDS BELOW 41.5', GRAY, (BRENNA FORMATION)
66' TO 68.5' (CH) FAT CLAY, MEDIUM STIFF, WET, WITH TILL INCLUSIONS, GRAY, (ARGUSVILLE FORMATION)
68.5' TO 80' (CL) SANDY LEAN CLAY WITH GRAVEL, GRAVEL FINE TO COARSE , MEDIUM STIFF, WET, GRAY, (UNIT "A" TILL) (TILL)
80' TO 88' (CL) SANDY LEAN CLAY, HARD, MOIST, GRAY, (UNIT "A" TILL) (TILL)
88' TO 95.5' (SC) CLAYEY SAND WITH GRAVEL, VERY DENSE, MOIST, GRAY
95.5' TO 106.5' (CL) SANDY LEAN CLAY WITH GRAVEL, HARD, MOIST, GRAY
106.5' TO 120' (SP-SC) POORLY GRADED SAND WITH CLAY, DENSE, WET, OL SEAM 109.1'-109.3', GRAY, (CRIFT)
120' TO 132' (SP-SC) POORLY GRADED SAND WITH CLAY AND GRAVEL, SAND MEDIUM, DENSE, WET, GRAY
NOTES:
1. WATER LEVEL DETERMINED AFTER 14 HOURS
BOTTOM OF AUGER EL. 811.11
2. HOLE STABILIZED WITH 4" CASING TO EL. 811.1
3. UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers
ST. PAUL DISTRICT
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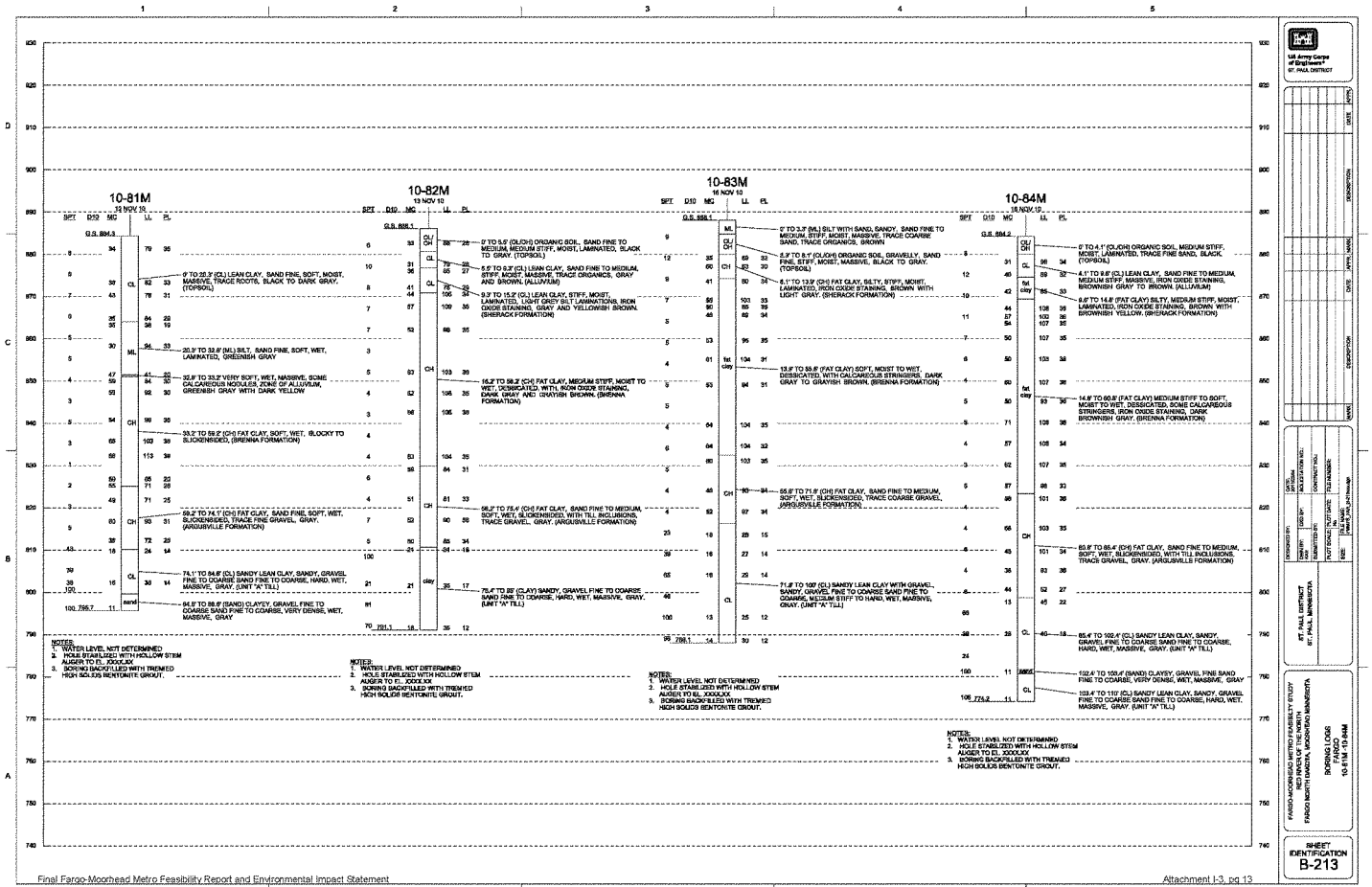
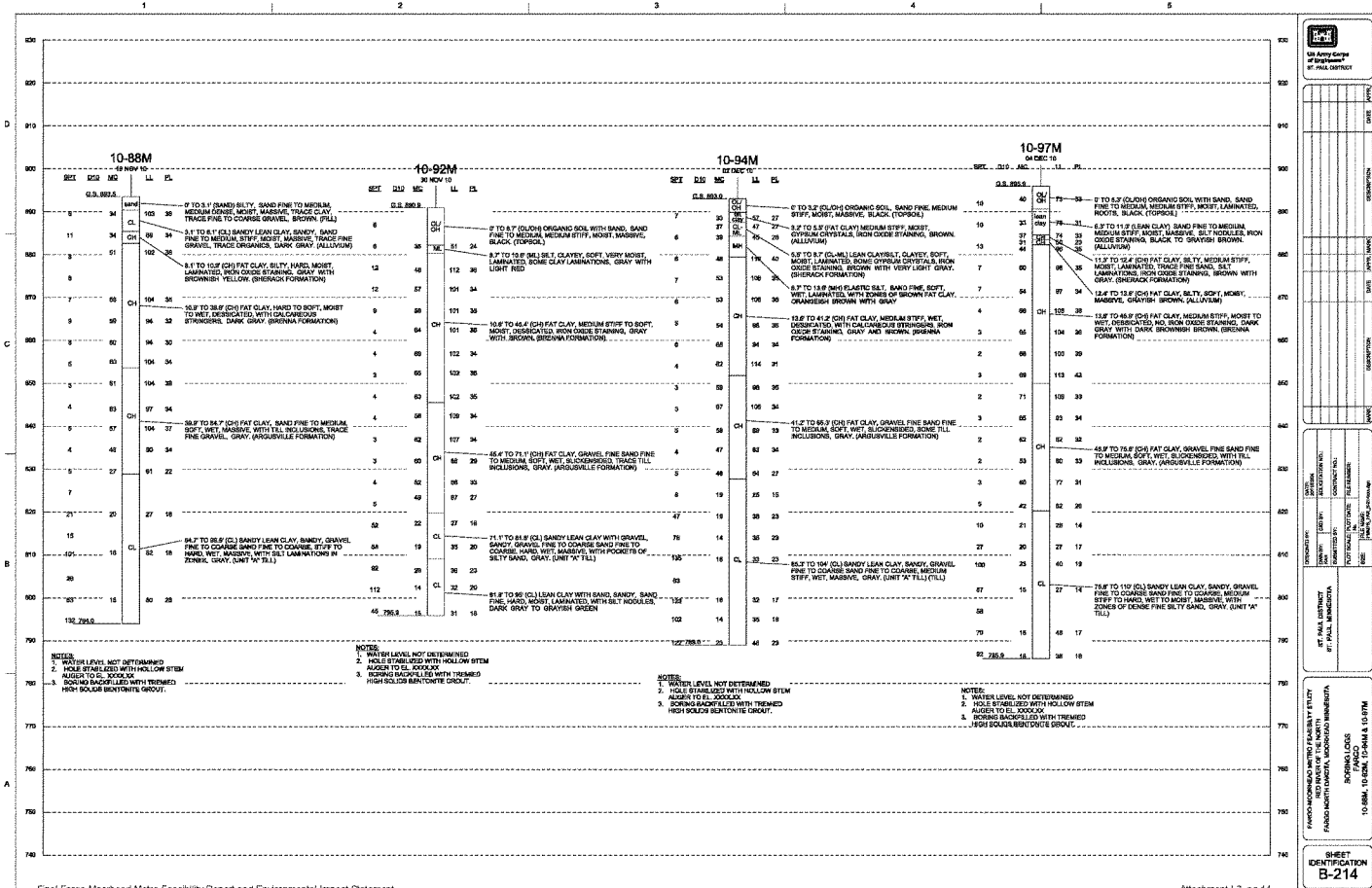
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO NORTH DAKOTA AND MOORHEAD MINNESOTA
BORING LOGS
TH-01
10-77M, 10-78M
10-79M, 10-80M
SHEET IDENTIFICATION
B-212

1504


10-81M
12 NOV 10
G.S. 894.3
9' TO 20.3' (CL) LEAN CLAY, SAND FINE, SOFT, MOIST, MASSIVE, TRACE ROOTS, BLACK TO DARK GRAY. (TOPSOIL)
20.3' TO 32.9' (ML) SILT, SAND FINE, SOFT, WET, LAMINATED, GREENISH GRAY
32.9' TO 33.2' VERY SOFT, WET, MASSIVE, SOME CALCAREOUS NODULES. ZONE OF ALLUVIUM, GREENISH GRAY WITH DARK YELLOW
33.2' TO 59.2' (CH) FAT CLAY, SOFT, WET, BLOCKY TO SLICKENSIDED, (BRENNA FORMATION)
59.2' TO 74.1' (CH) FAT CLAY, SAND FINE, SOFT, WET, SLICKENSIDED, TRACE FINE GRAVEL, GRAY. (ARGUSVILLE FORMATION)
74.1' TO 94.6' (CL) SANDY LEAN CLAY, SANDY, GRAVEL FINE TO COARSE SAND FINE TO COARSE, HARD, WET, MASSIVE, GRAY. (UNIT "A" TILL)
94.6' TO 98.6' (SAND) CLAYEY, GRAVEL FINE TO COARSE SAND FINE TO COARSE, VERY DENSE, WET, MASSIVE, GRAY
NOTES:
1. WATER LEVEL NOT DETERMINED
2. HOLE STABILIZED WITH HOLLOW STEM AUGER TO EL. XXXX.XX
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-82M
13 NOV 10
G.S. 895.1
0' TO 5.5' (OL/OH) ORGANIC SOIL, SAND FINE TO MEDIUM, MEDIUM STIFF, MOIST, LAMINATED, BLACK TO GRAY. (TOPSOIL)
5.5' TO 9.3' (CL) LEAN CLAY, SAND FINE TO MEDIUM, STIFF, MOIST, MASSIVE, TRACE ORGANICS, GRAY AND BROWN. (ALLUVIUM)
9.3' TO 15.2' (CL) LEAN CLAY, STIFF, MOIST, LAMINATED, LIGHT GREY SILT LAMINATIONS, IRON OXIDE STAINING, GRAY AND YELLOWISH BROWN. (SHERACK FORMATION)
15.2' TO 59.2' (CH) FAT CLAY, MEDIUM STIFF, MOIST TO WET, DESSICATED, WITH, IRON OXIDE STAINING, DARK GRAY AND OLIVEISH BROWN. (BRENNA FORMATION)
59.2' TO 75.4' (CH) FAT CLAY, SAND FINE TO MEDIUM, SOFT, WET, SLICKENSIDED, WITH TILL INCLUSIONS, TRACE GRAVEL, GRAY. (ARGUSVILLE FORMATION)
75.4' TO 89' (CLAY) SANDY, GRAVEL FINE TO COARSE SAND FINE TO COARSE, HARD, WET, MASSIVE, GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL NOT DETERMINED
2. HOLE STABILIZED WITH HOLLOW STEM AUGER TO EL. XXXX.XX
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-83M
16 NOV 10
G.S. 895.1
0' TO 3.3' (ML) SILT WITH SAND, SANDY, SAND FINE TO MEDIUM, STIFF, MOIST, MASSIVE, TRACE COARSE SAND, TRACE ORGANICS, BROWN
3.3' TO 8.1' (OL/OH) ORGANIC SOIL, GRAVELLY, SAND FINE, STIFF, MOIST, MASSIVE, BLACK TO GRAY. (TOPSOIL)
8.1' TO 13.9' (CH) FAT CLAY, SILTY, STIFF, MOIST, LAMINATED, IRON OXIDE STAINING, BROWN WITH LIGHT GRAY. (SHERACK FORMATION)
13.9' TO 55.6' (FAT CLAY) SOFT, MOIST TO WET, DESSICATED, WITH CALCAREOUS STRINGERS, DARK GRAY TO GRAYISH BROWN. (BRENNA FORMATION)
55.6' TO 71.9' (CH) FAT CLAY, SAND FINE TO MEDIUM, SOFT, WET, SLICKENSIDED, TRACE COARSE GRAVEL, (ARGUSVILLE FORMATION)
71.9' TO 100' (CL) SANDY LEAN CLAY WITH GRAVEL, SANDY, GRAVEL FINE TO COARSE SAND FINE TO COARSE, MEDIUM STIFF TO HARD, WET, MASSIVE, GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL NOT DETERMINED
2. HOLE STABILIZED WITH HOLLOW STEM AUGER TO EL. XXXX.XX
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-84M
18 NOV 10
G.S. 894.2
0' TO 4.1' (OL/OH) ORGANIC SOIL, MEDIUM STIFF, MOIST, LAMINATED, TRACE FINE SAND, BLACK. (TOPSOIL)
4.1' TO 9.6' (CL) LEAN CLAY, SAND FINE TO MEDIUM, MEDIUM STIFF, MASSIVE, IRON OXIDE STAINING, BROWNISH GRAY TO BROWN. (ALLUVIUM)
9.6' TO 14.8' (FAT CLAY) SILTY, MEDIUM STIFF, MOIST, LAMINATED, IRON OXIDE STAINING, BROWN WITH BROWNISH YELLOW. (SHERACK FORMATION)
14.8' TO 60.8' (FAT CLAY) MEDIUM STIFF TO SOFT, MOIST TO WET, DESSICATED, SOME CALCAREOUS STRINGERS, IRON OXIDE STAINING, DARK BROWNISH GRAY. (BRENNA FORMATION)
60.8' TO 85.4' (CH) FAT CLAY, SAND FINE TO MEDIUM, SOFT, WET, SLICKENSIDED, WITH TILL INCLUSIONS, TRACE GRAVEL, GRAY. (ARGUSVILLE FORMATION)
85.4' TO 102.4' (CL) SANDY LEAN CLAY, SANDY, GRAVEL FINE TO COARSE SAND FINE TO COARSE, HARD, WET, MASSIVE, GRAY. (UNIT "A" TILL)
102.4' TO 105.4' (SAND) CLAYEY, GRAVEL FINE SAND FINE TO COARSE, VERY DENSE, WET, MASSIVE, GRAY
105.4' TO 110' (CL) SANDY LEAN CLAY, SANDY, GRAVEL FINE TO COARSE SAND FINE TO COARSE, HARD, WET, MASSIVE, GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL NOT DETERMINED
2. HOLE STABILIZED WITH HOLLOW STEM AUGER TO EL. XXXX.XX
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO, NORTH DAKOTA, MOORHEAD, MINNESOTA
BORING LOGS
10-81M TO 10-84M
SHEET IDENTIFICATION
B-213



US Army Corps of Engineers® ST. PAUL DISTRICT

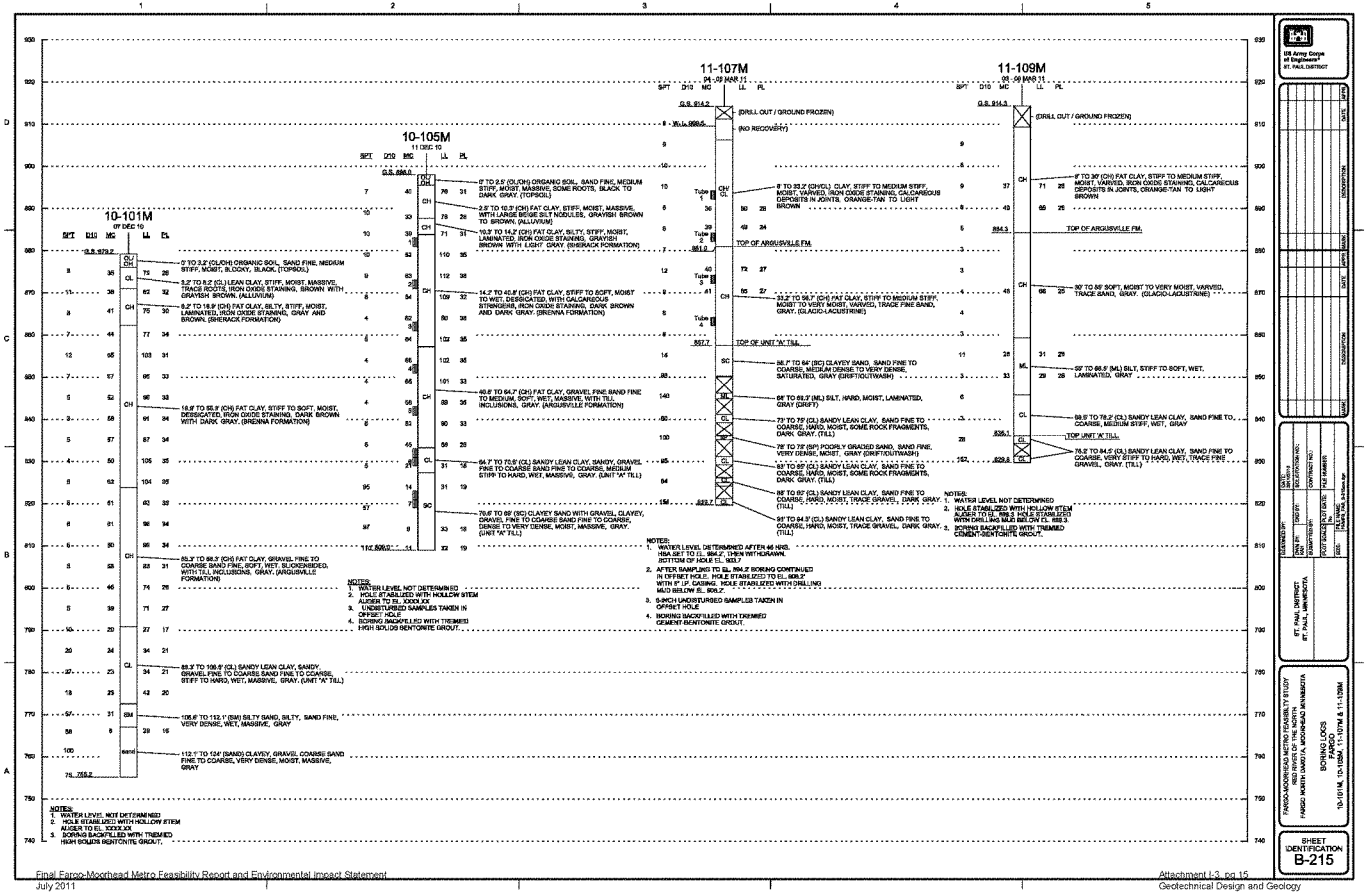
MARK	DESCRIPTION	DATE	APPD.

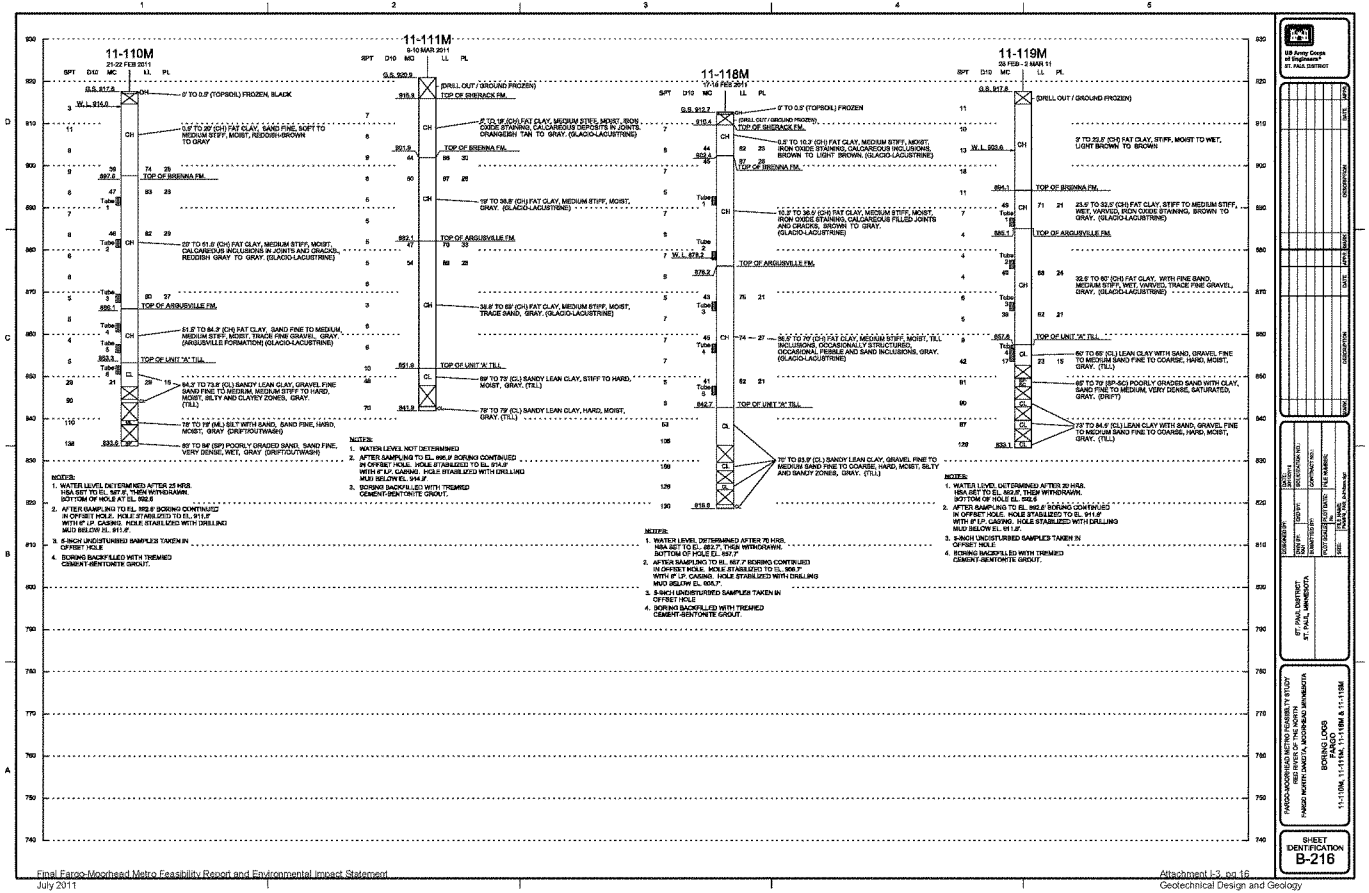
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO NORTH DAKOTA & MOORHEAD MINNESOTA

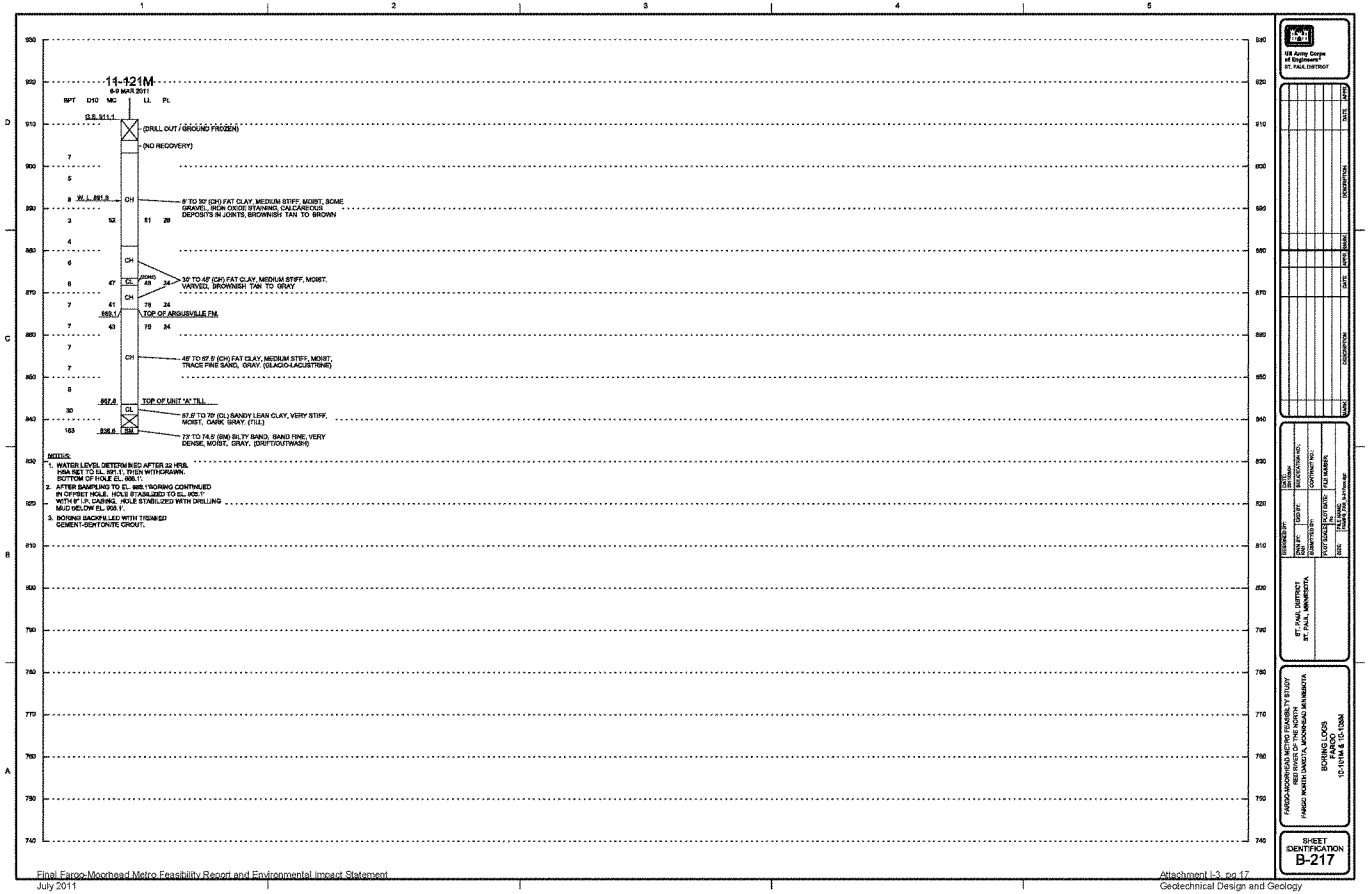
BORING LOGS
FARGO
10-88M, 10-92M, 10-94M & 10-97M

SHEET IDENTIFICATION
B-214


10-101M
07 DEC 10
G.S. 879.2
0' TO 3.2' (OL/OH) ORGANIC SOIL, SAND FINE, MEDIUM STIFF, MOIST, BLOCKY, BLACK, (TOPSOIL)
3.2' TO 8.2' (CL) LEAN CLAY, STIFF, MOIST, MASSIVE, TRACE ROOTS, IRON OXIDE STAINING, BROWN WITH GRAYISH BROWN, (ALLUVIUM)
8.2' TO 18.9' (CH) FAT CLAY, SILTY, STIFF, MOIST, LAMINATED, IRON OXIDE STAINING, GRAY AND BROWN, (BRENNICK FORMATION)
18.9' TO 85.9' (CH) FAT CLAY, STIFF TO SOFT, MOIST, DESICCATED, IRON OXIDE STAINING, DARK BROWN WITH DARK GRAY, (BRENNA FORMATION)
85.9' TO 98.3' (CH) FAT CLAY, GRAVEL FINE TO COARSE SAND FINE, SOFT, WET, SLICKENSIDED, WITH TILL INCLUSIONS, GRAY, (ARGUSVILLE FORMATION)
98.3' TO 106.9' (CL) SANDY LEAN CLAY, SANDY, GRAVEL FINE TO COARSE SAND FINE TO COARSE, STIFF TO HARD, WET, MASSIVE, GRAY, (UNIT "A" TILL)
106.9' TO 112.1' (SM) SILTY SAND, SILTY, SAND FINE, VERY DENSE, WET, MASSIVE, GRAY
112.1' TO 124' (SM/CL) CLAYEY, GRAVEL, COARSE SAND FINE TO COARSE, VERY DENSE, MOIST, MASSIVE, GRAY
NOTES:
1. WATER LEVEL NOT DETERMINED
2. HOLE STABILIZED WITH HOLLOW STEM AUGER TO EL. XXXX.XX
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-105M
11 DEC 10
G.S. 886.0
0' TO 2.5' (OL/OH) ORGANIC SOIL, SAND FINE, MEDIUM STIFF, MOIST, MASSIVE, SOME ROOTS, BLACK TO DARK GRAY, (TOPSOIL)
2.5' TO 10.3' (CH) FAT CLAY, STIFF, MOIST, MASSIVE, WITH LARGE BEIGE SILT NODULES, GRAYISH BROWN TO BROWN, (ALLUVIUM)
10.3' TO 14.2' (CH) FAT CLAY, SILTY, STIFF, MOIST, LAMINATED, IRON OXIDE STAINING, GRAYISH BROWN WITH LIGHT GRAY, (BRENNICK FORMATION)
14.2' TO 40.8' (CH) FAT CLAY, STIFF TO SOFT, MOIST TO WET, DESICCATED, WITH CALCAREOUS STRINGERS, IRON OXIDE STAINING, DARK BROWN AND DARK GRAY, (BRENNA FORMATION)
40.8' TO 64.7' (CH) FAT CLAY, GRAVEL FINE SAND FINE TO MEDIUM, SOFT, WET, MASSIVE, WITH TILL INCLUSIONS, GRAY (ARGUSVILLE FORMATION)
64.7' TO 70.6' (CL) SANDY LEAN CLAY, SANDY, GRAVEL FINE TO COARSE SAND FINE TO COARSE, MEDIUM STIFF TO HARD, WET, MASSIVE, GRAY, (UNIT "A" TILL)
70.6' TO 95' (SC) CLAYEY SAND WITH GRAVEL, CLAYEY, GRAVEL FINE TO COARSE SAND FINE TO COARSE, DENSE TO VERY DENSE, MOIST, MASSIVE, GRAY, (UNIT "A" TILL)
NOTES:
1. WATER LEVEL NOT DETERMINED
2. HOLE STABILIZED WITH HOLLOW STEM AUGER TO EL. XXXX.XX
3. UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
11-107M
04-22 MAR 11
G.S. 914.2
(DRILL OUT / GROUND FROZEN)
(NO RECOVERY)
W.L. 888.5
8' TO 33.2' (CH/CL) CLAY, STIFF TO MEDIUM STIFF, MOIST, VARVED, IRON OXIDE STAINING, CALCAREOUS DEPOSITS IN JOINTS, ORANGE-TAN TO LIGHT BROWN
TOP OF ARGUSVILLE FM.
33.2' TO 56.7' (CH) FAT CLAY, STIFF TO MEDIUM STIFF, MOIST TO VERY MOIST, VARVED, TRACE FINE SAND, GRAY, (GLACIO-LACUSTRINE)
TOP OF UNIT "A" TILL
56.7' TO 64' (SC) CLAYEY SAND, SAND FINE TO COARSE, MEDIUM DENSE TO VERY DENSE, SATURATED, GRAY (DRIFT/OUTWASH)
64' TO 69.7' (ML) SILT, HARD, MOIST, LAMINATED, GRAY (DRIFT)
73' TO 79' (CL) SANDY LEAN CLAY, SAND FINE TO COARSE, HARD, MOIST, SOME ROCK FRAGMENTS, DARK GRAY, (TILL)
79' TO 79' (SP) POORLY GRADED SAND, SAND FINE, VERY DENSE, MOIST, GRAY (DRIFT/OUTWASH)
80' TO 85' (CL) SANDY LEAN CLAY, SAND FINE TO COARSE, HARD, MOIST, SOME ROCK FRAGMENTS, DARK GRAY, (TILL)
88' TO 89' (CL) SANDY LEAN CLAY, SAND FINE TO COARSE, HARD, MOIST, TRACE GRAVEL, DARK GRAY, (TILL)
89' TO 94.5' (CL) SANDY LEAN CLAY, SAND FINE TO COARSE, HARD, MOIST, TRACE GRAVEL, DARK GRAY, (TILL)
NOTES:
1. WATER LEVEL NOT DETERMINED AFTER 48 HRS. HBA SET TO EL. 894.2'. THEN WITH HURAWL BOTTOM OF HOLE EL. 903.7
2. AFTER SAMPLING TO EL. 894.2 BORING CONTINUED IN OFFSET HOLE. HOLE STABILIZED TO EL. 908.3' WITH 8" LP. CASING. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 908.2'.
3. 5-INCH UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.
11-109M
08-09 MAR 11
G.S. 914.3
(DRILL OUT / GROUND FROZEN)
8' TO 30' (CH) FAT CLAY, STIFF TO MEDIUM STIFF, MOIST, VARVED, IRON OXIDE STAINING, CALCAREOUS DEPOSITS IN JOINTS, ORANGE-TAN TO LIGHT BROWN
884.3
TOP OF ARGUSVILLE FM.
30' TO 59' SOFT, MOIST TO VERY MOIST, VARVED, TRACE SAND, GRAY, (GLACIO-LACUSTRINE)
59' TO 69.5' (ML) SILT, STIFF TO SOFT, WET, LAMINATED, GRAY
69.5' TO 78.2' (CL) SANDY LEAN CLAY, SAND FINE TO COARSE, MEDIUM STIFF, WET, GRAY
836.1
TOP UNIT "A" TILL
78.2' TO 94.5' (CL) SANDY LEAN CLAY, SAND FINE TO COARSE, VERY STIFF TO HARD, WET, TRACE FINE GRAVEL, GRAY, (TILL)
829.8
NOTES:
1. WATER LEVEL NOT DETERMINED
2. HOLE STABILIZED WITH HOLLOW STEM AUGER TO EL. 888.3 HOLE STABILIZED WITH DRILLING MUD BELOW EL. 888.3
2. BORING BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.
US Army Corps of Engineers® ST. PAUL DISTRICT
ST. PAUL DISTRICT
FARGO-MOORHEAD METRO FEASIBILITY STUDY
FARGO, NORTH DAKOTA & MOORHEAD, MINNESOTA
BORING LOGS
FARGO
10-101M, 10-105M, 11-107M & 11-109M
SHEET IDENTIFICATION
B-215


11-110M
21-22 FEB 2011
11-111M
9-10 MAR 2011
11-118M
10-16 FEB 2011
11-119M
26 FEB - 2 MAR 11
SPT D10 MC LL PL
G.S. 917.8
0' TO 0.5' (TOPSOIL) FROZEN, BLACK
W.L. 916.0
0.5' TO 20' (CH) FAT CLAY, SAND FINE, SOFT TO MEDIUM STIFF, MOIST, REDDISH-BROWN TO GRAY
TOP OF BRENNA FM.
20' TO 61.5' (CH) FAT CLAY, MEDIUM STIFF, MOIST, CALCAREOUS INCLUSIONS IN JOINTS AND GRAVEL, REDDISH GRAY TO GRAY. (GLACIO-LACUSTRINE)
TOP OF ARGUSVILLE FM.
61.5' TO 84.3' (CH) FAT CLAY, SAND FINE TO MEDIUM, MEDIUM STIFF, MOIST, TRACE FINE GRAVEL, GRAY. (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
TOP OF UNIT "A" TILL
84.3' TO 73.8' (CL) SANDY LEAN CLAY, GRAVEL FINE SAND FINE TO MEDIUM, MEDIUM STIFF TO HARD, MOIST, SILTY AND CLAYEY ZONES, GRAY. (TILL)
73' TO 78' (ML) SILT WITH SAND, SAND FINE, HARD, MOIST, GRAY (DRIFTOUTWASH)
83.5' TO 84' (SP) POORLY GRADED SAND, SAND FINE, VERY DENSE, WET, GRAY (DRIFTOUTWASH)
NOTES:
1. WATER LEVEL DETERMINED AFTER 25 HRS. HSA SET TO EL. 927.8, THEN WITHDRAWN. BOTTOM OF HOLE AT EL. 892.6
2. AFTER SAMPLING TO EL. 892.6' BORING CONTINUED IN OFFSET HOLE. HOLE STABILIZED TO EL. 911.6' WITH 6" LP. CASING. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 911.6'.
3. 5-INCH UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.
(DRILL OUT / GROUND FROZEN)
TOP OF SHERACK FM.
8' TO 18' (CH) FAT CLAY, MEDIUM STIFF, MOIST, IRON OXIDE STAINING, CALCAREOUS DEPOSITS IN JOINTS, ORANGEISH TAN TO GRAY. (GLACIO-LACUSTRINE)
18' TO 38.8' (CH) FAT CLAY, MEDIUM STIFF, MOIST, GRAY. (GLACIO-LACUSTRINE)
38.8' TO 68' (CH) FAT CLAY, MEDIUM STIFF, MOIST, TRACE SAND, GRAY. (GLACIO-LACUSTRINE)
68' TO 73' (CL) SANDY LEAN CLAY, STIFF TO HARD, MOIST, GRAY. (TILL)
73' TO 79' (CL) SANDY LEAN CLAY, HARD, MOIST, GRAY. (TILL)
NOTES:
1. WATER LEVEL NOT DETERMINED
2. AFTER SAMPLING TO EL. 896.9' BORING CONTINUED IN OFFSET HOLE. HOLE STABILIZED TO EL. 914.9' WITH 4" LP. CASING. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 914.9'.
3. BORING BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.
0' TO 0.5' (TOPSOIL) FROZEN
(DRILL OUT / GROUND FROZEN)
TOP OF SHERACK FM.
0.5' TO 10.2' (CH) FAT CLAY, MEDIUM STIFF, MOIST, IRON OXIDE STAINING, CALCAREOUS INCLUSIONS, BROWN TO LIGHT BROWN. (GLACIO-LACUSTRINE)
TOP OF BRENNA FM.
10.2' TO 38.5' (CH) FAT CLAY, MEDIUM STIFF, MOIST, IRON OXIDE STAINING, CALCAREOUS FILLED JOINTS AND GRAVEL, BROWN TO GRAY. (GLACIO-LACUSTRINE)
TOP OF ARGUSVILLE FM.
38.5' TO 76' (CH) FAT CLAY, MEDIUM STIFF, MOIST, TILL INCLUSIONS, OCCASIONALLY STRUCTURED, OCCASIONAL PEBBLE AND SAND INCLUSIONS, GRAY. (GLACIO-LACUSTRINE)
TOP OF UNIT "A" TILL
76' TO 83.9' (CL) SANDY LEAN CLAY, GRAVEL FINE TO MEDIUM SAND FINE TO COARSE, HARD, MOIST, SILTY AND SANDY ZONES, GRAY. (TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 70 HRS. HSA SET TO EL. 895.7, THEN WITHDRAWN. BOTTOM OF HOLE EL. 895.7
2. AFTER SAMPLING TO EL. 897.7 BORING CONTINUED IN OFFSET HOLE. HOLE STABILIZED TO EL. 906.7' WITH 8" LP. CASING. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 906.7'.
3. 5-INCH UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.
(DRILL OUT / GROUND FROZEN)
9' TO 23.5' (CH) FAT CLAY, STIFF, MOIST TO WET, LIGHT BROWN TO BROWN
TOP OF BRENNA FM.
23.5' TO 32.5' (CH) FAT CLAY, STIFF TO MEDIUM STIFF, WET, VARVED, IRON OXIDE STAINING, BROWN TO GRAY. (GLACIO-LACUSTRINE)
TOP OF ARGUSVILLE FM.
32.5' TO 60' (CH) FAT CLAY, WITH FINE SAND, MEDIUM STIFF, WET, VARVED, TRACE FINE GRAVEL, GRAY. (GLACIO-LACUSTRINE)
TOP OF UNIT "A" TILL
60' TO 68' (CL) LEAN CLAY WITH SAND, GRAVEL FINE TO MEDIUM SAND FINE TO COARSE, HARD, MOIST, GRAY. (TILL)
68' TO 79' (SP-SC) POORLY GRADED SAND WITH CLAY, SAND FINE TO MEDIUM, VERY DENSE, SATURATED, GRAY. (DRIFT)
73' TO 84.5' (CL) LEAN CLAY WITH SAND, GRAVEL FINE TO MEDIUM SAND FINE TO COARSE, HARD, MOIST, GRAY. (TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 20 HRS. HSA SET TO EL. 892.8', THEN WITHDRAWN. BOTTOM OF HOLE EL. 892.6
2. AFTER SAMPLING TO EL. 892.6' BORING CONTINUED IN OFFSET HOLE. HOLE STABILIZED TO EL. 911.6' WITH 6" LP. CASING. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 911.6'.
3. 5-INCH UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.
US Army Corps of Engineers ST. PAUL DISTRICT
DATE DESCRIPTION
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
FARGO, NORTH DAKOTA, MOORHEAD, MINNESOTA
BORING LOGS
FARGO
11-110M, 11-111M, 11-118M & 11-119M
SHEET IDENTIFICATION
B-216

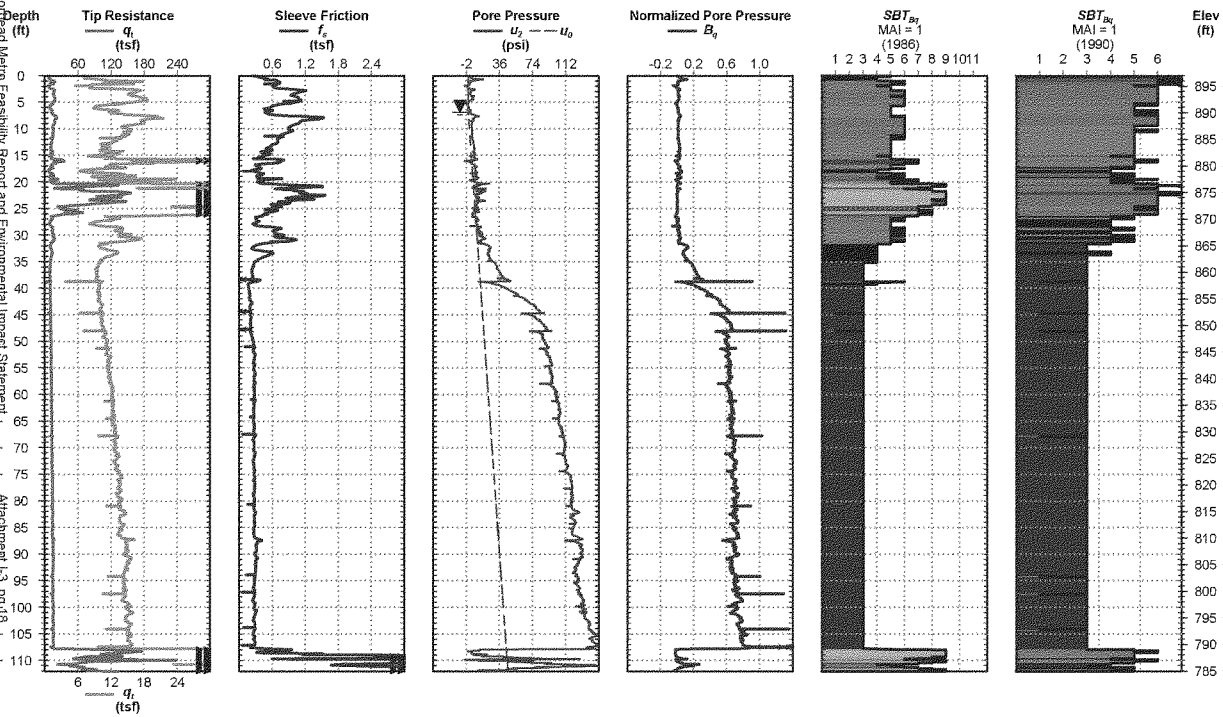
1508


11-121M
6-9 MAR 2011
BPT D10 MC LL PL
G.S. 911.1
(DRILL OUT / GROUND FROZEN)
(NO RECOVERY)
W.L. 891.8
CH
6' TO 30' (CH) FAT CLAY, MEDIUM STIFF, MOIST, SOME GRAVEL, IRON OXIDE STAINING, CALCAREOUS DEPOSITS IN JOINTS, BROWNISH TAN TO BROWN
30' TO 45' (CH) FAT CLAY, MEDIUM STIFF, MOIST, VARVED, BROWNISH TAN TO GRAY
TOP OF ARGUSVILLE FM.
45' TO 67.5' (CH) FAT CLAY, MEDIUM STIFF, MOIST, TRACE FINE SAND, GRAY. (GLACIO-LACUSTRINE)
TOP OF UNIT "A" TILL
67.5' TO 70' (CL) SANDY LEAN CLAY, VERY STIFF, MOIST, DARK GRAY. (TILL)
72' TO 74.5' (SM) SILTY SAND, SAND FINE, VERY DENSE, MOIST, GRAY. (DRIFT/OUTWASH)
NOTES:
1. WATER LEVEL DETERMINED AFTER 22 HRS. HSA SET TO EL. 891.1', THEN WITHDRAWN. BOTTOM OF HOLE EL. 888.1'.
2. AFTER SAMPLING TO EL. 888.1' BORING CONTINUED IN OFFSET HOLE. HOLE STABILIZED TO EL. 905.1' WITH 6" I.P. CASING. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 905.1'.
3. BORING BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.
US Army Corps of Engineers
ST. PAUL DISTRICT
ST. PAUL, DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
REDRIVER OF THE NORTH
FARGO NORTH DAKOTA, MOORHEAD MINNESOTA
BORING LOGS
FARGO
10-121M & 10-120M
SHEET IDENTIFICATION
B-217

Fargo Moorehead

Cone Penetration Test 09-F-23C

Date:	Jun. 24, 2009	**Northing:**	1995989.995	**Elevation:**	897.0
Operator:	MARKOV	**Easting:**	1040908.073	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	112.1 ft



Page 1 of 1

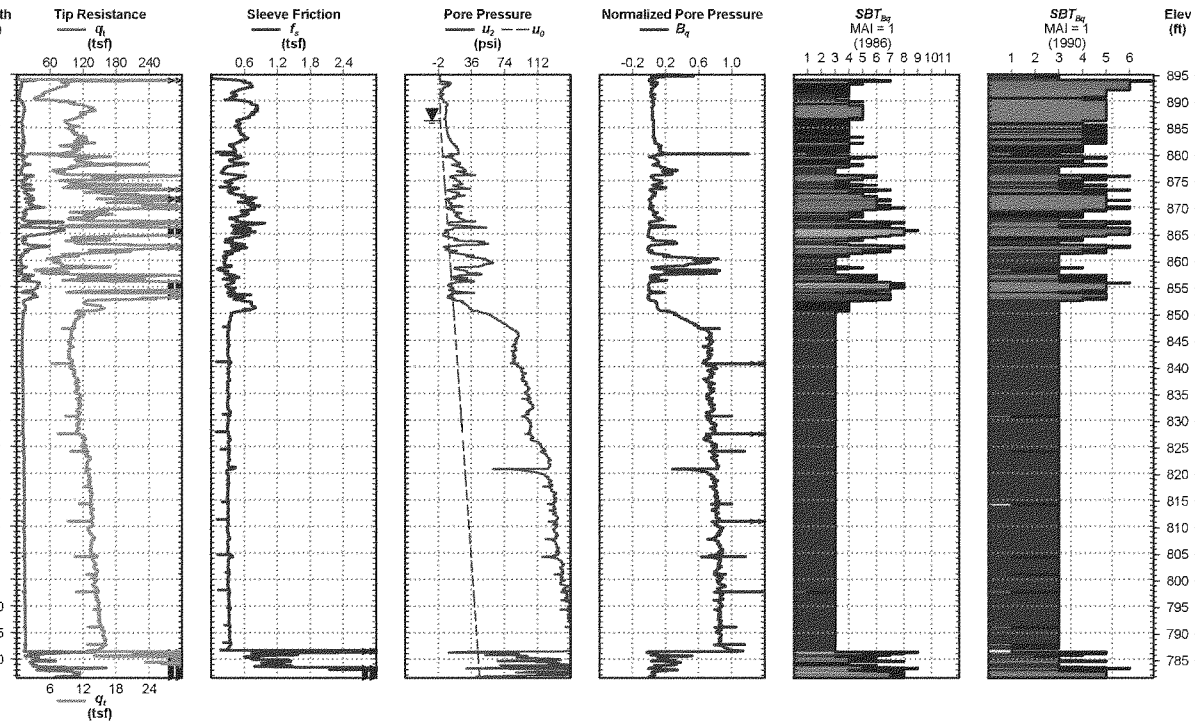
Electronic Filename: 09-23C.cpt

Fargo Moorehead

Cone Penetration Test

09-F-24C

Date:	Jun. 22, 2009	**Northing:**	1989365.114	**Elevation:**	895.3
Operator:	MARKOV	**Easting:**	1045881.8	**Water Depth:**	8.69
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	113.5 ft



Page 1 of 1

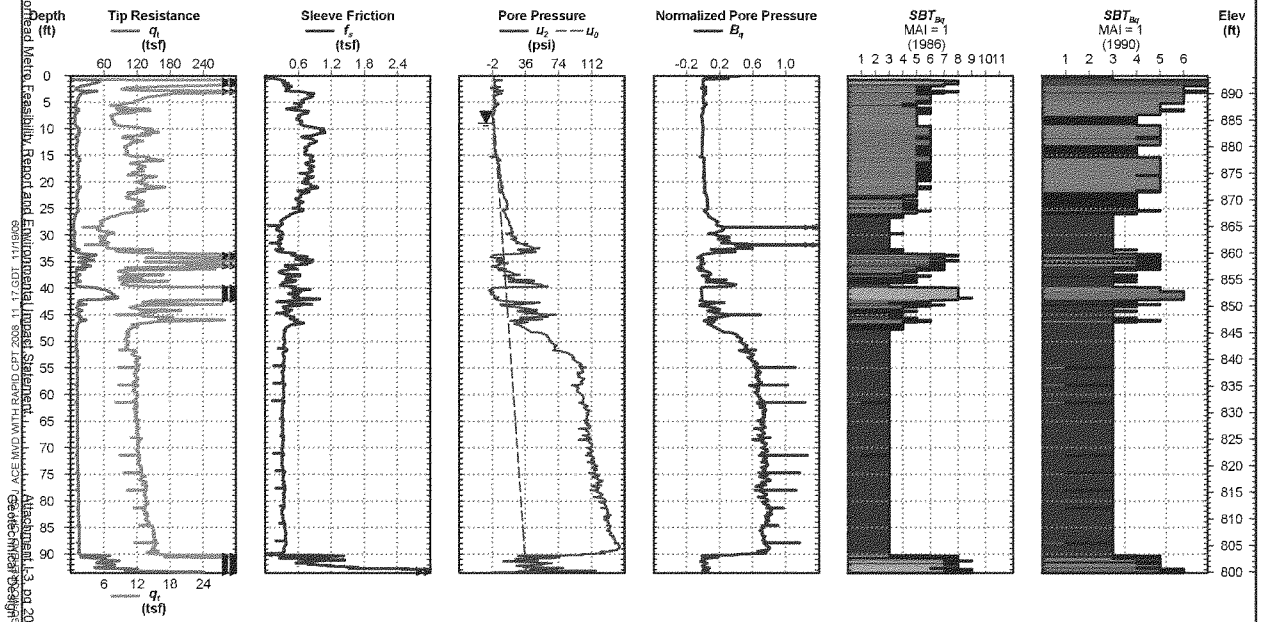
Electronic Filename: 09-24C.cpt

CPT REPORT - Copy 1 ACE MVD WITH RAPID CPT 2008 11 17.GDT 11/19/09
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
Attachment I-3, pg 19
Geotechnical Design and Quality
July 2011
1511

Fargo Moorehead

Cone Penetration Test 09-F13-25C

Date:	Jul. 19, 2009	**Northing:**	1991535.54	**Elevation:**	893.4
Operator:	MARKOV	**Easting:**	1023016.653	**Water Depth:**	8.99
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	93.5 ft



Page 1 of 1

Electronic Filename: 09-25C FARGO-F13.cpt

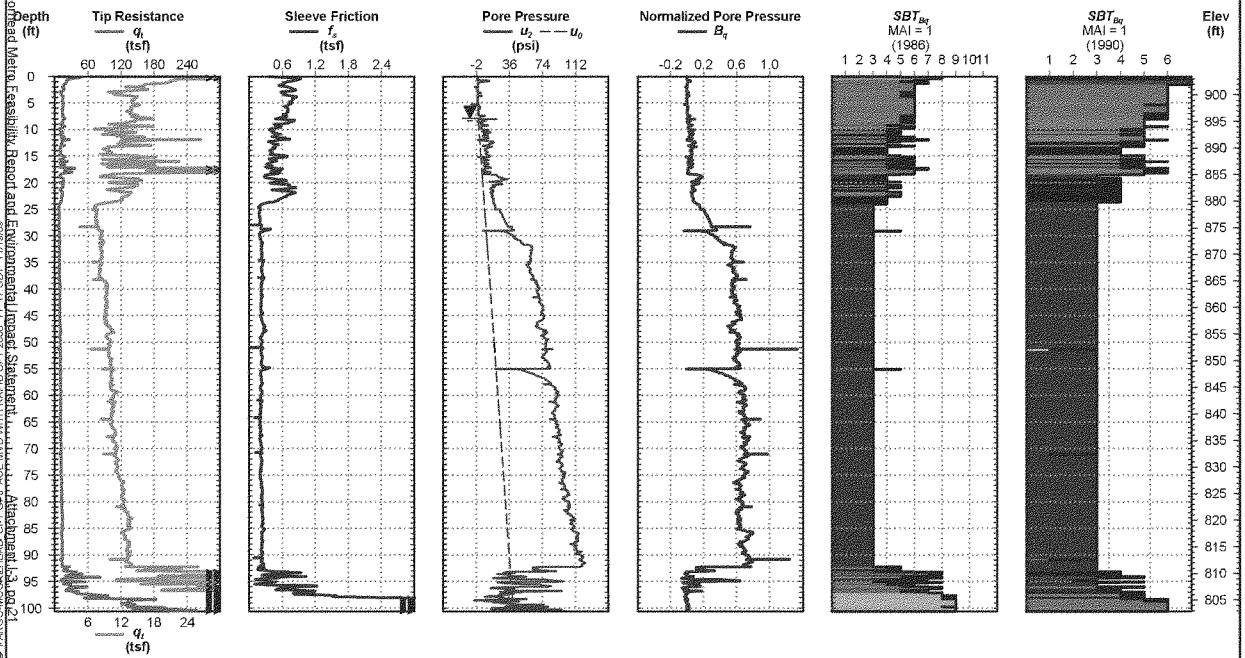
Fargo Moorehead

Cone Penetration Test 09-F15-26C

Date: Jul. 22, 2009
Operator: MARKOV
Drilling Agency: USACE, Savannah District

Northing: 1991012.693
Easting: 1015199.01
Probe ID/Net Area Ratio: DDG1117 / 0.8

Elevation: 903.5
Water Depth: 7.87
Total Depth: 100.6 ft



Page 1 of 1

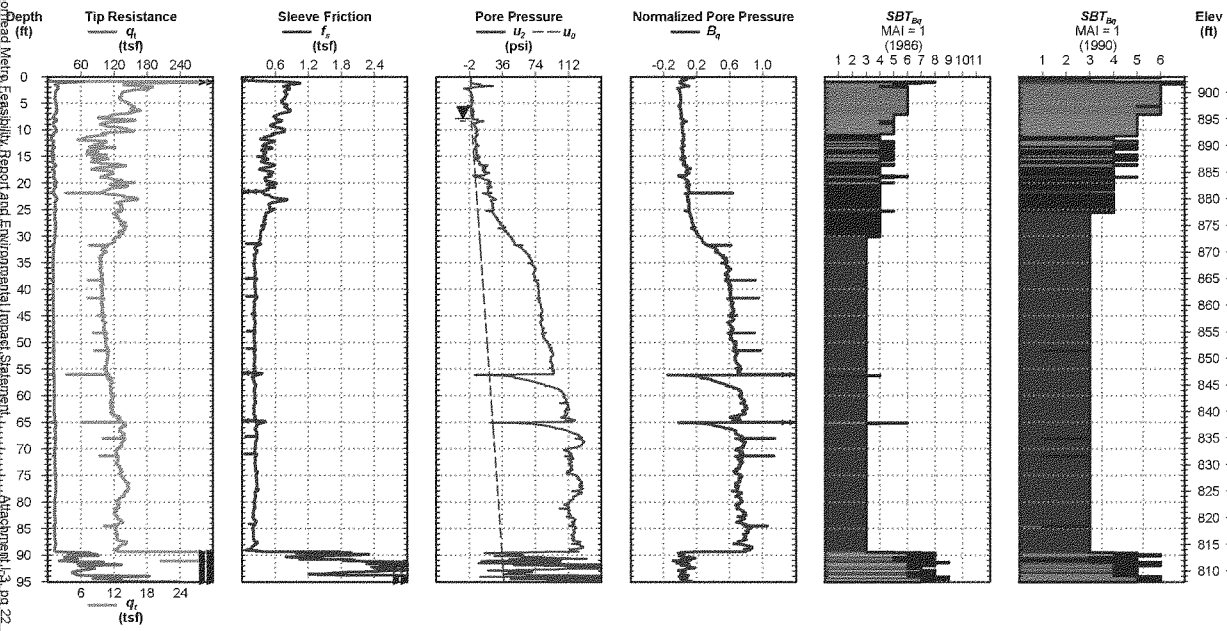
Electronic Filename: F-15 (26C-FARGO).cpt

Fargo Moorehead

Cone Penetration Test

09-F-27C

Date:	Jul. 21, 2009	**Northing:**	1988783.267	**Elevation:**	903.0
Operator:	MARKOV	**Easting:**	1005319.731	**Water Depth:**	7.87
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	95.0 ft



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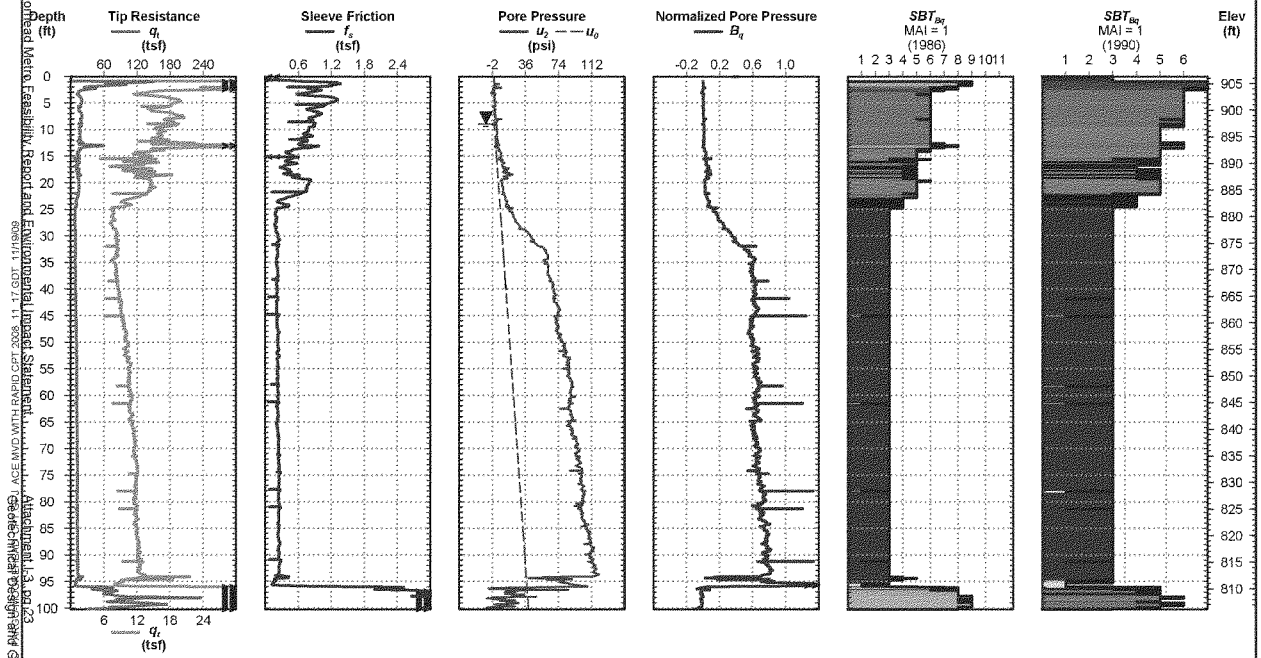
Electronic Filename: 09-27C-FARGO.cpt

Fargo Moorehead

Cone Penetration Test

09-F-28C

Date:	Jul. 20, 2009	**Northing:**	1989113.168	**Elevation:**	906.4
Operator:	MARKOV	**Easting:**	1009436.114	**Water Depth:**	8.99
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	100.2 ft



Page 1 of 1

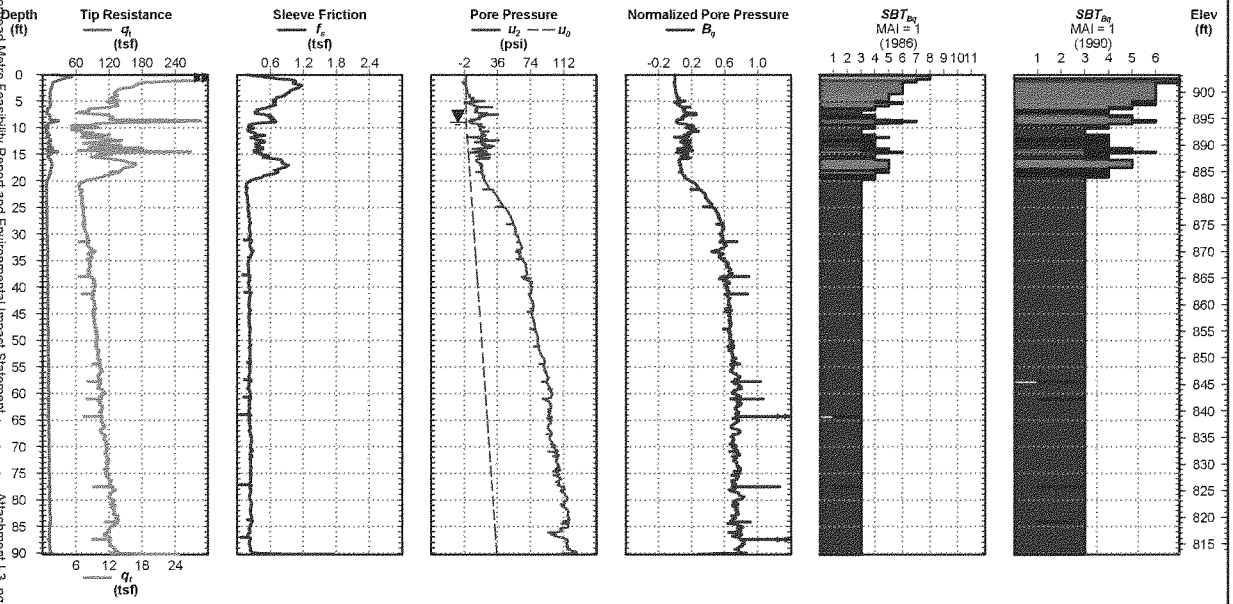
Electronic Filename: 09-28C-FARGO-A.cpt

Fargo Moorehead

Cone Penetration Test

09-F-29C

Date:	Jul. 20, 2009	Northing:	1987719.866	Elevation:	903.3
Operator:	MARKOV	Easting:	1007375.407	Water Depth:	8.99
Drilling Agency:	USACE, Savannah District	Probe ID/Net Area Ratio:	DDG1117 / 0.8	Total Depth:	90.2 ft



Page 1 of 1

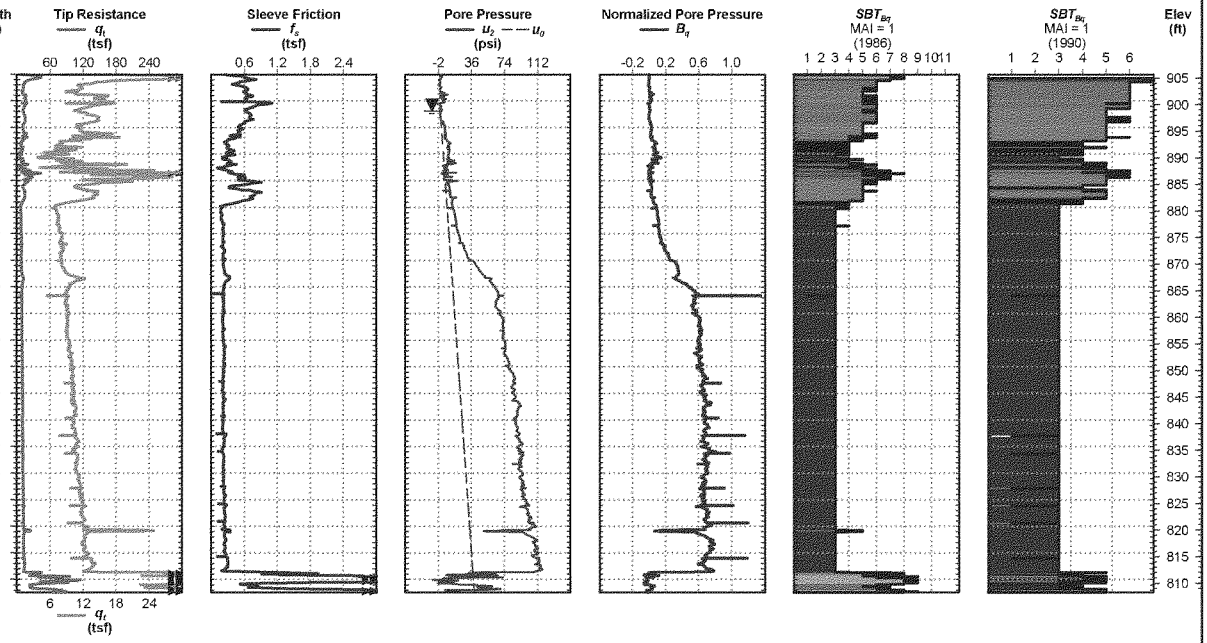
Electronic Filename: 09-29C-FARGO.cpt

Fargo Moorehead

Cone Penetration Test

09-F-30C

Date:	Jul. 21, 2009	**Northing:**	1990030.081	**Elevation:**	905.7
Operator:	MARKOV	**Easting:**	1013905.894	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	97.4 ft



Page 1 of 1

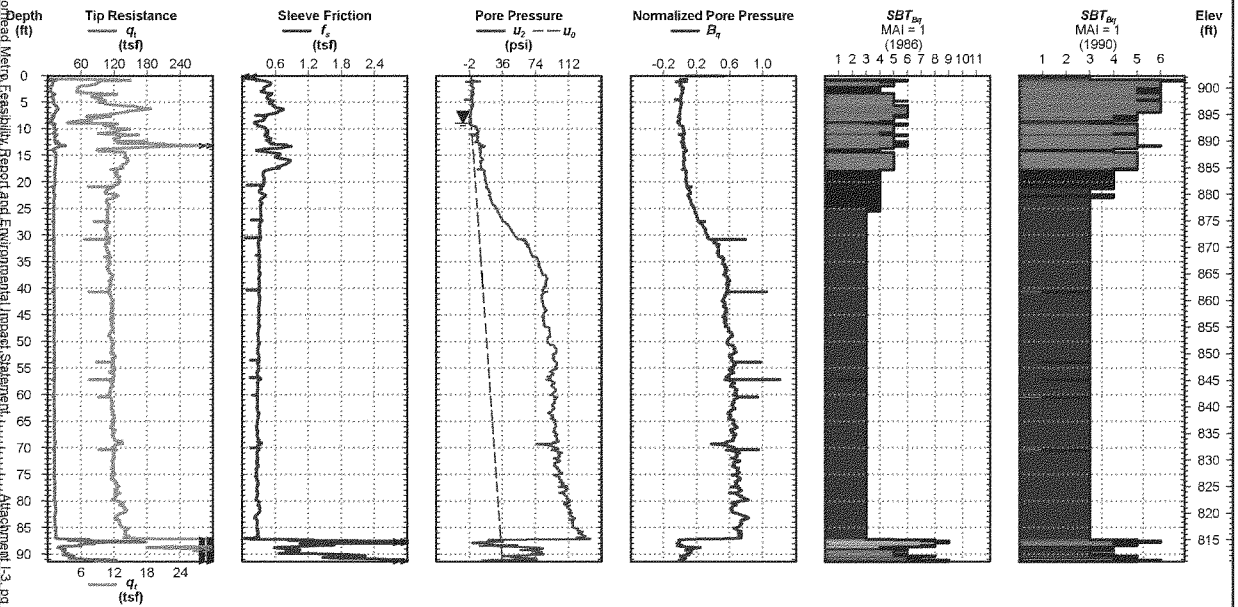
Electronic Filename: 09-30C-FARGO.cpt

Fargo Moorehead

Cone Penetration Test

09-F-31C

Date:	Jul. 22, 2009	Northing:	1986951.531	Elevation:	902.3
Operator:	MARKOV	Easting:	1003342.478	Water Depth:	8.99
Drilling Agency:	USACE, Savannah District	Probe ID/Net Area Ratio:	DDG1117 / 0.8	Total Depth:	91.4 ft



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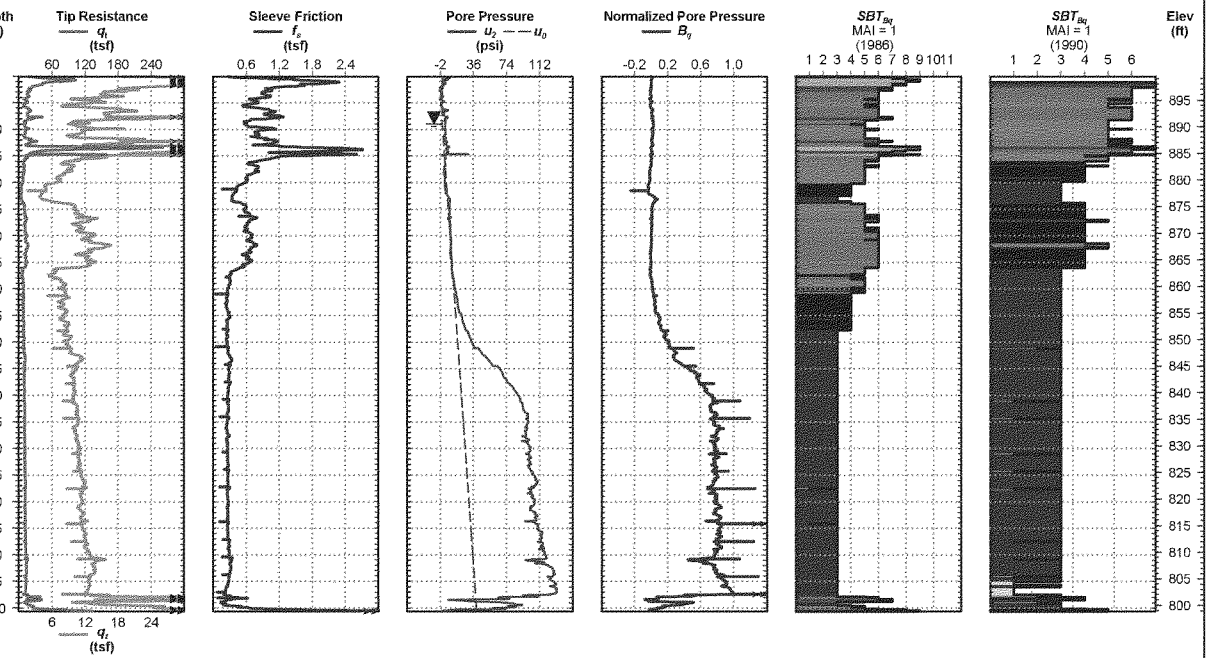
Electronic Filename: 09-31C-FARGO.cpt

Fargo Moorehead

Cone Penetration Test

09-F-32C

Date:	Jul. 23, 2009	**Northing:**	1991879.321	**Elevation:**	899.5
Operator:	MARKOV	**Easting:**	1021246.849	**Water Depth:**	8.99
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	100.6 ft



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Electronic Filename: 09-32C-FARGO.cpt

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July 2011
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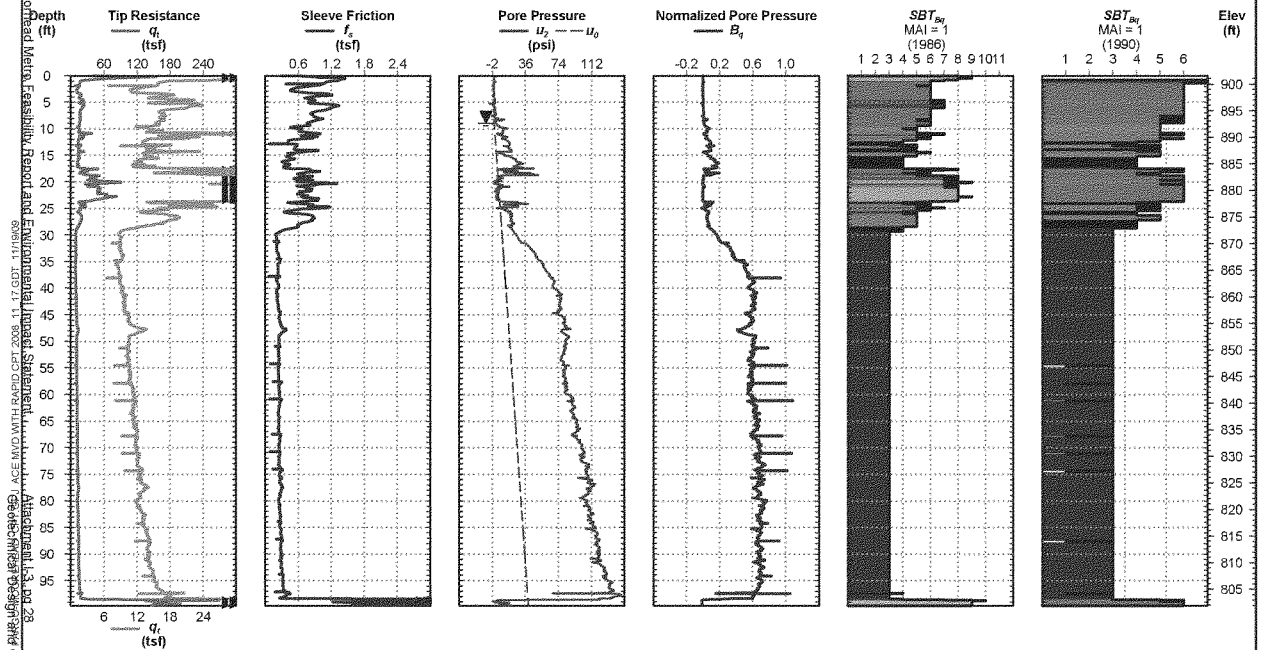
Fargo Moorehead

Cone Penetration Test

09-F-33C

Date:	Jul. 23, 2009	**Northing:**	1992067.098	**Elevation:**	901.6
Operator:	MARKOV	**Easting:**	1024225.724	**Water Depth:**	8.99
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	99.7 ft



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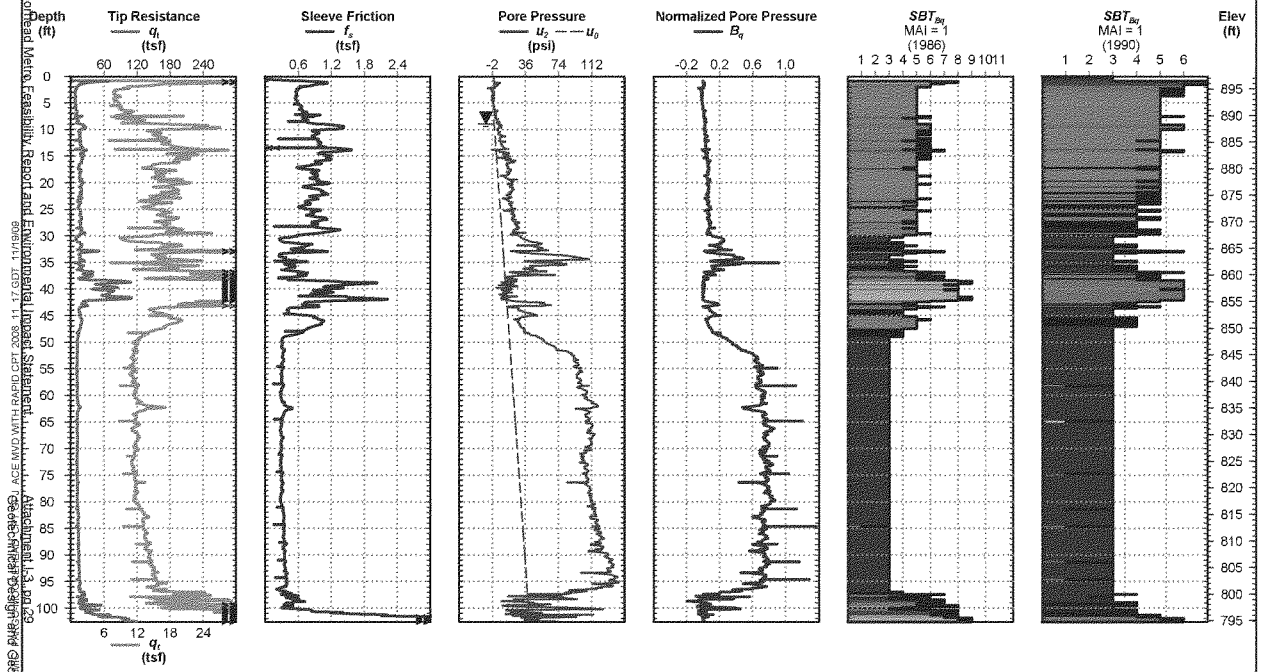
Electronic Filename: 09-33C-FARGO.cpt

Fargo Moorehead

Cone Penetration Test

09-F-34C

Date:	Jul. 23, 2009	**Northing:**	1994149.233	**Elevation:**	897.4
Operator:	MARKOV	**Easting:**	1024476.761	**Water Depth:**	8.99
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	102.6 ft



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Electronic Filename: 09-34C-FARGO.cpt

Fargo Moorehead

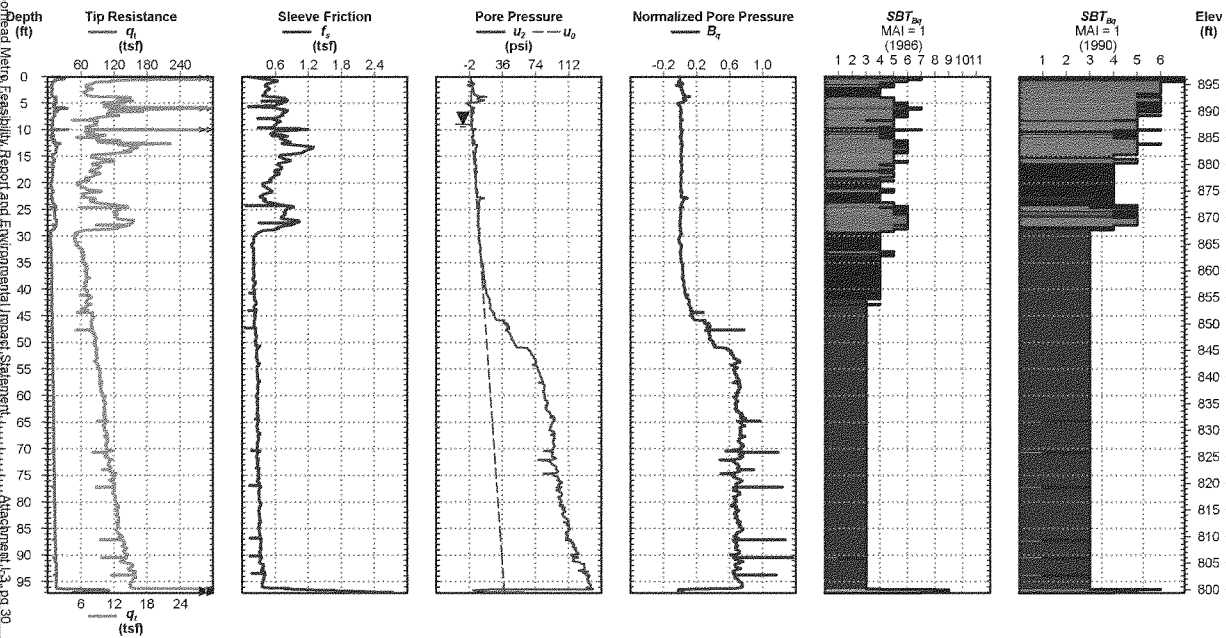
Cone Penetration Test

09-F-36C

Date: Jul. 24, 2009
Operator: MARKOV
Drilling Agency: USACE, Savannah District

Northing: 1992504.008
Easting: 1026233.312
Probe ID/Net Area Ratio: DDG1117 / 0.8

Elevation: 896.5
Water Depth: 8.99
Total Depth: 97.1 ft



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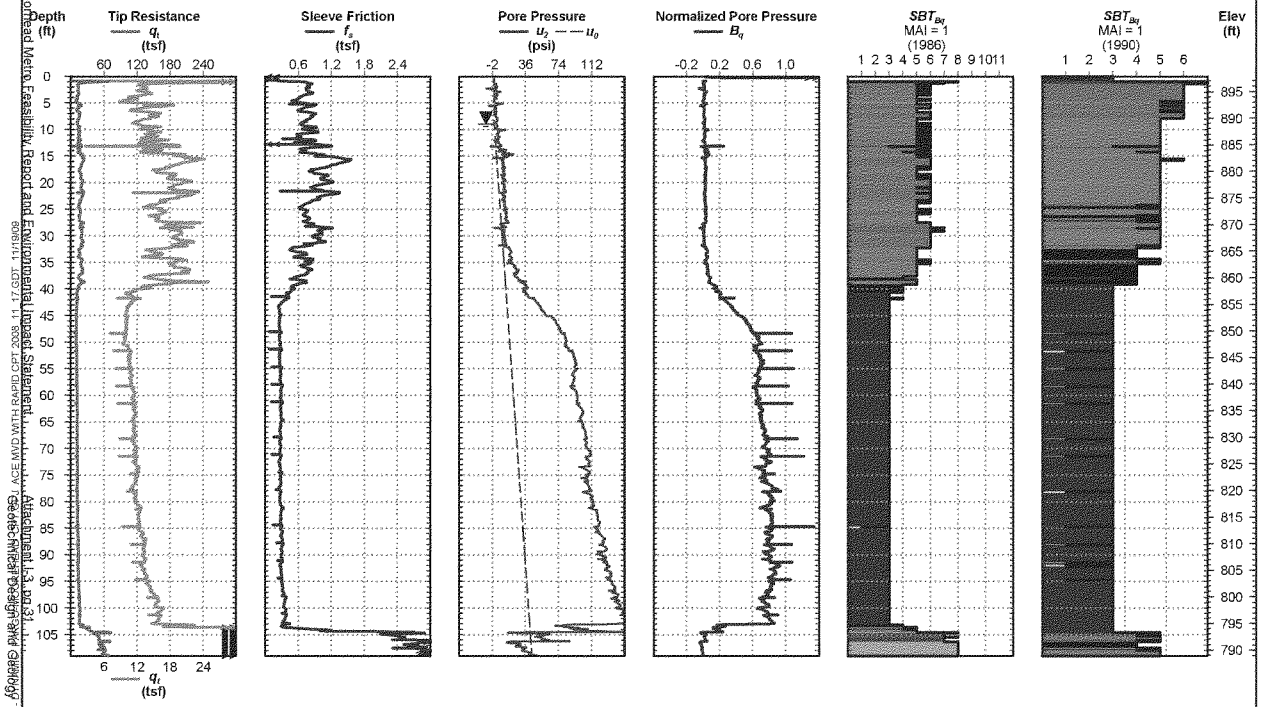
Electronic Filename: 09-36C-FARGO.cpt

Fargo Moorehead

Cone Penetration Test 09-F-37C

Date:	Jul. 24, 2009	**Northing:**	1993630.141	**Elevation:**	897.9
Operator:	MARKOV	**Easting:**	1027970.793	**Water Depth:**	8.99
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	109.0 ft



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Electronic Filename: 09-37C-FARGO.cpt

Fargo Moorehead

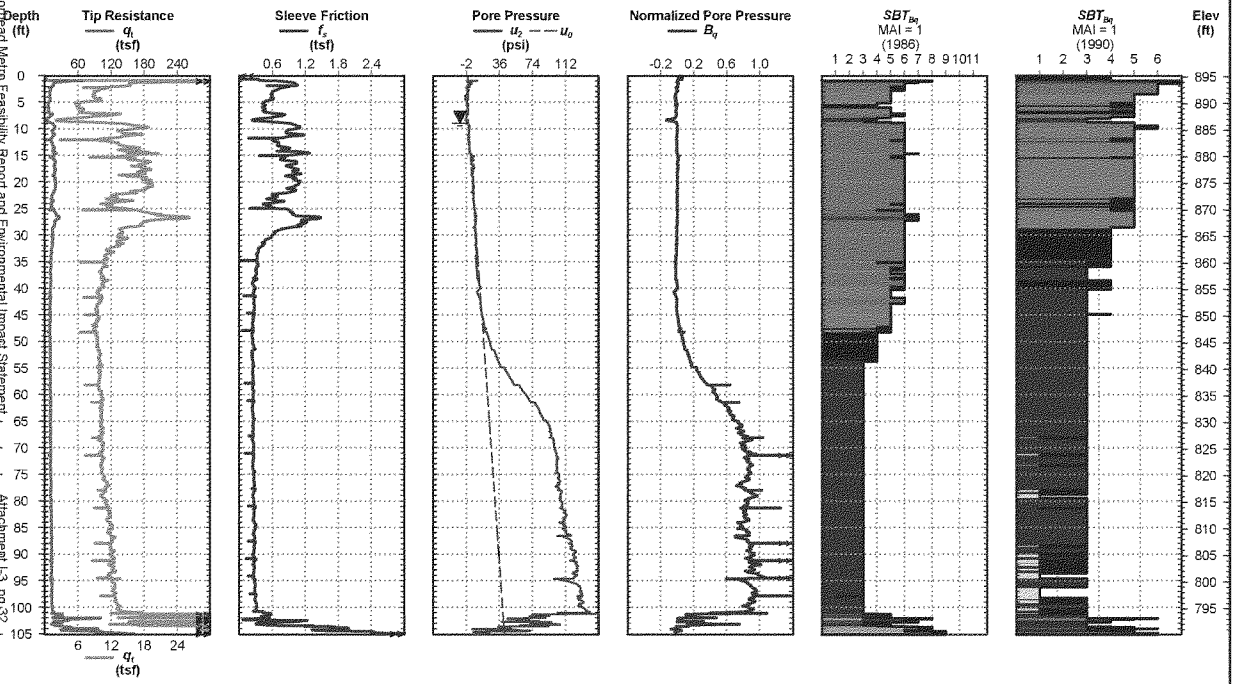
Cone Penetration Test

09-F-38C

Date: Jul. 24, 2009
Operator: MARKOV
Drilling Agency: USACE, Savannah District

Northing: 1995881.285
Easting: 1034025.821
Probe ID/Net Area Ratio: DDG1117 / 0.8

Elevation: 895.3
Water Depth: 8.99
Total Depth: 105.1 ft



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Electronic Filename: 09-38C-FARGO.cpt

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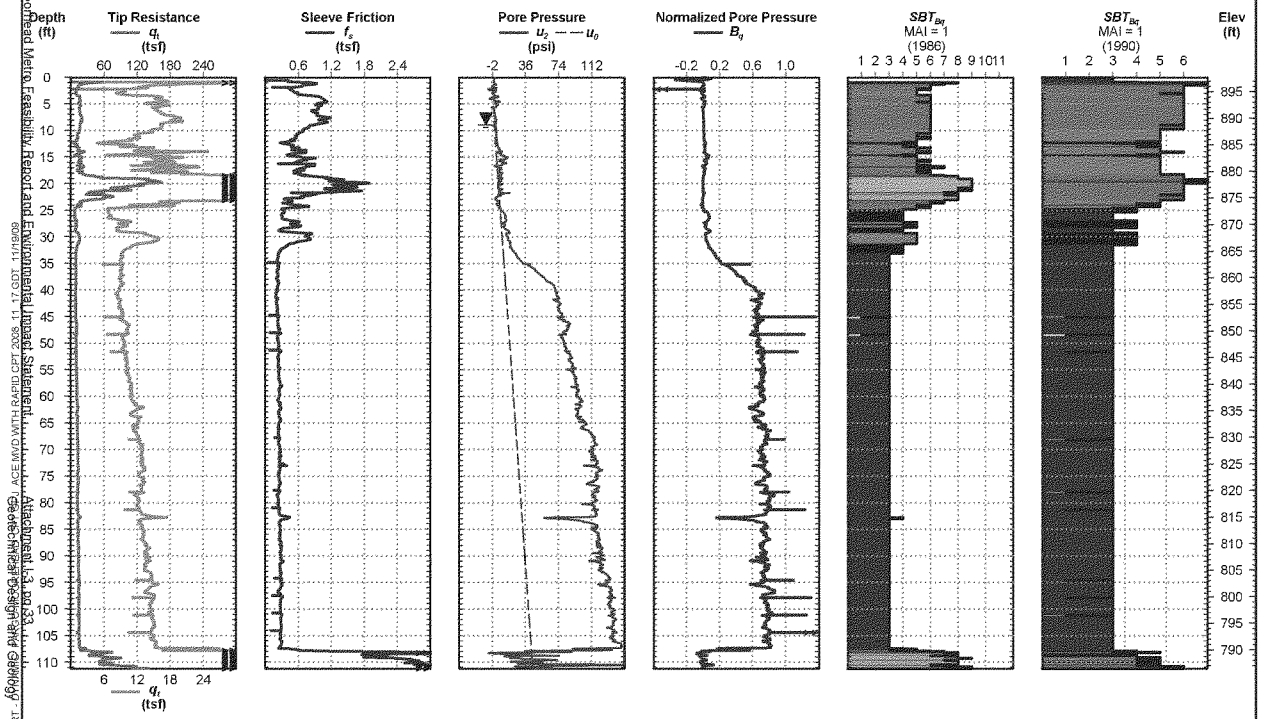
Fargo Moorehead

Cone Penetration Test

09-F-39C

Date:	Jul. 24, 2009	**Northing:**	1995628.878	**Elevation:**	897.7
Operator:	MARKOV	**Easting:**	1035840.106	**Water Depth:**	8.99
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	111.2 ft



