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

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY, CIVIL WORKS, THE DEPARTMENT OF DEFENSE

TRANSMITTING

THE CORPS FINAL FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT

PART 4 OF 7

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Final Feasibility Report and Environmental Impact Statement

Fargo-Moorhead Metropolitan Area Flood Risk Management

Volume 4
Appendix I continued

July 2011

US Army Corps of Engineers ®

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Attachment I-4: Test Data

(Continued)

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	0.0107	18.790	0.0	0.0	0.000	0.500	0.500	1.00	6.640	0.500	0.000
1	0.0127	21.900	3.1	0.1	0.145	0.414	0.559	1.35	6.726	0.486	0.072
2	0.0158	25.630	6.8	0.2	0.318	0.312	0.630	2.02	6.828	0.471	0.159
3	0.0317	33.010	14.2	0.7	0.658	0.161	0.819	5.09	6.979	0.490	0.329
4	0.0544	36.220	17.4	1.6	0.800	0.148	0.948	6.41	6.992	0.548	0.400
5	0.0774	37.960	19.2	2.4	0.873	0.157	1.030	6.56	6.983	0.593	0.436
6	0.1014	40.270	21.5	3.2	0.970	0.173	1.143	6.60	6.967	0.658	0.485
7	0.1263	41.500	22.7	4.1	1.016	0.204	1.220	5.98	6.936	0.712	0.508
8	0.1510	43.210	24.4	5.0	1.082	0.235	1.317	5.60	6.905	0.776	0.541
9	0.1770	43.910	25.1	5.9	1.102	0.274	1.376	5.02	6.866	0.825	0.551
10	0.2028	43.540	24.8	6.8	1.076	0.313	1.389	4.44	6.827	0.851	0.538
11	0.2278	43.480	24.7	7.7	1.063	0.351	1.414	4.03	6.789	0.882	0.531
12	0.2638	43.670	24.9	9.0	1.056	0.383	1.439	3.76	6.757	0.911	0.528
13	0.2896	44.000	25.2	9.9	1.059	0.403	1.462	3.63	6.737	0.933	0.530
14	0.3168	44.320	25.5	10.9	1.061	0.423	1.484	3.51	6.717	0.954	0.531
15	0.3435	44.000	25.2	11.8	1.037	0.445	1.482	3.33	6.695	0.963	0.518
16	0.3705	44.270	25.5	12.8	1.036	0.458	1.494	3.26	6.682	0.976	0.518
17	0.3963	44.200	25.4	13.7	1.023	0.474	1.497	3.16	6.666	0.985	0.511
18	0.4322	44.430	25.6	15.0	1.017	0.495	1.512	3.05	6.645	1.003	0.508

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	112.390			165.090
Moisture content: Dry soil+tare, gms.	94.000			134.540
Moisture content: Tare, gms.	30.000			30.260
Moisture, %	28.7	29.8	29.4	29.3
Moist specimen weight, gms.	134.3			
Diameter, in.	1.39	1.39	1.38	
Area, in.^{2}	1.51	1.51	1.50	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	120.5	121.5	121.9	
Dry density, pcf	93.6	93.6	94.1	
Void ratio	0.8080	0.8080	0.7984	
Saturation, %	96.4	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.136 tsf
Consolidation back pressure = 6.144 tsf
Consolidation effective confining stress = 0.992 tsf
Peak Stress = 1.483 tsf **at reading no.** 17
Ult. Stress = 1.451 tsf **at reading no.** 18

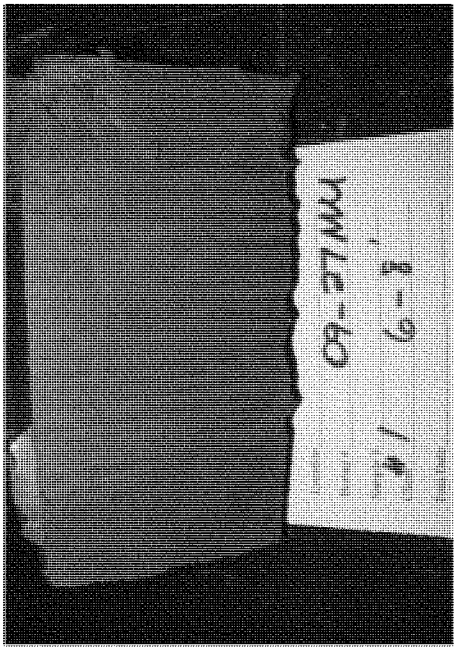
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0146	19.950	0.0	0.0	0.000	0.992	0.992	1.00	6.144	0.992	0.000
1	0.0167	23.610	3.7	0.1	0.175	0.889	1.064	1.20	6.247	0.977	0.088
2	0.0186	27.060	7.1	0.1	0.340	0.808	1.148	1.42	6.328	0.978	0.170
3	0.0256	31.400	11.4	0.4	0.546	0.676	1.222	1.81	6.460	0.949	0.273
4	0.0467	37.290	17.3	1.1	0.821	0.522	1.343	2.57	6.614	0.932	0.410
5	0.0682	40.250	20.3	1.9	0.954	0.447	1.401	3.13	6.689	0.924	0.477
6	0.0835	41.930	22.0	2.5	1.027	0.420	1.447	3.44	6.716	0.933	0.513
7	0.1064	44.830	24.9	3.3	1.153	0.395	1.548	3.92	6.741	0.971	0.576
8	0.1372	47.150	27.2	4.4	1.246	0.384	1.630	4.24	6.752	1.007	0.623
9	0.1621	48.820	28.9	5.3	1.310	0.402	1.712	4.26	6.734	1.057	0.655
10	0.1879	49.770	29.8	6.2	1.340	0.412	1.752	4.25	6.724	1.082	0.670
11	0.2219	50.930	31.0	7.4	1.374	0.438	1.812	4.14	6.698	1.125	0.687
12	0.2567	52.470	32.5	8.6	1.423	0.468	1.891	4.04	6.668	1.180	0.712
13	0.2827	52.860	32.9	9.5	1.426	0.493	1.919	3.89	6.643	1.206	0.713
14	0.3086	54.030	34.1	10.5	1.461	0.517	1.978	3.83	6.619	1.248	0.731
15	0.3446	54.470	34.5	11.8	1.459	0.558	2.017	3.61	6.578	1.287	0.729
16	0.3714	55.290	35.3	12.7	1.477	0.578	2.055	3.56	6.558	1.317	0.739
17	0.3985	55.810	35.9	13.7	1.483	0.606	2.089	3.45	6.530	1.347	0.741
18	0.4350	55.570	35.6	15.0	1.451	0.640	2.091	3.27	6.496	1.365	0.725

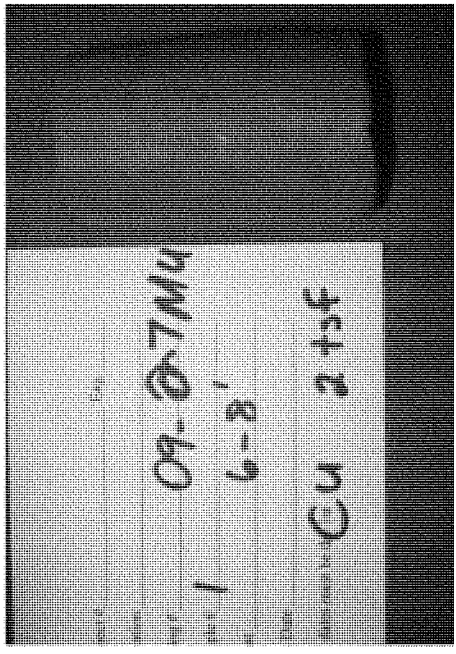
Parameters for Specimen No. 3				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	99.490			165.240
Moisture content: Dry soil+tare, gms.	84.190			136.250
Moisture content: Tare, gms.	30.960			30.240
Moisture, %	28.7	29.2	27.5	27.3
Moist specimen weight, gms.	135.9			
Diameter, in.	1.39	1.39	1.38	
Area, in.²	1.52	1.52	1.49	
Height, in.	2.80	2.80	2.77	
Net decrease in height, in.		0.00	0.03	
Wet Density, pcf	121.6	122.0	123.7	
Dry density, pcf	94.4	94.4	97.0	
Void ratio	0.7930	0.7930	0.7453	
Saturation, %	98.3	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 5.135 tsf
Consolidation effective confining stress = 2.005 tsf
Peak Stress = 2.350 tsf **at reading no.** 14
Ult. Stress = 2.335 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	0.0100	19.860	0.0	0.0	0.000	2.005	2.005	1.00	5.135	2.005	0.000
1	0.0118	27.490	7.6	0.1	0.367	1.853	2.220	1.20	5.287	2.037	0.184
2	0.0160	34.540	14.7	0.2	0.706	1.672	2.378	1.42	5.468	2.025	0.353
3	0.0389	46.840	27.0	1.0	1.286	1.322	2.608	1.97	5.818	1.965	0.643
4	0.0617	52.460	32.6	1.9	1.541	1.143	2.684	2.35	5.997	1.914	0.771
5	0.0857	57.130	37.3	2.7	1.746	1.027	2.773	2.70	6.113	1.900	0.873
6	0.1185	62.680	42.8	3.9	1.982	0.942	2.924	3.10	6.198	1.933	0.991
7	0.1524	65.120	45.3	5.1	2.068	0.907	2.975	3.28	6.233	1.941	1.034
8	0.1783	67.040	47.2	6.1	2.135	0.903	3.038	3.36	6.237	1.970	1.067
9	0.2052	69.230	49.4	7.0	2.211	0.904	3.115	3.45	6.236	2.009	1.105
10	0.2313	70.770	50.9	8.0	2.257	0.914	3.171	3.47	6.226	2.042	1.128
11	0.2570	71.860	52.0	8.9	2.282	0.919	3.201	3.48	6.221	2.060	1.141
12	0.2839	72.930	53.1	9.9	2.304	0.945	3.249	3.44	6.195	2.097	1.152
13	0.3108	74.430	54.6	10.8	2.344	0.972	3.316	3.41	6.168	2.144	1.172
14	0.3386	75.190	55.3	11.8	2.350	1.012	3.362	3.32	6.128	2.187	1.175
15	0.3659	75.590	55.7	12.8	2.340	1.019	3.359	3.30	6.121	2.189	1.170
16	0.3836	75.670	55.8	13.5	2.326	1.038	3.364	3.24	6.102	2.201	1.163
17	0.4096	76.170	56.3	14.4	2.322	1.067	3.389	3.18	6.073	2.228	1.161
18	0.4270	76.900	57.0	15.0	2.335	1.092	3.427	3.14	6.048	2.259	1.167


09-27MW
6-8'
Cu 1+sf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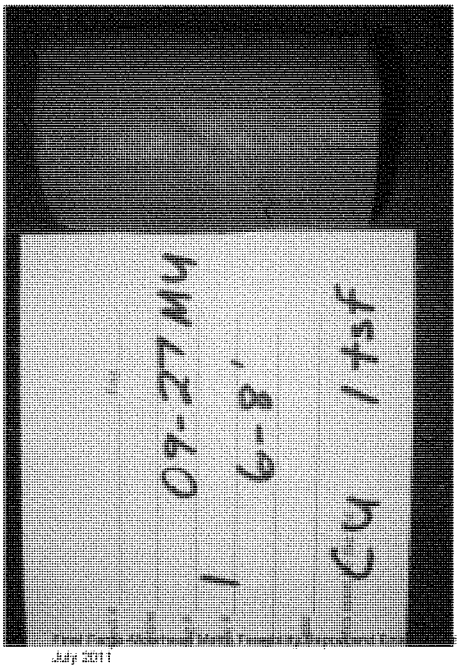
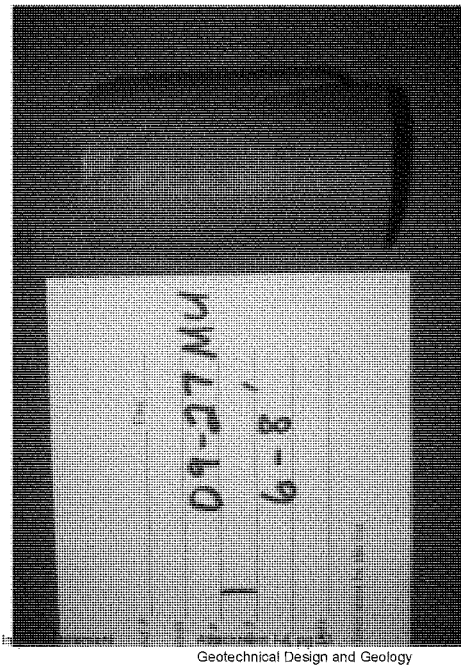
6-8'
Cu 2+sf

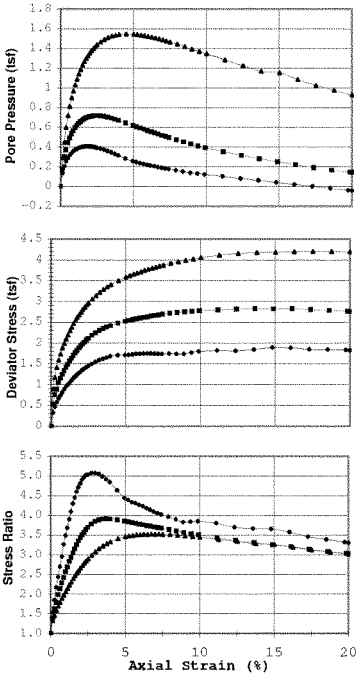

09-27MW
6-8'
Cu 1+sf


09-27MW
6-8'

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 8/26/10

Project: **FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING**
Boring #: **10-78MU** Fargo Sample #: 1 Type: **5T** Depth (ft): **13-15 (Mid)**
Soil Type: **Fat Clay w/a few laminations of silt (CH)** Alluvium



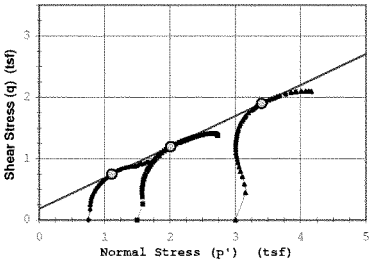
Failure Criterion: **Max. Stress Ratio**
Angle of internal friction, ϕ' = **30.2 °**
Apparent Cohesion, c' = **0.21 (tsf)**

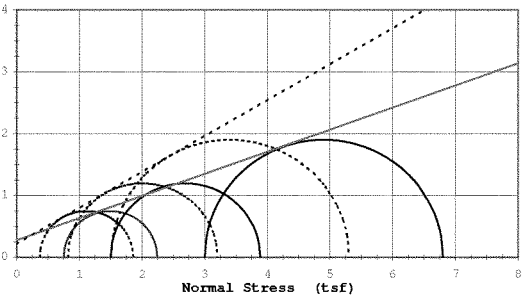
Test Date:	8/20/10	Liquid Limit:	55.8
Test Type:	CU w/pp	Plastic Limit:	22.1
Strain Rate (in/min):	0.002027	Plasticity Index:	33.7
Strain Rate (%/min):	0.050	Spec. Gravity (Assumed):	2.72

Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.08	4.08	4.08		
Water Content (%)	28.6	28.8	28.9		
Dry Density (pcf)	94.4	94.1	93.8		
Void Ratio	0.80	0.80	0.81		
After Consolidation					
Diameter (in)	1.93	1.91	1.91		
Height (in)	4.05	4.03	3.99		
Water Content (%)	28.0	26.7	26.3		
Dry Density (pcf)	96.4	98.3	99.0		
Void Ratio	0.76	0.73	0.71		
Back Pressure (tsf)	5.8	5.8	5.8		
Minor Principal Stress (tsf)	0.75	1.50	3.00		
Max. Deviator Stress (tsf)	1.89	2.82	4.20		
Ultimate Deviator Stress (tsf)	1.82	2.75	4.19		
Deviator Stress at Failure (tsf)	1.49	2.39	3.80		
Max. Pore Pressure Buildup (tsf)	0.41	0.72	1.55		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	2.7	3.7	6.8		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





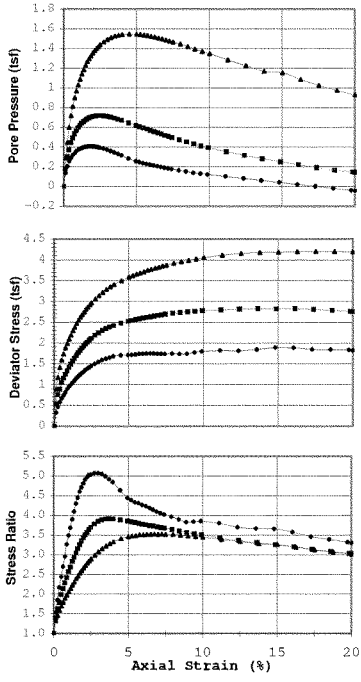
Rupture Envelope at Failure
α = 26.7 ° a = 0.2 (tsf)

----------	Effective ϕ': 30.2 °	c'=	0.21 (tsf)
_____	Total ϕ': 19.7 °	c=	0.28 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 8/26/10

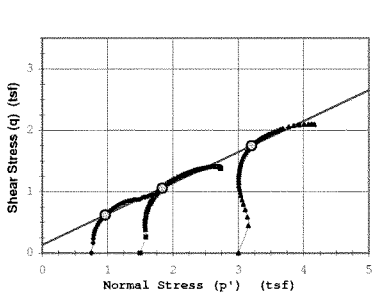
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING
Boring #: 10-78MU Fargo Sample #: 1 Type: 5T Depth (ft): 13-15 (Mid)
Soil Type: Fat Clay w/a few laminations of silt (CH) Alluvium

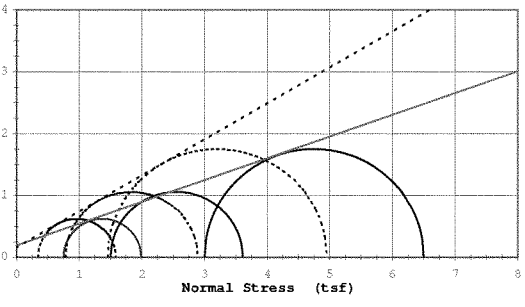


Failure Criterion:	Max. Pore Pressure				
Angle of internal friction, ϕ' =	30.3 °				
Apparent Cohesion, c' =	0.15 (tsf)				
Test Date: 8/20/10		Liquid Limit:		55.8	
Test Type: CU w/pp		Plastic Limit:		22.1	
Strain Rate (in/min): 0.002027		Plasticity Index:		33.7	
Strain Rate (%/min): 0.050		Spec. Gravity (Assumed):		2.72	
Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.08	4.08	4.08		
Water Content (%)	28.6	28.8	28.9		
Dry Density (pcf)	94.4	94.1	93.8		
Void Ratio	0.80	0.80	0.81		
After Consolidation					
Diameter (in)	1.93	1.91	1.91		
Height (in)	4.05	4.03	3.99		
Water Content (%)	28.0	26.7	26.3		
Dry Density (pcf)	96.4	98.3	99.0		
Void Ratio	0.76	0.73	0.71		
Back Pressure (tsf)	5.8	5.8	5.8		
Minor Principal Stress (tsf)	0.75	1.50	3.00		
Max. Deviator Stress (tsf)	1.89	2.82	4.20		
Ultimate Deviator Stress (tsf)	1.82	2.75	4.19		
Deviator Stress at Failure (tsf)	1.24	2.11	3.50		
Max. Pore Pressure Buildup (tsf)	0.41	0.72	1.55		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	1.7	2.5	4.5		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





Rupture Envelope at Failure	
α = 26.8 °	a = 0.1 (tsf)

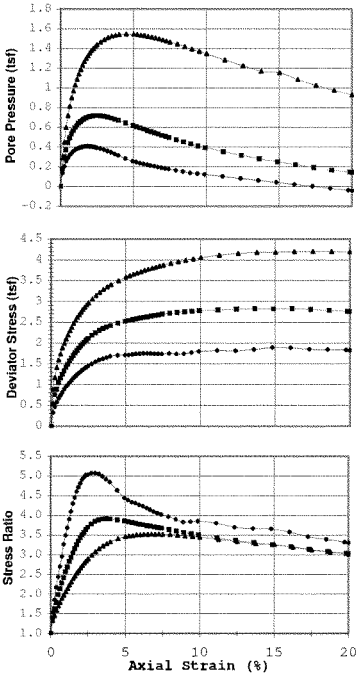
----------	Effective ϕ': 30.3 °	c'=	0.15 (tsf)
_____	Total ϕ': 19.4 °	c=	0.19 (tsf)

9301 Bryant Ave. South Suite #107
SOIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55420-3436

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 8/26/10

Project: **FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING**
Boring #: **10-78MU** Fargo Sample #: 1 Type: **5T** Depth (ft): **13-15 (Mid)**
Soil Type: **Fat Clay w/a few laminations of silt (CH)** Alluvium



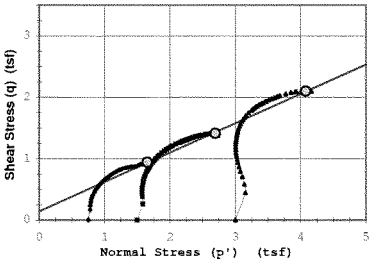
Failure Criterion:	**Max. Deviator Stress**
Angle of internal friction, ϕ' =	**28.6 °**
Apparent Cohesion, c' =	**0.16 (tsf)**

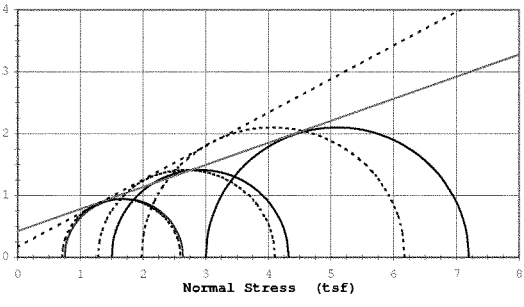
Test Date:	8/20/10	Liquid Limit:	55.8
Test Type:	CU w/pp	Plastic Limit:	22.1
Strain Rate (in/min):	0.002027	Plasticity Index:	33.7
Strain Rate (%/min):	0.050	Spec. Gravity (Assumed):	2.72

Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.08	4.08	4.08		
Water Content (%)	28.6	28.8	28.9		
Dry Density (pcf)	94.4	94.1	93.8		
Void Ratio	0.80	0.80	0.81		
After Consolidation					
Diameter (in)	1.93	1.91	1.91		
Height (in)	4.05	4.03	3.99		
Water Content (%)	28.0	26.7	26.3		
Dry Density (pcf)	96.4	98.3	99.0		
Void Ratio	0.76	0.73	0.71		
Back Pressure (tsf)	5.8	5.8	5.8		
Minor Principal Stress (tsf)	0.75	1.50	3.00		
Max. Deviator Stress (tsf)	1.89	2.82	4.20		
Ultimate Deviator Stress (tsf)	1.82	2.75	4.19		
Deviator Stress at Failure (tsf)	1.89	2.82	4.20		
Max. Pore Pressure Buildup (tsf)	0.41	0.72	1.55		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	14.8	16.1	17.5		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





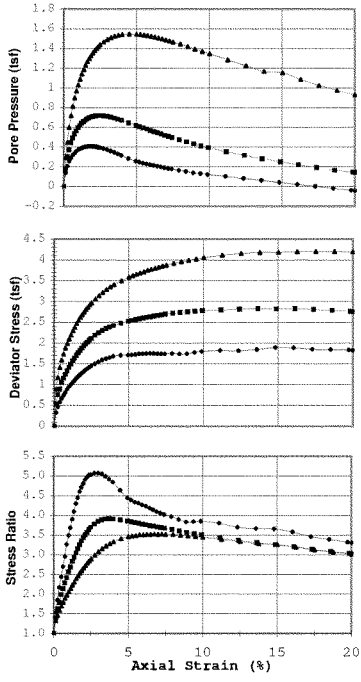
Rupture Envelope at Failure	
α = 25.6 °	a = 0.1 (tsf)

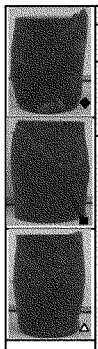
----------	Effective ϕ': 28.6 °	c'=	0.16 (tsf)
_____	Total ϕ': 19.7 °	c=	0.42 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 8/26/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING
Boring #: 10-78MU Fargo Sample #: 1 Type: 5T Depth (ft): 13-15 (Mid)
Soil Type: Fat Clay w/a few laminations of silt (CH) Alluvium

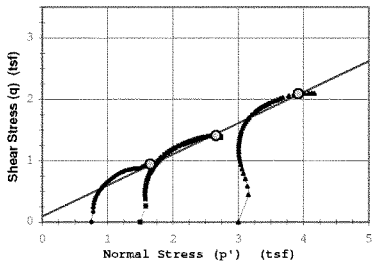


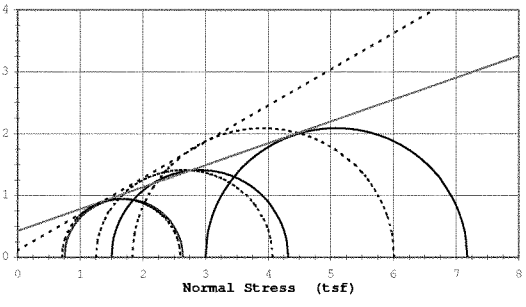


Failure Criterion:	Given Strain of: 15%				
Angle of internal friction, ϕ' =	30.4 °				
Apparent Cohesion, c' =	0.11 (tsf)				
Test Date: 8/20/10		Liquid Limit:	55.8		
Test Type: CU w/pp		Plastic Limit:	22.1		
Strain Rate (in/min): 0.002027		Plasticity Index:	33.7		
Strain Rate (%/min): 0.050		Spec. Gravity (Assumed):	2.72		
Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.08	4.08	4.08		
Water Content (%)	28.6	28.8	28.9		
Dry Density (pcf)	94.4	94.1	93.8		
Void Ratio	0.80	0.80	0.81		
After Consolidation					
Diameter (in)	1.93	1.91	1.91		
Height (in)	4.05	4.03	3.99		
Water Content (%)	28.0	26.7	26.3		
Dry Density (pcf)	96.4	98.3	99.0		
Void Ratio	0.76	0.73	0.71		
Back Pressure (tsf)	5.8	5.8	5.8		
Minor Principal Stress (tsf)	0.75	1.50	3.00		
Max. Deviator Stress (tsf)	1.89	2.82	4.20		
Ultimate Deviator Stress (tsf)	1.82	2.75	4.19		
Deviator Stress at Failure (tsf)	1.89	2.82	4.18		
Max. Pore Pressure Buildup (tsf)	0.41	0.72	1.55		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	15.0	15.0	15.0		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen: Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





Rupture Envelope at Failure
α = 26.8 ° a = 0.1 (tsf)

---------- Effective ϕ': 30.4 ° c'= 0.11 (tsf)
_____ Total ϕ': 19.5 ° c= 0.43 (tsf)

8301 Bryant Ave. South Suite #107
Bloomington, Minnesota 55420-3436

Triaxial Plot Data Summary

Job #: 7577

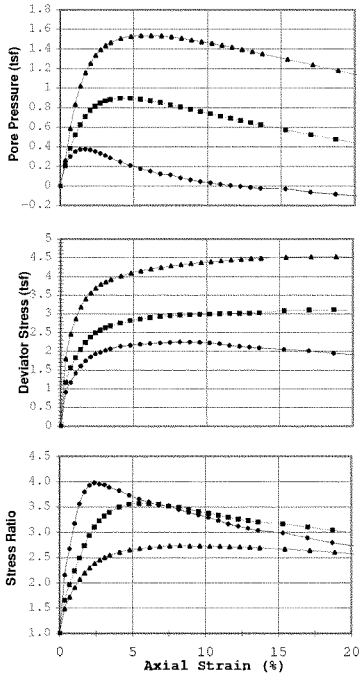
Boring: 10-78MU Sample: 1 Depth: 13-15 (Mid) Test Type: CU

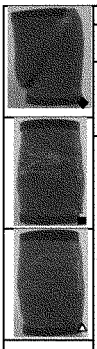
Sample 1			Sample 2			Sample 3			Sample 4			Sample 5		
Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
0.12	0.33	0.14	0.12	0.52	0.18	0.13	0.89	0.29						
0.25	0.47	0.20	0.25	0.76	0.30	0.25	1.17	0.44						
0.37	0.58	0.25	0.37	0.89	0.37	0.38	1.41	0.60						
0.49	0.67	0.29	0.50	1.04	0.45	0.50	1.59	0.72						
0.62	0.74	0.31	0.62	1.15	0.49	0.63	1.74	0.81						
0.74	0.81	0.34	0.75	1.24	0.53	0.75	1.88	0.90						
0.86	0.89	0.36	0.87	1.33	0.56	0.88	1.98	0.97						
0.99	0.95	0.37	0.99	1.42	0.60	1.00	2.09	1.03						
1.11	0.99	0.38	1.12	1.49	0.62	1.13	2.19	1.09						
1.23	1.05	0.39	1.24	1.57	0.64	1.25	2.29	1.14						
1.36	1.10	0.40	1.37	1.63	0.66	1.38	2.38	1.18						
1.48	1.15	0.40	1.49	1.70	0.67	1.50	2.47	1.23						
1.60	1.19	0.40	1.61	1.76	0.68	1.63	2.54	1.26						
1.73	1.24	0.41	1.74	1.82	0.70	1.75	2.62	1.30						
1.85	1.27	0.41	1.86	1.88	0.70	1.88	2.68	1.32						
1.97	1.31	0.41	1.99	1.93	0.71	2.00	2.74	1.35						
2.10	1.35	0.40	2.11	1.97	0.71	2.13	2.81	1.38						
2.22	1.38	0.40	2.24	2.02	0.72	2.25	2.86	1.40						
2.34	1.41	0.40	2.36	2.07	0.72	2.38	2.91	1.42						
2.47	1.44	0.39	2.48	2.11	0.72	2.50	2.96	1.44						
2.71	1.49	0.38	2.73	2.18	0.72	2.75	3.06	1.47						
2.96	1.54	0.37	2.98	2.25	0.71	3.01	3.14	1.49						
3.21	1.59	0.36	3.23	2.30	0.70	3.26	3.22	1.51						
3.45	1.62	0.34	3.48	2.35	0.69	3.51	3.28	1.52						
3.70	1.65	0.33	3.72	2.39	0.68	3.76	3.35	1.53						
3.95	1.68	0.31	3.97	2.42	0.67	4.01	3.40	1.54						
4.44	1.70	0.28	4.47	2.47	0.64	4.51	3.50	1.55						
4.94	1.71	0.26	4.97	2.52	0.62	5.01	3.58	1.54						
5.18	1.71	0.25	5.21	2.54	0.61	5.26	3.62	1.54						
5.43	1.72	0.24	5.46	2.56	0.59	5.51	3.65	1.53						
5.68	1.73	0.23	5.71	2.58	0.58	5.76	3.68	1.53						
5.92	1.74	0.22	5.96	2.60	0.57	6.01	3.71	1.52						
6.17	1.74	0.21	6.21	2.61	0.55	6.26	3.75	1.51						
6.42	1.74	0.20	6.45	2.63	0.54	6.51	3.77	1.50						
6.66	1.74	0.20	6.70	2.65	0.53	6.76	3.80	1.50						
6.91	1.74	0.19	6.95	2.66	0.52	7.01	3.82	1.48						
7.16	1.73	0.18	7.20	2.67	0.51	7.26	3.85	1.47						
7.40	1.73	0.18	7.45	2.69	0.50	7.51	3.87	1.46						
7.90	1.74	0.16	7.95	2.71	0.47	8.01	3.91	1.44						
8.39	1.74	0.15	8.44	2.73	0.45	8.51	3.95	1.42						
8.88	1.73	0.14	8.94	2.75	0.43	9.01	3.98	1.39						
9.38	1.76	0.13	9.43	2.76	0.41	9.52	4.02	1.37						
9.87	1.79	0.12	9.93	2.77	0.39	10.02	4.05	1.35						
11.11	1.82	0.10	11.17	2.80	0.35	11.27	4.11	1.28						
12.34	1.81	0.08	12.41	2.81	0.31	12.52	4.15	1.22						
13.57	1.84	0.06	13.65	2.82	0.28	13.77	4.18	1.17						
14.80	1.89	0.04	14.90	2.82	0.25	15.03	4.18	1.15						
16.04	1.88	0.02	16.14	2.82	0.22	16.28	4.19	1.08						
17.27	1.85	0.00	17.38	2.80	0.19	17.53	4.20	1.02						
18.51	1.84	-0.02	18.62	2.78	0.17	18.78	4.20	0.97						
19.74	1.83	-0.04	19.86	2.75	0.15	20.00	4.19	0.93						
20.00	1.82	-0.04	20.00	2.75	0.14									

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-79MU Fargo Sample #: 1 Type: 5T Depth (ft): 20 - 22 (Mid-Top)
Soil Type: Fat Clay w/a few Laminations of Silt (CH) Alluvium



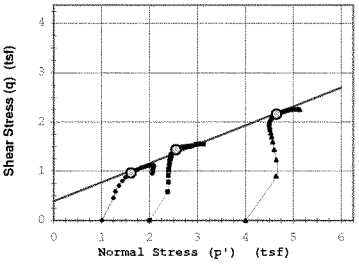


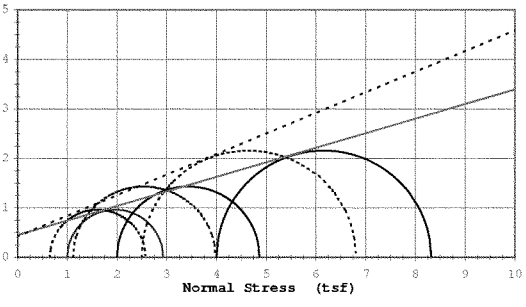
Failure Criterion:	Max. Stress Ratio
Angle of internal friction, ϕ' =	22.6 °
Apparent Cohesion, c' =	0.42 (tsf)
Test Date: 8/12/10	Liquid Limit: 51.8
Test Type: CU w/pp	Plastic Limit: 20.5
Strain Rate (in/min): 0.0039	Plasticity Index: 31.3
Strain Rate (%/min): 0.132	Spec. Gravity (Assumed): 2.70

Before Consolidation	A	B	C	D	E
Diameter (in)	1.45	1.45	1.45		
Height (in)	2.99	2.99	2.99		
Water Content (%)	26.3	26.6	26.1		
Dry Density (pcf)	96.3	95.2	95.3		
Void Ratio	0.75	0.77	0.77		
After Consolidation					
Diameter (in)	1.44	1.42	1.42		
Height (in)	2.94	2.94	2.92		
Water Content (%)	26.4	25.3	24.2		
Dry Density (pcf)	98.4	100.2	102.0		
Void Ratio	0.71	0.68	0.65		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	2.25	3.11	4.52		
Ultimate Deviator Stress (tsf)	1.90	3.10	4.50		
Deviator Stress at Failure (tsf)	1.93	2.86	4.31		
Max. Pore Pressure Buildup (tsf)	0.38	0.90	1.54		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	2.4	5.4	8.2		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





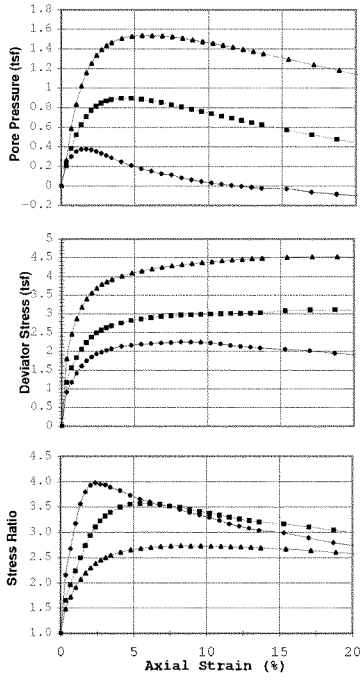
Rupture Envelope at Failure	
α = 21.1 °	a = 0.4 (tsf)

----------	Effective ϕ': 22.6 °	c'=	0.42 (tsf)
_____	Total ϕ': 16.4 °	c=	0.45 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

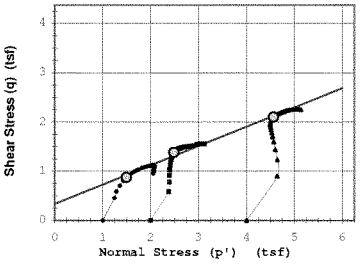
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-79MU Fargo Sample #: 1 Type: 5T Depth (ft): 20 - 22 (Mid-Top)
Soil Type: Fat Clay w/a few Laminations of Silt (CH) Alluvium

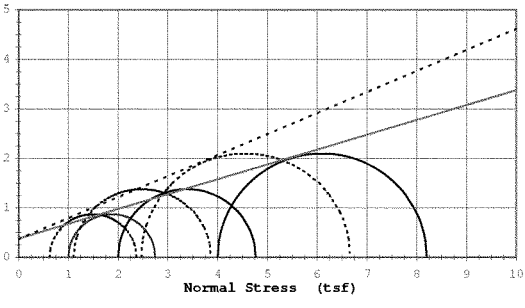


Failure Criterion:	Max. Pore Pressure				
Angle of internal friction, ϕ' =	23.1 °				
Apparent Cohesion, c' =	0.36 (tsf)				
Test Date: 8/12/10			Liquid Limit:		51.8
Test Type: CU w/pp			Plastic Limit:		20.5
Strain Rate (in/min): 0.0039			Plasticity Index:		31.3
Strain Rate (%/min): 0.132			Spec. Gravity (Assumed):		2.70
Before Consolidation	A	B	C	D	E
Diameter (in)	1.45	1.45	1.45		
Height (in)	2.99	2.99	2.99		
Water Content (%)	26.3	26.6	26.1		
Dry Density (pcf)	96.3	95.2	95.3		
Void Ratio	0.75	0.77	0.77		
After Consolidation					
Diameter (in)	1.44	1.42	1.42		
Height (in)	2.94	2.94	2.92		
Water Content (%)	26.4	25.3	24.2		
Dry Density (pcf)	98.4	100.2	102.0		
Void Ratio	0.71	0.68	0.65		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	2.25	3.11	4.52		
Ultimate Deviator Stress (tsf)	1.90	3.10	4.50		
Deviator Stress at Failure (tsf)	1.74	2.76	4.20		
Max. Pore Pressure Buildup (tsf)	0.38	0.90	1.54		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	1.7	4.1	6.2		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





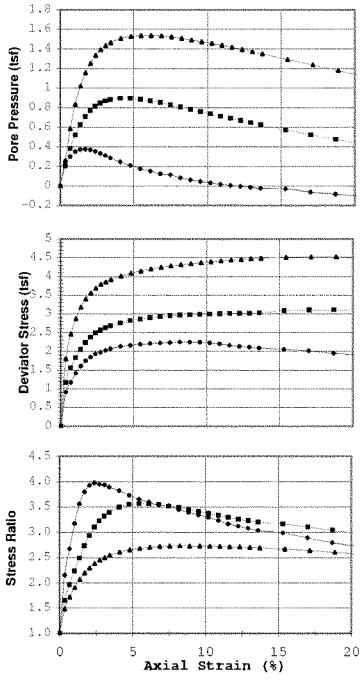
Rupture Envelope at Failure
α = 21.4 ° a = 0.3 (tsf)

---------- Effective ϕ': 23.1 ° c'= 0.36 (tsf)
_____ Total ϕ': 16.7 ° c= 0.38 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-79MU Fargo Sample #: 1 Type: 5T Depth (ft): 20 - 22 (Mid-Top)
Soil Type: Fat Clay w/a few Laminations of Silt (CH) Alluvium

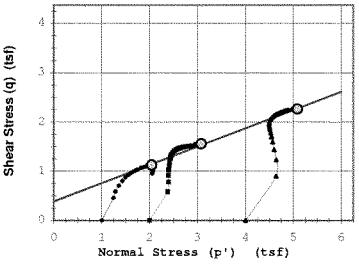


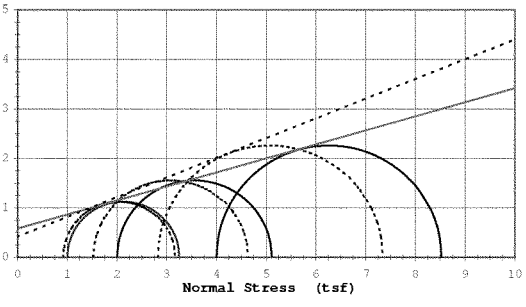
Failure Criterion:	Max. Deviator Stress
Angle of internal friction, ϕ' =	21.8 °
Apparent Cohesion, c' =	0.41 (tsf)
Test Date: 8/12/10	Liquid Limit: 51.8
Test Type: CU w/pp	Plastic Limit: 20.5
Strain Rate (in/min): 0.0039	Plasticity Index: 31.3
Strain Rate (%/min): 0.132	Spec. Gravity (Assumed): 2.70

Before Consolidation	A	B	C	D	E
Diameter (in)	1.45	1.45	1.45		
Height (in)	2.99	2.99	2.99		
Water Content (%)	26.3	26.6	26.1		
Dry Density (pcf)	96.3	95.2	95.3		
Void Ratio	0.75	0.77	0.77		
After Consolidation					
Diameter (in)	1.44	1.42	1.42		
Height (in)	2.94	2.94	2.92		
Water Content (%)	26.4	25.3	24.2		
Dry Density (pcf)	98.4	100.2	102.0		
Void Ratio	0.71	0.68	0.65		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	2.25	3.11	4.52		
Ultimate Deviator Stress (tsf)	1.90	3.10	4.50		
Deviator Stress at Failure (tsf)	2.25	3.11	4.52		
Max. Pore Pressure Buildup (tsf)	0.38	0.90	1.54		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	8.2	18.7	18.9		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





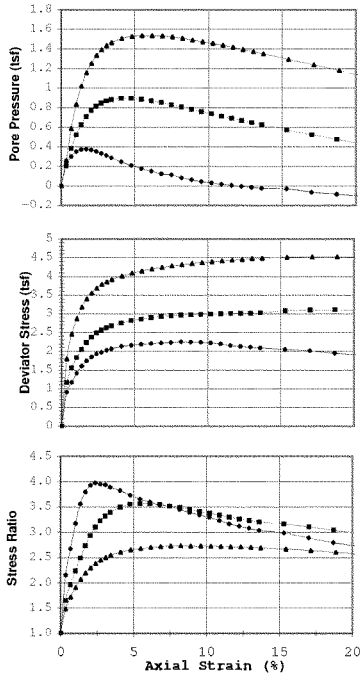
Rupture Envelope at Failure	
α = 20.4 °	a = 0.4 (tsf)

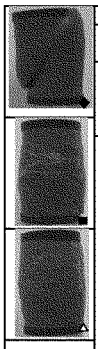
----------	Effective ϕ': 21.8 °	c'=	0.41 (tsf)
_____	Total ϕ': 15.8 °	c=	0.58 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-79MU Fargo Sample #: 1 Type: ST Depth (ft): 20 - 22 (Mid-Top)
Soil Type: Fat Clay w/a few Laminations of Silt (CH) Alluvium





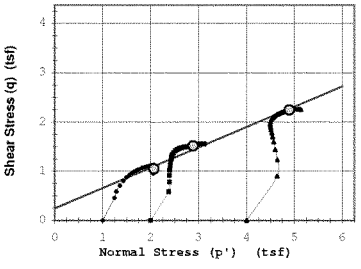
Failure Criterion:	Given Strain of: 15%
Angle of internal friction, ϕ' =	24.4 °
Apparent Cohesion, c' =	0.27 (tsf)

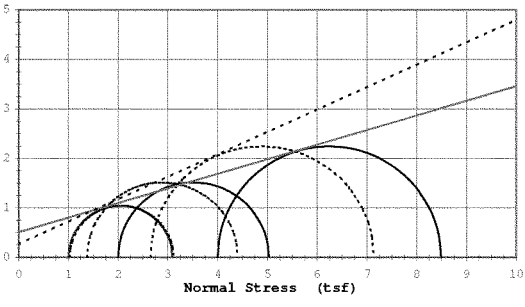
Test Date:	8/12/10		Liquid Limit:		51.8
Test Type:	CU w/pp		Plastic Limit:		20.5
Strain Rate (in/min):	0.0039		Plasticity Index:		31.3
Strain Rate (%/min):	0.132		Spec. Gravity (Assumed):		2.70

	A	B	C	D	E
Before Consolidation					
Diameter (in)	1.45	1.45	1.45		
Height (in)	2.99	2.99	2.99		
Water Content (%)	26.3	26.6	26.1		
Dry Density (pcf)	96.3	95.2	95.3		
Void Ratio	0.75	0.77	0.77		
After Consolidation					
Diameter (in)	1.44	1.42	1.42		
Height (in)	2.94	2.94	2.92		
Water Content (%)	26.4	25.3	24.2		
Dry Density (pcf)	98.4	100.2	102.0		
Void Ratio	0.71	0.68	0.65		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	2.25	3.11	4.52		
Ultimate Deviator Stress (tsf)	1.90	3.10	4.50		
Deviator Stress at Failure (tsf)	2.09	3.03	4.49		
Max. Pore Pressure Buildup (tsf)	0.38	0.90	1.54		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	15.0	15.0	15.0		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





Rupture Envelope at Failure	
α = 22.5 °	a = 0.2 (tsf)

----------	Effective ϕ': 24.4 °	c'=	0.27 (tsf)
_____	Total ϕ': 16.5 °	c=	0.51 (tsf)

Job No.: 7577

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095 Test Type: CU w/pp

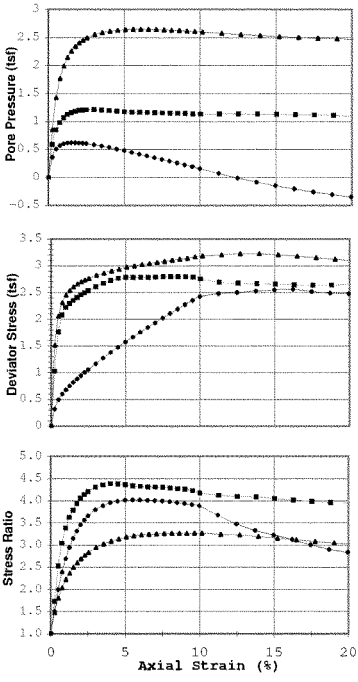
Boring No.: 10-79MU, Sample No.: 1, Depth (ft.): 20 - 22 (Mid-Top)

Sample 1			Sample 2			Sample 3		
Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.34	0.91	0.21	0.34	1.17	0.21	0.34	1.80	0.26
0.68	1.17	0.30	0.68	1.55	0.38	0.69	2.46	0.59
1.02	1.41	0.35	1.02	1.83	0.52	1.03	2.87	0.83
1.36	1.60	0.37	1.36	2.05	0.63	1.37	3.18	1.02
1.70	1.74	0.38	1.70	2.24	0.71	1.72	3.40	1.16
2.04	1.85	0.37	2.04	2.38	0.77	2.06	3.55	1.25
2.38	1.93	0.35	2.38	2.49	0.81	2.40	3.68	1.33
2.72	1.97	0.33	2.72	2.57	0.85	2.74	3.78	1.39
3.06	2.02	0.31	3.06	2.63	0.87	3.09	3.85	1.43
3.40	2.06	0.29	3.40	2.68	0.88	3.43	3.92	1.46
4.08	2.13	0.25	4.08	2.76	0.90	4.12	4.01	1.51
4.76	2.16	0.21	4.76	2.82	0.90	4.81	4.08	1.53
5.44	2.18	0.18	5.44	2.86	0.89	5.49	4.14	1.53
6.12	2.21	0.15	6.13	2.90	0.87	6.17	4.20	1.54
6.79	2.22	0.12	6.81	2.93	0.85	6.86	4.24	1.53
7.47	2.23	0.11	7.49	2.95	0.83	7.55	4.28	1.52
8.15	2.25	0.08	8.17	2.97	0.81	8.23	4.31	1.51
8.83	2.24	0.06	8.85	2.98	0.78	8.92	4.34	1.49
9.51	2.24	0.04	9.53	2.99	0.76	9.60	4.37	1.47
10.19	2.22	0.03	10.21	3.00	0.74	10.29	4.39	1.46
10.87	2.19	0.02	10.89	3.00	0.72	10.98	4.41	1.44
11.55	2.16	0.00	11.57	3.01	0.69	11.66	4.43	1.41
12.23	2.13	0.00	12.25	3.01	0.67	12.35	4.45	1.39
12.91	2.11	-0.01	12.93	3.02	0.65	13.03	4.47	1.37
13.59	2.09	-0.02	13.61	3.03	0.63	13.72	4.49	1.35
15.29	2.05	-0.03	15.31	3.08	0.57	15.43	4.51	1.29
16.98	2.01	-0.06	17.01	3.10	0.52	17.15	4.52	1.24
18.68	1.95	-0.09	18.72	3.11	0.48	18.86	4.52	1.18
20.38	1.90	-0.10	20.42	3.10	0.43	20.58	4.50	1.12

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

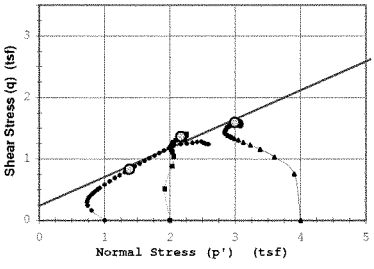
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 1 Type: 5T Depth (ft): 23 - 25
Soil Type: Silty Clay w/a few pockets of Silty Sand (CL-ML) Alluvium

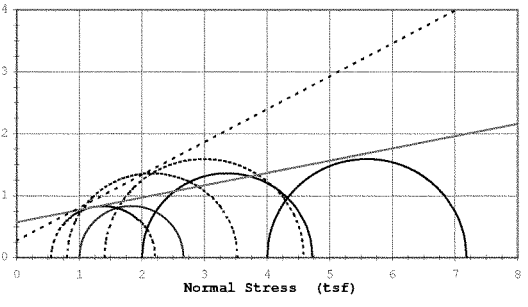


Failure Criterion:	Max. Stress Ratio				
Angle of internal friction, ϕ' =	28.0 °				
Apparent Cohesion, c' =	0.27 (tsf)				
Test Date: 8/26/10		Liquid Limit:		28.2	
Test Type: CU w/pp		Plastic Limit:		17.1	
Strain Rate (in/min): 0.00236		Plasticity Index:		11.1	
Strain Rate (%/min): 0.059		Spec. Gravity (Assumed):		2.67	
Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	27.6	28.6	34.1		
Dry Density (pcf)	95.8	94.2	87.2		
Void Ratio	0.74	0.77	0.91		
After Consolidation					
Diameter (in)	1.94	1.93	1.90		
Height (in)	4.01	3.99	3.94		
Water Content (%)	26.3	26.1	28.4		
Dry Density (pcf)	97.9	98.3	94.8		
Void Ratio	0.70	0.70	0.76		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	2.56	2.80	3.23		
Ultimate Deviator Stress (tsf)	2.48	2.66	3.08		
Deviator Stress at Failure (tsf)	1.66	2.72	3.18		
Max. Pore Pressure Buildup (tsf)	0.62	1.21	2.64		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	5.5	4.0	10.2		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





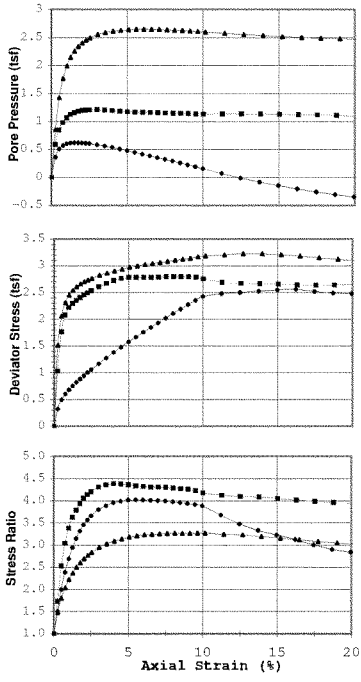
Rupture Envelope at Failure
α = 25.2 ° a = 0.2 (tsf)

---------- Effective φ': 28.0 ° c'= 0.27 (tsf)
_____ Total φ': 11.2 ° c= 0.57 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

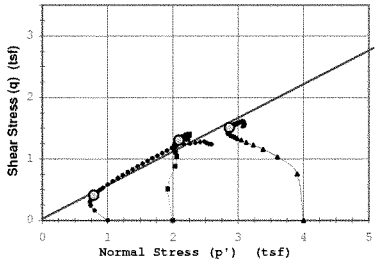
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 1 Type: 5T Depth (ft): 23 - 25
Soil Type: Silty Clay w/a few pockets of Silty Sand (CL-ML) Alluvium

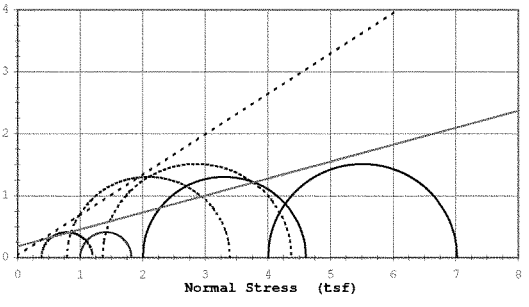


Failure Criterion:	Max. Pore Pressure				
Angle of internal friction, ϕ' =	33.1 °				
Apparent Cohesion, c' =	0.03 (tsf)				
Test Date: 8/26/10		Liquid Limit:		28.2	
Test Type: CU w/pp		Plastic Limit:		17.1	
Strain Rate (in/min): 0.00236		Plasticity Index:		11.1	
Strain Rate (%/min): 0.059		Spec. Gravity (Assumed):		2.67	
Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	27.6	28.6	34.1		
Dry Density (pcf)	95.8	94.2	87.2		
Void Ratio	0.74	0.77	0.91		
After Consolidation					
Diameter (in)	1.94	1.93	1.90		
Height (in)	4.01	3.99	3.94		
Water Content (%)	26.3	26.1	28.4		
Dry Density (pcf)	97.9	98.3	94.8		
Void Ratio	0.70	0.70	0.76		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	2.56	2.80	3.23		
Ultimate Deviator Stress (tsf)	2.48	2.66	3.08		
Deviator Stress at Failure (tsf)	0.82	2.61	3.02		
Max. Pore Pressure Buildup (tsf)	0.62	1.21	2.64		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	1.5	3.0	6.1		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





Rupture Envelope at Failure	
α = 28.7 °	a = 0.0 (tsf)

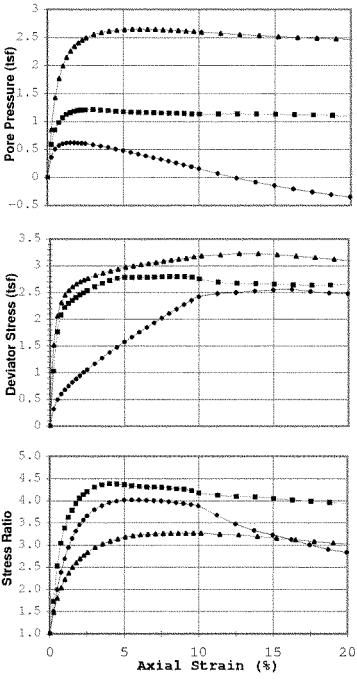
----------	Effective ϕ': 33.1 °	c'=	0.03 (tsf)
_____	Total ϕ': 15.3 °	c=	0.18 (tsf)

SOIL ENGINEERING TESTING, INC.
9301 Bryant Ave. South Suite #107 Bloomington, Minnesota 55420-3436

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

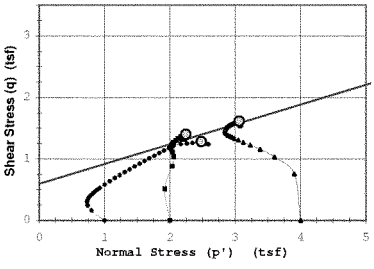
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 1 Type: 5T Depth (ft): 23 - 25
Soil Type: Silty Clay w/a few pockets of Silty Sand (CL-ML) Alluvium

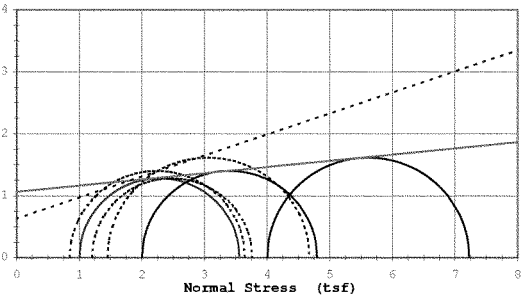


Failure Criterion:	Max. Deviator Stress				
Angle of internal friction, ϕ' =	18.8 °				
Apparent Cohesion, c' =	0.63 (tsf)				
Test Date: 8/26/10		Liquid Limit:		28.2	
Test Type: CU w/pp		Plastic Limit:		17.1	
Strain Rate (in/min): 0.00236		Plasticity Index:		11.1	
Strain Rate (%/min): 0.059		Spec. Gravity (Assumed):		2.67	
Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	27.6	28.6	34.1		
Dry Density (pcf)	95.8	94.2	87.2		
Void Ratio	0.74	0.77	0.91		
After Consolidation					
Diameter (in)	1.94	1.93	1.90		
Height (in)	4.01	3.99	3.94		
Water Content (%)	26.3	26.1	28.4		
Dry Density (pcf)	97.9	98.3	94.8		
Void Ratio	0.70	0.70	0.76		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	2.56	2.80	3.23		
Ultimate Deviator Stress (tsf)	2.48	2.66	3.08		
Deviator Stress at Failure (tsf)	2.56	2.80	3.23		
Max. Pore Pressure Buildup (tsf)	0.62	1.21	2.64		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	16.2	7.5	12.7		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





Rupture Envelope at Failure
α = 17.9 ° a = 0.6 (tsf)

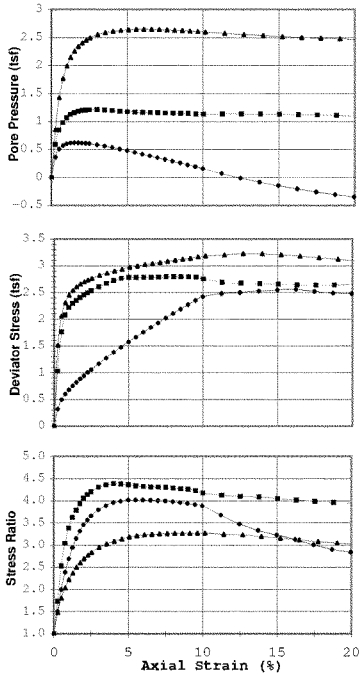
---------- Effective ϕ': 18.8 ° c'= 0.63 (tsf)
_____ Total ϕ': 5.7 ° c= 1.06 (tsf)

9301 Bryant Ave. South Suite #107 Bloomington, Minnesota 55420-3436
OIL ENGINEERING TESTING, INC.

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 1 Type: 5T Depth (ft): 23 - 25
Soil Type: Silty Clay w/a few pockets of Silty Sand (CL-ML) Alluvium

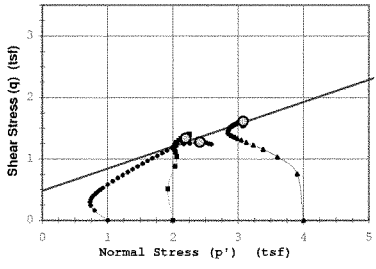


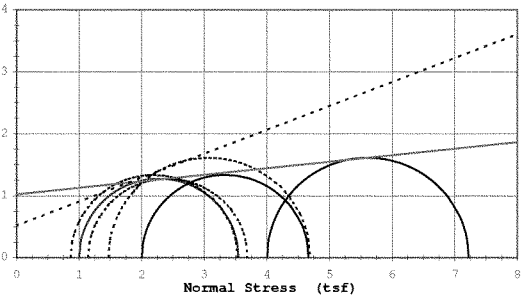
Failure Criterion:	Given Strain of: 15%
Angle of internal friction, ϕ' =	21.2 °
Apparent Cohesion, c' =	0.51 (tsf)
Test Date: 8/26/10	Liquid Limit: 28.2
Test Type: CU w/pp	Plastic Limit: 17.1
Strain Rate (in/min): 0.00236	Plasticity Index: 11.1
Strain Rate (%/min): 0.059	Spec. Gravity (Assumed): 2.67

Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	27.6	28.6	34.1		
Dry Density (pcf)	95.8	94.2	87.2		
Void Ratio	0.74	0.77	0.91		
After Consolidation					
Diameter (in)	1.94	1.93	1.90		
Height (in)	4.01	3.99	3.94		
Water Content (%)	26.3	26.1	28.4		
Dry Density (pcf)	97.9	98.3	94.8		
Void Ratio	0.70	0.70	0.76		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	2.56	2.80	3.23		
Ultimate Deviator Stress (tsf)	2.48	2.66	3.08		
Deviator Stress at Failure (tsf)	2.54	2.66	3.22		
Max. Pore Pressure Buildup (tsf)	0.62	1.21	2.64		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	15.0	15.0	15.0		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





Rupture Envelope at Failure	
α = 19.8 °	a = 0.5 (tsf)

----------	Effective ϕ': 21.2 °	c'=	0.51 (tsf)
_____	Total ϕ': 6.0 °	c=	1.02 (tsf)

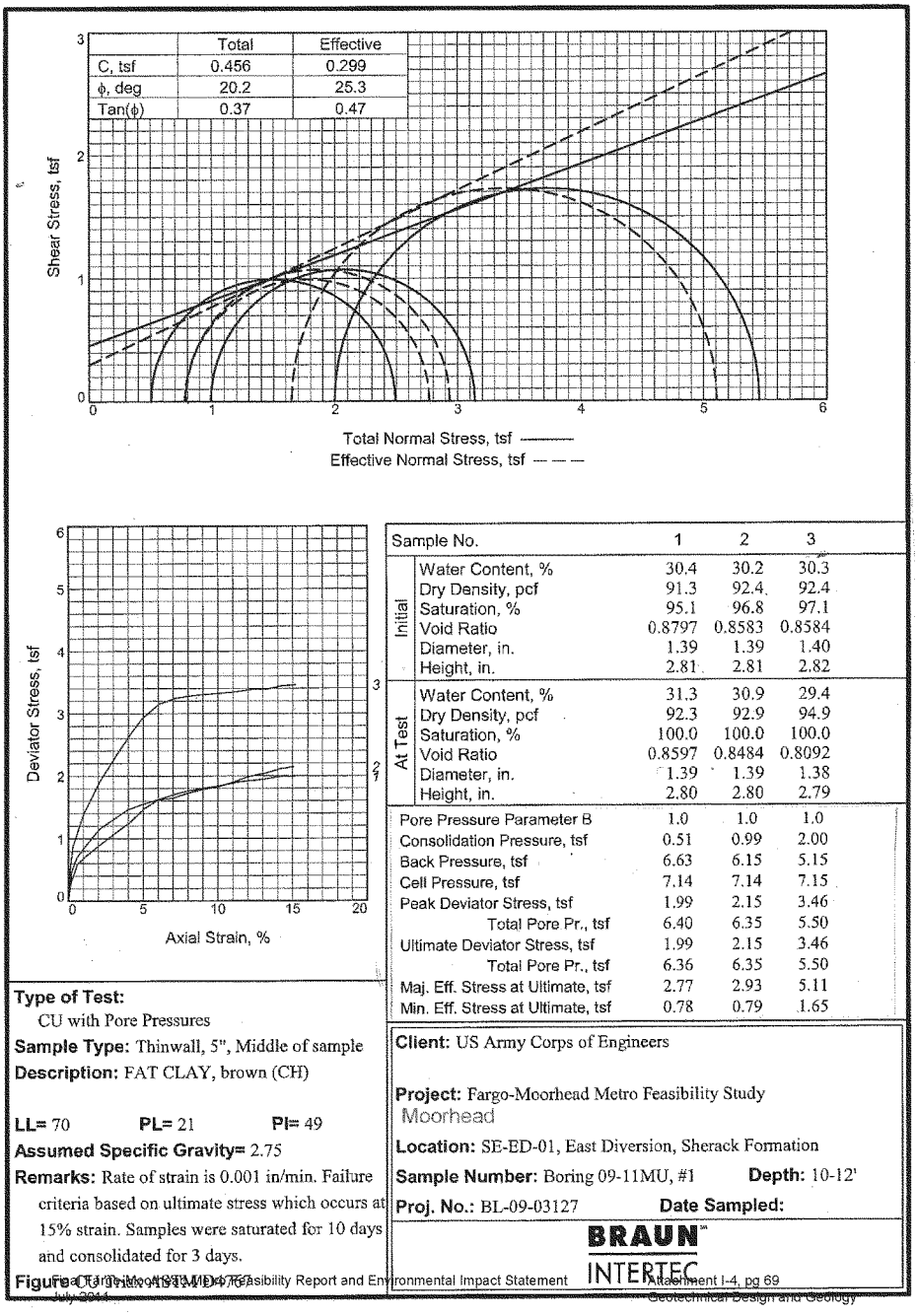
9301 Bryant Ave. South Suite #107 Bloomington, Minnesota 55420-3436

Job No.: 7577

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095 Test Type: CU w/pp

Boring No.: 10-80MU, Sample No.: 1, Depth (ft.): 23 - 25

Sample 1			Sample 2			Sample 3		
Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	0.32	0.36	0.25	1.03	0.59	0.25	1.51	0.85
0.50	0.49	0.51	0.50	1.76	0.85	0.51	2.06	1.43
0.75	0.60	0.57	0.75	2.08	0.98	0.76	2.31	1.77
1.00	0.68	0.60	1.00	2.22	1.07	1.02	2.45	1.99
1.25	0.75	0.61	1.25	2.30	1.13	1.27	2.54	2.14
1.50	0.82	0.62	1.51	2.35	1.16	1.52	2.61	2.26
1.75	0.88	0.62	1.76	2.41	1.18	1.78	2.66	2.34
2.00	0.94	0.62	2.01	2.45	1.20	2.03	2.70	2.40
2.24	1.00	0.61	2.26	2.49	1.21	2.28	2.73	2.45
2.49	1.05	0.60	2.51	2.54	1.21	2.54	2.76	2.49
2.99	1.16	0.58	3.01	2.61	1.21	3.05	2.82	2.55
3.49	1.27	0.56	3.51	2.67	1.21	3.55	2.86	2.59
3.99	1.38	0.53	4.01	2.72	1.20	4.06	2.90	2.61
4.49	1.47	0.51	4.51	2.76	1.18	4.57	2.93	2.63
4.99	1.57	0.48	5.02	2.78	1.17	5.08	2.97	2.64
5.49	1.66	0.45	5.52	2.78	1.17	5.58	2.99	2.64
5.99	1.75	0.42	6.02	2.78	1.16	6.09	3.02	2.64
6.48	1.84	0.39	6.52	2.78	1.16	6.60	3.04	2.64
6.98	1.93	0.36	7.02	2.79	1.16	7.11	3.06	2.64
7.48	2.02	0.33	7.52	2.80	1.15	7.61	3.08	2.64
7.98	2.10	0.29	8.03	2.79	1.15	8.12	3.10	2.63
8.48	2.19	0.26	8.53	2.79	1.15	8.63	3.12	2.62
8.98	2.27	0.23	9.03	2.80	1.14	9.14	3.14	2.61
9.48	2.35	0.19	9.53	2.79	1.14	9.65	3.16	2.61
9.98	2.42	0.16	10.03	2.76	1.13	10.15	3.18	2.60
11.22	2.48	0.07	11.29	2.69	1.14	11.42	3.20	2.57
12.47	2.50	-0.01	12.54	2.67	1.14	12.69	3.23	2.55
13.72	2.52	-0.08	13.79	2.66	1.14	13.96	3.22	2.53
14.96	2.54	-0.14	15.05	2.66	1.13	15.23	3.20	2.51
16.21	2.56	-0.20	16.30	2.64	1.12	16.50	3.18	2.50
17.46	2.52	-0.26	17.56	2.63	1.12	17.77	3.15	2.48
18.70	2.49	-0.31	18.81	2.64	1.11	19.03	3.12	2.48
19.95	2.48	-0.35	20.06	2.66	1.10	20.30	3.08	2.47



Sample No.		1	2	3
Initial	Water Content, %	30.4	30.2	30.3
	Dry Density, pcf	91.3	92.4	92.4
	Saturation, %	95.1	96.8	97.1
	Void Ratio	0.8797	0.8583	0.8584
	Diameter, in.	1.39	1.39	1.40
	Height, in.	2.81	2.81	2.82
At Test	Water Content, %	31.3	30.9	29.4
	Dry Density, pcf	92.3	92.9	94.9
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.8597	0.8484	0.8092
	Diameter, in.	1.39	1.39	1.38
	Height, in.	2.80	2.80	2.79
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.51	0.99	2.00
Back Pressure, tsf		6.63	6.15	5.15
Cell Pressure, tsf		7.14	7.14	7.15
Peak Deviator Stress, tsf		1.99	2.15	3.46
Total Pore Pr., tsf		6.40	6.35	5.50
Ultimate Deviator Stress, tsf		1.99	2.15	3.46
Total Pore Pr., tsf		6.36	6.35	5.50
Maj. Eff. Stress at Ultimate, tsf		2.77	2.93	5.11
Min. Eff. Stress at Ultimate, tsf		0.78	0.79	1.65

Type of Test:
CU with Pore Pressures
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, brown (CH)

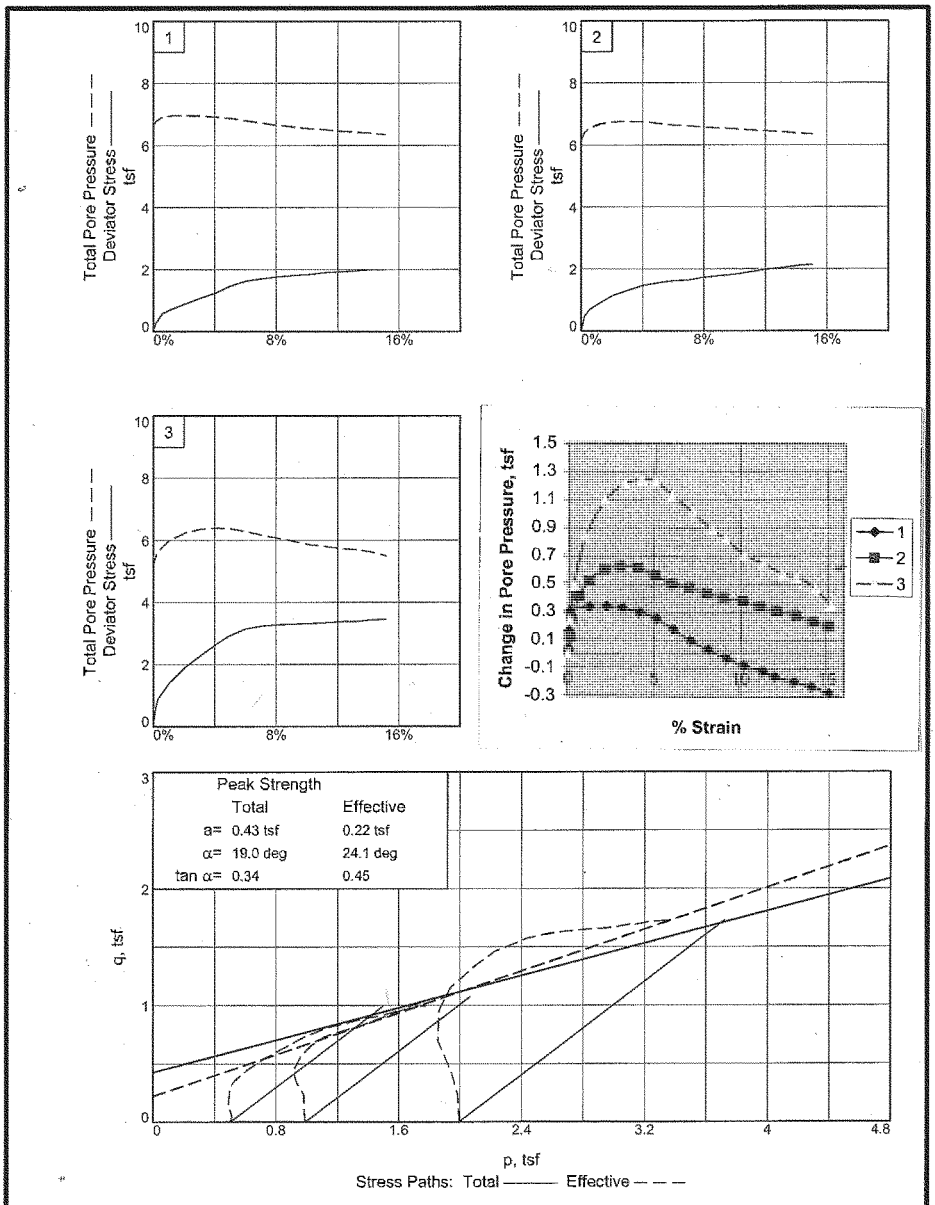
LL= 70 **PL=** 21 **PI=** 49
Assumed Specific Gravity= 2.75
Remarks: Rate of strain is 0.001 in/min. Failure criteria based on ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Moorhead
Location: SE-ED-01, East Diversion, Sherack Formation
Sample Number: Boring 09-11MU, #1 **Depth:** 10-12'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Figure C-3 Triaxial ASTM D4767



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: SE-ED-01, East Diversion, Sherack Formation **Depth:** 10-12' **Sample No.:** Boring 09-11MU, #1
Project No.: BL-09-00127 **Figure** **Braun Intertec**

TRIAXIAL COMPRESSION TEST 10/12/2009
CU with Pore Pressures 3:02 PM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-ED-01, East Diversion, Sherack Formation
Depth: 10-12' **Sample Number:** Boring 09-11MU, #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=**70 **PL=**21 **PI=**49
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	94.090			165.200
Moisture content: Dry soil+tare, gms.	79.430			133.140
Moisture content: Tare, gms.	31.260			30.350
Moisture, %	30.4	32.0	31.3	31.2
Moist specimen weight, gms.	133.9			
Diameter, in.	1.39	1.39	1.39	
Area, in.^{2}	1.52	1.52	1.51	
Height, in.	2.81	2.81	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	119.1	120.5	121.2	
Dry density, pcf	91.3	91.3	92.3	
Void ratio	0.8797	0.8797	0.8597	
Saturation, %	95.1	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.136 tsf
Consolidation back pressure = 6.633 tsf
Consolidation effective confining stress = 0.503 tsf
Fail. Stress = 1.990 tsf **at reading no.** 17
Ult. Stress = 1.988 tsf **at reading no.** 18

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	0.0167	18.850	0.0	0.0	0.000	0.503	0.503	1.00	6.633	0.503	0.000
1	0.0173	20.750	1.9	0.0	0.091	0.469	0.560	1.19	6.667	0.514	0.045
2	0.0214	24.960	6.1	0.2	0.291	0.345	0.636	1.84	6.791	0.490	0.145
3	0.0335	31.240	12.4	0.6	0.587	0.206	0.793	3.85	6.930	0.499	0.293
4	0.0506	34.200	15.4	1.2	0.723	0.171	0.894	5.23	6.965	0.532	0.361
5	0.0773	38.360	19.5	2.2	0.910	0.167	1.077	6.45	6.969	0.622	0.455
6	0.1043	42.290	23.4	3.1	1.082	0.177	1.259	7.11	6.959	0.718	0.541
7	0.1310	46.230	27.4	4.1	1.251	0.209	1.460	6.99	6.927	0.835	0.626
8	0.1588	51.540	32.7	5.1	1.479	0.255	1.734	6.80	6.881	0.994	0.739
9	0.1866	55.230	36.4	6.1	1.628	0.329	1.957	5.95	6.807	1.143	0.814
10	0.2157	57.340	38.5	7.1	1.704	0.410	2.114	5.16	6.726	1.262	0.852
11	0.2446	59.230	40.4	8.1	1.768	0.473	2.241	4.74	6.663	1.357	0.884
12	0.2736	60.550	41.7	9.2	1.805	0.536	2.341	4.37	6.600	1.438	0.902
13	0.3024	61.930	43.1	10.2	1.844	0.588	2.432	4.14	6.548	1.510	0.922
14	0.3325	63.800	44.9	11.3	1.901	0.626	2.527	4.04	6.510	1.576	0.950
15	0.3535	64.660	45.8	12.0	1.921	0.665	2.586	3.89	6.471	1.625	0.960
16	0.3834	65.860	47.0	13.1	1.947	0.700	2.647	3.78	6.436	1.673	0.973
17	0.4123	67.470	48.6	14.1	1.990	0.734	2.724	3.71	6.402	1.729	0.995
18	0.4400	68.000	49.2	15.1	1.988	0.779	2.767	3.55	6.357	1.773	0.994

Parameters for Specimen No. 2				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	121.370			165.960
Moisture content: Dry soil+tare, gms.	100.210			134.150
Moisture content: Tare, gms.	30.180			30.780
Moisture, %	30.2	31.2	30.9	30.8
Moist specimen weight, gms.	134.9			
Diameter, in.	1.39	1.39	1.39	
Area, in.^{2}	1.52	1.52	1.52	
Height, in.	2.81	2.81	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	120.3	121.2	121.5	
Dry density, pcf	92.4	92.4	92.9	
Void ratio	0.8583	0.8583	0.8484	
Saturation, %	96.8	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.139 tsf

Consolidation back pressure = 6.148 tsf

Consolidation effective confining stress = 0.991 tsf

Fail. Stress = 2.147 tsf at reading no. 18

Ult. Stress = 2.147 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	0.0099	19.490	0.0	0.0	0.000	0.991	0.991	1.00	6.148	0.991	0.000
1	0.0128	23.920	4.4	0.1	0.210	0.878	1.088	1.24	6.261	0.983	0.105
2	0.0158	29.440	10.0	0.2	0.471	0.745	1.216	1.63	6.394	0.981	0.236
3	0.0256	34.270	14.8	0.6	0.698	0.583	1.281	2.20	6.556	0.932	0.349
4	0.0426	38.360	18.9	1.2	0.885	0.471	1.356	2.88	6.668	0.914	0.443
5	0.0684	44.310	24.8	2.1	1.154	0.389	1.543	3.97	6.750	0.966	0.577
6	0.0953	48.000	28.5	3.0	1.312	0.372	1.684	4.53	6.767	1.028	0.656
7	0.1223	51.630	32.1	4.0	1.465	0.381	1.846	4.84	6.758	1.113	0.732
8	0.1492	53.800	34.3	5.0	1.548	0.435	1.983	4.56	6.704	1.209	0.774
9	0.1770	55.690	36.2	6.0	1.616	0.492	2.108	4.29	6.647	1.300	0.808
10	0.2058	56.730	37.2	7.0	1.645	0.518	2.163	4.17	6.621	1.340	0.822
11	0.2345	59.050	39.6	8.0	1.728	0.559	2.287	4.09	6.580	1.423	0.864
12	0.2627	60.760	41.3	9.0	1.783	0.590	2.373	4.02	6.549	1.481	0.891
13	0.2917	62.220	42.7	10.1	1.825	0.615	2.440	3.97	6.524	1.527	0.912
14	0.3206	64.660	45.2	11.1	1.907	0.655	2.562	3.91	6.484	1.608	0.953
15	0.3495	67.230	47.7	12.1	1.992	0.683	2.675	3.92	6.456	1.679	0.996
16	0.3792	69.000	49.5	13.2	2.041	0.715	2.756	3.85	6.424	1.735	1.020
17	0.4084	71.440	52.0	14.2	2.116	0.760	2.876	3.78	6.379	1.818	1.058
18	0.4320	72.720	53.2	15.1	2.147	0.787	2.934	3.73	6.352	1.860	1.073

Parameters for Specimen No. 3				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	120.470			166.510
Moisture content: Dry soil+tare, gms.	99.790			135.780
Moisture content: Tare, gms.	31.550			30.900
Moisture, %	30.3	31.2	29.4	29.3
Moist specimen weight, gms.	136.2			
Diameter, in.	1.40	1.40	1.38	
Area, in.²	1.53	1.53	1.50	
Height, in.	2.82	2.82	2.79	
Net decrease in height, in.		0.00	0.03	
Wet Density, pcf	120.4	121.2	122.8	
Dry density, pcf	92.4	92.4	94.9	
Void ratio	0.8584	0.8584	0.8092	
Saturation, %	97.1	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.147 tsf

Consolidation back pressure = 5.153 tsf

Consolidation effective confining stress = 1.994 tsf

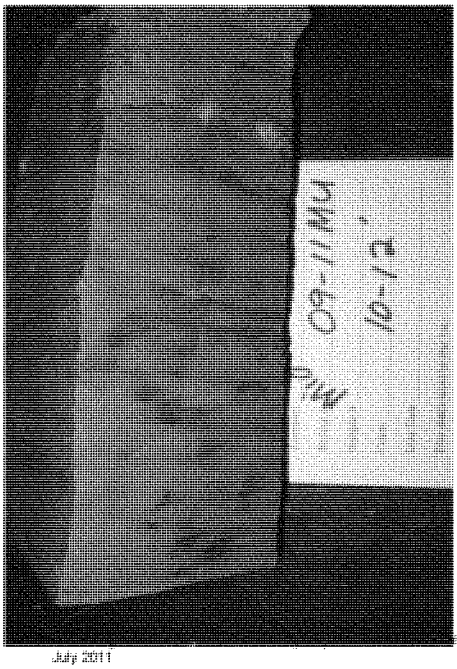
Fail. Stress = 3.458 tsf at reading no. 17

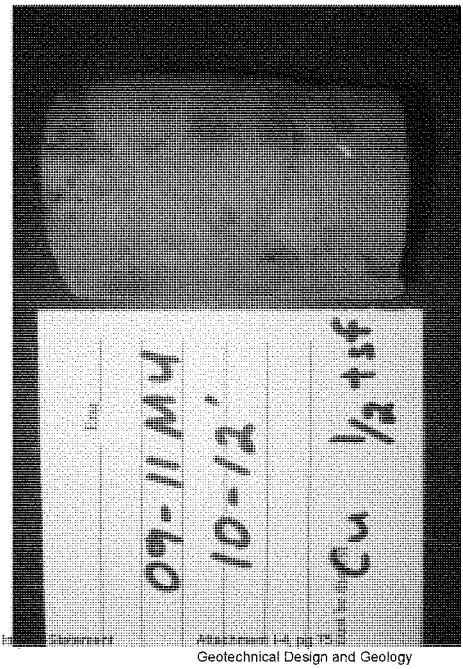
Ult. Stress = 3.458 tsf at reading no. 17

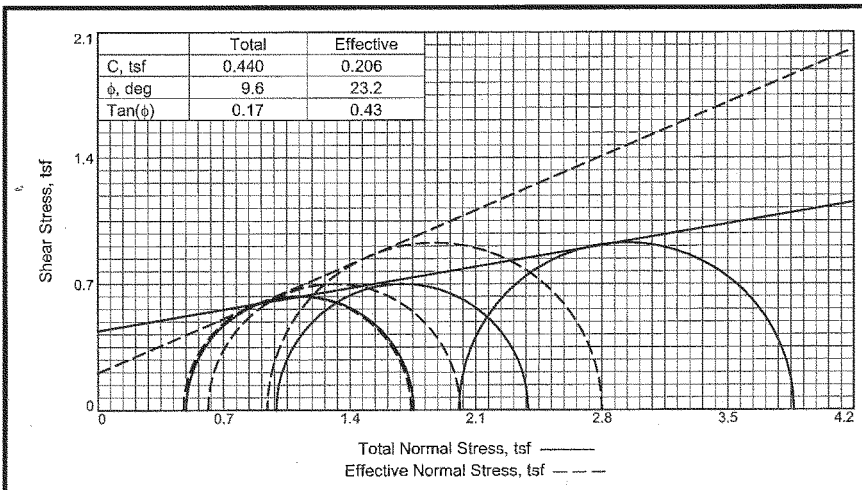
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0230	18.670	0.0	0.0	0.000	1.994	1.994	1.00	5.153	1.994	0.000
1	0.0258	28.280	9.6	0.1	0.460	1.756	2.216	1.26	5.391	1.986	0.230
2	0.0309	36.920	18.3	0.3	0.872	1.508	2.380	1.58	5.639	1.944	0.436
3	0.0517	48.150	29.5	1.0	1.397	1.156	2.553	2.21	5.991	1.855	0.699
4	0.0817	59.630	41.0	2.1	1.920	0.903	2.823	3.13	6.244	1.863	0.960
5	0.1114	68.570	49.9	3.2	2.314	0.784	3.098	3.95	6.363	1.941	1.157
6	0.1412	77.510	58.8	4.2	2.699	0.758	3.457	4.56	6.389	2.107	1.349
7	0.1613	82.950	64.3	5.0	2.926	0.765	3.691	4.82	6.382	2.228	1.463
8	0.1917	88.720	70.1	6.0	3.152	0.865	4.017	4.64	6.282	2.441	1.576
9	0.2232	91.710	73.0	7.2	3.247	0.986	4.233	4.29	6.161	2.610	1.624
10	0.2549	93.510	74.8	8.3	3.286	1.104	4.390	3.98	6.043	2.747	1.643
11	0.2759	94.510	75.8	9.1	3.303	1.172	4.475	3.82	5.975	2.823	1.651
12	0.3070	95.930	77.3	10.2	3.324	1.286	4.610	3.58	5.861	2.948	1.662
13	0.3377	97.500	78.8	11.3	3.350	1.349	4.699	3.48	5.798	3.024	1.675
14	0.3697	99.550	80.9	12.4	3.392	1.419	4.811	3.39	5.728	3.115	1.696
15	0.3907	100.070	81.4	13.2	3.385	1.442	4.827	3.35	5.705	3.134	1.692
16	0.4216	102.510	83.8	14.3	3.442	1.525	4.967	3.26	5.622	3.246	1.721
17	0.4463	103.790	85.1	15.2	3.458	1.647	5.105	3.10	5.500	3.376	1.729

09-11 MW
10-12'
CH 2 +sf

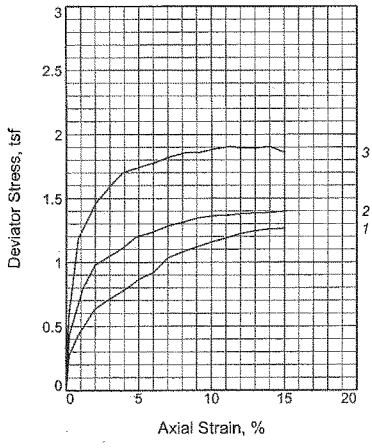
09-11 MW
10-12'
CH 1+sf


09-11 MW
10-12'


09-11 MW
10-12'
CH 1/2 +sf



	Total	Effective
C, tsf	0.440	0.206
ϕ, deg	9.6	23.2
Tan(ϕ)	0.17	0.43



Sample No.		1	2	3
Initial	Water Content, %	38.1	38.8	41.4
	Dry Density, pcf	83.5	83.0	79.8
	Saturation, %	99.3	99.8	98.9
	Void Ratio	1.0551	1.0693	1.1516
	Diameter, in.	1.41	1.39	1.40
	Height, in.	2.80	2.83	2.81
At Test	Water Content, %	36.8	36.1	36.9
	Dry Density, pcf	85.4	86.1	85.2
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.0113	0.9931	1.0156
	Diameter, in.	1.40	1.37	1.37
	Height, in.	2.78	2.79	2.75
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.49	0.99	2.01
Back Pressure, tsf		6.65	6.15	5.14
Cell Pressure, tsf		7.14	7.14	7.15
Peak Deviator Stress, tsf		1.26	1.40	1.91
Total Pore Pr., tsf		6.66	6.53	6.28
Ultimate Deviator Stress, tsf		1.26	1.40	1.86
Total Pore Pr., tsf		6.66	6.53	6.21
Maj. Eff. Stress at Ultimate, tsf		1.74	2.01	2.80
Min. Eff. Stress at Ultimate, tsf		0.48	0.61	0.94

Type of Test:
CU with Pore Pressures

Sample Type: Thinwall, 5", Middle of sample

Description: FAT CLAY with layers of SILT, brown (CH)

LL= 54 **PL=** 19 **PI=** 35

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
Moorhead

Location: SE-ED-15, East Diversion, Sherack Formation

Sample Number: Boring 09-14MU, #1 **Depth:** 8-10'

Proj. No.: BL-09-03127 **Date Sampled:**

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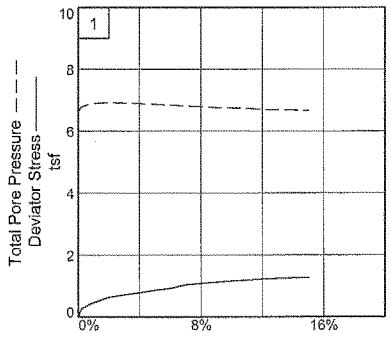
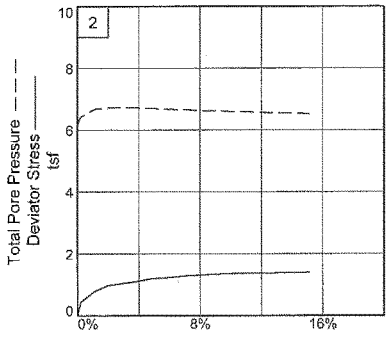
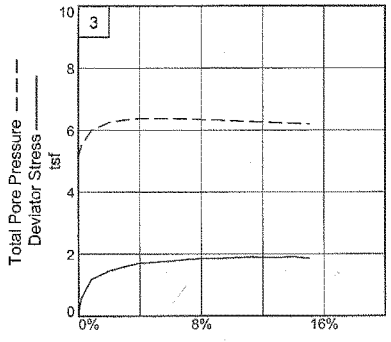
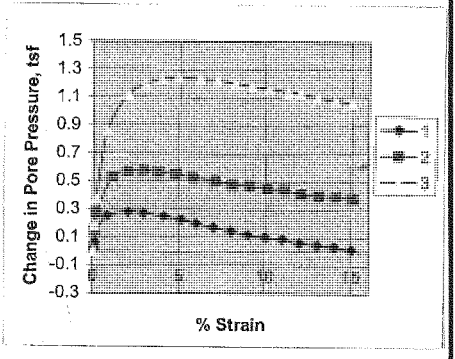
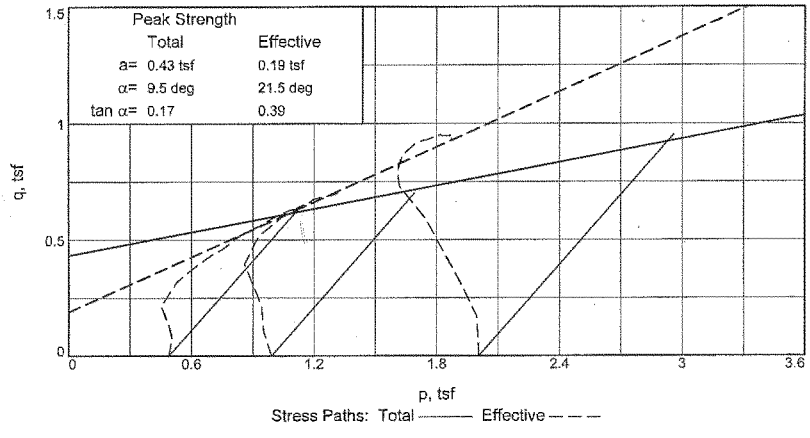
Figure CTX Triaxial ASTM D4767











Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: SE-ED-15, East Diversion, Sherack Formation **Depth:** 8-10' **Sample No.:** Boring 09-14MU, #1
Project No.: BL-09-0127 **Figure**

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST 10/12/2009
CU with Pore Pressures 3:49 PM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-ED-15, East Diversion, Sherack Formation
Depth: 8-10' **Sample Number:** Boring 09-14MU, #1
Description: FAT CLAY with layers of SILT, 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=2.75 **LL=**54 **PL=**19 **PI=**35
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	96.200			160.570
Moisture content: Dry soil+tare, gms.	77.950			126.200
Moisture content: Tare, gms.	30.060			29.890
Moisture, %	38.1	38.4	36.8	35.7
Moist specimen weight, gms.	132.6			
Diameter, in.	1.41	1.41	1.40	
Area, in.^{2}	1.56	1.56	1.54	
Height, in.	2.80	2.80	2.78	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	115.4	115.6	116.7	
Dry density, pcf	83.5	83.5	85.4	
Void ratio	1.0551	1.0551	1.0113	
Saturation, %	99.3	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.136 tsf
Consolidation back pressure = 6.646 tsf
Consolidation effective confining stress = 0.490 tsf
Fail. Stress = 1.264 tsf **at reading no.** 17
Ult. Stress = 1.264 tsf **at reading no.** 17

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	0.0139	18.940	0.0	0.0	0.000	0.490	0.490	1.00	6.646	0.490	0.000
1	0.0169	22.300	3.4	0.1	0.157	0.428	0.585	1.37	6.708	0.507	0.079
2	0.0197	24.770	5.8	0.2	0.272	0.353	0.625	1.77	6.783	0.489	0.136
3	0.0366	28.190	9.3	0.8	0.429	0.238	0.667	2.80	6.898	0.453	0.215
4	0.0686	32.770	13.8	2.0	0.634	0.211	0.845	4.01	6.925	0.528	0.317
5	0.0936	34.420	15.5	2.9	0.703	0.220	0.923	4.20	6.916	0.572	0.352
6	0.1283	36.550	17.6	4.1	0.790	0.241	1.031	4.28	6.895	0.636	0.395
7	0.1545	38.530	19.6	5.1	0.870	0.265	1.135	4.28	6.871	0.700	0.435
8	0.1812	39.870	20.9	6.0	0.920	0.291	1.211	4.16	6.845	0.751	0.460
9	0.2091	42.720	23.8	7.0	1.034	0.319	1.353	4.24	6.817	0.836	0.517
10	0.2359	44.020	25.1	8.0	1.080	0.345	1.425	4.13	6.791	0.885	0.540
11	0.2639	45.220	26.3	9.0	1.119	0.372	1.491	4.01	6.764	0.931	0.559
12	0.2918	46.440	27.5	10.0	1.158	0.389	1.547	3.98	6.747	0.968	0.579
13	0.3198	47.510	28.6	11.0	1.190	0.403	1.593	3.95	6.733	0.998	0.595
14	0.3473	48.640	29.7	12.0	1.223	0.431	1.654	3.84	6.705	1.042	0.611
15	0.3756	49.530	30.6	13.0	1.245	0.444	1.689	3.80	6.692	1.066	0.622
16	0.4045	50.260	31.3	14.0	1.259	0.457	1.716	3.76	6.679	1.087	0.630
17	0.4324	50.750	31.8	15.0	1.264	0.476	1.740	3.66	6.660	1.108	0.632

Parameters for Specimen No. 2				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	91.830			156.070
Moisture content: Dry soil+tare, gms.	74.510			123.400
Moisture content: Tare, gms.	29.880			30.150
Moisture, %	38.8	38.9	36.1	35.0
Moist specimen weight, gms.	129.3			
Diameter, in.	1.39	1.39	1.37	
Area, in.²	1.51	1.51	1.48	
Height, in.	2.83	2.83	2.79	
Net decrease in height, in.		0.00	0.04	
Wet Density, pcf	115.2	115.2	117.2	
Dry density, pcf	83.0	83.0	86.1	
Void ratio	1.0693	1.0693	0.9931	
Saturation, %	99.8	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.145 tsf

Consolidation back pressure = 6.154 tsf

Consolidation effective confining stress = 0.991 tsf

Fail. Stress = 1.401 tsf at reading no. 17

Ult. Stress = 1.401 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	0.991	0.991	1.00	6.154	0.991	0.000
1	0.0137	23.980	4.4	0.1	0.213	0.846	1.059	1.25	6.299	0.952	0.106
2	0.0168	28.590	9.0	0.2	0.437	0.723	1.160	1.60	6.422	0.941	0.218
3	0.0424	36.040	16.4	1.1	0.792	0.463	1.255	2.71	6.682	0.859	0.396
4	0.0663	40.060	20.4	2.0	0.977	0.422	1.399	3.32	6.723	0.911	0.489
5	0.0924	41.650	22.0	2.9	1.043	0.413	1.456	3.53	6.732	0.935	0.522
6	0.1181	43.190	23.6	3.8	1.106	0.426	1.532	3.60	6.719	0.979	0.553
7	0.1451	45.380	25.8	4.8	1.196	0.443	1.639	3.70	6.702	1.041	0.598
8	0.1720	46.360	26.7	5.8	1.229	0.464	1.693	3.65	6.681	1.079	0.615
9	0.2087	48.000	28.4	7.1	1.287	0.485	1.772	3.65	6.660	1.128	0.643
10	0.2368	48.940	29.3	8.1	1.315	0.515	1.830	3.55	6.630	1.172	0.657
11	0.2636	49.980	30.4	9.1	1.347	0.521	1.868	3.59	6.624	1.195	0.674
12	0.2917	50.690	31.1	10.1	1.363	0.543	1.906	3.51	6.602	1.225	0.682
13	0.3204	51.150	31.5	11.1	1.368	0.550	1.918	3.49	6.595	1.234	0.684
14	0.3484	51.780	32.2	12.1	1.379	0.578	1.957	3.39	6.567	1.268	0.690
15	0.3763	52.280	32.7	13.1	1.385	0.588	1.973	3.36	6.557	1.280	0.692
16	0.4045	52.800	33.2	14.1	1.391	0.598	1.989	3.33	6.547	1.293	0.695
17	0.4323	53.430	33.8	15.1	1.401	0.613	2.014	3.28	6.532	1.313	0.700

Parameters for Specimen No. 3				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	93.490			152.510
Moisture content: Dry soil+tare, gms.	74.960			120.390
Moisture content: Tare, gms.	30.240			29.810
Moisture, %	41.4	41.9	36.9	35.5
Moist specimen weight, gms.	128.2			
Diameter, in.	1.40	1.40	1.37	
Area, in.^{2}	1.54	1.54	1.48	
Height, in.	2.81	2.81	2.75	
Net decrease in height, in.		0.00	0.06	
Wet Density, pcf	112.9	113.2	116.6	
Dry density, pcf	79.8	79.8	85.2	
Void ratio	1.1516	1.1516	1.0156	
Saturation, %	98.9	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.146 tsf

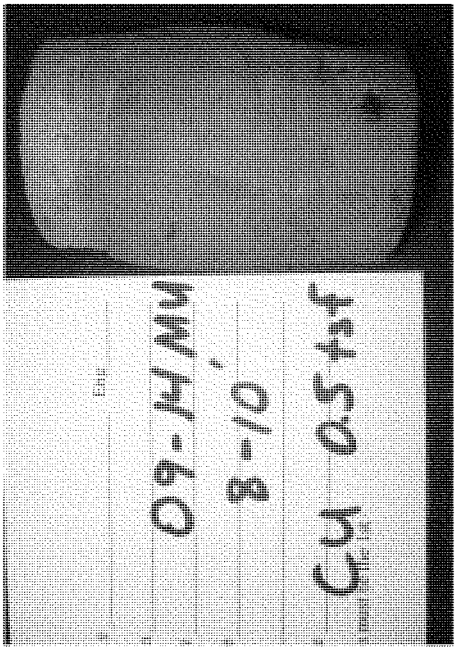
Consolidation back pressure = 5.139 tsf

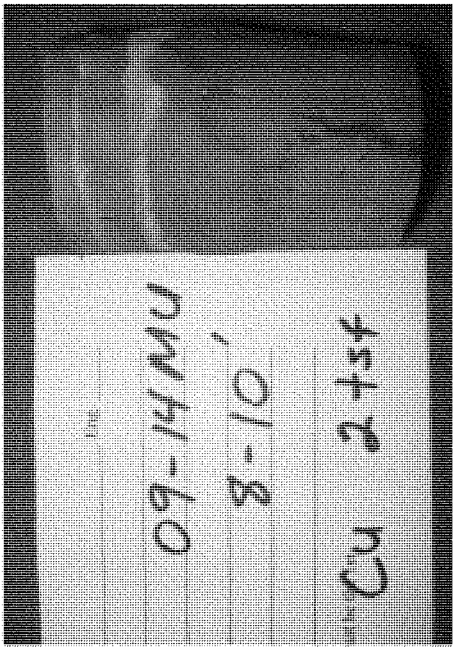
Consolidation effective confining stress = 2.007 tsf

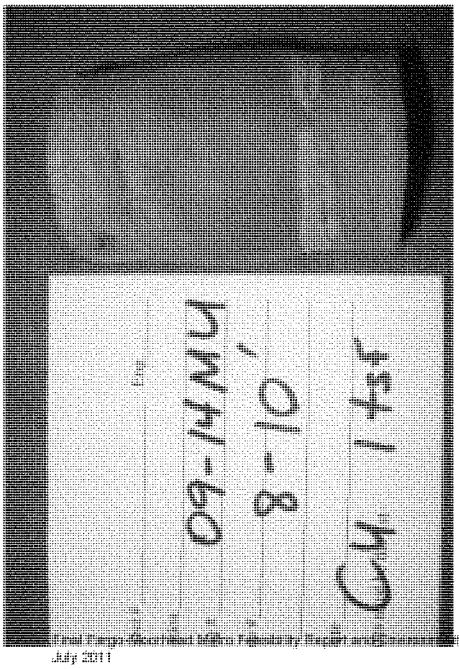
Fail. Stress = 1.906 tsf **at reading no.** 13

Ult. Stress = 1.859 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	20.130	0.0	0.0	0.000	2.007	2.007	1.00	5.139	2.007	0.000
1	0.0128	27.120	7.0	0.1	0.341	1.826	2.167	1.19	5.320	1.996	0.170
2	0.0159	32.190	12.1	0.2	0.587	1.635	2.222	1.36	5.511	1.929	0.294
3	0.0336	44.670	24.5	0.8	1.187	1.151	2.338	2.03	5.995	1.745	0.594
4	0.0664	50.690	30.6	2.0	1.461	0.888	2.349	2.65	6.258	1.618	0.730
5	0.0924	53.710	33.6	3.0	1.590	0.814	2.404	2.95	6.332	1.609	0.795
6	0.1182	56.420	36.3	3.9	1.701	0.777	2.478	3.19	6.369	1.628	0.851
7	0.1451	57.550	37.4	4.9	1.737	0.769	2.506	3.26	6.377	1.637	0.868
8	0.1810	59.110	39.0	6.2	1.784	0.776	2.560	3.30	6.370	1.668	0.892
9	0.2091	60.510	40.4	7.2	1.828	0.783	2.611	3.33	6.363	1.697	0.914
10	0.2369	61.640	41.5	8.2	1.859	0.808	2.667	3.30	6.338	1.737	0.929
11	0.2647	62.160	42.0	9.2	1.861	0.825	2.686	3.26	6.321	1.756	0.931
12	0.2917	63.200	43.1	10.2	1.887	0.845	2.732	3.23	6.301	1.788	0.943
13	0.3207	64.150	44.0	11.3	1.906	0.869	2.775	3.19	6.277	1.822	0.953
14	0.3395	64.240	44.1	12.0	1.895	0.878	2.773	3.16	6.268	1.825	0.947
15	0.3674	64.760	44.6	13.0	1.895	0.904	2.799	3.10	6.242	1.851	0.947
16	0.3963	65.550	45.4	14.0	1.905	0.926	2.831	3.06	6.220	1.879	0.953
17	0.4240	64.970	44.8	15.0	1.859	0.941	2.800	2.98	6.205	1.870	0.929


09-MW4
8-10'
Cu 0.5 tsf


09-MW4
8-10'
Cu 2 tsf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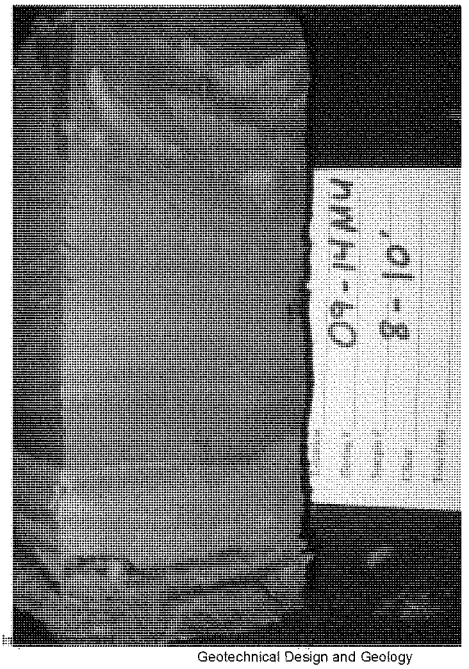
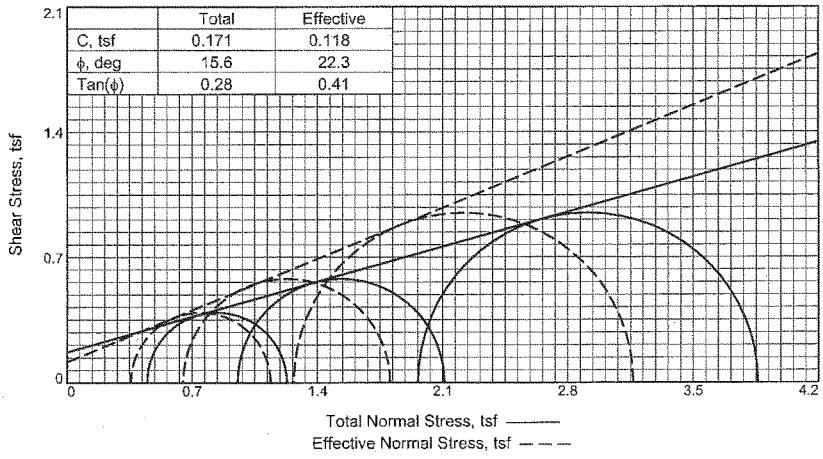
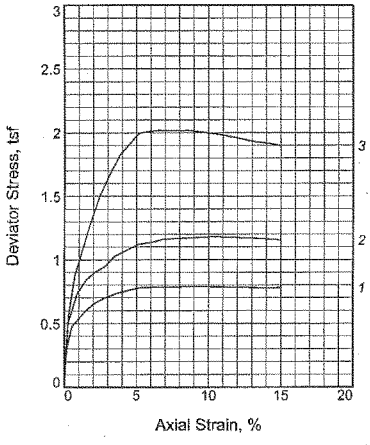
8-10'
Cu 1 tsf


09-MW4
8-10'



	Total	Effective
C, tsf	0.171	0.118
ϕ, deg	15.6	22.3
Tan(ϕ)	0.28	0.41



Sample No.		1	2	3
Initial	Water Content, %	41.9	35.8	36.9
	Dry Density, pcf	79.8	83.3	82.3
	Saturation, %	100.0	92.7	93.4
	Void Ratio	1.1514	1.0611	1.0864
	Diameter, in.	1.34	1.41	1.34
	Height, in.	2.81	2.72	2.81
At Test	Water Content, %	41.9	38.6	39.5
	Dry Density, pcf	79.8	83.3	82.3
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.1514	1.0611	1.0864
	Diameter, in.	1.34	1.41	1.34
	Height, in.	2.81	2.72	2.81
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.45	0.96	1.97
Back Pressure, tsf		5.39	5.37	4.82
Cell Pressure, tsf		5.84	6.33	6.79
Peak Deviator Stress, tsf		0.79	1.18	2.02
Total Pore Pr., tsf		5.55	5.82	5.64
Ultimate Deviator Stress, tsf		0.78	1.16	1.90
Total Pore Pr., tsf		5.48	5.68	5.52
Maj. Eff. Stress at Ultimate, tsf		1.14	1.81	3.16
Min. Eff. Stress at Ultimate, tsf		0.36	0.65	1.27

Type of Test:
CU with Pore Pressures

Sample Type: Thinwall, 5", Middle of sample

Description: FAT CLAY with layers of Silt, brown (CH)

LL= 84 **PL=** 20 **PI=** 64

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.