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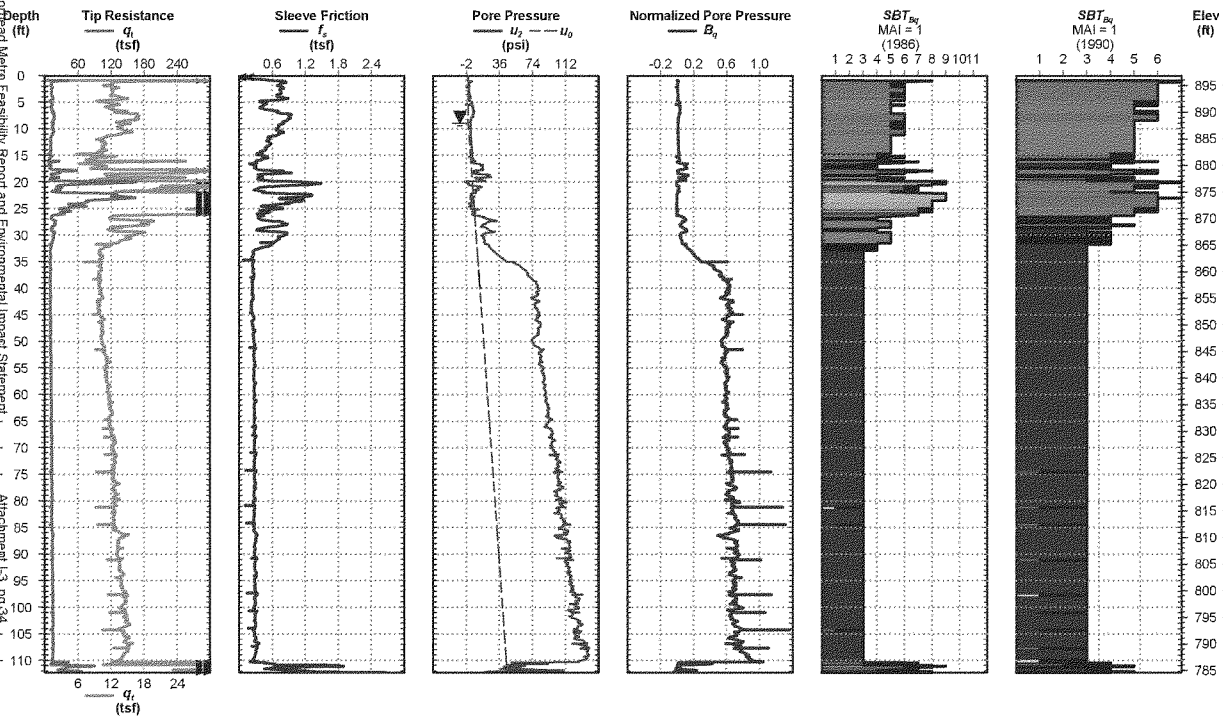
Electronic Filename: 09-39C-FARGO.cpt

Fargo Moorehead

Cone Penetration Test

09-F-40C

Date:	Jul. 25, 2009	**Northing:**	1996365.961	**Elevation:**	896.9
Operator:	MARKOV	**Easting:**	1038892.81	**Water Depth:**	8.99
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	112.3 ft



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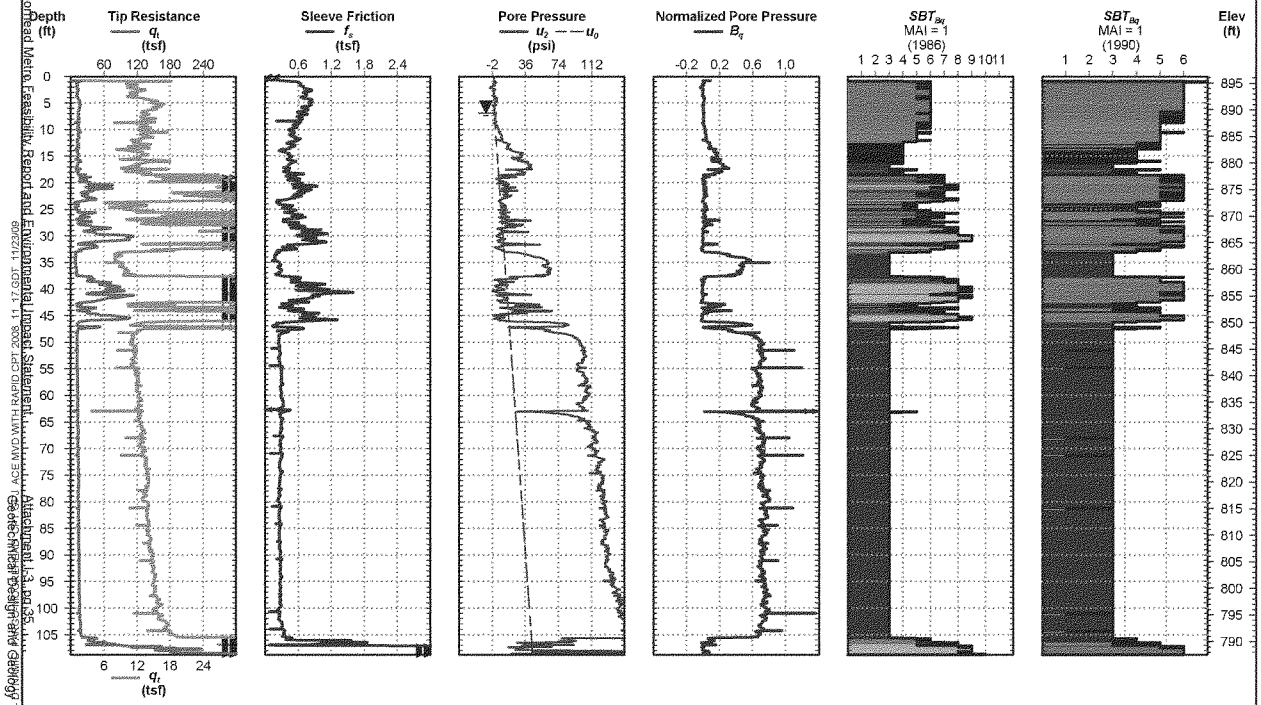
Electronic Filename: 09-40C-FARGO.cpt

Fargo Moorehead

Cone Penetration Test

09-F-41C

Date:	Jun. 23, 2009	Northing:	1989376.25	Elevation:	896.3
Operator:	MARKOV	Easting:	1041637.556	Water Depth:	6.89
Drilling Agency:	USACE, Savannah District	Probe ID/Net Area Ratio:	DDG1117 / 0.8	Total Depth:	108.8 ft



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Electronic Filename: 09-25C.cpt

Fargo Moorehead

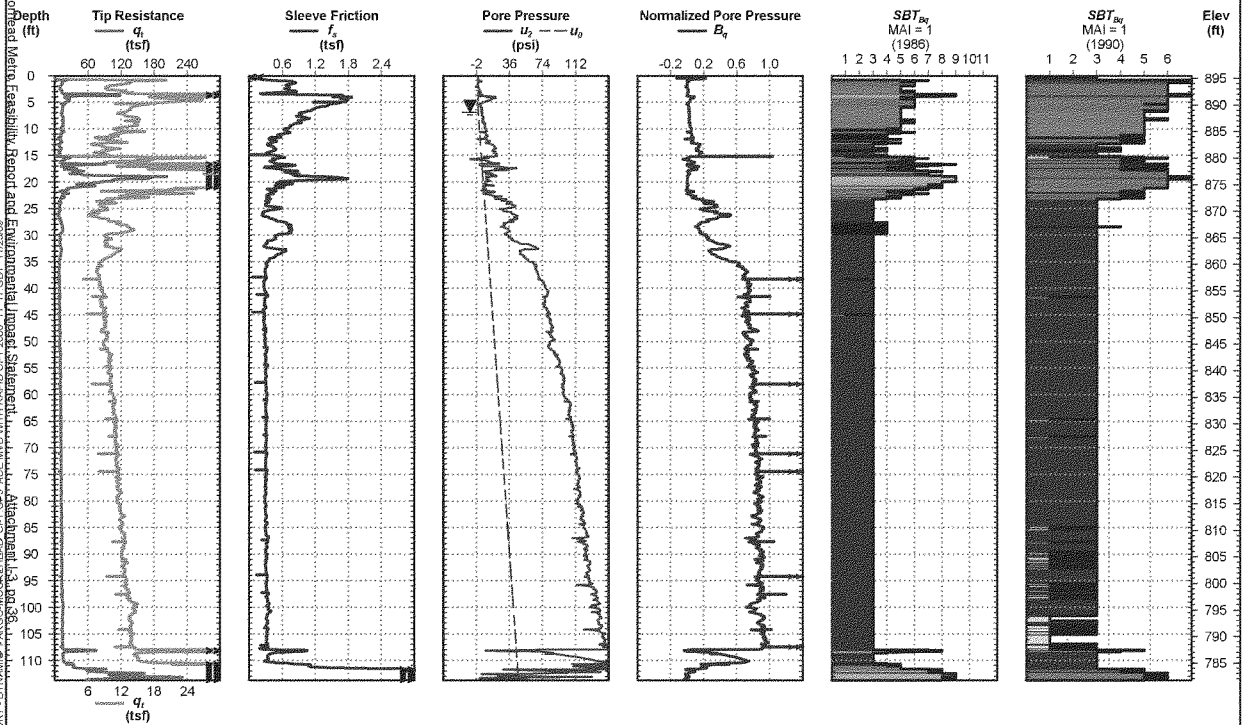
Cone Penetration Test

09-F-56C

Date: Jun. 23, 2009
Operator: MARKOV
Drilling Agency: USACE, Savannah District

Northing: 1993023.229
Easting: 1040064.784
Probe ID/Net Area Ratio: DDG1117 / 0.8

Elevation: 895.5
Water Depth: 6.89
Total Depth: 113.7 ft



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Electronic Filename: 09-26C.cpt

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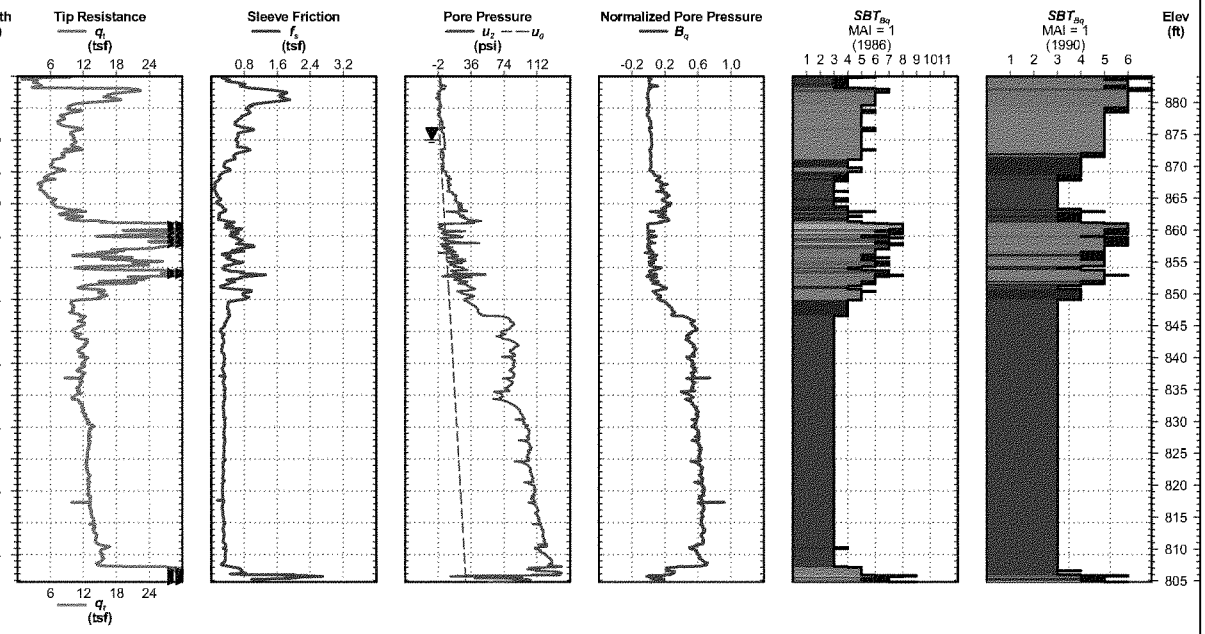
CPT REPORT - ACE MVD WITH RAPID CPT 2008 11 17 GDT 11/23/09

Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test 10-81-Ca

Date:	Nov. 20, 2010	**Latitude:**	47° 2' 12.588"	**Elevation:**	884.1
Operator:	Johnston	**Longitude:**	-96° 52' 52.176"	**Water Depth:**	10.01
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1069 / 0.8	**Total Depth:**	79.3 ft



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CPT REPORT - Fargo Red River Diversion ACE MVD WITH RAPID CPT 2008_11_17.GDT 3/9/11
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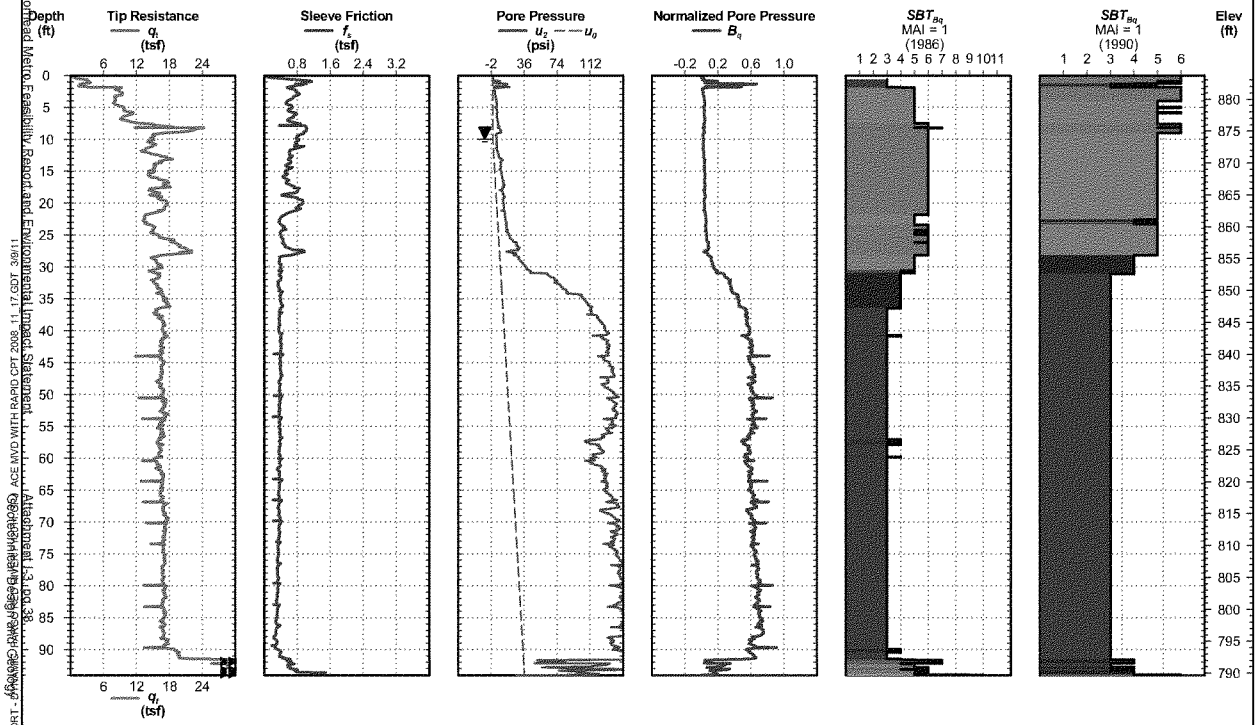
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

10-85-C

Date:	Nov. 18, 2010	**Latitude:**	47° 4' 14.448"	**Elevation:**	883.7
Operator:	Johnston	**Longitude:**	-96° 50' 13.668"	**Water Depth:**	10.01
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1069 / 0.8	**Total Depth:**	94.0 ft



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CPT REPORT - ACE MVD WITH RAPID CPT 2008_11_17.GDT 3/9/11

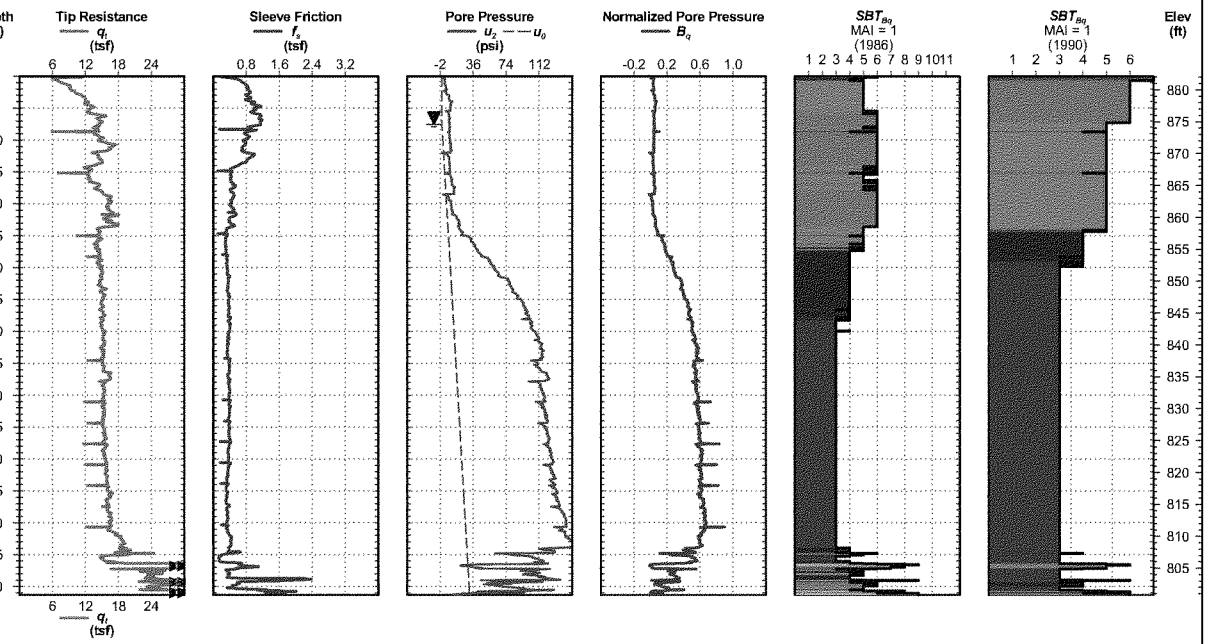
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

10-86-C

Date:	Nov. 19, 2010	**Latitude:**	47° 3' 30.924"	**Elevation:**	882.1
Operator:	Johnston	**Longitude:**	-96° 52' 26.868"	**Water Depth:**	7.51
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1069 / 0.8	**Total Depth:**	81.3 ft



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Electronic Filename: 10-86-C.cpt

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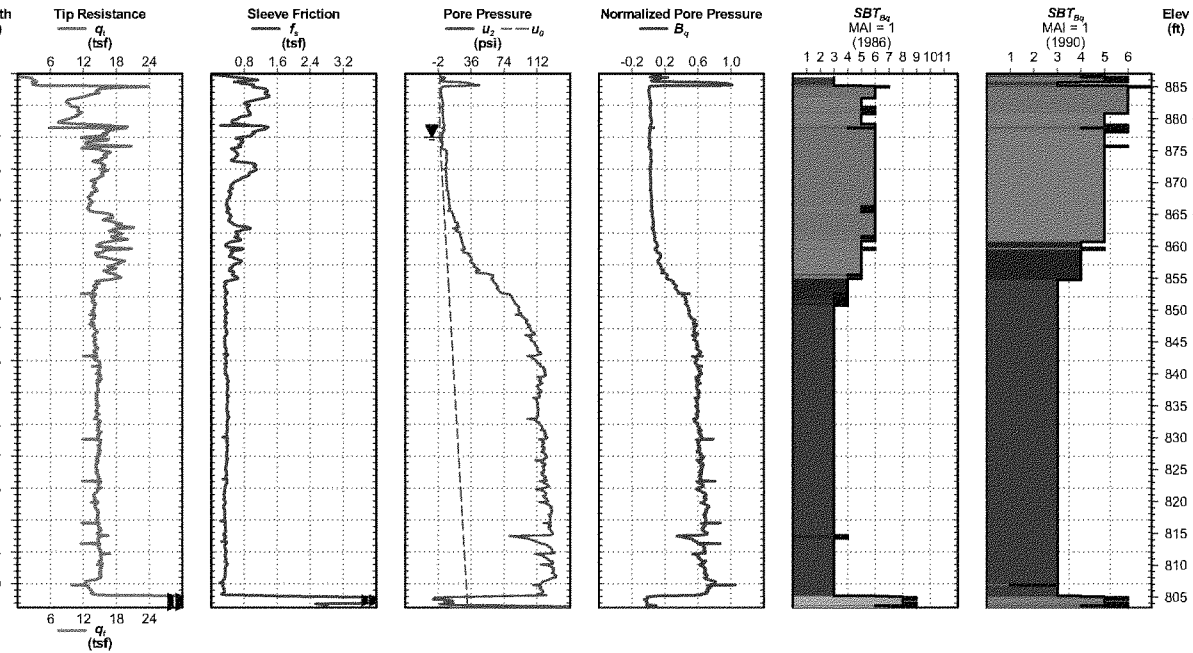
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

10-87-Ca

Date:	Nov. 19, 2010	**Latitude:**	47° 2' 36.168"	**Elevation:**	887.1
Operator:	Johnston	**Longitude:**	-96° 52' 51.708"	**Water Depth:**	10.01
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1069 / 0.8	**Total Depth:**	83.7 ft



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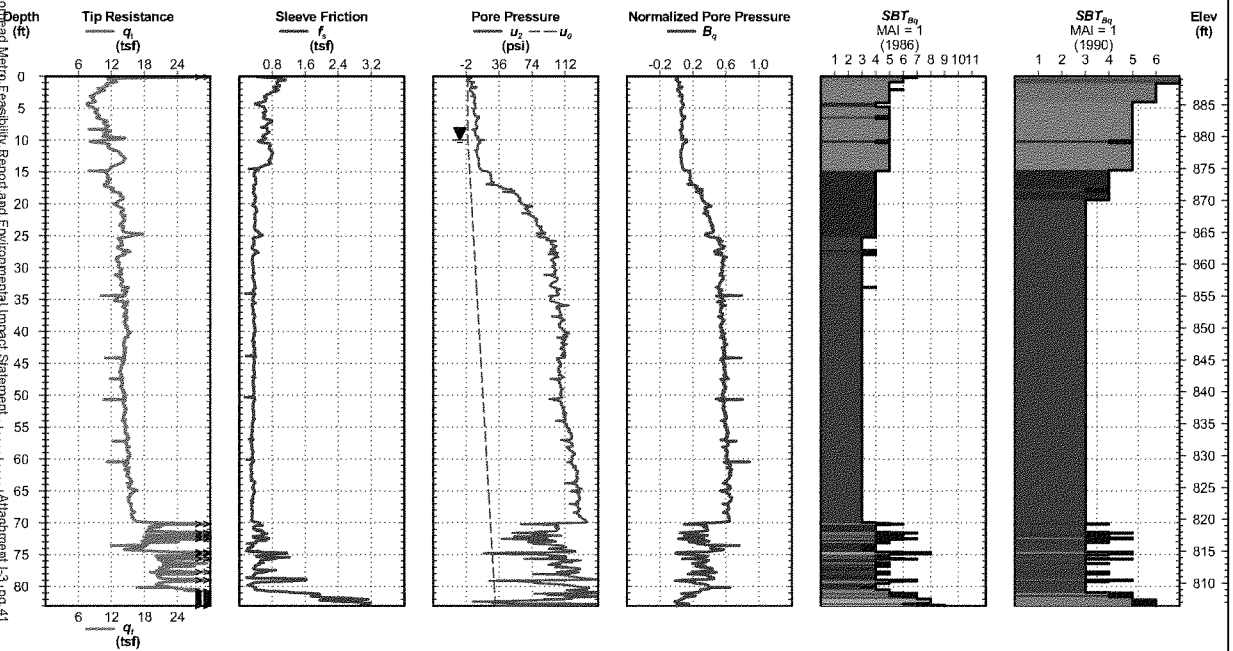
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

10-89-C

Date:	Nov. 21, 2010	**Latitude:**	47° 1' 14.448"	**Elevation:**	889.5
Operator:	Johnston	**Longitude:**	-96° 55' 56.316"	**Water Depth:**	10.01
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1069 / 0.8	**Total Depth:**	83.0 ft



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Electronic Filename: 10-89-C.cpt

CPT REPORT - ACE MVD WITH RAPID CPT 2008_11_17.GDT 3/9/11
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Fargo Red River Diversion

Project No: FY 2011

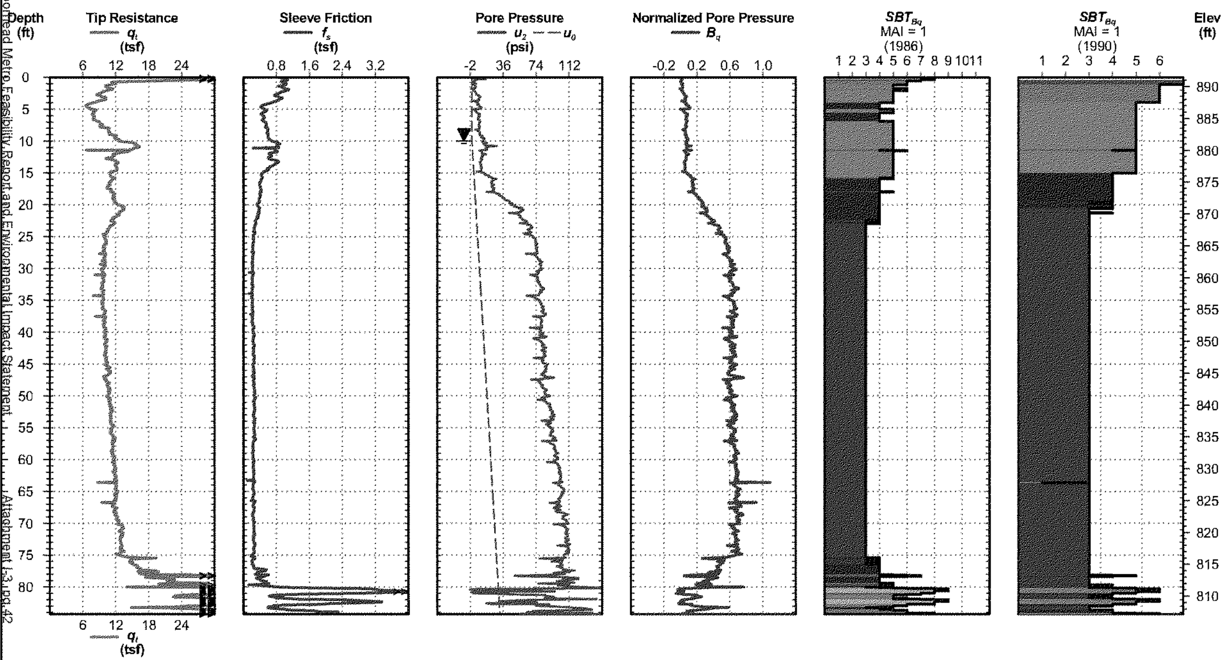
Cone Penetration Test

10-90-C

Date: Nov. 21, 2010
Operator: Johnston
Drilling Agency: USACE, Savannah District

Latitude: 46° 59' 30.3"
Longitude: -96° 55' 58.8"
Probe ID/Net Area Ratio: DDG1069 / 0.8

Elevation: 891.5
Water Depth: 10.01
Total Depth: 84.3 ft



Electronic Filename: 10-90-C.cpt

CPT REPORT - DYNAMIC FARGO RED RIVER 2011.GPJ ACE MVD WITH RAPID CPT 2008_11_17.GDT 3/9/11

Fargo Red River Diversion

Project No: FY 2011

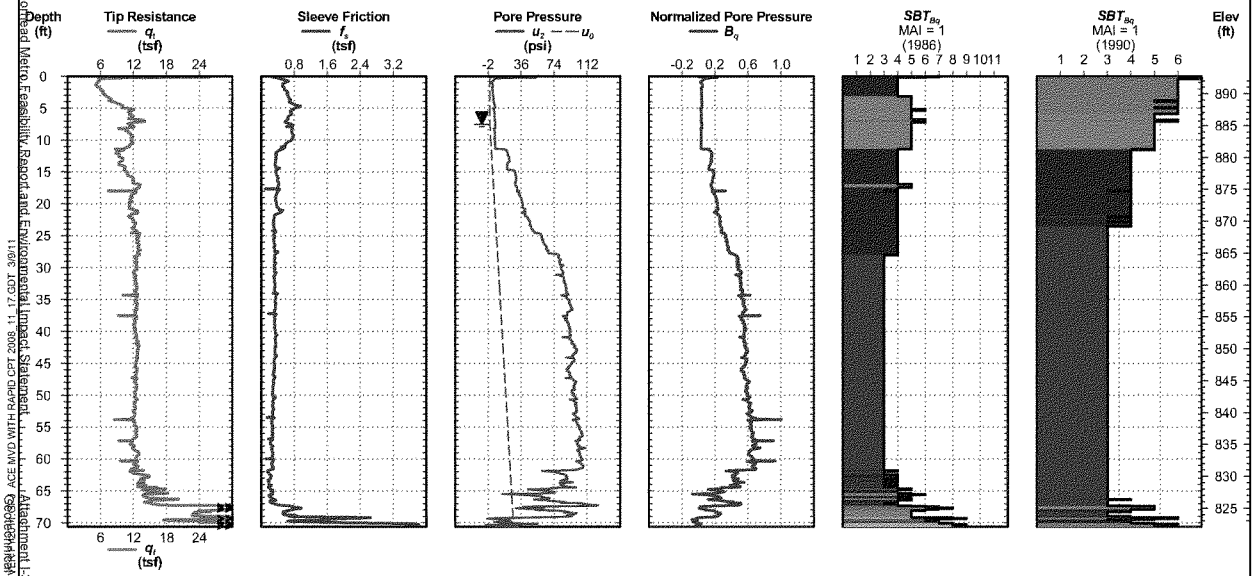
Cone Penetration Test

10-91-C

Date: Nov. 30, 2010
Operator: Johnston
Drilling Agency: USACE, Savannah District

Latitude: 46° 57' 43.272"
Longitude: -96° 57' 25.128"
Probe ID/Net Area Ratio: DDG1069 / 0.8

Elevation: 892.7
Water Depth: 7.51
Total Depth: 70.6 ft



Electronic Filename: 10-91-C.cpt

CPT REPORT - ACE MVD WITH RAPID CPT 2006_11_17.GDT 3/9/11
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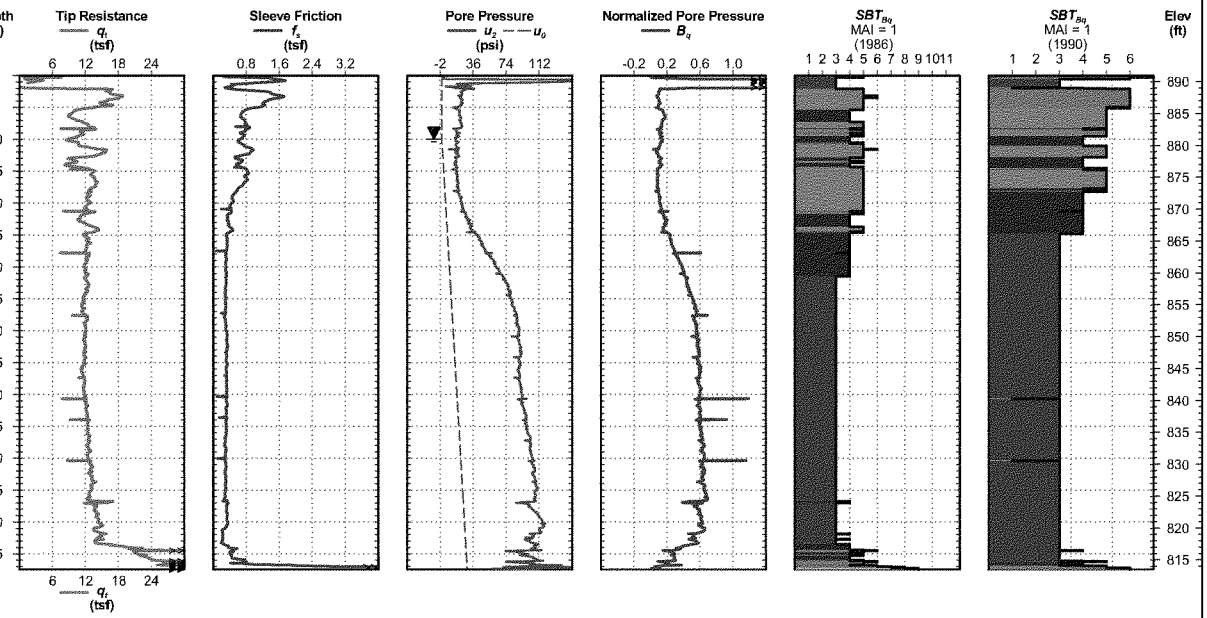
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

10-92-Ca

Date:	Dec. 4, 2010	**Latitude:**	46° 58' 38.388"	**Elevation:**	890.9
Operator:	Johnston	**Longitude:**	-96° 56' 42.684"	**Water Depth:**	10.01
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1069 / 0.8	**Total Depth:**	77.4 ft



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Electronic Filename: 10-92-C.cpt

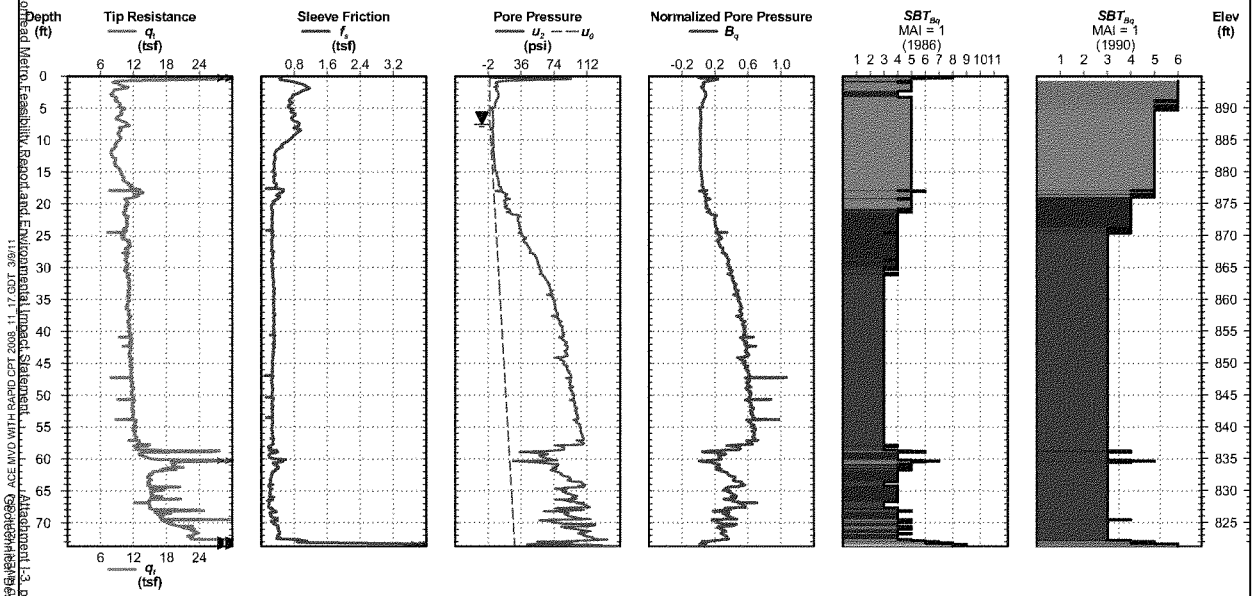
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

10-93-C

Date:	Dec. 1, 2010	**Latitude:**	46° 57' 25.56"	**Elevation:**	895.0
Operator:	Johnston	**Longitude:**	-96° 57' 21.384"	**Water Depth:**	7.51
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1069 / 0.8	**Total Depth:**	73.7 ft



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CPT REPORT - J:\Projects\Fargo\Fargo Flood Mitigation\Geotechnical\Geotech Field Data\Fargo Flood Mitigation\Fargo Flood Mitigation.gpj
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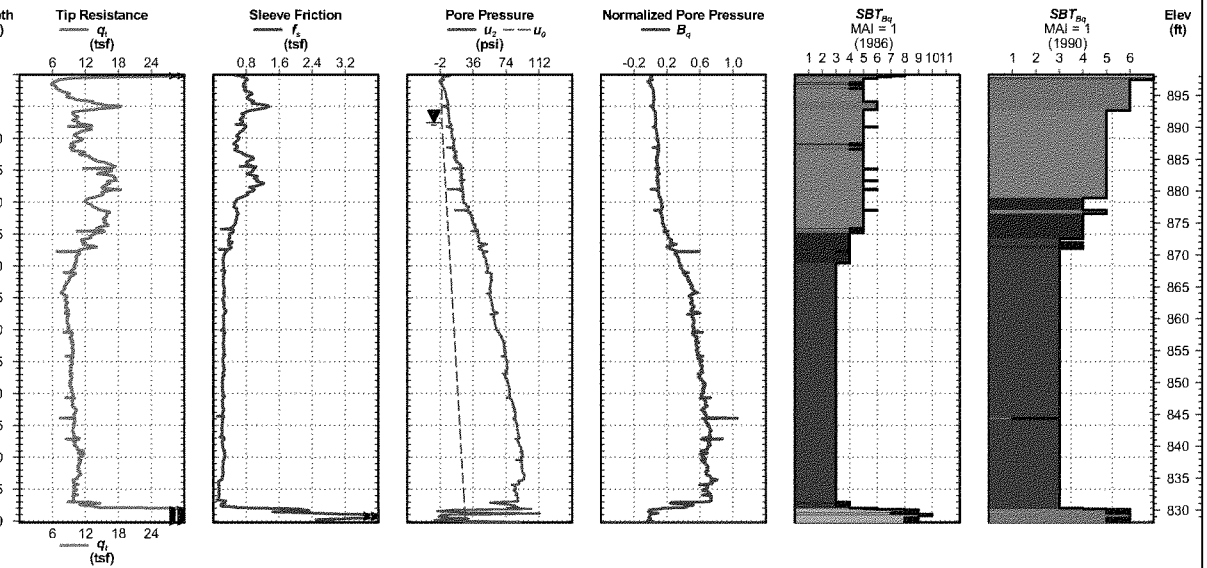
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

10-95-C

Date:	Dec. 2, 2010	**Latitude:**	46° 55' 51.168"	**Elevation:**	898.3
Operator:	Johnston	**Longitude:**	-96° 57' 53.64"	**Water Depth:**	7.51
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1069 / 0.8	**Total Depth:**	70.2 ft



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Fargo Red River Diversion

Project No: FY 2011

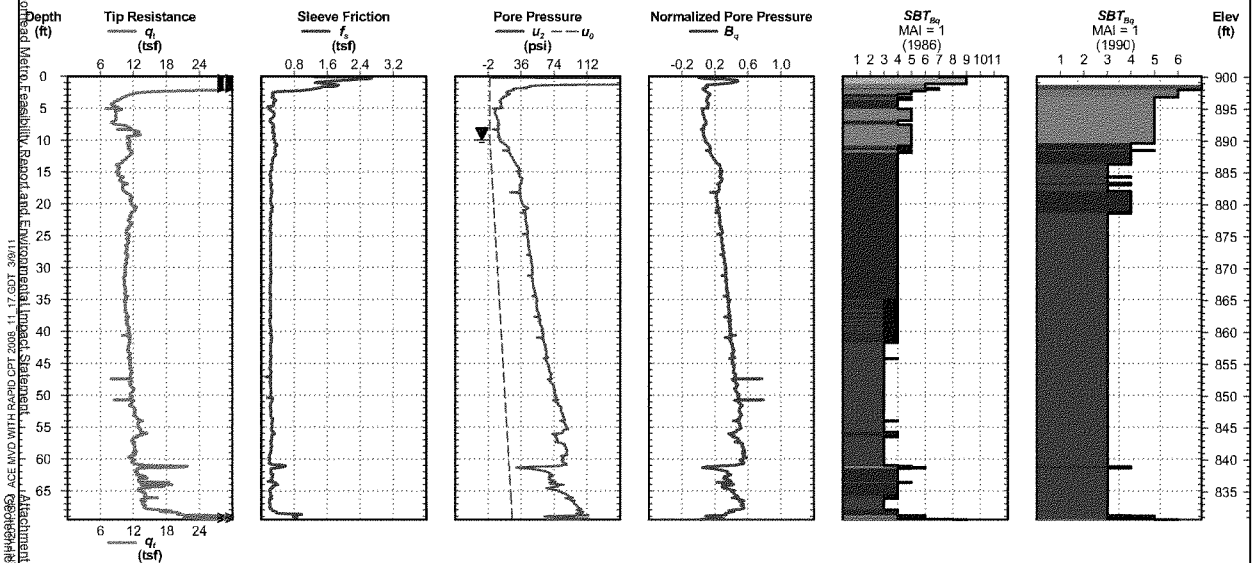
Cone Penetration Test

10-96-C

Date: Dec. 3, 2010
Operator: Johnston
Drilling Agency: USACE, Savannah District

Latitude: 46° 55' 14.376"
Longitude: -96° 57' 38.196"
Probe ID/Net Area Ratio: DDG1069 / 0.8

Elevation: 900.2
Water Depth: 10.01
Total Depth: 69.5 ft



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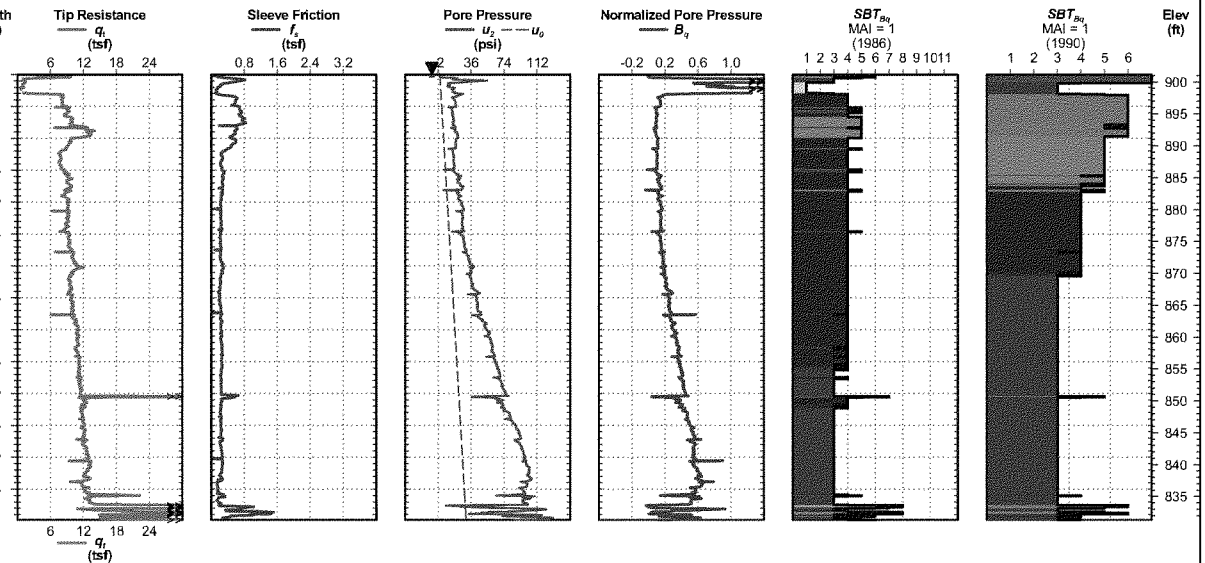
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

10-98-C

Date:	Dec. 6, 2010	**Latitude:**	46° 52' 18.516"	**Elevation:**	901.2
Operator:	Johnston	**Longitude:**	-96° 56' 50.784"	**Water Depth:**	0
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1069 / 0.8	**Total Depth:**	69.8 ft



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Electronic Filename: 10-98-C.cpt

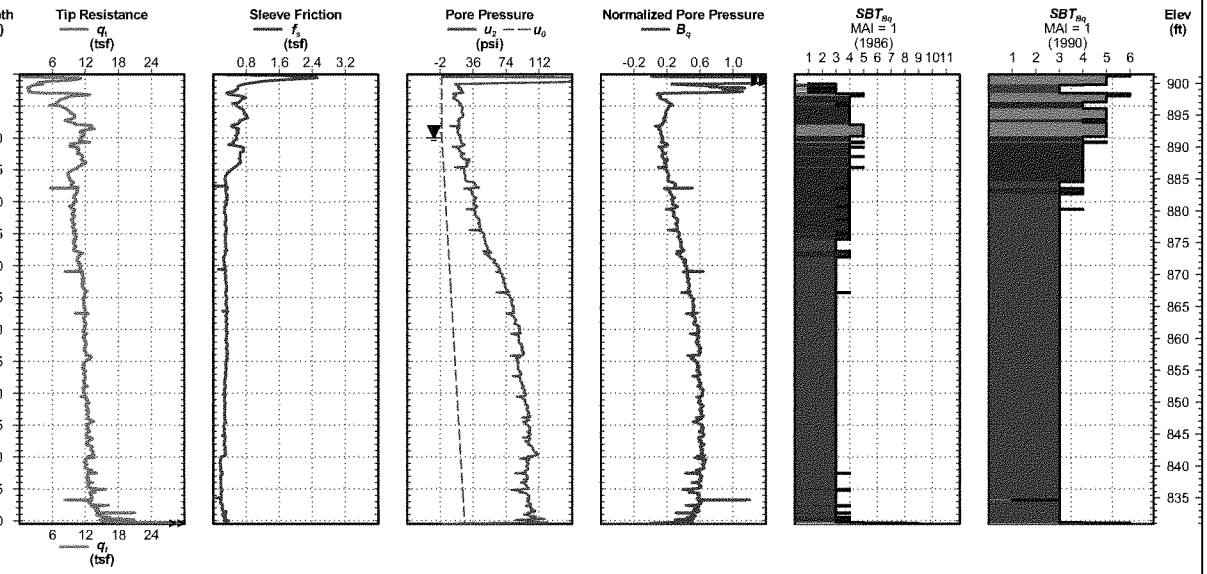
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

10-99-C

Date:	Dec. 7, 2010	**Latitude:**	46° 51' 45.36"	**Elevation:**	901.4
Operator:	Johnston	**Longitude:**	-96° 56' 0.6"	**Water Depth:**	10.01
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1069 / 0.8	**Total Depth:**	70.5 ft



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Fargo Red River Diversion

Project No: FY 2011

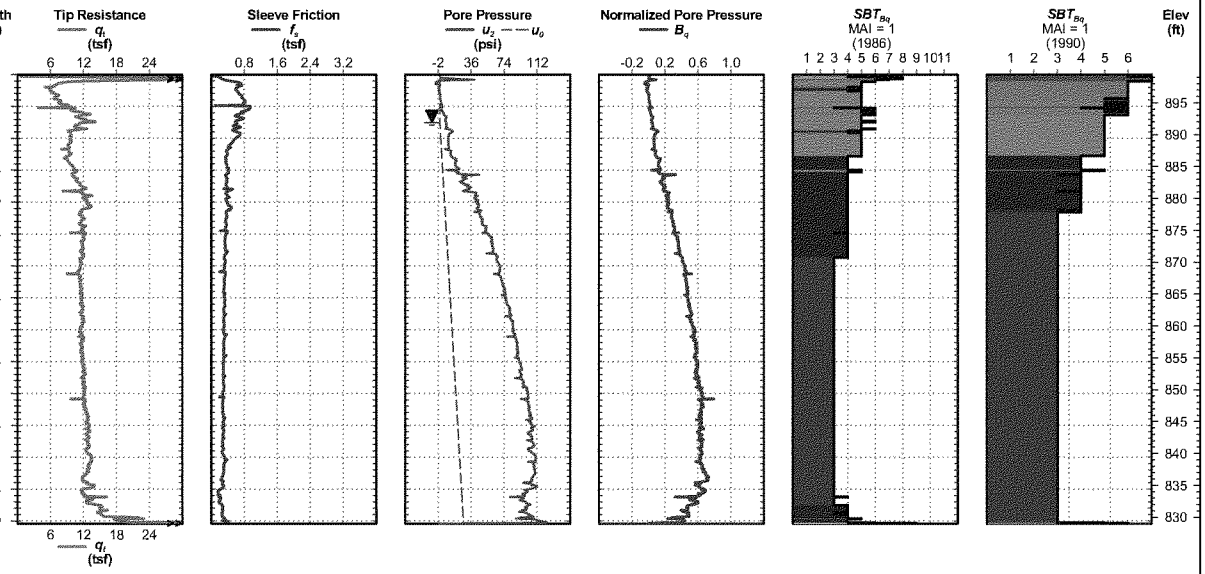
Cone Penetration Test

10-100-C

Date: Dec. 8, 2010
Operator: Johnston
Drilling Agency: USACE, Savannah District

Latitude: 46° 51' 16.272"
Longitude: -96° 55' 21.396"
Probe ID/Net Area Ratio: DDG1117 / 0.8

Elevation: 899.4
Water Depth: 7.51
Total Depth: 70.4 ft



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Electronic Filename: 10-100-C.cpt

Fargo Red River Diversion

Project No: FY 2011

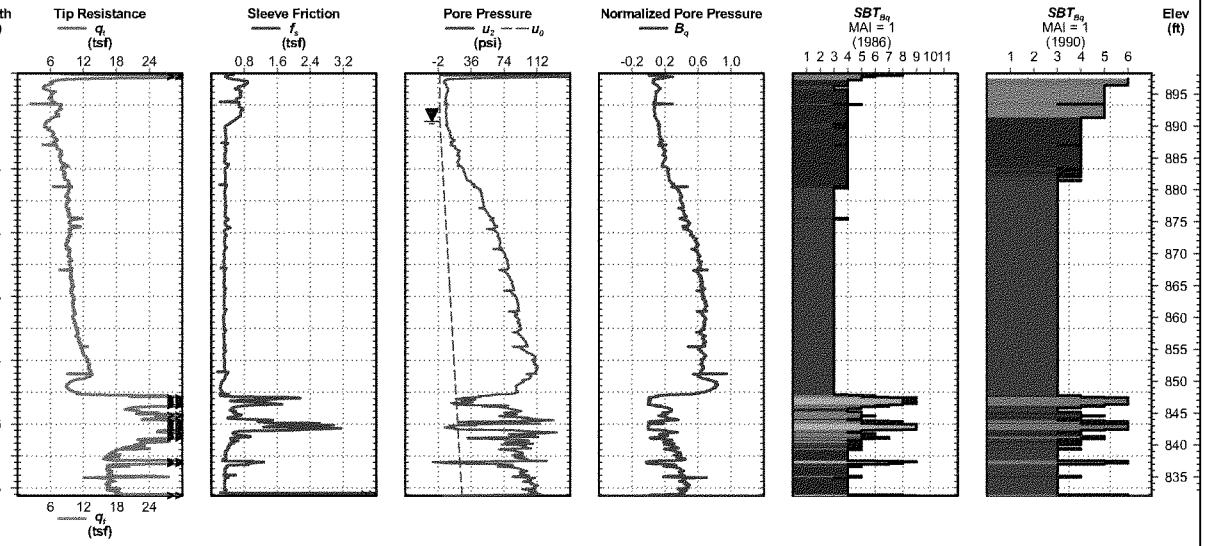
Cone Penetration Test

10-102-C

Date: Dec. 8, 2010
Operator: Johnston
Drilling Agency: USACE, Savannah District

Latitude: 46° 50' 26.952"
Longitude: -96° 55' 37.128"
Probe ID/Net Area Ratio: DDG1117 / 0.8

Elevation: 898.3
Water Depth: 7.51
Total Depth: 66.2 ft



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Electronic Filename: 10-102-C.cpt

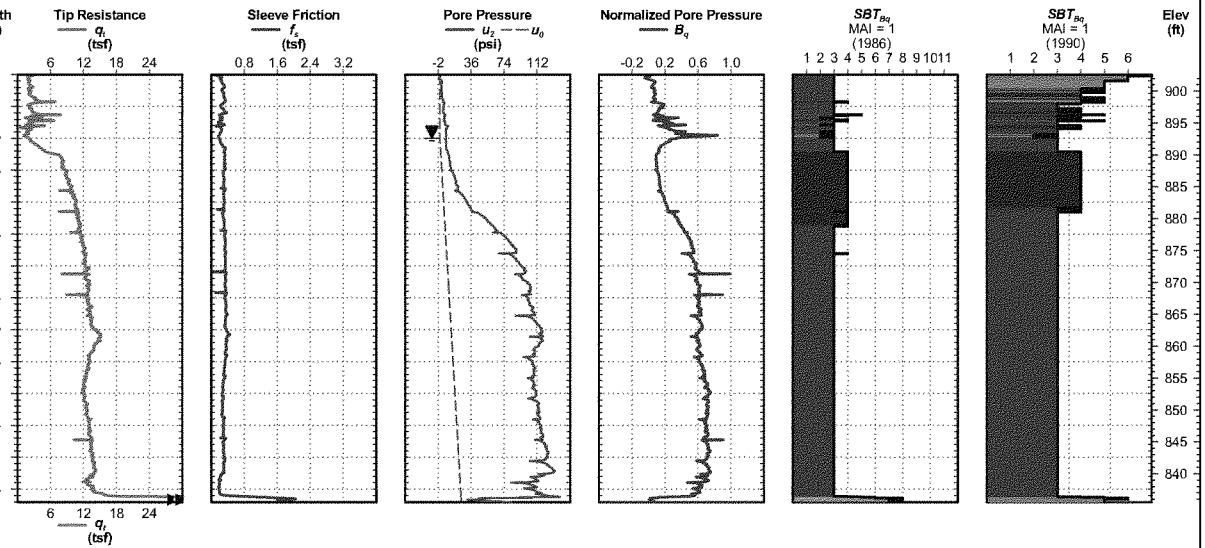
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

10-103-C

Date:	Dec. 9, 2010	**Latitude:**	46° 49' 34.14"	**Elevation:**	902.6
Operator:	Johnston	**Longitude:**	-96° 55' 30.396"	**Water Depth:**	10.01
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	67.1 ft



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Electronic Filename: 10-103-C.cpt

CPT REPORT - Geotechnical Engineering Group - Fargo Red River Diversion ACE MVD WITH RAPID CPT 2008_11_17.GDT 3/9/11
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
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Fargo Red River Diversion

Project No: FY 2011

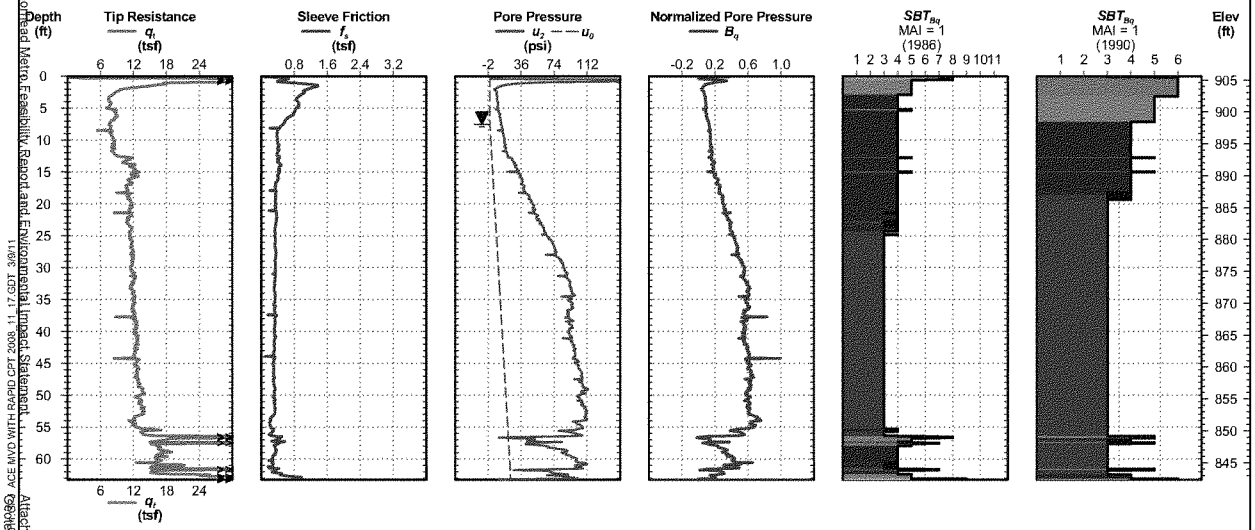
Cone Penetration Test

10-104-C

Date: Dec. 10, 2010
Operator: Johnston
Drilling Agency: USACE, Savannah District

Latitude: 46° 47' 50.208"
Longitude: -96° 55' 36.912"
Probe ID/Net Area Ratio: DDG1117 / 0.8

Elevation: 905.6
Water Depth: 7.51
Total Depth: 63.3 ft



Electronic Filename: 10-104-C.cpt

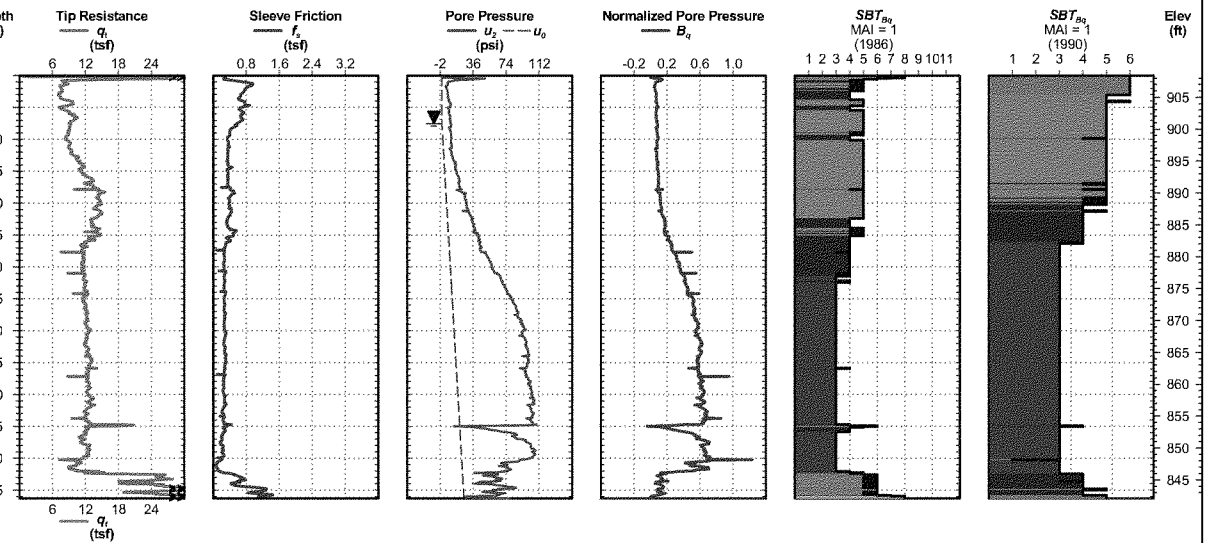
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

10-106-C

Date:	Dec. 10, 2010	**Latitude:**	46° 46' 58.26"	**Elevation:**	908.4
Operator:	Johnston	**Longitude:**	-96° 55' 37.164"	**Water Depth:**	7.51
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	66.3 ft



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Electronic Filename: 10-106-C.cpt

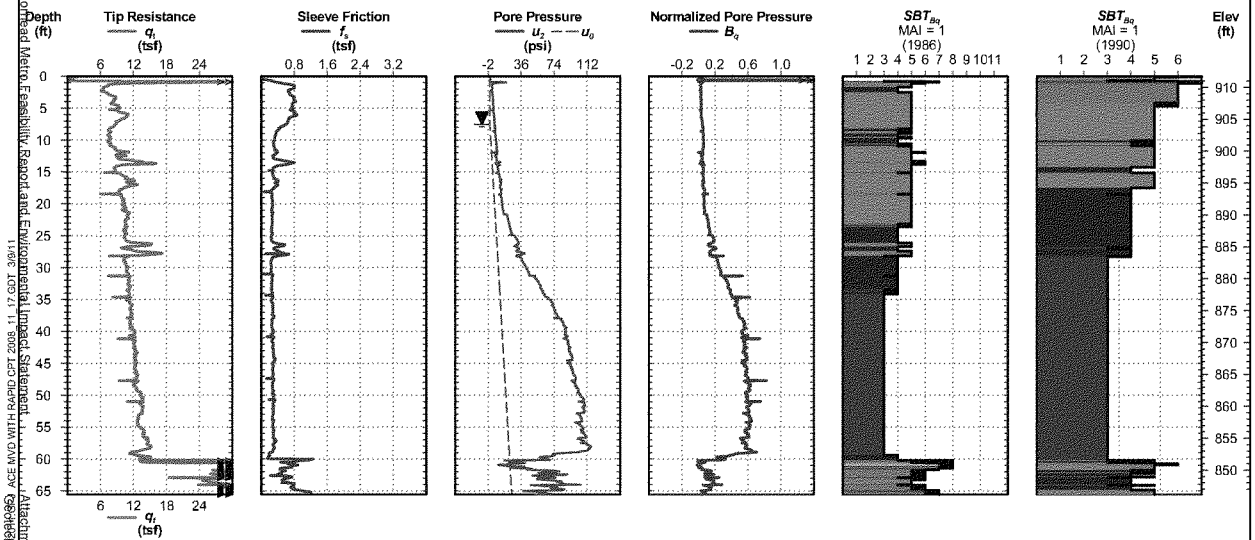
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Attachment I-3, pg 54
CPT REPORT - Advanced Geotechnical Engineering, ACE MVD WITH RAPID CPT 2008_11_17.GDT 3/9/11

Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test 10-107-C

Date:	Dec. 11, 2010	**Latitude:**	46° 46' 5.124"	**Elevation:**	911.8
Operator:	Johnston	**Longitude:**	-96° 55' 51.528"	**Water Depth:**	7.51
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	65.6 ft



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Electronic Filename: 10-107-C.cpt

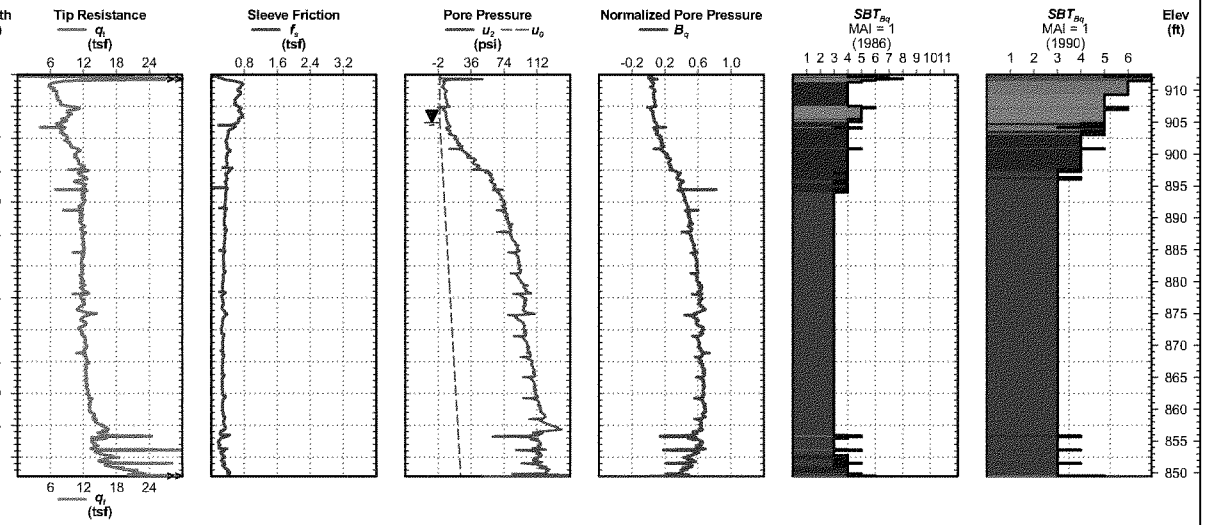
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

10-108-C

Date:	Dec. 11, 2010	**Latitude:**	46° 45' 11.448"	**Elevation:**	912.5
Operator:	Johnston	**Longitude:**	-96° 56' 26.772"	**Water Depth:**	7.51
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	63.0 ft



Page 1 of 1

Electronic Filename: 10-108-C.cpt

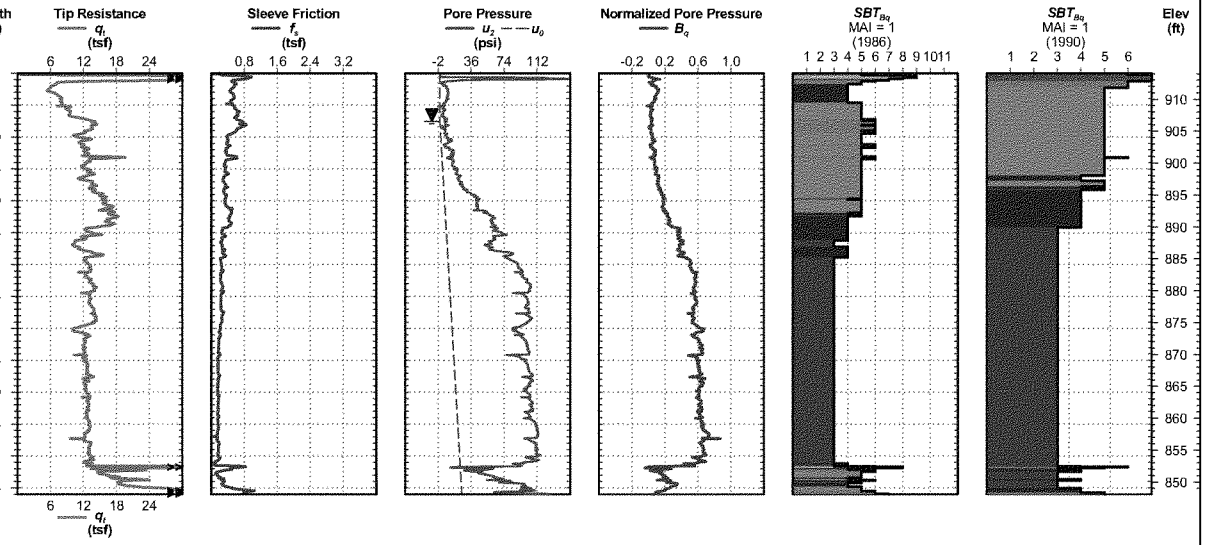
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

10-109-C

Date:	Dec. 13, 2010	**Latitude:**	46° 44' 24.648"	**Elevation:**	914.1
Operator:	Johnston	**Longitude:**	-96° 56' 19.248"	**Water Depth:**	7.51
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	66.0 ft



Electronic Filename: 10-109-C.cpt

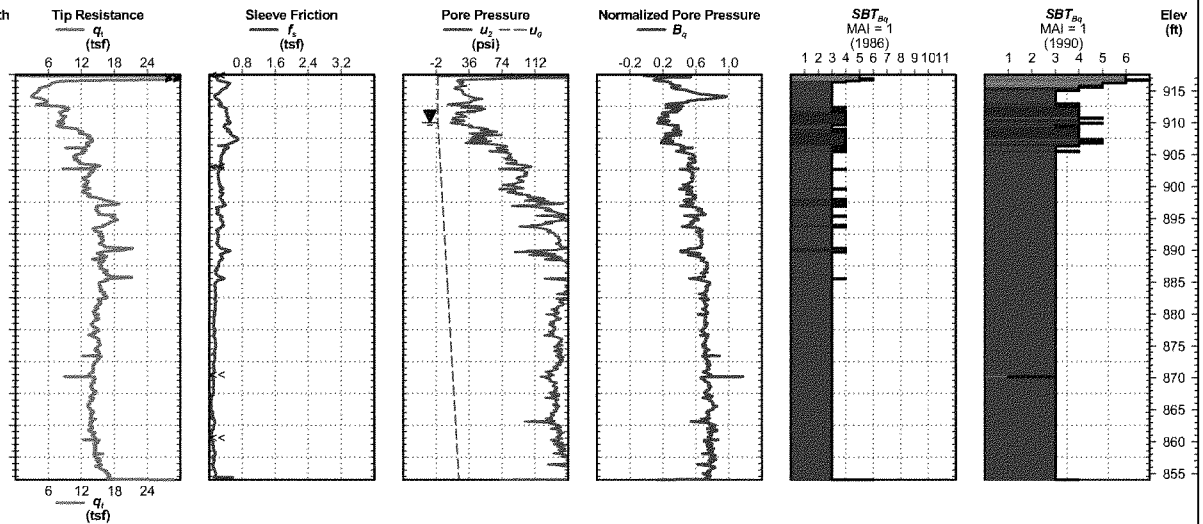
CPT REPORT - J:\Projects\Fargo\Fargo Moorhead Metro Feasibility Report and Environmental Impact Statement - Attachment I-3, pg 57
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Attachment I-3, pg 57
ACE MVD WITH RAPID CPT 2008_11_17.GDT 3/9/11

Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test 10-110-Ca

Date:	Dec. 14, 2010	**Latitude:**	46° 44' 18.6"	**Elevation:**	917.6
Operator:	Johnston	**Longitude:**	-96° 55' 44.292"	**Water Depth:**	7.51
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	63.5 ft



Electronic Filename: 10-110-Ca.cpt

Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Attachment I-3, pg 58
CPT REPORT - Johnston, Savannah District - ACE MVD WITH RAPID CPT 2008_11_17.GDT 3/9/11

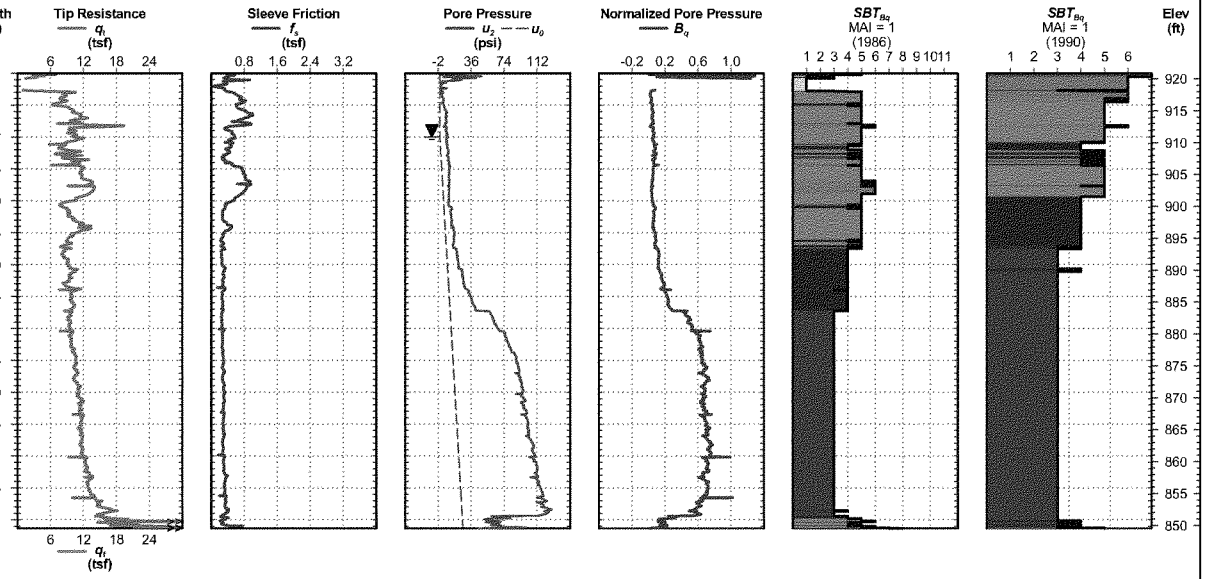
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

11-111-C

Date:	Jan. 10, 2011	**Latitude:**	46° 43' 54.48"	**Elevation:**	920.9
Operator:	Johnston	**Longitude:**	-96° 55' 4.8"	**Water Depth:**	10.01
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	71.3 ft



Page 1 of 1

Electronic Filename: 10-111-C.cpt

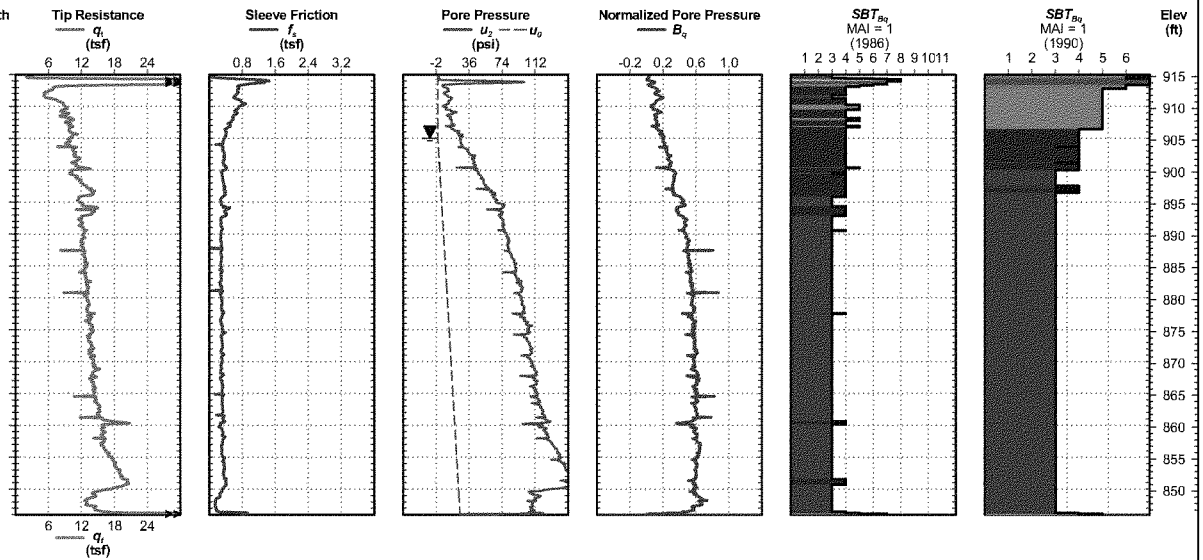
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

11-112-C

Date:	Jan. 11, 2011	**Latitude:**	46° 43' 40.512"	**Elevation:**	915.3
Operator:	Johnston	**Longitude:**	-96° 54' 49.068"	**Water Depth:**	10.01
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	69.0 ft



Electronic Filename: 10-112-C.cpt

CPT REPORT - ACE MVD WITH RAPID CPT 2008_11_17.GDT 3/9/11
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
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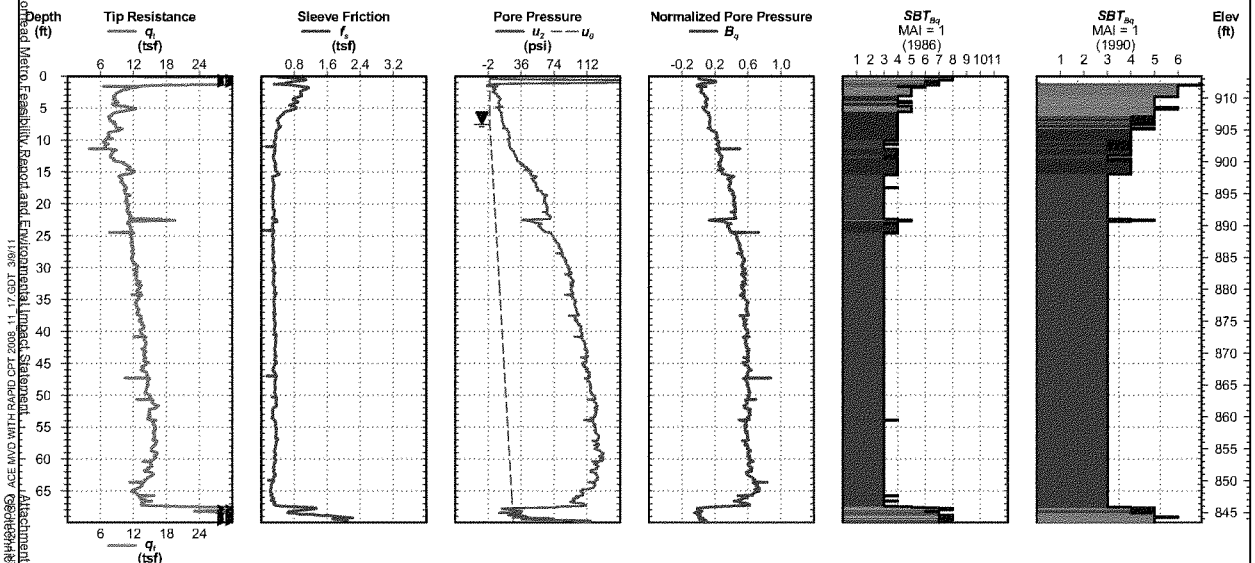
July 2011

Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test 11-113-C

Date:	Jan. 12, 2011	**Latitude:**	46° 43' 17.76"	**Elevation:**	913.4
Operator:	Johnston	**Longitude:**	-96° 53' 32.244"	**Water Depth:**	7.51
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	70.0 ft



Page 1 of 1

Electronic Filename: 10-113-C.cpt

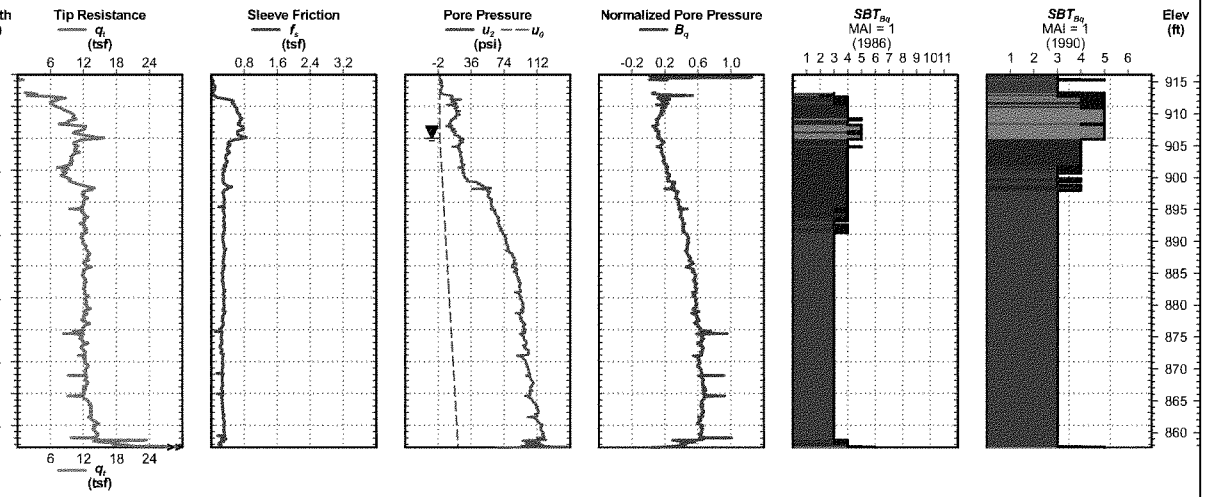
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

11-114-C

Date:	Jan. 12, 2011	**Latitude:**	46° 43' 1.416"	**Elevation:**	916.2
Operator:	Johnston	**Longitude:**	-96° 53' 16.512"	**Water Depth:**	10.01
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	58.5 ft



Electronic Filename: 10-114-C.cpt

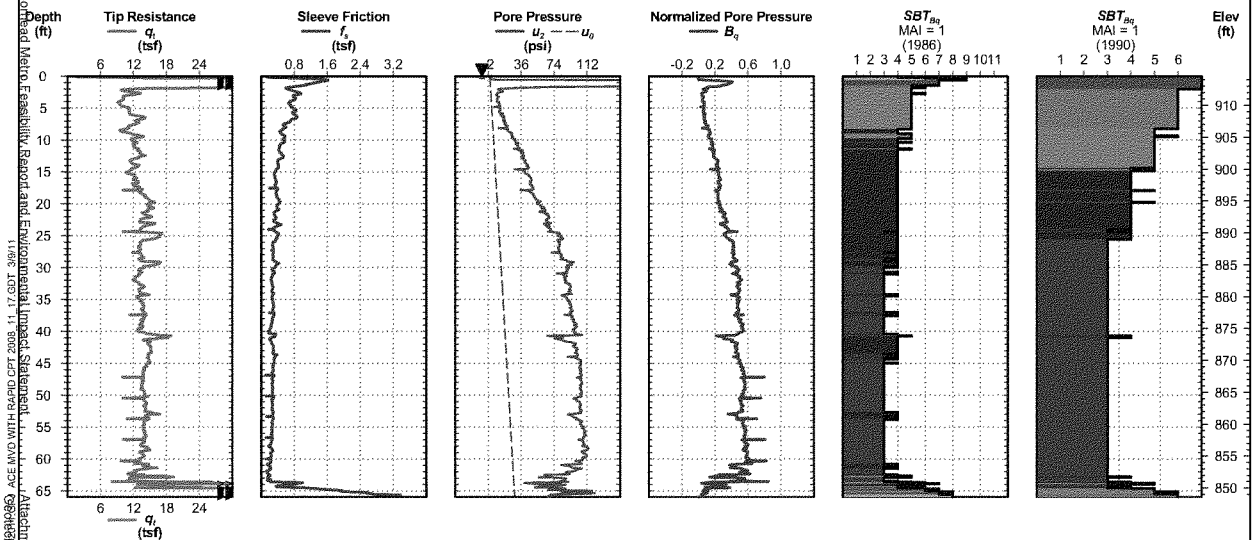
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Attachment I-3, pg 62
CPT REPORT - ACE MVD WITH RAPID CPT 2008_11_17.GDT 3/9/11

Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test 11-115-C

Date:	Jan. 13, 2011	**Latitude:**	46° 42' 47.592"	**Elevation:**	914.6
Operator:	Johnston	**Longitude:**	-96° 53' 0.6"	**Water Depth:**	0
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	65.9 ft



Page 1 of 1

Electronic Filename: 10-115-C.cpt

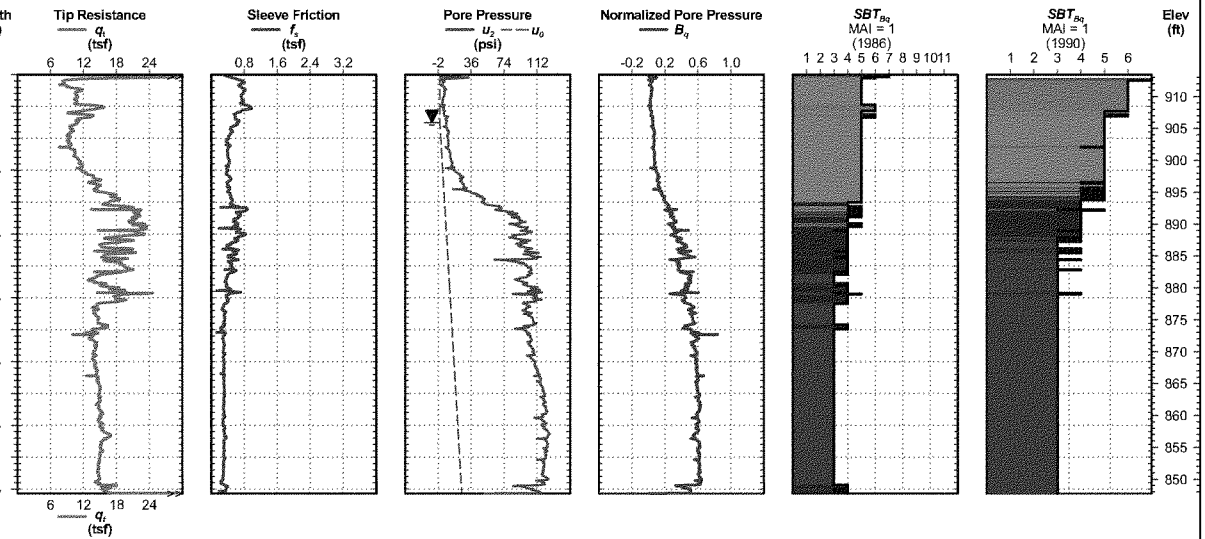
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

11-116-C

Date:	Jan. 14, 2011	**Latitude:**	46° 41' 47.4"	**Elevation:**	913.5
Operator:	Johnston	**Longitude:**	-96° 50' 30.948"	**Water Depth:**	7.51
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	65.7 ft



Electronic Filename: 10-116-C.cpt

CPT REPORT - Attachment I-3 pg 64
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Contractor Name: Geotechnical Design Group
Contractor Address: ACE MVD WITH RAPID CPT 2008_11_17.GDT 3/9/11

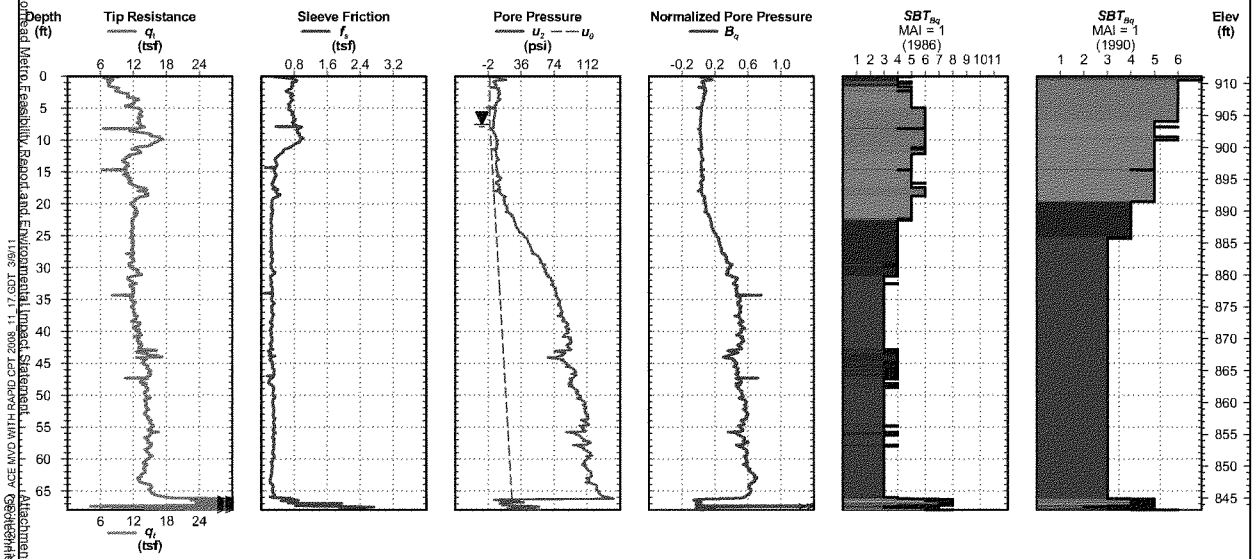
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

11-117-C

Date:	Jan. 15, 2011	**Latitude:**	46° 42' 2.412"	**Elevation:**	911.2
Operator:	Johnston	**Longitude:**	-96° 50' 16.332"	**Water Depth:**	7.51
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	68.0 ft



Page 1 of 1

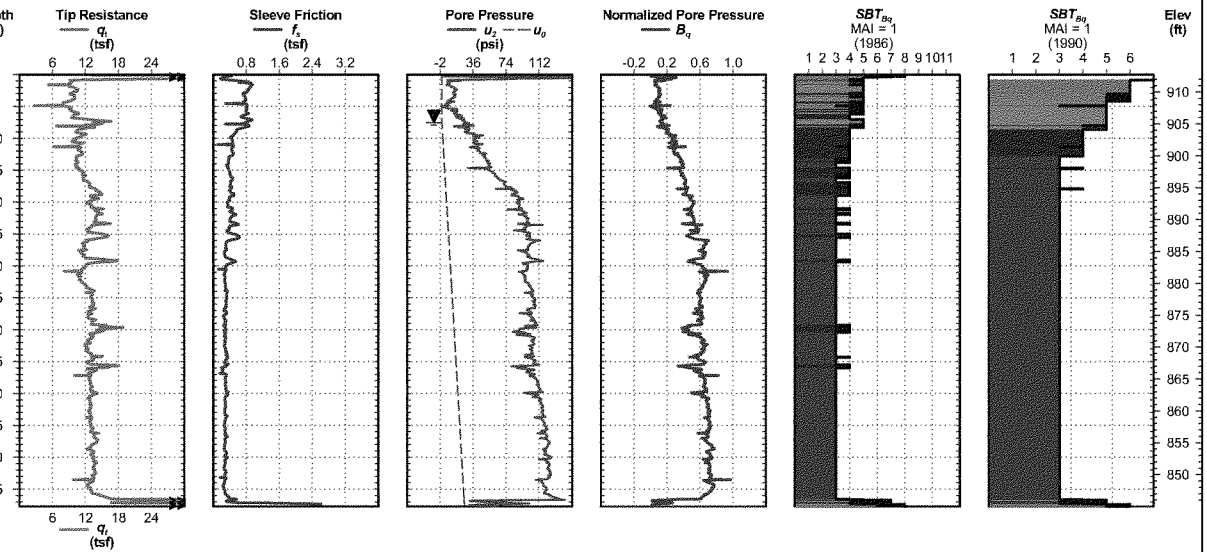
Electronic Filename: 10-117-C.cpt

Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test 11-118-Ca

Date:	Jan. 15, 2011	**Latitude:**	46° 41' 58.56"	**Elevation:**	912.7
Operator:	Johnston	**Longitude:**	-96° 50' 12.948"	**Water Depth:**	7.51
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	67.7 ft



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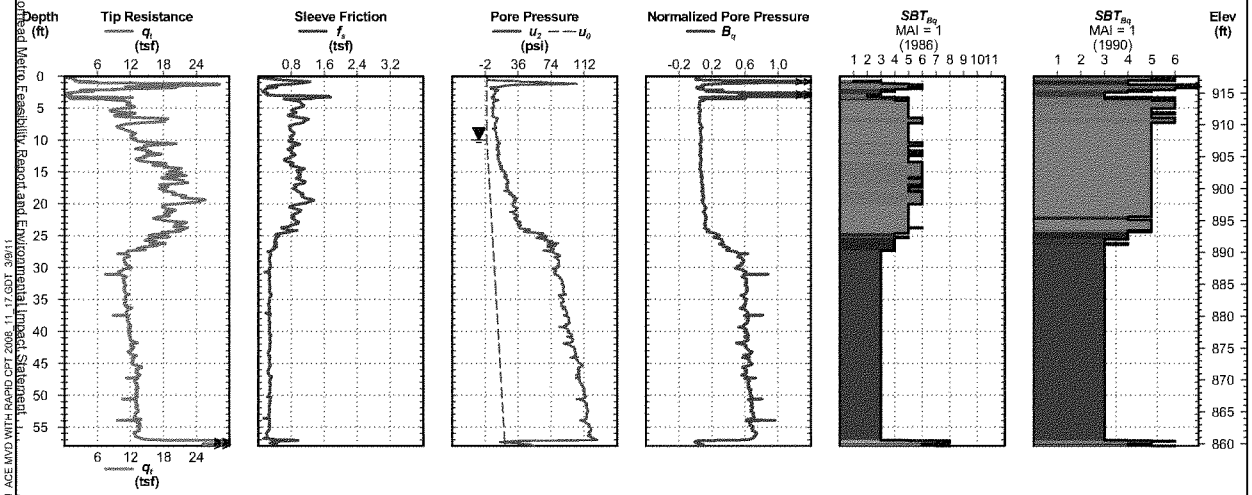
Electronic Filename: 10-118-C.cpt

Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test 11-119-C

Date:	Jan. 16, 2011	**Latitude:**	46° 42' 4.5"	**Elevation:**	917.6
Operator:	Johnston	**Longitude:**	-96° 47' 19.248"	**Water Depth:**	10.01
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	57.9 ft



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Electronic Filename: 10-119-C.cpt