Figure CU Triax ASTM D4767

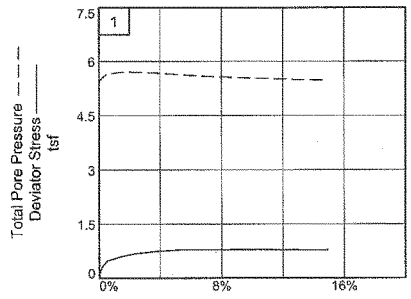
Client: US Army Corps of Engineers

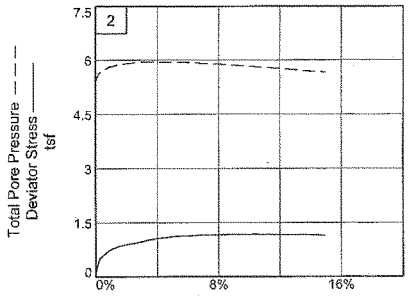
Project: Fargo-Moorhead Metro Feasibility Study
Fargo

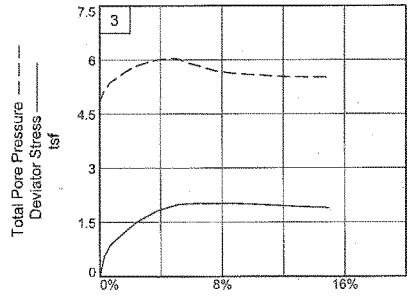
Sample Number: Boring 09-23MU, #2 **Depth:** 10-12'
Sherack

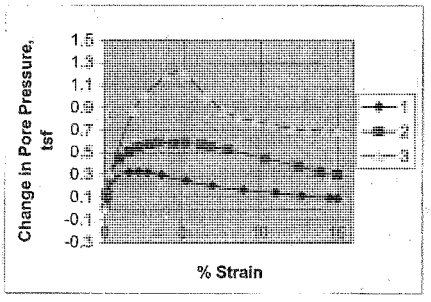
Proj. No.: BL-09-03127 **Date Sampled:**

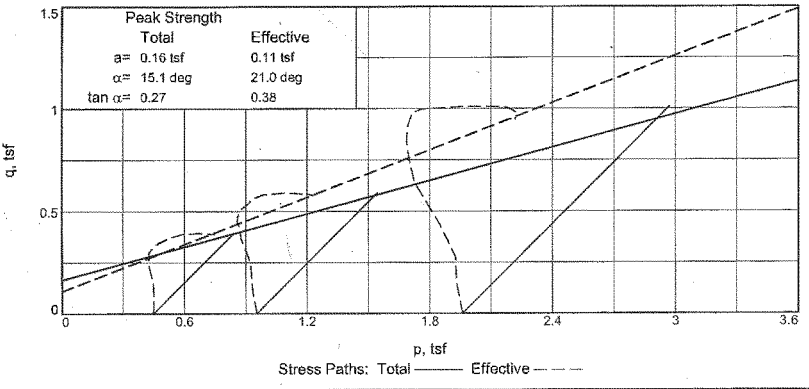
BRAUN INTERTEC











Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Fargo
Depth: 10-12' **Sample Number:** Boring 09-23MU, #2 Sherack
Project No.: BL-09-03127 **Figure** _____

Braun Intertec

Tested By: jrs **Checked By:** rs

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

8/31/2009
3:34 PM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL-09-03127 Fargo
Depth: 10-12' **Sample Number:** Boring 09-23MU, #2
Description: FAT CLAY with layers of Silt, brown (CH) Sherack
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=84** **PL=20** **PI=64**
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	83.560			370.600
Moisture content: Dry soil+tare, gms.	67.710			336.590
Moisture content: Tare, gms.	29.860			251.660
Moisture, %	41.9	41.9	41.9	40.0
Moist specimen weight, gms.	117.9			
Diameter, in.	1.34	1.34	1.34	
Area, in.^{2}	1.41	1.41	1.41	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	113.2	113.2	113.2	
Dry density, pcf	79.8	79.8	79.8	
Void ratio	1.1514	1.1514	1.1514	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 5.836 tsf
Consolidation back pressure = 5.388 tsf
Consolidation effective confining stress = 0.448 tsf
Fail. Stress = 0.781 tsf **at reading no.** 14
Ult. Stress = 0.781 tsf **at reading no.** 14

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	0.0152	15.130	0.0	0.0	0.000	0.448	0.448	1.00	5.388	0.448	0.000
1	0.0172	18.490	3.4	0.1	0.171	0.365	0.536	1.47	5.471	0.451	0.086
2	0.0203	21.200	6.1	0.2	0.309	0.292	0.601	2.06	5.544	0.446	0.154
3	0.0303	24.560	9.4	0.5	0.478	0.186	0.664	3.57	5.650	0.425	0.239
4	0.0560	27.000	11.9	1.5	0.596	0.128	0.724	5.66	5.708	0.426	0.298
5	0.0731	28.250	13.1	2.1	0.655	0.122	0.777	6.37	5.714	0.450	0.328
6	0.0900	29.080	13.9	2.7	0.692	0.128	0.820	6.41	5.708	0.474	0.346
7	0.1169	30.110	15.0	3.6	0.736	0.151	0.887	5.87	5.685	0.519	0.368
8	0.1626	31.270	16.1	5.2	0.780	0.203	0.983	4.84	5.633	0.593	0.390
9	0.2086	31.640	16.5	6.9	0.784	0.245	1.029	4.20	5.591	0.637	0.392
10	0.2655	32.100	17.0	8.9	0.788	0.283	1.071	3.78	5.553	0.677	0.394
11	0.3241	32.430	17.3	11.0	0.785	0.308	1.093	3.55	5.528	0.700	0.392
12	0.3720	32.680	17.5	12.7	0.781	0.333	1.114	3.35	5.503	0.723	0.390
13	0.4210	32.920	17.8	14.5	0.776	0.353	1.129	3.20	5.483	0.741	0.388
14	0.4350	33.140	18.0	15.0	0.781	0.357	1.138	3.19	5.479	0.747	0.390

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	68.600			397.180
Moisture content: Dry soil+tare, gms.	58.660			362.440
Moisture content: Tare, gms.	30.880			271.860
Moisture, %	35.8	38.6	38.6	38.4
Moist specimen weight, gms.	125.9			
Diameter, in.	1.41	1.41	1.41	
Area, in.²	1.56	1.56	1.56	
Height, in.	2.72	2.72	2.72	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	113.1	115.4	115.4	
Dry density, pcf	83.3	83.3	83.3	
Void ratio	1.0611	1.0611	1.0611	
Saturation, %	92.7	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 6.326 tsf

Consolidation back pressure = 5.372 tsf

Consolidation effective confining stress = 0.954 tsf

Fail. Stress = 1.156 tsf **at reading no.** 16

Ult. Stress = 1.156 tsf **at reading no.** 16

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	0.0154	15.950	0.0	0.0	0.000	0.954	0.954	1.00	5.372	0.954	0.000
1	0.0173	20.620	4.7	0.1	0.215	0.825	1.040	1.26	5.501	0.933	0.108
2	0.0225	26.820	10.9	0.3	0.500	0.672	1.172	1.74	5.654	0.922	0.250
3	0.0392	31.980	16.0	0.9	0.733	0.511	1.244	2.43	5.815	0.877	0.366
4	0.0561	34.500	18.6	1.5	0.843	0.449	1.292	2.88	5.877	0.870	0.421
5	0.0731	35.940	20.0	2.1	0.902	0.407	1.309	3.22	5.919	0.858	0.451
6	0.0912	37.070	21.1	2.8	0.947	0.386	1.333	3.45	5.940	0.859	0.473
7	0.1090	38.970	23.0	3.4	1.025	0.368	1.393	3.79	5.958	0.880	0.512
8	0.1358	40.520	24.6	4.4	1.083	0.374	1.457	3.89	5.952	0.915	0.541
9	0.1549	41.590	25.6	5.1	1.122	0.369	1.491	4.04	5.957	0.930	0.561
10	0.1826	42.290	26.3	6.2	1.140	0.385	1.525	3.96	5.941	0.955	0.570
11	0.2014	42.960	27.0	6.8	1.160	0.404	1.564	3.87	5.922	0.984	0.580
12	0.2300	43.420	27.5	7.9	1.167	0.430	1.597	3.71	5.896	1.013	0.583
13	0.2964	44.520	28.6	10.3	1.181	0.506	1.687	3.33	5.820	1.097	0.591
14	0.3551	45.010	29.1	12.5	1.172	0.576	1.748	3.04	5.750	1.162	0.586
15	0.3931	45.280	29.3	13.9	1.164	0.627	1.791	2.86	5.699	1.209	0.582
16	0.4220	45.440	29.5	15.0	1.156	0.650	1.806	2.78	5.676	1.228	0.578

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	78.650			369.820
Moisture content: Dry soil+tare, gms.	65.780			337.920
Moisture content: Tare, gms.	30.890			253.800
Moisture, %	36.9	39.5	39.5	37.9
Moist specimen weight, gms.	116.8			
Diameter, in.	1.34	1.34	1.34	
Area, in.²	1.40	1.40	1.40	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	112.6	114.8	114.8	
Dry density, pcf	82.3	82.3	82.3	
Void ratio	1.0864	1.0864	1.0864	
Saturation, %	93.4	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 6.786 tsf

Consolidation back pressure = 4.824 tsf

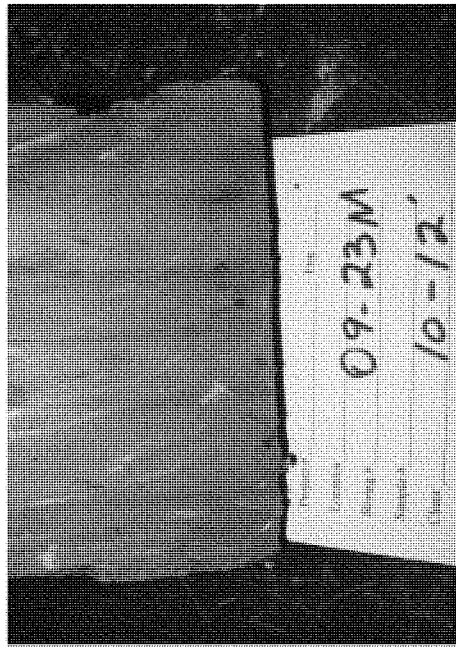
Consolidation effective confining stress = 1.962 tsf

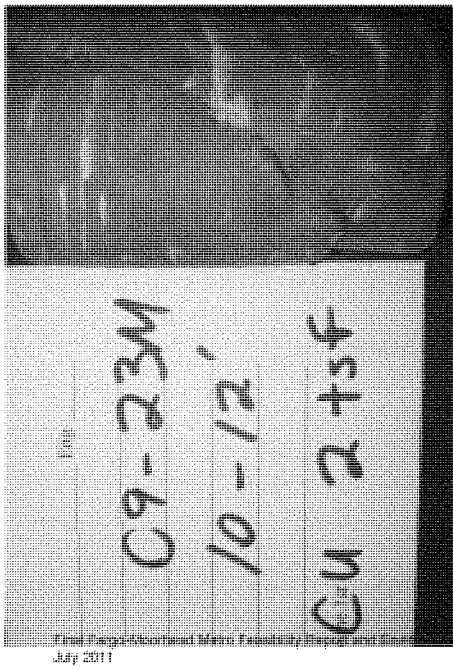
Fail. Stress = 1.898 tsf **at reading no.** 19

Ult. Stress = 1.898 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	0.0192	17.390	0.0	0.0	0.000	1.962	1.962	1.00	4.824	1.962	0.000
1	0.0236	23.400	6.0	0.2	0.308	1.778	2.086	1.17	5.008	1.932	0.154
2	0.0275	28.190	10.8	0.3	0.552	1.651	2.203	1.33	5.135	1.927	0.276
3	0.0392	34.540	17.1	0.7	0.873	1.413	2.286	1.62	5.373	1.850	0.437
4	0.0692	42.810	25.4	1.8	1.280	1.087	2.367	2.18	5.699	1.727	0.640
5	0.0883	47.540	30.1	2.5	1.508	0.945	2.453	2.60	5.841	1.699	0.754
6	0.1082	51.140	33.8	3.2	1.676	0.849	2.525	2.97	5.937	1.687	0.838
7	0.1278	54.440	37.0	3.9	1.827	0.778	2.605	3.35	6.008	1.691	0.913
8	0.1559	57.480	40.1	4.9	1.956	0.737	2.693	3.65	6.049	1.715	0.978
9	0.1648	58.420	41.0	5.2	1.995	0.762	2.757	3.62	6.024	1.760	0.998
10	0.1837	59.000	41.6	5.8	2.009	0.873	2.882	3.30	5.913	1.878	1.005
11	0.2028	59.500	42.1	6.5	2.019	0.957	2.976	3.11	5.829	1.966	1.009
12	0.2323	59.970	42.6	7.6	2.018	1.087	3.105	2.86	5.699	2.096	1.009
13	0.2616	60.490	43.1	8.6	2.020	1.149	3.169	2.76	5.637	2.159	1.010
14	0.2925	60.630	43.2	9.7	2.002	1.186	3.188	2.69	5.600	2.187	1.001
15	0.3214	60.760	43.4	10.7	1.985	1.211	3.196	2.64	5.575	2.204	0.993
16	0.3593	60.790	43.4	12.1	1.957	1.249	3.206	2.57	5.537	2.227	0.978
17	0.3891	60.700	43.3	13.1	1.929	1.261	3.190	2.53	5.525	2.226	0.965
18	0.4191	60.900	43.5	14.2	1.914	1.266	3.180	2.51	5.520	2.223	0.957
19	0.4400	60.900	43.5	15.0	1.898	1.267	3.165	2.50	5.519	2.216	0.949

09-23M
10-12'
Cu 0.5+sf


09-23M
10-12'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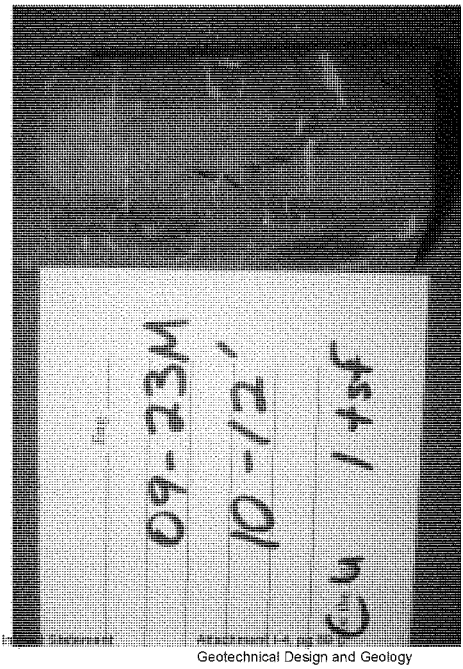
10-12'
Cu 2+sf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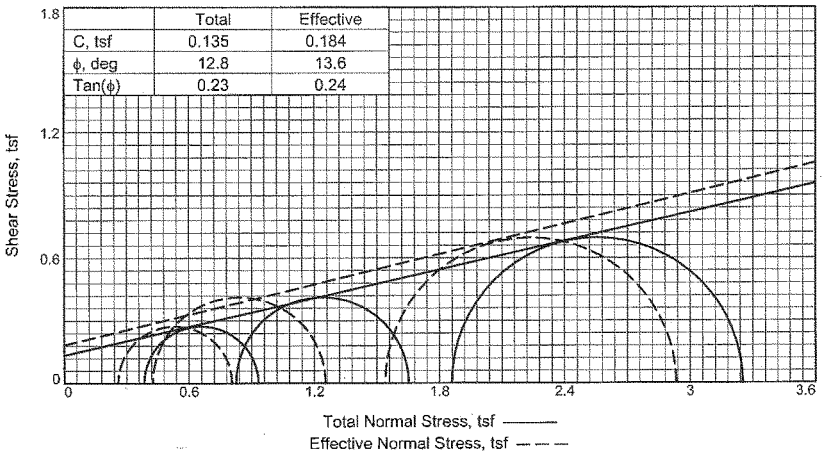
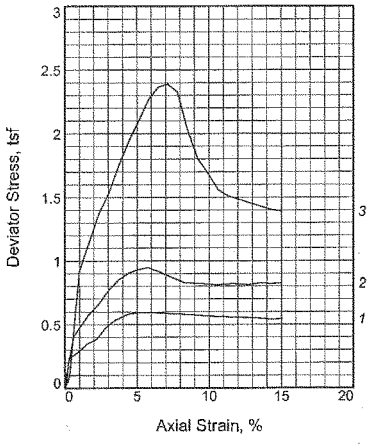
10-12'
Cu 1+sf





Sample No.		1	2	3
Initial	Water Content, %	37.5	37.5	38.9
	Dry Density, pcf	83.3	82.2	81.9
	Saturation, %	97.2	94.8	97.5
	Void Ratio	1.0618	1.0878	1.0966
	Diameter, in.	1.40	1.36	1.40
	Height, in.	2.80	2.67	2.80
At Test	Water Content, %	38.6	39.6	39.9
	Dry Density, pcf	83.3	82.2	81.9
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.0618	1.0878	1.0966
	Diameter, in.	1.40	1.36	1.40
	Height, in.	2.80	2.67	2.80
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.39	0.83	1.86
Back Pressure, tsf		5.59	5.64	5.03
Cell Pressure, tsf		5.98	6.47	6.89
Peak Deviator Stress, tsf		0.60	0.95	2.39
Total Pore Pr., tsf		5.84	6.20	6.12
Ultimate Deviator Stress, tsf		0.55	0.83	1.39
Total Pore Pr., tsf		5.72	6.04	5.35
Maj. Eff. Stress at Ultimate, tsf		0.81	1.25	2.93
Min. Eff. Stress at Ultimate, tsf		0.26	0.43	1.54

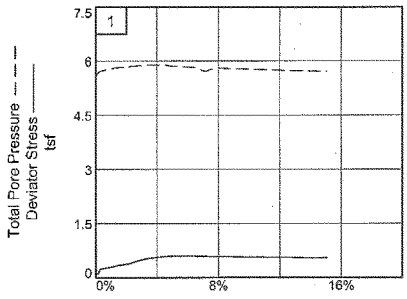
Type of Test:
CU with Pore Pressures
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY with layers of Silt, brown (CH)
LL= 82 **PL=** 20 **PI=** 62
Assumed Specific Gravity= 2.75
Remarks: Rate of strain is 0.001 in/min. Failure criteria based on the ultimate stress which occurs at 15% strain. Samples were satuated for 10 days and consolidated for 3 days.

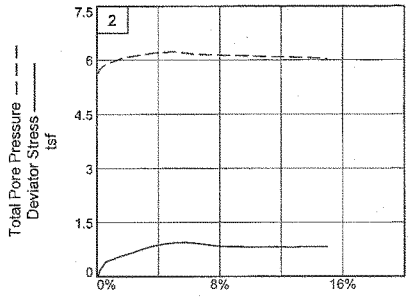
Client: US Army Corps of Engineers

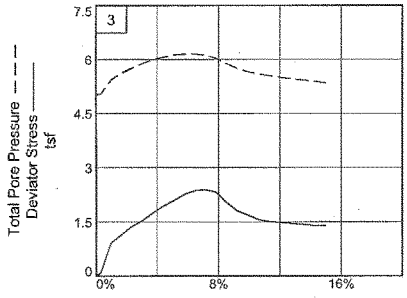
Project: Fargo-Moorhead Metro Feasibility Study
Moorhead
Sample Number: Boring 09-25MU, #1 **Depth:** 8-10'
Sherack
Proj. No.: BL-09-03127 **Date Sampled:**

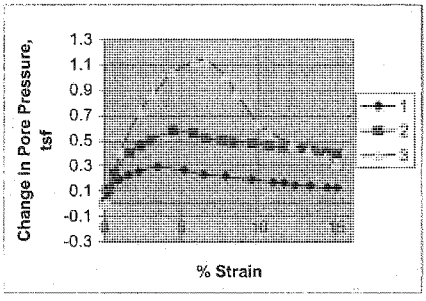
BRAUN INTERTEC

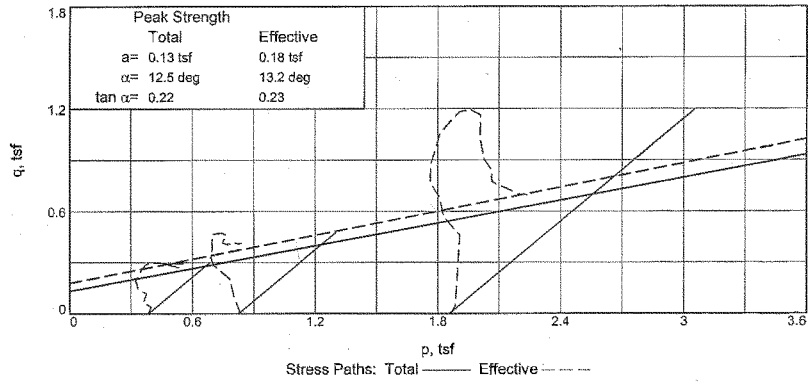
Figure CU Triax ASTM D4767











Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Depth: 8-10' **Sample Number:** Boring 09-25MU Moorhead Sherack
Project No.: BL-09-03127 **Figure** _____
Braun Intertec

Tested By: jrs **Checked By:** rs

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

8/31/2009
2:13 PM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL-09-03127 Moorhead
Depth: 8-10' **Sample Number:** Boring 09-25MU
Description: FAT CLAY with layers of Silt, brown (CH) Sherack
Remarks: Rate of strain is 0.001 in/min. Failure criteria based on the ultimate stress which occurs at 15% strain. Samples were satuated for 10 days and consolidated for 3 days.
Type of Sample: Thinwall, 5", Middle of sample
Assumed Specific Gravity=2.75 **LL=**82 **PL=**20 **PI=**62
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	113.100			161.930
Moisture content: Dry soil+tare, gms.	90.560			124.690
Moisture content: Tare, gms.	30.510			31.250
Moisture, %	37.5	38.6	38.6	39.9
Moist specimen weight, gms.	128.9			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.53	1.53	1.53	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	114.5	115.4	115.4	
Dry density, pcf	83.3	83.3	83.3	
Void ratio	1.0618	1.0618	1.0618	
Saturation, %	97.2	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 5.980 tsf
Consolidation back pressure = 5.595 tsf
Consolidation effective confining stress = 0.385 tsf
Fail. Stress = 0.546 tsf **at reading no.** 24
Ult. Stress = 0.546 tsf **at reading no.** 24

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	0.0224	16.690	0.0	0.0	0.000	0.385	0.385	1.00	5.595	0.385	0.000
1	0.0232	18.360	1.7	0.0	0.079	0.360	0.439	1.22	5.620	0.399	0.039
2	0.0272	19.490	2.8	0.2	0.131	0.295	0.426	1.45	5.685	0.361	0.066
3	0.0303	21.690	5.0	0.3	0.235	0.259	0.494	1.91	5.721	0.376	0.117
4	0.0473	22.700	6.0	0.9	0.280	0.195	0.475	2.44	5.785	0.335	0.140
5	0.0651	24.130	7.4	1.5	0.345	0.157	0.502	3.20	5.823	0.329	0.172
6	0.0833	25.020	8.3	2.2	0.383	0.131	0.514	3.93	5.849	0.323	0.192
7	0.1011	27.030	10.3	2.8	0.473	0.105	0.578	5.50	5.875	0.341	0.236
8	0.1190	28.440	11.8	3.4	0.534	0.090	0.624	6.93	5.890	0.357	0.267
9	0.1458	29.630	12.9	4.4	0.582	0.085	0.667	7.85	5.895	0.376	0.291
10	0.1647	30.000	13.3	5.1	0.594	0.121	0.715	5.91	5.859	0.418	0.297
11	0.1838	30.150	13.5	5.8	0.597	0.141	0.738	5.23	5.839	0.439	0.298
12	0.2024	30.170	13.5	6.4	0.593	0.152	0.745	4.90	5.828	0.449	0.297
13	0.2224	30.160	13.5	7.1	0.588	0.261	0.849	3.25	5.719	0.555	0.294
14	0.2413	30.150	13.5	7.8	0.584	0.167	0.751	4.50	5.813	0.459	0.292
15	0.2694	30.170	13.5	8.8	0.578	0.187	0.765	4.09	5.793	0.476	0.289
16	0.2885	30.120	13.4	9.5	0.572	0.192	0.764	3.98	5.788	0.478	0.286
17	0.3083	30.090	13.4	10.2	0.566	0.204	0.770	3.77	5.776	0.487	0.283
18	0.3271	30.160	13.5	10.9	0.565	0.215	0.780	3.63	5.765	0.497	0.282
19	0.3472	30.070	13.4	11.6	0.556	0.221	0.777	3.52	5.759	0.499	0.278
20	0.3670	30.180	13.5	12.3	0.557	0.239	0.796	3.33	5.741	0.517	0.278
21	0.3961	30.190	13.5	13.3	0.550	0.243	0.793	3.26	5.737	0.518	0.275
22	0.4250	30.120	13.4	14.4	0.541	0.256	0.797	3.11	5.724	0.526	0.270
23	0.4352	30.250	13.6	14.7	0.544	0.262	0.806	3.08	5.718	0.534	0.272
24	0.4441	30.360	13.7	15.0	0.546	0.259	0.805	3.11	5.721	0.532	0.273

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	103.210			147.560
Moisture content: Dry soil+tare, gms.	83.420			113.540
Moisture content: Tare, gms.	30.670			29.980
Moisture, %	37.5	39.6	39.6	40.7
Moist specimen weight, gms.	115.9			
Diameter, in.	1.36	1.36	1.36	
Area, in.^{2}	1.46	1.46	1.46	
Height, in.	2.67	2.67	2.67	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	113.1	114.8	114.8	
Dry density, pcf	82.2	82.2	82.2	
Void ratio	1.0878	1.0878	1.0878	
Saturation, %	94.8	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 6.466 tsf

Consolidation back pressure = 5.641 tsf

Consolidation effective confining stress = 0.825 tsf

Fail. Stress = 0.827 tsf **at reading no.** 20

Ult. Stress = 0.827 tsf **at reading no.** 20

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	0.0512	17.050	0.0	0.0	0.000	0.825	0.825	1.00	5.641	0.825	0.000
1	0.0541	17.780	0.7	0.1	0.036	0.812	0.848	1.04	5.654	0.830	0.018
2	0.0570	20.710	3.7	0.2	0.180	0.715	0.895	1.25	5.751	0.805	0.090
3	0.0671	25.380	8.3	0.6	0.407	0.578	0.985	1.70	5.888	0.782	0.204
4	0.0941	28.830	11.8	1.6	0.570	0.419	0.989	2.36	6.047	0.704	0.285
5	0.1120	30.630	13.6	2.3	0.653	0.364	1.017	2.79	6.102	0.690	0.326
6	0.1309	33.000	15.9	3.0	0.761	0.316	1.077	3.41	6.150	0.697	0.381
7	0.1500	34.940	17.9	3.7	0.848	0.271	1.119	4.13	6.195	0.695	0.424
8	0.1689	36.300	19.2	4.4	0.905	0.248	1.153	4.65	6.218	0.701	0.453
9	0.1866	37.000	19.9	5.1	0.932	0.233	1.165	5.00	6.233	0.699	0.466
10	0.2046	37.500	20.4	5.7	0.948	0.268	1.216	4.54	6.198	0.742	0.474
11	0.2236	37.000	19.9	6.5	0.918	0.308	1.226	3.98	6.158	0.767	0.459
12	0.2536	36.000	18.9	7.6	0.862	0.321	1.183	3.68	6.145	0.752	0.431
13	0.2734	35.400	18.3	8.3	0.828	0.333	1.161	3.49	6.133	0.747	0.414
14	0.3034	35.490	18.4	9.5	0.822	0.346	1.168	3.37	6.120	0.757	0.411
15	0.3331	35.470	18.4	10.6	0.811	0.365	1.176	3.22	6.101	0.770	0.405
16	0.3620	35.900	18.8	11.6	0.819	0.377	1.196	3.17	6.089	0.787	0.410
17	0.3921	35.950	18.9	12.8	0.811	0.387	1.198	3.10	6.079	0.793	0.406
18	0.4120	36.500	19.4	13.5	0.828	0.397	1.225	3.08	6.069	0.811	0.414
19	0.4328	36.520	19.5	14.3	0.821	0.413	1.234	2.99	6.053	0.823	0.410
20	0.4520	36.820	19.8	15.0	0.827	0.426	1.253	2.94	6.040	0.839	0.413

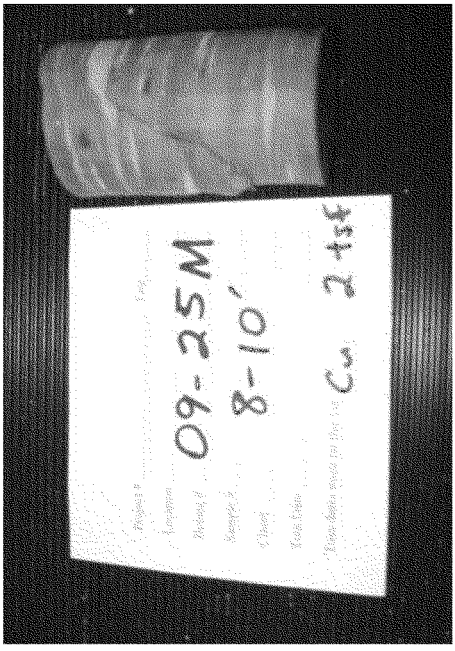
Parameters for Specimen No. 3

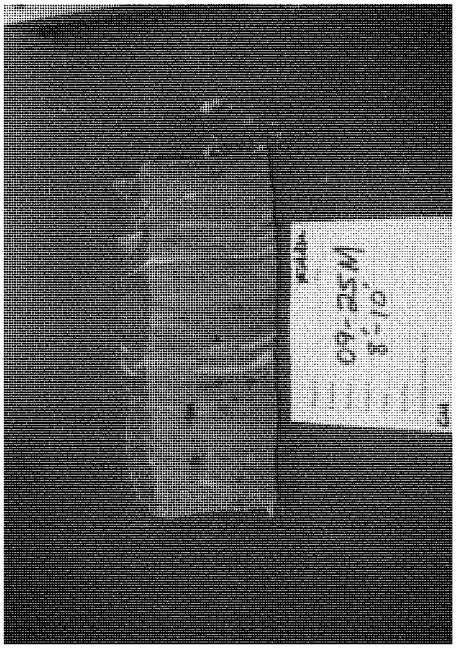
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	121.550			158.250
Moisture content: Dry soil+tare, gms.	96.280			124.380
Moisture content: Tare, gms.	31.260			30.290
Moisture, %	38.9	39.9	39.9	36.0
Moist specimen weight, gms.	129.1			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.54	1.54	1.54	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	113.7	114.5	114.5	
Dry density, pcf	81.9	81.9	81.9	
Void ratio	1.0966	1.0966	1.0966	
Saturation, %	97.5	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 6.886 tsf
Consolidation back pressure = 5.028 tsf
Consolidation effective confining stress = 1.858 tsf
Fail. Stress = 1.394 tsf **at reading no.** 23
Ult. Stress = 1.394 tsf **at reading no.** 23

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	0.1100	18.850	0.0	0.0	0.000	1.858	1.858	1.00	5.028	1.858	0.000
1	0.1108	19.770	0.9	0.0	0.043	1.856	1.899	1.02	5.030	1.877	0.021
2	0.1151	19.890	1.0	0.2	0.048	1.851	1.899	1.03	5.035	1.875	0.024
3	0.1187	20.780	1.9	0.3	0.090	1.842	1.932	1.05	5.044	1.887	0.045
4	0.1379	38.750	19.9	1.0	0.919	1.448	2.367	1.63	5.438	1.907	0.459
5	0.1566	43.730	24.9	1.7	1.141	1.258	2.399	1.91	5.628	1.829	0.571
6	0.1757	48.920	30.1	2.3	1.370	1.122	2.492	2.22	5.764	1.807	0.685
7	0.1956	52.880	34.0	3.1	1.539	0.995	2.534	2.55	5.891	1.764	0.769
8	0.2146	57.800	38.9	3.7	1.749	0.891	2.640	2.96	5.995	1.765	0.874
9	0.2344	62.470	43.6	4.4	1.944	0.819	2.763	3.37	6.067	1.791	0.972
10	0.2545	66.470	47.6	5.2	2.106	0.757	2.863	3.78	6.129	1.810	1.053
11	0.2733	70.520	51.7	5.8	2.269	0.734	3.003	4.09	6.152	1.869	1.135
12	0.2915	73.070	54.2	6.5	2.365	0.726	3.091	4.26	6.160	1.908	1.182
13	0.3102	74.040	55.2	7.1	2.390	0.765	3.155	4.12	6.121	1.960	1.195
14	0.3293	73.000	54.1	7.8	2.328	0.845	3.173	3.75	6.041	2.009	1.164
15	0.3482	66.680	47.8	8.5	2.041	0.988	3.029	3.07	5.898	2.009	1.021
16	0.3682	61.460	42.6	9.2	1.804	1.126	2.930	2.60	5.760	2.028	0.902
17	0.3881	59.050	40.2	9.9	1.689	1.221	2.910	2.38	5.665	2.065	0.844
18	0.4079	56.270	37.4	10.6	1.560	1.284	2.844	2.21	5.602	2.064	0.780
19	0.4272	55.390	36.5	11.3	1.511	1.335	2.846	2.13	5.551	2.091	0.756
20	0.4500	55.000	36.1	12.1	1.481	1.386	2.867	2.07	5.500	2.127	0.741
21	0.4800	54.500	35.6	13.2	1.443	1.437	2.880	2.00	5.449	2.159	0.722
22	0.5100	54.000	35.1	14.3	1.405	1.488	2.893	1.94	5.398	2.191	0.703
23	0.5300	54.000	35.1	15.0	1.394	1.539	2.933	1.91	5.347	2.236	0.697


09-25M
8-10'
Cu 2 tsf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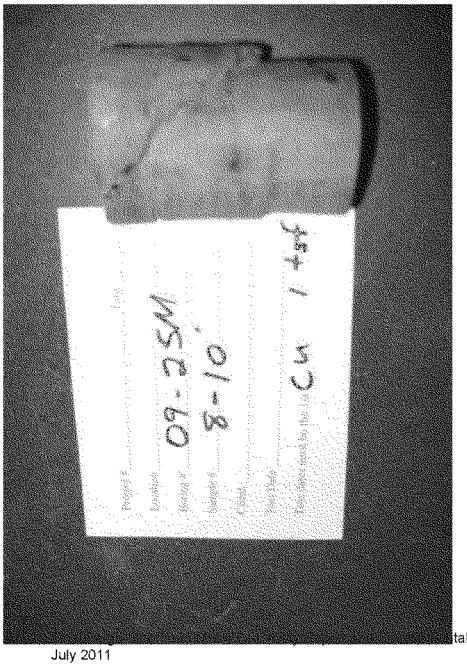
8-10'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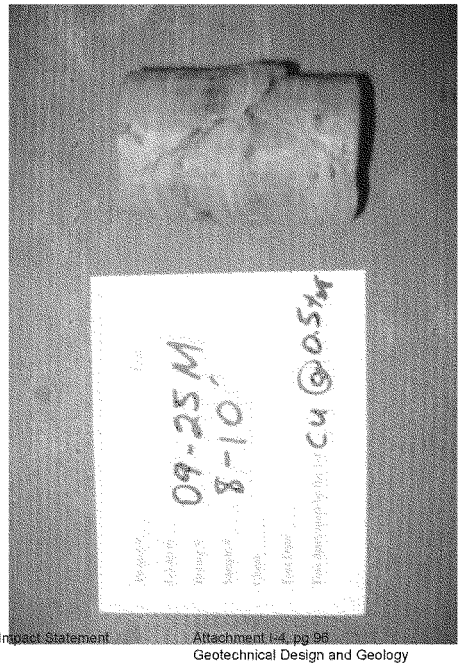
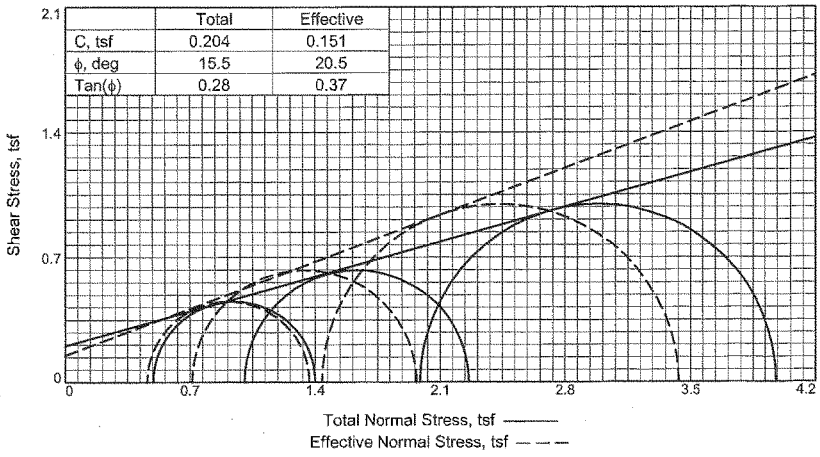
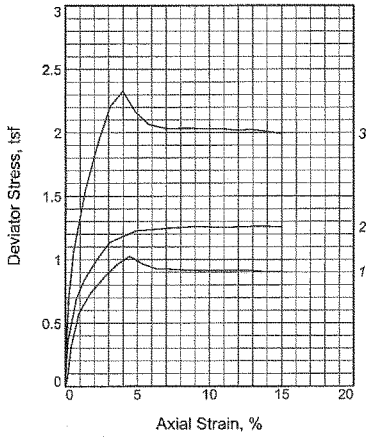
8-10'
Cu 1 tsf


09-25M
8-10'
Cu @ 0.5 tsf



	Total	Effective
C, tsf	0.204	0.151
ϕ, deg	15.5	20.5
Tan(ϕ)	0.28	0.37



Sample No.		1	2	3
Initial	Water Content, %	35.1	33.8	32.5
	Dry Density, pcf	85.1	88.0	89.6
	Saturation, %	95.2	98.1	97.9
	Void Ratio	1.0090	0.9433	0.9079
	Diameter, in.	1.42	1.40	1.40
	Height, in.	2.81	2.81	2.80
At Test	Water Content, %	36.9	33.3	31.3
	Dry Density, pcf	85.1	89.4	92.0
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.0090	0.9122	0.8571
	Diameter, in.	1.42	1.39	1.39
	Height, in.	2.81	2.79	2.78
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.50	1.01	1.99
Back Pressure, tsf		6.64	6.13	5.14
Cell Pressure, tsf		7.14	7.14	7.13
Peak Deviator Stress, tsf		1.03	1.26	2.33
Total Pore Pr., tsf		6.89	6.44	6.06
Ultimate Deviator Stress, tsf		0.91	1.26	1.99
Total Pore Pr., tsf		6.68	6.43	5.69
Maj. Eff. Stress at Ultimate, tsf		1.27	1.96	3.40
Min. Eff. Stress at Ultimate, tsf		0.25	0.70	1.08

Type of Test:
CU with Pore Pressures

Sample Type: Thinwall, 5", Middle of sample

Description: FAT CLAY with layers of silt, brown (CH)

LL= 67 **PL=** 17 **PI=** 50

Assumed Specific Gravity= 2.738

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.

Figure CU Tri-Axial ASTM D4767

Client: US Army Corps of Engineer

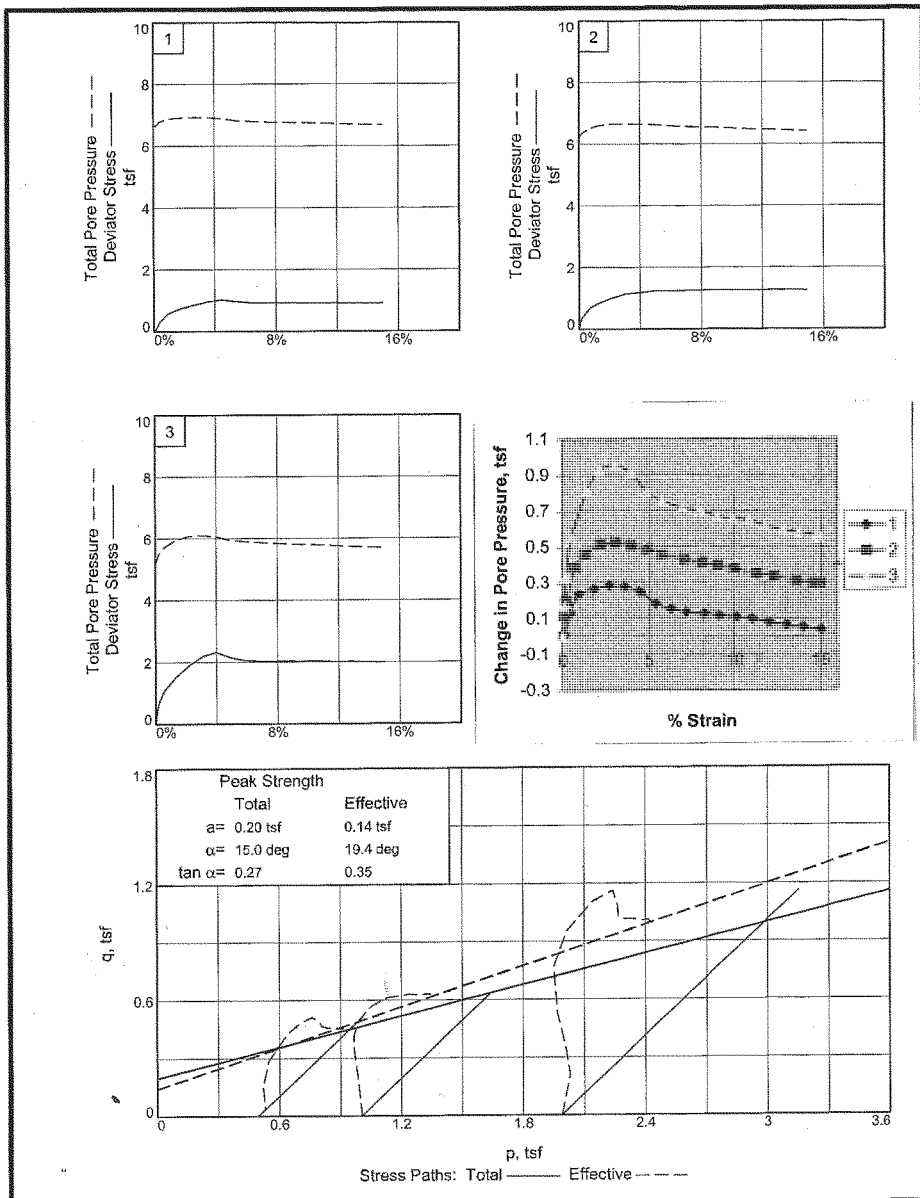
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115

Location: SE-F-15, Fargo, Sherack Formation

Sample Number: Boring 09-26MU, #1 **Depth:** 8-10'

Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC



Client: US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study

Location: SE-F-15, Fargo, Sherack Formation **Depth:** 8-10' **Sample Number:** Boring 09-26MU, #1

Project No.: BI-09-03127 **Figure**

Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

11/9/2009
12:55 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-15, Fargo, Sherack Formation
Depth: 8-10' **Sample Number:** Boring 09-26MU, #1
Description: FAT CLAY with layers of silt, 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=2.738 **LL=**67 **PL=**17 **PI=**50
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	122.140			164.220
Moisture content: Dry soil+tare, gms.	98.330			128.010
Moisture content: Tare, gms.	30.480			30.410
Moisture, %	35.1	36.9	36.9	37.1
Moist specimen weight, gms.	133.5			
Diameter, in.	1.42	1.42	1.42	
Area, in.²	1.58	1.58	1.58	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	114.9	116.4	116.4	
Dry density, pcf	85.1	85.1	85.1	
Void ratio	1.0090	1.0090	1.0090	
Saturation, %	95.2	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 6.645 tsf
Consolidation effective confining stress = 0.495 tsf
Peak Stress = 1.026 tsf **at reading no.** 7
Ult. Stress = 0.906 tsf **at reading no.** 18

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	-0.0009	17.330	0.0	0.0	0.000	0.495	0.495	1.00	6.645	0.495	0.000
1	0.0030	18.910	1.6	0.1	0.072	0.495	0.567	1.15	6.645	0.531	0.036
2	0.0098	24.100	6.8	0.4	0.308	0.366	0.674	1.84	6.774	0.520	0.154
3	0.0248	30.050	12.7	0.9	0.575	0.260	0.835	3.21	6.880	0.548	0.288
4	0.0492	33.930	16.6	1.8	0.744	0.230	0.974	4.24	6.910	0.602	0.372
5	0.0746	36.740	19.4	2.7	0.862	0.211	1.073	5.09	6.929	0.642	0.431
6	0.0994	39.150	21.8	3.6	0.961	0.218	1.179	5.41	6.922	0.698	0.480
7	0.1243	40.860	23.5	4.5	1.026	0.247	1.273	5.16	6.893	0.760	0.513
8	0.1494	39.700	22.4	5.4	0.967	0.316	1.283	4.06	6.824	0.799	0.483
9	0.1752	39.030	21.7	6.3	0.929	0.343	1.272	3.71	6.797	0.807	0.464
10	0.2019	39.170	21.8	7.2	0.925	0.361	1.286	3.56	6.779	0.824	0.463
11	0.2289	39.250	21.9	8.2	0.919	0.367	1.286	3.50	6.773	0.826	0.459
12	0.2558	39.330	22.0	9.1	0.913	0.384	1.297	3.38	6.756	0.840	0.456
13	0.2817	39.560	22.2	10.1	0.913	0.390	1.303	3.34	6.750	0.846	0.456
14	0.3086	39.850	22.5	11.0	0.915	0.401	1.316	3.28	6.739	0.858	0.457
15	0.3368	40.150	22.8	12.0	0.916	0.421	1.337	3.18	6.719	0.879	0.458
16	0.3635	40.310	23.0	13.0	0.913	0.435	1.348	3.10	6.705	0.891	0.456
17	0.3905	40.340	23.0	14.0	0.904	0.447	1.351	3.02	6.693	0.899	0.452
18	0.4190	40.670	23.3	15.0	0.906	0.461	1.367	2.97	6.679	0.914	0.453

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	102.110			163.700
Moisture content: Dry soil+tare, gms.	83.910			131.170
Moisture content: Tare, gms.	30.040			30.420
Moisture, %	33.8	34.5	33.3	32.3
Moist specimen weight, gms.	133.9			
Diameter, in.	1.40	1.40	1.39	
Area, in.^{2}	1.54	1.54	1.53	
Height, in.	2.81	2.81	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	117.7	118.3	119.2	
Dry density, pcf	88.0	88.0	89.4	
Void ratio	0.9433	0.9433	0.9122	
Saturation, %	98.1	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 6.135 tsf
Consolidation effective confining stress = 1.005 tsf
Peak Stress = 1.263 tsf **at reading no.** 16
Ult. Stress = 1.257 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	0.0070	18.730	0.0	0.0	0.000	1.005	1.005	1.00	6.135	1.005	0.000
1	0.0091	23.250	4.5	0.1	0.213	0.888	1.101	1.24	6.252	0.994	0.106
2	0.0118	26.420	7.7	0.2	0.362	0.806	1.168	1.45	6.334	0.987	0.181
3	0.0279	33.530	14.8	0.7	0.692	0.620	1.312	2.12	6.520	0.966	0.346
4	0.0428	36.680	17.9	1.3	0.835	0.548	1.383	2.52	6.592	0.966	0.418
5	0.0677	40.490	21.8	2.2	1.004	0.491	1.495	3.04	6.649	0.993	0.502
6	0.0927	43.570	24.8	3.1	1.135	0.483	1.618	3.35	6.657	1.051	0.568
7	0.1188	44.890	26.2	4.0	1.184	0.499	1.683	3.37	6.641	1.091	0.592
8	0.1446	46.110	27.4	4.9	1.227	0.519	1.746	3.36	6.621	1.133	0.614
9	0.1695	46.560	27.8	5.8	1.236	0.549	1.785	3.25	6.591	1.167	0.618
10	0.2053	47.210	28.5	7.1	1.247	0.575	1.822	3.17	6.565	1.199	0.624
11	0.2322	47.650	28.9	8.1	1.253	0.595	1.848	3.11	6.545	1.222	0.627
12	0.2591	48.120	29.4	9.0	1.260	0.610	1.870	3.07	6.530	1.240	0.630
13	0.2861	48.350	29.6	10.0	1.257	0.630	1.887	2.99	6.510	1.258	0.628
14	0.3228	48.730	30.0	11.3	1.254	0.656	1.910	2.91	6.484	1.283	0.627
15	0.3498	49.150	30.4	12.3	1.258	0.676	1.934	2.86	6.464	1.305	0.629
16	0.3878	49.740	31.0	13.6	1.263	0.698	1.961	2.81	6.442	1.329	0.631
17	0.4152	50.010	31.3	14.6	1.259	0.712	1.971	2.77	6.428	1.342	0.630
18	0.4246	50.080	31.3	15.0	1.257	0.713	1.970	2.76	6.427	1.341	0.628

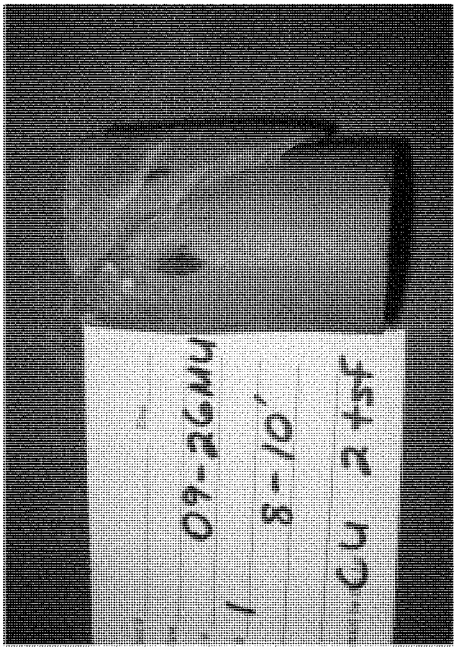
Parameters for Specimen No. 3

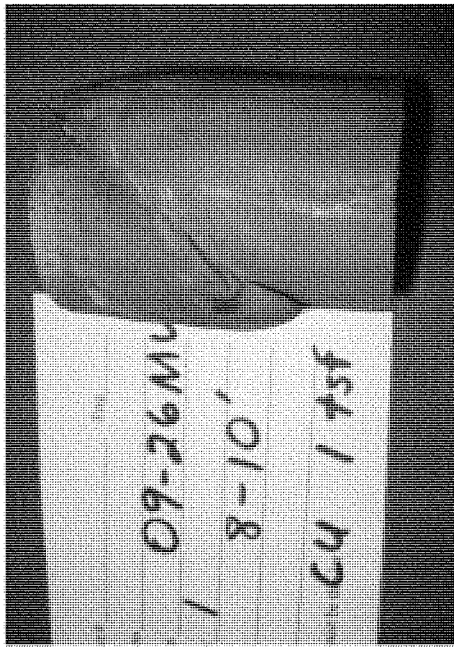
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	95.780			163.110
Moisture content: Dry soil+tare, gms.	79.790			132.190
Moisture content: Tare, gms.	30.520			30.370
Moisture, %	32.5	33.2	31.3	30.4
Moist specimen weight, gms.	134.5			
Diameter, in.	1.40	1.40	1.39	
Area, in.^{2}	1.54	1.54	1.51	
Height, in.	2.80	2.80	2.78	
Net decrease in height, in.		0.00	0.03	
Wet Density, pcf	118.7	119.3	120.9	
Dry density, pcf	89.6	89.6	92.0	
Void ratio	0.9079	0.9079	0.8571	
Saturation, %	97.9	100.0	100.0	

Test Readings for Specimen No. 3

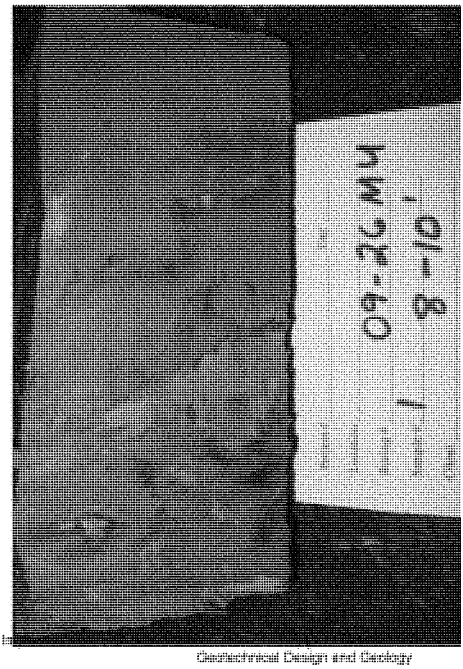
Consolidation cell pressure = 7.133 tsf
Consolidation back pressure = 5.144 tsf
Consolidation effective confining stress = 1.989 tsf
Peak Stress = 2.327 tsf **at reading no.** 7
Ult. Stress = 1.992 tsf **at reading no.** 19

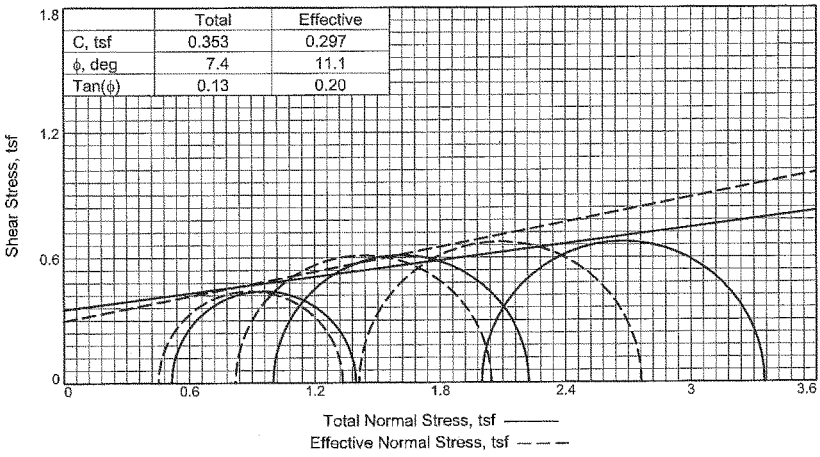
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0112	18.880	0.0	0.0	0.000	1.989	1.989	1.00	5.144	1.989	0.000
1	0.0139	27.670	8.8	0.1	0.418	1.820	2.238	1.23	5.313	2.029	0.209
2	0.0172	33.530	14.7	0.2	0.695	1.661	2.356	1.42	5.472	2.009	0.348
3	0.0261	41.260	22.4	0.5	1.059	1.438	2.497	1.74	5.695	1.967	0.529
4	0.0488	51.690	32.8	1.4	1.539	1.180	2.719	2.30	5.953	1.950	0.770
5	0.0728	59.900	41.0	2.2	1.907	1.060	2.967	2.80	6.073	2.014	0.954
6	0.0975	66.800	47.9	3.1	2.208	1.035	3.243	3.13	6.098	2.139	1.104
7	0.1216	69.850	51.0	4.0	2.327	1.076	3.403	3.16	6.057	2.240	1.164
8	0.1465	66.680	47.8	4.9	2.162	1.183	3.345	2.83	5.950	2.264	1.081
9	0.1714	64.940	46.1	5.8	2.064	1.234	3.298	2.67	5.899	2.266	1.032
10	0.2061	64.820	45.9	7.0	2.031	1.272	3.303	2.60	5.861	2.288	1.016
11	0.2331	65.350	46.5	8.0	2.033	1.289	3.322	2.58	5.844	2.306	1.017
12	0.2601	65.830	47.0	9.0	2.032	1.320	3.352	2.54	5.813	2.336	1.016
13	0.2857	66.230	47.4	9.9	2.029	1.332	3.361	2.52	5.801	2.347	1.015
14	0.3130	66.810	47.9	10.9	2.031	1.344	3.375	2.51	5.789	2.360	1.016
15	0.3399	67.000	48.1	11.8	2.017	1.374	3.391	2.47	5.759	2.383	1.009
16	0.3676	67.730	48.9	12.8	2.025	1.403	3.428	2.44	5.730	2.415	1.012
17	0.3947	67.950	49.1	13.8	2.011	1.413	3.424	2.42	5.720	2.419	1.006
18	0.4225	68.130	49.3	14.8	1.995	1.432	3.427	2.39	5.701	2.430	0.998
19	0.4280	68.170	49.3	15.0	1.992	1.440	3.432	2.38	5.693	2.436	0.996


09-26MW
1
8-10'
Cu 2 tsf

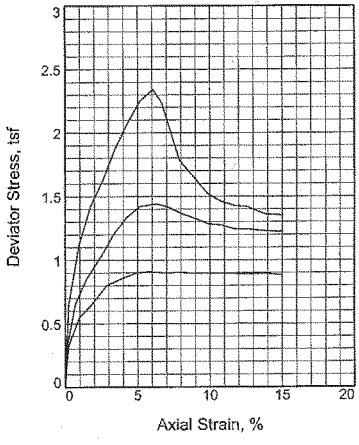

09-26MW
1
8-10'
Cu 1 tsf

09-26MW
1
8-10'
Cu 0.5 tsf


09-26MW
1
8-10'



	Total	Effective
C, tsf	0.353	0.297
ϕ, deg	7.4	11.1
Tan(ϕ)	0.13	0.20



Sample No.		1	2	3
Initial	Water Content, %	43.0	42.6	42.9
	Dry Density, pcf	77.7	78.2	78.3
	Saturation, %	97.7	98.0	98.8
	Void Ratio	1.2094	1.1958	1.1928
	Diameter, in.	1.43	1.38	1.40
	Height, in.	2.81	2.79	2.82
At Test	Water Content, %	44.0	42.8	41.5
	Dry Density, pcf	77.7	78.9	80.2
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.2094	1.1769	1.1418
	Diameter, in.	1.43	1.38	1.39
	Height, in.	2.81	2.78	2.80
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.51	1.00	2.00
Back Pressure, tsf		6.63	6.14	5.14
Cell Pressure, tsf		7.14	7.14	7.14
Peak Deviator Stress, tsf		0.91	1.44	2.34
Total Pore Pr., tsf		6.93	6.70	6.33
Ultimate Deviator Stress, tsf		0.88	1.22	1.35
Total Pore Pr., tsf		6.69	6.32	5.73
Maj. Eff. Stress at Ultimate, tsf		1.12	1.88	3.16
Min. Eff. Stress at Ultimate, tsf		0.21	0.44	0.81

Type of Test:
CU with Pore Pressures

Sample Type: Thinwall, 5", Middle of sample

Description: FAT CLAY with layers of silt, brown (CH)

Assumed Specific Gravity= 2.75

Remarks: Rate of strain is 0.001 in/min. Failure criteria is 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

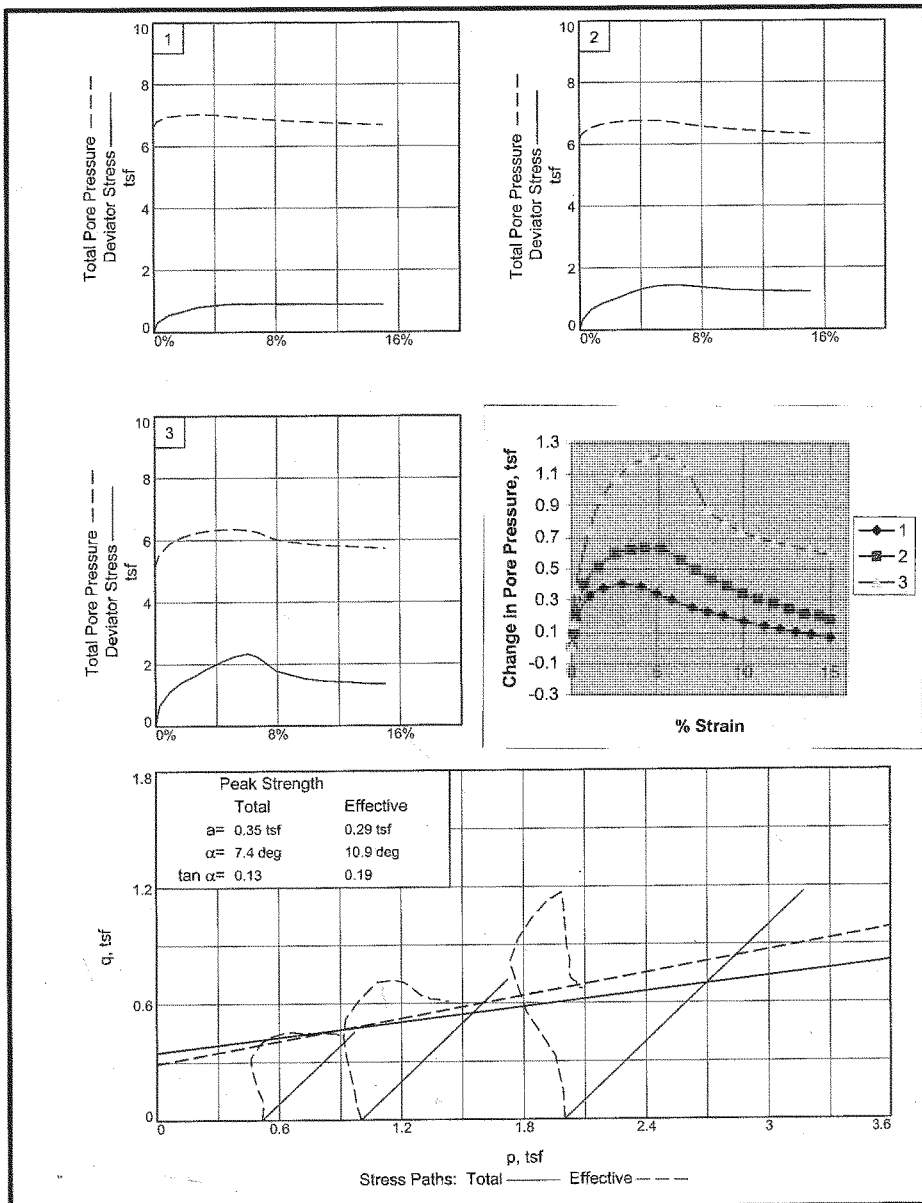
Location: SE-M-18, Moorhead, Sherack Formation

Sample Number: Boring 09-34MU, #1 **Depth:** 8-10'

Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Figure CU STRENGTH TEST DATA



Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
Loc.: SE-M-18, Moorhead, Sherack Formation **Depth:** 8-10' **Sample No.:** Boring 09-34MU, #1
Project No.: BL-09-00127 **Figure** **Braun Intertec**

Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

11/17/2009
9:24 AM

Date:
Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-M-18, Moorhead, Sherack Formation
Depth: 8-10' **Sample Number:** Boring 09-34MU, #1
Description: FAT CLAY with layers of silt, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is 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.	92.060			161.080
Moisture content: Dry soil+tare, gms.	73.840			120.640
Moisture content: Tare, gms.	31.450			30.600
Moisture, %	43.0	44.0	44.0	44.9
Moist specimen weight, gms.	130.5			
Diameter, in.	1.43	1.43	1.43	
Area, in.²	1.59	1.59	1.59	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	111.1	111.9	111.9	
Dry density, pcf	77.7	77.7	77.7	
Void ratio	1.2094	1.2094	1.2094	
Saturation, %	97.7	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 6.625 tsf
Consolidation effective confining stress = 0.515 tsf
Peak Stress = 0.909 tsf **at reading no.** 8
Ult. Stress = 0.881 tsf **at reading no.** 17

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	0.0130	19.310	0.0	0.0	0.000	0.515	0.515	1.00	6.625	0.515	0.000
1	0.0159	23.310	4.0	0.1	0.180	0.434	0.614	1.42	6.706	0.524	0.090
2	0.0195	26.540	7.2	0.2	0.326	0.330	0.656	1.99	6.810	0.493	0.163
3	0.0407	31.640	12.3	1.0	0.551	0.188	0.739	3.93	6.952	0.464	0.276
4	0.0635	33.900	14.6	1.8	0.647	0.138	0.785	5.69	7.002	0.461	0.323
5	0.0936	37.620	18.3	2.9	0.803	0.112	0.915	8.17	7.028	0.513	0.401
6	0.1255	39.150	19.8	4.0	0.860	0.127	0.987	7.77	7.013	0.557	0.430
7	0.1505	40.250	20.9	4.9	0.899	0.172	1.071	6.23	6.968	0.622	0.450
8	0.1753	40.680	21.4	5.8	0.909	0.211	1.120	5.31	6.929	0.665	0.454
9	0.2082	40.690	21.4	7.0	0.898	0.261	1.159	4.44	6.879	0.710	0.449
10	0.2338	41.040	21.7	7.9	0.904	0.289	1.193	4.13	6.851	0.741	0.452
11	0.2590	41.070	21.8	8.8	0.896	0.313	1.209	3.86	6.827	0.761	0.448
12	0.2938	41.320	22.0	10.0	0.894	0.349	1.243	3.56	6.791	0.796	0.447
13	0.3268	41.680	22.4	11.2	0.897	0.377	1.274	3.38	6.763	0.825	0.448
14	0.3529	41.790	22.5	12.1	0.892	0.395	1.287	3.26	6.745	0.841	0.446
15	0.3778	42.010	22.7	13.0	0.892	0.414	1.306	3.15	6.726	0.860	0.446
16	0.4043	42.310	23.0	13.9	0.894	0.431	1.325	3.07	6.709	0.878	0.447
17	0.4334	42.260	22.9	15.0	0.881	0.452	1.333	2.95	6.688	0.892	0.440

Parameters for Specimen No. 2				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	78.490			151.860
Moisture content: Dry soil+tare, gms.	64.300			115.540
Moisture content: Tare, gms.	30.990			30.210
Moisture, %	42.6	43.5	42.8	42.6
Moist specimen weight, gms.	122.6			
Diameter, in.	1.38	1.38	1.38	
Area, in.^{2}	1.50	1.50	1.49	
Height, in.	2.79	2.79	2.78	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	111.5	112.2	112.6	
Dry density, pcf	78.2	78.2	78.9	
Void ratio	1.1958	1.1958	1.1769	
Saturation, %	98.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.140 tsf

Consolidation back pressure = 6.139 tsf

Consolidation effective confining stress = 1.001 tsf

Peak Stress = 1.442 tsf **at reading no.** 9

Ult. Stress = 1.223 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	0.0088	19.620	0.0	0.0	0.000	1.001	1.001	1.00	6.139	1.001	0.000
1	0.0108	22.640	3.0	0.1	0.145	0.907	1.052	1.16	6.233	0.980	0.073
2	0.0130	26.330	6.7	0.2	0.323	0.805	1.128	1.40	6.335	0.966	0.161
3	0.0287	33.380	13.8	0.7	0.659	0.599	1.258	2.10	6.541	0.928	0.329
4	0.0497	37.620	18.0	1.5	0.855	0.487	1.342	2.76	6.653	0.914	0.427
5	0.0796	41.800	22.2	2.5	1.042	0.403	1.445	3.59	6.737	0.924	0.521
6	0.1024	45.560	25.9	3.4	1.208	0.379	1.587	4.19	6.761	0.983	0.604
7	0.1263	48.550	28.9	4.2	1.336	0.371	1.707	4.60	6.769	1.039	0.668
8	0.1521	50.690	31.1	5.2	1.421	0.372	1.793	4.82	6.768	1.082	0.710
9	0.1841	51.540	31.9	6.3	1.442	0.441	1.883	4.27	6.699	1.162	0.721
10	0.2079	51.240	31.6	7.2	1.415	0.508	1.923	3.79	6.632	1.216	0.708
11	0.2329	50.380	30.8	8.1	1.363	0.567	1.930	3.40	6.573	1.249	0.682
12	0.2579	49.860	30.2	9.0	1.327	0.606	1.933	3.19	6.534	1.270	0.664
13	0.2839	49.160	29.5	9.9	1.283	0.655	1.938	2.96	6.485	1.297	0.642
14	0.3088	49.260	29.6	10.8	1.275	0.693	1.968	2.84	6.447	1.330	0.637
15	0.3336	48.870	29.2	11.7	1.245	0.716	1.961	2.74	6.424	1.339	0.623
16	0.3587	49.130	29.5	12.6	1.244	0.751	1.995	2.66	6.389	1.373	0.622
17	0.3847	49.160	29.5	13.5	1.231	0.783	2.014	2.57	6.357	1.399	0.616
18	0.4095	49.320	29.7	14.4	1.225	0.794	2.019	2.54	6.346	1.407	0.613
19	0.4266	49.480	29.9	15.0	1.223	0.821	2.044	2.49	6.319	1.433	0.612

Parameters for Specimen No. 3

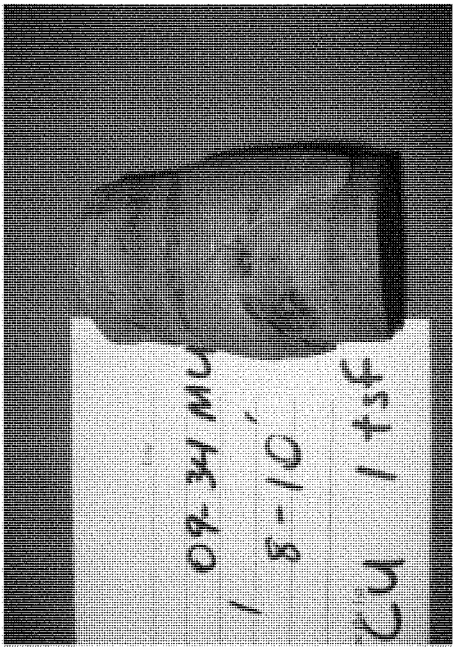
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	104.870			155.880
Moisture content: Dry soil+tare, gms.	82.730			119.670
Moisture content: Tare, gms.	31.080			30.140
Moisture, %	42.9	43.4	41.5	40.4
Moist specimen weight, gms.	128.1			
Diameter, in.	1.40	1.40	1.39	
Area, in.^{2}	1.55	1.55	1.52	
Height, in.	2.82	2.82	2.80	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	111.9	112.2	113.4	
Dry density, pcf	78.3	78.3	80.2	
Void ratio	1.1928	1.1928	1.1418	
Saturation, %	98.8	100.0	100.0	

Test Readings for Specimen No. 3

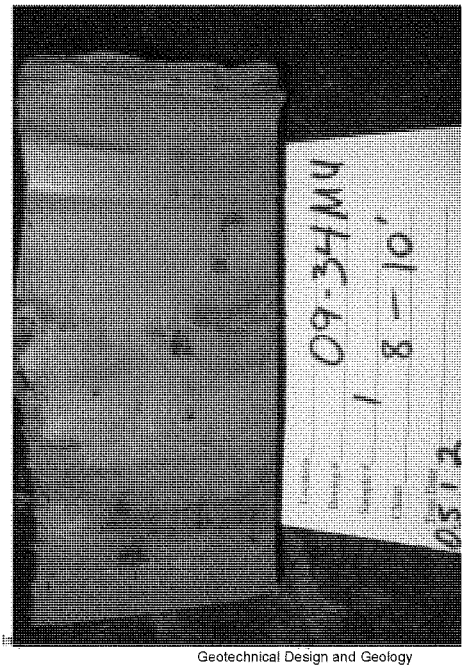
Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 5.141 tsf
Consolidation effective confining stress = 1.999 tsf
Peak Stress = 2.342 tsf **at reading no.** 9
Ult. Stress = 1.351 tsf **at reading no.** 18

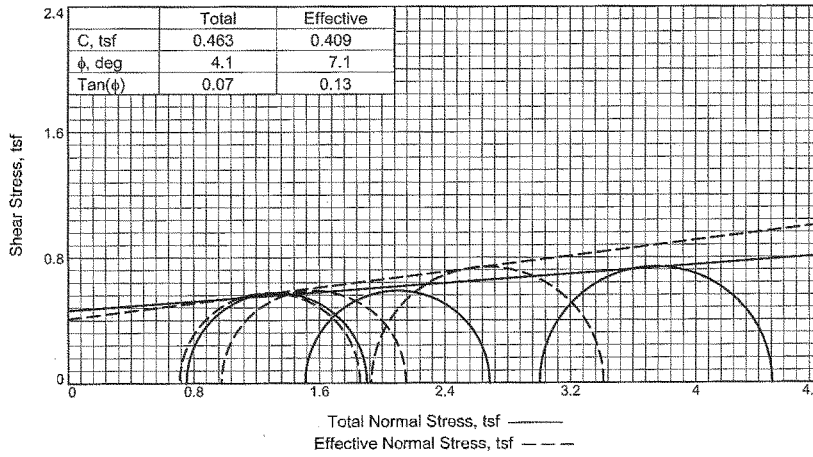
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0103	18.940	0.0	0.0	0.000	1.999	1.999	1.00	5.141	1.999	0.000
1	0.0130	25.110	6.2	0.1	0.292	1.846	2.138	1.16	5.294	1.992	0.146
2	0.0170	32.800	13.9	0.2	0.654	1.628	2.282	1.40	5.512	1.955	0.327
3	0.0369	42.780	23.8	1.0	1.117	1.251	2.368	1.89	5.889	1.810	0.559
4	0.0588	49.590	30.7	1.7	1.425	1.050	2.475	2.36	6.090	1.762	0.712
5	0.0826	54.170	35.2	2.6	1.624	0.920	2.544	2.76	6.220	1.732	0.812
6	0.1056	59.750	40.8	3.4	1.865	0.840	2.705	3.22	6.300	1.772	0.932
7	0.1304	64.700	45.8	4.3	2.072	0.803	2.875	3.58	6.337	1.839	1.036
8	0.1554	69.120	50.2	5.2	2.251	0.788	3.039	3.86	6.352	1.913	1.125
9	0.1802	71.650	52.7	6.1	2.342	0.815	3.157	3.87	6.325	1.986	1.171
10	0.1971	69.610	50.7	6.7	2.237	0.875	3.112	3.56	6.265	1.994	1.119
11	0.2319	59.810	40.9	7.9	1.781	1.120	2.901	2.59	6.020	2.010	0.890
12	0.2600	57.070	38.1	8.9	1.643	1.205	2.848	2.36	5.935	2.027	0.822
13	0.2857	54.650	35.7	9.8	1.523	1.260	2.783	2.21	5.880	2.022	0.762
14	0.3117	53.560	34.6	10.8	1.462	1.299	2.761	2.13	5.841	2.030	0.731
15	0.3365	53.160	34.2	11.7	1.430	1.328	2.758	2.08	5.812	2.043	0.715
16	0.3634	53.250	34.3	12.6	1.418	1.348	2.766	2.05	5.792	2.057	0.709
17	0.3976	52.300	33.4	13.8	1.360	1.382	2.742	1.98	5.758	2.062	0.680
18	0.4313	52.550	33.6	15.0	1.351	1.412	2.763	1.96	5.728	2.087	0.675

09-34 MW
1 8-10'
Cu 2 tsf

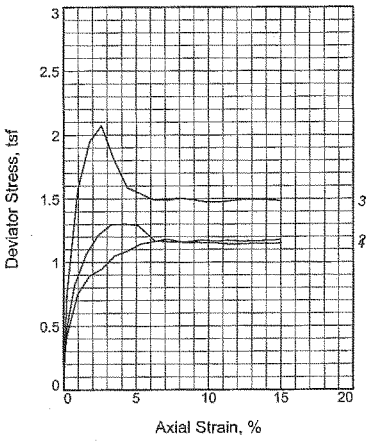

09-34 MW
1 8-10'
Cu 1 tsf

09-34 MW
1 8-10'
Cu 0.5 tsf


09-34MW
1 8-10'



	Total	Effective
C, tsf	0.463	0.409
ϕ, deg	4.1	7.1
Tan(ϕ)	0.07	0.13



Sample No.		1	2	3
Initial	Water Content, %	40.9	42.6	43.8
	Dry Density, pcf	80.2	78.2	75.8
	Saturation, %	98.5	98.2	95.3
	Void Ratio	1.1410	1.1940	1.2647
	Diameter, in.	1.42	1.42	1.42
	Height, in.	2.80	2.80	2.82
At Test	Water Content, %	40.5	42.3	43.0
	Dry Density, pcf	81.2	79.4	78.7
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.1136	1.1635	1.1812
	Diameter, in.	1.41	1.41	1.41
	Height, in.	2.79	2.79	2.79
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.75	1.51	3.01
Back Pressure, tsf		6.39	5.63	4.13
Cell Pressure, tsf		7.14	7.14	7.14
Peak Deviator Stress, tsf		1.18	1.30	2.07
Total Pore Pr., tsf		6.60	6.36	5.37
Ultimate Deviator Stress, tsf		1.15	1.18	1.48
Total Pore Pr., tsf		6.43	6.16	5.21
Maj. Eff. Stress at Ultimate, tsf		1.72	2.08	3.85
Min. Eff. Stress at Ultimate, tsf		0.54	0.78	1.77

Type of Test:
CU with Pore Pressures

Sample Type: Thinwall, 5", Middle of sample

Description: FAT CLAY with layers of silt, brown (CH)

LL= 55 **PL=** 21 **PI=** 34

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-M-11, Moorhead, ~~PL Sherack Formation~~ Sherack

Sample Number: Boring 09-53MU, #1 **Depth:** 18-20'

Proj. No.: BL-09-03127 **Date Sampled:**

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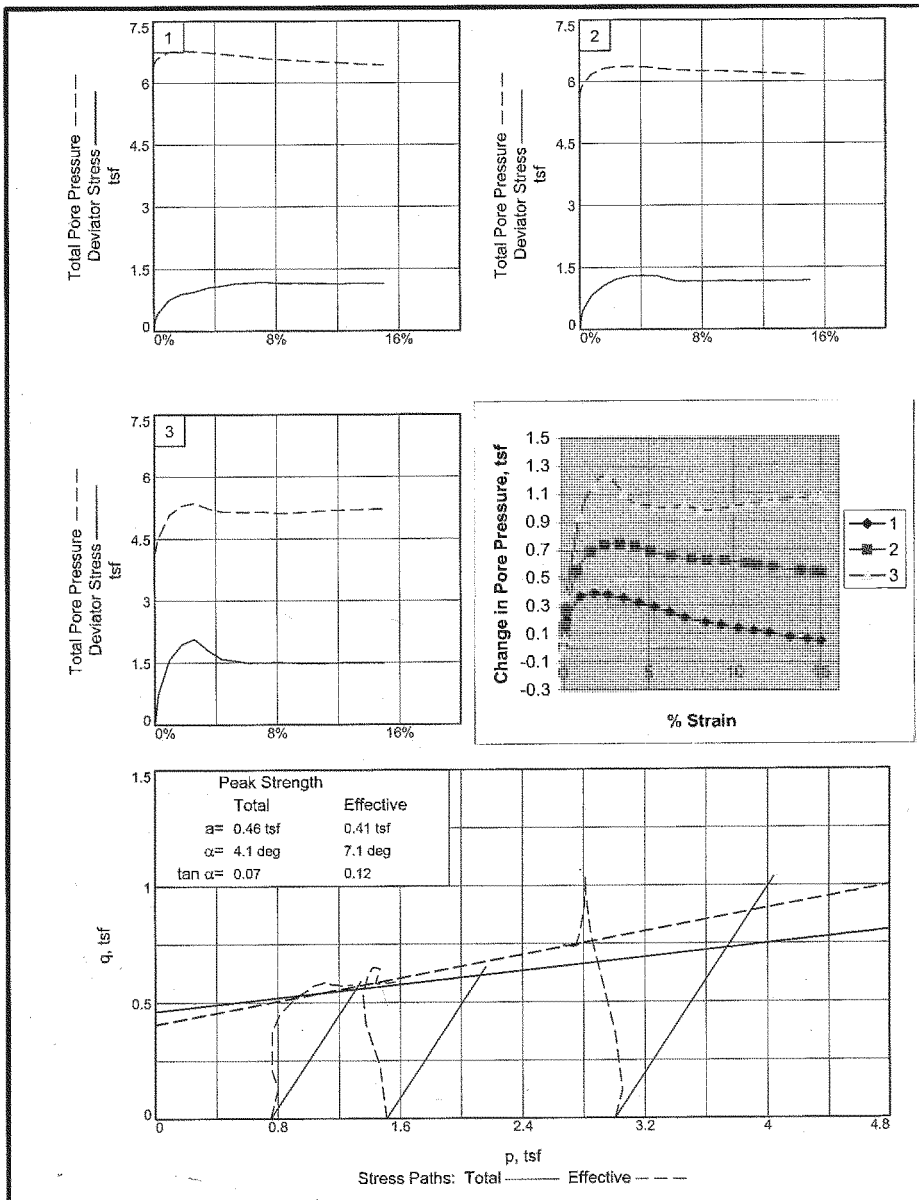
Figure CU Triax ASTM D-4767



Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
Loc.: SE-M-11, Moorhead, ~~PL Sherack Formation~~ **Depth:** 18-20'
Project No.: BL-09-01127

Sherack
Sample No.: Boring 09-53MU, #1

Figure

Braun Intertec
Geotechnical Design and Geology

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-M-11, Moorhead, ~~PL Sherack Formation~~
Depth: 18-20' **Sample Number:** Boring 09-53MU, #1
Description: FAT CLAY with layers of silt, brown (CH) Sherack
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=**55 **PL=**21 **PI=**34
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	104.970			160.870
Moisture content: Dry soil+tare, gms.	83.520			123.650
Moisture content: Tare, gms.	31.040			30.190
Moisture, %	40.9	41.5	40.5	39.8
Moist specimen weight, gms.	131.5			
Diameter, in.	1.42	1.42	1.41	
Area, in.^{2}	1.58	1.58	1.57	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	113.0	113.5	114.1	
Dry density, pcf	80.2	80.2	81.2	
Void ratio	1.1410	1.1410	1.1136	
Saturation, %	98.5	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 6.387 tsf
Consolidation effective confining stress = 0.753 tsf
Peak Stress = 1.182 tsf **at reading no.** 10
Ult. Stress = 1.150 tsf **at reading no.** 18

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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	0.0069	17.660	0.0	0.0	0.000	0.753	0.753	1.00	6.387	0.753	0.000
1	0.0088	23.340	5.7	0.1	0.260	0.671	0.931	1.39	6.469	0.801	0.130
2	0.0127	26.640	9.0	0.2	0.411	0.556	0.967	1.74	6.584	0.761	0.205
3	0.0343	34.200	16.5	1.0	0.751	0.387	1.138	2.94	6.753	0.763	0.376
4	0.0565	37.500	19.8	1.8	0.894	0.364	1.258	3.45	6.776	0.811	0.447
5	0.0802	38.910	21.2	2.6	0.949	0.374	1.323	3.54	6.766	0.848	0.474
6	0.1053	41.410	23.7	3.5	1.051	0.400	1.451	3.63	6.740	0.925	0.525
7	0.1301	42.520	24.9	4.4	1.090	0.434	1.524	3.51	6.706	0.979	0.545
8	0.1550	44.020	26.4	5.3	1.145	0.463	1.608	3.47	6.677	1.035	0.572
9	0.1801	44.680	27.0	6.2	1.162	0.500	1.662	3.32	6.640	1.081	0.581
10	0.2050	45.410	27.7	7.1	1.182	0.539	1.721	3.19	6.601	1.130	0.591
11	0.2396	45.100	27.4	8.3	1.153	0.573	1.726	3.01	6.567	1.150	0.577
12	0.2646	45.410	27.7	9.2	1.155	0.593	1.748	2.95	6.547	1.170	0.577
13	0.2907	45.660	28.0	10.2	1.153	0.616	1.769	2.87	6.524	1.193	0.577
14	0.3168	45.710	28.1	11.1	1.143	0.633	1.776	2.81	6.507	1.205	0.572
15	0.3426	46.000	28.3	12.0	1.143	0.647	1.790	2.77	6.493	1.219	0.572
16	0.3755	46.520	28.9	13.2	1.148	0.678	1.826	2.69	6.462	1.252	0.574
17	0.4024	46.860	29.2	14.2	1.149	0.694	1.843	2.66	6.446	1.269	0.575
18	0.4263	47.190	29.5	15.0	1.150	0.710	1.860	2.62	6.430	1.285	0.575

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	132.340			158.950
Moisture content: Dry soil+tare, gms.	101.710			121.110
Moisture content: Tare, gms.	29.880			31.300
Moisture, %	42.6	43.4	42.3	42.1
Moist specimen weight, gms.	129.5			
Diameter, in.	1.42	1.42	1.41	
Area, in.²	1.58	1.58	1.56	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	111.6	112.2	112.9	
Dry density, pcf	78.2	78.2	79.4	
Void ratio	1.1940	1.1940	1.1635	
Saturation, %	98.2	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 5.630 tsf
Consolidation effective confining stress = 1.510 tsf
Peak Stress = 1.302 tsf **at reading no.** 7
Ult. Stress = 1.176 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	0.0099	19.490	0.0	0.0	0.000	1.510	1.510	1.00	5.630	1.510	0.000
1	0.0120	24.830	5.3	0.1	0.246	1.363	1.609	1.18	5.777	1.486	0.123
2	0.0150	29.410	9.9	0.2	0.456	1.239	1.695	1.37	5.901	1.467	0.228
3	0.0310	37.500	18.0	0.8	0.823	0.962	1.785	1.86	6.178	1.373	0.411
4	0.0539	43.090	23.6	1.6	1.069	0.823	1.892	2.30	6.317	1.357	0.534
5	0.0766	46.600	27.1	2.4	1.218	0.778	1.996	2.57	6.362	1.387	0.609
6	0.1015	48.640	29.2	3.3	1.297	0.769	2.066	2.69	6.371	1.418	0.649
7	0.1264	49.010	29.5	4.2	1.302	0.783	2.085	2.66	6.357	1.434	0.651
8	0.1524	49.040	29.6	5.1	1.290	0.823	2.113	2.57	6.317	1.468	0.645
9	0.1861	46.520	27.0	6.3	1.165	0.856	2.021	2.36	6.284	1.439	0.583
10	0.2198	46.780	27.3	7.5	1.161	0.876	2.037	2.33	6.264	1.457	0.581
11	0.2451	47.000	27.5	8.4	1.159	0.884	2.043	2.31	6.256	1.464	0.580
12	0.2720	47.650	28.2	9.4	1.174	0.887	2.061	2.32	6.253	1.474	0.587
13	0.3069	47.850	28.4	10.7	1.166	0.911	2.077	2.28	6.229	1.494	0.583
14	0.3248	48.230	28.7	11.3	1.173	0.920	2.093	2.28	6.220	1.507	0.587
15	0.3506	48.350	28.9	12.2	1.166	0.935	2.101	2.25	6.205	1.518	0.583
16	0.3945	49.000	29.5	13.8	1.171	0.958	2.129	2.22	6.182	1.543	0.585
17	0.4205	49.470	30.0	14.7	1.176	0.972	2.148	2.21	6.168	1.560	0.588
18	0.4284	49.570	30.1	15.0	1.176	0.977	2.153	2.20	6.163	1.565	0.588

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	114.420			155.030
Moisture content: Dry soil+tare, gms.	88.830			119.200
Moisture content: Tare, gms.	30.470			30.510
Moisture, %	43.8	46.0	43.0	40.4
Moist specimen weight, gms.	128.4			
Diameter, in.	1.42	1.42	1.41	
Area, in.²	1.59	1.59	1.55	
Height, in.	2.82	2.82	2.79	
Net decrease in height, in.		0.00	0.04	
Wet Density, pcf	109.0	110.7	112.5	
Dry density, pcf	75.8	75.8	78.7	
Void ratio	1.2647	1.2647	1.1812	
Saturation, %	95.3	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.140 tsf

Consolidation back pressure = 4.135 tsf

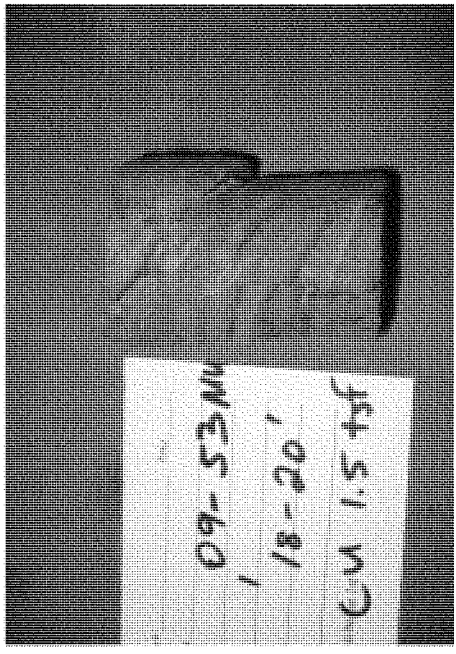
Consolidation effective confining stress = 3.005 tsf

Peak Stress = 2.073 tsf **at reading no.** 5

Ult. Stress = 1.481 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	0.0078	18.490	0.0	0.0	0.000	3.005	3.005	1.00	4.135	3.005	0.000
1	0.0097	23.740	5.3	0.1	0.244	2.930	3.174	1.08	4.210	3.052	0.122
2	0.0137	34.390	15.9	0.2	0.737	2.636	3.373	1.28	4.504	3.004	0.368
3	0.0347	52.640	34.2	1.0	1.570	2.063	3.633	1.76	5.077	2.848	0.785
4	0.0575	61.220	42.7	1.8	1.948	1.838	3.786	2.06	5.302	2.812	0.974
5	0.0804	64.330	45.8	2.6	2.073	1.775	3.848	2.17	5.365	2.811	1.036
6	0.1044	58.840	40.4	3.5	1.808	1.899	3.707	1.95	5.241	2.803	0.904
7	0.1290	54.230	35.7	4.3	1.587	1.981	3.568	1.80	5.159	2.775	0.794
8	0.1543	53.560	35.1	5.3	1.542	1.993	3.535	1.77	5.147	2.764	0.771
9	0.1800	52.760	34.3	6.2	1.493	2.004	3.497	1.74	5.136	2.750	0.746
10	0.2060	53.010	34.5	7.1	1.489	1.989	3.478	1.75	5.151	2.733	0.744
11	0.2309	53.760	35.3	8.0	1.506	2.024	3.530	1.74	5.116	2.777	0.753
12	0.2567	53.780	35.3	8.9	1.492	2.020	3.512	1.74	5.120	2.766	0.746
13	0.2825	53.730	35.2	9.9	1.475	1.999	3.474	1.74	5.141	2.736	0.737
14	0.3086	54.100	35.6	10.8	1.475	1.973	3.448	1.75	5.167	2.710	0.737
15	0.3356	54.780	36.3	11.8	1.487	1.959	3.446	1.76	5.181	2.702	0.743
16	0.3524	55.230	36.7	12.4	1.495	1.951	3.446	1.77	5.189	2.698	0.747
17	0.3875	55.710	37.2	13.6	1.492	1.938	3.430	1.77	5.202	2.684	0.746
18	0.4136	56.030	37.5	14.6	1.489	1.923	3.412	1.77	5.217	2.667	0.744
19	0.4250	56.000	37.5	15.0	1.481	1.931	3.412	1.77	5.209	2.671	0.740

09-53MW
1 18-20'
CH 2 tsf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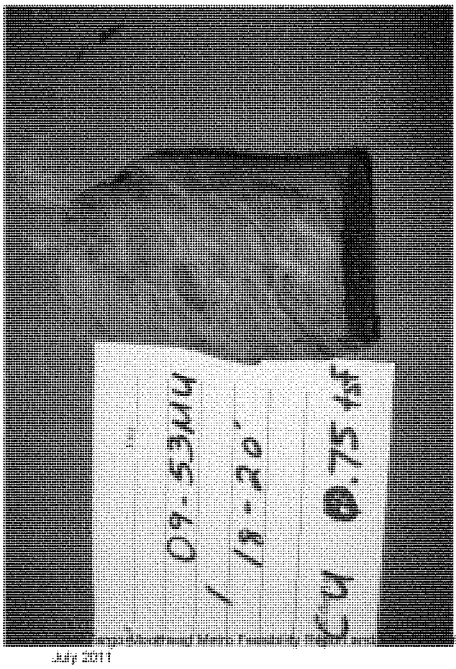
1 18-20'
CH 1.5 tsf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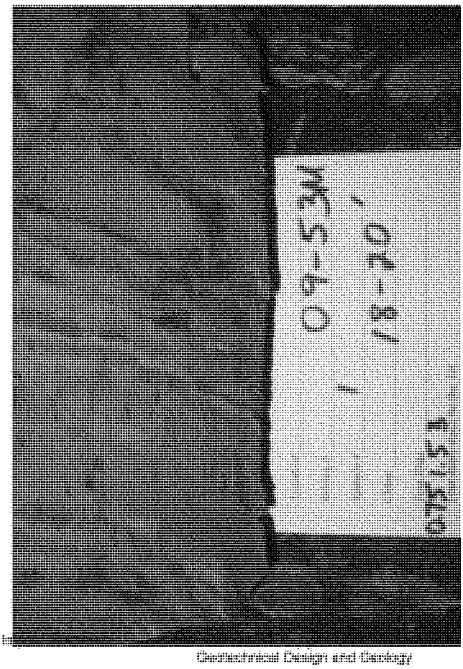
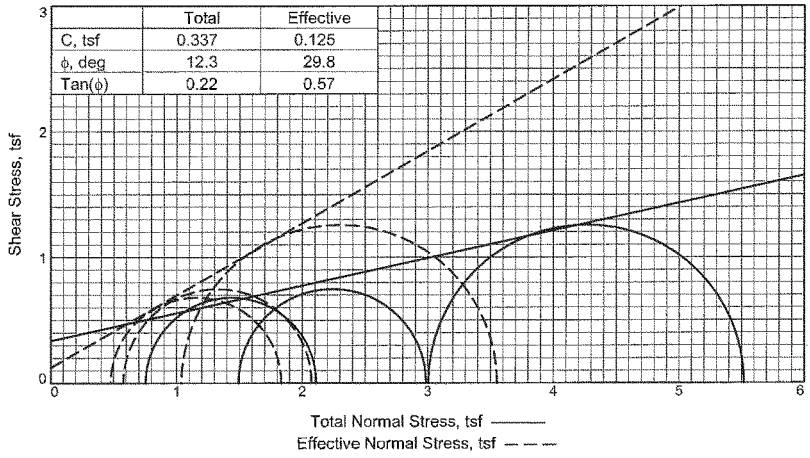
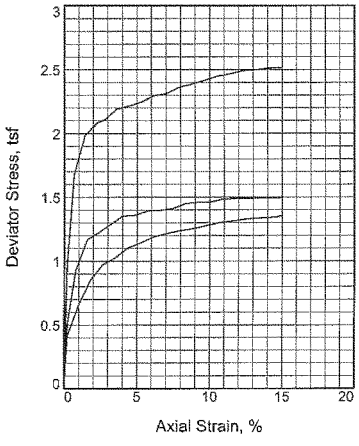
CH 0.75 tsf


09-53W
1 18-20'



	Total	Effective
C, tsf	0.337	0.125
ϕ, deg	12.3	29.8
Tan(ϕ)	0.22	0.57



Sample No.		1	2	3
Initial	Water Content, %	39.1	41.9	40.7
	Dry Density, pcf	82.7	79.2	81.0
	Saturation, %	99.9	98.7	100.0
	Void Ratio	1.0765	1.1677	1.1200
	Diameter, in.	1.41	1.41	1.42
	Height, in.	2.80	2.79	2.81
At Test	Water Content, %	38.3	40.4	37.9
	Dry Density, pcf	83.6	81.4	84.1
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.0543	1.1099	1.0414
	Diameter, in.	1.40	1.39	1.40
	Height, in.	2.79	2.77	2.77
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.75	1.49	3.01
Back Pressure, tsf		6.40	5.64	4.14
Cell Pressure, tsf		7.15	7.13	7.15
Peak Deviator Stress, tsf		1.36	1.50	2.52
	Total Pore Pr., tsf	6.67	6.56	6.11
Ultimate Deviator Stress, tsf		1.36	1.50	2.52
	Total Pore Pr., tsf	6.67	6.56	6.11
Maj. Eff. Stress at Ultimate, tsf		1.83	2.07	3.55
Min. Eff. Stress at Ultimate, tsf		0.48	0.58	1.03

Type of Test:
CU with Pore Pressures

Sample Type: Thinwall, 5", Middle of sample

Description: FAT CLAY with layers of silt, gray (CH)

LL= 50 **PL=** 22 **PI=** 28

Assumed Specific Gravity= 2.75

Remarks: Rate of strain is 0.001 in/min. Failure criteria is 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

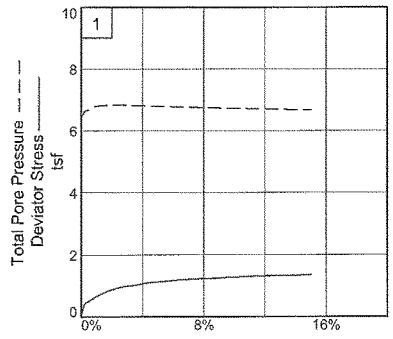
Location: SE-F-15, Fargo Poplar River

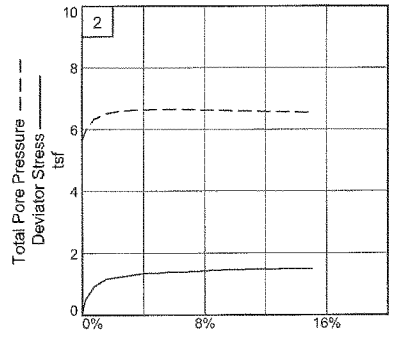
Sample Number: Boring 09-26MU, #2 **Depth:** 16-18'

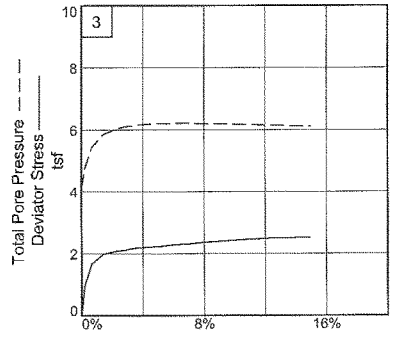
Proj. No.: BL-09-03127 **Date Sampled:**

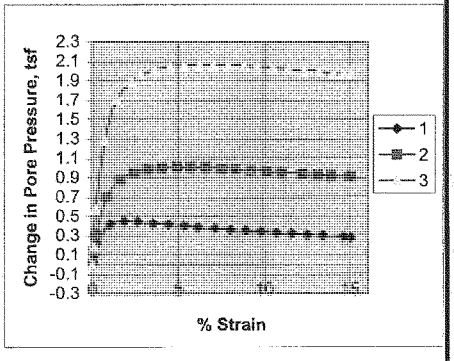
BRAUN INTERTEC

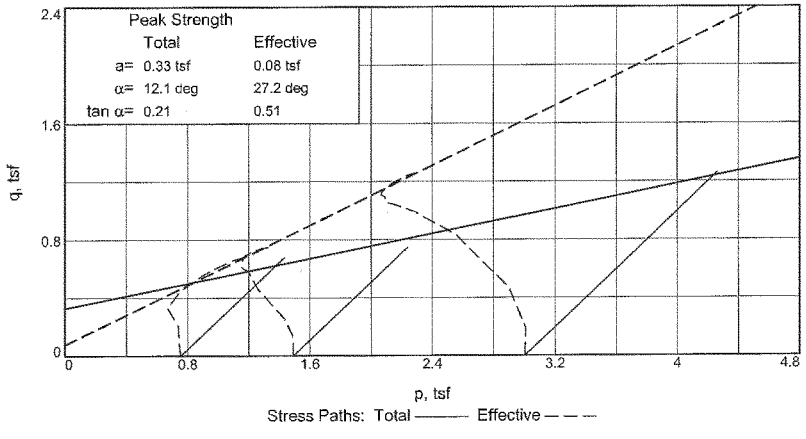
Figure CU Tests ASTM D 4767











Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
Location: SE-F-15, Fargo **Depth:** 16-18' **Sample Number:** Boring 09-26MU, #2
Project No.: MN-09-00127

Poplar River

Figure

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

11/17/2009
9:26 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-15, Fargo
Depth: 16-18' **Sample Number:** Boring 09-26MU, #2
Description: FAT CLAY with layers of silt, gray (CH) Poplar River
Remarks: Rate of strain is 0.001 in/min. Failure criteria is 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=**50 **PL=**22 **PI=**28
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	87.720			161.300
Moisture content: Dry soil+tare, gms.	71.500			125.590
Moisture content: Tare, gms.	30.030			31.360
Moisture, %	39.1	39.1	38.3	37.9
Moist specimen weight, gms.	131.4			
Diameter, in.	1.41	1.41	1.40	
Area, in.²	1.55	1.55	1.54	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	115.0	115.0	115.6	
Dry density, pcf	82.7	82.7	83.6	
Void ratio	1.0765	1.0765	1.0543	
Saturation, %	99.9	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.150 tsf
Consolidation back pressure = 6.396 tsf
Consolidation effective confining stress = 0.754 tsf
Peak Stress = 1.358 tsf **at reading no.** 19
Ult. Stress = 1.358 tsf **at reading no.** 19

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	0.0109	19.520	0.0	0.0	0.000	0.754	0.754	1.00	6.396	0.754	0.000
1	0.0128	23.520	4.0	0.1	0.186	0.651	0.837	1.29	6.499	0.744	0.093
2	0.0168	28.440	8.9	0.2	0.415	0.532	0.947	1.78	6.618	0.740	0.208
3	0.0389	33.870	14.3	1.0	0.663	0.338	1.001	2.96	6.812	0.669	0.331
4	0.0616	38.110	18.6	1.8	0.851	0.309	1.160	3.75	6.841	0.735	0.426
5	0.0847	40.920	21.4	2.6	0.972	0.312	1.284	4.11	6.838	0.798	0.486
6	0.1093	42.350	22.8	3.5	1.027	0.331	1.358	4.10	6.819	0.845	0.514
7	0.1332	44.280	24.8	4.4	1.104	0.340	1.444	4.25	6.810	0.892	0.552
8	0.1573	45.380	25.9	5.3	1.143	0.354	1.497	4.23	6.796	0.925	0.571
9	0.1822	46.660	27.1	6.1	1.188	0.370	1.558	4.21	6.780	0.964	0.594
10	0.2079	47.580	28.1	7.1	1.216	0.381	1.597	4.19	6.769	0.989	0.608
11	0.2331	48.360	28.8	8.0	1.238	0.395	1.633	4.13	6.755	1.014	0.619
12	0.2589	49.010	29.5	8.9	1.253	0.405	1.658	4.09	6.745	1.032	0.627
13	0.2838	49.920	30.4	9.8	1.279	0.416	1.695	4.07	6.734	1.056	0.640
14	0.3088	50.710	31.2	10.7	1.299	0.426	1.725	4.05	6.724	1.076	0.650
15	0.3335	51.380	31.9	11.6	1.314	0.435	1.749	4.02	6.715	1.092	0.657
16	0.3585	52.070	32.5	12.5	1.329	0.446	1.775	3.98	6.704	1.110	0.664
17	0.3834	52.580	33.1	13.4	1.336	0.453	1.789	3.95	6.697	1.121	0.668
18	0.4174	53.220	33.7	14.6	1.343	0.469	1.812	3.86	6.681	1.140	0.671
19	0.4302	53.800	34.3	15.0	1.358	0.476	1.834	3.85	6.674	1.155	0.679

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	106.050			155.790
Moisture content: Dry soil+tare, gms.	83.620			120.880
Moisture content: Tare, gms.	30.110			31.350
Moisture, %	41.9	42.5	40.4	39.0
Moist specimen weight, gms.	127.8			
Diameter, in.	1.41	1.41	1.39	
Area, in.^{2}	1.55	1.55	1.52	
Height, in.	2.79	2.79	2.77	
Net decrease in height, in.		0.00	0.03	
Wet Density, pcf	112.4	112.8	114.2	
Dry density, pcf	79.2	79.2	81.4	
Void ratio	1.1677	1.1677	1.1099	
Saturation, %	98.7	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.135 tsf
Consolidation back pressure = 5.644 tsf
Consolidation effective confining stress = 1.491 tsf
Peak Stress = 1.496 tsf **at reading no.** 19
Ult. Stress = 1.496 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	0.0130	19.590	0.0	0.0	0.000	1.491	1.491	1.00	5.644	1.491	0.000
1	0.0159	25.540	5.9	0.1	0.281	1.345	1.626	1.21	5.790	1.486	0.141
2	0.0190	30.360	10.8	0.2	0.508	1.182	1.690	1.43	5.953	1.436	0.254
3	0.0347	39.330	19.7	0.8	0.926	0.796	1.722	2.16	6.339	1.259	0.463
4	0.0566	44.670	25.1	1.6	1.167	0.615	1.782	2.90	6.520	1.199	0.584
5	0.0793	46.140	26.6	2.4	1.225	0.540	1.765	3.27	6.595	1.153	0.613
6	0.1024	47.800	28.2	3.2	1.291	0.507	1.798	3.55	6.628	1.152	0.645
7	0.1243	49.370	29.8	4.0	1.352	0.492	1.844	3.75	6.643	1.168	0.676
8	0.1483	49.830	30.2	4.9	1.360	0.483	1.843	3.82	6.652	1.163	0.680
9	0.1721	50.840	31.3	5.7	1.393	0.484	1.877	3.88	6.651	1.180	0.696
10	0.1960	51.230	31.6	6.6	1.397	0.487	1.884	3.87	6.648	1.186	0.699
11	0.2200	51.850	32.3	7.5	1.411	0.496	1.907	3.85	6.639	1.202	0.706
12	0.2440	53.020	33.4	8.3	1.449	0.504	1.953	3.87	6.631	1.228	0.724
13	0.2680	53.590	34.0	9.2	1.460	0.515	1.975	3.83	6.620	1.245	0.730
14	0.2918	53.950	34.4	10.1	1.461	0.527	1.988	3.77	6.608	1.258	0.731
15	0.3167	54.870	35.3	11.0	1.485	0.537	2.022	3.77	6.598	1.280	0.743
16	0.3497	55.450	35.9	12.2	1.489	0.552	2.041	3.70	6.583	1.297	0.745
17	0.3745	55.870	36.3	13.1	1.492	0.562	2.054	3.65	6.573	1.308	0.746
18	0.3987	56.320	36.7	13.9	1.495	0.569	2.064	3.63	6.566	1.316	0.747
19	0.4295	56.820	37.2	15.0	1.496	0.578	2.074	3.59	6.557	1.326	0.748

Parameters for Specimen No. 3

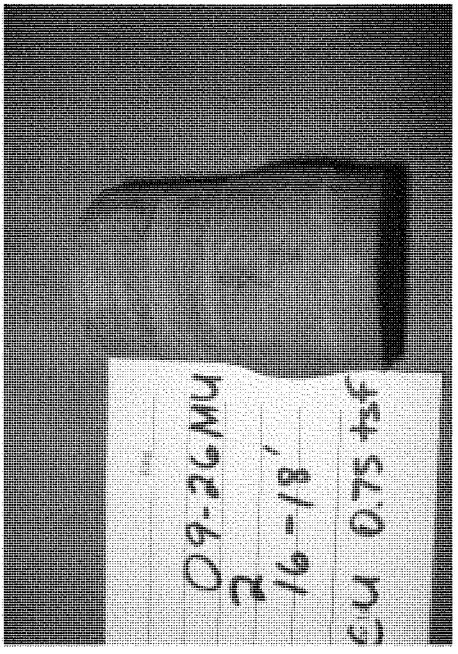
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	111.980			157.950
Moisture content: Dry soil+tare, gms.	88.360			125.380
Moisture content: Tare, gms.	30.340			30.360
Moisture, %	40.7	40.7	37.9	34.3
Moist specimen weight, gms.	132.4			
Diameter, in.	1.42	1.42	1.40	
Area, in.^{2}	1.58	1.58	1.54	
Height, in.	2.81	2.81	2.77	
Net decrease in height, in.		0.00	0.04	
Wet Density, pcf	113.9	114.0	115.9	
Dry density, pcf	81.0	81.0	84.1	
Void ratio	1.1200	1.1200	1.0414	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 3

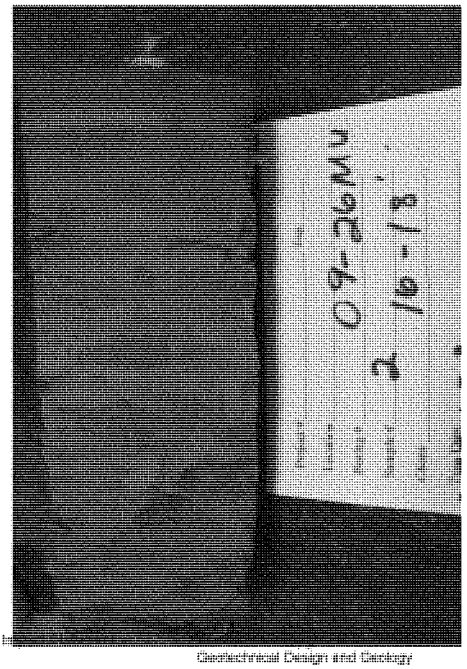
Consolidation cell pressure = 7.148 tsf
Consolidation back pressure = 4.144 tsf
Consolidation effective confining stress = 3.004 tsf
Peak Stress = 2.516 tsf **at reading no.** 20
Ult. Stress = 2.516 tsf **at reading no.** 21

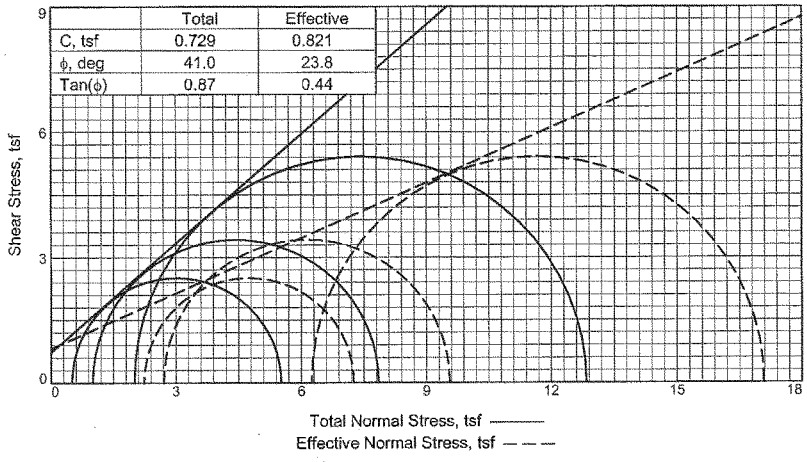
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0101	19.310	0.0	0.0	0.000	3.004	3.004	1.00	4.144	3.004	0.000
1	0.0121	27.400	8.1	0.1	0.379	2.819	3.198	1.13	4.329	3.008	0.189
2	0.0152	39.450	20.1	0.2	0.942	2.428	3.370	1.39	4.720	2.899	0.471
3	0.0285	55.290	36.0	0.7	1.675	1.714	3.389	1.98	5.434	2.551	0.837
4	0.0497	62.280	43.0	1.4	1.985	1.295	3.280	2.53	5.853	2.287	0.992
5	0.0728	64.760	45.5	2.3	2.081	1.117	3.198	2.86	6.031	2.158	1.041
6	0.0876	65.580	46.3	2.8	2.107	1.049	3.156	3.01	6.099	2.103	1.054
7	0.1107	67.850	48.5	3.6	2.192	0.992	3.184	3.21	6.156	2.088	1.096
8	0.1343	68.790	49.5	4.5	2.215	0.959	3.174	3.31	6.189	2.066	1.107
9	0.1577	69.950	50.6	5.3	2.247	0.946	3.193	3.37	6.202	2.069	1.123
10	0.1813	71.550	52.2	6.2	2.297	0.940	3.237	3.44	6.208	2.088	1.148
11	0.2053	72.420	53.1	7.0	2.313	0.941	3.254	3.46	6.207	2.098	1.157
12	0.2293	74.070	54.8	7.9	2.363	0.946	3.309	3.50	6.202	2.128	1.182
13	0.2534	75.180	55.9	8.8	2.388	0.952	3.340	3.51	6.196	2.146	1.194
14	0.2772	76.380	57.1	9.6	2.417	0.964	3.381	3.51	6.184	2.172	1.208
15	0.3019	77.720	58.4	10.5	2.449	0.976	3.425	3.51	6.172	2.200	1.224
16	0.3268	78.760	59.5	11.4	2.468	0.986	3.454	3.50	6.162	2.220	1.234
17	0.3506	79.950	60.6	12.3	2.493	1.001	3.494	3.49	6.147	2.247	1.246
18	0.3755	80.740	61.4	13.2	2.499	1.012	3.511	3.47	6.136	2.262	1.250
19	0.3994	81.700	62.4	14.0	2.513	1.032	3.545	3.44	6.116	2.289	1.257
20	0.4154	82.200	62.9	14.6	2.516	1.034	3.550	3.43	6.114	2.292	1.258
21	0.4250	82.450	63.1	15.0	2.516	1.037	3.553	3.43	6.111	2.295	1.258

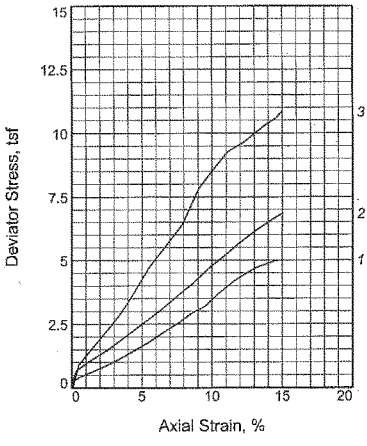
09-26MW
2 @ 16-18'
CU 1.5 tsf


09-26MW
2 @ 16-18'
CU 0.75 tsf

09-26MW
2 @ 16-18'
CU 3 tsf


09-26MW
2 @ 16-18'