Fargo Red River Diversion

Project No: FY 2011

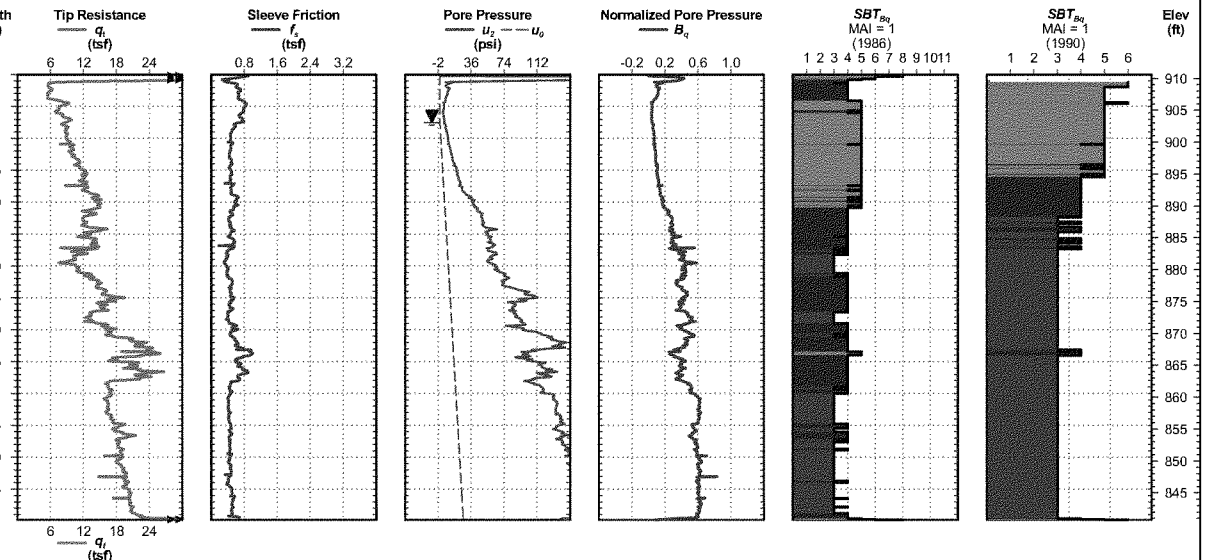
Cone Penetration Test

11-120-C

Date: Jan. 17, 2011
Operator: Johnston
Drilling Agency: USACE, Savannah District

Latitude: 46° 41' 55.644"
Longitude: -96° 48' 34.776"
Probe ID/Net Area Ratio: DDG1117 / 0.8

Elevation: 910.6
Water Depth: 7.51
Total Depth: 69.8 ft



Electronic Filename: 10-120-C.cpt

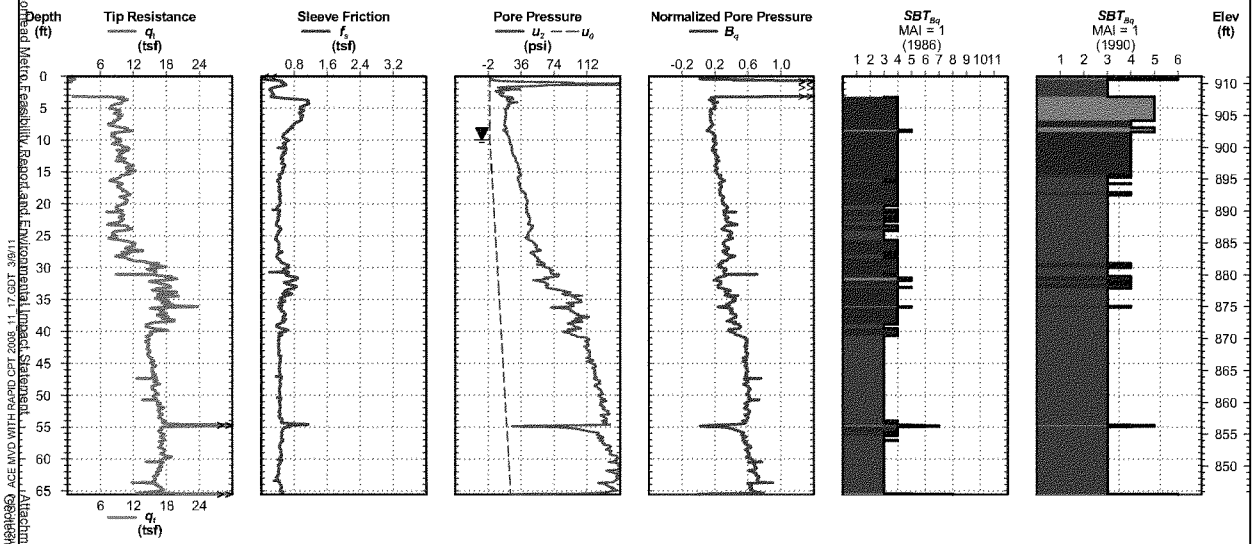
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

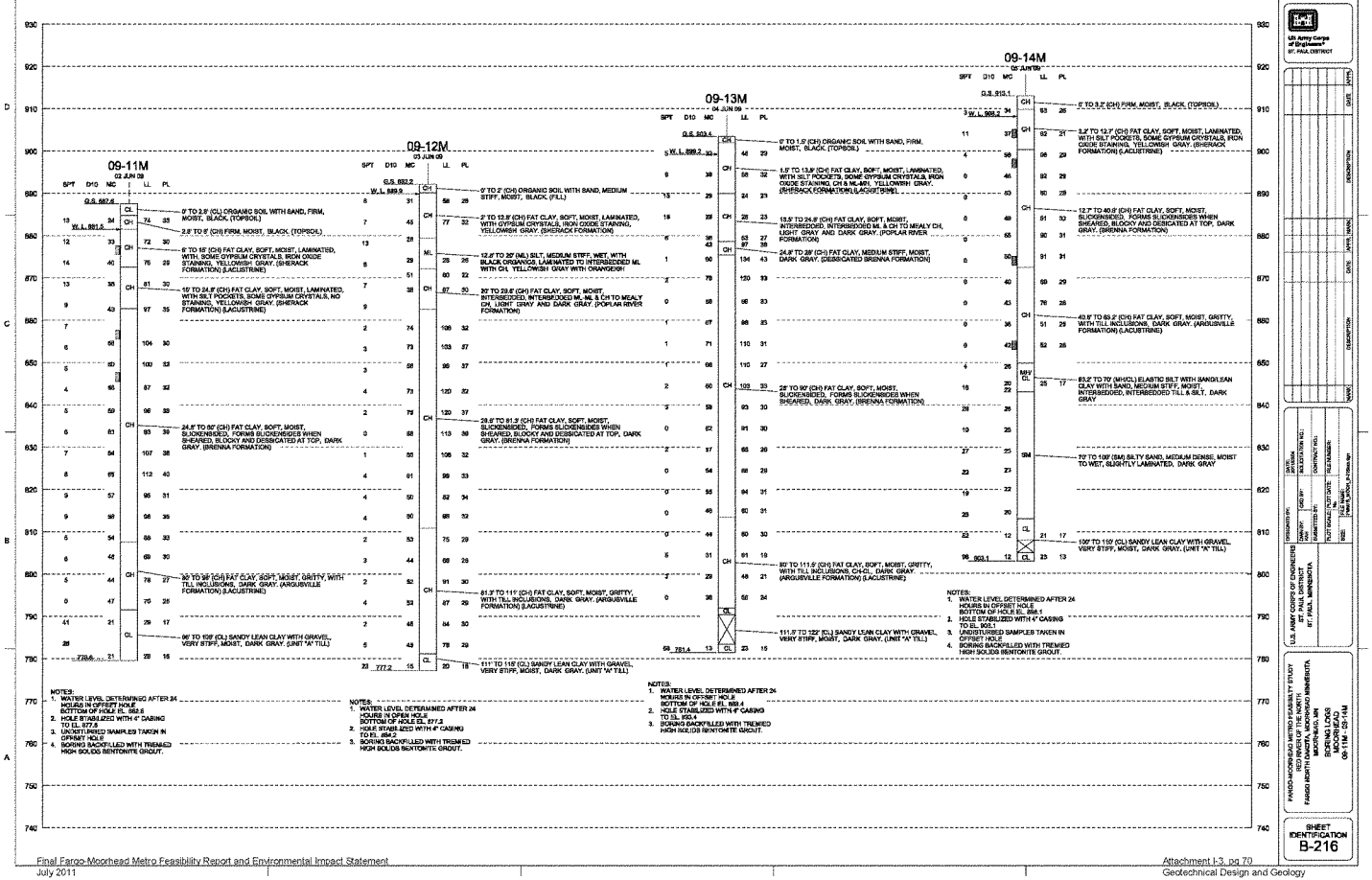
11-121-C

Date:	Jan. 17, 2011	**Latitude:**	46° 41' 55.572"	**Elevation:**	911.1
Operator:	Johnston	**Longitude:**	-96° 49' 12.648"	**Water Depth:**	10.01
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	65.6 ft

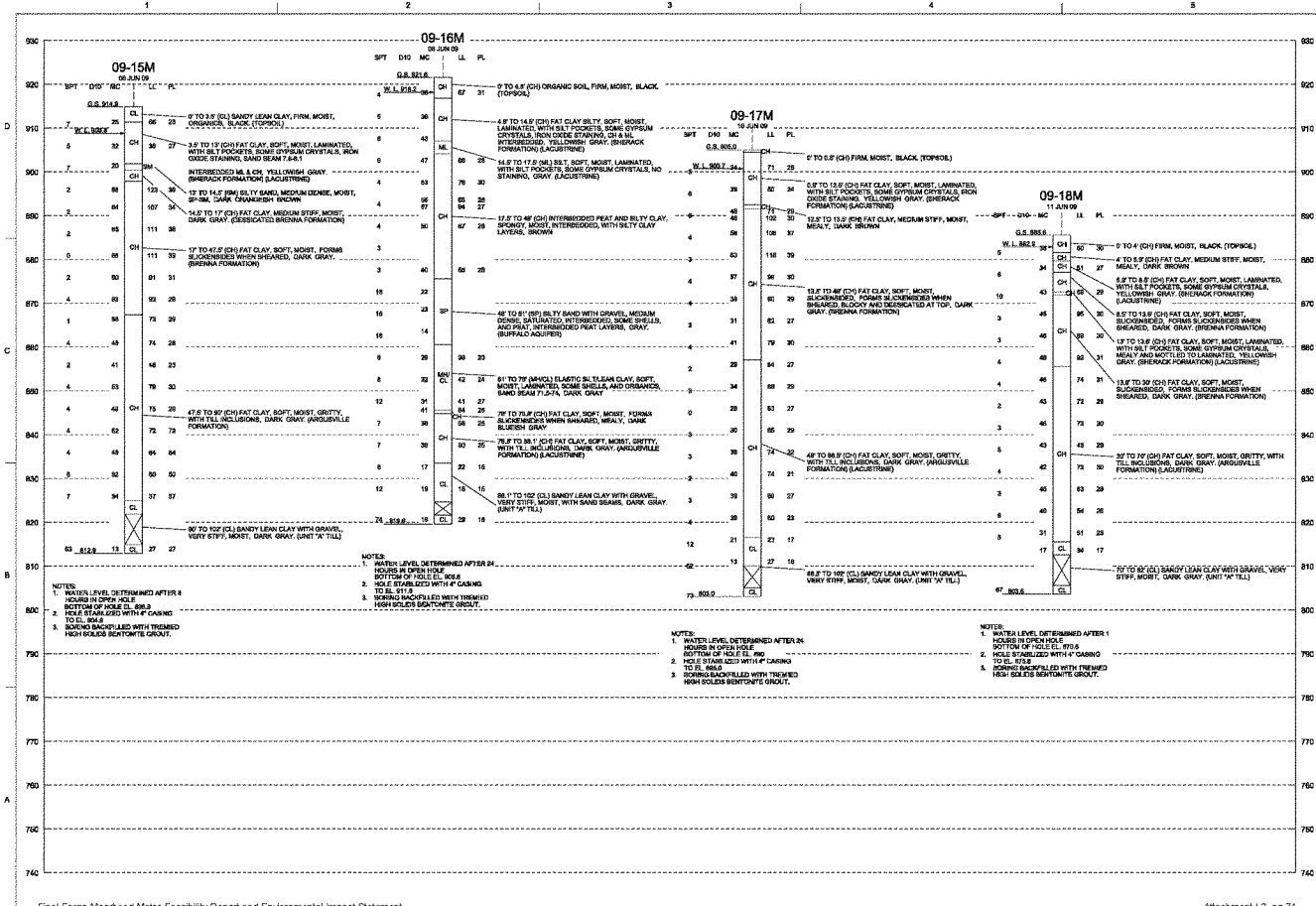


Electronic Filename: 10-121-C.cpt

CPT REPORT - Attachment I-3, pg 69
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Attachment I-3, pg 69
ACE MVD WITH RAPID CPT 2008_11_17.GDT 3/9/11


09-11M
02 JUN 09
09-12M
03 JUN 09
09-13M
04 JUN 09
09-14M
05 JUN 09
SPT D10 MC LL PL
0' TO 2.9' (CL) ORGANIC SOIL WITH SAND, FIRM, MOIST, BLACK, (TOPSOIL)
2.9' TO 6' (CH) FIRM, MOIST, BLACK, (TOPSOIL)
6' TO 16' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH, SOME GYPSUM CRYSTALS, IRON OXIDE STAINING, YELLOWISH GRAY, (SHERACK FORMATION) (LACUSTRINE)
16' TO 24.8' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH SILT POCKETS, SOME GYPSUM CRYSTALS, NO STAINING, YELLOWISH GRAY, (SHERACK FORMATION) (LACUSTRINE)
24.8' TO 90' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, FORMS SLICKENSIDES WHEN SHEARED, BLOCKY AND DESSICATED AT TOP, DARK GRAY, (BRENNA FORMATION)
90' TO 98' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY, (ARGUSVILLE FORMATION) (LACUSTRINE)
98' TO 108' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, DARK GRAY, (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OFFSET HOLE BOTTOM OF HOLE EL. 883.6
2. HOLE STABILIZED WITH 4" CASING TO EL. 877.8
3. UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
0' TO 2' (CH) ORGANIC SOIL WITH SAND, MEDIUM STIFF, MOIST, BLACK, (FILL)
2' TO 12.8' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH GYPSUM CRYSTALS, IRON OXIDE STAINING, YELLOWISH GRAY, (SHERACK FORMATION)
12.8' TO 20' (ML) SILT, MEDIUM STIFF, WET, WITH BLACK ORGANICS, LAMINATED TO INTERBEDDED ML WITH CH, YELLOWISH GRAY WITH ORANGERH
20' TO 29.8' (CH) FAT CLAY, SOFT, MOIST, INTERBEDDED, INTERBEDDED ML, ML & CH TO MEALY CH, LIGHT GRAY AND DARK GRAY, (POPLAR RIVER FORMATION)
29.8' TO 81.3' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, FORMS SLICKENSIDES WHEN SHEARED, BLOCKY AND DESSICATED AT TOP, DARK GRAY, (BRENNA FORMATION)
81.3' TO 111' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY, (ARGUSVILLE FORMATION) (LACUSTRINE)
111' TO 118' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, DARK GRAY, (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OFFSET HOLE BOTTOM OF HOLE EL. 877.2
2. HOLE STABILIZED WITH 4" CASING TO EL. 884.2
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
0' TO 1.5' (CH) ORGANIC SOIL WITH SAND, FIRM, MOIST, BLACK, (TOPSOIL)
1.5' TO 13.5' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH SILT POCKETS, SOME GYPSUM CRYSTALS, IRON OXIDE STAINING, CH & ML401, YELLOWISH GRAY, (SHERACK FORMATION) (LACUSTRINE)
13.5' TO 24.8' (CH) FAT CLAY, SOFT, MOIST, INTERBEDDED, INTERBEDDED ML & CH TO MEALY CH, LIGHT GRAY AND DARK GRAY, (POPLAR RIVER FORMATION)
24.8' TO 28' (CH) FAT CLAY, MEDIUM STIFF, MOIST, DARK GRAY, (DESSICATED BRENNA FORMATION)
28' TO 90' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, FORMS SLICKENSIDES WHEN SHEARED, DARK GRAY, (BRENNA FORMATION)
90' TO 111.5' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, CH-CL, DARK GRAY, (ARGUSVILLE FORMATION) (LACUSTRINE)
111.5' TO 122' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, DARK GRAY, (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OFFSET HOLE BOTTOM OF HOLE EL. 886.4
2. HOLE STABILIZED WITH 4" CASING TO EL. 903.1
3. UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
0' TO 3.2' (CH) FIRM, MOIST, BLACK, (TOPSOIL)
3.2' TO 12.7' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH SILT POCKETS, SOME GYPSUM CRYSTALS, IRON OXIDE STAINING, YELLOWISH GRAY, (SHERACK FORMATION) (LACUSTRINE)
12.7' TO 40.9' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, FORMS SLICKENSIDES WHEN SHEARED, BLOCKY AND DESICATED AT TOP, DARK GRAY, (BRENNA FORMATION)
40.9' TO 83.2' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY, (ARGUSVILLE FORMATION) (LACUSTRINE)
83.2' TO 70' (MH/CL) ELASTIC SILT WITH SAND/LEAN CLAY WITH SAND, MEDIUM STIFF, MOIST, INTERBEDDED, INTERBEDDED TILL & SILT, DARK GRAY
70' TO 100' (SM) SILTY SAND, MEDIUM DENSE, MOIST TO WET, SLIGHTLY LAMINATED, DARK GRAY
100' TO 110' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, DARK GRAY, (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OFFSET HOLE BOTTOM OF HOLE EL. 896.1
2. HOLE STABILIZED WITH 4" CASING TO EL. 903.1
3. UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers
ST. PAUL DISTRICT
DATE
DESCRIPTION
DATE
DESCRIPTION
DATE
DATE
DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:
CHECK BY:
PLOT SCALE:
PLOT DATE:
SIZE:
SOLICITATION NO.:
CONTRACT NO.:
FILE NUMBER:
FILE NAME:
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO, NORTH DAKOTA AND MOORHEAD, MINNESOTA
BORING LOGS
SHEET 1 OF 2
SHEET 1 OF 1
SHEET IDENTIFICATION
B-216

1562



US Army Corps of Engineers ST. PAUL DISTRICT

MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY: | DATE: 09-Jun-09 | DRAWN BY: | CHECKED BY: | SOLICITATION NO.: | CONTRACT NO.: | SUBMITTED BY: | FILE NUMBER: | PLOT SCALE: | PLOT DATE: | SIZE: 22 X 34 | FILE NAME: 09-Borings_B-217.dgn

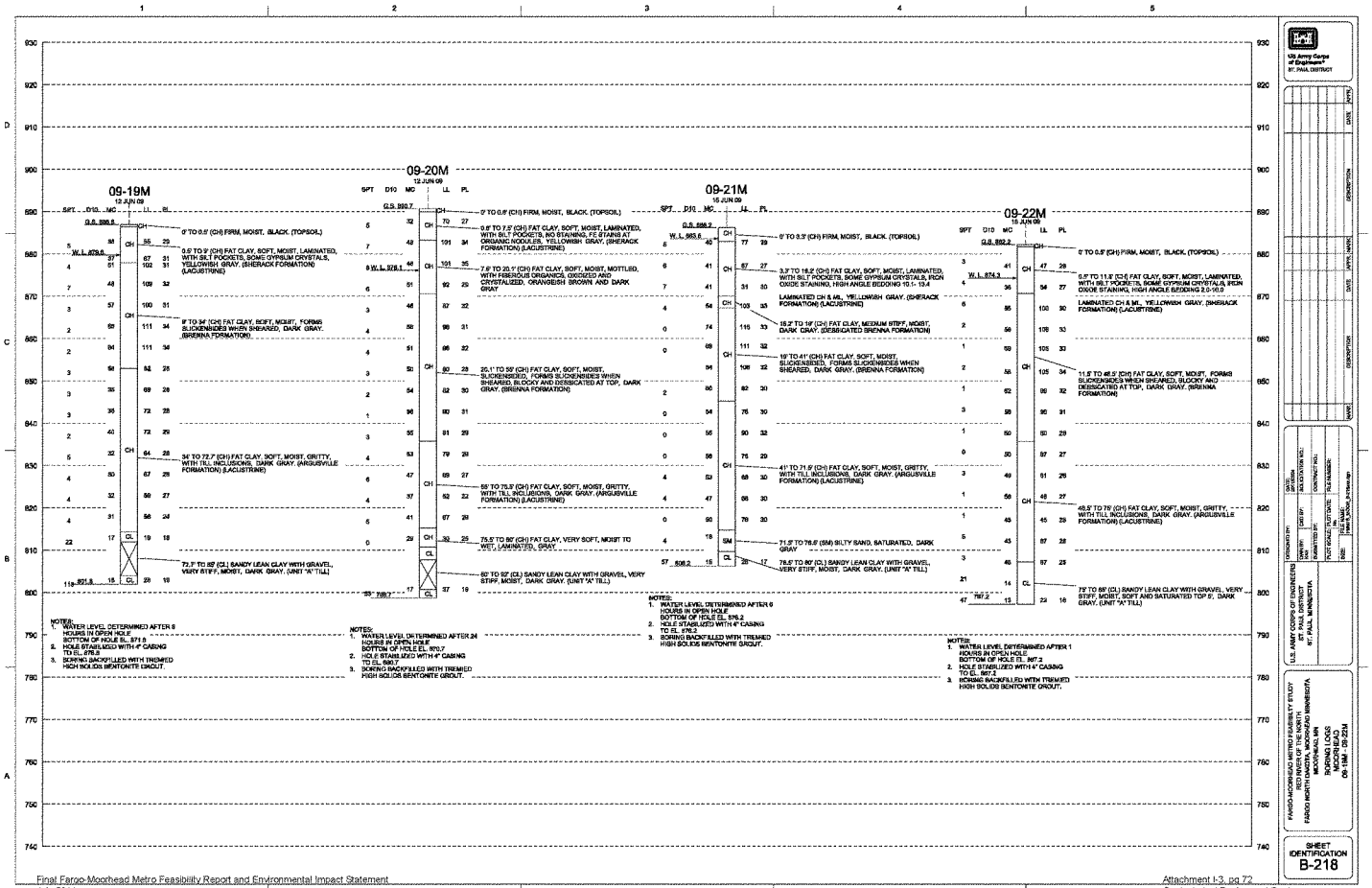
U.S. ARMY CORPS OF ENGINEERS ST. PAUL DISTRICT ST. PAUL, MINNESOTA

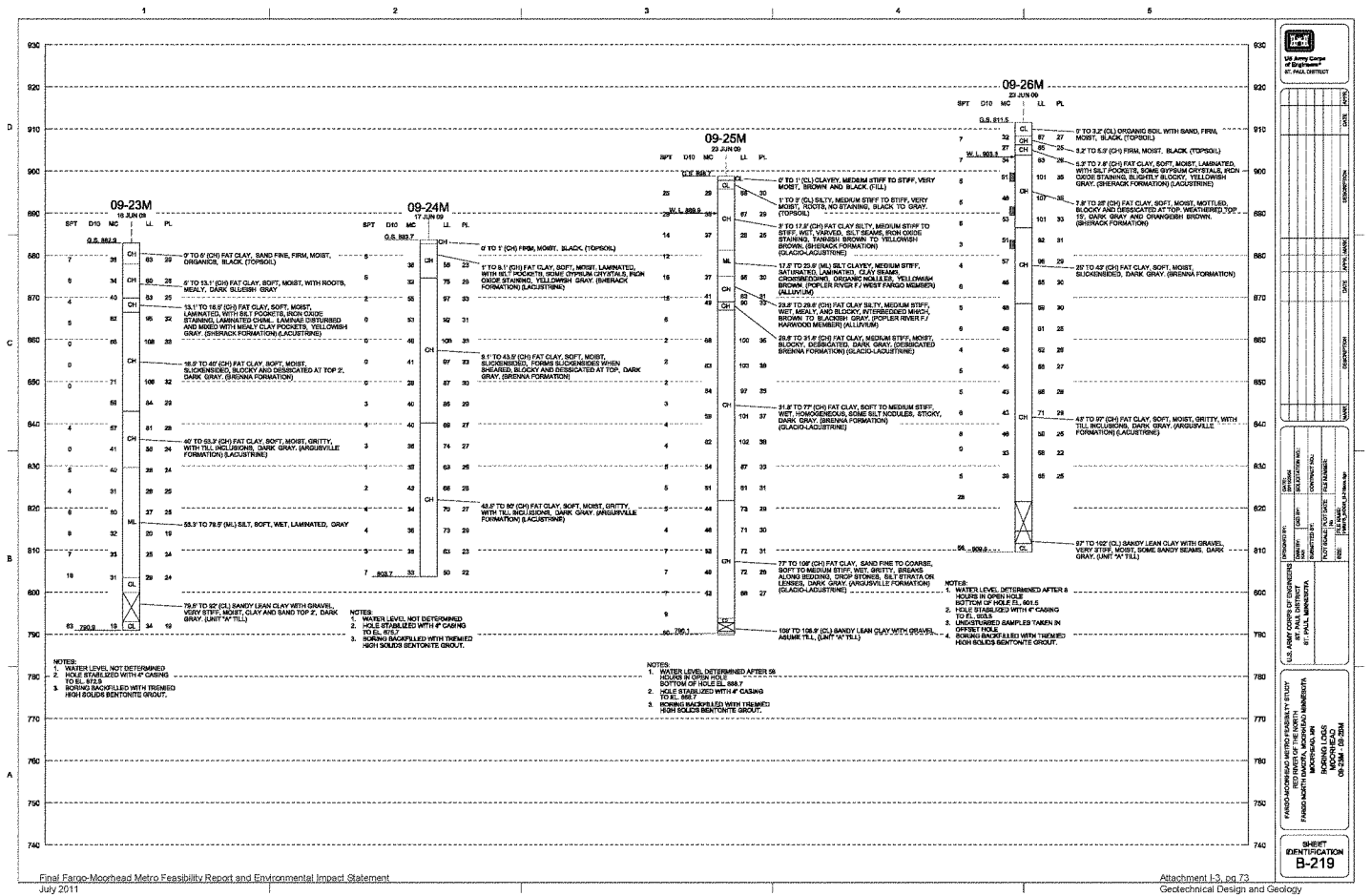
FARGO-MOORHEAD METRO FEASIBILITY STUDY RED RIVER OF THE NORTH FARGO, NORTH DAKOTA AND WEST FARGO, MOORHEAD, MINNESOTA

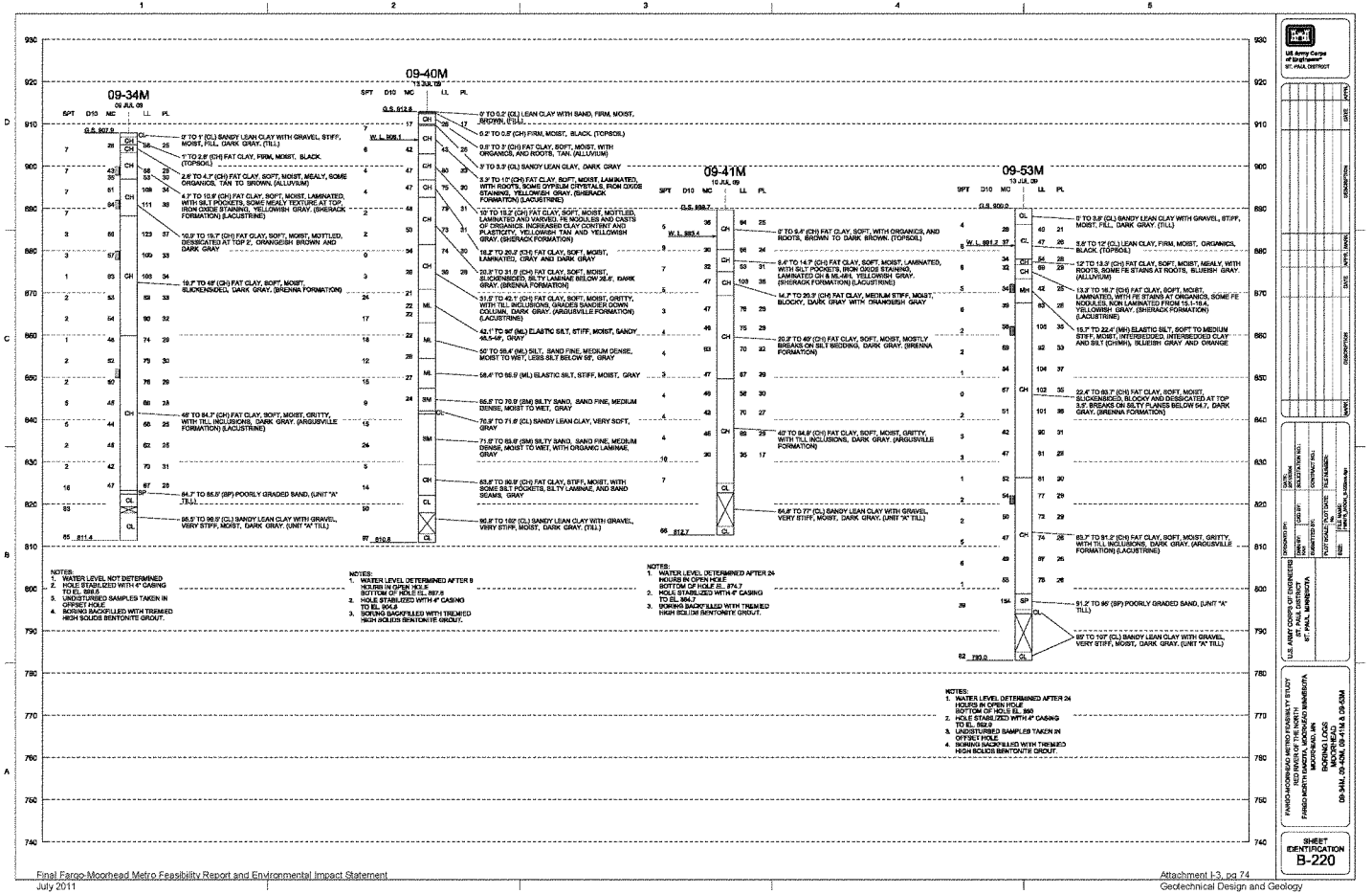
BORING LOGS (SHEET 2 OF 2) (09-15M TO 09-18M)

SHEET IDENTIFICATION B-217

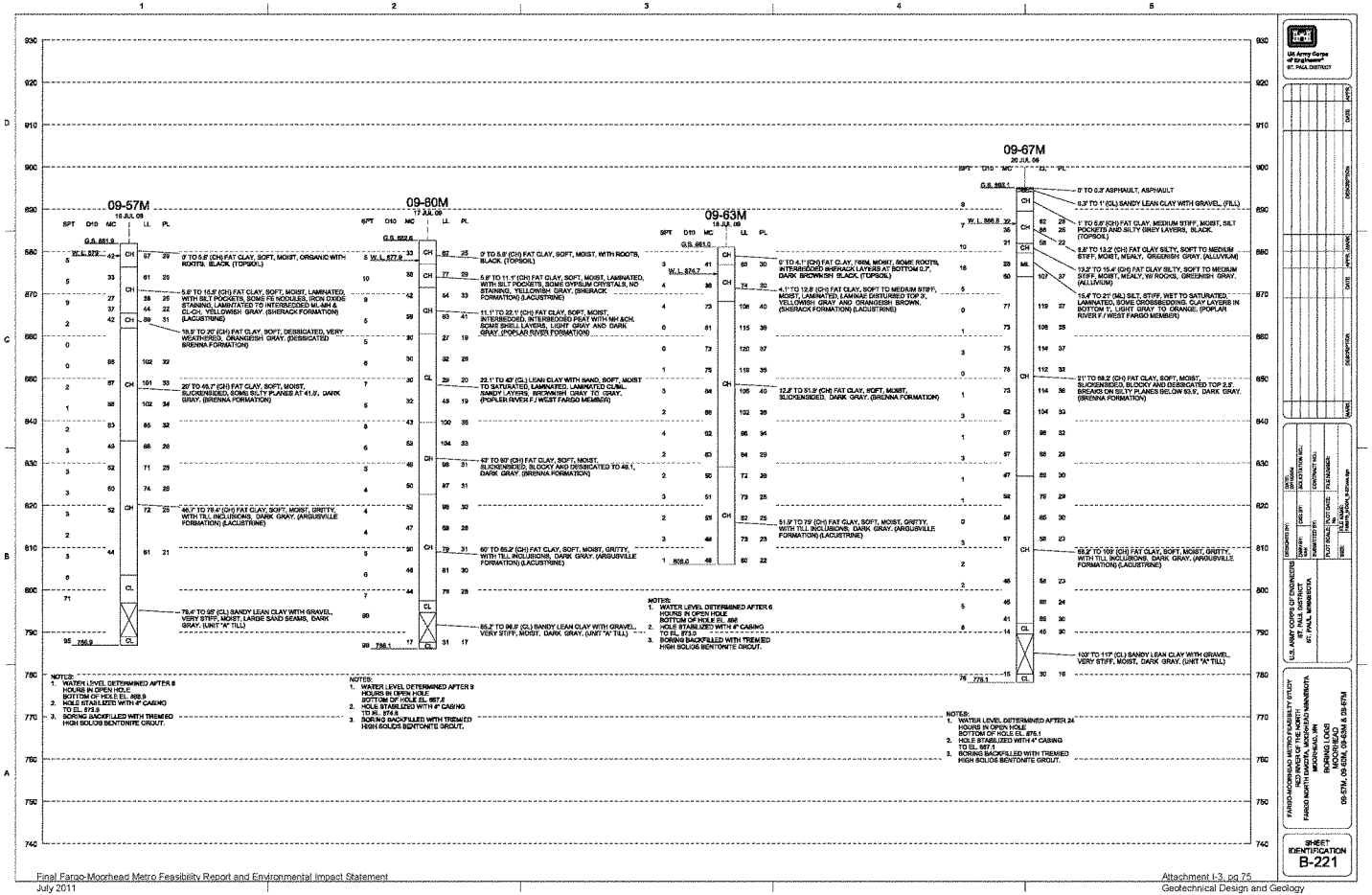
1563

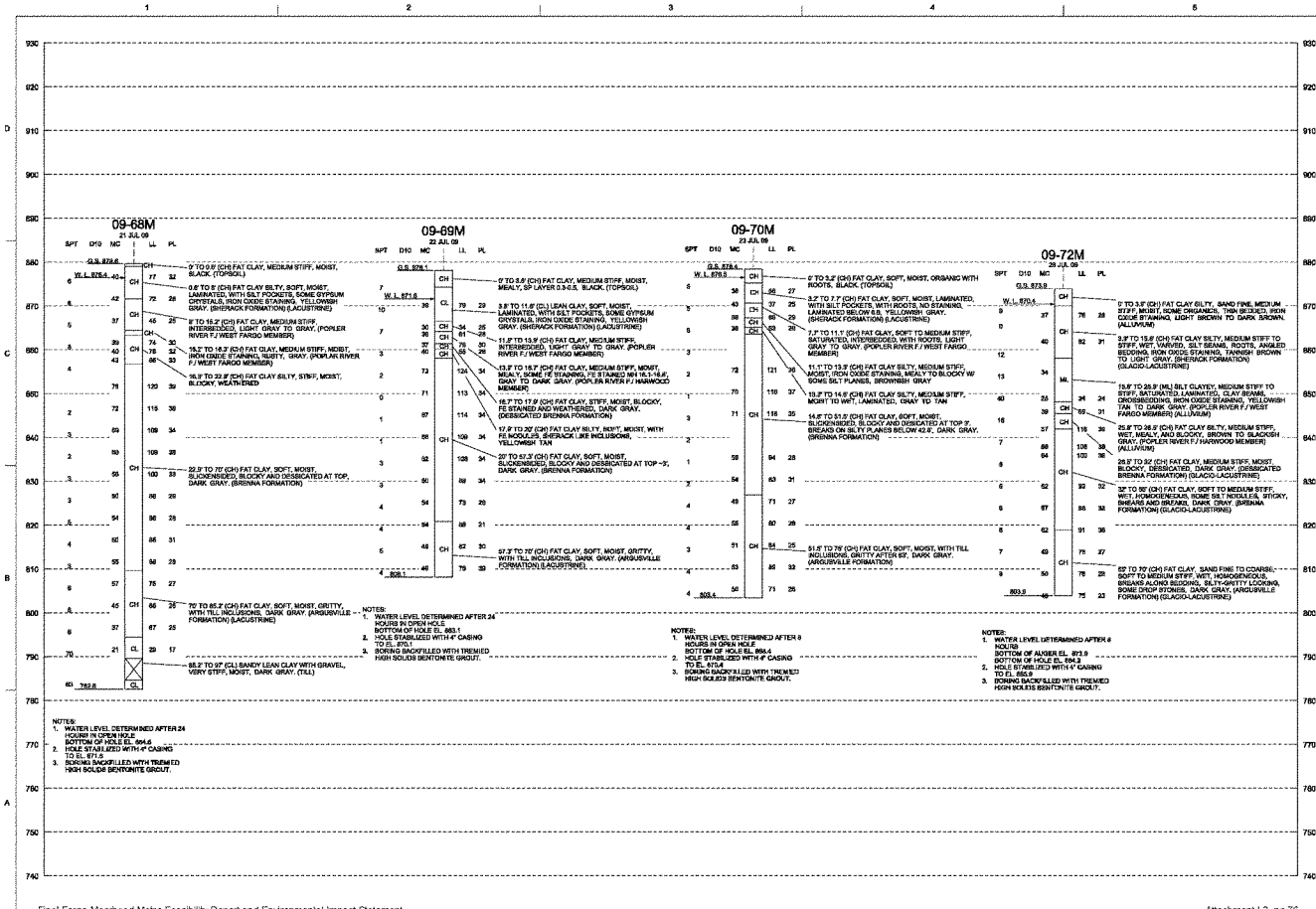

09-19M
12 JUN 09
09-20M
12 JUN 09
09-21M
15 JUN 09
09-22M
16 JUN 09
0' TO 0.5' (CH) FIRM, MOIST, BLACK, (TOPSOIL)
0.5' TO 9' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH SILT POCKETS, SOME GYPSUM CRYSTALS, YELLOWISH GRAY, (SHERACK FORMATION) (LACUSTRINE)
9' TO 34' (CH) FAT CLAY, SOFT, MOIST, FORMS SLICKENSIDES WHEN SHEARED, DARK GRAY, (BRENNA FORMATION)
34' TO 72.7' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY, (ARGUSVILLE FORMATION) (LACUSTRINE)
72.7' TO 82' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, DARK GRAY, (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 6 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 571.8
2. HOLE STABILIZED WITH 4" CASING TO EL. 575.8
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
0' TO 0.6' (CH) FIRM, MOIST, BLACK, (TOPSOIL)
0.6' TO 7.5' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH SILT POCKETS, NO STAINING, FS 6' FANS AT ORGANIC NODULES, YELLOWISH GRAY, (SHERACK FORMATION) (LACUSTRINE)
7.6' TO 20.1' (CH) FAT CLAY, SOFT, MOIST, MOTTLED, WITH FIBROUS ORGANICS, OXIDIZED AND CRYSTALIZED, ORANGEISH BROWN AND DARK GRAY
20.1' TO 55' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, FORMS SLICKENSIDES WHEN SHEARED, BLOCKY AND DESSICATED AT TOP, DARK GRAY, (BRENNA FORMATION)
55' TO 75.3' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY, (ARGUSVILLE FORMATION) (LACUSTRINE)
75.5' TO 80' (CH) FAT CLAY, VERY SOFT, MOIST TO WET, LAMINATED, GRAY
80' TO 92' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, DARK GRAY, (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 570.7
2. HOLE STABILIZED WITH 4" CASING TO EL. 580.7
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
0' TO 0.3' (CH) FIRM, MOIST, BLACK, (TOPSOIL)
3.3' TO 18.2' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH SILT POCKETS, SOME GYPSUM CRYSTALS, IRON OXIDE STAINING, HIGH ANGLE BEDDING 10.1- 13.4
LAMINATED CH & ML, YELLOWISH GRAY, (SHERACK FORMATION) (LACUSTRINE)
18.2' TO 19' (CH) FAT CLAY, MEDIUM STIFF, MOIST, DARK GRAY, (DESSICATED BRENNA FORMATION)
19' TO 41' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, FORMS SLICKENSIDES WHEN SHEARED, DARK GRAY, (BRENNA FORMATION)
41' TO 71.9' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY, (ARGUSVILLE FORMATION) (LACUSTRINE)
71.9' TO 76.6' (SM) SILTY SAND, SATURATED, DARK GRAY
76.6' TO 80' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, DARK GRAY, (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 6 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 576.2
2. HOLE STABILIZED WITH 4" CASING TO EL. 576.2
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
0' TO 0.5' (CH) FIRM, MOIST, BLACK, (TOPSOIL)
0.5' TO 11.8' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH SILT POCKETS, SOME GYPSUM CRYSTALS, IRON OXIDE STAINING, HIGH ANGLE BEDDING 2.5-10.0
LAMINATED CH & ML, YELLOWISH GRAY, (SHERACK FORMATION) (LACUSTRINE)
11.8' TO 46.5' (CH) FAT CLAY, SOFT, MOIST, FORMS SLICKENSIDES WHEN SHEARED, BLOCKY AND DESSICATED AT TOP, DARK GRAY, (BRENNA FORMATION)
46.5' TO 79' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY, (ARGUSVILLE FORMATION) (LACUSTRINE)
79' TO 88' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, SOFT AND SATURATED TOP 5', DARK GRAY, (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 1 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 567.2
2. HOLE STABILIZED WITH 4" CASING TO EL. 567.2
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers
ST. PAUL DISTRICT
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO NORTH DAKOTA AND MOORHEAD MINNESOTA
BORING LOGS
SHEET IDENTIFICATION
B-218


US Army Corps of Engineers
ST. PAUL DISTRICT
09-23M
16 JUN 09
G.S. 882.9
0' TO 6' (CH) FAT CLAY, SAND FINE, FIRM, MOIST, ORGANICS, BLACK (TOPSOIL)
6' TO 13.1' (CH) FAT CLAY, SOFT, MOIST, WITH ROOTS, MEALY, DARK BLUISH GRAY
13.1' TO 16.5' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH SILT POCKETS, IRON OXIDE STAINING, LAMINATED CHINE, LAMINAR DISTURBED AND MIXED WITH MEALY CLAY POCKETS, YELLOWISH GRAY. (SHERACK FORMATION) (LACUSTRINE)
16.5' TO 40' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, BLOCKY AND DESSICATED AT TOP 2', DARK GRAY. (BRENNA FORMATION)
40' TO 53.3' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY. (ARGUSVILLE FORMATION) (LACUSTRINE)
53.3' TO 79.5' (ML) SILT, SOFT, WET, LAMINATED, GRAY
79.5' TO 92' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, CLAY AND SAND TOP 2', DARK GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL NOT DETERMINED
2. HOLE STABILIZED WITH 4" CASING TO EL. 872.9
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-24M
17 JUN 09
G.S. 893.7
0' TO 1' (CH) FIRM, MOIST, BLACK (TOPSOIL)
1' TO 9.1' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH SILT POCKETS, SOME GYPSUM CRYSTALS, IRON OXIDE STAINING, YELLOWISH GRAY. (SHERACK FORMATION) (LACUSTRINE)
9.1' TO 43.5' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, FORMS SLICKENSIDES WHEN SHEARED, BLOCKY AND DESSICATED AT TOP, DARK GRAY. (BRENNA FORMATION)
43.5' TO 82' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY. (ARGUSVILLE FORMATION) (LACUSTRINE)
82' TO 92.7' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, CLAY AND SAND TOP 2', DARK GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL NOT DETERMINED
2. HOLE STABILIZED WITH 4" CASING TO EL. 875.7
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-25M
23 JUN 09
0' TO 1' (CL) CLAYEY, MEDIUM STIFF TO STIFF, VERY MOIST, BROWN AND BLACK (FILL)
1' TO 2' (CL) SILTY, MEDIUM STIFF TO STIFF, VERY MOIST, ROOTS, NO STAINING, BLACK TO GRAY. (TOPSOIL)
2' TO 11.2' (CH) FAT CLAY SILTY, MEDIUM STIFF TO STIFF, WET, VARVED, SILT SEAMS, IRON OXIDE STAINING, TAMBISH BROWN TO YELLOWISH BROWN. (SHERACK FORMATION) (GLACIO-LACUSTRINE)
11.2' TO 20.6' (ML) SILT CLAYEY, MEDIUM STIFF, SATURATED, LAMINATED, CLAY SEAMS, CROSSBEDDING, ORGANIC NODULES, YELLOWISH BROWN. (POPLER RIVER F / WEST FARGO MEMBER) (ALLUVIUM)
20.6' TO 29.6' (CH) FAT CLAY SILTY, MEDIUM STIFF, WET, MEALY, AND BLOCKY, INTERBEDDED MIHCH, BROWN TO BLACKISH GRAY. (POPLER RIVER F / HARWOOD MEMBER) (ALLUVIUM)
29.6' TO 31.4' (CH) FAT CLAY, MEDIUM STIFF, MOIST, BLOCKY, DESSICATED, DARK GRAY. (DESSICATED BRENNA FORMATION) (GLACIO-LACUSTRINE)
31.4' TO 77' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, WET, HOMOGENEOUS, SOME SILT NODULES, STICKY, DARK GRAY. (BRENNA FORMATION) (GLACIO-LACUSTRINE)
77' TO 108' (CH) FAT CLAY, SAND FINE TO COARSE, SOFT TO MEDIUM STIFF, WET, GRITTY, BREAKS ALONG BEDDING, CROP STONES, SILT STRATA OR LENSES, DARK GRAY. (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
108' TO 109.9' (CL) SANDY LEAN CLAY WITH GRAVEL, ASUME TILL (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 98 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 888.7
2. HOLE STABILIZED WITH 4" CASING TO EL. 888.7
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-26M
23 JUN 09
G.S. 911.5
0' TO 3.2' (CL) ORGANIC SOIL WITH SAND, FIRM, MOIST, BLACK (TOPSOIL)
3.2' TO 5.3' (CH) FIRM, MOIST, BLACK (TOPSOIL)
5.3' TO 7.8' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH SILT POCKETS, SOME GYPSUM CRYSTALS, IRON OXIDE STAINING, SLIGHTLY BLOCKY, YELLOWISH GRAY. (SHERACK FORMATION) (LACUSTRINE)
7.8' TO 20' (CH) FAT CLAY, SOFT, MOIST, MOTTLED, BLOCKY AND DESSICATED AT TOP, WEATHERED TOP 15', DARK GRAY AND ORANGEISH BROWN. (SHERACK FORMATION)
20' TO 42' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, DARK GRAY. (BRENNA FORMATION)
42' TO 97' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY. (ARGUSVILLE FORMATION) (LACUSTRINE)
97' TO 102' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, SOME SANDY SEAMS, DARK GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 8 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 901.5
2. HOLE STABILIZED WITH 4" CASING TO EL. 903.5
3. UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO-NORTH MOORHEAD, CASS COUNTY, ND
MOORHEAD, MN
BORING LOGS
SHEET 2 OF 2
09-23M, 09-24M, 09-25M, 09-26M
SHEET IDENTIFICATION
B-219


09-34M
06 JUL 09
09-40M
13 JUL 09
09-41M
10 JUL 09
09-53M
13 JUL 09
SPT D10 MC LL PL
0' TO 1' (CL) SANDY LEAN CLAY WITH GRAVEL, STIFF, MOIST, FILL, DARK GRAY. (TILL)
1' TO 2.8' (CH) FAT CLAY, FIRM, MOIST, BLACK (TOPSOIL)
2.8' TO 4.7' (CH) FAT CLAY, SOFT, MOIST, MEALY, SOME ORGANICS, TAN TO BROWN. (ALLUVIUM)
4.7' TO 10.9' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH SILT POCKETS, SOME MEALY TEXTURE AT TOP, IRON OXIDE STAINING, YELLOWISH GRAY. (SHERACK FORMATION) (LACUSTRINE)
10.9' TO 19.7' (CH) FAT CLAY, SOFT, MOIST, MOTTLED, DESSICATED AT TOP 2', ORANGEISH BROWN AND DARK GRAY
19.7' TO 49' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, DARK GRAY. (BRENNA FORMATION)
49' TO 54.7' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY. (ARGUSVILLE FORMATION) (LACUSTRINE)
54.7' TO 55.5' (SP) POORLY GRADED SAND, (UNIT "A" TILL)
55.5' TO 96.5' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, DARK GRAY. (UNIT "A" TILL)
0' TO 0.2' (CL) LEAN CLAY WITH SAND, FIRM, MOIST, BROWN, (FILL)
0.2' TO 0.8' (CH) FIRM, MOIST, BLACK, (TOPSOIL)
0.8' TO 3' (CH) FAT CLAY, SOFT, MOIST, WITH ORGANICS, AND ROOTS, TAN. (ALLUVIUM)
3' TO 3.3' (CL) SANDY LEAN CLAY, DARK GRAY
3.3' TO 13' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH ROOTS, SOME GYPSUM CRYSTALS, IRON OXIDE STAINING, YELLOWISH GRAY. (SHERACK FORMATION) (LACUSTRINE)
13' TO 19.2' (CH) FAT CLAY, SOFT, MOIST, MOTTLED, LAMINATED AND VARVED, FE NODULES AND CASTS OF ORGANICS, INCREASED CLAY CONTENT AND PLASTICITY, YELLOWISH TAN AND YELLOWISH GRAY. (SHERACK FORMATION)
19.2' TO 20.2' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, GRAY AND DARK GRAY
20.2' TO 31.5' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, SILTY LAMINAE BELOW 26.5', DARK GRAY. (BRENNA FORMATION)
31.5' TO 42.1' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, GRADES SANDIER DOWN COLUMN, DARK GRAY. (ARGUSVILLE FORMATION) (LACUSTRINE)
42.1' TO 50' (ML) ELASTIC SILT, STIFF, MOIST, SANDY, 45.5-50', GRAY
50' TO 58.4' (ML) SILT, SAND FINE, MEDIUM DENSE, MOIST TO WET, LESS SILT BELOW 55', GRAY
58.4' TO 66.9' (ML) ELASTIC SILT, STIFF, MOIST, GRAY
66.9' TO 70.9' (SM) SILTY SAND, SAND FINE, MEDIUM DENSE, MOIST TO WET, GRAY
70.9' TO 71.8' (CL) SANDY LEAN CLAY, VERY SOFT, GRAY
71.8' TO 83.8' (SM) SILTY SAND, SAND FINE, MEDIUM DENSE, MOIST TO WET, WITH ORGANIC LAMINAE, GRAY
83.8' TO 90.8' (CH) FAT CLAY, STIFF, MOIST, WITH SOME SILT POCKETS, SILTY LAMINAE, AND SAND SEAMS, GRAY
90.8' TO 102' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, DARK GRAY. (TILL)
0' TO 9.4' (CH) FAT CLAY, SOFT, WITH ORGANICS, AND ROOTS, BROWN TO DARK BROWN. (TOPSOIL)
9.4' TO 14.7' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH SILT POCKETS, IRON OXIDE STAINING, LAMINATED CH & ML-ML1, YELLOWISH GRAY. (SHERACK FORMATION) (LACUSTRINE)
14.7' TO 20.3' (CH) FAT CLAY, MEDIUM STIFF, MOIST, BLOCKY, DARK GRAY WITH ORANGEISH GRAY
20.3' TO 40' (CH) FAT CLAY, SOFT, MOIST, MOSTLY BREAKS ON SILT BEDDING, DARK GRAY. (BRENNA FORMATION)
40' TO 64.8' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY. (ARGUSVILLE FORMATION)
64.8' TO 77' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, DARK GRAY. (UNIT "A" TILL)
0' TO 3.8' (CL) SANDY LEAN CLAY WITH GRAVEL, STIFF, MOIST, FILL, DARK GRAY. (TILL)
3.8' TO 12' (CL) LEAN CLAY, FIRM, MOIST, ORGANICS, BLACK. (TOPSOIL)
12' TO 13.3' (CH) FAT CLAY, SOFT, MOIST, MEALY, WITH ROOTS, SOME FE STAINS AT ROOTS, BLUEISH GRAY. (ALLUVIUM)
13.3' TO 18.7' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH FE STAINS AT ORGANICS, SOME FE NODULES, NON LAMINATED FROM 15.1-16.4, YELLOWISH GRAY. (SHERACK FORMATION) (LACUSTRINE)
18.7' TO 22.4' (MH) ELASTIC SILT, SOFT TO MEDIUM STIFF, MOIST, INTERBEDDED, INTERBEDDED CLAY AND SILT (CHMH), BLUEISH GRAY AND ORANGE
22.4' TO 63.7' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, BLOCKY AND DESICCATED AT TOP 3.5', BREAKS ON SILTY PLANES BELOW 54.7', DARK GRAY. (BRENNA FORMATION)
63.7' TO 91.2' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY. (ARGUSVILLE FORMATION) (LACUSTRINE)
91.2' TO 96' (SP) POORLY GRADED SAND, (UNIT "A" TILL)
96' TO 107' (CL) SANDY LEAN CLAY WITH GRAVEL VERY STIFF, MOIST, DARK GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL NOT DETERMINED
2. HOLE STABILIZED WITH 4" CASING TO EL. 886.6
3. UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
NOTES:
1. WATER LEVEL DETERMINED AFTER 9 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 867.5
2. HOLE STABILIZED WITH 4" CASING TO EL. 904.6
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 874.7
2. HOLE STABILIZED WITH 4" CASING TO EL. 904.7
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 850
2. HOLE STABILIZED WITH 4" CASING TO EL. 852.9
3. UNDISTURBED SAMPLES TAKEN IN OFFSET HOLE
4. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers
ST. PAUL DISTRICT
LUE, ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO, NORTH DAKOTA AND MOORHEAD, MINNESOTA
BORING LOGS
09-34M, 09-40M, 09-41M & 09-53M
SHEET IDENTIFICATION
B-220

1566


09-57M
16 JUL 09
G.S. 881.9
W.L. 873
0' TO 5.8' (CH) FAT CLAY, SOFT, MOIST, ORGANIC WITH ROOTS, BLACK. (TOPSOIL)
5.8' TO 16.8' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH SILT POCKETS, SOME FE NODULES, IRON OXIDE STAINING, LAMINATED TO INTERBEDDED ML-MH & CL-CH, YELLOWISH GRAY. (SHERACK FORMATION) (LACUSTRINE)
16.9' TO 20' (CH) FAT CLAY, SOFT, DESSICATED, VERY WEATHERED, ORANGEISH GRAY. (DESSICATED BRENNA FORMATION)
20' TO 49.7' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, SOME SILTY PLANES AT 41.9', DARK GRAY. (BRENNA FORMATION)
46.7' TO 78.4' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY. (ARGUSVILLE FORMATION) (LACUSTRINE)
78.4' TO 95' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, LARGE SAND SEAMS, DARK GRAY. (UNIT "A" TILL)
95 756.9
NOTES:
1. WATER LEVEL DETERMINED AFTER 6 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 856.9
2. HOLE STABILIZED WITH 8" CASING TO EL. 872.9
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-80M
17 JUL 09
G.S. 882.6
W.L. 877.9
0' TO 5.8' (CH) FAT CLAY, SOFT, MOIST, WITH ROOTS, BLACK. (TOPSOIL)
5.8' TO 11.1' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, WITH SILT POCKETS, SOME GYPSUM CRYSTALS, NO STAINING, YELLOWISH GRAY. (SHERACK FORMATION) (LACUSTRINE)
11.1' TO 22.1' (CH) FAT CLAY, SOFT, MOIST, INTERBEDDED, INTERBEDDED PEAT WITH MH &CH, SOME SHELL LAYERS, LIGHT GRAY AND DARK GRAY. (POPLAR RIVER FORMATION)
22.1' TO 43' (CL) LEAN CLAY WITH SAND, SOFT, MOIST TO SATURATED, LAMINATED, LAMINATED CLML SANDY LAYERS, BROWNISH GRAY TO GRAY. (POPLER RIVER F / WEST FARGO MEMBER)
43' TO 97' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, BLOCKY AND DESSICATED TO 46.1, DARK GRAY. (BRENNA FORMATION)
60' TO 85.2' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY. (ARGUSVILLE FORMATION) (LACUSTRINE)
85.2' TO 98.6' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, DARK GRAY. (UNIT "A" TILL)
99 788.1
NOTES:
1. WATER LEVEL DETERMINED AFTER 9 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 867.6
2. HOLE STABILIZED WITH 8" CASING TO EL. 874.6
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-63M
18 JUL 09
G.S. 881.0
W.L. 874.7
0' TO 4.1' (CH) FAT CLAY, TRACE, MOIST, SOME ROOTS, INTERBEDDED SHERACK LAYERS AT BOTTOM 0.7', DARK BROWNISH BLACK. (TOPSOIL)
4.1' TO 12.8' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, MOIST, LAMINATED, LAMINAR DISTURBED TOP 3', YELLOWISH GRAY AND ORANGEISH BROWN. (SHERACK FORMATION) (LACUSTRINE)
12.8' TO 51.5' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, DARK GRAY. (BRENNA FORMATION)
51.5' TO 79' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY. (ARGUSVILLE FORMATION) (LACUSTRINE)
NOTES:
1. WATER LEVEL DETERMINED AFTER 6 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 856
2. HOLE STABILIZED WITH 8" CASING TO EL. 873.0
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
09-67M
20 JUL 09
G.S. 883.1
W.L. 866.8
0' TO 0.3' ASPHAULT, ASPHAULT
0.3' TO 1' (CL) SANDY LEAN CLAY WITH GRAVEL. (FILL)
1' TO 5.6' (CH) FAT CLAY, MEDIUM STIFF, MOIST, SILT POCKETS AND SILTY GREY LAYERS, BLACK. (TOPSOIL)
5.6' TO 13.2' (CH) FAT CLAY SILTY, SOFT TO MEDIUM STIFF, MOIST, WEALTY, GREENISH GRAY. (ALLUVIUM)
13.2' TO 15.4' (CH) FAT CLAY SILTY, SOFT TO MEDIUM STIFF, MOIST, WEALTY, W/ ROCKS, GREENISH GRAY. (ALLUVIUM)
15.4' TO 21' (ML) SILT, STIFF, WET TO SATURATED, LAMINATED, SOME CROSSBEDDING, CLAY LAYERS IN BOTTOM 1', LIGHT GRAY TO ORANGE. (POPLAR RIVER F / WEST FARGO MEMBER)
21' TO 58.2' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, BLOCKY AND DESSICATED TOP 2.3' BREAKS ON SILTY PLANES BELOW 53.3', DARK GRAY. (BRENNA FORMATION)
58.2' TO 102' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, DARK GRAY. (ARGUSVILLE FORMATION) (LACUSTRINE)
102' TO 110' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY STIFF, MOIST, DARK GRAY. (UNIT "A" TILL)
76 778.1
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 875.1
2. HOLE STABILIZED WITH 4" CASING TO EL. 867.1
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers
ST. PAUL DISTRICT
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO NORTH DAKOTA AND MOORHEAD MINNESOTA
BORING LOGS
09-57M, 09-80M, 09-63M & 09-67M
SHEET IDENTIFICATION
B-221



US Army Corps of Engineers®
ST. PAUL DISTRICT

SYMBOL	DATE	DESCRIPTION	DATE	APPL. MARK	DESCRIPTION	DATE	SYMBOL

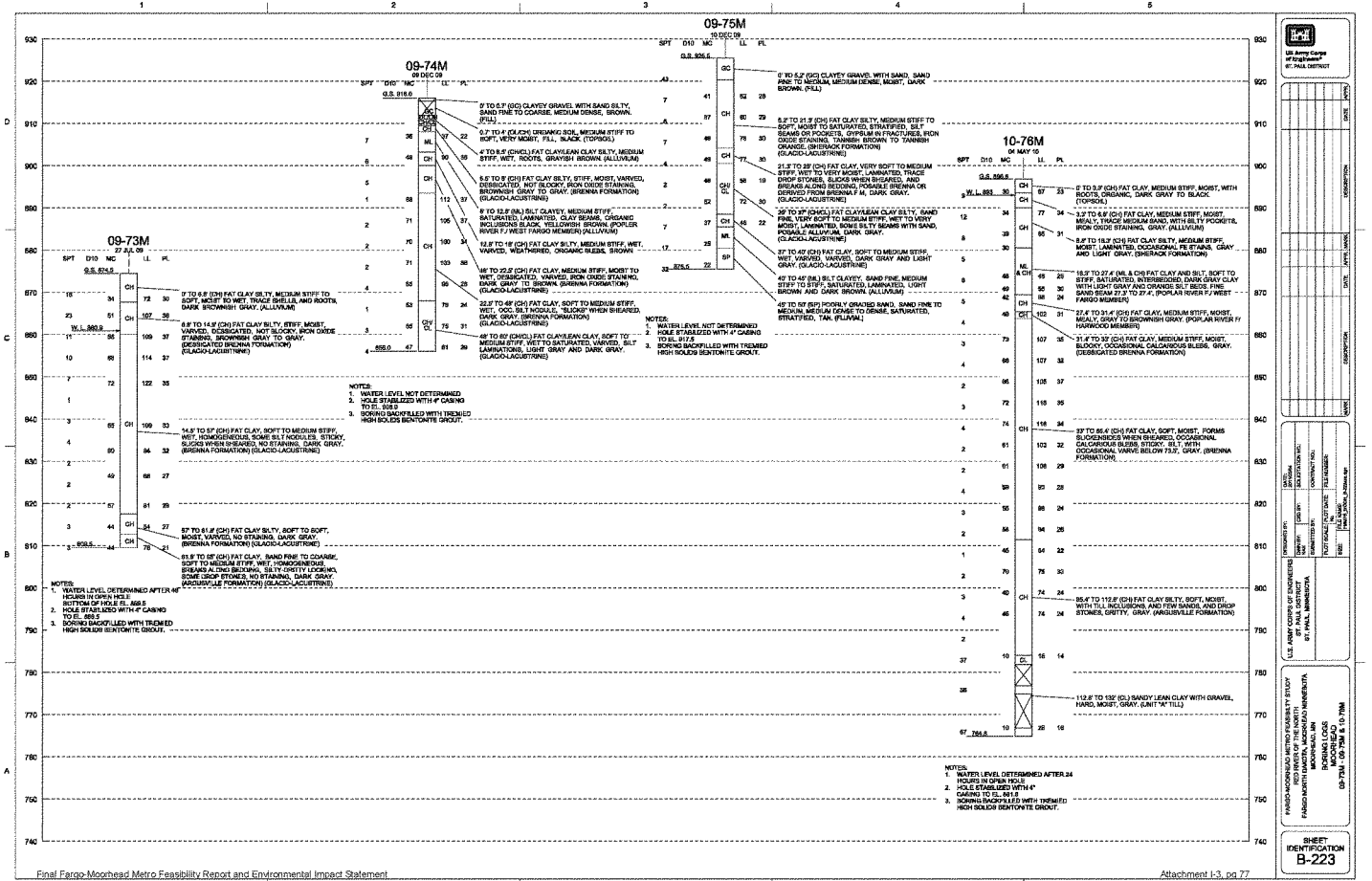
DESIGNED BY: | DRAWN BY: | CHECKED BY: | SUBMITTED BY: | CHIEF BY: | PLOT SCALE: | PLOT DATE: | SIZE: | FILE NAME: 09FARGOMOORHEAD_B222.DGN | SOLICITATION NO.: | CONTRACT NO.: | IDENT. NO.: | FILE NUMBER:

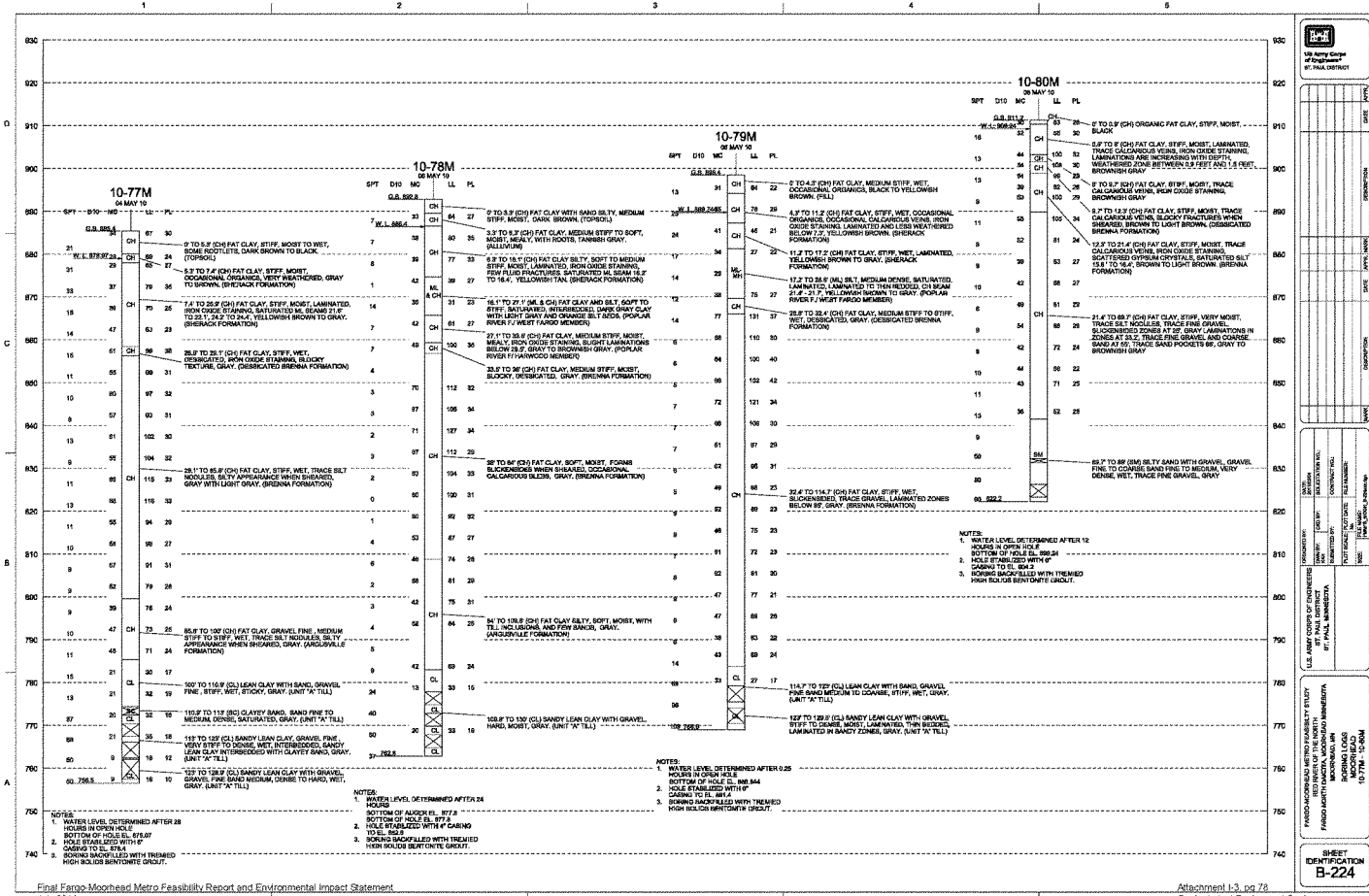
LUS. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO NORTH DAKOTA AND MOORHEAD MINNESOTA
BORING LOGS
09-68M, 09-69M, 09-70M & 09-72M

SHEET IDENTIFICATION
B-222

1568


09-73M
27 JUL 09
09-74M
09 DEC 09
09-75M
10 DEC 09
10-76M
04 MAY 10
NOTES:
1. WATER LEVEL NOT DETERMINED
2. HOLE STABILIZED WITH 4" CASING TO EL. 898.9
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
NOTES:
1. WATER LEVEL DETERMINED AFTER 48 HOURS IN OPEN HOLE
BOTTOM OF HOLE EL. 868.5
2. HOLE STABILIZED WITH 4" CASING TO EL. 885.1
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE
2. HOLE STABILIZED WITH 4" CASING TO EL. 841.8
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers
ST. PAUL DISTRICT
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO-NORTH MOORHEAD, NORTH DAKOTA AND MINNESOTA
BORING LOGS
09-73M, 09-74M, 09-75M & 10-76M
SHEET IDENTIFICATION
B-223



US Army Corps of Engineers
ST. PAUL DISTRICT

SYMBOL	DATE	APPD	DESCRIPTION

SYMBOL	DATE	APPD	DESCRIPTION

SYMBOL	DATE	APPD	DESCRIPTION

DESIGNED BY: | DATE: | SYMBOL: BOLSTA FOR REL.
DRAWN BY: | CHECK BY: | CONTRACT NO.:
SUBMITTED BY: | PLOT SCALE: | PLOT DATE: | FILE NUMBER:
NGS | FILE NAME: 1570-B-224_BORING.dwg

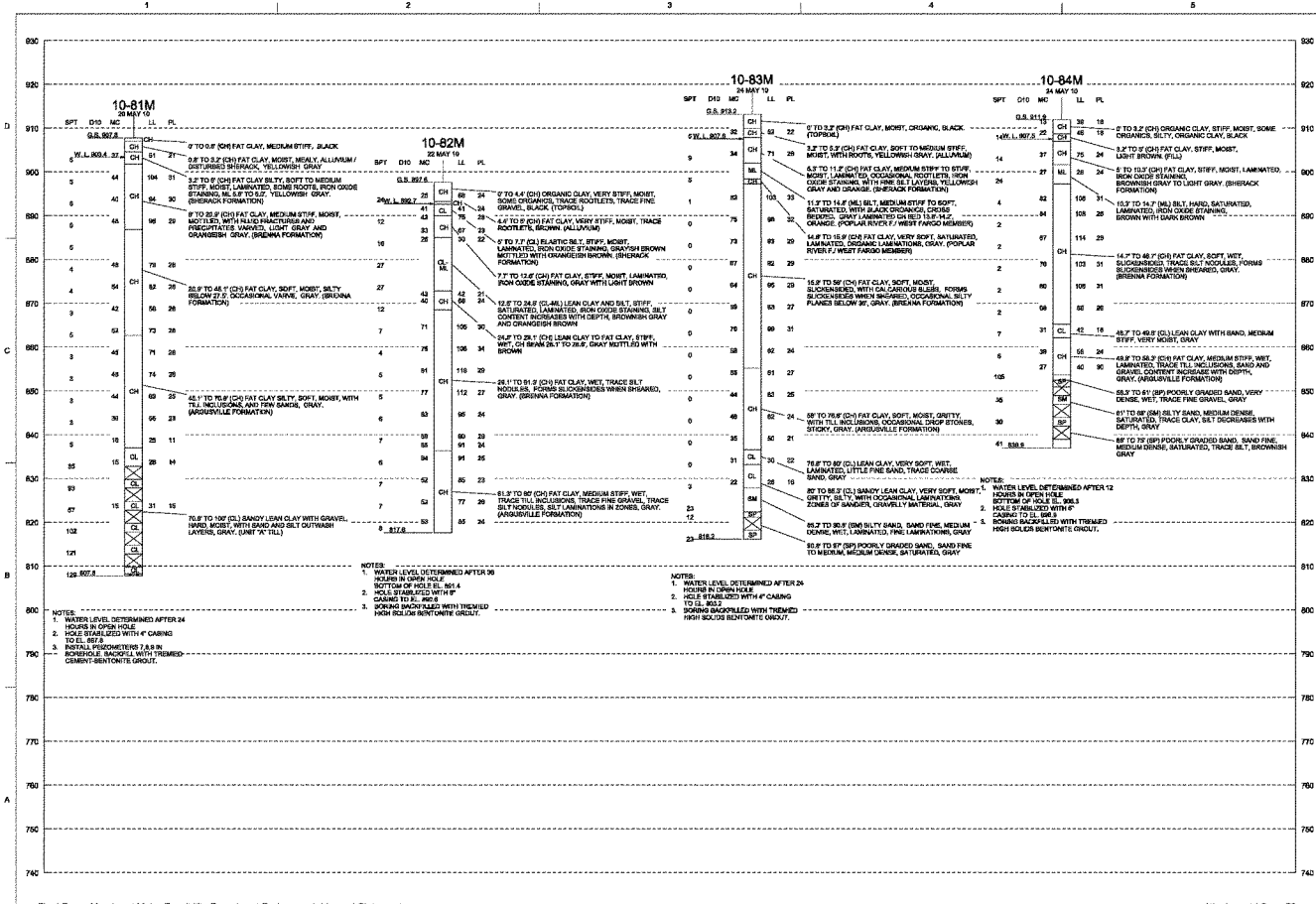
LUE ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

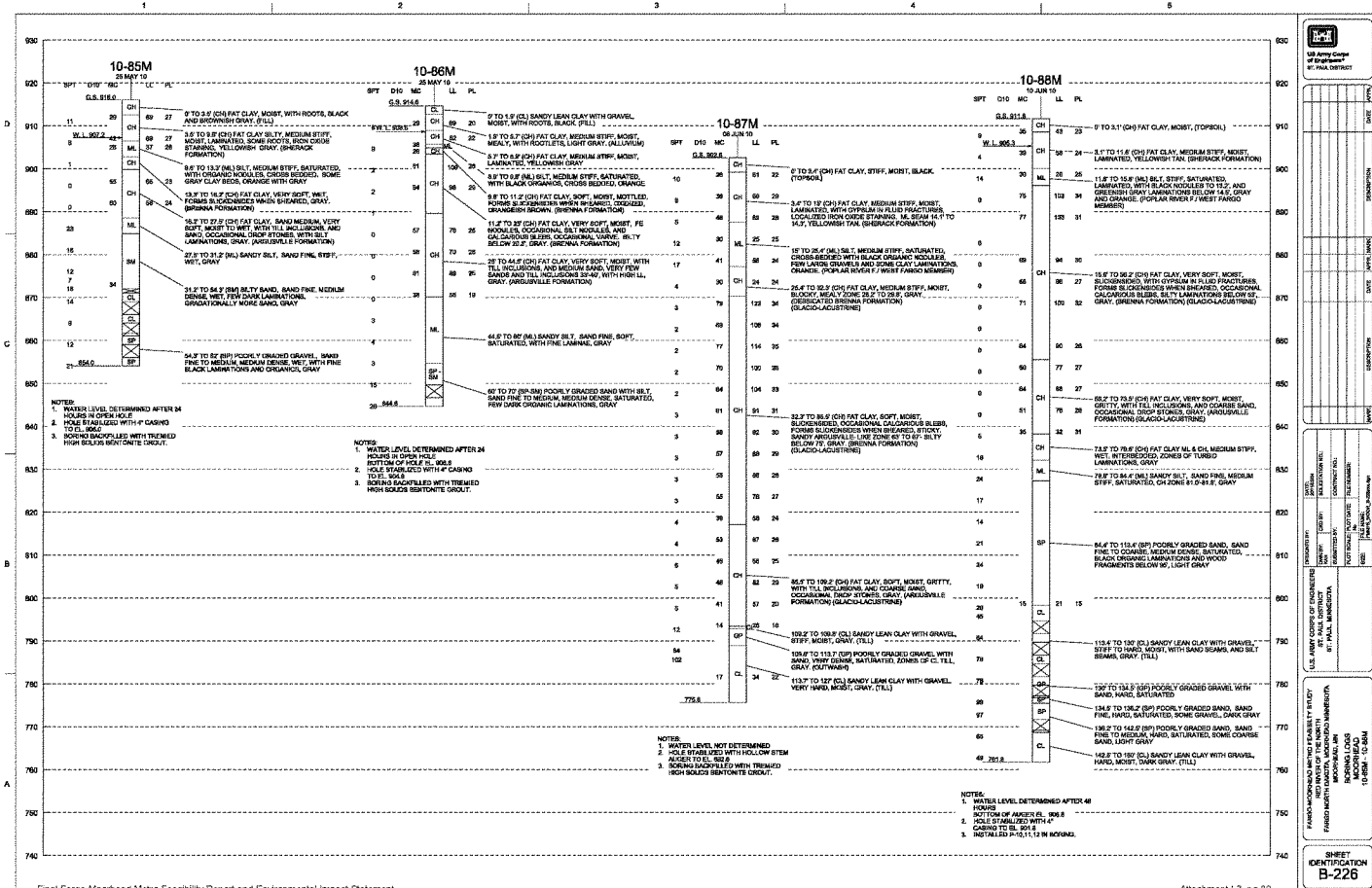
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO, NORTH DAKOTA AND MOORHEAD, MINNESOTA

BORING LOGS
SHEET 1 OF 1
10-77M, 10-78M, 10-79M, 10-80M

SHEET IDENTIFICATION
B-224

1570


10-81M
26 MAY 10
G.S. 907.8
W.L. 903.4
0' TO 0.8' (CH) FAT CLAY, MEDIUM STIFF, BLACK
0.8' TO 3.2' (CH) FAT CLAY, MOIST, MEALY, ALLUVIUM / DISTURBED SHERACK, YELLOWISH GRAY
3.2' TO 9' (CH) FAT CLAY SILTY, SOFT TO MEDIUM STIFF, MOIST, LAMINATED, SOME ROOTS, IRON OXIDE STAINING, ML 5.8' TO 6.2', YELLOWISH GRAY. (SHERACK FORMATION)
9' TO 20.9' (CH) FAT CLAY, MEDIUM STIFF, MOIST, MOTTLED, WITH NUMEROUS FRACTURES AND PRECIPITATES VARIED, LIGHT GRAY AND ORANGEISH GRAY. (BRENNA FORMATION)
20.9' TO 45.1' (CH) FAT CLAY SILTY, SOFT, MOIST, WITH TILL INCLUSIONS, AND THIN SANDS, GRAY. (ARGUSVILLE FORMATION)
45.1' TO 70.8' (CH) FAT CLAY SILTY, SOFT, MOIST, WITH TILL INCLUSIONS, AND THIN SANDS, GRAY. (ARGUSVILLE FORMATION)
70.8' TO 100' (CL) SANDY LEAN CLAY WITH GRAVEL, HARD, MOIST, WITH SAND AND SILT OUTWASH LAYERS, GRAY. (UNIT "A" TILL)
129.907.8
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE
2. HOLE STABILIZED WITH 4" CASING TO EL. 857.8
3. INSTALL PIEZOMETERS 7, 8, 9 IN BOREHOLE BACKFILL WITH TREMIED CEMENT-BENTONITE GROUT.
10-82M
22 MAY 10
G.S. 897.6
W.L. 890.7
0' TO 4.4' (CH) ORGANIC CLAY, VERY STIFF, MOIST, SOME ORGANICS, TRACE ROOTLETS, TRACE FINE GRAVEL, BLACK. (TOPSOIL)
4.4' TO 9' (CH) FAT CLAY, VERY STIFF, MOIST, TRACE ROOTLETS, BROWN. (ALLUVIUM)
9' TO 7.7' (CL) ELASTIC SILT, STIFF, MOIST, LAMINATED, IRON OXIDE STAINING, GRAYISH BROWN MOTTLED WITH ORANGEISH BROWN. (SHERACK FORMATION)
7.7' TO 12.6' (CH) FAT CLAY, STIFF, MOIST, LAMINATED, IRON OXIDE STAINING, GRAY WITH LIGHT BROWN
12.6' TO 24.0' (CL-ML) LEAN CLAY AND SILT, STIFF, SATURATED, LAMINATED, IRON OXIDE STAINING, SILT CONTENT INCRSEASES WITH DEPTH, BROWNISH GRAY AND ORANGEISH BROWN
24.0' TO 29.1' (CH) LEAN CLAY TO FAT CLAY, STIFF, WET, CH SEAM 26.1' TO 26.6', GRAY MOTTLED WITH BROWN
29.1' TO 51.2' (CH) FAT CLAY, WET, TRACE SILT NODULES, FORMS SLICKENSIDES WHEN SHEARED, GRAY. (BRENNA FORMATION)
51.2' TO 85' (CH) FAT CLAY, MEDIUM STIFF, WET, TRACE TILL INCLUSIONS, TRACE FINE GRAVEL, TRACE SILT NODULES, SILT LAMINATIONS IN ZONES, GRAY. (ARGUSVILLE FORMATION)
85 TO 100' (CL) LEAN CLAY, VERY SOFT, WET, LAMINATED, LITTLE FINE SAND, TRACE COARSE SAND, GRAY
NOTES:
1. WATER LEVEL DETERMINED AFTER 96 HOURS IN OPEN HOLE
BOTTOM OF HOLE EL. 801.4
2. HOLE STABILIZED WITH 8" CASING TO EL. 890.6
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-83M
24 MAY 10
G.S. 912.2
W.L. 907.8
0' TO 3.2' (CH) FAT CLAY, MOIST, ORGANIC, BLACK. (TOPSOIL)
3.2' TO 5.3' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, MOIST, WITH ROOTS, YELLOWISH GRAY. (ALLUVIUM)
5.3' TO 11.7' (CH) FAT CLAY, MEDIUM STIFF TO STIFF, MOIST, LAMINATED, OCCASIONAL ROOTLETS, IRON OXIDE STAINING, WITH FINE SILT LAYERS, YELLOWISH GRAY AND ORANGE. (SHERACK FORMATION)
11.7' TO 14.4' (ML) SILT, MEDIUM STIFF TO SOFT, SATURATED, WITH BLACK ORGANICS, CRUSE REDDISH GRAY LAMINATED CH RED 13.8'-14.2' ORANGE. (POPLAR RIVER F / WEST FARGO MEMBER)
14.4' TO 16.9' (CH) FAT CLAY, VERY SOFT, SATURATED, LAMINATED, ORGANIC LAMINATIONS, GRAY. (POPLAR RIVER F / WEST FARGO MEMBER)
16.9' TO 28.7' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, WITH CALCAROUS BLEBS, FORMS SLICKENSIDES WHEN SHEARED, OCCASIONAL SILTY PLANES BELOW 30', GRAY. (BRENNA FORMATION)
28.7' TO 58' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, WITH CALCAROUS BLEBS, FORMS SLICKENSIDES WHEN SHEARED, OCCASIONAL SILTY PLANES BELOW 30', GRAY. (BRENNA FORMATION)
58' TO 76.8' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, OCCASIONAL DROP STONES, STICKY, GRAY. (ARGUSVILLE FORMATION)
76.8' TO 80' (CL) LEAN CLAY, VERY SOFT, WET, LAMINATED, LITTLE FINE SAND, TRACE COARSE SAND, GRAY
80' TO 85.2' (CL) SANDY LEAN CLAY, VERY SOFT, MOIST, GRITTY, SILTY, WITH OCCASIONAL LAMINATIONS, ZONES OF SANDIER, GRAVELLY MATERIAL, GRAY
85.2' TO 90.6' (SM) SILTY SAND, SAND FINE, MEDIUM DENSE, WET, LAMINATED, FINE LAMINATIONS, GRAY
90.6' TO 97' (SP) POORLY GRADED SAND, SAND FINE TO MEDIUM, MEDIUM DENSE, SATURATED, GRAY
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE
2. HOLE STABILIZED WITH 4" CASING TO EL. 903.2
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-84M
24 MAY 10
G.S. 911.6
W.L. 907.5
0' TO 3.2' (CH) ORGANIC CLAY, STIFF, MOIST, SOME ORGANICS, SILTY, ORGANIC CLAY, BLACK
3.2' TO 5' (CH) FAT CLAY, STIFF, MOIST, LIGHT BROWN. (FILL)
5' TO 10.3' (CH) FAT CLAY, STIFF, MOIST, LAMINATED, IRON OXIDE STAINING, BROWNISH GRAY TO LIGHT GRAY. (SHERACK FORMATION)
10.3' TO 14.7' (ML) SILT, HARD, SATURATED, LAMINATED, IRON OXIDE STAINING, BROWN WITH DARK BROWN
14.7' TO 46.7' (CH) FAT CLAY, SOFT, WET, SLICKENSIDED, TRACE SILT NODULES, FORMS SLICKENSIDES WHEN SHEARED, GRAY. (BRENNA FORMATION)
46.7' TO 49.8' (CL) LEAN CLAY WITH SAND, MEDIUM STIFF, VERY MOIST, GRAY
49.8' TO 55.2' (CH) FAT CLAY, MEDIUM STIFF, WET, LAMINATED, TRACE TILL INCLUSIONS, SAND AND GRAVEL CONTENT INCRSAME WITH DEPTH, GRAY. (ARGUSVILLE FORMATION)
55.2' TO 61' (SP) POORLY GRADED SAND, VERY DENSE, WET, TRACE FINE GRAVEL, GRAY
61' TO 68' (SM) SILTY SAND, MEDIUM DENSE, SATURATED, TRACE CLAY, SILT DECREASES WITH DEPTH, GRAY
68' TO 72' (SP) POORLY GRADED SAND, SAND FINE, MEDIUM DENSE, SATURATED, TRACE SILT, BROWNISH GRAY
NOTES:
1. WATER LEVEL DETERMINED AFTER 12 HOURS IN OPEN HOLE
BOTTOM OF HOLE EL. 906.5
2. HOLE STABILIZED WITH 6" CASING TO EL. 908.5
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers
ST. PAUL DISTRICT
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO, NORTH DAKOTA AND MOORHEAD, MINNESOTA
MOORHEAD, MN
BORING LOGS
10-81M, 10-82M
10-83M, 10-84M
SHEET IDENTIFICATION
B-225