Sample No.		1	2	3
Initial	Water Content, %	28.2	28.1	27.4
	Dry Density, pcf	94.6	96.7	96.2
	Saturation, %	95.1	99.7	96.1
	Void Ratio	0.8147	0.7749	0.7852
	Diameter, in.	1.48	1.46	1.48
	Height, in.	3.01	3.06	3.04
At Test	Water Content, %	29.6	28.2	28.6
	Dry Density, pcf	94.6	96.7	96.2
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.8147	0.7749	0.7852
	Diameter, in.	1.48	1.46	1.48
	Height, in.	3.01	3.06	3.04
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.5	1.0	2.0
Back Pressure, tsf		6.7	6.2	5.3
Cell Pressure, tsf		7.2	7.2	7.3
Peak Deviator Stress, tsf		5.0	6.8	10.8
Total Pore Pr., tsf		4.9	4.5	1.1
Ultimate Deviator Stress, tsf		5.0	6.8	10.8
Total Pore Pr., tsf		4.9	4.5	1.1
Maj. Eff. Stress at Ultimate, tsf		7.3	9.6	17.1
Min. Eff. Stress at Ultimate, tsf		2.2	2.7	6.2

Type of Test:
CU with Pore Pressures
Sample Type: Thinwall, 5", Middle of sample
Description: SILT, brown (ML)

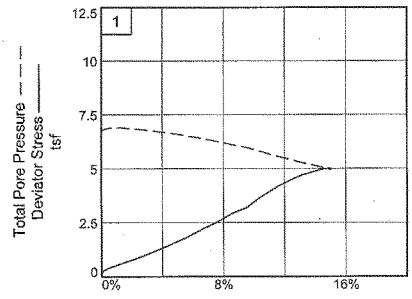
LL= 31 **PL=** 23 **PI=** 8
Assumed Specific Gravity= 2.75
Remarks: Rate of strain is 0.001 in/min. Failure criteria based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

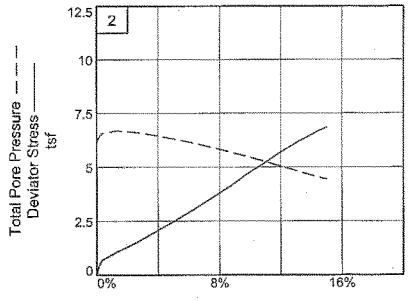
Client: US Army Corps of Engineers

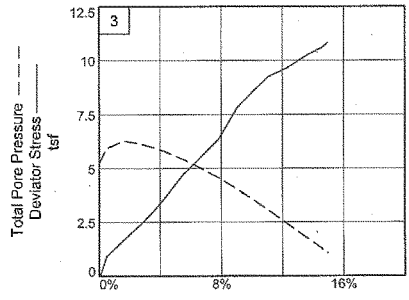
Project: Fargo-Moorhead Metro Feasibility Study
Fargo
Sample Number: Boring 09-23MU, #3 **Depth:** 20-22'
Poplar River - West Fargo
Proj. No.: BL-09-03127 **Date Sampled:**

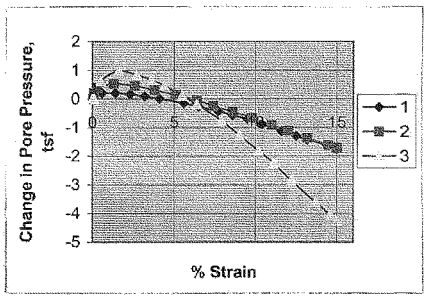
BRAUN INTERTEC

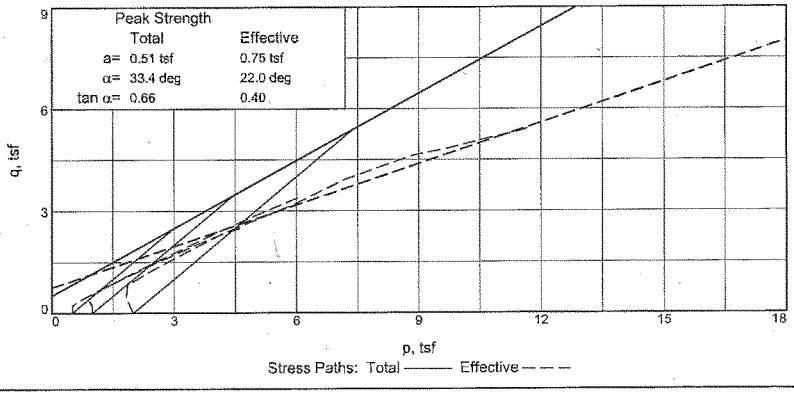
Figure CU Triax ASTM D4767











Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Fargo
Depth: 20-22' **Sample Number:** Boring 09-23MU, #3 Poplar River - West Fargo
Project No.: BL-09-03127 **Figure** _____ **Braun Intertec**

Tested By: jrs **Checked By:** rs

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

9/1/2009
4:37 PM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL-09-03127
Depth: 20-22'
Sample Number: Boring 09-23MU, #3
Description: SILT, brown (ML)
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=** **PL=** **PI=**
Test Method: COE uniform strain

Fargo
Poplar River - West Fargo

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	145.890			193.570
Moisture content: Dry soil+tare, gms.	120.540			156.720
Moisture content: Tare, gms.	30.550			30.480
Moisture, %	28.2	29.6	29.6	29.2
Moist specimen weight, gms.	164.5			
Diameter, in.	1.48	1.48	1.48	
Area, in.^{2}	1.72	1.72	1.72	
Height, in.	3.01	3.01	3.01	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	121.3	122.6	122.6	
Dry density, pcf	94.6	94.6	94.6	
Void ratio	0.8147	0.8147	0.8147	
Saturation, %	95.1	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.186 tsf
Consolidation back pressure = 6.686 tsf
Consolidation effective confining stress = 0.500 tsf
Fail. Stress = 5.017 tsf **at reading no.** 19
Ult. Stress = 5.017 tsf **at reading no.** 19

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	0.0176	19.100	0.0	0.0	0.000	0.500	0.500	1.00	6.686	0.500	0.000
1	0.0185	22.210	3.1	0.0	0.130	0.450	0.580	1.29	6.736	0.515	0.065
2	0.0218	25.750	6.6	0.1	0.278	0.366	0.644	1.76	6.820	0.505	0.139
3	0.0343	29.140	10.0	0.6	0.418	0.296	0.714	2.41	6.890	0.505	0.209
4	0.0593	34.020	14.9	1.4	0.617	0.296	0.913	3.08	6.890	0.604	0.308
5	0.0863	39.270	20.2	2.3	0.826	0.340	1.166	3.43	6.846	0.753	0.413
6	0.1129	45.530	26.4	3.2	1.073	0.408	1.481	3.63	6.778	0.944	0.536
7	0.1398	52.300	33.2	4.1	1.335	0.493	1.828	3.71	6.693	1.160	0.667
8	0.1676	59.930	40.8	5.0	1.626	0.580	2.206	3.80	6.606	1.393	0.813
9	0.1846	64.730	45.6	5.6	1.806	0.652	2.458	3.77	6.534	1.555	0.903
10	0.2126	73.880	54.8	6.5	2.147	0.768	2.915	3.80	6.418	1.841	1.073
11	0.2486	85.390	66.3	7.7	2.565	0.931	3.496	3.75	6.255	2.213	1.282
12	0.2763	95.740	76.6	8.6	2.936	1.073	4.009	3.74	6.113	2.541	1.468
13	0.3044	103.670	84.6	9.5	3.206	1.199	4.405	3.67	5.987	2.802	1.603
14	0.3306	116.730	97.6	10.4	3.666	1.389	5.055	3.64	5.797	3.222	1.833
15	0.3673	132.640	113.5	11.6	4.205	1.628	5.833	3.58	5.558	3.731	2.103
16	0.3943	142.220	123.1	12.5	4.514	1.797	6.311	3.51	5.389	4.054	2.257
17	0.4143	148.630	129.5	13.2	4.713	1.919	6.632	3.46	5.267	4.275	2.356
18	0.4511	157.480	138.4	14.4	4.964	2.117	7.081	3.34	5.069	4.599	2.482
19	0.4700	160.000	140.9	15.0	5.017	2.239	7.256	3.24	4.947	4.748	2.509

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	122.450			194.480
Moisture content: Dry soil+tare, gms.	102.480			158.190
Moisture content: Tare, gms.	31.370			30.280
Moisture, %	28.1	28.2	28.2	28.4
Moist specimen weight, gms.	165.8			
Diameter, in.	1.46	1.46	1.46	
Area, in.²	1.67	1.67	1.67	
Height, in.	3.06	3.06	3.06	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	123.9	124.0	124.0	
Dry density, pcf	96.7	96.7	96.7	
Void ratio	0.7749	0.7749	0.7749	
Saturation, %	99.7	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.163 tsf
Consolidation back pressure = 6.163 tsf
Consolidation effective confining stress = 1.000 tsf
Fail. Stress = 6.850 tsf **at reading no.** 15
Ult. Stress = 6.850 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	0.0155	18.330	0.0	0.0	0.000	1.000	1.000	1.00	6.163	1.000	0.000
1	0.0194	27.280	9.0	0.1	0.386	0.800	1.186	1.48	6.363	0.993	0.193
2	0.0252	33.900	15.6	0.3	0.670	0.607	1.277	2.10	6.556	0.942	0.335
3	0.0550	43.180	24.9	1.3	1.059	0.468	1.527	3.26	6.695	0.998	0.530
4	0.0941	53.830	35.5	2.6	1.494	0.549	2.043	3.72	6.614	1.296	0.747
5	0.1330	66.890	48.6	3.8	2.016	0.692	2.708	3.91	6.471	1.700	1.008
6	0.1719	80.050	61.7	5.1	2.529	0.862	3.391	3.93	6.301	2.126	1.264
7	0.2098	93.780	75.5	6.4	3.051	1.054	4.105	3.89	6.109	2.580	1.526
8	0.2426	107.030	88.7	7.4	3.546	1.240	4.786	3.86	5.923	3.013	1.773
9	0.2794	121.980	103.7	8.6	4.090	1.451	5.541	3.82	5.712	3.496	2.045
10	0.3144	138.430	120.1	9.8	4.679	1.665	6.344	3.81	5.498	4.005	2.340
11	0.3522	154.550	136.2	11.0	5.235	1.908	7.143	3.74	5.255	4.525	2.617
12	0.3813	167.830	149.5	12.0	5.684	2.103	7.787	3.70	5.060	4.945	2.842
13	0.4191	183.790	165.5	13.2	6.202	2.363	8.565	3.62	4.800	5.464	3.101
14	0.4580	199.080	180.8	14.5	6.676	2.613	9.289	3.55	4.550	5.951	3.338
15	0.4750	205.000	186.7	15.0	6.850	2.711	9.560	3.53	4.452	6.135	3.425

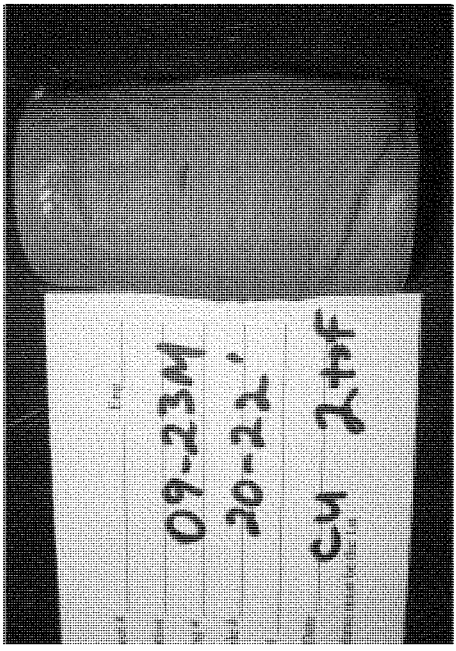
Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	103.050			197.050
Moisture content: Dry soil+tare, gms.	87.410			161.910
Moisture content: Tare, gms.	30.410			31.040
Moisture, %	27.4	28.6	28.6	26.9
Moist specimen weight, gms.	168.2			
Diameter, in.	1.48	1.48	1.48	
Area, in.^{2}	1.72	1.72	1.72	
Height, in.	3.04	3.04	3.04	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	122.6	123.6	123.6	
Dry density, pcf	96.2	96.2	96.2	
Void ratio	0.7852	0.7852	0.7852	
Saturation, %	96.1	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.309 tsf
Consolidation back pressure = 5.309 tsf
Consolidation effective confining stress = 2.000 tsf
Fail. Stress = 10.831 tsf **at reading no.** 16
Ult. Stress = 10.831 tsf **at reading no.** 16

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	0.0252	23.860	0.0	0.0	0.000	2.000	2.000	1.00	5.309	2.000	0.000
1	0.0274	24.190	0.3	0.1	0.014	1.990	2.004	1.01	5.319	1.997	0.007
2	0.0401	45.560	21.7	0.5	0.904	1.378	2.282	1.66	5.931	1.830	0.452
3	0.0740	64.210	40.3	1.6	1.662	1.025	2.687	2.62	6.284	1.856	0.831
4	0.1080	82.280	58.4	2.7	2.378	1.161	3.539	3.05	6.148	2.350	1.189
5	0.1338	98.180	74.3	3.6	2.999	1.340	4.339	3.24	5.969	2.840	1.500
6	0.1578	115.180	91.3	4.4	3.655	1.533	5.188	3.38	5.776	3.361	1.828
7	0.1926	143.070	119.2	5.5	4.714	1.879	6.593	3.51	5.430	4.236	2.357
8	0.2195	159.914	136.1	6.4	5.330	2.186	7.516	3.44	5.123	4.851	2.665
9	0.2644	189.610	165.8	7.9	6.391	2.752	9.143	3.32	4.557	5.948	3.196
10	0.3003	229.620	205.8	9.0	7.832	3.264	11.096	3.40	4.045	7.180	3.916
11	0.3353	254.270	230.4	10.2	8.660	3.817	12.477	3.27	3.492	8.147	4.330
12	0.3622	272.810	248.9	11.1	9.264	4.245	13.509	3.18	3.064	8.877	4.632
13	0.3971	286.190	262.3	12.2	9.636	4.850	14.486	2.99	2.459	9.668	4.818
14	0.4422	308.910	285.1	13.7	10.294	5.610	15.904	2.83	1.699	10.757	5.147
15	0.4680	320.048	296.2	14.6	10.591	6.033	16.624	2.76	1.276	11.328	5.295
16	0.4800	328.190	304.3	15.0	10.831	6.245	17.076	2.73	1.065	11.660	5.416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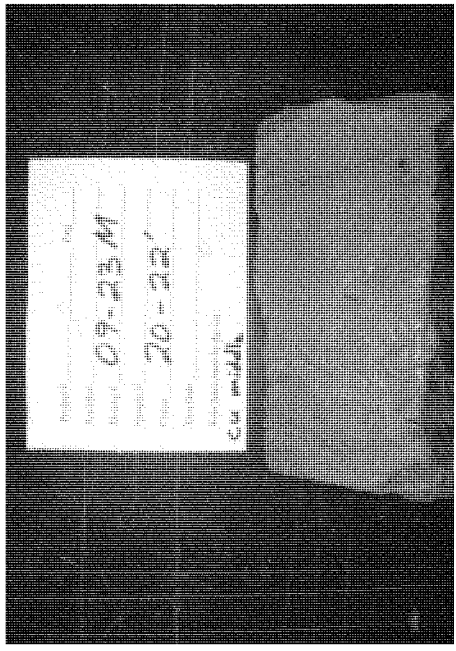
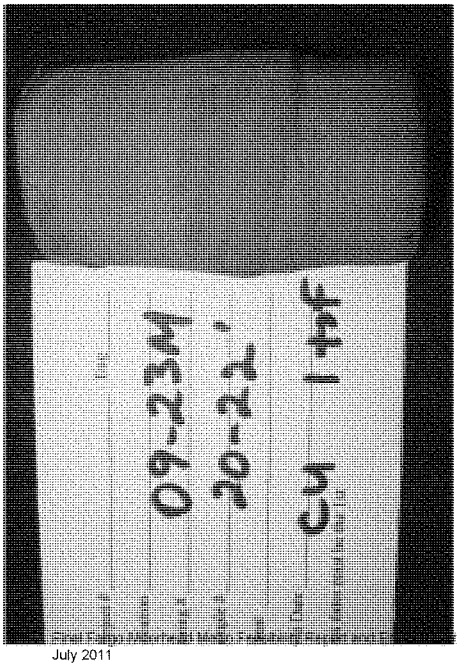
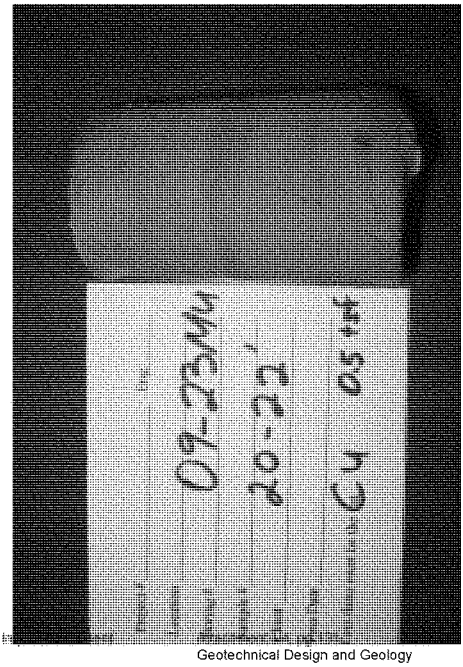
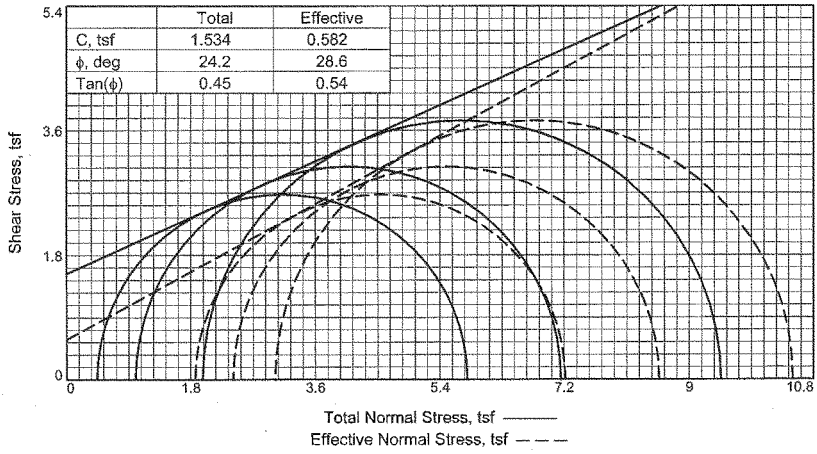
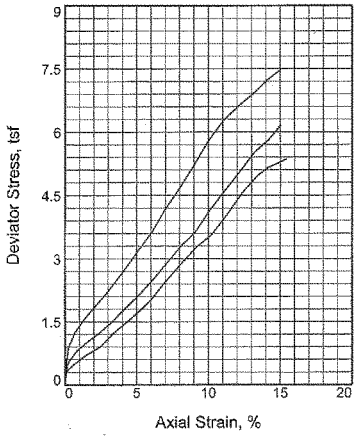
20-22'
Cu 2+tF


09-23M
20-22'


09-23M
20-22'
Cu 1+tF


09-23M
20-22'
Cu 05+tF





Sample No.		1	2	3
Initial	Water Content, %	28.5	27.7	29.1
	Dry Density, pcf	96.2	97.4	95.3
	Saturation, %	99.9	99.8	100.0
	Void Ratio	0.7841	0.7629	0.8006
	Diameter, in.	1.39	1.41	1.39
	Height, in.	2.81	2.81	2.80
At Test	Water Content, %	28.5	27.7	29.1
	Dry Density, pcf	96.2	97.4	95.3
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.7841	0.7629	0.8006
	Diameter, in.	1.39	1.41	1.39
	Height, in.	2.81	2.81	2.80
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.4	1.0	2.0
Back Pressure, tsf		6.7	6.1	5.2
Cell Pressure, tsf		7.1	7.1	7.1
Peak Deviator Stress, tsf		5.4	6.2	7.5
Total Pore Pr., tsf		5.3	4.7	4.1
Ultimate Deviator Stress, tsf		5.4	6.2	7.5
Total Pore Pr., tsf		5.3	4.7	4.1
Maj. Eff. Stress at Ultimate, tsf		7.2	8.6	10.5
Min. Eff. Stress at Ultimate, tsf		1.9	2.4	3.0

Type of Test:
CU with Pore Pressures

Sample Type: Thinwall, 5", Middle of sample

Description: SILT, layers of clay, gray-brown (ML)

LL= 30 **PL=** 24 **PI=** 6

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
Moorhead

Sample Number: Boring 09-25MU, #2 **Depth:** 21-23'
Poplar River - West Fargo

Proj. No.: BL-09-03127 **Date Sampled:**

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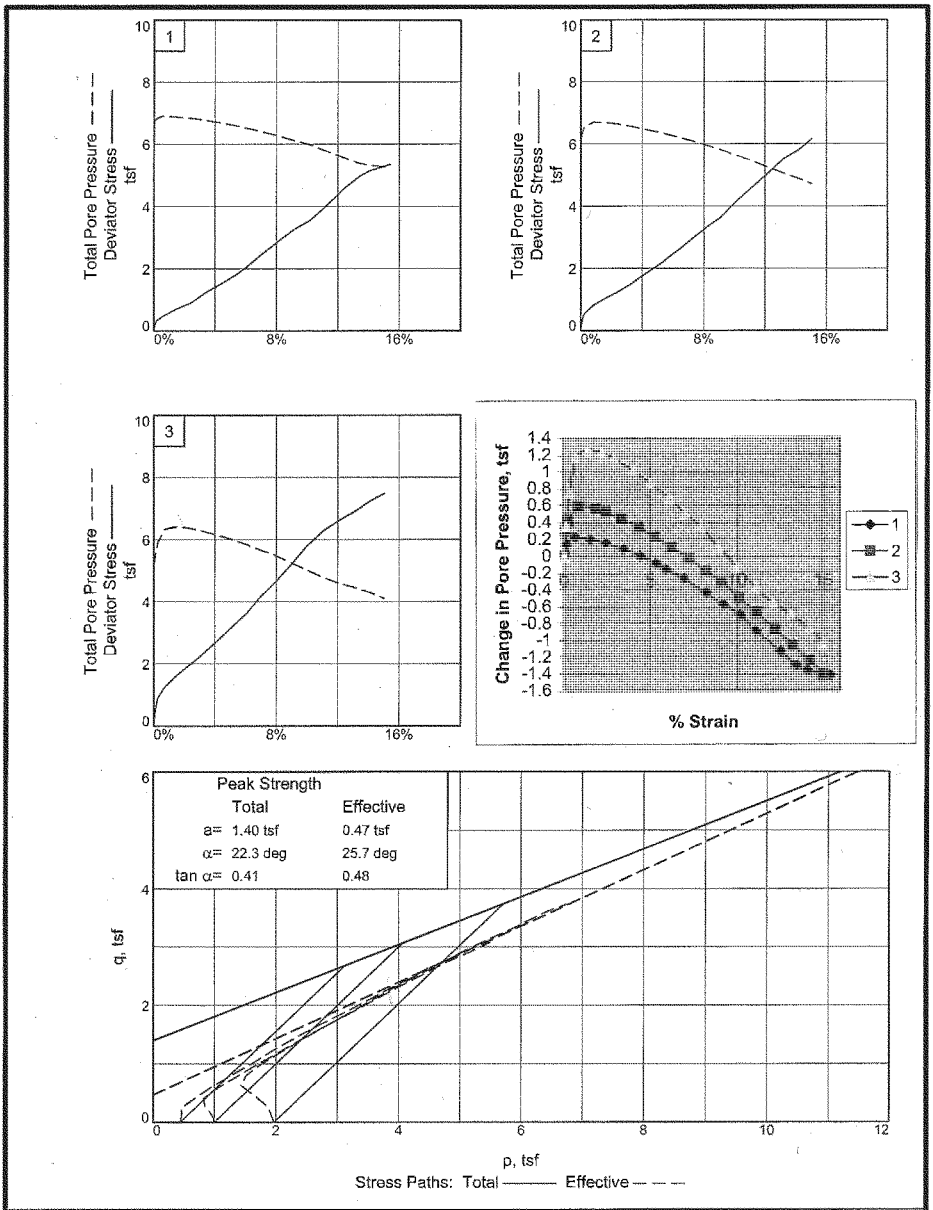
Figure C - Triax ASTM D4767


1
Total Pore Pressure — — —
Deviator Stress ———
tsf
0%
8%
16%
2
3
Change in Pore Pressure, tsf
% Strain
Peak Strength
Total
Effective
a= 1.40 tsf
0.47 tsf
α= 22.3 deg
25.7 deg
tan α= 0.41
0.48
q, tsf
p, tsf
Stress Paths: Total ——— Effective — — —
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Moorhead
Poplar River - West Fargo
Depth: 21-23'
Sample Number: Boring 09-25MU, #2
Project No.: DI-09-0212
Figure
Braun Intertec

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

9/14/2009
4:26 PM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL-09-03127
Depth: 21-23' **Sample Number:** Boring 09-25MU, #2
Description: SILT, layers of clay, gray-brown (ML)
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=30** **PL=24** **PI=6**
Test Method: COE uniform strain

Moorhead
Poplar River - West Fargo

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	107.480			166.550
Moisture content: Dry soil+tare, gms.	90.410			137.250
Moisture content: Tare, gms.	30.470			29.940
Moisture, %	28.5	28.5	28.5	27.3
Moist specimen weight, gms.	138.1			
Diameter, in.	1.39	1.39	1.39	
Area, in.²	1.52	1.52	1.52	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	123.6	123.7	123.7	
Dry density, pcf	96.2	96.2	96.2	
Void ratio	0.7841	0.7841	0.7841	
Saturation, %	99.9	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.130 tsf
Consolidation back pressure = 6.686 tsf
Consolidation effective confining stress = 0.444 tsf
Fail. Stress = 5.353 tsf **at reading no.** 18
Ult. Stress = 5.353 tsf **at reading no.** 18

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	0.0176	19.100	0.0	0.0	0.000	0.444	0.444	1.00	6.686	0.444	0.000
1	0.0185	22.180	3.1	0.0	0.146	0.388	0.534	1.38	6.742	0.461	0.073
2	0.0218	25.950	6.8	0.1	0.325	0.309	0.634	2.05	6.821	0.471	0.162
3	0.0343	29.240	10.1	0.6	0.479	0.220	0.699	3.18	6.910	0.459	0.239
4	0.0593	34.210	15.1	1.5	0.707	0.250	0.957	3.83	6.880	0.604	0.354
5	0.0863	38.520	19.4	2.4	0.900	0.291	1.191	4.09	6.839	0.741	0.450
6	0.1129	45.910	26.8	3.4	1.231	0.361	1.592	4.41	6.769	0.976	0.615
7	0.1398	52.150	33.0	4.4	1.502	0.443	1.945	4.39	6.687	1.194	0.751
8	0.1676	58.930	39.8	5.3	1.791	0.531	2.322	4.37	6.599	1.427	0.896
9	0.1846	63.950	44.9	5.9	2.004	0.601	2.605	4.34	6.529	1.603	1.002
10	0.2126	74.010	54.9	6.9	2.428	0.713	3.141	4.41	6.417	1.927	1.214
11	0.2486	86.120	67.0	8.2	2.923	0.880	3.803	4.32	6.250	2.341	1.461
12	0.2763	95.280	76.2	9.2	3.286	1.019	4.305	4.23	6.111	2.662	1.643
13	0.3044	102.570	83.5	10.2	3.561	1.144	4.705	4.11	5.986	2.925	1.781
14	0.3306	113.240	94.1	11.1	3.975	1.334	5.309	3.98	5.796	3.321	1.987
15	0.3673	129.640	110.5	12.5	4.598	1.573	6.171	3.92	5.557	3.872	2.299
16	0.3943	139.720	120.6	13.4	4.963	1.742	6.705	3.85	5.388	4.223	2.481
17	0.4143	145.390	126.3	14.1	5.153	1.802	6.955	3.86	5.328	4.379	2.577
18	0.4511	152.310	133.2	15.4	5.353	1.864	7.217	3.87	5.266	4.540	2.676

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	107.300			172.910
Moisture content: Dry soil+tare, gms.	90.650			141.820
Moisture content: Tare, gms.	30.500			30.510
Moisture, %	27.7	27.7	27.7	27.9
Moist specimen weight, gms.	142.6			
Diameter, in.	1.41	1.41	1.41	
Area, in.²	1.56	1.56	1.56	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	124.3	124.4	124.4	
Dry density, pcf	97.4	97.4	97.4	
Void ratio	0.7629	0.7629	0.7629	
Saturation, %	99.8	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.125 tsf
Consolidation back pressure = 6.124 tsf
Consolidation effective confining stress = 1.001 tsf
Fail. Stress = 6.154 tsf **at reading no.** 19
Ult. Stress = 6.154 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	0.0117	19.950	0.0	0.0	0.000	1.001	1.001	1.00	6.124	1.001	0.000
1	0.0128	22.850	2.9	0.0	0.134	0.924	1.058	1.15	6.201	0.991	0.067
2	0.0156	29.080	9.1	0.1	0.422	0.696	1.118	1.61	6.429	0.907	0.211
3	0.0187	31.700	11.8	0.2	0.542	0.580	1.122	1.93	6.545	0.851	0.271
4	0.0355	37.620	17.7	0.8	0.810	0.421	1.231	2.92	6.704	0.826	0.405
5	0.0614	43.670	23.7	1.8	1.077	0.443	1.520	3.43	6.682	0.982	0.539
6	0.0783	47.120	27.2	2.4	1.227	0.480	1.707	3.56	6.645	1.093	0.613
7	0.1044	53.590	33.6	3.3	1.504	0.567	2.071	3.65	6.558	1.319	0.752
8	0.1312	61.490	41.5	4.3	1.839	0.666	2.505	3.76	6.459	1.586	0.920
9	0.1588	69.400	49.5	5.2	2.167	0.772	2.939	3.81	6.353	1.855	1.083
10	0.1868	78.700	58.8	6.2	2.547	0.899	3.446	3.83	6.226	2.173	1.274
11	0.2138	88.380	68.4	7.2	2.936	1.029	3.965	3.85	6.096	2.497	1.468
12	0.2416	98.480	78.5	8.2	3.334	1.178	4.512	3.83	5.947	2.845	1.667
13	0.2666	106.300	86.3	9.1	3.630	1.307	4.937	3.78	5.818	3.122	1.815
14	0.2954	119.790	99.8	10.1	4.150	1.497	5.647	3.77	5.628	3.572	2.075
15	0.3245	132.270	112.3	11.1	4.615	1.672	6.287	3.76	5.453	3.979	2.307
16	0.3532	144.260	124.3	12.2	5.049	1.866	6.915	3.71	5.259	4.390	2.524
17	0.3813	157.140	137.2	13.2	5.508	2.061	7.569	3.67	5.064	4.815	2.754
18	0.4094	166.240	146.3	14.2	5.806	2.242	8.048	3.59	4.883	5.145	2.903
19	0.4333	176.560	156.6	15.0	6.154	2.411	8.565	3.55	4.714	5.488	3.077

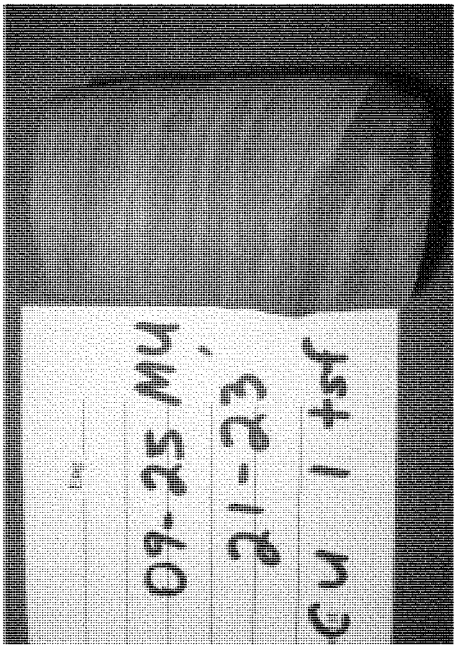
Parameters for Specimen No. 3

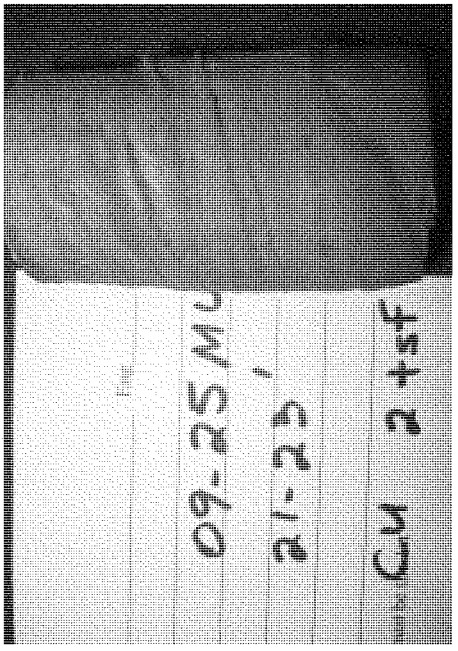
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	139.650			165.260
Moisture content: Dry soil+tare, gms.	115.250			136.420
Moisture content: Tare, gms.	31.470			30.630
Moisture, %	29.1	29.1	29.1	27.3
Moist specimen weight, gms.	136.7			
Diameter, in.	1.39	1.39	1.39	
Area, in.^{2}	1.51	1.51	1.51	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	123.1	123.1	123.1	
Dry density, pcf	95.3	95.3	95.3	
Void ratio	0.8006	0.8006	0.8006	
Saturation, %	100.0	100.0	100.0	

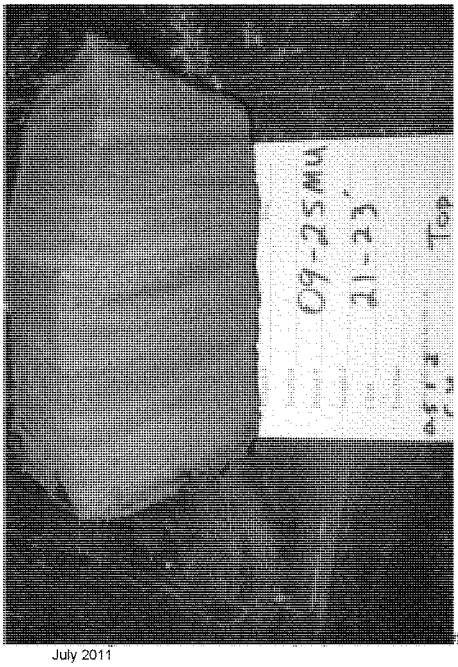
Test Readings for Specimen No. 3

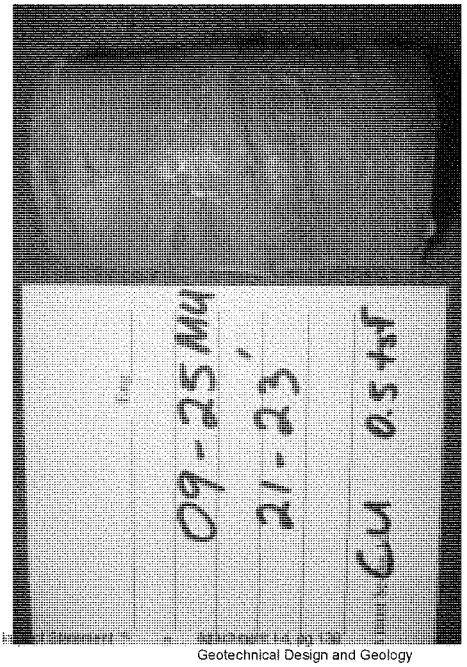
Consolidation cell pressure = 7.127 tsf
Consolidation back pressure = 5.156 tsf
Consolidation effective confining stress = 1.971 tsf
Fail. Stress = 7.483 tsf **at reading no.** 18
Ult. Stress = 7.483 tsf **at reading no.** 18

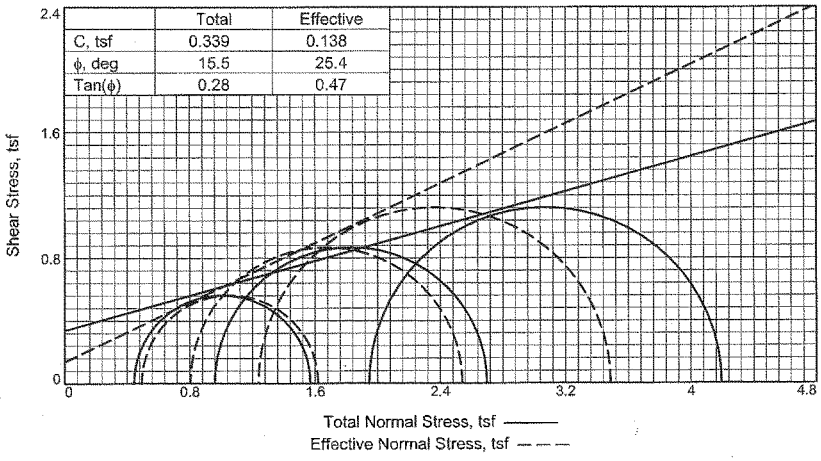
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0067	17.780	0.0	0.0	0.000	1.971	1.971	1.00	5.156	1.971	0.000
1	0.0097	28.830	11.0	0.1	0.526	1.615	2.141	1.33	5.512	1.878	0.263
2	0.0137	36.490	18.7	0.3	0.889	1.225	2.114	1.73	5.902	1.670	0.445
3	0.0265	44.310	26.5	0.7	1.255	0.807	2.062	2.56	6.320	1.435	0.628
4	0.0463	51.630	33.9	1.4	1.590	0.715	2.305	3.22	6.412	1.510	0.795
5	0.0672	58.410	40.6	2.2	1.894	0.745	2.639	3.54	6.382	1.692	0.947
6	0.0872	64.730	47.0	2.9	2.173	0.819	2.992	3.65	6.308	1.905	1.086
7	0.1181	75.870	58.1	4.0	2.658	0.962	3.620	3.76	6.165	2.291	1.329
8	0.1477	87.400	69.6	5.0	3.151	1.112	4.263	3.83	6.015	2.687	1.575
9	0.1778	99.490	81.7	6.1	3.656	1.293	4.949	3.83	5.834	3.121	1.828
10	0.2026	111.880	94.1	7.0	4.170	1.473	5.643	3.83	5.654	3.558	2.085
11	0.2275	122.780	105.0	7.9	4.609	1.626	6.235	3.83	5.501	3.930	2.304
12	0.2565	136.820	119.0	8.9	5.167	1.864	7.031	3.77	5.263	4.447	2.583
13	0.2863	152.630	134.8	10.0	5.784	2.104	7.888	3.75	5.023	4.996	2.892
14	0.3164	165.840	148.1	11.1	6.275	2.344	8.619	3.68	4.783	5.482	3.138
15	0.3454	175.700	157.9	12.1	6.615	2.528	9.143	3.62	4.599	5.836	3.308
16	0.3742	184.700	166.9	13.1	6.910	2.666	9.576	3.59	4.461	6.121	3.455
17	0.4030	194.990	177.2	14.2	7.249	2.829	10.078	3.56	4.298	6.454	3.625
18	0.4280	202.620	184.8	15.0	7.483	3.020	10.503	3.48	4.107	6.761	3.741

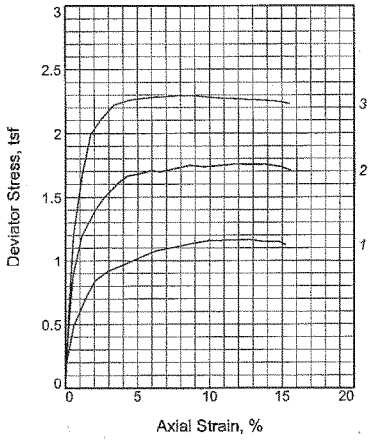

09-25 MW
21-23'
CU 1 tsf


09-25 MW
21-23'
CU 2 tsf


09-25MW
21-23'
Top


09-25 MW
21-23'
CU 0.5 tsf





Sample No.		1	2	3
Initial	Water Content, %	36.0	37.0	36.7
	Dry Density, pcf	83.1	83.2	82.0
	Saturation, %	92.9	95.7	92.3
	Void Ratio	1.0666	1.0631	1.0939
	Diameter, in.	1.37	1.39	1.40
	Height, in.	2.81	2.81	2.81
At Test	Water Content, %	38.8	38.7	39.8
	Dry Density, pcf	83.1	83.2	82.0
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.0666	1.0631	1.0939
	Diameter, in.	1.37	1.39	1.40
	Height, in.	2.81	2.81	2.81
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.44	0.96	1.95
Back Pressure, tsf		5.39	5.38	4.82
Cell Pressure, tsf		5.83	6.34	6.77
Peak Deviator Stress, tsf		1.17	1.76	2.30
Total Pore Pr., tsf		5.37	5.59	5.74
Ultimate Deviator Stress, tsf		1.13	1.74	2.25
Total Pore Pr., tsf		5.34	5.54	5.53
Maj. Eff. Stress at Ultimate, tsf		1.62	2.54	3.49
Min. Eff. Stress at Ultimate, tsf		0.49	0.80	1.24

Type of Test:
CU with Pore Pressures

Sample Type: Thinwall, 5", Middle of sample

Description: FAT CLAY with layers of Silt, gray (CH)

LL= 83 **PL=** 20 **PI=** 63

Assumed Specific Gravity= 2.75

Remarks: Rate of strain is 0.001 in/min. Failure crieria 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, #4 **Depth:** 28-30'

Poplar River - Harwood

Proj. No.: BL-09-03127 **Date Sampled:**

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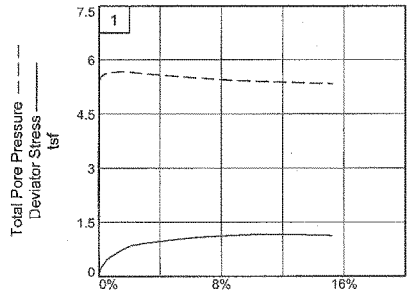
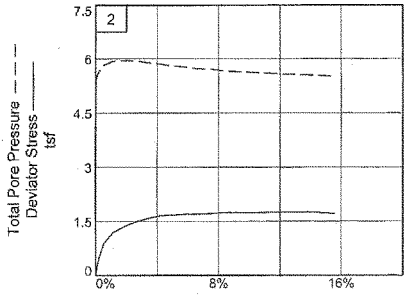
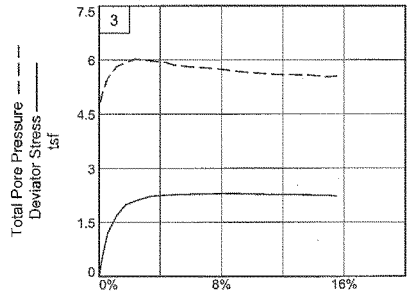
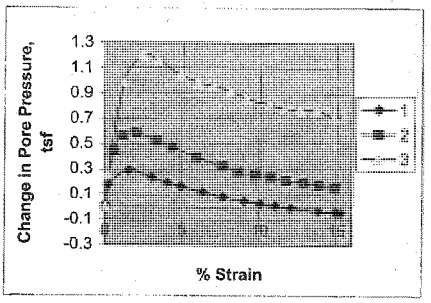
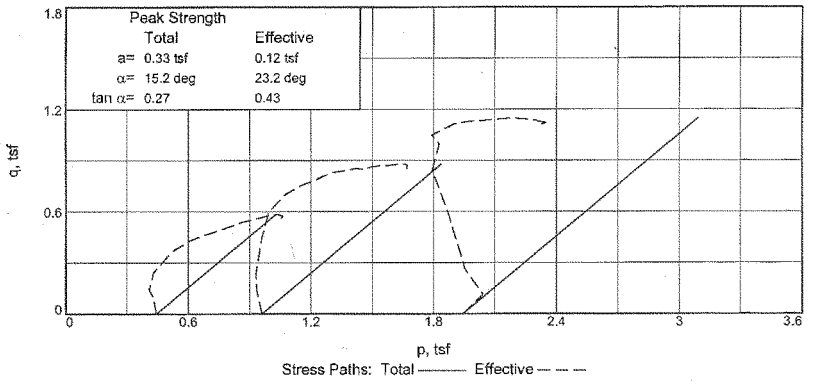
Figure CU, Praxis ASTM D4767











Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Fargo
Depth: 28-30' **Sample Number:** Boring 09-23MU, #4 Poplar River - Harwood
Project No.: BL-09-03127 **Figure** _____ **Braun Intertec**

Tested By: jrs **Checked By:** rs

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

8/31/2009
3:51 PM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL-09-03127 Fargo
Depth: 28-30' **Sample Number:** Boring 09-23MU, #4
Description: FAT CLAY with layers of Silt, gray (CH) Poplar River - Harwood
Remarks: Rate of strain is 0.001 in/min. Failure crieria 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=**83 **PL=**20 **PI=**63
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	85.750			382.010
Moisture content: Dry soil+tare, gms.	71.140			348.720
Moisture content: Tare, gms.	30.570			262.280
Moisture, %	36.0	38.8	38.8	38.5
Moist specimen weight, gms.	122.5			
Diameter, in.	1.37	1.37	1.37	
Area, in.^{2}	1.47	1.47	1.47	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	113.0	115.3	115.3	
Dry density, pcf	83.1	83.1	83.1	
Void ratio	1.0666	1.0666	1.0666	
Saturation, %	92.9	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 5.831 tsf
Consolidation back pressure = 5.387 tsf
Consolidation effective confining stress = 0.444 tsf
Fail. Stress = 1.125 tsf **at reading no.** 18
Ult. Stress = 1.125 tsf **at reading no.** 18

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	0.0771	16.230	0.0	0.0	0.000	0.444	0.444	1.00	5.387	0.444	0.000
1	0.0792	20.170	3.9	0.1	0.193	0.333	0.526	1.58	5.498	0.429	0.096
2	0.0831	21.970	5.7	0.2	0.280	0.269	0.549	2.04	5.562	0.409	0.140
3	0.0931	26.180	9.9	0.6	0.484	0.188	0.672	3.57	5.643	0.430	0.242
4	0.1178	31.090	14.9	1.5	0.716	0.156	0.872	5.59	5.675	0.514	0.358
5	0.1349	33.870	17.6	2.1	0.845	0.172	1.017	5.91	5.659	0.595	0.423
6	0.1617	35.670	19.4	3.0	0.922	0.212	1.134	5.35	5.619	0.673	0.461
7	0.1886	36.770	20.5	4.0	0.965	0.251	1.216	4.84	5.580	0.733	0.482
8	0.2156	38.050	21.8	4.9	1.015	0.284	1.299	4.57	5.547	0.791	0.507
9	0.2535	39.760	23.5	6.3	1.079	0.329	1.408	4.28	5.502	0.868	0.539
10	0.2904	40.740	24.5	7.6	1.108	0.366	1.474	4.03	5.465	0.920	0.554
11	0.3284	41.800	25.6	9.0	1.139	0.399	1.538	3.85	5.432	0.968	0.569
12	0.3572	42.570	26.3	10.0	1.160	0.418	1.578	3.77	5.413	0.998	0.580
13	0.3861	42.900	26.7	11.0	1.161	0.435	1.596	3.67	5.396	1.015	0.580
14	0.4150	43.270	27.0	12.0	1.163	0.452	1.615	3.57	5.379	1.034	0.582
15	0.4346	43.540	27.3	12.7	1.166	0.458	1.624	3.54	5.373	1.041	0.583
16	0.4640	43.500	27.3	13.8	1.150	0.480	1.630	3.40	5.351	1.055	0.575
17	0.4939	43.800	27.6	14.9	1.148	0.487	1.635	3.36	5.344	1.061	0.574
18	0.5040	43.360	27.1	15.2	1.125	0.493	1.618	3.28	5.338	1.056	0.563

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	121.670			388.410
Moisture content: Dry soil+tare, gms.	97.090			354.910
Moisture content: Tare, gms.	30.650			262.280
Moisture, %	37.0	38.7	38.7	36.2
Moist specimen weight, gms.	126.7			
Diameter, in.	1.39	1.39	1.39	
Area, in.^{2}	1.51	1.51	1.51	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	114.0	115.4	115.4	
Dry density, pcf	83.2	83.2	83.2	
Void ratio	1.0631	1.0631	1.0631	
Saturation, %	95.7	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 6.340 tsf
Consolidation back pressure = 5.380 tsf
Consolidation effective confining stress = 0.960 tsf
Fail. Stress = 1.738 tsf **at reading no.** 20
Ult. Stress = 1.738 tsf **at reading no.** 20

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	0.0056	16.530	0.0	0.0	0.000	0.960	0.960	1.00	5.380	0.960	0.000
1	0.0087	22.360	5.8	0.1	0.278	0.795	1.073	1.35	5.545	0.934	0.139
2	0.0115	26.570	10.0	0.2	0.478	0.691	1.169	1.69	5.649	0.930	0.239
3	0.0204	35.150	18.6	0.5	0.884	0.517	1.401	2.71	5.823	0.959	0.442
4	0.0372	41.770	25.2	1.1	1.191	0.396	1.587	4.01	5.944	0.991	0.595
5	0.0631	46.410	29.9	2.0	1.397	0.374	1.771	4.73	5.966	1.072	0.698
6	0.0811	48.820	32.3	2.7	1.499	0.394	1.893	4.81	5.946	1.144	0.750
7	0.0989	50.560	34.0	3.3	1.570	0.435	2.005	4.61	5.905	1.220	0.785
8	0.1079	51.570	35.0	3.6	1.611	0.450	2.061	4.58	5.890	1.256	0.806
9	0.1259	52.940	36.4	4.3	1.663	0.484	2.147	4.44	5.856	1.316	0.832
10	0.1437	53.500	37.0	4.9	1.677	0.526	2.203	4.19	5.814	1.365	0.839
11	0.1719	54.500	38.0	5.9	1.705	0.567	2.272	4.01	5.773	1.419	0.852
12	0.1905	54.600	38.1	6.6	1.697	0.608	2.305	3.79	5.732	1.457	0.849
13	0.2195	55.570	39.0	7.6	1.721	0.634	2.355	3.71	5.706	1.495	0.861
14	0.2484	56.610	40.1	8.6	1.747	0.684	2.431	3.55	5.656	1.558	0.874
15	0.2774	56.800	40.3	9.7	1.736	0.701	2.437	3.48	5.639	1.569	0.868
16	0.3053	57.460	40.9	10.7	1.745	0.722	2.467	3.42	5.618	1.594	0.872
17	0.3351	58.220	41.7	11.7	1.756	0.750	2.506	3.34	5.590	1.628	0.878
18	0.3642	58.650	42.1	12.8	1.753	0.766	2.519	3.29	5.574	1.643	0.877
19	0.3939	59.200	42.7	13.8	1.755	0.785	2.540	3.24	5.555	1.662	0.877
20	0.4240	59.320	42.8	14.9	1.738	0.803	2.541	3.16	5.537	1.672	0.869
21	0.4429	58.960	42.4	15.6	1.709	0.814	2.523	3.10	5.526	1.669	0.855

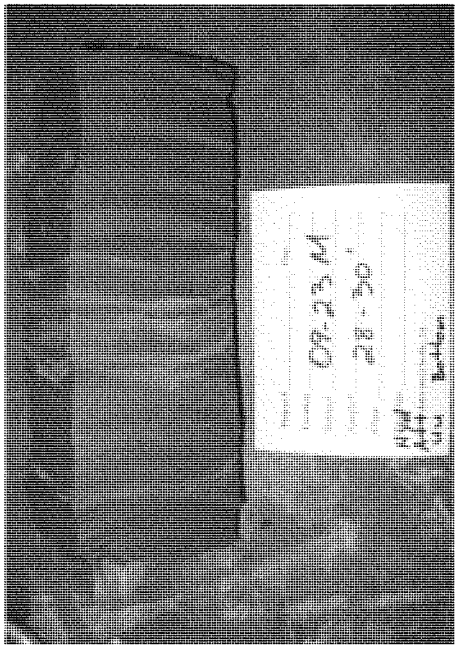
Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	107.400			378.770
Moisture content: Dry soil+tare, gms.	87.000			344.000
Moisture content: Tare, gms.	31.410			252.750
Moisture, %	36.7	39.8	39.8	38.1
Moist specimen weight, gms.	127.5			
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	112.1	114.6	114.6	
Dry density, pcf	82.0	82.0	82.0	
Void ratio	1.0939	1.0939	1.0939	
Saturation, %	92.3	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 6.767 tsf
Consolidation back pressure = 4.822 tsf
Consolidation effective confining stress = 1.945 tsf
Fail. Stress = 2.249 tsf **at reading no.** 18
Ult. Stress = 2.249 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	0.0058	18.490	0.0	0.0	0.000	1.945	1.945	1.00	4.822	1.945	0.000
1	0.0084	23.340	4.9	0.1	0.226	1.929	2.155	1.12	4.838	2.042	0.113
2	0.0116	29.840	11.4	0.2	0.529	1.690	2.219	1.31	5.077	1.955	0.265
3	0.0215	44.340	25.9	0.6	1.201	1.270	2.471	1.95	5.497	1.870	0.600
4	0.0383	54.900	36.4	1.2	1.681	0.953	2.634	2.76	5.814	1.793	0.840
5	0.0552	61.890	43.4	1.8	1.991	0.832	2.823	3.39	5.935	1.828	0.996
6	0.0732	64.540	46.1	2.4	2.099	0.742	2.841	3.83	6.025	1.792	1.050
7	0.1002	67.720	49.2	3.4	2.222	0.786	3.008	3.83	5.981	1.897	1.111
8	0.1279	69.000	50.5	4.3	2.257	0.832	3.089	3.71	5.935	1.960	1.128
9	0.1427	69.500	51.0	4.9	2.266	0.902	3.168	3.51	5.865	2.035	1.133
10	0.1757	70.500	52.0	6.0	2.282	0.960	3.242	3.38	5.807	2.101	1.141
11	0.2040	71.200	52.7	7.0	2.288	0.987	3.275	3.32	5.780	2.131	1.144
12	0.2336	72.000	53.5	8.1	2.297	1.026	3.323	3.24	5.741	2.174	1.148
13	0.2627	72.500	54.0	9.1	2.292	1.089	3.381	3.10	5.678	2.235	1.146
14	0.3035	73.000	54.5	10.6	2.276	1.135	3.411	3.01	5.632	2.273	1.138
15	0.3322	73.500	55.0	11.6	2.271	1.170	3.441	2.94	5.597	2.306	1.136
16	0.3613	74.000	55.5	12.6	2.265	1.175	3.440	2.93	5.592	2.307	1.132
17	0.3910	74.500	56.0	13.7	2.258	1.181	3.439	2.91	5.586	2.310	1.129
18	0.4221	75.000	56.5	14.8	2.249	1.238	3.487	2.82	5.529	2.362	1.124
19	0.4421	75.000	56.5	15.5	2.230	1.216	3.446	2.83	5.551	2.331	1.115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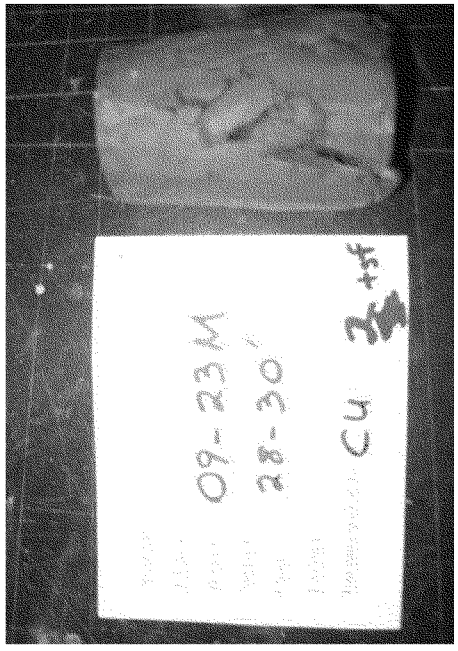
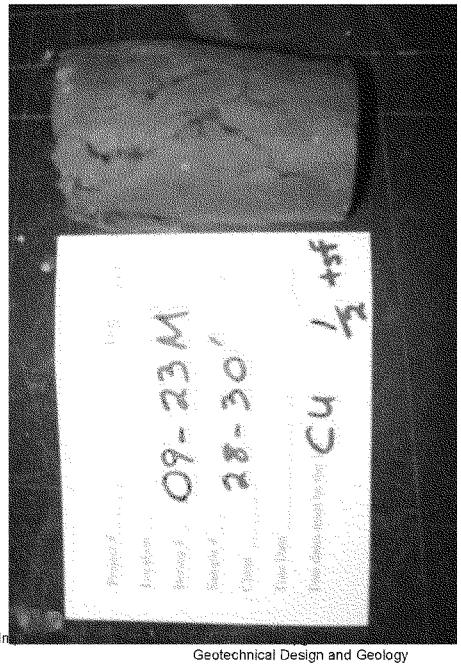
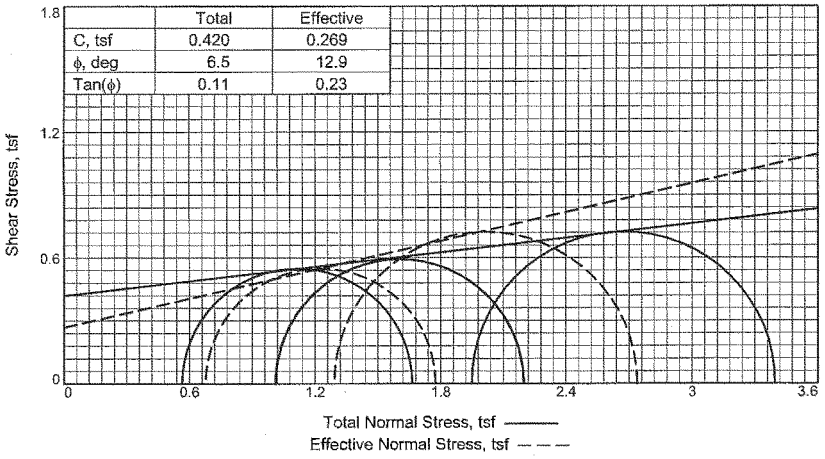
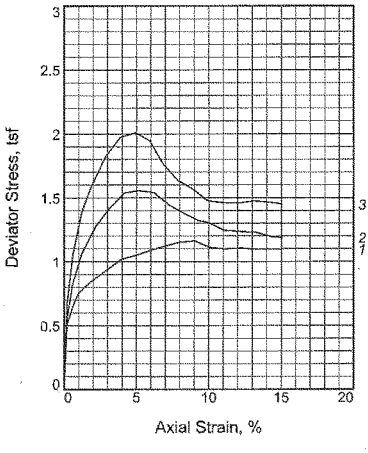
28-30'
Cu 1+4f


09-23M
28-30'
Cu 2+4f

09-23M
28-30'
Cu 1+4f


09-23M
28-30'
Cu 3+4f





Sample No.		1	2	3
Initial	Water Content, %	37.0	37.0	37.0
	Dry Density, pcf	84.1	84.3	83.5
	Saturation, %	97.7	98.2	96.4
	Void Ratio	1.0417	1.0367	1.0565
	Diameter, in.	1.41	1.41	1.41
	Height, in.	2.82	2.81	2.82
At Test	Water Content, %	37.9	37.7	38.4
	Dry Density, pcf	84.1	84.3	83.5
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.0417	1.0367	1.0565
	Diameter, in.	1.41	1.41	1.41
	Height, in.	2.82	2.81	2.82
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.57	1.01	1.95
Back Pressure, tsf		6.64	6.13	5.18
Cell Pressure, tsf		7.21	7.14	7.13
Peak Deviator Stress, tsf		1.16	1.56	2.01
Total Pore Pr., tsf		6.72	6.53	6.30
Ultimate Deviator Stress, tsf		1.10	1.19	1.45
Total Pore Pr., tsf		6.53	6.13	5.84
Maj. Eff. Stress at Ultimate, tsf		1.77	2.20	2.74
Min. Eff. Stress at Ultimate, tsf		0.68	1.01	1.29

Type of Test:
CU with Pore Pressures
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, brown (CH)

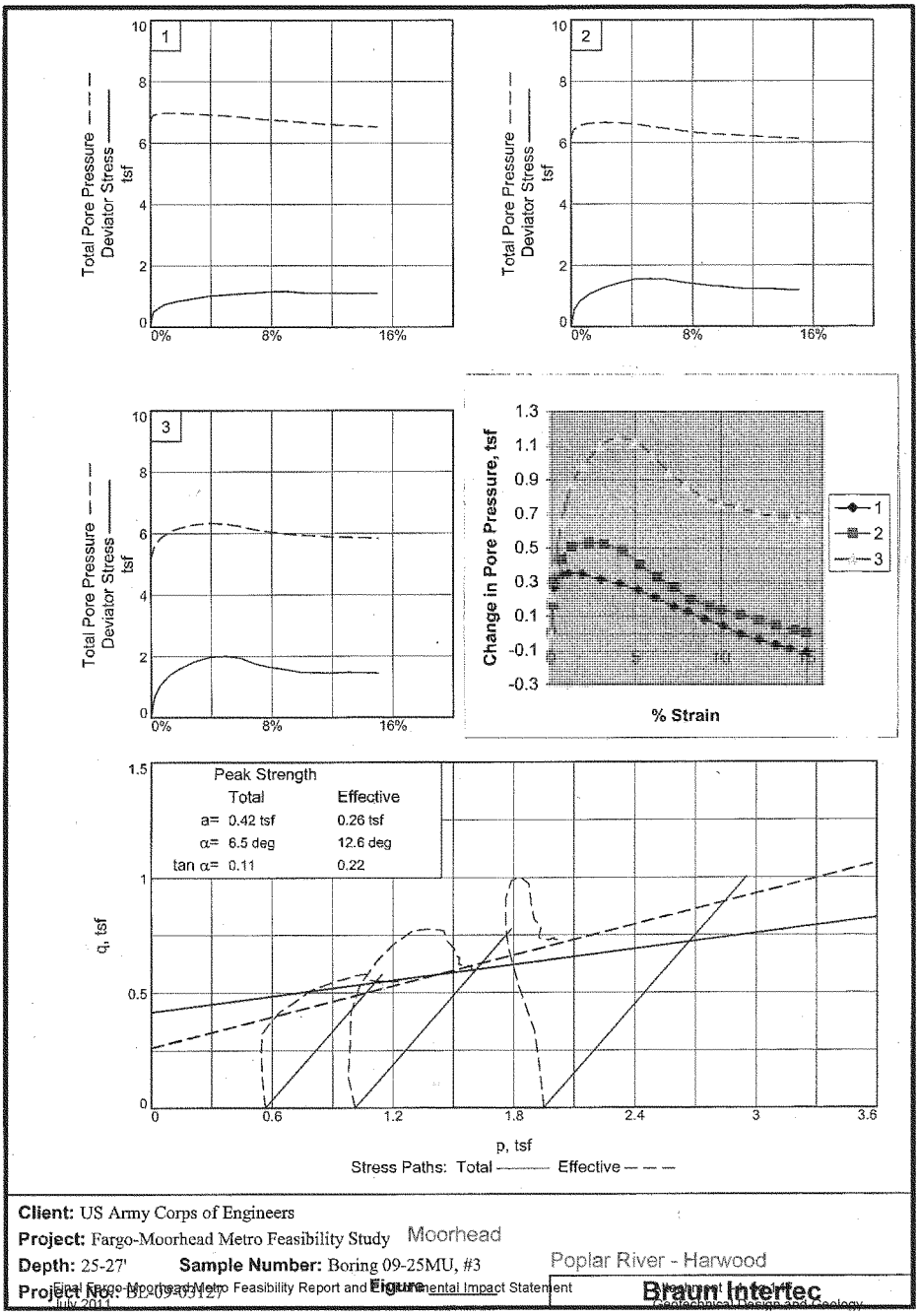
LL= 80 **PL=** 21 **PI=** 59
Assumed Specific Gravity= 2.75
Remarks: Rate of strain is 0.001 in/min. Failure criteria based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Moorhead
Sample Number: Boring 09-25MU, #3 **Depth:** 25-27'
Poplar River - Harwood
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Figure CU Triax ASTM D4767



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Moorhead
Depth: 25-27' **Sample Number:** Boring 09-25MU, #3
Project No: BE-09-0312 **Figure**

Poplar River - Harwood

Braun Intertec
Geotechnical, Materials and Environmental

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

9/14/2009
10:42 AM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL-09-03127 Moorhead
Depth: 25-27' **Sample Number:** Boring 09-25MU, #3
Description: FAT CLAY, brown (CH) Poplar River - Harwood
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=** **PL=** **PI=**
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	111.090			164.110
Moisture content: Dry soil+tare, gms.	89.260			127.890
Moisture content: Tare, gms.	30.250			31.070
Moisture, %	37.0	37.9	37.9	37.4
Moist specimen weight, gms.	132.3			
Diameter, in.	1.41	1.41	1.41	
Area, in.²	1.55	1.55	1.55	
Height, in.	2.82	2.82	2.82	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	115.2	115.9	115.9	
Dry density, pcf	84.1	84.1	84.1	
Void ratio	1.0417	1.0417	1.0417	
Saturation, %	97.7	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.206 tsf
Consolidation back pressure = 6.640 tsf
Consolidation effective confining stress = 0.566 tsf
Fail. Stress = 1.098 tsf **at reading no.** 18
Ult. Stress = 1.098 tsf **at reading no.** 18

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	0.0075	18.090	0.0	0.0	0.000	0.566	0.566	1.00	6.640	0.566	0.000
1	0.0084	23.710	5.6	0.0	0.261	0.420	0.681	1.62	6.786	0.550	0.130
2	0.0125	28.800	10.7	0.2	0.496	0.297	0.793	2.67	6.909	0.545	0.248
3	0.0245	32.190	14.1	0.6	0.651	0.226	0.877	3.88	6.980	0.551	0.325
4	0.0353	34.480	16.4	1.0	0.754	0.219	0.973	4.44	6.987	0.596	0.377
5	0.0573	36.460	18.4	1.8	0.838	0.221	1.059	4.79	6.985	0.640	0.419
6	0.0882	38.650	20.6	2.9	0.927	0.254	1.181	4.65	6.952	0.718	0.464
7	0.1190	40.910	22.8	4.0	1.018	0.279	1.297	4.65	6.927	0.788	0.509
8	0.1500	41.970	23.9	5.1	1.053	0.316	1.369	4.33	6.890	0.842	0.526
9	0.1808	43.210	25.1	6.1	1.095	0.359	1.454	4.05	6.847	0.906	0.547
10	0.2117	44.280	26.2	7.2	1.128	0.413	1.541	3.73	6.793	0.977	0.564
11	0.2325	45.010	26.9	8.0	1.150	0.441	1.591	3.61	6.765	1.016	0.575
12	0.2616	45.590	27.5	9.0	1.162	0.487	1.649	3.39	6.719	1.068	0.581
13	0.2916	44.670	26.6	10.1	1.110	0.527	1.637	3.11	6.679	1.082	0.555
14	0.3213	44.730	26.6	11.1	1.100	0.573	1.673	2.92	6.633	1.123	0.550
15	0.3523	45.210	27.1	12.2	1.106	0.606	1.712	2.82	6.600	1.159	0.553
16	0.3813	45.270	27.2	13.2	1.095	0.635	1.730	2.72	6.571	1.183	0.548
17	0.4011	45.560	27.5	14.0	1.098	0.657	1.755	2.67	6.549	1.206	0.549
18	0.4311	45.910	27.8	15.0	1.098	0.677	1.775	2.62	6.529	1.226	0.549

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	131.410			164.140
Moisture content: Dry soil+tare, gms.	104.060			128.290
Moisture content: Tare, gms.	30.160			31.050
Moisture, %	37.0	37.7	37.7	36.9
Moist specimen weight, gms.	133.0			
Diameter, in.	1.41	1.41	1.41	
Area, in.^{2}	1.56	1.56	1.56	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	115.5	116.1	116.1	
Dry density, pcf	84.3	84.3	84.3	
Void ratio	1.0367	1.0367	1.0367	
Saturation, %	98.2	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.143 tsf

Consolidation back pressure = 6.131 tsf

Consolidation effective confining stress = 1.012 tsf

Fail. Stress = 1.187 tsf **at reading no.** 18

Ult. Stress = 1.187 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	0.0098	18.850	0.0	0.0	0.000	1.012	1.012	1.00	6.131	1.012	0.000
1	0.0127	24.710	5.9	0.1	0.270	0.842	1.112	1.32	6.301	0.977	0.135
2	0.0156	30.880	12.0	0.2	0.554	0.710	1.264	1.78	6.433	0.987	0.277
3	0.0263	36.830	18.0	0.6	0.825	0.577	1.402	2.43	6.566	0.990	0.413
4	0.0443	42.200	23.4	1.2	1.065	0.503	1.568	3.12	6.640	1.035	0.532
5	0.0712	47.120	28.3	2.2	1.277	0.482	1.759	3.65	6.661	1.120	0.638
6	0.0981	50.590	31.7	3.1	1.420	0.491	1.911	3.89	6.652	1.201	0.710
7	0.1270	53.620	34.8	4.2	1.539	0.529	2.068	3.91	6.614	1.298	0.769
8	0.1560	54.380	35.5	5.2	1.555	0.611	2.166	3.55	6.532	1.389	0.778
9	0.1849	54.440	35.6	6.2	1.541	0.682	2.223	3.26	6.461	1.453	0.771
10	0.2136	52.610	33.8	7.2	1.446	0.747	2.193	2.94	6.396	1.470	0.723
11	0.2416	51.480	32.6	8.2	1.383	0.814	2.197	2.70	6.329	1.505	0.691
12	0.2716	50.410	31.6	9.3	1.322	0.855	2.177	2.55	6.288	1.516	0.661
13	0.2914	50.260	31.4	10.0	1.305	0.877	2.182	2.49	6.266	1.530	0.653
14	0.3213	49.160	30.3	11.1	1.245	0.904	2.149	2.38	6.239	1.526	0.622
15	0.3522	49.310	30.5	12.2	1.235	0.937	2.172	2.32	6.206	1.555	0.618
16	0.3818	49.570	30.7	13.2	1.231	0.970	2.201	2.27	6.173	1.585	0.615
17	0.4122	49.050	30.2	14.3	1.195	0.995	2.190	2.20	6.148	1.593	0.598
18	0.4332	49.110	30.3	15.0	1.187	1.010	2.197	2.18	6.133	1.604	0.594

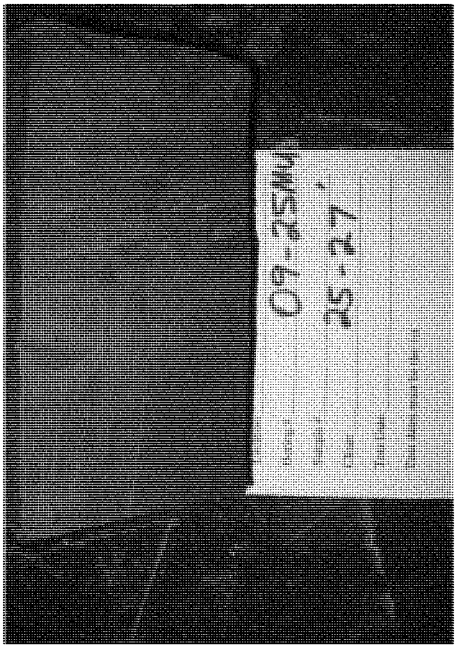
Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	142.460			161.080
Moisture content: Dry soil+tare, gms.	112.200			125.150
Moisture content: Tare, gms.	30.490			30.240
Moisture, %	37.0	38.4	38.4	37.9
Moist specimen weight, gms.	131.4			
Diameter, in.	1.41	1.41	1.41	
Area, in.²	1.55	1.55	1.55	
Height, in.	2.82	2.82	2.82	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	114.4	115.6	115.6	
Dry density, pcf	83.5	83.5	83.5	
Void ratio	1.0565	1.0565	1.0565	
Saturation, %	96.4	100.0	100.0	

Test Readings for Specimen No. 3

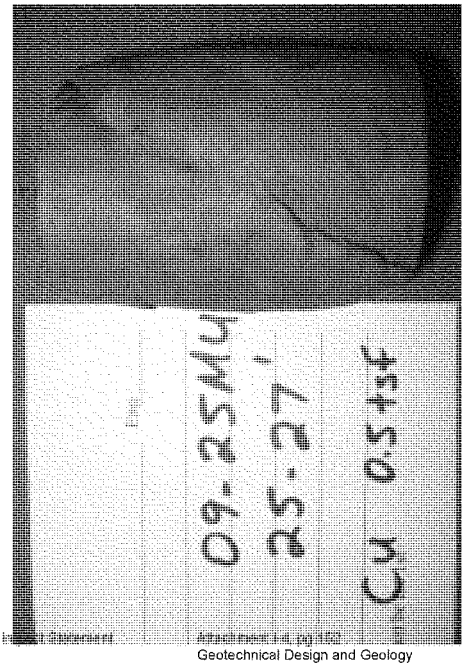
Consolidation cell pressure = 7.130 tsf
Consolidation back pressure = 5.181 tsf
Consolidation effective confining stress = 1.949 tsf
Fail. Stress = 1.448 tsf **at reading no.** 19
Ult. Stress = 1.448 tsf **at reading no.** 19

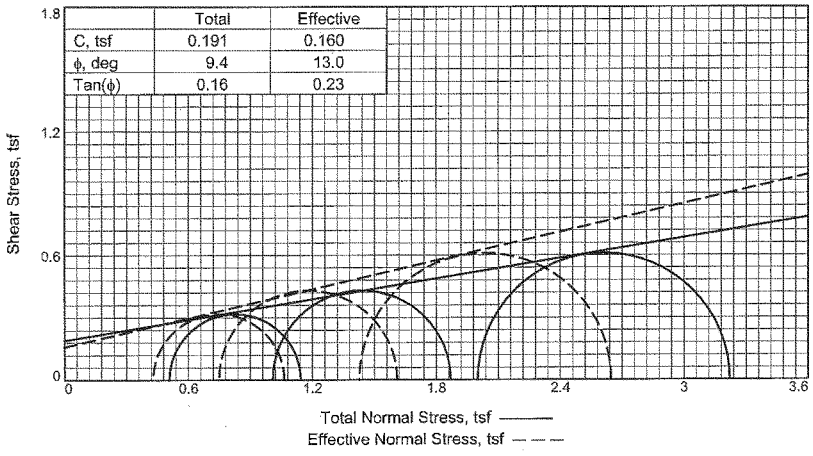
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0063	18.360	0.0	0.0	0.000	1.949	1.949	1.00	5.181	1.949	0.000
1	0.0094	26.390	8.0	0.1	0.371	1.740	2.111	1.21	5.390	1.926	0.186
2	0.0122	32.920	14.6	0.2	0.673	1.566	2.239	1.43	5.564	1.902	0.336
3	0.0232	41.260	22.9	0.6	1.054	1.299	2.353	1.81	5.831	1.826	0.527
4	0.0413	48.920	30.6	1.2	1.398	1.074	2.472	2.30	6.056	1.773	0.699
5	0.0591	53.370	35.0	1.9	1.591	0.965	2.556	2.65	6.165	1.760	0.795
6	0.0871	58.900	40.5	2.9	1.823	0.850	2.673	3.15	6.280	1.762	0.912
7	0.1152	62.710	44.4	3.9	1.974	0.802	2.776	3.46	6.328	1.789	0.987
8	0.1449	63.990	45.6	4.9	2.009	0.827	2.836	3.43	6.303	1.832	1.005
9	0.1726	63.050	44.7	5.9	1.947	0.902	2.849	3.16	6.228	1.876	0.974
10	0.1996	59.200	40.8	6.9	1.761	1.007	2.768	2.75	6.123	1.888	0.881
11	0.2276	56.730	38.4	7.9	1.637	1.082	2.719	2.51	6.048	1.901	0.819
12	0.2557	55.630	37.3	8.9	1.573	1.149	2.722	2.37	5.981	1.936	0.787
13	0.2853	53.800	35.4	9.9	1.479	1.185	2.664	2.25	5.945	1.924	0.739
14	0.3153	53.830	35.5	11.0	1.462	1.212	2.674	2.21	5.918	1.943	0.731
15	0.3462	54.200	35.8	12.1	1.459	1.245	2.704	2.17	5.885	1.975	0.730
16	0.3751	55.050	36.7	13.1	1.476	1.263	2.739	2.17	5.867	2.001	0.738
17	0.4052	55.230	36.9	14.2	1.465	1.267	2.732	2.16	5.863	2.000	0.733
18	0.4241	55.290	36.9	14.8	1.456	1.292	2.748	2.13	5.838	2.020	0.728
19	0.4296	55.160	36.8	15.0	1.448	1.291	2.739	2.12	5.839	2.015	0.724


09-25MW
25-27'

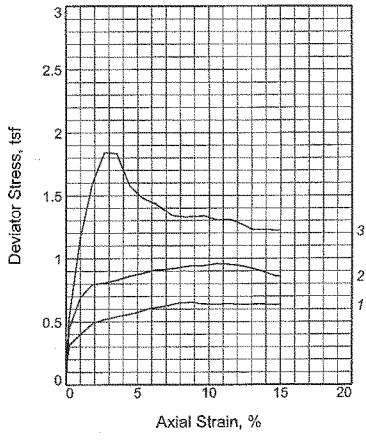
09-25MW
25-27'
Cu 2 tsf

09-25MW
25-27'
Cu 1 tsf


09-25MW
25-27'
Cu 0.5 tsf



	Total	Effective
C, tsf	0.191	0.160
ϕ, deg	9.4	13.0
Tan(ϕ)	0.16	0.23



Sample No.		1	2	3
Initial	Water Content, %	51.6	51.7	50.6
	Dry Density, pcf	70.9	70.7	70.8
	Saturation, %	99.7	99.6	97.7
	Void Ratio	1.4221	1.4268	1.4255
	Diameter, in.	1.40	1.40	1.40
	Height, in.	2.80	2.80	2.80
At Test	Water Content, %	51.7	51.7	50.9
	Dry Density, pcf	70.9	70.9	71.5
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.4221	1.4216	1.3995
	Diameter, in.	1.40	1.40	1.39
	Height, in.	2.80	2.80	2.79
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.51	1.01	2.00
Back Pressure, tsf		6.63	6.13	5.14
Cell Pressure, tsf		7.14	7.14	7.14
Peak Deviator Stress, tsf		0.65	0.96	1.84
Total Pore Pr., tsf		6.80	6.49	6.27
Ultimate Deviator Stress, tsf		0.63	0.86	1.22
Total Pore Pr., tsf		6.71	6.39	5.71
Maj. Eff. Stress at Ultimate, tsf		0.99	1.61	2.71
Min. Eff. Stress at Ultimate, tsf		0.34	0.65	0.87

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 the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Figure CU Triax ASTM D 4767

Client: US Army Corps of Engineer

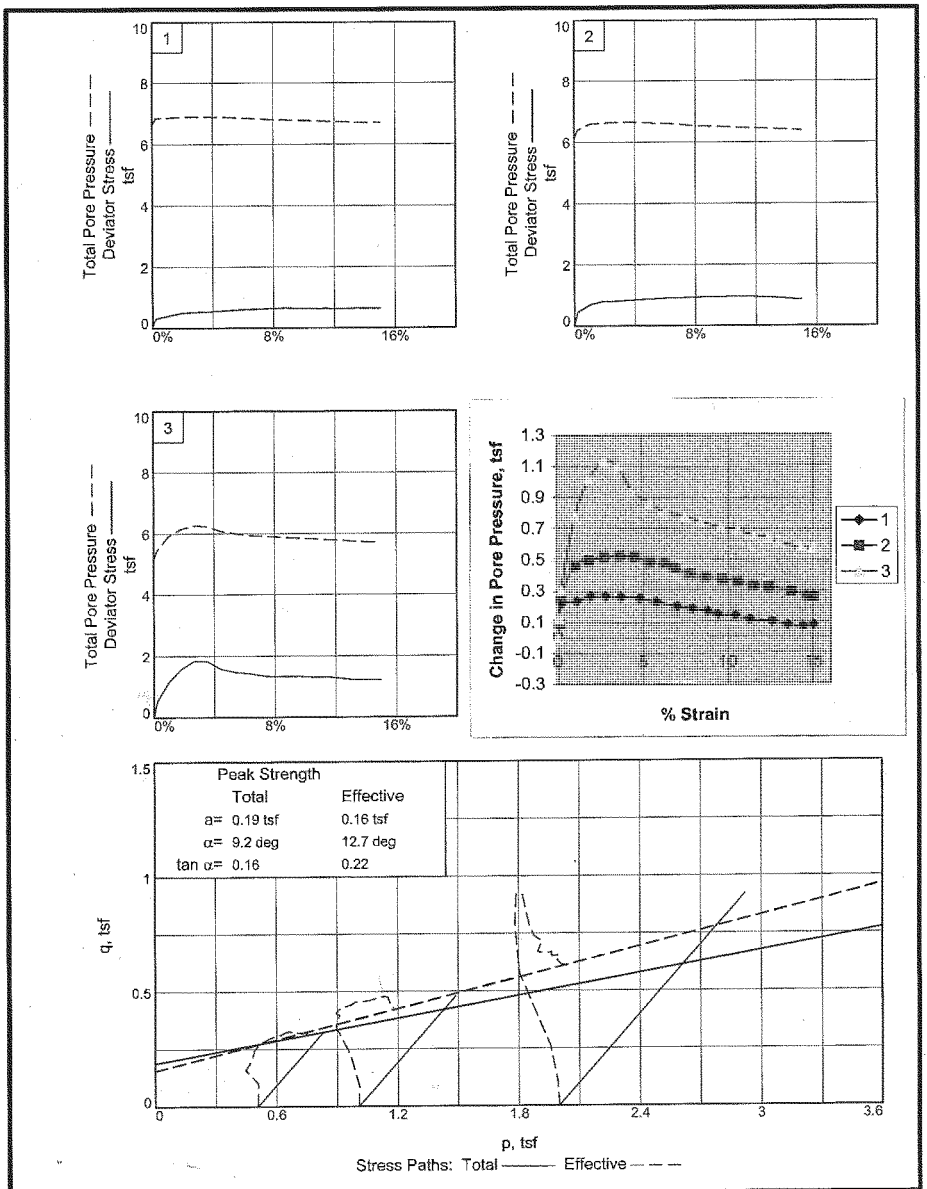
Project: Fargo-Moorhead Feasibility Study
Moorhead Oxidized Brenna

Location: SE-ED-29, East Diversion, ~~PL Sherack Formation~~

Sample Number: Boring 09-26MU, #2 **Depth:** 20-22'

Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC



Client: US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study Moorhead Oxidized Brenna

Loc.: SE-ED-29, East Diversion, ~~PL Sherack Formation~~ **Depth:** 20-22' **Sample No.:** Boring 09-26MU, #2

Project No.: ~~BL-09-08127~~ Figure **Braun Intertec**

Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

11/17/2009
9:18 AM

Date:
Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-ED-29, East Diversion, ~~PL Sherack Formation~~ Moorhead
Depth: 20-22' **Sample Number:** Boring 09-26MU, #2
Description: FAT CLAY, brown (CH) Oxidized Brenna
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=** **PL=** **PI=**
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	138.130			152.360
Moisture content: Dry soil+tare, gms.	101.740			110.510
Moisture content: Tare, gms.	31.160			31.100
Moisture, %	51.6	51.7	51.7	52.7
Moist specimen weight, gms.	120.8			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.53	1.53	1.53	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	107.4	107.5	107.5	
Dry density, pcf	70.9	70.9	70.9	
Void ratio	1.4221	1.4221	1.4221	
Saturation, %	99.7	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 6.632 tsf
Consolidation effective confining stress = 0.508 tsf
Peak Stress = 0.654 tsf **at reading no.** 11
Ult. Stress = 0.635 tsf **at reading no.** 18

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	0.508	0.508	1.00	6.632	0.508	0.000
1	0.0176	23.490	4.3	0.1	0.202	0.408	0.610	1.49	6.732	0.509	0.101
2	0.0219	25.970	6.8	0.2	0.318	0.288	0.606	2.10	6.852	0.447	0.159
3	0.0447	27.930	8.7	1.1	0.406	0.274	0.680	2.48	6.866	0.477	0.203
4	0.0686	29.840	10.6	1.9	0.491	0.245	0.736	3.00	6.895	0.490	0.245
5	0.0925	30.600	11.4	2.8	0.521	0.244	0.765	3.14	6.896	0.505	0.261
6	0.1176	31.170	12.0	3.7	0.542	0.247	0.789	3.19	6.893	0.518	0.271
7	0.1503	31.920	12.7	4.8	0.569	0.256	0.825	3.22	6.884	0.541	0.285
8	0.1761	32.820	13.6	5.8	0.603	0.279	0.882	3.16	6.861	0.581	0.302
9	0.2101	33.470	14.3	7.0	0.624	0.309	0.933	3.02	6.831	0.621	0.312
10	0.2353	34.140	14.9	7.9	0.647	0.326	0.973	2.98	6.814	0.649	0.323
11	0.2619	34.450	15.3	8.8	0.654	0.340	0.994	2.92	6.800	0.667	0.327
12	0.2788	34.300	15.1	9.4	0.643	0.361	1.004	2.78	6.779	0.682	0.321
13	0.3046	34.320	15.1	10.4	0.637	0.368	1.005	2.73	6.772	0.687	0.319
14	0.3317	34.600	15.4	11.3	0.642	0.393	1.035	2.63	6.747	0.714	0.321
15	0.3665	34.680	15.5	12.6	0.636	0.405	1.041	2.57	6.735	0.723	0.318
16	0.3925	34.970	15.8	13.5	0.641	0.428	1.069	2.50	6.712	0.749	0.321
17	0.4183	35.000	15.8	14.4	0.636	0.435	1.071	2.46	6.705	0.753	0.318
18	0.4355	35.100	15.9	15.0	0.635	0.429	1.064	2.48	6.711	0.746	0.317

Parameters for Specimen No. 2				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	118.630			151.880
Moisture content: Dry soil+tare, gms.	88.550			110.780
Moisture content: Tare, gms.	30.320			31.090
Moisture, %	51.7	51.9	51.7	51.6
Moist specimen weight, gms.	121.2			
Diameter, in.	1.40	1.40	1.40	
Area, in.^{2}	1.53	1.53	1.53	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	107.3	107.4	107.5	
Dry density, pcf	70.7	70.7	70.9	
Void ratio	1.4268	1.4268	1.4216	
Saturation, %	99.6	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.138 tsf

Consolidation back pressure = 6.130 tsf

Consolidation effective confining stress = 1.008 tsf

Peak Stress = 0.958 tsf **at reading no.** 14

Ult. Stress = 0.862 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	0.0170	19.070	0.0	0.0	0.000	1.008	1.008	1.00	6.130	1.008	0.000
1	0.0190	22.790	3.7	0.1	0.175	0.922	1.097	1.19	6.216	1.009	0.087
2	0.0232	28.560	9.5	0.2	0.445	0.744	1.189	1.60	6.394	0.966	0.222
3	0.0459	34.080	15.0	1.0	0.698	0.545	1.243	2.28	6.593	0.894	0.349
4	0.0687	36.310	17.2	1.8	0.795	0.514	1.309	2.55	6.624	0.911	0.397
5	0.0925	36.740	17.7	2.7	0.808	0.491	1.299	2.64	6.647	0.895	0.404
6	0.1168	37.410	18.3	3.6	0.831	0.487	1.318	2.71	6.651	0.902	0.415
7	0.1421	38.260	19.2	4.5	0.861	0.492	1.353	2.75	6.646	0.923	0.431
8	0.1672	38.940	19.9	5.4	0.883	0.524	1.407	2.69	6.614	0.966	0.442
9	0.1929	39.730	20.7	6.3	0.910	0.534	1.444	2.70	6.604	0.989	0.455
10	0.2099	39.910	20.8	6.9	0.912	0.561	1.473	2.62	6.577	1.017	0.456
11	0.2358	40.410	21.3	7.8	0.924	0.600	1.524	2.54	6.538	1.062	0.462
12	0.2617	41.020	22.0	8.7	0.941	0.620	1.561	2.52	6.518	1.090	0.470
13	0.2877	41.290	22.2	9.7	0.943	0.635	1.578	2.48	6.503	1.106	0.471
14	0.3137	41.870	22.8	10.6	0.958	0.652	1.610	2.47	6.486	1.131	0.479
15	0.3404	41.960	22.9	11.5	0.951	0.676	1.627	2.41	6.462	1.152	0.476
16	0.3653	41.870	22.8	12.4	0.938	0.685	1.623	2.37	6.453	1.154	0.469
17	0.4014	41.260	22.2	13.7	0.899	0.713	1.612	2.26	6.425	1.163	0.450
18	0.4275	40.550	21.5	14.7	0.861	0.744	1.605	2.16	6.394	1.175	0.431
19	0.4364	40.640	21.6	15.0	0.862	0.748	1.610	2.15	6.390	1.179	0.431

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	122.850			148.500
Moisture content: Dry soil+tare, gms.	92.010			109.240
Moisture content: Tare, gms.	31.100			30.430
Moisture, %	50.6	51.8	50.9	49.8
Moist specimen weight, gms.	120.3			
Diameter, in.	1.40	1.40	1.39	
Area, in.²	1.54	1.54	1.53	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	106.6	107.5	108.0	
Dry density, pcf	70.8	70.8	71.5	
Void ratio	1.4255	1.4255	1.3995	
Saturation, %	97.7	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.140 tsf

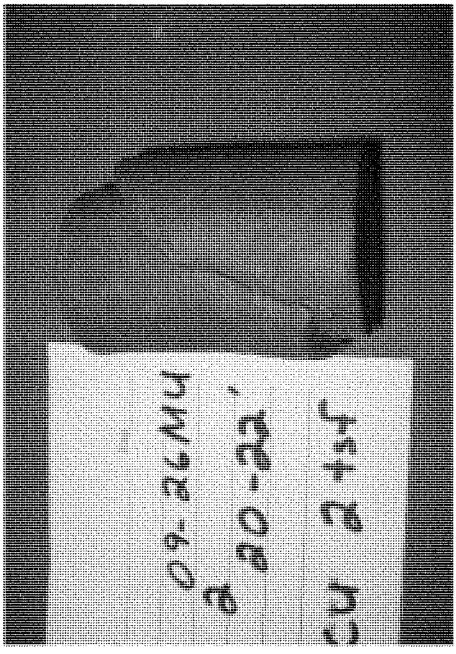
Consolidation back pressure = 5.140 tsf

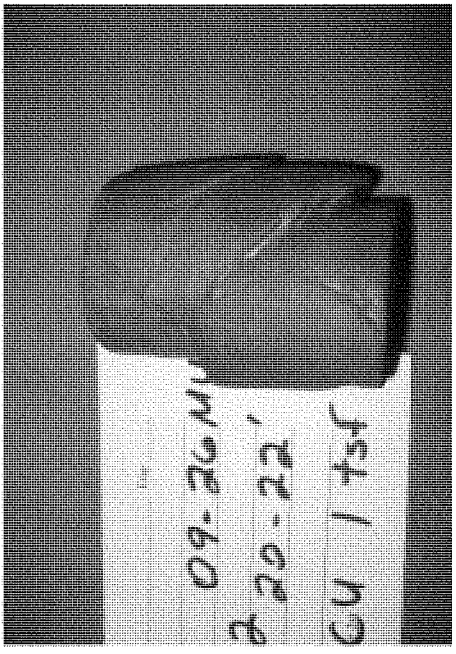
Consolidation effective confining stress = 2.000 tsf

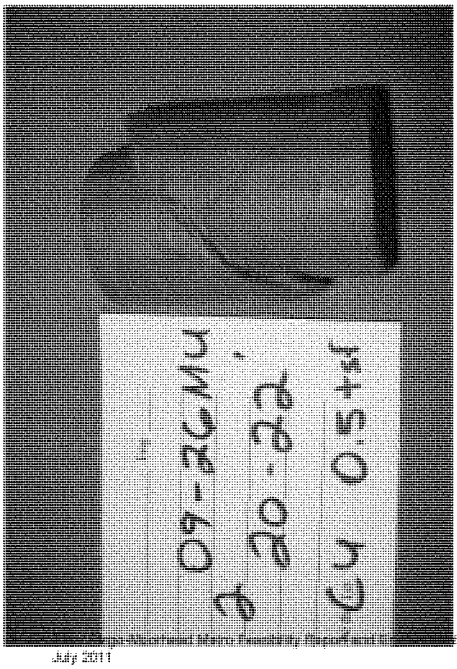
Peak Stress = 1.842 tsf **at reading no.** 5

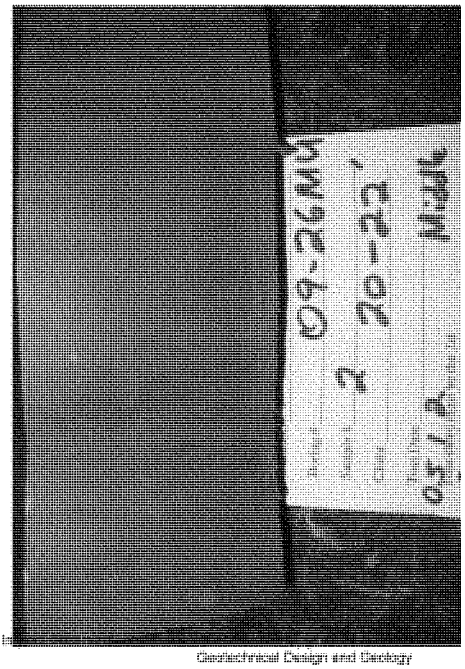
Ult. Stress = 1.221 tsf **at reading no.** 18

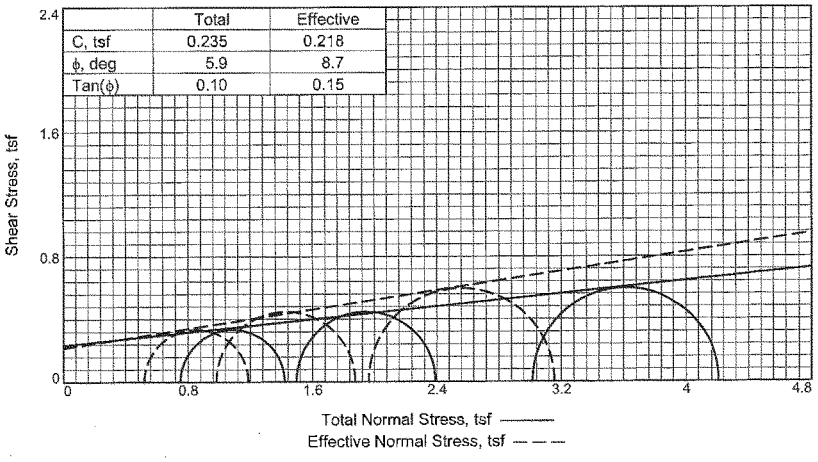
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0139	19.550	0.0	0.0	0.000	2.000	2.000	1.00	5.140	2.000	0.000
1	0.0159	24.250	4.7	0.1	0.222	1.880	2.102	1.12	5.260	1.991	0.111
2	0.0198	30.690	11.1	0.2	0.524	1.694	2.218	1.31	5.446	1.956	0.262
3	0.0415	44.310	24.8	1.0	1.157	1.225	2.382	1.94	5.915	1.803	0.578
4	0.0647	53.950	34.4	1.8	1.593	0.984	2.577	2.62	6.156	1.781	0.797
5	0.0883	59.660	40.1	2.7	1.842	0.868	2.710	3.12	6.272	1.789	0.921
6	0.1121	59.930	40.4	3.5	1.838	0.899	2.737	3.04	6.241	1.818	0.919
7	0.1376	54.500	35.0	4.4	1.576	1.064	2.640	2.48	6.076	1.852	0.788
8	0.1632	52.700	33.2	5.4	1.480	1.135	2.615	2.30	6.005	1.875	0.740
9	0.1888	51.970	32.4	6.3	1.433	1.199	2.632	2.20	5.941	1.916	0.717
10	0.2217	50.260	30.7	7.5	1.341	1.223	2.564	2.10	5.917	1.893	0.670
11	0.2476	50.350	30.8	8.4	1.331	1.261	2.592	2.06	5.879	1.927	0.666
12	0.2826	50.950	31.4	9.6	1.339	1.292	2.631	2.04	5.848	1.961	0.669
13	0.3086	50.480	30.9	10.6	1.305	1.312	2.617	1.99	5.828	1.964	0.652
14	0.3344	50.930	31.4	11.5	1.310	1.346	2.656	1.97	5.794	2.001	0.655
15	0.3605	50.170	30.6	12.4	1.265	1.358	2.623	1.93	5.782	1.990	0.632
16	0.3772	49.530	30.0	13.0	1.230	1.395	2.625	1.88	5.745	2.010	0.615
17	0.4132	49.860	30.3	14.3	1.225	1.421	2.646	1.86	5.719	2.034	0.613
18	0.4313	49.980	30.4	15.0	1.221	1.426	2.647	1.86	5.714	2.036	0.610


09-26MW
@ 20-22'
CU 2 tsf

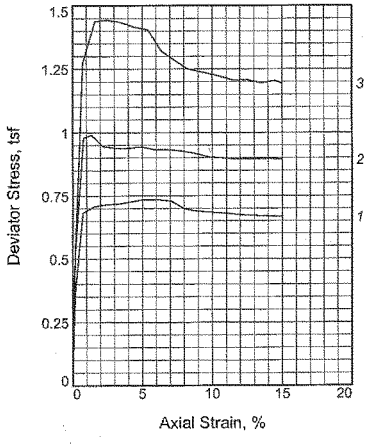

09-26MW
@ 22-22'
CU 1 tsf


09-26MW
@ 20-22
CU 0.5tsf


09-26MW
@ 20-22'
MRK



	Total	Effective
C, tsf	0.235	0.218
ϕ, deg	5.9	8.7
Tan(ϕ)	0.10	0.15



Sample No.		1	2	3
Initial	Water Content, %	61.0	60.5	62.1
	Dry Density, pcf	63.7	64.0	63.0
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.6488	1.6370	1.6777
	Diameter, in.	1.40	1.41	1.39
	Height, in.	2.80	2.79	2.82
At Test	Water Content, %	61.0	59.5	57.9
	Dry Density, pcf	63.7	64.7	65.8
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.6488	1.6088	1.5649
	Diameter, in.	1.40	1.40	1.37
	Height, in.	2.80	2.79	2.78
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.75	1.50	3.01
Back Pressure, tsf		6.39	5.64	4.13
Cell Pressure, tsf		7.14	7.14	7.14
Peak Deviator Stress, tsf		0.73	0.99	1.44
Total Pore Pr., tsf		6.74	6.26	5.12
Ultimate Deviator Stress, tsf		0.67	0.89	1.19
Total Pore Pr., tsf		6.62	6.16	5.18
Maj. Eff. Stress at Ultimate, tsf		1.14	1.87	3.46
Min. Eff. Stress at Ultimate, tsf		0.40	0.88	2.02

Type of Test:
CU with Pore Pressures
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, brown (CH)

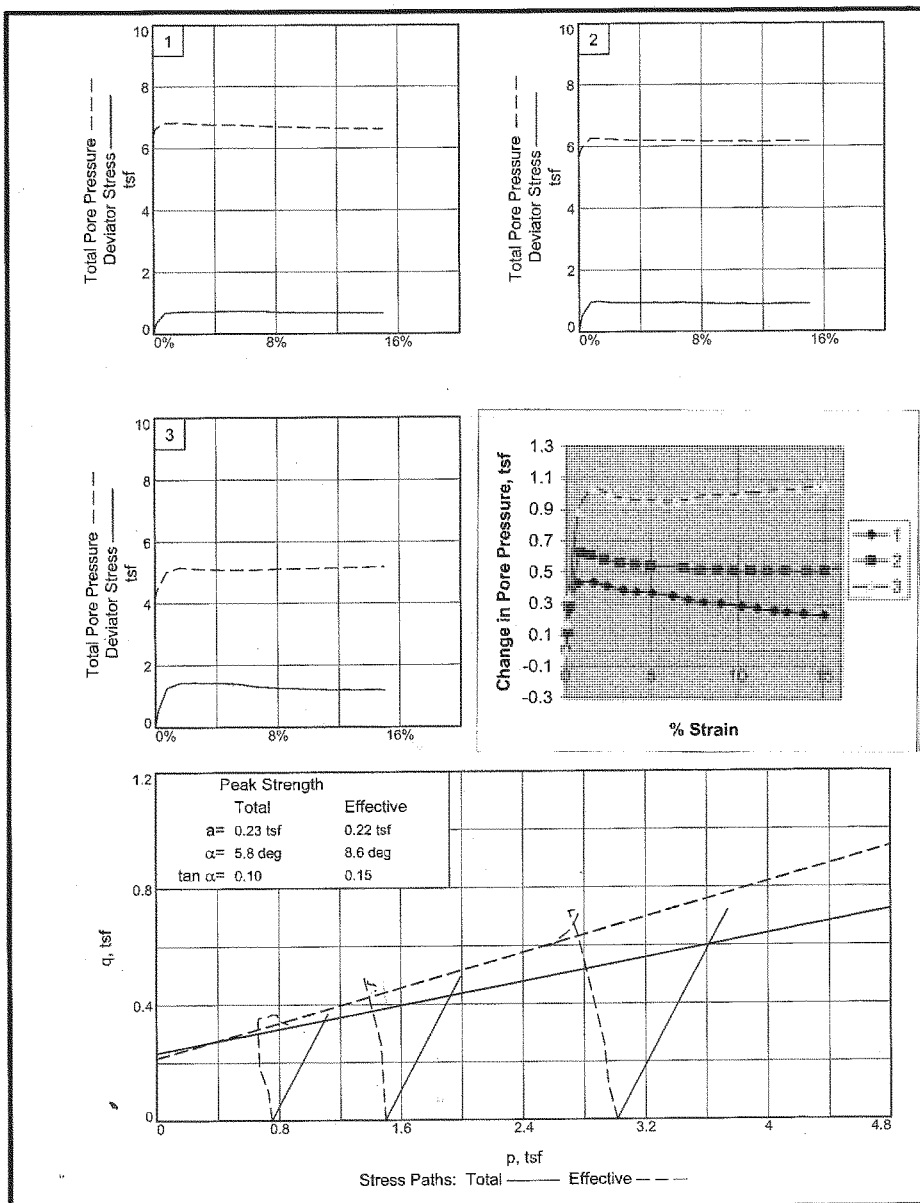
LL= 114 **PL=** 24 **PI=** 90
Assumed Specific Gravity= 2.704
Remarks: Rate of strain is 0.001 in/min. Failure criteria based on ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115 Oxidized Brenna
Location: SE-M-18, Moorhead, ~~PL Sherack Formation~~
Sample Number: Boring 09-34MU, #2 **Depth:** 16-18'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Figure UG-Attx-Ast-M-09-763



Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
Loc.: SE-M-18, Moorhead, ~~PL Sherack Formation~~
Project No.: Boring 09-34MU

Oxidized Brenna
Depth: 16-18'
Sample No.: Boring 09-34MU, #2

Figure

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

11/9/2009
1:00 PM

Date:
Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-M-18, Moorhead, ~~PL Sheyenne Formation~~
Depth: 16-18' **Sample Number:** Boring 09-34MU, #2
Description: FAT CLAY, brown (CH) Oxidized Brenna
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=2.704 **LL=**114 **PL=**24 **PI=**90
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	118.660			147.010
Moisture content: Dry soil+tare, gms.	85.600			102.640
Moisture content: Tare, gms.	31.370			30.600
Moisture, %	61.0	61.0	61.0	61.6
Moist specimen weight, gms.	116.3			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.54	1.54	1.54	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	102.6	102.6	102.6	
Dry density, pcf	63.7	63.7	63.7	
Void ratio	1.6488	1.6488	1.6488	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.138 tsf
Consolidation back pressure = 6.387 tsf
Consolidation effective confining stress = 0.751 tsf
Peak Stress = 0.734 tsf **at reading no.** 9
Ult. Stress = 0.668 tsf **at reading no.** 18

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	0.0167	19.190	0.0	0.0	0.000	0.751	0.751	1.00	6.387	0.751	0.000
1	0.0186	23.520	4.3	0.1	0.202	0.625	0.827	1.32	6.513	0.726	0.101
2	0.0216	27.030	7.8	0.2	0.366	0.488	0.854	1.75	6.650	0.671	0.183
3	0.0374	33.900	14.7	0.7	0.682	0.320	1.002	3.13	6.818	0.661	0.341
4	0.0604	34.600	15.4	1.6	0.709	0.314	1.023	3.26	6.824	0.668	0.354
5	0.0845	34.900	15.7	2.4	0.716	0.339	1.055	3.11	6.799	0.697	0.358
6	0.1083	35.090	15.9	3.3	0.718	0.364	1.082	2.97	6.774	0.723	0.359
7	0.1321	35.400	16.2	4.1	0.726	0.376	1.102	2.93	6.762	0.739	0.363
8	0.1561	35.730	16.5	5.0	0.734	0.382	1.116	2.92	6.756	0.749	0.367
9	0.1899	35.950	16.8	6.2	0.734	0.403	1.137	2.82	6.735	0.770	0.367
10	0.2159	36.000	16.8	7.1	0.729	0.425	1.154	2.72	6.713	0.790	0.365
11	0.2418	35.450	16.3	8.0	0.698	0.441	1.139	2.58	6.697	0.790	0.349
12	0.2678	35.390	16.2	9.0	0.689	0.451	1.140	2.53	6.687	0.795	0.344
13	0.3027	35.510	16.3	10.2	0.684	0.468	1.152	2.46	6.670	0.810	0.342
14	0.3286	35.570	16.4	11.1	0.680	0.480	1.160	2.42	6.658	0.820	0.340
15	0.3566	35.610	16.4	12.1	0.674	0.495	1.169	2.36	6.643	0.832	0.337
16	0.3754	35.730	16.5	12.8	0.674	0.503	1.177	2.34	6.635	0.840	0.337
17	0.4023	35.800	16.6	13.8	0.669	0.514	1.183	2.30	6.624	0.848	0.334
18	0.4374	36.010	16.8	15.0	0.668	0.520	1.188	2.28	6.618	0.854	0.334

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	113.430			146.380
Moisture content: Dry soil+tare, gms.	82.280			103.090
Moisture content: Tare, gms.	30.830			30.420
Moisture, %	60.5	60.5	59.5	59.6
Moist specimen weight, gms.	116.9			
Diameter, in.	1.41	1.41	1.40	
Area, in.²	1.55	1.55	1.54	
Height, in.	2.79	2.79	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	102.8	102.8	103.2	
Dry density, pcf	64.0	64.0	64.7	
Void ratio	1.6370	1.6370	1.6088	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.140 tsf

Consolidation back pressure = 5.644 tsf

Consolidation effective confining stress = 1.496 tsf

Peak Stress = 0.990 tsf **at reading no.** 4

Ult. Stress = 0.894 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	0.0090	18.060	0.0	0.0	0.000	1.496	1.496	1.00	5.644	1.496	0.000
1	0.0109	22.820	4.8	0.1	0.222	1.373	1.595	1.16	5.767	1.484	0.111
2	0.0139	29.260	11.2	0.2	0.523	1.206	1.729	1.43	5.934	1.467	0.261
3	0.0309	39.150	21.1	0.8	0.979	0.868	1.847	2.13	6.272	1.357	0.489
4	0.0468	39.520	21.5	1.4	0.990	0.882	1.872	2.12	6.258	1.377	0.495
5	0.0707	38.710	20.7	2.2	0.944	0.909	1.853	2.04	6.231	1.381	0.472
6	0.0956	38.760	20.7	3.1	0.938	0.932	1.870	2.01	6.208	1.401	0.469
7	0.1203	38.960	20.9	4.0	0.939	0.941	1.880	2.00	6.199	1.410	0.469
8	0.1465	39.270	21.2	4.9	0.943	0.951	1.894	1.99	6.189	1.423	0.472
9	0.1721	39.230	21.2	5.9	0.932	0.956	1.888	1.98	6.184	1.422	0.466
10	0.1980	39.450	21.4	6.8	0.933	0.962	1.895	1.97	6.178	1.428	0.466
11	0.2260	39.560	21.5	7.8	0.927	0.977	1.904	1.95	6.163	1.441	0.464
12	0.2531	39.550	21.5	8.8	0.917	0.976	1.893	1.94	6.164	1.435	0.459
13	0.2797	39.450	21.4	9.7	0.903	0.985	1.888	1.92	6.155	1.437	0.452
14	0.3070	39.590	21.5	10.7	0.899	0.982	1.881	1.92	6.158	1.432	0.450
15	0.3347	39.730	21.7	11.7	0.895	0.987	1.882	1.91	6.153	1.435	0.448
16	0.3616	39.970	21.9	12.7	0.895	0.982	1.877	1.91	6.158	1.430	0.448
17	0.3994	40.350	22.3	14.0	0.896	0.986	1.882	1.91	6.154	1.434	0.448
18	0.4265	40.550	22.5	15.0	0.894	0.981	1.875	1.91	6.159	1.428	0.447

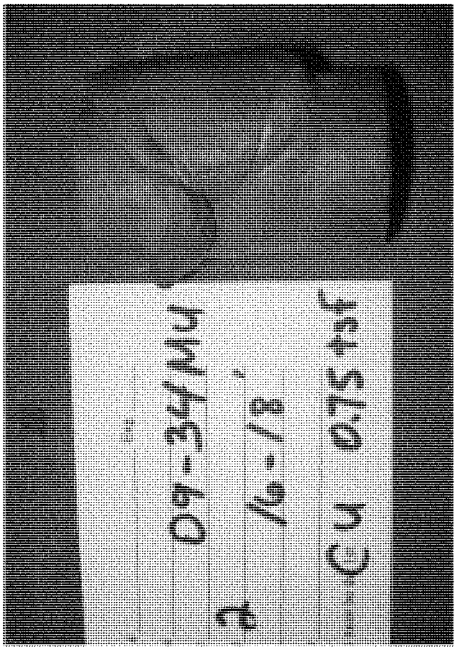
Parameters for Specimen No. 3

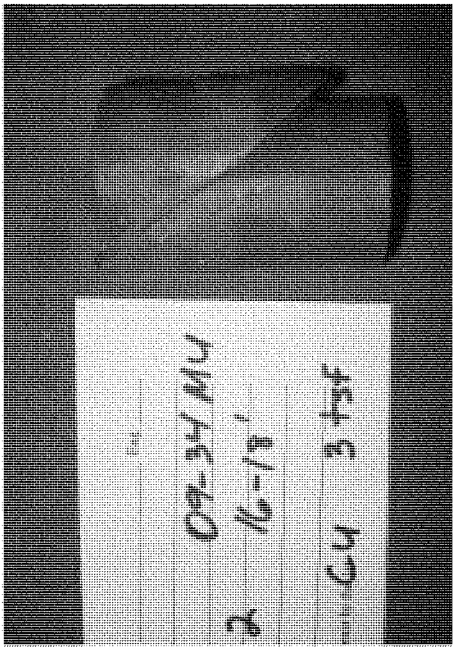
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	116.730			142.610
Moisture content: Dry soil+tare, gms.	83.650			101.810
Moisture content: Tare, gms.	30.360			30.000
Moisture, %	62.1	62.0	57.9	56.8
Moist specimen weight, gms.	115.4			
Diameter, in.	1.39	1.39	1.37	
Area, in.²	1.53	1.53	1.48	
Height, in.	2.82	2.82	2.78	
Net decrease in height, in.		0.00	0.04	
Wet Density, pcf	102.2	102.2	103.9	
Dry density, pcf	63.0	63.0	65.8	
Void ratio	1.6777	1.6777	1.5649	
Saturation, %	100.0	100.0	100.0	

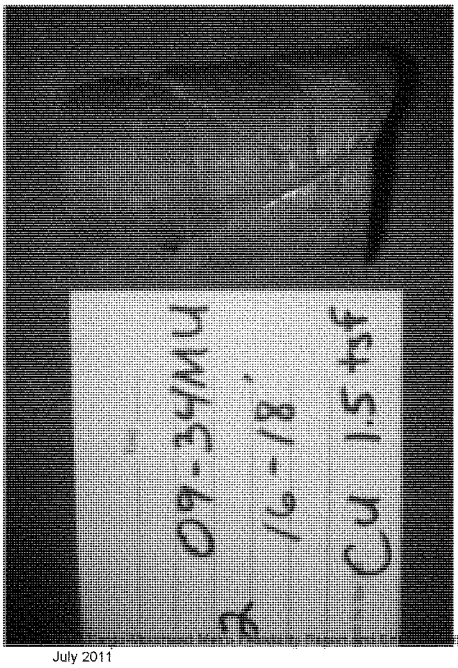
Test Readings for Specimen No. 3

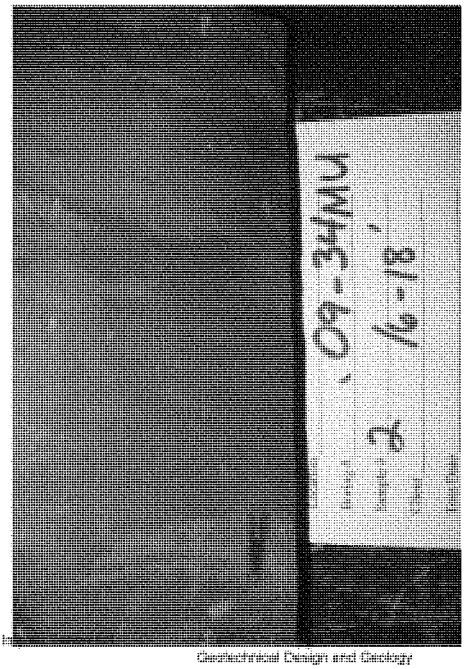
Consolidation cell pressure = 7.142 tsf
Consolidation back pressure = 4.128 tsf
Consolidation effective confining stress = 3.014 tsf
Peak Stress = 1.444 tsf **at reading no.** 5
Ult. Stress = 1.193 tsf **at reading no.** 18

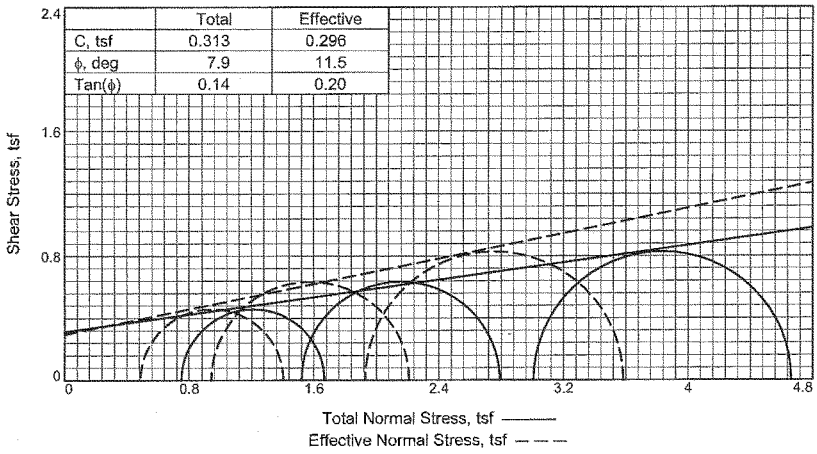
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0051	19.920	0.0	0.0	0.000	3.014	3.014	1.00	4.128	3.014	0.000
1	0.0069	24.740	4.8	0.1	0.234	2.840	3.074	1.08	4.302	2.957	0.117
2	0.0099	30.880	11.0	0.2	0.531	2.663	3.194	1.20	4.479	2.929	0.266
3	0.0257	46.350	26.4	0.7	1.274	2.123	3.397	1.60	5.019	2.760	0.637
4	0.0507	50.050	30.1	1.6	1.439	1.978	3.417	1.73	5.164	2.697	0.719
5	0.0748	50.430	30.5	2.5	1.444	2.019	3.463	1.72	5.123	2.741	0.722
6	0.0987	50.540	30.6	3.4	1.437	2.039	3.476	1.70	5.103	2.757	0.718
7	0.1305	50.430	30.5	4.5	1.415	2.054	3.469	1.69	5.088	2.761	0.707
8	0.1553	50.510	30.6	5.4	1.405	2.054	3.459	1.68	5.088	2.756	0.702
9	0.1822	49.020	29.1	6.4	1.323	2.060	3.383	1.64	5.082	2.721	0.661
10	0.2091	48.490	28.6	7.3	1.285	2.041	3.326	1.63	5.101	2.684	0.643
11	0.2362	47.990	28.1	8.3	1.250	2.013	3.263	1.62	5.129	2.638	0.625
12	0.2629	48.030	28.1	9.3	1.238	2.023	3.261	1.61	5.119	2.642	0.619
13	0.2899	48.040	28.1	10.2	1.225	2.010	3.235	1.61	5.132	2.623	0.613
14	0.3257	47.990	28.1	11.5	1.206	1.995	3.201	1.60	5.147	2.598	0.603
15	0.3537	48.350	28.4	12.5	1.207	1.986	3.193	1.61	5.156	2.590	0.604
16	0.3815	48.410	28.5	13.5	1.196	1.981	3.177	1.60	5.161	2.579	0.598
17	0.4085	48.920	29.0	14.5	1.204	1.964	3.168	1.61	5.178	2.566	0.602
18	0.4220	48.820	28.9	15.0	1.193	1.962	3.155	1.61	5.180	2.558	0.596


09-34MW
2
16-18'
Cu 0.75 tsf

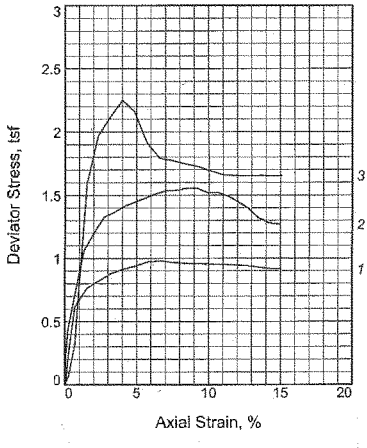

09-34MW
2
16-18'
Cu 3 tsf


09-34MW
2
16-18'
Cu 1.5 tsf


09-34MW
2
16-18'



	Total	Effective
C, tsf	0.313	0.296
ϕ, deg	7.9	11.5
Tan(ϕ)	0.14	0.20



Sample No.		1	2	3
Initial	Water Content, %	39.5	38.1	39.1
	Dry Density, pcf	82.2	83.8	82.3
	Saturation, %	99.9	99.9	99.0
	Void Ratio	1.0875	1.0479	1.0849
	Diameter, in.	1.41	1.40	1.40
	Height, in.	2.82	2.82	2.80
At Test	Water Content, %	39.4	38.1	38.6
	Dry Density, pcf	82.4	83.8	83.2
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.0831	1.0479	1.0627
	Diameter, in.	1.41	1.40	1.40
	Height, in.	2.81	2.82	2.79
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.75	1.51	3.01
Back Pressure, tsf		6.39	5.62	4.13
Cell Pressure, tsf		7.14	7.13	7.14
Peak Deviator Stress, tsf		0.98	1.56	2.25
Total Pore Pr., tsf		6.88	6.43	5.55
Ultimate Deviator Stress, tsf		0.92	1.27	1.66
Total Pore Pr., tsf		6.65	6.20	5.21
Maj. Eff. Stress at Ultimate, tsf		1.40	2.21	3.58
Min. Eff. Stress at Ultimate, tsf		0.49	0.94	1.93

Type of Test:
CU with Pore Pressures

Sample Type: Thinwall, 5", Top of sample

Description: FAT CLAY, brown (CH)

LL= 89 **PL=** 21 **PI=** 68

Assumed Specific Gravity= 2.75

Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Figure: CU Triax ASTM D 4767

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Fargo

Location: WD-28, ND Div Oxidized Brenna

Sample Number: Boring 09-59MU, #1 **Depth:** 10-12'

Proj. No.: BL0903127A **Date Sampled:**

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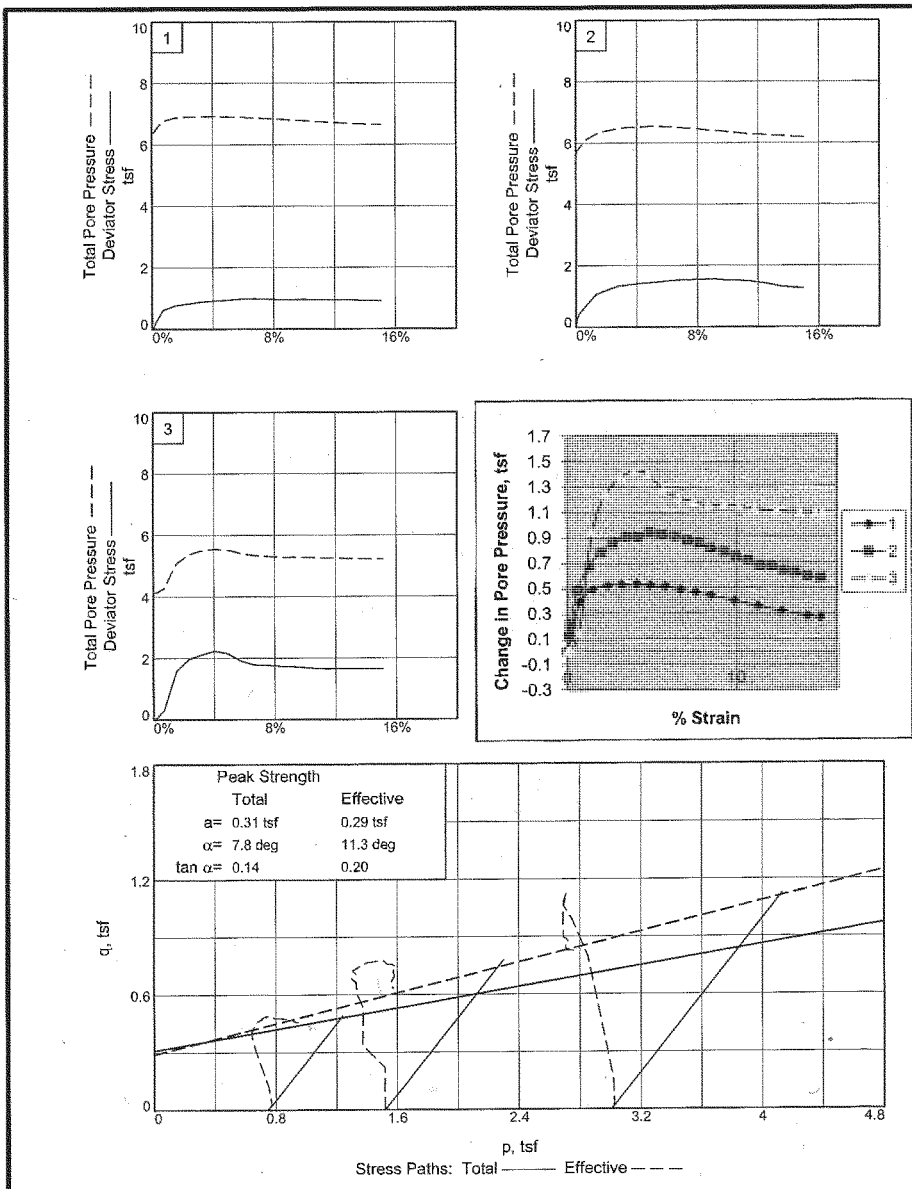

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study Fargo Oxidized Brenna

Location: WD-28, ND Div **Depth:** 10-12' **Sample Number:** Boring 09-59MU, #1

Project No.: BL09031274 **Figure**

Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

2/23/2010
11:03 AM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL0903127A
Location: WD-28, ND Div
Depth: 10-12'
Sample Number: Boring 09-59MU, #1
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is 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", Top of sample
Assumed Specific Gravity=2.75 **LL=**89 **PL=**21 **PI=**68
Test Method: COE uniform strain

Fargo
Oxidized Brenna

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	144.800			162.820
Moisture content: Dry soil+tare, gms.	112.610			125.690
Moisture content: Tare, gms.	31.100			30.690
Moisture, %	39.5	39.5	39.4	39.1
Moist specimen weight, gms.	132.0			
Diameter, in.	1.41	1.41	1.41	
Area, in.^{2}	1.56	1.56	1.55	
Height, in.	2.82	2.82	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	114.7	114.8	114.9	
Dry density, pcf	82.2	82.2	82.4	
Void ratio	1.0875	1.0875	1.0831	
Saturation, %	99.9	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 6.390 tsf
Consolidation effective confining stress = 0.750 tsf
Fail. Stress = 0.980 tsf **at reading no.** 10
Ult. Stress = 0.916 tsf **at reading no.** 17

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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	0.0082	18.670	0.0	0.0	0.000	0.750	0.750	1.00	6.390	0.750	0.000
1	0.0110	19.950	1.3	0.1	0.059	0.745	0.804	1.08	6.395	0.775	0.030
2	0.0151	23.830	5.2	0.2	0.238	0.635	0.873	1.38	6.505	0.754	0.119
3	0.0278	31.980	13.3	0.7	0.612	0.362	0.974	2.69	6.778	0.668	0.306
4	0.0508	35.430	16.8	1.5	0.764	0.260	1.024	3.94	6.880	0.642	0.382
5	0.0746	36.820	18.1	2.4	0.821	0.230	1.051	4.57	6.910	0.640	0.410
6	0.0985	38.290	19.6	3.2	0.879	0.221	1.100	4.98	6.919	0.661	0.440
7	0.1225	39.240	20.6	4.1	0.914	0.214	1.128	5.27	6.926	0.671	0.457
8	0.1462	39.960	21.3	4.9	0.938	0.228	1.166	5.11	6.912	0.697	0.469
9	0.1712	40.920	22.3	5.8	0.971	0.238	1.209	5.08	6.902	0.723	0.485
10	0.1962	41.350	22.7	6.7	0.980	0.265	1.245	4.70	6.875	0.755	0.490
11	0.2211	41.260	22.6	7.6	0.967	0.284	1.251	4.40	6.856	0.767	0.483
12	0.2469	41.300	22.6	8.5	0.959	0.310	1.269	4.09	6.830	0.790	0.480
13	0.2868	41.570	22.9	9.9	0.955	0.352	1.307	3.71	6.788	0.830	0.478
14	0.3258	41.800	23.1	11.3	0.950	0.395	1.345	3.41	6.745	0.870	0.475
15	0.3665	41.930	23.3	12.7	0.940	0.435	1.375	3.16	6.705	0.905	0.470
16	0.4065	41.750	23.1	14.2	0.917	0.473	1.390	2.94	6.667	0.932	0.459
17	0.4314	41.960	23.3	15.0	0.916	0.487	1.403	2.88	6.653	0.945	0.458

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	153.500			161.920
Moisture content: Dry soil+tare, gms.	119.480			125.650
Moisture content: Tare, gms.	30.100			30.310
Moisture, %	38.1	38.1	38.1	38.0
Moist specimen weight, gms.	132.1			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.54	1.54	1.54	
Height, in.	2.82	2.82	2.82	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	115.7	115.8	115.8	
Dry density, pcf	83.8	83.8	83.8	
Void ratio	1.0479	1.0479	1.0479	
Saturation, %	99.9	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.135 tsf
Consolidation back pressure = 5.615 tsf
Consolidation effective confining stress = 1.520 tsf
Fail. Stress = 1.557 tsf **at reading no.** 14
Ult. Stress = 1.269 tsf **at reading no.** 23

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	0.0215	19.580	0.0	0.0	0.000	1.520	1.520	1.00	5.615	1.520	0.000
1	0.0233	24.830	5.3	0.1	0.245	1.393	1.638	1.18	5.742	1.515	0.122
2	0.0276	28.980	9.4	0.2	0.437	1.301	1.738	1.34	5.834	1.520	0.219
3	0.0395	34.160	14.6	0.6	0.676	1.034	1.710	1.65	6.101	1.372	0.338
4	0.0588	42.750	23.2	1.3	1.066	0.842	1.908	2.27	6.293	1.375	0.533
5	0.0792	45.920	26.3	2.0	1.203	0.733	1.936	2.64	6.402	1.335	0.602
6	0.0988	48.850	29.3	2.7	1.328	0.664	1.992	3.00	6.471	1.328	0.664
7	0.1193	49.970	30.4	3.5	1.368	0.614	1.982	3.23	6.521	1.298	0.684
8	0.1399	51.290	31.7	4.2	1.417	0.617	2.034	3.30	6.518	1.325	0.708
9	0.1604	52.240	32.7	4.9	1.448	0.581	2.029	3.49	6.554	1.305	0.724
10	0.1804	53.200	33.6	5.6	1.480	0.597	2.077	3.48	6.538	1.337	0.740
11	0.2008	54.220	34.6	6.4	1.513	0.609	2.122	3.48	6.526	1.365	0.756
12	0.2214	55.060	35.5	7.1	1.537	0.642	2.179	3.39	6.493	1.411	0.769
13	0.2419	55.390	35.8	7.8	1.539	0.665	2.204	3.31	6.470	1.435	0.770
14	0.2614	56.080	36.5	8.5	1.557	0.707	2.264	3.20	6.428	1.486	0.779
15	0.2822	56.300	36.7	9.3	1.554	0.734	2.288	3.12	6.401	1.511	0.777
16	0.3019	55.750	36.2	10.0	1.519	0.773	2.292	2.97	6.362	1.532	0.759
17	0.3221	56.030	36.5	10.7	1.519	0.804	2.323	2.89	6.331	1.563	0.759
18	0.3420	55.640	36.1	11.4	1.490	0.847	2.337	2.76	6.288	1.592	0.745
19	0.3615	54.820	35.2	12.1	1.445	0.850	2.295	2.70	6.285	1.573	0.723
20	0.3810	53.920	34.3	12.8	1.397	0.883	2.280	2.58	6.252	1.582	0.699
21	0.4015	52.280	32.7	13.5	1.319	0.898	2.217	2.47	6.237	1.558	0.660
22	0.4214	51.590	32.0	14.2	1.281	0.927	2.208	2.38	6.208	1.567	0.640
23	0.4431	51.590	32.0	15.0	1.269	0.940	2.209	2.35	6.195	1.575	0.635

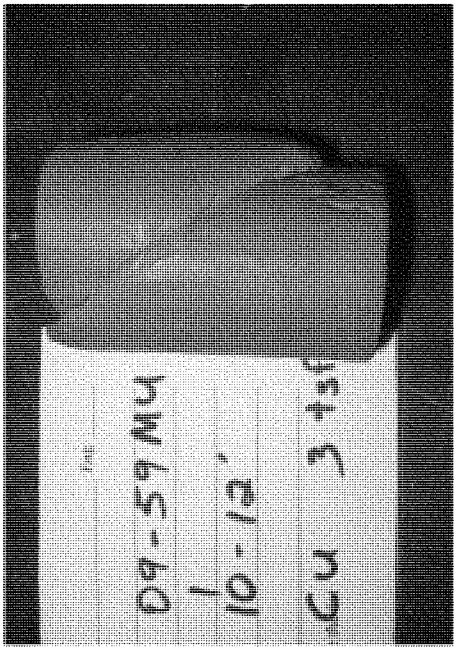
Parameters for Specimen No. 3

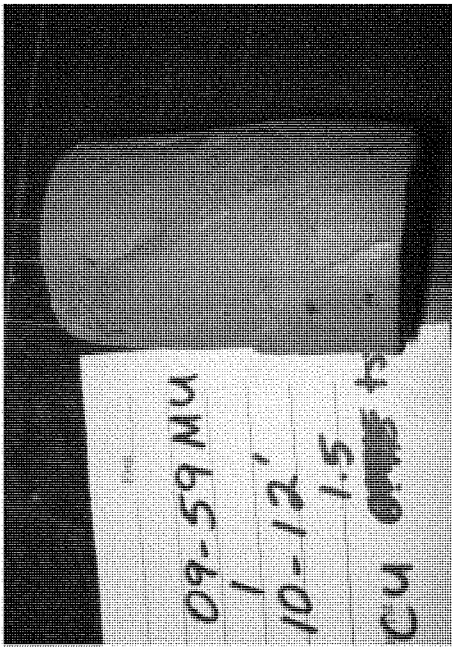
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	177.500			158.580
Moisture content: Dry soil+tare, gms.	136.410			123.950
Moisture content: Tare, gms.	31.200			30.800
Moisture, %	39.1	39.5	38.6	37.2
Moist specimen weight, gms.	130.5			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.55	1.55	1.54	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	114.5	114.8	115.4	
Dry density, pcf	82.3	82.3	83.2	
Void ratio	1.0849	1.0849	1.0627	
Saturation, %	99.0	100.0	100.0	

Test Readings for Specimen No. 3

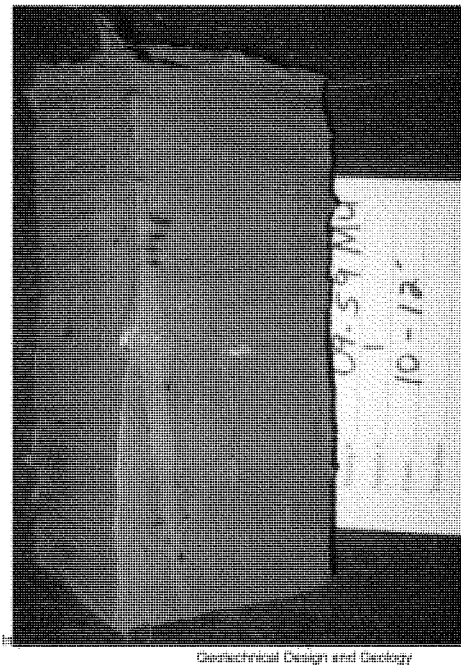
Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 4.133 tsf
Consolidation effective confining stress = 3.007 tsf
Fail. Stress = 2.249 tsf **at reading no.** 7
Ult. Stress = 1.656 tsf **at reading no.** 19

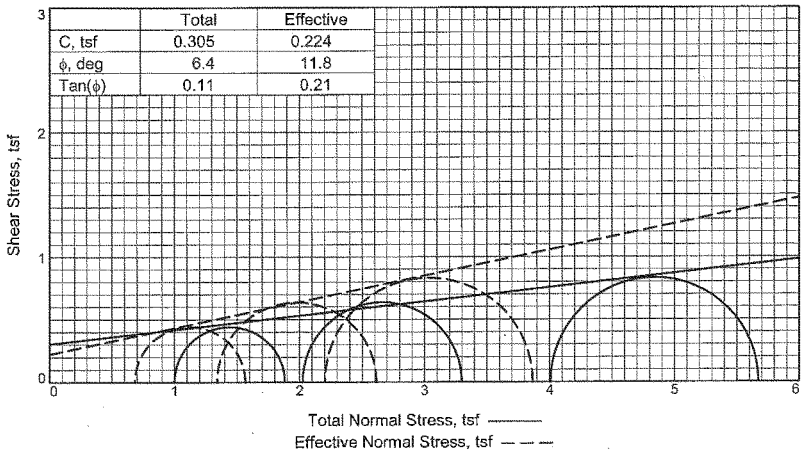
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0070	17.780	0.0	0.0	0.000	3.007	3.007	1.00	4.133	3.007	0.000
1	0.0099	18.520	0.7	0.1	0.035	3.001	3.036	1.01	4.139	3.018	0.017
2	0.0138	19.100	1.3	0.2	0.062	2.993	3.055	1.02	4.147	3.024	0.031
3	0.0267	24.590	6.8	0.7	0.317	2.860	3.177	1.11	4.280	3.018	0.158
4	0.0495	52.270	34.5	1.5	1.591	2.058	3.649	1.77	5.082	2.853	0.795
5	0.0725	60.880	43.1	2.3	1.971	1.765	3.736	2.12	5.375	2.751	0.986
6	0.0955	64.510	46.7	3.2	2.120	1.633	3.753	2.30	5.507	2.693	1.060
7	0.1193	67.810	50.0	4.0	2.249	1.586	3.835	2.42	5.554	2.711	1.125
8	0.1423	66.280	48.5	4.8	2.162	1.610	3.772	2.34	5.530	2.691	1.081
9	0.1671	61.090	43.3	5.7	1.912	1.731	3.643	2.10	5.409	2.687	0.956
10	0.1920	58.710	40.9	6.6	1.790	1.797	3.587	2.00	5.343	2.692	0.895
11	0.2168	58.710	40.9	7.5	1.773	1.826	3.599	1.97	5.314	2.713	0.887
12	0.2418	58.440	40.7	8.4	1.744	1.855	3.599	1.94	5.285	2.727	0.872
13	0.2656	58.410	40.6	9.3	1.727	1.848	3.575	1.93	5.292	2.711	0.863
14	0.2917	57.920	40.1	10.2	1.689	1.861	3.550	1.91	5.279	2.705	0.844
15	0.3164	57.590	39.8	11.1	1.658	1.885	3.543	1.88	5.255	2.714	0.829
16	0.3544	58.120	40.3	12.4	1.655	1.899	3.554	1.87	5.241	2.726	0.827
17	0.3914	58.760	41.0	13.8	1.655	1.914	3.569	1.86	5.226	2.742	0.828
18	0.4164	59.120	41.3	14.7	1.653	1.918	3.571	1.86	5.222	2.744	0.826
19	0.4292	59.420	41.6	15.1	1.656	1.927	3.583	1.86	5.213	2.755	0.828


09-59 MW
1
10-12'

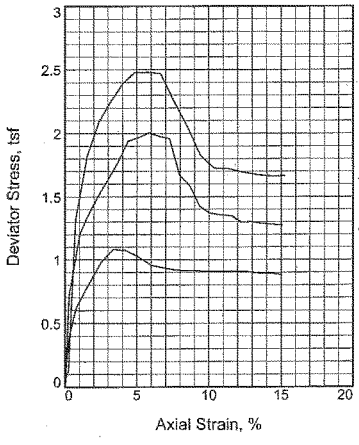

09-59 MW
1
10-12'

09-59 MW
1
10-12'


09-59 MW
1
10-12'



	Total	Effective
C, tsf	0.305	0.224
ϕ, deg	6.4	11.8
Tan(ϕ)	0.11	0.21



Sample No.		1	2	3
Initial	Water Content, %	47.5	48.0	50.4
	Dry Density, pcf	74.2	74.0	71.8
	Saturation, %	99.4	100.0	99.8
	Void Ratio	1.3147	1.3201	1.3906
	Diameter, in.	1.40	1.40	1.40
	Height, in.	2.81	2.82	2.81
At Test	Water Content, %	47.8	46.7	47.8
	Dry Density, pcf	74.2	75.2	74.2
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.3147	1.2831	1.3147
	Diameter, in.	1.40	1.39	1.38
	Height, in.	2.81	2.80	2.79
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		1.00	2.03	4.01
Back Pressure, tsf		6.14	5.11	3.13
Cell Pressure, tsf		7.14	7.14	7.14
Peak Deviator Stress, tsf		1.08	2.00	2.48
Total Pore Pr., tsf		6.68	6.13	5.03
Ultimate Deviator Stress, tsf		0.88	1.27	1.66
Total Pore Pr., tsf		6.46	5.80	4.94
Maj. Eff. Stress at Ultimate, tsf		1.57	2.61	3.87
Min. Eff. Stress at Ultimate, tsf		0.68	1.34	2.20

Type of Test:
CU with Pore Pressures
Sample Type: Thinwall, 5", Top of sample
Description: FAT CLAY, brown (CH)

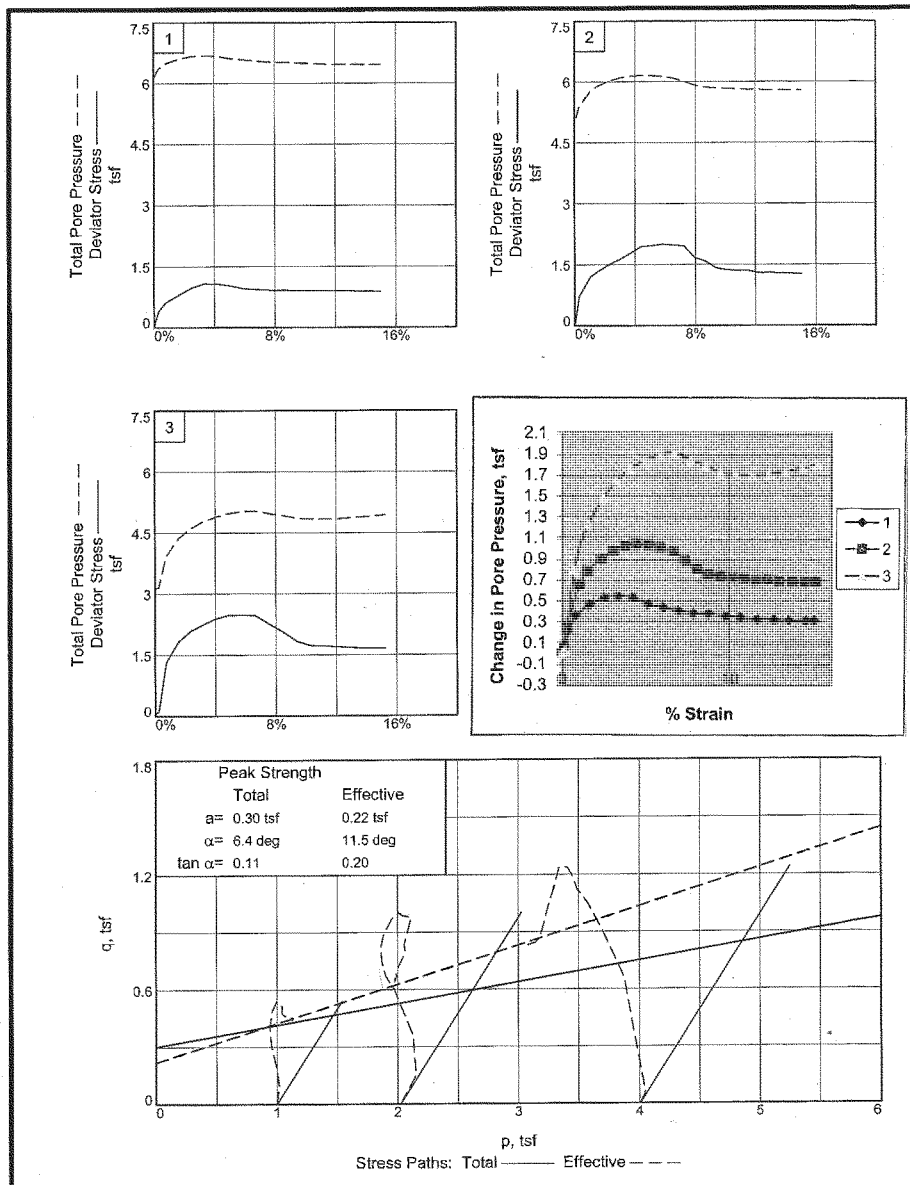
LL= 92 **PL=** 19 **PI=** 73
Assumed Specific Gravity= 2.75
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Fargo
Location: WD-28, ND Div Oxidized Brenna
Sample Number: Boring 09-59MU, #2 **Depth:** 20-22'
Proj. No.: BL0903127A **Date Sampled:**

BRAUN INTERTEC

Figure C-Fargo, Ad-1M-14-765



Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study Fargo Oxidized Brenna

Location: WD-28, ND Div **Depth:** 20-22' **Sample Number:** Boring 09-59MU, #2

Project No.: BL0903 M7A **Figure** **Braun Intertec**

Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

2/23/2010
11:04 AM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL0903127A
Location: WD-28, ND Div
Depth: 20-22'
Sample Number: Boring 09-59MU, #2
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is 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", Top of sample
Assumed Specific Gravity=2.75 **LL=**92 **PL=**19 **PI=**73
Test Method: COE uniform strain

Fargo
Oxidized Brenna

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	154.800			154.010
Moisture content: Dry soil+tare, gms.	114.700			114.370
Moisture content: Tare, gms.	30.290			30.710
Moisture, %	47.5	47.8	47.8	47.4
Moist specimen weight, gms.	124.4			
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	109.4	109.6	109.6	
Dry density, pcf	74.2	74.2	74.2	
Void ratio	1.3147	1.3147	1.3147	
Saturation, %	99.4	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 6.141 tsf
Consolidation effective confining stress = 0.999 tsf
Fail. Stress = 1.080 tsf **at reading no.** 6
Ult. Stress = 0.882 tsf **at reading no.** 19

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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	0.0066	17.970	0.0	0.0	0.000	0.999	0.999	1.00	6.141	0.999	0.000
1	0.0100	22.030	4.1	0.1	0.189	0.922	1.111	1.21	6.218	1.017	0.095
2	0.0150	26.570	8.6	0.3	0.400	0.793	1.193	1.51	6.347	0.993	0.200
3	0.0288	31.370	13.4	0.8	0.621	0.641	1.262	1.97	6.499	0.951	0.310
4	0.0528	35.490	17.5	1.6	0.805	0.537	1.342	2.50	6.603	0.939	0.402
5	0.0768	39.390	21.4	2.5	0.975	0.472	1.447	3.07	6.668	0.960	0.488
6	0.1006	41.900	23.9	3.3	1.080	0.457	1.537	3.36	6.683	0.997	0.540
7	0.1245	41.980	24.0	4.2	1.074	0.470	1.544	3.29	6.670	1.007	0.537
8	0.1501	41.070	23.1	5.1	1.024	0.531	1.555	2.93	6.609	1.043	0.512
9	0.1746	39.730	21.8	6.0	0.956	0.563	1.519	2.70	6.577	1.041	0.478
10	0.2002	39.480	21.5	6.9	0.935	0.590	1.525	2.59	6.550	1.058	0.468
11	0.2261	39.270	21.3	7.8	0.917	0.617	1.534	2.49	6.523	1.076	0.459
12	0.2510	39.430	21.5	8.7	0.915	0.619	1.534	2.48	6.521	1.077	0.458
13	0.2779	39.540	21.6	9.7	0.910	0.642	1.552	2.42	6.498	1.097	0.455
14	0.3058	39.700	21.7	10.6	0.907	0.652	1.559	2.39	6.488	1.105	0.453
15	0.3328	39.970	22.0	11.6	0.908	0.671	1.579	2.35	6.469	1.125	0.454
16	0.3597	40.180	22.2	12.6	0.907	0.673	1.580	2.35	6.467	1.126	0.453
17	0.3867	40.080	22.1	13.5	0.893	0.681	1.574	2.31	6.459	1.127	0.446
18	0.4137	40.240	22.3	14.5	0.889	0.685	1.574	2.30	6.455	1.130	0.445
19	0.4277	40.190	22.2	15.0	0.882	0.683	1.565	2.29	6.457	1.124	0.441

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	155.950			152.610
Moisture content: Dry soil+tare, gms.	115.190			115.080
Moisture content: Tare, gms.	30.300			30.410
Moisture, %	48.0	48.0	46.7	44.3
Moist specimen weight, gms.	124.5			
Diameter, in.	1.40	1.40	1.39	
Area, in.²	1.54	1.54	1.52	
Height, in.	2.82	2.82	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	109.5	109.5	110.3	
Dry density, pcf	74.0	74.0	75.2	
Void ratio	1.3201	1.3201	1.2831	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.138 tsf
Consolidation back pressure = 5.114 tsf
Consolidation effective confining stress = 2.024 tsf
Fail. Stress = 2.004 tsf **at reading no.** 10
Ult. Stress = 1.274 tsf **at reading no.** 23

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	0.0221	15.630	0.0	0.0	0.000	2.024	2.024	1.00	5.114	2.024	0.000
1	0.0259	21.970	6.3	0.1	0.300	2.000	2.300	1.15	5.138	2.150	0.150
2	0.0306	30.890	15.3	0.3	0.720	1.766	2.486	1.41	5.372	2.126	0.360
3	0.0511	41.290	25.7	1.0	1.202	1.372	2.574	1.88	5.766	1.973	0.601
4	0.0650	44.260	28.6	1.5	1.335	1.237	2.572	2.08	5.901	1.904	0.667
5	0.0855	47.980	32.3	2.3	1.497	1.120	2.617	2.34	6.018	1.868	0.748
6	0.1061	51.290	35.7	3.0	1.638	1.041	2.679	2.57	6.097	1.860	0.819
7	0.1259	54.600	39.0	3.7	1.777	0.997	2.774	2.78	6.141	1.885	0.888
8	0.1451	58.490	42.9	4.4	1.940	0.981	2.921	2.98	6.157	1.951	0.970
9	0.1661	59.450	43.8	5.1	1.968	0.987	2.955	2.99	6.151	1.971	0.984
10	0.1855	60.590	45.0	5.8	2.004	1.009	3.013	2.99	6.129	2.011	1.002
11	0.2060	60.310	44.7	6.6	1.976	1.050	3.026	2.88	6.088	2.038	0.988
12	0.2256	60.240	44.6	7.3	1.959	1.132	3.091	2.73	6.006	2.111	0.979
13	0.2448	53.970	38.3	8.0	1.671	1.218	2.889	2.37	5.920	2.053	0.835
14	0.2648	52.340	36.7	8.7	1.587	1.270	2.857	2.25	5.868	2.064	0.794
15	0.2843	48.790	33.2	9.4	1.423	1.286	2.709	2.11	5.852	1.997	0.711
16	0.3040	47.820	32.2	10.1	1.371	1.301	2.672	2.05	5.837	1.986	0.685
17	0.3246	47.720	32.1	10.8	1.355	1.309	2.664	2.04	5.829	1.987	0.678
18	0.3452	47.870	32.2	11.5	1.350	1.325	2.675	2.02	5.813	2.000	0.675
19	0.3647	46.840	31.2	12.2	1.297	1.323	2.620	1.98	5.815	1.971	0.648
20	0.3843	47.220	31.6	12.9	1.302	1.333	2.635	1.98	5.805	1.984	0.651
21	0.4050	47.130	31.5	13.7	1.287	1.333	2.620	1.97	5.805	1.977	0.644
22	0.4248	47.260	31.6	14.4	1.282	1.340	2.622	1.96	5.798	1.981	0.641
23	0.4440	47.310	31.7	15.1	1.274	1.340	2.614	1.95	5.798	1.977	0.637

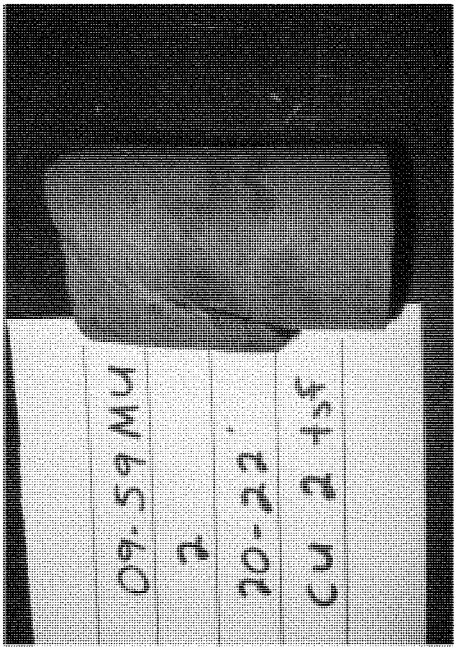
Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	169.890			147.120
Moisture content: Dry soil+tare, gms.	123.250			111.530
Moisture content: Tare, gms.	30.800			30.340
Moisture, %	50.4	50.6	47.8	43.8
Moist specimen weight, gms.	122.0			
Diameter, in.	1.40	1.40	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	0.03	
Wet Density, pcf	108.0	108.1	109.6	
Dry density, pcf	71.8	71.8	74.2	
Void ratio	1.3906	1.3906	1.3147	
Saturation, %	99.8	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 3.132 tsf
Consolidation effective confining stress = 4.008 tsf
Fail. Stress = 2.481 tsf **at reading no.** 9
Ult. Stress = 1.664 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	0.0061	17.330	0.0	0.0	0.000	4.008	4.008	1.00	3.132	4.008	0.000
1	0.0092	19.280	2.0	0.1	0.094	3.995	4.089	1.02	3.145	4.042	0.047
2	0.0130	19.920	2.6	0.2	0.124	3.985	4.109	1.03	3.155	4.047	0.062
3	0.0268	44.980	27.6	0.7	1.321	3.215	4.536	1.41	3.925	3.876	0.661
4	0.0488	55.810	38.5	1.5	1.824	2.779	4.603	1.66	4.361	3.691	0.912
5	0.0719	61.860	44.5	2.4	2.093	2.534	4.627	1.83	4.606	3.580	1.046
6	0.0949	65.610	48.3	3.2	2.250	2.363	4.613	1.95	4.777	3.488	1.125
7	0.1184	69.120	51.8	4.0	2.392	2.249	4.641	2.06	4.891	3.445	1.196
8	0.1413	71.410	54.1	4.9	2.477	2.168	4.645	2.14	4.972	3.406	1.238
9	0.1663	72.030	54.7	5.8	2.481	2.114	4.595	2.17	5.026	3.355	1.241
10	0.1913	72.330	55.0	6.6	2.471	2.102	4.573	2.18	5.038	3.338	1.236
11	0.2172	68.020	50.7	7.6	2.255	2.166	4.421	2.04	4.974	3.293	1.127
12	0.2433	63.900	46.6	8.5	2.051	2.219	4.270	1.92	4.921	3.244	1.025
13	0.2681	59.230	41.9	9.4	1.827	2.284	4.111	1.80	4.856	3.198	0.914
14	0.2939	57.310	40.0	10.3	1.726	2.306	4.032	1.75	4.834	3.169	0.863
15	0.3211	57.680	40.4	11.3	1.723	2.305	4.028	1.75	4.835	3.166	0.861
16	0.3489	57.440	40.1	12.3	1.693	2.296	3.989	1.74	4.844	3.143	0.847
17	0.3771	57.420	40.1	13.3	1.673	2.264	3.937	1.74	4.876	3.100	0.836
18	0.4038	57.600	40.3	14.3	1.662	2.239	3.901	1.74	4.901	3.070	0.831
19	0.4307	58.130	40.8	15.2	1.664	2.202	3.866	1.76	4.938	3.034	0.832


09-59 MW
2
20-22'
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09-59 MW
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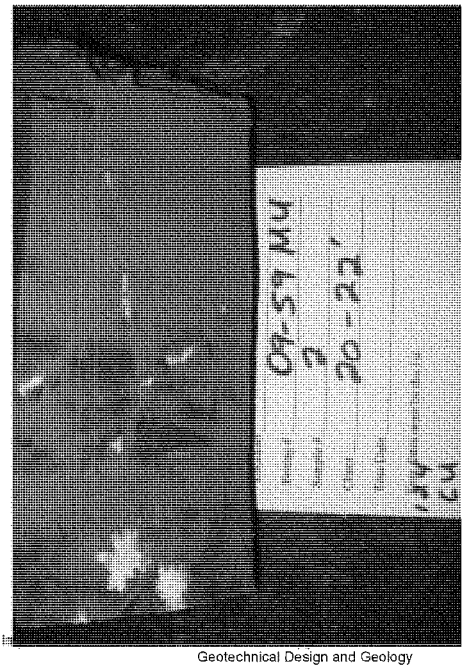
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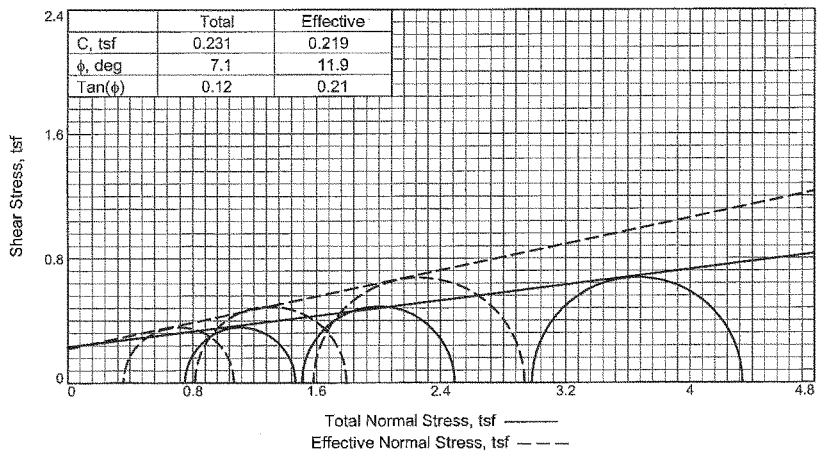
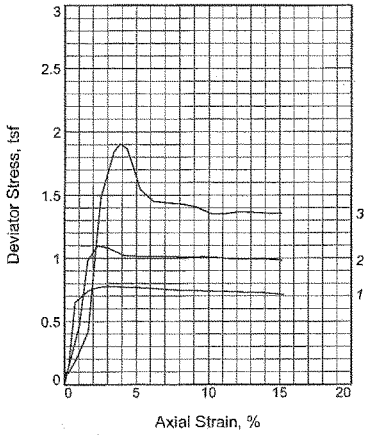


	Total	Effective
C, tsf	0.231	0.219
ϕ, deg	7.1	11.9
Tan(ϕ)	0.12	0.21



Sample No.		1	2	3
Initial	Water Content, %	59.1	59.5	58.7
	Dry Density, pcf	65.1	64.9	65.7
	Saturation, %	99.1	99.4	100.0
	Void Ratio	1.6381	1.6451	1.6144
	Diameter, in.	1.41	1.40	1.40
	Height, in.	2.79	2.80	2.80
At Test	Water Content, %	59.3	59.5	56.7
	Dry Density, pcf	65.3	65.1	67.1
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.6296	1.6366	1.5586
	Diameter, in.	1.41	1.40	1.39
	Height, in.	2.79	2.79	2.78
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.75	1.51	2.98
Back Pressure, tsf		6.39	5.63	4.16
Cell Pressure, tsf		7.14	7.14	7.14
Peak Deviator Stress, tsf		0.78	1.10	1.90
Total Pore Pr., tsf		6.89	6.44	5.69
Ultimate Deviator Stress, tsf		0.71	0.98	1.35
Total Pore Pr., tsf		6.78	6.33	5.56
Maj. Eff. Stress at Ultimate, tsf		1.07	1.79	2.94
Min. Eff. Stress at Ultimate, tsf		0.36	0.81	1.58

Type of Test: CU with Pore Pressures

Sample Type: Thinwall, 5", Top of sample

Description: FAT CLAY, brown (CH)

LL= 113 **PL=** 26 **PI=** 87

Assumed Specific Gravity= 2.75

Remarks: The rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

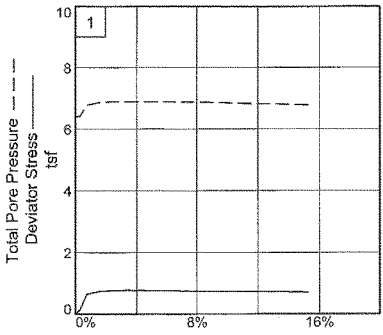
Fargo Oxidized Brenna

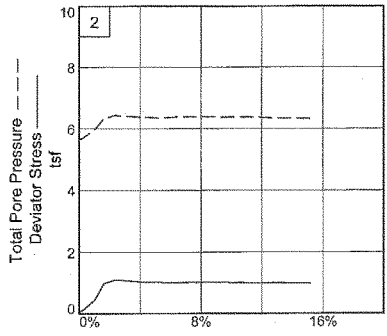
Location: WD-05, ND Div, ~~Sheyenne Formation~~

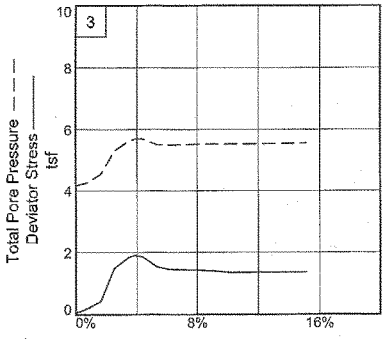
Sample Number: Boring 09-60MU, #1 **Depth:** 15-17'

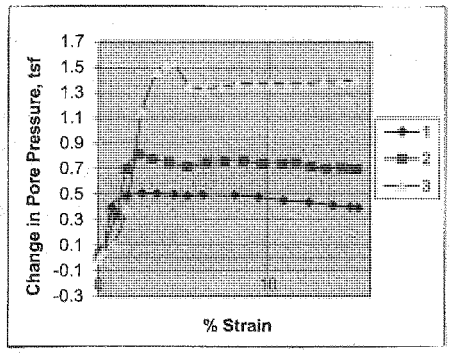
Proj. No.: BL0903127A **Date Sampled:**

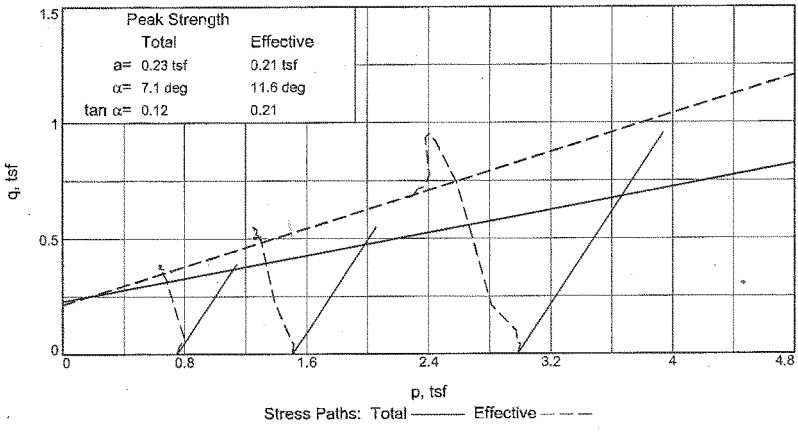
BRAUN INTERTEC











Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study Fargo Oxidized Brenna

Loc.: WD-05, ND Div, Sherack Formation **Depth:** 15-17' **Sample No.:** Boring 09-60MU, #1

Project No.: [illegible] Feasibility Report and Environmental Impact Statement **Figure**

July 2011

Braun Intertec

Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

2/23/2010
11:02 AM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL0903127A
Location: WD-05, ND Div, ~~Sheyenne Formation~~ Fargo
Depth: 15-17' **Sample Number:** Boring 09-60MU, #1
Description: FAT CLAY, brown (CH) Oxidized Brenna
Remarks: The rate of strain is 0.001 in/min. Failure criteria is 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", Top of sample
Assumed Specific Gravity=2.75 **LL=113** **PL=26** **PI=87**
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	129.000			149.400
Moisture content: Dry soil+tare, gms.	92.130			105.870
Moisture content: Tare, gms.	29.700			31.210
Moisture, %	59.1	59.6	59.3	58.3
Moist specimen weight, gms.	118.0			
Diameter, in.	1.41	1.41	1.41	
Area, in.²	1.55	1.55	1.55	
Height, in.	2.79	2.79	2.79	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	103.5	103.8	104.0	
Dry density, pcf	65.1	65.1	65.3	
Void ratio	1.6381	1.6381	1.6296	
Saturation, %	99.1	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 6.389 tsf
Consolidation effective confining stress = 0.751 tsf
Fail. Stress = 0.777 tsf **at reading no.** 6
Ult. Stress = 0.714 tsf **at reading no.** 16

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	0.0062	17.750	0.0	0.0	0.000	0.751	0.751	1.00	6.389	0.751	0.000
1	0.0092	18.940	1.2	0.1	0.055	0.734	0.789	1.08	6.406	0.762	0.028
2	0.0141	20.750	3.0	0.3	0.139	0.729	0.868	1.19	6.411	0.798	0.069
3	0.0271	31.850	14.1	0.7	0.649	0.354	1.003	2.83	6.786	0.679	0.325
4	0.0519	34.020	16.3	1.6	0.743	0.266	1.009	3.79	6.874	0.637	0.371
5	0.0769	34.850	17.1	2.5	0.773	0.245	1.018	4.16	6.895	0.632	0.387
6	0.1017	35.090	17.3	3.4	0.777	0.248	1.025	4.13	6.892	0.637	0.389
7	0.1276	35.090	17.3	4.4	0.770	0.255	1.025	4.02	6.885	0.640	0.385
8	0.1525	35.200	17.5	5.2	0.767	0.264	1.031	3.91	6.876	0.648	0.384
9	0.1773	35.240	17.5	6.1	0.762	0.256	1.018	3.98	6.884	0.637	0.381
10	0.2291	35.240	17.5	8.0	0.747	0.259	1.006	3.88	6.881	0.632	0.373
11	0.2691	35.400	17.6	9.4	0.742	0.274	1.016	3.71	6.866	0.645	0.371
12	0.3099	35.610	17.9	10.9	0.739	0.300	1.039	3.46	6.840	0.669	0.369
13	0.3516	35.770	18.0	12.4	0.733	0.315	1.048	3.33	6.825	0.681	0.366
14	0.3924	35.950	18.2	13.8	0.728	0.337	1.065	3.16	6.803	0.701	0.364
15	0.4196	35.890	18.1	14.8	0.717	0.352	1.069	3.04	6.788	0.711	0.359
16	0.4328	35.910	18.2	15.3	0.714	0.357	1.071	3.00	6.783	0.714	0.357

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	120.200			146.160
Moisture content: Dry soil+tare, gms.	86.640			103.280
Moisture content: Tare, gms.	30.200			29.810
Moisture, %	59.5	59.8	59.5	58.4
Moist specimen weight, gms.	117.1			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.54	1.54	1.54	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	103.5	103.7	103.9	
Dry density, pcf	64.9	64.9	65.1	
Void ratio	1.6451	1.6451	1.6366	
Saturation, %	99.4	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.138 tsf
Consolidation back pressure = 5.630 tsf
Consolidation effective confining stress = 1.508 tsf
Fail. Stress = 1.101 tsf **at reading no.** 5
Ult. Stress = 0.982 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	0.0208	18.000	0.0	0.0	0.000	1.508	1.508	1.00	5.630	1.508	0.000
1	0.0229	19.960	2.0	0.1	0.092	1.469	1.561	1.06	5.669	1.515	0.046
2	0.0267	20.260	2.3	0.2	0.106	1.451	1.557	1.07	5.687	1.504	0.053
3	0.0493	27.820	9.8	1.0	0.455	1.163	1.618	1.39	5.975	1.390	0.227
4	0.0658	39.280	21.3	1.6	0.980	0.812	1.792	2.21	6.326	1.302	0.490
5	0.0863	42.080	24.1	2.3	1.101	0.699	1.800	2.57	6.439	1.249	0.550
6	0.1069	41.780	23.8	3.1	1.079	0.735	1.814	2.47	6.403	1.274	0.539
7	0.1364	40.790	22.8	4.1	1.023	0.758	1.781	2.35	6.380	1.269	0.511
8	0.1672	40.880	22.9	5.2	1.015	0.792	1.807	2.28	6.346	1.299	0.507
9	0.1972	41.110	23.1	6.3	1.013	0.758	1.771	2.34	6.380	1.265	0.507
10	0.2274	41.410	23.4	7.4	1.015	0.749	1.764	2.35	6.389	1.256	0.507
11	0.2579	41.570	23.6	8.5	1.010	0.748	1.758	2.35	6.390	1.253	0.505
12	0.2901	41.900	23.9	9.6	1.011	0.766	1.777	2.32	6.372	1.271	0.505
13	0.3216	42.040	24.0	10.8	1.004	0.766	1.770	2.31	6.372	1.268	0.502
14	0.3459	42.010	24.0	11.6	0.993	0.759	1.752	2.31	6.379	1.255	0.496
15	0.3706	42.270	24.3	12.5	0.994	0.789	1.783	2.26	6.349	1.286	0.497
16	0.3950	42.510	24.5	13.4	0.994	0.804	1.798	2.24	6.334	1.301	0.497
17	0.4196	42.710	24.7	14.3	0.991	0.802	1.793	2.24	6.336	1.298	0.496
18	0.4364	42.790	24.8	14.9	0.988	0.811	1.799	2.22	6.327	1.305	0.494
19	0.4441	42.730	24.7	15.2	0.982	0.812	1.794	2.21	6.326	1.303	0.491

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	141.200			145.310
Moisture content: Dry soil+tare, gms.	100.210			104.610
Moisture content: Tare, gms.	30.400			30.680
Moisture, %	58.7	58.7	56.7	55.1
Moist specimen weight, gms.	117.7			
Diameter, in.	1.40	1.40	1.39	
Area, in.^{2}	1.54	1.54	1.52	
Height, in.	2.80	2.80	2.78	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	104.2	104.2	105.1	
Dry density, pcf	65.7	65.7	67.1	
Void ratio	1.6144	1.6144	1.5586	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 3

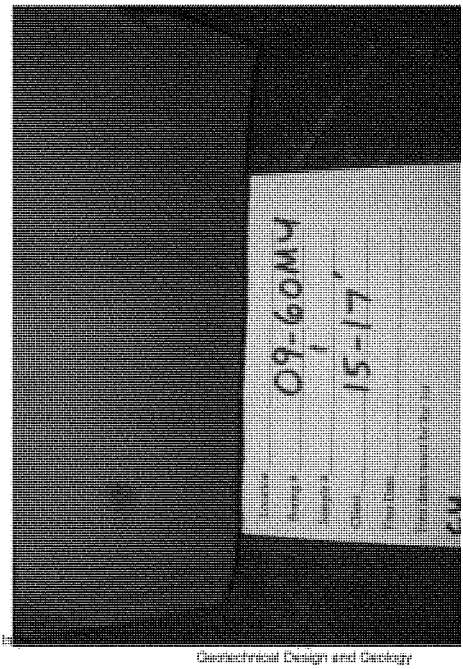
Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 4.157 tsf
Consolidation effective confining stress = 2.983 tsf
Fail. Stress = 1.905 tsf **at reading no.** 7
Ult. Stress = 1.354 tsf **at reading no.** 19

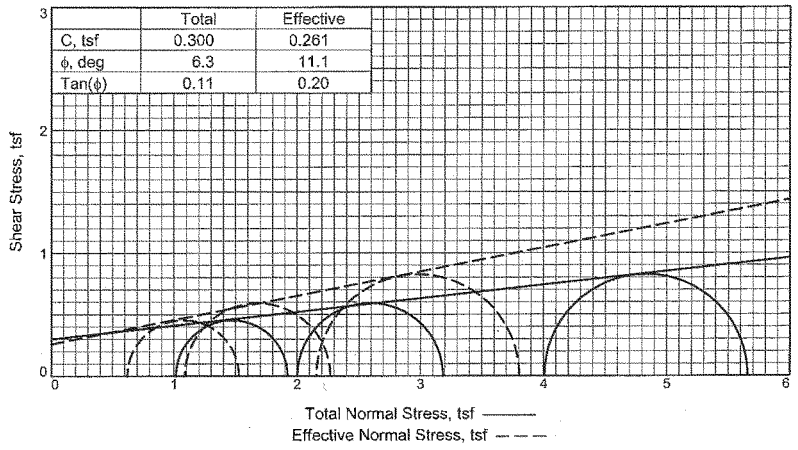
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0062	17.780	0.0	0.0	0.000	2.983	2.983	1.00	4.157	2.983	0.000
1	0.0103	19.620	1.8	0.1	0.087	2.957	3.044	1.03	4.183	3.001	0.044
2	0.0143	19.710	1.9	0.3	0.091	2.934	3.025	1.03	4.206	2.980	0.046
3	0.0288	21.970	4.2	0.8	0.197	2.875	3.072	1.07	4.265	2.974	0.099
4	0.0519	26.790	9.0	1.6	0.421	2.601	3.022	1.16	4.539	2.812	0.211
5	0.0768	49.920	32.1	2.5	1.488	1.837	3.325	1.81	5.303	2.581	0.744
6	0.1017	57.920	40.1	3.4	1.842	1.522	3.364	2.21	5.618	2.443	0.921
7	0.1136	59.480	41.7	3.9	1.905	1.451	3.356	2.31	5.689	2.403	0.952
8	0.1266	58.870	41.1	4.3	1.868	1.443	3.311	2.29	5.697	2.377	0.934
9	0.1525	52.150	34.4	5.3	1.547	1.631	3.178	1.95	5.509	2.405	0.774
10	0.1783	50.350	32.6	6.2	1.452	1.648	3.100	1.88	5.492	2.374	0.726
11	0.2062	50.440	32.7	7.2	1.440	1.636	3.076	1.88	5.504	2.356	0.720
12	0.2339	50.560	32.8	8.2	1.430	1.612	3.042	1.89	5.528	2.327	0.715
13	0.2612	50.320	32.5	9.2	1.404	1.612	3.016	1.87	5.528	2.314	0.702
14	0.2881	49.470	31.7	10.1	1.353	1.613	2.966	1.84	5.527	2.290	0.677
15	0.3157	49.830	32.0	11.1	1.353	1.609	2.962	1.84	5.531	2.286	0.677
16	0.3427	50.560	32.8	12.1	1.369	1.609	2.978	1.85	5.531	2.294	0.685
17	0.3716	50.840	33.1	13.2	1.364	1.599	2.963	1.85	5.541	2.281	0.682
18	0.3998	51.050	33.3	14.2	1.357	1.597	2.954	1.85	5.543	2.275	0.678
19	0.4265	51.360	33.6	15.1	1.354	1.581	2.935	1.86	5.559	2.258	0.677

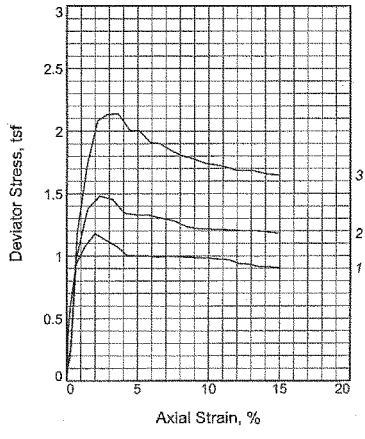
09-60 MJ
1
15 - 17'
Cu 1.5 tsf

09-60 MJ
1
15 - 17'
Cu 3 tsf

09-60 MJ
1
15 - 17'
Cu 0.75 tsf


09-60MJ
1
15-17'





Sample No.		1	2	3
Initial	Water Content, %	57.9	64.9	60.3
	Dry Density, pcf	65.6	61.3	63.5
	Saturation, %	99.7	100.0	98.3
	Void Ratio	1.5679	1.7516	1.6563
	Diameter, in.	1.40	1.40	1.39
	Height, in.	2.81	2.81	2.79
At Test	Water Content, %	57.6	62.7	58.2
	Dry Density, pcf	66.0	62.6	65.6
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.5542	1.6931	1.5713
	Diameter, in.	1.39	1.39	1.37
	Height, in.	2.81	2.79	2.76
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		1.01	2.00	4.01
Back Pressure, tsf		6.13	5.14	3.13
Cell Pressure, tsf		7.14	7.14	7.14
Peak Deviator Stress, tsf		1.18	1.48	2.14
Total Pore Pr., tsf		6.76	6.08	4.71
Ultimate Deviator Stress, tsf		0.91	1.18	1.65
Total Pore Pr., tsf		6.52	6.05	4.98
Maj. Eff. Stress at Ultimate, tsf		1.53	2.27	3.81
Min. Eff. Stress at Ultimate, tsf		0.62	1.09	2.16

Type of Test: CU with Pore Pressures

Sample Type: Thinwall, 5", Top of sample

Description: FAT CLAY, brown (CH)

LL= 106 **PL=** 24 **PI=** 82

Assumed Specific Gravity= 2.70

Remarks: Rate of strain is 0.001 in/min. Failure criteria is 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 Oxidized Brenna

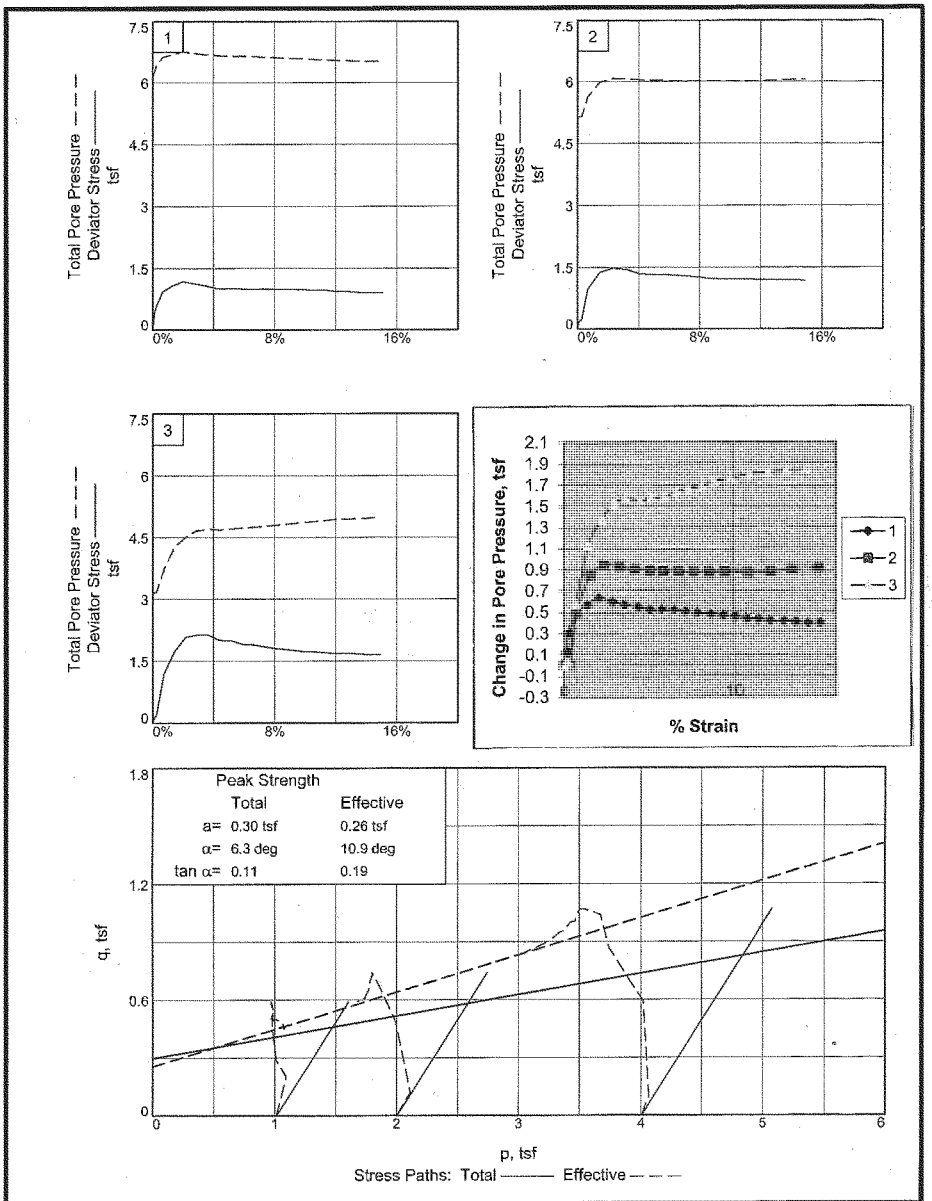
Location: WD-05, ND Div, ~~Sheyenne Formation~~

Sample Number: Boring 09-60MU, #2 **Depth:** 25-27'

Proj. No.: BL0903127A **Date Sampled:**

BRAUN INTERTEC

Figure C-9 Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement Attachment I-4, pg 188
July 2011 Geotechnical Design and Geology



Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study Fargo Oxidized Brenna

Loc.: WD-05, ND Div, ~~Sherack Formation~~ **Depth:** 25-27' **Sample No.:** Boring 09-60MU, #2

Project No.: BL0903124A **Figure** **Braun Intertec**

Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

2/23/2010
3:59 PM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL0903127A
Location: WD-05, ND Div, ~~Sheyenne Formation~~ Fargo
Depth: 25-27' **Sample Number:** Boring 09-60MU, #2
Description: FAT CLAY, brown (CH) Oxidized Brenna
Remarks: Rate of strain is 0.001 in/min. Failure criteria is 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", Top of sample
Assumed Specific Gravity=2.70 **LL=**106 **PL=**24 **PI=**82
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	130.200			145.890
Moisture content: Dry soil+tare, gms.	93.980			103.680
Moisture content: Tare, gms.	31.400			29.590
Moisture, %	57.9	58.1	57.6	57.0
Moist specimen weight, gms.	117.1			
Diameter, in.	1.40	1.40	1.39	
Area, in.²	1.53	1.53	1.53	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	103.6	103.8	104.0	
Dry density, pcf	65.6	65.6	66.0	
Void ratio	1.5679	1.5679	1.5542	
Saturation, %	99.7	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 6.125 tsf
Consolidation effective confining stress = 1.015 tsf
Fail. Stress = 1.180 tsf **at reading no.** 5
Ult. Stress = 0.907 tsf **at reading no.** 23

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	0.0490	16.600	0.0	0.0	0.000	1.015	1.015	1.00	6.125	1.015	0.000
1	0.0518	25.200	8.6	0.1	0.406	0.891	1.297	1.46	6.249	1.094	0.203
2	0.0559	28.980	12.4	0.2	0.583	0.719	1.302	1.81	6.421	1.011	0.292
3	0.0673	36.410	19.8	0.7	0.929	0.515	1.444	2.80	6.625	0.980	0.465
4	0.0850	39.700	23.1	1.3	1.077	0.447	1.524	3.41	6.693	0.985	0.538
5	0.1049	42.110	25.5	2.0	1.180	0.380	1.560	4.11	6.760	0.970	0.590
6	0.1262	41.210	24.6	2.8	1.130	0.419	1.549	3.70	6.721	0.984	0.565
7	0.1477	40.270	23.7	3.5	1.078	0.447	1.525	3.41	6.693	0.986	0.539
8	0.1683	38.850	22.3	4.3	1.006	0.469	1.475	3.14	6.671	0.972	0.503
9	0.1889	38.910	22.3	5.0	1.001	0.494	1.495	3.03	6.646	0.994	0.500
10	0.2094	39.090	22.5	5.7	1.001	0.492	1.493	3.03	6.648	0.993	0.501
11	0.2291	39.040	22.4	6.4	0.991	0.495	1.486	3.00	6.645	0.991	0.496
12	0.2496	39.380	22.8	7.1	0.999	0.510	1.509	2.96	6.630	1.009	0.499
13	0.2693	39.480	22.9	7.8	0.995	0.522	1.517	2.91	6.618	1.020	0.498
14	0.2898	39.530	22.9	8.6	0.990	0.534	1.524	2.85	6.606	1.029	0.495
15	0.3095	39.600	23.0	9.3	0.985	0.544	1.529	2.81	6.596	1.037	0.493
16	0.3302	39.750	23.1	10.0	0.983	0.558	1.541	2.76	6.582	1.050	0.492
17	0.3506	39.730	23.1	10.7	0.975	0.575	1.550	2.69	6.565	1.062	0.487
18	0.3703	39.780	23.2	11.4	0.969	0.582	1.551	2.67	6.558	1.067	0.485
19	0.3900	39.230	22.6	12.1	0.939	0.599	1.538	2.57	6.541	1.068	0.469
20	0.4103	39.340	22.7	12.9	0.935	0.601	1.536	2.56	6.539	1.069	0.468
21	0.4312	38.970	22.4	13.6	0.912	0.615	1.527	2.48	6.525	1.071	0.456
22	0.4508	39.150	22.5	14.3	0.912	0.622	1.534	2.47	6.518	1.078	0.456
23	0.4714	39.210	22.6	15.0	0.907	0.621	1.528	2.46	6.519	1.074	0.453

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	156.180			142.600
Moisture content: Dry soil+tare, gms.	106.760			100.290
Moisture content: Tare, gms.	30.600			30.300
Moisture, %	64.9	64.9	62.7	60.5
Moist specimen weight, gms.	114.1			
Diameter, in.	1.40	1.40	1.39	
Area, in.^{2}	1.53	1.53	1.51	
Height, in.	2.81	2.81	2.79	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	101.0	101.0	101.8	
Dry density, pcf	61.3	61.3	62.6	
Void ratio	1.7516	1.7516	1.6931	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 5.138 tsf
Consolidation effective confining stress = 2.002 tsf
Fail. Stress = 1.481 tsf **at reading no.** 5
Ult. Stress = 1.182 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	0.0058	15.830	0.0	0.0	0.000	2.002	2.002	1.00	5.138	2.002	0.000
1	0.0087	19.770	3.9	0.1	0.187	1.991	2.178	1.09	5.149	2.085	0.094
2	0.0137	20.870	5.0	0.3	0.239	1.991	2.230	1.12	5.149	2.111	0.120
3	0.0246	36.400	20.6	0.7	0.973	1.506	2.479	1.65	5.634	1.993	0.487
4	0.0467	45.220	29.4	1.5	1.379	1.155	2.534	2.19	5.985	1.845	0.690
5	0.0706	47.660	31.8	2.3	1.481	1.060	2.541	2.40	6.080	1.800	0.740
6	0.0955	47.390	31.6	3.2	1.455	1.073	2.528	2.36	6.067	1.800	0.727
7	0.1193	45.220	29.4	4.1	1.343	1.099	2.442	2.22	6.041	1.770	0.671
8	0.1441	45.190	29.4	5.0	1.329	1.108	2.437	2.20	6.032	1.772	0.664
9	0.1683	45.410	29.6	5.8	1.327	1.114	2.441	2.19	6.026	1.777	0.663
10	0.1920	45.160	29.3	6.7	1.303	1.119	2.422	2.16	6.021	1.771	0.652
11	0.2169	44.950	29.1	7.6	1.282	1.121	2.403	2.14	6.019	1.762	0.641
12	0.2428	44.150	28.3	8.5	1.234	1.125	2.359	2.10	6.015	1.742	0.617
13	0.2677	44.030	28.2	9.4	1.217	1.122	2.339	2.08	6.018	1.730	0.608
14	0.3053	44.370	28.5	10.8	1.213	1.132	2.345	2.07	6.008	1.739	0.607
15	0.3427	44.580	28.8	12.1	1.204	1.127	2.331	2.07	6.013	1.729	0.602
16	0.3805	45.010	29.2	13.4	1.203	1.105	2.308	2.09	6.035	1.706	0.601
17	0.4224	45.010	29.2	15.0	1.182	1.087	2.269	2.09	6.053	1.678	0.591

Parameters for Specimen No. 3				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	156.290			138.740
Moisture content: Dry soil+tare, gms.	108.990			99.790
Moisture content: Tare, gms.	30.510			30.280
Moisture, %	60.3	61.3	58.2	56.0
Moist specimen weight, gms.	112.8			
Diameter, in.	1.39	1.39	1.37	
Area, in.^{2}	1.51	1.51	1.48	
Height, in.	2.79	2.79	2.76	
Net decrease in height, in.		0.00	0.03	
Wet Density, pcf	101.7	102.4	103.7	
Dry density, pcf	63.5	63.5	65.6	
Void ratio	1.6563	1.6563	1.5713	
Saturation, %	98.3	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.140 tsf

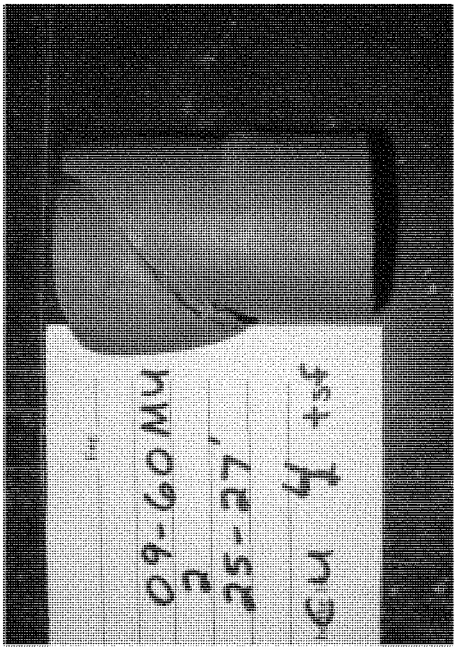
Consolidation back pressure = 3.133 tsf

Consolidation effective confining stress = 4.007 tsf

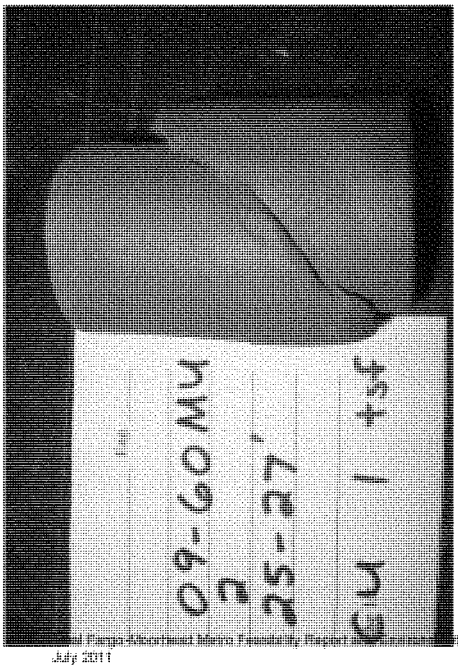
Fail. Stress = 2.139 tsf **at reading no.** 7

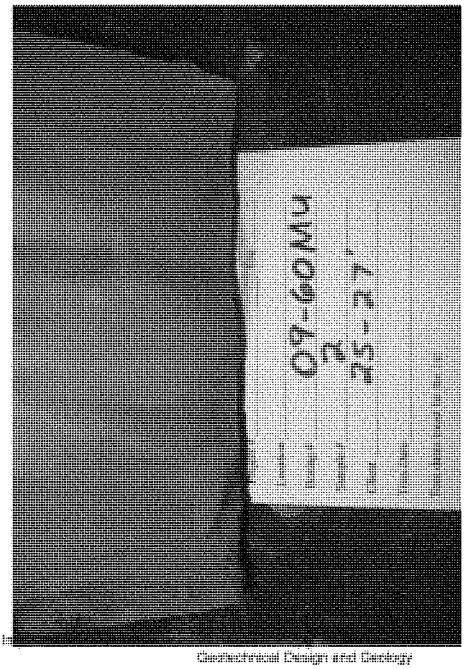
Ult. Stress = 1.648 tsf **at reading no.** 20

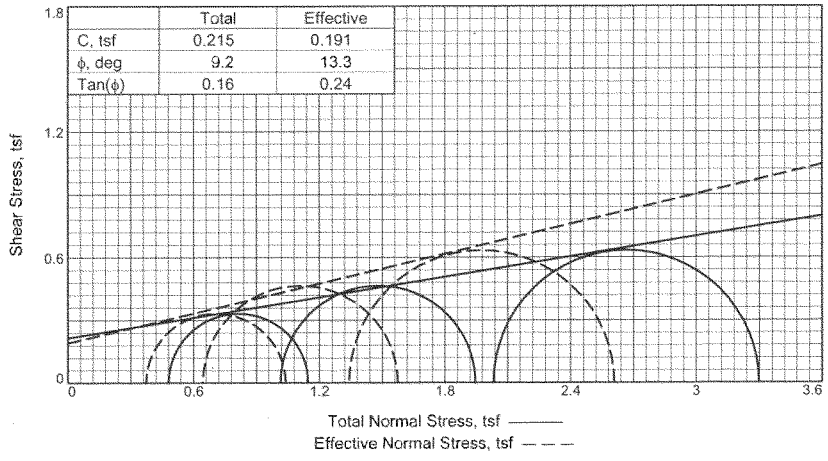
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0218	14.290	0.0	0.0	0.000	4.007	4.007	1.00	3.133	4.007	0.000
1	0.0246	16.810	2.5	0.1	0.122	3.979	4.101	1.03	3.161	4.040	0.061
2	0.0285	18.250	4.0	0.2	0.192	3.971	4.163	1.05	3.169	4.067	0.096
3	0.0422	38.910	24.6	0.7	1.188	3.424	4.612	1.35	3.716	4.018	0.594
4	0.0616	50.550	36.3	1.4	1.738	2.871	4.609	1.61	4.269	3.740	0.869
5	0.0814	58.050	43.8	2.2	2.082	2.631	4.713	1.79	4.509	3.672	1.041
6	0.1012	59.510	45.2	2.9	2.136	2.480	4.616	1.86	4.660	3.548	1.068
7	0.1224	59.940	45.6	3.6	2.139	2.431	4.570	1.88	4.709	3.501	1.070
8	0.1440	57.500	43.2	4.4	2.008	2.458	4.466	1.82	4.682	3.462	1.004
9	0.1635	57.690	43.4	5.1	2.002	2.428	4.430	1.82	4.712	3.429	1.001
10	0.1843	56.040	41.8	5.9	1.911	2.413	4.324	1.79	4.727	3.368	0.955
11	0.2037	56.120	41.8	6.6	1.900	2.393	4.293	1.79	4.747	3.343	0.950
12	0.2243	55.300	41.0	7.3	1.848	2.371	4.219	1.78	4.769	3.295	0.924
13	0.2449	54.680	40.4	8.1	1.806	2.339	4.145	1.77	4.801	3.242	0.903
14	0.2646	54.490	40.2	8.8	1.783	2.322	4.105	1.77	4.818	3.214	0.892
15	0.2931	54.020	39.7	9.8	1.742	2.273	4.015	1.77	4.867	3.144	0.871
16	0.3233	54.030	39.7	10.9	1.722	2.244	3.966	1.77	4.896	3.105	0.861
17	0.3530	53.660	39.4	12.0	1.685	2.204	3.889	1.76	4.936	3.046	0.842
18	0.3843	54.140	39.9	13.1	1.684	2.189	3.873	1.77	4.951	3.031	0.842
19	0.4138	53.960	39.7	14.2	1.655	2.171	3.826	1.76	4.969	2.999	0.828
20	0.4356	54.150	39.9	15.0	1.648	2.156	3.804	1.76	4.984	2.980	0.824

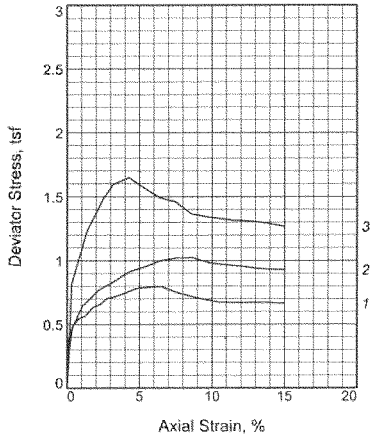

09-60MW
25-27'
4 tsf

09-60MW
25-27'
7 tsf


09-60MW
25-27'
1 tsf


09-60MW
25-27'





Sample No.		1	2	3
Initial	Water Content, %	48.6	48.9	48.3
	Dry Density, pcf	73.8	73.2	74.0
	Saturation, %	100.0	99.4	100.0
	Void Ratio	1.3499	1.3681	1.3413
	Diameter, in.	1.40	1.42	1.40
	Height, in.	2.81	2.79	2.82
At Test	Water Content, %	48.2	48.4	47.0
	Dry Density, pcf	74.2	74.0	75.2
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.3374	1.3428	1.3041
	Diameter, in.	1.39	1.41	1.39
	Height, in.	2.81	2.78	2.80
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.48	1.01	2.03
Back Pressure, tsf		6.63	6.12	5.10
Cell Pressure, tsf		7.11	7.13	7.13
Peak Deviator Stress, tsf		0.80	1.02	1.65
Total Pore Pr., tsf		6.90	6.66	6.16
Ultimate Deviator Stress, tsf		0.67	0.93	1.27
Total Pore Pr., tsf		6.73	6.49	5.79
Maj. Eff. Stress at Ultimate, tsf		1.04	1.57	2.61
Min. Eff. Stress at Ultimate, tsf,		0.37	0.64	1.34

Type of Test:
CU with Pore Pressures
Sample Type: 5" Thinwall, Middle of sample
Description: FAT CLAY, brown (CH)

LL= 113 **PL=** 32 **PI=** 81
Specific Gravity= 2.777
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Maple River, Dessicated Brenna Formation
Sample Number: Boring10-105MU, #1 **Depth:** 15-17'
Proj. No.: BL-10-10065 **Date Sampled:**

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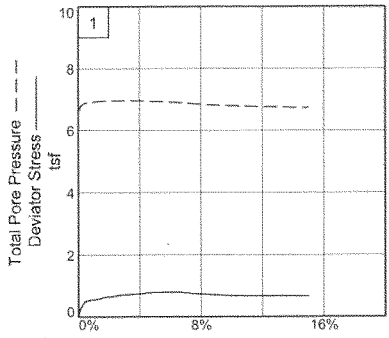
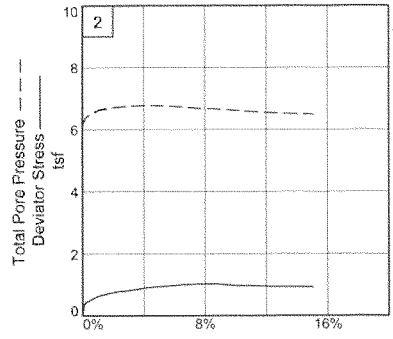
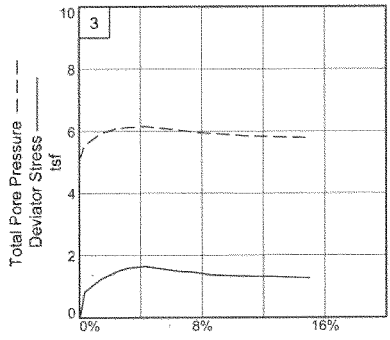
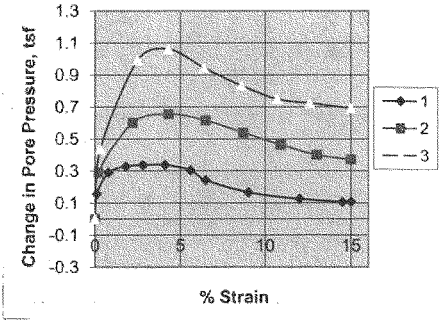
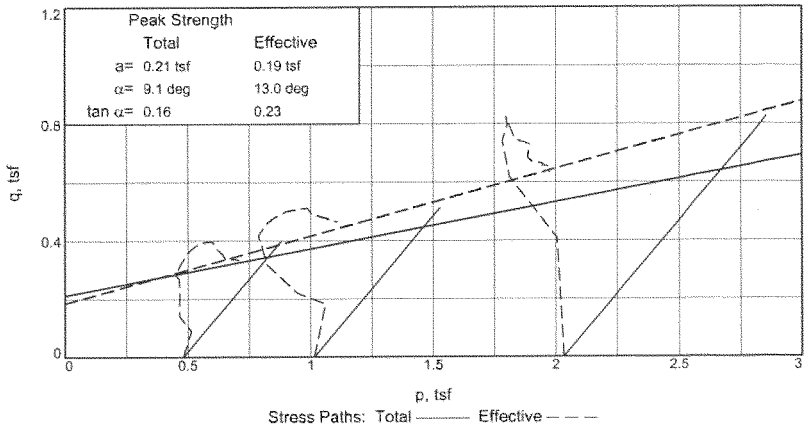
Figure CU Triax ASTM D 4767











Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: Maple River, Dessicated Brenna Formation **Depth:** 15-17' **Sample No.:** Boring10-105MU, #1

Parameters for Specimen No. 3				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	111.460			154.080
Moisture content: Dry soil+tare, gms.	85.170			114.730
Moisture content: Tare, gms.	30.750			30.510
Moisture, %	48.3	48.3	47.0	46.7
Moist specimen weight, gms.	125.2			
Diameter, in.	1.40	1.40	1.39	
Area, in.²	1.54	1.54	1.53	
Height, in.	2.82	2.82	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	109.8	109.8	110.6	
Dry density, pcf	74.0	74.0	75.2	
Void ratio	1.3413	1.3413	1.3041	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.132 tsf

Consolidation back pressure = 5.100 tsf

Consolidation effective confining stress = 2.032 tsf

Peak Stress = 1.648 tsf at reading no. 6

Ult. Stress = 1.266 tsf at reading no. 16

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	0.0244	17.440	0.0	0.0	0.000	2.032	2.032	1.00	5.100	2.032	0.000
1	0.0276	21.790	4.3	0.1	0.205	1.924	2.129	1.11	5.208	2.027	0.103
2	0.0335	34.770	17.3	0.3	0.815	1.598	2.413	1.51	5.534	2.006	0.408
3	0.0635	43.970	26.5	1.4	1.235	1.193	2.428	2.04	5.939	1.810	0.617
4	0.0940	49.640	32.2	2.5	1.482	1.040	2.522	2.43	6.092	1.781	0.741
5	0.1134	52.330	34.9	3.2	1.595	1.005	2.600	2.59	6.127	1.802	0.797
6	0.1441	53.900	36.5	4.3	1.648	0.972	2.620	2.70	6.160	1.796	0.824
7	0.1742	52.500	35.1	5.3	1.567	1.033	2.600	2.52	6.099	1.816	0.783
8	0.2037	51.200	33.8	6.4	1.492	1.088	2.580	2.37	6.044	1.834	0.746
9	0.2340	50.860	33.4	7.5	1.460	1.162	2.622	2.26	5.970	1.892	0.730
10	0.2641	49.110	31.7	8.6	1.367	1.201	2.568	2.14	5.931	1.885	0.684
11	0.2949	48.900	31.5	9.7	1.342	1.231	2.573	2.09	5.901	1.902	0.671
12	0.3256	48.920	31.5	10.7	1.326	1.284	2.610	2.03	5.848	1.947	0.663
13	0.3465	48.900	31.5	11.5	1.314	1.286	2.600	2.02	5.846	1.943	0.657
14	0.3772	49.200	31.8	12.6	1.311	1.310	2.621	2.00	5.822	1.965	0.655
15	0.4074	49.200	31.8	13.7	1.294	1.328	2.622	1.97	5.804	1.975	0.647
16	0.4450	49.000	31.6	15.0	1.266	1.341	2.607	1.94	5.791	1.974	0.633

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

3/4/2011
2:07 PM

Date:
Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project No.: BL-10-10065
Location: Maple River, Dessicated Brenna Formation
Depth: 15-17' **Sample Number:** Boring10-105MU, #1
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.777 **LL=**113 **PL=**32 **PI=**81
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	120.890			154.680
Moisture content: Dry soil+tare, gms.	91.240			113.130
Moisture content: Tare, gms.	30.250			29.720
Moisture, %	48.6	48.6	48.2	49.8
Moist specimen weight, gms.	123.9			
Diameter, in.	1.40	1.40	1.39	
Area, in.²	1.53	1.53	1.53	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	109.6	109.6	109.9	
Dry density, pcf	73.8	73.8	74.2	
Void ratio	1.3499	1.3499	1.3374	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.107 tsf
Consolidation back pressure = 6.626 tsf
Consolidation effective confining stress = 0.481 tsf
Peak Stress = 0.796 tsf **at reading no.** 13
Ult. Stress = 0.665 tsf **at reading no.** 20

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	0.0095	18.730	0.0	0.0	0.000	0.481	0.481	1.00	6.626	0.481	0.000
1	0.0116	22.550	3.8	0.1	0.180	0.424	0.604	1.43	6.683	0.514	0.090
2	0.0136	24.740	6.0	0.1	0.283	0.325	0.608	1.87	6.782	0.467	0.142
3	0.0206	29.050	10.3	0.4	0.485	0.225	0.710	3.16	6.882	0.468	0.243
4	0.0325	30.360	11.6	0.8	0.545	0.192	0.737	3.84	6.915	0.464	0.272
5	0.0455	30.860	12.1	1.3	0.565	0.168	0.733	4.36	6.939	0.451	0.283
6	0.0593	32.370	13.6	1.8	0.632	0.153	0.785	5.13	6.954	0.469	0.316
7	0.0731	32.950	14.2	2.3	0.656	0.148	0.804	5.43	6.959	0.476	0.328
8	0.0871	34.020	15.3	2.8	0.702	0.145	0.847	5.84	6.962	0.496	0.351
9	0.1010	34.390	15.7	3.3	0.715	0.141	0.856	6.07	6.966	0.499	0.358
10	0.1232	35.240	16.5	4.1	0.748	0.144	0.892	6.19	6.963	0.518	0.374
11	0.1447	36.160	17.4	4.8	0.783	0.158	0.941	5.96	6.949	0.550	0.392
12	0.1677	36.460	17.7	5.6	0.790	0.178	0.968	5.44	6.929	0.573	0.395
13	0.1916	36.770	18.0	6.5	0.796	0.204	1.000	4.90	6.903	0.602	0.398
14	0.2204	35.940	17.2	7.5	0.751	0.239	0.990	4.14	6.868	0.615	0.376
15	0.2625	35.150	16.4	9.0	0.705	0.290	0.995	3.43	6.817	0.643	0.353
16	0.3043	34.690	16.0	10.5	0.674	0.316	0.990	3.13	6.791	0.653	0.337
17	0.3459	34.860	16.1	12.0	0.670	0.336	1.006	2.99	6.771	0.671	0.335
18	0.3878	35.240	16.5	13.5	0.674	0.356	1.030	2.89	6.751	0.693	0.337
19	0.4159	35.240	16.5	14.5	0.667	0.375	1.042	2.78	6.732	0.708	0.333
20	0.4300	35.300	16.6	15.0	0.665	0.374	1.039	2.78	6.733	0.707	0.333

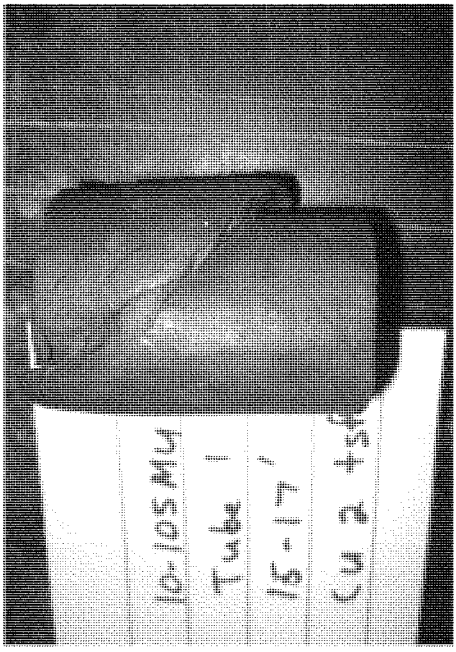
Parameters for Specimen No. 2

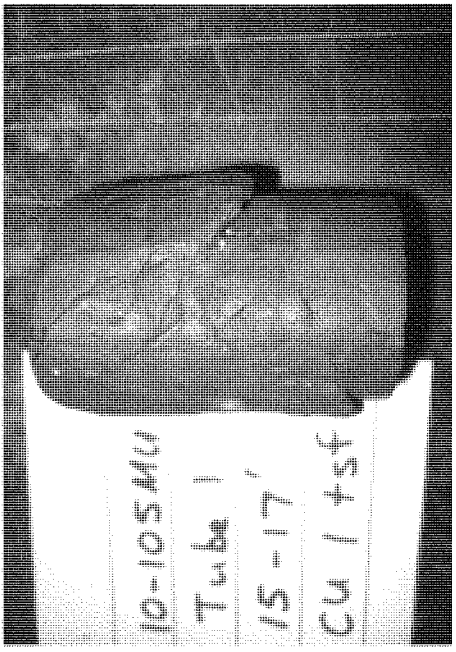
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	129.880			156.970
Moisture content: Dry soil+tare, gms.	97.340			115.210
Moisture content: Tare, gms.	30.860			31.280
Moisture, %	48.9	49.3	48.4	49.8
Moist specimen weight, gms.	125.8			
Diameter, in.	1.42	1.42	1.41	
Area, in.^{2}	1.57	1.57	1.56	
Height, in.	2.79	2.79	2.78	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	109.0	109.3	109.8	
Dry density, pcf	73.2	73.2	74.0	
Void ratio	1.3681	1.3681	1.3428	
Saturation, %	99.4	100.0	100.0	

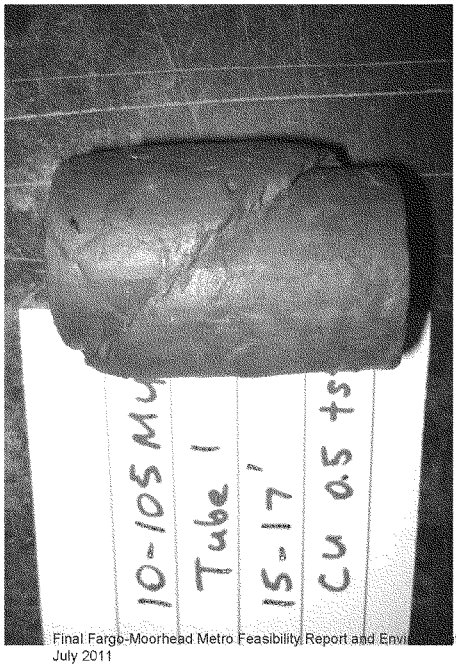
Test Readings for Specimen No. 2

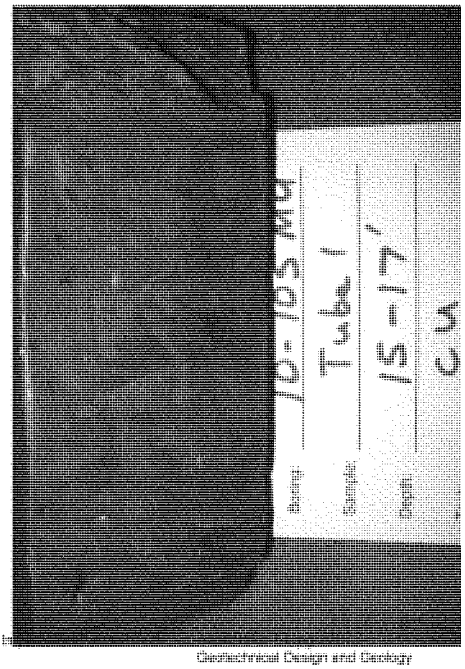
Consolidation cell pressure = 7.135 tsf
Consolidation back pressure = 6.120 tsf
Consolidation effective confining stress = 1.015 tsf
Peak Stress = 1.023 tsf **at reading no.** 10
Ult. Stress = 0.930 tsf **at reading no.** 16

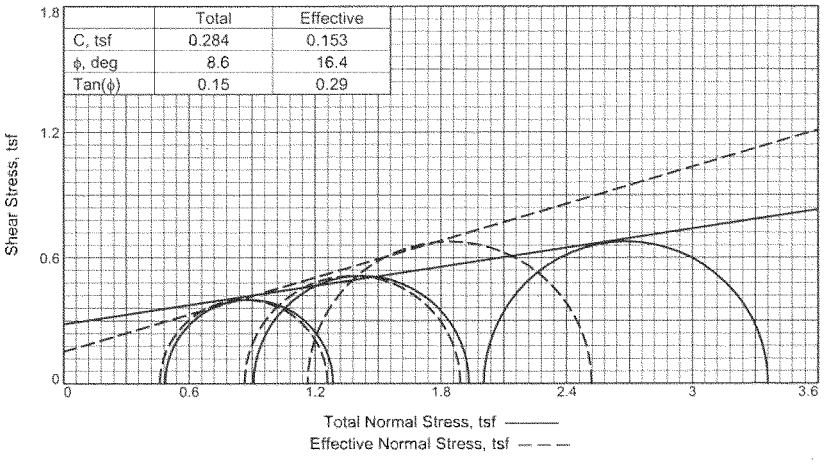
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0305	18.860	0.0	0.0	0.000	1.015	1.015	1.00	6.120	1.015	0.000
1	0.0334	26.840	8.0	0.1	0.368	0.876	1.244	1.42	6.259	1.060	0.184
2	0.0374	28.420	9.6	0.2	0.440	0.727	1.167	1.60	6.408	0.947	0.220
3	0.0599	32.880	14.0	1.1	0.640	0.501	1.141	2.28	6.634	0.821	0.320
4	0.0914	35.930	17.1	2.2	0.770	0.415	1.185	2.86	6.720	0.800	0.385
5	0.1206	37.570	18.7	3.2	0.835	0.370	1.205	3.26	6.765	0.787	0.417
6	0.1509	39.610	20.8	4.3	0.916	0.361	1.277	3.54	6.774	0.819	0.458
7	0.1813	40.720	21.9	5.4	0.953	0.372	1.325	3.56	6.763	0.849	0.477
8	0.2117	42.080	23.2	6.5	1.001	0.400	1.401	3.50	6.735	0.901	0.501
9	0.2419	42.810	24.0	7.6	1.021	0.451	1.472	3.26	6.684	0.961	0.510
10	0.2723	43.150	24.3	8.7	1.023	0.477	1.500	3.14	6.658	0.988	0.511
11	0.3028	42.500	23.6	9.8	0.984	0.512	1.496	2.92	6.623	1.004	0.492
12	0.3333	42.400	23.5	10.9	0.968	0.552	1.520	2.75	6.583	1.036	0.484
13	0.3634	42.400	23.5	12.0	0.956	0.583	1.539	2.64	6.552	1.061	0.478
14	0.3937	42.300	23.4	13.0	0.940	0.616	1.556	2.53	6.519	1.086	0.470
15	0.4243	42.400	23.5	14.1	0.932	0.631	1.563	2.48	6.504	1.097	0.466
16	0.4490	42.600	23.7	15.0	0.930	0.644	1.574	2.44	6.491	1.109	0.465

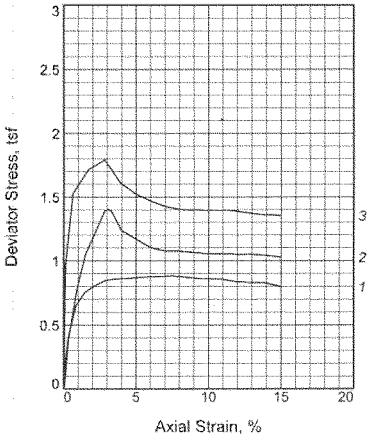

10-105 MU
Tube 1
15-17'
Cu a +sf


10-105 MU
Tube 1
15-17'
Cu 1 +sf


10-105 MU
Tube 1
15-17'
Cu a5 +s


10-105 MU
Tube 1
15-17'





Sample No.		1	2	3
Initial	Water Content, %	43.7	43.8	43.4
	Dry Density, pcf	77.9	77.8	78.2
	Saturation, %	99.9	100.0	100.0
	Void Ratio	1.1995	1.2029	1.1901
	Diameter, in.	1.42	1.40	1.39
	Height, in.	2.80	2.81	2.81
At Test	Water Content, %	43.7	43.7	43.3
	Dry Density, pcf	77.9	77.9	78.3
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.1995	1.1982	1.1878
	Diameter, in.	1.42	1.40	1.39
	Height, in.	2.80	2.81	2.81
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.48	0.91	2.01
Back Pressure, tsf		6.64	6.13	5.12
Cell Pressure, tsf		7.12	7.04	7.13
Peak Deviator Stress, tsf		0.88	1.40	1.79
Total Pore Pr., tsf		6.80	6.70	6.17
Ultimate Deviator Stress, tsf		0.80	1.03	1.35
Total Pore Pr., tsf		6.66	6.17	5.96
Maj. Eff. Stress at Ultimate, tsf		1.26	1.89	2.52
Min. Eff. Stress at Ultimate, tsf		0.46	0.86	1.16

Type of Test:
CU with Pore Pressures
Sample Type: Undisturbed, 5" Thinwall, Middle
Description: FAT CLAY, brown (CH)

LL= 82 **PL=** 23 **PI=** 59
Specific Gravity= 2.744
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Sheyenne River, OX Brenna Formation
Sample Number: Boring11-110MU, #1 **Depth:** 25-27'
Proj. No.: BL-10-10065 **Date Sampled:**

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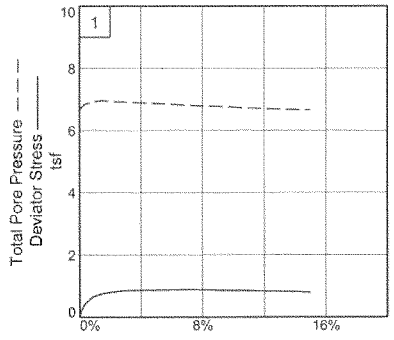
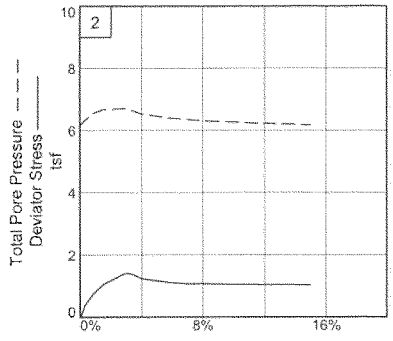
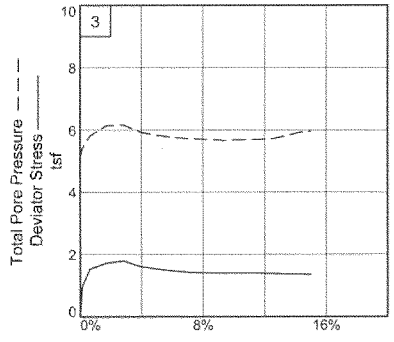
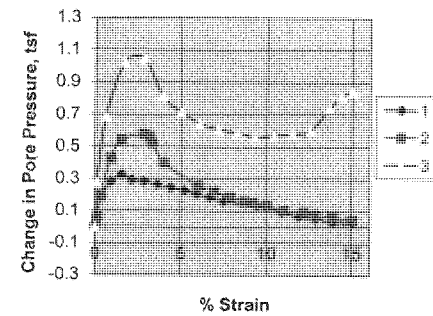
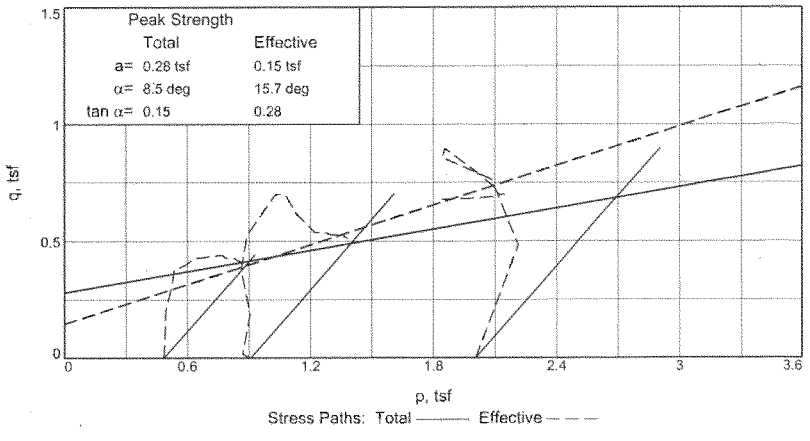
Figure CTS Project No. SEA 1767











Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Loc.: Sheyenne River, OX Brenna Formation **Depth:** 25-27' **Sample No.:** Boring11-110MU, #1

Project No.: BI-10-10065 **Figure**

Braun Intertec

Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST 4/26/2011
CU with Pore Pressures 8:18 AM

Date:
Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project No.: BL-10-10065
Location: Sheyenne River, OX Brenna Formation
Depth: 25-27' **Sample Number:** Boring11-110MU, #1
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: Undisturbed, 5" Thinwall, Middle
Specific Gravity=2.744 **LL=**82 **PL=**23 **PI=**59
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	109.010			161.700
Moisture content: Dry soil+tare, gms.	85.070			121.120
Moisture content: Tare, gms.	30.270			30.330
Moisture, %	43.7	43.7	43.7	44.7
Moist specimen weight, gms.	130.5			
Diameter, in.	1.42	1.42	1.42	
Area, in.²	1.59	1.59	1.59	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	111.9	111.9	111.9	
Dry density, pcf	77.9	77.9	77.9	
Void ratio	1.1995	1.1995	1.1995	
Saturation, %	99.9	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.124 tsf
Consolidation back pressure = 6.638 tsf
Consolidation effective confining stress = 0.486 tsf
Peak Stress = 0.882 tsf **at reading no.** 12
Ult. Stress = 0.799 tsf **at reading no.** 18

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	0.0116	19.500	0.0	0.0	0.000	0.486	0.486	1.00	6.638	0.486	0.000
1	0.0137	23.250	3.8	0.1	0.170	0.406	0.576	1.42	6.718	0.491	0.085
2	0.0204	28.380	8.9	0.3	0.402	0.294	0.696	2.37	6.830	0.495	0.201
3	0.0355	33.870	14.4	0.9	0.647	0.205	0.852	4.16	6.919	0.528	0.323
4	0.0524	36.310	16.8	1.5	0.752	0.160	0.913	5.69	6.963	0.537	0.376
5	0.0714	37.620	18.1	2.1	0.805	0.194	0.999	5.15	6.930	0.597	0.403
6	0.0913	38.660	19.2	2.8	0.845	0.204	1.049	5.14	6.920	0.627	0.423
7	0.1131	39.120	19.6	3.6	0.858	0.223	1.081	4.85	6.901	0.652	0.429
8	0.1339	39.340	19.8	4.4	0.861	0.242	1.103	4.56	6.882	0.673	0.431
9	0.1559	39.650	20.1	5.2	0.868	0.261	1.129	4.32	6.863	0.695	0.434
10	0.1779	39.970	20.5	5.9	0.874	0.281	1.155	4.11	6.843	0.718	0.437
11	0.1998	40.250	20.8	6.7	0.879	0.304	1.183	3.89	6.820	0.743	0.439
12	0.2227	40.520	21.0	7.5	0.882	0.328	1.210	3.69	6.796	0.769	0.441
13	0.2747	40.400	20.9	9.4	0.860	0.352	1.212	3.44	6.772	0.782	0.430
14	0.3161	40.680	21.2	10.9	0.857	0.395	1.252	3.17	6.729	0.824	0.429
15	0.3445	40.460	21.0	11.9	0.839	0.421	1.260	2.99	6.703	0.840	0.419
16	0.3720	40.540	21.0	12.9	0.832	0.434	1.266	2.92	6.690	0.850	0.416
17	0.4003	40.670	21.2	13.9	0.828	0.454	1.282	2.82	6.670	0.868	0.414
18	0.4310	40.190	20.7	15.0	0.799	0.460	1.259	2.74	6.664	0.859	0.399