10-85M
25 MAY 10
G.S. 916.0
W.L. 907.2
9' TO 3.5' (CH) FAT CLAY, MOIST, WITH ROOTS, BLACK AND BROWNISH GRAY, (FILL)
3.5' TO 9.8' (CH) FAT CLAY SILTY, MEDIUM STIFF, MOIST, LAMINATED, SOME ROOTS, IRON OXIDE STAINING, YELLOWISH GRAY, (SHERACK FORMATION)
9.8' TO 13.7' (ML) SILT, MEDIUM STIFF, SATURATED, WITH ORGANIC NODULES, CROSS BEDDED, SOME GRAY CLAY BEDS, ORANGE WITH GRAY
13.7' TO 16.2' (CH) FAT CLAY, VERY SOFT, WET, FORMS SLICKENSIDES WHEN SHEARED, GRAY, (BRENNA FORMATION)
16.2' TO 27.5' (CH) FAT CLAY, SAND MEDIUM, VERY SOFT, MOIST TO WET, WITH TILL INCLUSIONS, AND SAND, OCCASIONAL CROP STONES, WITH SILT LAMINATIONS, GRAY, (ARGUSVILLE FORMATION)
27.5' TO 31.2' (ML) SANDY SILT, SAND FINE, STIFF, WET, GRAY
31.2' TO 54.3' (SM) SILTY SAND, SAND FINE, MEDIUM DENSE, WET, FEW DARK LAMINATIONS, GRADATIONALLY MORE SAND, GRAY
54.3' TO 62' (SP) POORLY GRADED GRAVEL, SAND FINE TO MEDIUM, MEDIUM DENSE, WET, WITH FINE BLACK LAMINATIONS AND ORGANICS, GRAY
654.0
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE
2. HOLE STABILIZED WITH 4" CASING TO EL. 906.0
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-86M
25 MAY 10
G.S. 914.6
EW "L" 909.5
0' TO 1.9' (CL) SANDY LEAN CLAY WITH GRAVEL, MOIST, WITH ROOTS, BLACK, (FILL)
1.9' TO 5.7' (CH) FAT CLAY, MEDIUM STIFF, MOIST, MEALY, WITH ROOTLETS, LIGHT GRAY, (ALLUVIUM)
5.7' TO 8.9' (CH) FAT CLAY, MEDIUM STIFF, MOIST, LAMINATED, YELLOWISH GRAY
8.9' TO 9.8' (ML) SILT, MEDIUM STIFF, SATURATED, WITH BLACK ORGANICS, CROSS BEDDED, ORANGE
9.8' TO 11.2' (CH) FAT CLAY, SOFT, MOIST, MOTTLED, FORMS SLICKENSIDES WHEN SHEARED, OXIDIZED, ORANGEISH BROWN, (BRENNA FORMATION)
11.2' TO 23' (CH) FAT CLAY, VERY SOFT, MOIST, FE NODULES, OCCASIONAL SILT NODULES, AND CALCAROUS BLEBS, OCCASIONAL VARVE, SILTY BELOW 20.5', GRAY, (BRENNA FORMATION)
23' TO 44.5' (CH) FAT CLAY, VERY SOFT, MOIST, WITH TILL INCLUSIONS, AND MEDIUM SAND, VERY FEW SANDS AND TILL INCLUSIONS 33'-40', WITH HIGH LL, GRAY, (ARGUSVILLE FORMATION)
44.5' TO 60' (ML) SANDY SILT, SAND FINE, SOFT, SATURATED, WITH FINE LAMINAE, GRAY
60' TO 72' (SP-SM) POORLY GRADED SAND WITH SILT, SAND FINE TO MEDIUM, MEDIUM DENSE, SATURATED, FEW DARK ORGANIC LAMINATIONS, GRAY
664.6
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 906.6
2. HOLE STABILIZED WITH 4" CASING TO EL. 904.6
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-87M
06 JUN 10
G.S. 902.6
0' TO 3.4' (CH) FAT CLAY, STIFF, MOIST, BLACK, (TOPSOIL)
3.4' TO 12' (CH) FAT CLAY, MEDIUM STIFF, MOIST, LAMINATED, WITH GYPSUM IN FLUID FRACTURES, LOCALIZED IRON OXIDE STAINING, ML SEAM 14.1' TO 14.3', YELLOWISH TAN, (SHERACK FORMATION)
12' TO 25.4' (ML) SILT, MEDIUM STIFF, SATURATED, CROSS-BEDDED WITH BLACK ORGANIC NODULES, FEW LARGE GRAVELS AND SOME CLAY LAMINATIONS, ORANGE, (POPLAR RIVER F / WEST FARGO MEMBER)
25.4' TO 32.5' (CH) FAT CLAY, MEDIUM STIFF, MOIST, BLOCKY, MEALY ZONE 29.2' TO 29.8', GRAY, (DESSICATED BRENNA FORMATION) (GLACIO-LACUSTRINE)
32.5' TO 85.5' (CH) FAT CLAY, SOFT, MOIST, SLICKENSIDED, OCCASIONAL CALCAROUS BLEBS, FORMS SLICKENSIDES WHEN SHEARED, STICKY, SANDY ARGUSVILLE- LIKE ZONE 63' TO 67', SILTY BELOW 70', GRAY, (BRENNA FORMATION) (GLACIO-LACUSTRINE)
85.5' TO 109.2' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, AND COARSE SAND, OCCASIONAL FINCH STONES, GRAY, (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
109.2' TO 109.9' (CL) SANDY LEAN CLAY WITH GRAVEL, STIFF, MOIST, GRAY, (TILL)
109.9' TO 113.7' (GP) POORLY GRADED GRAVEL WITH SAND, VERY DENSE, SATURATED, ZONES OF CL TILL, GRAY, (OUTWASH)
113.7' TO 127' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY HARD, MOIST, GRAY, (TILL)
775.6
NOTES:
1. WATER LEVEL NOT DETERMINED
2. HOLE STABILIZED WITH HOLLOW STEM AUGER TO EL. 902.6
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-88M
10 JUN 10
G.S. 911.8
W.L. 905.3
0' TO 3.1' (CH) FAT CLAY, MOIST, (TOPSOIL)
3.1' TO 11.6' (CH) FAT CLAY, MEDIUM STIFF, MOIST, LAMINATED, YELLOWISH TAN, (SHERACK FORMATION)
11.6' TO 15.8' (ML) SILT, STIFF, SATURATED, LAMINATED, WITH BLACK NODULES TO 13.2', AND GREENISH GRAY LAMINATIONS BELOW 14.5', GRAY AND ORANGE, (POPLAR RIVER F / WEST FARGO MEMBER)
15.8' TO 56.2' (CH) FAT CLAY, VERY SOFT, MOIST, SLICKENSIDED, WITH GYPSUM IN FLUID FRACTURES, FORMS SLICKENSIDES WHEN SHEARED, OCCASIONAL CALCAROUS BLEBS, SILTY LAMINATIONS BELOW 52', GRAY, (BRENNA FORMATION) (GLACIO-LACUSTRINE)
56.2' TO 73.5' (CH) FAT CLAY, VERY SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, AND COARSE SAND, OCCASIONAL CROP STONES, GRAY, (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
73.5' TO 79.6' (CH) FAT CLAY ML & CH, MEDIUM STIFF, WET, WITH INTERBEDDED ZONES OF TURBID LAMINATIONS, GRAY
79.6' TO 84.4' (ML) SANDY SILT, SAND FINE, MEDIUM STIFF, SATURATED, CH ZONE 81.5'-85.5', GRAY
84.4' TO 113.4' (SP) POORLY GRADED SAND, SAND FINE TO COARSE, MEDIUM DENSE, SATURATED, BLACK ORGANIC LAMINATIONS AND WOOD FRAGMENTS BELOW 90', LIGHT GRAY
113.4' TO 130' (CL) SANDY LEAN CLAY WITH GRAVEL, STIFF TO HARD, MOIST, WITH SAND SEAMS, AND SILT SEAMS, GRAY, (TILL)
130' TO 134.5' (GP) POORLY GRADED GRAVEL WITH SAND, HARD, SATURATED
134.5' TO 136.2' (SP) POORLY GRADED SAND, SAND FINE, HARD, SATURATED, SOME GRAVEL, DARK GRAY
136.2' TO 142.5' (SP) POORLY GRADED SAND, SAND FINE TO MEDIUM, HARD, SATURATED, SOME COARSE SAND, LIGHT GRAY
142.5' TO 150' (CL) SANDY LEAN CLAY WITH GRAVEL, HARD, MOIST, DARK GRAY, (TILL)
761.8
NOTES:
1. WATER LEVEL DETERMINED AFTER 48 HOURS BOTTOM OF AUGER EL. 906.8
2. HOLE STABILIZED WITH 4" CASING TO EL. 901.8
3. INSTALLED P-10, 11, 12 IN BORING.
US Army Corps of Engineers ST. PAUL DISTRICT
DESIGNED BY: DRAWN BY: SUBMITTED BY: CHECKED BY: PLOT SCALE: PLOT DATE: CONTRACT NO.: FILE NUMBER: FILE NAME: FARGO_MOORHEAD_BORING.dgn
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SYSTEM: SOLICITATION NO.:
DATE: APPR. BAND:
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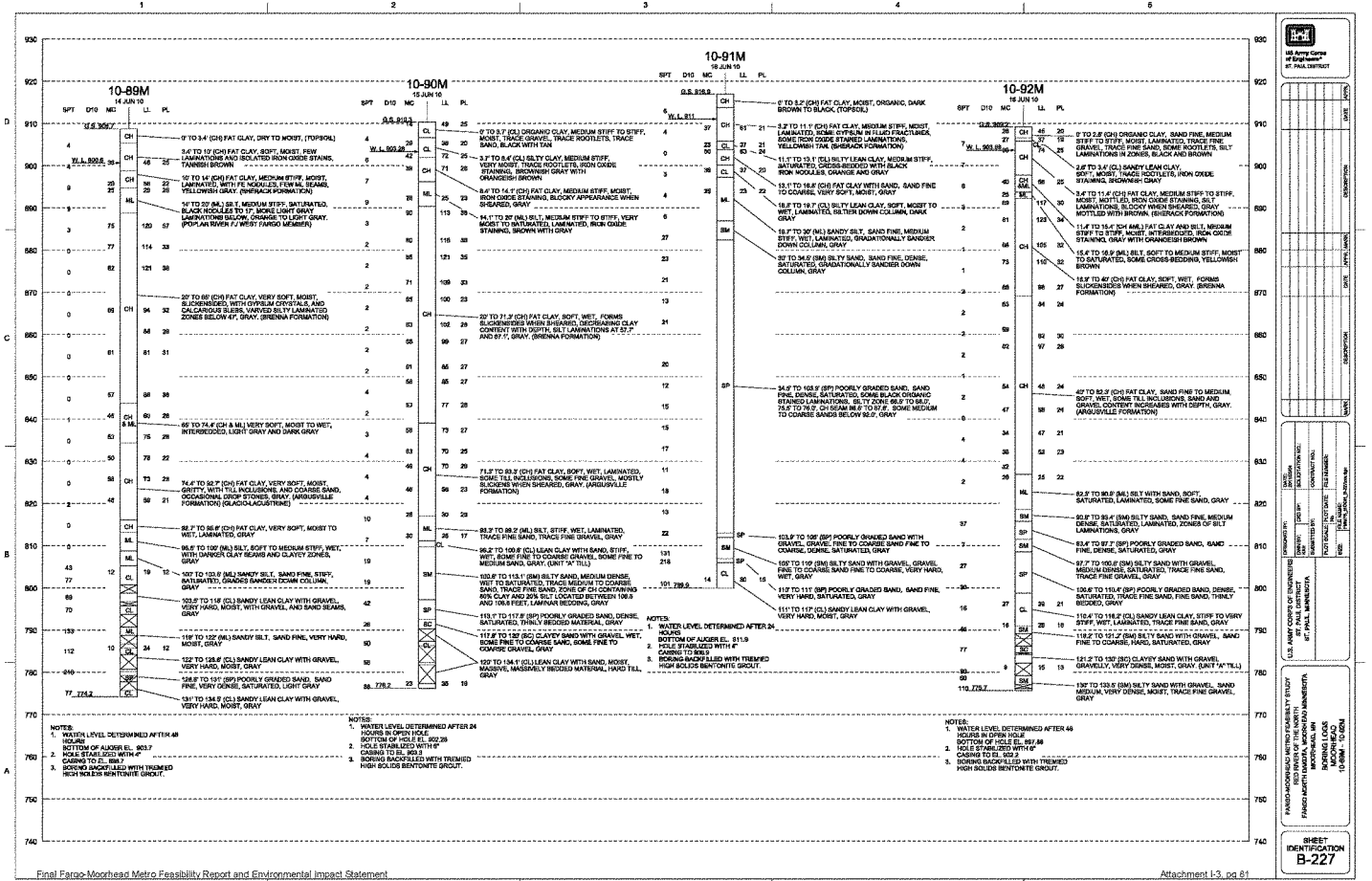
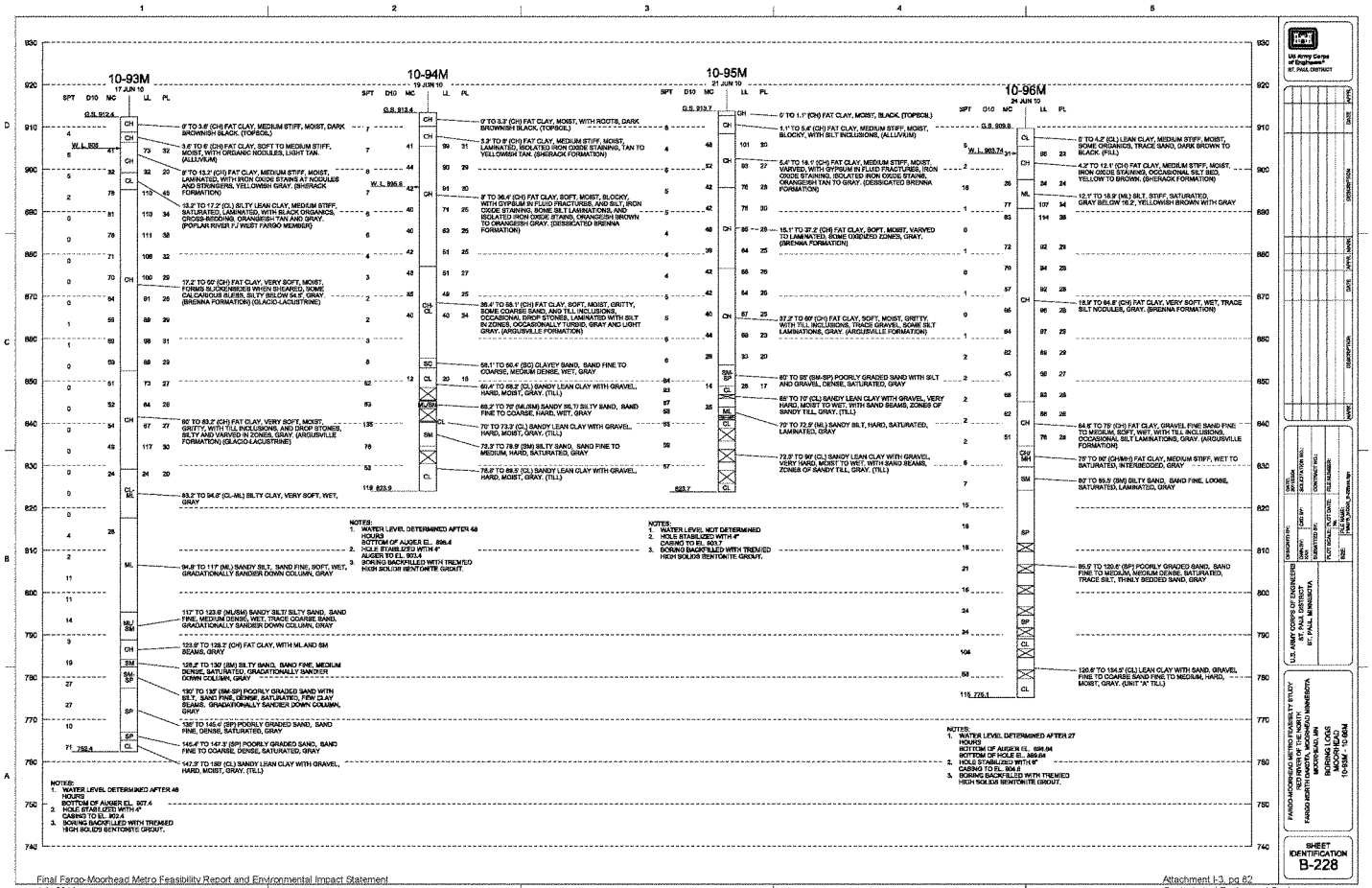
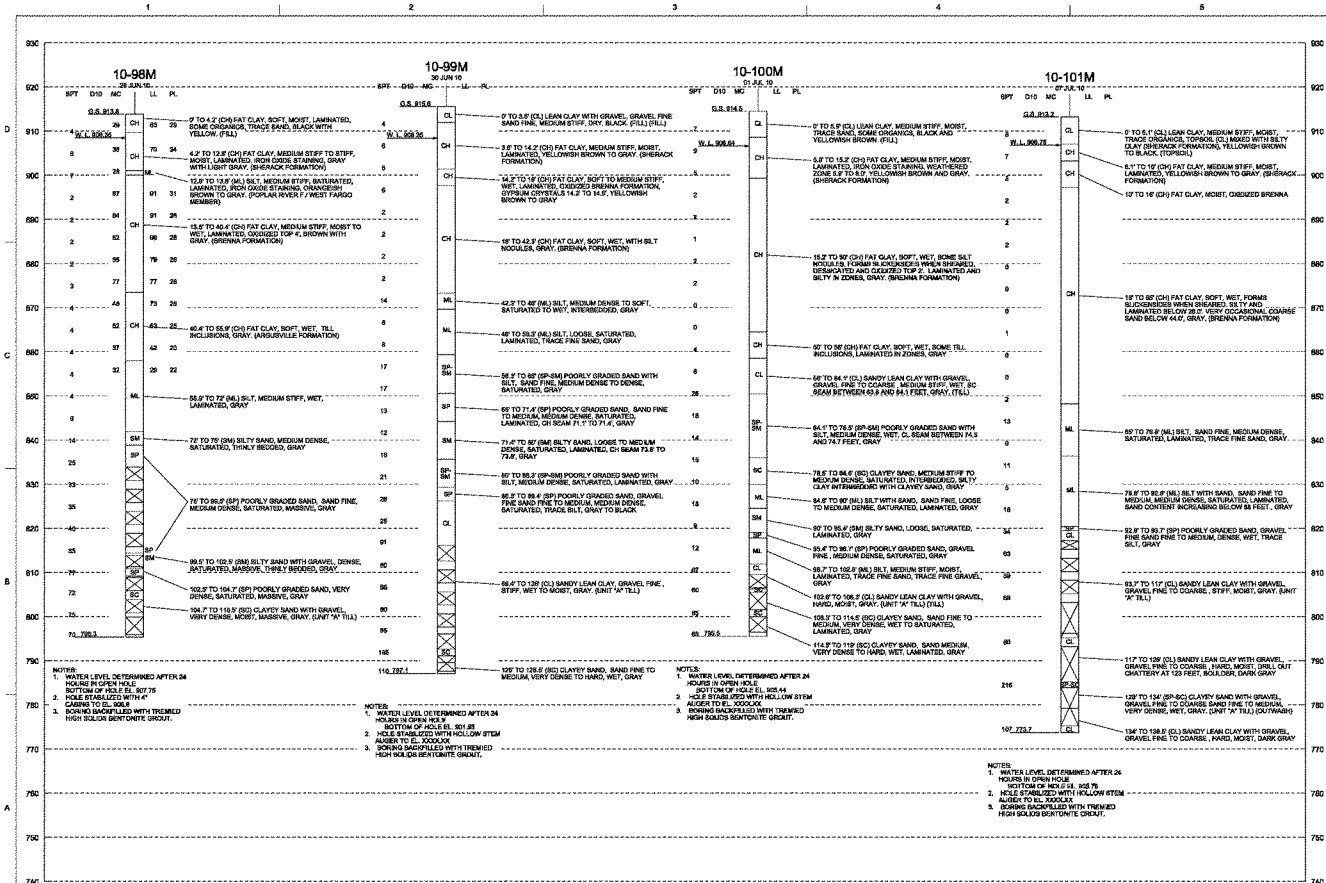
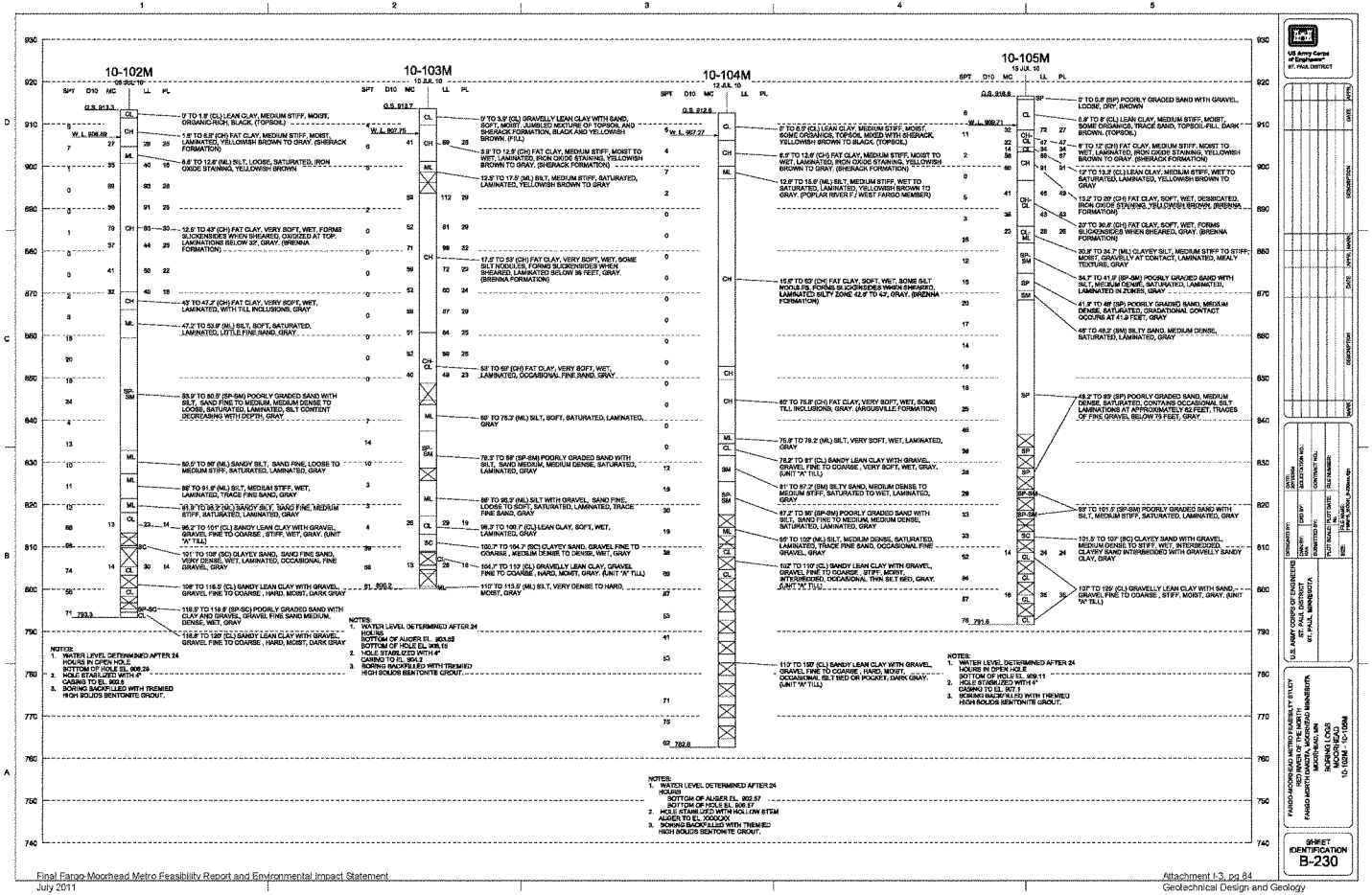
U.S. ARMY CORPS OF ENGINEERS ST. PAUL DISTRICT ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY RED RIVER OF THE NORTH FARGO NORTH DAKOTA AND MOORHEAD, MINNESOTA
BORING LOGS
10-85M, 10-86M, 10-87M, 10-88M
SHEET IDENTIFICATION B-226


10-89M
14 JUN 10
10-90M
15 JUN 10
10-91M
16 JUN 10
10-92M
16 JUN 10
SPT D10 MC LL PL
0' TO 3.4' (CH) FAT CLAY, DRY TO MOIST, (TOPSOIL)
3.4' TO 10' (CH) FAT CLAY, SOFT, MOIST, FEW LAMINATIONS AND ISOLATED IRON OXIDE STAINS, TANNISH BROWN
10' TO 14' (CH) FAT CLAY, MEDIUM STIFF, MOIST, LAMINATED, WITH FE NODULES, FEW ML SEAMS, YELLOWISH GRAY, (SHEYAK FORMATION)
14' TO 20' (ML) SILT, MEDIUM STIFF, SATURATED, BLACK NODULES TO 17', MORE LIGHT GRAY LAMINATIONS BELOW, ORANGE TO LIGHT GRAY, (POPLAR RIVER / WEST FARGO MEMBER)
20' TO 65' (CH) FAT CLAY, VERY SOFT, MOIST, SLICKENSIDED, WITH GYPSUM CRYSTALS, AND CALCAREOUS SILESS, VARVED SILTY LAMINATED ZONES BELOW 47', GRAY, (BRENNA FORMATION)
65' TO 74.4' (CH & ML) VERY SOFT, MOIST TO WET, INTERBEDDED, LIGHT GRAY AND DARK GRAY
74.4' TO 92.7' (CH) FAT CLAY, VERY SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, AND COARSE SAND, OCCASIONAL DROP STONES, GRAY, (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
92.7' TO 96.8' (CH) FAT CLAY, VERY SOFT, MOIST TO WET, LAMINATED, GRAY
96.8' TO 100' (ML) SILT, SOFT TO MEDIUM STIFF, WET, WITH DARKER CLAY SEAMS AND CLAYEY ZONES, GRAY
100' TO 103.8' (ML) SANDY SILT, SAND FINE, STIFF, SATURATED, GRADES SANDIER DOWN COLUMN, GRAY
103.8' TO 118' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY HARD, MOIST, WITH GRAVEL, AND SAND SEAMS, GRAY
118' TO 122' (ML) SANDY SILT, SAND FINE, VERY HARD, MOIST, GRAY
122' TO 128.8' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY HARD, MOIST, GRAY
128.8' TO 131' (SP) POORLY GRADED SAND, SAND FINE, VERY DENSE, SATURATED, LIGHT GRAY
131' TO 134.5' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY HARD, MOIST, GRAY
0' TO 3.7' (CL) ORGANIC CLAY, MEDIUM STIFF TO STIFF, MOIST, TRACE GRAVEL, TRACE ROOTLETS, TRACE SAND, BLACK WITH TAN
3.7' TO 8.4' (CL) SILTY CLAY, MEDIUM STIFF, VERY MOIST, TRACE ROOTLETS, IRON OXIDE STAINING, BROWNISH GRAY WITH ORANGEISH BROWN
8.4' TO 14.1' (CH) FAT CLAY, MEDIUM STIFF, MOIST, IRON OXIDE STAINING, BLOCKY APPEARANCE WHEN SHEARED, GRAY
14.1' TO 20' (ML) SILT, MEDIUM STIFF TO STIFF, VERY MOIST TO SATURATED, LAMINATED, IRON OXIDE STAINING, BROWN WITH GRAY
20' TO 71.3' (CH) FAT CLAY, SOFT, WET, FORMS SLICKENSIDES WHEN SHEARED, DECREASING CLAY CONTENT WITH DEPTH, SILT LAMINATIONS AT 57.7' AND 67.7', GRAY, (BRENNA FORMATION)
71.3' TO 93.2' (CH) FAT CLAY, SOFT, WET, LAMINATED, SOME TILL INCLUSIONS, SOME FINE GRAVEL, MOSTLY SLICKENS WHEN SHEARED, GRAY, (ARGUSVILLE FORMATION)
93.2' TO 95.7' (ML) SILT, STIFF, WET, LAMINATED, TRACE FINE SAND, TRACE FINE GRAVEL, GRAY
95.7' TO 100.8' (CL) LEAN CLAY WITH SAND, STIFF, WET, SOME FINE TO COARSE GRAVEL, SOME FINE TO MEDIUM SAND, GRAY, (UNIT "A" TILL)
100.8' TO 113.1' (SM) SILTY SAND, MEDIUM DENSE, WET TO SATURATED, TRACE MEDIUM TO COARSE SAND, TRACE FINE SAND, ZONE OF CH CONTAINING 60% CLAY AND 20% SILT LOCATED BETWEEN 106.9 AND 106.6 FEET, LAMINAR BEDDING, GRAY
113.1' TO 117.8' (SP) POORLY GRADED SAND, DENSE, SATURATED, THINLY BEDDED MATERIAL, GRAY
117.8' TO 132' (SC) CLAYEY SAND WITH GRAVEL, WET, SOME FINE TO COARSE SAND, SOME FINE TO COARSE GRAVEL, GRAY
132' TO 134.1' (CL) LEAN CLAY WITH SAND, MOIST, MASSIVE, MASSIVELY BEDDED MATERIAL, HARD TILL, GRAY
0' TO 2.2' (CH) FAT CLAY, MOIST, ORGANIC, DARK BROWN TO BLACK, (TOPSOIL)
2.2' TO 11.1' (CH) FAT CLAY, MEDIUM STIFF, MOIST, LAMINATED, SOME GYPSUM IN FLUID FRACTURES, SOME IRON OXIDE STAINED LAMINATIONS, YELLOWISH TAN, (SHEYAK FORMATION)
11.1' TO 13.1' (CL) SILTY LEAN CLAY, MEDIUM STIFF, SATURATED, CROSS-BEDDED WITH BLACK IRON NODULES, ORANGE AND GRAY
13.1' TO 18.6' (CH) FAT CLAY WITH SAND, SAND FINE TO COARSE, VERY SOFT, MOIST, GRAY
18.6' TO 19.7' (CL) SILTY LEAN CLAY, SOFT, MOIST TO WET, LAMINATED, SILTIER DOWN COLUMN, DARK GRAY
19.7' TO 30' (ML) SANDY SILT, SAND FINE, MEDIUM STIFF, WET, LAMINATED, GRADATIONALLY SANDIER DOWN COLUMN, GRAY
30' TO 34.5' (SM) SILTY SAND, SAND FINE, DENSE, SATURATED, GRADATIONALLY SANDIER DOWN COLUMN, GRAY
34.5' TO 103.5' (SP) POORLY GRADED SAND, SAND FINE, DENSE, SATURATED, SOME BLACK ORGANIC STAINED LAMINATIONS, SILTY ZONE 66.0' TO 68.0', 75.5' TO 76.0' CH SEAM 86.0' TO 87.0', SOME MEDIUM TO COARSE SANDS BELOW 92.0', GRAY
103.5' TO 106' (SP) POORLY GRADED SAND WITH GRAVEL, GRAVEL FINE TO COARSE SAND FINE TO COARSE, DENSE, SATURATED, GRAY
106' TO 109' (SM) SILTY SAND WITH GRAVEL, GRAVEL FINE TO COARSE SAND FINE TO COARSE, VERY HARD, WET, GRAY
109' TO 111' (SP) POORLY GRADED SAND, SAND FINE, VERY HARD, SATURATED, GRAY
111' TO 119' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY HARD, MOIST, GRAY
0' TO 2.6' (CH) ORGANIC CLAY, SAND FINE, MEDIUM STIFF TO STIFF, MOIST, LAMINATED, TRACE FINE GRAVEL, TRACE FINE SAND, SOME ROOTLETS, SILT LAMINATIONS IN ZONES, BLACK AND BROWN
2.6' TO 3.4' (CL) SANDY LEAN CLAY, SOFT, MOIST, TRACE ROOTLETS, IRON OXIDE STAINING, BROWNISH GRAY
3.4' TO 11.4' (CH) FAT CLAY, MEDIUM STIFF TO STIFF, MOIST, MOTTLED, IRON OXIDE STAINING, SILT LAMINATIONS, BLOCKY WHEN SHEARED, GRAY MOTTLED WITH BROWN, (SHEYAK FORMATION)
11.4' TO 15.4' (CH & ML) FAT CLAY AND SILT, MEDIUM STIFF TO STIFF, MOIST, INTERBEDDED, IRON OXIDE STAINING, GRAY WITH ORANGEISH BROWN
15.4' TO 16.9' (ML) SILT, SOFT TO MEDIUM STIFF, MOIST TO SATURATED, SOME CROSS-BEDDING, YELLOWISH BROWN
16.9' TO 40' (CH) FAT CLAY, SOFT, WET, FORMS SLICKENSIDES WHEN SHEARED, GRAY, (BRENNA FORMATION)
40' TO 52.3' (CH) FAT CLAY, SAND FINE TO MEDIUM, SOFT, WET, SOME TILL INCLUSIONS, SAND AND GRAVEL CONTENT INCREASES WITH DEPTH, GRAY, (ARGUSVILLE FORMATION)
52.3' TO 90.9' (ML) SILT WITH SAND, SOFT, SATURATED, LAMINATED, SOME FINE SAND, GRAY
90.9' TO 93.4' (SM) SILTY SAND, SAND FINE, MEDIUM DENSE, SATURATED, LAMINATED, ZONES OF SILT LAMINATIONS, GRAY
93.4' TO 97.7' (SP) POORLY GRADED SAND, SAND FINE, DENSE, SATURATED, GRAY
97.7' TO 100.6' (SM) SILTY SAND WITH GRAVEL, MEDIUM DENSE, SATURATED, TRACE FINE SAND, TRACE FINE GRAVEL, GRAY
100.6' TO 110.4' (SP) POORLY GRADED SAND, DENSE, SATURATED, TRACE FINE SAND, FINE SAND, THINLY BEDDED, GRAY
110.4' TO 118.2' (CL) SANDY LEAN CLAY, STIFF TO VERY STIFF, WET, LAMINATED, TRACE FINE SAND, GRAY
118.2' TO 121.2' (SM) SILTY SAND WITH GRAVEL, SAND FINE TO COARSE, HARD, SATURATED, GRAY
121.2' TO 130' (SC) CLAYEY SAND WITH GRAVEL, GRAVELLY, VERY DENSE, MOIST, GRAY, (UNIT "A" TILL)
130' TO 133.5' (SM) SILTY SAND WITH GRAVEL, SAND MEDIUM, VERY DENSE, MOIST, TRACE FINE GRAVEL, GRAY
NOTES:
1. WATER LEVEL DETERMINED AFTER 48 HOURS
BOTTOM OF AUGER EL. 903.7
2. HOLE STABILIZED WITH 4" CASING TO EL. 898.7
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE
BOTTOM OF HOLE EL. 902.28
2. HOLE STABILIZED WITH 6" CASING TO EL. 903.3
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS
BOTTOM OF AUGER EL. 911.9
2. HOLE STABILIZED WITH 4" CASING TO 909.9
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
NOTES:
1. WATER LEVEL DETERMINED AFTER 48 HOURS IN OPEN HOLE
BOTTOM OF HOLE EL. 897.88
2. HOLE STABILIZED WITH 6" CASING TO EL. 902.2
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers
St. Paul District
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO-NORTH MOORHEAD, NORTH DAKOTA AND MINNESOTA
MOORHEAD, MN
BORING LOGS
MOORHEAD
(10-89M, 10-90M, 10-91M, 10-92M)
SHEET IDENTIFICATION
B-227


10-93M
17 JUN 10
G.S. 912.4
W.L. 908
0' TO 3.6' (CH) FAT CLAY, MEDIUM STIFF, MOIST, DARK BROWNISH BLACK, (TOPSOIL)
3.6' TO 6' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, MOIST, WITH ORGANIC NODULES, LIGHT TAN. (ALLUVIUM)
6' TO 13.2' (CH) FAT CLAY, MEDIUM STIFF, MOIST, LAMINATED, WITH IRON OXIDE STAINS AT NODULES AND STRINGERS, YELLOWISH GRAY. (SHERACK FORMATION)
13.2' TO 17.2' (CL) SILTY LEAN CLAY, MEDIUM STIFF, SATURATED, LAMINATED, WITH BLACK ORGANICS, CROSS-BEDDING, ORANGEISH-TAN AND GRAY. (POPLAR RIVER FJ WEST FARGO MEMBER)
17.2' TO 65' (CH) FAT CLAY, VERY SOFT, MOIST, FORMS SLICKENSIDES WHEN SHEARED, SOME CALCAREOUS BLEBS, SILTY BELOW 54.9', GRAY. (BRENNA FORMATION) (GLACIO-LACUSTRINE)
65' TO 83.2' (CH) FAT CLAY, VERY SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, AND DROP STONES, SILTY AND VARVED IN ZONES, GRAY. (ARGUSVILLE FORMATION) (GLACIO-LACUSTRINE)
83.2' TO 94.6' (CL-ML) SILTY CLAY, VERY SOFT, WET, GRAY
94.6' TO 117' (ML) SANDY SILT, SAND FINE, SOFT, WET, GRADATIONALLY SANDIER DOWN COLUMN, GRAY
117' TO 123.6' (ML/SM) SANDY SILT/ SILTY SAND, SAND FINE, MEDIUM DENSE, WET, TRACE COARSE SAND, GRADATIONALLY SANDIER DOWN COLUMN, GRAY
123.6' TO 128.2' (CH) FAT CLAY, WITH ML AND SM SEAMS, GRAY
128.2' TO 130' (SM) SILTY SAND, SAND FINE, MEDIUM DENSE, SATURATED, GRADATIONALLY SANDIER DOWN COLUMN, GRAY
130' TO 136' (SM-SP) POORLY GRADED SAND WITH SILT, SAND FINE, DENSE, SATURATED, FEW CLAY SEAMS, GRADATIONALLY SANDIER DOWN COLUMN, GRAY
136' TO 145.4' (SP) POORLY GRADED SAND, SAND FINE, DENSE, SATURATED, GRAY
145.4' TO 147.3' (SP) POORLY GRADED SAND, SAND FINE TO COARSE, DENSE, SATURATED, GRAY
147.3' TO 189' (CL) SANDY LEAN CLAY WITH GRAVEL, HARD, MOIST, GRAY, (TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 48 HOURS
BOTTOM OF AUGER EL. 907.4
2. HOLE STABILIZED WITH 4" CASING TO EL. 903.4
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-94M
19 JUN 10
G.S. 913.4
W.L. 906.8
0' TO 3.3' (CH) FAT CLAY, MOIST, WITH ROOTS, DARK BROWNISH BLACK, (TOPSOIL)
3.3' TO 8' (CH) FAT CLAY, MEDIUM STIFF, MOIST, LAMINATED, ISOLATED IRON OXIDE STAINING, TAN TO YELLOWISH TAN. (SHERACK FORMATION)
8' TO 36.4' (CH) FAT CLAY, SOFT, MOIST, BLOCKY, WITH GYPSUM IN FLUID FRACTURES, AND SILT, IRON OXIDE STAINING, SOME SILT LAMINATIONS, AND ISOLATED IRON OXIDE STAINS, ORANGEISH BROWN TO ORANGEISH GRAY. (DESSICATED BRENNA FORMATION)
36.4' TO 58.1' (CH) FAT CLAY, SOFT, MOIST, GRITTY, SOME COARSE SAND, AND TILL INCLUSIONS, OCCASIONAL DROP STONES, LAMINATED WITH SILT IN ZONES, OCCASIONALLY TURBID, GRAY AND LIGHT GRAY. (ARGUSVILLE FORMATION)
58.1' TO 59.4' (SC) CLAYEY SAND, SAND FINE TO COARSE, MEDIUM DENSE, WET, GRAY
59.4' TO 69.2' (CL) SANDY LEAN CLAY WITH GRAVEL, HARD, MOIST, GRAY, (TILL)
69.2' TO 70' (ML/SM) SANDY SILT/ SILTY SAND, SAND FINE TO COARSE, HARD, WET, GRAY
70' TO 73.3' (CL) SANDY LEAN CLAY WITH GRAVEL, HARD, MOIST, GRAY, (TILL)
73.3' TO 78.9' (SM) SILTY SAND, SAND FINE TO MEDIUM, HARD, SATURATED, GRAY
78.9' TO 89.3' (CL) SANDY LEAN CLAY WITH GRAVEL, HARD, MOIST, GRAY, (TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 48 HOURS
BOTTOM OF AUGER EL. 896.4
2. HOLE STABILIZED WITH 6" AUGER TO EL. 903.4
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-95M
21 JUN 10
G.S. 913.7
0' TO 1.1' (CH) FAT CLAY, MOIST, BLACK, (TOPSOIL)
1.1' TO 5.4' (CH) FAT CLAY, MEDIUM STIFF, MOIST, BLOCKY, WITH SILT INCLUSIONS, (ALLUVIUM)
5.4' TO 18.1' (CH) FAT CLAY, MEDIUM STIFF, MOIST, VARVED, WITH GYPSUM IN FLUID FRACTURES, IRON OXIDE STAINING, (ISOLATED IRON OXIDE STAINS, ORANGEISH TAN TO GRAY. (DESSICATED BRENNA FORMATION)
18.1' TO 37.2' (CH) FAT CLAY, SOFT, MOIST, VARVED TO LAMINATED, SOME OXIDIZED ZONES, GRAY, (BRENNA FORMATION)
37.2' TO 60' (CH) FAT CLAY, SOFT, MOIST, GRITTY, WITH TILL INCLUSIONS, TRACE GRAVEL, SOME SILT LAMINATIONS, GRAY. (ARGUSVILLE FORMATION)
60' TO 65' (SM-SP) POORLY GRADED SAND WITH SILT AND GRAVEL, DENSE, SATURATED, GRAY
65' TO 70' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY HARD, MOIST TO WET, WITH SAND SEAMS, ZONES OF SANDY TILL, GRAY, (TILL)
70' TO 72.5' (ML) SANDY SILT, HARD, SATURATED, LAMINATED, GRAY
72.5' TO 90' (CL) SANDY LEAN CLAY WITH GRAVEL, VERY HARD, MOIST TO WET, WITH SAND SEAMS, ZONES OF SANDY TILL, GRAY, (TILL)
10-96M
24 JUN 10
G.S. 909.8
W.L. 903.74
0' TO 4.5' (CL) LEAN CLAY, MEDIUM STIFF, MOIST, SOME ORGANICS, TRACE SAND, DARK BROWN TO BLACK, (FILL)
4.5' TO 12.1' (CH) FAT CLAY, MEDIUM STIFF, MOIST, IRON OXIDE STAINING, OCCASIONAL SILT SEO, YELLOW TO BROWN, (SHERACK FORMATION)
12.1' TO 18.9' (ML) SILT, STIFF, SATURATED, GRAY BELOW 16.2', YELLOWISH BROWN WITH GRAY
18.9' TO 64.8' (CH) FAT CLAY, VERY SOFT, WET, TRACE SILT NODULES, GRAY. (BRENNA FORMATION)
64.8' TO 75' (CH) FAT CLAY, GRAVEL FINE SAND FINE TO MEDIUM, SOFT, WET, WITH TILL INCLUSIONS, OCCASIONAL SILT LAMINATIONS, GRAY. (ARGUSVILLE FORMATION)
75' TO 80' (CH/MH) FAT CLAY, MEDIUM STIFF, WET TO SATURATED, INTERBEDDED, GRAY
80' TO 85.5' (SM) SILTY SAND, SAND FINE, LOOSE, SATURATED, LAMINATED, GRAY
85.5' TO 120.6' (SP) POORLY GRADED SAND, SAND FINE TO MEDIUM, MEDIUM DENSE, SATURATED, TRACE SILT, THINLY BEDDED SAND, GRAY
120.6' TO 134.5' (CL) LEAN CLAY WITH SAND, GRAVEL FINE TO COARSE SAND FINE TO MEDIUM, HARD, MOIST, GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 27 HOURS
BOTTOM OF AUGER EL. 896.64
BOTTOM OF HOLE EL. 889.64
2. HOLE STABILIZED WITH 6" CASING TO EL. 906.8
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
Uni Army Corps of Engineers
ST. PAUL DISTRICT
LEGEND
SPT D10 MC LL PL
CH
CL
CL-ML
ML
ML/SM
SM
SM-SP
SP
SC
MH
CH/MH
SHEET IDENTIFICATION
B-228


10-98M
26 JUN 10
G.S. 913.8
W.L. 908.36
0' TO 4.2' (CH) FAT CLAY, SOFT, MOIST, LAMINATED, SOME ORGANICS, TRACE SAND, BLACK WITH YELLOW. (FILL)
4.2' TO 12.8' (CH) FAT CLAY, MEDIUM STIFF TO STIFF, MOIST, LAMINATED, IRON OXIDE STAINING, GRAY WITH LIGHT GRAY. (SHERACK FORMATION)
12.8' TO 13.8' (ML) SILT, MEDIUM STIFF, SATURATED, LAMINATED, IRON OXIDE STAINING, ORANGEISH BROWN TO GRAY. (POPLAR RIVER F / WEST FARGO MEMBER)
13.8' TO 40.4' (CH) FAT CLAY, MEDIUM STIFF, MOIST TO WET, LAMINATED, OXIDIZED TOP 4', BROWN WITH GRAY. (BRENNA FORMATION)
40.4' TO 55.9' (CH) FAT CLAY, SOFT, WET, TILL INCLUSIONS, GRAY. (ARGUSVILLE FORMATION)
55.9' TO 72' (ML) SILT, MEDIUM STIFF, WET, LAMINATED, GRAY
72' TO 76' (SM) SILTY SAND, MEDIUM DENSE, SATURATED, THINLY BEDDED, GRAY
76' TO 99.5' (SP) POORLY GRADED SAND, SAND FINE, MEDIUM DENSE, SATURATED, MASSIVE, GRAY
99.5' TO 102.5' (SM) SILTY SAND WITH GRAVEL, DENSE, SATURATED, MASSIVE, THINLY BEDDED, GRAY
102.5' TO 104.7' (SP) POORLY GRADED SAND, VERY DENSE, SATURATED, MASSIVE, GRAY
104.7' TO 118.5' (SC) CLAYEY SAND WITH GRAVEL, VERY DENSE, MOIST, MASSIVE, GRAY, (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 907.75
2. HOLE STABILIZED WITH 4" CASING TO EL. 906.8
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-99M
30 JUN 10
G.S. 915.6
W.L. 908.36
0' TO 3.8' (CL) LEAN CLAY WITH GRAVEL, GRAVEL FINE SAND FINE, MEDIUM STIFF, DRY, BLACK. (FILL) (FILL)
3.8' TO 14.2' (CH) FAT CLAY, MEDIUM STIFF, MOIST, LAMINATED, YELLOWISH BROWN TO GRAY. (SHERACK FORMATION)
14.2' TO 18' (CH) FAT CLAY, SOFT TO MEDIUM STIFF, WET, LAMINATED, OXIDIZED BRENNA FORMATION, GYPSUM CRYSTALS 14.2' TO 14.5', YELLOWISH BROWN TO GRAY
18' TO 42.3' (CH) FAT CLAY, SOFT, WET, WITH SILT NODULES, GRAY. (BRENNA FORMATION)
42.3' TO 48' (ML) SILT, MEDIUM DENSE TO SOFT, SATURATED TO WET, INTERBEDDED, GRAY
48' TO 59.5' (ML) SILT, LOOSE, SATURATED, LAMINATED, TRACE FINE SAND, GRAY
59.5' TO 65' (SP-SM) POORLY GRADED SAND WITH SILT, SAND FINE, MEDIUM DENSE TO DENSE, SATURATED, GRAY
65' TO 71.4' (SP) POORLY GRADED SAND, SAND FINE TO MEDIUM, MEDIUM DENSE, SATURATED, LAMINATED, CH SEAM 71.1' TO 71.4', GRAY
71.4' TO 87' (SM) SILTY SAND, LOOSE TO MEDIUM DENSE, SATURATED, LAMINATED, CH SEAM 73.8' TO 73.9', GRAY
87' TO 88.3' (SP-SM) POORLY GRADED SAND WITH SILT, MEDIUM DENSE, SATURATED, LAMINATED, GRAY
88.3' TO 89.4' (SP) POORLY GRADED SAND, GRAVEL FINE SAND FINE TO MEDIUM, MEDIUM DENSE, SATURATED, TRACE SILT, GRAY TO BLACK
89.4' TO 129' (CL) SANDY LEAN CLAY, GRAVEL FINE, STIFF, WET TO MOIST, GRAY. (UNIT "A" TILL)
129' TO 139.5' (SC) CLAYEY SAND, SAND FINE TO MEDIUM, VERY DENSE TO HARD, WET, GRAY
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 901.88
2. HOLE STABILIZED WITH HOLLOW STEM AUGER TO EL. XXXXXX
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-100M
01 JUL 10
G.S. 914.5
W.L. 908.64
0' TO 5.9' (CL) LEAN CLAY, MEDIUM STIFF, MOIST, TRACE SAND, SOME ORGANICS, BLACK AND YELLOWISH BROWN. (FILL)
5.9' TO 15.2' (CH) FAT CLAY, MEDIUM STIFF, MOIST, LAMINATED, IRON OXIDE STAINING, WEATHERED ZONE 5.9' TO 6.9', YELLOWISH BROWN AND GRAY. (SHERACK FORMATION)
15.2' TO 50' (CH) FAT CLAY, SOFT, WET, SOME SILT NODULES, FORMS SLICKENSIDES WHEN SHEARED, DESICCATED AND OXIDIZED TOP 2'. LAMINATED AND SILTY IN ZONES, GRAY. (BRENNA FORMATION)
50' TO 58' (CH) FAT CLAY, SOFT, WET, SOME TILL INCLUSIONS, LAMINATED IN ZONES, GRAY
58' TO 64.1' (CL) SANDY LEAN CLAY WITH GRAVEL, GRAVEL FINE TO COARSE, MEDIUM STIFF, WET, SC SEAM BETWEEN 63.8 AND 64.1 FEET, GRAY, (TILL)
64.1' TO 78.5' (SP-SM) POORLY GRADED SAND WITH SILT, MEDIUM DENSE, WET, CL SEAM BETWEEN 74.5 AND 74.7 FEET, GRAY
78.5' TO 84.6' (SC) CLAYEY SAND, MEDIUM STIFF TO MEDIUM DENSE, SATURATED, INTERBEDDED, SILTY CLAY INTERMIXED WITH CLAYEY SAND, GRAY
84.6' TO 90' (ML) SILT WITH SAND, SAND FINE, LOOSE TO MEDIUM DENSE, SATURATED, LAMINATED, GRAY
90' TO 95.4' (SM) SILTY SAND, LOOSE, SATURATED, LAMINATED, GRAY
95.4' TO 99.1' (SP) POORLY GRADED SAND, GRAVEL FINE, MEDIUM DENSE, SATURATED, GRAY
99.7' TO 102.6' (ML) SILT, MEDIUM STIFF, MOIST, LAMINATED, TRACE FINE SAND, TRACE FINE GRAVEL, GRAY
102.6' TO 108.5' (CL) SANDY LEAN CLAY WITH GRAVEL, HARD, MOIST, GRAY. (UNIT "A" TILL) (TILL)
108.5' TO 114.5' (SC) CLAYEY SAND, SAND FINE TO MEDIUM, VERY DENSE, WET TO SATURATED, LAMINATED, GRAY
114.5' TO 119' (SC) CLAYEY SAND, SAND MEDIUM, VERY DENSE TO HARD, WET, LAMINATED, GRAY
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 905.44
2. HOLE STABILIZED WITH HOLLOW STEM AUGER TO EL. XXXXXX
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-101M
27 JUL 10
G.S. 913.2
W.L. 906.78
0' TO 6.1' (CL) LEAN CLAY, MEDIUM STIFF, MOIST, TRACE ORGANICS, TOPSOIL (CL) MIXED WITH SILTY CLAY (SHERACK FORMATION), YELLOWISH BROWN TO BLACK. (TOPSOIL)
6.1' TO 10' (CH) FAT CLAY, MEDIUM STIFF, MOIST, LAMINATED, YELLOWISH BROWN TO GRAY. (SHERACK FORMATION)
10' TO 18' (CH) FAT CLAY, MOIST, OXIDIZED BRENNA
18' TO 68' (CH) FAT CLAY, SOFT, WET, FORMS SLICKENSIDES WHEN SHEARED, SILTY AND LAMINATED BELOW 38.2', VERY OCCASIONAL COARSE SAND BELOW 44.0', GRAY. (BRENNA FORMATION)
68' TO 76.8' (ML) SILT, SAND FINE, MEDIUM DENSE, SATURATED, LAMINATED, TRACE FINE SAND, GRAY
76.8' TO 92.8' (ML) SILT WITH SAND, SAND FINE TO MEDIUM, MEDIUM DENSE, SATURATED, LAMINATED, SAND CONTENT INCREASING BELOW 88 FEET, GRAY
92.8' TO 93.7' (SP) POORLY GRADED SAND, GRAVEL FINE SAND FINE TO MEDIUM, DENSE, WET, TRACE SILT, GRAY
93.7' TO 117' (CL) SANDY LEAN CLAY WITH GRAVEL, GRAVEL FINE TO COARSE, STIFF, MOIST, GRAY. (UNIT "A" TILL)
117' TO 129' (CL) SANDY LEAN CLAY WITH GRAVEL, GRAVEL FINE TO COARSE, HARD, MOIST, DRILL OUT CHATTERY AT 123 FEET, BOULDER, DARK GRAY
129' TO 134' (SP-SC) CLAYEY SAND WITH GRAVEL, GRAVEL FINE TO COARSE, SAND FINE TO MEDIUM, VERY DENSE, WET, GRAY. (UNIT "A" TILL) (OUTWASH)
134' TO 138.5' (CL) SANDY LEAN CLAY WITH GRAVEL, GRAVEL FINE TO COARSE, HARD, MOIST, DARK GRAY
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 905.75
2. HOLE STABILIZED WITH HOLLOW STEM AUGER TO EL. XXXXXX
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers
ST. PAUL DISTRICT
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO-NORTH MOORHEAD, NORTH DAKOTA AND MOORHEAD, MN
BORING LOGS
MOORHEAD REACH
10-98M, 10-99M, 10-100M, 10-101M
SHEET IDENTIFICATION
B-229


10-102M
05 JUL 10
G.S. 913.3
0' TO 1.8' (CL) LEAN CLAY, MEDIUM STIFF, MOIST, ORGANIC-RICH, BLACK. (TOPSOIL)
1.8' TO 5.0' (CH) FAT CLAY, MEDIUM STIFF, MOIST, LAMINATED, YELLOWISH BROWN TO GRAY. (SHERACK FORMATION)
5.0' TO 12.6' (ML) SILT, LOOSE, SATURATED, IRON OXIDE STAINING, YELLOWISH BROWN
12.5' TO 43' (CH) FAT CLAY, VERY SOFT, WET, FORMS SLICKENSIDES WHEN SHEARED, OXIDIZED AT TOP. LAMINATIONS BELOW 32', GRAY. (BRENNA FORMATION)
43' TO 47.2' (CH) FAT CLAY, VERY SOFT, WET, LAMINATED, WITH TILL INCLUSIONS, GRAY
47.2' TO 53.9' (ML) SILT, SOFT, SATURATED, LAMINATED, LITTLE FINE SAND, GRAY
53.9' TO 80.5' (SP-SM) POORLY GRADED SAND WITH SILT, SAND FINE TO MEDIUM, MEDIUM DENSE TO LOOSE, SATURATED, LAMINATED, SILT CONTENT DECREASING WITH DEPTH, GRAY
80.5' TO 86' (ML) SANDY SILT, SAND FINE, LOOSE TO MEDIUM STIFF, SATURATED, LAMINATED, GRAY
86' TO 91.5' (ML) SILT, MEDIUM STIFF, WET, LAMINATED, TRACE FINE SAND, GRAY
91.5' TO 95.3' (ML) SANDY SILT, SAND FINE, MEDIUM STIFF, SATURATED, LAMINATED, GRAY
95.3' TO 101' (CL) SANDY LEAN CLAY WITH GRAVEL, GRAVEL FINE TO COARSE, STIFF, WET, GRAY. (UNIT "A" TILL)
101' TO 108' (SC) CLAYEY SAND, SAND FINE SAND, VERY DENSE, WET, LAMINATED, OCCASIONAL FINE GRAVEL, GRAY
108' TO 118.5' (CL) SANDY LEAN CLAY WITH GRAVEL, GRAVEL FINE TO COARSE, HARD, MOIST, DARK GRAY
118.5' TO 119.5' (SP-SC) POORLY GRADED SAND WITH CLAY AND GRAVEL, GRAVEL FINE SAND MEDIUM, DENSE, WET, GRAY
119.5' TO 120' (CL) SANDY LEAN CLAY WITH GRAVEL, GRAVEL FINE TO COARSE, HARD, MOIST, DARK GRAY
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 906.29
2. HOLE STABILIZED WITH 4" CASING TO EL. 902.6
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-103M
10 JUL 10
G.S. 913.7
9' TO 3.9' (CL) GRAVELLY LEAN CLAY WITH SAND, SOFT, MOIST, LAYERED MIXTURE OF TOPSOIL AND SHERACK FORMATION, BLACK AND YELLOWISH BROWN. (FILL)
3.9' TO 12.5' (CH) FAT CLAY, MEDIUM STIFF, MOIST TO WET, LAMINATED, IRON OXIDE STAINING, YELLOWISH BROWN TO GRAY. (SHERACK FORMATION)
12.5' TO 17.9' (ML) SILT, MEDIUM STIFF, SATURATED, LAMINATED, YELLOWISH BROWN TO GRAY
17.5' TO 53' (CH) FAT CLAY, VERY SOFT, WET, SOME SILT NODULES, FORMS SLICKENSIDES WHEN SHEARED, LAMINATED BELOW 36 FEET, GRAY. (BRENNA FORMATION)
53' TO 69' (CH) FAT CLAY, VERY SOFT, WET, LAMINATED, OCCASIONAL FINE SAND, GRAY
69' TO 75.3' (ML) SILT, SOFT, SATURATED, LAMINATED, GRAY
75.3' TO 88' (SP-SM) POORLY GRADED SAND WITH SILT, SAND MEDIUM, MEDIUM DENSE, SATURATED, LAMINATED, GRAY
88' TO 95.3' (ML) SILT WITH GRAVEL, SAND FINE, LOOSE TO SOFT, SATURATED, LAMINATED, TRACE FINE SAND, GRAY
95.3' TO 100.7' (CL) LEAN CLAY, SOFT, WET, LAMINATED, GRAY
100.7' TO 104.7' (SC) CLAYEY SAND, GRAVEL FINE TO COARSE, MEDIUM DENSE TO DENSE, WET, GRAY
104.7' TO 112' (CL) GRAVELLY LEAN CLAY, GRAVEL FINE TO COARSE, HARD, MOIST, GRAY. (UNIT "A" TILL)
112' TO 115.5' (ML) SILT, VERY DENSE TO HARD, MOIST, GRAY
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS BOTTOM OF AUGER EL. 903.48 BOTTOM OF HOLE EL. 906.15
2. HOLE STABILIZED WITH 4" CASING TO EL. 904.2
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-104M
12 JUL 10
G.S. 912.6
0' TO 6.5' (CL) LEAN CLAY, MEDIUM STIFF, MOIST, SOME ORGANICS, TOPSOIL MIXED WITH SHERACK, YELLOWISH BROWN TO BLACK. (TOPSOIL)
6.5' TO 12.6' (CH) FAT CLAY, MEDIUM STIFF, MOIST TO WET, LAMINATED, IRON OXIDE STAINING, YELLOWISH BROWN TO GRAY. (SHERACK FORMATION)
12.6' TO 15.6' (ML) SILT, MEDIUM STIFF, WET TO SATURATED, LAMINATED, YELLOWISH BROWN TO GRAY. (POPLAR RIVER / WEST FARGO MEMBER)
15.6' TO 69' (CH) FAT CLAY, SOFT, WET, SOME SILT NODULES, FORMS SLICKENSIDES WHEN SHEARED, LAMINATED SILTY ZONE 42.6' TO 43', GRAY. (BRENNA FORMATION)
69' TO 75.9' (CH) FAT CLAY, VERY SOFT, WET, SOME TILL INCLUSIONS, GRAY. (ARGUSVILLE FORMATION)
75.9' TO 78.2' (ML) SILT, VERY SOFT, WET, LAMINATED, GRAY
78.2' TO 81' (CL) SANDY LEAN CLAY WITH GRAVEL, GRAVEL FINE TO COARSE, VERY SOFT, WET, GRAY. (UNIT "A" TILL)
81' TO 87.2' (SM) SILTY SAND, MEDIUM DENSE TO MEDIUM STIFF, SATURATED TO WET, LAMINATED, GRAY
87.2' TO 89' (SP-SM) POORLY GRADED SAND WITH SILT, SAND FINE TO MEDIUM, MEDIUM DENSE, SATURATED, LAMINATED, GRAY
89' TO 102' (ML) SILT, MEDIUM DENSE, SATURATED, LAMINATED, TRACE FINE SAND, OCCASIONAL FINE GRAVEL, GRAY
102' TO 110' (CL) SANDY LEAN CLAY WITH GRAVEL, GRAVEL FINE TO COARSE, STIFF, MOIST, INTERBEDDED, OCCASIONAL THIN SILT BED, GRAY. (UNIT "A" TILL)
110' TO 120' (CL) SANDY LEAN CLAY WITH GRAVEL, GRAVEL FINE TO COARSE, HARD, MOIST, OCCASIONAL SILT BED OR POCKET, DARK GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS
BOTTOM OF AUGER EL. 902.57
BOTTOM OF HOLE EL. 906.57
2. HOLE STABILIZED WITH HOLLOW STEM AUGER TO EL. XXXXXX
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
10-105M
15 JUL 10
G.S. 918.6
0' TO 0.8' (SP) POORLY GRADED SAND WITH GRAVEL, LOOSE, DRY, BROWN
0.8' TO 8' (CL) LEAN CLAY, MEDIUM STIFF, MOIST, SOME ORGANICS, TRACE SAND, TOPSOIL-FILL, DARK BROWN. (TOPSOIL)
8' TO 12' (CH) FAT CLAY, MEDIUM STIFF, MOIST TO WET, LAMINATED, IRON OXIDE STAINING, YELLOWISH BROWN TO GRAY. (SHERACK FORMATION)
12' TO 13.2' (CL) LEAN CLAY, MEDIUM STIFF, WET TO SATURATED, LAMINATED, YELLOWISH BROWN TO GRAY
13.2' TO 20' (CH) FAT CLAY, SOFT, WET, DESSICATED, IRON OXIDE STAINING, YELLOWISH BROWN. (BRENNA FORMATION)
20' TO 36.8' (CH) FAT CLAY, SOFT, WET, FORMS SLICKENSIDES WHEN SHEARED, GRAY. (BRENNA FORMATION)
36.8' TO 38.7' (ML) CLAYEY SILT, MEDIUM STIFF TO STIFF; MOIST, GRAVELLY AT CONTACT, LAMINATED, MEALY TEXTURE, GRAY
38.7' TO 41.2' (SP-SM) POORLY GRADED SAND WITH SILT, MEDIUM DENSE, SATURATED, LAMINATED, LAMINATED IN ZONES, GRAY
41.2' TO 48' (SP) POORLY GRADED SAND, MEDIUM DENSE, SATURATED, GRADATIONAL CONTACT OCCURS AT 41.2 FEET, GRAY
48' TO 48.2' (SM) SILTY SAND, MEDIUM DENSE, SATURATED, LAMINATED, GRAY
48.2' TO 89' (SP) POORLY GRADED SAND, MEDIUM DENSE, SATURATED, CONTAINS OCCASIONAL SILT LAMINATIONS AT APPROXIMATELY 62 FEET, TRACES OF FINE GRAVEL BELOW 75 FEET, GRAY
89' TO 101.5' (SP-SM) POORLY GRADED SAND WITH SILT, MEDIUM STIFF, SATURATED, LAMINATED, GRAY
101.5' TO 107' (SC) CLAYEY SAND WITH GRAVEL, MEDIUM DENSE TO STIFF, WET, INTERBEDDED CLAYEY SAND INTERBEDDED WITH GRAVELLY SANDY CLAY, GRAY
107' TO 125' (CL) GRAVELLY LEAN CLAY WITH SAND, GRAVEL FINE TO COARSE, STIFF, MOIST, GRAY. (UNIT "A" TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 909.11
2. HOLE STABILIZED WITH 4" CASING TO EL. 907.1
3. BORING BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.
US Army Corps of Engineers
ST. PAUL DISTRICT
DATE
DESCRIPTION
DATE
DESCRIPTION
DATE
DESCRIPTION
DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:
SYSTEM:
SOLICITATION NO.:
CONTRACT NO.:
FILE NAME:
(FILE PATH\FILE_NAME.DWG)
PLOT SCALE:
PLOT DATE:
FILE NUMBER:
MED
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO NORTH DAKOTA AND MOORHEAD MINNESOTA
BORING LOGS
10-102M
10-103M
10-104M
10-105M
SHEET IDENTIFICATION
B-230

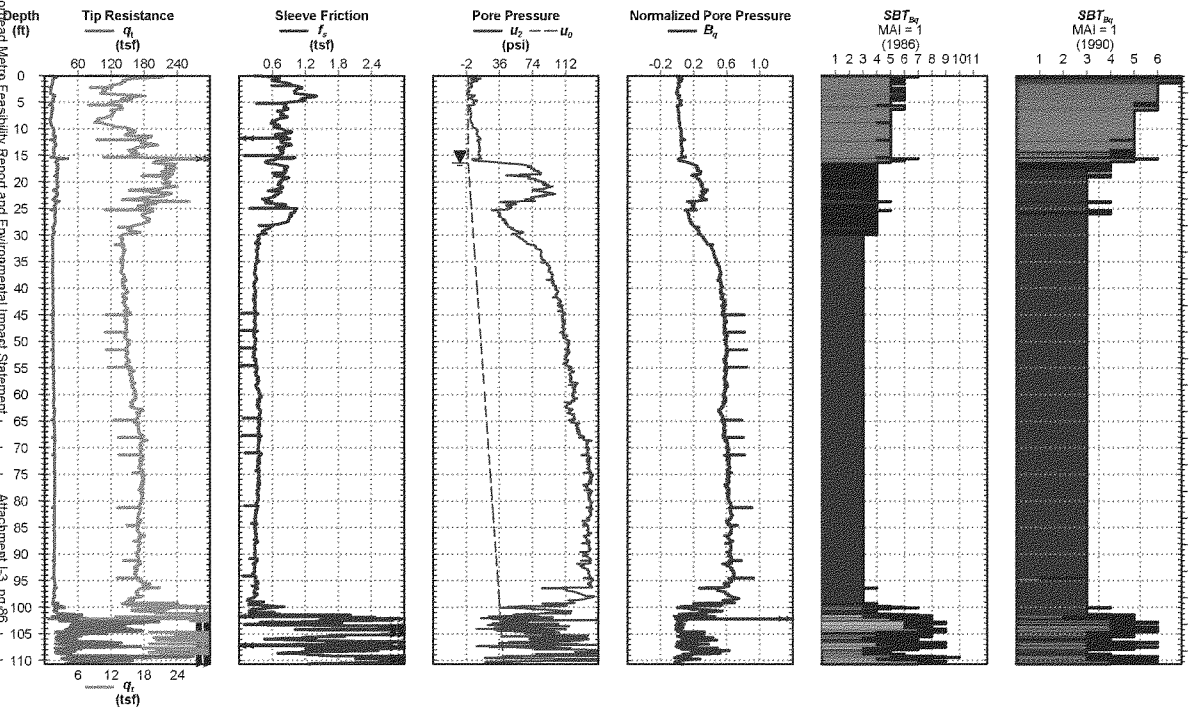
1576

10-106M
SPT
DYD
MC
LL
PL
C.S. 912.5
P.C. 909.0
0' TO 3.2' (CL) LEAN CLAY, MEDIUM STIFF, MOIST, TRACE SAND, SOME ORGANICS, ORANGE RICH, DARK BROWN TO BLACK. (TOPSOIL)
3.2' TO 4.3' (CL) LEAN CLAY, MEDIUM STIFF, MOIST, LIGHT BROWN. (FILL)
4.3' TO 7' (SP) POORLY GRADED SAND WITH GRAVEL, GRAVEL: FINE TO COARSE SAND MEDIUM, MEDIUM DENSE, MOIST, BROWN. (FILL)
7' TO 11.3' (CH) FAT CLAY, MEDIUM STIFF, MOIST, LAMINATED, IRON OXIDE STAINING, YELLOWISH BROWN TO GRAY. (SHERAK FORMATION)
11.3' TO 13.6' (ML) SILT, SOFT, SATURATED, LAMINATED, ORANGE TO BROWN
13.6' TO 18' (CH) FAT CLAY, SOFT, WET, PRE-EXISTING SLICKENSIDE AT 16.2', YELLOW TO BROWN. (BRENNA FORMATION)
18' TO 53' (CH) FAT CLAY, VERY SOFT, WET, FORMS SLICKENSIDES WHEN SHEARED, GRAY. (BRENNA FORMATION)
53' TO 63.9' (CH) FAT CLAY, VERY SOFT, WET, TRACE SAND, SOME TILL INCLUSIONS, GRAY. (ARGUSVILLE FORMATION)
63.9' TO 64.9' (CH) FAT CLAY, VERY SOFT, WET, LAMINATED, GRAY. (UNIT "A" TILL)
64.9' TO 70' (ML) SILT, SAND FINE, MEDIUM DENSE, SATURATED, LAMINATED, GRAY
70' TO 75.1' (SP-SM) POORLY GRADED SAND WITH SILT, SAND MEDIUM, MEDIUM DENSE, SATURATED, GRAY
75.1' TO 76.9' (ML) SILT WITH SAND, SAND FINE, LOOSE TO SOFT, SATURATED, LAMINATED, GRAY
76.9' TO 80.3' (CL) LEAN CLAY, VERY SOFT, WET, LAMINATED, GRAY
80.3' TO 91.7' (SP-SM) POORLY GRADED SAND WITH SILT, SAND MEDIUM, MEDIUM DENSE, SATURATED, LAMINATED, GRAY
91.7' TO 95.1' (SP-SM) POORLY GRADED SAND WITH SILT, MEDIUM DENSE TO STIFF, SATURATED TO WET, INTERBEDDED, SAND INTERBEDDED WITH SANDY SILT, GRAY
95.1' TO 96.7' (ML) SILT, MEDIUM STIFF, WET, LAMINATED, GRAY
96.7' TO 97.6' (CL) SANDY LEAN CLAY WITH GRAVEL, SOFT, WET, GRAY
97.6' TO 99.6' (SP-SC) POORLY GRADED SAND WITH CLAY AND GRAVEL, MEDIUM DENSE, SATURATED, BROWN
99.6' TO 113' (CL) SANDY LEAN CLAY WITH GRAVEL, GRAVEL: FINE TO COARSE, DENSE TO HARD, MOIST, GRAY. (TILL)
NOTES:
1. WATER LEVEL DETERMINED AFTER 24 HOURS IN OPEN HOLE BOTTOM OF HOLE EL. 908.29
2. HOLE STABILIZED WITH 4" CASING TO EL. 905.8
3. INSTALL VIBRATING WIRE PIEZOMETER CLUSTER IN COMPLETED BOREHOLE.
US Army Corps of Engineers
ST. PAUL DISTRICT
DATE
DESCRIPTION
DESIGNED BY:
DRAWN BY:
SUBMITTED BY:
DATE SUBMITTED:
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO, NORTH DAKOTA AND MOORHEAD, MINNESOTA
BORING LOGS
MOORHEAD
SHEET IDENTIFICATION
B-231

Fargo Moorehead

Cone Penetration Test 09-ED-11C

Date:	Jun. 19, 2009	**Northing:**	1985347.371	**Elevation:**	888.2
Operator:	MARKOV	**Easting:**	1076468.962	**Water Depth:**	16.4
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DSG1071 / 0.8	**Total Depth:**	110.7 ft



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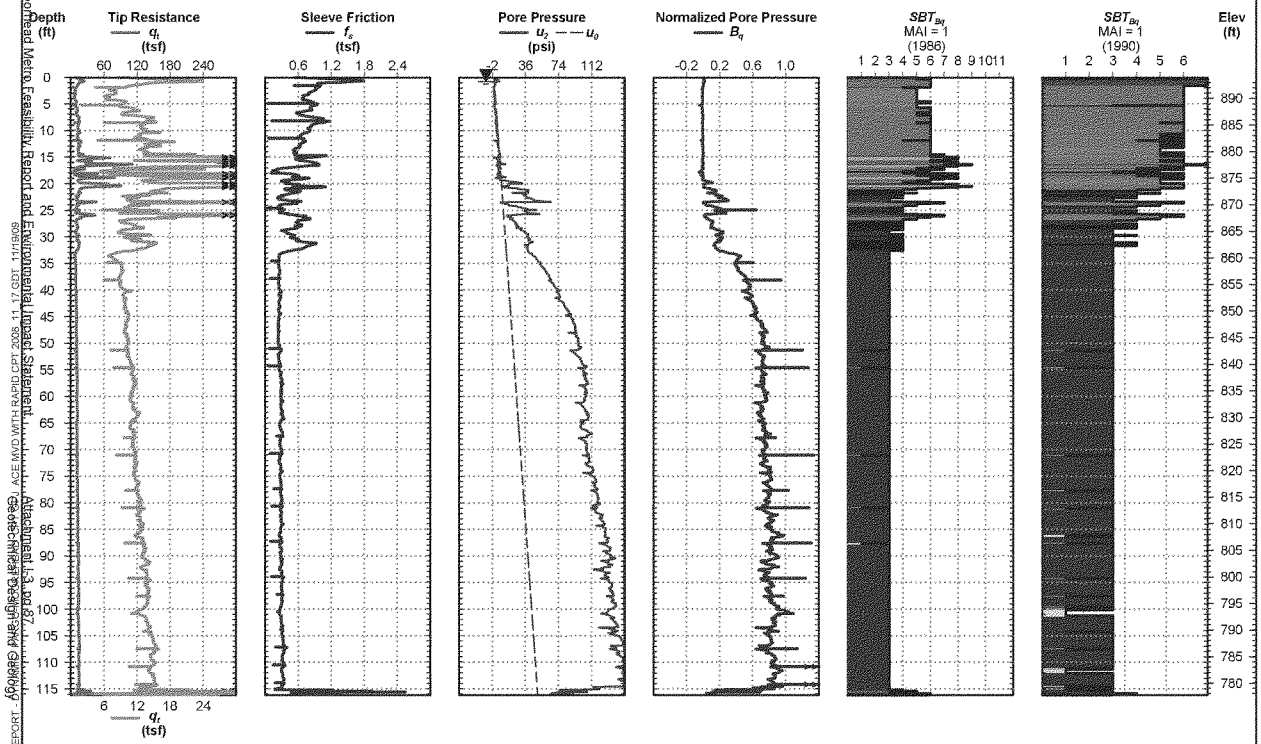
Electronic Filename: ED-01CPT.cpt

Fargo Moorehead

Cone Penetration Test 09-ED-12C

Date:	Jun. 20, 2009	**Northing:**	2005250.814	**Elevation:**	894.0
Operator:	MARKOV	**Easting:**	1064018.93	**Water Depth:**	0.82
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	116.1 ft



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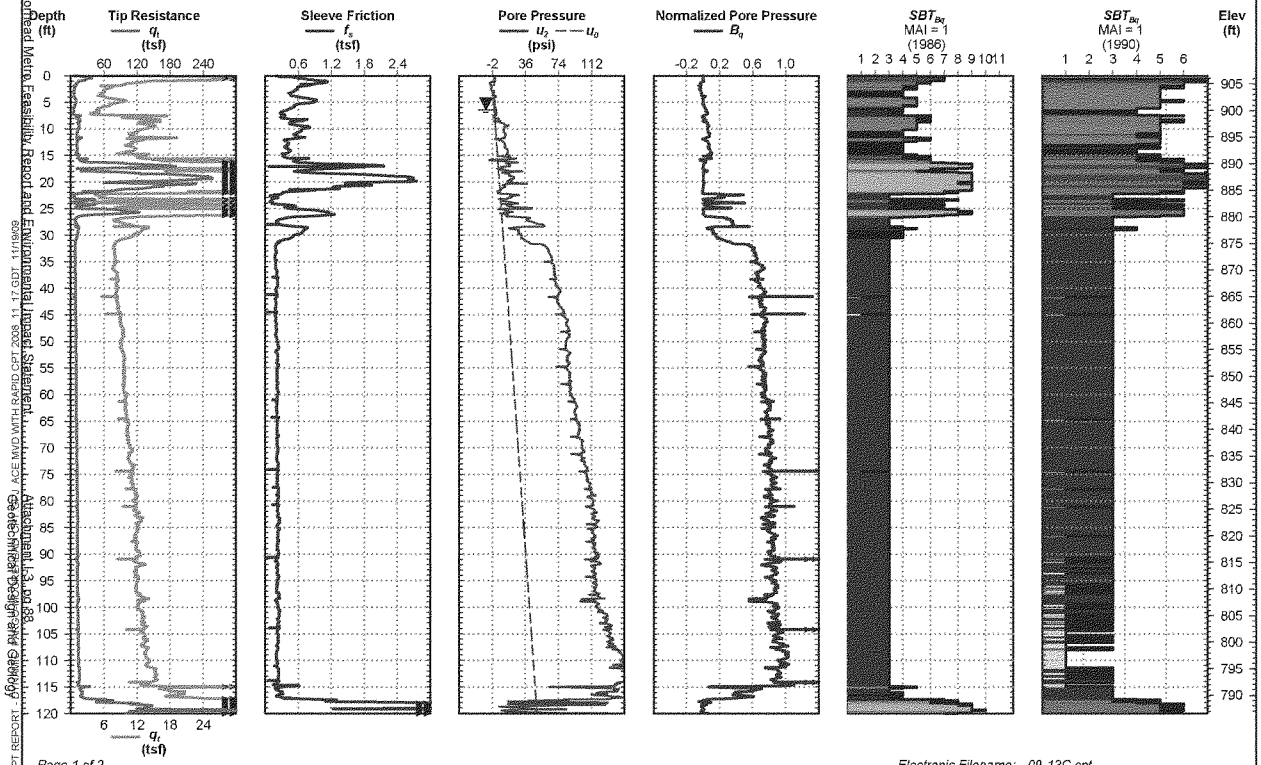
Electronic Filename: 09-12C.cpt

Fargo Moorehead

Cone Penetration Test 09-ED-13C

Date:	Jun. 20, 2009	**Northing:**	2014432.074	**Elevation:**	906.6
Operator:	MARKOV	**Easting:**	1053468.79	**Water Depth:**	6.43
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	120.3 ft



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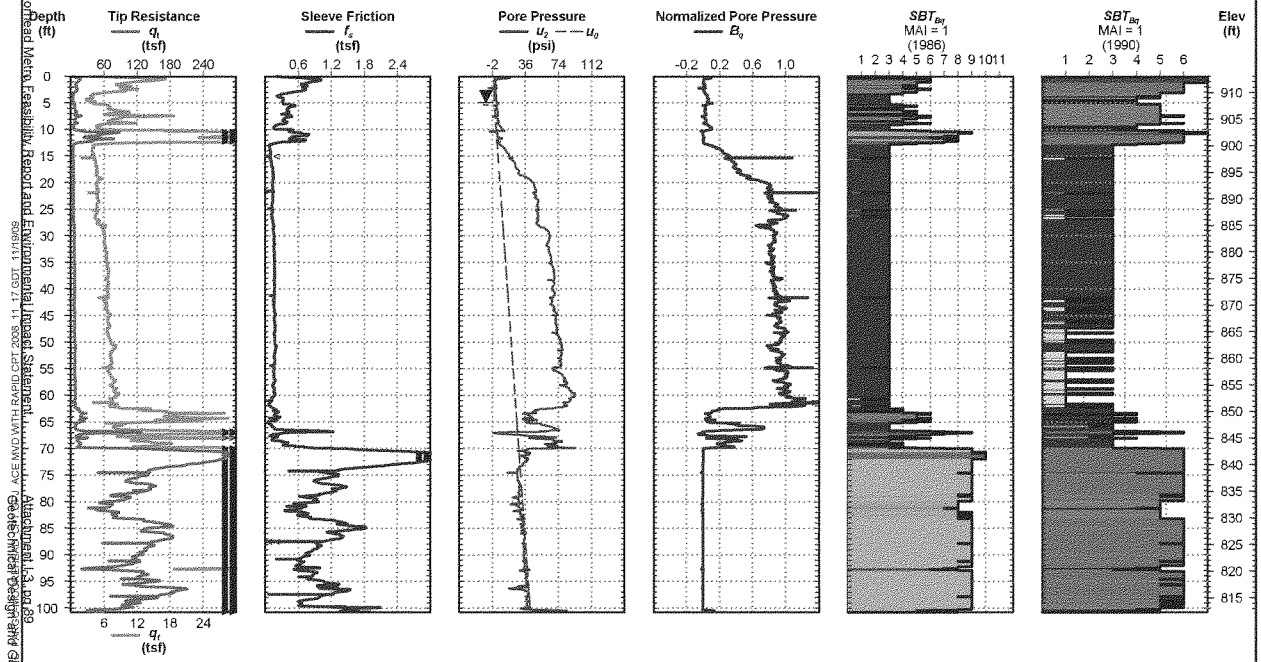
Electronic Filename: 09-13C.cpt

Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Attachment I-3, pg 88
Geotechnical Design and Geology
CPT REPORT - ... ACE MVD WITH RAPID CPT 2008 11 17 GDT 11/19/09

Fargo Moorehead

Cone Penetration Test 09-ED-14C

Date:	Jun. 21, 2009	**Northing:**	2019148.353	**Elevation:**	913.1
Operator:	MARKOV	**Easting:**	1032092.853	**Water Depth:**	4.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	100.8 ft



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Electronic Filename: 09-14C.cpt

CPT REPORT - J:\ACE MVD WITH RAPID CPT 2008 11 17.GDT 11/19/09
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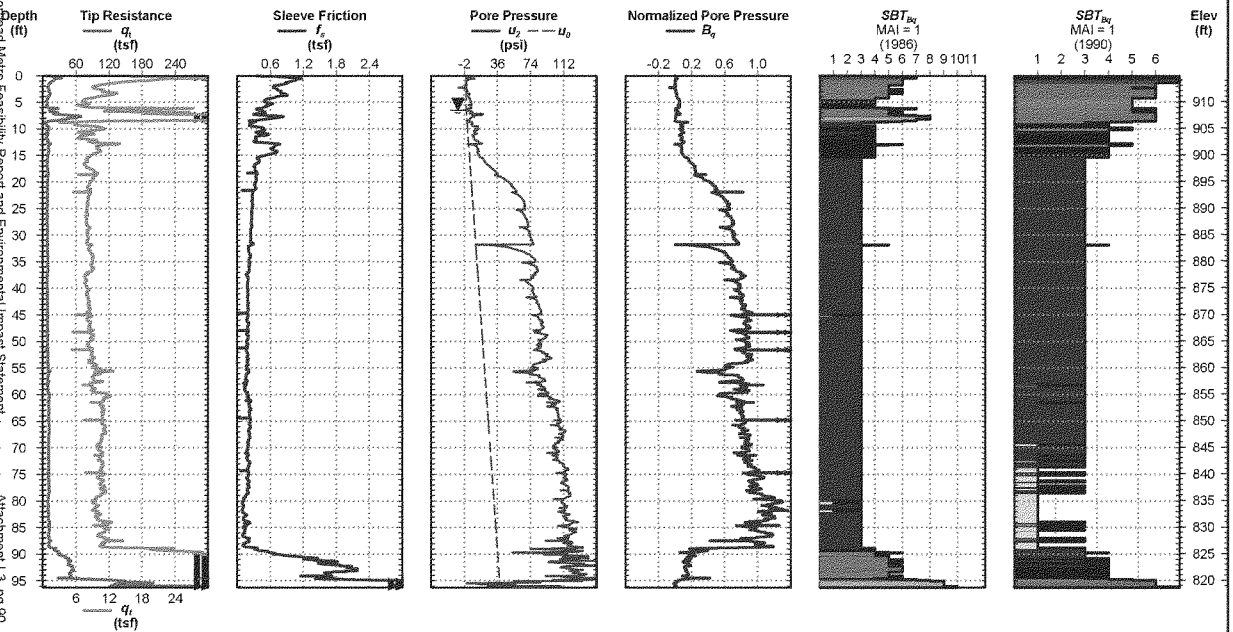
July 2011

Fargo Moorehead

Cone Penetration Test 09-ED-15C

Date:	Jun. 21, 2009	**Northing:**	2018445.437	**Elevation:**	914.9
Operator:	MARKOV	**Easting:**	1005853.612	**Water Depth:**	6.5
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	96.3 ft



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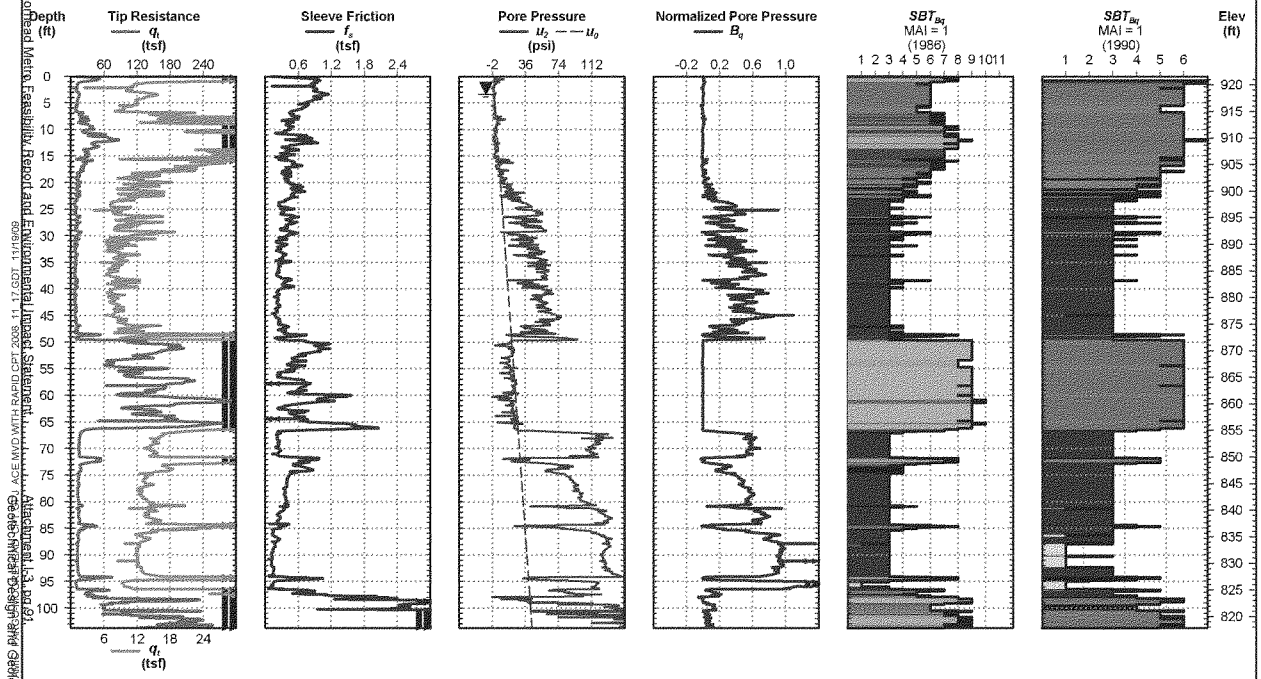
Electronic Filename: 09-15C.cpt

Fargo Moorehead

Cone Penetration Test 09-ED-16C

Date:	Jun. 22, 2009	**Northing:**	2012118.968	**Elevation:**	921.6
Operator:	MARKOV	**Easting:**	979624.728	**Water Depth:**	3.38
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	103.7 ft



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Electronic Filename: 09-16C.cpt

CPT REPORT - Geotechnical Design Part Cover.doc
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
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Geotechnical Design Part Cover.doc
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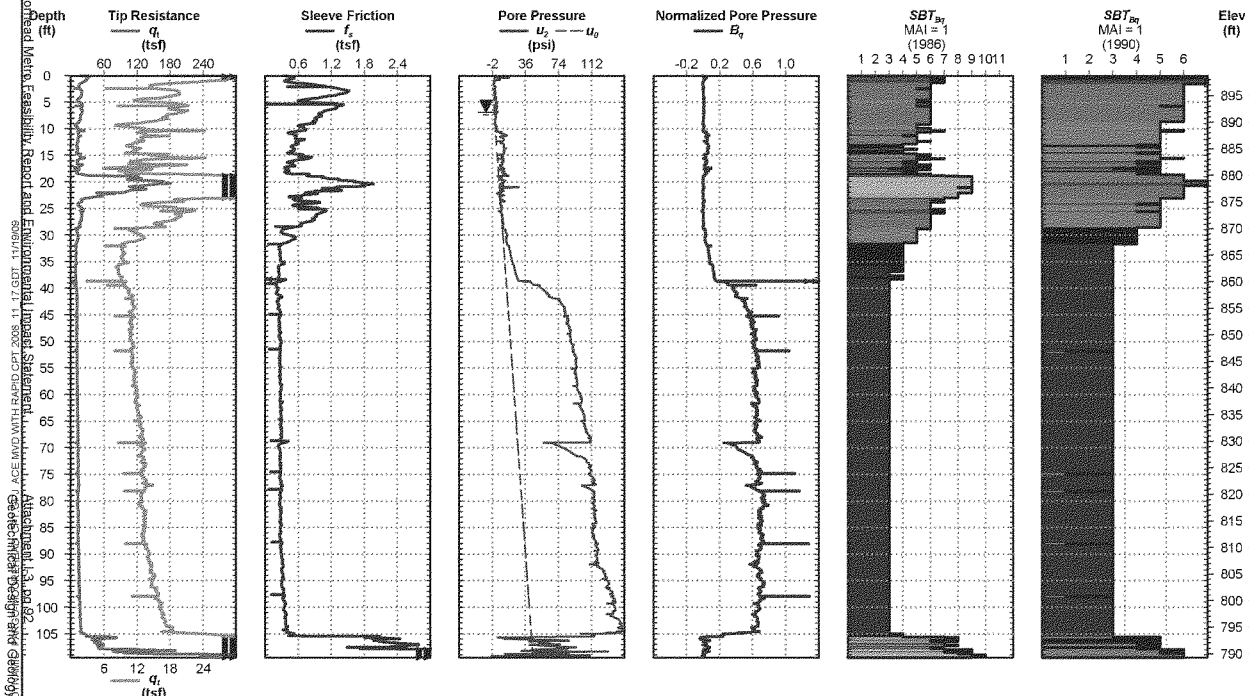
Fargo Moorehead

Cone Penetration Test 09-M-25C

Date:	Jul. 17, 2009	**Northing:**	1994771.615	**Elevation:**	898.7
Operator:	MARKOV	**Easting:**	1031886.969	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	109.5 ft



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Electronic Filename: 09-25C-MOORHEAD.cpt

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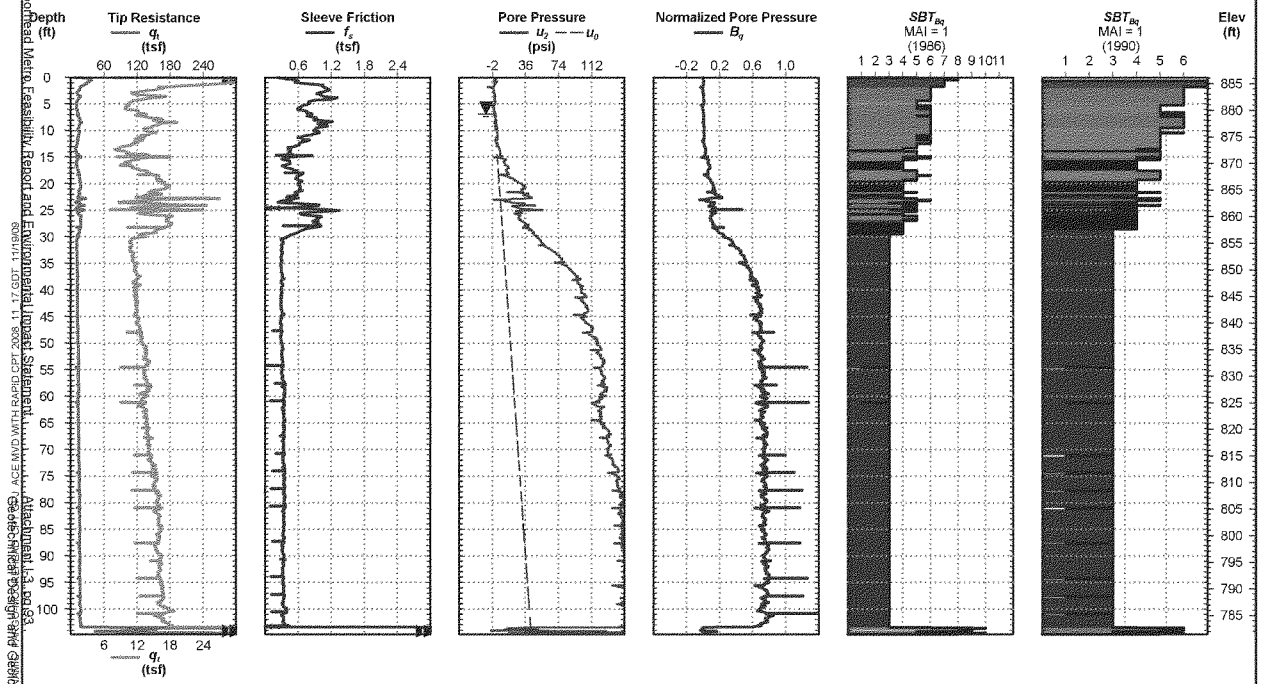
July 2011 Geotechnical Design and Geology

Fargo Moorehead

Cone Penetration Test 09-ED-27C

Date:	Jul. 7, 2009	**Northing:**	1989818.41	**Elevation:**	886.2
Operator:	MARKOV	**Easting:**	1075116.923	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	104.7 ft



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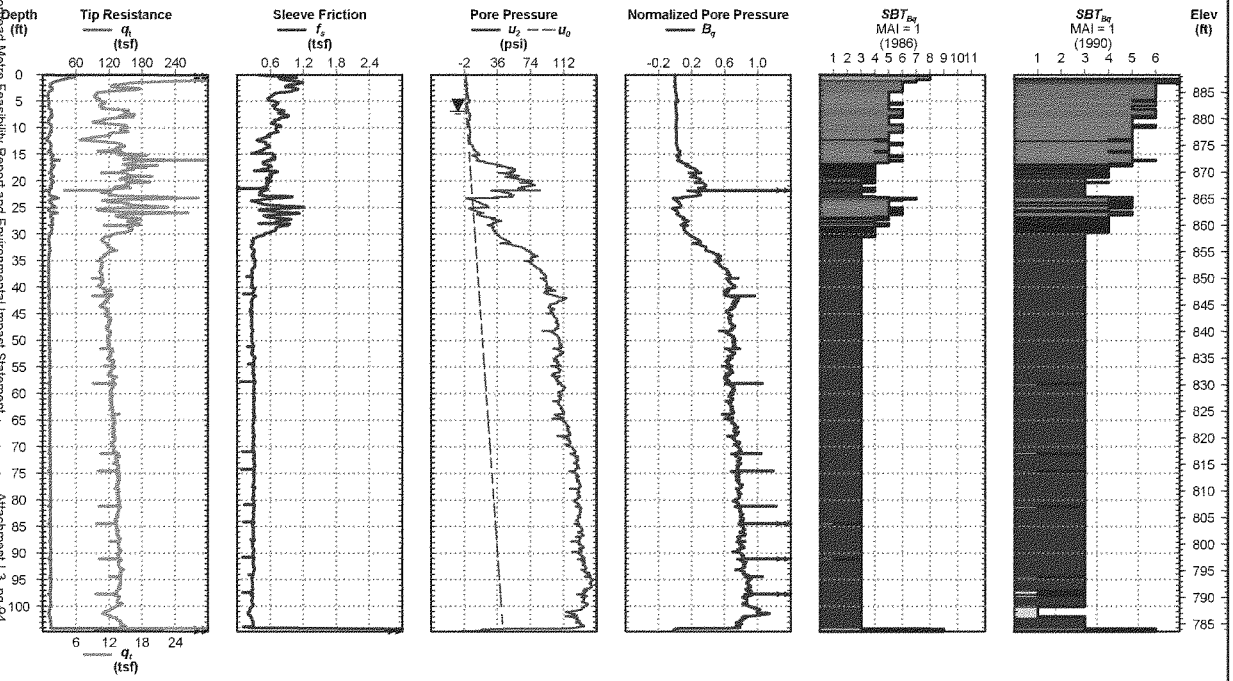
Electronic Filename: 09-27C.cpt

Fargo Moorehead

Cone Penetration Test 09-ED-28C

Date:	Jul. 7, 2009	**Northing:**	1989657.367	**Elevation:**	888.4
Operator:	MARKOV	**Easting:**	1069764.57	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	104.7 ft



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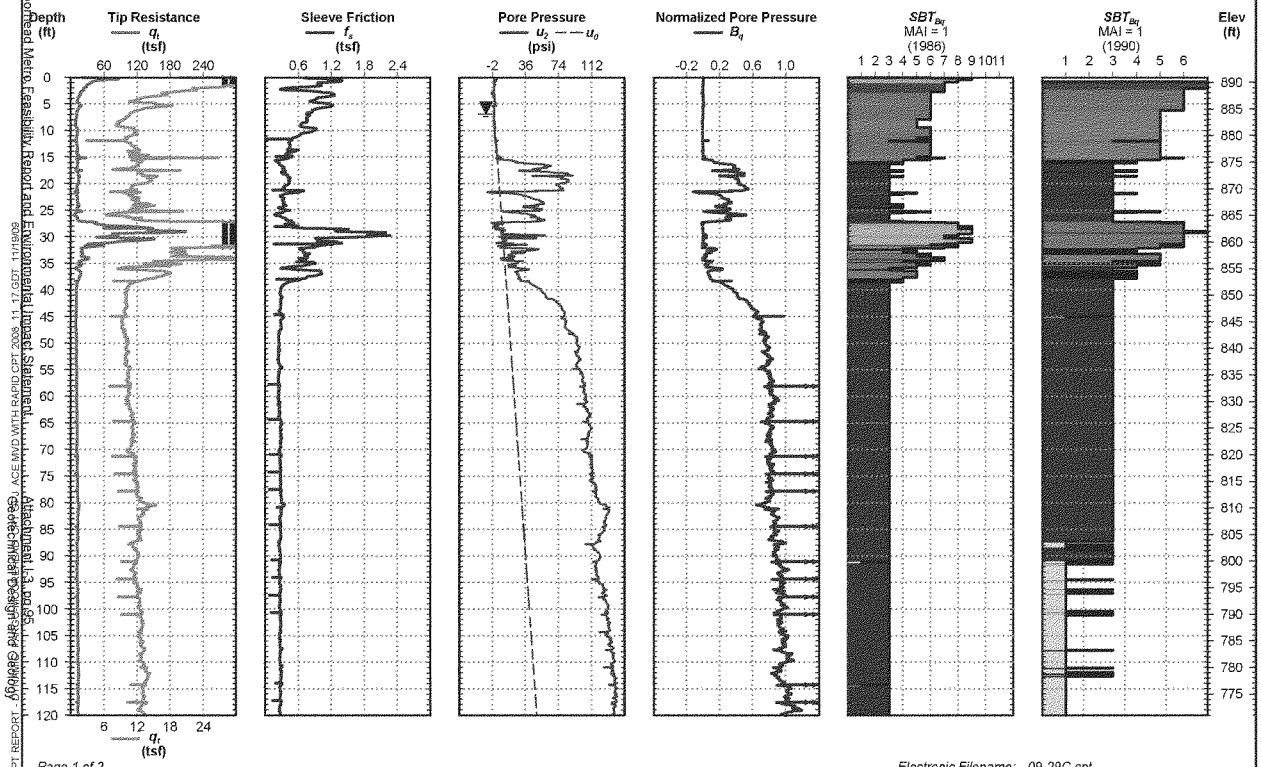
Electronic Filename: 09-28C.cpt