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	138.070			157.720
Moisture content: Dry soil+tare, gms.	105.170			118.880
Moisture content: Tare, gms.	30.100			30.520
Moisture, %	43.8	43.8	43.7	44.0
Moist specimen weight, gms.	127.2			
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	111.8	111.9	112.0	
Dry density, pcf	77.8	77.8	77.9	
Void ratio	1.2029	1.2029	1.1982	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.039 tsf
Consolidation back pressure = 6.132 tsf
Consolidation effective confining stress = 0.907 tsf
Peak Stress = 1.403 tsf **at reading no.** 6
Ult. Stress = 1.028 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	0.0076	21.130	0.0	0.0	0.000	0.907	0.907	1.00	6.132	0.907	0.000
1	0.0096	21.840	0.7	0.1	0.033	0.851	0.884	1.04	6.188	0.868	0.017
2	0.0167	29.200	8.1	0.3	0.376	0.716	1.092	1.53	6.323	0.904	0.188
3	0.0325	37.500	16.4	0.9	0.759	0.481	1.240	2.58	6.558	0.860	0.379
4	0.0503	43.940	22.8	1.5	1.051	0.365	1.416	3.88	6.674	0.890	0.525
5	0.0870	51.690	30.6	2.8	1.389	0.329	1.718	5.22	6.710	1.023	0.694
6	0.0933	52.060	30.9	3.1	1.403	0.342	1.745	5.10	6.697	1.043	0.701
7	0.1002	51.850	30.7	3.3	1.389	0.385	1.774	4.61	6.654	1.080	0.695
8	0.1197	48.670	27.5	4.0	1.237	0.510	1.747	3.42	6.529	1.128	0.618
9	0.1758	46.230	25.1	6.0	1.104	0.653	1.757	2.69	6.386	1.205	0.552
10	0.2056	45.830	24.7	7.0	1.074	0.687	1.761	2.56	6.352	1.224	0.537
11	0.2287	46.110	25.0	7.9	1.076	0.721	1.797	2.49	6.318	1.259	0.538
12	0.2515	46.110	25.0	8.7	1.067	0.748	1.815	2.43	6.291	1.281	0.533
13	0.2666	46.140	25.0	9.2	1.062	0.756	1.818	2.40	6.283	1.287	0.531
14	0.2885	46.170	25.0	10.0	1.054	0.772	1.826	2.37	6.267	1.299	0.527
15	0.3263	46.540	25.4	11.3	1.054	0.805	1.859	2.31	6.234	1.332	0.527
16	0.3502	46.640	25.5	12.2	1.048	0.814	1.862	2.29	6.225	1.338	0.524
17	0.3693	46.910	25.8	12.9	1.051	0.828	1.879	2.27	6.211	1.353	0.525
18	0.3981	47.030	25.9	13.9	1.043	0.844	1.887	2.24	6.195	1.366	0.522
19	0.4291	46.990	25.9	15.0	1.028	0.865	1.893	2.19	6.174	1.379	0.514

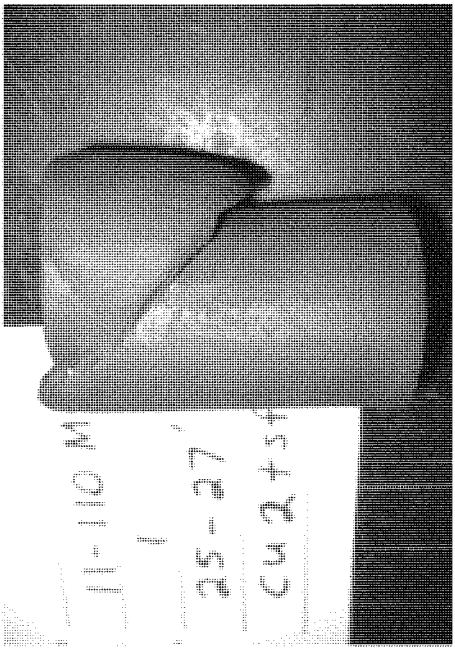
Parameters for Specimen No. 3

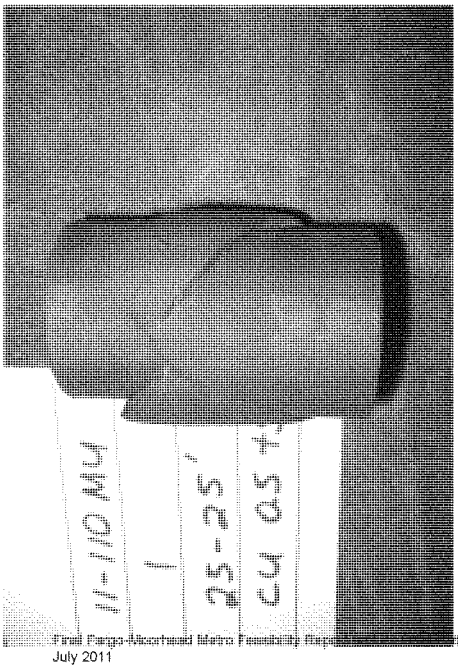
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	143.720			157.340
Moisture content: Dry soil+tare, gms.	109.390			118.280
Moisture content: Tare, gms.	30.250			30.700
Moisture, %	43.4	43.4	43.3	44.6
Moist specimen weight, gms.	125.9			
Diameter, in.	1.39	1.39	1.39	
Area, in.²	1.52	1.52	1.52	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	112.1	112.1	112.2	
Dry density, pcf	78.2	78.2	78.3	
Void ratio	1.1901	1.1901	1.1878	
Saturation, %	100.0	100.0	100.0	

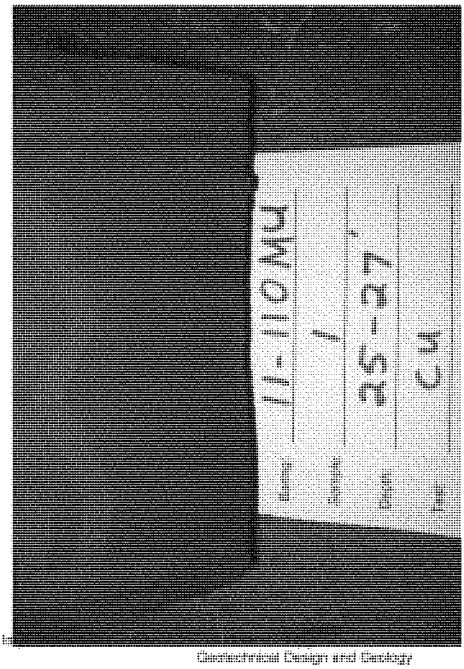
Test Readings for Specimen No. 3

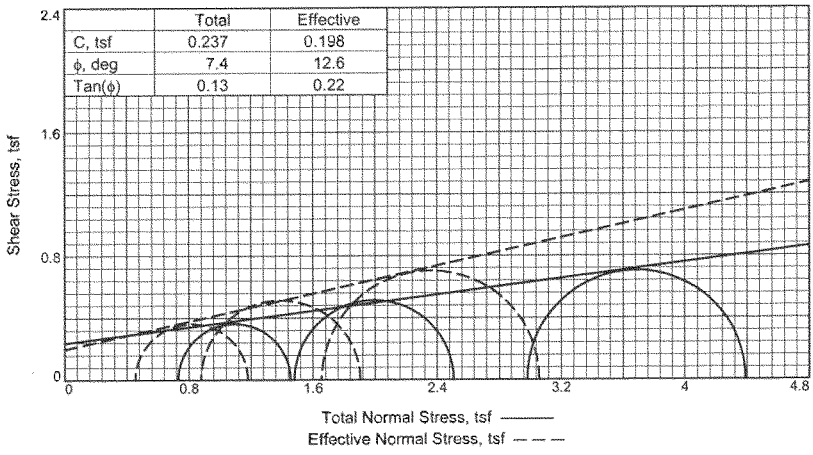
Consolidation cell pressure = 7.127 tsf
Consolidation back pressure = 5.121 tsf
Consolidation effective confining stress = 2.006 tsf
Peak Stress = 1.791 tsf **at reading no.** 4
Ult. Stress = 1.354 tsf **at reading no.** 16

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	0.0403	19.950	0.0	0.0	0.000	2.006	2.006	1.00	5.121	2.006	0.000
1	0.0439	40.400	20.4	0.1	0.967	1.730	2.697	1.56	5.397	2.213	0.483
2	0.0579	52.400	32.5	0.6	1.526	1.321	2.847	2.16	5.806	2.084	0.763
3	0.0883	56.830	36.9	1.7	1.716	0.985	2.701	2.74	6.142	1.843	0.858
4	0.1194	58.900	39.0	2.8	1.791	0.961	2.752	2.86	6.166	1.857	0.896
5	0.1511	55.300	35.3	3.9	1.607	1.194	2.801	2.35	5.933	1.997	0.803
6	0.1812	53.800	33.8	5.0	1.522	1.294	2.816	2.18	5.833	2.055	0.761
7	0.2117	52.900	33.0	6.1	1.464	1.363	2.827	2.07	5.764	2.095	0.732
8	0.2420	52.300	32.3	7.2	1.421	1.401	2.822	2.01	5.726	2.112	0.711
9	0.2723	52.200	32.3	8.3	1.400	1.419	2.819	1.99	5.708	2.119	0.700
10	0.3028	52.530	32.6	9.3	1.398	1.447	2.845	1.97	5.680	2.146	0.699
11	0.3324	52.900	33.0	10.4	1.397	1.438	2.835	1.97	5.689	2.137	0.699
12	0.3628	53.300	33.3	11.5	1.397	1.426	2.823	1.98	5.701	2.125	0.699
13	0.3930	53.270	33.3	12.6	1.379	1.405	2.784	1.98	5.722	2.094	0.689
14	0.4244	53.260	33.3	13.7	1.361	1.270	2.631	2.07	5.857	1.950	0.680
15	0.4439	53.500	33.5	14.4	1.360	1.192	2.552	2.14	5.935	1.872	0.680
16	0.4610	53.610	33.7	15.0	1.354	1.164	2.518	2.16	5.963	1.841	0.677

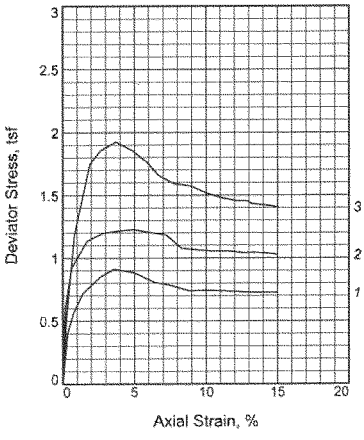

11-110 M
1
25-27'
CU 2 +5


11-110 MU
1
25-25'
CU 0.5 +


11-110MU
1
25-27'
CU



	Total	Effective
C, tsf	0.237	0.198
ϕ, deg	7.4	12.6
Tan(ϕ)	0.13	0.22



Sample No.		1	2	3
Initial	Water Content, %	55.7	54.0	49.7
	Dry Density, pcf	67.8	69.2	70.8
	Saturation, %	99.6	100.0	95.5
	Void Ratio	1.5462	1.4953	1.4399
	Diameter, in.	1.40	1.40	1.39
	Height, in.	2.81	2.81	2.82
At Test	Water Content, %	55.4	52.6	50.2
	Dry Density, pcf	68.2	70.3	72.3
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.5327	1.4555	1.3882
	Diameter, in.	1.39	1.39	1.38
	Height, in.	2.81	2.80	2.80
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.73	1.48	2.98
Back Pressure, tsf		6.37	5.65	4.14
Cell Pressure, tsf		7.10	7.13	7.12
Peak Deviator Stress, tsf		0.91	1.23	1.92
Total Pore Pr., tsf		6.83	6.35	5.49
Ultimate Deviator Stress, tsf		0.72	1.03	1.41
Total Pore Pr., tsf		6.64	6.25	5.47
Maj. Eff. Stress at Ultimate, tsf		1.18	1.90	3.06
Min. Eff. Stress at Ultimate, tsf		0.46	0.88	1.65

Type of Test:
CU with Pore Pressures

Sample Type: 5" Thinwall, Middle of sample

Description: FAT CLAY, brown (CH)

LL= 91 **PL=** 24 **PI=** 67

Specific Gravity= 2.767

Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Figure CU-TIM-ASTM D 4767

Client: USACE W912ES-11-P-0024

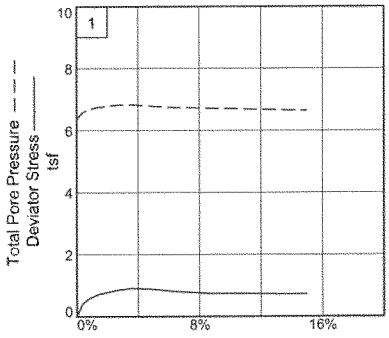
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2

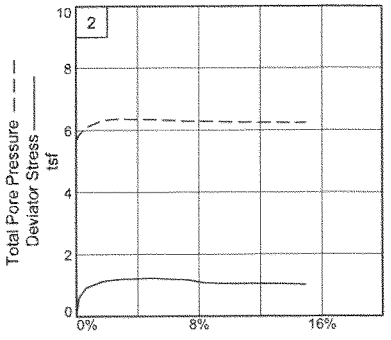
Location: Wild Rice, OX Brenna Formation

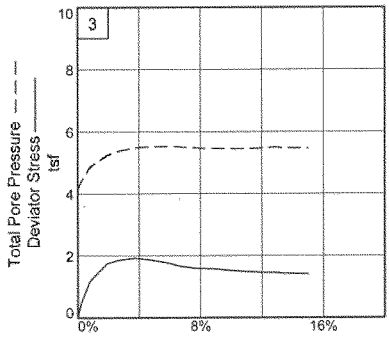
Sample Number: Boring11-118MU, #1 **Depth:** 20-21'

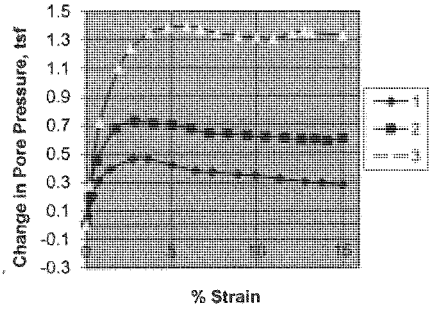
Proj. No.: BL-10-10065 **Date Sampled:**

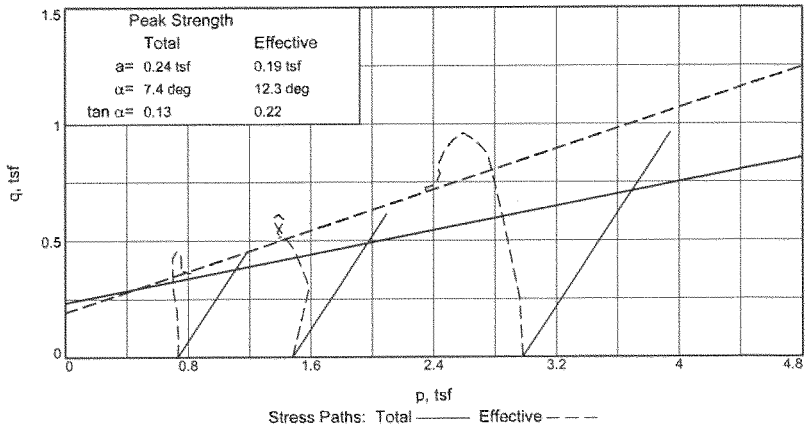
BRAUN INTERTEC











Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Location: Wild Rice, OX Brenna Formation **Depth:** 20-21' **Sample Number:** Boring11-118MU, #1

Project No: BL-10-10065 **Figure**

Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

5/15/2011
11:42 AM

Date:
Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Project No.: BL-10-10065
Location: Wild Rice, OX Brenna Formation
Depth: 20-21' **Sample Number:** Boring11-118MU, #1
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.767 **LL=**91 **PL=**24 **PI=**67
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	118.690			147.510
Moisture content: Dry soil+tare, gms.	87.230			106.500
Moisture content: Tare, gms.	30.730			30.100
Moisture, %	55.7	55.9	55.4	53.7
Moist specimen weight, gms.	119.3			
Diameter, in.	1.40	1.40	1.39	
Area, in.^{2}	1.53	1.53	1.53	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	105.6	105.8	106.0	
Dry density, pcf	67.8	67.8	68.2	
Void ratio	1.5462	1.5462	1.5327	
Saturation, %	99.6	100.0	100.0	

Test Results for Specimen No. 1

Consolidation cell pressure = 7.097 tsf
Consolidation back pressure = 6.366 tsf
Consolidation effective confining stress = 0.731 tsf
Peak Stress = 0.912 tsf **at reading no.** 6
Ult. Stress = 0.725 tsf **at reading no.** 15

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	0.0098	18.250	0.0	0.0	0.000	0.731	0.731	1.00	6.366	0.731	0.000
1	0.0127	20.960	2.7	0.1	0.128	0.672	0.800	1.19	6.425	0.736	0.064
2	0.0197	26.880	8.6	0.4	0.406	0.523	0.929	1.78	6.574	0.726	0.203
3	0.0305	30.210	12.0	0.7	0.560	0.424	0.984	2.32	6.673	0.704	0.280
4	0.0490	33.660	15.4	1.4	0.717	0.340	1.057	3.11	6.757	0.699	0.359
5	0.0842	36.770	18.5	2.7	0.851	0.271	1.122	4.14	6.826	0.697	0.426
6	0.1109	38.290	20.0	3.6	0.912	0.269	1.181	4.39	6.828	0.725	0.456
7	0.1500	37.930	19.7	5.0	0.883	0.311	1.194	3.84	6.786	0.752	0.441
8	0.1903	36.520	18.3	6.4	0.807	0.352	1.159	3.29	6.745	0.756	0.404
9	0.2174	36.250	18.0	7.4	0.787	0.363	1.150	3.17	6.734	0.756	0.393
10	0.2585	35.430	17.2	8.9	0.739	0.379	1.118	2.95	6.718	0.749	0.370
11	0.2862	35.670	17.4	9.9	0.741	0.387	1.128	2.92	6.710	0.758	0.371
12	0.3281	35.910	17.7	11.3	0.739	0.409	1.148	2.81	6.688	0.779	0.370
13	0.3691	35.970	17.7	12.8	0.729	0.431	1.160	2.69	6.666	0.796	0.365
14	0.3969	36.090	17.8	13.8	0.726	0.441	1.167	2.65	6.656	0.804	0.363
15	0.4299	36.310	18.1	15.0	0.725	0.455	1.180	2.59	6.642	0.817	0.362

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	125.900			149.220
Moisture content: Dry soil+tare, gms.	92.280			109.810
Moisture content: Tare, gms.	30.070			30.420
Moisture, %	54.0	54.0	52.6	49.6
Moist specimen weight, gms.	121.3			
Diameter, in.	1.40	1.40	1.39	
Area, in.^{2}	1.54	1.54	1.53	
Height, in.	2.81	2.81	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	106.6	106.6	107.4	
Dry density, pcf	69.2	69.2	70.3	
Void ratio	1.4953	1.4953	1.4555	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.126 tsf
Consolidation back pressure = 5.646 tsf
Consolidation effective confining stress = 1.480 tsf
Peak Stress = 1.228 tsf **at reading no.** 6
Ult. Stress = 1.027 tsf **at reading no.** 16

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	0.0981	20.500	0.0	0.0	0.000	1.480	1.480	1.00	5.646	1.480	0.000
1	0.1029	33.310	12.8	0.2	0.604	1.287	1.891	1.47	5.839	1.589	0.302
2	0.1155	40.190	19.7	0.6	0.924	1.031	1.955	1.90	6.095	1.493	0.462
3	0.1461	44.970	24.5	1.7	1.135	0.803	1.938	2.41	6.323	1.371	0.568
4	0.1763	46.580	26.1	2.8	1.197	0.755	1.952	2.59	6.371	1.353	0.598
5	0.2068	47.270	26.8	3.9	1.215	0.769	1.984	2.58	6.357	1.376	0.607
6	0.2373	47.870	27.4	5.0	1.228	0.780	2.008	2.57	6.346	1.394	0.614
7	0.2693	47.630	27.1	6.1	1.202	0.805	2.007	2.49	6.321	1.406	0.601
8	0.2999	47.510	27.0	7.2	1.183	0.839	2.022	2.41	6.287	1.431	0.592
9	0.3301	45.390	24.9	8.3	1.078	0.842	1.920	2.28	6.284	1.381	0.539
10	0.3606	45.370	24.9	9.4	1.064	0.853	1.917	2.25	6.273	1.385	0.532
11	0.3909	45.430	24.9	10.5	1.054	0.864	1.918	2.22	6.262	1.391	0.527
12	0.4213	45.810	25.3	11.6	1.057	0.871	1.928	2.21	6.255	1.399	0.528
13	0.4516	45.750	25.3	12.6	1.041	0.882	1.923	2.18	6.244	1.403	0.521
14	0.4714	46.020	25.5	13.4	1.044	0.880	1.924	2.19	6.246	1.402	0.522
15	0.4919	46.110	25.6	14.1	1.039	0.892	1.931	2.16	6.234	1.411	0.519
16	0.5167	46.090	25.6	15.0	1.027	0.877	1.904	2.17	6.249	1.391	0.514

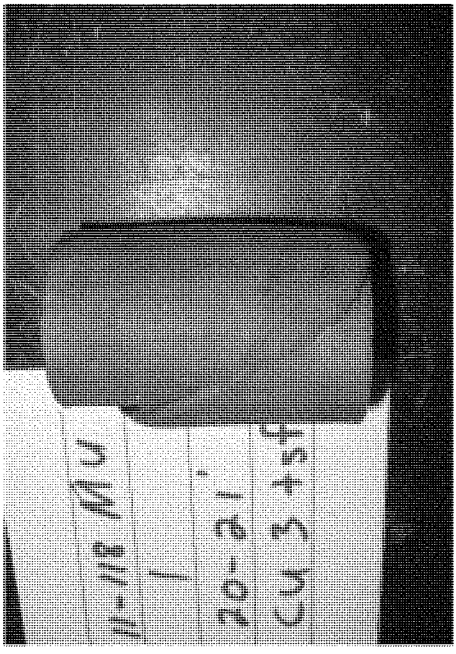
Preliminary for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	88.990			144.050
Moisture content: Dry soil+tare, gms.	69.390			108.130
Moisture content: Tare, gms.	29.970			31.060
Moisture, %	49.7	52.0	50.2	46.6
Moist specimen weight, gms.	118.7			
Diameter, in.	1.39	1.39	1.38	
Area, in.²	1.51	1.51	1.49	
Height, in.	2.82	2.82	2.80	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	106.0	107.6	108.6	
Dry density, pcf	70.8	70.8	72.3	
Void ratio	1.4399	1.4399	1.3882	
Saturation, %	95.5	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.120 tsf
Consolidation back pressure = 4.138 tsf
Consolidation effective confining stress = 2.982 tsf
Peak Stress = 1.924 tsf **at reading no.** 5
Ult. Stress = 1.407 tsf **at reading no.** 16

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	0.0646	17.640	0.0	0.0	0.000	2.982	2.982	1.00	4.138	2.982	0.000
1	0.0714	28.190	10.6	0.2	0.508	2.707	3.215	1.19	4.413	2.961	0.254
2	0.0873	42.390	24.8	0.8	1.185	2.259	3.444	1.52	4.861	2.851	0.592
3	0.1179	54.520	36.9	1.9	1.746	1.880	3.626	1.93	5.240	2.753	0.873
4	0.1382	57.110	39.5	2.6	1.855	1.744	3.599	2.06	5.376	2.672	0.928
5	0.1685	59.030	41.4	3.7	1.924	1.632	3.556	2.18	5.488	2.594	0.962
6	0.1999	58.040	40.4	4.8	1.856	1.594	3.450	2.16	5.526	2.522	0.928
7	0.2300	56.410	38.8	5.9	1.761	1.587	3.348	2.11	5.533	2.467	0.880
8	0.2508	54.510	36.9	6.7	1.661	1.605	3.266	2.04	5.515	2.436	0.831
9	0.2810	53.400	35.8	7.7	1.593	1.637	3.230	1.97	5.483	2.433	0.796
10	0.3125	53.460	35.8	8.9	1.576	1.656	3.232	1.95	5.464	2.444	0.788
11	0.3431	52.630	35.0	10.0	1.521	1.665	3.186	1.91	5.455	2.425	0.760
12	0.3733	52.110	34.5	11.0	1.480	1.674	3.154	1.88	5.446	2.414	0.740
13	0.4037	51.980	34.3	12.1	1.457	1.638	3.095	1.89	5.482	2.366	0.728
14	0.4242	52.210	34.6	12.8	1.454	1.620	3.074	1.90	5.500	2.347	0.727
15	0.4345	51.850	34.2	13.2	1.433	1.634	3.067	1.88	5.486	2.351	0.717
16	0.4851	51.950	34.3	15.0	1.407	1.654	3.061	1.85	5.466	2.358	0.704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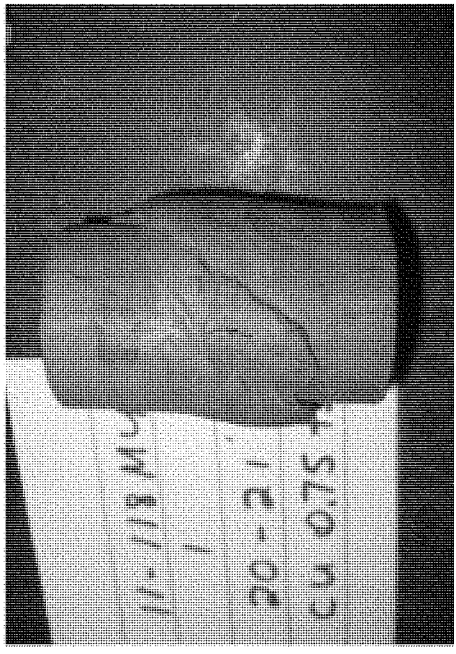
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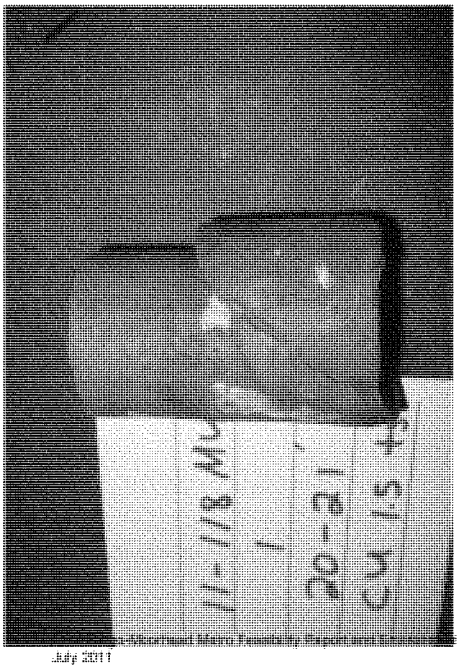
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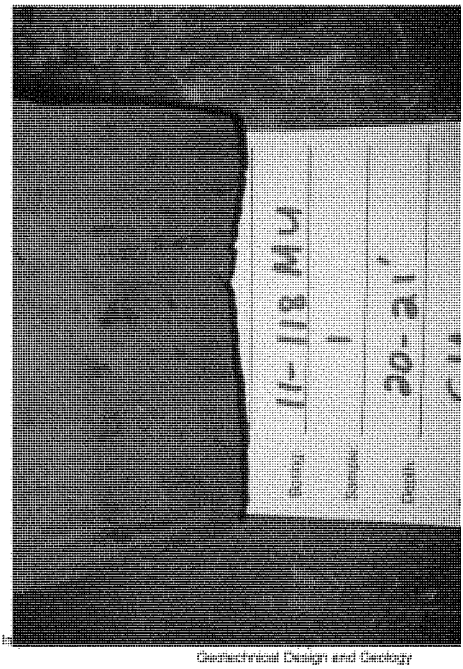
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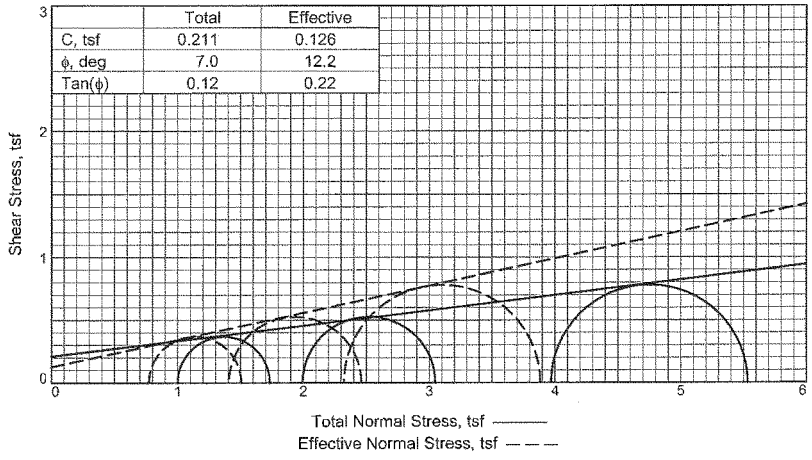
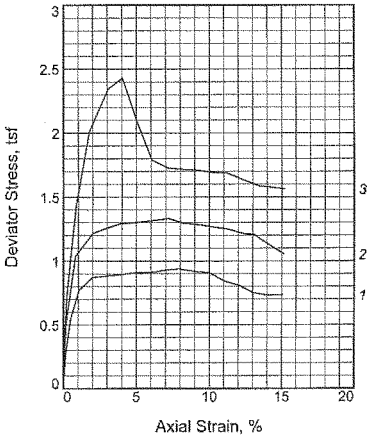




Sample No.		1	2	3
Initial	Water Content, %	56.4	55.8	58.5
	Dry Density, pcf	66.7	67.1	65.3
	Saturation, %	98.7	98.4	98.7
	Void Ratio	1.5728	1.5581	1.6308
	Diameter, in.	1.39	1.39	1.40
	Height, in.	2.80	2.80	2.81
At Test	Water Content, %	56.2	54.2	55.3
	Dry Density, pcf	67.4	68.9	68.1
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.5453	1.4899	1.5197
	Diameter, in.	1.39	1.38	1.38
	Height, in.	2.79	2.77	2.77
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		1.00	2.00	3.97
Back Pressure, tsf		6.14	5.14	3.17
Cell Pressure, tsf		7.14	7.14	7.14
Peak Deviator Stress, tsf		0.94	1.33	2.43
Total Pore Pr., tsf		6.57	5.78	4.85
Ultimate Deviator Stress, tsf		0.73	1.05	1.56
Total Pore Pr., tsf		6.37	5.73	4.82
Maj. Eff. Stress at Ultimate, tsf		1.51	2.46	3.89
Min. Eff. Stress at Ultimate, tsf		0.77	1.41	2.32

Type of Test:
CU with Pore Pressures
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, gray (CH)

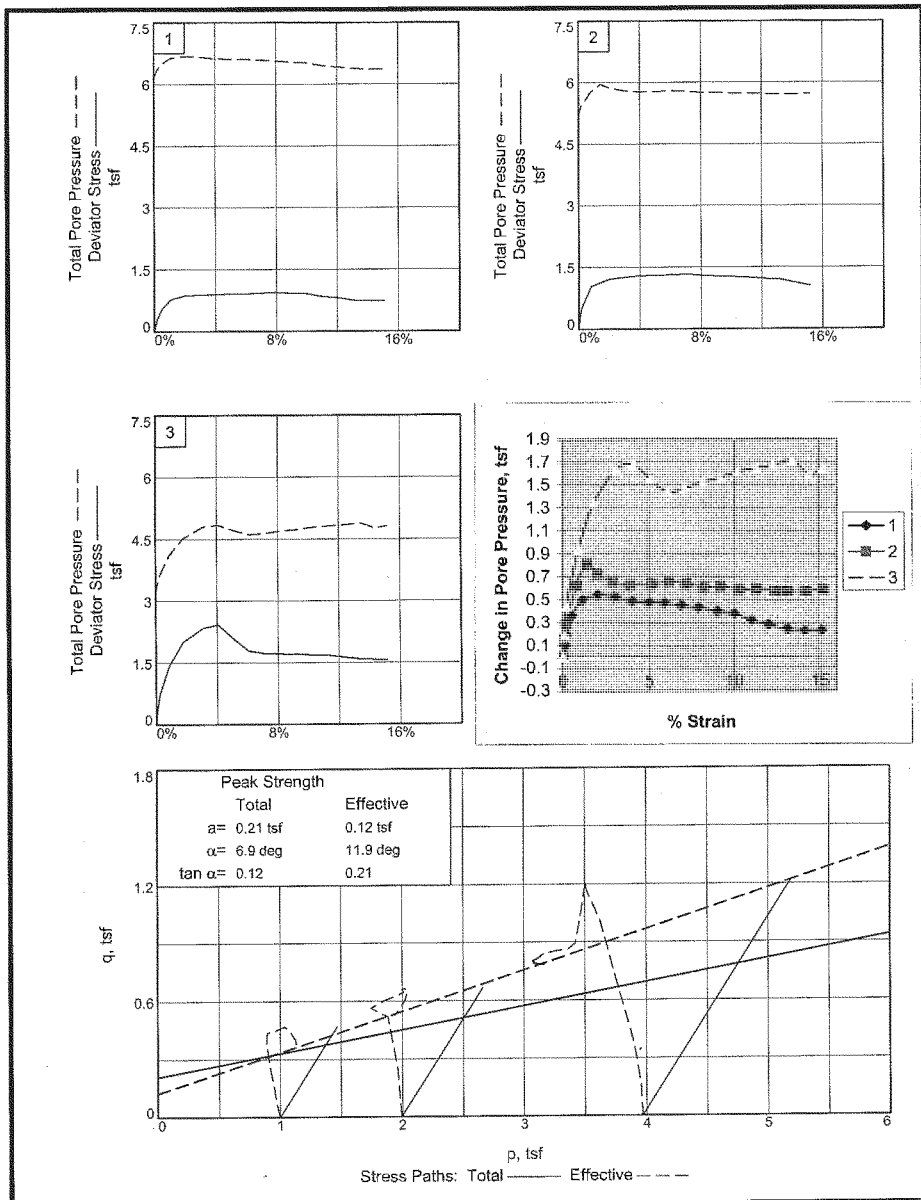
LL= 102 **PL=** 24 **PI=** 78
Assumed Specific Gravity= 2.75
Remarks: Rate of strain is 0.001 in/min. Failure criteria based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Moorhead
Location: SE-ED-01, East Diversion, Brenna Formation
Sample Number: Boring 09-11MU, #2 **Depth:** 30-32'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Figure CU Triax ASTM D4767



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: SE-ED-01, East Diversion, Brenna Formation **Depth:** 30-32' **Sample No.:** Boring 09-11MU, #2
Project No.: BL-09-03127 **Figure**

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST 10/12/2009
CU with Pore Pressures 3:20 PM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-ED-01, East Diversion, Brenna Formation
Depth: 30-32' **Sample Number:** Boring 09-11MU, #2
Description: FAT CLAY, gray (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=2.75 **LL=**102 **PL=**24 **PI=**78
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	109.110			146.840
Moisture content: Dry soil+tare, gms.	80.640			105.100
Moisture content: Tare, gms.	30.200			30.510
Moisture, %	56.4	57.2	56.2	56.0
Moist specimen weight, gms.	116.5			
Diameter, in.	1.39	1.39	1.39	
Area, in.^{2}	1.52	1.52	1.51	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	104.4	104.9	105.3	
Dry density, pcf	66.7	66.7	67.4	
Void ratio	1.5728	1.5728	1.5453	
Saturation, %	98.7	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.137 tsf
Consolidation back pressure = 6.138 tsf
Consolidation effective confining stress = 0.999 tsf
Fail. Stress = 0.940 tsf **at reading no.** 11
Ult. Stress = 0.735 tsf **at reading no.** 18

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	0.0088	19.100	0.0	0.0	0.000	0.999	0.999	1.00	6.138	0.999	0.000
1	0.0108	21.970	2.9	0.1	0.137	0.903	1.040	1.15	6.234	0.971	0.068
2	0.0139	25.320	6.2	0.2	0.296	0.804	1.100	1.37	6.333	0.952	0.148
3	0.0227	30.630	11.5	0.5	0.547	0.639	1.186	1.86	6.498	0.913	0.274
4	0.0386	35.460	16.4	1.1	0.772	0.503	1.275	2.54	6.634	0.889	0.386
5	0.0644	37.750	18.6	2.0	0.872	0.457	1.329	2.91	6.680	0.893	0.436
6	0.0912	38.170	19.1	3.0	0.883	0.473	1.356	2.87	6.664	0.915	0.442
7	0.1191	38.610	19.5	4.0	0.894	0.513	1.407	2.74	6.624	0.960	0.447
8	0.1469	39.150	20.1	5.0	0.909	0.523	1.432	2.74	6.614	0.978	0.455
9	0.1740	39.380	20.3	5.9	0.910	0.528	1.438	2.72	6.609	0.983	0.455
10	0.2019	39.990	20.9	6.9	0.928	0.549	1.477	2.69	6.588	1.013	0.464
11	0.2298	40.490	21.4	7.9	0.940	0.567	1.507	2.66	6.570	1.037	0.470
12	0.2583	40.250	21.1	9.0	0.919	0.600	1.519	2.53	6.537	1.059	0.459
13	0.2875	40.260	21.2	10.0	0.909	0.622	1.531	2.46	6.515	1.076	0.454
14	0.3165	38.910	19.8	11.0	0.841	0.684	1.525	2.23	6.453	1.104	0.420
15	0.3444	38.360	19.3	12.0	0.808	0.721	1.529	2.12	6.416	1.125	0.404
16	0.3733	37.170	18.1	13.1	0.750	0.759	1.509	1.99	6.378	1.134	0.375
17	0.4022	36.930	17.8	14.1	0.731	0.773	1.504	1.95	6.364	1.138	0.365
18	0.4290	37.230	18.1	15.1	0.735	0.771	1.506	1.95	6.366	1.138	0.367

Parameters for Specimen No. 2				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	147.290			145.340
Moisture content: Dry soil+tare, gms.	105.370			105.040
Moisture content: Tare, gms.	30.180			29.960
Moisture, %	55.8	56.7	54.2	53.7
Moist specimen weight, gms.	117.0			
Diameter, in.	1.39	1.39	1.38	
Area, in.²	1.52	1.52	1.50	
Height, in.	2.80	2.80	2.77	
Net decrease in height, in.		0.00	0.03	
Wet Density, pcf	104.5	105.1	106.3	
Dry density, pcf	67.1	67.1	68.9	
Void ratio	1.5581	1.5581	1.4899	
Saturation, %	98.4	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.137 tsf

Consolidation back pressure = 5.143 tsf

Consolidation effective confining stress = 1.994 tsf

Fail. Stress = 1.331 tsf at reading no. 10

Ult. Stress = 1.054 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	0.0078	18.790	0.0	0.0	0.000	1.994	1.994	1.00	5.143	1.994	0.000
1	0.0096	24.560	5.8	0.1	0.277	1.837	2.114	1.15	5.300	1.976	0.139
2	0.0127	29.350	10.6	0.2	0.507	1.709	2.216	1.30	5.428	1.963	0.254
3	0.0306	40.520	21.7	0.8	1.037	1.366	2.403	1.76	5.771	1.884	0.518
4	0.0476	42.610	23.8	1.4	1.129	1.181	2.310	1.96	5.956	1.746	0.565
5	0.0642	44.610	25.8	2.0	1.217	1.266	2.483	1.96	5.871	1.874	0.608
6	0.0895	45.730	26.9	2.9	1.258	1.332	2.590	1.94	5.805	1.961	0.629
7	0.1160	46.730	27.9	3.9	1.292	1.364	2.656	1.95	5.773	2.010	0.646
8	0.1509	47.350	28.6	5.2	1.303	1.356	2.659	1.96	5.781	2.007	0.651
9	0.1789	47.980	29.2	6.2	1.317	1.338	2.655	1.98	5.799	1.997	0.659
10	0.2078	48.610	29.8	7.2	1.331	1.357	2.688	1.98	5.780	2.022	0.665
11	0.2357	48.120	29.3	8.2	1.295	1.384	2.679	1.94	5.753	2.031	0.647
12	0.2638	48.240	29.5	9.2	1.286	1.382	2.668	1.93	5.755	2.025	0.643
13	0.2928	48.120	29.3	10.3	1.266	1.405	2.671	1.90	5.732	2.038	0.633
14	0.3217	48.060	29.3	11.3	1.249	1.406	2.655	1.89	5.731	2.030	0.624
15	0.3513	47.600	28.8	12.4	1.214	1.418	2.632	1.86	5.719	2.025	0.607
16	0.3713	47.690	28.9	13.1	1.208	1.419	2.627	1.85	5.718	2.023	0.604
17	0.4005	46.020	27.2	14.2	1.124	1.422	2.546	1.79	5.715	1.984	0.562
18	0.4285	44.610	25.8	15.2	1.054	1.407	2.461	1.75	5.730	1.934	0.527

Parameters for Specimen No. 3				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	117.940			144.100
Moisture content: Dry soil+tare, gms.	85.580			104.940
Moisture content: Tare, gms.	30.290			30.740
Moisture, %	58.5	59.3	55.3	52.8
Moist specimen weight, gms.	117.0			
Diameter, in.	1.40	1.40	1.38	
Area, in.²	1.53	1.53	1.49	
Height, in.	2.82	2.82	2.78	
Net decrease in height, in.		0.00	0.04	
Wet Density, pcf	103.4	104.0	105.8	
Dry density, pcf	65.3	65.3	68.1	
Void ratio	1.6308	1.6308	1.5197	
Saturation, %	98.7	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.138 tsf

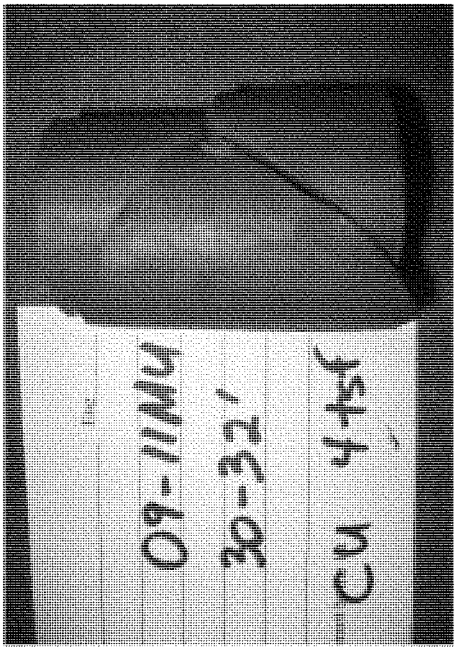
Consolidation back pressure = 3.168 tsf

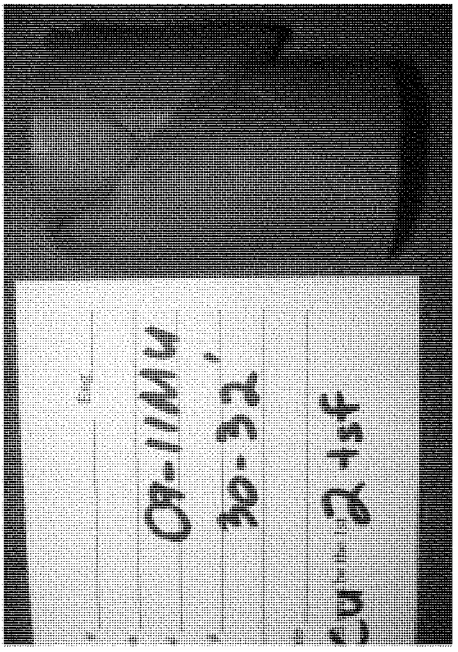
Consolidation effective confining stress = 3.970 tsf

Fail. Stress = 2.430 tsf at reading no. 6

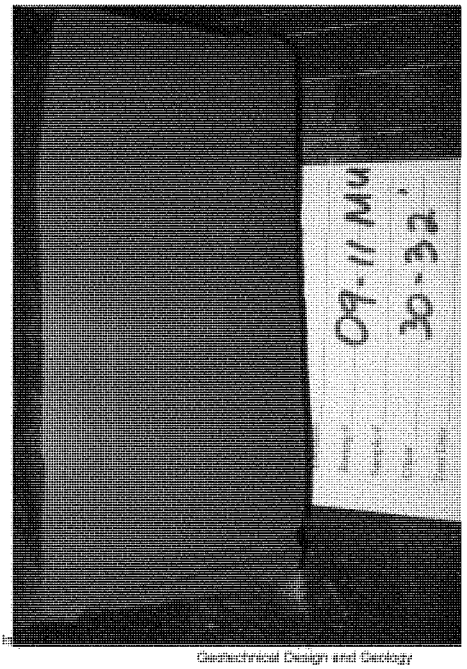
Ult. Stress = 1.563 tsf at reading no. 17

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	0.0188	19.280	0.0	0.0	0.000	3.970	3.970	1.00	3.168	3.970	0.000
1	0.0206	26.420	7.1	0.1	0.345	3.782	4.127	1.09	3.356	3.955	0.173
2	0.0255	34.720	15.4	0.2	0.746	3.528	4.274	1.21	3.610	3.901	0.373
3	0.0426	49.160	29.9	0.9	1.434	3.032	4.466	1.47	4.106	3.749	0.717
4	0.0682	61.550	42.3	1.8	2.010	2.623	4.633	1.77	4.515	3.628	1.005
5	0.1044	69.300	50.0	3.1	2.347	2.338	4.685	2.00	4.800	3.512	1.174
6	0.1312	71.590	52.3	4.1	2.430	2.292	4.722	2.06	4.846	3.507	1.215
7	0.1591	64.660	45.4	5.1	2.086	2.421	4.507	1.86	4.717	3.464	1.043
8	0.1869	58.620	39.3	6.1	1.789	2.528	4.317	1.71	4.610	3.423	0.895
9	0.2168	57.710	38.4	7.1	1.728	2.500	4.228	1.69	4.638	3.364	0.864
10	0.2459	57.920	38.6	8.2	1.718	2.442	4.160	1.70	4.696	3.301	0.859
11	0.2747	58.190	38.9	9.2	1.710	2.408	4.118	1.71	4.730	3.263	0.855
12	0.3024	58.190	38.9	10.2	1.691	2.356	4.047	1.72	4.782	3.202	0.846
13	0.3315	58.532	39.3	11.3	1.686	2.324	4.010	1.73	4.814	3.167	0.843
14	0.3605	57.800	38.5	12.3	1.635	2.297	3.932	1.71	4.841	3.115	0.818
15	0.3915	57.170	37.9	13.4	1.588	2.258	3.846	1.70	4.880	3.052	0.794
16	0.4193	57.270	38.0	14.4	1.574	2.382	3.956	1.66	4.756	3.169	0.787
17	0.4400	57.340	38.1	15.2	1.563	2.322	3.885	1.67	4.816	3.104	0.782

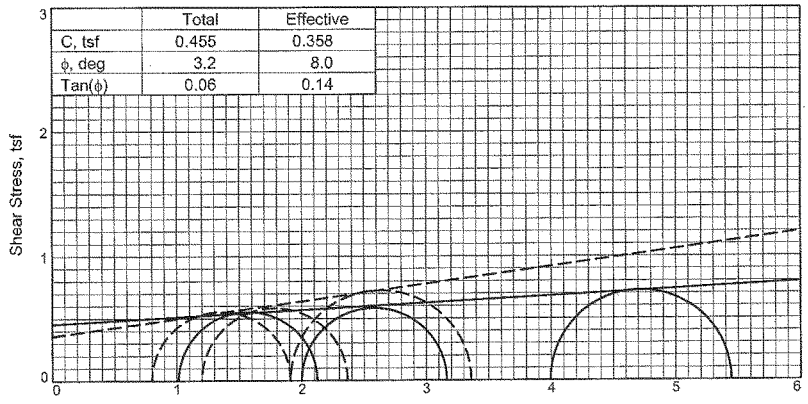

09-11MW
20-32'
Cu 4+f

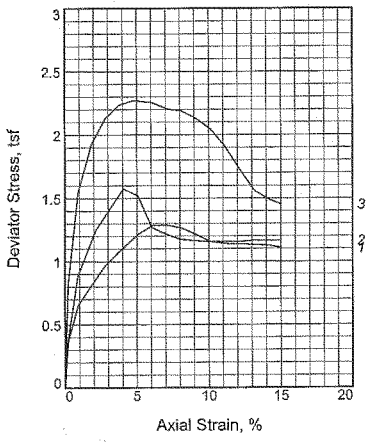

09-11MW
20-32'
Cu 2+f

09-11 MW
20-32'
Cu 1+f


09-11 MW
20-32'

	Total	Effective
C, tsf	0.455	0.358
ϕ, deg	3.2	8.0
Tan(ϕ)	0.06	0.14





Sample No.		1	2	3
Initial	Water Content, %	52.1	54.8	54.8
	Dry Density, pcf	70.1	67.3	67.2
	Saturation, %	98.8	97.3	96.8
	Void Ratio	1.4505	1.5508	1.5562
	Diameter, in.	1.39	1.40	1.39
	Height, in.	2.82	2.82	2.81
At Test	Water Content, %	51.3	53.4	52.7
	Dry Density, pcf	71.2	69.5	70.1
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.4115	1.4699	1.4482
	Diameter, in.	1.38	1.38	1.37
	Height, in.	2.80	2.79	2.77
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		1.01	2.00	4.00
Back Pressure, tsf		6.13	5.14	3.15
Cell Pressure, tsf		7.14	7.14	7.15
Peak Deviator Stress, tsf		1.29	1.58	2.27
	Total Pore Pr., tsf	6.53	6.07	4.90
Ultimate Deviator Stress, tsf		1.11	1.17	1.45
	Total Pore Pr., tsf	6.34	5.94	5.24
Maj. Eff. Stress at Ultimate, tsf		1.91	2.37	3.36
Min. Eff. Stress at Ultimate, tsf		0.80	1.20	1.91

Type of Test:
CU with Pore Pressures
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, gray (CH)

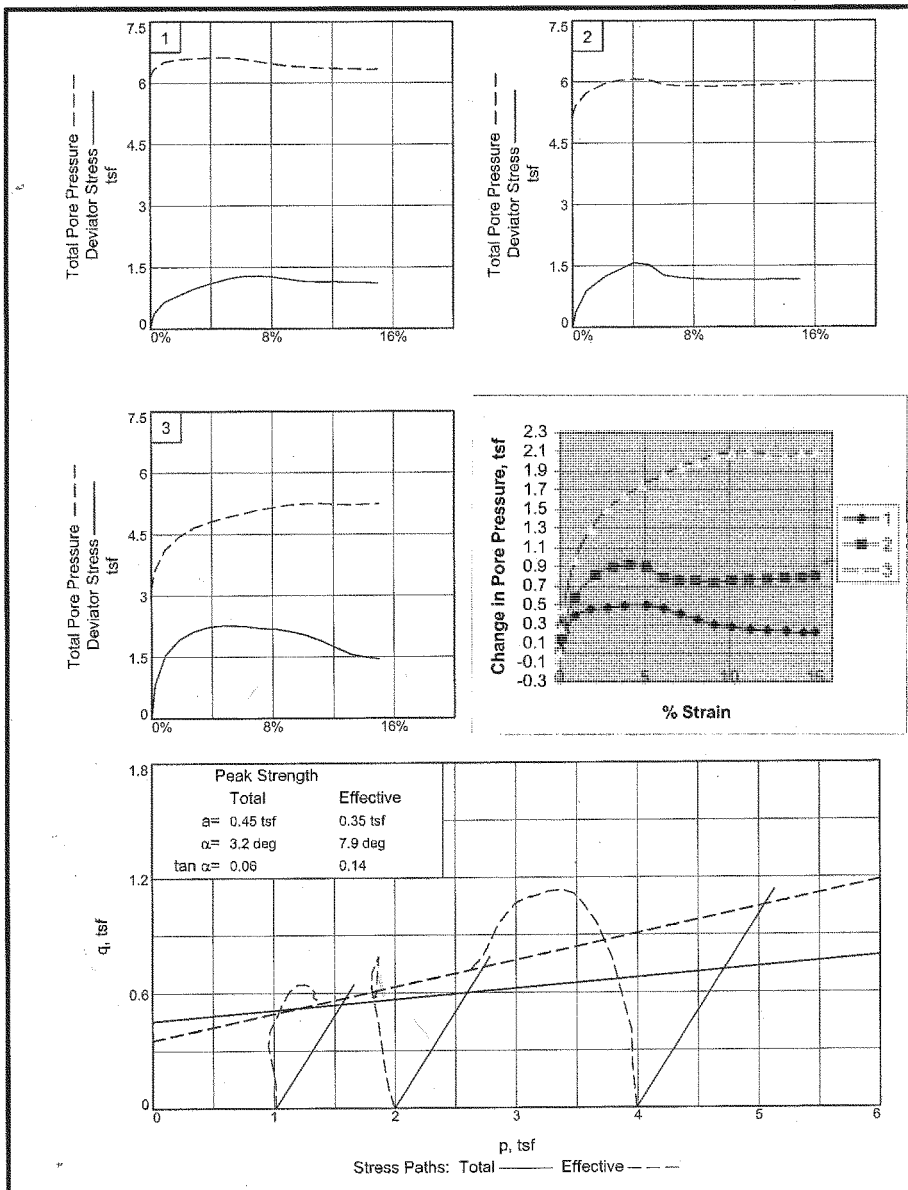
LL= 90 **PL=** 24 **PI=** 66
Assumed Specific Gravity= 2.75
Remarks: Rate of strain is 0.001 in/min. Failure criteria based on the ulimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Moorhead
Location: SE-ED-01, East Diversion, Brenna Formation
Sample Number: Boring 09-11MU, #3 **Depth:** 40-42'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Figure Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Attachment I-4, pg 223
Geotechnical Design and Geology



Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Loc.: SE-ED-01, East Diversion, Brenna Formation **Depth:** 40-42' **Sample No.:** Boring 09-11MU, #3

Project No.: BL-09-01427 **Figure** **Braun Intertec**

Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2014
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST 10/12/2009
CU with Pore Pressures 3:32 PM

Date:	
Client:	US Army Corps of Engineers
Project:	Fargo-Moorhead Metro Feasibility Study W912ES-09-P-0115
Project No.:	BL-09-03127
Location:	SE-ED-01, East Diversion, Brenna Formation
Depth:	40-42' **Sample Number:** Boring 09-11MU, #3
Description:	FAT CLAY, gray (CH)
Remarks:	Rate of strain is 0.001 in/min. Failure criteria based on the ulimate 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=90** **PL=24** **PI=66**
Test Method:	COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	136.180			149.200
Moisture content: Dry soil+tare, gms.	100.340			109.230
Moisture content: Tare, gms.	31.590			30.630
Moisture, %	52.1	52.7	51.3	50.9
Moist specimen weight, gms.	119.1			
Diameter, in.	1.39	1.39	1.38	
Area, in.^{2}	1.51	1.51	1.49	
Height, in.	2.82	2.82	2.80	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	106.6	107.0	107.7	
Dry density, pcf	70.1	70.1	71.2	
Void ratio	1.4505	1.4505	1.4115	
Saturation, %	98.8	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.139 tsf
Consolidation back pressure = 6.125 tsf
Consolidation effective confining stress = 1.014 tsf
Fail. Stress = 1.290 tsf **at reading no.** 9
Ult. Stress = 1.108 tsf **at reading no.** 17

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	0.0107	18.490	0.0	0.0	0.000	1.014	1.014	1.00	6.125	1.014	0.000
1	0.0137	23.340	4.9	0.1	0.233	0.899	1.132	1.26	6.240	1.016	0.117
2	0.0178	26.450	8.0	0.3	0.382	0.805	1.187	1.48	6.334	0.996	0.191
3	0.0364	32.220	13.7	0.9	0.655	0.627	1.282	2.05	6.512	0.955	0.328
4	0.0625	35.610	17.1	1.8	0.809	0.563	1.372	2.44	6.576	0.968	0.405
5	0.0893	39.180	20.7	2.8	0.969	0.545	1.514	2.78	6.594	1.029	0.484
6	0.1162	41.740	23.3	3.8	1.078	0.525	1.603	3.05	6.614	1.064	0.539
7	0.1532	45.090	26.6	5.1	1.216	0.520	1.736	3.34	6.619	1.128	0.608
8	0.1812	46.900	28.4	6.1	1.285	0.552	1.837	3.33	6.587	1.195	0.643
9	0.2088	47.300	28.8	7.1	1.290	0.610	1.900	3.11	6.529	1.255	0.645
10	0.2369	47.120	28.6	8.1	1.268	0.669	1.937	2.89	6.470	1.303	0.634
11	0.2655	46.230	27.7	9.1	1.215	0.725	1.940	2.68	6.414	1.332	0.607
12	0.2939	45.220	26.7	10.1	1.157	0.745	1.902	2.55	6.394	1.324	0.579
13	0.3235	45.130	26.6	11.2	1.140	0.771	1.911	2.48	6.368	1.341	0.570
14	0.3533	45.410	26.9	12.2	1.138	0.785	1.923	2.45	6.354	1.354	0.569
15	0.3824	45.560	27.1	13.3	1.131	0.789	1.920	2.43	6.350	1.354	0.565
16	0.4102	45.750	27.3	14.3	1.126	0.804	1.930	2.40	6.335	1.367	0.563
17	0.4304	45.550	27.1	15.0	1.108	0.800	1.908	2.39	6.339	1.354	0.554

Parameters for Specimen No. 2				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	109.990			147.470
Moisture content: Dry soil+tare, gms.	81.790			107.120
Moisture content: Tare, gms.	30.370			30.950
Moisture, %	54.8	56.4	53.4	53.0
Moist specimen weight, gms.	118.5			
Diameter, in.	1.40	1.40	1.38	
Area, in.²	1.54	1.54	1.50	
Height, in.	2.82	2.82	2.79	
Net decrease in height, in.		0.00	0.03	
Wet Density, pcf	104.2	105.3	106.7	
Dry density, pcf	67.3	67.3	69.5	
Void ratio	1.5508	1.5508	1.4699	
Saturation, %	97.3	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.142 tsf

Consolidation back pressure = 5.145 tsf

Consolidation effective confining stress = 1.997 tsf

Fail. Stress = 1.575 tsf at reading no. 6

Ult. Stress = 1.167 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	0.0208	18.970	0.0	0.0	0.000	1.997	1.997	1.00	5.145	1.997	0.000
1	0.0237	22.940	4.0	0.1	0.190	1.853	2.043	1.10	5.289	1.948	0.095
2	0.0266	26.790	7.8	0.2	0.373	1.733	2.106	1.22	5.409	1.920	0.187
3	0.0455	37.620	18.6	0.9	0.885	1.420	2.305	1.62	5.722	1.862	0.442
4	0.0804	45.560	26.6	2.1	1.245	1.182	2.427	2.05	5.960	1.805	0.623
5	0.1073	49.430	30.5	3.1	1.413	1.103	2.516	2.28	6.039	1.809	0.706
6	0.1342	53.280	34.3	4.1	1.575	1.076	2.651	2.46	6.066	1.864	0.788
7	0.1621	52.460	33.5	5.1	1.522	1.100	2.622	2.38	6.042	1.861	0.761
8	0.1897	47.180	28.2	6.1	1.268	1.213	2.481	2.05	5.929	1.847	0.634
9	0.2168	46.320	27.4	7.0	1.217	1.243	2.460	1.98	5.899	1.851	0.608
10	0.2450	45.680	26.7	8.0	1.175	1.243	2.418	1.95	5.899	1.831	0.588
11	0.2738	45.730	26.8	9.1	1.164	1.265	2.429	1.92	5.877	1.847	0.582
12	0.3015	45.830	26.9	10.1	1.156	1.243	2.399	1.93	5.899	1.821	0.578
13	0.3306	46.140	27.2	11.1	1.156	1.235	2.391	1.94	5.907	1.813	0.578
14	0.3597	46.440	27.5	12.2	1.155	1.228	2.383	1.94	5.914	1.805	0.577
15	0.3874	47.020	28.1	13.2	1.166	1.218	2.384	1.96	5.924	1.801	0.583
16	0.4174	47.310	28.3	14.2	1.163	1.214	2.377	1.96	5.928	1.796	0.582
17	0.4385	47.650	28.7	15.0	1.167	1.199	2.366	1.97	5.943	1.782	0.583

Parameters for Specimen No. 3				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	142.960			141.820
Moisture content: Dry soil+tare, gms.	103.140			104.670
Moisture content: Tare, gms.	30.420			30.260
Moisture, %	54.8	56.6	52.7	49.9
Moist specimen weight, gms.	116.0			
Diameter, in.	1.39	1.39	1.37	
Area, in.^{2}	1.51	1.51	1.47	
Height, in.	2.81	2.81	2.77	
Net decrease in height, in.		0.00	0.04	
Wet Density, pcf	103.9	105.2	107.1	
Dry density, pcf	67.2	67.2	70.1	
Void ratio	1.5562	1.5562	1.4482	
Saturation, %	96.8	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.148 tsf

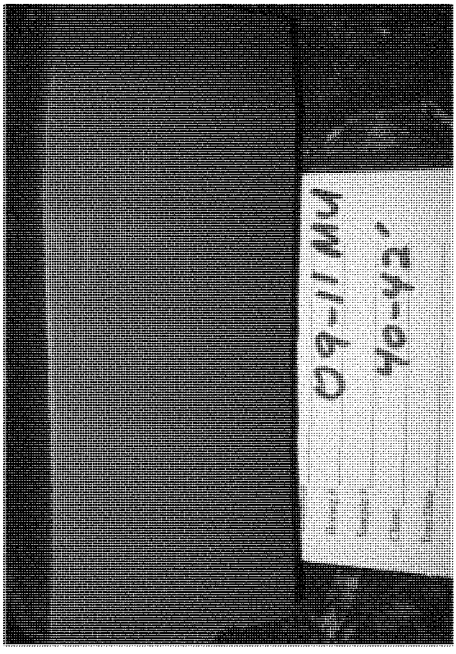
Consolidation back pressure = 3.155 tsf

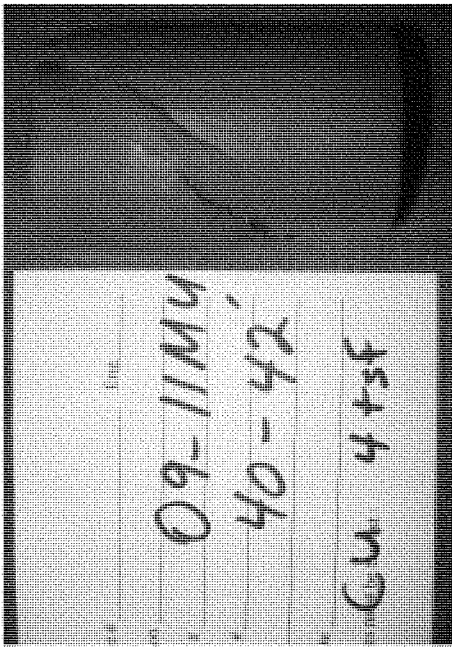
Consolidation effective confining stress = 3.993 tsf

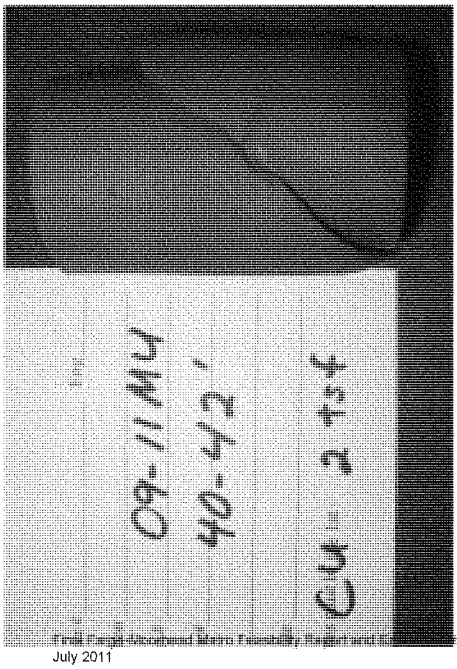
Fail. Stress = 2.272 tsf at reading no. 7

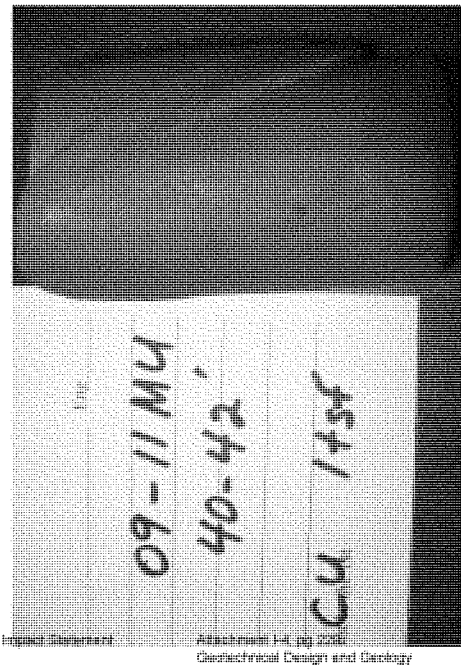
Ult. Stress = 1.451 tsf at reading no. 17

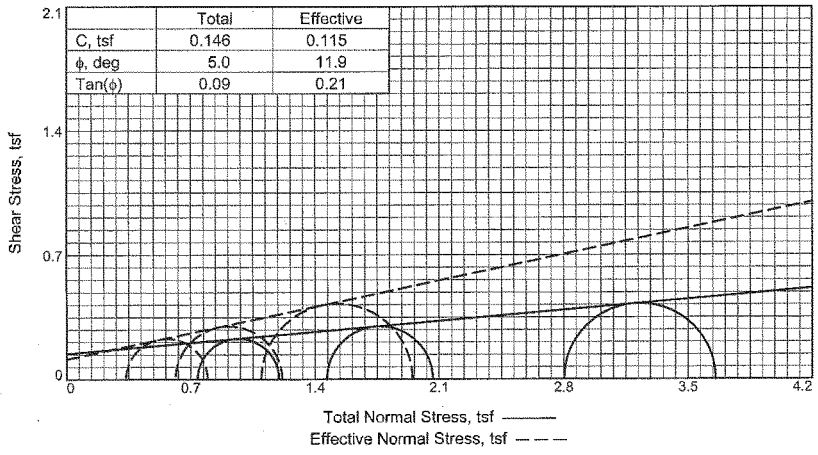
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0506	19.770	0.0	0.0	0.000	3.993	3.993	1.00	3.155	3.993	0.000
1	0.0535	28.440	8.7	0.1	0.425	3.745	4.170	1.11	3.403	3.957	0.212
2	0.0566	36.490	16.7	0.2	0.818	3.540	4.358	1.23	3.608	3.949	0.409
3	0.0757	51.600	31.8	0.9	1.547	3.020	4.567	1.51	4.128	3.794	0.774
4	0.1015	59.720	40.0	1.8	1.923	2.704	4.627	1.71	4.444	3.666	0.962
5	0.1285	64.390	44.6	2.8	2.127	2.488	4.615	1.85	4.660	3.552	1.064
6	0.1552	67.110	47.3	3.8	2.234	2.361	4.595	1.95	4.787	3.478	1.117
7	0.1832	68.420	48.7	4.8	2.272	2.245	4.517	2.01	4.903	3.381	1.136
8	0.2198	68.750	49.0	6.1	2.256	2.138	4.394	2.06	5.010	3.266	1.128
9	0.2480	68.160	48.4	7.1	2.205	2.049	4.254	2.08	5.099	3.151	1.102
10	0.2759	68.380	48.6	8.1	2.191	1.997	4.188	2.10	5.151	3.092	1.095
11	0.3037	67.560	47.8	9.1	2.130	1.930	4.060	2.10	5.218	2.995	1.065
12	0.3318	66.100	46.3	10.1	2.042	1.911	3.953	2.07	5.237	2.932	1.021
13	0.3596	63.510	43.7	11.1	1.906	1.898	3.804	2.00	5.250	2.851	0.953
14	0.3877	59.810	40.0	12.2	1.725	1.924	3.649	1.90	5.224	2.787	0.863
15	0.4165	56.390	36.6	13.2	1.559	1.936	3.495	1.81	5.212	2.716	0.780
16	0.4445	55.170	35.4	14.2	1.490	1.913	3.403	1.78	5.235	2.658	0.745
17	0.4670	54.590	34.8	15.0	1.451	1.908	3.359	1.76	5.240	2.634	0.726


09-11 MW
40-42'

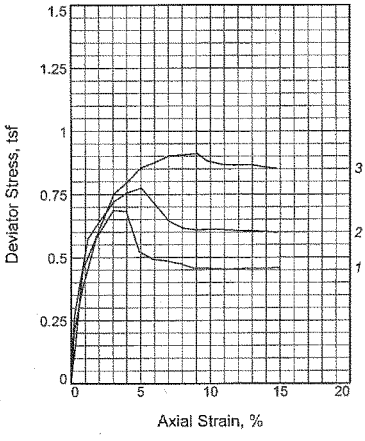

09-11 MW
40-42'
Cu: 4 tsf


09-11 MW
40-42'
Cu: 2 tsf


09-11 MW
40-42'
Cu: 1 tsf



	Total	Effective
C, tsf	0.146	0.115
ϕ, deg	5.0	11.9
Tan(ϕ)	0.09	0.21



Sample No.		1	2	3
Initial	Water Content, %	88.2	89.4	88.1
	Dry Density, pcf	49.9	49.3	49.9
	Saturation, %	99.5	99.1	99.3
	Void Ratio	2.4385	2.4789	2.4393
	Diameter, in.	1.39	1.39	1.40
	Height, in.	2.81	2.81	2.79
At Test	Water Content, %	86.7	83.5	75.6
	Dry Density, pcf	50.7	52.1	55.8
	Saturation, %	100.0	100.0	100.0
	Void Ratio	2.3836	2.2954	2.0787
	Diameter, in.	1.38	1.37	1.35
	Height, in.	2.79	2.76	2.69
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.74	1.47	2.80
Back Pressure, tsf		6.40	5.67	4.34
Cell Pressure, tsf		7.14	7.14	7.14
Peak Deviator Stress, tsf		0.69	0.77	0.91
Total Pore Pr., tsf		6.86	6.37	5.84
Ultimate Deviator Stress, tsf		0.46	0.60	0.85
Total Pore Pr., tsf		6.80	6.53	6.05
Maj. Eff. Stress at Ultimate, tsf		0.79	1.21	1.95
Min. Eff. Stress at Ultimate, tsf		0.33	0.61	1.10

Type of Test:
CU with Pore Pressures
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, brown (CH)

LL= 124 **PL=** 25 **PI=** 99
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
Moorhead Brenna
Location: SE-ED-15, East Diversion, ~~PL Sheyenne Formation~~
Sample Number: Boring 09-14MU, #2 **Depth:** 15-17'
Proj. No.: BL-09-03127 **Date Sampled:**

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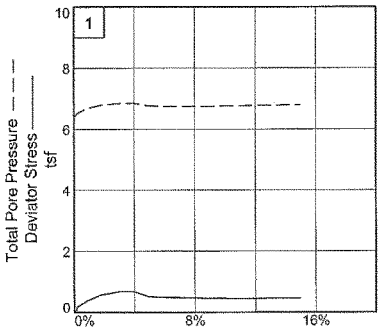

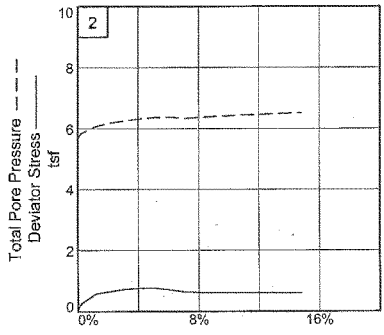

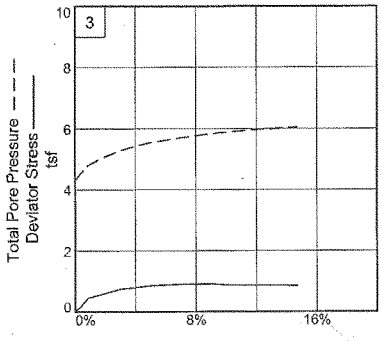

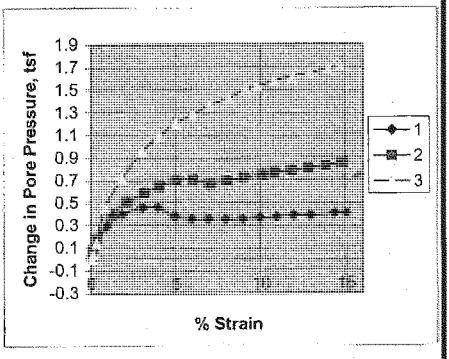

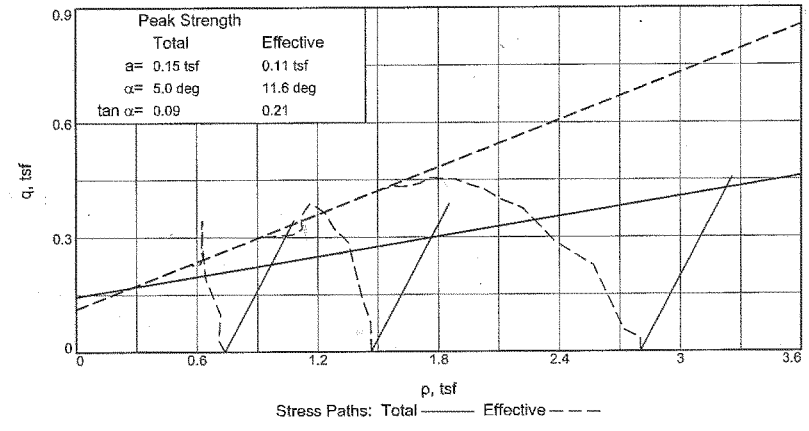

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Loc.: SE-ED-15, East Diversion, ~~PI. Sherack Formation~~ **Depth:** 15-17' **Sample No.:** Boring 09-14MU, #2

Project No.: 09-03127

Brenna

Figure

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Geotechnical Design and Geology

Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011

TRIAXIAL COMPRESSION TEST 10/13/2009
CU with Pore Pressures 1:19 PM

Date:	
Client:	US Army Corps of Engineers
Project:	Fargo-Moorhead Metro Feasibility Study W912ES-09-P-0115
Project No.:	BL-09-03127
Location:	SE-ED-15, East Diversion, ~~Pk Sherack Formation~~
Depth:	15-17' **Sample Number:** Boring 09-14MU, #2
Description:	FAT CLAY, brown (CH) Brenna
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=124** **PL=25** **PI=99**
Test Method:	COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	100.230			133.350
Moisture content: Dry soil+tare, gms.	67.530			85.610
Moisture content: Tare, gms.	30.450			30.220
Moisture, %	88.2	88.7	86.7	86.2
Moist specimen weight, gms.	105.5			
Diameter, in.	1.39	1.39	1.38	
Area, in.²	1.52	1.52	1.51	
Height, in.	2.81	2.81	2.80	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	94.0	94.2	94.7	
Dry density, pcf	49.9	49.9	50.7	
Void ratio	2.4385	2.4385	2.3836	
Saturation, %	99.5	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 6.402 tsf
Consolidation effective confining stress = 0.738 tsf
Fail. Stress = 0.686 tsf **at reading no.** 5
Ult. Stress = 0.460 tsf **at reading no.** 17

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	0.0209	19.070	0.0	0.0	0.000	0.738	0.738	1.00	6.402	0.738	0.000
1	0.0237	20.350	1.3	0.1	0.061	0.677	0.738	1.09	6.463	0.708	0.031
2	0.0268	23.190	4.1	0.2	0.197	0.618	0.815	1.32	6.522	0.716	0.098
3	0.0447	27.180	8.1	0.9	0.385	0.451	0.836	1.85	6.689	0.643	0.192
4	0.0705	31.270	12.2	1.8	0.573	0.340	0.913	2.69	6.800	0.627	0.287
5	0.1054	33.870	14.8	3.0	0.686	0.285	0.971	3.41	6.855	0.628	0.343
6	0.1312	33.930	14.9	3.9	0.683	0.283	0.966	3.41	6.857	0.624	0.341
7	0.1577	30.570	11.5	4.9	0.523	0.362	0.885	2.44	6.778	0.624	0.262
8	0.1850	30.020	10.9	5.9	0.493	0.385	0.878	2.28	6.755	0.631	0.246
9	0.2129	29.990	10.9	6.9	0.486	0.384	0.870	2.27	6.756	0.627	0.243
10	0.2409	29.840	10.8	7.9	0.475	0.386	0.861	2.23	6.754	0.623	0.237
11	0.2686	29.550	10.5	8.9	0.457	0.383	0.840	2.19	6.757	0.611	0.228
12	0.2966	29.670	10.6	9.9	0.457	0.373	0.830	2.22	6.767	0.601	0.228
13	0.3255	29.700	10.6	10.9	0.453	0.368	0.821	2.23	6.772	0.594	0.226
14	0.3533	29.850	10.8	11.9	0.454	0.355	0.809	2.28	6.785	0.582	0.227
15	0.3814	30.060	11.0	12.9	0.458	0.354	0.812	2.29	6.786	0.583	0.229
16	0.4194	30.220	11.1	14.3	0.457	0.336	0.793	2.36	6.804	0.565	0.229
17	0.4391	30.370	11.3	15.0	0.460	0.335	0.795	2.37	6.805	0.565	0.230

Parameters for Specimen No. 2				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	121.760			128.000
Moisture content: Dry soil+tare, gms.	78.950			86.000
Moisture content: Tare, gms.	31.040			31.480
Moisture, %	89.4	90.1	83.5	77.0
Moist specimen weight, gms.	104.8			
Diameter, in.	1.39	1.39	1.37	
Area, in.²	1.52	1.52	1.47	
Height, in.	2.81	2.81	2.76	
Net decrease in height, in.		0.00	0.05	
Wet Density, pcf	93.4	93.8	95.6	
Dry density, pcf	49.3	49.3	52.1	
Void ratio	2.4789	2.4789	2.2954	
Saturation, %	99.1	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.140 tsf

Consolidation back pressure = 5.674 tsf

Consolidation effective confining stress = 1.466 tsf

Fail. Stress = 0.774 tsf at reading no. 7

Ult. Stress = 0.599 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	0.0546	18.490	0.0	0.0	0.000	1.466	1.466	1.00	5.674	1.466	0.000
1	0.0575	21.600	3.1	0.1	0.153	1.387	1.540	1.11	5.753	1.463	0.076
2	0.0616	23.920	5.4	0.3	0.266	1.292	1.558	1.21	5.848	1.425	0.133
3	0.0874	30.300	11.8	1.2	0.573	1.066	1.639	1.54	6.074	1.353	0.287
4	0.1124	31.940	13.5	2.1	0.647	0.957	1.604	1.68	6.183	1.280	0.323
5	0.1392	33.660	15.2	3.1	0.722	0.880	1.602	1.82	6.260	1.241	0.361
6	0.1661	34.550	16.1	4.0	0.757	0.820	1.577	1.92	6.320	1.199	0.379
7	0.1938	35.090	16.6	5.0	0.774	0.771	1.545	2.00	6.369	1.158	0.387
8	0.2207	33.900	15.4	6.0	0.711	0.760	1.471	1.94	6.380	1.116	0.356
9	0.2487	32.580	14.1	7.0	0.644	0.801	1.445	1.80	6.339	1.123	0.322
10	0.2767	32.120	13.6	8.0	0.616	0.769	1.385	1.80	6.371	1.077	0.308
11	0.3035	32.120	13.6	9.0	0.609	0.739	1.348	1.82	6.401	1.044	0.305
12	0.3324	32.330	13.8	10.1	0.611	0.716	1.327	1.85	6.424	1.022	0.306
13	0.3516	32.430	13.9	10.8	0.611	0.699	1.310	1.87	6.441	1.005	0.306
14	0.3805	32.500	14.0	11.8	0.607	0.678	1.285	1.90	6.462	0.982	0.304
15	0.4083	32.620	14.1	12.8	0.605	0.657	1.262	1.92	6.483	0.960	0.303
16	0.4353	32.750	14.3	13.8	0.604	0.636	1.240	1.95	6.504	0.938	0.302
17	0.4634	32.800	14.3	14.8	0.599	0.615	1.214	1.97	6.525	0.914	0.299

Parameters for Specimen No. 3				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	124.690			124.480
Moisture content: Dry soil+tare, gms.	80.510			86.640
Moisture content: Tare, gms.	30.370			31.070
Moisture, %	88.1	88.7	75.6	68.1
Moist specimen weight, gms.	105.5			
Diameter, in.	1.40	1.40	1.35	
Area, in.²	1.53	1.53	1.42	
Height, in.	2.79	2.79	2.69	
Net decrease in height, in.		0.00	0.10	
Wet Density, pcf	93.9	94.2	97.9	
Dry density, pcf	49.9	49.9	55.8	
Void ratio	2.4393	2.4393	2.0787	
Saturation, %	99.3	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.144 tsf

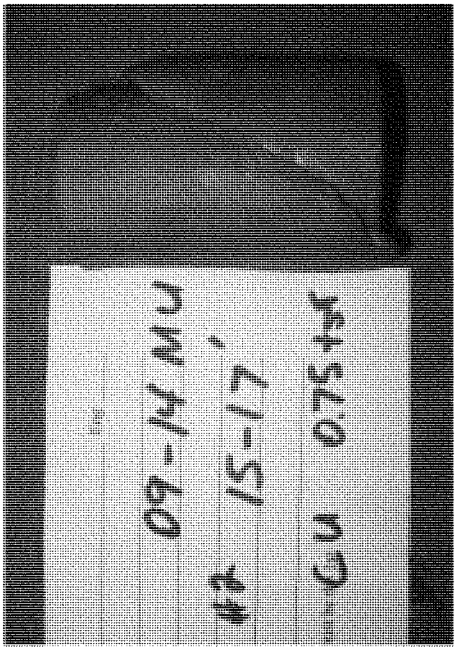
Consolidation back pressure = 4.342 tsf

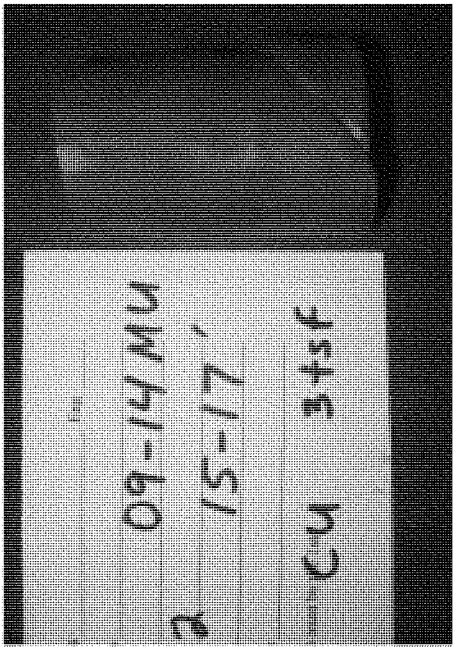
Consolidation effective confining stress = 2.802 tsf

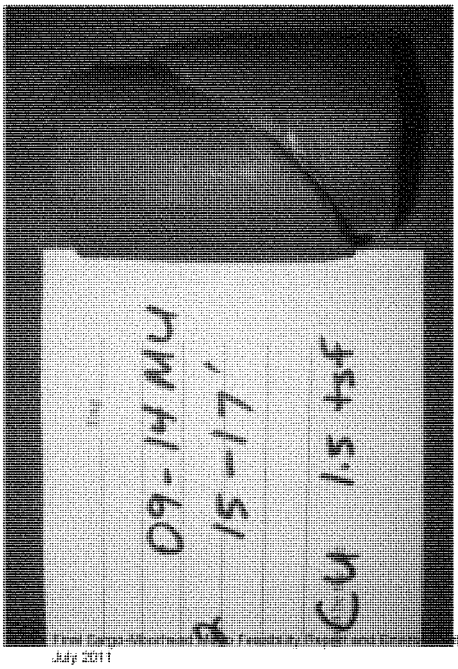
Fail. Stress = 0.911 tsf at reading no. 11

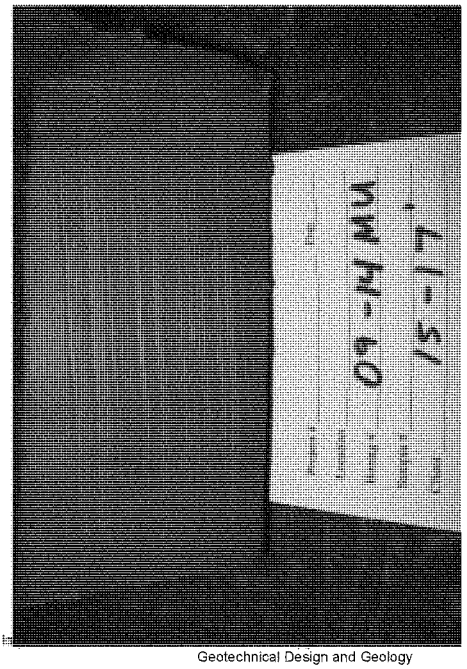
Ult. Stress = 0.854 tsf at reading no. 17

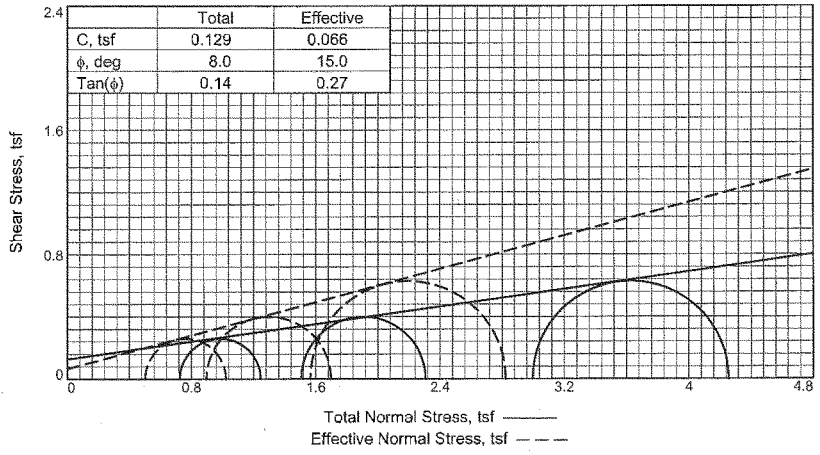
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0159	19.860	0.0	0.0	0.000	2.802	2.802	1.00	4.342	2.802	0.000
1	0.0189	21.290	1.4	0.1	0.072	2.763	2.835	1.03	4.381	2.799	0.036
2	0.0228	22.120	2.3	0.3	0.114	2.662	2.776	1.04	4.482	2.719	0.057
3	0.0386	28.890	9.0	0.8	0.453	2.343	2.796	1.19	4.801	2.570	0.227
4	0.0635	31.460	11.6	1.8	0.577	2.091	2.668	1.28	5.053	2.379	0.288
5	0.0975	35.150	15.3	3.0	0.750	1.846	2.596	1.41	5.298	2.221	0.375
6	0.1241	36.280	16.4	4.0	0.797	1.713	2.510	1.47	5.431	2.112	0.399
7	0.1503	37.640	17.8	5.0	0.855	1.594	2.449	1.54	5.550	2.021	0.427
8	0.1771	38.250	18.4	6.0	0.875	1.518	2.393	1.58	5.626	1.955	0.437
9	0.2050	39.030	19.2	7.0	0.902	1.438	2.340	1.63	5.706	1.889	0.451
10	0.2331	39.330	19.5	8.1	0.906	1.373	2.279	1.66	5.771	1.826	0.453
11	0.2599	39.670	19.8	9.1	0.911	1.300	2.211	1.70	5.844	1.756	0.456
12	0.2788	39.180	19.3	9.8	0.882	1.270	2.152	1.69	5.874	1.711	0.441
13	0.3068	39.110	19.3	10.8	0.869	1.222	2.091	1.71	5.922	1.656	0.434
14	0.3357	39.280	19.4	11.9	0.866	1.182	2.048	1.73	5.962	1.615	0.433
15	0.3634	39.550	19.7	12.9	0.868	1.152	2.020	1.75	5.992	1.586	0.434
16	0.3924	39.550	19.7	14.0	0.857	1.117	1.974	1.77	6.027	1.545	0.428
17	0.4114	39.640	19.8	14.7	0.854	1.097	1.951	1.78	6.047	1.524	0.427

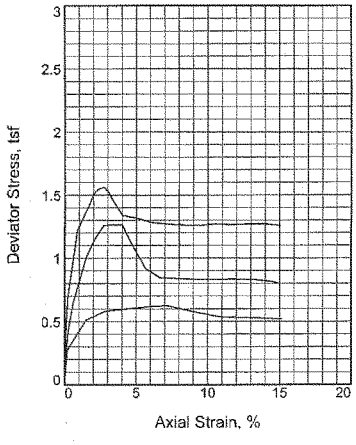

09-14 MW
#2 15-17'
Cu 0.75+sf


09-14 MW
#2 15-17'
Cu 3+sf


09-14 MW
#2 15-17'
Cu 1.5 +sf


09-14 MW
15-17'





Sample No.		1	2	3
Initial	Water Content, %	65.6	65.8	67.0
	Dry Density, pcf	60.3	60.7	59.6
	Saturation, %	97.7	99.0	98.1
	Void Ratio	1.8466	1.8271	1.8783
	Diameter, in.	1.41	1.41	1.41
	Height, in.	2.81	2.81	2.81
At Test	Water Content, %	67.1	66.4	68.3
	Dry Density, pcf	60.3	60.7	59.6
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.8466	1.8271	1.8783
	Diameter, in.	1.41	1.41	1.41
	Height, in.	2.81	2.81	2.81
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.73	1.51	2.99
Back Pressure, tsf		6.39	5.63	4.14
Cell Pressure, tsf		7.12	7.14	7.13
Peak Deviator Stress, tsf		0.63	1.26	1.56
Total Pore Pr., tsf		6.66	6.33	5.24
Ultimate Deviator Stress, tsf		0.52	0.80	1.26
Total Pore Pr., tsf		6.61	6.24	5.57
Maj. Eff. Stress at Ultimate, tsf		1.08	2.07	3.46
Min. Eff. Stress at Ultimate, tsf		0.46	0.80	1.90

Type of Test:
CU with Pore Pressures
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, gray (CH)

LL= 116 **PL=** 25 **PI=** 91
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 Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Moorhead
Sample Number: Boring 09-25MU, #4 **Depth:** 38-40'
Brenna
Proj. No.: BL-09-03127 **Date Sampled:**

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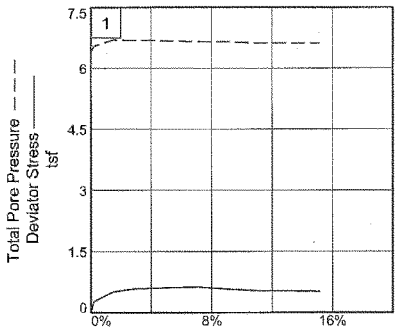
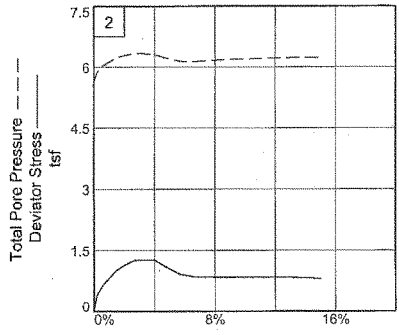
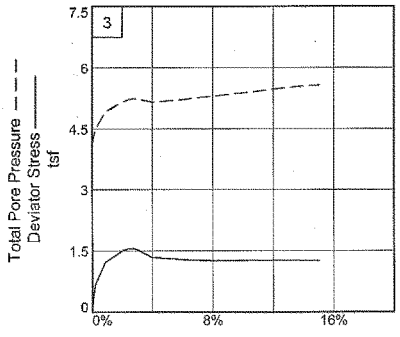
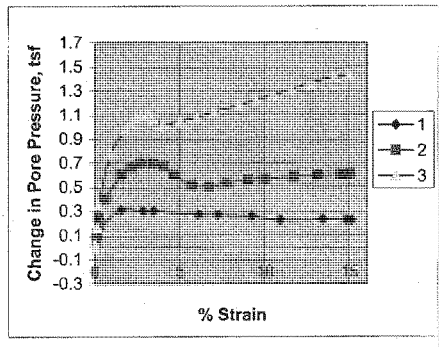
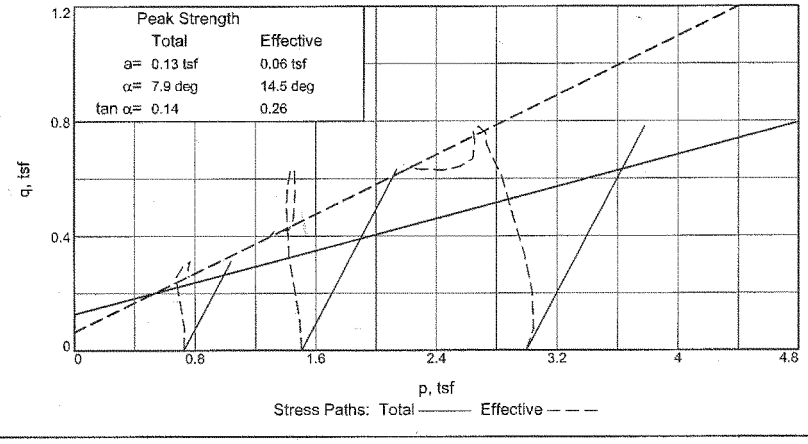
Figure CU Triax ASTM D4767











Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Moorhead
Depth: 38-40' **Sample Number:** Boring 09-25MU, #4 Brenna
Project No.: DE-09-05127 **Figure**

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Geotechnical, Design and Ecology

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

9/10/2009
2:24 PM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL-09-03127 Moorhead
Depth: 38-40' **Sample Number:** Boring 09-25MU, #4
Description: FAT CLAY, gray (CH) Brenna
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=**116 **PL=**25 **PI=**91
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	102.860			144.790
Moisture content: Dry soil+tare, gms.	74.100			99.450
Moisture content: Tare, gms.	30.260			29.960
Moisture, %	65.6	67.1	67.1	65.2
Moist specimen weight, gms.	114.4			
Diameter, in.	1.41	1.41	1.41	
Area, in.^{2}	1.55	1.55	1.55	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	99.9	100.8	100.8	
Dry density, pcf	60.3	60.3	60.3	
Void ratio	1.8466	1.8466	1.8466	
Saturation, %	97.7	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.117 tsf
Consolidation back pressure = 6.391 tsf
Consolidation effective confining stress = 0.726 tsf
Fail. Stress = 0.519 tsf **at reading no.** 12
Ult. Stress = 0.519 tsf **at reading no.** 12

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	0.0290	18.730	0.0	0.0	0.000	0.726	0.726	1.00	6.391	0.726	0.000
1	0.0314	21.940	3.2	0.1	0.149	0.655	0.804	1.23	6.462	0.729	0.074
2	0.0343	24.650	5.9	0.2	0.274	0.574	0.848	1.48	6.543	0.711	0.137
3	0.0710	29.900	11.2	1.5	0.511	0.416	0.927	2.23	6.701	0.671	0.255
4	0.1082	31.610	12.9	2.8	0.581	0.425	1.006	2.37	6.692	0.716	0.291
5	0.1258	31.890	13.2	3.4	0.590	0.424	1.014	2.39	6.693	0.719	0.295
6	0.2015	32.920	14.2	6.1	0.619	0.453	1.072	2.37	6.664	0.762	0.309
7	0.2305	33.230	14.5	7.2	0.625	0.456	1.081	2.37	6.661	0.769	0.313
8	0.2883	32.310	13.6	9.2	0.573	0.467	1.040	2.23	6.650	0.753	0.286
9	0.3362	31.700	13.0	10.9	0.537	0.498	1.035	2.08	6.619	0.766	0.268
10	0.4061	31.850	13.1	13.4	0.528	0.496	1.024	2.06	6.621	0.760	0.264
11	0.4450	31.890	13.2	14.8	0.521	0.499	1.020	2.04	6.618	0.759	0.260
12	0.4551	31.900	13.2	15.1	0.519	0.503	1.022	2.03	6.614	0.763	0.260

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	105.480			144.430
Moisture content: Dry soil+tare, gms.	75.690			100.490
Moisture content: Tare, gms.	30.400			30.480
Moisture, %	65.8	66.4	66.4	62.8
Moist specimen weight, gms.	115.3			
Diameter, in.	1.41	1.41	1.41	
Area, in.^{2}	1.55	1.55	1.55	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	100.7	101.1	101.1	
Dry density, pcf	60.7	60.7	60.7	
Void ratio	1.8271	1.8271	1.8271	
Saturation, %	99.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.138 tsf
Consolidation back pressure = 5.632 tsf
Consolidation effective confining stress = 1.506 tsf
Fail. Stress = 0.800 tsf **at reading no.** 18
Ult. Stress = 0.800 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	0.0165	19.340	0.0	0.0	0.000	1.506	1.506	1.00	5.632	1.506	0.000
1	0.0193	23.920	4.6	0.1	0.212	1.387	1.599	1.15	5.751	1.493	0.106
2	0.0225	27.980	8.6	0.2	0.399	1.264	1.663	1.32	5.874	1.464	0.200
3	0.0331	33.440	14.1	0.6	0.649	1.099	1.748	1.59	6.039	1.424	0.325
4	0.0582	41.350	22.0	1.5	1.004	0.904	1.908	2.11	6.234	1.406	0.502
5	0.0752	44.730	25.4	2.1	1.151	0.838	1.989	2.37	6.300	1.414	0.576
6	0.0930	47.300	28.0	2.7	1.259	0.804	2.063	2.57	6.334	1.434	0.630
7	0.1107	47.600	28.3	3.4	1.265	0.805	2.070	2.57	6.333	1.437	0.632
8	0.1288	47.760	28.4	4.0	1.263	0.827	2.090	2.53	6.311	1.459	0.632
9	0.1468	44.700	25.4	4.6	1.120	0.903	2.023	2.24	6.235	1.463	0.560

Test Readings for Specimen No. 2

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
10	0.1753	40.350	21.0	5.7	0.918	0.992	1.910	1.93	6.146	1.451	0.459
11	0.2036	38.900	19.6	6.7	0.845	1.000	1.845	1.85	6.138	1.423	0.423
12	0.2314	39.010	19.7	7.7	0.841	0.973	1.814	1.86	6.165	1.394	0.421
13	0.2694	39.120	19.8	9.0	0.833	0.946	1.779	1.88	6.192	1.363	0.417
14	0.2973	39.330	20.0	10.0	0.833	0.940	1.773	1.89	6.198	1.357	0.417
15	0.3462	39.780	20.4	11.7	0.835	0.916	1.751	1.91	6.222	1.334	0.418
16	0.3842	40.040	20.7	13.1	0.833	0.907	1.740	1.92	6.231	1.324	0.417
17	0.4232	39.910	20.6	14.5	0.815	0.900	1.715	1.91	6.238	1.307	0.407
18	0.4370	39.670	20.3	15.0	0.800	0.897	1.697	1.89	6.241	1.297	0.400

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	86.100			138.850
Moisture content: Dry soil+tare, gms.	63.780			98.430
Moisture content: Tare, gms.	30.470			30.300
Moisture, %	67.0	68.3	68.3	59.3
Moist specimen weight, gms.	114.2			
Diameter, in.	1.41	1.41	1.41	
Area, in.^{2}	1.55	1.55	1.55	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	99.6	100.4	100.4	
Dry density, pcf	59.6	59.6	59.6	
Void ratio	1.8783	1.8783	1.8783	
Saturation, %	98.1	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.135 tsf

Consolidation back pressure = 4.138 tsf

Consolidation effective confining stress = 2.997 tsf

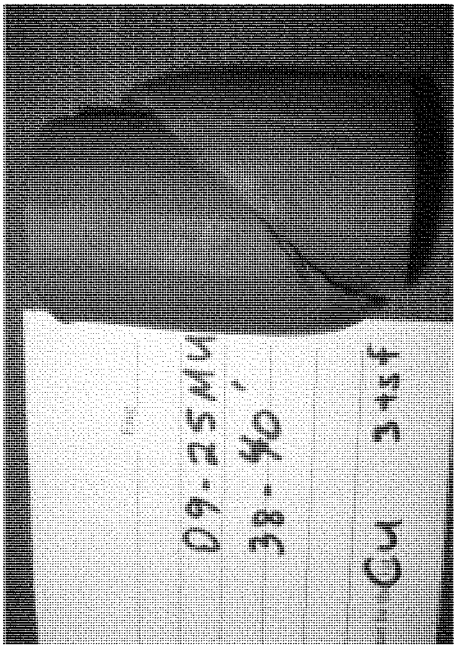
Fail. Stress = 1.259 tsf **at reading no.** 21

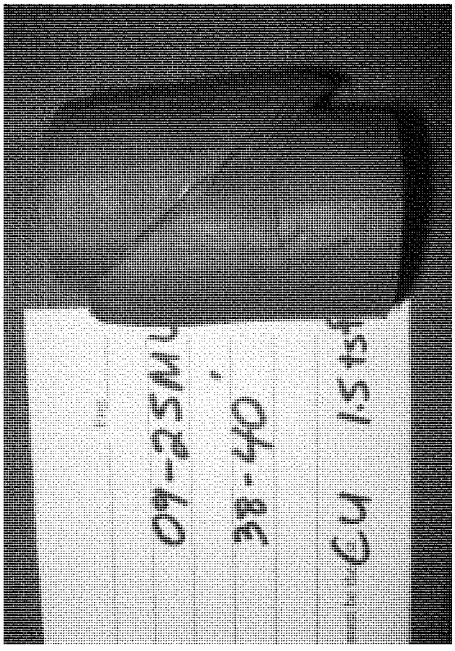
Ult. Stress = 1.259 tsf **at reading no.** 21

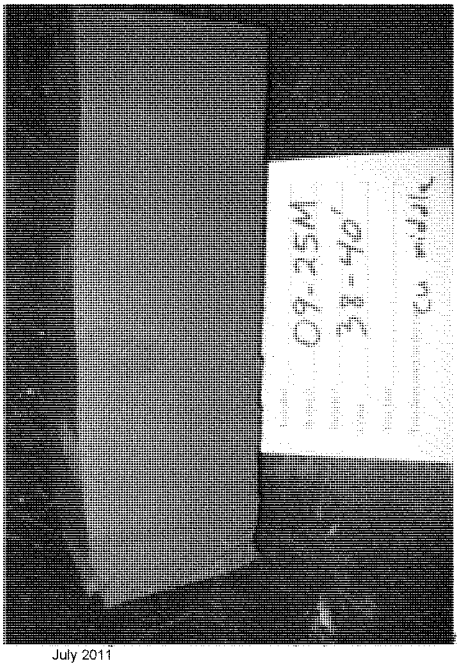
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0058	16.990	0.0	0.0	0.000	2.997	2.997	1.00	4.138	2.997	0.000
1	0.0065	20.170	3.2	0.0	0.147	2.970	3.117	1.05	4.165	3.044	0.074
2	0.0084	25.870	8.9	0.1	0.411	2.830	3.241	1.15	4.305	3.035	0.205
3	0.0115	31.640	14.7	0.2	0.677	2.645	3.322	1.26	4.490	2.984	0.339
4	0.0302	43.570	26.6	0.9	1.220	2.222	3.442	1.55	4.913	2.832	0.610
5	0.0553	48.580	31.6	1.8	1.437	2.017	3.454	1.71	5.118	2.736	0.719
6	0.0642	50.470	33.5	2.1	1.518	1.969	3.487	1.77	5.166	2.728	0.759
7	0.0733	51.300	34.3	2.4	1.551	1.916	3.467	1.81	5.219	2.691	0.775
8	0.0821	51.690	34.7	2.7	1.563	1.898	3.461	1.82	5.237	2.680	0.782
9	0.0918	50.990	34.0	3.1	1.526	1.883	3.409	1.81	5.252	2.646	0.763
10	0.1002	49.620	32.6	3.4	1.460	1.925	3.385	1.76	5.210	2.655	0.730
11	0.1190	47.100	30.1	4.0	1.338	1.975	3.313	1.68	5.160	2.644	0.669
12	0.1461	46.950	30.0	5.0	1.318	1.949	3.267	1.68	5.186	2.608	0.659
13	0.1739	46.520	29.5	6.0	1.286	1.918	3.204	1.67	5.217	2.561	0.643

Test Readings for Specimen No. 3

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
14	0.2031	46.540	29.6	7.0	1.272	1.867	3.139	1.68	5.268	2.503	0.636
15	0.2437	46.710	29.7	8.5	1.260	1.817	3.077	1.69	5.318	2.447	0.630
16	0.2727	47.050	30.1	9.5	1.260	1.771	3.031	1.71	5.364	2.401	0.630
17	0.3015	47.650	30.7	10.5	1.270	1.732	3.002	1.73	5.403	2.367	0.635
18	0.3315	47.880	30.9	11.6	1.265	1.681	2.946	1.75	5.454	2.313	0.632
19	0.3614	48.380	31.4	12.7	1.270	1.630	2.900	1.78	5.505	2.265	0.635
20	0.4014	48.920	31.9	14.1	1.270	1.578	2.848	1.81	5.557	2.213	0.635
21	0.4280	48.980	32.0	15.0	1.259	1.564	2.823	1.80	5.571	2.193	0.629


09-25MW
38-40'
CU 3+5+


09-25MW
38-40'
CU 1.5+5+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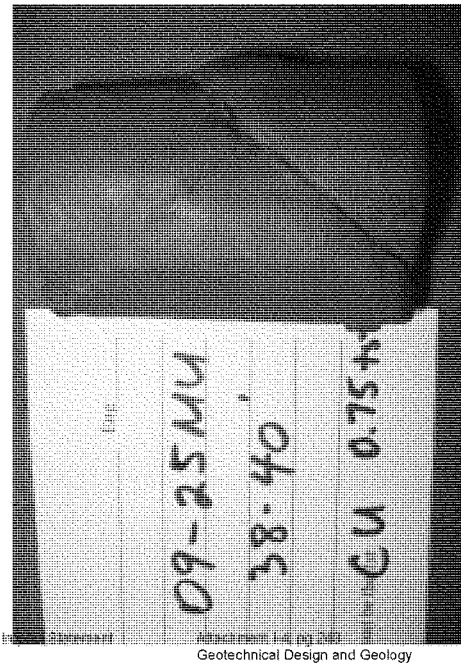
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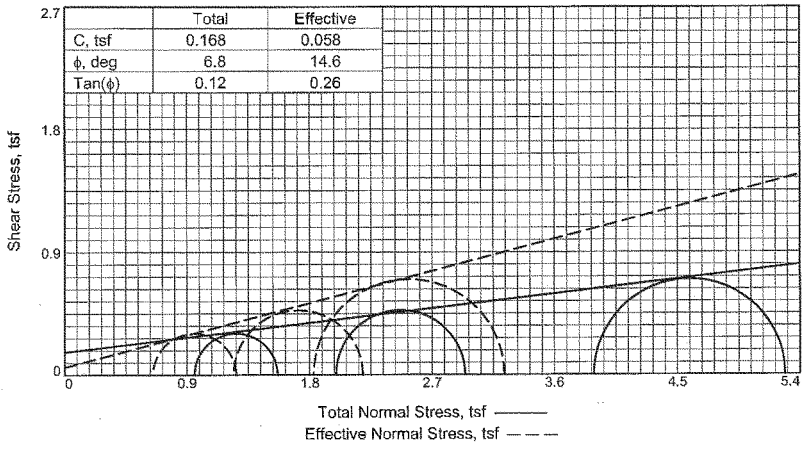
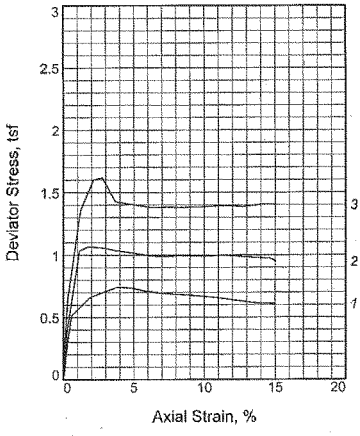
CU 0.75+5+





Sample No.		1	2	3
Initial	Water Content, %	54.5	58.1	52.5
	Dry Density, pcf	66.7	65.1	69.4
	Saturation, %	95.1	97.7	97.9
	Void Ratio	1.5754	1.6360	1.4744
	Diameter, in.	1.40	1.42	1.41
	Height, in.	2.81	2.81	2.81
At Test	Water Content, %	57.3	59.5	53.6
	Dry Density, pcf	66.7	65.1	69.4
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.5754	1.6360	1.4744
	Diameter, in.	1.40	1.42	1.41
	Height, in.	2.81	2.81	2.81
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.95	2.00	3.89
Back Pressure, tsf		5.88	6.50	3.32
Cell Pressure, tsf		6.83	8.50	7.21
Peak Deviator Stress, tsf		0.74	1.07	1.62
Total Pore Pr., tsf		6.29	7.16	4.69
Ultimate Deviator Stress, tsf		0.61	0.95	1.40
Total Pore Pr., tsf		6.18	7.25	5.38
Maj. Eff. Stress at Ultimate, tsf		1.26	2.19	3.23
Min. Eff. Stress at Ultimate, tsf		0.65	1.24	1.83

Type of Test:
CU with Pore Pressures
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, gray (CH)

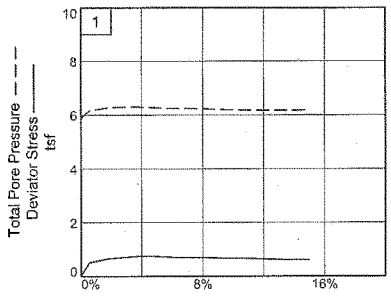
LL= 87 **PL=** 22 **PI=** 65
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.001 in/min. Failure criteria based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3

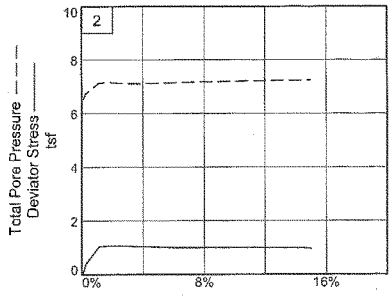
Client: US Army Corps of Engineers

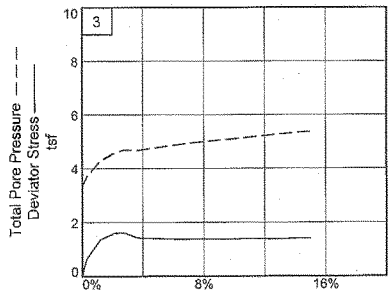
Project: Fargo-Moorhead Metro Feasibility Study
Moorhead
Sample Number: Boring 09-25MU, #5 **Depth:** 68-70'
Brenna / Argusville Transition
Proj. No.: BL-09-03127 **Date Sampled:**

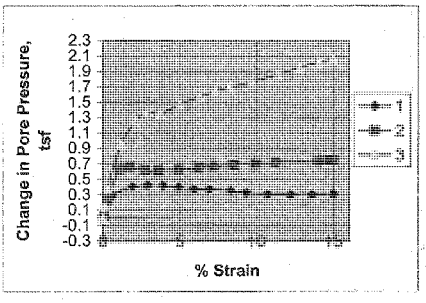
BRAUN INTERTEC

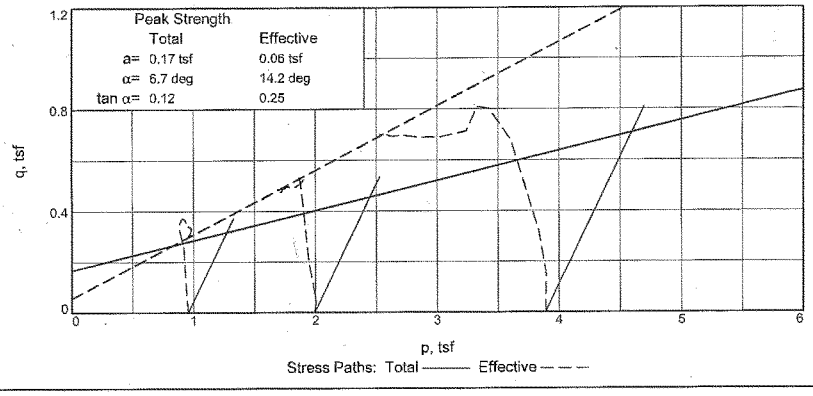
Figure CU Triax ASTM D4767











Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Moorhead
Depth: 68-70' **Sample Number:** Boring 09-25MU, #5
Project No.: BL-09-03127 **Figure** _____

Brenna / Argusville Transition

Braun Intertec

Tested By: jrs **Checked By:** rs

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

9/1/2009
5:35 PM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL-09-03127 Moorhead
Depth: 68-70' **Sample Number:** Boring 09-25MU, #5
Description: FAT CLAY, gray (CH) Brenna / Argusville Transition
Remarks: The 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=** **PL=** **PI=**
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	125.950			148.740
Moisture content: Dry soil+tare, gms.	92.250			105.700
Moisture content: Tare, gms.	30.400			30.970
Moisture, %	54.5	57.3	57.3	57.6
Moist specimen weight, gms.	117.6			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.55	1.55	1.55	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	103.0	104.8	104.8	
Dry density, pcf	66.7	66.7	66.7	
Void ratio	1.5754	1.5754	1.5754	
Saturation, %	95.1	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 6.832 tsf
Consolidation back pressure = 5.877 tsf
Consolidation effective confining stress = 0.955 tsf
Fail. Stress = 0.609 tsf **at reading no.** 14
Ult. Stress = 0.609 tsf **at reading no.** 14

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	0.0225	17.690	0.0	0.0	0.000	0.955	0.955	1.00	5.877	0.955	0.000
1	0.0263	20.750	3.1	0.1	0.142	0.872	1.014	1.16	5.960	0.943	0.071
2	0.0384	28.740	11.0	0.6	0.511	0.665	1.176	1.77	6.167	0.920	0.255
3	0.0751	32.130	14.4	1.9	0.659	0.554	1.213	2.19	6.278	0.883	0.329
4	0.1030	33.260	15.6	2.9	0.703	0.534	1.237	2.32	6.298	0.886	0.352
5	0.1309	34.330	16.6	3.9	0.744	0.537	1.281	2.39	6.295	0.909	0.372
6	0.1590	34.330	16.6	4.9	0.736	0.559	1.295	2.32	6.273	0.927	0.368
7	0.1877	33.900	16.2	5.9	0.710	0.584	1.294	2.21	6.248	0.939	0.355
8	0.2164	33.750	16.1	6.9	0.695	0.585	1.280	2.19	6.247	0.933	0.348
9	0.2565	33.750	16.1	8.3	0.685	0.605	1.290	2.13	6.227	0.947	0.342
10	0.2852	33.700	16.0	9.3	0.675	0.632	1.307	2.07	6.200	0.969	0.337
11	0.3242	33.600	15.9	10.7	0.660	0.654	1.314	2.01	6.178	0.984	0.330
12	0.3642	33.300	15.6	12.2	0.638	0.658	1.296	1.97	6.174	0.977	0.319
13	0.4050	32.980	15.3	13.6	0.614	0.661	1.275	1.93	6.171	0.968	0.307
14	0.4441	33.100	15.4	15.0	0.609	0.651	1.260	1.94	6.181	0.956	0.305

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	144.940			147.570
Moisture content: Dry soil+tare, gms.	102.840			104.100
Moisture content: Tare, gms.	30.430			30.180
Moisture, %	58.1	59.5	59.5	58.8
Moist specimen weight, gms.	119.4			
Diameter, in.	1.42	1.42	1.42	
Area, in.^{2}	1.57	1.57	1.57	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	103.0	103.9	103.9	
Dry density, pcf	65.1	65.1	65.1	
Void ratio	1.6360	1.6360	1.6360	
Saturation, %	97.7	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 8.496 tsf

Consolidation back pressure = 6.503 tsf

Consolidation effective confining stress = 1.993 tsf

Fail. Stress = 0.949 tsf **at reading no.** 15

Ult. Stress = 0.949 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	0.0123	22.120	0.0	0.0	0.000	1.993	1.993	1.00	6.503	1.993	0.000
1	0.0154	24.010	1.9	0.1	0.086	1.963	2.049	1.04	6.533	2.006	0.043
2	0.0199	30.690	8.6	0.3	0.391	1.751	2.142	1.22	6.745	1.947	0.196
3	0.0441	44.980	22.9	1.1	1.035	1.359	2.394	1.76	7.137	1.876	0.517
4	0.0611	45.830	23.7	1.7	1.067	1.332	2.399	1.80	7.164	1.865	0.533
5	0.0870	45.930	23.8	2.7	1.061	1.375	2.436	1.77	7.121	1.906	0.531
6	0.1138	45.690	23.6	3.6	1.040	1.379	2.419	1.75	7.117	1.899	0.520
7	0.1507	45.470	23.3	4.9	1.016	1.367	2.383	1.74	7.129	1.875	0.508
8	0.1865	45.250	23.1	6.2	0.993	1.342	2.335	1.74	7.154	1.839	0.497
9	0.2144	45.370	23.2	7.2	0.988	1.324	2.312	1.75	7.172	1.818	0.494
10	0.2513	45.850	23.7	8.5	0.994	1.307	2.301	1.76	7.189	1.804	0.497
11	0.2903	46.110	24.0	9.9	0.990	1.290	2.280	1.77	7.206	1.785	0.495
12	0.3281	46.660	24.5	11.2	0.997	1.273	2.270	1.78	7.223	1.772	0.499
13	0.4049	46.950	24.8	14.0	0.978	1.256	2.234	1.78	7.240	1.745	0.489
14	0.4249	47.010	24.9	14.7	0.972	1.246	2.218	1.78	7.250	1.732	0.486
15	0.4347	46.530	24.4	15.0	0.949	1.241	2.190	1.77	7.255	1.716	0.475

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	129.550			145.300
Moisture content: Dry soil+tare, gms.	95.800			105.000
Moisture content: Tare, gms.	31.470			29.950
Moisture, %	52.5	53.6	53.6	53.7
Moist specimen weight, gms.	120.8			
Diameter, in.	1.41	1.40	1.41	
Area, in.²	1.55	1.55	1.55	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	105.8	106.6	106.6	
Dry density, pcf	69.4	69.4	69.4	
Void ratio	1.4744	1.4744	1.4744	
Saturation, %	97.9	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.207 tsf

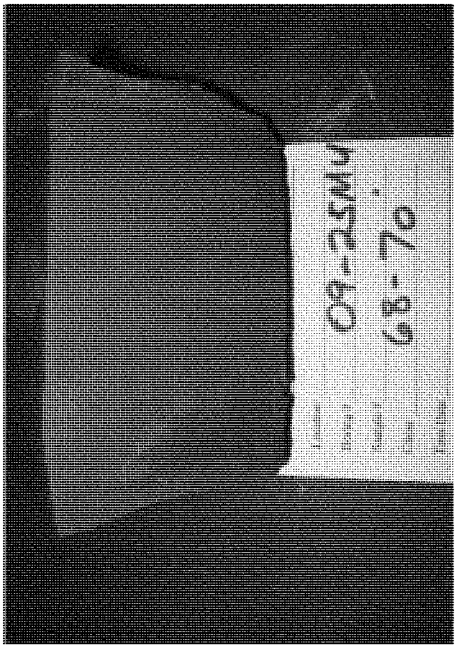
Consolidation back pressure = 3.319 tsf

Consolidation effective confining stress = 3.888 tsf

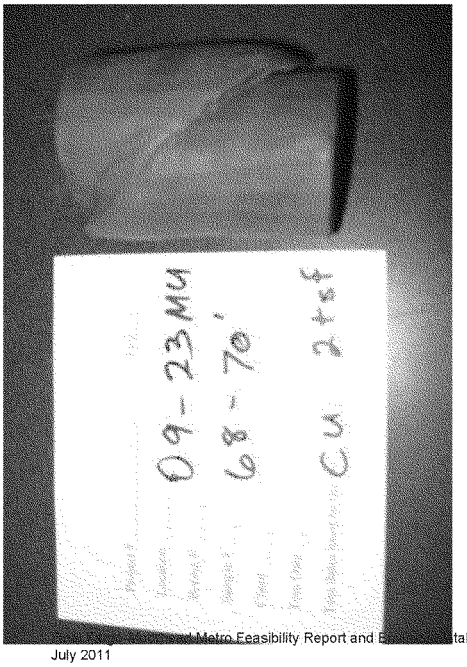
Fail. Stress = 1.403 tsf **at reading no.** 15

Ult. Stress = 1.403 tsf **at reading no.** 15

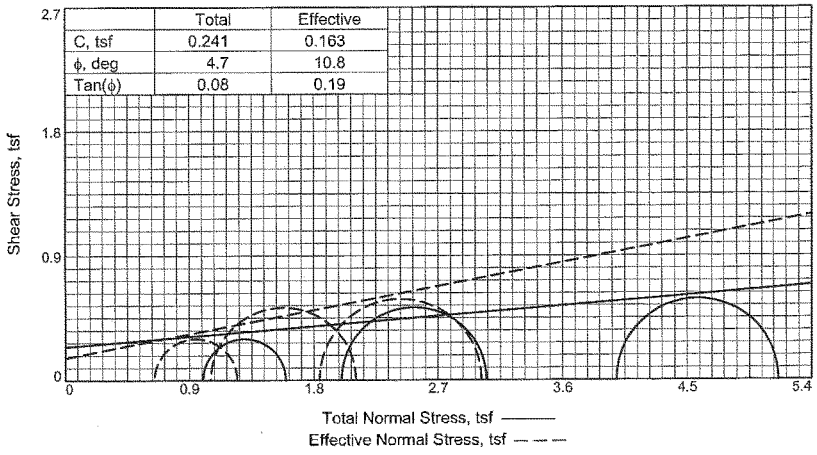
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0212	18.790	0.0	0.0	0.000	3.888	3.888	1.00	3.319	3.888	0.000
1	0.0244	25.320	6.5	0.1	0.303	3.741	4.044	1.08	3.466	3.892	0.151
2	0.0300	32.890	14.1	0.3	0.653	3.506	4.159	1.19	3.701	3.832	0.326
3	0.0552	48.400	29.6	1.2	1.358	2.925	4.283	1.46	4.282	3.604	0.679
4	0.0809	54.040	35.3	2.1	1.602	2.626	4.228	1.61	4.581	3.427	0.801
5	0.0989	54.590	35.8	2.8	1.617	2.519	4.136	1.64	4.688	3.327	0.808
6	0.1245	50.670	31.9	3.7	1.426	2.530	3.956	1.56	4.677	3.243	0.713
7	0.1616	50.570	31.8	5.0	1.402	2.423	3.825	1.58	4.784	3.124	0.701
8	0.1986	50.480	31.7	6.3	1.379	2.315	3.694	1.60	4.892	3.004	0.689
9	0.2264	50.920	32.1	7.3	1.383	2.250	3.633	1.61	4.957	2.941	0.691
10	0.2541	51.190	32.4	8.3	1.380	2.191	3.571	1.63	5.016	2.881	0.690
11	0.2929	51.750	33.0	9.7	1.382	2.122	3.504	1.65	5.085	2.813	0.691
12	0.3409	52.700	33.9	11.4	1.395	2.022	3.417	1.69	5.185	2.720	0.698
13	0.3790	53.010	34.2	12.8	1.387	1.939	3.326	1.72	5.268	2.632	0.693
14	0.4169	54.010	35.2	14.1	1.405	1.862	3.267	1.75	5.345	2.564	0.702
15	0.4420	54.320	35.5	15.0	1.403	1.828	3.231	1.77	5.379	2.529	0.701


09-25MU
68-70'

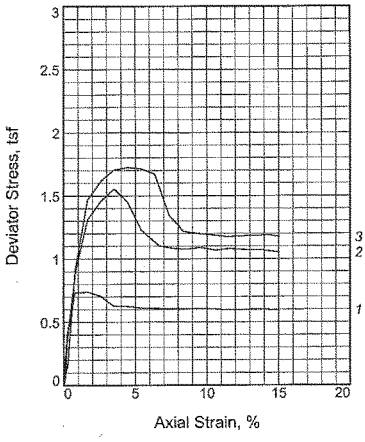
09-25 MU
68-70'
Cu 4 tsf


09-23MU
68-70'
Cu 2 tsf

09-25MU
68-70'
Cu 1 tsf



	Total	Effective
C, tsf	0.241	0.163
ϕ, deg	4.7	10.8
Tan(ϕ)	0.08	0.19



Sample No.		1	2	3
Initial	Water Content, %	63.1	63.1	62.9
	Dry Density, pcf	62.4	62.3	62.8
	Saturation, %	99.1	99.0	99.7
	Void Ratio	1.7508	1.7537	1.7353
	Diameter, in.	1.40	1.39	1.39
	Height, in.	2.81	2.81	2.80
At Test	Water Content, %	63.6	62.2	58.9
	Dry Density, pcf	62.5	63.4	65.5
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.7479	1.7097	1.6191
	Diameter, in.	1.40	1.38	1.37
	Height, in.	2.81	2.79	2.76
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		1.00	2.00	3.99
Back Pressure, tsf		6.14	5.14	3.15
Cell Pressure, tsf		7.14	7.14	7.14
Peak Deviator Stress, tsf		0.74	1.55	1.72
Total Pore Pr., tsf		6.68	6.20	4.93
Ultimate Deviator Stress, tsf		0.60	1.05	1.17
Total Pore Pr., tsf		6.49	6.09	5.30
Maj. Eff. Stress at Ultimate, tsf		1.20	2.49	3.93
Min. Eff. Stress at Ultimate, tsf		0.46	0.94	2.21

Type of Test:
CU with Pore Pressures

Sample Type: Thinwall, 5", Middle of sample

Description: FAT CLAY, gray (CH)

LL= 108 **PL=** 22 **PI=** 86

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. Specimens were saturated for 10 days and consolidated for 3 days.

Figure CU Tri-Axial ASTM D4767

Client: US Army Corps of Engineer

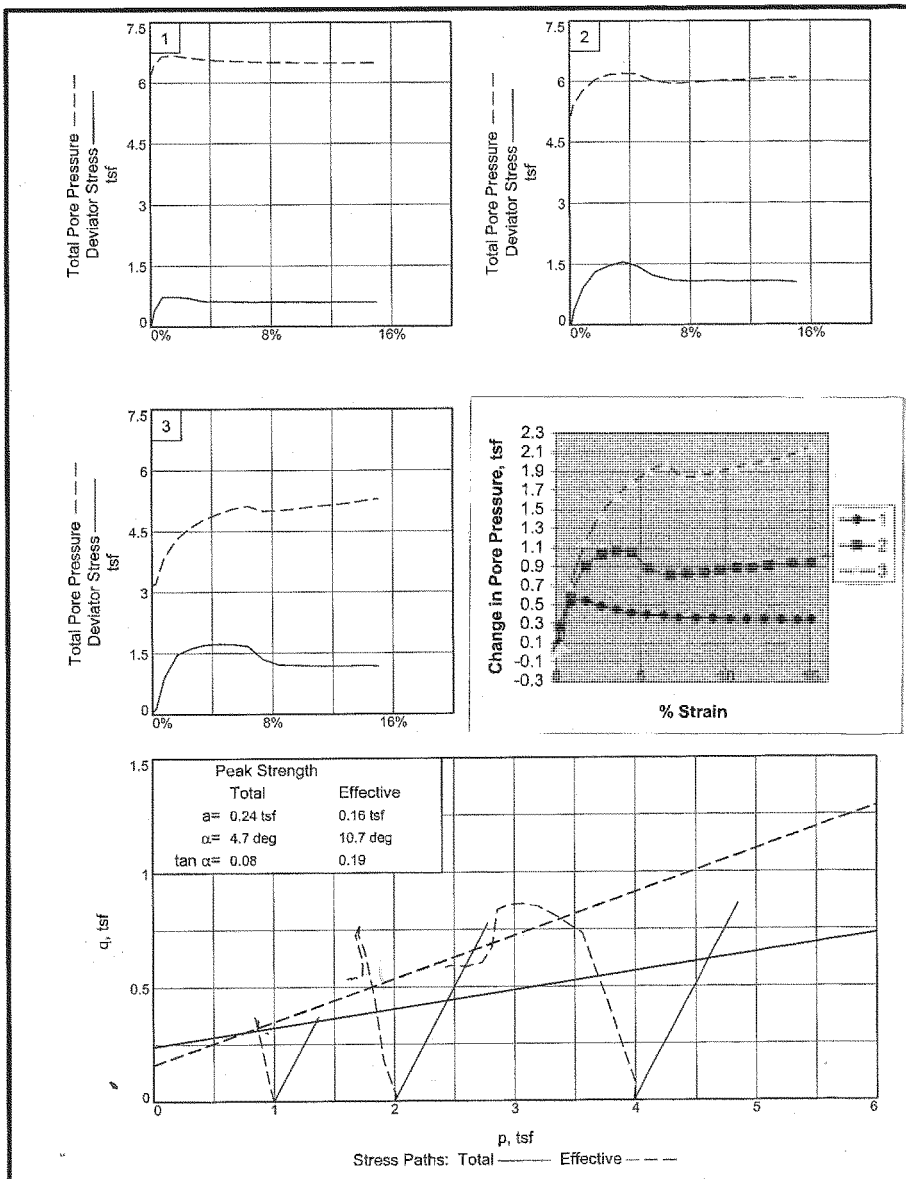
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115

Location: SE-F-13, Fargo, Brenna Formation

Sample Number: Boring 09-25MU, #4 **Depth:** 50-52'

Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC



Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
Loc.: SE-F-13, Fargo, Brenna Formation **Depth:** 50-52' **Sample No.:** Boring 09-25MU, #4
Project No.: BL-09-03127 **Figure**

TRIAXIAL COMPRESSION TEST 11/9/2009
CU with Pore Pressures 12:55 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, Brenna Formation
Depth: 50-52' **Sample Number:** Boring 09-25MU, #4
Description: FAT CLAY, gray (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria based on the ultimate stress which occurs at 15% strain. Specimens were saturated for 10 days and consolidated for 3 days.
Type of Sample: Thinwall, 5", Middle of sample
Assumed Specific Gravity=2.75 **LL=**108 **PL=**22 **PI=**86
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	115.080			144.800
Moisture content: Dry soil+tare, gms.	82.550			100.190
Moisture content: Tare, gms.	30.970			29.910
Moisture, %	63.1	63.7	63.6	63.5
Moist specimen weight, gms.	115.1			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.53	1.53	1.53	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	101.8	102.1	102.2	
Dry density, pcf	62.4	62.4	62.5	
Void ratio	1.7508	1.7508	1.7479	
Saturation, %	99.1	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 6.141 tsf
Consolidation effective confining stress = 0.999 tsf
Peak Stress = 0.739 tsf **at reading no.** 4
Ult. Stress = 0.597 tsf **at reading no.** 18

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	0.0128	18.970	0.0	0.0	0.000	0.999	0.999	1.00	6.141	0.999	0.000
1	0.0148	21.780	2.8	0.1	0.132	0.898	1.030	1.15	6.242	0.964	0.066
2	0.0197	27.580	8.6	0.2	0.404	0.712	1.116	1.57	6.428	0.914	0.202
3	0.0346	34.660	15.7	0.8	0.733	0.481	1.214	2.52	6.659	0.847	0.366
4	0.0595	34.940	16.0	1.7	0.739	0.461	1.200	2.60	6.679	0.831	0.370
5	0.0847	34.390	15.4	2.6	0.707	0.518	1.225	2.37	6.622	0.872	0.354
6	0.1103	32.800	13.8	3.5	0.628	0.550	1.178	2.14	6.590	0.864	0.314
7	0.1363	32.870	13.9	4.4	0.626	0.585	1.211	2.07	6.555	0.898	0.313
8	0.1632	32.730	13.8	5.3	0.613	0.604	1.217	2.02	6.536	0.911	0.307
9	0.1901	32.830	13.9	6.3	0.611	0.613	1.224	2.00	6.527	0.919	0.306
10	0.2168	32.800	13.8	7.2	0.604	0.631	1.235	1.96	6.509	0.933	0.302
11	0.2448	32.980	14.0	8.2	0.605	0.636	1.241	1.95	6.504	0.939	0.303
12	0.2718	33.150	14.2	9.2	0.606	0.639	1.245	1.95	6.501	0.942	0.303
13	0.2998	33.250	14.3	10.2	0.604	0.643	1.247	1.94	6.497	0.945	0.302
14	0.3276	33.290	14.3	11.2	0.599	0.646	1.245	1.93	6.494	0.945	0.299
15	0.3564	33.450	14.5	12.2	0.598	0.647	1.245	1.92	6.493	0.946	0.299
16	0.3845	33.620	14.6	13.2	0.599	0.649	1.248	1.92	6.491	0.948	0.299
17	0.4123	33.820	14.9	14.2	0.600	0.649	1.249	1.92	6.491	0.949	0.300
18	0.4350	33.900	14.9	15.0	0.597	0.648	1.245	1.92	6.492	0.947	0.299

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	104.250			142.560
Moisture content: Dry soil+tare, gms.	75.430			100.000
Moisture content: Tare, gms.	29.780			30.650
Moisture, %	63.1	63.8	62.2	61.4
Moist specimen weight, gms.	113.5			
Diameter, in.	1.39	1.39	1.38	
Area, in.^{2}	1.51	1.51	1.50	
Height, in.	2.81	2.81	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	101.7	102.1	102.7	
Dry density, pcf	62.3	62.3	63.4	
Void ratio	1.7537	1.7537	1.7097	
Saturation, %	99.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 5.140 tsf
Consolidation effective confining stress = 2.000 tsf
Peak Stress = 1.554 tsf **at reading no.** 6
Ult. Stress = 1.050 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	0.0079	18.390	0.0	0.0	0.000	2.000	2.000	1.00	5.140	2.000	0.000
1	0.0108	19.520	1.1	0.1	0.054	1.985	2.039	1.03	5.155	2.012	0.027
2	0.0148	25.870	7.5	0.2	0.359	1.729	2.088	1.21	5.411	1.908	0.179
3	0.0306	37.260	18.9	0.8	0.900	1.386	2.286	1.65	5.754	1.836	0.450
4	0.0546	46.140	27.8	1.7	1.312	1.099	2.411	2.19	6.041	1.755	0.656
5	0.0805	49.560	31.2	2.6	1.460	0.973	2.433	2.50	6.167	1.703	0.730
6	0.1065	51.880	33.5	3.5	1.554	0.938	2.492	2.66	6.202	1.715	0.777
7	0.1322	50.010	31.6	4.4	1.453	0.953	2.406	2.52	6.187	1.680	0.727
8	0.1591	45.380	27.0	5.4	1.228	1.122	2.350	2.09	6.018	1.736	0.614
9	0.1950	42.960	24.6	6.7	1.103	1.184	2.287	1.93	5.956	1.735	0.551
10	0.2229	42.780	24.4	7.7	1.083	1.175	2.258	1.92	5.965	1.716	0.541
11	0.2498	42.900	24.5	8.7	1.077	1.160	2.237	1.93	5.980	1.698	0.538
12	0.2758	43.420	25.0	9.6	1.088	1.131	2.219	1.96	6.009	1.675	0.544
13	0.3037	43.230	24.8	10.6	1.068	1.109	2.177	1.96	6.031	1.643	0.534
14	0.3306	43.790	25.4	11.5	1.081	1.106	2.187	1.98	6.034	1.646	0.540
15	0.3584	43.890	25.5	12.5	1.073	1.084	2.157	1.99	6.056	1.620	0.536
16	0.3954	44.210	25.8	13.9	1.070	1.062	2.132	2.01	6.078	1.597	0.535
17	0.4280	44.090	25.7	15.0	1.050	1.054	2.104	2.00	6.086	1.579	0.525

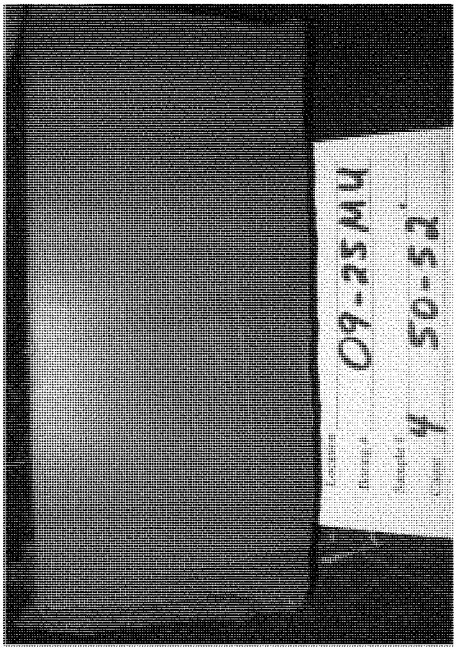
Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	123.380			138.970
Moisture content: Dry soil+tare, gms.	87.320			100.390
Moisture content: Tare, gms.	29.990			30.860
Moisture, %	62.9	63.1	58.9	55.5
Moist specimen weight, gms.	113.5			
Diameter, in.	1.39	1.39	1.37	
Area, in.²	1.51	1.51	1.47	
Height, in.	2.80	2.80	2.76	
Net decrease in height, in.		0.00	0.04	
Wet Density, pcf	102.2	102.4	104.1	
Dry density, pcf	62.8	62.8	65.5	
Void ratio	1.7353	1.7353	1.6191	
Saturation, %	99.7	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 3.151 tsf
Consolidation effective confining stress = 3.989 tsf
Peak Stress = 1.723 tsf **at reading no.** 7
Ult. Stress = 1.174 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	0.0058	17.050	0.0	0.0	0.000	3.989	3.989	1.00	3.151	3.989	0.000
1	0.0081	18.730	1.7	0.1	0.082	3.953	4.035	1.02	3.187	3.994	0.041
2	0.0129	20.100	3.1	0.3	0.149	3.926	4.075	1.04	3.214	4.001	0.075
3	0.0277	35.760	18.7	0.8	0.909	3.301	4.210	1.28	3.839	3.756	0.455
4	0.0515	47.510	30.5	1.7	1.467	2.827	4.294	1.52	4.313	3.561	0.734
5	0.0773	50.930	33.9	2.6	1.617	2.538	4.155	1.64	4.602	3.346	0.808
6	0.1023	53.100	36.0	3.5	1.704	2.343	4.047	1.73	4.797	3.195	0.852
7	0.1283	53.860	36.8	4.4	1.723	2.205	3.928	1.78	4.935	3.067	0.862
8	0.1544	54.040	37.0	5.4	1.714	2.087	3.801	1.82	5.053	2.944	0.857
9	0.1810	53.490	36.4	6.4	1.672	2.020	3.692	1.83	5.120	2.856	0.836
10	0.2088	46.720	29.7	7.4	1.346	2.141	3.487	1.63	4.999	2.814	0.673
11	0.2368	44.150	27.1	8.4	1.216	2.125	3.341	1.57	5.015	2.733	0.608
12	0.2647	44.090	27.0	9.4	1.200	2.098	3.298	1.57	5.042	2.698	0.600
13	0.2917	44.180	27.1	10.4	1.191	2.045	3.236	1.58	5.095	2.641	0.596
14	0.3198	44.120	27.1	11.4	1.175	2.007	3.182	1.59	5.133	2.594	0.587
15	0.3469	44.570	27.5	12.4	1.181	1.980	3.161	1.60	5.160	2.571	0.591
16	0.3755	45.010	28.0	13.4	1.186	1.932	3.118	1.61	5.208	2.525	0.593
17	0.4023	45.410	28.4	14.4	1.189	1.867	3.056	1.64	5.273	2.462	0.595
18	0.4203	45.260	28.2	15.0	1.174	1.840	3.014	1.64	5.300	2.427	0.587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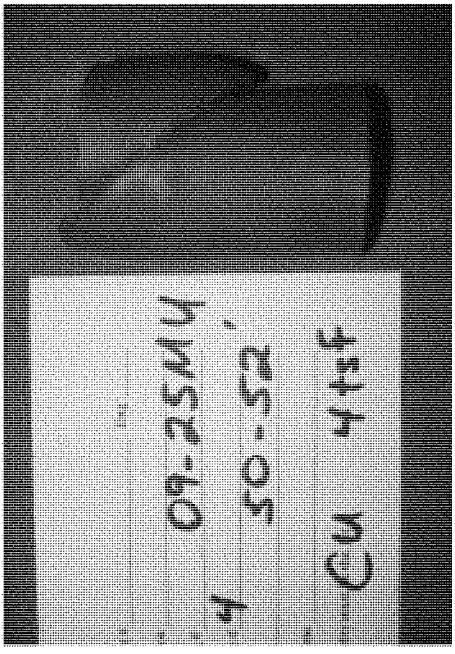
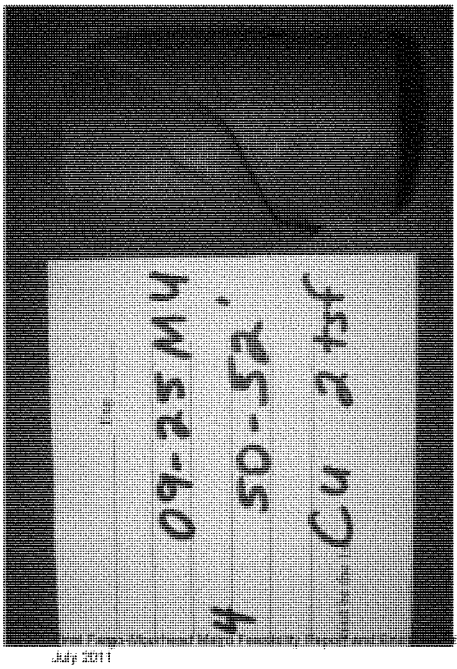
4' 50-52'


09-25MW
4' 50-52'
Cu 4+54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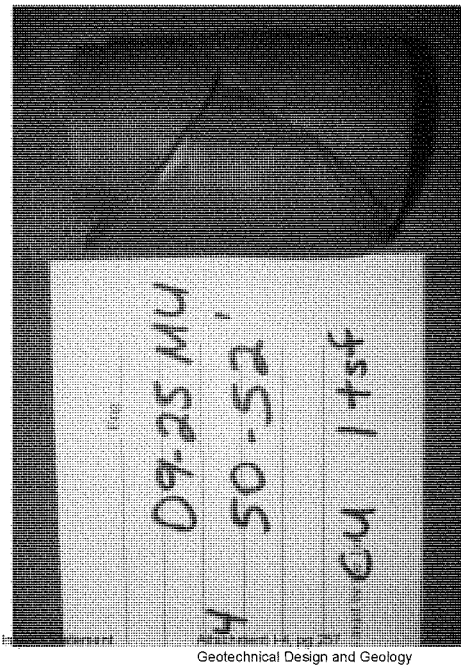
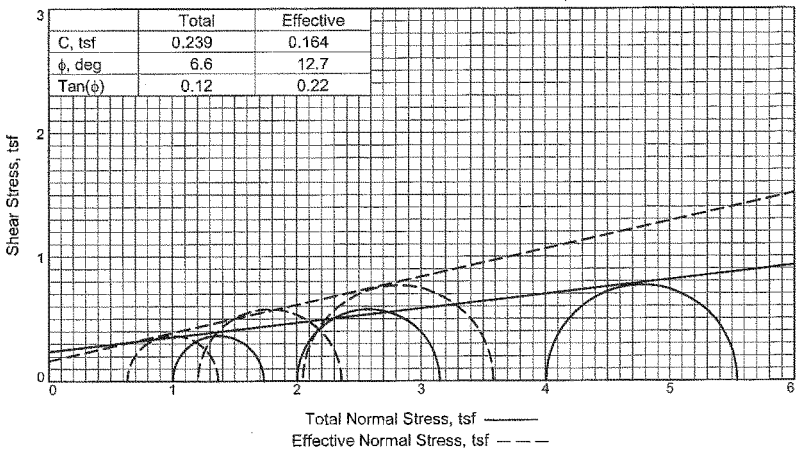
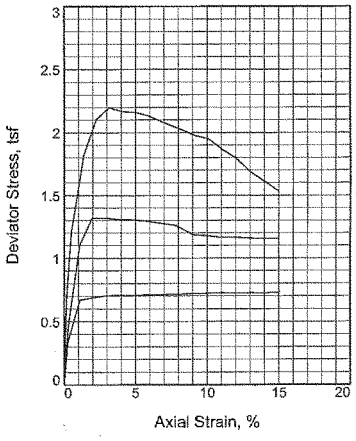
4' 50-52'
Cu 2+54


09-25MW
4' 50-52'
Cu 1+54





Sample No.		1	2	3
Initial	Water Content, %	55.5	55.7	55.6
	Dry Density, pcf	67.9	66.7	67.5
	Saturation, %	99.7	97.4	99.1
	Void Ratio	1.5301	1.5734	1.5425
	Diameter, in.	1.41	1.40	1.40
	Height, in.	2.80	2.82	2.81
At Test	Water Content, %	54.7	55.2	52.2
	Dry Density, pcf	68.6	68.2	70.5
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.5030	1.5190	1.4349
	Diameter, in.	1.40	1.39	1.38
	Height, in.	2.79	2.80	2.77
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		1.00	2.00	4.01
Back Pressure, tsf		6.14	5.14	3.13
Cell Pressure, tsf		7.14	7.14	7.14
Peak Deviator Stress, tsf		0.73	1.32	2.20
Total Pore Pr., tsf		6.50	6.05	4.78
Ultimate Deviator Stress, tsf		0.73	1.15	1.54
Total Pore Pr., tsf		6.50	5.94	5.09
Maj. Eff. Stress at Ultimate, tsf		1.37	2.41	4.56
Min. Eff. Stress at Ultimate, tsf		0.63	1.09	2.37

Type of Test:
CU with Pore Pressures
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, gray (CH)

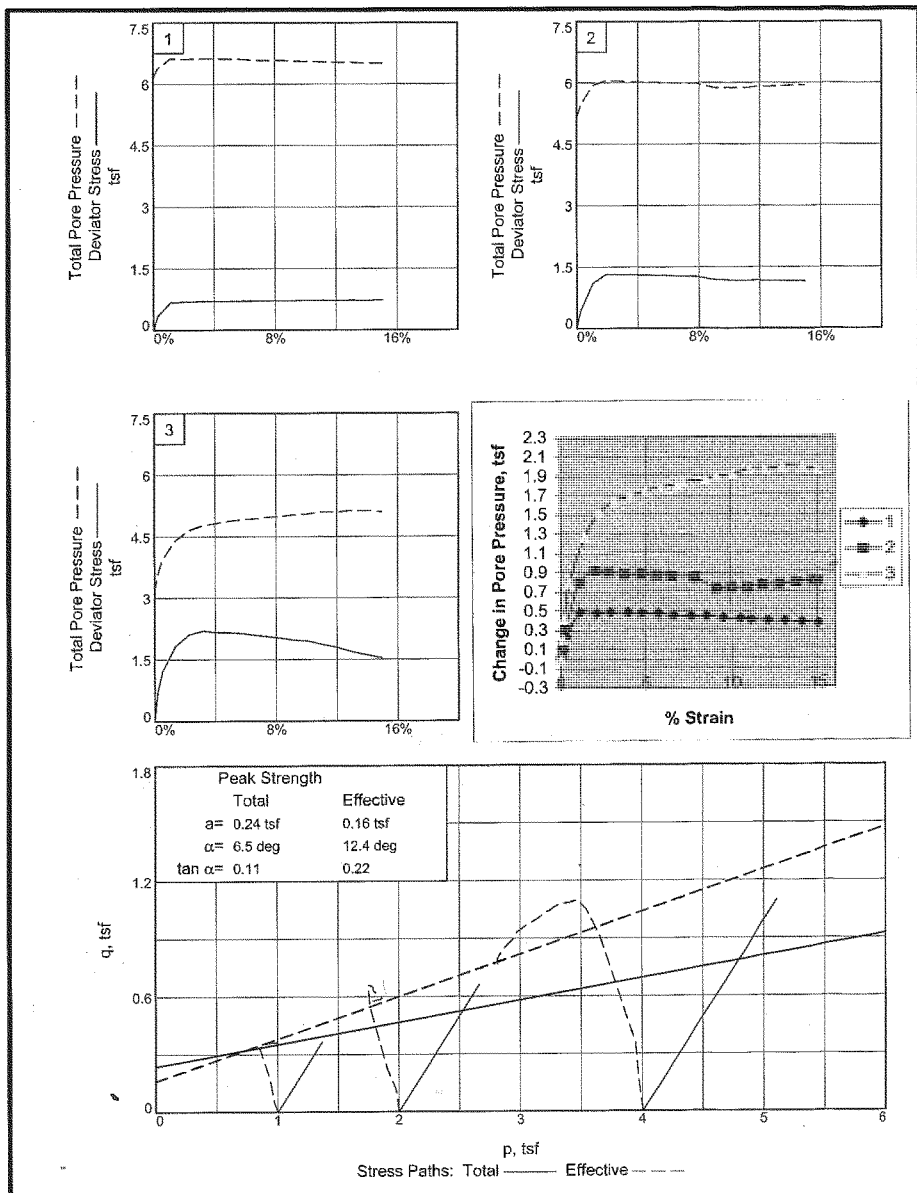
LL= 110 **PL=** 24 **PI=** 86
Assumed Specific Gravity= 2.75
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Location: SE-F-15, Fargo, Brenna Formation
Sample Number: Boring 09-26MU, #3 **Depth:** 28-30'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Figure C-3 Triaxial Test Results



Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
Loc.: SE-F-15, Fargo, Brenna Formation **Depth:** 28-30' **Sample No.:** Boring 09-26MU, #3
Project No.: 01-09-01427 **Figure** **Braun Intertec**

Final Report - Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

11/9/2009
12:57 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-15, Fargo, Brenna Formation
Depth: 28-30' **Sample Number:** Boring 09-26MU, #3
Description: FAT CLAY, gray (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is 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=**110 **PL=**24 **PI=**86
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	119.540			151.350
Moisture content: Dry soil+tare, gms.	87.720			109.440
Moisture content: Tare, gms.	30.360			31.090
Moisture, %	55.5	55.6	54.7	53.5
Moist specimen weight, gms.	120.7			
Diameter, in.	1.41	1.41	1.40	
Area, in.^{2}	1.56	1.56	1.55	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	105.5	105.6	106.1	
Dry density, pcf	67.9	67.9	68.6	
Void ratio	1.5301	1.5301	1.5030	
Saturation, %	99.7	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 6.138 tsf
Consolidation effective confining stress = 1.002 tsf
Peak Stress = 0.730 tsf **at reading no.** 18
Ult. Stress = 0.730 tsf **at reading no.** 18

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	0.0237	19.800	0.0	0.0	0.000	1.002	1.002	1.00	6.138	1.002	0.000
1	0.0258	22.150	2.3	0.1	0.109	0.918	1.027	1.12	6.222	0.973	0.055
2	0.0308	27.060	7.3	0.3	0.337	0.771	1.108	1.44	6.369	0.940	0.169
3	0.0547	34.330	14.5	1.1	0.669	0.520	1.189	2.29	6.620	0.855	0.335
4	0.0815	34.910	15.1	2.1	0.689	0.530	1.219	2.30	6.610	0.875	0.345
5	0.1053	35.360	15.6	2.9	0.704	0.521	1.225	2.35	6.619	0.873	0.352
6	0.1313	35.590	15.8	3.9	0.707	0.522	1.229	2.35	6.618	0.876	0.354
7	0.1562	35.730	15.9	4.7	0.707	0.528	1.235	2.34	6.612	0.881	0.353
8	0.1823	35.930	16.1	5.7	0.709	0.529	1.238	2.34	6.611	0.883	0.354
9	0.2091	36.150	16.3	6.6	0.711	0.554	1.265	2.28	6.586	0.909	0.355
10	0.2359	36.440	16.6	7.6	0.716	0.563	1.279	2.27	6.577	0.921	0.358
11	0.2621	36.650	16.8	8.5	0.718	0.561	1.279	2.28	6.579	0.920	0.359
12	0.2897	36.890	17.1	9.5	0.720	0.582	1.302	2.24	6.558	0.942	0.360
13	0.3157	37.150	17.3	10.5	0.723	0.587	1.310	2.23	6.553	0.949	0.362
14	0.3336	37.320	17.5	11.1	0.725	0.598	1.323	2.21	6.542	0.961	0.363
15	0.3615	37.450	17.7	12.1	0.723	0.611	1.334	2.18	6.529	0.972	0.361
16	0.3885	37.720	17.9	13.1	0.725	0.611	1.336	2.19	6.529	0.974	0.363
17	0.4163	37.900	18.1	14.1	0.724	0.626	1.350	2.16	6.514	0.988	0.362
18	0.4433	38.260	18.5	15.0	0.730	0.635	1.365	2.15	6.505	1.000	0.365

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	160.290			147.800
Moisture content: Dry soil+tare, gms.	113.600			107.000
Moisture content: Tare, gms.	29.800			30.690
Moisture, %	55.7	57.2	55.2	53.5
Moist specimen weight, gms.	118.7			
Diameter, in.	1.40	1.40	1.39	
Area, in.²	1.54	1.54	1.52	
Height, in.	2.82	2.82	2.80	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	103.9	104.9	105.8	
Dry density, pcf	66.7	66.7	68.2	
Void ratio	1.5734	1.5734	1.5190	
Saturation, %	97.4	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.143 tsf
Consolidation back pressure = 5.141 tsf
Consolidation effective confining stress = 2.002 tsf
Peak Stress = 1.320 tsf **at reading no.** 4
Ult. Stress = 1.153 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	0.0139	20.710	0.0	0.0	0.000	2.002	2.002	1.00	5.141	2.002	0.000
1	0.0170	25.380	4.7	0.1	0.221	1.869	2.090	1.12	5.274	1.980	0.111
2	0.0219	30.390	9.7	0.3	0.457	1.673	2.130	1.27	5.470	1.902	0.229
3	0.0446	44.280	23.6	1.1	1.104	1.209	2.313	1.91	5.934	1.761	0.552
4	0.0686	49.130	28.4	2.0	1.320	1.089	2.409	2.21	6.054	1.749	0.660
5	0.0936	49.370	28.7	2.8	1.319	1.100	2.419	2.20	6.043	1.760	0.660
6	0.1183	49.440	28.7	3.7	1.310	1.125	2.435	2.16	6.018	1.780	0.655
7	0.1443	49.620	28.9	4.7	1.306	1.122	2.428	2.16	6.021	1.775	0.653
8	0.1703	49.720	29.0	5.6	1.298	1.139	2.437	2.14	6.004	1.788	0.649
9	0.1960	49.680	29.0	6.5	1.283	1.146	2.429	2.12	5.997	1.788	0.642
10	0.2322	49.620	28.9	7.8	1.263	1.158	2.421	2.09	5.985	1.790	0.632
11	0.2679	48.210	27.5	9.1	1.185	1.271	2.456	1.93	5.872	1.863	0.592
12	0.2938	48.330	27.6	10.0	1.178	1.263	2.441	1.93	5.880	1.852	0.589
13	0.3199	48.330	27.6	10.9	1.166	1.267	2.433	1.92	5.876	1.850	0.583
14	0.3458	48.610	27.9	11.8	1.165	1.238	2.403	1.94	5.905	1.821	0.583
15	0.3736	48.790	28.1	12.8	1.160	1.228	2.388	1.94	5.915	1.808	0.580
16	0.4005	48.970	28.3	13.8	1.154	1.212	2.366	1.95	5.931	1.789	0.577
17	0.4274	49.310	28.6	14.7	1.155	1.198	2.353	1.96	5.945	1.776	0.578
18	0.4350	49.340	28.6	15.0	1.153	1.203	2.356	1.96	5.940	1.779	0.576

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	124.750			145.450
Moisture content: Dry soil+tare, gms.	91.260			106.970
Moisture content: Tare, gms.	31.010			30.300
Moisture, %	55.6	56.1	52.2	50.2
Moist specimen weight, gms.	119.3			
Diameter, in.	1.40	1.40	1.38	
Area, in.²	1.54	1.54	1.50	
Height, in.	2.81	2.81	2.77	
Net decrease in height, in.		0.00	0.04	
Wet Density, pcf	105.1	105.4	107.3	
Dry density, pcf	67.5	67.5	70.5	
Void ratio	1.5425	1.5425	1.4349	
Saturation, %	99.1	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.142 tsf

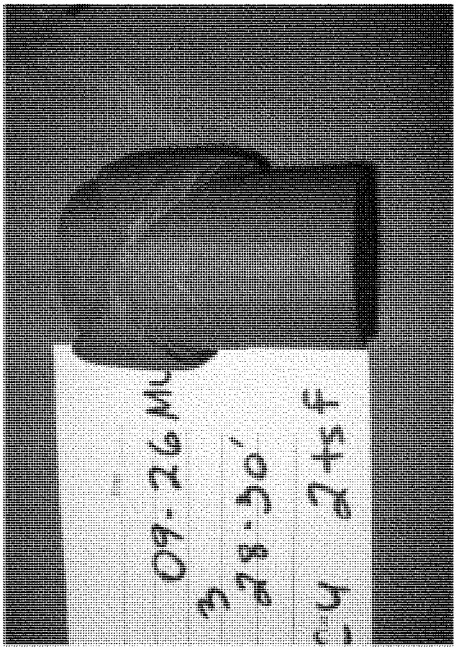
Consolidation back pressure = 3.135 tsf

Consolidation effective confining stress = 4.007 tsf

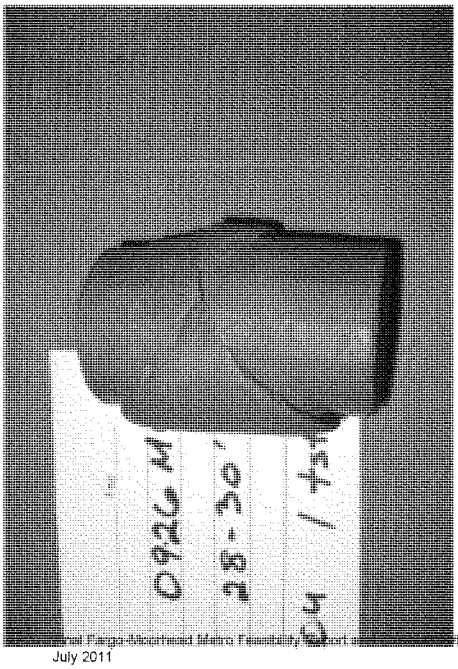
Peak Stress = 2.198 tsf **at reading no.** 6

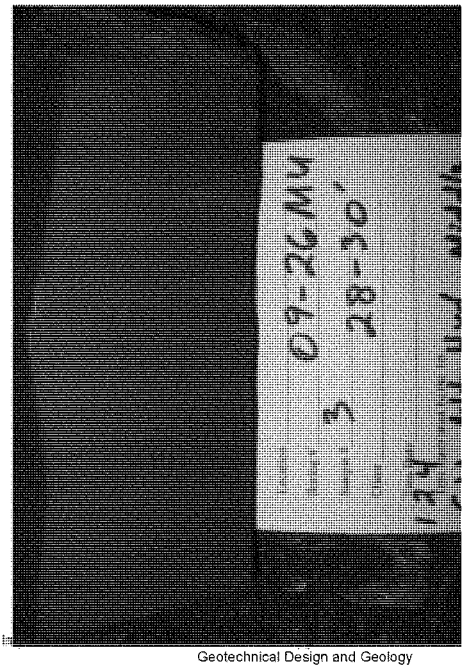
Ult. Stress = 1.536 tsf **at reading no.** 19

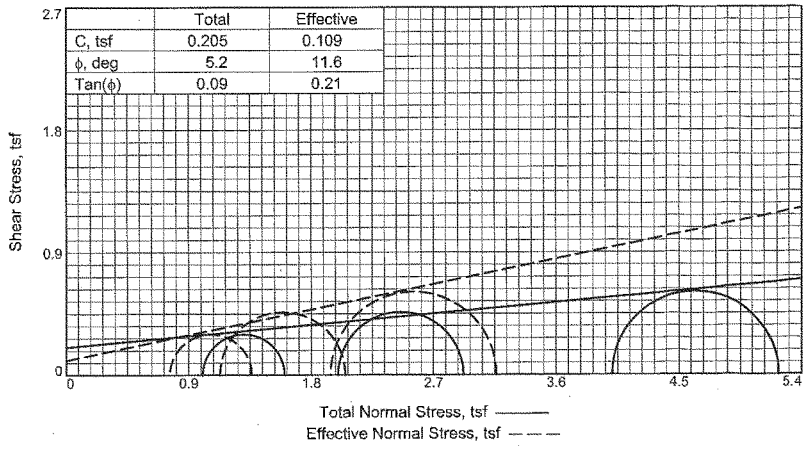
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0485	19.740	0.0	0.0	0.000	4.007	4.007	1.00	3.135	4.007	0.000
1	0.0506	26.790	7.1	0.1	0.339	3.803	4.142	1.09	3.339	3.972	0.169
2	0.0536	34.510	14.8	0.2	0.709	3.592	4.301	1.20	3.550	3.946	0.354
3	0.0626	44.980	25.2	0.5	1.207	3.213	4.420	1.38	3.929	3.817	0.604
4	0.0863	58.190	38.5	1.4	1.823	2.743	4.566	1.66	4.399	3.655	0.912
5	0.1113	64.570	44.8	2.3	2.106	2.488	4.594	1.85	4.654	3.541	1.053
6	0.1361	66.950	47.2	3.2	2.198	2.366	4.564	1.93	4.776	3.465	1.099
7	0.1611	66.710	47.0	4.1	2.166	2.315	4.481	1.94	4.827	3.398	1.083
8	0.1860	67.020	47.3	5.0	2.160	2.261	4.421	1.96	4.881	3.341	1.080
9	0.2118	66.860	47.1	5.9	2.132	2.221	4.353	1.96	4.921	3.287	1.066
10	0.2390	66.310	46.6	6.9	2.085	2.198	4.283	1.95	4.944	3.240	1.042
11	0.2469	66.160	46.4	7.2	2.072	2.172	4.244	1.95	4.970	3.208	1.036
12	0.2837	65.460	45.7	8.5	2.011	2.146	4.157	1.94	4.996	3.152	1.006
13	0.3015	65.000	45.3	9.1	1.977	2.114	4.091	1.94	5.028	3.102	0.988
14	0.3276	64.850	45.1	10.1	1.950	2.091	4.041	1.93	5.051	3.066	0.975
15	0.3544	63.350	43.6	11.1	1.865	2.039	3.904	1.91	5.103	2.971	0.932
16	0.3812	62.160	42.4	12.0	1.794	2.046	3.840	1.88	5.096	2.943	0.897
17	0.4083	60.060	40.3	13.0	1.686	2.011	3.697	1.84	5.131	2.854	0.843
18	0.4420	58.410	38.7	14.2	1.595	2.018	3.613	1.79	5.124	2.815	0.797
19	0.4624	57.310	37.6	15.0	1.536	2.048	3.584	1.75	5.094	2.816	0.768

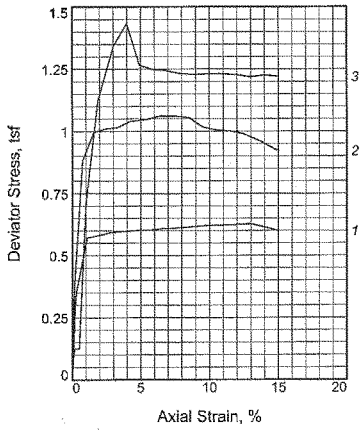

09-26MU
3
28-30'
2tsf

09-26MU
3
28-30'
4tsf


0926 M
28-30'
1 tsf


09-26MU
3
28-30'





Sample No.		1	2	3
Initial	Water Content, %	69.2	68.3	71.1
	Dry Density, pcf	59.1	59.7	57.4
	Saturation, %	100.0	100.0	98.3
	Void Ratio	1.9031	1.8767	1.9886
	Diameter, in.	1.39	1.39	1.40
	Height, in.	2.82	2.79	2.81
At Test	Water Content, %	69.2	66.0	65.5
	Dry Density, pcf	59.1	61.0	61.3
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.9031	1.8152	1.7999
	Diameter, in.	1.39	1.38	1.37
	Height, in.	2.82	2.77	2.75
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		1.00	1.99	4.01
Back Pressure, tsf		6.14	5.14	3.13
Cell Pressure, tsf		7.14	7.13	7.14
Peak Deviator Stress, tsf		0.63	1.06	1.43
Total Pore Pr., tsf		6.38	5.89	4.59
Ultimate Deviator Stress, tsf		0.60	0.92	1.22
Total Pore Pr., tsf		6.38	6.01	5.20
Maj. Eff. Stress at Ultimate, tsf		1.39	2.31	3.98
Min. Eff. Stress at Ultimate, tsf		0.77	1.25	2.55

Type of Test:
CU with Pore Pressures
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, gray (CH)

LL= 117 **PL=** 25 **PI=** 92
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 Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Location: SE-F-19, Fargo, Brenna Formation
Sample Number: Boring 09-27MU, #3 **Depth:** 32-34'
Proj. No.: BL-09-03127 **Date Sampled:**

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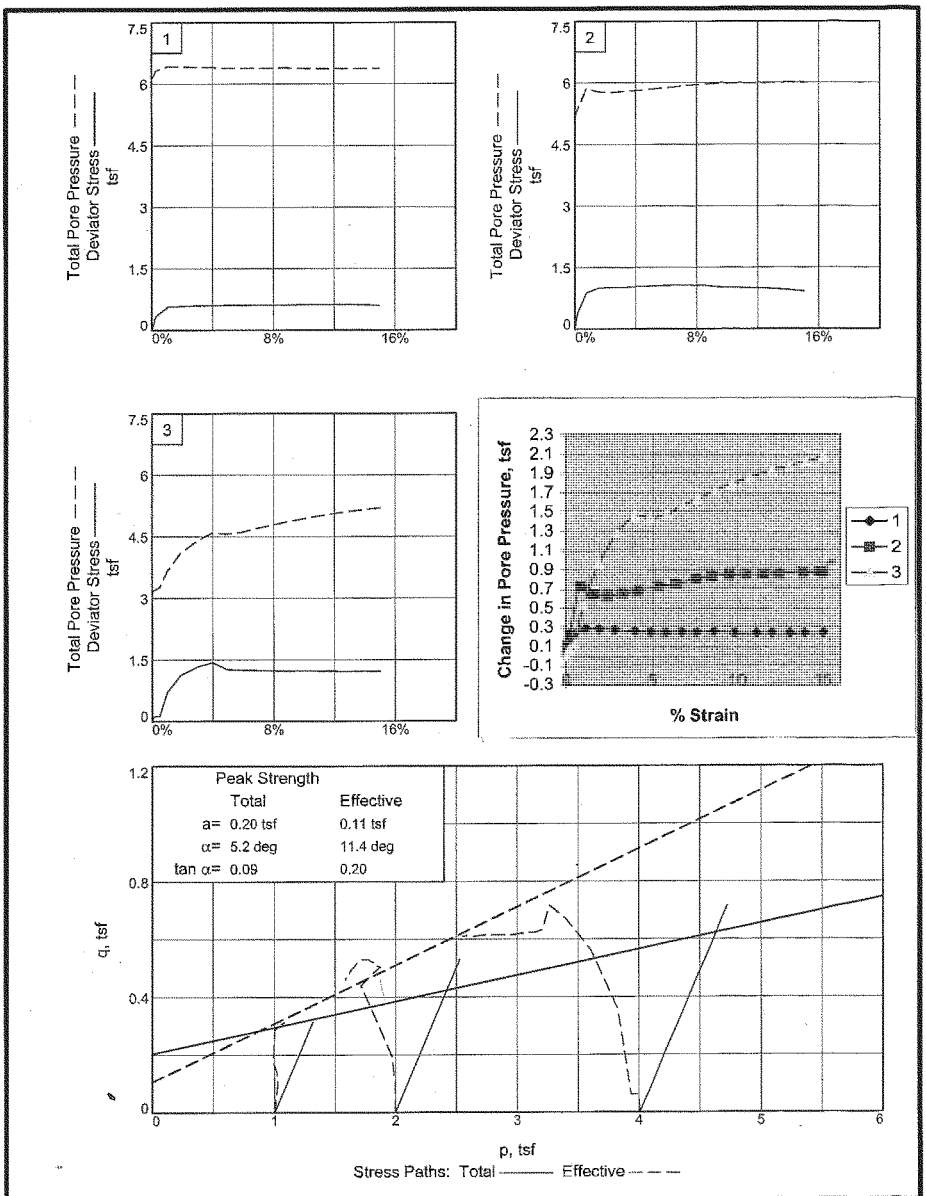
Figure C U with Pore Pressures ASTM D4767



Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
Loc.: SE-F-19, Fargo, Brenna Formation **Depth:** 32-34' **Sample No.:** Boring 09-27MU, #3
Project No.: BL-09-03127 **Figure**

Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST 11/9/2009
CU with Pore Pressures 12:59 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, Brenna Formation
Depth: 32-34' **Sample Number:** Boring 09-27MU, #3
Description: FAT CLAY, gray (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=2.75 **LL=**117 **PL=**25 **PI=**92
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	101.750			142.150
Moisture content: Dry soil+tare, gms.	72.560			96.480
Moisture content: Tare, gms.	30.370			30.280
Moisture, %	69.2	69.2	69.2	69.0
Moist specimen weight, gms.	112.7			
Diameter, in.	1.39	1.39	1.39	
Area, in.^{2}	1.52	1.52	1.52	
Height, in.	2.82	2.82	2.82	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	100.0	100.1	100.1	
Dry density, pcf	59.1	59.1	59.1	
Void ratio	1.9031	1.9031	1.9031	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.142 tsf
Consolidation back pressure = 6.139 tsf
Consolidation effective confining stress = 1.003 tsf
Peak Stress = 0.627 tsf **at reading no.** 16
Ult. Stress = 0.600 tsf **at reading no.** 18

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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	0.0036	18.360	0.0	0.0	0.000	1.003	1.003	1.00	6.139	1.003	0.000
1	0.0079	22.550	4.2	0.2	0.198	0.929	1.127	1.21	6.213	1.028	0.099
2	0.0090	24.130	5.8	0.2	0.272	0.887	1.159	1.31	6.255	1.023	0.136
3	0.0122	25.840	7.5	0.3	0.352	0.816	1.168	1.43	6.326	0.992	0.176
4	0.0344	30.600	12.2	1.1	0.572	0.717	1.289	1.80	6.425	1.003	0.286
5	0.0574	30.900	12.5	1.9	0.581	0.724	1.305	1.80	6.418	1.015	0.291
6	0.0824	31.280	12.9	2.8	0.593	0.730	1.323	1.81	6.412	1.027	0.297
7	0.1163	31.560	13.2	4.0	0.599	0.744	1.343	1.80	6.398	1.043	0.299
8	0.1412	31.760	13.4	4.9	0.602	0.754	1.356	1.80	6.388	1.055	0.301
9	0.1660	31.900	13.5	5.8	0.603	0.758	1.361	1.80	6.384	1.059	0.301
10	0.1919	32.190	13.8	6.7	0.610	0.754	1.364	1.81	6.388	1.059	0.305
11	0.2178	32.350	14.0	7.6	0.611	0.756	1.367	1.81	6.386	1.061	0.305
12	0.2447	32.600	14.2	8.6	0.615	0.749	1.364	1.82	6.393	1.057	0.308
13	0.2807	32.940	14.6	9.8	0.621	0.763	1.384	1.81	6.379	1.074	0.311
14	0.3155	33.180	14.8	11.1	0.623	0.766	1.389	1.81	6.376	1.077	0.311
15	0.3417	33.390	15.0	12.0	0.625	0.763	1.388	1.82	6.379	1.075	0.312
16	0.3694	33.620	15.3	13.0	0.627	0.767	1.394	1.82	6.375	1.081	0.314
17	0.3963	33.500	15.1	13.9	0.616	0.762	1.378	1.81	6.380	1.070	0.308
18	0.4250	33.290	14.9	15.0	0.600	0.763	1.363	1.79	6.379	1.063	0.300

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	125.260			140.970
Moisture content: Dry soil+tare, gms.	86.610			97.950
Moisture content: Tare, gms.	30.000			31.210
Moisture, %	68.3	68.2	66.0	64.5
Moist specimen weight, gms.	112.5			
Diameter, in.	1.39	1.39	1.38	
Area, in.^{2}	1.53	1.53	1.50	
Height, in.	2.79	2.79	2.77	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	100.4	100.4	101.2	
Dry density, pcf	59.7	59.7	61.0	
Void ratio	1.8767	1.8767	1.8152	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.135 tsf

Consolidation back pressure = 5.137 tsf

Consolidation effective confining stress = 1.998 tsf

Peak Stress = 1.061 tsf **at reading no.** 9

Ult. Stress = 0.922 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	0.0058	18.300	0.0	0.0	0.000	1.998	1.998	1.00	5.137	1.998	0.000
1	0.0079	22.850	4.6	0.1	0.218	1.886	2.104	1.12	5.249	1.995	0.109
2	0.0107	26.540	8.2	0.2	0.394	1.773	2.167	1.22	5.362	1.970	0.197
3	0.0267	36.830	18.5	0.8	0.880	1.275	2.155	1.69	5.860	1.715	0.440
4	0.0495	39.450	21.2	1.6	0.996	1.355	2.351	1.74	5.780	1.853	0.498
5	0.0726	39.910	21.6	2.4	1.009	1.368	2.377	1.74	5.767	1.873	0.505
6	0.0975	40.240	21.9	3.3	1.015	1.339	2.354	1.76	5.796	1.847	0.508
7	0.1232	40.990	22.7	4.2	1.040	1.315	2.355	1.79	5.820	1.835	0.520
8	0.1561	41.450	23.2	5.4	1.048	1.270	2.318	1.83	5.865	1.794	0.524
9	0.1822	41.980	23.7	6.4	1.061	1.248	2.309	1.85	5.887	1.779	0.531
10	0.2169	42.290	24.0	7.6	1.061	1.194	2.255	1.89	5.941	1.724	0.530
11	0.2429	42.380	24.1	8.5	1.054	1.171	2.225	1.90	5.964	1.698	0.527
12	0.2698	41.780	23.5	9.5	1.017	1.155	2.172	1.88	5.980	1.663	0.508
13	0.2966	41.760	23.5	10.5	1.005	1.147	2.152	1.88	5.988	1.650	0.503
14	0.3236	41.920	23.6	11.5	1.001	1.147	2.148	1.87	5.988	1.648	0.501
15	0.3506	41.930	23.6	12.4	0.990	1.138	2.128	1.87	5.997	1.633	0.495
16	0.3875	41.510	23.2	13.8	0.958	1.129	2.087	1.85	6.006	1.608	0.479
17	0.4155	41.010	22.7	14.8	0.926	1.121	2.047	1.83	6.014	1.584	0.463
18	0.4231	40.980	22.7	15.0	0.922	1.129	2.051	1.82	6.006	1.590	0.461

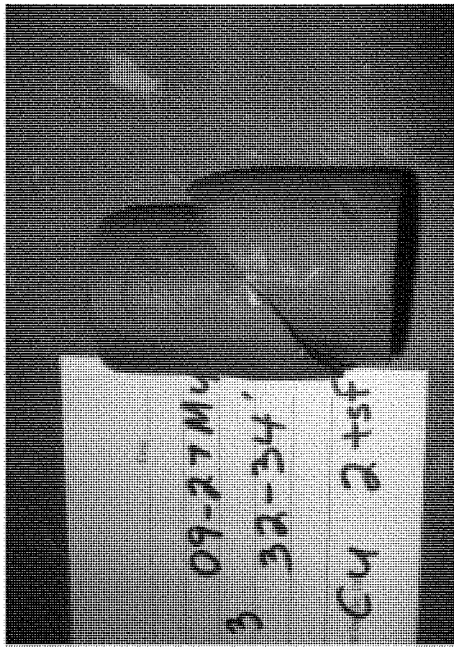
Parameters for Specimen No. 3				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	130.180			133.220
Moisture content: Dry soil+tare, gms.	88.460			95.800
Moisture content: Tare, gms.	29.780			30.960
Moisture, %	71.1	72.3	65.5	57.7
Moist specimen weight, gms.	111.9			
Diameter, in.	1.40	1.40	1.37	
Area, in.^{2}	1.54	1.54	1.48	
Height, in.	2.81	2.81	2.75	
Net decrease in height, in.		0.00	0.06	
Wet Density, pcf	98.3	99.0	101.4	
Dry density, pcf	57.4	57.4	61.3	
Void ratio	1.9886	1.9886	1.7999	
Saturation, %	98.3	100.0	100.0	

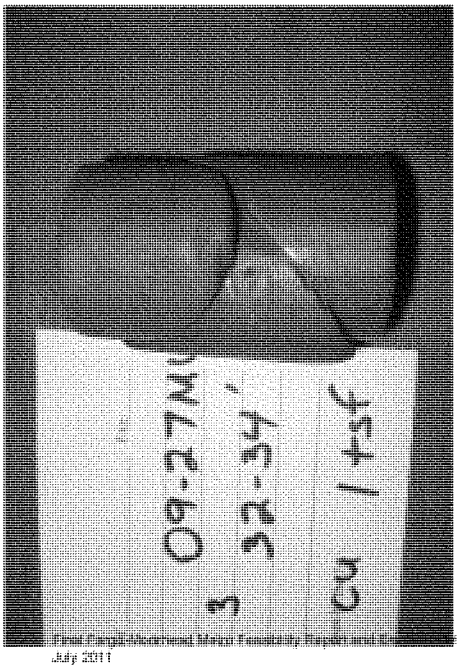
Test Readings for Specimen No. 3

Consolidation cell pressure = 7.138 tsf
Consolidation back pressure = 3.129 tsf
Consolidation effective confining stress = 4.009 tsf
Peak Stress = 1.433 tsf **at reading no.** 7
Ult. Stress = 1.220 tsf **at reading no.** 18

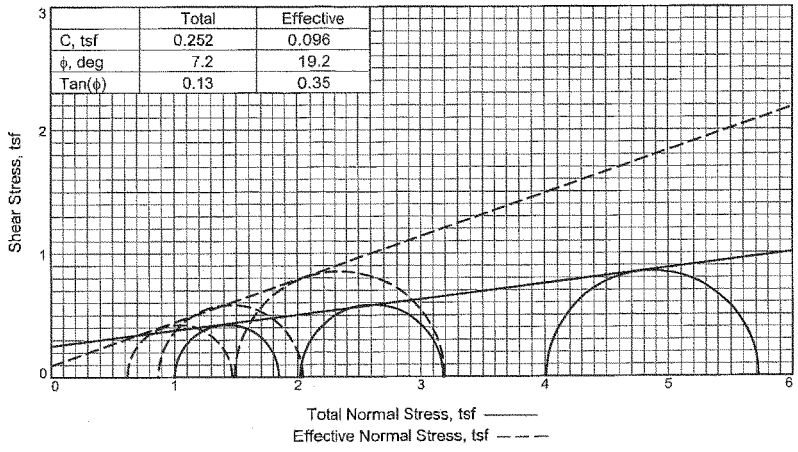
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0061	16.750	0.0	0.0	0.000	4.009	4.009	1.00	3.129	4.009	0.000
1	0.0082	18.490	1.7	0.1	0.085	3.960	4.045	1.02	3.178	4.002	0.042
2	0.0112	19.310	2.6	0.2	0.124	3.933	4.057	1.03	3.205	3.995	0.062
3	0.0201	19.310	2.6	0.5	0.124	3.874	3.998	1.03	3.264	3.936	0.062
4	0.0338	31.580	14.8	1.0	0.715	3.470	4.185	1.21	3.668	3.828	0.358
5	0.0577	40.250	23.5	1.9	1.123	3.045	4.168	1.37	4.093	3.607	0.562
6	0.0895	45.220	28.5	3.0	1.345	2.726	4.071	1.49	4.412	3.398	0.672
7	0.1156	47.390	30.6	4.0	1.433	2.550	3.983	1.56	4.588	3.267	0.717
8	0.1416	44.090	27.3	4.9	1.266	2.573	3.839	1.49	4.565	3.206	0.633
9	0.1672	44.000	27.3	5.9	1.250	2.532	3.782	1.49	4.606	3.157	0.625
10	0.1933	44.180	27.4	6.8	1.245	2.443	3.688	1.51	4.695	3.066	0.623
11	0.2189	44.190	27.4	7.7	1.233	2.370	3.603	1.52	4.768	2.987	0.617
12	0.2462	44.390	27.6	8.7	1.229	2.288	3.517	1.54	4.850	2.903	0.615
13	0.2737	44.730	28.0	9.7	1.231	2.219	3.450	1.55	4.919	2.834	0.615
14	0.3008	45.080	28.3	10.7	1.232	2.152	3.384	1.57	4.986	2.768	0.616
15	0.3367	45.380	28.6	12.0	1.227	2.079	3.306	1.59	5.059	2.693	0.614
16	0.3635	45.510	28.8	13.0	1.219	2.029	3.248	1.60	5.109	2.639	0.610
17	0.3916	46.020	29.3	14.0	1.226	1.986	3.212	1.62	5.152	2.599	0.613
18	0.4195	46.230	29.5	15.0	1.220	1.942	3.162	1.63	5.196	2.552	0.610

09-27MW
32-34'
CU 4+34

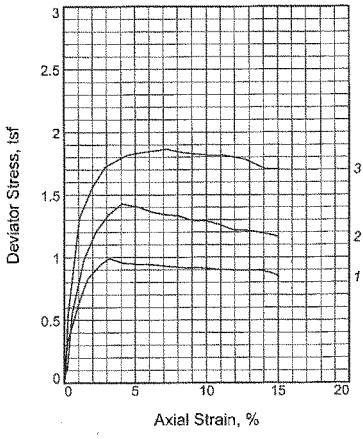

09-27MW
32-34'
CU 2+34


09-27MW
32-34'
CU 1+34

09-27MW
32-34'



	Total	Effective
C, tsf	0.252	0.096
ϕ, deg	7.2	19.2
Tan(ϕ)	0.13	0.35



Sample No.		1	2	3
Initial	Water Content, %	52.3	49.7	50.2
	Dry Density, pcf	69.9	72.1	70.8
	Saturation, %	100.0	100.0	98.3
	Void Ratio	1.4140	1.3423	1.3827
	Diameter, in.	1.42	1.42	1.41
	Height, in.	2.81	2.81	2.81
At Test	Water Content, %	51.7	47.1	46.5
	Dry Density, pcf	70.4	74.3	74.8
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.3986	1.2727	1.2568
	Diameter, in.	1.42	1.40	1.39
	Height, in.	2.80	2.78	2.76
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		1.00	2.02	4.01
Back Pressure, tsf		6.14	5.12	3.13
Cell Pressure, tsf		7.14	7.14	7.14
Peak Deviator Stress, tsf		0.99	1.43	1.87
Total Pore Pr., tsf		6.66	6.09	5.30
Ultimate Deviator Stress, tsf		0.85	1.17	1.71
Total Pore Pr., tsf		6.52	6.27	5.66
Maj. Eff. Stress at Ultimate, tsf		1.47	2.48	3.71
Min. Eff. Stress at Ultimate, tsf		0.48	1.05	1.84

Type of Test:
CU with Pore Pressures

Sample Type: Thinwall, 5", Middle of sample

Description: FAT CLAY, gray (CH)

LL= 89 **PL=** 20 **PI=** 69

Assumed Specific Gravity= 2.704

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 Brenna / Argusville Transition

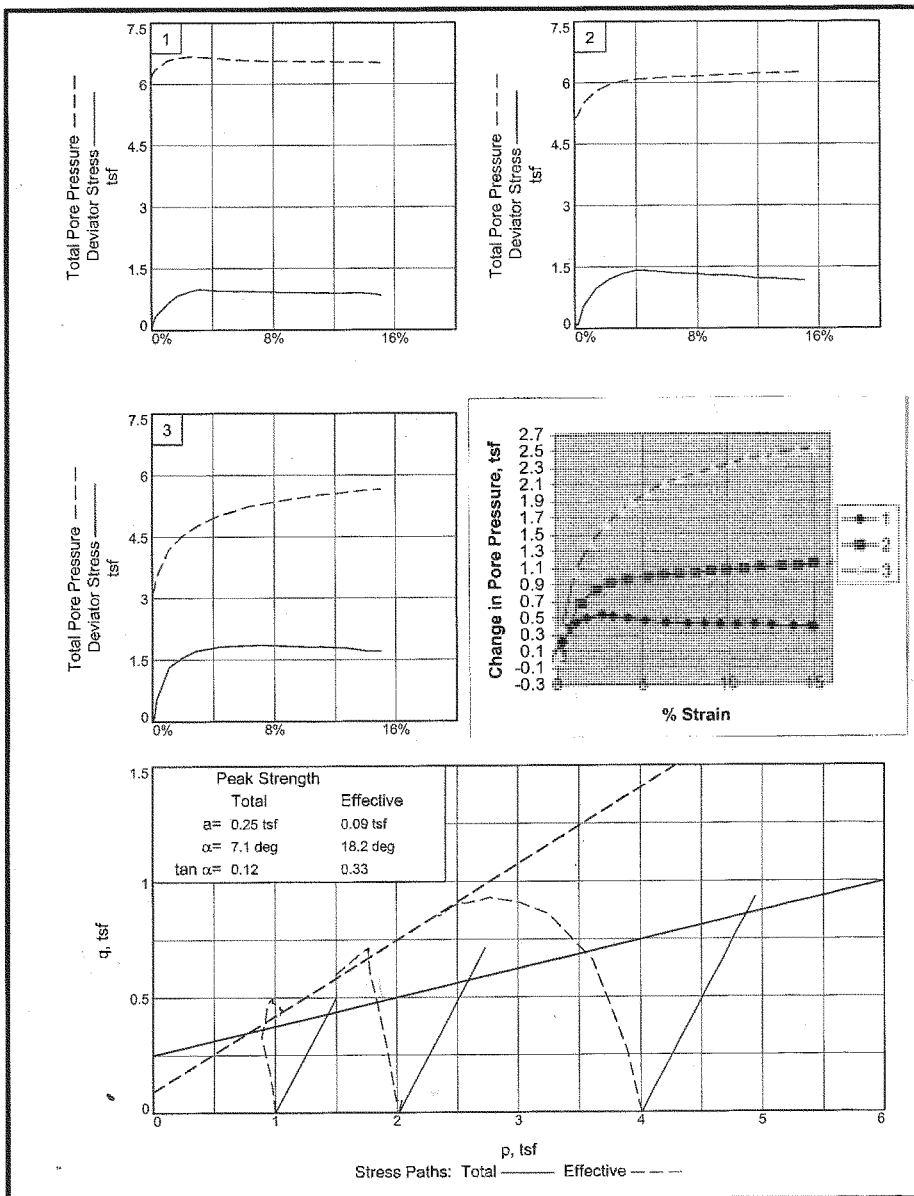
Location: SE-F-19, Fargo, ~~Argusville Formation~~

Sample Number: Boring 09-27MU, #4 **Depth:** 64-66'

Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Figure Fargo-Moorhead Feasibility Report and Environmental Impact Statement Attachment I-4, pg 272
July 2011 Geotechnical Design and Geology



Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
Loc.: SE-F-19, Fargo, ~~Argusville Formation~~ **Depth:** 64-66'
Project No.: BL-09-01-27

Brenna / Argusville Transition
Sample No.: Boring 09-27MU, #4

Figure

Fargo-Moorhead Feasibility Report and Environmental Impact Statement
July 2011

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

11/9/2009
1:47 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, ~~Argusville Formation~~
Depth: 64-66' **Sample Number:** Boring 09-27MU, #4
Description: FAT CLAY, gray (CH) Brenna / Argusville Transition
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=2.704 **LL=**89 **PL=**20 **PI=**69
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	123.490			154.160
Moisture content: Dry soil+tare, gms.	91.590			112.320
Moisture content: Tare, gms.	30.590			30.470
Moisture, %	52.3	52.3	51.7	51.1
Moist specimen weight, gms.	124.2			
Diameter, in.	1.42	1.42	1.42	
Area, in.²	1.58	1.58	1.58	
Height, in.	2.81	2.81	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	106.5	106.5	106.8	
Dry density, pcf	69.9	69.9	70.4	
Void ratio	1.4140	1.4140	1.3986	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.140 tsf
Consolidation back pressure = 6.139 tsf
Consolidation effective confining stress = 1.001 tsf
Peak Stress = 0.991 tsf **at reading no.** 6
Ult. Stress = 0.845 tsf **at reading no.** 18

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	0.0199	19.340	0.0	0.0	0.000	1.001	1.001	1.00	6.139	1.001	0.000
1	0.0220	23.000	3.7	0.1	0.167	0.900	1.067	1.19	6.240	0.983	0.083
2	0.0270	26.730	7.4	0.3	0.337	0.789	1.126	1.43	6.351	0.957	0.168
3	0.0506	33.900	14.6	1.1	0.658	0.560	1.218	2.17	6.580	0.889	0.329
4	0.0667	37.840	18.5	1.7	0.831	0.507	1.338	2.64	6.633	0.922	0.415
5	0.0925	40.580	21.2	2.6	0.945	0.464	1.409	3.04	6.676	0.936	0.472
6	0.1094	41.770	22.4	3.2	0.991	0.482	1.473	3.06	6.658	0.978	0.496
7	0.1352	41.160	21.8	4.1	0.955	0.501	1.456	2.91	6.639	0.979	0.478
8	0.1613	41.160	21.8	5.1	0.946	0.535	1.481	2.77	6.605	1.008	0.473
9	0.1962	41.340	22.0	6.3	0.941	0.562	1.503	2.67	6.578	1.033	0.471
10	0.2329	41.280	21.9	7.6	0.926	0.575	1.501	2.61	6.565	1.038	0.463
11	0.2601	41.260	21.9	8.6	0.915	0.577	1.492	2.59	6.563	1.034	0.457
12	0.2870	41.510	22.2	9.5	0.916	0.583	1.499	2.57	6.557	1.041	0.458
13	0.3140	41.500	22.2	10.5	0.905	0.593	1.498	2.53	6.547	1.046	0.453
14	0.3416	41.650	22.3	11.5	0.902	0.585	1.487	2.54	6.555	1.036	0.451
15	0.3696	41.730	22.4	12.5	0.895	0.600	1.495	2.49	6.540	1.047	0.447
16	0.4067	42.110	22.8	13.8	0.896	0.609	1.505	2.47	6.531	1.057	0.448
17	0.4343	41.530	22.2	14.8	0.863	0.612	1.475	2.41	6.528	1.044	0.432
18	0.4410	41.130	21.8	15.0	0.845	0.619	1.464	2.37	6.521	1.042	0.423

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	106.290			153.410
Moisture content: Dry soil+tare, gms.	80.980			115.020
Moisture content: Tare, gms.	30.010			30.920
Moisture, %	49.7	49.6	47.1	45.6
Moist specimen weight, gms.	125.1			
Diameter, in.	1.42	1.42	1.40	
Area, in.²	1.57	1.57	1.54	
Height, in.	2.81	2.81	2.78	
Net decrease in height, in.		0.00	0.03	
Wet Density, pcf	107.9	107.8	109.2	
Dry density, pcf	72.1	72.1	74.3	
Void ratio	1.3423	1.3423	1.2727	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.139 tsf
Consolidation back pressure = 5.122 tsf
Consolidation effective confining stress = 2.017 tsf
Peak Stress = 1.428 tsf **at reading no.** 7
Ult. Stress = 1.165 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	0.0070	19.370	0.0	0.0	0.000	2.017	2.017	1.00	5.122	2.017	0.000
1	0.0099	21.970	2.6	0.1	0.121	1.981	2.102	1.06	5.158	2.042	0.061
2	0.0128	21.510	2.1	0.2	0.100	1.945	2.045	1.05	5.194	1.995	0.050
3	0.0223	31.240	11.9	0.6	0.551	1.647	2.198	1.33	5.492	1.923	0.276
4	0.0456	40.680	21.3	1.4	0.982	1.342	2.324	1.73	5.797	1.833	0.491
5	0.0698	45.830	26.5	2.3	1.208	1.176	2.384	2.03	5.963	1.780	0.604
6	0.0944	49.010	29.6	3.1	1.341	1.095	2.436	2.22	6.044	1.766	0.671
7	0.1201	51.240	31.9	4.1	1.428	1.050	2.478	2.36	6.089	1.764	0.714
8	0.1543	50.960	31.6	5.3	1.398	1.025	2.423	2.36	6.114	1.724	0.699
9	0.1800	50.450	31.1	6.2	1.362	0.996	2.358	2.37	6.143	1.677	0.681
10	0.2057	50.300	30.9	7.1	1.342	0.992	2.334	2.35	6.147	1.663	0.671
11	0.2309	50.370	31.0	8.1	1.332	0.980	2.312	2.36	6.159	1.646	0.666
12	0.2566	49.810	30.4	9.0	1.294	0.961	2.255	2.35	6.178	1.608	0.647
13	0.2837	50.080	30.7	9.9	1.292	0.949	2.241	2.36	6.190	1.595	0.646
14	0.3105	49.680	30.3	10.9	1.261	0.936	2.197	2.35	6.203	1.567	0.631
15	0.3375	48.960	29.6	11.9	1.218	0.909	2.127	2.34	6.230	1.518	0.609
16	0.3723	49.190	29.8	13.1	1.210	0.904	2.114	2.34	6.235	1.509	0.605
17	0.3992	48.980	29.6	14.1	1.188	0.899	2.087	2.32	6.240	1.493	0.594
18	0.4250	48.730	29.4	15.0	1.165	0.871	2.036	2.34	6.268	1.454	0.583

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	129.690			145.990
Moisture content: Dry soil+tare, gms.	96.600			110.880
Moisture content: Tare, gms.	30.740			30.240
Moisture, %	50.2	51.1	46.5	43.5
Moist specimen weight, gms.	122.6			
Diameter, in.	1.41	1.41	1.39	
Area, in.²	1.56	1.56	1.51	
Height, in.	2.81	2.81	2.76	
Net decrease in height, in.		0.00	0.05	
Wet Density, pcf	106.4	107.1	109.6	
Dry density, pcf	70.8	70.8	74.8	
Void ratio	1.3827	1.3827	1.2568	
Saturation, %	98.3	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.140 tsf

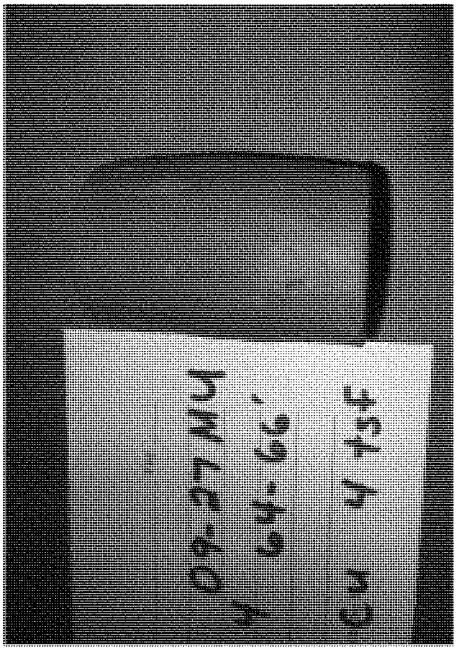
Consolidation back pressure = 3.130 tsf

Consolidation effective confining stress = 4.010 tsf

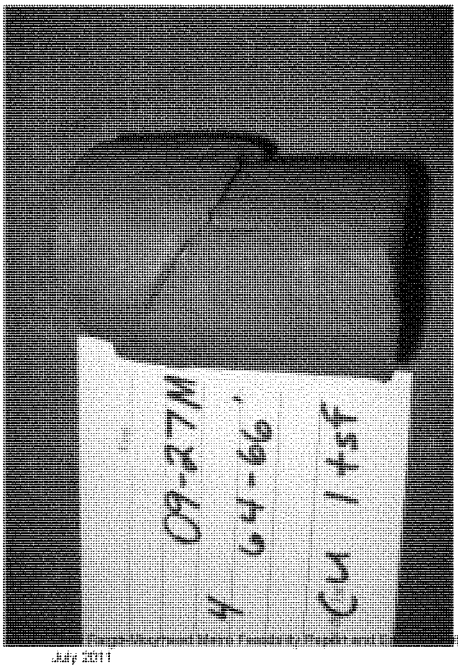
Peak Stress = 1.866 tsf at reading no. 10

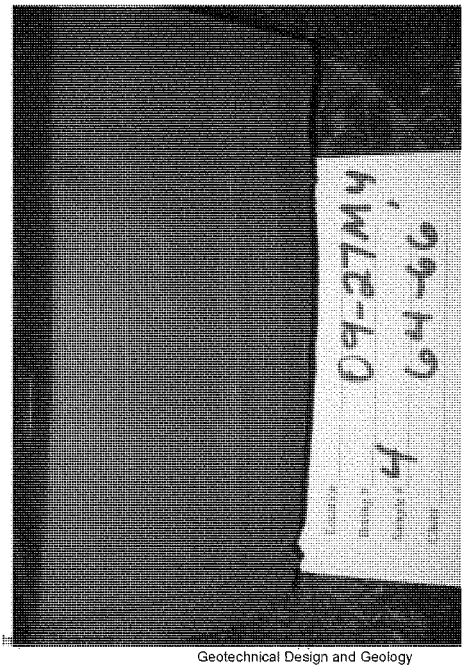
Ult. Stress = 1.709 tsf at reading no. 18

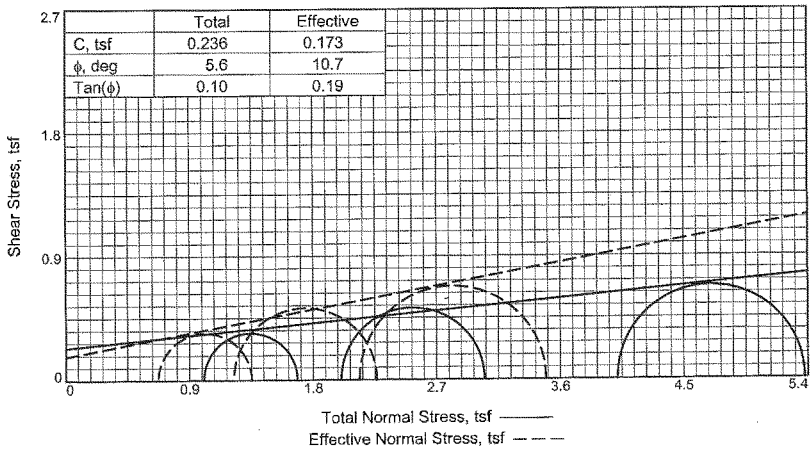
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0069	20.930	0.0	0.0	0.000	4.010	4.010	1.00	3.130	4.010	0.000
1	0.0098	22.820	1.9	0.1	0.090	3.941	4.031	1.02	3.199	3.986	0.045
2	0.0139	32.190	11.3	0.3	0.536	3.626	4.162	1.15	3.514	3.894	0.268
3	0.0366	48.820	27.9	1.1	1.317	2.955	4.272	1.45	4.185	3.614	0.659
4	0.0615	54.230	33.3	2.0	1.558	2.615	4.173	1.60	4.525	3.394	0.779
5	0.0864	58.040	37.1	2.9	1.721	2.394	4.115	1.72	4.746	3.254	0.860
6	0.1117	59.660	38.7	3.8	1.779	2.218	3.997	1.80	4.922	3.107	0.889
7	0.1292	60.730	39.8	4.4	1.816	2.118	3.934	1.86	5.022	3.026	0.908
8	0.1543	61.520	40.6	5.3	1.834	2.014	3.848	1.91	5.126	2.931	0.917
9	0.1801	62.270	41.3	6.3	1.850	1.899	3.749	1.97	5.241	2.824	0.925
10	0.2060	63.050	42.1	7.2	1.866	1.840	3.706	2.01	5.300	2.773	0.933
11	0.2331	62.890	42.0	8.2	1.839	1.777	3.616	2.03	5.363	2.697	0.920
12	0.2599	63.050	42.1	9.2	1.826	1.716	3.542	2.06	5.424	2.629	0.913
13	0.2868	63.190	42.3	10.2	1.813	1.668	3.481	2.09	5.472	2.574	0.906
14	0.3129	63.720	42.8	11.1	1.816	1.615	3.431	2.12	5.525	2.523	0.908
15	0.3396	63.780	42.9	12.1	1.799	1.591	3.390	2.13	5.549	2.490	0.899
16	0.3585	63.660	42.7	12.8	1.780	1.557	3.337	2.14	5.583	2.447	0.890
17	0.3956	62.530	41.6	14.1	1.706	1.502	3.208	2.14	5.638	2.355	0.853
18	0.4210	63.050	42.1	15.0	1.709	1.485	3.194	2.15	5.655	2.339	0.854


09-27MW
4 64-66'
Cu 4 tsf

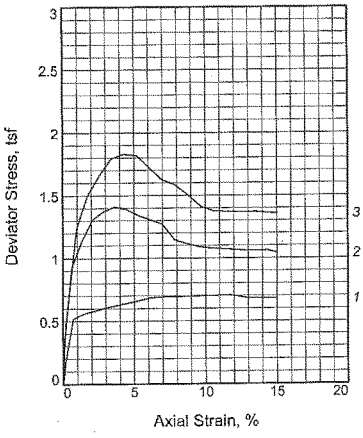
09-27MW
4 64-66'
Cu 2 tsf


09-27M
4 64-66'
Cu 1 tsf


09-27MW
4 64-66'



	Total	Effective
C, tsf	0.236	0.173
ϕ, deg	5.6	10.7
Tan(ϕ)	0.10	0.19



Sample No.		1	2	3
Initial	Water Content, %	65.1	65.0	65.2
	Dry Density, pcf	61.0	61.1	60.7
	Saturation, %	98.7	98.7	98.1
	Void Ratio	1.8130	1.8107	1.8265
	Diameter, in.	1.42	1.40	1.41
	Height, in.	2.80	2.81	2.81
At Test	Water Content, %	65.4	63.7	63.1
	Dry Density, pcf	61.4	62.4	62.7
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.7980	1.7510	1.7365
	Diameter, in.	1.41	1.39	1.39
	Height, in.	2.80	2.79	2.78
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		1.01	2.01	4.02
Back Pressure, tsf		6.13	5.13	3.14
Cell Pressure, tsf		7.14	7.14	7.16
Peak Deviator Stress, tsf		0.70	1.41	1.83
Total Pore Pr., tsf		6.51	5.89	4.77
Ultimate Deviator Stress, tsf		0.68	1.04	1.36
Total Pore Pr., tsf		6.47	5.92	5.02
Maj. Eff. Stress at Ultimate, tsf		1.34	2.66	4.21
Min. Eff. Stress at Ultimate, tsf		0.63	1.25	2.38

Type of Test:
CU with Pore Pressures
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, gray (CH)

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 Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Location: SE-M-11, Moorhead, Brenna Formation
Sample Number: Boring 09-53MU, #2 **Depth:** 28-30'
Proj. No.: BL-09-03127 **Date Sampled:**

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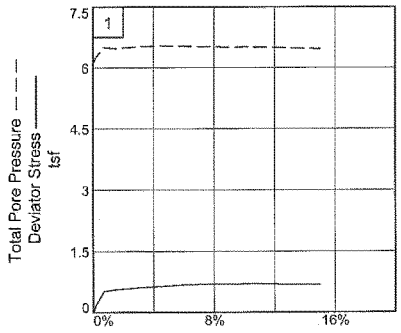
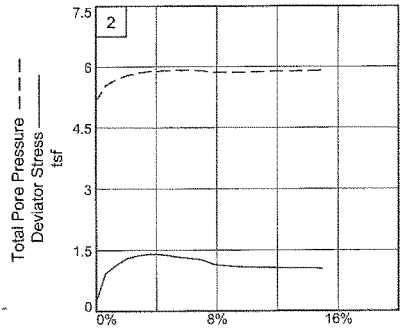
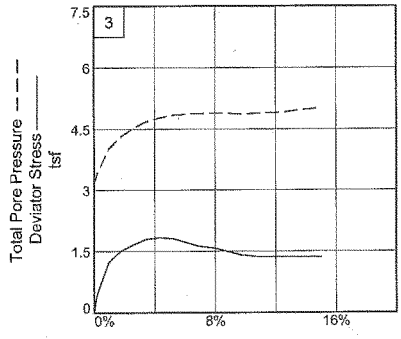
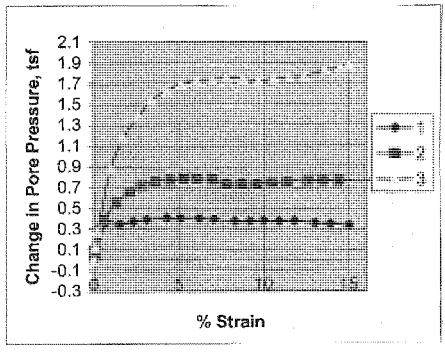
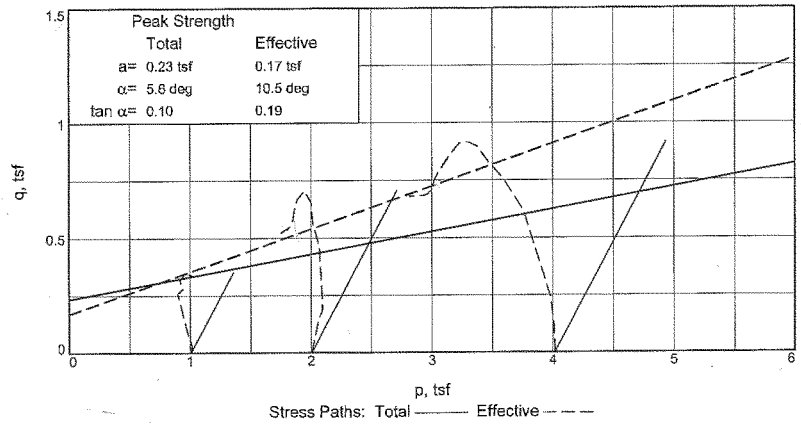
Figure CU-Triax ASTM D 4767











Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
Loc.: SE-M-11, Moorhead, Brenna Formation **Depth:** 28-30' **Sample No.:** Boring 09-53MU, #2
Project No.: [illegible] Feasibility Report and Environmental Impact Statement

Figure

July 2011

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

11/18/2009
10:50 AM

Date:
Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-M-11, Moorhead, Brenna Formation
Depth: 28-30' **Sample Number:** Boring 09-53MU, #2
Description: FAT CLAY, gray (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=2.75 **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.	109.180			147.290
Moisture content: Dry soil+tare, gms.	78.530			101.360
Moisture content: Tare, gms.	31.430			30.600
Moisture, %	65.1	65.9	65.4	64.9
Moist specimen weight, gms.	116.8			
Diameter, in.	1.42	1.42	1.41	
Area, in.^{2}	1.57	1.57	1.57	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	100.7	101.3	101.5	
Dry density, pcf	61.0	61.0	61.4	
Void ratio	1.8130	1.8130	1.7980	
Saturation, %	98.7	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.139 tsf
Consolidation back pressure = 6.134 tsf
Consolidation effective confining stress = 1.005 tsf
Peak Stress = 0.704 tsf **at reading no.** 15
Ult. Stress = 0.680 tsf **at reading no.** 18

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	0.0071	18.910	0.0	0.0	0.000	1.005	1.005	1.00	6.134	1.005	0.000
1	0.0092	20.230	1.3	0.1	0.061	0.985	1.046	1.06	6.154	1.015	0.030
2	0.0121	22.760	3.9	0.2	0.176	0.891	1.067	1.20	6.248	0.979	0.088
3	0.0270	30.290	11.4	0.7	0.518	0.637	1.155	1.81	6.502	0.896	0.259
4	0.0489	31.340	12.4	1.5	0.562	0.660	1.222	1.85	6.479	0.941	0.281
5	0.0718	31.960	13.1	2.3	0.585	0.636	1.221	1.92	6.503	0.928	0.292
6	0.0947	32.610	13.7	3.1	0.609	0.617	1.226	1.99	6.522	0.921	0.304
7	0.1263	33.380	14.5	4.3	0.636	0.599	1.235	2.06	6.540	0.917	0.318
8	0.1503	33.990	15.1	5.1	0.657	0.603	1.260	2.09	6.536	0.931	0.328
9	0.1813	34.850	15.9	6.2	0.686	0.605	1.291	2.13	6.534	0.948	0.343
10	0.2062	35.130	16.2	7.1	0.691	0.614	1.305	2.13	6.525	0.960	0.346
11	0.2393	35.420	16.5	8.3	0.695	0.629	1.324	2.10	6.510	0.976	0.347
12	0.2639	35.650	16.7	9.2	0.698	0.632	1.330	2.10	6.507	0.981	0.349
13	0.2876	35.850	16.9	10.0	0.699	0.625	1.324	2.12	6.514	0.975	0.350
14	0.3129	36.100	17.2	10.9	0.703	0.634	1.337	2.11	6.505	0.985	0.351
15	0.3378	36.310	17.4	11.8	0.704	0.631	1.335	2.12	6.508	0.983	0.352
16	0.3705	35.970	17.1	13.0	0.681	0.650	1.331	2.05	6.489	0.991	0.341
17	0.3958	36.150	17.2	13.9	0.681	0.660	1.341	2.03	6.479	1.001	0.341
18	0.4275	36.340	17.4	15.0	0.680	0.673	1.353	2.01	6.466	1.013	0.340

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	127.430			142.540
Moisture content: Dry soil+tare, gms.	89.230			99.980
Moisture content: Tare, gms.	30.420			30.690
Moisture, %	65.0	65.8	63.7	61.4
Moist specimen weight, gms.	114.3			
Diameter, in.	1.40	1.40	1.39	
Area, in.²	1.54	1.54	1.52	
Height, in.	2.81	2.81	2.79	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	100.8	101.3	102.1	
Dry density, pcf	61.1	61.1	62.4	
Void ratio	1.8107	1.8107	1.7510	
Saturation, %	98.7	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.139 tsf
Consolidation back pressure = 5.134 tsf
Consolidation effective confining stress = 2.005 tsf
Peak Stress = 1.411 tsf **at reading no.** 7
Ult. Stress = 1.043 tsf **at reading no.** 20

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	0.0060	15.590	0.0	0.0	0.000	2.005	2.005	1.00	5.134	2.005	0.000
1	0.0070	21.690	6.1	0.0	0.290	1.918	2.208	1.15	5.221	2.063	0.145
2	0.0099	23.640	8.1	0.1	0.382	1.906	2.288	1.20	5.233	2.097	0.191
3	0.0231	35.150	19.6	0.6	0.924	1.607	2.531	1.57	5.532	2.069	0.462
4	0.0428	39.700	24.1	1.3	1.130	1.448	2.578	1.78	5.691	2.013	0.565
5	0.0639	43.670	28.1	2.1	1.307	1.349	2.656	1.97	5.790	2.002	0.653
6	0.0847	45.280	29.7	2.8	1.371	1.283	2.654	2.07	5.856	1.968	0.685
7	0.1074	46.410	30.8	3.6	1.411	1.247	2.658	2.13	5.892	1.953	0.706
8	0.1305	46.230	30.6	4.5	1.391	1.232	2.623	2.13	5.907	1.927	0.695
9	0.1545	45.410	29.8	5.3	1.342	1.219	2.561	2.10	5.920	1.890	0.671
10	0.1772	44.890	29.3	6.1	1.307	1.225	2.532	2.07	5.914	1.878	0.653
11	0.2010	44.370	28.8	7.0	1.272	1.231	2.503	2.03	5.908	1.867	0.636
12	0.2250	41.740	26.2	7.8	1.145	1.276	2.421	1.90	5.863	1.849	0.573
13	0.2491	41.280	25.7	8.7	1.114	1.276	2.390	1.87	5.863	1.833	0.557
14	0.2739	40.950	25.4	9.6	1.089	1.272	2.361	1.86	5.867	1.817	0.545
15	0.2977	40.920	25.3	10.5	1.078	1.263	2.341	1.85	5.876	1.802	0.539
16	0.3228	41.070	25.5	11.4	1.073	1.250	2.323	1.86	5.889	1.787	0.537
17	0.3566	41.130	25.5	12.6	1.061	1.244	2.305	1.85	5.895	1.775	0.531
18	0.3819	41.340	25.8	13.5	1.059	1.237	2.296	1.86	5.902	1.766	0.529
19	0.4067	41.650	26.1	14.4	1.060	1.240	2.300	1.86	5.899	1.770	0.530
20	0.4235	41.410	25.8	15.0	1.043	1.221	2.264	1.85	5.918	1.743	0.522

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	127.880			140.080
Moisture content: Dry soil+tare, gms.	89.200			98.000
Moisture content: Tare, gms.	29.850			30.470
Moisture, %	65.2	66.4	63.1	62.3
Moist specimen weight, gms.	115.4			
Diameter, in.	1.41	1.41	1.39	
Area, in.²	1.56	1.56	1.53	
Height, in.	2.81	2.81	2.78	
Net decrease in height, in.		0.00	0.03	
Wet Density, pcf	100.3	101.1	102.4	
Dry density, pcf	60.7	60.7	62.7	
Void ratio	1.8265	1.8265	1.7365	
Saturation, %	98.1	100.0	100.0	

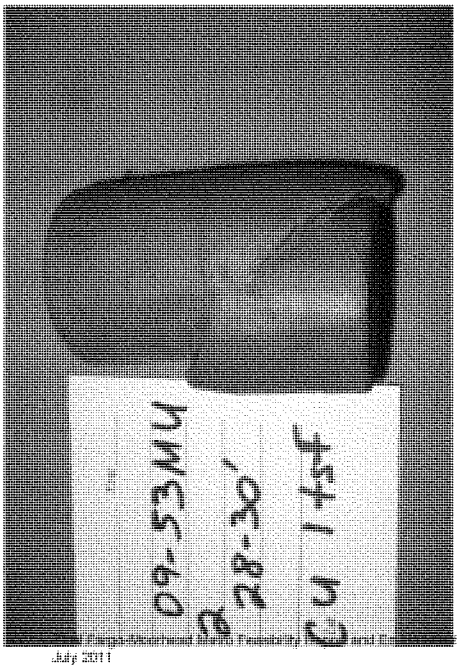
Test Readings for Specimen No. 3

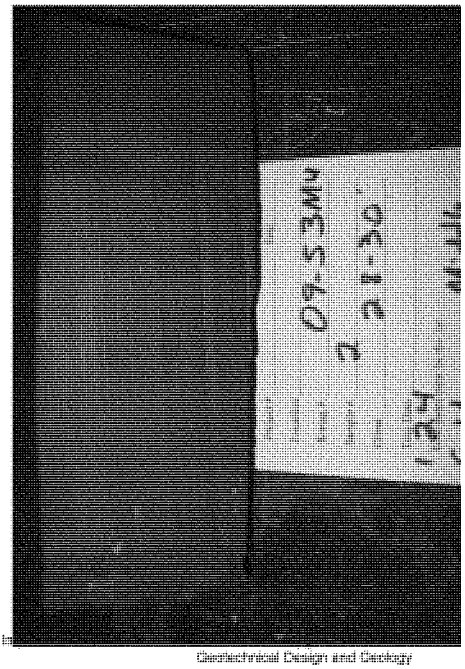
Consolidation cell pressure = 7.155 tsf
Consolidation back pressure = 3.137 tsf
Consolidation effective confining stress = 4.018 tsf
Peak Stress = 1.830 tsf **at reading no.** 7
Ult. Stress = 1.359 tsf **at reading no.** 19

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	0.0072	16.500	0.0	0.0	0.000	4.018	4.018	1.00	3.137	4.018	0.000
1	0.0092	21.540	5.0	0.1	0.237	3.890	4.127	1.06	3.265	4.009	0.119
2	0.0130	26.730	10.2	0.2	0.481	3.741	4.222	1.13	3.414	3.982	0.241
3	0.0339	42.930	26.4	1.0	1.233	3.143	4.376	1.39	4.012	3.760	0.617
4	0.0557	49.010	32.5	1.7	1.505	2.844	4.349	1.53	4.311	3.597	0.753
5	0.0787	52.670	36.2	2.6	1.660	2.636	4.296	1.63	4.519	3.466	0.830
6	0.1015	55.910	39.4	3.4	1.794	2.479	4.273	1.72	4.676	3.376	0.897
7	0.1255	57.070	40.6	4.3	1.830	2.384	4.214	1.77	4.771	3.299	0.915
8	0.1503	57.220	40.7	5.2	1.820	2.315	4.135	1.79	4.840	3.225	0.910
9	0.1753	55.420	38.9	6.1	1.723	2.288	4.011	1.75	4.867	3.149	0.861
10	0.2002	53.560	37.1	7.0	1.625	2.274	3.899	1.71	4.881	3.086	0.812
11	0.2250	53.010	36.5	7.8	1.585	2.265	3.850	1.70	4.890	3.058	0.793
12	0.2511	51.450	35.0	8.8	1.502	2.270	3.772	1.66	4.885	3.021	0.751
13	0.2761	49.680	33.2	9.7	1.412	2.288	3.700	1.62	4.867	2.994	0.706
14	0.3012	49.190	32.7	10.6	1.377	2.272	3.649	1.61	4.883	2.961	0.689
15	0.3259	49.380	32.9	11.5	1.371	2.253	3.624	1.61	4.902	2.939	0.686
16	0.3516	49.670	33.2	12.4	1.369	2.248	3.617	1.61	4.907	2.932	0.684
17	0.3848	50.130	33.6	13.6	1.369	2.188	3.557	1.63	4.967	2.873	0.685
18	0.4103	50.280	33.8	14.5	1.361	2.159	3.520	1.63	4.996	2.839	0.680
19	0.4244	50.440	33.9	15.0	1.359	2.138	3.497	1.64	5.017	2.817	0.679

09-53MW
28-30'
CU 4+sf

09-53MW
28-30'
CU 2+sf

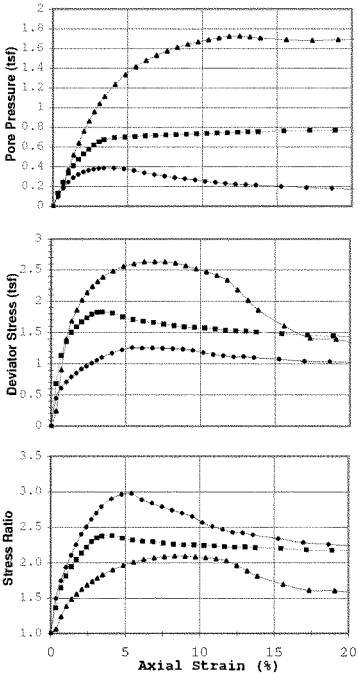

09-53MW
28-30'
CU 1+sf


09-53MW
21-30'

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-78MU Fargo Sample #: 2 Type: 5T Depth (ft): 25 - 27 (Top)
Soil Type: Fat Clay (CH) Brenna

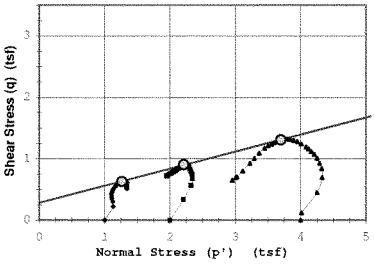


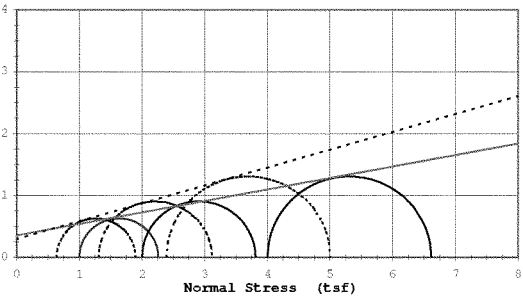
Failure Criterion:	Max. Stress Ratio
Angle of internal friction, ϕ' =	16.1 °
Apparent Cohesion, c' =	0.29 (tsf)
Test Date: 8/12/10	Liquid Limit: 63.8
Test Type: CU w/pp	Plastic Limit: 23.1
Strain Rate (in/min): 0.0039	Plasticity Index: 40.7
Strain Rate (%/min): 0.132	Spec. Gravity (Assumed): 2.76

	A	B	C	D	E
Before Consolidation					
Diameter (in)	1.45	1.45	1.45		
Height (in)	2.99	2.99	2.99		
Water Content (%)	41.2	42.8	44.4		
Dry Density (pcf)	78.9	77.4	76.0		
Void Ratio	1.18	1.23	1.27		
After Consolidation					
Diameter (in)	1.43	1.43	1.39		
Height (in)	2.95	2.91	2.88		
Water Content (%)	40.3	39.9	36.6		
Dry Density (pcf)	81.5	82.0	85.7		
Void Ratio	1.11	1.10	1.01		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	1.26	1.83	2.63		
Ultimate Deviator Stress (tsf)	1.02	1.44	1.30		
Deviator Stress at Failure (tsf)	1.26	1.81	2.61		
Max. Pore Pressure Buildup (tsf)	0.39	0.77	1.72		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	5.4	4.1	8.3		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





Rupture Envelope at Failure
α = 15.5 ° a = 0.3 (tsf)

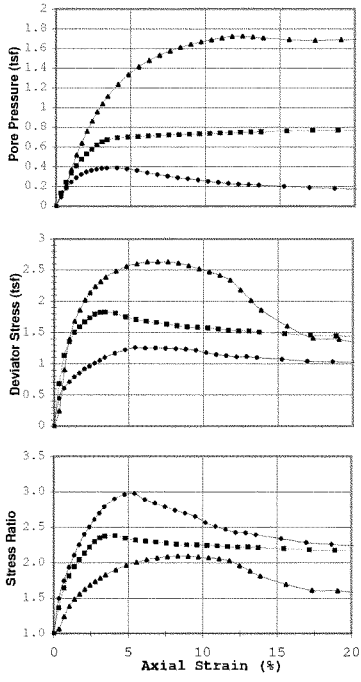
---------- Effective ϕ': 16.1 ° c'= 0.29 (tsf)
_____ Total ϕ': 10.5 ° c= 0.36 (tsf)

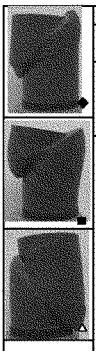
9301 Bryant Ave. South, Suite #107 Bloomington, Minnesota 55420-3436

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-78MU Fargo Sample #: 2 Type: 5T Depth (ft): 25 - 27 (Top)
Soil Type: Fat Clay (CH) Brenna