Fargo Moorehead

Cone Penetration Test 09-ED-29C

Date:	Jul. 7, 2009	**Northing:**	2000144.994	**Elevation:**	891.0
Operator:	MARKOV	**Easting:**	1069476.461	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	123.8 ft



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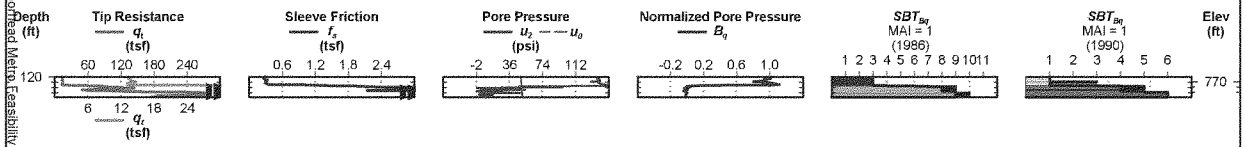
Electronic Filename: 09-29C.cpt

Fargo Moorehead

Cone Penetration Test 09-ED-29C

Date:	Jul. 7, 2009	**Northing:**	2000144.994	**Elevation:**	891.0
Operator:	MARKOV	**Easting:**	1069476.461	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	123.8 ft

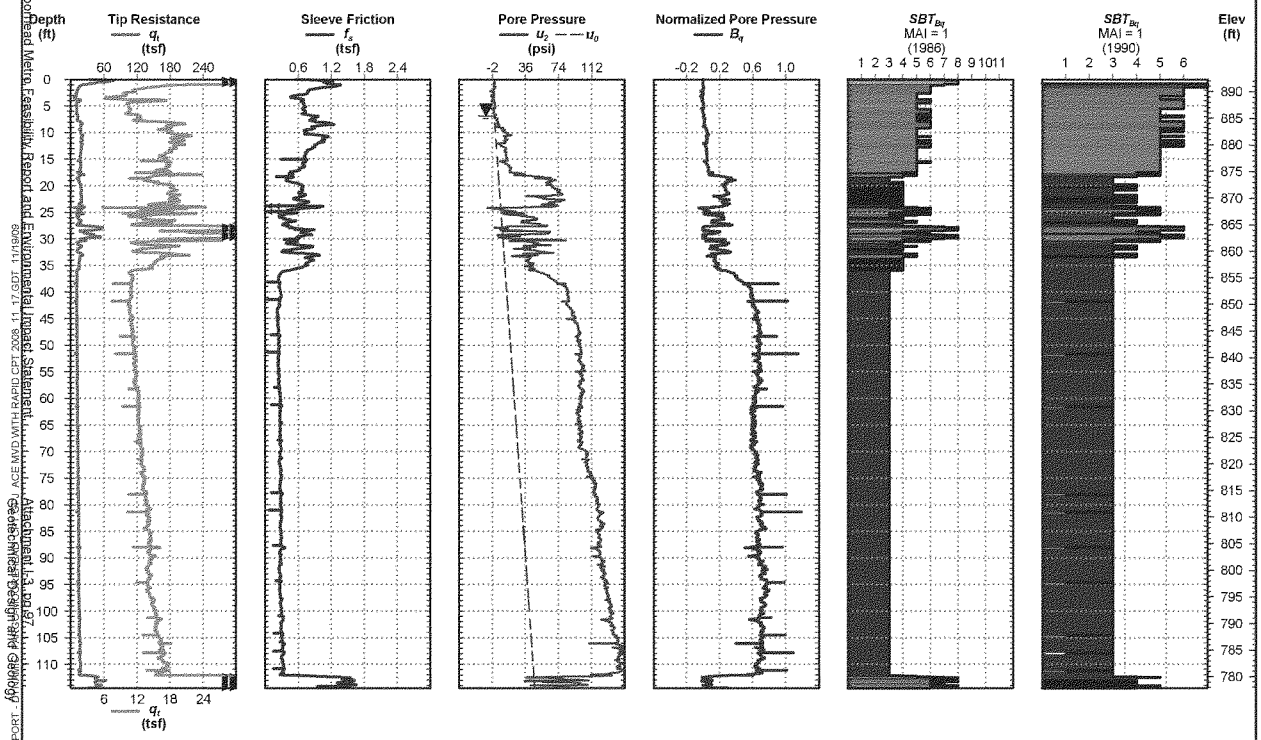


Electronic Filename: 09-29C.cpt

Fargo Moorehead

Cone Penetration Test 09-ED-30C

Date:	Jul. 8, 2009	**Northing:**	1994853.052	**Elevation:**	892.4
Operator:	MARKOV	**Easting:**	1064369.425	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	114.5 ft



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CPT REPORT - 09-ED-30C.cpt Geotechnical Design and Geology
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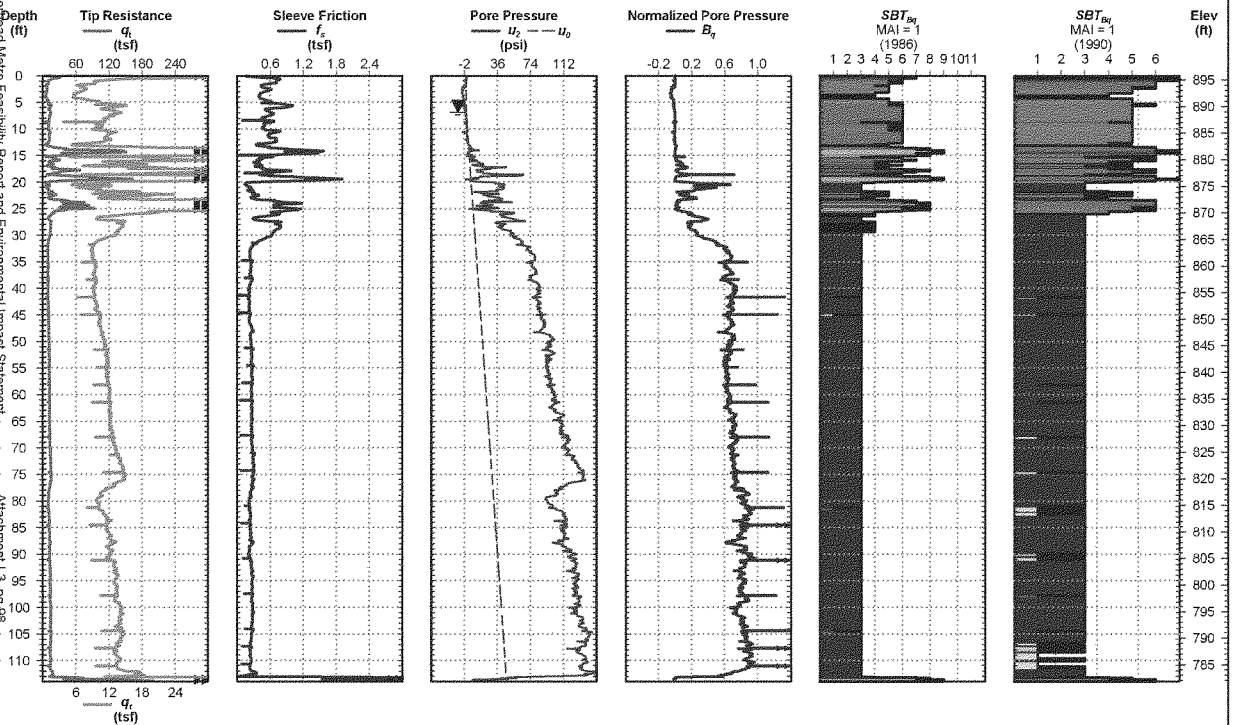
Fargo Moorehead

Cone Penetration Test 09-ED-31C

Date: Jul. 8, 2009
Operator: MARKOV
Drilling Agency: USACE, Savannah District

Northing: 2005180.111
Easting: 1058817.526
Probe ID/Net Area Ratio: DDG1117 / 0.8

Elevation: 895.8
Water Depth: 6.89
Total Depth: 113.9 ft



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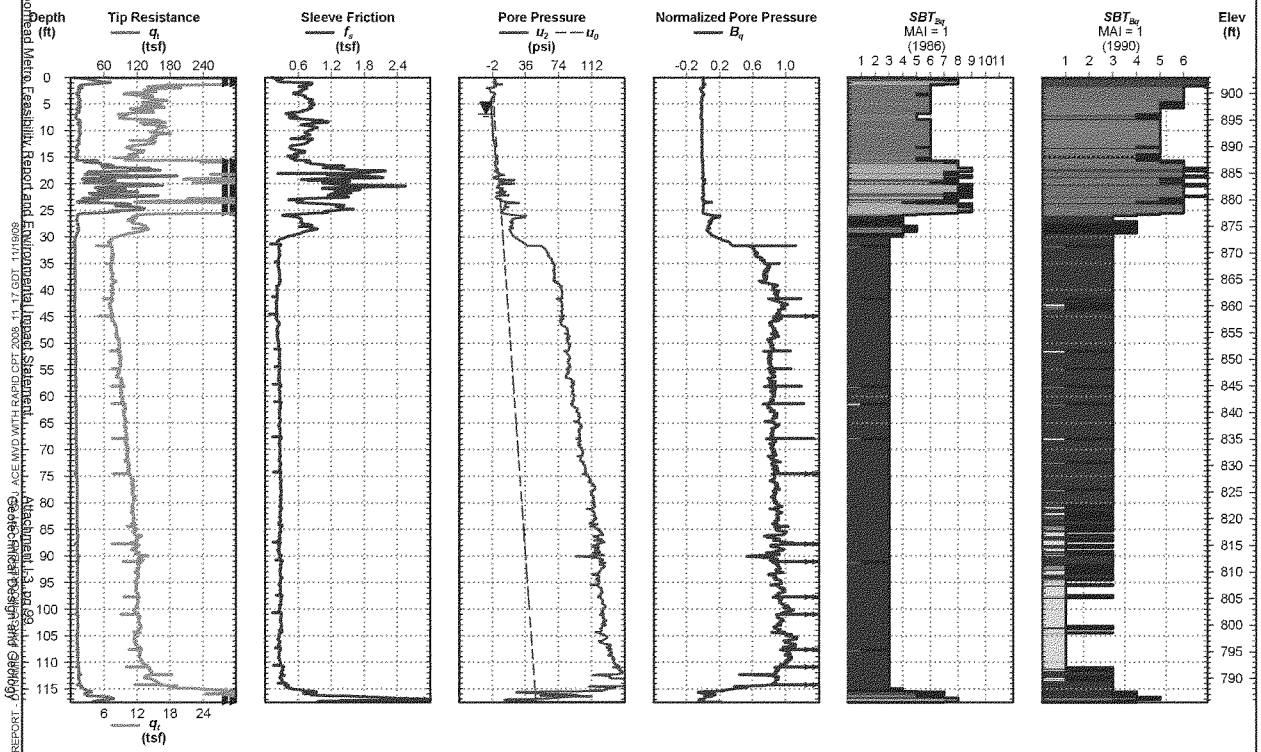
Fargo Moorehead

Cone Penetration Test 09-ED-32C

Date:	Jul. 8, 2009	Northing:	2012978.784	Elevation:	903.0
Operator:	MARKOV	Easting:	1058472.773	Water Depth:	6.89
Drilling Agency:	USACE, Savannah District	Probe ID/Net Area Ratio:	DDG1117 / 0.8	Total Depth:	117.5 ft



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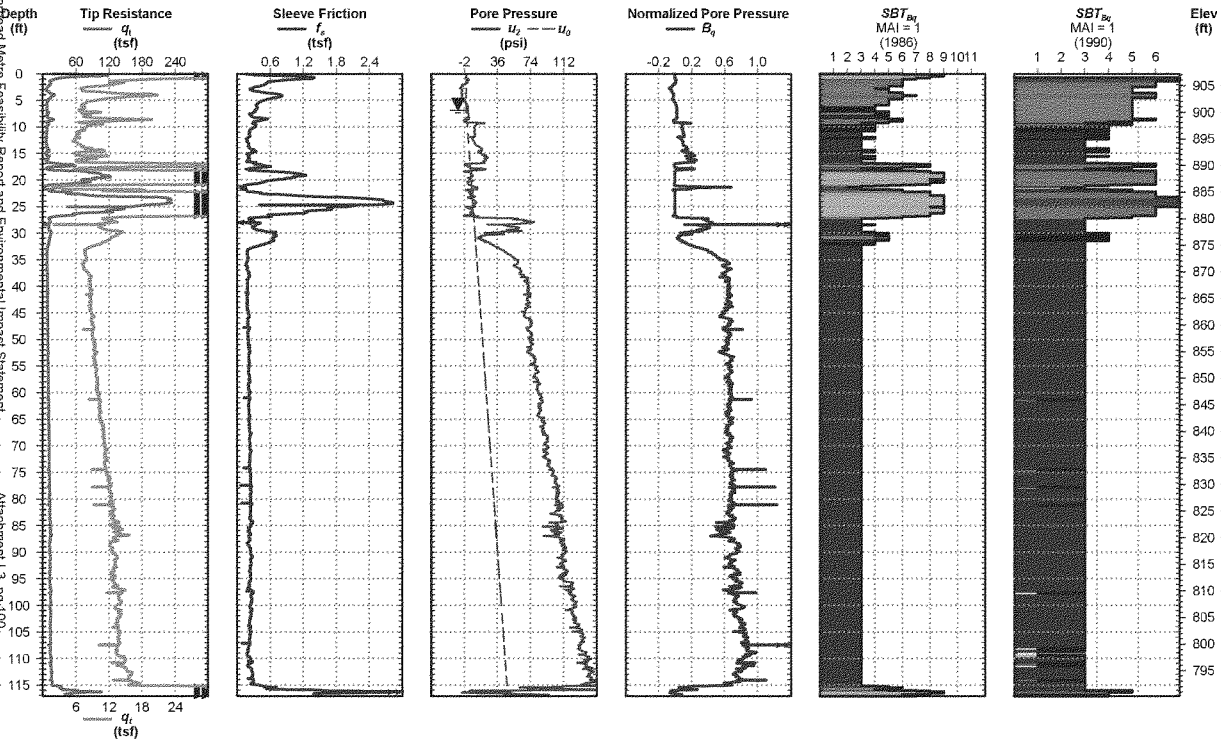
Fargo Moorehead

Cone Penetration Test 09-ED-33C

Date:	Jul. 9, 2009	**Northing:**	2014279.359	**Elevation:**	907.3
Operator:	MARKOV	**Easting:**	1048182.44	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	117.1 ft



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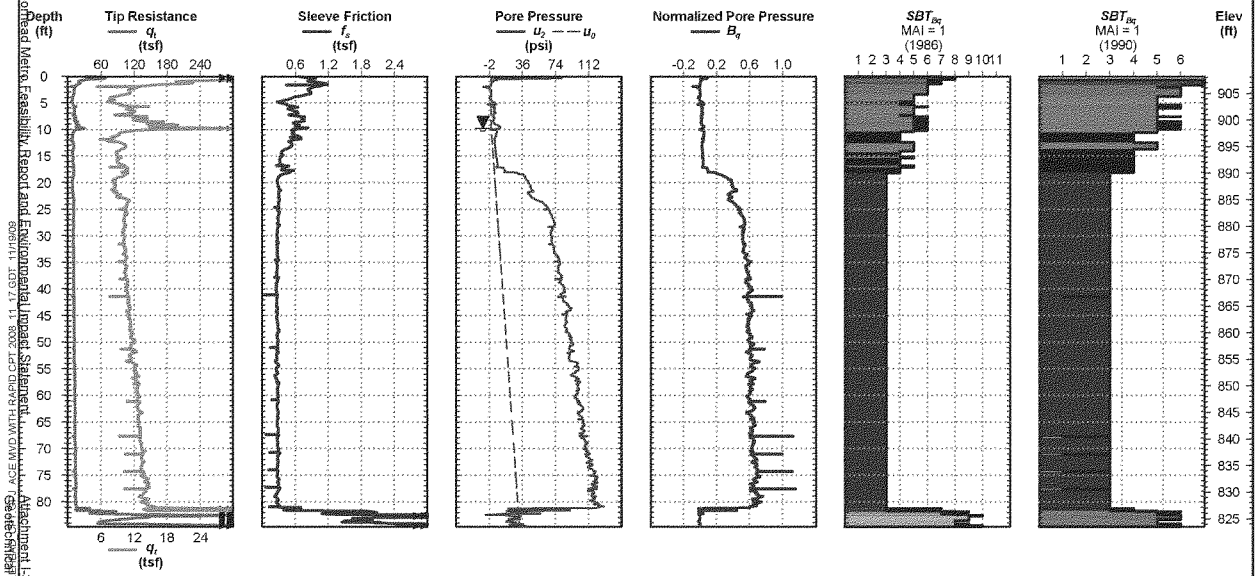
Fargo Moorehead

Cone Penetration Test 09-M-34C

Date:	Jul. 14, 2009	**Northing:**	1988877.165	**Elevation:**	908.2
Operator:	MARKOV	**Easting:**	991064.019	**Water Depth:**	9.78
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	84.7 ft



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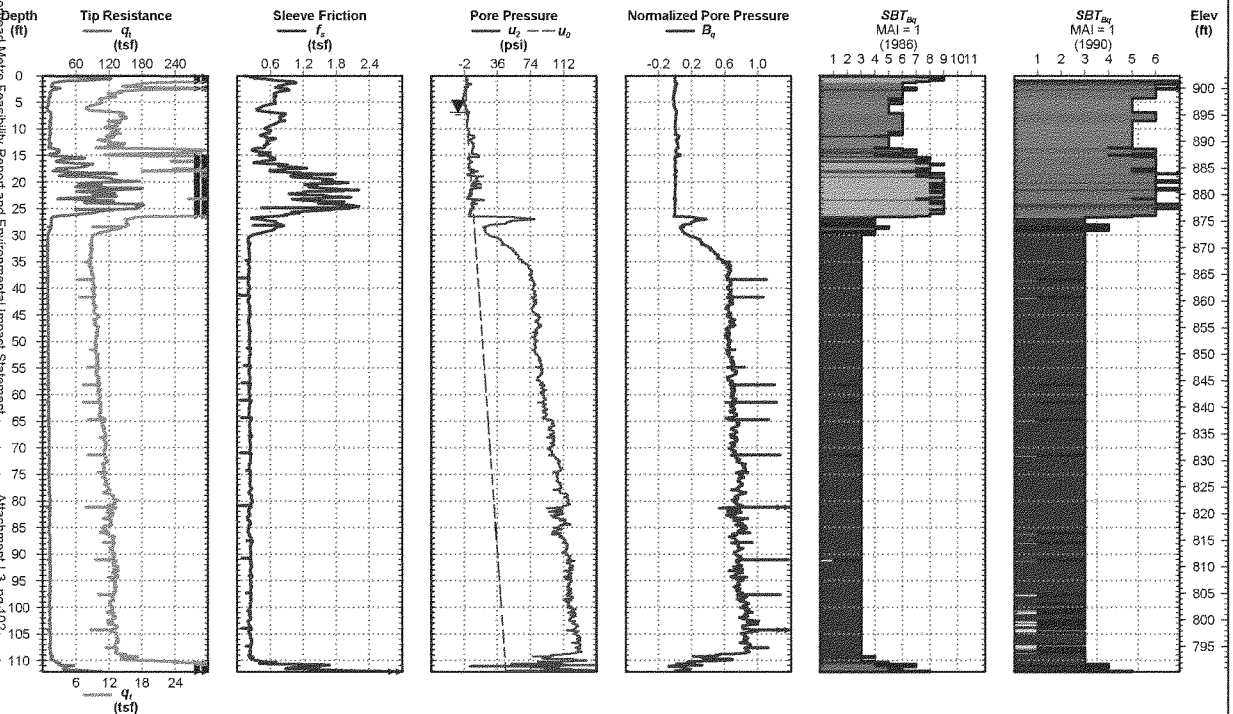
Fargo Moorehead

Cone Penetration Test 09-ED-35C

Date:	Jul. 9, 2009	**Northing:**	2009195.271	**Elevation:**	902.4
Operator:	MARKOV	**Easting:**	1053533.505	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	112.1 ft



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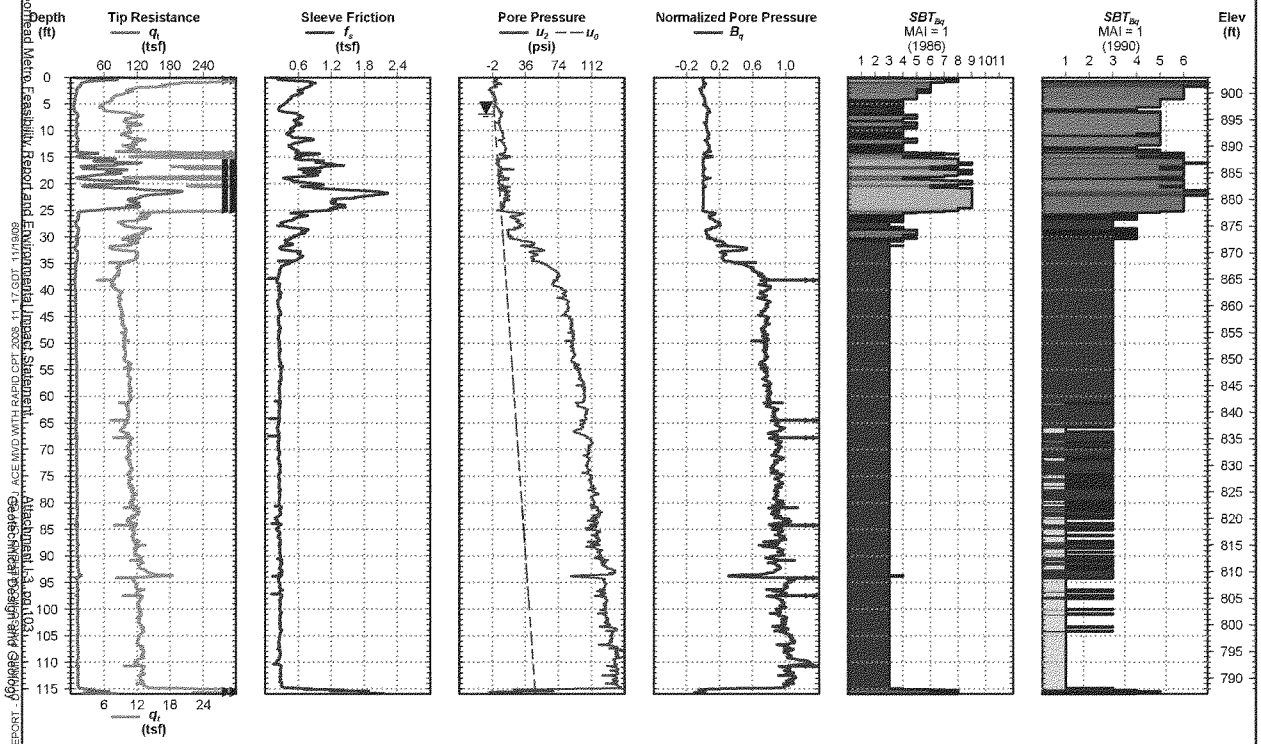
Fargo Moorehead

Cone Penetration Test 09-ED-36C

Date:	Jul. 9, 2009	Northing:	2009001.112	Elevation:	903.0
Operator:	MARKOV	Easting:	1043053.704	Water Depth:	6.89
Drilling Agency:	USACE, Savannah District	Probe ID/Net Area Ratio:	DDG1117 / 0.8	Total Depth:	115.9 ft



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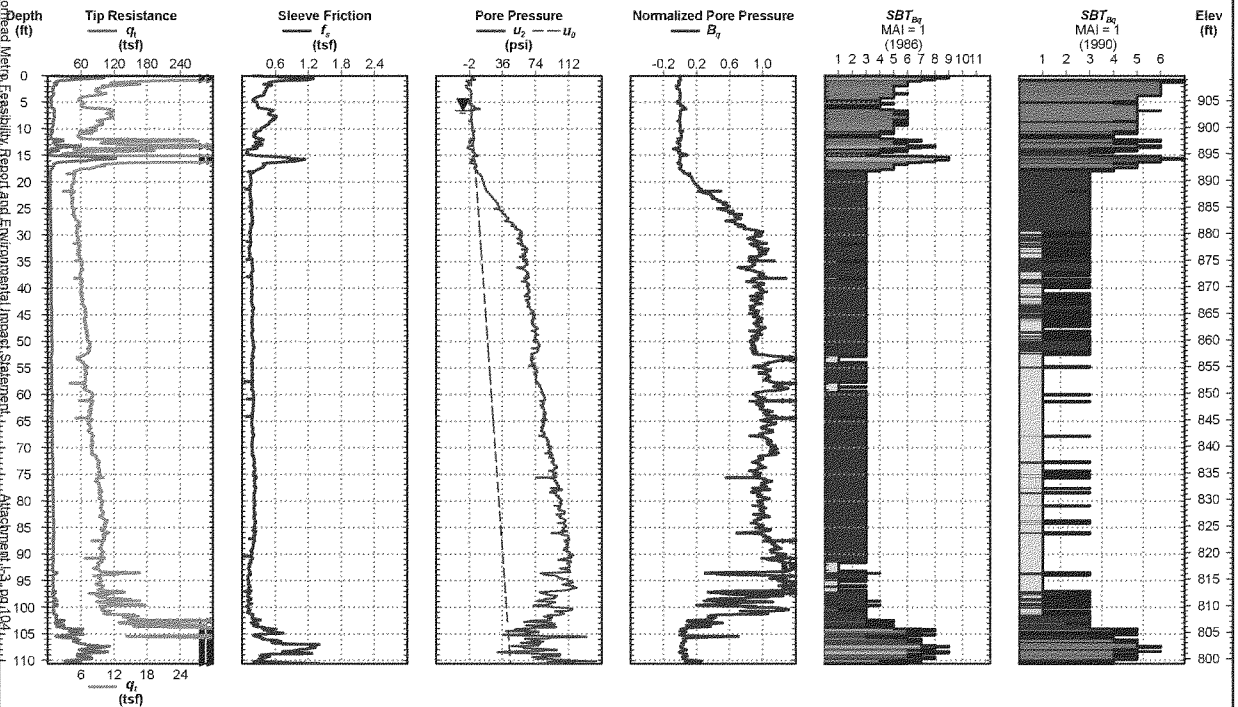
Fargo Moorehead

Cone Penetration Test 09-ED-37C

Date:	Jul. 9, 2009	**Northing:**	2019462.535	**Elevation:**	909.7
Operator:	MARKOV	**Easting:**	1042722.879	**Water Depth:**	6.56
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	110.6 ft



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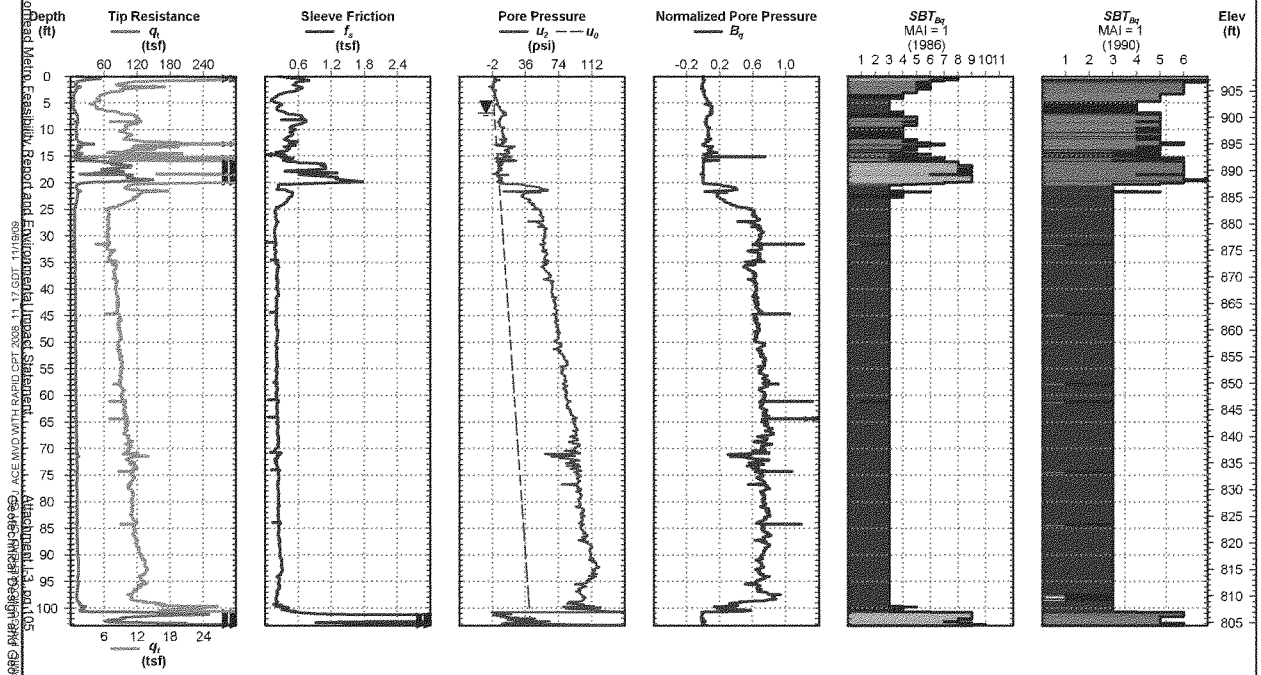
Fargo Moorehead

Cone Penetration Test 09-ED-38C

Date:	Jul. 10, 2009	**Northing:**	2014018.872	**Elevation:**	907.8
Operator:	MARKOV	**Easting:**	1037544.621	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	103.3 ft



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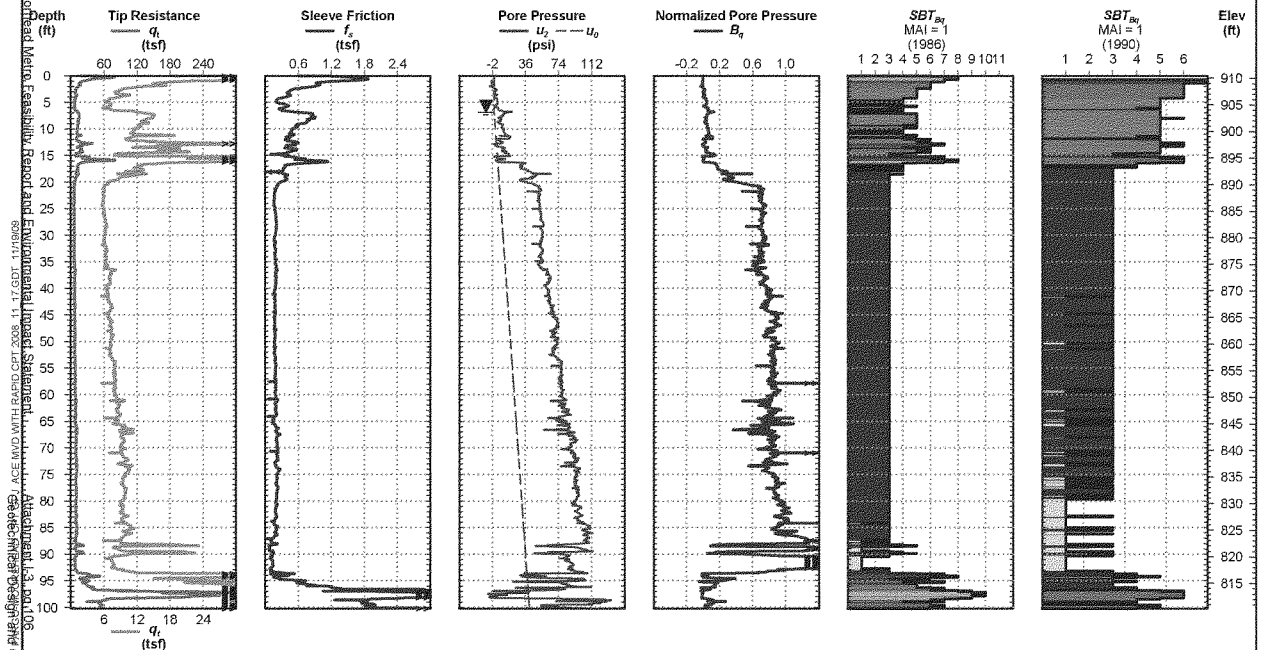
Fargo Moorehead

Cone Penetration Test 09-ED-39C

Date:	Jul. 10, 2009	**Northing:**	2013801.596	**Elevation:**	910.5
Operator:	MARKOV	**Easting:**	1027067.886	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	100.2 ft



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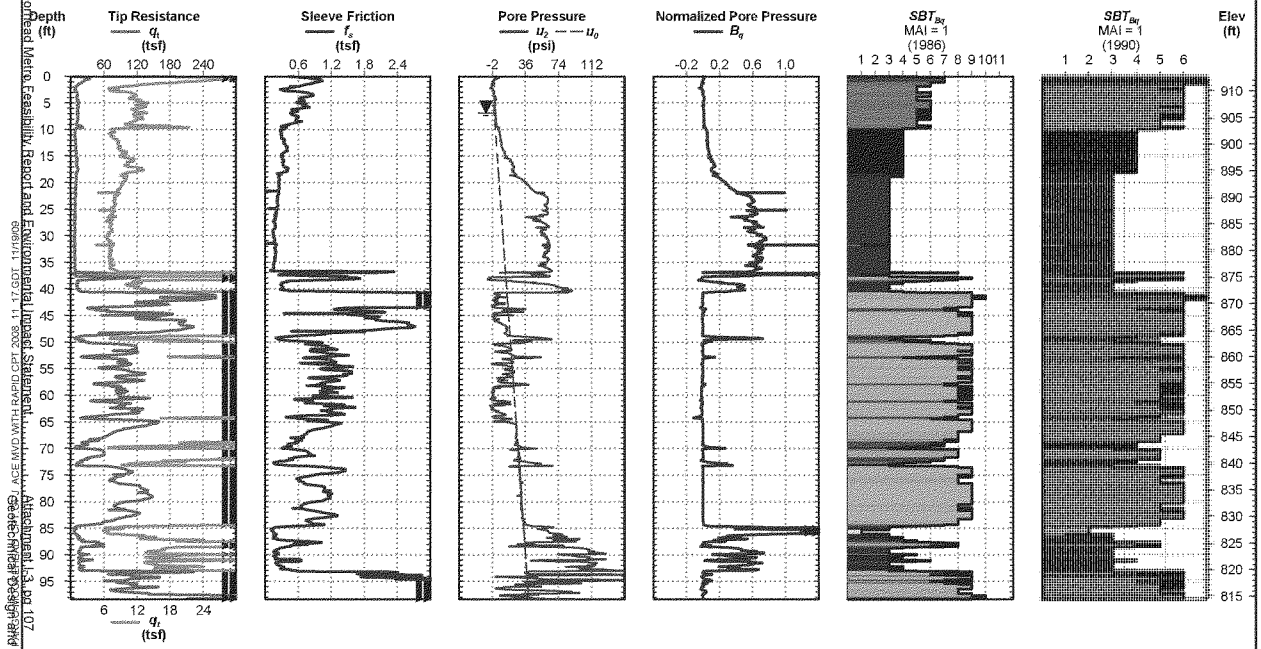
Fargo Moorehead

Cone Penetration Test 09-ED-40C

Date:	Jul. 10, 2009	**Northing:**	2018885.603	**Elevation:**	912.8
Operator:	MARKOV	**Easting:**	1021759.164	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	98.3 ft



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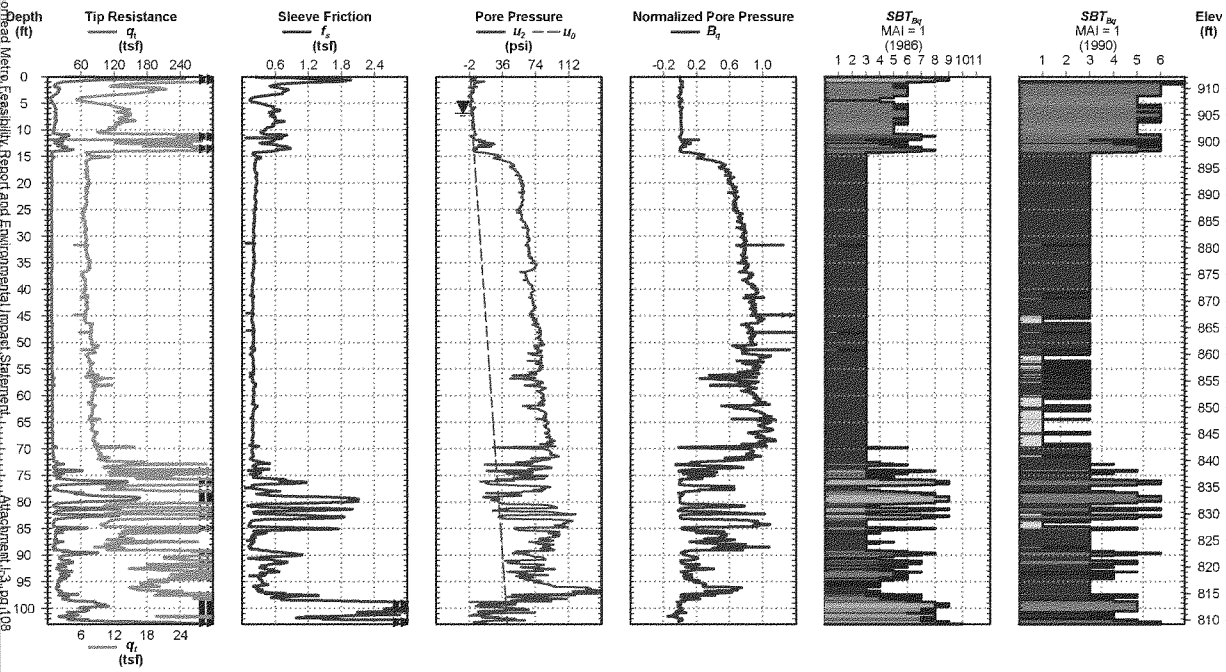
Fargo Moorehead

Cone Penetration Test 09-ED-42C

Date:	Jul. 10, 2009	**Northing:**	2013492.377	**Elevation:**	912.2
Operator:	MARKOV	**Easting:**	1016554.705	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	103.0 ft



Electronic Filename: 09-42C.cpt

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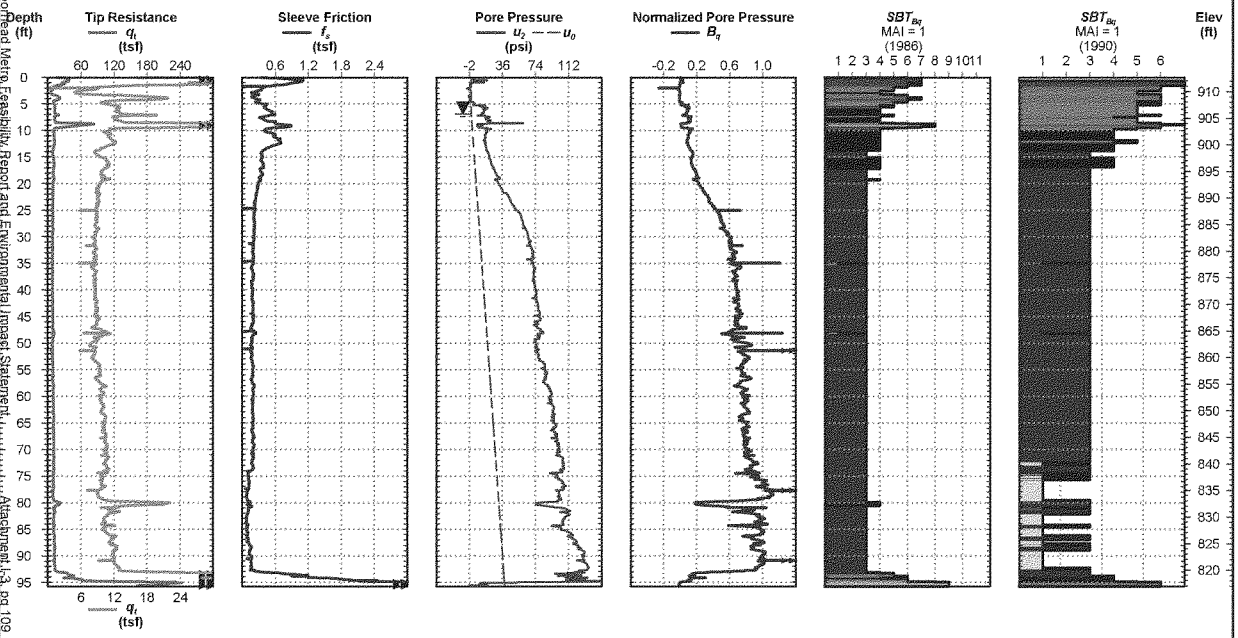
Fargo Moorehead

Cone Penetration Test 09-ED-43C

Date:	Jul. 11, 2009	Northing:	2018504.623	Elevation:	912.7
Operator:	MARKOV	Easting:	1011147.339	Water Depth:	6.89
Drilling Agency:	USACE, Savannah District	Probe ID/Net Area Ratio:	DDG1117 / 0.8	Total Depth:	95.7 ft



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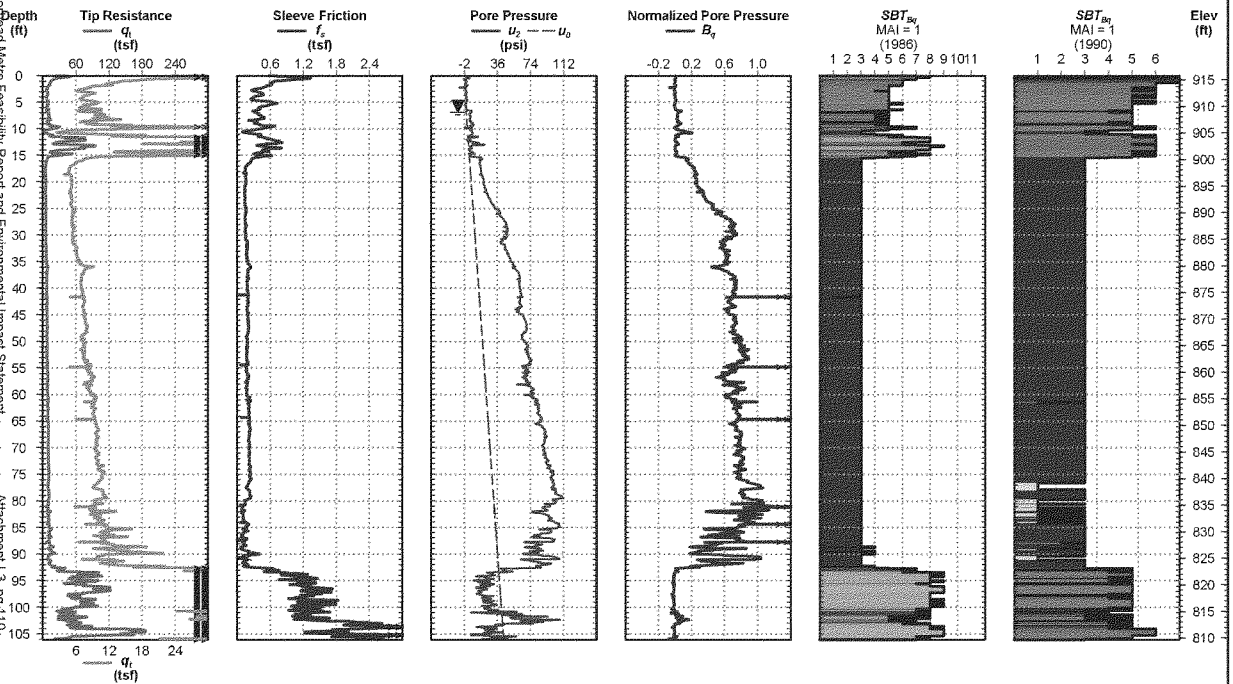
Fargo Moorehead

Cone Penetration Test 09-ED-44C

Date:	Jul. 11, 2009	**Northing:**	2010317.301	**Elevation:**	915.8
Operator:	MARKOV	**Easting:**	1000822.056	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	106.1 ft



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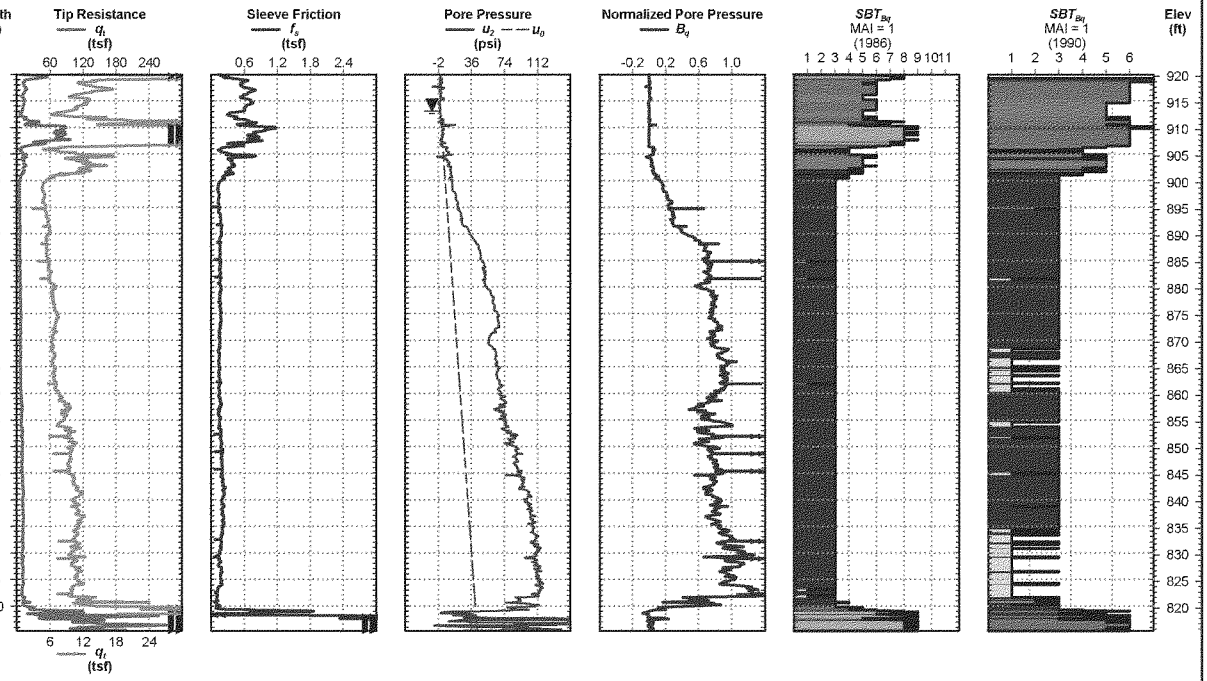
Fargo Moorehead

Cone Penetration Test 09-ED-45C

Date:	Jul. 11, 2009	**Northing:**	2015546.235	**Elevation:**	920.4
Operator:	MARKOV	**Easting:**	995390.533	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	104.7 ft



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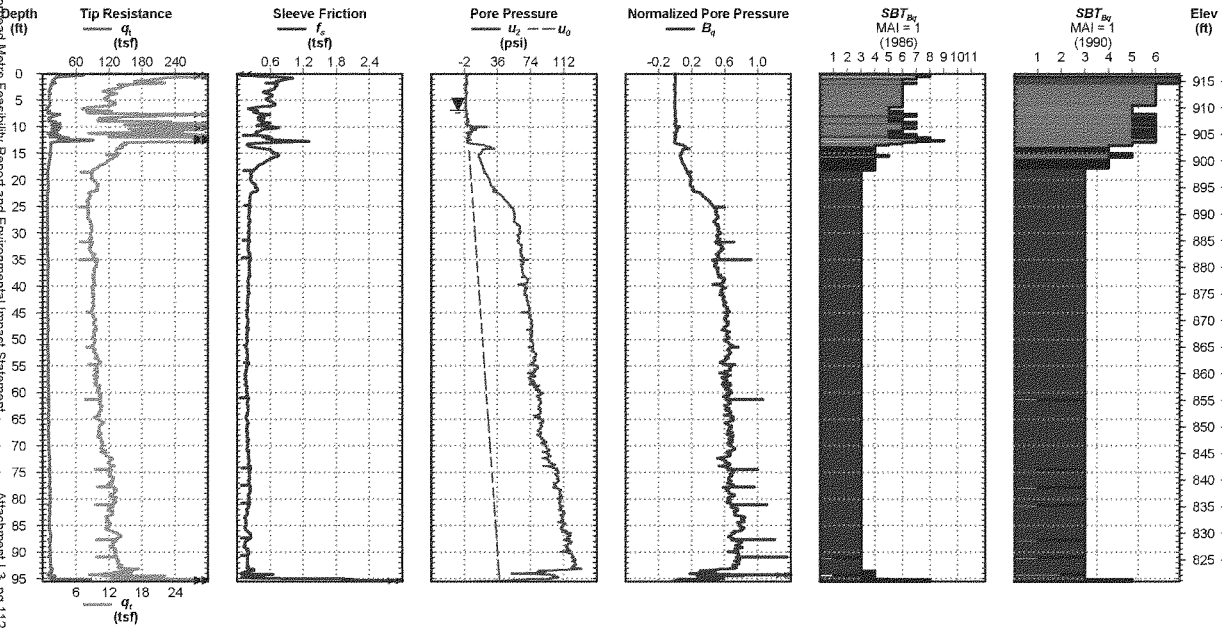
Fargo Moorehead

Cone Penetration Test 09-ED-46C

Date: Jul. 12, 2009
Operator: MARKOV
Drilling Agency: USACE, Savannah District

Northing: 2007352.063
Easting: 990257.215
Probe ID/Net Area Ratio: DDG1117 / 0.8

Elevation: 916.5
Water Depth: 6.89
Total Depth: 95.5 ft



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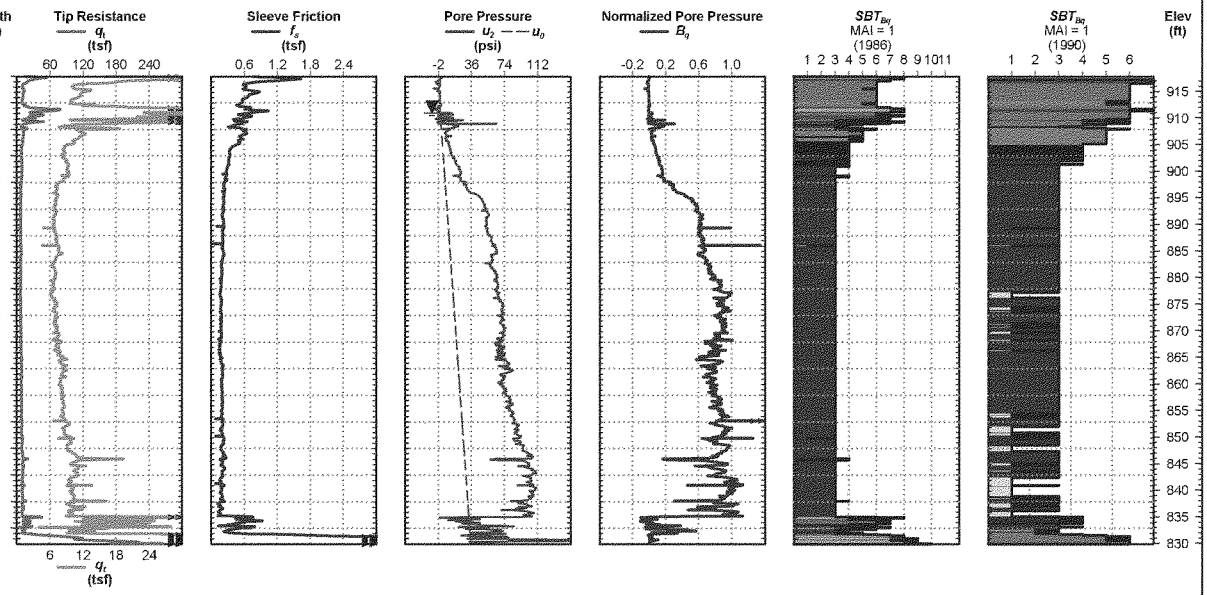
Fargo Moorehead

Cone Penetration Test 09-ED-47C

Date:	Jul. 12, 2009	Northing:	2012302.781	Elevation:	917.8
Operator:	MARKOV	Easting:	984883.322	Water Depth:	6.89
Drilling Agency:	USACE, Savannah District	Probe ID/Net Area Ratio:	DDG1117 / 0.8	Total Depth:	87.9 ft



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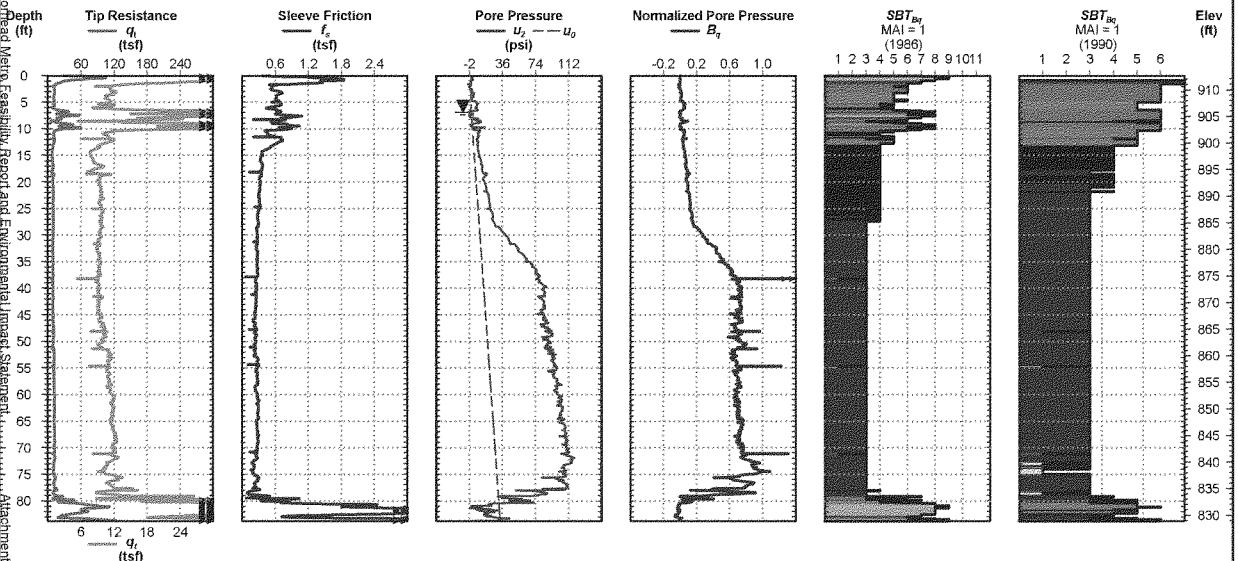
Fargo Moorehead

Cone Penetration Test 09-ED-48C

Date:	Jul. 12, 2009	Northing:	2001711.916	Elevation:	912.7
Operator:	MARKOV	Easting:	985122.949	Water Depth:	6.89
Drilling Agency:	USACE, Savannah District	Probe ID/Net Area Ratio:	DDG1117 / 0.8	Total Depth:	83.8 ft



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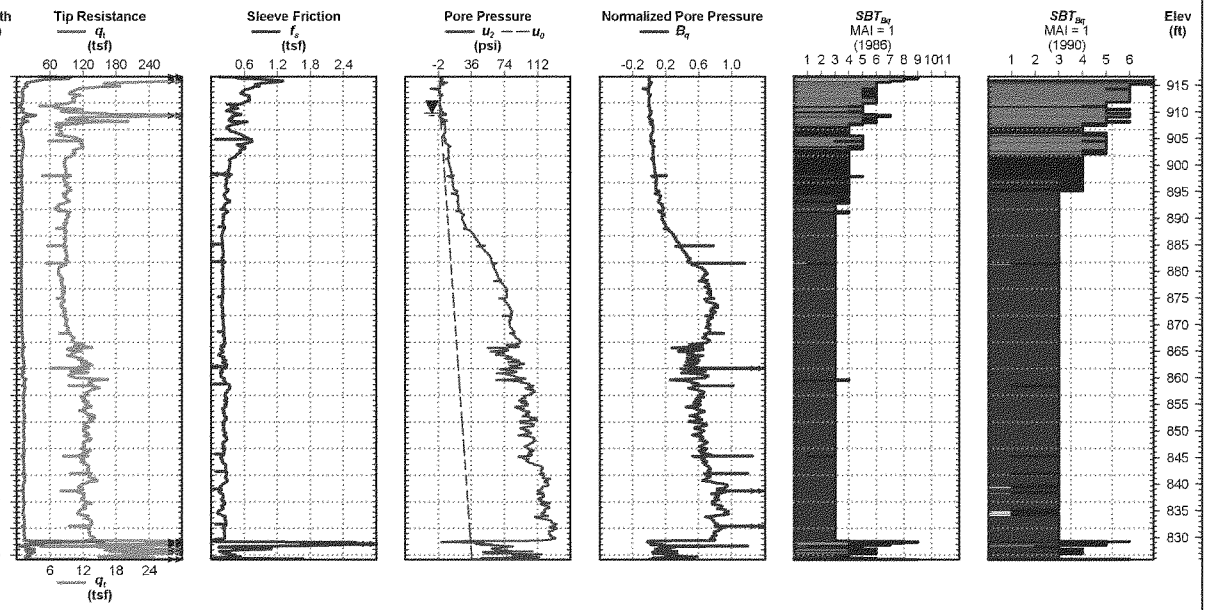
Electronic Filename: 09-48C.cpt

Fargo Moorehead

Cone Penetration Test 09-ED-49C

Date:	Jul. 12, 2009	**Northing:**	2006864.46	**Elevation:**	916.7
Operator:	MARKOV	**Easting:**	979727.246	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	90.9 ft



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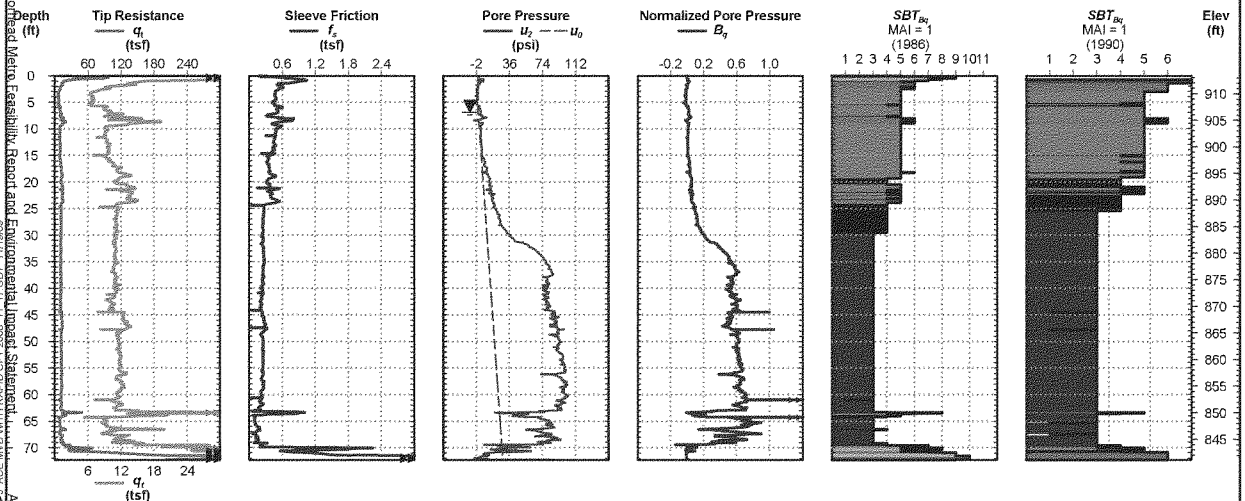
Fargo Moorehead

Cone Penetration Test 09-ED-50C

Date: Jul. 13, 2009
Operator: MARKOV
Drilling Agency: USACE, Savannah District

Northing: 1996211.113
Easting: 979899.051
Probe ID/Net Area Ratio: DDG1117 / 0.8

Elevation: 913.4
Water Depth: 6.89
Total Depth: 72.2 ft



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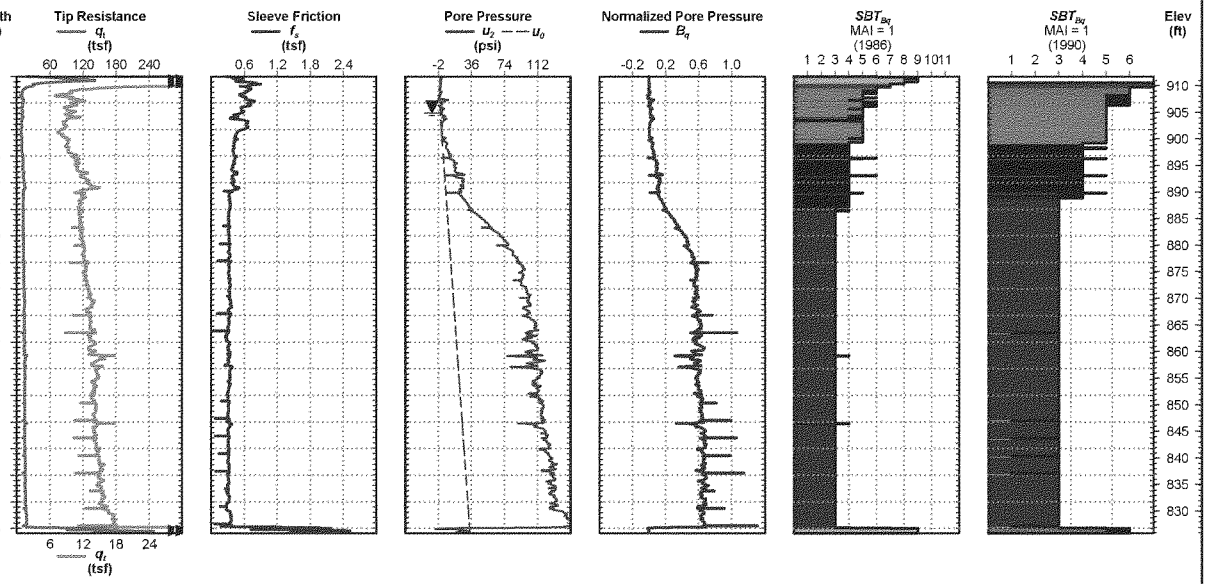
Fargo Moorehead

Cone Penetration Test 09-ED-51C

Date:	Jul. 13, 2009	**Northing:**	1993604.9	**Elevation:**	911.8
Operator:	MARKOV	**Easting:**	979953.4	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	85.9 ft



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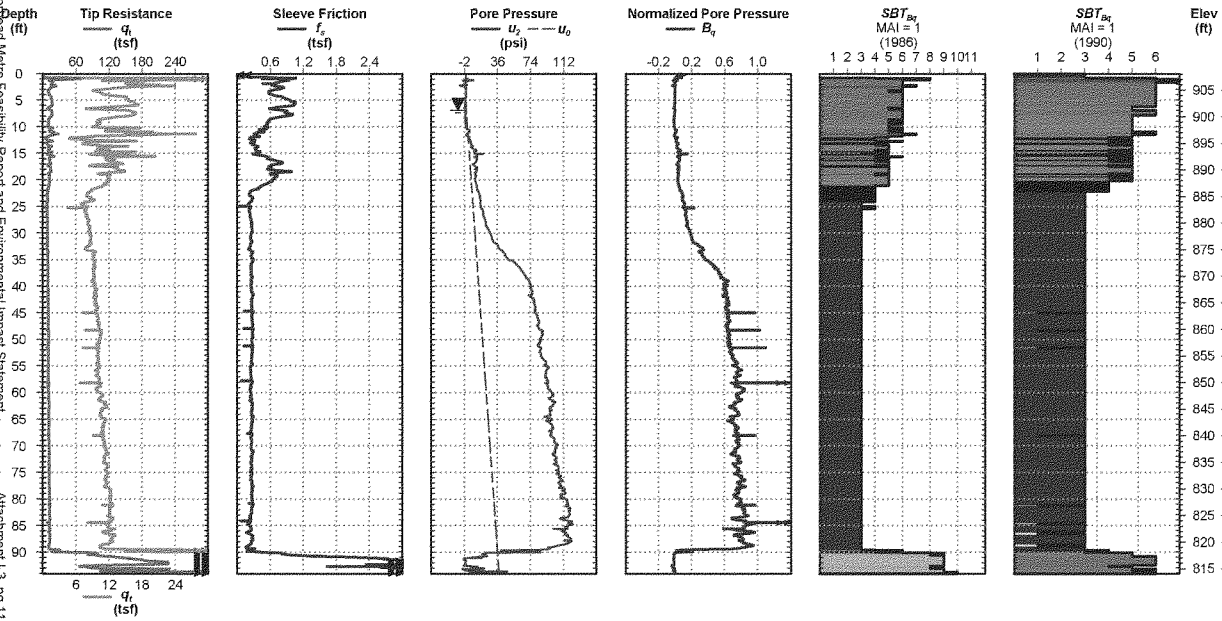
CPT REPORT - 09-ED-51C.dwg Geotechnical Design and Geology

Fargo Moorehead

Cone Penetration Test 09-M-52C

Date:	Jul. 13, 2009	**Northing:**	1991813.382	**Elevation:**	908.1
Operator:	MARKOV	**Easting:**	1004170.432	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	94.0 ft



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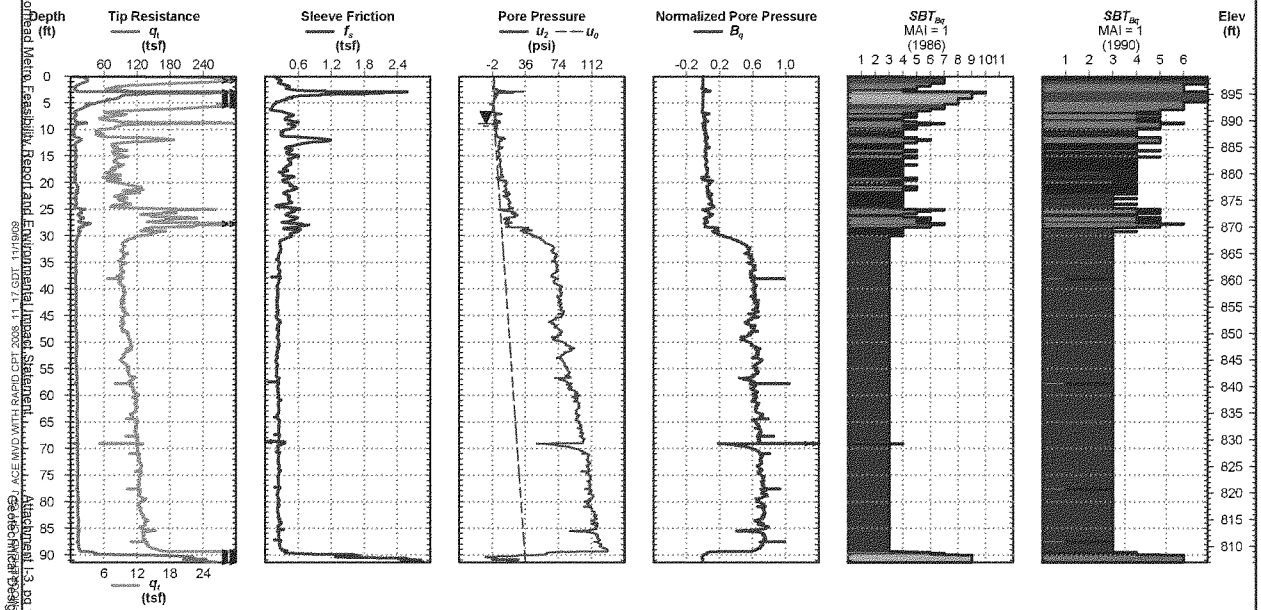
Fargo Moorehead

Cone Penetration Test

09-M-53C

Date:	Jul. 16, 2009	**Northing:**	1993033.858	**Elevation:**	898.4
Operator:	MARKOV	**Easting:**	1014381.484	**Water Depth:**	8.86
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	91.4 ft



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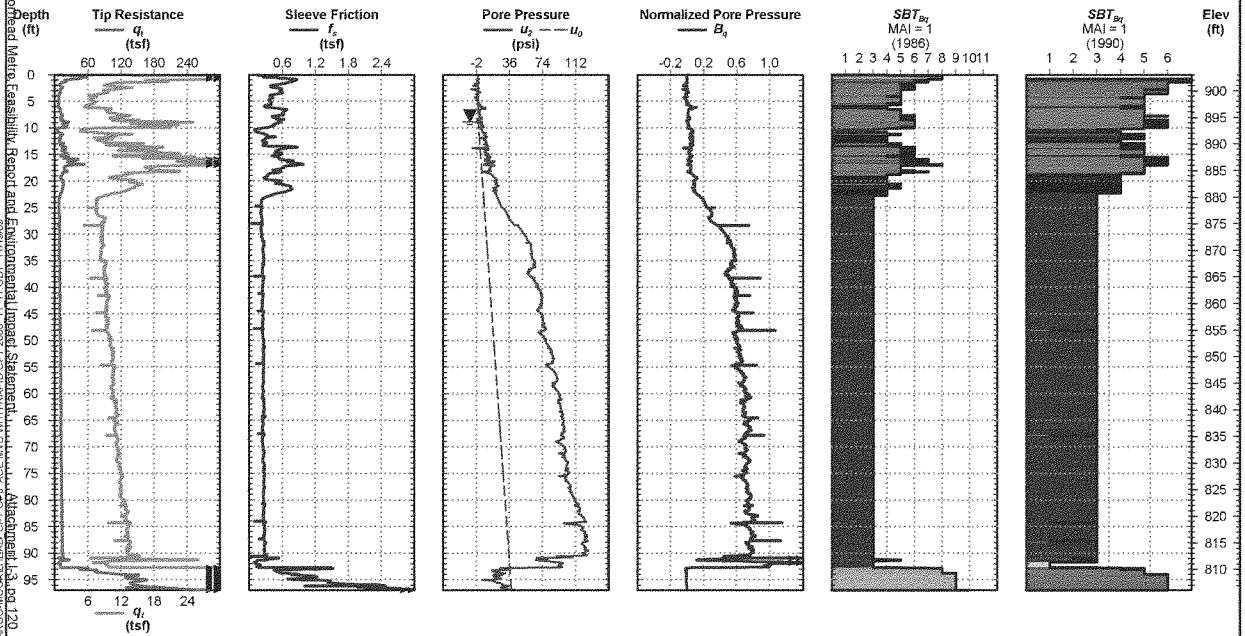
Electronic Filename: 09-53C.cpt

Fargo Moorehead

Cone Penetration Test 09-M-54C

Date:	Jul. 15, 2009	**Northing:**	1992959.16	**Elevation:**	903.1
Operator:	MARKOV	**Easting:**	1013970.783	**Water Depth:**	8.86
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	96.9 ft



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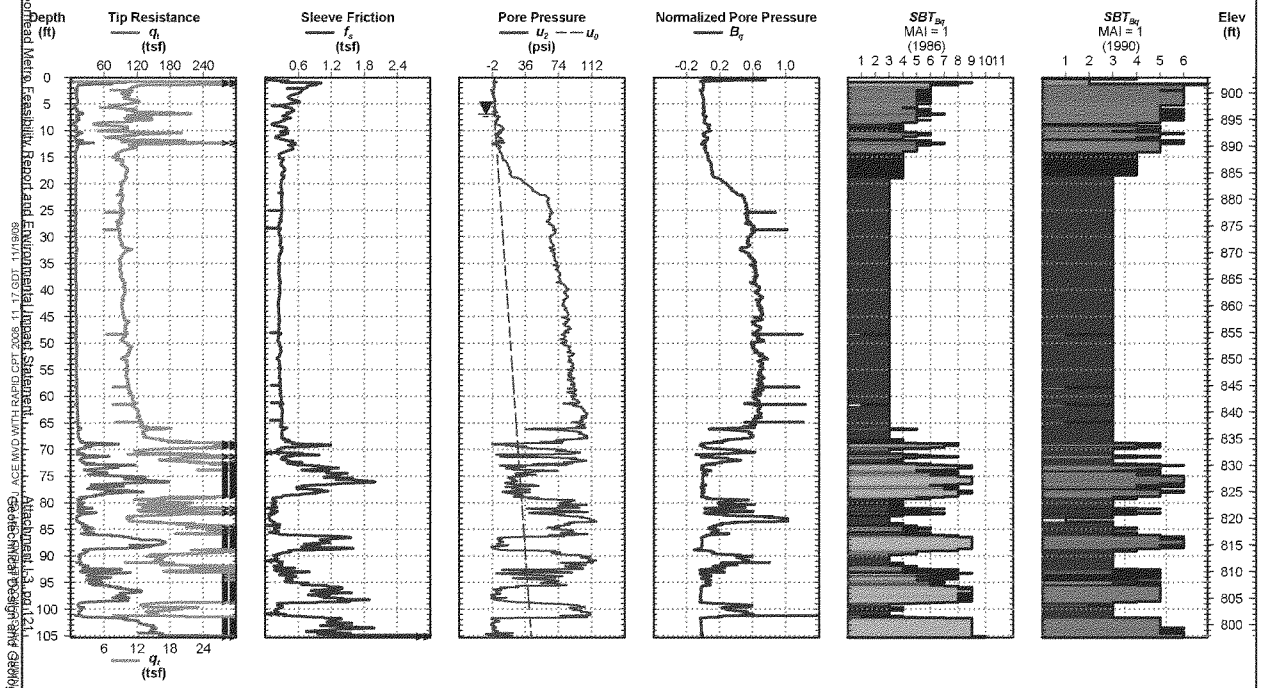
Fargo Moorehead

Cone Penetration Test 09-M-55C

Date:	Jul. 15, 2009	**Northing:**	1993429.575	**Elevation:**	903.0
Operator:	MARKOV	**Easting:**	1009075.102	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	105.3 ft



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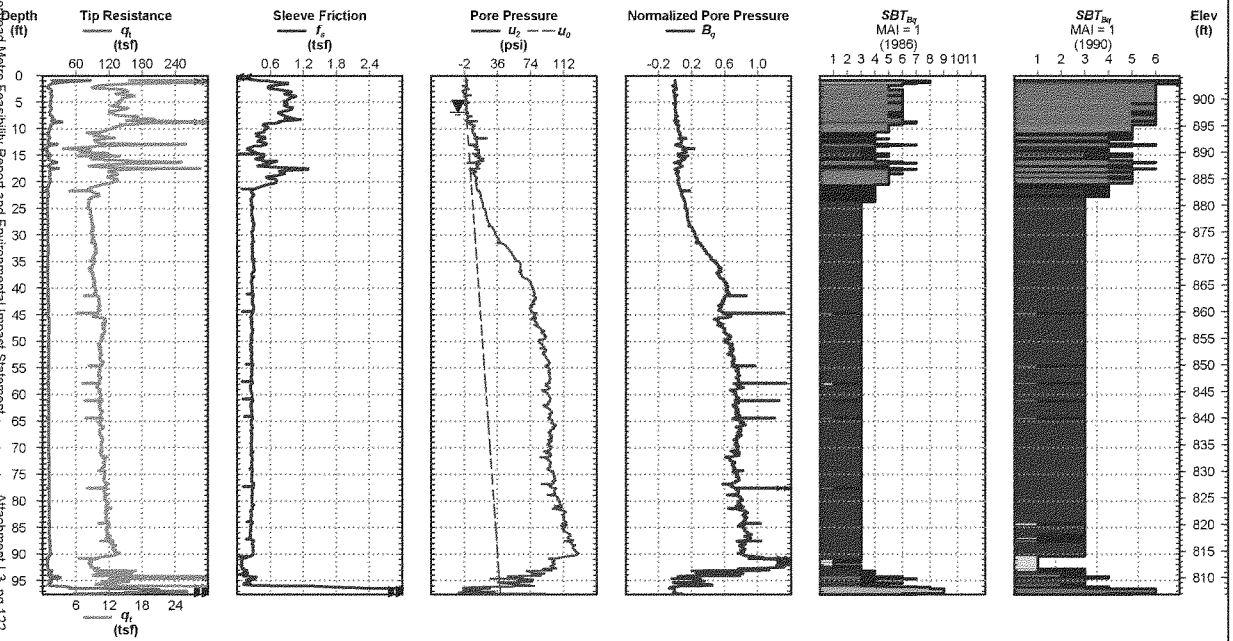
Fargo Moorehead

Cone Penetration Test 09-M-56C

Date:	Jul. 15, 2009	**Northing:**	1990641.26	**Elevation:**	904.5
Operator:	MARKOV	**Easting:**	1006586.726	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	97.6 ft



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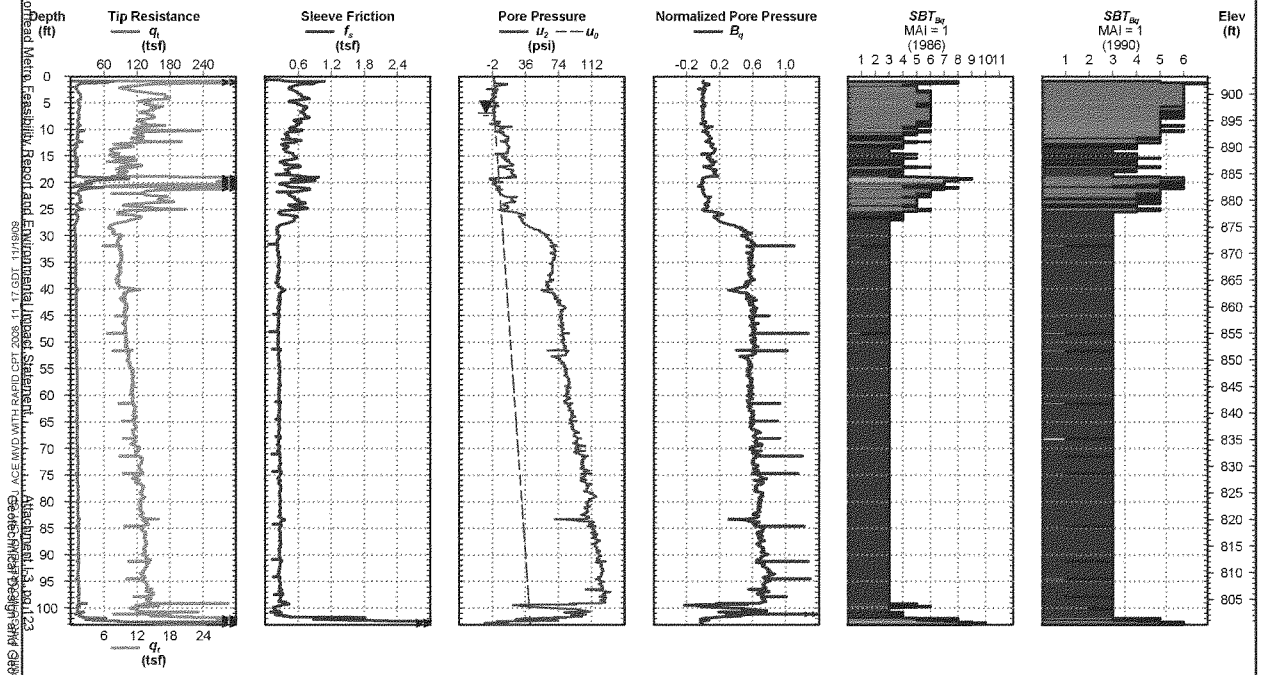
Electronic Filename: 09-56C.cpt

Fargo Moorehead

Cone Penetration Test 09-M-58C

Date:	Jul. 16, 2009	**Northing:**	1992155.126	**Elevation:**	903.4
Operator:	MARKOV	**Easting:**	1016369.888	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	103.2 ft



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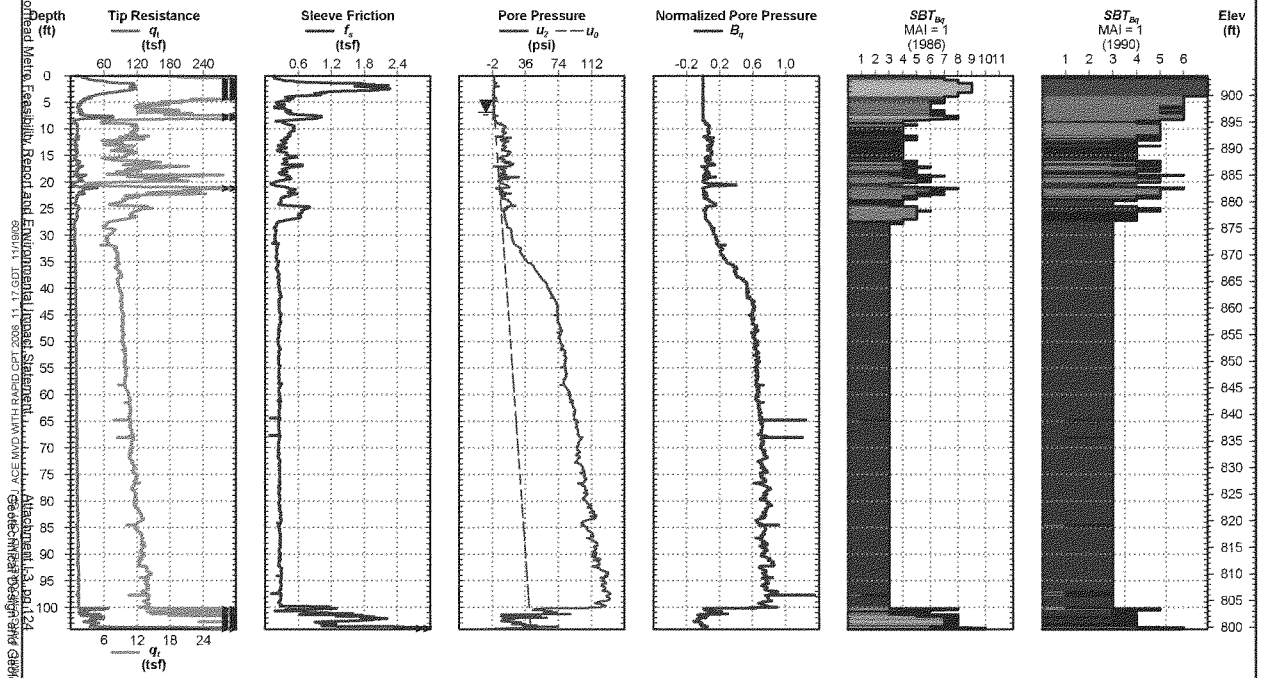
Electronic Filename: 09-58C.cpt

CPT REPORT - Geotechnical Design and Geology
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Attachment I-3, pg 123

Fargo Moorehead

Cone Penetration Test 09-M-59C

Date:	Jul. 16, 2009	**Northing:**	1992052.316	**Elevation:**	903.7
Operator:	MARKOV	**Easting:**	1019820.402	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	104.1 ft



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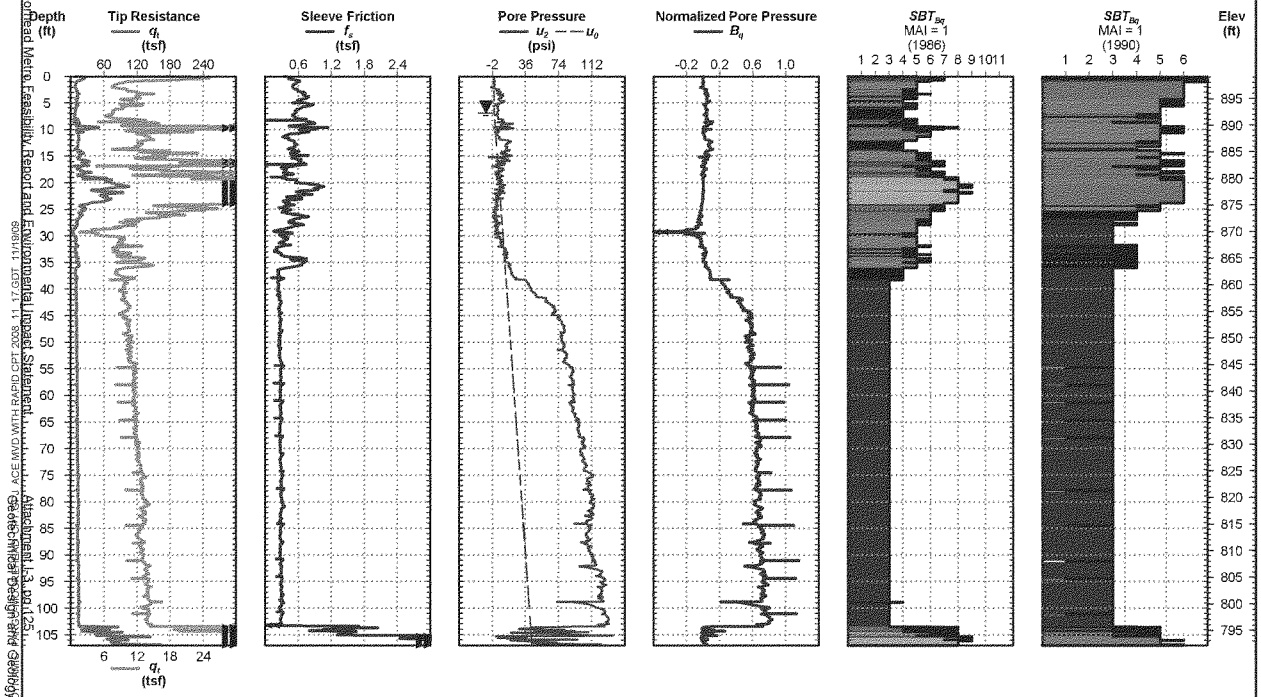
Electronic Filename: 09-59C.cpt

Fargo Moorehead

Cone Penetration Test

09-M-61C

Date:	Jul. 17, 2009	Northing:	1994842.434	Elevation:	899.2
Operator:	MARKOV	Easting:	1028797.307	Water Depth:	6.89
Drilling Agency:	USACE, Savannah District	Probe ID/Net Area Ratio:	DDG1117 / 0.8	Total Depth:	107.0 ft



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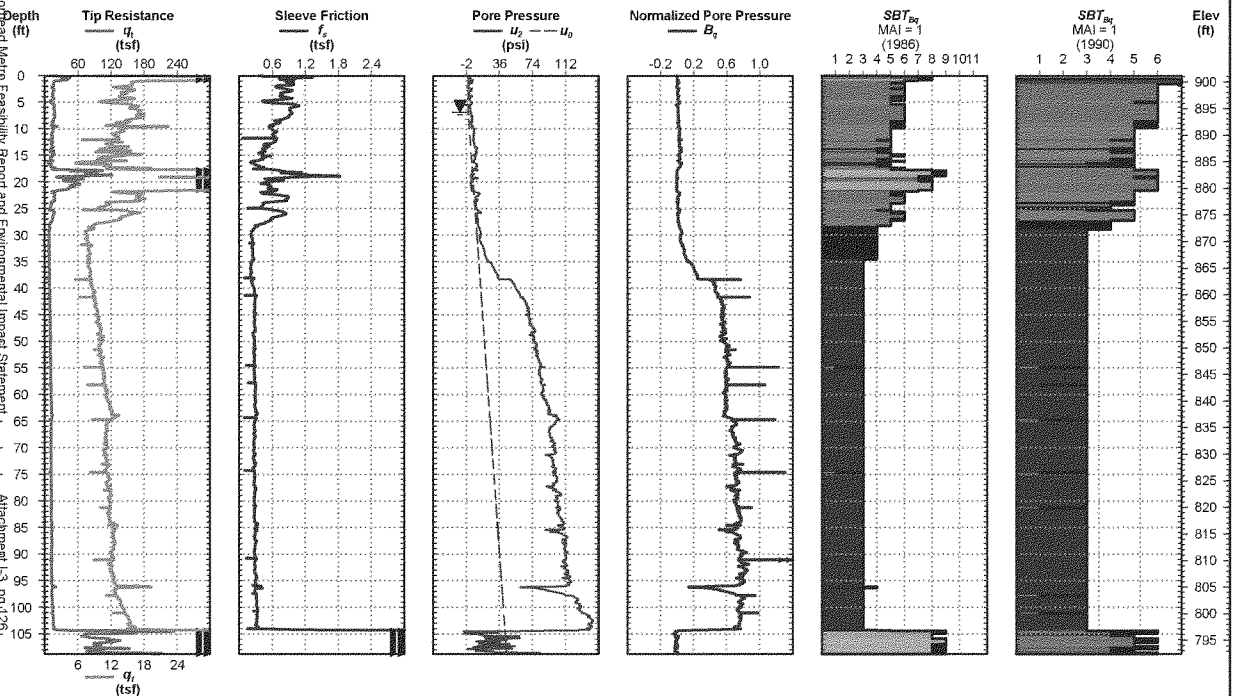
Electronic Filename: 09-61C.cpt

Fargo Moorehead

Cone Penetration Test 09-M-62C

Date:	Jul. 18, 2009	Northing:	1994776.664	Elevation:	901.2
Operator:	MARKOV	Easting:	1025795.964	Water Depth:	6.89
Drilling Agency:	USACE, Savannah District	Probe ID/Net Area Ratio:	DDG1117 / 0.8	Total Depth:	108.8 ft



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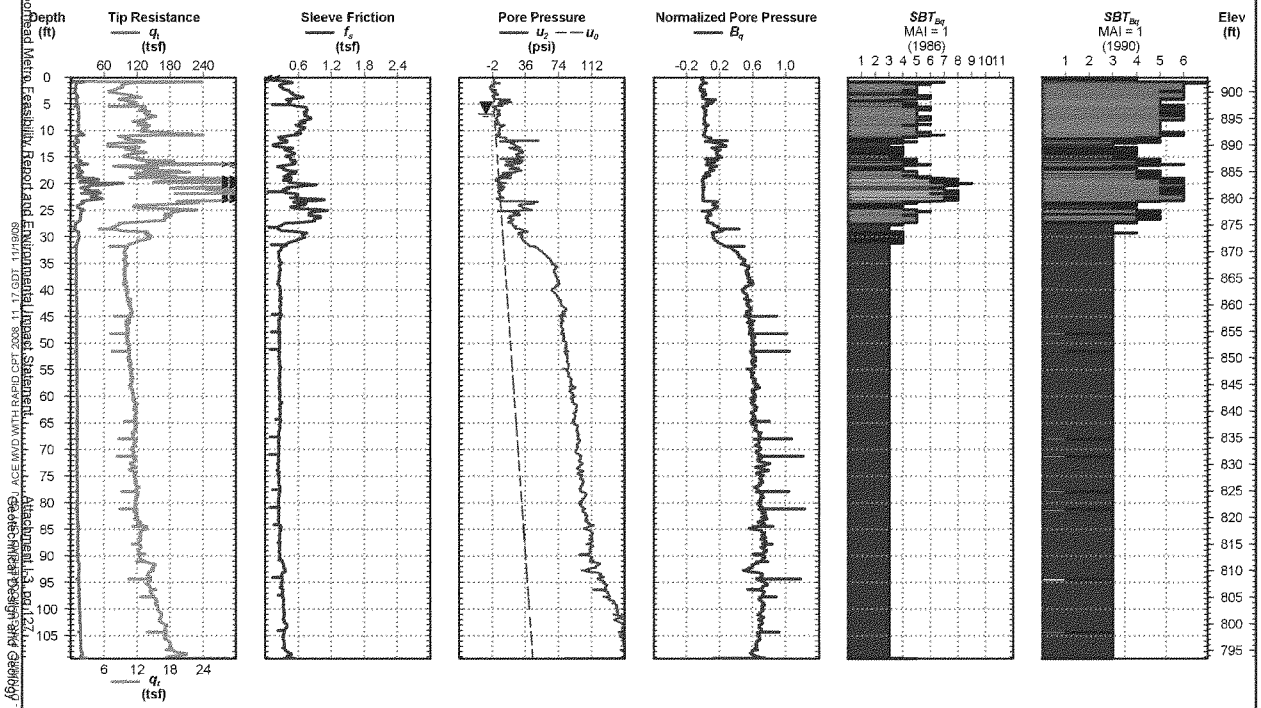
Electronic Filename: 09-62C.cpt