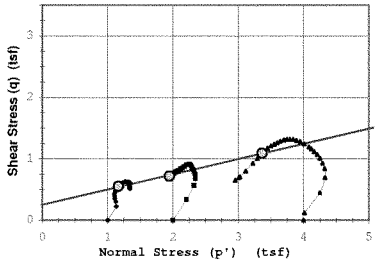


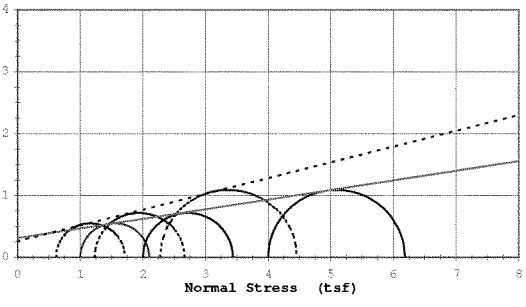


Failure Criterion:	Max. Pore Pressure				
Angle of internal friction, ϕ' =	14.3 °				
Apparent Cohesion, c' =	0.26 (tsf)				
Test Date: 8/12/10		Liquid Limit:	63.8		
Test Type: CU w/pp		Plastic Limit:	23.1		
Strain Rate (in/min): 0.0039		Plasticity Index:	40.7		
Strain Rate (%/min): 0.132		Spec. Gravity (Assumed):	2.76		
Before Consolidation	A	B	C	D	E
Diameter (in)	1.45	1.45	1.45		
Height (in)	2.99	2.99	2.99		
Water Content (%)	41.2	42.8	44.4		
Dry Density (pcf)	78.9	77.4	76.0		
Void Ratio	1.18	1.23	1.27		
After Consolidation					
Diameter (in)	1.43	1.43	1.39		
Height (in)	2.95	2.91	2.88		
Water Content (%)	40.3	39.9	36.6		
Dry Density (pcf)	81.5	82.0	85.7		
Void Ratio	1.11	1.10	1.01		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	1.26	1.83	2.63		
Ultimate Deviator Stress (tsf)	1.02	1.44	1.30		
Deviator Stress at Failure (tsf)	1.10	1.44	2.18		
Max. Pore Pressure Buildup (tsf)	0.39	0.77	1.72		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	3.4	20.6	12.5		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





Rupture Envelope at Failure			
α = 13.9 °	a = 0.3 (tsf)		

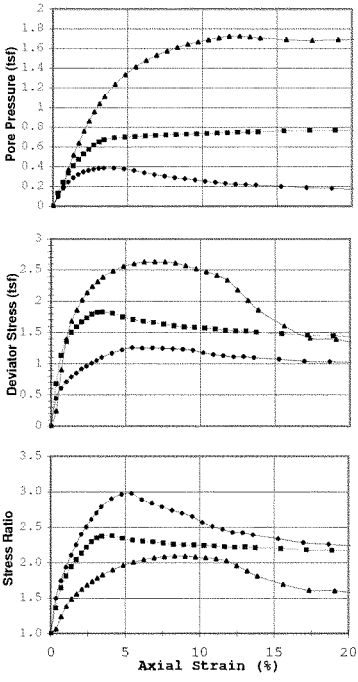
----------	Effective ϕ':	14.3 °	c'=	0.26 (tsf)
_____	Total ϕ':	8.8 °	c=	0.31 (tsf)

SOIL ENGINEERING TESTING, INC.
9301 Bryant Ave. South Suite #107 Bloomington, Minnesota 55420-3436

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-78MU Fargo Sample #: 2 Type: 5T Depth (ft): 25 - 27 (Top)
Soil Type: Fat Clay (CH) Brenna

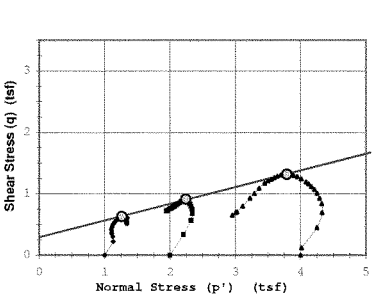


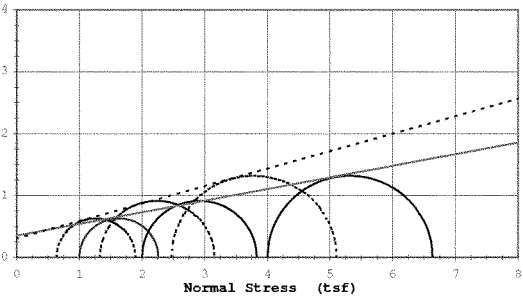
Failure Criterion:	Max. Deviator Stress
Angle of internal friction, ϕ' =	15.8 °
Apparent Cohesion, c' =	0.30 (tsf)
Test Date: 8/12/10	Liquid Limit: 63.8
Test Type: CU w/pp	Plastic Limit: 23.1
Strain Rate (in/min): 0.0039	Plasticity Index: 40.7
Strain Rate (%/min): 0.132	Spec. Gravity (Assumed): 2.76

Before Consolidation	A	B	C	D	E
Diameter (in)	1.45	1.45	1.45		
Height (in)	2.99	2.99	2.99		
Water Content (%)	41.2	42.8	44.4		
Dry Density (pcf)	78.9	77.4	76.0		
Void Ratio	1.18	1.23	1.27		
After Consolidation					
Diameter (in)	1.43	1.43	1.39		
Height (in)	2.95	2.91	2.88		
Water Content (%)	40.3	39.9	36.6		
Dry Density (pcf)	81.5	82.0	85.7		
Void Ratio	1.11	1.10	1.01		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	1.26	1.83	2.63		
Ultimate Deviator Stress (tsf)	1.02	1.44	1.30		
Deviator Stress at Failure (tsf)	1.26	1.83	2.63		
Max. Pore Pressure Buildup (tsf)	0.39	0.77	1.72		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	5.4	3.4	6.9		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





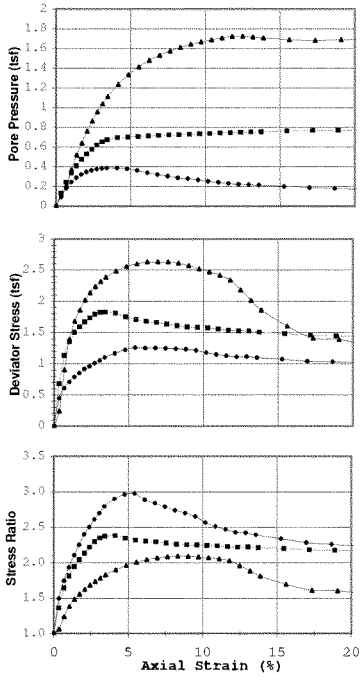
Rupture Envelope at Failure
α = 15.2 ° a = 0.3 (tsf)

---------- Effective ϕ': 15.8 ° c'= 0.30 (tsf)
_____ Total ϕ': 10.6 ° c= 0.35 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-78MU Fargo Sample #: 2 Type: 5T Depth (ft): 25 - 27 (Top)
Soil Type: Fat Clay (CH) Brenna

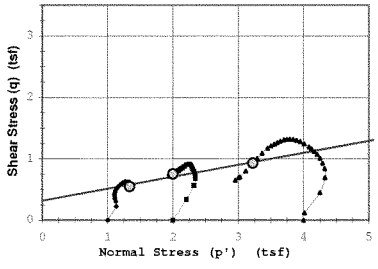


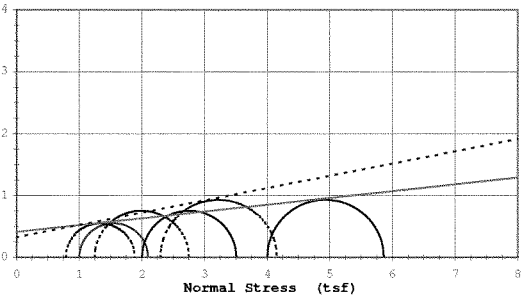
Failure Criterion:	Given Strain of: 15%
Angle of internal friction, ϕ' =	11.2 °
Apparent Cohesion, c' =	0.32 (tsf)
Test Date: 8/12/10	Liquid Limit: 63.8
Test Type: CU w/pp	Plastic Limit: 23.1
Strain Rate (in/min): 0.0039	Plasticity Index: 40.7
Strain Rate (%/min): 0.132	Spec. Gravity (Assumed): 2.76

Before Consolidation	A	B	C	D	E
Diameter (in)	1.45	1.45	1.45		
Height (in)	2.99	2.99	2.99		
Water Content (%)	41.2	42.8	44.4		
Dry Density (pcf)	78.9	77.4	76.0		
Void Ratio	1.18	1.23	1.27		
After Consolidation					
Diameter (in)	1.43	1.43	1.39		
Height (in)	2.95	2.91	2.88		
Water Content (%)	40.3	39.9	36.6		
Dry Density (pcf)	81.5	82.0	85.7		
Void Ratio	1.11	1.10	1.01		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	1.26	1.83	2.63		
Ultimate Deviator Stress (tsf)	1.02	1.44	1.30		
Deviator Stress at Failure (tsf)	1.10	1.51	1.86		
Max. Pore Pressure Buildup (tsf)	0.39	0.77	1.72		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	15.0	15.0	15.0		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen: Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





Rupture Envelope at Failure	
α = 11.0 °	a = 0.3 (tsf)

----------	Effective ϕ': 11.2 °	c'=	0.32 (tsf)
_____	Total ϕ': 6.3 °	c=	0.41 (tsf)

9301 Bryant Ave. South Suite #107
Bloomington, Minnesota 55420-3436

Job No.: 7577

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095 Test Type: CU w/pp

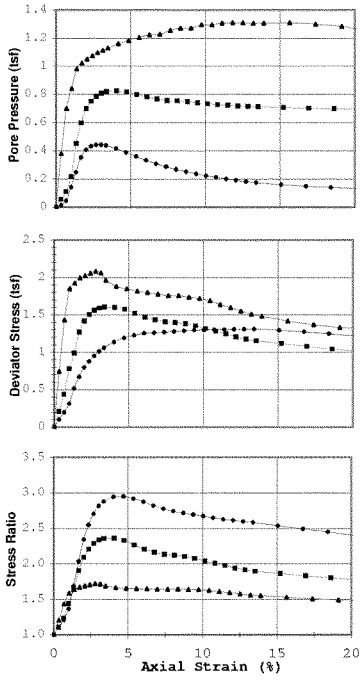
Boring No.: 10-78MU, Sample No.: 2, Depth (ft.): 25 - 27 (Top)

Sample 1			Sample 2			Sample 3		
Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.34	0.45	0.09	0.34	0.68	0.13	0.35	0.24	0.11
0.68	0.61	0.18	0.69	1.13	0.24	0.70	0.90	0.20
1.02	0.71	0.24	1.03	1.35	0.33	1.04	1.39	0.37
1.36	0.79	0.29	1.38	1.50	0.41	1.39	1.68	0.52
1.70	0.85	0.32	1.72	1.59	0.47	1.74	1.86	0.64
2.04	0.92	0.35	2.06	1.67	0.53	2.08	2.02	0.76
2.37	0.96	0.36	2.40	1.73	0.58	2.43	2.14	0.86
2.71	1.01	0.37	2.75	1.79	0.62	2.78	2.24	0.96
3.05	1.05	0.38	3.09	1.82	0.65	3.12	2.32	1.04
3.39	1.10	0.39	3.44	1.83	0.67	3.47	2.39	1.11
4.07	1.17	0.39	4.12	1.81	0.69	4.16	2.49	1.23
4.75	1.22	0.38	4.81	1.75	0.70	4.86	2.56	1.33
5.43	1.26	0.36	5.50	1.71	0.71	5.55	2.60	1.41
6.11	1.25	0.34	6.18	1.68	0.71	6.24	2.63	1.48
6.79	1.25	0.32	6.87	1.66	0.72	6.94	2.63	1.53
7.46	1.25	0.30	7.56	1.63	0.72	7.63	2.63	1.57
8.14	1.24	0.29	8.24	1.61	0.73	8.33	2.61	1.61
8.82	1.23	0.28	8.93	1.59	0.73	9.02	2.57	1.64
9.50	1.21	0.27	9.62	1.58	0.73	9.71	2.52	1.67
10.18	1.17	0.25	10.30	1.57	0.74	10.41	2.47	1.69
10.86	1.15	0.24	10.99	1.55	0.74	11.10	2.41	1.71
11.53	1.13	0.23	11.68	1.54	0.75	11.80	2.34	1.72
12.21	1.11	0.22	12.37	1.53	0.75	12.49	2.18	1.72
12.89	1.11	0.22	13.05	1.52	0.75	13.18	2.01	1.72
13.57	1.10	0.21	13.74	1.51	0.76	13.88	1.86	1.71
15.26	1.07	0.20	15.46	1.48	0.76	15.61	1.60	1.69
16.96	1.04	0.19	17.17	1.46	0.77	17.35	1.41	1.68
18.66	1.03	0.18	18.89	1.45	0.77	19.08	1.39	1.69
20.35	1.02	0.17	20.61	1.44	0.77	20.81	1.30	1.69

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 2 Type: 5T Depth (ft): 35 - 37 (Mid-Top)
Soil Type: Fat Clay w/Laminations of Silt (CH) Brenna

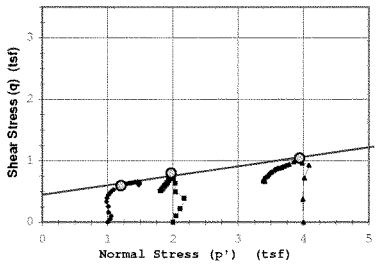


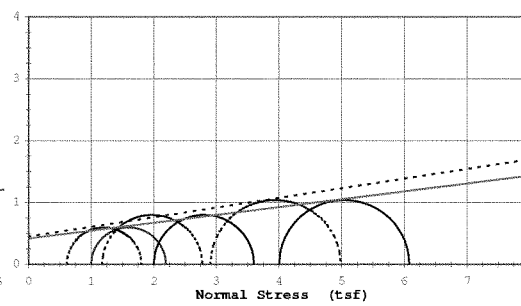
Failure Criterion:	Max. Stress Ratio		
Angle of internal friction, ϕ' =	8.9 °		
Apparent Cohesion, c' =	0.45 (tsf)		
Test Date:	8/13/10	Liquid Limit:	90.7
Test Type:	CU w/pp	Plastic Limit:	29.1
Strain Rate (in/min):	0.0039	Plasticity Index:	61.6
Strain Rate (%/min):	0.131	Spec. Gravity (Assumed):	2.78

Before Consolidation	A	B	C	D	E
Diameter (in)	1.45	1.45	1.45		
Height (in)	2.99	2.99	2.99		
Water Content (%)	39.3	43.1	47.2		
Dry Density (pcf)	80.7	76.9	73.5		
Void Ratio	1.15	1.26	1.36		
After Consolidation					
Diameter (in)	1.44	1.42	1.41		
Height (in)	2.99	2.95	2.88		
Water Content (%)	40.4	41.2	42.0		
Dry Density (pcf)	81.8	80.9	80.0		
Void Ratio	1.12	1.15	1.17		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	1.31	1.60	2.08		
Ultimate Deviator Stress (tsf)	1.22	1.01	1.32		
Deviator Stress at Failure (tsf)	1.19	1.60	2.08		
Max. Pore Pressure Buildup (tsf)	0.44	0.83	1.31		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	4.7	4.1	2.8		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





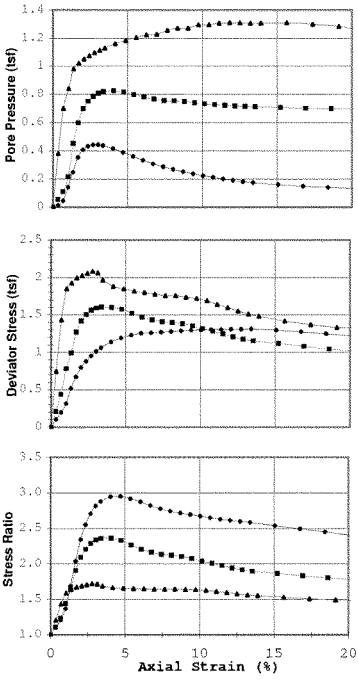
Rupture Envelope at Failure			
α = 8.8 °	a = 0.4 (tsf)		

----------	Effective ϕ': 8.9 °	c'=	0.45 (tsf)
_____	Total ϕ': 7.2 °	c=	0.42 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

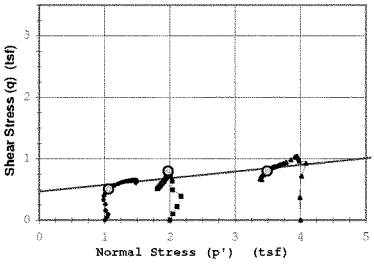
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 2 Type: 5T Depth (ft): 35 - 37 (Mid-Top)
Soil Type: Fat Clay w/Laminations of Silt (CH) Brenna

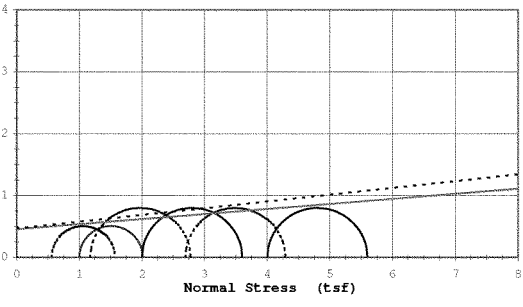


Failure Criterion:	Max. Pore Pressure				
Angle of internal friction, ϕ' =	6.2 °				
Apparent Cohesion, c' =	0.47 (tsf)				
Test Date: 8/13/10		Liquid Limit:	90.7		
Test Type: CU w/pp		Plastic Limit:	29.1		
Strain Rate (in/min): 0.0039		Plasticity Index:	61.6		
Strain Rate (%/min): 0.131		Spec. Gravity (Assumed):	2.78		
Before Consolidation	A	B	C	D	E
Diameter (in)	1.45	1.45	1.45		
Height (in)	2.99	2.99	2.99		
Water Content (%)	39.3	43.1	47.2		
Dry Density (pcf)	80.7	76.9	73.5		
Void Ratio	1.15	1.26	1.36		
After Consolidation					
Diameter (in)	1.44	1.42	1.41		
Height (in)	2.99	2.95	2.88		
Water Content (%)	40.4	41.2	42.0		
Dry Density (pcf)	81.8	80.9	80.0		
Void Ratio	1.12	1.15	1.17		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	1.31	1.60	2.08		
Ultimate Deviator Stress (tsf)	1.22	1.01	1.32		
Deviator Stress at Failure (tsf)	1.01	1.60	1.60		
Max. Pore Pressure Buildup (tsf)	0.44	0.83	1.31		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	3.0	4.1	11.8		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





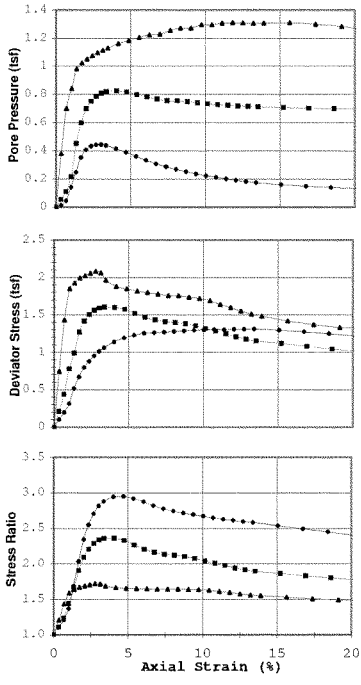
Rupture Envelope at Failure
α = 6.2 ° a = 0.5 (tsf)

---------- Effective ϕ': 6.2 ° c'= 0.47 (tsf)
_____ Total ϕ': 4.7 ° c= 0.46 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

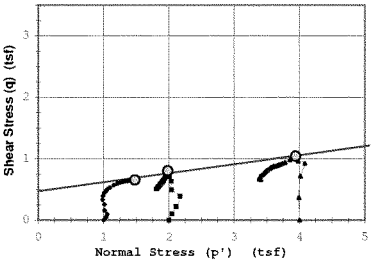
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 2 Type: 5T Depth (ft): 35 - 37 (Mid-Top)
Soil Type: Fat Clay w/Laminations of Silt (CH) Brenna

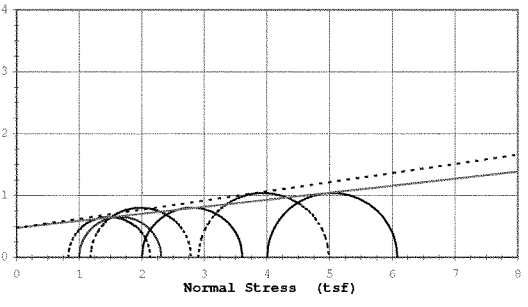


Failure Criterion:	Max. Deviator Stress				
Angle of internal friction, ϕ' =	8.4 °				
Apparent Cohesion, c' =	0.48 (tsf)				
Test Date: 8/13/10		Liquid Limit:	90.7		
Test Type: CU w/pp		Plastic Limit:	29.1		
Strain Rate (in/min): 0.0039		Plasticity Index:	61.6		
Strain Rate (%/min): 0.131		Spec. Gravity (Assumed):	2.78		
Before Consolidation	A	B	C	D	E
Diameter (in)	1.45	1.45	1.45		
Height (in)	2.99	2.99	2.99		
Water Content (%)	39.3	43.1	47.2		
Dry Density (pcf)	80.7	76.9	73.5		
Void Ratio	1.15	1.26	1.36		
After Consolidation					
Diameter (in)	1.44	1.42	1.41		
Height (in)	2.99	2.95	2.88		
Water Content (%)	40.4	41.2	42.0		
Dry Density (pcf)	81.8	80.9	80.0		
Void Ratio	1.12	1.15	1.17		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	1.31	1.60	2.08		
Ultimate Deviator Stress (tsf)	1.22	1.01	1.32		
Deviator Stress at Failure (tsf)	1.31	1.60	2.08		
Max. Pore Pressure Buildup (tsf)	0.44	0.83	1.31		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	13.4	3.4	2.8		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





Rupture Envelope at Failure			
α = 8.3 °	a = 0.5 (tsf)		

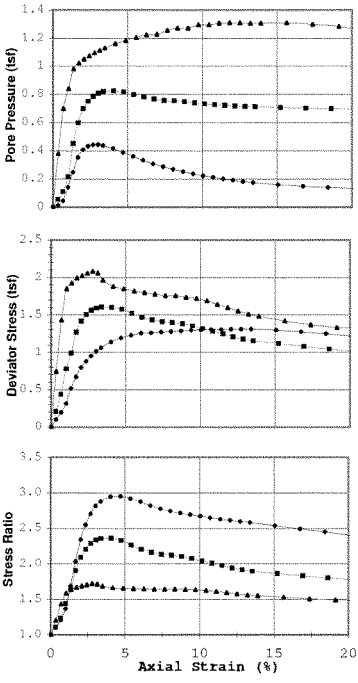
----------	Effective ϕ': 8.4 °	c'=	0.48 (tsf)
_____	Total ϕ': 6.5 °	c=	0.48 (tsf)

9301 Bryant Ave. South Suite #107
Bloomington, Minnesota 55420-3436
SOIL ENGINEERING TESTING, INC.

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 2 Type: 5T Depth (ft): 35 - 37 (Mid-Top)
Soil Type: Fat Clay w/Laminations of Silt (CH) Brenna

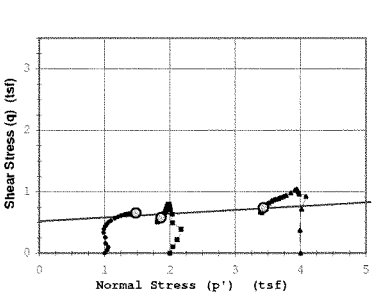


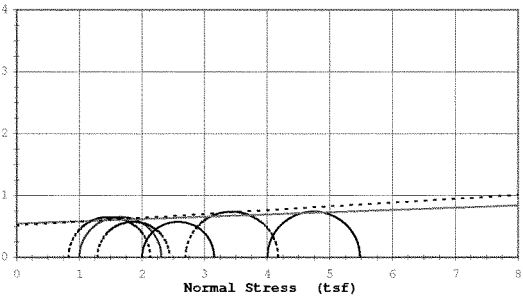
Failure Criterion:	Given Strain of: 15%
Angle of internal friction, ϕ' =	3.5 °
Apparent Cohesion, c' =	0.52 (tsf)
Test Date: 8/13/10	Liquid Limit: 90.7
Test Type: CU w/pp	Plastic Limit: 29.1
Strain Rate (in/min): 0.0039	Plasticity Index: 61.6
Strain Rate (%/min): 0.131	Spec. Gravity (Assumed): 2.78

Before Consolidation	A	B	C	D	E
Diameter (in)	1.45	1.45	1.45		
Height (in)	2.99	2.99	2.99		
Water Content (%)	39.3	43.1	47.2		
Dry Density (pcf)	80.7	76.9	73.5		
Void Ratio	1.15	1.26	1.36		
After Consolidation					
Diameter (in)	1.44	1.42	1.41		
Height (in)	2.99	2.95	2.88		
Water Content (%)	40.4	41.2	42.0		
Dry Density (pcf)	81.8	80.9	80.0		
Void Ratio	1.12	1.15	1.17		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	1.31	1.60	2.08		
Ultimate Deviator Stress (tsf)	1.22	1.01	1.32		
Deviator Stress at Failure (tsf)	1.31	1.15	1.48		
Max. Pore Pressure Buildup (tsf)	0.44	0.83	1.31		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	15.0	15.0	15.0		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.



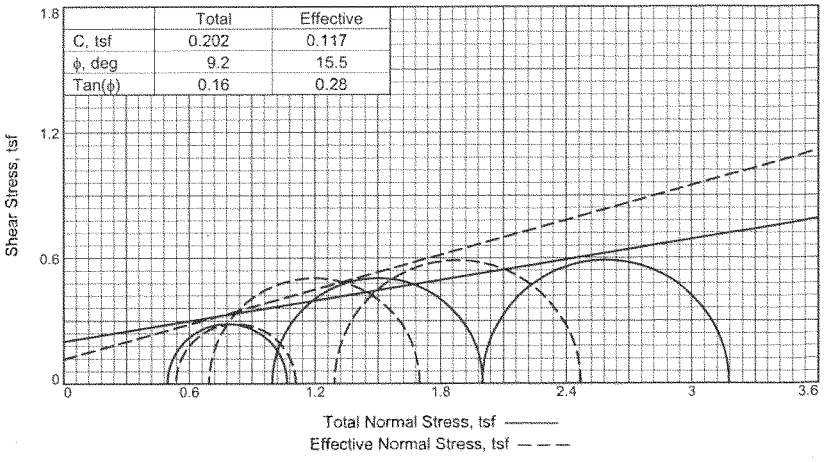


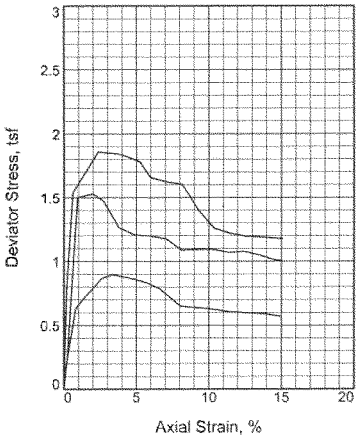
Rupture Envelope at Failure
α = 3.5 ° a = 0.5 (tsf)

---------- Effective ϕ': 3.5 ° c'= 0.52 (tsf)
_____ Total ϕ': 2.1 ° c= 0.55 (tsf)

Job No.: 7577
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095 Test Type: CU w/pp
Boring No.: 10-80MU, Sample No.: 2, Depth (ft.): 35 - 37 (Mid-Top)

Sample 1			Sample 2			Sample 3		
Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.34	0.10	0.01	0.34	0.21	0.06	0.35	0.74	0.38
0.67	0.20	0.05	0.68	0.44	0.11	0.70	1.43	0.70
1.01	0.31	0.14	1.02	0.78	0.22	1.04	1.85	0.84
1.34	0.52	0.25	1.35	0.99	0.45	1.39	1.92	0.98
1.67	0.67	0.35	1.69	1.27	0.60	1.74	1.99	1.02
2.01	0.80	0.41	2.03	1.42	0.70	2.09	2.02	1.05
2.34	0.88	0.43	2.37	1.50	0.75	2.43	2.05	1.08
2.68	0.95	0.44	2.71	1.56	0.79	2.78	2.08	1.10
3.01	1.01	0.44	3.05	1.59	0.81	3.13	2.06	1.11
3.35	1.06	0.44	3.39	1.60	0.82	3.48	1.96	1.13
4.02	1.14	0.41	4.06	1.60	0.83	4.17	1.88	1.16
4.69	1.19	0.39	4.74	1.58	0.82	4.87	1.85	1.18
5.36	1.23	0.36	5.42	1.52	0.80	5.56	1.82	1.20
6.03	1.25	0.33	6.09	1.47	0.78	6.26	1.80	1.22
6.69	1.26	0.31	6.77	1.43	0.77	6.96	1.78	1.23
7.36	1.27	0.29	7.45	1.41	0.76	7.65	1.76	1.25
8.03	1.27	0.27	8.13	1.40	0.75	8.35	1.76	1.27
8.70	1.29	0.25	8.80	1.38	0.75	9.04	1.74	1.27
9.37	1.29	0.24	9.48	1.35	0.74	9.74	1.72	1.29
10.04	1.30	0.22	10.16	1.32	0.73	10.43	1.69	1.29
10.71	1.30	0.21	10.83	1.28	0.73	11.13	1.64	1.31
11.38	1.30	0.20	11.51	1.25	0.72	11.82	1.60	1.31
12.05	1.31	0.19	12.19	1.21	0.72	12.52	1.55	1.31
12.72	1.31	0.18	12.87	1.18	0.71	13.21	1.51	1.30
13.39	1.31	0.17	13.54	1.15	0.71	13.91	1.48	1.31
15.06	1.29	0.16	15.24	1.12	0.71	15.65	1.42	1.31
16.74	1.27	0.15	16.93	1.08	0.70	17.39	1.37	1.30
18.41	1.25	0.14	18.62	1.04	0.70	19.13	1.33	1.28
20.08	1.22	0.13	20.31	1.01	0.70	20.86	1.32	1.25





Sample No.		1	2	3
Initial	Water Content, %	57.5	57.3	58.4
	Dry Density, pcf	66.2	66.4	65.5
	Saturation, %	100.0	100.0	99.8
	Void Ratio	1.5632	1.5578	1.5926
	Diameter, in.	1.40	1.41	1.41
	Height, in.	2.82	2.82	2.80
At Test	Water Content, %	57.5	56.8	57.8
	Dry Density, pcf	66.2	66.7	66.0
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.5632	1.5442	1.5732
	Diameter, in.	1.40	1.41	1.40
	Height, in.	2.82	2.81	2.79
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.49	1.00	2.00
Back Pressure, tsf		6.65	6.13	5.13
Cell Pressure, tsf		7.14	7.13	7.13
Peak Deviator Stress, tsf		0.89	1.53	1.86
Total Pore Pr., tsf		6.87	6.85	6.16
Ultimate Deviator Stress, tsf		0.57	1.01	1.18
Total Pore Pr., tsf		6.61	6.43	5.84
Maj. Eff. Stress at Ultimate, tsf		1.11	1.70	2.47
Min. Eff. Stress at Ultimate, tsf		0.54	0.69	1.29

Type of Test:
CU with Pore Pressures
Sample Type: 5" Thinwall, Middle of sample
Description: FAT CLAY, brown (CH)

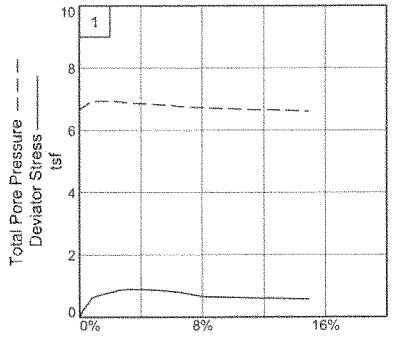
LL= 119 **PL=** 32 **PI=** 87
Specific Gravity= 2.720
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

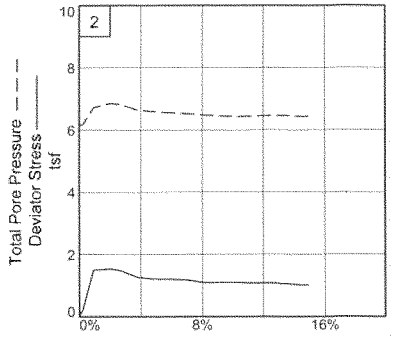
Client: W912ES-11-P-0024

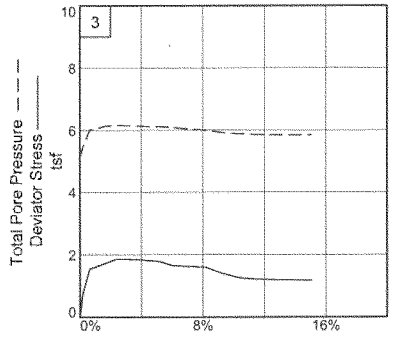
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Maple River, Brenna Formation
Sample Number: Boring10-105MU, #2 **Depth:** 25-27'
Proj. No.: BL-10-10065 **Date Sampled:**

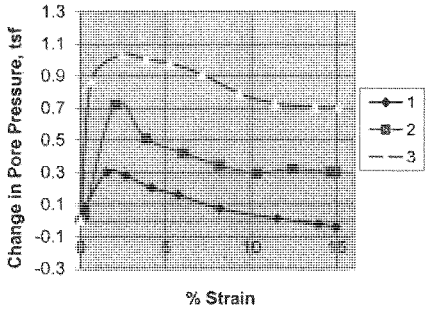
BRAUN INTERTEC
Geotechnical Design and Geology

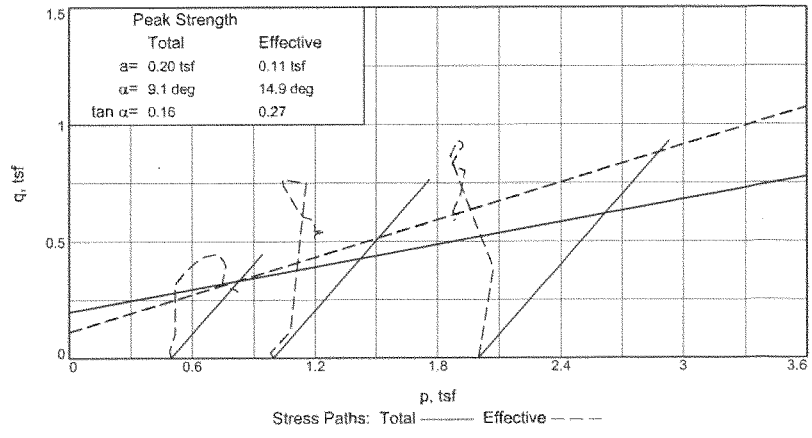
Figure C-3 Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement July 2011











Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Location: Maple River, Brenna Formation **Depth:** 25-27' **Sample Number:** Boring10-105MU, #2

TRIAXIAL COMPRESSION TEST 3/4/2011
CU with Pore Pressures 2:16 PM

Date:
Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project No.: BL-10-10065
Location: Maple River, Brenna Formation
Depth: 25-27' **Sample Number:** Boring10-105MU, #2
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.720 **LL=**119 **PL=**32 **PI=**87
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	113.990			149.530
Moisture content: Dry soil+tare, gms.	83.510			105.390
Moisture content: Tare, gms.	30.500			30.270
Moisture, %	57.5	57.5	57.5	58.8
Moist specimen weight, gms.	118.1			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.53	1.53	1.53	
Height, in.	2.82	2.82	2.82	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	104.3	104.3	104.3	
Dry density, pcf	66.2	66.2	66.2	
Void ratio	1.5632	1.5632	1.5632	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.142 tsf
Consolidation back pressure = 6.646 tsf
Consolidation effective confining stress = 0.496 tsf
Peak Stress = 0.894 tsf **at reading no.** 7
Ult. Stress = 0.572 tsf **at reading no.** 17

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	0.0085	18.730	0.0	0.0	0.000	0.496	0.496	1.00	6.646	0.496	0.000
1	0.0105	20.200	1.5	0.1	0.069	0.456	0.525	1.15	6.686	0.491	0.035
2	0.0137	23.100	4.4	0.2	0.205	0.414	0.619	1.50	6.728	0.517	0.103
3	0.0317	32.280	13.6	0.8	0.632	0.200	0.832	4.16	6.942	0.516	0.316
4	0.0495	34.330	15.6	1.5	0.723	0.195	0.918	4.71	6.947	0.557	0.362
5	0.0693	36.310	17.6	2.2	0.809	0.203	1.012	4.99	6.939	0.608	0.405
6	0.0823	37.680	18.9	2.6	0.868	0.219	1.087	4.96	6.923	0.653	0.434
7	0.1022	38.390	19.7	3.3	0.894	0.276	1.170	4.24	6.866	0.723	0.447
8	0.1241	38.250	19.5	4.1	0.881	0.293	1.174	4.01	6.849	0.733	0.440
9	0.1459	37.980	19.2	4.9	0.861	0.312	1.173	3.76	6.830	0.743	0.431
10	0.1690	37.530	18.8	5.7	0.834	0.337	1.171	3.47	6.805	0.754	0.417
11	0.1946	36.650	17.9	6.6	0.787	0.370	1.157	3.13	6.772	0.764	0.394
12	0.2365	33.760	15.0	8.1	0.650	0.421	1.071	2.54	6.721	0.746	0.325
13	0.2903	33.620	14.9	10.0	0.630	0.457	1.087	2.38	6.685	0.772	0.315
14	0.3324	33.230	14.5	11.5	0.604	0.485	1.089	2.24	6.657	0.787	0.302
15	0.3602	33.290	14.6	12.5	0.599	0.487	1.086	2.23	6.655	0.787	0.300
16	0.4010	33.290	14.6	13.9	0.590	0.518	1.108	2.14	6.624	0.813	0.295
17	0.4288	33.010	14.3	14.9	0.572	0.536	1.108	2.07	6.606	0.822	0.286

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	107.010			153.000
Moisture content: Dry soil+tare, gms.	79.280			108.090
Moisture content: Tare, gms.	30.860			30.590
Moisture, %	57.3	57.3	56.8	57.9
Moist specimen weight, gms.	121.3			
Diameter, in.	1.41	1.41	1.41	
Area, in.²	1.57	1.57	1.56	
Height, in.	2.82	2.82	2.81	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	104.4	104.4	104.6	
Dry density, pcf	66.4	66.4	66.7	
Void ratio	1.5578	1.5578	1.5442	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.128 tsf

Consolidation back pressure = 6.133 tsf

Consolidation effective confining stress = 0.995 tsf

Peak Stress = 1.530 tsf at reading no. 4

Ult. Stress = 1.007 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	0.0238	20.370	0.0	0.0	0.000	0.995	0.995	1.00	6.133	0.995	0.000
1	0.0246	21.420	1.1	0.0	0.048	0.959	1.007	1.05	6.169	0.983	0.024
2	0.0305	25.440	5.1	0.2	0.233	0.962	1.195	1.24	6.166	1.078	0.116
3	0.0502	53.300	32.9	0.9	1.501	0.406	1.907	4.70	6.722	1.157	0.751
4	0.0806	54.300	33.9	2.0	1.530	0.274	1.804	6.58	6.854	1.039	0.765
5	0.1000	53.300	32.9	2.7	1.474	0.309	1.783	5.77	6.819	1.046	0.737
6	0.1304	48.910	28.5	3.8	1.263	0.486	1.749	3.60	6.642	1.118	0.632
7	0.1619	47.930	27.6	4.9	1.206	0.545	1.751	3.21	6.583	1.148	0.603
8	0.1920	48.070	27.7	6.0	1.198	0.575	1.773	3.08	6.553	1.174	0.599
9	0.2225	47.850	27.5	7.1	1.175	0.607	1.782	2.94	6.521	1.195	0.588
10	0.2526	46.100	25.7	8.1	1.088	0.654	1.742	2.66	6.474	1.198	0.544
11	0.2832	46.540	26.2	9.2	1.093	0.676	1.769	2.62	6.452	1.223	0.547
12	0.3137	46.820	26.4	10.3	1.092	0.701	1.793	2.56	6.427	1.247	0.546
13	0.3440	46.600	26.2	11.4	1.070	0.685	1.755	2.56	6.443	1.220	0.535
14	0.3732	47.100	26.7	12.4	1.077	0.674	1.751	2.60	6.454	1.213	0.539
15	0.4037	46.750	26.4	13.5	1.050	0.672	1.722	2.56	6.456	1.197	0.525
16	0.4339	46.110	25.7	14.6	1.012	0.695	1.707	2.46	6.433	1.201	0.506
17	0.4441	46.100	25.7	14.9	1.007	0.693	1.700	2.45	6.435	1.197	0.504

Parameters for Specimen No. 3				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	107.250			149.350
Moisture content: Dry soil+tare, gms.	78.840			106.400
Moisture content: Tare, gms.	30.210			31.580
Moisture, %	58.4	58.6	57.8	57.4
Moist specimen weight, gms.	118.2			
Diameter, in.	1.41	1.40	1.40	
Area, in.^{2}	1.55	1.55	1.54	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	103.8	103.8	104.2	
Dry density, pcf	65.5	65.5	66.0	
Void ratio	1.5926	1.5926	1.5732	
Saturation, %	99.8	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.130 tsf

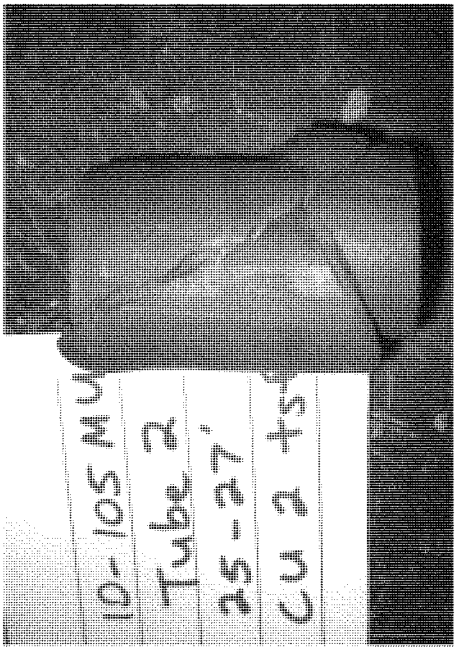
Consolidation back pressure = 5.131 tsf

Consolidation effective confining stress = 1.999 tsf

Peak Stress = 1.858 tsf **at reading no.** 4

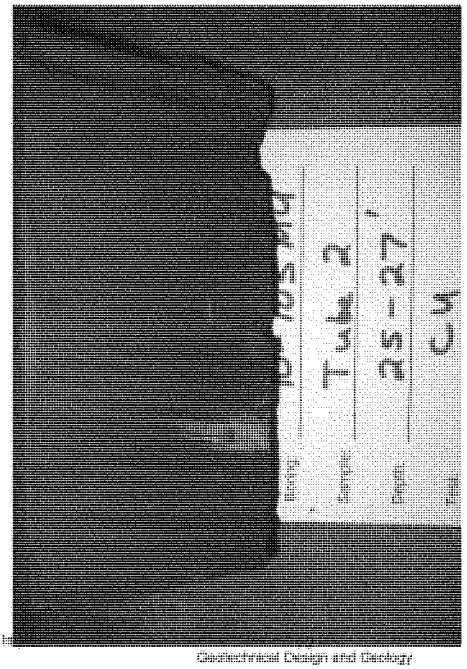
Ult. Stress = 1.178 tsf **at reading no.** 17

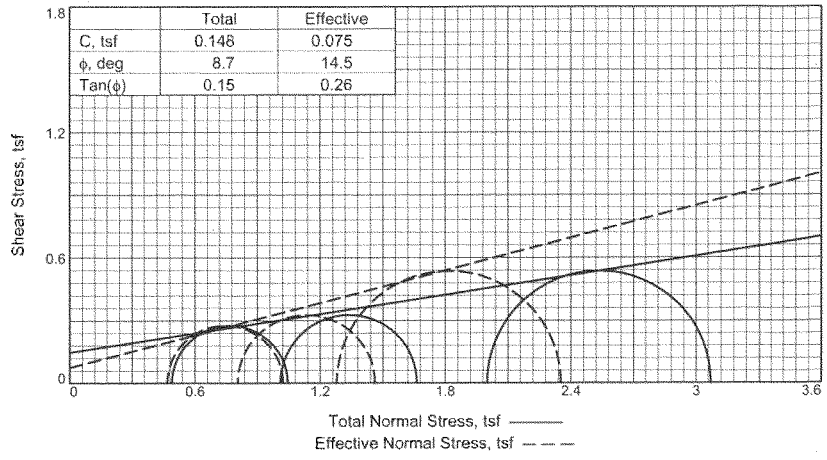
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0274	17.190	0.0	0.0	0.000	1.999	1.999	1.00	5.131	1.999	0.000
1	0.0325	33.790	16.6	0.2	0.773	1.684	2.457	1.46	5.446	2.071	0.387
2	0.0444	50.370	33.2	0.6	1.539	1.132	2.671	2.36	5.998	1.902	0.770
3	0.0737	54.880	37.7	1.7	1.730	0.997	2.727	2.74	6.133	1.862	0.865
4	0.0932	57.970	40.8	2.4	1.858	0.966	2.824	2.92	6.164	1.895	0.929
5	0.1137	58.090	40.9	3.1	1.850	0.986	2.836	2.88	6.144	1.911	0.925
6	0.1332	58.210	41.0	3.8	1.842	0.999	2.841	2.84	6.131	1.920	0.921
7	0.1538	57.880	40.7	4.5	1.813	1.017	2.830	2.78	6.113	1.924	0.907
8	0.1736	57.420	40.2	5.2	1.779	1.019	2.798	2.75	6.111	1.909	0.890
9	0.1940	54.940	37.8	6.0	1.657	1.040	2.697	2.59	6.090	1.868	0.828
10	0.2242	54.640	37.5	7.1	1.625	1.091	2.716	2.49	6.039	1.903	0.812
11	0.2556	54.560	37.4	8.2	1.602	1.132	2.734	2.41	5.998	1.933	0.801
12	0.2862	50.360	33.2	9.3	1.405	1.209	2.614	2.16	5.921	1.911	0.702
13	0.3168	47.260	30.1	10.4	1.258	1.245	2.503	2.01	5.885	1.874	0.629
14	0.3469	46.710	29.5	11.4	1.220	1.272	2.492	1.96	5.858	1.882	0.610
15	0.3783	46.490	29.3	12.6	1.196	1.284	2.480	1.93	5.846	1.882	0.598
16	0.4106	46.710	29.5	13.7	1.189	1.291	2.480	1.92	5.839	1.885	0.594
17	0.4481	46.900	29.7	15.1	1.178	1.291	2.469	1.91	5.839	1.880	0.589

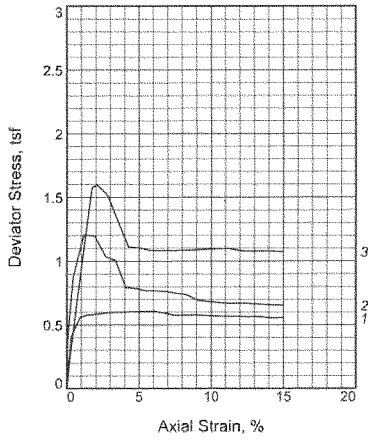

10-105 MW
Tube 2
25-27'
Cu 2 tsf

10-105MW
Tube 2
25-27'
Cu 1 tsf

10-105 MW
Tube 2
25-27'
Cu 0.5 tsf


Tube 2
25-27'
Cu





Sample No.		1	2	3
Initial	Water Content, %	61.5	61.1	61.2
	Dry Density, pcf	63.9	64.2	63.9
	Saturation, %	100.0	100.0	99.4
	Void Ratio	1.6987	1.6893	1.7000
	Diameter, in.	1.39	1.39	1.40
	Height, in.	2.80	2.80	2.80
At Test	Water Content, %	61.5	61.1	61.5
	Dry Density, pcf	63.9	64.2	63.9
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.6987	1.6893	1.7000
	Diameter, in.	1.39	1.39	1.40
	Height, in.	2.80	2.80	2.80
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.49	1.01	2.00
Back Pressure, tsf		6.64	6.12	5.13
Cell Pressure, tsf		7.13	7.13	7.13
Peak Deviator Stress, tsf		0.61	1.21	1.60
	Total Pore Pr., tsf	6.76	6.67	6.01
Ultimate Deviator Stress, tsf		0.55	0.65	1.07
	Total Pore Pr., tsf	6.66	6.33	5.85
Maj. Eff. Stress at Ultimate, tsf		1.02	1.46	2.35
Min. Eff. Stress at Ultimate, tsf		0.47	0.81	1.28

Type of Test:
CU with Pore Pressures

Sample Type: 5" Thinwall, Middle of sample

Description: FAT CLAY, brown (CH)

LL= 106 **PL=** 29 **PI=** 77

Specific Gravity= 2.764

Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

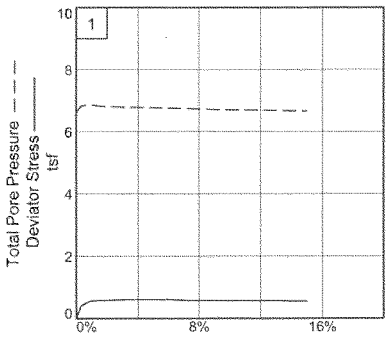
Location: Maple River, Brenna Formation

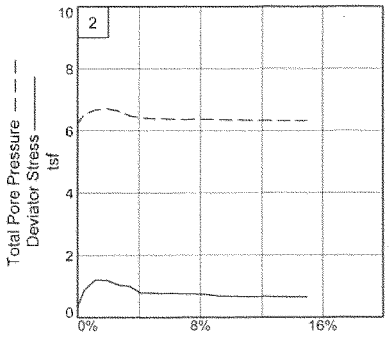
Sample Number: Boring10-105MU, #3 **Depth:** 35-37'

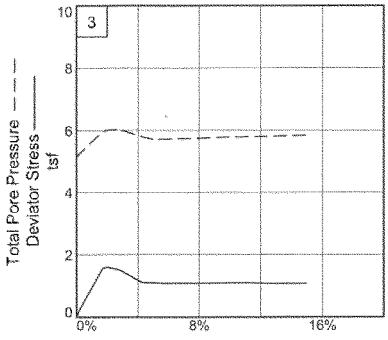
Proj. No.: BL-10-10065 **Date Sampled:**

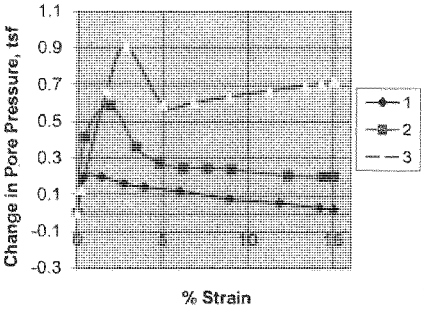
BRAUN INTERTEC

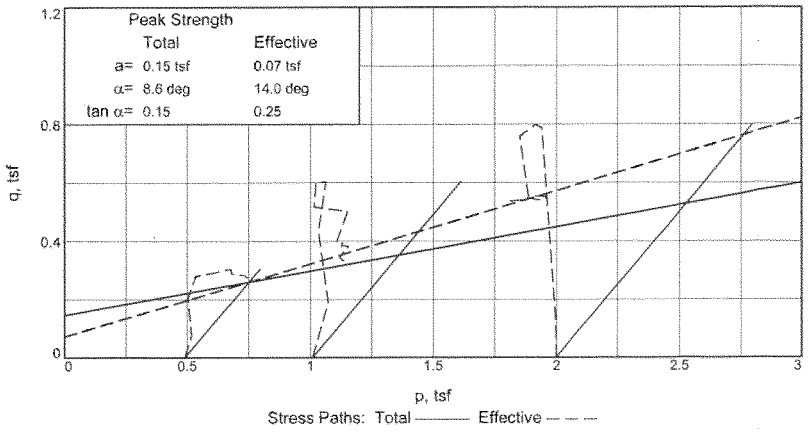
Figure C-3-Max-A-SS-MU-1-75











Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Location: Maple River, Brenna Formation **Depth:** 35-37' **Sample Number:** Boring10-105MU, #3

Project No.: [illegible] **Figure**

Braun Intertec

Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

3/4/2011
2:22 PM

Date:
Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project No.: BL-10-10065
Location: Maple River, Brenna Formation
Depth: 35-37' **Sample Number:** Boring10-105MU, #3
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.764 **LL=**106 **PL=**29 **PI=**77
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	105.580			147.960
Moisture content: Dry soil+tare, gms.	76.750			102.970
Moisture content: Tare, gms.	29.840			31.280
Moisture, %	61.5	61.5	61.5	62.8
Moist specimen weight, gms.	115.5			
Diameter, in.	1.39	1.39	1.39	
Area, in.^{2}	1.52	1.52	1.52	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	103.2	103.2	103.2	
Dry density, pcf	63.9	63.9	63.9	
Void ratio	1.6987	1.6987	1.6987	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.131 tsf
Consolidation back pressure = 6.641 tsf
Consolidation effective confining stress = 0.490 tsf
Peak Stress = 0.609 tsf **at reading no.** 10
Ult. Stress = 0.554 tsf **at reading no.** 17

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	0.0067	18.690	0.0	0.0	0.000	0.490	0.490	1.00	6.641	0.490	0.000
1	0.0096	21.840	3.1	0.1	0.149	0.443	0.592	1.34	6.688	0.517	0.074
2	0.0158	27.430	8.7	0.3	0.412	0.298	0.710	2.38	6.833	0.504	0.206
3	0.0325	30.630	11.9	0.9	0.560	0.254	0.814	3.20	6.877	0.534	0.280
4	0.0445	31.020	12.3	1.4	0.575	0.293	0.868	2.96	6.838	0.581	0.288
5	0.0634	31.290	12.6	2.0	0.584	0.322	0.906	2.81	6.809	0.614	0.292
6	0.0833	31.580	12.9	2.7	0.593	0.331	0.924	2.79	6.800	0.628	0.297
7	0.0963	31.760	13.1	3.2	0.599	0.342	0.941	2.75	6.789	0.641	0.299
8	0.1162	31.910	13.2	3.9	0.601	0.348	0.949	2.73	6.783	0.648	0.300
9	0.1380	32.090	13.4	4.7	0.604	0.355	0.959	2.70	6.776	0.657	0.302
10	0.1758	32.400	13.7	6.0	0.609	0.371	0.980	2.64	6.760	0.676	0.305
11	0.2157	31.850	13.2	7.5	0.576	0.391	0.967	2.47	6.740	0.679	0.288
12	0.2563	32.090	13.4	8.9	0.577	0.413	0.990	2.40	6.718	0.702	0.289
13	0.2963	32.100	13.4	10.3	0.569	0.426	0.995	2.34	6.705	0.710	0.284
14	0.3373	32.300	13.6	11.8	0.568	0.436	1.004	2.30	6.695	0.720	0.284
15	0.3780	32.500	13.8	13.3	0.567	0.451	1.018	2.26	6.680	0.734	0.283
16	0.4052	32.370	13.7	14.2	0.555	0.460	1.015	2.21	6.671	0.738	0.278
17	0.4269	32.470	13.8	15.0	0.554	0.468	1.022	2.18	6.663	0.745	0.277

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	122.390			146.280
Moisture content: Dry soil+tare, gms.	87.730			102.020
Moisture content: Tare, gms.	31.040			30.210
Moisture, %	61.1	61.1	61.1	61.6
Moist specimen weight, gms.	115.3			
Diameter, in.	1.39	1.39	1.39	
Area, in.^{2}	1.52	1.52	1.52	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	103.4	103.4	103.4	
Dry density, pcf	64.2	64.2	64.2	
Void ratio	1.6893	1.6893	1.6893	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.132 tsf
Consolidation back pressure = 6.123 tsf
Consolidation effective confining stress = 1.009 tsf
Peak Stress = 1.208 tsf **at reading no.** 3
Ult. Stress = 0.654 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	0.0238	18.000	0.0	0.0	0.000	1.009	1.009	1.00	6.123	1.009	0.000
1	0.0248	25.990	8.0	0.0	0.380	0.883	1.263	1.43	6.249	1.073	0.190
2	0.0361	36.410	18.4	0.4	0.871	0.597	1.468	2.46	6.535	1.032	0.435
3	0.0571	43.720	25.7	1.2	1.208	0.459	1.667	3.63	6.673	1.063	0.604
4	0.0775	43.690	25.7	1.9	1.197	0.424	1.621	3.82	6.708	1.023	0.599
5	0.0989	40.400	22.4	2.7	1.036	0.497	1.533	3.08	6.635	1.015	0.518
6	0.1186	39.890	21.9	3.4	1.005	0.649	1.654	2.55	6.483	1.151	0.502
7	0.1382	35.400	17.4	4.1	0.793	0.709	1.502	2.12	6.423	1.106	0.397
8	0.1579	35.400	17.4	4.8	0.787	0.738	1.525	2.07	6.394	1.132	0.394
9	0.1773	35.110	17.1	5.5	0.768	0.742	1.510	2.04	6.390	1.126	0.384
10	0.1980	35.250	17.3	6.2	0.769	0.763	1.532	2.01	6.369	1.147	0.384
11	0.2174	35.210	17.2	6.9	0.761	0.774	1.535	1.98	6.358	1.155	0.381
12	0.2371	35.060	17.1	7.6	0.749	0.766	1.515	1.98	6.366	1.140	0.374
13	0.2576	34.910	16.9	8.3	0.736	0.772	1.508	1.95	6.360	1.140	0.368
14	0.2773	34.050	16.0	9.0	0.694	0.772	1.466	1.90	6.360	1.119	0.347
15	0.3372	33.850	15.9	11.2	0.669	0.796	1.465	1.84	6.336	1.130	0.334
16	0.3677	34.110	16.1	12.3	0.672	0.805	1.477	1.83	6.327	1.141	0.336
17	0.3968	34.080	16.1	13.3	0.662	0.810	1.472	1.82	6.322	1.141	0.331
18	0.4272	34.150	16.1	14.4	0.657	0.809	1.466	1.81	6.323	1.137	0.328
19	0.4449	34.200	16.2	15.0	0.654	0.807	1.461	1.81	6.325	1.134	0.327

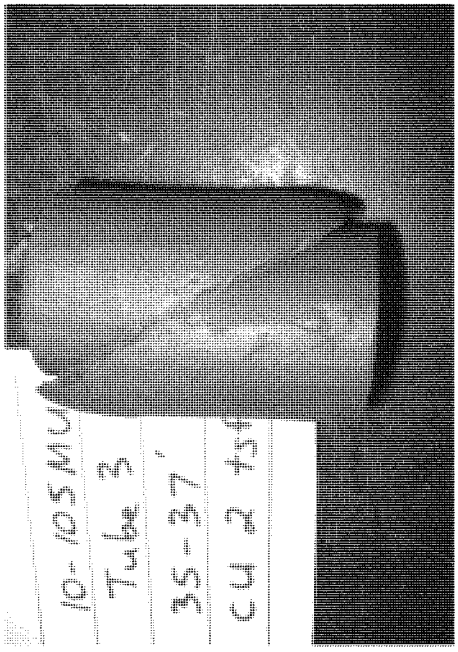
Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	111.410			145.980
Moisture content: Dry soil+tare, gms.	80.520			103.150
Moisture content: Tare, gms.	30.010			30.440
Moisture, %	61.2	61.5	61.5	58.9
Moist specimen weight, gms.	117.1			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.55	1.55	1.55	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	103.0	103.2	103.2	
Dry density, pcf	63.9	63.9	63.9	
Void ratio	1.7000	1.7000	1.7000	
Saturation, %	99.4	100.0	100.0	

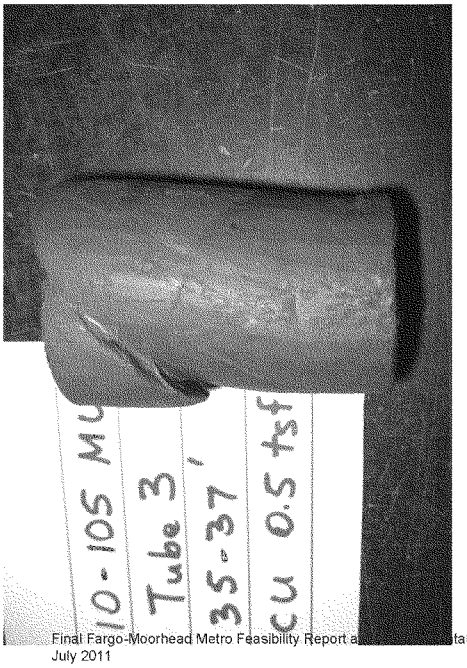
Test Readings for Specimen No. 3

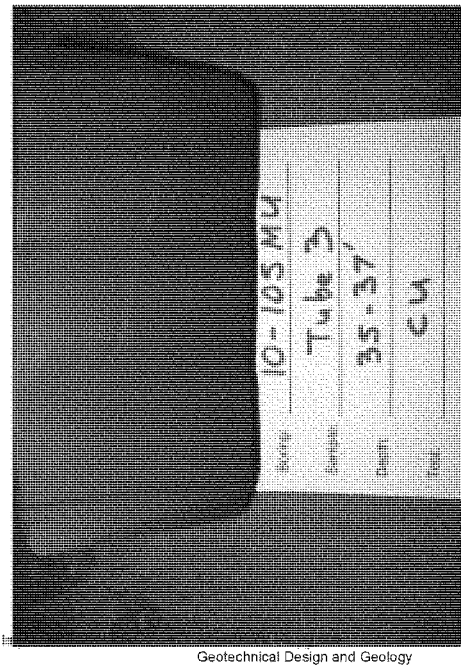
Consolidation cell pressure = 7.127 tsf
Consolidation back pressure = 5.128 tsf
Consolidation effective confining stress = 1.999 tsf
Peak Stress = 1.596 tsf **at reading no.** 3
Ult. Stress = 1.074 tsf **at reading no.** 16

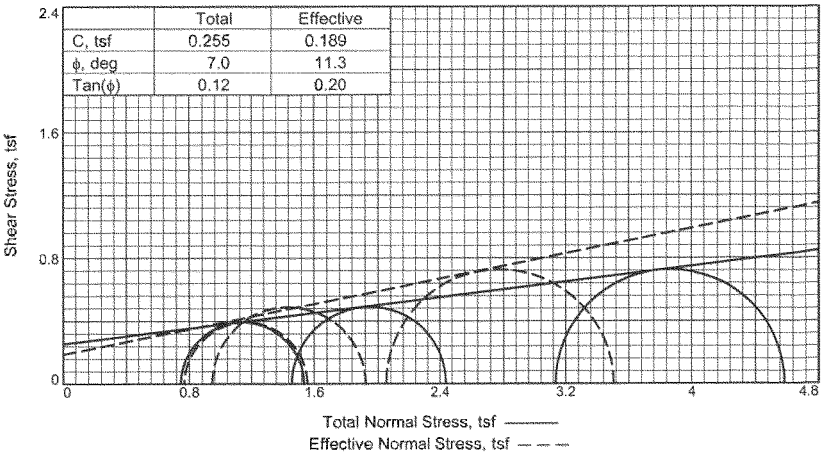
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0274	18.500	0.0	0.0	0.000	1.999	1.999	1.00	5.128	1.999	0.000
1	0.0334	23.860	5.4	0.2	0.249	1.872	2.121	1.13	5.255	1.997	0.125
2	0.0757	52.900	34.4	1.7	1.574	1.155	2.729	2.36	5.972	1.942	0.787
3	0.0854	53.500	35.0	2.1	1.596	1.118	2.714	2.43	6.009	1.916	0.798
4	0.1059	52.000	33.5	2.8	1.516	1.095	2.611	2.38	6.032	1.853	0.758
5	0.1469	43.400	24.9	4.3	1.110	1.332	2.442	1.83	5.795	1.887	0.555
6	0.1667	43.480	25.0	5.0	1.106	1.407	2.513	1.79	5.720	1.960	0.553
7	0.1877	43.210	24.7	5.7	1.085	1.410	2.495	1.77	5.717	1.952	0.542
8	0.2183	43.460	25.0	6.8	1.083	1.395	2.478	1.78	5.732	1.937	0.542
9	0.2478	43.750	25.3	7.9	1.083	1.381	2.464	1.78	5.746	1.923	0.542
10	0.2781	44.150	25.6	8.9	1.088	1.363	2.451	1.80	5.764	1.907	0.544
11	0.3085	44.630	26.1	10.0	1.095	1.341	2.436	1.82	5.786	1.888	0.547
12	0.3400	45.060	26.6	11.2	1.099	1.332	2.431	1.83	5.795	1.881	0.549
13	0.3694	44.890	26.4	12.2	1.079	1.317	2.396	1.82	5.810	1.857	0.540
14	0.3990	45.190	26.7	13.3	1.078	1.304	2.382	1.83	5.823	1.843	0.539
15	0.4292	45.510	27.0	14.3	1.078	1.290	2.368	1.84	5.837	1.829	0.539
16	0.4468	45.610	27.1	15.0	1.074	1.279	2.353	1.84	5.848	1.816	0.537


10-105 MH
Tube 3
35-37'
CU 2 tsf

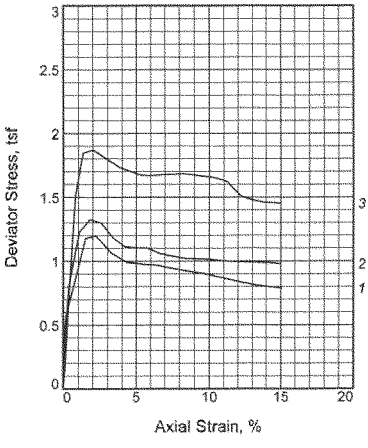
10-105 MH
Tube 3
35-37'
CU 1 tsf


10-105 MH
Tube 3
35-37'
CU 0.5 tsf


10-105 MH
Tube 3
35-37'
CU



	Total	Effective
C, tsf	0.255	0.189
ϕ, deg	7.0	11.3
Tan(ϕ)	0.12	0.20



Sample No.		1	2	3
Initial	Water Content, %	40.5	43.0	46.1
	Dry Density, pcf	81.1	77.3	74.9
	Saturation, %	100.0	97.3	98.2
	Void Ratio	1.1095	1.2125	1.2860
	Diameter, in.	1.39	1.40	1.38
	Height, in.	2.81	2.80	2.80
At Test	Water Content, %	40.5	44.2	46.0
	Dry Density, pcf	81.1	77.3	75.7
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.1095	1.2125	1.2616
	Diameter, in.	1.39	1.40	1.38
	Height, in.	2.81	2.80	2.79
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.75	1.46	3.14
Back Pressure, tsf		6.38	5.63	3.99
Cell Pressure, tsf		7.13	7.09	7.13
Peak Deviator Stress, tsf		1.20	1.33	1.87
Total Pore Pr., tsf		6.92	6.49	5.31
Ultimate Deviator Stress, tsf		0.79	0.98	1.45
Total Pore Pr., tsf		6.36	6.15	5.08
Maj. Eff. Stress at Ultimate, tsf		1.56	1.92	3.50
Min. Eff. Stress at Ultimate, tsf		0.77	0.94	2.05

Type of Test:
CU with Pore Pressures

Sample Type: 5" Thinwall, Middle of sample

Description: FAT CLAY, brown (CH)

LL= 71 **PL=** 19 **PI=** 52

Specific Gravity= 2.741

Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Figure CU Triaxial Test Data

Client: USACE W912ES-11-P-0024

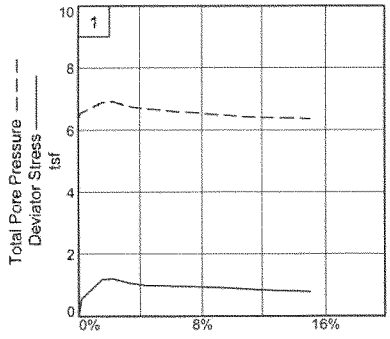
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3

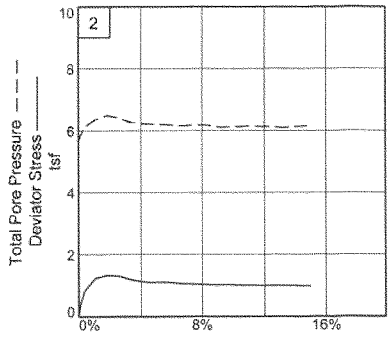
Location: ND RRCS, MN, Brenna Formation

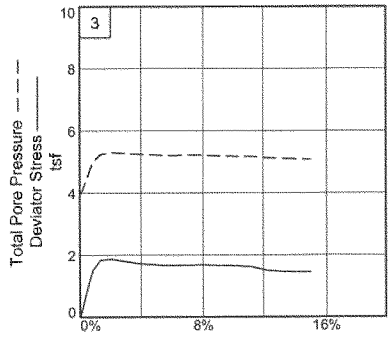
Sample Number: Boring11-107MU, #1 **Depth:** 20-22'

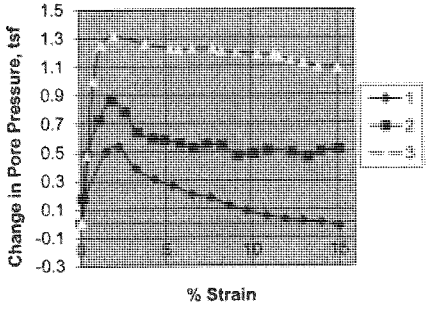
Proj. No.: BL-10-10065 **Date Sampled:**

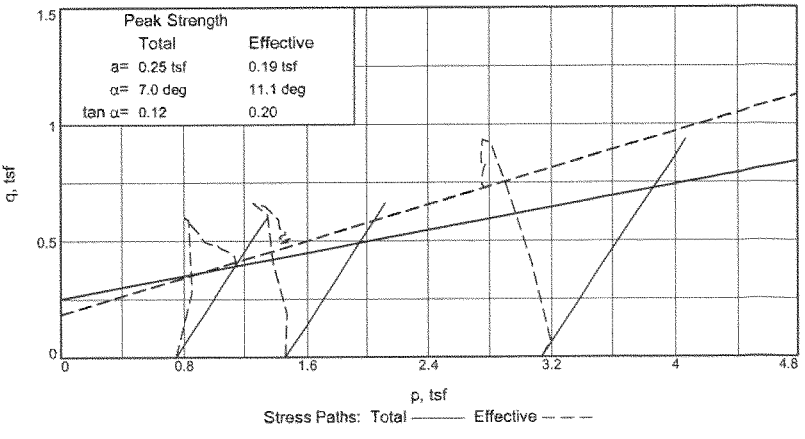
BRAUN INTERTEC











Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: ND RRCS, MN, Brenna Formation **Depth:** 20-22' **Sample No.:** Boring11-107MU, #1
Project No.: Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011

Figure

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST 5/30/2011
CU with Pore Pressures 12:19 PM

Date:
Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Project No.: BL-10-10065
Location: ND RRCS, MN, Brenna Formation
Depth: 20-22' **Sample Number:** Boring11-107MU, #1
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.741 **LL=**71 **PL=**19 **PI=**52
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	161.620			158.820
Moisture content: Dry soil+tare, gms.	123.870			121.320
Moisture content: Tare, gms.	30.570			30.570
Moisture, %	40.5	40.5	40.5	41.3
Moist specimen weight, gms.	127.3			
Diameter, in.	1.39	1.39	1.39	
Area, in.²	1.52	1.52	1.52	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	113.9	113.9	113.9	
Dry density, pcf	81.1	81.1	81.1	
Void ratio	1.1095	1.1095	1.1095	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.129 tsf
Consolidation back pressure = 6.382 tsf
Consolidation effective confining stress = 0.747 tsf
Peak Stress = 1.200 tsf **at reading no.** 3
Ult. Stress = 0.788 tsf **at reading no.** 15

Test Reading 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	0.0327	19.870	0.0	0.0	0.000	0.747	0.747	1.00	6.382	0.747	0.000
1	0.0375	31.710	11.8	0.2	0.561	0.573	1.134	1.98	6.556	0.853	0.280
2	0.0748	45.070	25.2	1.5	1.178	0.243	1.421	5.85	6.886	0.832	0.589
3	0.0944	45.720	25.8	2.2	1.200	0.207	1.407	6.79	6.922	0.807	0.600
4	0.1235	43.070	23.2	3.2	1.065	0.364	1.429	3.93	6.765	0.897	0.533
5	0.1539	41.700	21.8	4.3	0.991	0.438	1.429	3.26	6.691	0.934	0.496
6	0.1843	41.610	21.7	5.4	0.976	0.483	1.459	3.02	6.646	0.971	0.488
7	0.2156	41.640	21.8	6.5	0.966	0.543	1.509	2.78	6.586	1.026	0.483
8	0.2461	41.360	21.5	7.6	0.942	0.568	1.510	2.66	6.561	1.039	0.471
9	0.2755	41.080	21.2	8.7	0.919	0.623	1.542	2.48	6.506	1.083	0.460
10	0.3060	40.890	21.0	9.7	0.900	0.660	1.560	2.36	6.469	1.110	0.450
11	0.3360	40.480	20.6	10.8	0.872	0.698	1.570	2.25	6.431	1.134	0.436
12	0.3667	40.030	20.2	11.9	0.843	0.719	1.562	2.17	6.410	1.140	0.421
13	0.3959	39.670	19.8	12.9	0.818	0.731	1.549	2.12	6.398	1.140	0.409
14	0.4264	39.550	19.7	14.0	0.803	0.743	1.546	2.08	6.386	1.144	0.401
15	0.4548	39.420	19.6	15.0	0.788	0.769	1.557	2.02	6.360	1.163	0.394

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	132.150			155.490
Moisture content: Dry soil+tare, gms.	101.480			116.780
Moisture content: Tare, gms.	30.210			30.550
Moisture, %	43.0	44.2	44.2	44.9
Moist specimen weight, gms.	124.8			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.53	1.53	1.53	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	110.6	111.6	111.6	
Dry density, pcf	77.3	77.3	77.3	
Void ratio	1.2125	1.2125	1.2125	
Saturation, %	97.3	100.0	100.0	

Consolidation cell pressure = 7.091 tsf
Consolidation back pressure = 5.632 tsf
Consolidation effective confining stress = 1.459 tsf
Peak Stress = 1.325 tsf **at reading no.** 4
Ult. Stress = 0.980 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	0.0101	18.490	0.0	0.0	0.000	1.459	1.459	1.00	5.632	1.459	0.000
1	0.0131	26.450	8.0	0.1	0.374	1.284	1.658	1.29	5.807	1.471	0.187
2	0.0210	35.880	17.4	0.4	0.814	0.974	1.788	1.84	6.117	1.381	0.407
3	0.0404	44.890	26.4	1.1	1.227	0.734	1.961	2.67	6.357	1.347	0.613
4	0.0609	47.220	28.7	1.8	1.325	0.597	1.922	3.22	6.494	1.260	0.663
5	0.0819	46.900	28.4	2.6	1.300	0.682	1.982	2.91	6.409	1.332	0.650
6	0.1040	44.610	26.1	3.3	1.186	0.823	2.009	2.44	6.268	1.416	0.593
7	0.1266	43.270	24.8	4.2	1.116	0.865	1.981	2.29	6.226	1.423	0.558
8	0.1485	43.210	24.7	4.9	1.104	0.877	1.981	2.26	6.214	1.429	0.552
9	0.1714	43.390	24.9	5.8	1.102	0.900	2.002	2.22	6.191	1.451	0.551
10	0.1954	42.660	24.2	6.6	1.060	0.932	1.992	2.14	6.159	1.462	0.530
11	0.2183	42.430	23.9	7.4	1.041	0.906	1.947	2.15	6.185	1.427	0.521
12	0.2432	42.200	23.7	8.3	1.021	0.912	1.933	2.12	6.179	1.423	0.511
13	0.2672	42.350	23.9	9.2	1.018	0.983	2.001	2.04	6.108	1.492	0.509
14	0.2921	42.500	24.0	10.1	1.014	0.969	1.983	2.05	6.122	1.476	0.507
15	0.3160	42.400	23.9	10.9	1.001	0.948	1.949	2.06	6.143	1.448	0.500
16	0.3553	42.580	24.1	12.3	0.992	0.962	1.954	2.03	6.129	1.458	0.496
17	0.3798	42.800	24.3	13.2	0.991	0.998	1.989	1.99	6.093	1.494	0.496
18	0.4037	42.950	24.5	14.0	0.988	0.953	1.941	2.04	6.138	1.447	0.494
19	0.4307	43.040	24.6	15.0	0.980	0.943	1.923	2.04	6.148	1.433	0.490

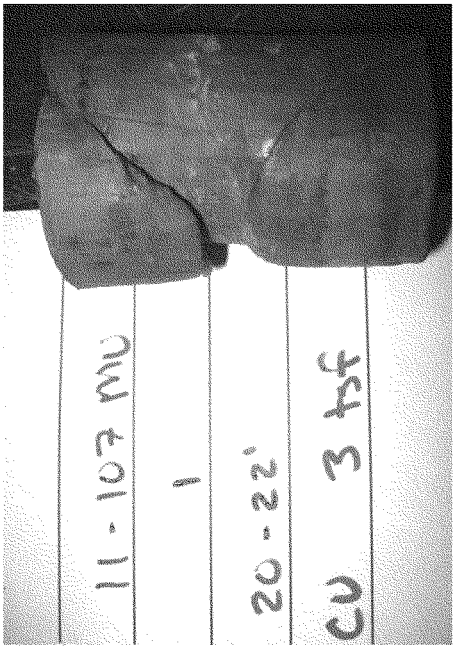
Parameters for Specimen No. 1

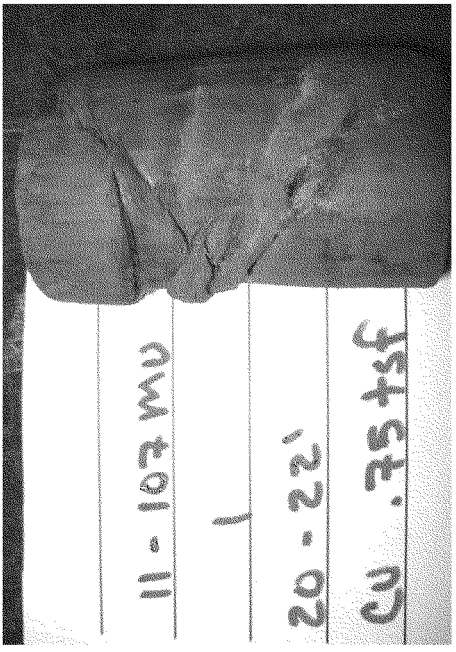
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	150.620			149.270
Moisture content: Dry soil+tare, gms.	112.810			112.160
Moisture content: Tare, gms.	30.750			30.270
Moisture, %	46.1	46.9	46.0	45.3
Moist specimen weight, gms.	120.4			
Diameter, in.	1.38	1.38	1.38	
Area, in.²	1.50	1.50	1.49	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	109.3	110.0	110.5	
Dry density, pcf	74.9	74.9	75.7	
Void ratio	1.2860	1.2860	1.2616	
Saturation, %	98.2	100.0	100.0	

Test Results for Specimen No. 1

Consolidation cell pressure = 7.126 tsf
Consolidation back pressure = 3.990 tsf
Consolidation effective confining stress = 3.136 tsf
Peak Stress = 1.869 tsf **at reading no.** 5
Ult. Stress = 1.452 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	0.0370	17.500	0.0	0.0	0.000	3.136	3.136	1.00	3.990	3.136	0.000
1	0.0400	20.400	2.9	0.1	0.140	3.124	3.264	1.04	4.002	3.194	0.070
2	0.0490	34.600	17.1	0.4	0.824	2.658	3.482	1.31	4.468	3.070	0.412
3	0.0600	49.100	31.6	0.8	1.517	2.139	3.656	1.71	4.987	2.898	0.759
4	0.0740	56.100	38.6	1.3	1.844	1.887	3.731	1.98	5.239	2.809	0.922
5	0.0930	56.900	39.4	2.0	1.869	1.820	3.689	2.03	5.306	2.755	0.935
6	0.1440	54.700	37.2	3.8	1.732	1.878	3.610	1.92	5.248	2.744	0.866
7	0.1860	54.000	36.5	5.3	1.673	1.910	3.583	1.88	5.216	2.746	0.836
8	0.1990	54.100	36.6	5.8	1.669	1.915	3.584	1.87	5.211	2.750	0.835
9	0.2200	54.500	37.0	6.6	1.674	1.910	3.584	1.88	5.216	2.747	0.837
10	0.2550	55.200	37.7	7.8	1.683	1.910	3.593	1.88	5.216	2.751	0.841
11	0.2680	55.400	37.9	8.3	1.683	1.926	3.609	1.87	5.200	2.768	0.842
12	0.2940	55.500	38.0	9.2	1.670	1.936	3.606	1.86	5.190	2.771	0.835
13	0.3270	55.570	38.1	10.4	1.652	1.949	3.601	1.85	5.177	2.775	0.826
14	0.3510	55.200	37.7	11.3	1.620	1.951	3.571	1.83	5.175	2.761	0.810
15	0.3600	54.400	36.9	11.6	1.580	1.966	3.546	1.80	5.160	2.756	0.790
16	0.3790	52.900	35.4	12.3	1.504	1.997	3.501	1.75	5.129	2.749	0.752
17	0.4000	52.600	35.1	13.0	1.478	2.013	3.491	1.73	5.113	2.752	0.739
18	0.4240	52.500	35.0	13.9	1.460	2.036	3.496	1.72	5.090	2.766	0.730
19	0.4560	52.800	35.3	15.0	1.452	2.051	3.503	1.71	5.075	2.777	0.726


11-107 MW
1
20-22'
CU 3 tsf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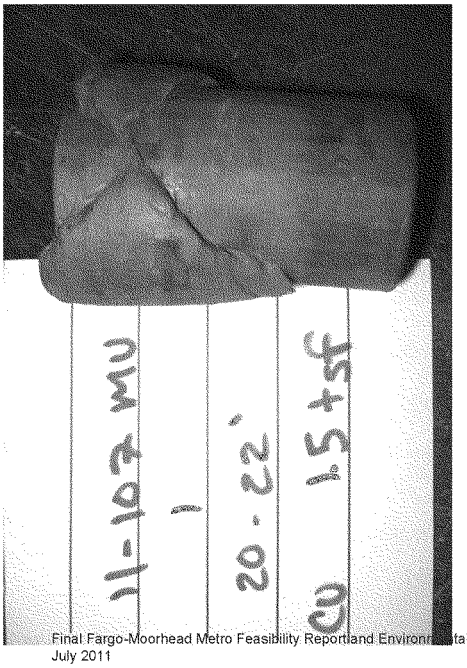
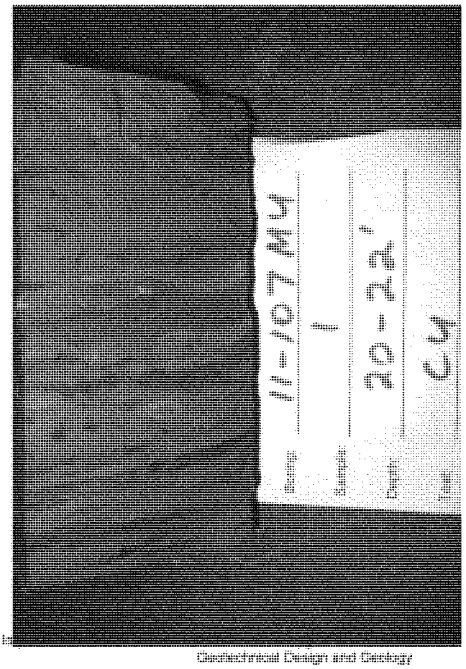
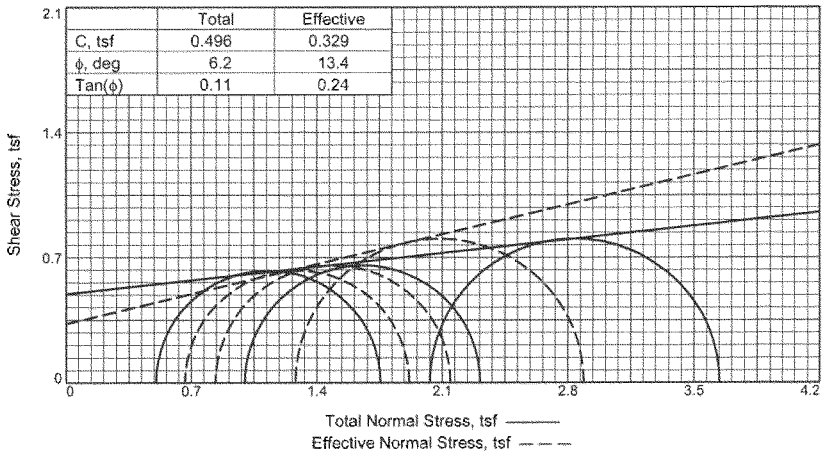
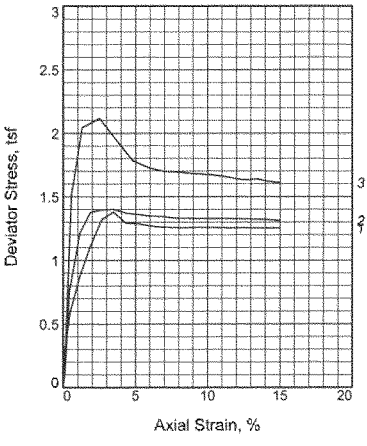
1
20-22'
CU 2.5 tsf


11-107 MW
1
20-22'
CU 1.5 tsf


11-107 MW
1
20-22'
CU





Sample No.		1	2	3
Initial	Water Content, %	40.3	39.9	39.6
	Dry Density, pcf	80.9	80.5	80.0
	Saturation, %	98.4	96.8	94.8
	Void Ratio	1.1297	1.1392	1.1538
	Diameter, in.	1.39	1.39	1.40
	Height, in.	2.80	2.80	2.81
At Test	Water Content, %	40.9	40.9	41.4
	Dry Density, pcf	80.9	81.0	80.4
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.1297	1.1278	1.1423
	Diameter, in.	1.39	1.39	1.40
	Height, in.	2.80	2.80	2.80
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.50	1.00	2.03
Back Pressure, tsf		6.63	6.13	5.11
Cell Pressure, tsf		7.13	7.13	7.14
Peak Deviator Stress, tsf		1.38	1.40	2.12
Total Pore Pr., tsf		6.78	6.54	6.18
Ultimate Deviator Stress, tsf		1.25	1.31	1.61
Total Pore Pr., tsf		6.47	6.29	5.87
Maj. Eff. Stress at Ultimate, tsf		1.92	2.15	2.89
Min. Eff. Stress at Ultimate, tsf		0.67	0.83	1.28

Type of Test:
CU with Pore Pressures
Sample Type: 5" Thinwall, Middle of sample
Description: FAT CLAY, brown (CH)

LL= 52 **PL=** 21 **PI=** 31
Specific Gravity= 2.76
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: ND RRCS, MN, Brenna Formation
Sample Number: Boring11-107MU, #2 **Depth:** 30-32'
Proj. No.: BL-10-10065 **Date Sampled:**

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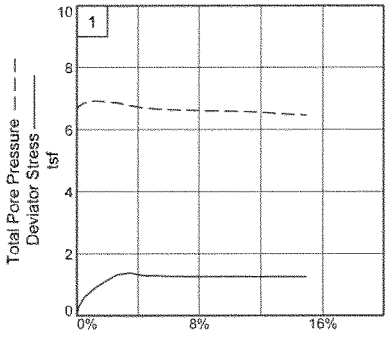
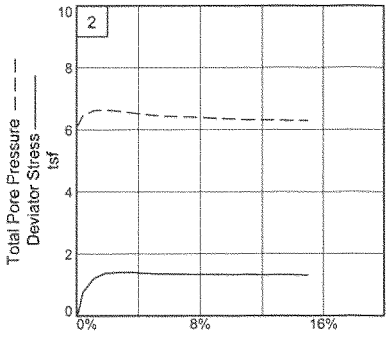
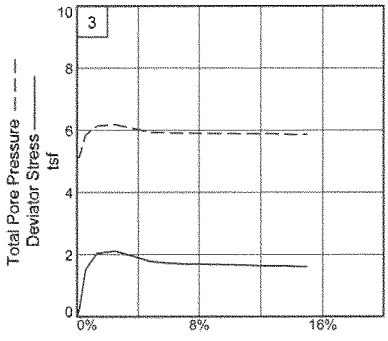
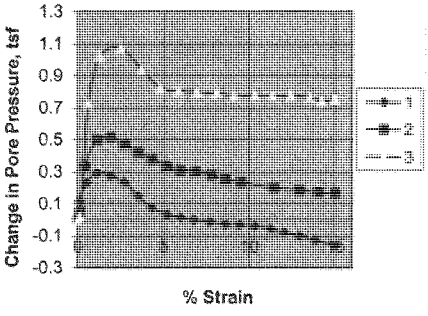
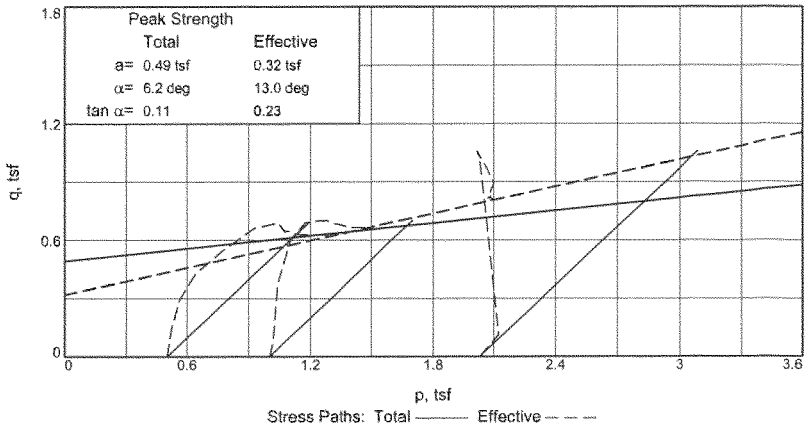
Figure C Triax ASTM D 4767











Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Loc.: ND RRCS, MN, Brenna Formation **Depth:** 30-32' **Sample No.:** Boring11-107MU, #2

Project No.: BL-10-10066 **Figure**

Braun Intertec

Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

5/30/2011
12:19 PM

Date:
Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Project No.: BL-10-10065
Location: ND RRCS, MN, Brenna Formation
Depth: 30-32' **Sample Number:** Boring11-107MU, #2
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.76 **LL=**52 **PL=**21 **PI=**31
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	141.470			158.370
Moisture content: Dry soil+tare, gms.	109.540			121.530
Moisture content: Tare, gms.	30.290			31.220
Moisture, %	40.3	40.9	40.9	40.8
Moist specimen weight, gms.	126.9			
Diameter, in.	1.39	1.39	1.39	
Area, in.²	1.52	1.52	1.52	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	113.5	114.0	114.0	
Dry density, pcf	80.9	80.9	80.9	
Void ratio	1.1297	1.1297	1.1297	
Saturation, %	98.4	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.131 tsf
Consolidation back pressure = 6.629 tsf
Consolidation effective confining stress = 0.502 tsf
Peak Stress = 1.379 tsf **at reading no.** 6
Ult. Stress = 1.253 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	0.0094	19.310	0.0	0.0	0.000	0.502	0.502	1.00	6.629	0.502	0.000
1	0.0125	25.260	6.0	0.1	0.282	0.382	0.664	1.74	6.749	0.523	0.141
2	0.0223	31.700	12.4	0.5	0.584	0.271	0.855	3.16	6.860	0.563	0.292
3	0.0410	37.780	18.5	1.1	0.865	0.212	1.077	5.08	6.919	0.645	0.433
4	0.0620	43.150	23.8	1.9	1.108	0.228	1.336	5.86	6.903	0.782	0.554
5	0.0840	47.970	28.7	2.7	1.322	0.267	1.589	5.95	6.864	0.928	0.661
6	0.1066	49.470	30.2	3.5	1.379	0.354	1.733	4.90	6.777	1.044	0.690
7	0.1305	47.840	28.5	4.3	1.293	0.427	1.720	4.03	6.704	1.074	0.647
8	0.1545	47.960	28.7	5.2	1.287	0.469	1.756	3.74	6.662	1.113	0.644
9	0.1773	47.810	28.5	6.0	1.269	0.487	1.756	3.61	6.644	1.122	0.635
10	0.2011	47.910	28.6	6.8	1.262	0.503	1.765	3.51	6.628	1.134	0.631
11	0.2242	48.080	28.8	7.7	1.259	0.514	1.773	3.45	6.617	1.143	0.629
12	0.2492	48.320	29.0	8.6	1.257	0.531	1.788	3.37	6.600	1.159	0.628
13	0.2732	48.670	29.4	9.4	1.260	0.534	1.794	3.36	6.597	1.164	0.630
14	0.2980	48.910	29.6	10.3	1.258	0.542	1.800	3.32	6.589	1.171	0.629
15	0.3219	49.150	29.8	11.2	1.256	0.558	1.814	3.25	6.573	1.186	0.628
16	0.3460	49.440	30.1	12.0	1.256	0.580	1.836	3.17	6.551	1.208	0.628
17	0.3697	49.720	30.4	12.9	1.256	0.604	1.860	3.08	6.527	1.232	0.628
18	0.3947	50.000	30.7	13.8	1.254	0.630	1.884	2.99	6.501	1.257	0.627
19	0.4287	50.410	31.1	15.0	1.253	0.665	1.918	2.88	6.466	1.291	0.626

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	139.780			155.490
Moisture content: Dry soil+tare, gms.	108.610			119.160
Moisture content: Tare, gms.	30.570			29.890
Moisture, %	39.9	41.3	40.9	40.7
Moist specimen weight, gms.	126.0			
Diameter, in.	1.39	1.39	1.39	
Area, in.^{2}	1.52	1.52	1.51	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	112.7	113.8	114.1	
Dry density, pcf	80.5	80.5	81.0	
Void ratio	1.1392	1.1392	1.1278	
Saturation, %	96.8	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.125 tsf
Consolidation back pressure = 6.125 tsf
Consolidation effective confining stress = 1.000 tsf
Peak Stress = 1.402 tsf **at reading no.** 6
Ult. Stress = 1.313 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	0.0065	17.660	0.0	0.0	0.000	1.000	1.000	1.00	6.125	1.000	0.000
1	0.0104	20.530	2.9	0.1	0.136	0.949	1.085	1.14	6.176	1.017	0.068
2	0.0182	33.500	15.8	0.4	0.750	0.666	1.416	2.13	6.459	1.041	0.375
3	0.0383	43.420	25.8	1.1	1.211	0.502	1.713	3.41	6.623	1.107	0.605
4	0.0591	47.240	29.6	1.9	1.380	0.484	1.864	3.85	6.641	1.174	0.690
5	0.0809	47.820	30.2	2.7	1.396	0.527	1.923	3.65	6.598	1.225	0.698
6	0.1039	48.210	30.6	3.5	1.402	0.580	1.982	3.42	6.545	1.281	0.701
7	0.1278	47.820	30.2	4.3	1.372	0.624	1.996	3.20	6.501	1.310	0.686
8	0.1507	47.820	30.2	5.2	1.360	0.666	2.026	3.04	6.459	1.346	0.680
9	0.1747	47.840	30.2	6.0	1.349	0.693	2.042	2.95	6.432	1.367	0.674
10	0.1997	48.040	30.4	6.9	1.345	0.701	2.046	2.92	6.424	1.373	0.672
11	0.2234	48.030	30.4	7.8	1.332	0.722	2.054	2.85	6.403	1.388	0.666
12	0.2483	48.310	30.7	8.6	1.331	0.747	2.078	2.78	6.378	1.413	0.666
13	0.2736	48.550	30.9	9.5	1.329	0.767	2.096	2.73	6.358	1.431	0.664
14	0.3250	49.190	31.5	11.4	1.329	0.801	2.130	2.66	6.324	1.465	0.664
15	0.3676	49.670	32.0	12.9	1.326	0.817	2.143	2.62	6.308	1.480	0.663
16	0.3969	49.980	32.3	14.0	1.322	0.829	2.151	2.60	6.296	1.490	0.661
17	0.4258	50.140	32.5	15.0	1.313	0.834	2.147	2.57	6.291	1.490	0.656

Test Results for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	123.360			156.230
Moisture content: Dry soil+tare, gms.	97.000			119.560
Moisture content: Tare, gms.	30.500			30.280
Moisture, %	39.6	41.8	41.4	41.1
Moist specimen weight, gms.	127.1			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.54	1.54	1.54	
Height, in.	2.81	2.81	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	111.7	113.4	113.7	
Dry density, pcf	80.0	80.0	80.4	
Void ratio	1.1538	1.1538	1.1423	
Saturation, %	94.8	100.0	100.0	

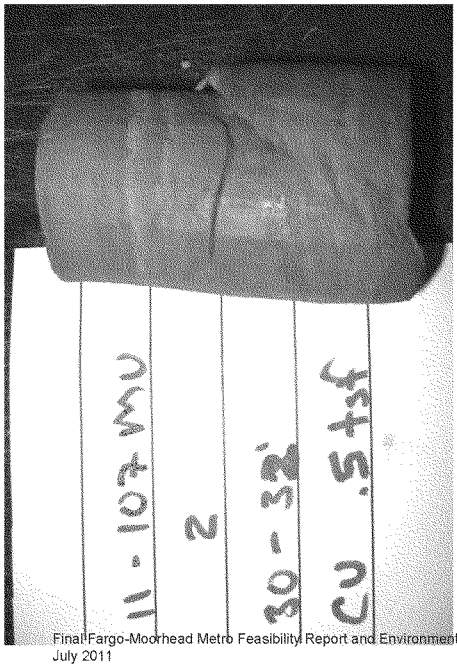
Test Reading for Specimen No. 3

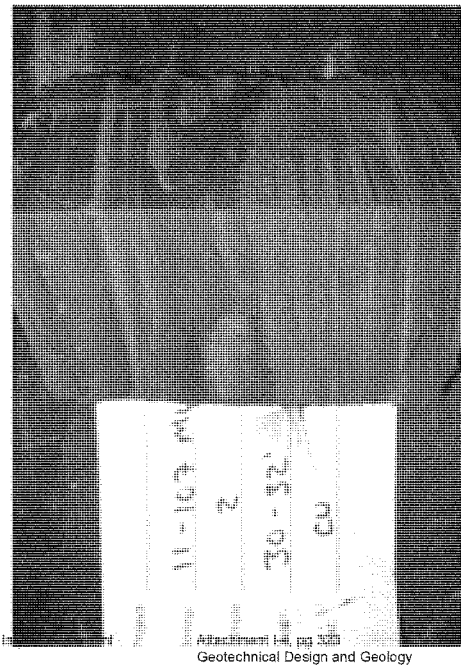
Consolidation cell pressure = 7.143 tsf
Consolidation back pressure = 5.112 tsf
Consolidation effective confining stress = 2.031 tsf
Peak Stress = 2.117 tsf **at reading no.** 4
Ult. Stress = 1.611 tsf **at reading no.** 16

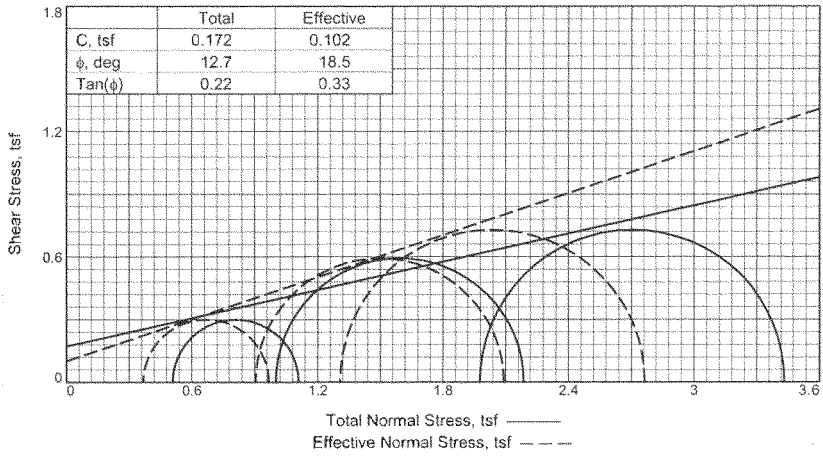
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0476	17.410	0.0	0.0	0.000	2.031	2.031	1.00	5.112	2.031	0.000
1	0.0516	22.270	4.9	0.1	0.227	2.010	2.237	1.11	5.133	2.124	0.114
2	0.0632	49.940	32.5	0.6	1.514	1.302	2.816	2.16	5.841	2.059	0.757
3	0.0844	61.650	44.2	1.3	2.043	1.008	3.051	3.03	6.135	2.030	1.022
4	0.1179	63.800	46.4	2.5	2.117	0.959	3.076	3.21	6.184	2.017	1.058
5	0.1513	60.530	43.1	3.7	1.944	1.094	3.038	2.78	6.049	2.066	0.972
6	0.1815	57.450	40.0	4.8	1.785	1.208	2.993	2.48	5.935	2.100	0.892
7	0.2128	56.620	39.2	5.9	1.727	1.225	2.952	2.41	5.918	2.089	0.864
8	0.2433	56.420	39.0	7.0	1.698	1.234	2.932	2.38	5.909	2.083	0.849
9	0.2739	56.720	39.3	8.1	1.691	1.240	2.931	2.36	5.903	2.086	0.846
10	0.3039	56.920	39.5	9.1	1.680	1.255	2.935	2.34	5.888	2.095	0.840
11	0.3353	57.230	39.8	10.3	1.672	1.252	2.924	2.34	5.891	2.088	0.836
12	0.3646	57.300	39.9	11.3	1.656	1.258	2.914	2.32	5.885	2.086	0.828
13	0.3953	57.210	39.8	12.4	1.632	1.255	2.887	2.30	5.888	2.071	0.816
14	0.4254	57.840	40.4	13.5	1.637	1.267	2.904	2.29	5.876	2.086	0.819
15	0.4462	57.720	40.3	14.2	1.618	1.288	2.906	2.26	5.855	2.097	0.809
16	0.4679	57.900	40.5	15.0	1.611	1.278	2.889	2.26	5.865	2.083	0.805

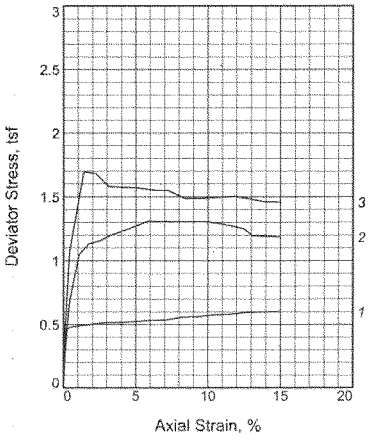
11-102 MW
2
30-32'
CU 2 tsf

11-102 MW
2
30-32'
CU 1 tsf


11-102 MW
2
30-32'
CU .5 tsf


11-102 MW
2
30-32'
CU





Sample No.		1	2	3
Initial	Water Content, %	47.7	39.5	38.0
	Dry Density, pcf	73.2	81.8	83.3
	Saturation, %	98.4	100.0	99.6
	Void Ratio	1.3167	1.0737	1.0380
	Diameter, in.	1.41	1.41	1.40
	Height, in.	2.81	2.81	2.81
At Test	Water Content, %	48.4	38.7	37.4
	Dry Density, pcf	73.2	82.7	84.2
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.3167	1.0516	1.0163
	Diameter, in.	1.41	1.41	1.39
	Height, in.	2.81	2.80	2.80
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.51	1.00	1.98
Back Pressure, tsf		6.60	6.13	5.15
Cell Pressure, tsf		7.11	7.13	7.13
Peak Deviator Stress, tsf		0.60	1.31	1.69
Total Pore Pr., tsf		6.75	6.35	5.93
Ultimate Deviator Stress, tsf		0.60	1.19	1.46
Total Pore Pr., tsf		6.75	6.22	5.82
Maj. Eff. Stress at Ultimate, tsf		0.97	2.09	2.76
Min. Eff. Stress at Ultimate, tsf		0.37	0.91	1.31

Type of Test:
CU with Pore Pressures
Sample Type: Undisturbed, 5" Thinwall, Middle
Description: FAT CLAY, brown (CH)

LL= 95 **PL=** 28 **PI=** 67
Specific Gravity= 2.718
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Sheyenne River, Brenna Formation
Sample Number: Boring11-110MU, #2 **Depth:** 35-37'
Proj. No.: BL-10-10065 **Date Sampled:**

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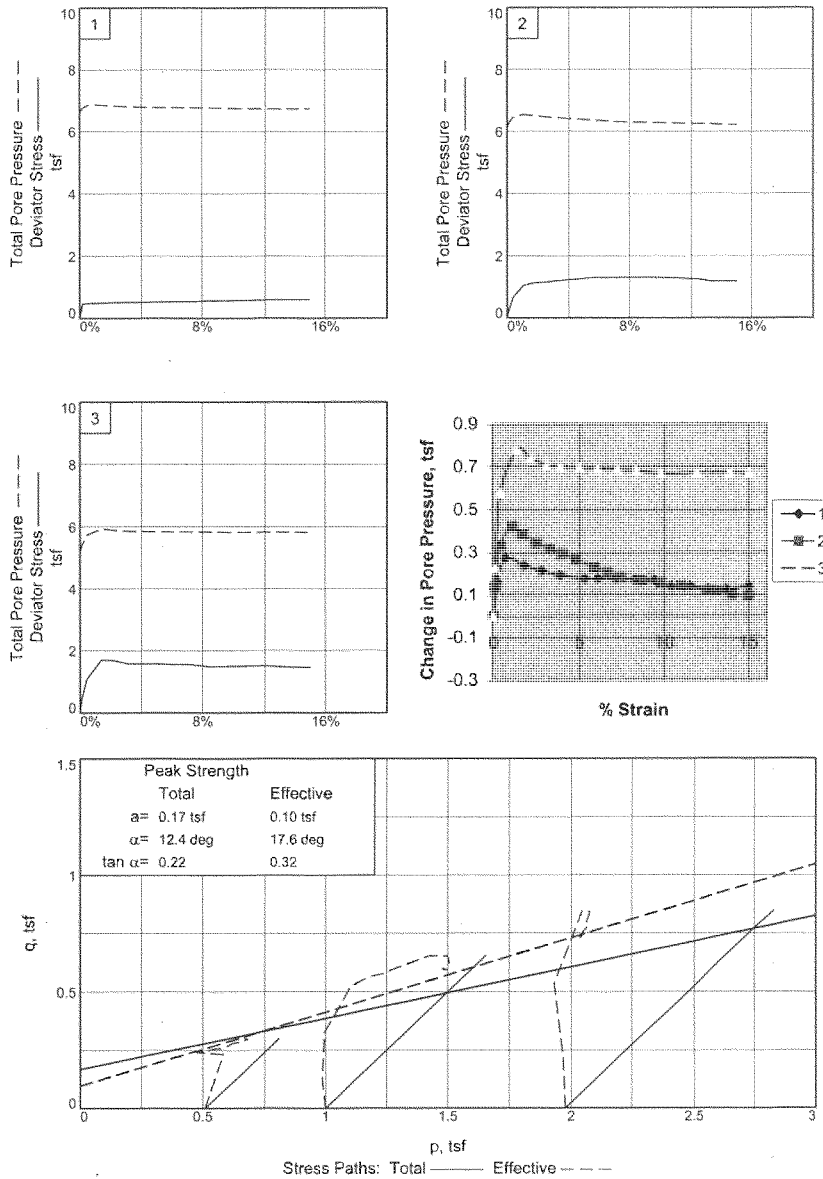
Figure CTE - ASTM D 4767



Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Loc.: Sheyenne River, Brenna Formation **Depth:** 35-37' **Sample No.:** Boring11-110MU, #2

Project No.: [illegible]

Figure

Braun Intertec

Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

4/26/2011
8:18 AM

Date:
Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project No.: BL-10-10065
Location: Sheyenne River, Brenna Formation
Depth: 35-37' **Sample Number:** Boring11-110MU, #2
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: Undisturbed, 5" Thinwall, Middle
Specific Gravity=2.718 **LL=**95 **PL=**28 **PI=**67
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	124.130			156.790
Moisture content: Dry soil+tare, gms.	93.730			114.520
Moisture content: Tare, gms.	29.970			30.290
Moisture, %	47.7	48.4	48.4	50.2
Moist specimen weight, gms.	124.5			
Diameter, in.	1.41	1.41	1.41	
Area, in.^{2}	1.56	1.56	1.56	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	108.2	108.7	108.7	
Dry density, pcf	73.2	73.2	73.2	
Void ratio	1.3167	1.3167	1.3167	
Saturation, %	98.4	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.113 tsf
Consolidation back pressure = 6.604 tsf
Consolidation effective confining stress = 0.509 tsf
Peak Stress = 0.600 tsf **at reading no.** 15
Ult. Stress = 0.600 tsf **at reading no.** 15

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	0.0451	19.470	0.0	0.0	0.000	0.509	0.509	1.00	6.604	0.509	0.000
1	0.0502	29.610	10.1	0.2	0.466	0.350	0.816	2.33	6.763	0.583	0.233
2	0.0640	30.020	10.6	0.7	0.483	0.235	0.718	3.05	6.878	0.476	0.241
3	0.0942	30.490	11.0	1.8	0.499	0.271	0.770	2.84	6.842	0.520	0.249
4	0.1246	30.970	11.5	2.8	0.515	0.296	0.811	2.74	6.817	0.553	0.257
5	0.1558	31.120	11.7	3.9	0.515	0.318	0.833	2.62	6.795	0.576	0.258
6	0.1951	31.530	12.1	5.3	0.526	0.333	0.859	2.58	6.780	0.596	0.263
7	0.2160	31.790	12.3	6.1	0.533	0.331	0.864	2.61	6.782	0.597	0.266
8	0.2469	32.020	12.6	7.2	0.536	0.333	0.869	2.61	6.780	0.601	0.268
9	0.2772	32.690	13.2	8.3	0.558	0.337	0.895	2.66	6.776	0.616	0.279
10	0.3076	32.920	13.5	9.4	0.561	0.340	0.901	2.65	6.773	0.621	0.281
11	0.3382	33.430	14.0	10.4	0.576	0.368	0.944	2.56	6.745	0.656	0.288
12	0.3686	33.700	14.2	11.5	0.580	0.368	0.948	2.58	6.745	0.658	0.290
13	0.3989	34.200	14.7	12.6	0.593	0.382	0.975	2.55	6.731	0.678	0.296
14	0.4292	34.500	15.0	13.7	0.597	0.383	0.980	2.56	6.730	0.682	0.299
15	0.4650	34.800	15.3	15.0	0.600	0.368	0.968	2.63	6.745	0.668	0.300