Fargo Moorehead

Cone Penetration Test

09-M-64C

Date:	Jul. 18, 2009	Northing:	1994850.143	Elevation:	902.8
Operator:	MARKOV	Easting:	1022600.768	Water Depth:	6.89
Drilling Agency:	USACE, Savannah District	Probe ID/Net Area Ratio:	DDG1117 / 0.8	Total Depth:	109.3 ft



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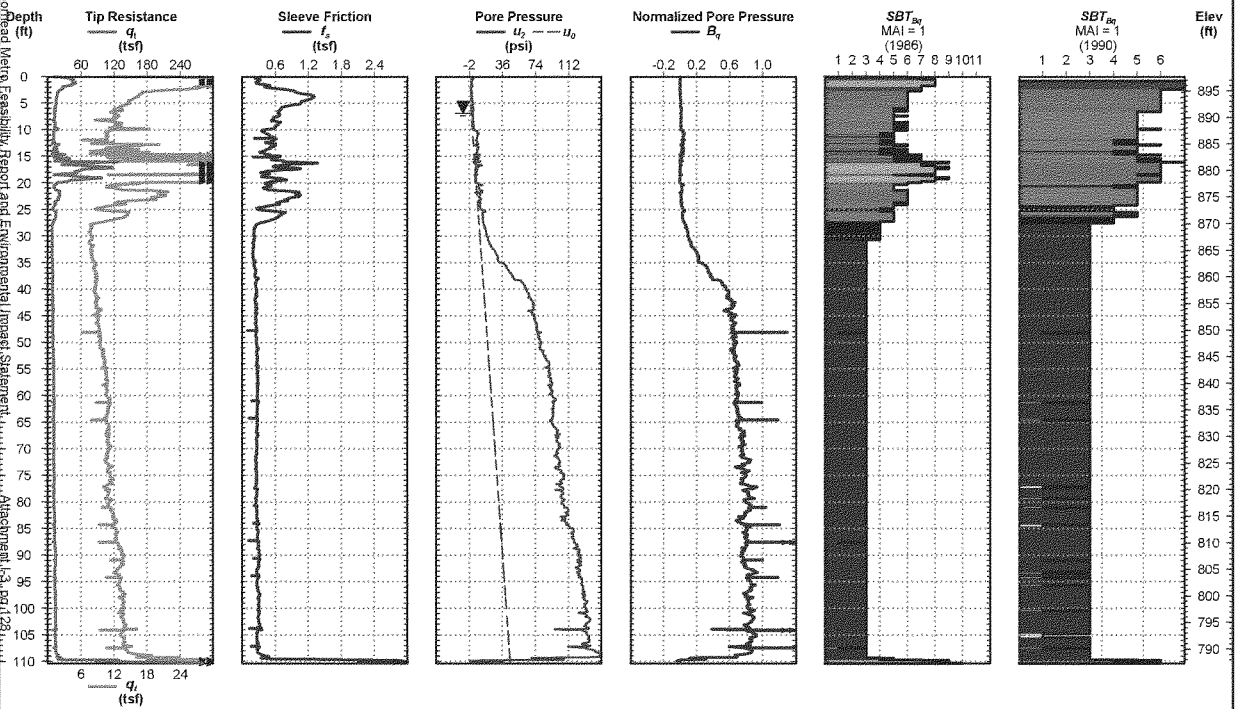
Electronic Filename: 09-64C.cpt

Fargo Moorehead

Cone Penetration Test 09-M-65C

Date:	Jul. 18, 2009	**Northing:**	1996542.454	**Elevation:**	897.7
Operator:	MARKOV	**Easting:**	1032559.816	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	110.4 ft



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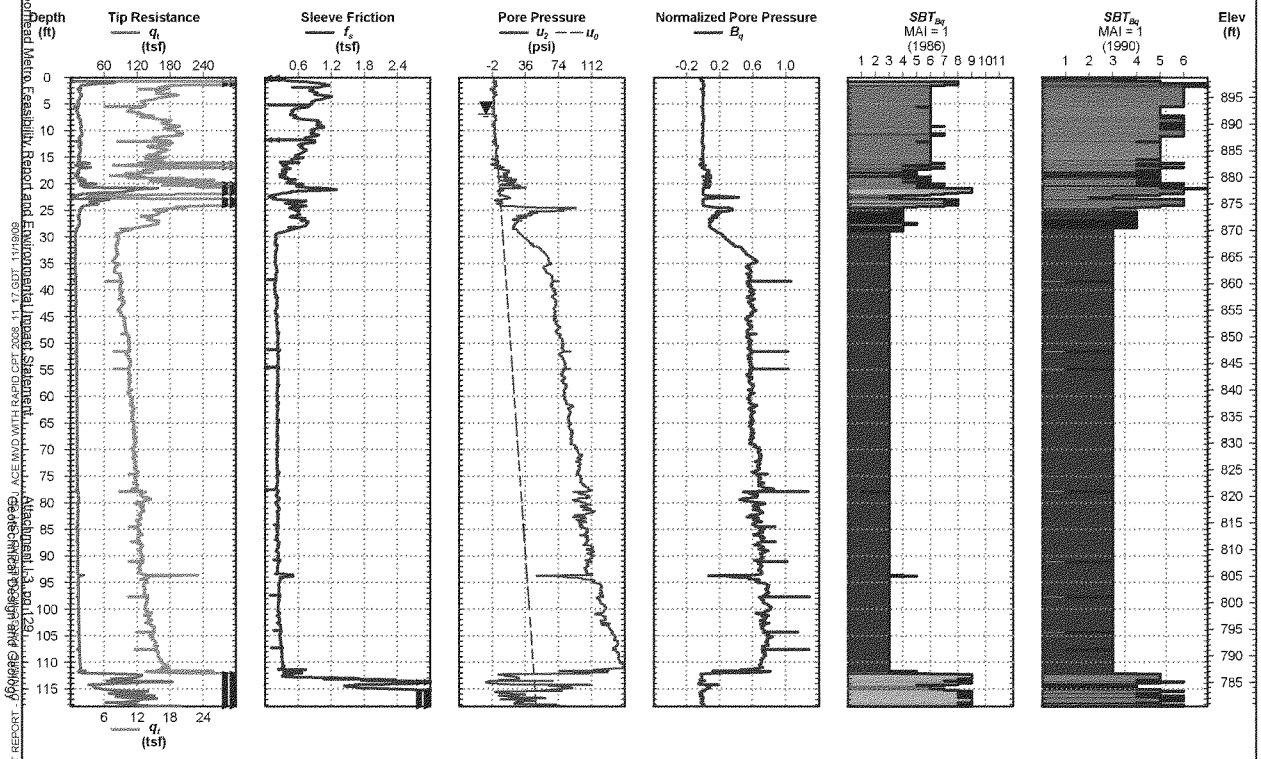
Electronic Filename: 09-65C.cpt

Fargo Moorehead

Cone Penetration Test

09-M-66C

Date:	Jul. 18, 2009	Northing:	1999566.278	Elevation:	898.8
Operator:	MARKOV	Easting:	1036525.392	Water Depth:	6.89
Drilling Agency:	USACE, Savannah District	Probe ID/Net Area Ratio:	DDG1117 / 0.8	Total Depth:	118.3 ft



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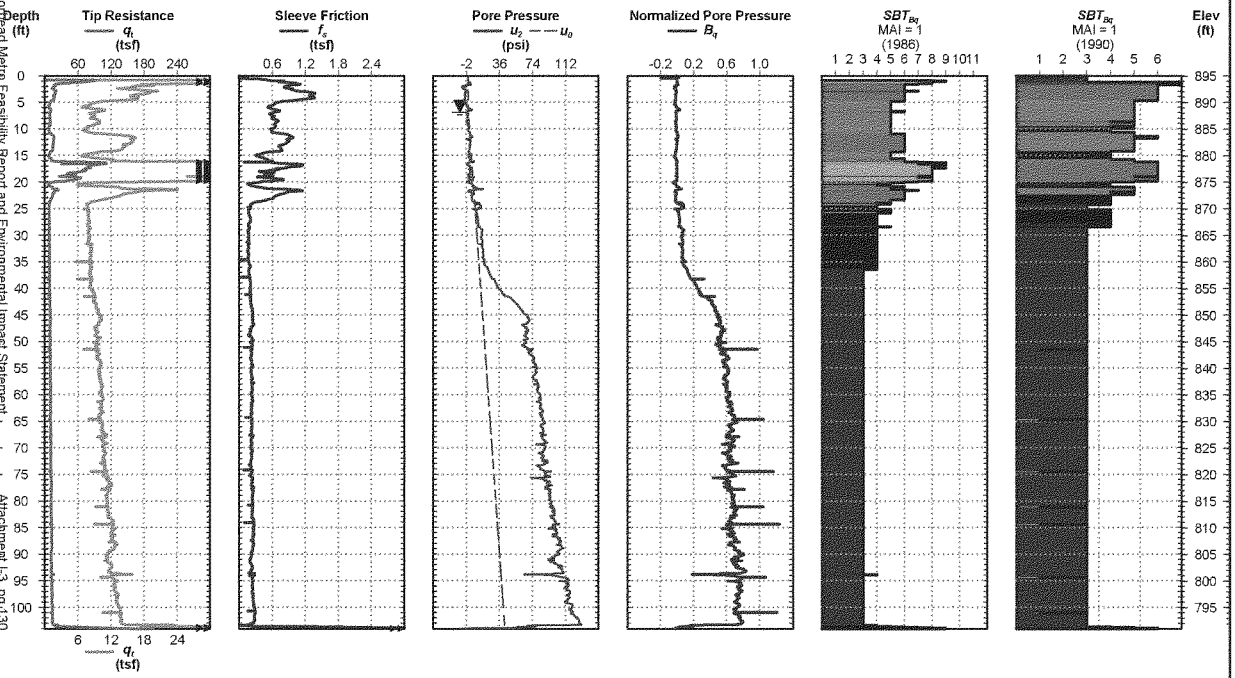
Electronic Filename: 09-66C.cpt

Fargo Moorehead

Cone Penetration Test 09-M-67C

Date:	Jul. 19, 2009	**Northing:**	1999637.586	**Elevation:**	895.1
Operator:	MARKOV	**Easting:**	1039810.893	**Water Depth:**	6.89
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1117 / 0.8	**Total Depth:**	104.1 ft



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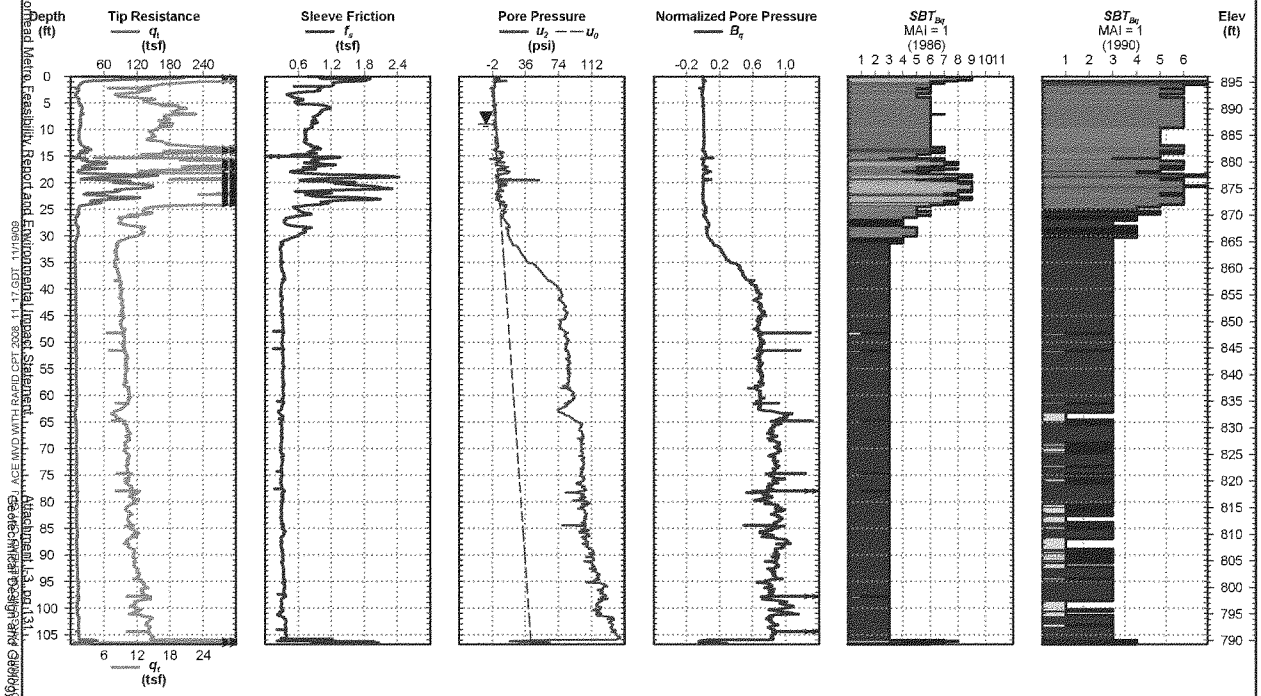
Electronic Filename: 09-67C.cpt

Fargo Moorehead

Cone Penetration Test

09-M-71C

Date:	Jul. 25, 2009	Northing:	1998637.438	Elevation:	896.1
Operator:	MARKOV	Easting:	1042017.336	Water Depth:	8.99
Drilling Agency:	USACE, Savannah District	Probe ID/Net Area Ratio:	DDG1117 / 0.8	Total Depth:	106.8 ft



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Electronic Filename: 09-71C.cpt

Fargo Red River Diversion

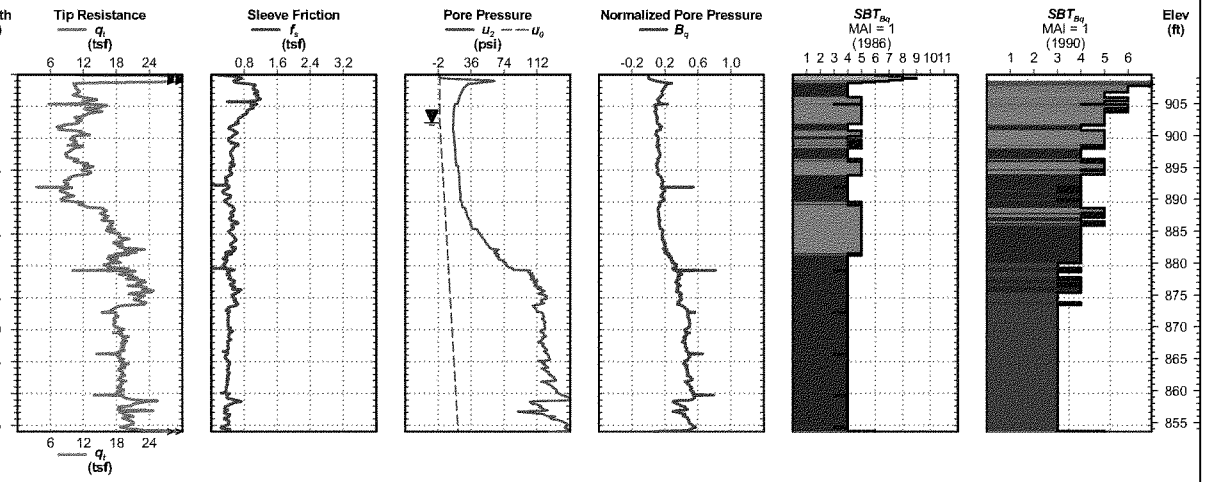
Project No: FY 2011

Cone Penetration Test 11-107-Ca

Date: Jan. 26, 2011
Operator: Johnston
Drilling Agency: USACE, Savannah District

Latitude: 46° 45' 35.892"
Longitude: -96° 49' 10.848"
Probe ID/Net Area Ratio: DDG1069 / 0.8

Elevation: 909.6
Water Depth: 7.51
Total Depth: 56.0 ft



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Electronic Filename: 10-122-C.cpt

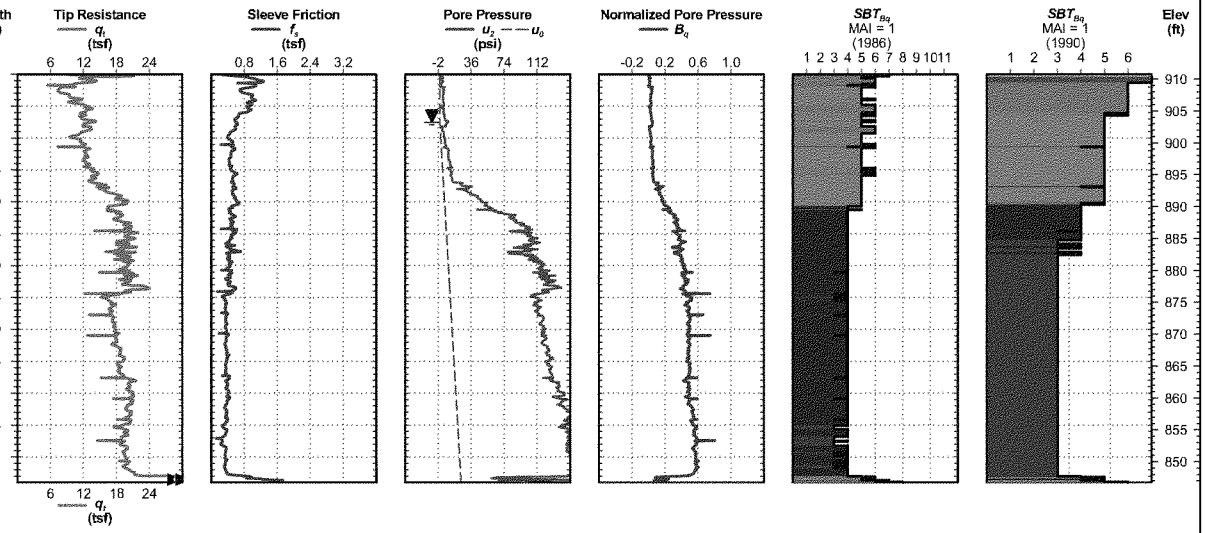
CPT REPORT - ACE MVD WITH RAPID CPT 2008_11_17.GDT 3/9/11

Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test 11-108-C

Date:	Jan. 26, 2011	**Latitude:**	46° 45' 37.044"	**Elevation:**	910.8
Operator:	Johnston	**Longitude:**	-96° 52' 57"	**Water Depth:**	7.51
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1069 / 0.8	**Total Depth:**	64.0 ft



Electronic Filename: 10-123-C.cpt

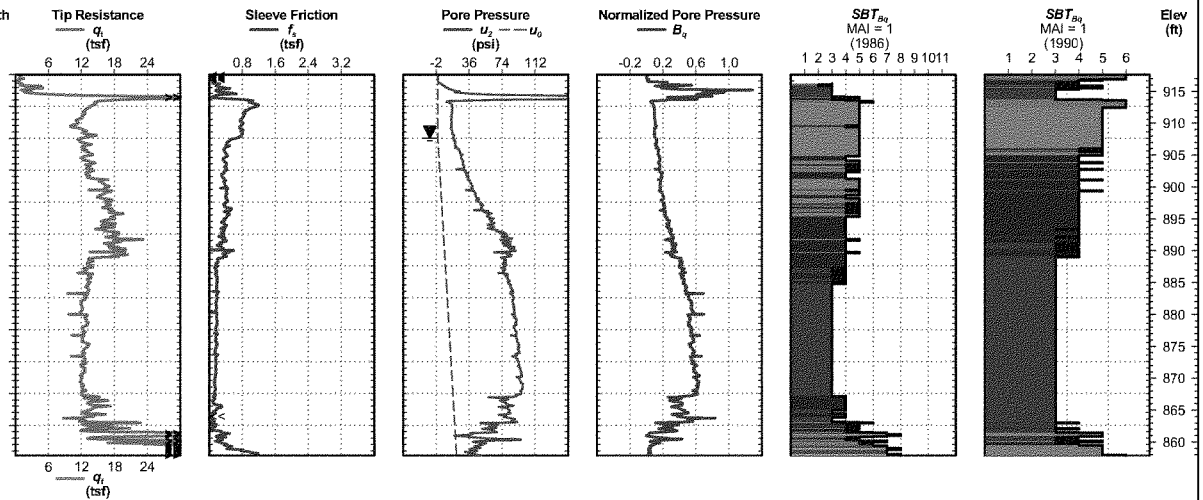
Fargo Red River Diversion

Project No: FY 2011

Cone Penetration Test

11-109-C

Date:	Jan. 27, 2011	**Latitude:**	46° 43' 52.608"	**Elevation:**	917.6
Operator:	Johnston	**Longitude:**	-96° 54' 15.3"	**Water Depth:**	10.01
Drilling Agency:	USACE, Savannah District	**Probe ID/Net Area Ratio:**	DDG1069 / 0.8	**Total Depth:**	59.7 ft



Electronic Filename: 10-124-C.cpt

CPT REPORT - Fargo Red River Diversion ACE MVD WITH RAPID CPT 2008_11_17.GDT 3/9/11
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Attachment I-3, pg 134

Attachment I-4: Test Data

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH Latest Revision: 2/18/2011
Date: JUL 09 By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
09-21M	Fargo	1	4.5	878	873.5	CH	29.2	58	24	34	G4127A	alluvium
09-21M	Fargo	2	9.5	878	868.5	CH	33.2	59	25	34	G4127A	alluvium
09-21M	Fargo	3	14.5	878	863.5	CH	36.4	72	26	46	G4127A	sherack
09-21M	Fargo	4	19	878	859	CL	34.7	34	23	11	G4127A	sherack
09-21M	Fargo	5	24.5	878	853.5	MH	43.4	51	43	8	G4127A	poplar river
09-21M	Fargo	6	29.5	878	848.5	ML	38.2	42	29	13	G4127A	poplar river
09-21M	Fargo	7	33.5	878	844.5	ML	26.2				G4127A	poplar river
09-21M	Fargo	8	41.5	878	836.5	CH	60.5	106	38	68	G4127A	brenna
09-21M	Fargo	9	49.5	878	828.5	CH	54.6	98	29	69	G4127A	brenna
09-21M	Fargo	10	54.5	878	823.5	CH	54.8	92	31	61	G4127A	argusville
09-21M	Fargo	11	64.5	878	813.5	CH	52.3	88	27	61	G4127A	argusville
09-21M	Fargo	12	69.5	878	808.5	CH	49.6	74	30	44	G4127A	argusville
09-21M	Fargo	13	74.5	878	803.5	CH	50	75	27	48	G4127A	argusville
09-21M	Fargo	14	80.5	878	797.5	CH	58.7	94	35	59	G4127A	argusville
09-21M	Fargo	15	86.5	878	791.5	CH	50.4	82	31	51	G4127A	argusville
09-22M	Fargo	1	4.5	874.2	869.7	CH	42.5	63	28	35	G4127A	alluvium
09-22M	Fargo	2	9.5	874.2	864.7	CH	42.3	77	30	47	G4127A	sherack
09-22M	Fargo	3	15	874.2	859.2	CH	36.5	63	30	33	G4127A	sherack
09-22M	Fargo	4	17.5	874.2	856.7	CH	47.7	90	36	54	G4127A	brenna
09-22M	Fargo	5	24.5	874.2	849.7	CH	69.8	103	36	67	G4127A	brenna
09-22M	Fargo	6	31	874.2	843.2	CH	70.6	114	30	84	G4127A	brenna
09-22M	Fargo	7	37.5	874.2	836.7	CH	66.6	106	31	75	G4127A	brenna
09-22M	Fargo	8	43.6	874.2	830.6	CH	65.7	102	32	70	G4127A	brenna
09-22M	Fargo	9	49.5	874.2	824.7	CH	61.3	99	29	70	G4127A	brenna
09-22M	Fargo	10	55.5	874.2	818.7	CH	8.3	84	31	53	G4127A	brenna
09-22M	Fargo	11	64.5	874.2	809.7	CH	60.8	76	25	51	G4127A	argusville
09-22M	Fargo	12	69.5	874.2	804.7	CH	48.5	74	26	48	G4127A	argusville
09-22M	Fargo	13	74.5	874.2	799.7	CH	51.2	75	28	47	G4127A	argusville
09-22M	Fargo	14	79.5	874.2	794.7	CH	52.1	74	27	47	G4127A	argusville
09-22M	Fargo	15	84.5	874.2	789.7	CH	49.4	79	27	52	G4127A	argusville
09-22M	Fargo	16	86.5	874.2	787.7						G4127A	till
09-23M	Fargo	1	3	897	894	CH	26.3	62	23	39	G4127A	alluvium
09-23M	Fargo	2	9.5	897	887.5	CH	34	69	26	43	G4127A	sherack
09-23M	Fargo	3	14.5	897	882.5	CH	38.9	66	24	42	G4127A	sherack
09-23M	Fargo	4	19.5	897	877.5	ML	37.1	32	26	6	G4127A	poplar river
09-23M	Fargo	5	24.5	897	872.5	ML	26.2				G4127A	poplar river
09-23M	Fargo	6	29	897	868	CH	36.7	70	29	41	G4127A	poplar river
09-23M	Fargo	7	34.5	897	862.5	CH	52.8	101	31	70	G4127A	brenna
09-23M	Fargo	8	39.5	897	857.5	CH	65.1	104	32	72	G4127A	brenna
09-23M	Fargo	9	44.5	897	852.5	CH	67	101	34	67	G4127A	brenna
09-23M	Fargo	10	49.5	897	847.5	CH	62.8	104	33	71	G4127A	brenna
09-23M	Fargo	11	54.5	897	842.5	CH	65.8	105	32	73	G4127A	brenna
09-23M	Fargo	12	59.5	897	837.5	CH	61.8	107	29	78	G4127A	brenna
09-23M	Fargo	13	64.5	897	832.5	CH	60.2	101	32	69	G4127A	brenna
09-23M	Fargo	14	69.5	897	827.5	CH	57	89	32	57	G4127A	brenna
09-23M	Fargo	15	74.5	897	822.5	CH	57.6	93	30	63	G4127A	brenna
09-23M	Fargo	16	79.5	897	817.5	CH	48.8	81	22	59	G4127A	argusville
09-23M	Fargo	17	84.5	897	812.5	CH	56.7	88	30	58	G4127A	argusville
09-23M	Fargo	18	89.5	897	807.5	CH	48.3	80	28	52	G4127A	argusville
09-23M	Fargo	19	94.5	897	802.5	CH	44.2	75	27	48	G4127A	argusville
09-23M	Fargo	20	99.5	897	797.5	CH	44.8	68	24	44	G4127A	argusville
09-23M	Fargo	21	104.5	897	792.5	CH	36.6	68	26	42	G4127A	argusville
09-23M	Fargo	22	109.5	897	787.5						G4127A	till
09-23M	Fargo	23	118.5	897	778.5						G4127A	till
09-24M	Fargo	1	4.5	895.4	890.9	CH	32.5	64	28	36	G4127A	sherack
09-24M	Fargo	2	9.5	895.4	885.9	CH	40.9	70	33	37	G4127A	sherack
09-24M	Fargo	3	16.5	895.4	878.9	CH	42.5	66	31	35	G4127A	sherack
09-24M	Fargo	4	19.5	895.4	875.9	ML	39	32	25	7	G4127A	poplar river
09-24M	Fargo	5	24.5	895.4	870.9	ML	35.1	40	38	2	G4127A	poplar river
09-24M	Fargo	6	29.5	895.4	865.9	ML	23.9				G4127A	poplar river
09-24M	Fargo	7	34.5	895.4	860.9	ML	36.9	43	32	11	G4127A	poplar river
09-24M	Fargo	8	39.5	895.4	855.9	ML	30.6	33	25	8	G4127A	poplar river
09-24M	Fargo	9	44.5	895.4	850.9	CH	43.9	94	38	56	G4127A	brenna
09-24M	Fargo	10	49.5	895.4	845.9	CH	65.6	113	40	73	G4127A	brenna
09-24M	Fargo	11	55.5	895.4	839.9	CH	61.8	107	33	74	G4127A	brenna
09-24M	Fargo	12	61.5	895.4	833.9	CH	66.9	108	34	74	G4127A	brenna
09-24M	Fargo	13	67.5	895.4	827.9	CH	65.2	109	33	76	G4127A	brenna
09-24M	Fargo	14	74	895.4	821.4	CH	51.5	89	25	64	G4127A	brenna
09-24M	Fargo	15	79.5	895.4	815.9	CH	58.3	91	26	65	G4127A	brenna
09-24M	Fargo	16	84.5	895.4	810.9	CH	54.2	83	28	55	G4127A	argusville
09-24M	Fargo	17	89.5	895.4	805.9	CH	46.8	76	21	55	G4127A	argusville
09-24M	Fargo	18	94.5	895.4	800.9	CH	48.6	76	23	53	G4127A	argusville
09-24M	Fargo	19	104.5	895.4	790.9	CH	55.3	90	24	66	G4127A	argusville
09-24M	Fargo	20	107.5	895.4	787.9						G4127A	till
09-24M	Fargo	21	109.5	895.4	785.9						G4127A	till

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH Latest Revision: 2/18/2011
Date: JUL 09 By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
09-25M	Fargo	1	2	893.4	891.4	ML	15.3				G4127A	fill
09-25M	Fargo	2	3	893.4	890.4	CH	26.7	54	25	29	G4127A	fill
09-25M	Fargo	3	4	893.4	889.4	CH	27.4	56	25	31	G4127A	alluvium
09-25M	Fargo	4	5.5	893.4	887.9	CH	37.7	56	29	27	G4127A	topsoil/alluvium
09-25M	Fargo	5	9.5	893.4	883.9	CH	28.6	55	24	31	G4127A	alluvium
09-25M	Fargo	6	14.5	893.4	878.9	CH	30	48	23	25	G4127A	alluvium
09-25M	Fargo	7	19.5	893.4	873.9	CH	28.4	53	24	29	G4127A	alluvium
09-25M	Fargo	8	23.5	893.4	869.9	CH	28.7	50	21	29	G4127A	alluvium
09-25M	Fargo	9	29.5	893.4	863.9	CH	39.8	54	31	23	G4127A	alluvium
09-25M	Fargo	10	33.5	893.4	859.9	CL-ML	28.4	25	20	5	G4127A	alluvium
09-25M	Fargo	11	38.5	893.4	854.9	CL	28.4	42	22	20	G4127A	alluvium
09-25M	Fargo	12	44	893.4	849.4	CL-ML	26.2	29	22	7	G4127A	alluvium
09-25M	Fargo	13	49.5	893.4	843.9	CH	50.8	93	33	60	G4127A	brenna
09-25M	Fargo	14	54	893.4	839.4	CH	46.8	82	26	56	G4127A	brenna
09-25M	Fargo	15	59.5	893.4	833.9	CH	41.6	71	27	44	G4127A	brenna
09-25M	Fargo	16	64.5	893.4	828.9	CH	39.4	54	29	25	G4127A	argusville
09-25M	Fargo	17	69.5	893.4	823.9	CH	34.3	60	23	37	G4127A	argusville
09-25M	Fargo	18	74.5	893.4	818.9	CH	45.3	71	27	44	G4127A	argusville
09-25M	Fargo	19	79.5	893.4	813.9	CH	45.8	68	27	41	G4127A	argusville
09-25M	Fargo	20	84	893.4	809.4	CH	40.7	68	28	40	G4127A	argusville
09-25M	Fargo	21	89.5	893.4	803.9	CH	41	66	28	38	G4127A	argusville
09-25M	Fargo	22	94.5	893.4	798.9						G4127A	till
09-25M	Fargo	23	101.5	893.4	791.9						G4127A	till
09-26M	Fargo	1	1.5	903.5	902	CH	24.5	59	29	30	G4127A	?
09-26M	Fargo	2	4.5	903.5	899	CH	32.3	65	30	35	G4127A	sherack
09-26M	Fargo	3	9.5	903.5	894	CH	35.7	68	29	39	G4127A	sherack
09-26M	Fargo	4	14.5	903.5	889	CH	45.8	64	30	34	G4127A	sherack
09-26M	Fargo	5	17.5	903.5	886	ML	35.3	30	27	3	G4127A	poplar river
09-26M	Fargo	6	19.25	903.5	884.25	CL	32.6	49	25	24	G4127A	poplar river
09-26M	Fargo	7	23.5	903.5	880	CH	46	88	37	51	G4127A	brenna
09-26M	Fargo	8	29.5	903.5	874	CH	73	114	39	75	G4127A	brenna
09-26M	Fargo	9	34.5	903.5	869	CH	63.6	103	34	69	G4127A	brenna
09-26M	Fargo	10	39.5	903.5	864	CH	60.7	95	33	62	G4127A	brenna
09-26M	Fargo	11	44.5	903.5	859	CH	61.9	99	34	65	G4127A	brenna
09-26M	Fargo	12	49.5	903.5	854	CH	61.8	102	34	68	G4127A	brenna
09-26M	Fargo	13	54.5	903.5	849	CH	55.4	98	33	65	G4127A	brenna
09-26M	Fargo	14	59.5	903.5	844	CH	48.2	79	29	50	G4127A	brenna
09-26M	Fargo	15	64	903.5	839.5	CH	49.9	74	29	45	G4127A	brenna
09-26M	Fargo	16	69.5	903.5	834	CH	49.1	80	25	55	G4127A	argusville
09-26M	Fargo	17	74.5	903.5	829	CH	51.7	72	27	45	G4127A	argusville
09-26M	Fargo	18	49.5	903.5	854	CH	55.4	73	31	42	G4127A	argusville
09-26M	Fargo	19	85.5	903.5	818	CH	54.7	78	32	46	G4127A	argusville
09-26M	Fargo	20	84	903.5	819.5	CH	45.3	73	28	45	G4127A	argusville
09-26M	Fargo	21	89.5	903.5	814	CH	51.8	78	30	48	G4127A	argusville
09-26M	Fargo	22	94.5	903.5	809						G4127A	till
09-26M	Fargo	23	101.5	903.5	802						G4127A	till
09-27M	Fargo	1	4.5	903.1	898.6	CH	22.8	62	23	39	G4127A	alluvium
09-27M	Fargo	2	9.5	903.1	893.6	CH	28.3	50	22	28	G4127A	alluvium
09-27M	Fargo	3	14.5	903.1	888.6	CL	28.7	45	20	25	G4127A	alluvium
09-27M	Fargo	4	19.5	903.1	883.6	CH	30.1	51	22	29	G4127A	alluvium
09-27M	Fargo	5	24.5	903.1	878.6	CH	27.6	51	19	32	G4127A	alluvium
09-27M	Fargo	6	29.25	903.1	873.85	CH	54.2	106	37	69	G4127A	brenna
09-27M	Fargo	7	33.25	903.1	869.85	CH	58.3	101	26	75	G4127A	brenna
09-27M	Fargo	8	39	903.1	864.1	CH	56.2	99	27	72	G4127A	brenna
09-27M	Fargo	9	44.5	903.1	858.6	CH	57.4	101	26	75	G4127A	brenna
09-27M	Fargo	10	49	903.1	854.1	CH	59.4	99	31	68	G4127A	brenna
09-27M	Fargo	11	54.5	903.1	848.6	CH	57	77	29	48	G4127A	brenna
09-27M	Fargo	12	59	903.1	844.1	CH	54.6	81	25	56	G4127A	brenna
09-27M	Fargo	13	64	903.1	839.1	CH	53.1	88	25	63	G4127A	argusville
09-27M	Fargo	14	69.5	903.1	833.6	CH	45.8	65	28	37	G4127A	argusville
09-27M	Fargo	15	74.5	903.1	828.6	CH	47.3	72	28	44	G4127A	argusville
09-27M	Fargo	16	79	903.1	824.1	CH	48.8	69	28	41	G4127A	argusville
09-27M	Fargo	17	84.5	903.1	818.6	CH	54.6	68	29	39	G4127A	argusville
09-27M	Fargo	18	89.5	903.1	813.6	CH	38.3	54	23	31	G4127A	argusville
09-27M	Fargo	19	100.5	903.1	802.6						G4127A	till
09-35M	Fargo	1	8.5	882.2	873.7	CH	33.5	68	23	45	G4127A	sherack
09-35M	Fargo	2	11.5	882.2	870.7	CH	35.3	75	25	50	G4127A	sherack
09-35M	Fargo	3	18.5	882.2	863.7	CH	72	106	33	73	G4127A	brenna
09-35M	Fargo	4	23.5	882.2	858.7	CH	73.5	113	31	82	G4127A	brenna
09-35M	Fargo	5	28.5	882.2	853.7	CH	66.9	112	32	80	G4127A	brenna
09-35M	Fargo	6	38.5	882.2	843.7	CH	57.2	88	24	64	G4127A	brenna
09-35M	Fargo	7	43.5	882.2	838.7	CH	59	82	29	53	G4127A	argusville
09-35M	Fargo	8	48.5	882.2	833.7	CH	55.8	88	20	68	G4127A	argusville
09-35M	Fargo	9	53.5	882.2	828.7	CH	51.3	80	28	52	G4127A	argusville
09-35M	Fargo	10	58.5	882.2	823.7	CH	24.4	84	26	58	G4127A	argusville
09-35M	Fargo	11	63.5	882.2	818.7	CH	49.4	77	25	52	G4127A	argusville
09-35M	Fargo	12	68.5	882.2	813.7	CH	46.7	69	25	44	G4127A	argusville
09-35M	Fargo	13	73.5	882.2	808.7	CL	18.2	49	12	37	G4127A	argusville
09-35M	Fargo	14	78.5	882.2	803.7						G4127A	till

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH Latest Revision: 2/18/2011
Date: JUL 09 By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
09-42M	Fargo	1	3.5	882.2	878.7	CH	38.1	59	26	33	G4127A	alluvium
09-42M	Fargo	2	8.5	882.2	873.7	CH	34.6	59	30	29	G4127A	alluvium
09-42M	Fargo	3	13.5	882.2	868.7	CH	26.1	59	23	36	G4127A	alluvium
09-42M	Fargo	4	18.5	882.2	863.7	CH	38.5	67	24	43	G4127A	sherack
09-42M	Fargo	5	23.5	882.2	858.7	CH	67.6	101	31	70	G4127A	brenna
09-42M	Fargo	6	28.5	882.2	853.7	CH	69.9	104	34	70	G4127A	brenna
09-42M	Fargo	7	33.5	882.2	848.7	CH	66.3	102	32	70	G4127A	brenna
09-42M	Fargo	8	38.5	882.2	843.7	CH	64.2	86	30	56	G4127A	brenna
09-42M	Fargo	9	43.5	882.2	838.7	CH	63.5	80	30	50	G4127A	brenna
09-42M	Fargo	10	48.5	882.2	833.7	CH	52.3	77	28	49	G4127A	argusville
09-42M	Fargo	11	53.5	882.2	828.7	CH	51.9	74	26	49	G4127A	argusville
09-42M	Fargo	12	58.5	882.2	823.7	CH	50.7	86	25	61	G4127A	argusville
09-42M	Fargo	13	63.5	882.2	818.7	CH	45.4	72	25	47	G4127A	argusville
09-42M	Fargo	14	68.5	882.2	813.7	CH	49.1	69	26	43	G4127A	argusville
09-43M	Fargo	1	8.5	898.2	889.7	CH	53.4	101	33	68	G4127A	brenna
09-43M	Fargo	2	13.5	898.2	884.7	CH	75.7	110	33	77	G4127A	brenna
09-43M	Fargo	3	18.5	898.2	879.7	CH	70.4	99	34	65	G4127A	brenna
09-43M	Fargo	4	23.5	898.2	874.7	CH	69.2	102	34	68	G4127A	brenna
09-43M	Fargo	5	28.5	898.2	869.7	CH	70	103	34	69	G4127A	brenna
09-43M	Fargo	6	33.5	898.2	864.7	CH	67	103	33	70	G4127A	brenna
09-43M	Fargo	7	38.5	898.2	859.7	CH	54.7	82	29	53	G4127A	brenna
09-43M	Fargo	8	43.5	898.2	854.7	CH	55.9	89	29	60	G4127A	brenna
09-43M	Fargo	9	48.5	898.2	849.7	CH	46.6	74	27	47	G4127A	brenna
09-43M	Fargo	10	53.5	898.2	844.7	CH	50.2	72	28	44	G4127A	argusville
09-43M	Fargo	11	58.5	898.2	839.7	CH	51.9	70	29	41	G4127A	argusville
09-43M	Fargo	12	63.5	898.2	834.7	CH	50.4	74	28	46	G4127A	argusville
09-43M	Fargo	13	68.5	898.2	829.7	CH	46.5	64	25	39	G4127A	argusville
09-44M	Fargo	1	4.5	885	880.5	CH	33	48	22	26	G4127A	sherack
09-44M	Fargo	2	6.5	885	878.5	CH	39.5	85	32	53	G4127A	PL sherack?
09-44M	Fargo	3	8.8	885	876.2	CH	55.3	101	32	69	G4127A	PL sherack?
09-44M	Fargo	4	13.5	885	871.5	CH	60.2	97	33	64	G4127A	PL sherack?
09-44M	Fargo	5	23.5	885	861.5	CH	59	97	31	66	G4127A	brenna
09-44M	Fargo	6	28.5	885	856.5	CH	61.6	92	29	63	G4127A	brenna
09-44M	Fargo	7	33.5	885	851.5	CH	54.6	90	26	64	G4127A	brenna
09-44M	Fargo	8	38.5	885	846.5	CH	50.9	76	28	48	G4127A	brenna
09-44M	Fargo	9	43.5	885	841.5	CH	42.6	69	24	45	G4127A	brenna
09-44M	Fargo	10	48.5	885	836.5	CH	51.8	76	26	50	G4127A	argusville
09-44M	Fargo	11	53.5	885	831.5	CH	49.6	80	29	51	G4127A	argusville
09-44M	Fargo	12	58.5	885	826.5	CH	49.4	75	27	48	G4127A	argusville
09-45M	Fargo	1	3.5	886.5	883	CH	30.5	68	26	42	G4127A	alluvium
09-45M	Fargo	2	8.5	886.5	878	CH	32.8	58	27	31	G4127A	topsoil/alluvium
09-45M	Fargo	3	13.5	886.5	873	CH	37.9	58	26	32	G4127A	alluvium
09-45M	Fargo	4	18.5	886.5	868	CH	35.5	55	26	29	G4127A	alluvium
09-45M	Fargo	5	23.5	886.5	863	CH	34.9	55	23	32	G4127A	alluvium
09-45M	Fargo	6	28.5	886.5	858	CH	35.8	58	23	35	G4127A	alluvium
09-45M	Fargo	7	33.5	886.5	853	CH	32.1	59	23	36	G4127A	alluvium
09-45M	Fargo	8	38.5	886.5	848	CH	59.6	91	30	61	G4127A	brenna
09-45M	Fargo	9	43.5	886.5	843	CH	63.9	96	30	66	G4127A	brenna
09-45M	Fargo	10	48.5	886.5	838	CH	58.9	80	29	51	G4127A	brenna
09-45M	Fargo	11	53.5	886.5	833	CH	56.3	75	27	48	G4127A	brenna
09-45M	Fargo	12	58.5	886.5	828	CH	52.1	72	27	45	G4127A	argusville
09-45M	Fargo	13	63.5	886.5	823	CH	50.5	73	26	47	G4127A	argusville
09-45M	Fargo	14	68.5	886.5	818	CH	49.8	68	26	42	G4127A	argusville
09-46M	Fargo	1	8.5	873.6	865.1	CH	41.7	62	25	37	G4127A	sherack
09-46M	Fargo	2	14.5	873.6	859.1	CH	45	55	23	32	G4127A	poplar river
09-46M	Fargo	3	19	873.6	854.6	CH	73	110	30	80	G4127A	brenna
09-46M	Fargo	4	24.5	873.6	849.1	CH	65	88	29	59	G4127A	brenna
09-46M	Fargo	5	29.5	873.6	844.1	CH	65.4	94	32	62	G4127A	brenna
09-46M	Fargo	6	35.5	873.6	838.1	CH	55.6	97	28	69	G4127A	brenna
09-46M	Fargo	7	41.5	873.6	832.1	CH	63.2	90	28	62	G4127A	brenna
09-46M	Fargo	8	47.5	873.6	826.1	CH	53.9	80	28	52	G4127A	brenna
09-46M	Fargo	9	54.5	873.6	819.1	CH	54.5	78	28	50	G4127A	brenna
09-46M	Fargo	10	59.5	873.6	814.1	CH	57.5	71	29	42	G4127A	brenna
09-46M	Fargo	11	65.5	873.6	808.1	CH	39	69	26	43	G4127A	brenna
09-46M	Fargo	12	71	873.6	802.6	CH	39.5	56	20	36	G4127A	argusville
09-46M	Fargo	13	79.5	873.6	794.1	CH	41.6	67	24	43	G4127A	argusville
09-46M	Fargo	14	89	873.6	784.6	CH					G4127A	till
09-47M	Fargo	1	3.5	890.9	887.4	CH	26.3	63	27	36	G4127A	topsoil/alluvium
09-47M	Fargo	2	13.5	890.9	877.4	CH	32	59	26	33	G4127A	alluvium
09-47M	Fargo	3	18.5	890.9	872.4	CH	31.2	56	24	32	G4127A	alluvium
09-47M	Fargo	4	23.5	890.9	867.4	CH	46.6	66	27	39	G4127A	alluvium
09-47M	Fargo	5	28.5	890.9	862.4	CH	42.8	61	26	35	G4127A	alluvium
09-47M	Fargo	6	33.5	890.9	857.4	CH	47.5	53	25	28	G4127A	alluvium
09-47M	Fargo	7	36.5	890.9	854.4	ML	24.4				G4127A	alluvium
09-47M	Fargo	8	38.3	890.9	852.6	ML	27.3				G4127A	alluvium
09-47M	Fargo	9	48.5	890.9	842.4	CH	56.1	91	33	58	G4127A	brenna
09-47M	Fargo	10	53.5	890.9	837.4	CH	53.6	83	29	54	G4127A	brenna
09-47M	Fargo	11	58.5	890.9	832.4	CH	48.5	80	28	52	G4127A	brenna
09-47M	Fargo	12	63.5	890.9	827.4	CH	45.9	75	27	48	G4127A	argusville
09-47M	Fargo	13	68.5	890.9	822.4	CH	47.3	62	24	38	G4127A	argusville
09-47M	Fargo	14	73.5	890.9	817.4	CH	42.3	65	25	40	G4127A	argusville

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH Latest Revision: 2/18/2011
Date: JUL 09 By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
09-48M	Fargo	1	4.5	877.5	873	CH	35.5	57	25	32	G4127A	topsoil/alluvium
09-48M	Fargo	2	9.5	877.5	868	CL	40.8	40	24	16	G4127A	poplar river
09-48M	Fargo	3	14.5	877.5	863	ML	28.9				G4127A	poplar river
09-48M	Fargo	4	19.5	877.5	858	CH	46.8	93	30	63	G4127A	brenna
09-48M	Fargo	5	24.5	877.5	853	CH	71.5	109	36	73	G4127A	brenna
09-48M	Fargo	6	30.5	877.5	847	CH	71.5	103	36	67	G4127A	brenna
09-48M	Fargo	7	36.5	877.5	841	CH	66.8	102	31	71	G4127A	brenna
09-48M	Fargo	8	44.5	877.5	833	CH	65.8	99	29	70	G4127A	brenna
09-48M	Fargo	9	49.5	877.5	828	CH	66.1	98	31	67	G4127A	brenna
09-48M	Fargo	10	54.5	877.5	823	CH	55.4	86	27	59	G4127A	brenna
09-48M	Fargo	11	65.5	877.5	812	CH	48.7	66	26	40	G4127A	argusville
09-49M	Fargo	1	8.5	881.1	872.6	CH	38.9	75	28	47	G4127A	sherack
09-49M	Fargo	2	13.5	881.1	867.6	CL	34.4	47	26	21	G4127A	poplar river
09-49M	Fargo	3	18.5	881.1	862.6	CL	31.4	28	21	7	G4127A	poplar river
09-49M	Fargo	4	23.25	881.1	857.85	CL	36.1	50	25	25	G4127A	poplar river
09-49M	Fargo	5	28.5	881.1	852.6	CH	67	102	32	70	G4127A	brenna
09-49M	Fargo	6	33.5	881.1	847.6	CH	69.3	101	34	67	G4127A	brenna
09-49M	Fargo	7	38.5	881.1	842.6	CH	60.2	101	31	70	G4127A	brenna
09-49M	Fargo	8	43.5	881.1	837.6	CH	56.9	89	27	62	G4127A	brenna
09-49M	Fargo	9	48.5	881.1	832.6	CH	51.9	75	27	48	G4127A	brenna
09-49M	Fargo	10	53.5	881.1	827.6	CH	59.5	85	27	58	G4127A	argusville
09-49M	Fargo	11	58.5	881.1	822.6	CH	46.6	70	27	43	G4127A	argusville
09-49M	Fargo	12	63.5	881.1	817.6	CH	50	73	26	47	G4127A	argusville
09-50M	Fargo	1	8.5	874.4	865.9	CH	47	67	26	41	G4127A	alluvium
09-50M	Fargo	2	14.5	874.4	859.9	CL	47.8	44	26	18	G4127A	sherack
09-50M	Fargo	3	19.5	874.4	854.9	ML	29.6	24	23	1	G4127A	poplar river
09-50M	Fargo	4	22.5	874.4	851.9	CH	38.4	55	27	28	G4127A	poplar river
09-50M	Fargo	5	29.5	874.4	844.9	CH	69	107	32	75	G4127A	brenna
09-50M	Fargo	6	35.5	874.4	838.9	CH	66.5	104	32	72	G4127A	brenna
09-50M	Fargo	7	44.5	874.4	829.9	CH	61	94	29	65	G4127A	brenna
09-50M	Fargo	8	49.5	874.4	824.9	CH	54.9	88	28	60	G4127A	brenna
09-50M	Fargo	9	54.5	874.4	819.9	CH	58.6	78	26	52	G4127A	brenna
09-50M	Fargo	10	59.5	874.4	814.9	CH	56.7	78	28	50	G4127A	brenna
09-50M	Fargo	11	64.5	874.4	809.9	CH	49.7	78	25	53	G4127A	argusville
09-51M	Fargo	1	8.5	879.3	870.8	CH	42.4	60	26	34	G4127A	topsoil/alluvium
09-51M	Fargo	2	13.5	879.3	865.8	CH	33.9	58	23	35	G4127A	alluvium
09-51M	Fargo	3	18.5	879.3	860.8	CH	35.5	63	19	44	G4127A	alluvium
09-51M	Fargo	4	23.5	879.3	855.8	CH	61.6	95	32	63	G4127A	brenna
09-51M	Fargo	5	28.5	879.3	850.8	CH	67.8	112	27	85	G4127A	brenna
09-51M	Fargo	6	33.5	879.3	845.8	CH	62	107	29	78	G4127A	brenna
09-51M	Fargo	7	38.5	879.3	840.8	CH	67.4	101	29	72	G4127A	brenna
09-51M	Fargo	8	43.5	879.3	835.8	CH	57.2	89	27	62	G4127A	brenna
09-51M	Fargo	9	48.5	879.3	830.8	CH	44.2	70	27	43	G4127A	brenna
09-51M	Fargo	10	53.5	879.3	825.8	CH	43.2	70	24	46	G4127A	argusville
09-51M	Fargo	11	58.5	879.3	820.8	CH	49.7	74	25	49	G4127A	argusville
09-51M	Fargo	12	63.5	879.3	815.8	CH	49.5	73	26	47	G4127A	argusville
09-52M	Fargo	1	5.5	874.3	868.8	CH	33.7	58	24	34	G4127A	alluvium
09-52M	Fargo	2	14.5	874.3	859.8	CL	35	49	25	24	G4127A	sherack
09-52M	Fargo	3	19.5	874.3	854.8	ML	29.5	24	23	1	G4127A	sherack
09-52M	Fargo	4	24.5	874.3	849.8	CL	36.2	44	24	20	G4127A	alluvium
09-52M	Fargo	5	29.5	874.3	844.8	CH	49.6	82	30	52	G4127A	brenna
09-52M	Fargo	6	34.5	874.3	839.8	CH	43.1	92	31	61	G4127A	brenna
09-52M	Fargo	7	40.5	874.3	833.8	CH	55.4	94	31	63	G4127A	brenna
09-52M	Fargo	8	44.5	874.3	829.8	CH	48.5	88	26	62	G4127A	brenna
09-52M	Fargo	9	49.5	874.3	824.8	CH	39.4	76	26	50	G4127A	brenna
09-52M	Fargo	10	54.5	874.3	819.8	CH	46.2	69	27	42	G4127A	argusville
09-52M	Fargo	11	57.5	874.3	816.8	CH	45.2	63	24	39	G4127A	argusville
09-53M	Fargo	1	8.5	876.9	868.4	CH	39.2	50	28	22	G4127A	topsoil/alluvium
09-53M	Fargo	2	13.5	876.9	863.4	CL	28.4	43	20	23	G4127A	alluvium
09-53M	Fargo	3	18.5	876.9	858.4	CL	26.9	48	22	26	G4127A	alluvium
09-53M	Fargo	4	23.5	876.9	853.4	CH	54.8	96	30	66	G4127A	brenna
09-53M	Fargo	5	28.5	876.9	848.4	CH	59	106	33	73	G4127A	brenna
09-53M	Fargo	6	33.5	876.9	843.4	CH	60.3	91	30	61	G4127A	brenna
09-53M	Fargo	7	38.5	876.9	838.4	CH	70.3	104	36	68	G4127A	brenna
09-53M	Fargo	8	43.5	876.9	833.4	CH	67	98	35	63	G4127A	brenna
09-53M	Fargo	9	48.5	876.9	828.4	CH	55.8	80	29	51	G4127A	brenna
09-53M	Fargo	10	53.5	876.9	823.4	CH	55.5	81	26	55	G4127A	brenna
09-53M	Fargo	11	58.5	876.9	818.4	CH	52.5	73	30	43	G4127A	argusville
09-53M	Fargo	12	63.5	876.9	813.4	CH	54.9	70	25	45	G4127A	argusville
09-53M	Fargo	13	68.5	876.9	808.4	CH	49.1	75	26	49	G4127A	argusville
09-54M	Fargo	1	4.5	876.7	872.2	CH	34.1	60	24	36	G4127A	alluvium
09-54M	Fargo	2	9.5	876.7	867.2	CH	29.3	56	23	33	G4127A	alluvium
09-54M	Fargo	3	15.5	876.7	861.2	CH	32.5	52	23	29	G4127A	alluvium
09-54M	Fargo	4	21.5	876.7	855.2	CH	33.2	53	22	31	G4127A	alluvium
09-54M	Fargo	5	29.5	876.7	847.2	CH	34.9	56	25	31	G4127A	poplar river
09-54M	Fargo	6	34.5	876.7	842.2	CH	54.3	86	25	61	G4127A	brenna
09-54M	Fargo	7	39.5	876.7	837.2	CH	54.9	77	27	50	G4127A	brenna
09-54M	Fargo	8	44.5	876.7	832.2	CH	48.4	71	22	49	G4127A	brenna
09-54M	Fargo	9	49.5	876.7	827.2	CH	43.1	56	23	33	G4127A	brenna
09-54M	Fargo	10	54.5	876.7	822.2	CH	47.1	66	24	42	G4127A	brenna
09-54M	Fargo	11	59.5	876.7	817.2	CH	45.2	68	21	47	G4127A	argusville
09-54M	Fargo	12	64.5	876.7	812.2	CH	47	69	25	44	G4127A	argusville

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH
Date: JUL 09

Latest Revision: 2/18/2011
By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
09-55M	Fargo	1	8.5	881.8	873.3	CH	32.2	61	27	34	G4127A	alluvium
09-55M	Fargo	2	13.5	881.8	868.3	CH	26.7	55	15	40	G4127A	alluvium
09-55M	Fargo	3	18.5	881.8	863.3	CH	30.6	59	20	39	G4127A	alluvium
09-55M	Fargo	4	28.5	881.8	853.3	CH	28	49	21	28	G4127A	alluvium
09-55M	Fargo	5	33.5	881.8	848.3	CH	28.1	62	20	42	G4127A	?
09-55M	Fargo	6	38.5	881.8	843.3	CH	62.5	107	36	71	G4127A	brenna
09-55M	Fargo	7	43.5	881.8	838.3	CH	66.9	106	35	71	G4127A	brenna
09-55M	Fargo	8	48.5	881.8	833.3	CH	62.6	104	34	70	G4127A	brenna
09-55M	Fargo	9	53.5	881.8	828.3	CH	54.8	78	29	49	G4127A	argusville
09-55M	Fargo	10	58.5	881.8	823.3	CH	48.6	72	27	45	G4127A	argusville
09-57M	ND Div	1	3.5	908.9	905.4	CH	28.3	65	23	42	7314	Topsoil
09-57M	ND Div	2	8.5	908.9	900.4	CH	29.8	59	24	35	7314	Alluvium
09-57M	ND Div	3	13.5	908.9	895.4	CH	26.4	58	23	35	7314	Alluvium
09-57M	ND Div	4	18.5	908.9	890.4	CH	27.5	65	22	43	7314	Alluvium
09-57M	ND Div	5	24.5	908.9	884.4	CL	32.7	59	20	39	7314	Sherack
09-57M	ND Div	6	28.5	908.9	880.4	CH	46.6	87	23	64	7314	Sherack
09-57M	ND Div	7	33.5	908.9	875.4	CH	40.1	65	23	42	7314	argusville
09-57M	ND Div	8	38.5	908.9	870.4	CH	42.9	65	25	40	7314	A?
09-57M	ND Div	9	43.5	908.9	865.4	CH	39.9	69	28	41	7314	Argusville
09-57M	ND Div	10	48.5	908.9	860.4	CL/CH	32.7	49	22	27	7314	Argusville
09-57M	ND Div	11	53.5	908.9	855.4	SM/SC-SM	13.1	20	16	4	7314	CL
09-58M	ND Div	1	4.5	882.3	877.8	CH	34.7	75	28	47	7314	Alluvium
09-58M	ND Div	2	9.5	882.3	872.8	CH	28.3	68	30	38	7314	Sherack
09-58M	ND Div	3	14.5	882.3	867.8	CH	43.8	76	32	44	7314	Sherack
09-58M	ND Div	4	19.5	882.3	862.8	CH	36.3	64	31	33	7314	PR - Harwood
09-58M	ND Div	5	24	882.3	858.3	CH	59.5	102	40	62	7314	PR - Harwood
09-58M	ND Div	6	29	882.3	853.3	CH	67.2	106	36	70	7314	Brenna
09-58M	ND Div	7	34	882.3	848.3	CH	62.7	97	36	61	7314	Brenna
09-58M	ND Div	8	39	882.3	843.3	CH	72.2	114	36	78	7314	Brenna
09-58M	ND Div	9	44	882.3	838.3	CH	58.7	97	35	62	7314	Brenna
09-58M	ND Div	10	54	882.3	828.3	CH	55.3	85	32	53	7314	Brenna
09-58M	ND Div	11	64	882.3	818.3	CH	65.6	116	32	84	7314	Brenna
09-58M	ND Div	12	69	882.3	813.3	CH	60.7	103	31	72	7314	Brenna
09-58M	ND Div	13	74	882.3	808.3	CH	62.4	97	30	67	7314	B/A
09-58M	ND Div	14	79	882.3	803.3	CH	53	86	30	56	7314	B/A
09-58M	ND Div	15	86	882.3	796.3	CH	49.7	65	27	38	7314	Argusville
09-58M	ND Div	16	94	882.3	788.3	CL	18.3	30	17	13	7314	Till
09-58M	ND Div	17	106	882.3	776.3	CL	20.2	34	16	18	7314	Till
09-59M	ND Div	1	3.5	916.2	912.7	CH	33.2	71	22	49	7314	Topsoil
09-59M	ND Div	2	8.5	916.2	907.7	CH	35.9	81	26	55	7314	CH
09-59M	ND Div	3	14.5	916.2	901.7	CH	46.8	83	26	57	7314	CH
09-59M	ND Div	4	18.9	916.2	897.3	CH	48.9	76	24	52	7314	CH
09-59M	ND Div	5	23.3	916.2	892.9	CH	43.9	78	28	50	7314	CH
09-59M	ND Div	6	28.5	916.2	887.7	CH	42.1	82	29	53	7314	CH
09-59M	ND Div	7	33.5	916.2	882.7	CH	44	78	31	47	7314	B/A
09-59M	ND Div	8	38.5	916.2	877.7	CH	38.1	59	25	34	7314	B/A
09-59M	ND Div	9	43.5	916.2	872.7	CH	45.4	76	27	49	7314	Argusville
09-59M	ND Div	10	48.5	916.2	867.7	CH	48.8	92	29	63	7314	Argusville
09-59M	ND Div	11	53.5	916.2	862.7	CH	34.9	56	25	31	7314	Argusville
09-59M	ND Div	12	58.5	916.2	857.7	CH	44.7	67	28	39	7314	Argusville
09-59M	ND Div	13	63.5	916.2	852.7	CH	47.2	78	23	55	7314	Argusville
09-59M	ND Div	14	68.5	916.2	847.7	CH	28.3	52	17	35	7314	Argusville
09-59M	ND Div	15	73.5	916.2	842.7	CH	18.1	26	15	11	7314	Till
09-60M	ND Div	1	4	887.3	883.3	CH	37.7	80	28	52	7314	Topsoil
09-60M	ND Div	2	9	887.3	878.3	CH	32.4	69	24	45	7314	Alluvium
09-60M	ND Div	3	14	887.3	873.3	CH	51.6	108	40	68	7314	CH
09-60M	ND Div	4	19	887.3	868.3	CH	52.1	100	37	63	7314	CH
09-60M	ND Div	5	24	887.3	863.3	CH	54.3	89	37	52	7314	CH
09-60M	ND Div	6	29	887.3	858.3	CH	51.2	95	37	58	7314	CH
09-60M	ND Div	7	36.5	887.3	850.8	CH	58.7	95	37	58	7314	Brenna
09-60M	ND Div	8	44	887.3	843.3	CH	61.5	106	36	70	7314	Brenna
09-60M	ND Div	10	56.5	887.3	830.8	CH	50.2	88	29	59	7314	Brenna
09-60M	ND Div	11	61.5	887.3	825.8	CH	48.5	72	28	44	7314	Argusville
09-60M	ND Div	12	69	887.3	818.3	CL	18.8				7314	Till
09-60M	ND Div	13	74	887.3	813.3	CL	19.8	30	16	14	7314	SP-SM
09-60M	ND Div	14	81	887.3	806.3	CL	17.3	33	16	17	7314	Till
09-60M	ND Div	15	91	887.3	796.3	CL	12	29	17	12	7314	Till
09-61M	ND Div	1	3.5	918.2	914.7	CH	42.1	85	29	56	7314	Alluvium
09-61M	ND Div	2	8.5	918.2	909.7	CH	35.9	87	29	58	7314	CH
09-61M	ND Div	3	13.5	918.2	904.7	CH	42.9	91	30	61	7314	CH
09-61M	ND Div	4	18.5	918.2	899.7	CH	46.8	83	23	60	7314	CH
09-61M	ND Div	5	23.85	918.2	894.35	CH	48	88	25	63	7314	Brenna
09-61M	ND Div	6	28.5	918.2	889.7	CH	45.6	80	26	54	7314	Brenna
09-61M	ND Div	7	33.35	918.2	884.85	CH	44.5	79	24	55	7314	Brenna
09-61M	ND Div	8	38.5	918.2	879.7	CH	55.6	78	27	51	7314	Argusville
09-61M	ND Div	9	43	918.2	875.2	CH	51.2	91	24	67	7314	Argusville
09-61M	ND Div	10	48.5	918.2	869.7	CH	46.1	84	24	60	7314	Argusville
09-61M	ND Div	11	53.5	918.2	864.7	CH	50.5	78	25	53	7314	Argusville
09-61M	ND Div	12	58.5	918.2	859.7	CH	54.1	79	25	54	7314	Argusville
09-61M	ND Div	13	63.5	918.2	854.7	CH	48.7	82	25	57	7314	Argusville
09-61M	ND Div	14	68.5	918.2	849.7	CL	14.9	28	16	12	7314	Till

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH Latest Revision: 2/18/2011
Date: JUL 09 By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
09-62M	ND Div	1	5.5	893.1	887.6	CH	34.3	74	26	48	7314	Alluvium
09-62M	ND Div	2	9	893.1	884.1	CH	34.3	81	25	56	7314	Sherack
09-62M	ND Div	3	14	893.1	879.1	CH	46	74	36	38	7314	Sherack
09-62M	ND Div	4	19	893.1	874.1	CH	59.7	115	42	73	7314	CH
09-62M	ND Div	5	24	893.1	869.1	CH	58.4	100	38	62	7314	CH
09-62M	ND Div	6	29	893.1	864.1	CH	53.3	98	36	62	7314	Brenna
09-62M	ND Div	7	34	893.1	859.1	CH	60.8	104	38	66	7314	Brenna
09-62M	ND Div	8	41.5	893.1	851.6	CH	62.3	102	33	69	7314	Brenna
09-62M	ND Div	9	49	893.1	844.1	CH	68.2	96	35	61	7314	Brenna
09-62M	ND Div	10	56.5	893.1	836.6	CH	49.9	88	32	56	7314	Brenna
09-62M	ND Div	11	64	893.1	829.1	CH	59.1	86	33	53	7314	Brenna
09-62M	ND Div	12	69	893.1	824.1	CL	19.5	28	17	11	7314	Till
09-62M	ND Div	13	75.5	893.1	817.6	CL	18.1	30	16	14	7314	Till
09-62M	ND Div	14	83.5	893.1	809.6	CL	19	40	17	23	7314	Till
09-63M	ND Div	1	9	903.7	894.7	CH	37.2	83	29	54	7314	Alluvium
09-63M	ND Div	2	13.5	903.7	890.2	CH	47.5	110	35	75	7314	CH
09-63M	ND Div	3	19.5	903.7	884.2	CH	51.8	100	31	69	7314	CH
09-63M	ND Div	4	23.5	903.7	880.2	CH	56.3	94	31	63	7314	Brenna
09-63M	ND Div	5	28.25	903.7	875.45	CH	56.1	87	34	53	7314	Brenna
09-63M	ND Div	6	33	903.7	870.7	CH	66.4	91	35	56	7314	Brenna
09-63M	ND Div	7	38.5	903.7	865.2	CH	61.5	95	35	60	7314	Argusville
09-63M	ND Div	8	43.5	903.7	860.2	CH	52.3	87	29	58	7314	Argusville
09-63M	ND Div	9	48.5	903.7	855.2	CH	50.2	77	26	51	7314	Argusville
09-63M	ND Div	10	53.5	903.7	850.2	CL	21.7	33	17	16	7314	Till
09-63M	ND Div	11	58.5	903.7	845.2	CL	21	26	17	9	7314	Till
09-63M	ND Div	12	63.5	903.7	840.2	CL	20.2	32	17	15	7314	Till
09-63M	ND Div	13	68.5	903.7	835.2	CL	18.7	41	21	20	7314	Till
09-64M	ND Div	1	7.5	898.3	890.8	CH	31.5	80	24	56	7314	Alluvium
09-64M	ND Div	2	11.5	898.3	886.8	CH	38.9	83	31	52	7314	Sherack
09-64M	ND Div	3	13.75	898.3	884.55	SC	32.6	26	19	7	7314	Alluvium
09-64M	ND Div	4	19	898.3	879.3	CH	63.8	120	34	86	7314	CH
09-64M	ND Div	5	24	898.3	874.3	CH	56.2	105	33	72	7314	Brenna
09-64M	ND Div	6	29	898.3	869.3	CH	63.2	104	33	71	7314	Brenna
09-64M	ND Div	7	34	898.3	864.3	CH	66.7	113	32	81	7314	Brenna
09-64M	ND Div	8	39	898.3	859.3	CH	59.4	109	30	79	7314	Brenna
09-64M	ND Div	9	44	898.3	854.3	CH	67.5	107	31	76	7314	Brenna
09-64M	ND Div	10	51.5	898.3	846.8	CH	60.9	90	31	59	7314	Brenna
09-64M	ND Div	11	57.5	898.3	840.8	CH	57.8	81	30	51	7314	Brenna
09-64M	ND Div	12	64	898.3	834.3	CH	57.4	86	28	58	7314	Brenna
09-64M	ND Div	13	69	898.3	829.3	CL	20.7	30	17	13	7314	Till
09-64M	ND Div	14	72.75	898.3	825.55	SC	18.2	33	20	13	7314	Till
09-65M	ND Div	1	9	902.6	893.6	CL	19.2	34	15	19	7314	Alluvium
09-65M	ND Div	2	14	902.6	888.6	CL	27.7	42	21	21	7314	Alluvium
09-65M	ND Div	3	19	902.6	883.6	CH	31.7	78	24	54	7314	Alluvium
09-65M	ND Div	4	24	902.6	878.6	CH	31.5	70	26	44	7314	Alluvium
09-65M	ND Div	5	29	902.6	873.6	CH	36.9	80	27	53	7314	Alluvium
09-65M	ND Div	6	34	902.6	868.6	CH	53.7	111	38	73	7314	Brenna
09-65M	ND Div	7	39	902.6	863.6	CH	63.5	114	36	78	7314	Brenna
09-65M	ND Div	8	44	902.6	858.6	CH	62.4	105	39	66	7314	Brenna
09-65M	ND Div	9	51.5	902.6	851.1	CH	62.6	97	34	63	7314	Brenna
09-65M	ND Div	10	59	902.6	843.6	CH	50.2	87	32	55	7314	Brenna
09-65M	ND Div	11	64	902.6	838.6	CH	29.7	40	18	22	7314	Till
09-65M	ND Div	12	69	902.6	833.6	CL	19.5	39	17	22	7314	Till
10-66M	Fargo	1	3.5	915.157	911.657	CH	37.5	73	24	49		Topsoil
10-66M	Fargo	2	8.5	915.157	906.657	CH	38	87	29	58		brenna
10-66M	Fargo	3	13.5	915.157	901.657	CH	44.1	80	26	54		Brenna
10-66M	Fargo	4	18.5	915.157	896.657	CH	46.8	83	26	57		Brenna
10-66M	Fargo	5	28.5	915.157	886.657	CH	39	64	22	42		Brenna
10-66M	Fargo	6	34.5	915.157	880.657	CH	40	56	24	32		Brenna
10-66M	Fargo	7	38.5	915.157	876.657	CH	37.5	63	27	36		Brenna
10-66M	Fargo	8	43.5	915.157	871.657	CH	38.1	56	26	30		Brenna
10-66M	Fargo	9	48.5	915.157	866.657	CH	41.7	68	26	42		argusville
10-66M	Fargo	10	53.5	915.157	861.657	CH	38.8	67	25	42		argusville
10-66M	Fargo	11	58.5	915.157	856.657	CH	40	91	28	63		argusville
10-66M	Fargo	12	64.2	915.157	850.957	SC	31.1	27	15	12		unit "A" till
10-66M	Fargo	13	70.5	915.157	844.657	CL – ML	15.3	19	12	7		unit "A" till
10-66M	Fargo	14	85.5	915.157	829.657	CL	14.7	30	16	14		unit "A" till

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH Latest Revision: 2/18/2011
Date: JUL 09 By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
10-67M	Fargo	1	3.25	885.73	882.48	CH	37.3	76	25	51		sherack
10-67M	Fargo	2	8.75	885.73	876.98	CH	32.3	73	23	50		sherack
10-67M	Fargo	3	13.25	885.73	872.48	CH	35.2	73	22	51		Sherack
10-67M	Fargo	4	15.75	885.73	869.98	CH	38.3	92	30	62		dessicated brenna
10-67M	Fargo	5	18.75	885.73	866.98	CH	51.9	100	30	70		brenna
10-67M	Fargo	6	23.75	885.73	861.98	CH	56.7	104	29	75		Brenna
10-67M	Fargo	7	29.75	885.73	855.98	CH	60.5	116	39	77		Brenna
10-67M	Fargo	8	34.25	885.73	851.48	CH	61.9	99	34	65		Brenna
10-67M	Fargo	9	38.25	885.73	847.48	CH	52.1	98	30	68		Brenna
10-67M	Fargo	10	43.75	885.73	841.98	CH	56.5	96	33	63		Brenna
10-67M	Fargo	11	49.25	885.73	836.48	CH	66.2	108	35	73		Brenna
10-67M	Fargo	12	54.25	885.73	831.48	CH	58.6	109	33	76		Brenna
10-67M	Fargo	13	58.75	885.73	826.98	CH	57.6	101	30	71		Brenna
10-67M	Fargo	14	64.25	885.73	821.48	CH	59.5	98	33	65		Brenna
10-67M	Fargo	15	69.75	885.73	815.98	CH	49.4	88	23	65		Brenna
10-67M	Fargo	16	71.25	885.73	814.48	CH	50.4	90	28	62		brenna
10-67M	Fargo	17	79.25	885.73	806.48	CH	50.2	85	22	63		brenna
10-67M	Fargo	18	81.25	885.73	804.48	ML	30.7	23	20	3		ML
10-67M	Fargo	19	82.2	885.73	803.53	CH	51.9	75	32	43		CH
10-67M	Fargo	20	84.25	885.73	801.48	CL – ML	18.3	22	16	6		unit "A" till
10-67M	Fargo	21	86.75	885.73	798.98	CL	17	32	14	18		unit "A" till
10-67M	Fargo	22	93.25	885.73	792.48	CL	24.5	32	17	15		unit "A" till
10-67M	Fargo	23	98.25	885.73	787.48	SM	10.8	13	10	3		SM
10-67M	Fargo	24	103.25	885.73	782.48	ML	11.2					ML
10-67M	Fargo	25	108.25	885.73	777.48	ML	9.8	12	12	0		ML
10-67M	Fargo	26	113.75	885.73	771.98	ML	8.9	13	12	1		ML
10-68M	Fargo	1	1.75	917.457	915.707	CH	35	74	26	48		Topsoil
10-68M	Fargo	2	8.75	917.457	908.707	CH	40.9	71	33	38		Oxidized Brenna
10-68M	Fargo	3	13.75	917.457	903.707	CH	43.9	76	27	49		Oxidized Brenna
10-68M	Fargo	4	18.75	917.457	898.707	CH	43.3	76	26	50		Oxidized Brenna
10-68M	Fargo	5	23.25	917.457	894.207	CH	47.8	78	25	53		Oxidized Brenna
10-68M	Fargo	6	28.5	917.457	888.957	CH	47.1	74	26	48		brenna
10-68M	Fargo	7	33.5	917.457	883.957	CH	42.1	91	30	61		brenna
10-68M	Fargo	8	38.5	917.457	878.957	CH	40	69	23	46		brenna
10-68M	Fargo	9	43.5	917.457	873.957	CH	49.5	57	22	35		brenna
10-68M	Fargo	10	48.5	917.457	868.957	CH	48.2	81	30	51		argusville
10-68M	Fargo	11	53.5	917.457	863.957	CH	50.4	76	31	45		argusville
10-68M	Fargo	12	58.5	917.457	858.957	CH	47	71	33	38		argusville
10-68M	Fargo	13	63.5	917.457	853.957	CH	41	59	27	32		argusville
10-68M	Fargo	14	68.5	917.457	848.957	CL – ML	12.1	21	16	5		unit "A" till
10-68M	Fargo	15	75.5	917.457	841.957	CL – ML	14.1	25	19	6		unit "A" till
10-69M	Fargo	1	8.5	895.104	886.604	CH	33	81	29	52		sherack
10-69M	Fargo	2	14	895.104	881.104	CH	41.9	99	35	64		Oxidized Brenna
10-69M	Fargo	3	18.5	895.104	876.604	CH	60	112	40	72		Oxidized Brenna
10-69M	Fargo	4	23.5	895.104	871.604	CH	67.4	108	34	74		brenna
10-69M	Fargo	5	28.3	895.104	866.804	CH	55.5	92	30	62		brenna
10-69M	Fargo	6	38.35	895.104	856.754	CH	70.7	113	31	82		brenna
10-69M	Fargo	7	43.5	895.104	851.604	CH	66.1	117	29	88		brenna
10-69M	Fargo	8	48.5	895.104	846.604	CH	59.6	108	30	78		argusville
10-69M	Fargo	9	53.5	895.104	841.604	CH	60.7	104	30	74		argusville
10-69M	Fargo	10	58.5	895.104	836.604	CH	61	92	32	60		argusville
10-69M	Fargo	11	63.5	895.104	831.604	CH	56.1	105	29	76		argusville
10-69M	Fargo	12	68.5	895.104	826.604	CH	50.9	75	26	49		argusville
10-69M	Fargo	13	73.5	895.104	821.604	CL	20	31	18	13		unit "A" till
10-69M	Fargo	14	80.5	895.104	814.604	CL	14.4	34	14	20		unit "A" till
10-70M	Fargo	1	1.25	918.345	917.095	CH	37.5	84	32	52		Topsoil
10-70M	Fargo	2	5.75	918.345	912.595	CH	35.5	72	21	51		Brenna
10-70M	Fargo	3	7.95	918.345	910.395	CH	33.8	77	23	54		Brenna
10-70M	Fargo	4	13.75	918.345	904.595	CH	40.5	74	26	48		Brenna
10-70M	Fargo	5	18.75	918.345	899.595	CH	47.5	84	29	55		Brenna
10-70M	Fargo	6	24.25	918.345	894.095	CH	41.8	75	26	49		Brenna
10-70M	Fargo	7	27.25	918.345	891.095	CH	43.7	81	25	56		argusville
10-70M	Fargo	8	33.75	918.345	884.595	CH	42.7	85	26	59		argusville
10-70M	Fargo	9	37.25	918.345	881.095	CH	43.8	72	28	44		argusville
10-70M	Fargo	10	44.25	918.345	874.095	CH	44.9	79	26	53		argusville
10-70M	Fargo	11	48.75	918.345	869.595	CH	42.7	65	25	40		argusville
10-70M	Fargo	12	53.25	918.345	865.095	CH	54.5	91	29	62		argusville
10-70M	Fargo	13	57.25	918.345	861.095	CH	47.7	73	28	45		argusville
10-70M	Fargo	14	64.75	918.345	853.595	CH	58.4	86	24	62		argusville
10-70M	Fargo	15	67.25	918.345	851.095	CL	42.5	47	26	21		unit "A" till
10-70M	Fargo	16	68.75	918.345	849.595	SC	17.3	25	14	11		unit "A" till
10-70M	Fargo	17	73.25	918.345	845.095	SP	17.1					sand
10-70M	Fargo	18	84.25	918.345	834.095	SP	16.8					sand
10-70M	Fargo	19	78.25	918.345	840.095	SP	22.8					sand

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH
Date: JUL 09

Latest Revision: 2/18/2011
By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
10-71M	Fargo	1	3.5	896.571	893.071	CH	39.6	75	30	45		Topsoil
10-71M	Fargo	2	8.5	896.571	888.071	CH	36.9	73	21	52		sherack
10-71M	Fargo	3	10.5	896.571	886.071	CH	37.1	73	26	47		sherack
10-71M	Fargo	4	13.5	896.571	883.071	CH	45.6	102	30	72		Oxidized Brenna
10-71M	Fargo	5	18.5	896.571	878.071	CH	52.3	111	29	82		Oxidized Brenna
10-71M	Fargo	6	23.6	896.571	872.971	CH	54.5	107	31	76		brenna
10-71M	Fargo	7	28.5	896.571	868.071	CH	55	92	30	62		brenna
10-71M	Fargo	8	33.5	896.571	863.071	CH	67.1	118	23	95		brenna
10-71M	Fargo	9	38.5	896.571	858.071	CH	60.8	115	17	98		brenna
10-71M	Fargo	10	43.5	896.571	853.071	CH	64.5	107	28	79		brenna
10-71M	Fargo	11	48.5	896.571	848.071	CH	62.4	102	28	74		argusville
10-71M	Fargo	12	53.5	896.571	843.071	CH	50.9	91	27	64		argusville
10-71M	Fargo	13	58.5	896.571	838.071	CH	51.2	76	24	52		argusville
10-71M	Fargo	14	64.15	896.571	832.421	CL	37.6	33	23	10		unit "A" till
10-71M	Fargo	15	68.5	896.571	828.071	SC	18.5	30	15	15		unit "A" till
10-71M	Fargo	16	73.5	896.571	823.071	CL	17	28	16	12		unit "A" till
10-71M	Fargo	17	93.5	896.571	803.071	ML	37.1	45	34	11		unit "A" till
10-72M	Fargo	1	3.75	894.034	890.284	CH	35.2	81	34	47		Topsoil
10-72M	Fargo	2	6.25	894.034	887.784	CH	33.9	74	29	45		fill
10-72M	Fargo	3	9.25	894.034	884.784	CH	32.9	74	26	48		sherack
10-72M	Fargo	4	11.75	894.034	882.284	CH	35.7	60	25	35		sherack
10-72M	Fargo	5	14.25	894.034	879.784	CH	41	98	36	62		Oxidized Brenna
10-72M	Fargo	6	19.25	894.034	874.784	CH	54.5	110	40	70		Oxidized Brenna
10-72M	Fargo	7	22.25	894.034	871.784	CH	63.3	114	29	85		Oxidized Brenna
10-72M	Fargo	8	27.75	894.034	866.284	CH	56.3	103	32	71		Brenna
10-72M	Fargo	9	30.25	894.034	863.784	CH	61	98	33	65		Brenna
10-72M	Fargo	10	39.25	894.034	854.784	CH	58.5	100	33	67		Brenna
10-72M	Fargo	11	43.75	894.034	850.284	CH	63.3	115	27	88		Brenna
10-72M	Fargo	12	49.25	894.034	844.784	CH	64.8	116	35	81		argusville
10-72M	Fargo	13	50.25	894.034	843.784	CH	63.3	109	33	76		argusville
10-72M	Fargo	14	54.75	894.034	839.284	CH	54.5	105	29	76		argusville
10-72M	Fargo	15	59.25	894.034	834.784	CH	53.8	98	29	69		argusville
10-72M	Fargo	16	63.25	894.034	830.784	CH	57	90	32	58		argusville
10-72M	Fargo	17	68.75	894.034	825.284	CH	58.6	99	30	69		argusville
10-72M	Fargo	18	72.25	894.034	821.784	CH	61	84	28	56		argusville
10-72M	Fargo	19	78.25	894.034	815.784	SC	17	29	16	13		unit "A" till
10-72M	Fargo	20	88.75	894.034	805.284	CL	13.5	33	17	16		unit "A" till
10-73M	Fargo	1	2	883.857	881.857	ML	40.7	55	30	25		dessicated brenna
10-73M	Fargo	2	4	883.857	879.857	CH	46.1	109	31	78		dessicated brenna
10-73M	Fargo	3	8.5	883.857	875.357	CH	61.9	112	30	82		dessicated brenna
10-73M	Fargo	4	13.5	883.857	870.357	CH	57.7	107	35	72		dessicated brenna
10-73M	Fargo	5	18.5	883.857	865.357	CH	54.1	96	35	61		dessicated brenna
10-73M	Fargo	6	23.5	883.857	860.357	CH	69.6	112	33	79		brenna
10-73M	Fargo	7	28.5	883.857	855.357	CH	63.1	102	34	68		brenna
10-73M	Fargo	8	33.5	883.857	850.357	CH	74.4	122	35	87		brenna
10-73M	Fargo	9	38.5	883.857	845.357	CH	62.2	113	29	84		brenna
10-73M	Fargo	10	40.5	883.857	843.357	CH	67.6	120	35	85		brenna
10-73M	Fargo	11	42.5	883.857	841.357	CH	60.7	103	30	73		argusville
10-73M	Fargo	12	48.5	883.857	835.357	CH	59.2	96	29	67		argusville
10-73M	Fargo	13	53.5	883.857	830.357	CH	59.7	93	30	63		argusville
10-73M	Fargo	14	58.5	883.857	825.357	CH	63.7	87	35	52		argusville
10-73M	Fargo	15	63.5	883.857	820.357	CL	18.5	26	16	10		unit "A" till
10-73M	Fargo	16	68.25	883.857	815.607	SC	18	26	15	11		unit "A" till
10-73M	Fargo	17	76	883.857	807.857	CL	17.7	33	19	14		unit "A" till
10-73M	Fargo	18	85.5	883.857	798.357	CL	22	33	18	15		unit "A" till
10-74M	Fargo	1	1.25	880.475	879.225	CH	36.5	70	23	47		Topsoil
10-74M	Fargo	2	4.75	880.475	875.725	CH	27.4	65	24	41		Alluvium
10-74M	Fargo	3	8.25	880.475	872.225	CH	38.4	84	29	55		sherack
10-74M	Fargo	4	13.75	880.475	866.725	CH	43.1	84	27	57		sherack
10-74M	Fargo	5	19.25	880.475	861.225	CH	36.6	69	26	43		sherack
10-74M	Fargo	6	21.25	880.475	859.225	CH	44.4	101	33	68		Oxidized Brenna
10-74M	Fargo	7	24.25	880.475	856.225	CH	59	115	37	78		Oxidized Brenna
10-74M	Fargo	8	28.75	880.475	851.725	CH	55.1	107	34	73		Oxidized Brenna
10-74M	Fargo	9	32.75	880.475	847.725	CH	56.8	102	29	73		Brenna
10-74M	Fargo	10	38.75	880.475	841.725	CH	55.9	98	30	68		Brenna
10-74M	Fargo	11	43.75	880.475	836.725	CH	75.7	109	28	81		Brenna
10-74M	Fargo	12	48.75	880.475	831.725	CH	50.8	94	28	66		Brenna
10-74M	Fargo	13	53.75	880.475	826.725	CH	63.6	110	31	79		Brenna
10-74M	Fargo	14	58.75	880.475	821.725	CH	60.1	111	25	86		Brenna
10-74M	Fargo	15	63.75	880.475	816.725	CH	54.5	106	31	75		Brenna
10-74M	Fargo	16	67.75	880.475	812.725	CH	58	103	30	73		Brenna
10-74M	Fargo	17	70.25	880.475	810.225	CH	59.8	108	27	81		Brenna
10-74M	Fargo	18	74.75	880.475	805.725	CH	57	98	29	69		argusville
10-74M	Fargo	19	76.25	880.475	804.225	CH	56	89	27	62		argusville
10-74M	Fargo	20	79.75	880.475	800.725	CH	51.8	74	27	47		argusville
10-74M	Fargo	21	81.75	880.475	798.725	CH	43.9	76	24	52		argusville
10-74M	Fargo	22	87.75	880.475	792.725	CH	36.5	59	24	35		argusville
10-74M	Fargo	23	93.25	880.475	787.225	CL	20.3	26	16	10		unit "A" till
10-74M	Fargo	24	95.75	880.475	784.725	CL	10.9	29	15	14		unit "A" till
10-74M	Fargo	25	98.35	880.475	782.125	CL	11.9	22	14	8		unit "A" till
10-74M	Fargo	26	103.25	880.475	777.225	CL	20.8	35	17	18		unit "A" till
10-74M	Fargo	27	108.25	880.475	772.225	CL-ML	21.6	23	19	4		unit "A" till
10-74M	Fargo	28	113.75	880.475	766.725	CL	20.9	35	19	16		unit "A" till

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH
Date: JUL 09

Latest Revision: 2/18/2011
By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
10-75M	Fargo	1	4.5	890.601	886.101	CH	30.2	66	23	43		Alluvium
10-75M	Fargo	2	8.1	890.601	882.501	CH	34	77	26	51		sherack
10-75M	Fargo	3	9.5	890.601	881.101	CH	40	105	32	73		dessicated brenna
10-75M	Fargo	4	13.5	890.601	877.101	CH	61.5	111	36	75		brenna
10-75M	Fargo	5	18.5	890.601	872.101	CH	50.7	96	35	61		brenna
10-75M	Fargo	6	23.5	890.601	867.101	CH	49.2	88	31	57		brenna
10-75M	Fargo	7	28.5	890.601	862.101	CH	60.7	94	32	62		brenna
10-75M	Fargo	8	33.4	890.601	857.201	CH	54.3	93	35	58		brenna
10-75M	Fargo	9	38.35	890.601	852.251	CH	57.3	92	34	58		brenna
10-75M	Fargo	10	43.5	890.601	847.101	CH	63.6	110	30	80		brenna
10-75M	Fargo	11	48.5	890.601	842.101	CH	60.9	100	32	68		argusville
10-75M	Fargo	12	53.5	890.601	837.101	CH	53	90	26	64		argusville
10-75M	Fargo	13	58.5	890.601	832.101	CH	61.9	76	31	45		argusville
10-75M	Fargo	14	63.5	890.601	827.101	CH	31.3	90	26	64		argusville
10-75M	Fargo	15	68.5	890.601	822.101	CL	14.6	28	17	11		unit "A" till
10-75M	Fargo	16	73.5	890.601	817.101	CL	18.5	27	17	10		unit "A" till
10-75M	Fargo	17	85.5	890.601	805.101	CL	12.5	42	19	23		unit "A" till
10-75M	Fargo	18	95.5	890.601	795.101	CL	19	30	17	13		unit "A" till
10-76M	Fargo	1	0.25	881.646	881.396	CH	39.8	70	22	48		Topsoil
10-76M	Fargo	2	4.75	881.646	876.896	CH	28.9	60	22	38		fill
10-76M	Fargo	3	5.25	881.646	876.396	CH	29.9	62	21	41		Alluvium
10-76M	Fargo	4	9.25	881.646	872.396	CH	28.4	64	22	42		sherack
10-76M	Fargo	5	12.25	881.646	869.396	CH	39.7	76	24	52		sherack
10-76M	Fargo	6	15.25	881.646	866.396	CH	38	75	28	47		sherack
10-76M	Fargo	7	16.35	881.646	865.296	CH	38.5	88	28	60		dessicated brenna
10-76M	Fargo	8	19.75	881.646	861.896	CH	43.3	112	33	79		dessicated brenna
10-76M	Fargo	9	23.75	881.646	857.896	CH	61.5	109	36	73		dessicated brenna
10-76M	Fargo	10	28.75	881.646	852.896	CH	54.8	105	34	71		Brenna
10-76M	Fargo	11	32.25	881.646	849.396	CH	54.6	97	30	67		Brenna
10-76M	Fargo	12	37.75	881.646	843.896	CH	51.8	82	28	54		Brenna
10-76M	Fargo	13	43.75	881.646	837.896	CH	53.2	86	32	54		Brenna
10-76M	Fargo	14	48.75	881.646	832.896	CH	58.1	94	29	65		Brenna
10-76M	Fargo	15	53.75	881.646	827.896	CH	60.3	105	31	74		Brenna
10-76M	Fargo	16	58.75	881.646	822.896	CH	62.1	113	31	82		Brenna
10-76M	Fargo	17	64.25	881.646	817.396	CH	60.6	96	28	68		Brenna
10-76M	Fargo	18	69.25	881.646	812.396	CH	61.1	92	27	65		Brenna
10-76M	Fargo	19	73.25	881.646	808.396	CH	59.4	92	33	59		Brenna
10-76M	Fargo	20	74.75	881.646	806.896	CH	58	96	30	66		Brenna
10-77M	Fargo	1	3.5	912.682	909.182	CH	28.3	72	24	48		Alluvium
10-77M	Fargo	2	8.5	912.682	904.182	CH	43.1	85	25	60		dessicated brenna
10-77M	Fargo	3	13.5	912.682	899.182	CH	46.8	79	26	53		dessicated brenna
10-77M	Fargo	4	23.5	912.682	889.182	CH	48.4	76	25	51		brenna
10-77M	Fargo	5	28.5	912.682	884.182	CH	38.7	68	21	47		brenna
10-77M	Fargo	6	33.5	912.682	879.182	CH	42.3	71	24	47		brenna
10-77M	Fargo	7	38.5	912.682	874.182	CH	41.5	73	29	44		brenna
10-77M	Fargo	8	43.5	912.682	869.182	CH	44.1	63	24	39		argusville
10-77M	Fargo	9	48.5	912.682	864.182	CH	48.7	74	24	50		argusville
10-77M	Fargo	10	53.5	912.682	859.182	CH	47.8	71	24	47		argusville
10-77M	Fargo	11	58.5	912.682	854.182	CH	46.3	67	24	43		argusville
10-77M	Fargo	12	63.5	912.682	849.182	CH	44.7	72	20	52		argusville
10-77M	Fargo	13	68.5	912.682	844.182	CH	44.7	59	22	37		argusville
10-77M	Fargo	14	73.5	912.682	839.182	CL	15.8	26	15	11		unit "A" till
10-77M	Fargo	15	78.5	912.682	834.182	CL	45.8	30	15	15		unit "A" till
10-78M	Fargo	1	8.5	905.68	897.18	CH	31	64	20	44		Alluvium
10-78M	Fargo	2	18.5	905.68	887.18	CH	30.9	67	22	45		Alluvium
10-78M	Fargo	3	23.5	905.68	882.18	CH	41.1	65	19	46		dessicated brenna
10-78M	Fargo	4	28.5	905.68	877.18	CH	39.6	69	23	46		dessicated brenna
10-78M	Fargo	5	33.5	905.68	872.18	CH	43.7	68	21	47		argusville
10-78M	Fargo	6	38.5	905.68	867.18	CH	43.3	65	19	46		argusville
10-78M	Fargo	7	43.5	905.68	862.18	CH	50.3	79	29	50		argusville
10-78M	Fargo	8	48.5	905.68	857.18	CH	46.2	78	23	55		argusville
10-78M	Fargo	9	53.5	905.68	852.18	CH	44.7	75	20	55		argusville
10-78M	Fargo	10	58.5	905.68	847.18	CH	51.1	69	21	48		argusville
10-78M	Fargo	11	63.5	905.68	842.18	CH	48.1	70	15	55		argusville
10-78M	Fargo	12	68.5	905.68	837.18	CL	18	32	18	14		unit "A" till
10-78M	Fargo	13	75.5	905.68	830.18	CL-ML	9.3	15	11	4		unit "A" till
10-79M	Fargo	1	8.5	905.252	896.752	CH	30.2	56	23	33		Alluvium
10-79M	Fargo	2	13.5	905.252	891.752	CH	28.7	58	22	36		Alluvium
10-79M	Fargo	3	18.5	905.252	886.752	CH	26.3	57	18	39		Alluvium
10-79M	Fargo	4	24.5	905.252	880.752	CL	25.4	48	17	31		Alluvium
10-79M	Fargo	5	28.5	905.252	876.752	CH	38.6	60	25	35		Alluvium
10-79M	Fargo	6	33.5	905.252	871.752	CH	39.3	62	29	33		argusville
10-79M	Fargo	7	38.5	905.252	866.752	CH	42.4	72	24	48		argusville
10-79M	Fargo	8	43.5	905.252	861.752	CH	61	79	21	58		argusville
10-79M	Fargo	10	53.5	905.252	851.752	CL-ML	11.3	17	13	4		unit "A" till
10-79M	Fargo	11	60.5	905.252	844.752	CL-ML	17.1	22	16	6		unit "A" till
10-79M	Fargo	12	70.5	905.252	834.752	CL	13.6	27	16	11		unit "A" till
10-79M	Fargo	14	90.5	905.252	814.752	ML	8.6	11	10	1		unit "A" till

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH Latest Revision: 2/18/2011
Date: JUL 09 By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
10-80M	Fargo	1	3.25	921.11	917.86	CL	29.4	48	23	25		topsoil
10-80M	Fargo	7	28.25	921.11	892.86	ML	29.9	35	27	8		Alluvium
10-80M	Fargo	8	33.25	921.11	887.86	CH	49.4	85	27	58		brenna
10-80M	Fargo	9	38.75	921.11	882.36	CH	51.2	95	25	70		brenna
10-80M	Fargo	10	43.25	921.11	877.86	CH	50	78	27	51		brenna
10-80M	Fargo	11	48.25	921.11	872.86	CH	60.5	100	34	66		brenna
10-80M	Fargo	12	52.75	921.11	868.36	CH	70.5	82	34	48		brenna
10-80M	Fargo	13	58.75	921.11	862.36	CH	50.4	79	24	55		brenna
10-80M	Fargo	14	63.25	921.11	857.86	CH	53.1	78	29	49		argusville
10-80M	Fargo	15	68.25	921.11	852.86	CL	19	26	15	11		unit "A" till
10-80M	Fargo	16	73.75	921.11	847.36	CL	21.2	29	16	13		unit "A" till
10-80M	Fargo	18	83.25	921.11	837.86	ML	8.1	14	11	3		unit "A" till
10-80M	Fargo	19	88.25	921.11	832.86	ML	8.3	13	11	2		unit "A" till
10-80M	Fargo	21	98.25	921.11	822.86	CL	23.9	43	21	22		unit "A" till
10-80M	Fargo	22	103.25	921.11	817.86	ML	21	Non-Plastic				unit "A" till
09-11M	MN Div	1	4.5	887.6	883.1	CH	32.9	74	33	41	G4127	topsoil/alluvium
09-11M	MN Div	2	9.5	887.6	878.1	CH	33	72	30	42	G4127	sherack
09-11M	MN Div	3	15.5	887.6	872.1	CH	39.5	75	29	46	G4127	sherack
09-11M	MN Div	4	19.5	887.6	868.1	CH	35.5	81	30	51	G4127	PL sherack
09-11M	MN Div	5	25.5	887.6	862.1	CH	42.5	97	35	62	G4127	brenna
09-11M	MN Div	6	33.5	887.6	854.1	CH	57.6	104	30	74	G4127	brenna
09-11M	MN Div	7	38.5	887.6	849.1	CH	60.1	100	32	68	G4127	brenna
09-11M	MN Div	8	44	887.6	843.6	CH	56.3	87	32	55	G4127	brenna
09-11M	MN Div	9	49.5	887.6	838.1	CH	58.6	96	39	57	G4127	brenna
09-11M	MN Div	10	54.5	887.6	833.1	CH	62.8	93	39	54	G4127	brenna
09-11M	MN Div	11	59.5	887.6	828.1	CH	63.5	107	38	69	G4127	brenna
09-11M	MN Div	12	64.5	887.6	823.1	CH	65.2	112	40	72	G4127	brenna
09-11M	MN Div	13	69.5	887.6	818.1	CH	57.4	95	31	64	G4127	brenna
09-11M	MN Div	14	74.5	887.6	813.1	CH	55.5	98	35	63	G4127	brenna
09-11M	MN Div	15	79.5	887.6	808.1	CH	53.5	88	33	55	G4127	brenna
09-11M	MN Div	16	84	887.6	803.6	CH	45.5	69	30	39	G4127	argusville
09-11M	MN Div	17	89.5	887.6	798.1	CH	44.2	78	27	51	G4127	argusville
09-11M	MN Div	18	94.5	887.6	793.1	CH	47	70	25	45	G4127	argusville
09-11M	MN Div	19	99.5	887.6	788.1	CL	20.5	29	17	12	G4127	till
09-11M	MN Div	20	107.5	887.6	780.1	CL	20.7	28	16	12	G4127	till
09-12M	MN Div	1	4.5	892.2	887.7	CH	31.1	58	28	30	G4127	sherack
09-12M	MN Div	2	9.5	892.2	882.7	CH	44.8	77	32	45	G4127	sherack
09-12M	MN Div	3	13.5	892.2	878.7	ML	27.5				G4127	poplar river
09-12M	MN Div	4	18.25	892.2	873.95	ML	29	28	26	2	G4127	poplar river
09-12M	MN Div	5	22	892.2	870.2	CH	51.3	60	22	38	G4127	poplar river
09-12M	MN Div	6	25.25	892.2	866.95	CH	37.8	67	30	37	G4127	poplar river
09-12M	MN Div	7	34.5	892.2	857.7	CH	74.1	108	32	76	G4127	brenna
09-12M	MN Div	8	39	892.2	853.2	CH	72.9	103	37	66	G4127	brenna
09-12M	MN Div	9	43.5	892.2	848.7	CH	57.6	99	37	62	G4127	brenna
09-12M	MN Div	10	49.5	892.2	842.7	CH	72.7	120	32	88	G4127	brenna
09-12M	MN Div	11	54.5	892.2	837.7	CH	74.6	120	37	83	G4127	brenna
09-12M	MN Div	12	59.5	892.2	832.7	CH	68.4	113	36	77	G4127	brenna
09-12M	MN Div	13	64.5	892.2	827.7	CH	65.1	106	32	74	G4127	brenna
09-12M	MN Div	14	69.5	892.2	822.7	CH	60.6	99	33	66	G4127	brenna
09-12M	MN Div	15	74.5	892.2	817.7	CH	49.5	82	34	48	G4127	brenna
09-12M	MN Div	16	79	892.2	813.2	CH	59.9	98	32	66	G4127	brenna
09-12M	MN Div	17	84.5	892.2	807.7	CH	53.4	75	29	46	G4127	argusville
09-12M	MN Div	18	89.5	892.2	802.7	CH	44.4	66	26	40	G4127	argusville
09-12M	MN Div	19	94.5	892.2	797.7	CH	51.5	91	30	61	G4127	argusville
09-12M	MN Div	20	99.5	892.2	792.7	CH	51.8	87	29	58	G4127	argusville
09-12M	MN Div	21	104.5	892.2	787.7	CH	45.3	84	30	54	G4127	argusville
09-12M	MN Div	22	109.5	892.2	782.7	CH	44.8	76	29	47	G4127	argusville
09-12M	MN Div	23	114.5	892.2	777.7	ML	15.2	20	18	2	G4127	till
09-13M	MN Div	1	4.5	903.4	898.9	ML	31.8	48	29	19	G4127	sherack
09-13M	MN Div	2	9.5	903.4	893.9	MH	37.5	58	32	26	G4127	sherack
09-13M	MN Div	3	14.5	903.4	888.9	ML	28.8	24	23	1	G4127	poplar river
09-13M	MN Div	4	19.5	903.4	883.9	ML	28.2	26	23	3	G4127	poplar river
09-13M	MN Div	5	24.5	903.4	878.9	CH	36.1	53	27	26	G4127	poplar river
09-13M	MN Div	6	25.5	903.4	877.9	CH	42.7	97	38	59	G4127	brenna
09-13M	MN Div	7	29.5	903.4	873.9	CH	80.4	134	43	91	G4127	brenna
09-13M	MN Div	8	34	903.4	869.4	CH	76.3	120	33	87	G4127	brenna
09-13M	MN Div	9	39.5	903.4	863.9	CH	68.4	99	33	66	G4127	brenna
09-13M	MN Div	10	44.5	903.4	858.9	CH	66.9	98	33	65	G4127	brenna
09-13M	MN Div	11	49.5	903.4	853.9	CH	71.4	110	31	79	G4127	brenna
09-13M	MN Div	12	54.5	903.4	848.9	CH	66.3	110	27	83	G4127	brenna
09-13M	MN Div	13	59.5	903.4	843.9	CH	59.8	103	33	70	G4127	brenna
09-13M	MN Div	14	64.5	903.4	838.9	CH	57.9	93	30	63	G4127	brenna
09-13M	MN Div	15	69.5	903.4	833.9	CH	61.6	91	30	61	G4127	brenna
09-13M	MN Div	16	74.5	903.4	828.9	CH	57.2	85	26	59	G4127	brenna
09-13M	MN Div	17	79.5	903.4	823.9	CH	54.3	88	29	59	G4127	brenna
09-13M	MN Div	18	84.5	903.4	818.9	CH	54.6	94	31	63	G4127	argusville
09-13M	MN Div	19	89	903.4	814.4	CH	46	80	31	49	G4127	argusville
09-13M	MN Div	20	94.5	903.4	808.9	CH	44.1	80	30	50	G4127	argusville
09-13M	MN Div	21	99.5	903.4	803.9	CH	30.9	61	19	42	G4127	argusville
09-13M	MN Div	22	104.5	903.4	798.9	CL	28.8	48	21	27	G4127	argusville
09-13M	MN Div	23	109.5	903.4	793.9	CH	36.1	56	24	32	G4127	argusville
09-13M	MN Div	24	121.5	903.4	781.9	CL	13.4	23	15	8	G4127	till

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH
Date: JUL 09

Latest Revision: 2/18/2011
By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
09-14M	MN Div	1	3.75	913.1	909.35	CH	33.6	63	26	37	G4127	sherack
09-14M	MN Div	2	9.5	913.1	903.6	CH	37.1	62	21	41	G4127	sherack
09-14M	MN Div	3	14.5	913.1	898.6	CH	56.3	96	29	67	G4127	brenna
09-14M	MN Div	4	19.5	913.1	893.6	CH	47.9	92	29	63	G4127	brenna
09-14M	MN Div	5	23.25	913.1	889.85	CH	53.2	80	28	52	G4127	brenna
09-14M	MN Div	6	29.5	913.1	883.6	CH	45.7	81	33	48	G4127	brenna
09-14M	MN Div	7	33.5	913.1	879.6	CH	55.2	90	31	59	G4127	brenna
09-14M	MN Div	8	38.5	913.1	874.6	CH	49.5	91	31	60	G4127	brenna
09-14M	MN Div	9	44.5	913.1	868.6	CH	39.7	69	29	40	G4127	argusville
09-14M	MN Div	10	49.5	913.1	863.6	CH	42.9	76	28	48	G4127	argusville
09-14M	MN Div	11	54.5	913.1	858.6	CH	37.9	51	26	26	G4127	argusville
09-14M	MN Div	12	59.5	913.1	853.6	CH	42.4	52	25	27	G4127	argusville
09-14M	MN Div	13	64.5	913.1	848.6	ML	26				G4127	Elastic Silt
09-14M	MN Div	14	68.5	913.1	844.6	CL	20.3	25	17	8	G4127	Interbedded Till?
09-14M	MN Div	15	69.5	913.1	843.6	SM	21.7				G4127	Sand
09-14M	MN Div	16	74.5	913.1	838.6	SM	26.4				G4127	Sand
09-14M	MN Div	17	79.5	913.1	833.6	SM	24.8				G4127	Sand
09-14M	MN Div	18	84.5	913.1	828.6	SM	22.9				G4127	Sand
09-14M	MN Div	19	89	913.1	824.1	SP-SM	23.1				G4127	Sand
09-14M	MN Div	20	93.5	913.1	819.6	SM	22.2				G4127	Sand
09-14M	MN Div	21	99	913.1	814.1	SP-SM	19.7				G4127	Sand
09-14M	MN Div	22	104.5	913.1	808.6	CL-ML	11.7	21	17	4	G4127	till
09-14M	MN Div	23	109.5	913.1	803.6	CL-ML	12.2	23	16	7	G4127	till
09-15M	MN Div	1	4	914.9	910.9	CH	24.6	66	23	43	G4127	sherack
09-15M	MN Div	2	9.5	914.9	905.4	ML	32.2	36	29	7	G4127	sherack
09-15M	MN Div	3	14	914.9	900.9	SP-SM	19.9				G4127	poplar river
09-15M	MN Div	4	19.5	914.9	895.4	CH	68.6	123	36	87	G4127	brenna
09-15M	MN Div	5	23.25	914.9	891.65	CH	63.9	107	34	73	G4127	brenna
09-15M	MN Div	6	28.15	914.9	886.75	CH	65	111	36	75	G4127	brenna
09-15M	MN Div	7	34.5	914.9	880.4	CH	67.6	111	39	72	G4127	brenna
09-15M	MN Div	8	39.5	914.9	875.4	CH	60.1	91	31	60	G4127	brenna
09-15M	MN Div	9	44.5	914.9	870.4	CH	63.2	92	26	66	G4127	brenna
09-15M	MN Div	10	49	914.9	865.9	CH	58.2	73	29	44	G4127	brenna
09-15M	MN Div	11	54.5	914.9	860.4	CH	47.5	74	28	46	G4127	brenna
09-15M	MN Div	12	59.5	914.9	855.4	CL	40.9	46	23	23	G4127	brenna
09-15M	MN Div	13	64.5	914.9	850.4	CH	52.6	79	30	49	G4127	argusville
09-15M	MN Div	14	69.5	914.9	845.4	CH	48.5	75	29	46	G4127	argusville
09-15M	MN Div	15	74.5	914.9	840.4	CH	61.9	72	28	44	G4127	argusville
09-15M	MN Div	16	79.5	914.9	835.4	CH	45.9	64	27	37	G4127	argusville
09-15M	MN Div	17	84	914.9	830.9	CH	32.3	50	22	28	G4127	argusville
09-15M	MN Div	18	89.5	914.9	825.4	CL	34	37	20	17	G4127	till
09-15M	MN Div	19	101.5	914.9	813.4	CL	13.3	27	18	9	G4127	till
09-16M	MN Div	1	4	921.6	917.6	CH	35.7	67	31	36	G4127	topsoil/fill
09-16M	MN Div	2	9.5	921.6	912.1	ML	35.8				G4127	sherack
09-16M	MN Div	3	14.5	921.6	907.1	ML	43.1				G4127	sherack
09-16M	MN Div	4	19.5	921.6	902.1	CH	46.8	66	28	38	G4127	poplar river
09-16M	MN Div	5	24.5	921.6	897.1	CH	63.3	78	30	48	G4127	poplar river
09-16M	MN Div	6	29.5	921.6	892.1	CH	55.7	65	28	37	G4127	poplar river
09-16M	MN Div	7	34.5	921.6	887.1	CH	66.5	94	27	67	G4127	poplar river
09-16M	MN Div	8	38.5	921.6	883.1	CH	50.1	67	28	39	G4127	poplar river
09-16M	MN Div	9	44.5	921.6	877.1	CH	39.9	55	26	29	G4127	poplar river
09-16M	MN Div	10	49.5	921.6	872.1	SP-ML	21.5				G4127	poplar river
09-16M	MN Div	11	53.5	921.6	868.1	SP-ML	22.2				G4127	poplar river
09-16M	MN Div	12	58.5	921.6	863.1	SP	14.1				G4127	poplar river
09-16M	MN Div	13	64.5	921.6	857.1	CL	29.2	38	23	15	G4127	?
09-16M	MN Div	14	69.5	921.6	852.1	CL	31.5	42	24	18	G4127	?
09-16M	MN Div	15	74.5	921.6	847.1	ML	31.4	41	27	14	G4127	?
09-16M	MN Div	16	76.5	921.6	845.1	CH	41	84	26	58	G4127	?
09-16M	MN Div	17	79.5	921.6	842.1	CH	35.7	56	25	31	G4127	argusville
09-16M	MN Div	18	84.5	921.6	837.1	CH	38.3	50	25	25	G4127	argusville
09-16M	MN Div	19	89.5	921.6	832.1	CL	16.5	22	16	6	G4127	till
09-16M	MN Div	20	94.5	921.6	827.1	ML	18.6	18	15	3	G4127	till
09-16M	MN Div	21	101.5	921.6	820.1	CL	17.8	29	18	11	G4127	till
09-17M	Moorhead	1	4.5	905.03	900.53	CH	33.5	71	28	43	G4127	sherack
09-17M	Moorhead	2	9.5	905.03	895.53	CH	39.3	50	24	26	G4127	sherack
09-17M	Moorhead	3	13.5	905.03	891.53	CH	45.1	71	29	42	G4127	poplar river
09-17M	Moorhead	4	14.5	905.03	890.53	CH	46.1	102	30	72	G4127	brenna
09-17M	Moorhead	5	18.25	905.03	886.78	CH	56	108	37	71	G4127	brenna
09-17M	Moorhead	6	23.5	905.03	881.53	CH	62.9	116	39	77	G4127	brenna
09-17M	Moorhead	7	28.5	905.03	876.53	CH	56.8	99	30	69	G4127	brenna
09-17M	Moorhead	8	34	905.03	871.03	CH	38.3	80	29	51	G4127	brenna
09-17M	Moorhead	9	39	905.03	866.03	CH	31	82	27	55	G4127	brenna
09-17M	Moorhead	10	44	905.03	861.03	CH	40.6	79	30	49	G4127	brenna
09-17M	Moorhead	11	49	905.03	856.03	CH	28.9	64	27	37	G4127	brenna
09-17M	Moorhead	12	54.5	905.03	850.53	CH	33.6	66	29	37	G4127	brenna
09-17M	Moorhead	13	59.5	905.03	845.53	CH	27.7	63	27	36	G4127	brenna
09-17M	Moorhead	14	64.5	905.03	840.53	CH	29.5	65	29	36	G4127	argusville
09-17M	Moorhead	15	69.5	905.03	835.53	CH	38.9	74	32	42	G4127	argusville
09-17M	Moorhead	16	74.5	905.03	830.53	CH	39.9	74	31	43	G4127	argusville
09-17M	Moorhead	17	79.5	905.03	825.53	CH	39	69	29	40	G4127	argusville
09-17M	Moorhead	18	84.5	905.03	820.53	CH	39.4	60	23	37	G4127	argusville
09-17M	Moorhead	19	89.5	905.03	815.53	CL-ML	21.4	23	17	6	G4127	till
09-17M	Moorhead	20	94	905.03	811.03	CL	12.6	27	16	11	G4127	till

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH
Date: JUL 09

Latest Revision: 2/18/2011
By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
09-18M	Moorhead	1	4.5	885.56	881.06	CH	37.9	60	30	30	G4127	alluvium
09-18M	Moorhead	2	8	885.56	877.56	CH	34.1	61	27	34	G4127	sherack
09-18M	Moorhead	3	14.5	885.56	871.06	CH	43.2	89	29	60	G4127	brenna
09-18M	Moorhead	4	18.5	885.56	867.06	CH	44.9	95	30	65	G4127	brenna
09-18M	Moorhead	5	23.5	885.56	862.06	CH	46.1	89	30	59	G4127	brenna
09-18M	Moorhead	6	28.25	885.56	857.31	CH	46.3	92	31	61	G4127	brenna
09-18M	Moorhead	7	33.5	885.56	852.06	CH	46.2	74	31	43	G4127	brenna
09-18M	Moorhead	8	38.5	885.56	847.06	CH	43.3	72	29	43	G4127	brenna
09-18M	Moorhead	9	44.5	885.56	841.06	CH	46.4	73	30	43	G4127	argusville
09-18M	Moorhead	10	49.5	885.56	836.06	CH	43.2	67	29	38	G4127	argusville
09-18M	Moorhead	11	54.5	885.56	831.06	CH	42.2	73	30	43	G4127	argusville
09-18M	Moorhead	12	59.5	885.56	826.06	CH	44.5	63	28	35	G4127	argusville
09-18M	Moorhead	13	64.5	885.56	821.06	CH	40.2	54	26	28	G4127	argusville
09-18M	Moorhead	14	69.5	885.56	816.06	CH	31.3	51	25	26	G4127	argusville
09-18M	Moorhead	15	72.5	885.56	813.06	CL	17	34	17	17	G4127	till
09-19M	Moorhead	1	4.5	886.84	882.34	CH	37.5	55	29	26	G4127	sherack
09-19M	Moorhead	2	7.5	886.84	879.34	CH	37.2	67	31	36	G4127	sherack
09-19M	Moorhead	3	8.5	886.84	878.34	CH	50.9	102	31	71	G4127	sherack
09-19M	Moorhead	4	14.5	886.84	872.34	CH	47	109	32	77	G4127	brenna
09-19M	Moorhead	5	19	886.84	867.84	CH	57.3	100	31	69	G4127	brenna
09-19M	Moorhead	6	23.5	886.84	863.34	CH	65.6	111	34	77	G4127	brenna
09-19M	Moorhead	7	29	886.84	857.84	CH	64.3	111	34	77	G4127	brenna
09-19M	Moorhead	8	34.5	886.84	852.34	CH	57.9	82	28	54	G4127	brenna
09-19M	Moorhead	9	39.5	886.84	847.34	CH	35.2	69	28	41	G4127	brenna
09-19M	Moorhead	10	44.5	886.84	842.34	CH	36.4	72	28	44	G4127	brenna
09-19M	Moorhead	11	49.5	886.84	837.34	CH	39.8	72	29	43	G4127	argusville
09-19M	Moorhead	12	54.5	886.84	832.34	CH	32.2	64	28	36	G4127	argusville
09-19M	Moorhead	13	59.5	886.84	827.34	CH	30.4	67	28	39	G4127	argusville
09-19M	Moorhead	14	64.5	886.84	822.34	CH	31.7	59	27	32	G4127	argusville
09-19M	Moorhead	15	69.5	886.84	817.34	CH	31.3	56	24	32	G4127	argusville
09-19M	Moorhead	16	74.5	886.84	812.34	ML	17.4	19	18	1	G4127	till
09-19M	Moorhead	17	84.5	886.84	802.34	CL	18.1	28	19	9	G4127	till
09-20M	Moorhead	1	4.5	890.71	886.21	CH	32.1	70	27	43	G4127	sherack
09-20M	Moorhead	2	9	890.71	881.71	CH	47.5	101	34	67	G4127	PL sherack
09-20M	Moorhead	3	14.5	890.71	876.21	CH	48.4	101	35	66	G4127	PL sherack
09-20M	Moorhead	4	19.5	890.71	871.21	CH	50.5	93	29	64	G4127	PL sherack
09-20M	Moorhead	5	23.5	890.71	867.21	CH	46.1	87	32	55	G4127	brenna
09-20M	Moorhead	6	29.5	890.71	861.21	CH	56.1	96	31	65	G4127	brenna
09-20M	Moorhead	7	33.5	890.71	857.21	CH	51	96	32	64	G4127	brenna
09-20M	Moorhead	8	39.5	890.71	851.21	CH	49.7	80	28	52	G4127	brenna
09-20M	Moorhead	9	44.5	890.71	846.21	CH	53.5	82	30	52	G4127	brenna
09-20M	Moorhead	10	49.5	890.71	841.21	CH	55.6	90	31	59	G4127	argusville
09-20M	Moorhead	11	54.5	890.71	836.21	CH	55.3	81	29	52	G4127	argusville
09-20M	Moorhead	12	59.5	890.71	831.21	CH	53	79	29	50	G4127	argusville
09-20M	Moorhead	13	64.5	890.71	826.21	CH	47.1	69	27	42	G4127	argusville
09-20M	Moorhead	14	69.5	890.71	821.21	CH	37.2	52	22	30	G4127	argusville
09-20M	Moorhead	15	74.5	890.71	816.21	CH	41.4	67	26	41	G4127	argusville
09-20M	Moorhead	16	79.5	890.71	811.21	ML	29.4	30	25	5	G4127	till
09-20M	Moorhead	17	91.5	890.71	799.21	CL	17.2	37	19	18	G4127	till
09-21M	Moorhead	1	4	886.2	882.2	CH	39.6	77	29	48	G4127	sherack
09-21M	Moorhead	2	9.5	886.2	876.7	CH	41.2	67	27	40	G4127	sherack
09-21M	Moorhead	3	14.5	886.2	871.7	ML	41	32	30	2	G4127	sherack
09-21M	Moorhead	4	19	886.2	867.2	CH	53.6	103	33	70	G4127	brenna
09-21M	Moorhead	5	24	886.2	862.2	CH	73.5	115	33	82	G4127	brenna
09-21M	Moorhead	6	28.5	886.2	857.7	CH	68.8	111	32	79	G4127	brenna
09-21M	Moorhead	7	33.5	886.2	852.7	CH	64	106	32	74	G4127	brenna
09-21M	Moorhead	8	38.5	886.2	847.7	CH	59.7	92	30	62	G4127	brenna
09-21M	Moorhead	9	44	886.2	842.2	CH	53.6	76	30	46	G4127	argusville
09-21M	Moorhead	10	49	886.2	837.2	CH	55.3	90	32	58	G4127	argusville
09-21M	Moorhead	11	54.5	886.2	831.7	CH	56	78	29	49	G4127	argusville
09-21M	Moorhead	12	59.5	886.2	826.7	CH	52.6	67	30	37	G4127	argusville
09-21M	Moorhead	13	64.5	886.2	821.7	CH	47.4	67	30	37	G4127	argusville
09-21M	Moorhead	14	69.5	886.2	816.7	CH	50.2	76	30	46	G4127	argusville
09-21M	Moorhead	15	73.5	886.2	812.7	SM	18.9				G4127	till
09-21M	Moorhead	16	79.5	886.2	806.7	CL	14.7	26	17	9	G4127	till
09-22M	Moorhead	1	4.5	882.2	877.7	ML	41.2	47	29	18	G4127	sherack
09-22M	Moorhead	2	9.5	882.2	872.7	CH	37.7	54	27	27	G4127	sherack
09-22M	Moorhead	3	14.5	882.2	867.7	CH	54.5	100	30	70	G4127	brenna
09-22M	Moorhead	4	19.5	882.2	862.7	CH	57.5	106	33	73	G4127	brenna
09-22M	Moorhead	5	24	882.2	858.2	CH	58.7	105	33	72	G4127	brenna
09-22M	Moorhead	6	29.5	882.2	852.7	CH	58.3	105	34	71	G4127	brenna
09-22M	Moorhead	7	34	882.2	848.2	CH	61.5	99	32	67	G4127	brenna
09-22M	Moorhead	8	39	882.2	843.2	CH	56.4	96	31	65	G4127	brenna
09-22M	Moorhead	9	44	882.2	838.2	CH	49.6	80	28	52	G4127	brenna
09-22M	Moorhead	10	49	882.2	833.2	CH	50.3	67	27	40	G4127	argusville
09-22M	Moorhead	11	54	882.2	828.2	CH	48.7	81	26	55	G4127	argusville
09-22M	Moorhead	12	59	882.2	823.2	CH	55.9	76	27	49	G4127	argusville
09-22M	Moorhead	13	64.5	882.2	817.7	CH	45.3	75	28	47	G4127	argusville
09-22M	Moorhead	14	69.5	882.2	812.7	CH	42.9	67	28	39	G4127	argusville
09-22M	Moorhead	15	74.5	882.2	807.7	CH	47.5	67	25	42	G4127	argusville
09-22M	Moorhead	16	79.5	882.2	802.7	SM	14.2				G4127	till
09-22M	Moorhead	17	84.5	882.2	797.7	CL-ML	12.7	22	16	6	G4127	till

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH
Date: JUL 09

Latest Revision: 2/18/2011
By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
09-23M	Moorhead	1	4.5	882.9	878.4	CH	37.6	63	29	34	G4127	topsoil/alluvium
09-23M	Moorhead	2	9.5	882.9	873.4	CH	34.1	60	28	32	G4127	alluvium
09-23M	Moorhead	3	13.5	882.9	869.4	CH	39.7	53	25	28	G4127	sherack
09-23M	Moorhead	4	18.25	882.9	864.65	CH	61.6	95	32	63	G4127	brenna
09-23M	Moorhead	5	24	882.9	858.9	CH	66.3	8	33	-25	G4127	brenna
09-23M	Moorhead	6	33.25	882.9	849.65	CH	71.2	106	32	74	G4127	brenna
09-23M	Moorhead	7	38.5	882.9	844.4	CH	58.9	84	29	55	G4127	brenna
09-23M	Moorhead	8	44.5	882.9	838.4	CH	56.7	81	28	53	G4127	argusville
09-23M	Moorhead	9	49.5	882.9	833.4	CH	40.7	55	24	31	G4127	argusville
09-23M	Moorhead	10	54.5	882.9	828.4	ML	39.8	28	24	4	G4127	argusville
09-23M	Moorhead	11	59.5	882.9	823.4	ML	31.2	26	25	1	G4127	argusville
09-23M	Moorhead	12	64.5	882.9	818.4	ML	29.9	27	25	2	G4127	argusville
09-23M	Moorhead	13	69.5	882.9	813.4	ML	31.8	20	19	1	G4127	argusville
09-23M	Moorhead	14	74.5	882.9	808.4	ML	32.5	25	24	1	G4127	argusville
09-23M	Moorhead	15	79.75	882.9	803.15	ML	30.8	29	24	5	G4127	argusville
09-23M	Moorhead	16	91.5	882.9	791.4	CL	19.2	34	19	15	G4127	till
09-24M	Moorhead	1	5.5	883.7	878.2	CH	35.9	55	23	32	G4127	sherack
09-24M	Moorhead	2	9.5	883.7	874.2	CH	32.4	75	26	49	G4127	brenna
09-24M	Moorhead	3	13.25	883.7	870.45	CH	55.4	97	33	64	G4127	brenna
09-24M	Moorhead	4	19.5	883.7	864.2	CH	53.1	92	31	61	G4127	brenna
09-24M	Moorhead	5	23.5	883.7	860.2	CH	46.1	106	33	73	G4127	brenna
09-24M	Moorhead	6	29	883.7	854.7	CH	41.2	97	33	64	G4127	brenna
09-24M	Moorhead	7	34	883.7	849.7	CH	28.2	87	30	57	G4127	brenna
09-24M	Moorhead	8	39	883.7	844.7	CH	40.2	85	29	56	G4127	brenna
09-24M	Moorhead	9	44.5	883.7	839.2	CH	40	69	27	42	G4127	brenna
09-24M	Moorhead	10	49.5	883.7	834.2	CH	36.3	74	27	47	G4127	argusville
09-24M	Moorhead	11	54.5	883.7	829.2	CH	34.9	63	25	38	G4127	argusville
09-24M	Moorhead	12	59.5	883.7	824.2	CH	42.8	66	26	40	G4127	argusville
09-24M	Moorhead	13	64.5	883.7	819.2	CH	33.8	70	27	43	G4127	argusville
09-24M	Moorhead	14	69.5	883.7	814.2	CH	36.2	73	29	44	G4127	argusville
09-24M	Moorhead	15	73.5	883.7	810.2	CH	34.6	63	23	40	G4127	argusville
09-24M	Moorhead	16	79.5	883.7	804.2	CH	32.8	50	22	28	G4127	argusville
09-25M	Moorhead	1	4.5	898.7	894.2	CH	28.5	68	30	38	G4127	sherack
09-25M	Moorhead	2	9.5	898.7	889.2	CH	34.7	67	29	38	G4127	sherack
09-25M	Moorhead	3	14.5	898.7	884.2	ML	37.3	28	25	3	G4127	poplar river
09-25M	Moorhead	4	24.5	898.7	874.2	MH	36.8	56	30	26	G4127	poplar river
09-25M	Moorhead	5	29	898.7	869.7	CH	41.3	63	31	32	G4127	poplar river
09-25M	Moorhead	6	30.5	898.7	868.2	CH	47.6	90	33	57	G4127	brenna
09-25M	Moorhead	7	39.5	898.7	859.2	CH	68.3	100	35	65	G4127	brenna
09-25M	Moorhead	8	45.5	898.7	853.2	CH	63.2	103	36	67	G4127	brenna
09-25M	Moorhead	9	51.5	898.7	847.2	CH	63.7	97	35	62	G4127	brenna
09-25M	Moorhead	10	57.5	898.7	841.2	CH	59.4	101	37	64	G4127	brenna
09-25M	Moorhead	11	63.75	898.7	834.95	CH	62.1	102	36	66	G4127	brenna
09-25M	Moorhead	12	69.5	898.7	829.2	CH	54	87	33	54	G4127	argusville
09-25M	Moorhead	13	74.5	898.7	824.2	CH	50.8	81	31	50	G4127	argusville
09-25M	Moorhead	14	79.5	898.7	819.2	CH	43.6	73	29	44	G4127	argusville
09-25M	Moorhead	15	84.5	898.7	814.2	CH	45.6	71	30	41	G4127	argusville
09-25M	Moorhead	6	89.5	898.7	809.2	CH	52.2	72	31	41	G4127	argusville
09-25M	Moorhead	17	94.5	898.7	804.2	CH	48.4	72	28	44	G4127	argusville
09-25M	Moorhead	18	99.5	898.7	799.2	CH	42.2	68	27	41	G4127	argusville
09-26M	MN Div	1	4	911.5	907.5	CH	32	67	27	40	G4127	topsoil/alluvium
09-26M	MN Div	2	6.5	911.5	905	CH	27.3	65	25	40	G4127	alluvium
09-26M	MN Div	3	9.5	911.5	902	CH	34.1	63	26	37	G4127	sherack
09-26M	MN Div	4	14.5	911.5	897	CH	50.9	101	35	66	G4127	PL sherack?
09-26M	MN Div	5	18.5	911.5	893	CH	48.4	107	35	72	G4127	PL sherack?
09-26M	MN Div	6	23.5	911.5	888	CH	53.3	101	33	68	G4127	PL sherack?
09-26M	MN Div	7	28.5	911.5	883	CH	50.8	93	31	62	G4127	brenna
09-26M	MN Div	8	33.25	911.5	878.25	CH	56.9	96	29	67	G4127	brenna
09-26M	MN Div	9	39.25	911.5	872.25	CH	48.3	85	30	55	G4127	brenna
09-26M	MN Div	10	44.5	911.5	867	CH	48.2	69	30	39	G4127	brenna
09-26M	MN Div	11	49.5	911.5	862	CH	45.8	61	25	36	G4127	brenna
09-26M	MN Div	12	54.5	911.5	857	CH	49.1	62	26	36	G4127	argusville
09-26M	MN Div	13	58.5	911.5	853	CH	44.5	68	27	41	G4127	argusville
09-26M	MN Div	14	64.5	911.5	847	CH	43.3	66	29	37	G4127	argusville
09-26M	MN Div	15	69.5	911.5	842	CH	42.5	71	28	43	G4127	argusville
09-26M	MN Div	16	74.5	911.5	837	CH	45.5	59	25	34	G4127	argusville
09-26M	MN Div	17	79	911.5	832.5	CH	32.7	56	22	34	G4127	argusville
09-26M	MN Div	18	84.5	911.5	827	CH	39.3	68	25	43	G4127	argusville
09-26M	MN Div	19	88.5	911.5	823	CL					G4127	till
09-26M	MN Div	20	101.5	911.5	810	CL					G4127	till
09-34M	Moorhead	1	3.5	907.9	904.4	CH	26.4	58	25	33	G4127	alluvium
09-34M	Moorhead	2	9.5	907.9	898.4	CH	42.9	58	29	29	G4127	sherack
09-34M	Moorhead	3	10.45	907.9	897.45	MH	35	53	30	23	G4127	sherack
09-34M	Moorhead	4	14	907.9	893.9	CH	51	109	34	75	G4127	PL sherack
09-34M	Moorhead	5	17.5	907.9	890.4	CH	63.7	111	33	78	G4127	PL sherack
09-34M	Moorhead	6	24.5	907.9	883.4	CH	56.4	123	37	86	G4127	brenna
09-34M	Moorhead	7	29.5	907.9	878.4	CH	57.3	100	33	67	G4127	brenna
09-34M	Moorhead	8	34.5	907.9	873.4	CH	63.2	103	34	69	G4127	brenna
09-34M	Moorhead	9	39.5	907.9	868.4	CH	53.1	89	33	56	G4127	brenna
09-34M	Moorhead	10	44.5	907.9	863.4	CH	54.2	90	32	58	G4127	brenna
09-34M	Moorhead	11	49.5	907.9	858.4	CH	47.9	74	29	45	G4127	brenna
09-34M	Moorhead	12	54.5	907.9	853.4	CH	51.8	75	30	45	G4127	argusville
09-34M	Moorhead	13	59.5	907.9	848.4	CH	49.8	76	29	47	G4127	argusville

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH Latest Revision: 2/18/2011
Date: JUL 09 By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
09-34M	Moorhead	14	64.5	907.9	843.4	CH	45	66	28	38	G4127	argusville
09-34M	Moorhead	15	69.5	907.9	838.4	CH	43.8	68	25	43	G4127	argusville
09-34M	Moorhead	16	74.5	907.9	833.4	CH	44.5	62	25	37	G4127	argusville
09-34M	Moorhead	17	79.5	907.9	828.4	CH	41.9	70	31	39	G4127	argusville
09-34M	Moorhead	18	84	907.9	823.9	CH	46.5	67	28	39	G4127	argusville
09-40M	MN Div	1	3.25	912.8	909.55	CL	17.1	26	17	9	G4127	?
09-40M	MN Div	2	9.5	912.8	903.3	CL	41.6	43	26	17	G4127	sherack
09-40M	MN Div	3	14.5	912.8	898.3	CH	46.7	80	33	47	G4127	sherack
09-40M	MN Div	4	18.35	912.8	894.45	CH	46.6	75	30	45	G4127	poplar river
09-40M	MN Div	5	23.2	912.8	889.6	CH	48.3	79	31	48	G4127	brenna
09-40M	MN Div	6	28.5	912.8	884.3	CH	52.5	73	31	42	G4127	brenna
09-40M	MN Div	7	33.4	912.8	879.4	CH	53.6	74	30	44	G4127	argusville
09-40M	MN Div	8	38.5	912.8	874.3	CL	26	38	28	10	G4127	argusville
09-40M	MN Div	9	43.25	912.8	869.55	ML	20.5				G4127	silt
09-40M	MN Div	10	46.5	912.8	866.3	ML	21.6				G4127	silt
09-40M	MN Div	11	49.5	912.8	863.3	ML	21.5				G4127	silt
09-40M	MN Div	12	53.5	912.8	859.3	ML	21.6				G4127	silt
09-40M	MN Div	13	59.5	912.8	853.3	ML	25.8				G4127	silt
09-40M	MN Div	14	64.5	912.8	848.3	ML	27				G4127	silt
09-40M	MN Div	15	68.5	912.8	844.3	ML	24.4				G4127	silt
09-41M	Moorhead	1	3.4	889.7	886.3	CH	36.2	64	25	39	G4127	topsoil/alluvium
09-41M	Moorhead	2	9.75	889.7	879.95	CH	30.2	66	24	42	G4127	sherack
09-41M	Moorhead	3	14	889.7	875.7	MH	31.8	53	31	22	G4127	sherack
09-41M	Moorhead	4	17.5	889.7	872.2	CH	47	103	38	65	G4127	brenna
09-41M	Moorhead	5	24	889.7	865.7	CH	47	76	28	48	G4127	brenna
09-41M	Moorhead	6	28.5	889.7	861.2	CH	48.8	75	28	47	G4127	brenna
09-41M	Moorhead	7	33.5	889.7	856.2	CH	63	70	32	38	G4127	brenna
09-41M	Moorhead	8	39.5	889.7	850.2	CH	47	67	29	38	G4127	brenna
09-41M	Moorhead	9	44	889.7	845.7	CH	48.3	58	30	28	G4127	argusville
09-41M	Moorhead	10	49.5	889.7	840.2	CH	41.5	70	27	43	G4127	argusville
09-41M	Moorhead	11	53.5	889.7	836.2	CH	45.1	69	29	40	G4127	argusville
09-41M	Moorhead	12	59.5	889.7	830.2	CL	30	35	17	18	G4127	argusville
09-53M	Moorhead	1	5.4	900	894.6	CL	25.8	40	21	19	G4127	topsoil/alluvium
09-53M	Moorhead	2	8.5	900	891.5	CL	36.7	47	26	21	G4127	topsoil/alluvium
09-53M	Moorhead	3	12.5	900	887.5	CH	34.4	54	28	26	G4127	alluvium
09-53M	Moorhead	4	14.5	900	885.5	CH	31.5	69	29	40	G4127	sherack
09-53M	Moorhead	5	19.5	900	880.5	CL	34.4	42	25	17	G4127	poplar river
09-53M	Moorhead	6	23.4	900	876.6	CH	38.9	83	28	55	G4127	brenna
09-53M	Moorhead	7	28.3	900	871.7	CH	56.4	105	35	70	G4127	brenna
09-53M	Moorhead	8	33.3	900	866.7	CH	58.6	92	33	59	G4127	brenna
09-53M	Moorhead	9	38.5	900	861.5	CH	54.2	104	37	67	G4127	brenna
09-53M	Moorhead	10	43.5	900	856.5	CH	57.1	102	35	67	G4127	brenna
09-53M	Moorhead	11	48.5	900	851.5	CH	50.8	101	36	65	G4127	brenna
09-53M	Moorhead	12	53.5	900	846.5	CH	42.3	90	31	59	G4127	brenna
09-53M	Moorhead	13	58.5	900	841.5	CH	47	81	27	54	G4127	brenna
09-53M	Moorhead	14	64.5	900	835.5	CH	51.7	81	30	51	G4127	argusville
09-53M	Moorhead	15	68.5	900	831.5	CH	53.5	77	28	49	G4127	argusville
09-53M	Moorhead	16	73.5	900	826.5	CH	50.4	72	29	43	G4127	argusville
09-53M	Moorhead	17	78.5	900	821.5	CH	46.5	74	26	48	G4127	argusville
09-53M	Moorhead	18	83.5	900	816.5	CH	48.5	67	26	41	G4127	argusville
09-53M	Moorhead	19	88.5	900	811.5	CH	55.3	78	26	52	G4127	argusville
09-53M	Moorhead	20	93.5	900	806.5	ML	15.4				G4127	till
09-53M	Moorhead	21	106.5	900	793.5						G4127	till
09-57M	Moorhead	1	3.5	881.9	878.4	CH	41.9	57	29	28	G4127	topsoil/alluvium
09-57M	Moorhead	2	8.5	881.9	873.4	CH	32.9	61	25	36	G4127	sherack
09-57M	Moorhead	3	13.5	881.9	868.4	ML	27.1	28	25	3	G4127	sherack
09-57M	Moorhead	4	16	881.9	865.9	CL	37.1	44	22	22	G4127	poplar river
09-57M	Moorhead	5	18.4	881.9	863.5	CH	42.4	89	31	58	G4127	brenna
09-57M	Moorhead	6	28.5	881.9	853.4	CH	68	102	32	70	G4127	brenna
09-57M	Moorhead	7	33.5	881.9	848.4	CH	66.7	101	33	68	G4127	brenna
09-57M	Moorhead	8	38.5	881.9	843.4	CH	66.2	102	34	68	G4127	brenna
09-57M	Moorhead	9	43.5	881.9	838.4	CH	63.1	85	32	53	G4127	brenna
09-57M	Moorhead	10	48.5	881.9	833.4	CH	49.4	66	26	40	G4127	argusville
09-57M	Moorhead	11	53.5	881.9	828.4	CH	52.1	71	28	43	G4127	argusville
09-57M	Moorhead	12	58.5	881.9	823.4	CH	49.5	74	26	48	G4127	argusville
09-57M	Moorhead	13	63.5	881.9	818.4	CH	51.6	72	25	47	G4127	argusville
09-57M	Moorhead	14	73.5	881.9	808.4	CH	43.5	61	21	40	G4127	argusville
09-57M	Moorhead	15	79.5	881.9	802.4	CH					G4127	till
09-57M	Moorhead	16	83.5	881.9	798.4	CH					G4127	till
09-57M	Moorhead	17	93.5	881.9	788.4	CH					G4127	till

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH
Date: JUL 09

Latest Revision: 2/18/2011
By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
09-60M	Moorhead	1	3.5	882.6	879.1	CH	33.3	62	25	37	G4127	topsoil/alluvium
09-60M	Moorhead	2	8.5	882.6	874.1	CH	38	77	29	48	G4127	sherack
09-60M	Moorhead	3	13.5	882.6	869.1	MH	42.1	54	33	21	G4127	poplar river
09-60M	Moorhead	4	18.5	882.6	864.1	MH	59.4	83	41	42	G4127	poplar river
09-60M	Moorhead	5	23.5	882.6	859.1	CL	30	27	19	8	G4127	poplar river
09-60M	Moorhead	6	28.5	882.6	854.1	ML	30.4	32	26	6	G4127	poplar river
09-60M	Moorhead	7	33.5	882.6	849.1	CL	29.6	29	20	9	G4127	poplar river
09-60M	Moorhead	8	38.5	882.6	844.1	CL	32.3	43	19	24	G4127	poplar river
09-60M	Moorhead	9	43.5	882.6	839.1	CH	42.8	100	36	64	G4127	brenna
09-60M	Moorhead	10	48.5	882.6	834.1	CH	53.3	104	33	71	G4127	brenna
09-60M	Moorhead	11	53.5	882.6	829.1	CH	49	98	31	67	G4127	brenna
09-60M	Moorhead	12	58.5	882.6	824.1	CH	49.7	87	31	56	G4127	argusville
09-60M	Moorhead	13	63.5	882.6	819.1	CH	52	98	30	68	G4127	argusville
09-60M	Moorhead	14	68.5	882.6	814.1	CH	47	68	28	40	G4127	argusville
09-60M	Moorhead	15	73.5	882.6	809.1	CH	50.4	79	31	48	G4127	argusville
09-60M	Moorhead	16	78.5	882.6	804.1	CH	48	81	30	51	G4127	argusville
09-60M	Moorhead	17	83.5	882.6	799.1	CH	44.4	78	28	50	G4127	argusville
09-60M	Moorhead	18	95.5	882.6	787.1	CL	17.3	31	17	14	G4127	till
09-63M	Moorhead	1	3.5	881	877.5	CH	40.5	63	30	33	G4127	topsoil/alluvium
09-63M	Moorhead	2	8.5	881	872.5	CH	37.6	74	30	44	G4127	sherack
09-63M	Moorhead	3	13.5	881	867.5	CH	73.4	108	40	68	G4127	brenna
09-63M	Moorhead	4	18.25	881	862.75	CH	81	115	38	77	G4127	brenna
09-63M	Moorhead	5	23.5	881	857.5	CH	72.4	120	37	83	G4127	brenna
09-63M	Moorhead	6	28.5	881	852.5	CH	75.4	119	35	84	G4127	brenna
09-63M	Moorhead	7	33.5	881	847.5	CH	64.4	105	40	65	G4127	brenna
09-63M	Moorhead	8	38.5	881	842.5	CH	67.7	102	38	64	G4127	brenna
09-63M	Moorhead	9	43.5	881	837.5	CH	62.4	96	34	62	G4127	brenna
09-63M	Moorhead	10	48.5	881	832.5	CH	62.8	84	29	55	G4127	brenna
09-63M	Moorhead	11	53.5	881	827.5	CH	49.9	72	26	46	G4127	argusville
09-63M	Moorhead	12	58.5	881	822.5	CH	51.4	73	25	48	G4127	argusville
09-63M	Moorhead	13	63.5	881	817.5	CH	55.4	82	25	57	G4127	argusville
09-63M	Moorhead	14	68.5	881	812.5	CH	47.6	73	23	50	G4127	argusville
09-63M	Moorhead	15	73.5	881	807.5	CH	45.8	60	22	38	G4127	argusville
09-67M	Moorhead	1	8.3	895.1	886.8	CH	32.3	62	28	34	G4127	topsoil/alluvium
09-67M	Moorhead	2	10.5	895.1	884.6	CH	35.1	68	25	43	G4127	alluvium
09-67M	Moorhead	3	14.5	895.1	880.6	CH	30.8	58	22	36	G4127	alluvium
09-67M	Moorhead	4	18.5	895.1	876.6	ML	27.5				G4127	poplar river
09-67M	Moorhead	5	21.5	895.1	873.6	CH	49.8	107	37	70	G4127	brenna
09-67M	Moorhead	6	28.3	895.1	866.8	CH	77	119	37	82	G4127	brenna
09-67M	Moorhead	7	33.5	895.1	861.6	CH	73.3	108	35	73	G4127	brenna
09-67M	Moorhead	8	38.5	895.1	856.6	CH	74.8	114	37	77	G4127	brenna
09-67M	Moorhead	9	43.5	895.1	851.6	CH	77.8	112	32	80	G4127	brenna
09-67M	Moorhead	10	48.5	895.1	846.6	CH	72.7	114	36	78	G4127	brenna
09-67M	Moorhead	11	53.5	895.1	841.6	CH	62.1	104	33	71	G4127	brenna
09-67M	Moorhead	12	58.5	895.1	836.6	CH	66.5	98	32	66	G4127	brenna
09-67M	Moorhead	13	63.5	895.1	831.6	CH	57.3	88	29	59	G4127	brenna
09-67M	Moorhead	14	68.5	895.1	826.6	CH	47.3	89	30	59	G4127	argusville
09-67M	Moorhead	15	73.5	895.1	821.6	CH	51.7	79	29	50	G4127	argusville
09-67M	Moorhead	16	78.5	895.1	816.6	CH	54.2	85	30	55	G4127	argusville
09-67M	Moorhead	17	83.5	895.1	811.6	CH	56.6	58	23	35	G4127	argusville
09-67M	Moorhead	18	93.5	895.1	801.6	CH	47.7	58	23	35	G4127	argusville
09-67M	Moorhead	19	98.5	895.1	796.6	CH	45.4	64	24	40	G4127	argusville
09-67M	Moorhead	20	103.5	895.1	791.6	CH	40.9	89	30	59	G4127	argusville
09-67M	Moorhead	21	105.25	895.1	789.85	ML	14.3	45	30	15	G4127	till
09-67M	Moorhead	22	115.5	895.1	779.6	CL	14.5	30	16	14	G4127	till
09-68M	Moorhead	1	3.5	879.6	876.1	CH	39.7	77	32	45	G4127	sherack
09-68M	Moorhead	2	8.5	879.6	871.1	CH	42.4	72	28	44	G4127	poplar river
09-68M	Moorhead	3	13.5	879.6	866.1	CL	63.8	45	25	20	G4127	poplar river
09-68M	Moorhead	4	18.5	879.6	861.1	CH	39.1	74	30	44	G4127	poplar river
09-68M	Moorhead	5	10.5	879.6	869.1	CH	40.4	76	32	44	G4127	poplar river
09-68M	Moorhead	6	22.5	879.6	857.1	CH	43.1	84	33	51	G4127	poplar river
09-68M	Moorhead	7	28.2	879.6	851.4	CH	78.4	120	39	81	G4127	brenna
09-68M	Moorhead	8	33.5	879.6	846.1	CH	71.8	115	36	79	G4127	brenna
09-68M	Moorhead	9	38.5	879.6	841.1	CH	69.1	109	34	75	G4127	brenna
09-68M	Moorhead	10	43.5	879.6	836.1	CH	63.2	109	38	71	G4127	brenna
09-68M	Moorhead	11	48.5	879.6	831.1	CH	55.9	100	33	67	G4127	brenna
09-68M	Moorhead	12	53.5	879.6	826.1	CH	50.2	88	29	59	G4127	brenna
09-68M	Moorhead	13	58.5	879.6	821.1	CH	53.8	86	28	58	G4127	argusville
09-68M	Moorhead	14	63.5	879.6	816.1	CH	50.4	85	31	54	G4127	argusville
09-68M	Moorhead	15	68.5	879.6	811.1	CH	54.8	88	28	60	G4127	argusville
09-68M	Moorhead	16	73.5	879.6	806.1	CH	56.6	75	27	48	G4127	argusville
09-68M	Moorhead	17	78.5	879.6	801.1	CH	44.5	66	26	40	G4127	argusville
09-68M	Moorhead	18	83.5	879.6	796.1	CH	37.3	67	25	42	G4127	argusville
09-68M	Moorhead	19	88.5	879.6	791.1	CL	20.5	29	17	12	G4127	till

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH Latest Revision: 2/18/2011
Date: JUL 09 By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
09-69M	Moorhead	1	8.5	878.1	869.6	CH	38.5	79	29	50	G4127	sherack
09-69M	Moorhead	2	13.5	878.1	864.6	CL	29.9	34	25	9	G4127	poplar river
09-69M	Moorhead	3	14.5	878.1	863.6	CH	35.7	61	28	33	G4127	poplar river
09-69M	Moorhead	4	17.5	878.1	860.6	CH	36.8	76	30	46	G4127	brenna
09-69M	Moorhead	5	18.5	878.1	859.6	CH	40.3	55	26	29	G4127	sherack
09-69M	Moorhead	6	23.2	878.1	854.9	CH	71.6	124	34	90	G4127	brenna
09-69M	Moorhead	7	28.5	878.1	849.6	CH	71.3	113	34	79	G4127	brenna
09-69M	Moorhead	8	33.5	878.1	844.6	CH	66.6	114	34	80	G4127	brenna
09-69M	Moorhead	9	38.5	878.1	839.6	CH	67.6	109	34	75	G4127	brenna
09-69M	Moorhead	10	43.5	878.1	834.6	CH	62.1	108	34	74	G4127	brenna
09-69M	Moorhead	11	48.5	878.1	829.6	CH	60.1	89	34	55	G4127	brenna
09-69M	Moorhead	12	53.5	878.1	824.6	CH	54.3	73	26	47	G4127	brenna
09-69M	Moorhead	13	58.5	878.1	819.6	CH	54	88	21	67	G4127	argusville
09-69M	Moorhead	14	63.5	878.1	814.6	CH	48.6	82	30	52	G4127	argusville
09-69M	Moorhead	15	68.5	878.1	809.6	MH	49	78	39	39	G4127	argusville
09-70M	Moorhead	1	5.5	878.4	872.9	CH	38.3	56	27	29	G4127	sherack
09-70M	Moorhead	2	8.5	878.4	869.9	CL	42.7	37	25	12	G4127	poplar river
09-70M	Moorhead	3	11.5	878.4	866.9	CH	38	66	29	37	G4127	poplar river
09-70M	Moorhead	4	14	878.4	864.4	CH	37.7	53	26	27	G4127	poplar river
09-70M	Moorhead	5	23.2	878.4	855.2	CH	72.1	121	36	85	G4127	brenna
09-70M	Moorhead	6	28.35	878.4	850.05	CH	70.1	116	37	79	G4127	brenna
09-70M	Moorhead	7	33.5	878.4	844.9	CH	71	118	35	83	G4127	brenna
09-70M	Moorhead	8	43.5	878.4	834.9	CH	59.3	94	28	66	G4127	brenna
09-70M	Moorhead	9	48.5	878.4	829.9	CH	54.3	83	31	52	G4127	brenna
09-70M	Moorhead	10	53.5	878.4	824.9	CH	48.6	71	27	44	G4127	argusville
09-70M	Moorhead	11	58.5	878.4	819.9	CH	54.6	80	28	52	G4127	argusville
09-70M	Moorhead	12	63.5	878.4	814.9	CH	50.9	84	25	59	G4127	argusville
09-70M	Moorhead	13	68.5	878.4	809.9	CH	52.7	89	32	57	G4127	argusville
09-70M	Moorhead	14	73.5	878.4	804.9	CH	49.8	71	26	45	G4127	argusville
09-72M	Moorhead	1	5.5	873.9	868.4	CH	36.8	76	28	48	G4127	sherack
09-72M	Moorhead	2	11.5	873.9	862.4	CH	40.3	82	31	51	G4127	sherack
09-72M	Moorhead	3	18.5	873.9	855.4	ML	33.5				G4127	poplar river
09-72M	Moorhead	4	24.5	873.9	849.4	ML	27.8	24	24	0	G4127	poplar river
09-72M	Moorhead	5	27.5	873.9	846.4	CH	39.3	69	31	38	G4127	brenna/sherack
09-72M	Moorhead	6	31.5	873.9	842.4	CH	56.9	116	39	77	G4127	brenna
09-72M	Moorhead	7	35.25	873.9	838.65	CH	68.3	108	38	70	G4127	brenna
09-72M	Moorhead	8	37.25	873.9	836.65	CH	64.1	100	36	64	G4127	brenna
09-72M	Moorhead	9	44.5	873.9	829.4	CH	62.3	92	32	60	G4127	brenna
09-72M	Moorhead	10	49.5	873.9	824.4	CH	56.8	88	32	56	G4127	brenna
09-72M	Moorhead	11	54.5	873.9	819.4	CH	61.9	91	36	55	G4127	brenna
09-72M	Moorhead	12	59.5	873.9	814.4	CH	48.7	78	27	51	G4127	brenna
09-72M	Moorhead	13	64.5	873.9	809.4	CH	49.7	78	28	50	G4127	brenna
09-72M	Moorhead	14	69.5	873.9	804.4	CH	46	75	23	52	G4127	argusville
09-73M	Moorhead	1	5.5	874.5	869	CH	34.2	72	30	42	G4127	alluvium
09-73M	Moorhead	2	9.5	874.5	865	CH	50.7	107	36	71	G4127	PL sherack?
09-73M	Moorhead	3	14.5	874.5	860	CH	55.6	109	37	72	G4127	PL sherack?
09-73M	Moorhead	4	19.5	874.5	855	CH	65.7	114	37	77	G4127	brenna
09-73M	Moorhead	5	25.5	874.5	849	CH	72	122	35	87	G4127	brenna
09-73M	Moorhead	6	35.5	874.5	839	CH	65	109	33	76	G4127	brenna
09-73M	Moorhead	7	41.5	874.5	833	CH	60.2	94	32	62	G4127	brenna
09-73M	Moorhead	8	47.5	874.5	827	CH	49	68	27	41	G4127	brenna
09-73M	Moorhead	9	54.5	874.5	820	CH	57	81	29	52	G4127	brenna
09-73M	Moorhead	10	59.5	874.5	815	CH	43.5	54	27	27	G4127	brenna
09-73M	Moorhead	11	64.5	874.5	810	CH	43.9	78	21	57	G4127	argusville
09-74M	MN Div	1	9	916	907	CL	35.5	37	22	15	7314	ML
09-74M	MN Div	2	14	916	902	CH	48.8	90	36	54	7314	CH
09-74M	MN Div	3	24	916	892	CH	68.2	112	37	75	7314	Brenna
09-74M	MN Div	4	29	916	887	CH	70.7	105	37	68	7314	Brenna
09-74M	MN Div	5	33.5	916	882.5	CH	69.7	100	34	66	7314	Brenna
09-74M	MN Div	6	39	916	877	CH	71.1	103	36	67	7314	Brenna
09-74M	MN Div	7	44	916	872	CH	65.3	95	28	67	7314	Brenna
09-74M	MN Div	8	49	916	867	CH	53.4	76	24	52	7314	glacio-lacustrine
09-74M	MN Div	9	54	916	862	CH	54.6	75	31	44	7314	glacio-lacustrine
09-74M	MN Div	10	59	916	857	CH	47.2	61	29	32	7314	CH/CL
09-75M	MN Div	1	9	925.5	916.5	CH	41.2	82	28	54	7314	CH
09-75M	MN Div	2	14	925.5	911.5	CH	36.8	80	29	51	7314	CH
09-75M	MN Div	3	19	925.5	906.5	CL	45.6	78	30	48	7314	CH
09-75M	MN Div	4	24	925.5	901.5	CH	49.4	77	30	47	7314	Brenna
09-75M	MN Div	5	29	925.5	896.5	CH	47.7	58	19	39	7314	glacio-lacustrine
09-75M	MN Div	6	34	925.5	891.5	CL	52	72	30	42	7314	CH
09-75M	MN Div	7	39	925.5	886.5	CL	36.7	46	22	24	7314	CH
09-75M	MN Div	8	44	925.5	881.5	ML	24.5				7314	ML
09-75M	MN Div	9	49	925.5	876.5	SP-SM	21.8				7314	SP

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH
Date: JUL 09

Latest Revision: 2/18/2011
By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
10-76M	Moorhead	1	4.5	896.819	892.319	CH	29.6	67	23	44		Alluvium
10-76M	Moorhead	2	8.5	896.819	888.319	CH	34.4	77	34	43		sherack
10-76M	Moorhead	3	13.5	896.819	883.319	CH	38.7	85	31	54		sherack
10-76M	Moorhead	4	16.55	896.819	880.269	ML	30.4					PR-WF
10-76M	Moorhead	5	23.5	896.819	873.319	CH	48.2	48	25	23		PR-WF
10-76M	Moorhead	6	26.25	896.819	870.569	CH	49	55	30	25		PR-WF
10-76M	Moorhead	7	28.35	896.819	868.469	CH	41.6	68	24	44		PR - Harwood
10-76M	Moorhead	8	32.5	896.819	864.319	CH	47.9	102	31	71		dessicated brenna
10-76M	Moorhead	9	38.4	896.819	858.419	CH	72.6	107	35	72		brenna
10-76M	Moorhead	10	43.5	896.819	853.319	CH	65.6	107	32	75		brenna
10-76M	Moorhead	11	48.5	896.819	848.319	CH	65.6	105	37	68		brenna
10-76M	Moorhead	12	53.5	896.819	843.319	CH	72.1	118	35	83		brenna
10-76M	Moorhead	13	58.5	896.819	838.319	CH	73.6	118	34	84		brenna
10-76M	Moorhead	14	63.5	896.819	833.319	CH	60.6	103	32	71		brenna
10-76M	Moorhead	15	68.5	896.819	828.319	CH	61.3	108	29	79		brenna
10-76M	Moorhead	16	73.5	896.819	823.319	CH	59.4	93	28	65		brenna
10-76M	Moorhead	17	78.5	896.819	818.319	CH	54.6	98	24	74		brenna
10-76M	Moorhead	18	84.5	896.819	812.319	CH	55.5	84	26	58		brenna
10-76M	Moorhead	19	88.5	896.819	808.319	CH	45	64	22	42		argusville
10-76M	Moorhead	20	93.5	896.819	803.319	CH	69.7	75	33	42		argusville
10-76M	Moorhead	21	98.5	896.819	798.319	CH	40	74	24	50		argusville
10-76M	Moorhead	22	103.5	896.819	793.319	CH	46.3	74	24	50		argusville
10-76M	Moorhead	23	112.5	896.819	784.319	SM	9.8	16	14	2		unit "A" till
10-76M	Moorhead	24	130.5	896.819	766.319	CL	10.3	26	16	10		unit "A" till
10-77M	Moorhead	1	0.75	885.37	884.62	CH	33.8	67	30	37		Topsoil
10-77M	Moorhead	2	6.25	885.37	879.12	CH	29.4	69	24	45		sherack
10-77M	Moorhead	3	8.75	885.37	876.62	CH	29	65	27	38		sherack
10-77M	Moorhead	4	13.25	885.37	872.12	CH	36.9	79	35	44		sherack
10-77M	Moorhead	5	18.25	885.37	867.12	CH	38.5	70	25	45		sherack
10-77M	Moorhead	6	23.25	885.37	862.12	CH	47.3	63	23	40		sherack
10-77M	Moorhead	7	28.25	885.37	857.12	CH	50.9	99	36	63		dessicated brenna
10-77M	Moorhead	8	33.75	885.37	851.62	CH	54.5	99	31	68		Brenna
10-77M	Moorhead	9	38.75	885.37	846.62	CH	59.5	97	32	65		Brenna
10-77M	Moorhead	10	43.75	885.37	841.62	CH	56.7	93	31	62		Brenna
10-77M	Moorhead	11	48.75	885.37	836.62	CH	61.4	102	30	72		Brenna
10-77M	Moorhead	12	54.75	885.37	830.62	CH	55.2	104	32	72		Brenna
10-77M	Moorhead	13	58.75	885.37	826.62	CH	66.1	115	33	82		Brenna
10-77M	Moorhead	14	63.75	885.37	821.62	CH	62.9	116	33	83		Brenna
10-77M	Moorhead	15	68.25	885.37	817.12	CH	54.8	94	29	65		Brenna
10-77M	Moorhead	16	73.75	885.37	811.62	CH	58.3	98	27	71		Brenna
10-77M	Moorhead	17	78.75	885.37	806.62	CH	56.9	91	31	60		Brenna
10-77M	Moorhead	18	83.25	885.37	802.12	CH	52	79	28	51		Brenna
10-77M	Moorhead	19	87.25	885.37	798.12	CH	38.6	76	24	52		argusville
10-77M	Moorhead	20	93.25	885.37	792.12	CH	46.8	73	25	48		argusville
10-77M	Moorhead	21	98.75	885.37	786.62	CH	46.2	71	24	47		argusville
10-77M	Moorhead	22	103.75	885.37	781.62	CL	21.4	30	17	13		unit "A" till
10-77M	Moorhead	23	108.25	885.37	777.12	SC	20.8	32	19	13		unit "A" till
10-77M	Moorhead	24	113.75	885.37	771.62	CL	19.5	32	18	14		unit "A" till
10-77M	Moorhead	25	118.75	885.37	766.62	CL	21.2	35	18	17		unit "A" till
10-77M	Moorhead	26	123.25	885.37	762.12	SM	8.5	18	12	6		unit "A" till
10-77M	Moorhead	27	128.25	885.37	757.12	CL - ML	8.8	16	10	6		unit "A" till
10-78M	Moorhead	1	4	892.849	888.849	CH	33	64	27	37		Alluvium
10-78M	Moorhead	2	8.5	892.849	884.349	CH	37.6	80	35	45		sherack
10-78M	Moorhead	3	14.5	892.849	878.349	CH	38.7	77	33	44		sherack
10-78M	Moorhead	4	18.6	892.849	874.249	ML	41.8	39	27	12		PR-WF
10-78M	Moorhead	5	24.5	892.849	868.349	ML	35.4	31	23	8		PR-WF
10-78M	Moorhead	6	28.5	892.849	864.349	CH	41.6	61	27	34		PR - Harwood
10-78M	Moorhead	7	34	892.849	858.849	CH	48.5	100	35	65		dessicated brenna
10-78M	Moorhead	8	43.5	892.849	849.349	CH	69.5	112	32	80		brenna
10-78M	Moorhead	9	48.5	892.849	844.349	CH	66.8	105	34	71		brenna
10-78M	Moorhead	10	53.5	892.849	839.349	CH	70.9	127	34	93		brenna
10-78M	Moorhead	11	58.5	892.849	834.349	CH	67	112	29	83		brenna
10-78M	Moorhead	12	63.5	892.849	829.349	CH	62.7	104	33	71		brenna
10-78M	Moorhead	13	68.5	892.849	824.349	CH	59.9	100	31	69		brenna
10-78M	Moorhead	14	73.5	892.849	819.349	CH	59.9	92	32	60		brenna
10-78M	Moorhead	15	78.5	892.849	814.349	CH	52.9	87	27	60		brenna
10-78M	Moorhead	16	84.5	892.849	808.349	CH	45.5	74	28	46		argusville
10-78M	Moorhead	17	88.5	892.849	804.349	CH	58.2	81	29	52		argusville
10-78M	Moorhead	18	93.5	892.849	799.349	CH	42.1	75	31	44		argusville
10-78M	Moorhead	19	98.5	892.849	794.349	CH	51.5	84	26	58		argusville
10-78M	Moorhead	20	108.5	892.849	784.349	CH	42.4	69	24	45		argusville
10-78M	Moorhead	21	113.5	892.849	779.349	CL	13.2	33	15	18		unit "A" till
10-78M	Moorhead	22	123.5	892.849	769.349	CL	19.5	33	16	17		unit "A" till

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH Latest Revision: 2/18/2011
Date: JUL 09 By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
10-79M	Moorhead	1	3.25	898.444	895.194	CH	31.4	64	22	42		Fill
10-79M	Moorhead	2	8.75	898.444	889.694	CH	35.4	78	29	49		sherack
10-79M	Moorhead	3	13.75	898.444	884.694	CL	41.3	46	21	25		sherack
10-79M	Moorhead	4	18.75	898.444	879.694	MH	33.7	27	22	5		PR-WF
10-79M	Moorhead	5	23.25	898.444	876.194	ML	29.3					PR-WF
10-79M	Moorhead	6	29.25	898.444	869.194	CH	37.9	75	27	48		dessicated brenna
10-79M	Moorhead	7	33.25	898.444	865.194	CH	76.8	131	37	94		Brenna
10-79M	Moorhead	8	38.75	898.444	859.694	CH	68.1	110	30	80		Brenna
10-79M	Moorhead	9	43.75	898.444	854.694	CH	63.6	100	40	60		Brenna
10-79M	Moorhead	10	48.75	898.444	849.694	CH	66.2	102	42	60		Brenna
10-79M	Moorhead	11	53.75	898.444	844.694	CH	72.3	121	34	87		Brenna
10-79M	Moorhead	12	58.75	898.444	839.694	CH	65.7	109	30	79		Brenna
10-79M	Moorhead	13	63.75	898.444	834.694	CH	61	98	29	69		Brenna
10-79M	Moorhead	14	68.25	898.444	830.194	CH	62.4	95	31	64		Brenna
10-79M	Moorhead	15	73.25	898.444	825.194	CH	48.6	88	26	62		Brenna
10-79M	Moorhead	16	78.75	898.444	819.694	CH	52.1	89	26	63		Brenna
10-79M	Moorhead	17	83.25	898.444	815.194	CH	46.1	75	26	49		argusville
10-79M	Moorhead	18	88.75	898.444	809.694	CH	51	72	26	46		argusville
10-79M	Moorhead	19	93.75	898.444	804.694	CH	61.8	81	30	51		argusville
10-79M	Moorhead	20	98.75	898.444	799.694	CH	46.9	77	21	56		argusville
10-79M	Moorhead	21	103.75	898.444	794.694	CH	46.7	89	28	61		argusville
10-79M	Moorhead	22	108.75	898.444	789.694	CH	37.8	63	22	41		argusville
10-79M	Moorhead	23	112.25	898.444	786.194	CH	43	69	24	45		argusville
10-79M	Moorhead	24	118.25	898.444	780.194	SC	33.1	27	17	10		unit "A" till
10-80M	Moorhead	1	0.25	911.24	910.99	CH	29.8	63	26	37		Topsoil
10-80M	Moorhead	2	3.75	911.24	907.49	CH	32.4	55	30	25		sherack
10-80M	Moorhead	3	9.25	911.24	901.99	CH	43.9	100	32	68		sherack
10-80M	Moorhead	4	10.75	911.24	900.49	CH	54.4	108	30	78		Oxidized Brenna
10-80M	Moorhead	5	13.75	911.24	897.49	CH	53.6	99	28	71		Oxidized Brenna
10-80M	Moorhead	6	16	911.24	895.24	CH	38.8	82	26	56		Oxidized Brenna
10-80M	Moorhead	7	18.75	911.24	892.49	CH	53.3	100	29	71		Oxidized Brenna
10-80M	Moorhead	8	23.75	911.24	887.49	CH	55	105	34	71		argusville
10-80M	Moorhead	9	28.75	911.24	882.49	CH	52.3	81	24	57		argusville
10-80M	Moorhead	10	34.25	911.24	876.99	CH	39	63	27	36		argusville
10-80M	Moorhead	11	39.25	911.24	871.99	CH	42.3	68	27	41		argusville
10-80M	Moorhead	12	43.75	911.24	867.49	CH	48.6	61	29	32		argusville
10-80M	Moorhead	13	48.75	911.24	862.49	CH	53.5	88	29	59		argusville
10-80M	Moorhead	14	54.25	911.24	856.99	CH	42.3	72	24	48		argusville
10-80M	Moorhead	15	58.75	911.24	852.49	CH	43.5	66	22	44		argusville
10-80M	Moorhead	16	61.75	911.24	849.49	CH	43.4	71	25	46		argusville
10-80M	Moorhead	17	68.05	911.24	843.19	CH	35.9	52	25	27		argusville
10-81M	Moorhead	1	4.5	907.77	903.27	CH	36.9	51	21	30		sherack
10-81M	Moorhead	2	8.5	907.77	899.27	CH	44.4	104	31	73		oxidized brenna
10-81M	Moorhead	3	13.5	907.77	894.27	CH	40.2	94	30	64		oxidized brenna
10-81M	Moorhead	4	18.5	907.77	889.27	CH	46	96	29	67		brenna
10-81M	Moorhead	5	28.5	907.77	879.27	CH	47.9	79	26	53		brenna
10-81M	Moorhead	6	33.5	907.77	874.27	CH	53.8	82	26	56		brenna
10-81M	Moorhead	7	38.5	907.77	869.27	CH	41.6	58	28	30		brenna
10-81M	Moorhead	8	43.5	907.77	864.27	CH	51.5	73	28	45		argusville
10-81M	Moorhead	9	48.5	907.77	859.27	CH	44.9	71	26	45		argusville
10-81M	Moorhead	10	53.5	907.77	854.27	CH	47.5	74	26	48		argusville
10-81M	Moorhead	11	58.5	907.77	849.27	CH	43.7	69	25	44		argusville
10-81M	Moorhead	12	63.5	907.77	844.27	CH	39.2	55	23	32		argusville
10-81M	Moorhead	13	68.8	907.77	838.97	CL	16.1	25	11	14		unit "A" till
10-81M	Moorhead	14	73.5	907.77	834.27	CL	15.1	26	14	12		unit "A" till
10-81M	Moorhead	15	83.75	907.77	824.02	CL	15.4	31	15	16		unit "A" till
10-82M	Moorhead	1	3.5	906.383	902.883	CH	24.5	68	24	44		Topsoil
10-82M	Moorhead	2	4.75	906.383	901.633	CH	28.4	54	26	28		Alluvium
10-82M	Moorhead	3	6.25	906.383	900.133	CL	41.2	41	24	17		sherack
10-82M	Moorhead	4	9.25	906.383	897.133	CH	42.2	75	28	47		sherack
10-82M	Moorhead	5	11.25	906.383	895.133	CH	32.6	67	23	44		PR-WF
10-82M	Moorhead	6	14.25	906.383	892.133	CL	25.8	30	22	8		PR-WF
10-82M	Moorhead	9	25.75	906.383	880.633	CL	43.2	42	21	21		Oxidized Brenna
10-82M	Moorhead	10	26.35	906.383	880.033	CH	39.8	68	24	44		Oxidized Brenna
10-82M	Moorhead	11	34.25	906.383	872.133	CH	70.5	105	30	75		Brenna
10-82M	Moorhead	12	39.25	906.383	867.133	CH	74.9	106	34	72		Brenna
10-82M	Moorhead	13	44.25	906.383	862.133	CH	80.6	116	29	87		Brenna
10-82M	Moorhead	14	48.75	906.383	857.633	CH	76.4	112	27	85		Brenna
10-82M	Moorhead	15	54.25	906.383	852.133	CH	62.7	95	24	71		Brenna
10-82M	Moorhead	16	58.75	906.383	847.633	CH	69.4	90	29	61		Brenna
10-82M	Moorhead	17	60.25	906.383	846.133	CH	65.3	91	24	67		Brenna
10-82M	Moorhead	18	64.75	906.383	841.633	CH	63.9	91	25	66		argusville
10-82M	Moorhead	19	68.75	906.383	837.633	CH	51.6	85	23	62		argusville
10-82M	Moorhead	20	73.25	906.383	833.133	CH	52.2	77	26	51		argusville
10-82M	Moorhead	21	77.75	906.383	828.633	CH	53.2	85	24	61		argusville

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH Latest Revision: 2/18/2011
Date: JUL 09 By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
10-83M	Moorhead	1	3.65	913.167	909.517	CH	32.2	52	22	30		Alluvium
10-83M	Moorhead	2	8.5	913.167	904.667	CH	34.4	71	28	43		sherack
10-83M	Moorhead	4	18.5	913.167	894.667	CH	81.6	103	33	70		PR-WF
10-83M	Moorhead	5	23.5	913.167	889.667	CH	75.2	98	32	66		Brenna
10-83M	Moorhead	6	28.5	913.167	884.667	CH	72.5	93	29	64		Brenna
10-83M	Moorhead	7	33.5	913.167	879.667	CH	67.4	92	29	63		Brenna
10-83M	Moorhead	8	38.5	913.167	874.667	CH	63.7	95	29	66		Brenna
10-83M	Moorhead	9	43.5	913.167	869.667	CH	58.6	83	27	56		Brenna
10-83M	Moorhead	10	48.5	913.167	864.667	CH	75.5	99	31	68		Brenna
10-83M	Moorhead	11	53.5	913.167	859.667	CH	57.8	62	24	38		Brenna
10-83M	Moorhead	12	58.5	913.167	854.667	CH	55.2	81	27	54		argusville
10-83M	Moorhead	13	63.5	913.167	849.667	CH	44.2	63	25	38		argusville
10-83M	Moorhead	14	68.5	913.167	844.667	CH	45.5	62	24	38		argusville
10-83M	Moorhead	15	73.5	913.167	839.667	CH	34.7	50	21	29		argusville
10-83M	Moorhead	16	78.5	913.167	834.667	CL	31.2	30	22	8		argusville
10-83M	Moorhead	17	83.5	913.167	829.667	CL	22	26	16	10		argusville
10-84M	Moorhead	1	0.25	911.917	911.667	CL	12.5	39	19	20		topsoil
10-84M	Moorhead	2	4.25	911.917	907.667	CL	21.7	46	18	28		fill
10-84M	Moorhead	3	9.25	911.917	902.667	CH	36.9	75	24	51		sherack
10-84M	Moorhead	4	12.25	911.917	899.667	ML	26.9	26	24	2		silt
10-84M	Moorhead	5	18.75	911.917	893.167	CH	82	108	31	77		brenna
10-84M	Moorhead	6	21.75	911.917	890.167	CH	84.2	108	25	83		brenna
10-84M	Moorhead	7	27.25	911.917	884.667	CH	86.9	114	28	86		brenna
10-84M	Moorhead	8	34.25	911.917	877.667	CH	76	103	31	72		brenna
10-84M	Moorhead	9	38.75	911.917	873.167	CH	80.1	108	31	77		brenna
10-84M	Moorhead	10	43.75	911.917	868.167	CH	68	86	26	60		brenna
10-84M	Moorhead	11	48.75	911.917	863.167	CL	31	42	18	24		argusville
10-84M	Moorhead	12	53.75	911.917	858.167	CH	39.1	55	24	31		argusville
10-84M	Moorhead	13	56.75	911.917	855.167	ML	26.7	40	30	10		argusville
10-85M	Moorhead	1	4	916.047	912.047	CH	29.2	69	27	42		sherack
10-85M	Moorhead	2	8.5	916.047	907.547	CH	42.3	69	27	42		sherack
10-85M	Moorhead	3	10.5	916.047	905.547	ML	26.4	37	28	9		PR-WF
10-85M	Moorhead	4	18.5	916.047	897.547	CH	54.6	65	23	42		argusville
10-85M	Moorhead	5	23.5	916.047	892.547	CH	59.6	58	24	34		argusville
10-85M	Moorhead	9	42.5	916.047	873.547	ML	33.8					BA
10-86M	Moorhead	1	3.5	914.646	911.146	CH	28.8	69	20	49		Alluvium
10-86M	Moorhead	2	8.45	914.646	906.196	CH	38.2	62	22	40		sherack
10-86M	Moorhead	3	9.35	914.646	905.296	ML	25.5					PR-WF
10-86M	Moorhead	4	13.5	914.646	901.146	CH	60.9	109	28	81		brenna
10-86M	Moorhead	5	18.5	914.646	896.146	CH	63.8	98	29	69		brenna
10-86M	Moorhead	6	28.5	914.646	886.146	CH	56.7	76	25	51		argusville
10-86M	Moorhead	7	33.5	914.646	881.146	CH	58.4	70	26	44		argusville
10-86M	Moorhead	8	38.5	914.646	876.146	CH	60.9	89	25	64		argusville
10-86M	Moorhead	9	43.5	914.646	871.146	CH	38.2	55	19	36		argusville
10-87M	Moorhead	1	4	902.617	898.617	CH	28.1	61	22	39		sherack
10-87M	Moorhead	2	8.5	902.617	894.117	CH	35.6	69	29	40		sherack
10-87M	Moorhead	3	13.5	902.617	889.117	CH	45.9	69	28	41		sherack
10-87M	Moorhead	4	18.5	902.617	884.117	ML	30.2	25	25	0		PR-WF
10-87M	Moorhead	5	23.5	902.617	879.117	CH	41	56	24	32		PR-WF
10-87M	Moorhead	6	28.7	902.617	873.917	ML	30.3	24	24	0		dessicated brenna
10-87M	Moorhead	7	33.5	902.617	869.117	CH	78.9	122	34	88		brenna
10-87M	Moorhead	8	38.5	902.617	864.117	CH	68.6	106	34	72		brenna
10-87M	Moorhead	9	43.5	902.617	859.117	CH	76.6	114	35	79		brenna
10-87M	Moorhead	10	48.5	902.617	854.117	CH	69.7	100	36	64		brenna
10-87M	Moorhead	11	53.5	902.617	849.117	CH	63.8	104	33	71		brenna
10-87M	Moorhead	12	58.5	902.617	844.117	CH	60.8	91	31	60		brenna
10-87M	Moorhead	13	63.5	902.617	839.117	CH	58.4	92	30	62		brenna
10-87M	Moorhead	14	68.5	902.617	834.117	CH	56.5	88	29	59		brenna
10-87M	Moorhead	15	73.5	902.617	829.117	CH	54.7	86	28	58		brenna
10-87M	Moorhead	16	78.5	902.617	824.117	CH	55	76	27	49		brenna
10-87M	Moorhead	17	83.5	902.617	819.117	CH	38.9	56	24	32		brenna
10-87M	Moorhead	18	88.5	902.617	814.117	CH	53	87	28	59		argusville
10-87M	Moorhead	19	93.5	902.617	809.117	CH	45.3	56	25	31		argusville
10-87M	Moorhead	20	98.5	902.617	804.117	CH	45.6	82	29	53		argusville
10-87M	Moorhead	21	103.5	902.617	799.117	CH	41.4	57	20	37		argusville
10-87M	Moorhead	22	109.5	902.617	793.117	CL	13.9	26	16	10		unit "A" till
10-87M	Moorhead	24	120.5	902.617	782.117	CL	17	34	22	12		unit "A" till
10-88M	Moorhead	1	3.55	911.17	907.62	CL	35.3	43	23	20		sherack
10-88M	Moorhead	2	8.5	911.17	902.67	CH	38.7	58	24	34		sherack
10-88M	Moorhead	3	13.5	911.17	897.67	ML	30	26	25	1		PR-WF
10-88M	Moorhead	4	18.5	911.17	892.67	CH	74.5	103	34	69		brenna
10-88M	Moorhead	5	23.5	911.17	887.67	CH	77.3	133	31	102		brenna
10-88M	Moorhead	6	33.5	911.17	877.67	CH	68.8	94	30	64		brenna
10-88M	Moorhead	7	38.5	911.17	872.67	CH	68.2	96	27	69		brenna
10-88M	Moorhead	8	43.5	911.17	867.67	CH	71.2	100	32	68		brenna
10-88M	Moorhead	9	53.5	911.17	857.67	CH	63.5	90	26	64		brenna
10-88M	Moorhead	10	58.5	911.17	852.67	CH	59.5	77	27	50		argusville
10-88M	Moorhead	11	63.5	911.17	847.67	CH	63.8	88	27	61		argusville
10-88M	Moorhead	12	68.5	911.17	842.67	CH	51.4	76	26	50		argusville
10-88M	Moorhead	13	73.75	911.17	837.42	ML	34.6	32	31	1		BA
10-88M	Moorhead	21	114.5	911.17		CL-ML	15.3	21	15	6		BA

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH Latest Revision: 2/18/2011
Date: JUL 09 By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
10-89M	Moorhead	1	8.5	908.732	900.232	CL	35.5	46	25	21		Alluvium
10-89M	Moorhead	2	13.5	908.732	895.232	CH	29.1	58	22	36		sherack
10-89M	Moorhead	3	14.5	908.732	894.232	ML	25.1	29	26	3		PR-WF
10-89M	Moorhead	5	23.5	908.732	885.232	CH	74.8	120	57	63		brenna
10-89M	Moorhead	6	23.5	908.732	885.232	CH	76.5	114	33	81		brenna
10-89M	Moorhead	7	33.5	908.732	875.232	CH	81.9	121	36	85		brenna
10-89M	Moorhead	8	43.8	908.732	864.932	CH	68.9	94	32	62		brenna
10-89M	Moorhead	9	48.5	908.732	860.232	CH	60.9	88	29	59		brenna
10-89M	Moorhead	10	53.5	908.732	855.232	CH	60.9	81	31	50		brenna
10-89M	Moorhead	11	63.5	908.732	845.232	CH	57.2	88	38	50		brenna
10-89M	Moorhead	12	68.5	908.732	840.232	CH	45	60	28	32		argusville
10-89M	Moorhead	13	73.5	908.732	835.232	CH	52.9	75	28	47		argusville
10-89M	Moorhead	14	78.5	908.732	830.232	CH	50.3	78	22	56		argusville
10-89M	Moorhead	15	83.5	908.732	825.232	CH	56.4	73	23	50		argusville
10-89M	Moorhead	16	88.5	908.732	820.232	CH	46.3	59	21	38		argusville
10-89M	Moorhead	19	105.3	908.732	803.432	CL-ML	12.3	19	12	7		unit "A" till
10-89M	Moorhead	22	123.5	908.732	785.232	CL	10.3	24	12	12		unit "A" till
10-90M	Moorhead	1	0.75	910.281	909.531	CL	13.8	49	25	24		topsoil
10-90M	Moorhead	2	5.25	910.281	905.031	CL	29.4	39	20	19		Weathered sherack
10-90M	Moorhead	3	9.25	910.281	901.031	CH	41.6	72	25	47		Weathered sherack
10-90M	Moorhead	4	11.25	910.281	899.031	CH	38.7	71	26	45		Weathered sherack
10-90M	Moorhead	6	19.25	910.281	891.031	ML	25.6	25	23	2		Weathered sherack
10-90M	Moorhead	7	21.75	910.281	888.531	CH	79.5	113	38	75		brenna
10-90M	Moorhead	8	29.25	910.281	881.031	CH	80.4	116	36	80		brenna
10-90M	Moorhead	9	32.25	910.281	878.031	CH	84.6	121	35	86		brenna
10-90M	Moorhead	10	38.75	910.281	871.531	CH	70.6	109	33	76		brenna
10-90M	Moorhead	11	42.25	910.281	868.031	CH	64.8	100	23	77		brenna
10-90M	Moorhead	12	49.25	910.281	861.031	CH	63	102	28	74		brenna
10-90M	Moorhead	13	52.25	910.281	858.031	CH	68	99	27	72		brenna
10-90M	Moorhead	14	58.25	910.281	852.031	CH	60.8	85	27	58		brenna
10-90M	Moorhead	15	61.75	910.281	848.531	CH	56.3	85	27	58		brenna
10-90M	Moorhead	16	67.25	910.281	843.031	CH	53.1	77	28	49		brenna
10-90M	Moorhead	17	73.75	910.281	836.531	CH	58.3	73	27	46		argusville
10-90M	Moorhead	18	78.25	910.281	832.031	CH	63.1	70	25	45		argusville
10-90M	Moorhead	19	81.75	910.281	828.531	CH	49.4	70	26	44		argusville
10-90M	Moorhead	20	87.25	910.281	823.031	CH	46.3	58	23	35		argusville
10-90M	Moorhead	21	93.75	910.281	816.531	ML	27.8	30	23	7		unit "A" till
10-90M	Moorhead	22	99.75	910.281	810.531	CL	29.6	28	17	11		unit "A" till
10-90M	Moorhead	28	133.75	910.281	776.531	CL	23.4	35	16	19		unit "A" till
10-91M	Moorhead	2	8.5	916.928	908.428	CH	37.2	61	21	40		sherack
10-91M	Moorhead	3	12.5	916.928	904.428	CL	24.9	37	21	16		PR-WF
10-91M	Moorhead	4	13.55	916.928	903.378	CH	49.6	63	24	39		PR-WF
10-91M	Moorhead	5	18.5	916.928	898.428	CL	35.5	37	20	17		BA
10-91M	Moorhead	6	23.5	916.928	893.428	ML	24.8	23	22	1		BA
10-91M	Moorhead	21	115.5	916.928	801.428	CL	13.5	30	15	15		unit "A" till
10-92M	Moorhead	1	1.25	909.185	907.935	CL	25.9	45	20	25		topsoil
10-92M	Moorhead	2	3.05	909.185	906.135	CL	26.8	37	19	18		topsoil
10-92M	Moorhead	3	5.75	909.185	903.435	CH	32.5	74	25	49		sherack
10-92M	Moorhead	4	13.25	909.185	895.935	CH	40.2	58	25	33		sherack
10-92M	Moorhead	5	16.25	909.185	892.935	ML	24.6	Non-Plastic				PR-WF
10-92M	Moorhead	6	19.25	909.185	889.935	CH	69	117	30	87		brenna
10-92M	Moorhead	7	22.25	909.185	886.935	CH	81	123	34	89		brenna
10-92M	Moorhead	8	28.75	909.185	880.435	CH	67.7	105	32	73		brenna
10-92M	Moorhead	9	32.25	909.185	876.935	CH	72.8	110	32	78		brenna
10-92M	Moorhead	10	39.75	909.185	869.435	CH	66.2	98	27	71		brenna
10-92M	Moorhead	11	42.25	909.185	866.935	CH	53.2	84	24	60		argusville
10-92M	Moorhead	12	49.75	909.185	859.435	CH	59	82	30	52		argusville
10-92M	Moorhead	13	52.25	909.185	856.935	CH	61.5	97	28	69		argusville
10-92M	Moorhead	14	61.75	909.185	847.435	CL	54.1	48	24	24		argusville
10-92M	Moorhead	15	67.25	909.185	841.935	CH	47	56	24	32		argusville
10-92M	Moorhead	16	72.75	909.185	836.435	CL	34	47	21	26		argusville
10-92M	Moorhead	17	77.25	909.185	831.935	CH	38	52	23	29		argusville
10-92M	Moorhead	18	80.75	909.185	828.435	CL	32.2	42	21	21		argusville
10-92M	Moorhead	19	83.75	909.185	825.435	ML	25.8	25	22	3		BA
10-92M	Moorhead	25	113.25	909.185	795.935	CL	27.4	29	21	8		BA
10-92M	Moorhead	26	118.65	909.185	790.535	CL	16.3	26	18	8		BA
10-92M	Moorhead	28	129.25	909.185	779.935	ML	9.4	15	13	2		BA
10-93M	Moorhead	2	8.5	912.374	903.874	CH	41.2	73	32	41		sherack
10-93M	Moorhead	3	14.5	912.374	897.874	CL	32.2	32	20	12		PR-WF
10-93M	Moorhead	4	18.5	912.374	893.874	MH	78.4	110	45	65		brenna
10-93M	Moorhead	5	23.5	912.374	888.874	CH	81	110	34	76		brenna
10-93M	Moorhead	6	28.5	912.374	883.874	CH	78.1	111	36	75		brenna
10-93M	Moorhead	7	33.5	912.374	878.874	CH	70.7	106	32	74		brenna
10-93M	Moorhead	8	38.5	912.374	873.874	CH	69.6	100	29	71		brenna
10-93M	Moorhead	9	43.5	912.374	868.874	CH	63.5	91	28	63		brenna
10-93M	Moorhead	10	48.5	912.374	863.874	CH	59.2	89	29	60		brenna
10-93M	Moorhead	11	53.5	912.374	858.874	CH	69.1	98	31	67		brenna
10-93M	Moorhead	12	58.5	912.374	853.874	CH	59.2	89	29	60		brenna
10-93M	Moorhead	13	64.5	912.374	847.874	CH	51.2	73	27	46		argusville
10-93M	Moorhead	14	68.5	912.374	843.874	CH	52.4	64	26	38		argusville
10-93M	Moorhead	15	73.5	912.374	838.874	CH	54.2	67	27	40		argusville
10-93M	Moorhead	16	78.5	912.374	833.874	CH	49.3	117	30	87		argusville
10-93M	Moorhead	17	84.5	912.374	827.874	CL-ML	24.2	24	20	4		BA

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH
Date: JUL 09

Latest Revision: 2/18/2011
By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
10-93M	Moorhead	19	98.5	912.374	813.874	ML	24.9	Non-Plastic				BA

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH Latest Revision: 2/18/2011
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Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
10-94M	Moorhead	2	8.5	913.437	904.937	CH	40.5	99	31	68		dessicated brenna
10-94M	Moorhead	3	13.5	913.437	899.937	CH	44.2	90	29	61		dessicated brenna
10-94M	Moorhead	4	18.5	913.437	894.937	CH	42.1	91	30	61		dessicated brenna
10-94M	Moorhead	5	23.5	913.437	889.937	CH	40.1	71	25	46		dessicated brenna
10-94M	Moorhead	6	28.5	913.437	884.937	CH	40.2	63	26	37		dessicated brenna
10-94M	Moorhead	7	33.5	913.437	879.937	CH	42	51	25	26		dessicated brenna
10-94M	Moorhead	8	38.5	913.437	874.937	CH	48.2	51	27	24		argusville
10-94M	Moorhead	9	43.5	913.437	869.937	CL	35.4	49	25	24		argusville
10-94M	Moorhead	10	48.5	913.437	864.937	CL	39.6	40	24	16		argusville
10-94M	Moorhead	13	63.5	913.437	849.937	CL – ML	12.4	20	16	4		unit "A" till
10-95M	Moorhead	2	8.5	913.746	905.246	CH	47.5	101	30	71		dessicated brenna
10-95M	Moorhead	3	13.5	913.746	900.246	CH	51.7	93	27	66		dessicated brenna
10-95M	Moorhead	4	18.55	913.746	895.196	CH	41.9	76	28	48		brenna
10-95M	Moorhead	5	23.5	913.746	890.246	CH	42.2	78	30	48		brenna
10-95M	Moorhead	6	28.5	913.746	885.246	CH	47.6	85	28	57		brenna
10-95M	Moorhead	7	33.5	913.746	880.246	CH	39.3	64	25	39		brenna
10-95M	Moorhead	8	38.5	913.746	875.246	CH	42	68	26	42		argusville
10-95M	Moorhead	9	43.5	913.746	870.246	CH	42.4	64	26	38		argusville
10-95M	Moorhead	10	48.5	913.746	865.246	CH	40.3	67	25	42		argusville
10-95M	Moorhead	11	53.5	913.746	860.246	CH	44.2	66	23	43		argusville
10-95M	Moorhead	12	58.5	913.746	855.246	CL	25.6	33	20	13		argusville
10-95M	Moorhead	14	65.5	913.746	848.246	CL	14	28	17	11		unit "A" till
10-95M	Moorhead	15	71.5	913.746	842.246	ML	25.4	Non-Plastic				unit "A" till
10-96M	Moorhead	1	6.25	909.64	903.39	CH	30.8	66	23	43		sherack
10-96M	Moorhead	2	13.25	909.64	896.39	ML	25.6	24	24	0		sherack
10-96M	Moorhead	3	19.25	909.64	890.39	CH	77.3	107	34	73		brenna
10-96M	Moorhead	4	21.25	909.64	888.39	CH	82.8	114	36	78		brenna
10-96M	Moorhead	5	29.25	909.64	880.39	CH	72.2	92	29	63		brenna
10-96M	Moorhead	6	34.25	909.64	875.39	CH	69.5	94	28	66		brenna
10-96M	Moorhead	7	38.75	909.64	870.89	CH	56.9	92	28	64		brenna
10-96M	Moorhead	8	44.25	909.64	865.39	CH	65.1	98	28	70		brenna
10-96M	Moorhead	9	49.25	909.64	860.39	CH	64.3	97	29	68		brenna
10-96M	Moorhead	10	53.25	909.64	856.39	CH	61.6	89	29	60		brenna
10-96M	Moorhead	11	59.25	909.64	850.39	CH	43.1	59	27	32		brenna
10-96M	Moorhead	12	63.75	909.64	845.89	CH	67.8	92	28	64		brenna
10-96M	Moorhead	13	67.75	909.64	841.89	CH	52.4	88	28	60		argusville
10-96M	Moorhead	14	74.25	909.64	835.39	CH	51	78	28	50		argusville
10-98M	Moorhead	1	2.75	913.754	911.004	CH	28.8	63	29	34		Fill
10-98M	Moorhead	2	8.75	913.754	905.004	CH	35.6	70	24	46		sherack
10-98M	Moorhead	3	13.05	913.754	900.704	ML	28.3	Non-Plastic				PR-WF
10-98M	Moorhead	4	18.75	913.754	895.004	CH	67.3	91	31	60		Brenna
10-98M	Moorhead	5	23.75	913.754	890.004	CH	63.5	91	28	63		Brenna
10-98M	Moorhead	6	29.25	913.754	884.504	CH	62.2	96	28	68		Brenna
10-98M	Moorhead	7	33.25	913.754	880.504	CH	55.1	79	26	53		Brenna
10-98M	Moorhead	8	39.25	913.754	874.504	CH	76.7	77	26	51		Brenna
10-98M	Moorhead	9	43.25	913.754	870.504	CH	47.6	73	26	47		Argusville
10-98M	Moorhead	10	49.25	913.754	864.504	CH	51.8	63	25	38		Argusville
10-98M	Moorhead	11	54.25	913.754	859.504	CL	36.8	42	20	22		Argusville
10-98M	Moorhead	12	58.75	913.754	855.004	CL-ML	32.1	29	22	7		BA
10-102M	Moorhead	2	9.05	913.29	904.24	ML	26.6	26	25	1		sherack
10-102M	Moorhead	3	14.25	913.29	899.04	CL	31.5	40	18	22		Brenna
10-102M	Moorhead	4	18.75	913.29	894.54	CH	68.9	93	26	67		Brenna
10-102M	Moorhead	5	23.75	913.29	889.54	CH	57.6	91	26	65		Brenna
10-102M	Moorhead	6	28.25	913.29	885.04	CH	79	93	30	63		Brenna
10-102M	Moorhead	7	32.25	913.29	881.04	CL	36.6	44	23	21		?brenna
10-102M	Moorhead	8	38.75	913.29	874.54	CH	41	50	22	28		?brenna
10-102M	Moorhead	9	43.75	913.29	869.54	CL	31.5	40	18	22		BA transition
10-102M	Moorhead	20	98.25	913.29	815.04	CL	12.5	23	14	9		BA transition
10-102M	Moorhead	22	108.75	913.29	804.54	CL	13.5	30	14	16		BA transition
10-103M	Moorhead	1	8.25	913.653	905.403	CH	41.2	69	25	44		sherack
10-103M	Moorhead	3	21.25	913.653	892.403	CH	69.2	112	29	83		Brenna
10-103M	Moorhead	4	28.25	913.653	885.403	CH	62.2	81	29	52		Brenna
10-103M	Moorhead	5	33.25	913.653	880.403	CH	71.1	99	32	67		Brenna
10-103M	Moorhead	6	38.25	913.653	875.403	CH	59.3	72	29	43		Brenna
10-103M	Moorhead	7	43.25	913.653	870.403	CH	51.7	60	24	36		Brenna
10-103M	Moorhead	8	48.25	913.653	865.403	CH	58.8	87	29	58		Brenna
10-103M	Moorhead	9	53.25	913.653	860.403	CH	51	64	25	39		Argusville
10-103M	Moorhead	10	58.25	913.653	855.403	CH	52.1	56	26	30		Argusville
10-103M	Moorhead	11	63.25	913.653	850.403	CL	39.5	49	23	26		Argusville
10-103M	Moorhead	17	98.25	913.653	815.403	CL	25.9	29	19	10		Argusville
10-103M	Moorhead	19	108.25	913.653	805.403	CL	12.5	26	16	10		Argusville
10-105M	Moorhead	1	8.75	916.611	907.861	CH	31.6	72	27	45		sherack
10-105M	Moorhead	2	11.25	916.611	905.361	CL	31.6	47	25	22		sherack
10-105M	Moorhead	3	12.25	916.611	904.361	CL	13.6	34	18	16		sherack
10-105M	Moorhead	4	13.75	916.611	902.861	CH	55.7	87	30	57		oxidized brenna
10-105M	Moorhead	5	17.25	916.611	899.361	CH	59.6	91	35	56		oxidized brenna
10-105M	Moorhead	6	23.25	916.611	893.361	CL	41	48	20	28		?brenna
10-105M	Moorhead	7	28.25	916.611	888.361	CL	38.2	43	20	23		?brenna
10-105M	Moorhead	8	32.25	916.611	884.361	CL – ML	23.3	26	21	5		BA transition
10-105M	Moorhead	23	108.25	916.611	808.361	CL	14.1	24	15	9		unit "A" till
10-105M	Moorhead	25	118.75	916.611	797.861	CL	16.1	35	16	19		unit "A" till

Project: Fargo-Moorhead Metro Feasibility Study
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Created by: KAH Latest Revision: 2/18/2011
Date: JUL 09 By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
10-81M	Fargo	1	3.25	884.3	881.05		36.6	79	35	44		Alluvium
10-81M	Fargo	2	11.25	884.3	873.05		37.5	82	33	49		Alluvium
10-81M	Fargo	3	14.25	884.3	870.05		43.2	76	31	45		Alluvium
10-81M	Fargo	4	19.75	884.3	864.55		35.3	64	29	35		Alluvium
10-81M	Fargo	5	21.25	884.3	863.05		35.1	38	19	19		Alluvium
10-81M	Fargo	6	26.25	884.3	858.05		29.9	94	33	61		Poplar River
10-81M	Fargo	7	33	884.3	851.3		46.8	41	20	21		Alluvium
10-81M	Fargo	8	34.25	884.3	850.05		58.9	84	30	54		Brenna
10-81M	Fargo	9	37.25	884.3	847.05		59.4	92	30	62		Brenna
10-81M	Fargo	10	43.75	884.3	840.55		54.4	98	36	62		Brenna
10-81M	Fargo	11	48.75	884.3	835.55		66.22	103	36	67		Brenna
10-81M	Fargo	12	52.25	884.3	832.05		66	113	39	74		Brenna
10-81M	Fargo	13	57.75	884.3	826.55		58.99	85	20	65		Brenna
10-81M	Fargo	14	59.25	884.3	825.05		54.98	71	26	45		Argusville
10-81M	Fargo	15	62.75	884.3	821.55		49.01	71	25	46		Argusville
10-81M	Fargo	16	67.75	884.3	816.55		60.03	93	31	62		Argusville
10-81M	Fargo	17	72.25	884.3	812.05		35.57	72	25	47		Argusville
10-81M	Fargo	18	74.75	884.3	809.55		18.4	24	14	10		unit "A" till
10-81M	Fargo	19	82.25	884.3	802.05		15.8	35	14	21		unit "A" till
10-81M	Fargo	20	88.25	884.3	796.05		11.1					unit "A" till
10-82M	Fargo	1	3.75	886.14	882.39		33.07	88	28	60		topsoil
10-82M	Fargo	2	8.75	886.14	877.39		31.4	79	26	53		Alluvium
10-82M	Fargo	3	9.75	886.14	876.39		36.3	85	27	58		sherack
10-82M	Fargo	4	14.25	886.14	871.89		41.4	76	29	47		sherack
10-82M	Fargo	5	15.75	886.14	870.39		44.3	105	34	71		oxidized brenna
10-82M	Fargo	6	18.75	886.14	867.39		56.8	109	35	74		oxidized brenna
10-82M	Fargo	7	24.25	886.14	861.89		52.45	98	35	63		Brenna
10-82M	Fargo	8	34.25	886.14	851.89		62.76	103	36	67		Brenna
10-82M	Fargo	9	39.25	886.14	846.89		62.29	106	35	71		Brenna
10-82M	Fargo	10	43.75	886.14	842.39		65.98	106	36	70		Brenna
10-82M	Fargo	11	54.25	886.14	831.89		63.1	104	35	69		Brenna
10-82M	Fargo	12	57.25	886.14	828.89		59.02	84	31	53		Argusville
10-82M	Fargo	13	64.25	886.14	821.89		51.37	81	33	48		Argusville
10-82M	Fargo	14	69.25	886.14	816.89		52.03	90	36	54		Argusville
10-82M	Fargo	15	74.25	886.14	811.89		60.18	85	34	51		Argusville
10-82M	Fargo	16	76.25	886.14	809.89		20.89	31	16	15		unit "A" till
10-82M	Fargo	17	84.75	886.14	801.39		20.89	35	17	18		unit "A" till
10-82M	Fargo	18	94.75	886.14	791.39		17.72	35	12	23		unit "A" till
10-83M	Fargo	1	9.25	888.12	878.87		35.28	69	32	37		sherack
10-83M	Fargo	2	11.25	888.12	876.87		59.62	63	30	33		sherack
10-83M	Fargo	3	14.75	888.12	873.37		41.03	80	34	46		oxidized brenna
10-83M	Fargo	4	19.25	888.12	868.87		55.47	103	33	70		oxidized brenna
10-83M	Fargo	5	20.5	888.12	867.62		49.85	85	35	50		Brenna
10-83M	Fargo	6	22.75	888.12	865.37		46.28	89	34	55		Brenna
10-83M	Fargo	7	28.75	888.12	859.37		53.48	95	35	60		Brenna
10-83M	Fargo	8	33.25	888.12	854.87		61.46	104	31	73		Brenna
10-83M	Fargo	9	39.25	888.12	848.87		54.52	94	31	63		Brenna
10-83M	Fargo	10	48.75	888.12	839.37		63.61	104	35	69		Brenna
10-83M	Fargo	11	53.75	888.12	834.37		63.58	104	32	72		Brenna
10-83M	Fargo	12	57.25	888.12	830.87		59.62	103	35	68		Argusville
10-83M	Fargo	13	64.25	888.12	823.87		47.92	93	34	59		Argusville
10-83M	Fargo	14	69.25	888.12	818.87		52.4	97	34	63		Argusville
10-83M	Fargo	15	74.75	888.12	813.37		17.78	28	15	13		unit "A" till
10-83M	Fargo	16	79.25	888.12	808.87		15.8	27	14	13		unit "A" till
10-83M	Fargo	17	84.25	888.12	803.87		16.3	29	14	15		unit "A" till
10-83M	Fargo	18	89.25	888.12	798.87		12.99	25	12	13		unit "A" till
10-83M	Fargo	19	99.75	888.12	788.37		14.02	30	12	18		unit "A" till
10-84M	Fargo	1	6.25	884.16	877.91		31.11	96	34	62		Alluvium
10-84M	Fargo	2	9.25	884.16	874.91		39.79	89	32	57		sherack
10-84M	Fargo	3	13.25	884.16	870.91		42.22	85	33	52		sherack
10-84M	Fargo	4	17.25	884.16	866.91		44.05	106	35	71		oxidized brenna
10-84M	Fargo	5	19.75	884.16	864.41		54.29	107	35	72		oxidized brenna
10-84M	Fargo	6	24.25	884.16	859.91		50.06	107	35	72		Brenna
10-84M	Fargo	7	29.25	884.16	854.91		50.33	103	38	65		Brenna
10-84M	Fargo	8	34.75	884.16	849.41		59.95	107	36	71		Brenna
10-84M	Fargo	9	39.25	884.16	844.91		49.55	93	36	57		Brenna
10-84M	Fargo	10	44.25	884.16	839.91		70.52	108	36	72		Brenna
10-84M	Fargo	11	49.25	884.16	834.91		56.97	105	34	71		Brenna
10-84M	Fargo	12	54.25	884.16	829.91		62.32	107	35	72		Brenna
10-84M	Fargo	13	59.25	884.16	824.91		57.35	98	33	65		Brenna
10-84M	Fargo	14	62.25	884.16	821.91		58.32	101	36	65		Argusville
10-84M	Fargo	15	69.25	884.16	814.91		57.54	103	35	68		Argusville
10-84M	Fargo	16	74.75	884.16	809.41		44.69	101	34	67		Argusville
10-84M	Fargo	17	79.25	884.16	804.91		37.74	93	36	57		Argusville
10-84M	Fargo	18	83.75	884.16	800.41		44.01	52	27	25		Argusville
10-84M	Fargo	19	86.75	884.16	797.41		13.17	45	22	23		unit "A" till
10-84M	Fargo	20	94.25	884.16	789.91		28.39	40	18	22		unit "A" till
10-84M	Fargo	21	103.25	884.16	780.91		11.44					unit "A" till
10-84M	Fargo	22	109.75	884.16	774.41		10.55					unit "A" till

Project: Fargo-Moorhead Metro Feasibility Study
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Created by: KAH Latest Revision: 2/18/2011
Date: JUL 09 By: KAH

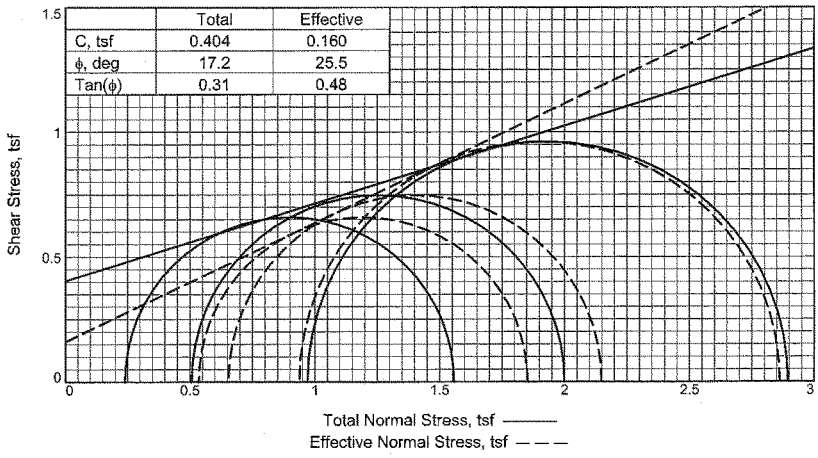
Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
10-88M	Fargo	1	4.25	893.5	889.25		34.09	103	36	67		Alluvium
10-88M	Fargo	2	9.25	893.5	884.25		34.39	89	34	55		sherack
10-88M	Fargo	3	13.25	893.5	880.25		51.35	102	36	66		oxidized brenna
10-88M	Fargo	4	19.25	893.5	874.25		56.53	100	36	64		Brenna
10-88M	Fargo	5	24.25	893.5	869.25		56.44	104	35	69		Brenna
10-88M	Fargo	6	29.25	893.5	864.25		58.71	94	32	62		Brenna
10-88M	Fargo	7	34.25	893.5	859.25		60.01	94	30	64		Brenna
10-88M	Fargo	8	38.75	893.5	854.75		59.9	104	34	70		Brenna
10-88M	Fargo	9	43.75	893.5	849.75		60.53	104	38	66		Argusville
10-88M	Fargo	10	49.75	893.5	843.75		63.17	97	34	63		Argusville
10-88M	Fargo	11	54.25	893.5	839.25		57.36	104	37	67		Argusville
10-88M	Fargo	12	59.25	893.5	834.25		45.67	90	34	56		Argusville
10-88M	Fargo	13	64.25	893.5	829.25		26.71	61	22	39		Argusville
10-88M	Fargo	14	69.25	893.5	824.25		20.8	64	29	35		unit "A" till
10-88M	Fargo	15	74.25	893.5	819.25		19.7	27	18	9		unit "A" till
10-88M	Fargo	16	83.25	893.5	810.25		15.81	52	18	34		unit "A" till
10-88M	Fargo	17	94.25	893.5	799.25		15.94	50	28	22		unit "A" till
10-92M	Fargo	1	9.25	890.94	881.69		35.01	51	24	27		Poplar River
10-92M	Fargo	2	14.75	890.94	876.19		45.9	112	35	77		oxidized brenna
10-92M	Fargo	3	19.25	890.94	871.69		56.69	101	34	67		Brenna
10-92M	Fargo	4	24.25	890.94	866.69		59.01	101	35	66		Brenna
10-92M	Fargo	5	28.75	890.94	862.19		64.21	101	36	65		Brenna
10-92M	Fargo	6	34.25	890.94	856.69		68.91	102	34	68		Brenna
10-92M	Fargo	7	38.75	890.94	852.19		65.41	102	36	66		Brenna
10-92M	Fargo	8	44.25	890.94	846.69		63.32	102	35	67		Brenna
10-92M	Fargo	9	48.75	890.94	842.19		58.17	109	34	75		Argusville
10-92M	Fargo	10	54.25	890.94	836.69		62.02	107	34	73		Argusville
10-92M	Fargo	11	59.25	890.94	831.69		59.89	86	29	57		Argusville
10-92M	Fargo	12	64.25	890.94	826.69		52.08	86	33	53		Argusville
10-92M	Fargo	13	67.75	890.94	823.19		49.31	87	27	60		Argusville
10-92M	Fargo	14	73.75	890.94	817.19		22.31	27	18	9		unit "A" till
10-92M	Fargo	15	79.25	890.94	811.69		18.71	35	20	15		unit "A" till
10-92M	Fargo	16	84.75	890.94	806.19		27.79	39	23	16		unit "A" till
10-92M	Fargo	17	88.75	890.94	802.19		14.44	32	20	12		unit "A" till
10-92M	Fargo	18	94.75	890.94	796.19		15.12	31	18	13		unit "A" till
10-94M	Fargo	1	4.75	893.04	888.29		32.67	57	27	30		Alluvium
10-94M	Fargo	2	6.75	893.04	886.29		37.39	47	27	20		sherack
10-94M	Fargo	3	9.25	893.04	883.79		39.11	45	28	17		Poplar River
10-94M	Fargo	4	14.25	893.04	878.79		47.82	116	40	76		oxidized brenna
10-94M	Fargo	5	18.75	893.04	874.29		53.10	106	35	71		Brenna
10-94M	Fargo	6	23.75	893.04	869.29		53.30	106	36	70		Brenna
10-94M	Fargo	7	29.75	893.04	863.29		54.30	86	36	50		Brenna
10-94M	Fargo	8	34.25	893.04	858.79		65.33	94	34	60		Brenna
10-94M	Fargo	9	38.75	893.04	854.29		61.84	114	31	83		Brenna
10-94M	Fargo	10	44.25	893.04	848.79		59.48	96	35	61		Argusville
10-94M	Fargo	11	48.75	893.04	844.29		66.50	105	34	71		Argusville
10-94M	Fargo	12	54.25	893.04	838.79		58.09	89	33	56		Argusville
10-94M	Fargo	13	58.75	893.04	834.29		47.40	83	34	49		Argusville
10-94M	Fargo	14	64.25	893.04	828.79		48.45	84	27	57		Argusville
10-94M	Fargo	15	69.25	893.04	823.79		19.01	25	15	10		unit "A" till
10-94M	Fargo	16	74.25	893.04	818.79		19.23	36	23	13		unit "A" till
10-94M	Fargo	17	79.25	893.04	813.79		13.63	35	23	12		unit "A" till
10-94M	Fargo	18	84.25	893.04	808.79		15.67	33	23	10		unit "A" till
10-94M	Fargo	19	93.75	893.04	799.29		18.30	32	17	15		unit "A" till
10-94M	Fargo	20	98.25	893.04	794.79		14.20	35	18	17		unit "A" till
10-94M	Fargo	21	103.75	893.04	789.29		22.60	46	23	23		unit "A" till
10-97M	Fargo	1	3.25	895.92	892.67		39.93	73	33	40		topsoil
10-97M	Fargo	2	8.75	895.92	887.17		33.22	78	31	47		Alluvium
10-97M	Fargo	3	11.75	895.92	884.17		36.8	74	33	41		sherack
10-97M	Fargo	4	13.25	895.92	882.67		30.75	50	23	27		Alluvium
10-97M	Fargo	5	14.75	895.92	881.17		44.28	96	35	61		oxidized brenna
10-97M	Fargo	6	19.25	895.92	876.67		60.07	98	35	63		Brenna
10-97M	Fargo	7	24.75	895.92	871.17		54.07	97	34	63		Brenna
10-97M	Fargo	8	29.25	895.92	866.67		65.79	108	38	70		Brenna
10-97M	Fargo	9	34.25	895.92	861.67		65.39	104	36	68		Brenna
10-97M	Fargo	10	39.25	895.92	856.67		65.59	100	39	61		Brenna
10-97M	Fargo	11	44.25	895.92	851.67		69.04	113	42	71		Brenna
10-97M	Fargo	12	49.25	895.92	846.67		71.02	109	33	76		Argusville
10-97M	Fargo	13	54.25	895.92	841.67		64.59	93	34	59		Argusville
10-97M	Fargo	14	59.25	895.92	836.67		62.02	82	32	50		Argusville
10-97M	Fargo	15	64.25	895.92	831.67		53.16	80	33	47		Argusville
10-97M	Fargo	16	69.25	895.92	826.67		59.8	77	31	46		Argusville
10-97M	Fargo	17	74.75	895.92	821.17		41.85	62	26	36		Argusville
10-97M	Fargo	18	79.25	895.92	816.67		20.87	26	14	12		unit "A" till
10-97M	Fargo	19	84.25	895.92	811.67		19.92	27	17	10		unit "A" till
10-97M	Fargo	20	88.25	895.92	807.67		22.78	40	19	21		unit "A" till
10-97M	Fargo	21	94.25	895.92	801.67		14.88	27	14	13		unit "A" till
10-97M	Fargo	22	104.25	895.92	791.67		18.22	48	17	31		unit "A" till
10-97M	Fargo	23	109.75	895.92	786.17		17.86	38	18	20		unit "A" till

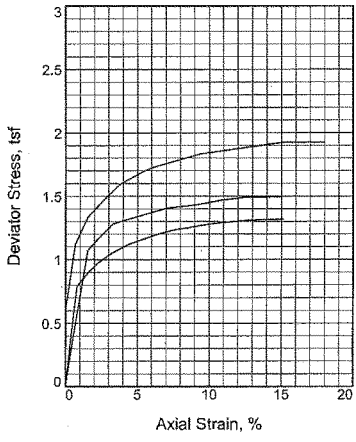
Project: Fargo-Moorhead Metro Feasibility Study
Subject: Jar Sample / Disturbed Testing Result from USACE Soil Exploration
Tested by: Midwest Testing Laboratory, Grand Forks, ND; SET, Minneapolis, MN; SETS, Tucker, GA

Created by: KAH
Date: JUL 09

Latest Revision: 2/18/2011
By: KAH

Boring #	Location	Sample #	Mid-Depth [ft]	Top of boring Elevation [ft]	Elevation [ft]	Classification	In-Situ Moisture [%]	Liquid Limit (LL) [%]	Plastic Limit (PL) [%]	Plasticity Index (PI) [%]	Project #	Soil Formation
10-101M	Fargo	1	4.75	879.18	874.43		34.66	79	26	53		Alluvium
10-101M	Fargo	2	9.25	879.18	869.93		37.97	82	32	50		sherack
10-101M	Fargo	3	13.75	879.18	865.43		40.68	75	30	45		sherack
10-101M	Fargo	4	19.25	879.18	859.93		44.46	77	34	43		oxidized brenna
10-101M	Fargo	5	24.25	879.18	854.93		65.3	103	31	72		Brenna
10-101M	Fargo	6	29.25	879.18	849.93		57.05	95	33	62		Brenna
10-101M	Fargo	7	34.25	879.18	844.93		51.53	96	33	63		Brenna
10-101M	Fargo	8	39.2	879.18	839.98		57.58	91	34	57		Brenna
10-101M	Fargo	9	44.25	879.18	834.93		56.99	87	34	53		Brenna
10-101M	Fargo	10	49.25	879.18	829.93		60.03	106	35	71		Brenna
10-101M	Fargo	11	54.25	879.18	824.93		62.33	104	35	69		Brenna
10-101M	Fargo	12	59.25	879.18	819.93		61.37	93	35	58		Argusville
10-101M	Fargo	13	64.25	879.18	814.93		61.07	96	34	62		Argusville
10-101M	Fargo	14	69.25	879.18	809.93		60.16	99	34	65		Argusville
10-101M	Fargo	15	74.25	879.18	804.93		57.87	83	31	52		Argusville
10-101M	Fargo	16	79.25	879.18	799.93		46.31	74	28	46		Argusville
10-101M	Fargo	17	84.25	879.18	794.93		39.38	71	27	44		Argusville
10-101M	Fargo	18	89.25	879.18	789.93		20.13	27	17	10		unit "A" till
10-101M	Fargo	19	94.25	879.18	784.93		23.9	34	21	13		unit "A" till
10-101M	Fargo	20	99.25	879.18	779.93		22.6	34	21	13		unit "A" till
10-101M	Fargo	21	104.25	879.18	774.93		22.95	42	20	22		unit "A" till
10-101M	Fargo	22	109.25	879.18	769.93		30.9	NP				SM
10-101M	Fargo	23	113.25	879.18	765.93		8.13	29	16	13		unit "A" till
10-105M	Fargo	1	4.25	898	893.75		40.14	76	31	45		Alluvium
10-105M	Fargo	2	10.25	898	887.75		33.38	78	28	50		Alluvium
10-105M	Fargo	3	14.25	898	883.75		39.16	71	31	40		sherack
10-105M	Fargo	4	19.25	898	878.75		52.14	110	35	75		oxidized brenna
10-105M	Fargo	5	24.25	898	873.75		62.94	112	38	74		Brenna
10-105M	Fargo	6	29.25	898	868.75		63.51	109	32	77		Brenna
10-105M	Fargo	7	34.25	898	863.75		62.33	80	33	47		Brenna
10-105M	Fargo	8	39.25	898	858.75		63.71	102	35	67		Brenna
10-105M	Fargo	9	44.25	898	853.75		66.37	102	35	67		Argusville
10-105M	Fargo	10	49.25	898	848.75		65.01	101	33	68		Argusville
10-105M	Fargo	11	54.25	898	843.75		58.41	99	35	64		Argusville
10-105M	Fargo	12	59.25	898	838.75		51.53	80	33	47		Argusville
10-105M	Fargo	13	64.25	898	833.75		44.92	68	25	43		Argusville
10-105M	Fargo	14	69.25	898	828.75		20.61	31	18	13		unit "A" till
10-105M	Fargo	15	74.25	898	823.75		14.2	31	19	12		unit "A" till
10-105M	Fargo	16	84.25	898	813.75		8.85	33	18	15		unit "A" till
10-105M	Fargo	17	88.75	898	809.25		11.4	32	19	13		unit "A" till
1839							1821	1773	1770	1768	983	1839





Sample No.		1	2	3
Initial	Water Content, %	26.3	26.0	24.9
	Dry Density, pcf	94.7	95.4	97.9
	Saturation, %	88.8	89.2	90.8
	Void Ratio	0.8131	0.8004	0.7534
	Diameter, in.	1.43	1.39	1.41
	Height, in.	2.99	2.93	2.95
At Test	Water Content, %	29.6	29.1	27.4
	Dry Density, pcf	94.7	95.4	97.9
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.8131	0.8004	0.7534
	Diameter, in.	1.43	1.39	1.41
	Height, in.	2.99	2.93	2.95
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.24	0.51	0.97
Back Pressure, tsf		5.51	5.46	5.52
Cell Pressure, tsf		5.75	5.97	6.49
Peak Deviator Stress, tsf		1.32	1.49	1.92
Total Pore Pr., tsf		5.22	5.32	5.55
Ultimate Deviator Stress, tsf		1.32	1.49	1.92
Total Pore Pr., tsf		5.22	5.32	5.55
Maj. Eff. Stress at Ultimate, tsf		1.85	2.15	2.86
Min. Eff. Stress at Ultimate, tsf		0.54	0.65	0.94

Type of Test:
CU with Pore Pressures

Sample Type: Thinwall, 5", Middle of sample

Description: FAT CLAY, gray (CH)

LL= 68 **PL=** 17 **PI=** 51

Assumed Specific Gravity= 2.75

Remarks: Rate of strain is 0.001 in/min. Failure criteria based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: US Army Corps of Engineers

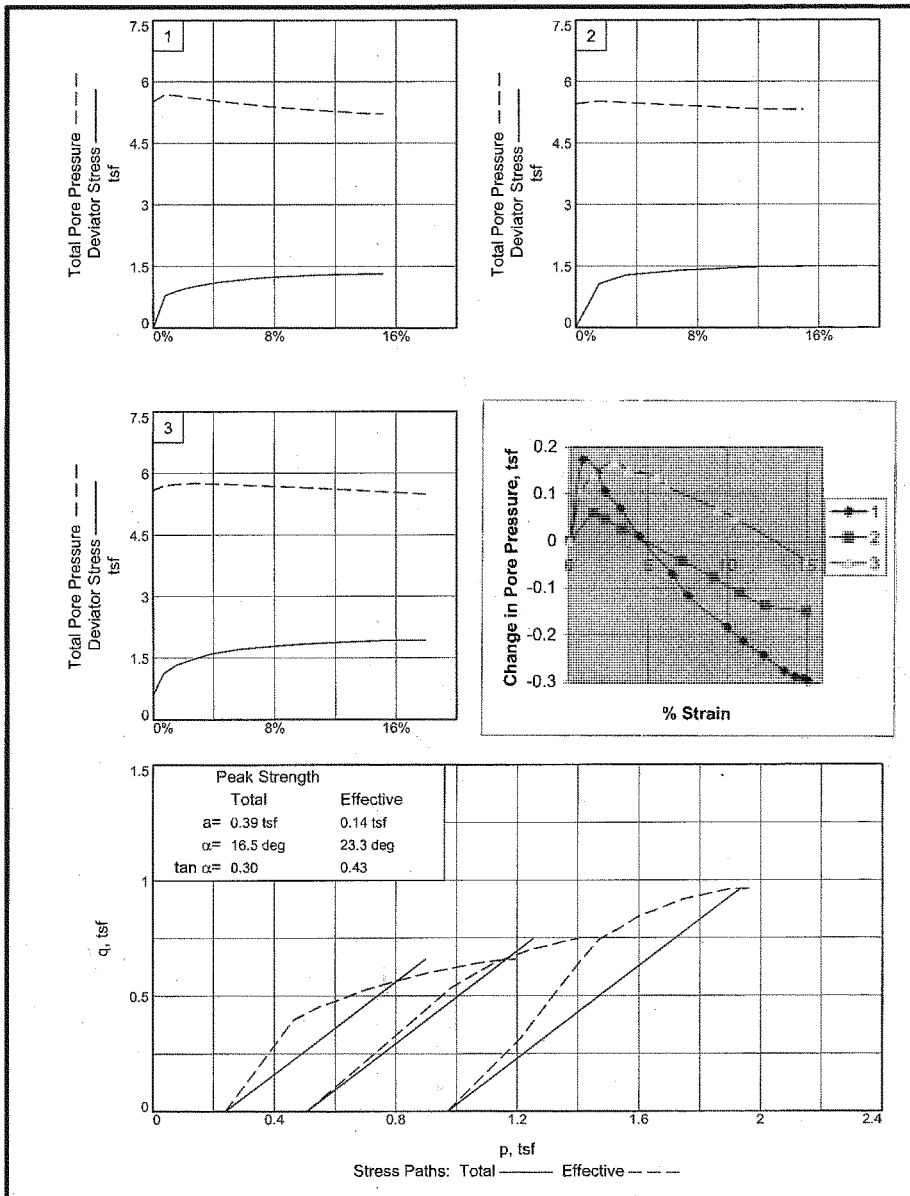
Project: Fargo-Moorhead Metro Feasibility Study
Fargo

Sample Number: Boring 09-23MU, #1 **Depth:** 2-4'
Alluvium

Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Figure: CU Triax 15-1M (3-47)



Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study Fargo

Depth: 2-4' **Sample Number:** Boring 09-23MU, #1 Alluvium

Project No.: BE-09-05127 **Figure** Braun Intertec

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

8/28/2009
12:51 PM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL-09-03127 Fargo
Depth: 2-4' **Sample Number:** Boring 09-23MU, #1
Description: FAT CLAY, gray (CH) Alluvium
Remarks: Rate of strain is 0.001 in/min. Failure criteria based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: Thinwall, 5", Middle of sample
Assumed Specific Gravity=2.75 **LL=**68 **PL=**17 **PI=**51
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	103.970			183.190
Moisture content: Dry soil+tare, gms.	88.690			148.690
Moisture content: Tare, gms.	30.510			30.690
Moisture, %	26.3	29.6	29.6	29.2
Moist specimen weight, gms.	149.8			
Diameter, in.	1.43	1.43	1.43	
Area, in.^{2}	1.59	1.59	1.59	
Height, in.	2.99	2.99	2.99	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	119.6	122.7	122.7	
Dry density, pcf	94.7	94.7	94.7	
Void ratio	0.8131	0.8131	0.8131	
Saturation, %	88.8	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 5.753 tsf
Consolidation back pressure = 5.514 tsf
Consolidation effective confining stress = 0.239 tsf
Fail. Stress = 1.318 tsf **at reading no.** 16
Ult. Stress = 1.318 tsf **at reading no.** 16

Braun Intertec

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0671	15.200	0.0	0.0	0.000	0.239	0.239	1.00	5.514	0.239	0.000
1	0.0671	15.200	0.0	0.0	0.000	0.239	0.239	1.00	5.514	0.239	0.000
2	0.0671	15.200	0.0	0.0	0.000	0.239	0.239	1.00	5.514	0.239	0.000
3	0.0910	32.900	17.7	0.8	0.793	0.066	0.859	13.01	5.687	0.462	0.396
4	0.1170	35.700	20.5	1.7	0.910	0.094	1.004	10.68	5.659	0.549	0.455
5	0.1340	37.200	22.0	2.2	0.971	0.133	1.104	8.30	5.620	0.619	0.486
6	0.1630	39.200	24.0	3.2	1.049	0.171	1.220	7.13	5.582	0.695	0.524
7	0.2000	41.200	26.0	4.4	1.122	0.230	1.352	5.88	5.523	0.791	0.561
8	0.2620	43.700	28.5	6.5	1.203	0.310	1.513	4.88	5.443	0.911	0.601
9	0.2920	44.700	29.5	7.5	1.232	0.355	1.587	4.47	5.398	0.971	0.616
10	0.3660	46.700	31.5	10.0	1.280	0.422	1.702	4.03	5.331	1.062	0.640
11	0.3960	47.400	32.2	11.0	1.294	0.452	1.746	3.86	5.301	1.099	0.647
12	0.4360	48.200	33.0	12.3	1.306	0.481	1.787	3.72	5.272	1.134	0.653
13	0.4740	48.900	33.7	13.6	1.315	0.515	1.830	3.55	5.238	1.172	0.657
14	0.4940	49.200	34.0	14.3	1.316	0.527	1.843	3.50	5.226	1.185	0.658
15	0.5090	49.400	34.2	14.8	1.316	0.531	1.847	3.48	5.222	1.189	0.658
16	0.5200	49.600	34.4	15.1	1.318	0.535	1.853	3.46	5.218	1.194	0.659

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	73.930			171.430
Moisture content: Dry soil+tare, gms.	65.130			139.310
Moisture content: Tare, gms.	31.240			30.790
Moisture, %	26.0	29.1	29.1	29.6
Moist specimen weight, gms.	139.1			
Diameter, in.	1.39	1.39	1.39	
Area, in.²	1.51	1.51	1.51	
Height, in.	2.93	2.93	2.93	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	120.1	123.1	123.1	
Dry density, pcf	95.4	95.4	95.4	
Void ratio	0.8004	0.8004	0.8004	
Saturation, %	89.2	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 5.969 tsf

Consolidation back pressure = 5.463 tsf

Consolidation effective confining stress = 0.506 tsf

Fail. Stress = 1.494 tsf **at reading no.** 15

Ult. Stress = 1.494 tsf **at reading no.** 15

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.1820	22.240	0.0	0.0	0.000	0.506	0.506	1.00	5.463	0.506	0.000
1	0.1820	22.240	0.0	0.0	0.000	0.506	0.506	1.00	5.463	0.506	0.000
2	0.1820	22.240	0.0	0.0	0.000	0.506	0.506	1.00	5.463	0.506	0.000
3	0.1820	22.400	0.2	0.0	0.008	0.506	0.514	1.02	5.463	0.510	0.004
4	0.1820	22.400	0.2	0.0	0.008	0.506	0.514	1.02	5.463	0.510	0.004
5	0.1820	22.400	0.2	0.0	0.008	0.506	0.514	1.02	5.463	0.510	0.004
6	0.1820	22.400	0.2	0.0	0.008	0.506	0.514	1.02	5.463	0.510	0.004
7	0.1820	22.400	0.2	0.0	0.008	0.506	0.514	1.02	5.463	0.510	0.004
8	0.2270	45.000	22.8	1.5	1.071	0.448	1.519	3.39	5.521	0.984	0.536
9	0.2470	47.000	24.8	2.2	1.157	0.460	1.617	3.52	5.509	1.039	0.579
10	0.2790	50.000	27.8	3.3	1.283	0.481	1.764	3.67	5.488	1.122	0.641
11	0.3890	53.900	31.7	7.1	1.406	0.548	1.954	3.57	5.421	1.251	0.703
12	0.4490	55.200	33.0	9.1	1.432	0.584	2.016	3.45	5.385	1.300	0.716
13	0.4970	56.600	34.4	10.8	1.465	0.615	2.080	3.38	5.354	1.348	0.733
14	0.5450	57.800	35.6	12.4	1.489	0.642	2.131	3.32	5.327	1.386	0.744
15	0.6200	59.000	36.8	15.0	1.494	0.654	2.148	3.28	5.315	1.401	0.747

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	70.200			179.550
Moisture content: Dry soil+tare, gms.	62.250			147.630
Moisture content: Tare, gms.	30.280			30.790
Moisture, %	24.9	27.4	27.4	27.3
Moist specimen weight, gms.	148.1			
Diameter, in.	1.41	1.41	1.41	
Area, in.²	1.56	1.56	1.56	
Height, in.	2.95	2.95	2.95	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	122.3	124.7	124.7	
Dry density, pcf	97.9	97.9	97.9	
Void ratio	0.7534	0.7534	0.7534	
Saturation, %	90.8	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 6.487 tsf
Consolidation back pressure = 5.517 tsf
Consolidation effective confining stress = 0.970 tsf
Fail. Stress = 1.925 tsf **at reading no.** 10
Ult. Stress = 1.925 tsf **at reading no.** 10

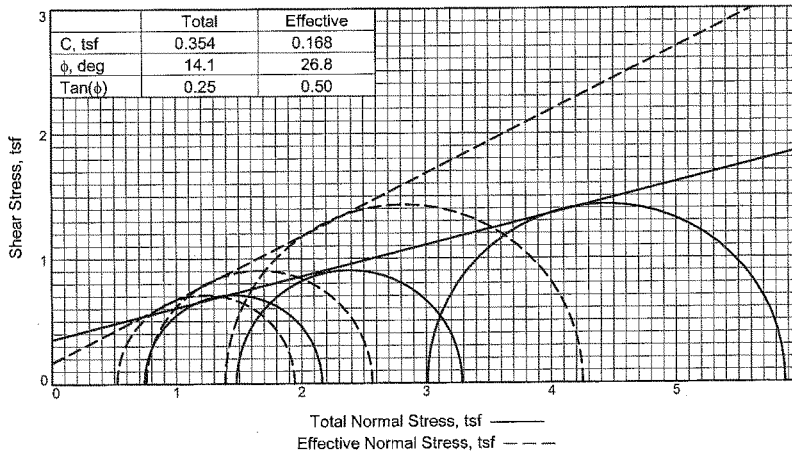
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0959	17.200	0.0	0.0	0.000	0.970	0.970	1.00	5.517	0.970	0.000
1	0.0970	30.900	13.7	0.0	0.631	0.895	1.526	1.70	5.592	1.210	0.315
2	0.1160	41.700	24.5	0.7	1.120	0.793	1.913	2.41	5.694	1.353	0.560
3	0.1410	46.600	29.4	1.5	1.333	0.752	2.085	2.77	5.735	1.419	0.667
4	0.1780	50.370	33.2	2.8	1.485	0.726	2.211	3.05	5.761	1.468	0.742
5	0.2060	53.100	35.9	3.7	1.591	0.745	2.336	3.14	5.742	1.541	0.796
6	0.2570	56.200	39.0	5.5	1.698	0.757	2.455	3.24	5.730	1.606	0.849
7	0.2770	57.200	40.0	6.1	1.729	0.778	2.507	3.22	5.709	1.642	0.864
8	0.3740	61.200	44.0	9.4	1.835	0.827	2.662	3.22	5.660	1.745	0.918
9	0.4050	62.100	44.9	10.5	1.851	0.846	2.697	3.19	5.641	1.771	0.925
10	0.5400	66.400	49.2	15.0	1.925	0.937	2.862	3.05	5.550	1.899	0.962
11	0.6260	68.200	51.0	18.0	1.926	0.998	2.924	2.93	5.489	1.961	0.963

09-23M
2-4
CU #1

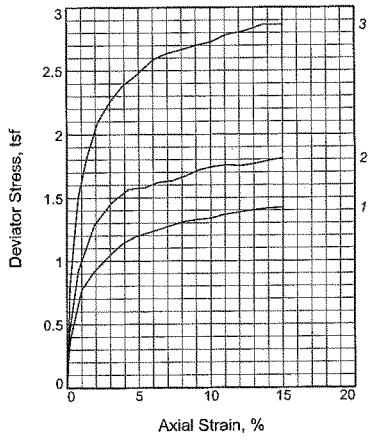
09-23M
2-4

09-23M
2-4
CU #4

09-23M
2-4
CU #4



	Total	Effective
C, tsf	0.354	0.168
ϕ, deg	14.1	26.8
Tan(ϕ)	0.25	0.50



	Sample No.	1	2	3
Initial	Water Content, %	31.1	31.5	30.9
	Dry Density, pcf	90.7	89.7	90.6
	Saturation, %	96.0	94.7	95.1
	Void Ratio	0.8921	0.9142	0.8943
	Diameter, in.	1.40	1.39	1.40
	Height, in.	2.81	2.81	2.80
At Test	Water Content, %	31.7	31.0	29.6
	Dry Density, pcf	91.7	92.6	94.6
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.8719	0.8534	0.8140
	Diameter, in.	1.39	1.38	1.38
	Height, in.	2.80	2.78	2.76
	Pore Pressure Parameter B	1.0	1.0	1.0
	Consolidation Pressure, tsf	0.74	1.48	3.00
	Back Pressure, tsf	6.39	5.65	4.13
	Cell Pressure, tsf	7.13	7.13	7.13
	Peak Deviator Stress, tsf	1.42	1.81	2.86
	Total Pore Pr., tsf	6.61	6.38	5.75
	Ultimate Deviator Stress, tsf	1.42	1.81	2.86
	Total Pore Pr., tsf	6.61	6.38	5.75
	Maj. Eff. Stress at Ultimate, tsf	1.94	2.57	4.22
	Min. Eff. Stress at Ultimate, tsf	0.52	0.76	1.39

Type of Test:
CU with Pore Pressures

Sample Type: Thinwall, 5", Middle of sample

Description: FAT CLAY, brown (CH)

Assumed Specific Gravity= 2.75

Remarks: Rate of strain is 0.001 in/min. Failure criteria based on ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115

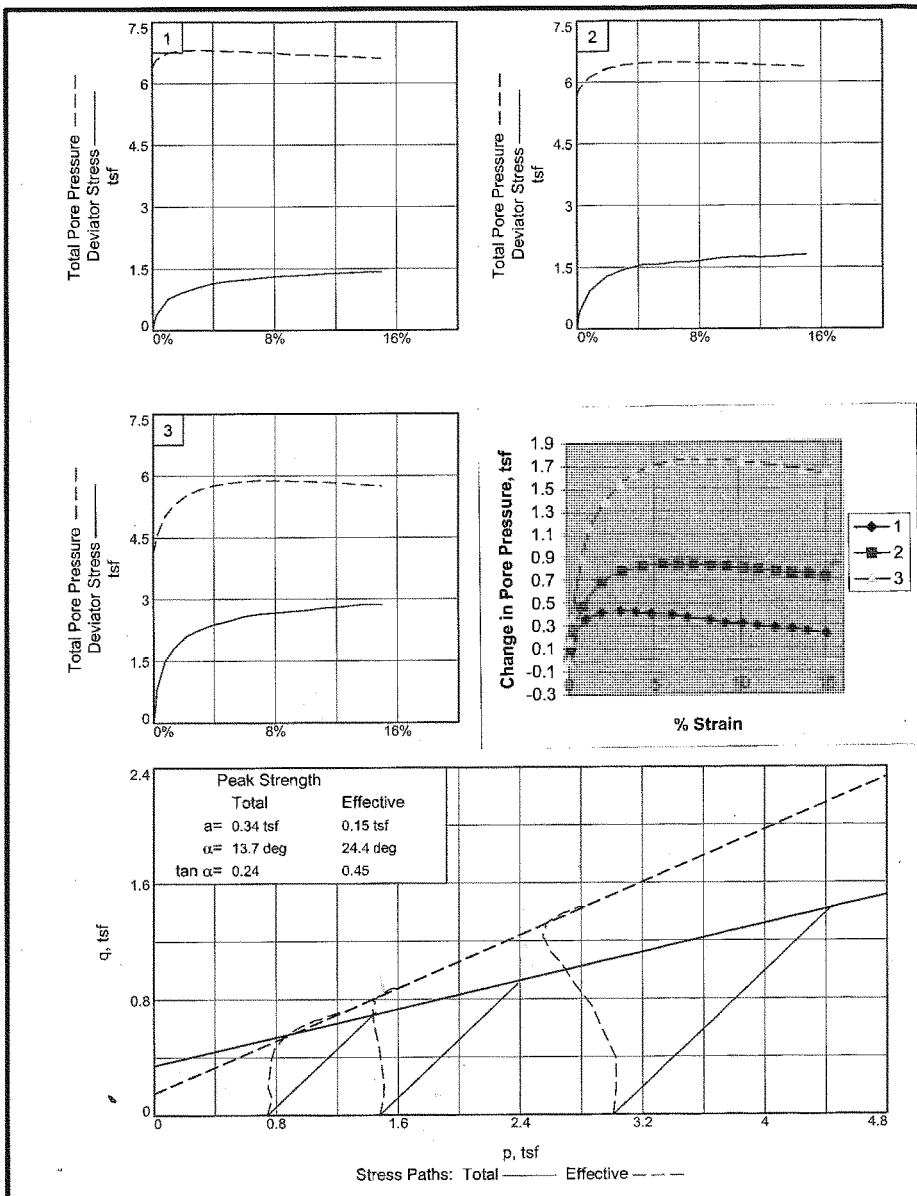
Location: SE-F-13, Fargo, Alluvium Formation

Sample Number: Boring 09-25MU, #1 **Depth:** 14-16'

Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Figure CU Triax ASTM D4767



Client: US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study

Loc.: SE-F-13, Fargo, Alluvium Formation **Depth:** 14-16' **Sample No.:** Boring 09-25MU, #1

Project No.: BL-09-03127 **Figure** **Braun Intertec**

Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

11/9/2009
12:53 PM

Date:
Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-F-13, Fargo, Alluvium Formation
Depth: 14-16' **Sample Number:** Boring 09-25MU, #1
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria based on ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: Thinwall, 5", Middle of sample
Assumed Specific Gravity=2.75 **LL=** **PL=** **PI=**
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	138.810			164.560
Moisture content: Dry soil+tare, gms.	113.090			132.190
Moisture content: Tare, gms.	30.500			29.900
Moisture, %	31.1	32.4	31.7	31.6
Moist specimen weight, gms.	134.6			
Diameter, in.	1.40	1.40	1.39	
Area, in.^{2}	1.53	1.53	1.52	
Height, in.	2.81	2.81	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	119.0	120.2	120.8	
Dry density, pcf	90.7	90.7	91.7	
Void ratio	0.8921	0.8921	0.8719	
Saturation, %	96.0	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.132 tsf
Consolidation back pressure = 6.390 tsf
Consolidation effective confining stress = 0.742 tsf
Peak Stress = 1.422 tsf **at reading no.** 17
Ult. Stress = 1.422 tsf **at reading no.** 17

Braun Intertec

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0150	19.190	0.0	0.0	0.000	0.742	0.742	1.00	6.390	0.742	0.000
1	0.0179	24.250	5.1	0.1	0.239	0.654	0.893	1.37	6.478	0.773	0.119
2	0.0216	27.250	8.1	0.2	0.380	0.556	0.936	1.68	6.576	0.746	0.190
3	0.0437	35.730	16.5	1.0	0.773	0.382	1.155	3.02	6.750	0.769	0.387
4	0.0676	38.970	19.8	1.9	0.917	0.331	1.248	3.77	6.801	0.789	0.458
5	0.1003	42.200	23.0	3.0	1.054	0.314	1.368	4.36	6.818	0.841	0.527
6	0.1244	44.310	25.1	3.9	1.140	0.322	1.462	4.54	6.810	0.892	0.570
7	0.1492	45.740	26.6	4.8	1.194	0.337	1.531	4.54	6.795	0.934	0.597
8	0.1819	46.960	27.8	6.0	1.234	0.351	1.585	4.51	6.781	0.968	0.617
9	0.2088	48.030	28.8	6.9	1.268	0.374	1.642	4.39	6.758	1.008	0.634
10	0.2449	49.470	30.3	8.2	1.313	0.395	1.708	4.32	6.737	1.051	0.656
11	0.2708	50.140	30.9	9.1	1.328	0.424	1.752	4.13	6.708	1.088	0.664
12	0.2965	50.700	31.5	10.1	1.339	0.432	1.771	4.10	6.700	1.101	0.669
13	0.3228	51.750	32.6	11.0	1.369	0.448	1.817	4.06	6.684	1.132	0.684
14	0.3497	52.460	33.3	12.0	1.384	0.465	1.849	3.98	6.667	1.157	0.692
15	0.3774	53.250	34.1	13.0	1.401	0.481	1.882	3.91	6.651	1.181	0.700
16	0.4044	53.990	34.8	13.9	1.415	0.499	1.914	3.84	6.633	1.207	0.708
17	0.4340	54.590	35.4	15.0	1.422	0.522	1.944	3.72	6.610	1.233	0.711

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	153.380			161.700
Moisture content: Dry soil+tare, gms.	123.860			131.370
Moisture content: Tare, gms.	30.100			30.650
Moisture, %	31.5	33.2	31.0	30.1
Moist specimen weight, gms.	132.3			
Diameter, in.	1.39	1.39	1.38	
Area, in.²	1.52	1.52	1.49	
Height, in.	2.81	2.81	2.78	
Net decrease in height, in.		0.00	0.03	
Wet Density, pcf	117.9	119.5	121.4	
Dry density, pcf	89.7	89.7	92.6	
Void ratio	0.9142	0.9142	0.8534	
Saturation, %	94.7	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.132 tsf

Consolidation back pressure = 5.653 tsf

Consolidation effective confining stress = 1.479 tsf

Peak Stress = 1.809 tsf **at reading no.** 17

Ult. Stress = 1.809 tsf **at reading no.** 17

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0128	19.340	0.0	0.0	0.000	1.479	1.479	1.00	5.653	1.479	0.000
1	0.0148	24.560	5.2	0.1	0.253	1.378	1.631	1.18	5.754	1.504	0.126
2	0.0179	28.560	9.2	0.2	0.446	1.283	1.729	1.35	5.849	1.506	0.223
3	0.0346	38.630	19.3	0.8	0.927	1.011	1.938	1.92	6.121	1.474	0.463
4	0.0657	46.350	27.0	1.9	1.283	0.798	2.081	2.61	6.334	1.439	0.641
5	0.0986	50.440	31.1	3.1	1.459	0.704	2.163	3.07	6.428	1.434	0.730
6	0.1323	53.220	33.9	4.3	1.570	0.663	2.233	3.37	6.469	1.448	0.785
7	0.1644	53.870	34.5	5.5	1.581	0.644	2.225	3.45	6.488	1.434	0.790
8	0.1902	55.160	35.8	6.4	1.624	0.649	2.273	3.50	6.483	1.461	0.812
9	0.2168	55.780	36.4	7.3	1.635	0.649	2.284	3.52	6.483	1.466	0.817
10	0.2438	57.030	37.7	8.3	1.673	0.659	2.332	3.54	6.473	1.496	0.837
11	0.2696	58.500	39.2	9.2	1.721	0.667	2.388	3.58	6.465	1.527	0.860
12	0.2966	59.500	40.2	10.2	1.746	0.680	2.426	3.57	6.452	1.553	0.873
13	0.3227	60.200	40.9	11.1	1.758	0.693	2.451	3.54	6.439	1.572	0.879
14	0.3484	60.450	41.1	12.1	1.750	0.710	2.460	3.46	6.422	1.585	0.875
15	0.3754	61.290	42.0	13.0	1.766	0.729	2.495	3.42	6.403	1.612	0.883
16	0.4023	62.350	43.0	14.0	1.791	0.732	2.523	3.45	6.400	1.627	0.895
17	0.4294	63.300	44.0	15.0	1.809	0.757	2.566	3.39	6.375	1.662	0.905

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	135.490			162.170
Moisture content: Dry soil+tare, gms.	110.710			133.820
Moisture content: Tare, gms.	30.590			30.790
Moisture, %	30.9	32.5	29.6	27.5
Moist specimen weight, gms.	134.5			
Diameter, in.	1.40	1.40	1.38	
Area, in.²	1.54	1.54	1.50	
Height, in.	2.80	2.80	2.76	
Net decrease in height, in.		0.00	0.04	
Wet Density, pcf	118.7	120.1	122.7	
Dry density, pcf	90.6	90.6	94.6	
Void ratio	0.8943	0.8943	0.8140	
Saturation, %	95.1	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.135 tsf

Consolidation back pressure = 4.126 tsf

Consolidation effective confining stress = 3.009 tsf

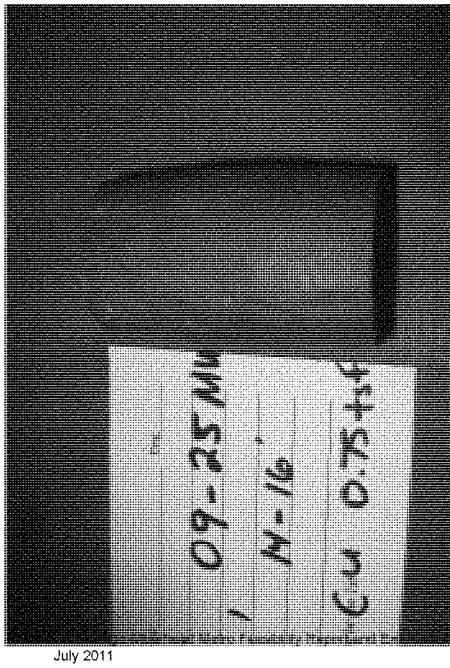
Peak Stress = 2.865 tsf **at reading no.** 16

Ult. Stress = 2.864 tsf **at reading no.** 17

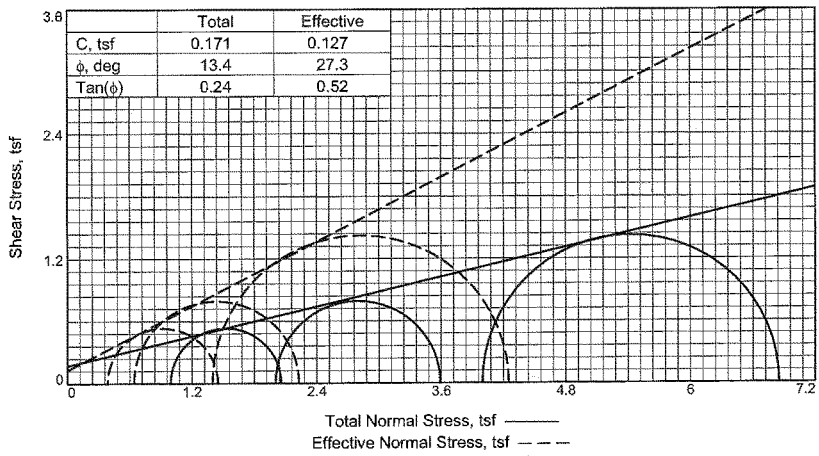
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0108	19.620	0.0	0.0	0.000	3.009	3.009	1.00	4.126	3.009	0.000
1	0.0141	27.340	7.7	0.1	0.371	2.841	3.212	1.13	4.294	3.027	0.186
2	0.0164	35.940	16.3	0.2	0.784	2.634	3.418	1.30	4.501	3.026	0.392
3	0.0321	51.080	31.5	0.8	1.503	2.118	3.621	1.71	5.017	2.869	0.751
4	0.0479	57.650	38.0	1.3	1.806	1.854	3.660	1.97	5.281	2.757	0.903
5	0.0706	64.180	44.6	2.2	2.099	1.617	3.716	2.30	5.518	2.666	1.049
6	0.0954	68.110	48.5	3.1	2.263	1.465	3.728	2.54	5.670	2.597	1.132
7	0.1194	71.200	51.6	3.9	2.386	1.378	3.764	2.73	5.757	2.571	1.193
8	0.1443	73.360	53.7	4.8	2.462	1.318	3.780	2.87	5.817	2.549	1.231
9	0.1772	76.780	57.2	6.0	2.586	1.274	3.860	3.03	5.861	2.567	1.293
10	0.2031	78.490	58.9	7.0	2.637	1.249	3.886	3.11	5.886	2.568	1.319
11	0.2291	79.680	60.1	7.9	2.663	1.255	3.918	3.12	5.880	2.587	1.332
12	0.2558	81.030	61.4	8.9	2.695	1.264	3.959	3.13	5.871	2.611	1.347
13	0.2908	82.740	63.1	10.1	2.731	1.278	4.009	3.14	5.857	2.644	1.366
14	0.3178	84.670	65.0	11.1	2.784	1.289	4.073	3.16	5.846	2.681	1.392
15	0.3527	86.300	66.7	12.4	2.813	1.320	4.133	3.13	5.815	2.727	1.407
16	0.3883	88.530	68.9	13.7	2.865	1.353	4.218	3.12	5.782	2.785	1.432
17	0.4250	89.600	70.0	15.0	2.864	1.388	4.252	3.06	5.747	2.820	1.432

09-25MW
14-16'
CU 3 tsf

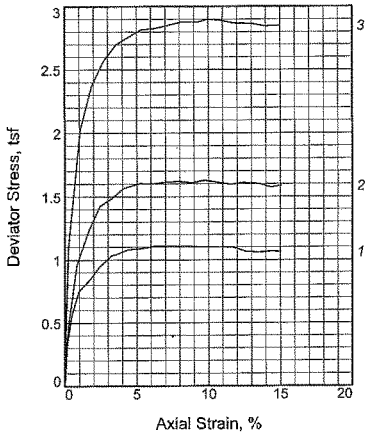
09-25MW
14-16'
CU 1.5tsf


09-25MW
14-16'
CU 0.75tsf

09-25MW
14-16'



	Total	Effective
C, tsf	0.171	0.127
ϕ, deg	13.4	27.3
Tan(ϕ)	0.24	0.52



Sample No.		1	2	3
Initial	Water Content, %	48.3	48.3	48.4
	Dry Density, pcf	73.0	71.5	72.4
	Saturation, %	98.3	94.9	97.2
	Void Ratio	1.3517	1.4000	1.3707
	Diameter, in.	1.39	1.40	1.40
	Height, in.	2.81	2.83	2.82
At Test	Water Content, %	47.3	46.3	40.9
	Dry Density, pcf	74.6	75.5	80.8
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.3018	1.2744	1.1245
	Diameter, in.	1.38	1.37	1.35
	Height, in.	2.79	2.78	2.72
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.99	2.00	4.00
Back Pressure, tsf		6.15	5.14	3.14
Cell Pressure, tsf		7.14	7.14	7.14
Peak Deviator Stress, tsf		1.11	1.63	2.90
Total Pore Pr., tsf		6.76	6.49	5.74
Ultimate Deviator Stress, tsf		1.06	1.59	2.85
Total Pore Pr., tsf		6.75	6.50	5.74
Maj. Eff. Stress at Ultimate, tsf		1.49	2.28	4.30
Min. Eff. Stress at Ultimate, tsf		0.38	0.65	1.40

Type of Test: CU with Pore Pressures

Sample Type: Thinwall, 5", Bottom of sample

Description: FAT CLAY with organic matter(shells), gray (CH)

Assumed Specific Gravity= 2.75

Remarks: The rate of strain is 0.001 in/min. Failure criteria based on ultimate stress which occures at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study W912ES-09-P-0115

Location: SE-F-13, Fargo, Alluvium Formation

Sample Number: Boring 09-25MU, #2 **Depth:** 26-28'

Proj. No.: BL-09-03127 **Date Sampled:**

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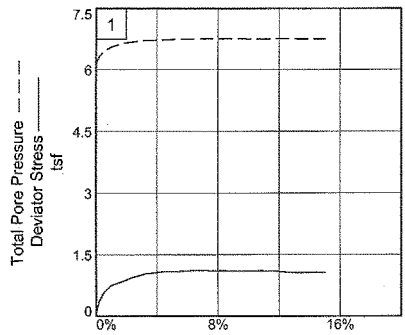
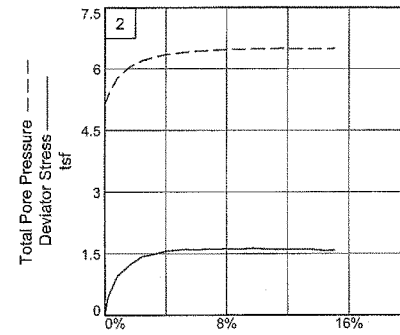
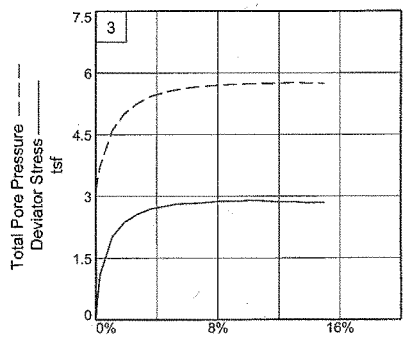
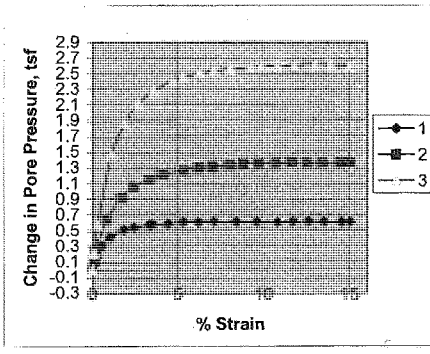
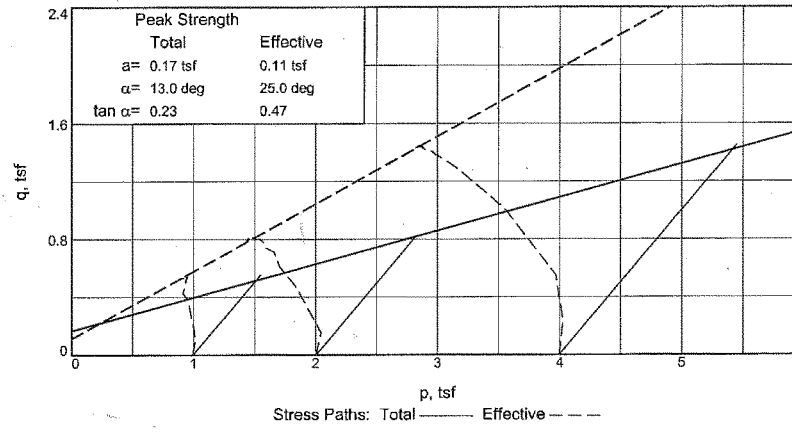
Figure CU Triax ASTM D4767











Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
Loc.: SE-F-13, Fargo, Alluvium Formation **Depth:** 26-28' **Sample No.:** Boring 09-25MU, #2
Project No.: BL-09-03137 **Figure** **Braun Intertec**

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

11/17/2009
9:17 AM

Date:
Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-F-13, Fargo, Alluvium Formation
Depth: 26-28' **Sample Number:** Boring 09-25MU, #2
Description: FAT CLAY with organic matter(shells), gray (CH)
Remarks: The rate of strain is 0.001 in/min. Failure criteria based on ultimate stress which occures at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.75 **LL=** **PL=** **PI=**
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	123.880			149.640
Moisture content: Dry soil+tare, gms.	93.480			113.270
Moisture content: Tare, gms.	30.590			31.110
Moisture, %	48.3	49.2	47.3	44.3
Moist specimen weight, gms.	122.1			
Diameter, in.	1.39	1.39	1.38	
Area, in.^{2}	1.53	1.53	1.50	
Height, in.	2.81	2.81	2.79	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	108.3	108.9	109.9	
Dry density, pcf	73.0	73.0	74.6	
Void ratio	1.3517	1.3517	1.3018	
Saturation, %	98.3	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 6.146 tsf
Consolidation effective confining stress = 0.994 tsf
Peak Stress = 1.108 tsf **at reading no.** 12
Ult. Stress = 1.064 tsf **at reading no.** 20

Braun Intertec

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0081	18.670	0.0	0.0	0.000	0.994	0.994	1.00	6.146	0.994	0.000
1	0.0099	22.330	3.7	0.1	0.175	0.925	1.100	1.19	6.215	1.013	0.088
2	0.0129	25.750	7.1	0.2	0.338	0.836	1.174	1.40	6.304	1.005	0.169
3	0.0219	30.570	11.9	0.5	0.567	0.694	1.261	1.82	6.446	0.977	0.283
4	0.0355	34.480	15.8	1.0	0.749	0.582	1.331	2.29	6.558	0.957	0.375
5	0.0595	36.920	18.3	1.8	0.857	0.484	1.341	2.77	6.656	0.913	0.429
6	0.0748	38.840	20.2	2.4	0.942	0.459	1.401	3.05	6.681	0.930	0.471
7	0.0996	41.070	22.4	3.3	1.037	0.420	1.457	3.47	6.720	0.938	0.518
8	0.1073	41.250	22.6	3.5	1.042	0.713	1.755	2.46	6.427	1.234	0.521
9	0.1322	42.350	23.7	4.4	1.083	0.410	1.493	3.64	6.730	0.951	0.541
10	0.1566	42.720	24.0	5.3	1.090	0.387	1.477	3.82	6.753	0.932	0.545
11	0.1821	43.360	24.7	6.2	1.108	0.389	1.497	3.85	6.751	0.943	0.554
12	0.2078	43.610	24.9	7.1	1.108	0.384	1.492	3.89	6.756	0.938	0.554
13	0.2419	43.910	25.2	8.4	1.107	0.385	1.492	3.87	6.755	0.938	0.553
14	0.2758	44.130	25.5	9.6	1.102	0.385	1.487	3.86	6.755	0.936	0.551
15	0.3096	44.510	25.8	10.8	1.103	0.390	1.493	3.83	6.750	0.942	0.552
16	0.3356	44.700	26.0	11.7	1.100	0.384	1.484	3.86	6.756	0.934	0.550
17	0.3605	44.170	25.5	12.6	1.066	0.380	1.446	3.81	6.760	0.913	0.533
18	0.3865	44.290	25.6	13.5	1.060	0.386	1.446	3.75	6.754	0.916	0.530
19	0.4125	44.780	26.1	14.5	1.069	0.387	1.456	3.76	6.753	0.921	0.534
20	0.4280	44.830	26.2	15.0	1.064	0.386	1.450	3.76	6.754	0.918	0.532

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	118.760			145.330
Moisture content: Dry soil+tare, gms.	89.760			110.750
Moisture content: Tare, gms.	29.760			30.710
Moisture, %	48.3	50.9	46.3	43.2
Moist specimen weight, gms.	120.7			
Diameter, in.	1.40	1.40	1.37	
Area, in.²	1.53	1.53	1.48	
Height, in.	2.83	2.83	2.78	
Net decrease in height, in.		0.00	0.05	
Wet Density, pcf	106.1	107.9	110.5	
Dry density, pcf	71.5	71.5	75.5	
Void ratio	1.4000	1.4000	1.2744	
Saturation, %	94.9	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.140 tsf

Consolidation back pressure = 5.137 tsf

Consolidation effective confining stress = 2.003 tsf

Peak Stress = 1.629 tsf **at reading no.** 13

Ult. Stress = 1.587 tsf **at reading no.** 19

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0079	18.940	0.0	0.0	0.000	2.003	2.003	1.00	5.137	2.003	0.000
1	0.0118	25.230	6.3	0.1	0.306	1.890	2.196	1.16	5.250	2.043	0.153
2	0.0148	28.590	9.6	0.2	0.469	1.759	2.228	1.27	5.381	1.994	0.235
3	0.0309	38.690	19.7	0.8	0.955	1.357	2.312	1.70	5.783	1.835	0.478
4	0.0539	44.520	25.6	1.7	1.227	1.088	2.315	2.13	6.052	1.701	0.613
5	0.0757	48.920	30.0	2.4	1.426	0.945	2.371	2.51	6.195	1.658	0.713
6	0.0984	50.440	31.5	3.3	1.486	0.850	2.336	2.75	6.290	1.593	0.743
7	0.1214	52.430	33.5	4.1	1.566	0.788	2.354	2.99	6.352	1.571	0.783
8	0.1543	53.710	34.8	5.3	1.606	0.735	2.341	3.19	6.405	1.538	0.803
9	0.1792	53.950	35.0	6.2	1.602	0.704	2.306	3.28	6.436	1.505	0.801
10	0.2039	54.590	35.7	7.0	1.616	0.687	2.303	3.35	6.453	1.495	0.808
11	0.2291	55.050	36.1	8.0	1.621	0.670	2.291	3.42	6.470	1.480	0.810
12	0.2537	55.150	36.2	8.8	1.610	0.658	2.268	3.45	6.482	1.463	0.805
13	0.2787	55.960	37.0	9.7	1.629	0.654	2.283	3.49	6.486	1.469	0.815
14	0.3046	55.950	37.0	10.7	1.612	0.650	2.262	3.48	6.490	1.456	0.806
15	0.3296	56.000	37.1	11.6	1.598	0.638	2.236	3.50	6.502	1.437	0.799
16	0.3555	56.670	37.7	12.5	1.610	0.648	2.258	3.48	6.492	1.453	0.805
17	0.3816	56.940	38.0	13.4	1.604	0.647	2.251	3.48	6.493	1.449	0.802
18	0.4074	56.670	37.7	14.4	1.576	0.648	2.224	3.43	6.492	1.436	0.788
19	0.4263	57.250	38.3	15.0	1.587	0.641	2.228	3.48	6.499	1.435	0.794

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	129.780			141.210
Moisture content: Dry soil+tare, gms.	97.630			112.000
Moisture content: Tare, gms.	31.260			29.430
Moisture, %	48.4	49.8	40.9	35.4
Moist specimen weight, gms.	122.5			
Diameter, in.	1.40	1.40	1.35	
Area, in.²	1.54	1.54	1.43	
Height, in.	2.82	2.82	2.72	
Net decrease in height, in.		0.00	0.10	
Wet Density, pcf	107.5	108.5	113.9	
Dry density, pcf	72.4	72.4	80.8	
Void ratio	1.3707	1.3707	1.1245	
Saturation, %	97.2	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.140 tsf

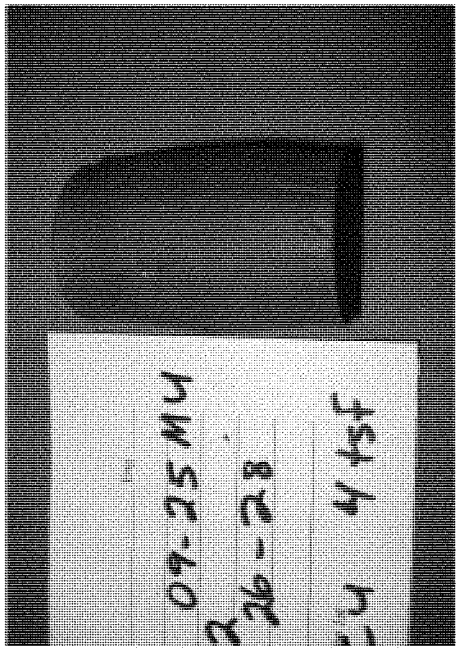
Consolidation back pressure = 3.142 tsf

Consolidation effective confining stress = 3.998 tsf

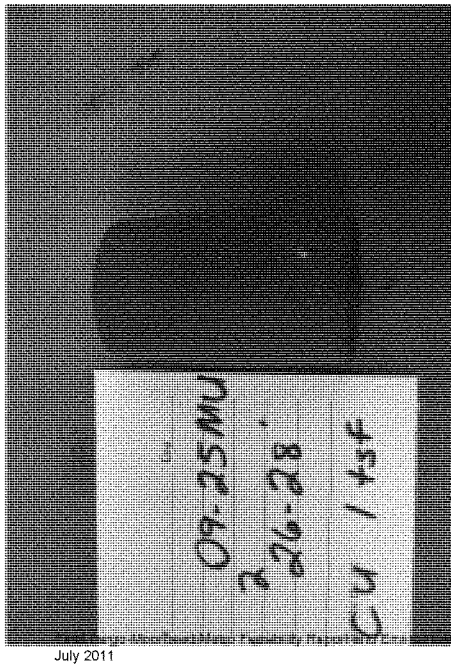
Peak Stress = 2.897 tsf **at reading no.** 13

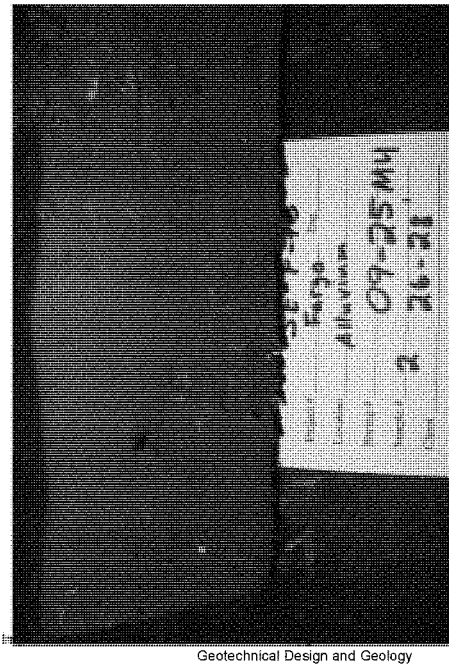
Ult. Stress = 2.851 tsf **at reading no.** 18

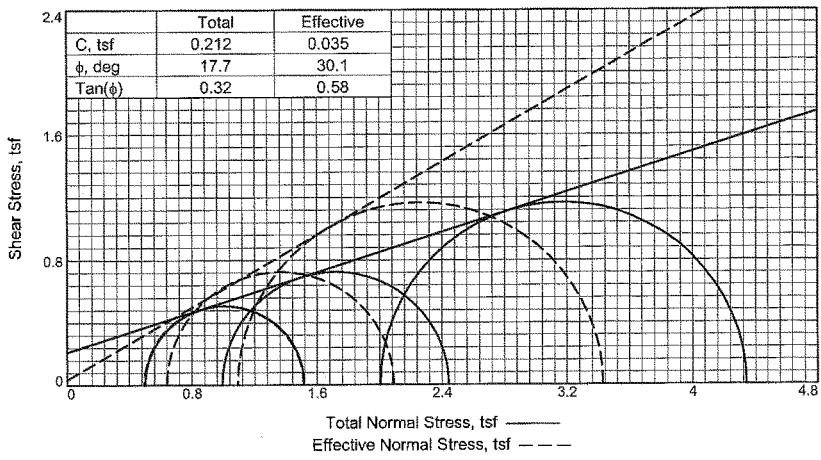
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0108	18.700	0.0	0.0	0.000	3.998	3.998	1.00	3.142	3.998	0.000
1	0.0130	28.290	9.6	0.1	0.482	3.785	4.267	1.13	3.355	4.026	0.241
2	0.0179	40.710	22.0	0.3	1.105	3.415	4.520	1.32	3.725	3.968	0.553
3	0.0398	59.320	40.6	1.1	2.023	2.538	4.561	1.80	4.602	3.550	1.012
4	0.0617	66.710	48.0	1.9	2.372	2.124	4.496	2.12	5.016	3.310	1.186
5	0.0847	71.170	52.5	2.7	2.570	1.884	4.454	2.36	5.256	3.169	1.285
6	0.1079	74.280	55.6	3.6	2.698	1.715	4.413	2.57	5.425	3.064	1.349
7	0.1392	76.630	57.9	4.7	2.779	1.590	4.369	2.75	5.550	2.979	1.389
8	0.1563	77.850	59.1	5.3	2.818	1.545	4.363	2.82	5.595	2.954	1.409
9	0.1814	78.640	59.9	6.3	2.828	1.492	4.320	2.90	5.648	2.906	1.414
10	0.2050	79.670	61.0	7.1	2.850	1.462	4.312	2.95	5.678	2.887	1.425
11	0.2313	80.920	62.2	8.1	2.878	1.437	4.315	3.00	5.703	2.876	1.439
12	0.2637	81.710	63.0	9.3	2.877	1.417	4.294	3.03	5.723	2.856	1.439
13	0.2800	82.570	63.9	9.9	2.897	1.404	4.301	3.06	5.736	2.853	1.449
14	0.3053	83.130	64.4	10.8	2.892	1.403	4.295	3.06	5.737	2.849	1.446
15	0.3307	83.280	64.6	11.8	2.869	1.394	4.263	3.06	5.746	2.828	1.434
16	0.3647	84.140	65.4	13.0	2.866	1.378	4.244	3.08	5.762	2.811	1.433
17	0.3897	84.380	65.7	13.9	2.846	1.391	4.237	3.05	5.749	2.814	1.423
18	0.4175	85.300	66.6	15.0	2.851	1.397	4.248	3.04	5.743	2.823	1.426


09-25MW
2 26-28
CU 4 tsf

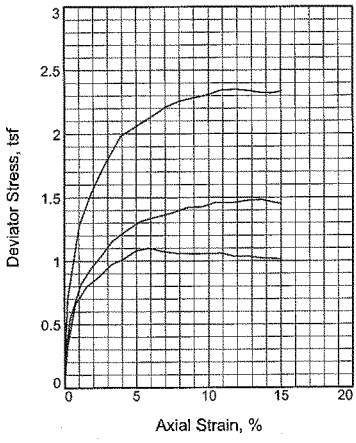
09-25MW
2 26-28
CU 2 tsf


09-25MW
2 26-28
CU 1 tsf


09-25MW
2 26-28



	Total	Effective
C, tsf	0.212	0.035
ϕ, deg	17.7	30.1
Tan(ϕ)	0.32	0.58



Sample No.		1	2	3
Initial	Water Content, %	29.7	28.7	28.7
	Dry Density, pcf	92.6	93.6	94.4
	Saturation, %	96.9	96.4	98.3
	Void Ratio	0.8328	0.8080	0.7930
	Diameter, in.	1.40	1.39	1.39
	Height, in.	2.81	2.81	2.80
At Test	Water Content, %	30.6	29.4	27.5
	Dry Density, pcf	92.6	94.1	97.0
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.8328	0.7984	0.7453
	Diameter, in.	1.40	1.38	1.38
	Height, in.	2.81	2.81	2.77
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.50	1.00	2.01
Back Pressure, tsf		6.64	6.14	5.13
Cell Pressure, tsf		7.14	7.14	7.14
Peak Deviator Stress, tsf		1.10	1.48	2.35
Total Pore Pr., tsf		6.87	6.53	6.13
Ultimate Deviator Stress, tsf		1.02	1.45	2.33
Total Pore Pr., tsf		6.64	6.50	6.05
Maj. Eff. Stress at Ultimate, tsf		1.38	2.09	3.36
Min. Eff. Stress at Ultimate, tsf		0.27	0.61	1.01

Type of Test:
CU with Pore Pressures
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, brown (CH)

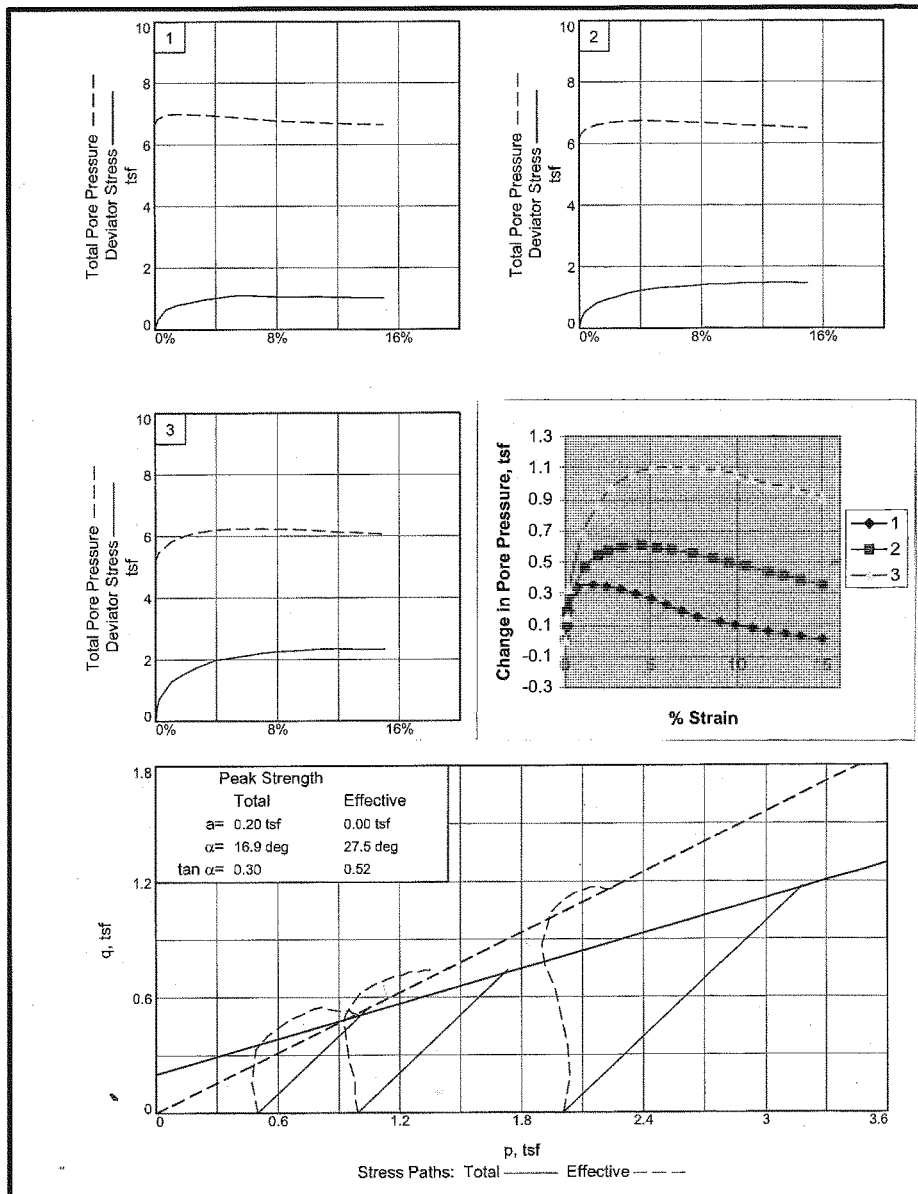
LL= 75 **PL=** 18 **PI=** 57
Assumed Specific Gravity= 2.718
Remarks: Rate of strain is 0.001 in/min. Failure criteria based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Location: SE-F-19, Fargo, Alluvium Formation
Sample Number: Boring 09-27MU, #1 **Depth:** 6-8'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Figure CU Triax ASTM D4767



Client: US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study

Location: SE-F-19, Fargo, Alluvium Formation **Depth:** 6-8' **Sample Number:** Boring 09-27MU, #1

Project No: BI-09-01127 **Figure** **Braun Intertec**

Fargo-Moorhead Feasibility Report and Environmental Impact Statement
July 2014
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

11/9/2009
12:58 PM

Date:
Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-F-19, Fargo, Alluvium Formation
Depth: 6-8' **Sample Number:** Boring 09-27MU, #1
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: Thinwall, 5", Middle of sample
Assumed Specific Gravity=2.718 **LL=**75 **PL=**18 **PI=**57
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	113.640			168.320
Moisture content: Dry soil+tare, gms.	94.720			135.630
Moisture content: Tare, gms.	30.980			30.110
Moisture, %	29.7	30.6	30.6	31.0
Moist specimen weight, gms.	136.9			
Diameter, in.	1.40	1.40	1.40	
Area, in.^{2}	1.54	1.54	1.54	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	120.1	120.9	120.9	
Dry density, pcf	92.6	92.6	92.6	
Void ratio	0.8328	0.8328	0.8328	
Saturation, %	96.9	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 6.640 tsf
Consolidation effective confining stress = 0.500 tsf
Peak Stress = 1.102 tsf **at reading no.** 9
Ult. Stress = 1.017 tsf **at reading no.** 18

Braun Intertec

FOR CONTINUATION OF HOUSE DOCUMENT 112-130

FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT: FARGO-MOORHEAD METROPOLITAN AREA FLOOD RISK MANAGEMENT, JULY 2011

SEE PART 4