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	140.600			163.130
Moisture content: Dry soil+tare, gms.	109.290			127.050
Moisture content: Tare, gms.	30.040			29.720
Moisture, %	39.5	39.5	38.7	37.1
Moist specimen weight, gms.	132.3			
Diameter, in.	1.41	1.41	1.41	
Area, in.^{2}	1.57	1.57	1.56	
Height, in.	2.81	2.81	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	114.2	114.1	114.7	
Dry density, pcf	81.8	81.8	82.7	
Void ratio	1.0737	1.0737	1.0516	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.125 tsf

Consolidation back pressure = 6.125 tsf

Consolidation effective confining stress = 1.000 tsf

Peak Stress = 1.308 tsf **at reading no.** 9

Ult. Stress = 1.186 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	0.0146	20.470	0.0	0.0	0.000	1.000	1.000	1.00	6.125	1.000	0.000
1	0.0176	25.840	5.4	0.1	0.248	0.862	1.110	1.29	6.263	0.986	0.124
2	0.0256	34.720	14.3	0.4	0.655	0.668	1.323	1.98	6.457	0.996	0.328
3	0.0444	43.380	22.9	1.1	1.047	0.579	1.626	2.81	6.546	1.102	0.523
4	0.0634	45.380	24.9	1.7	1.130	0.615	1.745	2.84	6.510	1.180	0.565
5	0.0843	46.110	25.6	2.5	1.155	0.656	1.811	2.76	6.469	1.233	0.577
6	0.1062	47.350	26.9	3.3	1.201	0.684	1.885	2.76	6.441	1.284	0.600
7	0.1271	48.180	27.7	4.0	1.228	0.708	1.936	2.73	6.417	1.322	0.614
8	0.1490	49.190	28.7	4.8	1.263	0.734	1.997	2.72	6.391	1.365	0.631
9	0.1789	50.560	30.1	5.9	1.308	0.771	2.079	2.70	6.354	1.425	0.654
10	0.2018	50.780	30.3	6.7	1.306	0.796	2.102	2.64	6.329	1.449	0.653
11	0.2257	51.080	30.6	7.5	1.307	0.818	2.125	2.60	6.307	1.472	0.654
12	0.2575	51.420	31.0	8.7	1.305	0.833	2.138	2.57	6.292	1.486	0.653
13	0.2904	51.820	31.4	9.8	1.305	0.846	2.151	2.54	6.279	1.499	0.653
14	0.3225	51.790	31.3	11.0	1.287	0.859	2.146	2.50	6.266	1.503	0.644
15	0.3643	51.420	31.0	12.5	1.251	0.881	2.132	2.42	6.244	1.506	0.625
16	0.3811	50.200	29.7	13.1	1.193	0.881	2.074	2.35	6.244	1.478	0.597
17	0.4062	50.430	30.0	14.0	1.190	0.899	2.089	2.32	6.226	1.494	0.595
18	0.4351	50.690	30.2	15.0	1.186	0.905	2.091	2.31	6.220	1.498	0.593

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	135.070			160.370
Moisture content: Dry soil+tare, gms.	106.200			125.630
Moisture content: Tare, gms.	30.290			30.580
Moisture, %	38.0	38.2	37.4	36.5
Moist specimen weight, gms.	130.0			
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	114.9	115.1	115.6	
Dry density, pcf	83.3	83.3	84.2	
Void ratio	1.0380	1.0380	1.0163	
Saturation, %	99.6	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.129 tsf

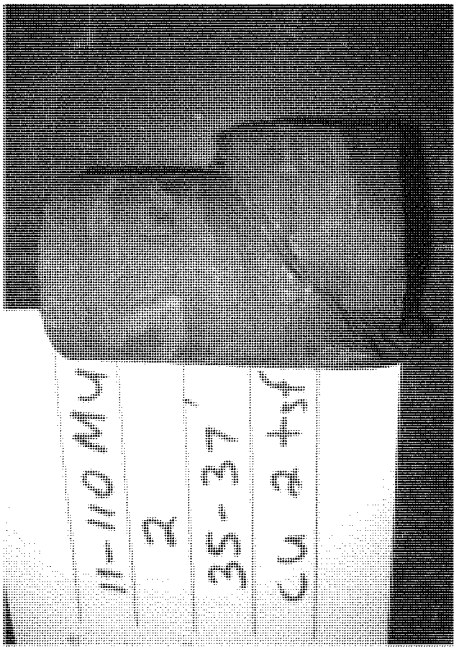
Consolidation back pressure = 5.152 tsf

Consolidation effective confining stress = 1.977 tsf

Peak Stress = 1.694 tsf at reading no. 3

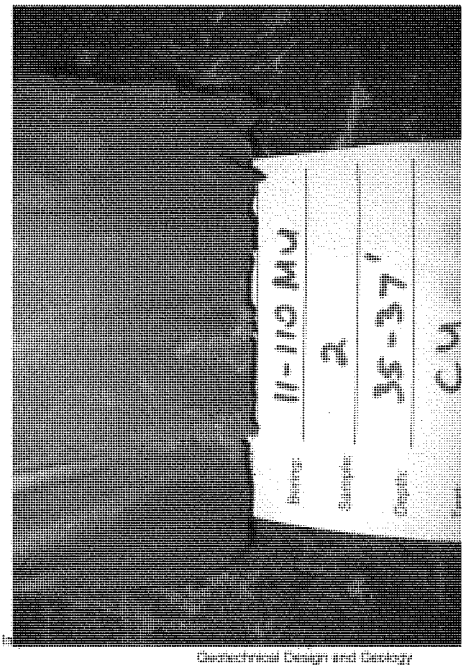
Ult. Stress = 1.458 tsf at reading no. 14

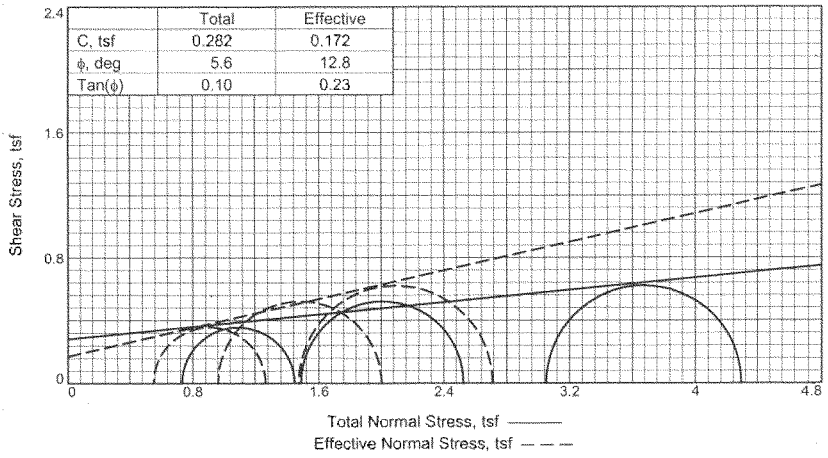
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0096	19.500	0.0	0.0	0.000	1.977	1.977	1.00	5.152	1.977	0.000
1	0.0125	28.590	9.1	0.1	0.429	1.754	2.183	1.24	5.375	1.968	0.214
2	0.0216	42.260	22.8	0.4	1.071	1.397	2.468	1.77	5.732	1.932	0.535
3	0.0484	55.870	36.4	1.4	1.694	1.198	2.892	2.41	5.931	2.045	0.847
4	0.0715	55.910	36.4	2.2	1.682	1.235	2.917	2.36	5.894	2.076	0.841
5	0.0962	54.040	34.5	3.1	1.581	1.270	2.851	2.25	5.859	2.061	0.791
6	0.1189	54.170	34.7	3.9	1.574	1.277	2.851	2.23	5.852	2.064	0.787
7	0.1501	54.510	35.0	5.0	1.571	1.280	2.851	2.23	5.849	2.065	0.785
8	0.1808	54.490	35.0	6.1	1.552	1.285	2.837	2.21	5.844	2.061	0.776
9	0.2126	54.850	35.4	7.3	1.549	1.290	2.839	2.20	5.839	2.064	0.774
10	0.2445	53.850	34.4	8.4	1.486	1.295	2.781	2.15	5.834	2.038	0.743
11	0.2844	54.440	34.9	9.8	1.488	1.309	2.797	2.14	5.820	2.053	0.744
12	0.3411	55.620	36.1	11.9	1.504	1.304	2.808	2.15	5.825	2.056	0.752
13	0.3981	55.420	35.9	13.9	1.461	1.304	2.765	2.12	5.825	2.035	0.731
14	0.4299	55.820	36.3	15.0	1.458	1.306	2.764	2.12	5.823	2.035	0.729


11-110 MW
2
35-37'
CH 2+Y

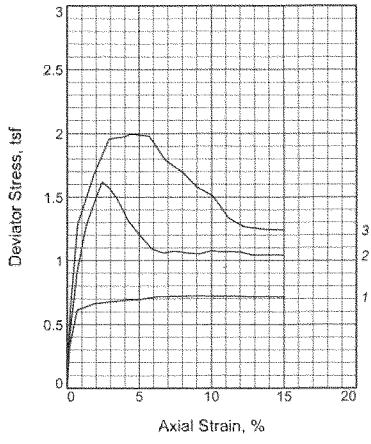
11-110 MW
2
35-37'
CH 0.5+S

11-110 MW
2
35-37'
CH 1+S


Boring: 11-110 MW
Sample: 2
Depth: 35-37'
CH



	Total	Effective
C, tsf	0.282	0.172
ϕ, deg	5.6	12.8
Tan(ϕ)	0.10	0.23



Sample No.		1	2	3
Initial	Water Content, %	54.8	55.7	55.9
	Dry Density, pcf	68.1	66.9	67.2
	Saturation, %	100.0	98.6	100.0
	Void Ratio	1.4861	1.5298	1.5165
	Diameter, in.	1.39	1.40	1.41
	Height, in.	2.81	2.81	2.80
At Test	Water Content, %	54.8	56.3	53.5
	Dry Density, pcf	68.1	66.9	69.1
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.4861	1.5271	1.4494
	Diameter, in.	1.39	1.40	1.39
	Height, in.	2.81	2.80	2.77
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.74	1.49	3.05
Back Pressure, tsf		6.38	5.64	4.12
Cell Pressure, tsf		7.12	7.13	7.17
Peak Deviator Stress, tsf		0.72	1.62	1.99
Total Pore Pr., tsf		6.61	6.33	5.50
Ultimate Deviator Stress, tsf		0.71	1.04	1.24
Total Pore Pr., tsf		6.56	6.17	5.70
Maj. Eff. Stress at Ultimate, tsf		1.27	2.00	2.71
Min. Eff. Stress at Ultimate, tsf		0.55	0.96	1.47

Type of Test:
CU with Pore Pressures

Sample Type: Undisturbed, 5" Thinwall, Middle

Description: FAT CLAY, brown (CH)

LL= 86 **PL=** 22 **PI=** 64

Specific Gravity= 2.710

Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Figure CU Triaxial ASTM D 4767

Client: W912ES-11-P-0024

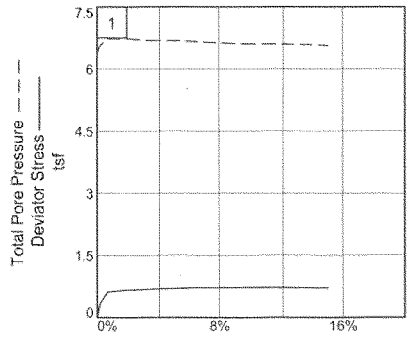
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

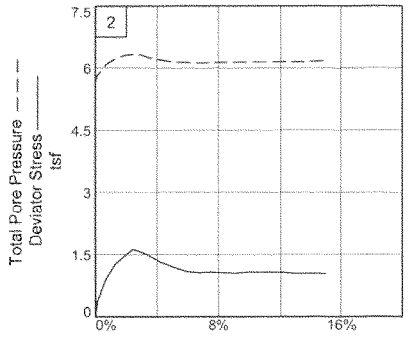
Location: Sheyenne River, Brenna Formation

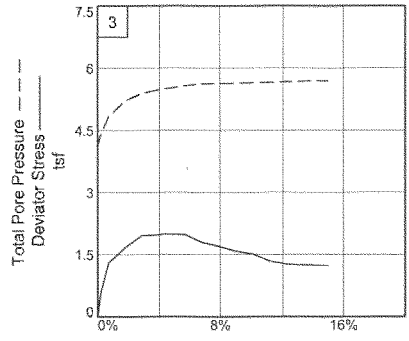
Sample Number: Boring11-110MU, #3 **Depth:** 48-50'

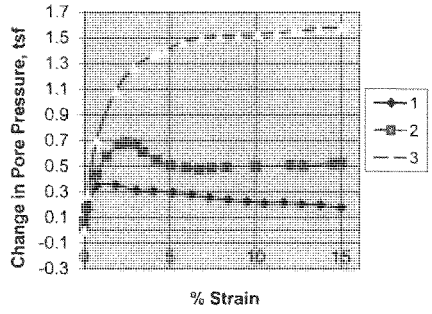
Proj. No.: BL-10-10065 **Date Sampled:**

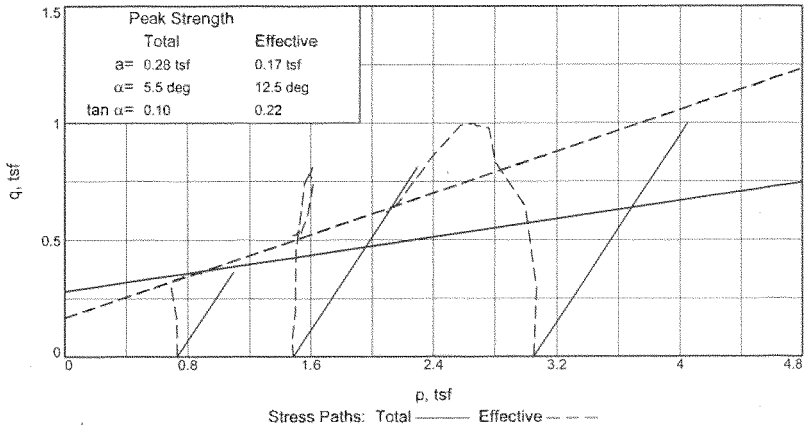
BRAUN INTERTEC











Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Loc.: Sheyenne River, Brenna Formation **Depth:** 48-50' **Sample No.:** Boring11-110MU, #3

Project No.: BL-10-10065 **Figure**

Braun Intertec

Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST 4/26/2011
CU with Pore Pressures 8:18 AM

Date:
Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project No.: BL-10-10065
Location: Sheyenne River, Brenna Formation
Depth: 48-50' **Sample Number:** Boring11-110MU, #3
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: Undisturbed, 5" Thinwall, Middle
Specific Gravity=2.710 **LL=**86 **PL=**22 **PI=**64
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	145.160			149.460
Moisture content: Dry soil+tare, gms.	104.740			107.140
Moisture content: Tare, gms.	31.020			30.460
Moisture, %	54.8	54.8	54.8	55.2
Moist specimen weight, gms.	118.2			
Diameter, in.	1.39	1.39	1.39	
Area, in.^{2}	1.52	1.52	1.52	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	105.4	105.4	105.4	
Dry density, pcf	68.1	68.1	68.1	
Void ratio	1.4861	1.4861	1.4861	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.116 tsf
Consolidation back pressure = 6.384 tsf
Consolidation effective confining stress = 0.732 tsf
Peak Stress = 0.724 tsf **at reading no.** 10
Ult. Stress = 0.714 tsf **at reading no.** 15

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	0.0579	20.500	0.0	0.0	0.000	0.732	0.732	1.00	6.384	0.732	0.000
1	0.0628	27.390	6.9	0.2	0.325	0.566	0.891	1.57	6.550	0.728	0.162
2	0.0773	33.550	13.0	0.7	0.612	0.386	0.998	2.59	6.730	0.692	0.306
3	0.1096	34.770	14.3	1.8	0.662	0.380	1.042	2.74	6.736	0.711	0.331
4	0.1412	35.290	14.8	3.0	0.678	0.418	1.096	2.62	6.698	0.757	0.339
5	0.1715	35.730	15.2	4.0	0.690	0.423	1.113	2.63	6.693	0.768	0.345
6	0.2020	36.070	15.6	5.1	0.698	0.437	1.135	2.60	6.679	0.786	0.349
7	0.2322	36.680	16.2	6.2	0.717	0.453	1.170	2.58	6.663	0.811	0.358
8	0.2627	36.920	16.4	7.3	0.719	0.475	1.194	2.51	6.641	0.835	0.360
9	0.2930	37.190	16.7	8.4	0.722	0.493	1.215	2.47	6.623	0.854	0.361
10	0.3233	37.430	16.9	9.5	0.724	0.506	1.230	2.43	6.610	0.868	0.362
11	0.3537	37.560	17.1	10.5	0.721	0.519	1.240	2.39	6.597	0.879	0.360
12	0.3840	37.790	17.3	11.6	0.722	0.516	1.238	2.40	6.600	0.877	0.361
13	0.4145	37.870	17.4	12.7	0.716	0.526	1.242	2.36	6.590	0.884	0.358
14	0.4460	38.110	17.6	13.8	0.717	0.533	1.250	2.34	6.583	0.891	0.358
15	0.4800	38.290	17.8	15.0	0.714	0.552	1.266	2.29	6.564	0.909	0.357

Parameters for Specimen No. 2				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	138.280			147.670
Moisture content: Dry soil+tare, gms.	99.670			105.340
Moisture content: Tare, gms.	30.290			29.710
Moisture, %	55.7	56.4	56.3	56.0
Moist specimen weight, gms.	118.5			
Diameter, in.	1.40	1.40	1.40	
Area, in.^{2}	1.55	1.55	1.54	
Height, in.	2.81	2.81	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	104.1	104.6	104.7	
Dry density, pcf	66.9	66.9	66.9	
Void ratio	1.5298	1.5298	1.5271	
Saturation, %	98.6	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.131 tsf
Consolidation back pressure = 5.645 tsf
Consolidation effective confining stress = 1.486 tsf
Peak Stress = 1.619 tsf **at reading no.** 6
Ult. Stress = 1.041 tsf **at reading no.** 21

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	0.0074	21.340	0.0	0.0	0.000	1.486	1.486	1.00	5.645	1.486	0.000
1	0.0085	24.130	2.8	0.0	0.130	1.411	1.541	1.09	5.720	1.476	0.065
2	0.0115	29.470	8.1	0.1	0.378	1.309	1.687	1.29	5.822	1.498	0.189
3	0.0263	40.890	19.6	0.7	0.905	1.049	1.954	1.86	6.082	1.501	0.452
4	0.0433	48.920	27.6	1.3	1.269	0.906	2.175	2.40	6.225	1.540	0.634
5	0.0621	53.800	32.5	2.0	1.483	0.819	2.302	2.81	6.312	1.561	0.742
6	0.0752	56.940	35.6	2.4	1.619	0.803	2.422	3.02	6.328	1.613	0.810
7	0.0902	55.940	34.6	3.0	1.565	0.813	2.378	2.92	6.318	1.595	0.782
8	0.1040	54.320	33.0	3.4	1.484	0.874	2.358	2.70	6.257	1.616	0.742
9	0.1258	50.780	29.4	4.2	1.314	0.936	2.250	2.40	6.195	1.593	0.657
10	0.1488	48.430	27.1	5.0	1.199	0.979	2.178	2.22	6.152	1.578	0.599
11	0.1716	46.230	24.9	5.9	1.092	0.999	2.091	2.09	6.132	1.545	0.546
12	0.1945	45.710	24.4	6.7	1.060	1.008	2.068	2.05	6.123	1.538	0.530
13	0.2163	46.230	24.9	7.4	1.074	1.000	2.074	2.07	6.131	1.537	0.537
14	0.2403	46.110	24.8	8.3	1.059	0.992	2.051	2.07	6.139	1.521	0.529
15	0.2643	46.170	24.8	9.2	1.051	0.990	2.041	2.06	6.141	1.516	0.526
16	0.2877	47.000	25.7	10.0	1.076	0.988	2.064	2.09	6.143	1.526	0.538
17	0.3122	47.050	25.7	10.9	1.068	0.984	2.052	2.09	6.147	1.518	0.534
18	0.3438	47.360	26.0	12.0	1.067	0.979	2.046	2.09	6.152	1.513	0.534
19	0.3669	47.010	25.7	12.8	1.043	0.981	2.024	2.06	6.150	1.503	0.522
20	0.4168	47.570	26.2	14.6	1.044	0.965	2.009	2.08	6.166	1.487	0.522
21	0.4280	47.610	26.3	15.0	1.041	0.962	2.003	2.08	6.169	1.482	0.520

Parameters for Specimen No. 3

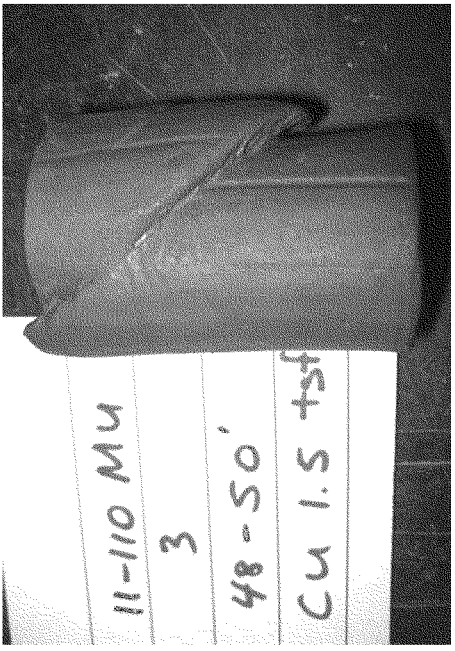
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	130.140			148.190
Moisture content: Dry soil+tare, gms.	94.360			108.690
Moisture content: Tare, gms.	30.400			31.190
Moisture, %	55.9	56.0	53.5	51.0
Moist specimen weight, gms.	119.4			
Diameter, in.	1.41	1.41	1.39	
Area, in.^{2}	1.55	1.55	1.52	
Height, in.	2.80	2.80	2.77	
Net decrease in height, in.		0.00	0.03	
Wet Density, pcf	104.8	104.8	106.0	
Dry density, pcf	67.2	67.2	69.1	
Void ratio	1.5165	1.5165	1.4494	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 3

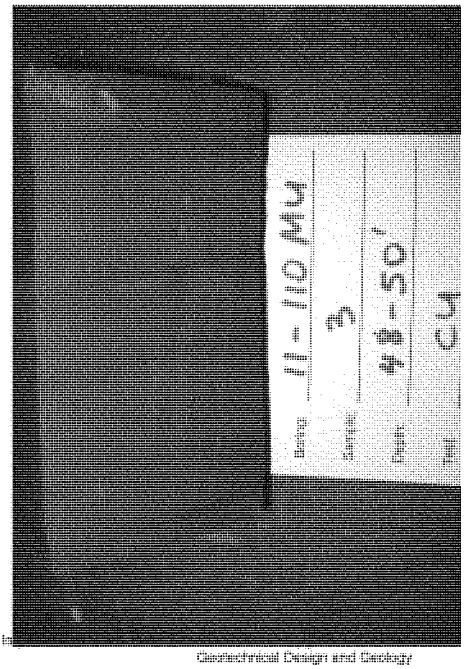
Consolidation cell pressure = 7.166 tsf
Consolidation back pressure = 4.115 tsf
Consolidation effective confining stress = 3.051 tsf
Peak Stress = 1.995 tsf **at reading no.** 6
Ult. Stress = 1.240 tsf **at reading no.** 17

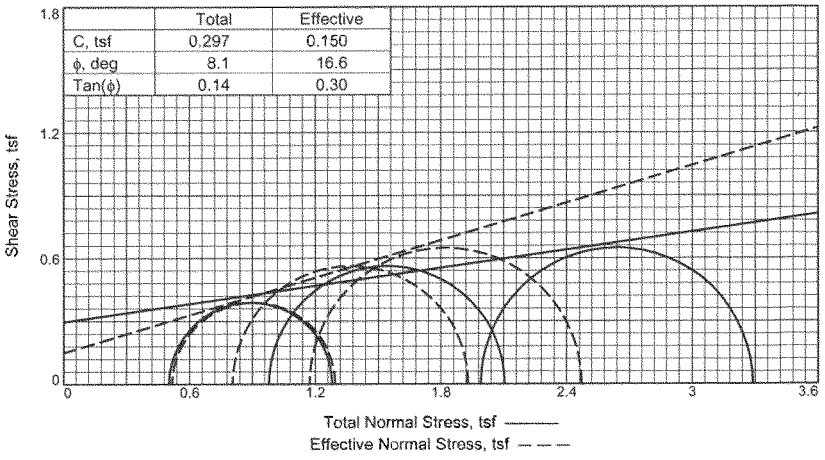
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0519	17.770	0.0	0.0	0.000	3.051	3.051	1.00	4.115	3.051	0.000
1	0.0577	30.320	12.6	0.2	0.592	2.772	3.364	1.21	4.394	3.068	0.296
2	0.0717	45.250	27.5	0.7	1.289	2.351	3.640	1.55	4.815	2.996	0.645
3	0.1018	53.660	35.9	1.8	1.665	1.970	3.635	1.85	5.196	2.803	0.833
4	0.1320	60.430	42.7	2.9	1.957	1.782	3.739	2.10	5.384	2.761	0.979
5	0.1627	61.310	43.5	4.0	1.975	1.690	3.665	2.17	5.476	2.678	0.988
6	0.1722	61.900	44.1	4.3	1.995	1.665	3.660	2.20	5.501	2.662	0.997
7	0.1830	62.010	44.2	4.7	1.992	1.651	3.643	2.21	5.515	2.647	0.996
8	0.2094	62.200	44.4	5.7	1.980	1.588	3.568	2.25	5.578	2.578	0.990
9	0.2409	58.420	40.7	6.8	1.790	1.551	3.341	2.15	5.615	2.446	0.895
10	0.2712	56.870	39.1	7.9	1.701	1.537	3.238	2.11	5.629	2.388	0.851
11	0.3006	54.520	36.8	9.0	1.581	1.532	3.113	2.03	5.634	2.322	0.790
12	0.3311	53.300	35.5	10.1	1.510	1.523	3.033	1.99	5.643	2.278	0.755
13	0.3615	49.580	31.8	11.2	1.335	1.516	2.851	1.88	5.650	2.184	0.668
14	0.3906	48.330	30.6	12.2	1.268	1.498	2.766	1.85	5.668	2.132	0.634
15	0.4006	48.270	30.5	12.6	1.260	1.500	2.760	1.84	5.666	2.130	0.630
16	0.4313	48.290	30.5	13.7	1.245	1.477	2.722	1.84	5.689	2.099	0.622
17	0.4680	48.660	30.9	15.0	1.240	1.471	2.711	1.84	5.695	2.091	0.620

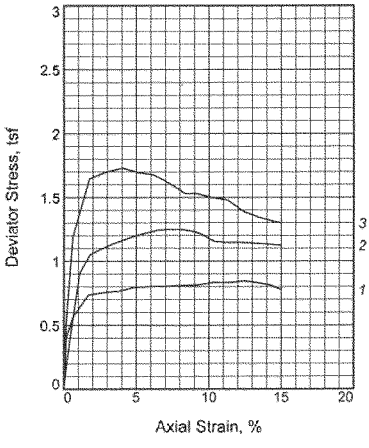
11-110 MH
3
48-50'
CH 3 tsf


11-110 MH
3
48-50'
CH 1.5 tsf

11-110 MH
3
48-50'
CH 0.75 t


11-110 MH
3
48-50'
CH





Sample No.		1	2	3
Initial	Water Content, %	43.4	44.8	41.4
	Dry Density, pcf	77.6	76.3	79.1
	Saturation, %	100.0	100.0	98.7
	Void Ratio	1.1726	1.2102	1.1307
	Diameter, in.	1.39	1.41	1.40
	Height, in.	2.80	2.80	2.80
At Test	Water Content, %	43.4	44.4	41.5
	Dry Density, pcf	77.6	76.7	79.5
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.1726	1.1984	1.1193
	Diameter, in.	1.39	1.41	1.39
	Height, in.	2.80	2.80	2.80
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.50	0.98	2.00
Back Pressure, tsf		6.63	6.13	5.13
Cell Pressure, tsf		7.13	7.11	7.13
Peak Deviator Stress, tsf		0.84	1.25	1.73
Total Pore Pr., tsf		6.64	6.37	5.92
Ultimate Deviator Stress, tsf		0.78	1.12	1.30
Total Pore Pr., tsf		6.62	6.30	5.95
Maj. Eff. Stress at Ultimate, tsf		1.30	1.93	2.47
Min. Eff. Stress at Ultimate, tsf		0.52	0.81	1.17

Type of Test:
CU with Pore Pressures
Sample Type: 5" Thinwall, Middle of sample
Description: FAT CLAY, brown (CH)

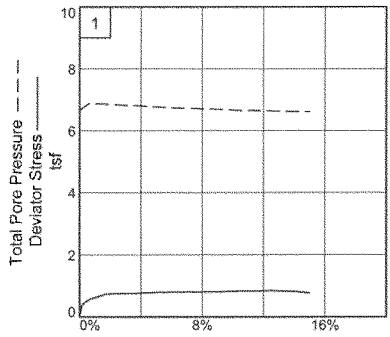
LL= 72 **PL=** 19 **PI=** 53
Specific Gravity= 2.70
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were satuated for 10 days and consolidated for 3 days.

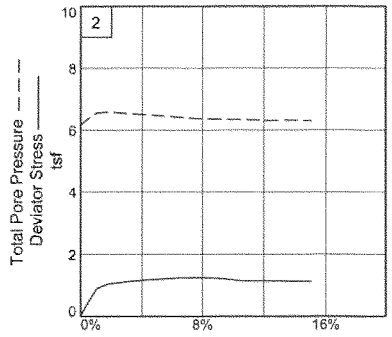
Client: USACE W912ES-11-P-0024

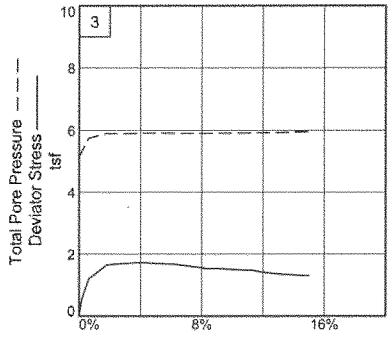
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Location: Wild Rice, Brenna Formation
Sample Number: Boring11-118MU, #2 **Depth:** 33-35'
Proj. No.: BL-10-10065 **Date Sampled:**

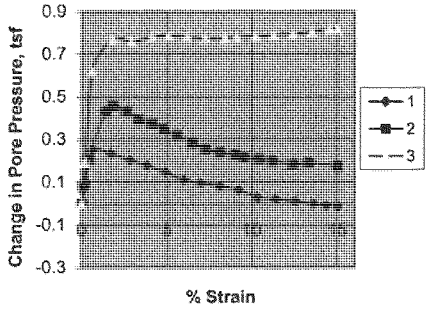
BRAUN INTERTEC

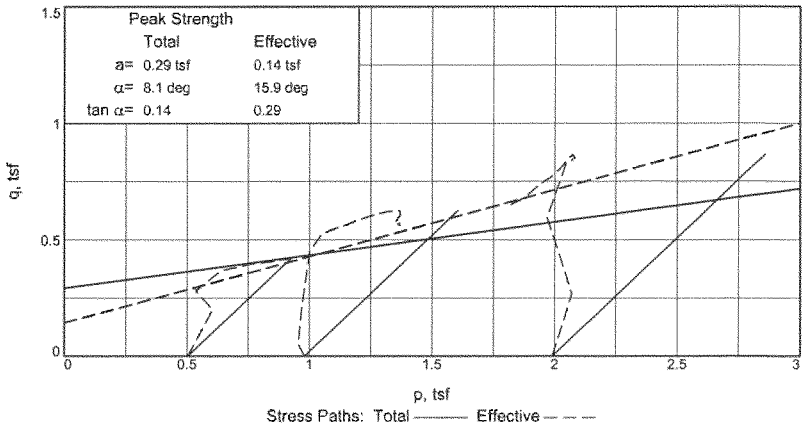
Figure Fargo-Moorhead Feasibility Report and Environmental Impact Statement Attachment I-4, pg 338
July 2011 Geotechnical Design and Geology











Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Location: Wild Rice, Brenna Formation **Depth:** 33-35' **Sample Number:** Boring11-118MU, #2
Project No. [illegible] **Figure**

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

5/15/2011
11:43 AM

Date:
Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Project No.: BL-10-10065
Location: Wild Rice, Brenna Formation
Depth: 33-35' **Sample Number:** Boring11-118MU, #2
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were satuated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.70 **LL=**72 **PL=**19 **PI=**53
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	141.240			155.300
Moisture content: Dry soil+tare, gms.	107.610			116.540
Moisture content: Tare, gms.	30.190			29.990
Moisture, %	43.4	43.4	43.4	44.8
Moist specimen weight, gms.	124.6			
Diameter, in.	1.39	1.39	1.39	
Area, in.²	1.52	1.52	1.52	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	111.3	111.3	111.3	
Dry density, pcf	77.6	77.6	77.6	
Void ratio	1.1726	1.1726	1.1726	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.134 tsf
Consolidation back pressure = 6.631 tsf
Consolidation effective confining stress = 0.503 tsf
Peak Stress = 0.844 tsf **at reading no.** 13
Ult. Stress = 0.777 tsf **at reading no.** 16

Test According to Specimen No.

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	0.0464	17.880	0.0	0.0	0.000	0.503	0.503	1.00	6.631	0.503	0.000
1	0.0511	26.420	8.5	0.2	0.403	0.404	0.807	2.00	6.730	0.606	0.202
2	0.0639	29.830	11.9	0.6	0.562	0.255	0.817	3.20	6.879	0.536	0.281
3	0.0941	33.730	15.8	1.7	0.737	0.270	1.007	3.73	6.864	0.639	0.369
4	0.1235	34.300	16.4	2.8	0.755	0.301	1.056	3.51	6.833	0.679	0.378
5	0.1538	34.740	16.9	3.8	0.767	0.326	1.093	3.35	6.808	0.710	0.384
6	0.1840	35.540	17.7	4.9	0.794	0.358	1.152	3.22	6.776	0.755	0.397
7	0.2137	35.900	18.0	6.0	0.802	0.393	1.195	3.04	6.741	0.794	0.401
8	0.2437	36.190	18.3	7.0	0.805	0.408	1.213	2.97	6.726	0.811	0.403
9	0.2743	36.520	18.6	8.1	0.810	0.423	1.233	2.92	6.711	0.828	0.405
10	0.3050	36.840	19.0	9.2	0.814	0.441	1.255	2.85	6.693	0.848	0.407
11	0.3352	37.520	19.6	10.3	0.833	0.474	1.307	2.76	6.660	0.891	0.417
12	0.3653	37.730	19.8	11.4	0.832	0.483	1.315	2.72	6.651	0.899	0.416
13	0.3959	38.270	20.4	12.5	0.844	0.493	1.337	2.71	6.641	0.915	0.422
14	0.4266	38.080	20.2	13.6	0.826	0.504	1.330	2.64	6.630	0.917	0.413
15	0.4462	37.900	20.0	14.3	0.812	0.514	1.326	2.58	6.620	0.920	0.406
16	0.4668	37.210	19.3	15.0	0.777	0.518	1.295	2.50	6.616	0.907	0.389

Parameters for Specimen No.2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	132.180			156.720
Moisture content: Dry soil+tare, gms.	100.700			119.370
Moisture content: Tare, gms.	30.480			30.160
Moisture, %	44.8	44.8	44.4	41.9
Moist specimen weight, gms.	126.7			
Diameter, in.	1.41	1.41	1.41	
Area, in.²	1.56	1.56	1.55	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	110.4	110.4	110.7	
Dry density, pcf	76.3	76.3	76.7	
Void ratio	1.2102	1.2102	1.1984	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No.2

Consolidation cell pressure = 7.111 tsf
Consolidation back pressure = 6.131 tsf
Consolidation effective confining stress = 0.980 tsf
Peak Stress = 1.249 tsf **at reading no.** 12
Ult. Stress = 1.125 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	0.0097	20.710	0.0	0.0	0.000	0.980	0.980	1.00	6.131	0.980	0.000
1	0.0125	22.970	2.3	0.1	0.105	0.902	1.007	1.12	6.209	0.954	0.052
2	0.0215	29.050	8.3	0.4	0.385	0.774	1.159	1.50	6.337	0.966	0.192
3	0.0403	40.400	19.7	1.1	0.902	0.550	1.452	2.64	6.561	1.001	0.451
4	0.0602	43.820	23.1	1.8	1.052	0.524	1.576	3.01	6.587	1.050	0.526
5	0.0811	44.930	24.2	2.6	1.094	0.550	1.644	2.99	6.561	1.097	0.547
6	0.1020	45.960	25.3	3.3	1.132	0.588	1.720	2.92	6.523	1.154	0.566
7	0.1238	46.900	26.2	4.1	1.164	0.607	1.771	2.92	6.504	1.189	0.582
8	0.1447	47.760	27.0	4.8	1.193	0.633	1.826	2.88	6.478	1.230	0.597
9	0.1670	48.590	27.9	5.6	1.219	0.663	1.882	2.84	6.448	1.273	0.610
10	0.1905	49.390	28.7	6.5	1.243	0.697	1.940	2.78	6.414	1.319	0.622
11	0.2136	49.790	29.1	7.3	1.249	0.728	1.977	2.72	6.383	1.353	0.625
12	0.2365	50.050	29.3	8.1	1.249	0.742	1.991	2.68	6.369	1.367	0.625
13	0.2605	49.920	29.2	9.0	1.232	0.753	1.985	2.64	6.358	1.369	0.616
14	0.2754	49.560	28.9	9.5	1.210	0.765	1.975	2.58	6.346	1.370	0.605
15	0.2994	48.530	27.8	10.4	1.156	0.773	1.929	2.50	6.338	1.351	0.578
16	0.3244	48.580	27.9	11.2	1.146	0.782	1.928	2.47	6.329	1.355	0.573
17	0.3560	48.910	28.2	12.4	1.145	0.797	1.942	2.44	6.314	1.370	0.573
18	0.3831	49.060	28.4	13.3	1.138	0.790	1.928	2.44	6.321	1.359	0.569
19	0.4300	49.270	28.6	15.0	1.125	0.806	1.931	2.40	6.305	1.368	0.562

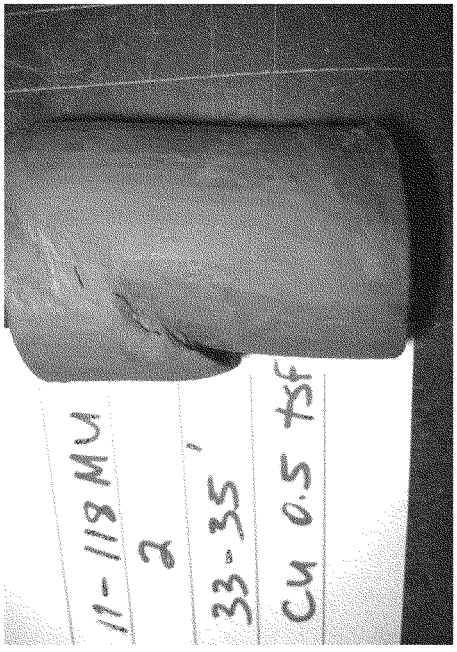
Parameters for Specimen No. 3

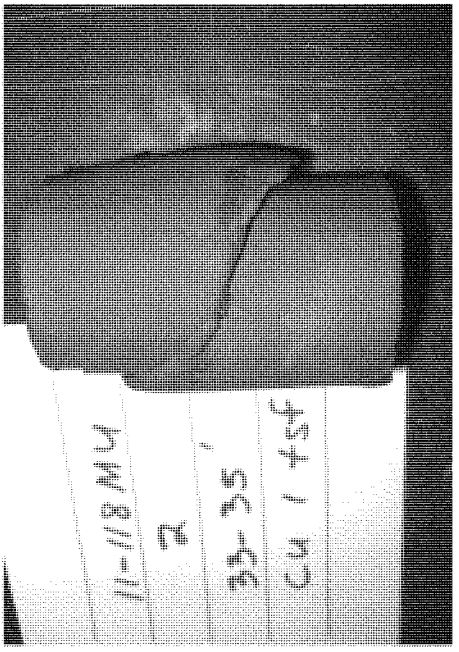
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	130.830			155.230
Moisture content: Dry soil+tare, gms.	101.690			118.650
Moisture content: Tare, gms.	31.220			30.610
Moisture, %	41.4	41.9	41.5	41.5
Moist specimen weight, gms.	125.7			
Diameter, in.	1.40	1.40	1.39	
Area, in.^{2}	1.53	1.53	1.52	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	111.8	112.2	112.5	
Dry density, pcf	79.1	79.1	79.5	
Void ratio	1.1307	1.1307	1.1193	
Saturation, %	98.7	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.126 tsf
Consolidation back pressure = 5.135 tsf
Consolidation effective confining stress = 1.991 tsf
Peak Stress = 1.730 tsf **at reading no.** 5
Ult. Stress = 1.298 tsf **at reading no.** 16

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	0.0464	17.970	0.0	0.0	0.000	1.991	1.991	1.00	5.135	1.991	0.000
1	0.0512	29.400	11.4	0.2	0.539	1.801	2.340	1.30	5.325	2.071	0.270
2	0.0638	43.360	25.4	0.6	1.193	1.373	2.566	1.87	5.753	1.969	0.596
3	0.0960	53.430	35.5	1.8	1.647	1.222	2.869	2.35	5.904	2.045	0.823
4	0.1284	55.010	37.0	2.9	1.700	1.233	2.933	2.38	5.893	2.083	0.850
5	0.1598	56.120	38.1	4.1	1.730	1.210	2.940	2.43	5.916	2.075	0.865
6	0.1890	55.760	37.8	5.1	1.695	1.206	2.901	2.41	5.920	2.054	0.848
7	0.2195	55.790	37.8	6.2	1.677	1.210	2.887	2.39	5.916	2.049	0.839
8	0.2506	54.690	36.7	7.3	1.609	1.217	2.826	2.32	5.909	2.022	0.805
9	0.2812	53.270	35.3	8.4	1.529	1.215	2.744	2.26	5.911	1.979	0.764
10	0.3019	53.590	35.6	9.1	1.530	1.213	2.743	2.26	5.913	1.978	0.765
11	0.3313	53.300	35.3	10.2	1.500	1.207	2.707	2.24	5.919	1.957	0.750
12	0.3616	53.240	35.3	11.3	1.479	1.202	2.681	2.23	5.924	1.942	0.740
13	0.3921	51.540	33.6	12.4	1.391	1.196	2.587	2.16	5.930	1.891	0.695
14	0.4235	50.780	32.8	13.5	1.342	1.187	2.529	2.13	5.939	1.858	0.671
15	0.4530	50.380	32.4	14.5	1.309	1.172	2.481	2.12	5.954	1.827	0.655
16	0.4659	50.280	32.3	15.0	1.298	1.172	2.470	2.11	5.954	1.821	0.649


11-118 MW
2
33-35'
CH 0.5 tsf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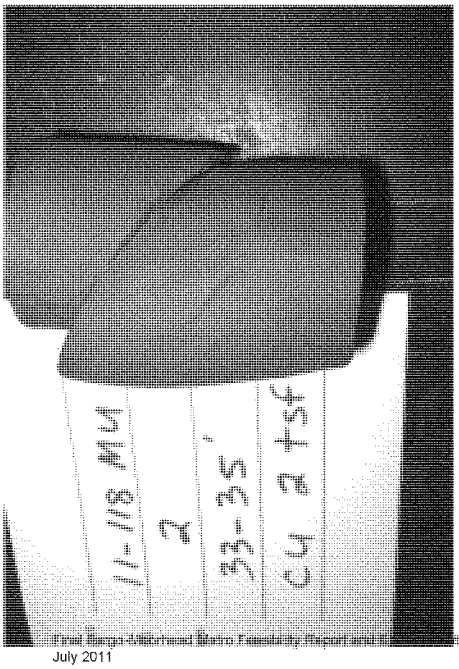
2
33-35'
CH 1 tsf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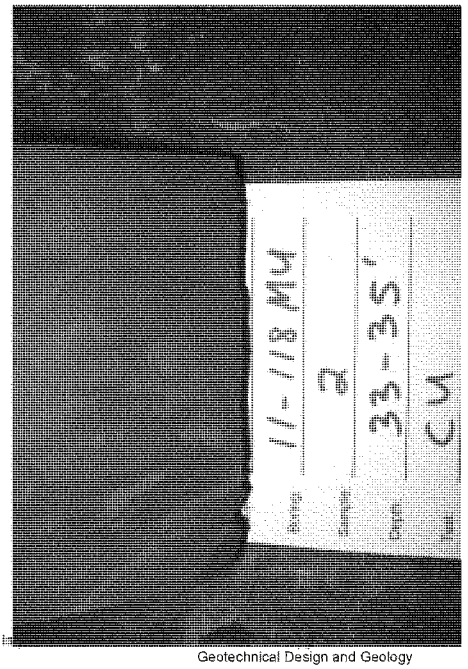
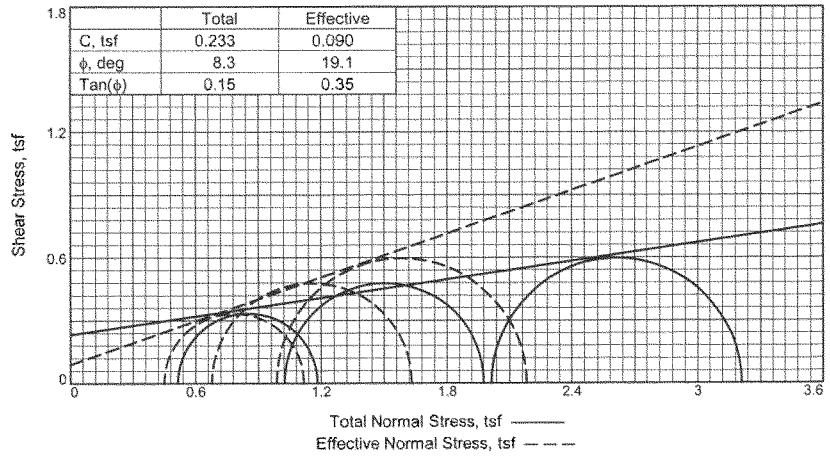
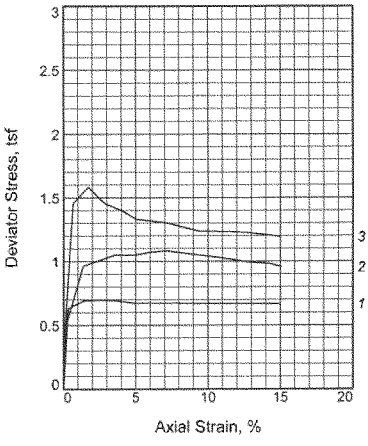
2
33-35'
CH 2 tsf


11-118 MW
2
33-35'
CH





Sample No.		1	2	3
Initial	Water Content, %	46.4	45.5	40.4
	Dry Density, pcf	73.0	75.7	80.4
	Saturation, %	95.4	100.0	99.4
	Void Ratio	1.3132	1.2298	1.0998
	Diameter, in.	1.39	1.40	1.39
	Height, in.	2.80	2.81	2.80
At Test	Water Content, %	48.6	45.3	39.8
	Dry Density, pcf	73.0	75.9	81.3
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.3132	1.2250	1.0773
	Diameter, in.	1.39	1.40	1.39
	Height, in.	2.80	2.81	2.79
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.52	1.02	2.02
Back Pressure, tsf		6.63	6.12	5.12
Cell Pressure, tsf		7.15	7.14	7.14
Peak Deviator Stress, tsf		0.70	1.08	1.58
Total Pore Pr., tsf		6.82	6.48	5.94
Ultimate Deviator Stress, tsf		0.67	0.96	1.19
Total Pore Pr., tsf		6.70	6.46	6.15
Maj. Eff. Stress at Ultimate, tsf		1.12	1.63	2.18
Min. Eff. Stress at Ultimate, tsf		0.45	0.68	0.99

Type of Test:
CU with Pore Pressures
Sample Type: 5" Thinwall, Middle of sample
Description: FAT CLAY, brown (CH)

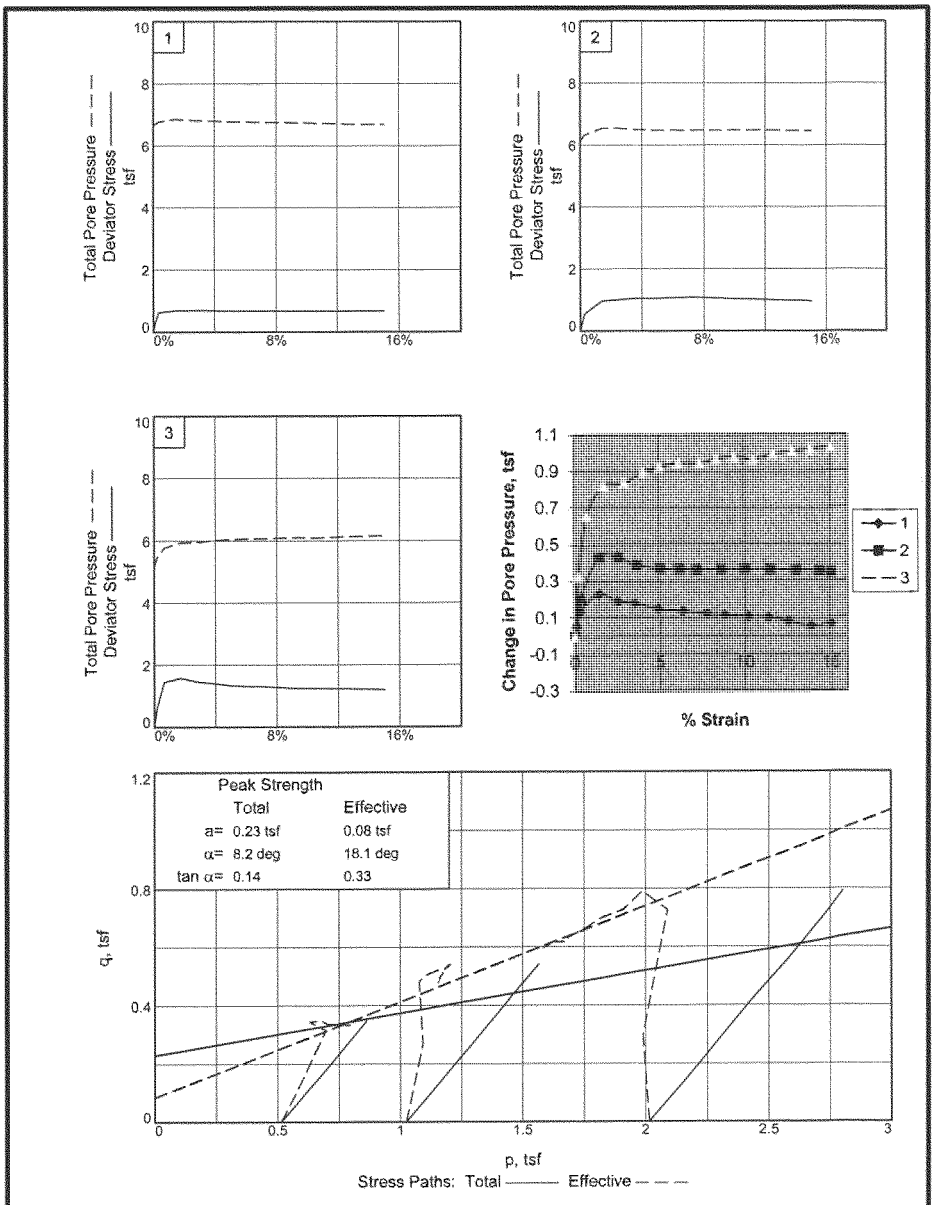
LL= 56 **PL=** 19 **PI=** 37
Specific Gravity= 2.704
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: Fargo Pile Load Test, Brenna Formation
Sample Number: Boring11-119MU, #1 **Depth:** 30-32'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Figure C-3 Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement July 2011



Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Loc.: Fargo Pile Load Test, Brenna Formation **Depth:** 30-32' **Sample No.:** Boring11-119MU, #1

Project No.: BL-10-10065 **Figure**

Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST 5/30/2011
CU with Pore Pressures 12:17 PM

Date:
Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Project No.: BL-10-10065
Location: Fargo Pile Load Test, Brenna Formation
Depth: 30-32' **Sample Number:** Boring11-119MU, #1
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.704 **LL=**56 **PL=**19 **PI=**37
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	137.720			150.030
Moisture content: Dry soil+tare, gms.	103.720			109.010
Moisture content: Tare, gms.	30.369			30.350
Moisture, %	46.4	48.6	48.6	52.1
Moist specimen weight, gms.	119.6			
Diameter, in.	1.39	1.39	1.39	
Area, in.²	1.52	1.52	1.52	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	106.8	108.4	108.4	
Dry density, pcf	73.0	73.0	73.0	
Void ratio	1.3132	1.3132	1.3132	
Saturation, %	95.4	100.0	100.0	

Test Conditions for Specimen No. 1

Consolidation cell pressure = 7.147 tsf
Consolidation back pressure = 6.632 tsf
Consolidation effective confining stress = 0.515 tsf
Peak Stress = 0.697 tsf **at reading no.** 4
Ult. Stress = 0.668 tsf **at reading no.** 14

Test Specimen No. 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	0.0494	18.500	0.0	0.0	0.000	0.515	0.515	1.00	6.632	0.515	0.000
1	0.0519	24.100	5.6	0.1	0.265	0.462	0.727	1.57	6.685	0.594	0.132
2	0.0589	31.900	13.4	0.3	0.632	0.380	1.012	2.66	6.767	0.696	0.316
3	0.0891	33.300	14.8	1.4	0.690	0.286	0.976	3.41	6.861	0.631	0.345
4	0.1183	33.600	15.1	2.5	0.697	0.325	1.022	3.14	6.822	0.673	0.348
5	0.1470	33.700	15.2	3.5	0.694	0.335	1.029	3.07	6.812	0.682	0.347
6	0.1871	33.500	15.0	4.9	0.675	0.365	1.040	2.85	6.782	0.702	0.337
7	0.2262	33.700	15.2	6.3	0.674	0.379	1.053	2.78	6.768	0.716	0.337
8	0.2662	33.950	15.5	7.7	0.674	0.393	1.067	2.72	6.754	0.730	0.337
9	0.2970	34.100	15.6	8.8	0.673	0.400	1.073	2.68	6.747	0.736	0.336
10	0.3359	34.300	15.8	10.2	0.671	0.410	1.081	2.64	6.737	0.746	0.336
11	0.3665	34.500	16.0	11.3	0.671	0.415	1.086	2.62	6.732	0.751	0.336
12	0.3967	34.680	16.2	12.4	0.671	0.435	1.106	2.54	6.712	0.770	0.335
13	0.4369	34.910	16.4	13.8	0.669	0.461	1.130	2.45	6.686	0.796	0.335
14	0.4700	35.100	16.6	15.0	0.668	0.449	1.117	2.49	6.698	0.783	0.334

Properties for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	134.750			155.370
Moisture content: Dry soil+tare, gms.	101.990			116.570
Moisture content: Tare, gms.	29.960			30.510
Moisture, %	45.5	45.5	45.3	45.1
Moist specimen weight, gms.	125.6			
Diameter, in.	1.40	1.40	1.40	
Area, in.^{2}	1.55	1.55	1.54	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	110.1	110.1	110.2	
Dry density, pcf	75.7	75.7	75.9	
Void ratio	1.2298	1.2298	1.2250	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.142 tsf
Consolidation back pressure = 6.118 tsf
Consolidation effective confining stress = 1.024 tsf
Peak Stress = 1.082 tsf **at reading no.** 7
Ult. Stress = 0.956 tsf **at reading no.** 13

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	0.0511	21.870	0.0	0.0	0.000	1.024	1.024	1.00	6.118	1.024	0.000
1	0.0589	33.420	11.6	0.3	0.537	0.824	1.361	1.65	6.318	1.093	0.269
2	0.0901	42.800	20.9	1.4	0.963	0.596	1.559	2.62	6.546	1.077	0.481
3	0.1201	43.970	22.1	2.5	1.005	0.595	1.600	2.69	6.547	1.098	0.503
4	0.1508	45.180	23.3	3.6	1.049	0.638	1.687	2.64	6.504	1.162	0.524
5	0.1909	45.560	23.7	5.0	1.050	0.656	1.706	2.60	6.486	1.181	0.525
6	0.2211	46.350	24.5	6.1	1.073	0.658	1.731	2.63	6.484	1.194	0.536
7	0.2516	46.860	25.0	7.1	1.082	0.664	1.746	2.63	6.478	1.205	0.541
8	0.2919	46.770	24.9	8.6	1.062	0.663	1.725	2.60	6.479	1.194	0.531
9	0.3311	46.660	24.8	10.0	1.041	0.660	1.701	2.58	6.482	1.180	0.520
10	0.3721	46.570	24.7	11.4	1.020	0.664	1.684	2.54	6.478	1.174	0.510
11	0.4125	46.300	24.4	12.9	0.993	0.665	1.658	2.49	6.477	1.161	0.496
12	0.4527	46.410	24.5	14.3	0.981	0.671	1.652	2.46	6.471	1.161	0.490
13	0.4735	46.000	24.1	15.0	0.956	0.677	1.633	2.41	6.465	1.155	0.478

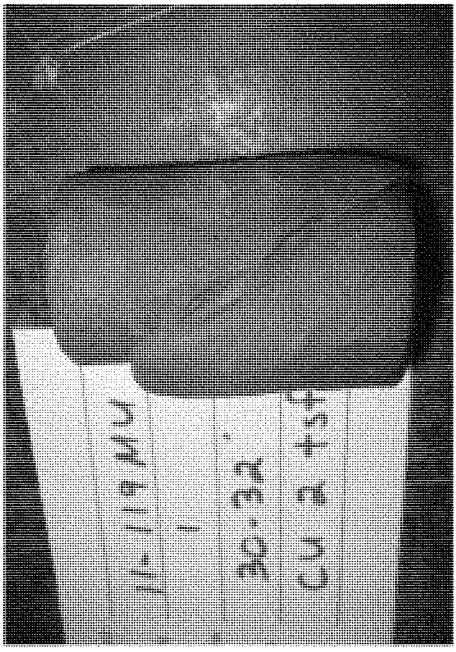
Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	135.190			155.660
Moisture content: Dry soil+tare, gms.	105.020			120.450
Moisture content: Tare, gms.	30.410			31.330
Moisture, %	40.4	40.7	39.8	39.5
Moist specimen weight, gms.	125.9			
Diameter, in.	1.39	1.39	1.39	
Area, in.^{2}	1.52	1.52	1.51	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	112.9	113.1	113.6	
Dry density, pcf	80.4	80.4	81.3	
Void ratio	1.0998	1.0998	1.0773	
Saturation, %	99.4	100.0	100.0	

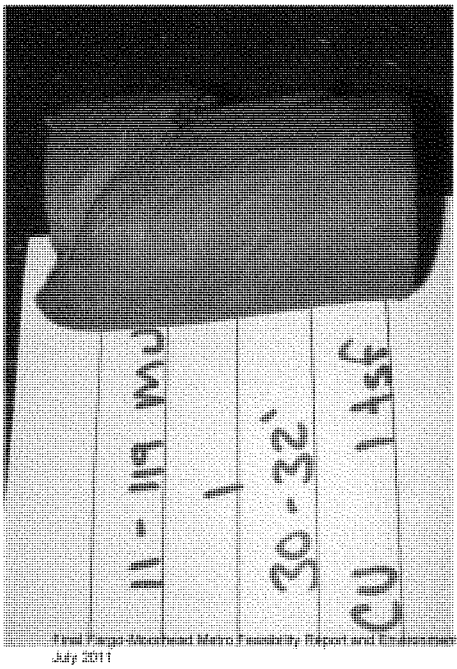
Test Readings for Specimen No. 3

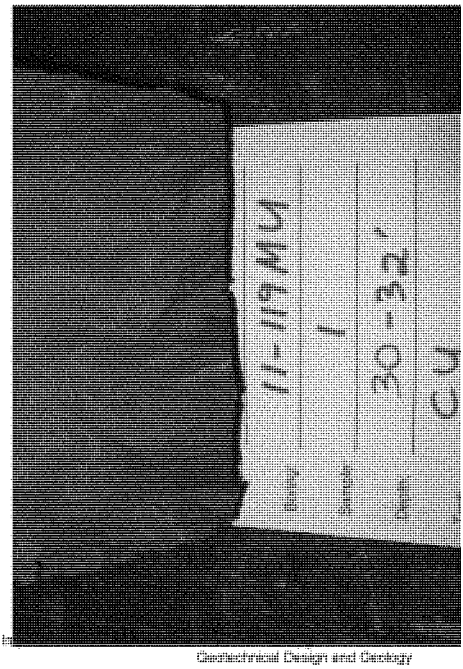
Consolidation cell pressure = 7.137 tsf
Consolidation back pressure = 5.121 tsf
Consolidation effective confining stress = 2.016 tsf
Peak Stress = 1.582 tsf **at reading no.** 3
Ult. Stress = 1.194 tsf **at reading no.** 15

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	0.0493	18.260	0.0	0.0	0.000	2.016	2.016	1.00	5.121	2.016	0.000
1	0.0541	30.750	12.5	0.2	0.596	1.692	2.288	1.35	5.445	1.990	0.298
2	0.0677	48.860	30.6	0.7	1.453	1.364	2.817	2.07	5.773	2.090	0.726
3	0.0972	51.940	33.7	1.7	1.582	1.197	2.779	2.32	5.940	1.988	0.791
4	0.1293	49.580	31.3	2.9	1.454	1.183	2.637	2.23	5.954	1.910	0.727
5	0.1597	48.820	30.6	4.0	1.403	1.121	2.524	2.25	6.016	1.822	0.701
6	0.1899	47.580	29.3	5.0	1.331	1.093	2.424	2.22	6.044	1.758	0.665
7	0.2203	47.600	29.3	6.1	1.316	1.072	2.388	2.23	6.065	1.730	0.658
8	0.2517	47.570	29.3	7.3	1.299	1.073	2.372	2.21	6.064	1.723	0.650
9	0.2821	47.170	28.9	8.3	1.266	1.052	2.318	2.20	6.085	1.685	0.633
10	0.3117	46.800	28.5	9.4	1.236	1.038	2.274	2.19	6.099	1.656	0.618
11	0.3412	47.140	28.9	10.5	1.236	1.052	2.288	2.17	6.085	1.670	0.618
12	0.3727	47.470	29.2	11.6	1.234	1.025	2.259	2.20	6.112	1.642	0.617
13	0.4030	47.630	29.4	12.7	1.226	1.010	2.236	2.21	6.127	1.623	0.613
14	0.4334	47.690	29.4	13.8	1.213	0.997	2.210	2.22	6.140	1.603	0.606
15	0.4680	47.660	29.4	15.0	1.194	0.986	2.180	2.21	6.151	1.583	0.597


11 - 119 MW
1
29 - 32'
30 ± 5'

11 - 119 MW
1
29 - 32'
30 ± 5'

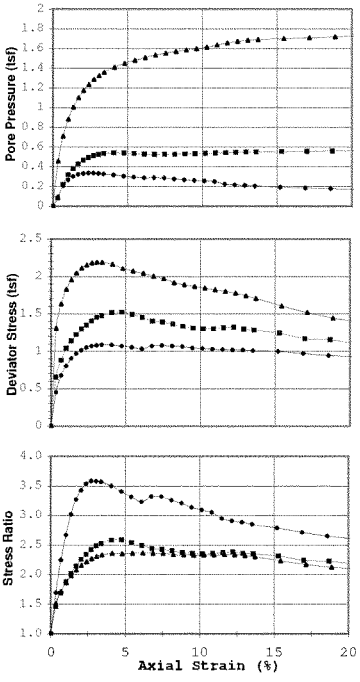

11 - 119 MW
1
29 - 32'
CU 1 ± 5'


11 - 119 MW
1
29 - 32'
CU

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

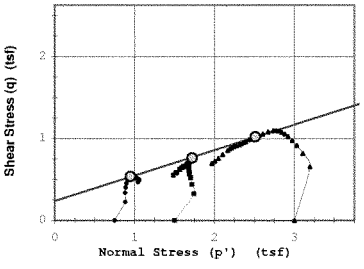
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-79MU Fargo Sample #: 2 Type: 5T Depth (ft): 40 - 42 (Mid-Top)
Soil Type: Fat Clay w/a few pieces of Gravel & a few pockets of Silt (CH) Argusville

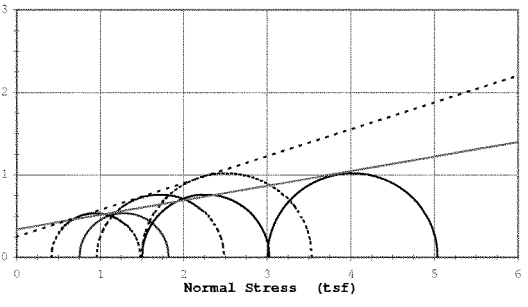


Failure Criterion:	Max. Stress Ratio				
Angle of internal friction, ϕ' =	18.1 °				
Apparent Cohesion, c' =	0.25 (tsf)				
Test Date: 8/13/10		Liquid Limit:	83.0		
Test Type: CU w/pp		Plastic Limit:	25.2		
Strain Rate (in/min): 0.0039		Plasticity Index:	57.8		
Strain Rate (%/min): 0.132		Spec. Gravity (Assumed):	2.78		
Before Consolidation	A	B	C	D	E
Diameter (in)	1.45	1.45	1.45		
Height (in)	3.00	3.00	3.00		
Water Content (%)	44.0	43.7	45.1		
Dry Density (pcf)	76.1	76.0	75.2		
Void Ratio	1.28	1.28	1.31		
After Consolidation					
Diameter (in)	1.44	1.43	1.42		
Height (in)	2.96	2.94	2.91		
Water Content (%)	43.8	42.5	41.1		
Dry Density (pcf)	78.2	79.6	81.0		
Void Ratio	1.22	1.18	1.14		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	0.75	1.50	3.00		
Max. Deviator Stress (tsf)	1.08	1.52	2.19		
Ultimate Deviator Stress (tsf)	0.93	1.10	1.39		
Deviator Stress at Failure (tsf)	1.07	1.52	2.04		
Max. Pore Pressure Buildup (tsf)	0.34	0.56	1.73		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	2.7	4.8	6.2		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





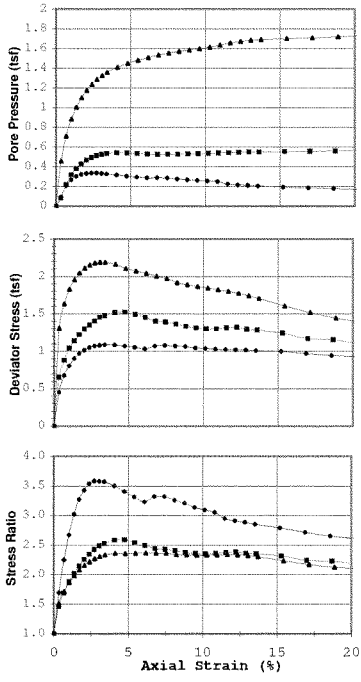
Rupture Envelope at Failure
α = 17.2 ° a = 0.2 (tsf)

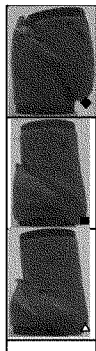
---------- Effective ϕ': 18.1 ° c'= 0.25 (tsf)
_____ Total ϕ': 10.0 ° c= 0.34 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-79MU Fargo Sample #: 2 Type: 5T Depth (ft): 40 - 42 (Mid-Top)
Soil Type: Fat Clay w/a few pieces of Gravel & a few pockets of Silt (CH) Argusville

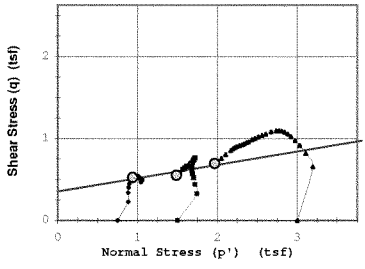


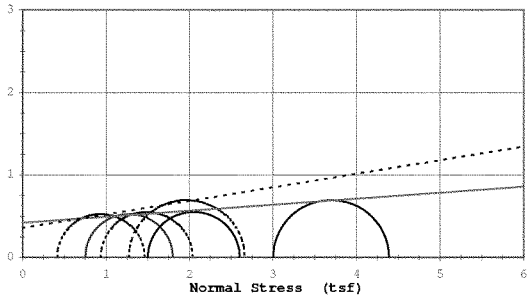


Failure Criterion:	Max. Pore Pressure				
Angle of internal friction, ϕ' =	9.3 °				
Apparent Cohesion, c' =	0.36 (tsf)				
Test Date: 8/13/10		Liquid Limit:	83.0		
Test Type: CU w/pp		Plastic Limit:	25.2		
Strain Rate (in/min): 0.0039		Plasticity Index:	57.8		
Strain Rate (%/min): 0.132		Spec. Gravity (Assumed):	2.78		
Before Consolidation	A	B	C	D	E
Diameter (in)	1.45	1.45	1.45		
Height (in)	3.00	3.00	3.00		
Water Content (%)	44.0	43.7	45.1		
Dry Density (pcf)	76.1	76.0	75.2		
Void Ratio	1.28	1.28	1.31		
After Consolidation					
Diameter (in)	1.44	1.43	1.42		
Height (in)	2.96	2.94	2.91		
Water Content (%)	43.8	42.5	41.1		
Dry Density (pcf)	78.2	79.6	81.0		
Void Ratio	1.22	1.18	1.14		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	0.75	1.50	3.00		
Max. Deviator Stress (tsf)	1.08	1.52	2.19		
Ultimate Deviator Stress (tsf)	0.93	1.10	1.39		
Deviator Stress at Failure (tsf)	1.05	1.10	1.39		
Max. Pore Pressure Buildup (tsf)	0.34	0.56	1.73		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	2.4	20.4	20.6		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





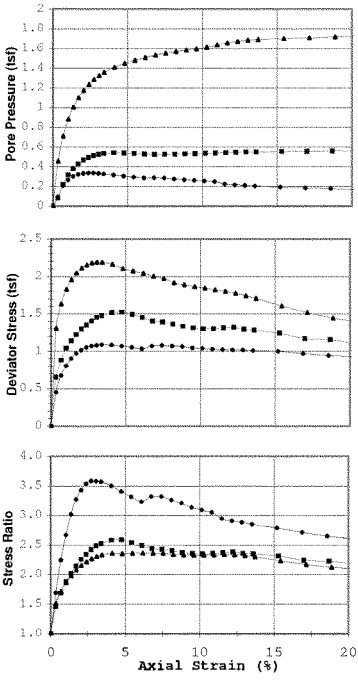
Rupture Envelope at Failure			
α = 9.2 °	a = 0.4 (tsf)		

----------	Effective ϕ': 9.3 °	c'=	0.36 (tsf)
_____	Total ϕ': 4.2 °	c=	0.42 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-79MU Fargo Sample #: 2 Type: ST Depth (ft): 40 - 42 (Mid-Top)
Soil Type: Fat Clay w/a few pieces of Gravel & a few pockets of Silt (CH) Argusville



Failure Criterion:	Max. Deviator Stress				
Angle of internal friction, ϕ' =	17.9 °				
Apparent Cohesion, c' =	0.25 (tsf)				
Test Date: 8/13/10			Liquid Limit:		83.0
Test Type: CU w/pp			Plastic Limit:		25.2
Strain Rate (in/min): 0.0039			Plasticity Index:		57.8
Strain Rate (%/min): 0.132			Spec. Gravity (Assumed):		2.78
Before Consolidation	A	B	C	D	E
Diameter (in)	1.45	1.45	1.45		
Height (in)	3.00	3.00	3.00		
Water Content (%)	44.0	43.7	45.1		
Dry Density (pcf)	76.1	76.0	75.2		
Void Ratio	1.28	1.28	1.31		
After Consolidation					
Diameter (in)	1.44	1.43	1.42		
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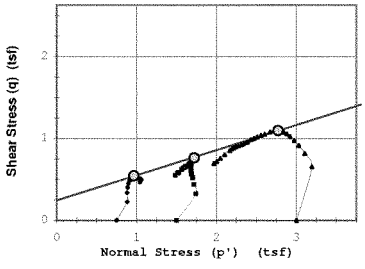
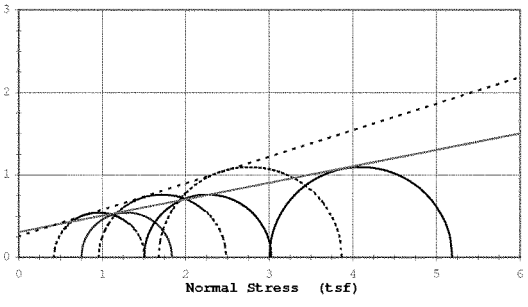
Minor Principal Stress (tsf)	0.75	1.50	3.00		
Max. Deviator Stress (tsf)	1.08	1.52	2.19		
Ultimate Deviator Stress (tsf)	0.93	1.10	1.39		
Deviator Stress at Failure (tsf)	1.08	1.52	2.19		
Max. Pore Pressure Buildup (tsf)	0.34	0.56	1.73		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	3.4	4.8	3.1		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





Rupture Envelope at Failure
α = 17.0 ° a = 0.2 (tsf)

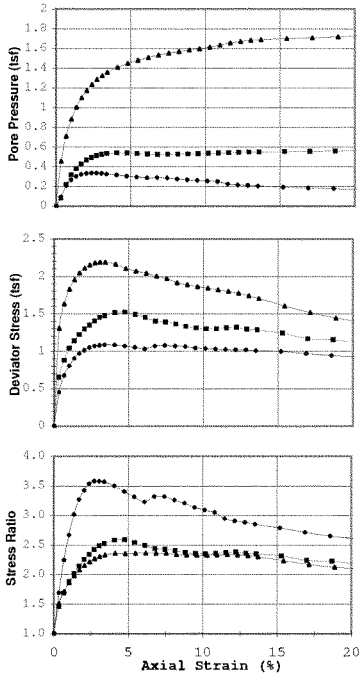
---------- Effective ϕ': 17.9 ° c'= 0.25 (tsf)
_____ Total ϕ': 11.3 ° c= 0.31 (tsf)

9301 Bryant Ave. South Suite #107 Bloomington, Minnesota 55420-3436
OIL ENGINEERING TESTING, INC.

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-79MU Fargo Sample #: 2 Type: 5T Depth (ft): 40 - 42 (Mid-Top)
Soil Type: Fat Clay w/a few pieces of Gravel & a few pockets of Silt (CH) Argusville

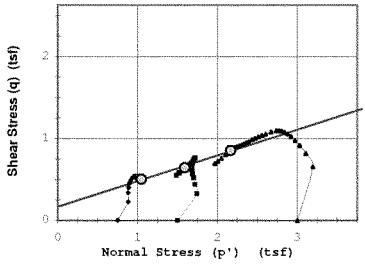


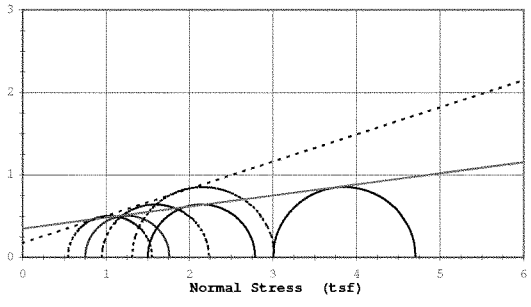
Failure Criterion:	Given Strain of: 15%
Angle of internal friction, ϕ' =	18.2 °
Apparent Cohesion, c' =	0.17 (tsf)
Test Date: 8/13/10	Liquid Limit: 83.0
Test Type: CU w/pp	Plastic Limit: 25.2
Strain Rate (in/min): 0.0039	Plasticity Index: 57.8
Strain Rate (%/min): 0.132	Spec. Gravity (Assumed): 2.78

Before Consolidation	A	B	C	D	E
Diameter (in)	1.45	1.45	1.45		
Height (in)	3.00	3.00	3.00		
Water Content (%)	44.0	43.7	45.1		
Dry Density (pcf)	76.1	76.0	75.2		
Void Ratio	1.28	1.28	1.31		
After Consolidation					
Diameter (in)	1.44	1.43	1.42		
Height (in)	2.96	2.94	2.91		
Water Content (%)	43.8	42.5	41.1		
Dry Density (pcf)	78.2	79.6	81.0		
Void Ratio	1.22	1.18	1.14		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	0.75	1.50	3.00		
Max. Deviator Stress (tsf)	1.08	1.52	2.19		
Ultimate Deviator Stress (tsf)	0.93	1.10	1.39		
Deviator Stress at Failure (tsf)	1.01	1.28	1.71		
Max. Pore Pressure Buildup (tsf)	0.34	0.56	1.73		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	15.0	15.0	15.0		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





Rupture Envelope at Failure	
α = 17.4 °	a = 0.2 (tsf)

----------	Effective ϕ': 18.2 °	c'=	0.17 (tsf)
_____	Total ϕ': 7.6 °	c=	0.35 (tsf)

9301 Bryant Ave. South Suite #107 Bloomington, Minnesota 55420-3436

Job No.: 7577

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095 Test Type: CU w/pp

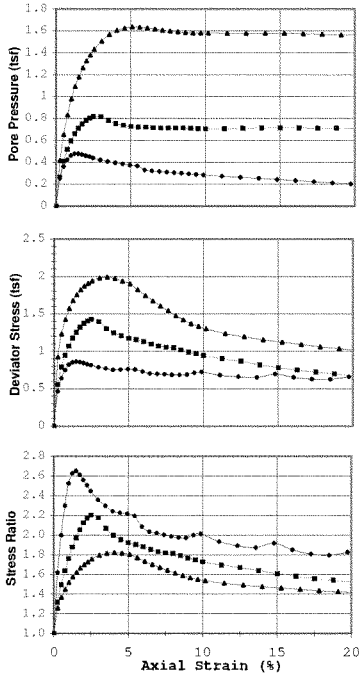
Boring No.: 10-79MU, Sample No.: 2, Depth (ft.): 40 - 42 (Mid-Top)

Sample 1			Sample 2			Sample 3		
Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.34	0.45	0.09	0.34	0.65	0.08	0.34	1.31	0.46
0.68	0.68	0.21	0.68	0.88	0.22	0.69	1.63	0.71
1.01	0.80	0.27	1.02	1.04	0.32	1.03	1.83	0.88
1.35	0.90	0.30	1.36	1.14	0.38	1.37	1.96	1.01
1.69	0.97	0.32	1.70	1.22	0.43	1.72	2.05	1.10
2.03	1.01	0.33	2.04	1.30	0.47	2.06	2.11	1.17
2.36	1.05	0.34	2.38	1.35	0.49	2.40	2.15	1.23
2.70	1.07	0.34	2.72	1.40	0.51	2.75	2.18	1.28
3.04	1.08	0.33	3.06	1.45	0.53	3.09	2.19	1.32
3.38	1.08	0.33	3.40	1.48	0.53	3.43	2.19	1.36
4.05	1.08	0.32	4.08	1.52	0.54	4.12	2.16	1.41
4.73	1.07	0.31	4.76	1.52	0.54	4.80	2.10	1.45
5.40	1.05	0.30	5.44	1.49	0.54	5.49	2.07	1.48
6.08	1.03	0.29	6.12	1.45	0.53	6.18	2.04	1.51
6.75	1.07	0.29	6.80	1.40	0.53	6.86	2.00	1.53
7.43	1.08	0.29	7.48	1.39	0.53	7.55	1.97	1.55
8.10	1.07	0.28	8.16	1.36	0.53	8.23	1.92	1.57
8.78	1.06	0.27	8.84	1.33	0.53	8.92	1.89	1.58
9.45	1.04	0.26	9.52	1.31	0.53	9.61	1.86	1.60
10.13	1.04	0.26	10.20	1.30	0.54	10.29	1.84	1.61
10.81	1.03	0.25	10.88	1.30	0.54	10.98	1.82	1.63
11.48	1.02	0.23	11.56	1.31	0.54	11.67	1.80	1.66
12.16	1.02	0.22	12.24	1.32	0.55	12.35	1.78	1.67
12.83	1.01	0.21	12.92	1.29	0.55	13.04	1.74	1.68
13.51	1.01	0.21	13.60	1.28	0.55	13.72	1.71	1.69
15.19	1.00	0.19	15.30	1.24	0.55	15.44	1.60	1.70
16.88	0.97	0.19	16.99	1.17	0.56	17.15	1.51	1.71
18.57	0.94	0.18	18.70	1.15	0.56	18.87	1.44	1.72
20.26	0.93	0.17	20.39	1.10	0.56	20.58	1.39	1.73

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 3 Type: 5T Depth (ft): 55 - 57 (Top)
Soil Type: Fat Clay w/a few pieces of Gravel, a few pockets of Silt (CH) Argusville

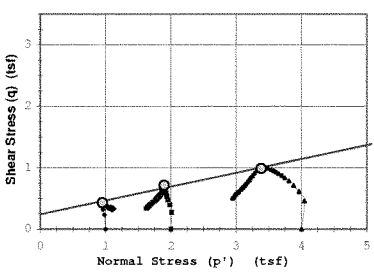


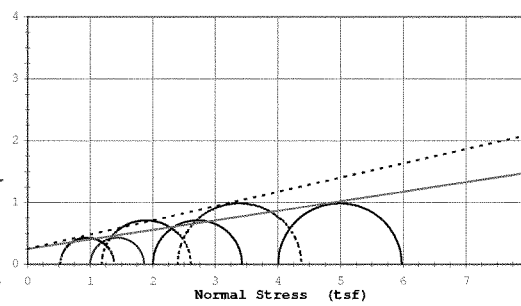
Failure Criterion:	Max. Stress Ratio		
Angle of internal friction, ϕ' =	13.0 °		
Apparent Cohesion, c' =	0.25 (tsf)		
Test Date:	8/24/10	Liquid Limit:	78.1
Test Type:	CU w/pp	Plastic Limit:	26.8
Strain Rate (in/min):	0.0039	Plasticity Index:	51.3
Strain Rate (%/min):	0.096	Spec. Gravity (Assumed):	2.78

Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	47.4	49.2	51.1		
Dry Density (pcf)	73.7	72.2	70.8		
Void Ratio	1.35	1.40	1.45		
After Consolidation					
Diameter (in)	1.92	1.91	1.88		
Height (in)	4.05	3.99	3.93		
Water Content (%)	46.2	45.5	43.7		
Dry Density (pcf)	75.9	76.6	78.4		
Void Ratio	1.29	1.26	1.21		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	0.86	1.42	1.99		
Ultimate Deviator Stress (tsf)	0.66	0.67	1.01		
Deviator Stress at Failure (tsf)	0.86	1.42	1.97		
Max. Pore Pressure Buildup (tsf)	0.48	0.82	1.64		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	1.5	2.5	4.1		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





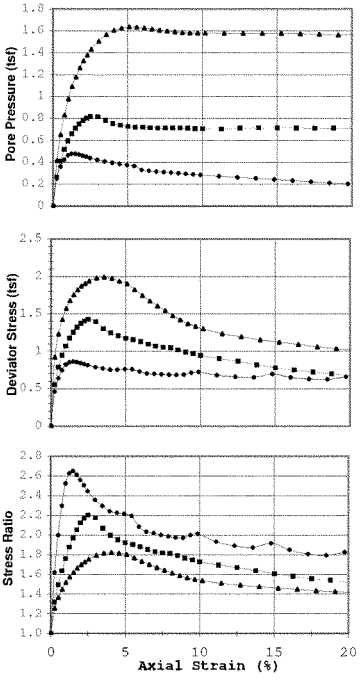
Rupture Envelope at Failure	
α = 12.7 °	a = 0.2 (tsf)

----------	Effective ϕ': 13.0 °	c'=	0.25 (tsf)
_____	Total ϕ': 8.8 °	c=	0.25 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

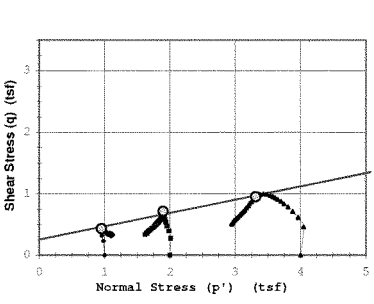
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 3 Type: 5T Depth (ft): 55 - 57 (Top)
Soil Type: Fat Clay w/a few pieces of Gravel, a few pockets of Silt (CH) Argusville

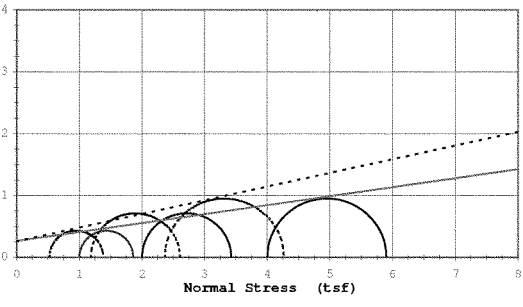


Failure Criterion:	Max. Pore Pressure				
Angle of internal friction, ϕ' =	12.5 °				
Apparent Cohesion, c' =	0.26 (tsf)				
Test Date: 8/24/10		Liquid Limit:	78.1		
Test Type: CU w/pp		Plastic Limit:	26.8		
Strain Rate (in/min): 0.0039		Plasticity Index:	51.3		
Strain Rate (%/min): 0.096		Spec. Gravity (Assumed):	2.78		
Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	47.4	49.2	51.1		
Dry Density (pcf)	73.7	72.2	70.8		
Void Ratio	1.35	1.40	1.45		
After Consolidation					
Diameter (in)	1.92	1.91	1.88		
Height (in)	4.05	3.99	3.93		
Water Content (%)	46.2	45.5	43.7		
Dry Density (pcf)	75.9	76.6	78.4		
Void Ratio	1.29	1.26	1.21		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	0.86	1.42	1.99		
Ultimate Deviator Stress (tsf)	0.66	0.67	1.01		
Deviator Stress at Failure (tsf)	0.86	1.42	1.90		
Max. Pore Pressure Buildup (tsf)	0.48	0.82	1.64		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	1.5	2.5	5.1		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





Rupture Envelope at Failure			
α = 12.2 °	a = 0.3 (tsf)		

----------	Effective ϕ':	12.5 °	c'=	0.26 (tsf)
_____	Total ϕ':	8.2 °	c=	0.27 (tsf)

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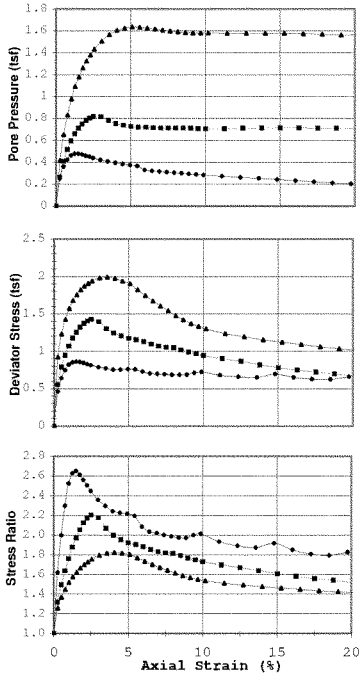
TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 3 Type: 5T Depth (ft): 55 - 57 (Top)
Soil Type: Fat Clay w/a few pieces of Gravel, a few pockets of Silt (CH) Argusville



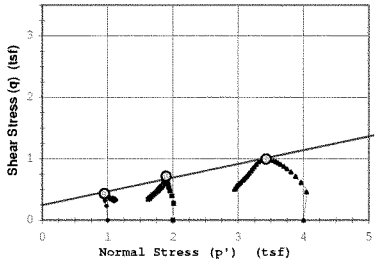
Failure Criterion:	Max. Deviator Stress
Angle of internal friction, ϕ' =	12.9 °
Apparent Cohesion, c' =	0.25 (tsf)
Test Date: 8/24/10	Liquid Limit: 78.1
Test Type: CU w/pp	Plastic Limit: 26.8
Strain Rate (in/min): 0.0039	Plasticity Index: 51.3
Strain Rate (%/min): 0.096	Spec. Gravity (Assumed): 2.78

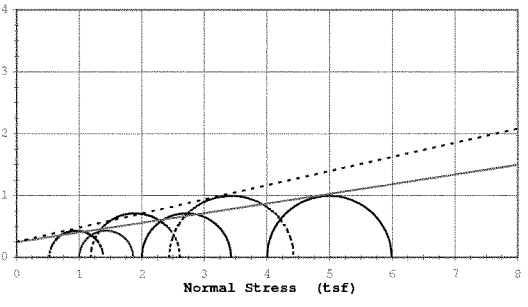
Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	47.4	49.2	51.1		
Dry Density (pcf)	73.7	72.2	70.8		
Void Ratio	1.35	1.40	1.45		
After Consolidation					
Diameter (in)	1.92	1.91	1.88		
Height (in)	4.05	3.99	3.93		
Water Content (%)	46.2	45.5	43.7		
Dry Density (pcf)	75.9	76.6	78.4		
Void Ratio	1.29	1.26	1.21		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	0.86	1.42	1.99		
Ultimate Deviator Stress (tsf)	0.66	0.67	1.01		
+ Deviator Stress at Failure (tsf)	0.86	1.42	1.99		
Max. Pore Pressure Buildup (tsf)	0.48	0.82	1.64		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	1.5	2.5	3.6		

X

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





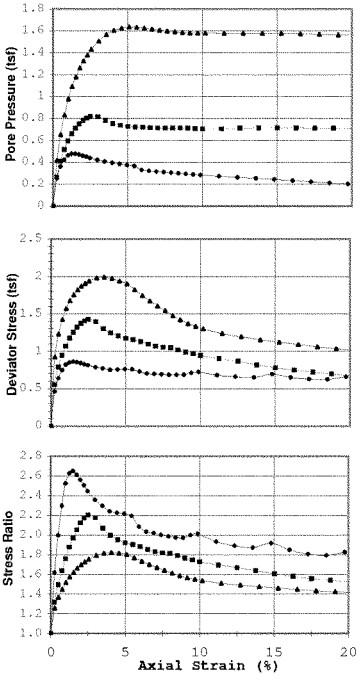
Rupture Envelope at Failure	
α = 12.6 °	a = 0.2 (tsf)

----------	Effective ϕ': 12.9 °	c'=	0.25 (tsf)
_____	Total ϕ': 8.9 °	c=	0.25 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

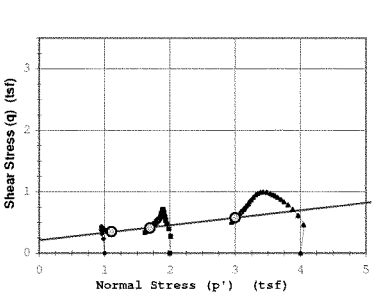
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 3 Type: 5T Depth (ft): 55 - 57 (Top)
Soil Type: Fat Clay w/a few pieces of Gravel, a few pockets of Silt (CH) Argusville

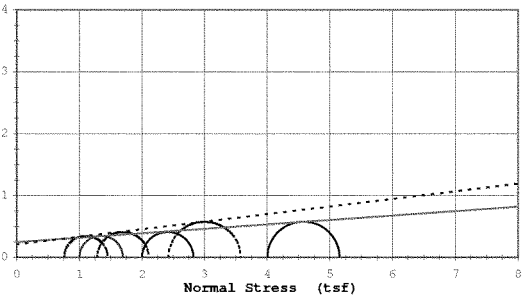


Failure Criterion:	Given Strain of: 15%				
Angle of internal friction, ϕ' =	7.0 °				
Apparent Cohesion, c' =	0.21 (tsf)				
Test Date: 8/24/10		Liquid Limit:	78.1		
Test Type: CU w/pp		Plastic Limit:	26.8		
Strain Rate (in/min): 0.0039		Plasticity Index:	51.3		
Strain Rate (%/min): 0.096		Spec. Gravity (Assumed):	2.78		
Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	47.4	49.2	51.1		
Dry Density (pcf)	73.7	72.2	70.8		
Void Ratio	1.35	1.40	1.45		
After Consolidation					
Diameter (in)	1.92	1.91	1.88		
Height (in)	4.05	3.99	3.93		
Water Content (%)	46.2	45.5	43.7		
Dry Density (pcf)	75.9	76.6	78.4		
Void Ratio	1.29	1.26	1.21		
Back Pressure (tsf)	5.76	5.76	5.76		
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	0.86	1.42	1.99		
Ultimate Deviator Stress (tsf)	0.66	0.67	1.01		
Deviator Stress at Failure (tsf)	0.70	0.82	1.15		
Max. Pore Pressure Buildup (tsf)	0.48	0.82	1.64		
Pore Pressure Parameter "B"	1.0	1.0	1.0		
Pct. Axial Strain at Failure	15.0	15.0	15.0		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.



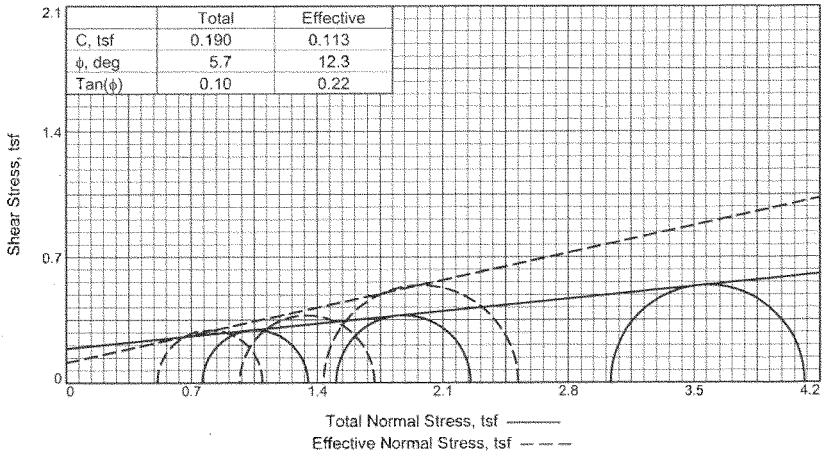


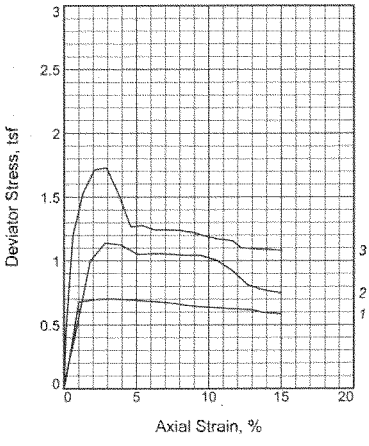
Rupture Envelope at Failure
α = 6.9 ° a = 0.2 (tsf)

---------- Effective ϕ': 7.0 ° c'= 0.21 (tsf)
_____ Total ϕ': 4.1 ° c= 0.25 (tsf)

Job No.: 7577
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095 Test Type: CU w/pp
Boring No.: 10-60MU, Sample No.: 3, Depth (ft.): 55 - 57 (Top)

Sample 1			Sample 2			Sample 3		
Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	0.46	0.25	0.25	0.55	0.26	0.26	0.92	0.42
0.49	0.64	0.36	0.50	0.79	0.41	0.51	1.23	0.65
0.74	0.75	0.42	0.75	0.95	0.52	0.76	1.42	0.83
0.99	0.82	0.46	1.00	1.07	0.60	1.02	1.57	0.98
1.23	0.85	0.48	1.25	1.18	0.66	1.27	1.68	1.09
1.48	0.86	0.48	1.50	1.25	0.71	1.53	1.75	1.18
1.73	0.85	0.47	1.75	1.32	0.75	1.78	1.82	1.26
1.97	0.84	0.46	2.00	1.37	0.78	2.04	1.87	1.33
2.22	0.83	0.45	2.25	1.41	0.80	2.29	1.91	1.38
2.47	0.81	0.44	2.51	1.42	0.82	2.55	1.94	1.43
2.96	0.79	0.42	3.01	1.39	0.82	3.06	1.98	1.51
3.45	0.77	0.41	3.51	1.30	0.78	3.57	1.99	1.56
3.95	0.75	0.39	4.01	1.24	0.75	4.07	1.97	1.60
4.44	0.76	0.38	4.51	1.21	0.74	4.58	1.94	1.62
4.93	0.76	0.38	5.01	1.17	0.73	5.09	1.90	1.64
5.43	0.76	0.37	5.51	1.15	0.72	5.60	1.82	1.63
5.92	0.73	0.33	6.01	1.13	0.72	6.11	1.74	1.62
6.42	0.70	0.32	6.51	1.09	0.72	6.62	1.67	1.62
6.91	0.70	0.32	7.01	1.07	0.71	7.13	1.60	1.61
7.40	0.69	0.31	7.51	1.05	0.71	7.64	1.54	1.60
7.90	0.68	0.31	8.02	1.05	0.71	8.15	1.48	1.59
8.39	0.68	0.30	8.52	1.02	0.71	8.66	1.42	1.58
8.88	0.69	0.29	9.02	0.99	0.71	9.17	1.37	1.58
9.38	0.71	0.29	9.52	0.97	0.71	9.68	1.33	1.58
9.87	0.72	0.28	10.02	0.94	0.71	10.19	1.30	1.58
11.10	0.68	0.27	11.27	0.90	0.71	11.46	1.24	1.58
12.34	0.66	0.26	12.52	0.86	0.71	12.73	1.19	1.58
13.57	0.65	0.25	13.78	0.82	0.72	14.01	1.15	1.58
14.80	0.70	0.24	15.03	0.78	0.72	15.28	1.12	1.58
16.04	0.65	0.23	16.28	0.75	0.71	16.55	1.09	1.57
17.27	0.63	0.22	17.53	0.72	0.71	17.83	1.06	1.57
18.50	0.62	0.21	18.78	0.70	0.71	19.10	1.03	1.56
19.74	0.66	0.20	20.04	0.67	0.71	20.37	1.01	1.56





Sample No.		1	2	3
Initial	Water Content, %	61.2	61.9	61.6
	Dry Density, pcf	62.7	63.1	62.5
	Saturation, %	97.7	99.9	97.8
	Void Ratio	1.6959	1.6802	1.7065
	Diameter, in.	1.43	1.41	1.43
	Height, in.	2.80	2.79	2.79
At Test	Water Content, %	62.6	61.8	61.9
	Dry Density, pcf	62.7	63.2	63.2
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.6959	1.6745	1.6774
	Diameter, in.	1.42	1.41	1.42
	Height, in.	2.80	2.79	2.78
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.76	1.50	3.04
Back Pressure, tsf		6.38	5.63	4.12
Cell Pressure, tsf		7.14	7.13	7.16
Peak Deviator Stress, tsf		0.70	1.14	1.73
Total Pore Pr., tsf		6.77	6.20	5.48
Ultimate Deviator Stress, tsf		0.59	0.75	1.08
Total Pore Pr., tsf		6.63	6.16	5.72
Maj. Eff. Stress at Ultimate, tsf		1.10	1.72	2.52
Min. Eff. Stress at Ultimate, tsf		0.51	0.97	1.44

Type of Test:
CU with Pore Pressures
Sample Type: 5" Thinwall, Middle of sample
Description: FAT CLAY, brown (CH)

LL= 90 **PL=** 27 **PI=** 63
Specific Gravity= 2.709
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Maple River, Argusville Formation
Sample Number: Boring10-105MU, #4 **Depth:** 45-47'
Proj. No.: BL-10-10065 **Date Sampled:**

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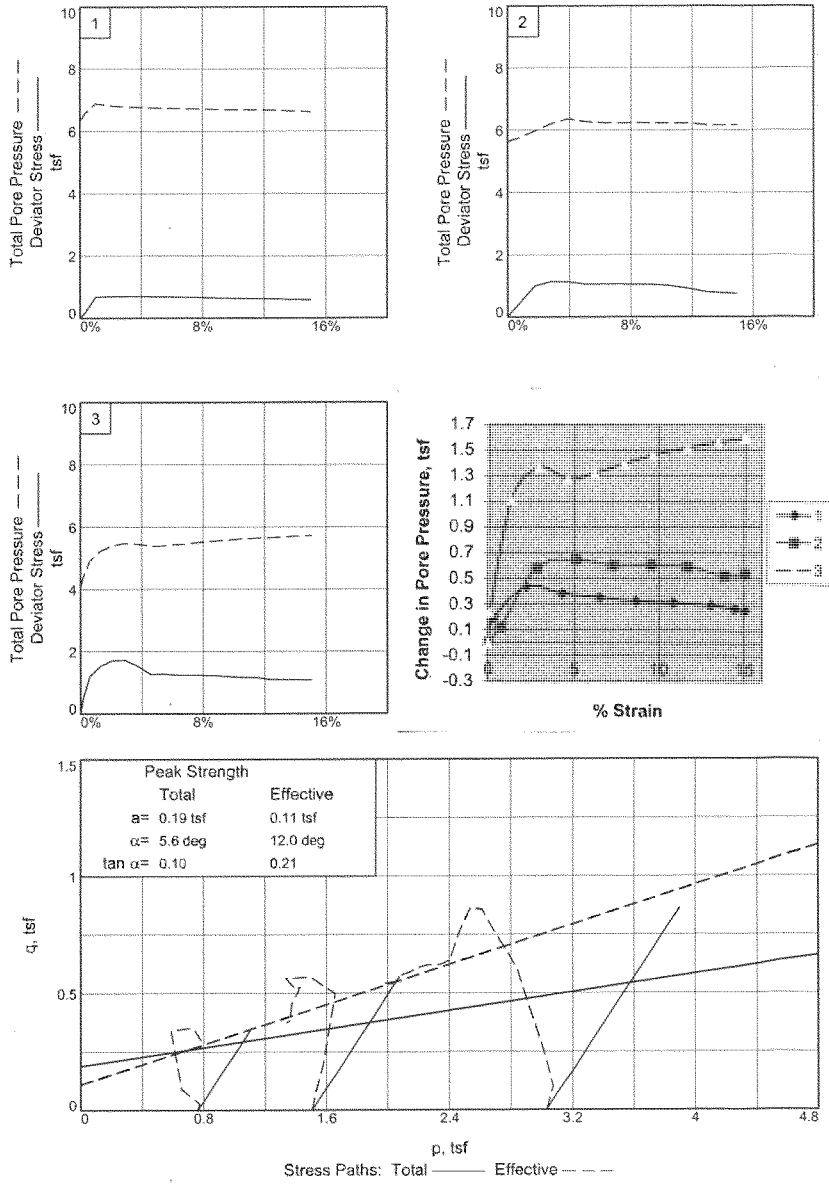
Figure Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement Attachment I-4, pg 362
July 2011 Geotechnical Design and Geology



Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Loc.: Maple River, Argusville Formation **Depth:** 45-47' **Sample No.:** Boring10-105MU, #4

Project No.: RI-10-10065 **Figure**

Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

3/4/2011
2:27 PM

Date:
Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project No.: BL-10-10065
Location: Maple River, Argusville Formation
Depth: 45-47' **Sample Number:** Boring10-105MU, #4
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.709 **LL=**90 **PL=**27 **PI=**63
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	124.540			150.290
Moisture content: Dry soil+tare, gms.	89.000			104.050
Moisture content: Tare, gms.	30.900			30.650
Moisture, %	61.2	62.6	62.6	63.0
Moist specimen weight, gms.	118.6			
Diameter, in.	1.43	1.43	1.42	
Area, in.²	1.59	1.59	1.59	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	101.1	102.0	102.0	
Dry density, pcf	62.7	62.7	62.7	
Void ratio	1.6959	1.6959	1.6959	
Saturation, %	97.7	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.137 tsf
Consolidation back pressure = 6.375 tsf
Consolidation effective confining stress = 0.762 tsf
Peak Stress = 0.703 tsf **at reading no.** 5
Ult. Stress = 0.587 tsf **at reading no.** 17

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	0.0374	19.400	0.0	0.0	0.000	0.762	0.762	1.00	6.375	0.762	0.000
1	0.0405	20.630	1.2	0.1	0.055	0.747	0.802	1.07	6.390	0.775	0.028
2	0.0464	23.430	4.0	0.3	0.181	0.567	0.748	1.32	6.570	0.658	0.091
3	0.0658	34.600	15.2	1.0	0.679	0.249	0.928	3.73	6.888	0.589	0.340
4	0.0981	35.200	15.8	2.2	0.698	0.327	1.025	3.13	6.810	0.676	0.349
5	0.1284	35.500	16.1	3.2	0.703	0.363	1.066	2.94	6.774	0.715	0.352
6	0.1587	35.500	16.1	4.3	0.695	0.381	1.076	2.83	6.756	0.729	0.348
7	0.1892	35.500	16.1	5.4	0.687	0.392	1.079	2.75	6.745	0.736	0.344
8	0.2195	35.500	16.1	6.5	0.680	0.410	1.090	2.66	6.727	0.750	0.340
9	0.2500	35.400	16.0	7.6	0.668	0.415	1.083	2.61	6.722	0.749	0.334
10	0.2792	35.150	15.8	8.6	0.650	0.436	1.086	2.49	6.701	0.761	0.325
11	0.3105	35.100	15.7	9.7	0.640	0.451	1.091	2.42	6.686	0.771	0.320
12	0.3410	35.100	15.7	10.8	0.632	0.449	1.081	2.41	6.688	0.765	0.316
13	0.3703	35.100	15.7	11.9	0.625	0.457	1.082	2.37	6.680	0.769	0.312
14	0.4009	35.100	15.7	13.0	0.617	0.469	1.086	2.32	6.668	0.777	0.308
15	0.4204	34.730	15.3	13.7	0.597	0.489	1.086	2.22	6.648	0.788	0.299
16	0.4407	34.710	15.3	14.4	0.592	0.497	1.089	2.19	6.640	0.793	0.296
17	0.4580	34.690	15.3	15.0	0.587	0.510	1.097	2.15	6.627	0.803	0.293

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	127.430			147.490
Moisture content: Dry soil+tare, gms.	90.390			102.780
Moisture content: Tare, gms.	30.590			30.480
Moisture, %	61.9	62.0	61.8	61.8
Moist specimen weight, gms.	117.2			
Diameter, in.	1.41	1.41	1.41	
Area, in.^{2}	1.57	1.57	1.56	
Height, in.	2.79	2.79	2.79	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	102.2	102.2	102.3	
Dry density, pcf	63.1	63.1	63.2	
Void ratio	1.6802	1.6802	1.6745	
Saturation, %	99.9	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.130 tsf

Consolidation back pressure = 5.625 tsf

Consolidation effective confining stress = 1.505 tsf

Peak Stress = 1.138 tsf at reading no. 4

Ult. Stress = 0.750 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	0.0354	19.860	0.0	0.0	0.000	1.505	1.505	1.00	5.625	1.505	0.000
1	0.0414	22.940	3.1	0.2	0.142	1.456	1.598	1.10	5.674	1.527	0.071
2	0.0551	28.220	8.4	0.7	0.382	1.385	1.767	1.28	5.745	1.576	0.191
3	0.0851	41.900	22.0	1.8	0.997	1.155	2.152	1.86	5.975	1.653	0.498
4	0.1145	45.300	25.4	2.8	1.138	0.926	2.064	2.23	6.204	1.495	0.569
5	0.1443	45.300	25.4	3.9	1.126	0.773	1.899	2.46	6.357	1.336	0.563
6	0.1764	43.900	24.0	5.1	1.051	0.861	1.912	2.22	6.269	1.386	0.525
7	0.2077	44.300	24.4	6.2	1.056	0.890	1.946	2.19	6.240	1.418	0.528
8	0.2380	44.500	24.6	7.3	1.052	0.902	1.954	2.17	6.228	1.428	0.526
9	0.2683	44.580	24.7	8.4	1.043	0.893	1.936	2.17	6.237	1.415	0.522
10	0.2989	44.870	25.0	9.5	1.043	0.900	1.943	2.16	6.230	1.421	0.521
11	0.3292	44.230	24.4	10.5	1.004	0.909	1.913	2.10	6.221	1.411	0.502
12	0.3597	42.500	22.6	11.6	0.921	0.913	1.834	2.01	6.217	1.374	0.461
13	0.3901	40.010	20.1	12.7	0.810	0.960	1.770	1.84	6.170	1.365	0.405
14	0.4195	39.290	19.4	13.8	0.771	0.980	1.751	1.79	6.150	1.366	0.386
15	0.4530	39.010	19.1	15.0	0.750	0.968	1.718	1.77	6.162	1.343	0.375

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	119.720			145.960
Moisture content: Dry soil+tare, gms.	85.630			102.860
Moisture content: Tare, gms.	30.280			30.250
Moisture, %	61.6	63.0	61.9	59.4
Moist specimen weight, gms.	118.6			
Diameter, in.	1.43	1.43	1.42	
Area, in.^{2}	1.60	1.60	1.59	
Height, in.	2.79	2.79	2.78	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	101.0	101.8	102.3	
Dry density, pcf	62.5	62.5	63.2	
Void ratio	1.7065	1.7065	1.6774	
Saturation, %	97.8	100.0	100.0	

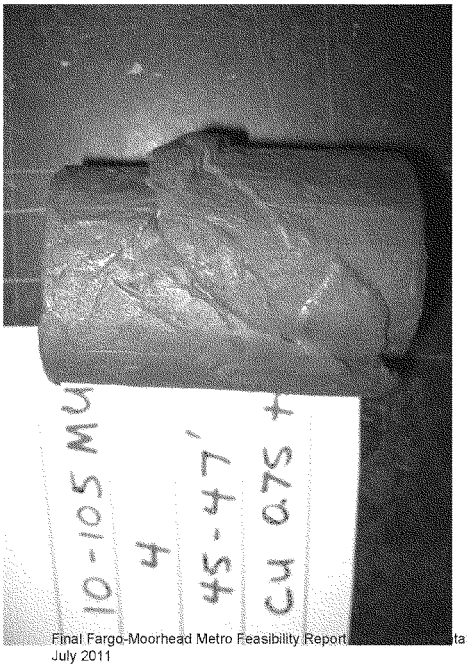
Test Readings for Specimen No. 3

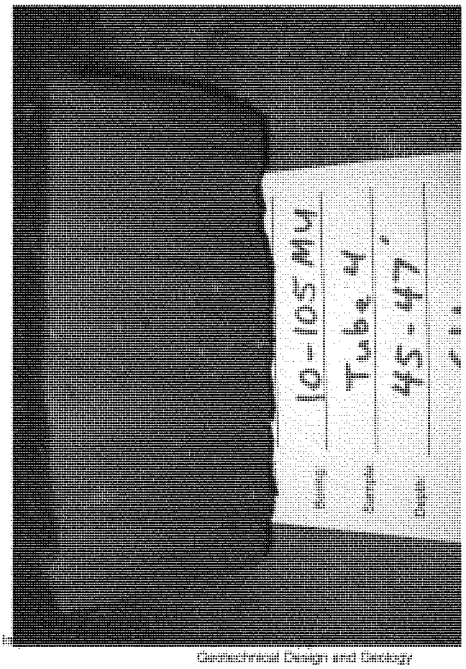
Consolidation cell pressure = 7.155 tsf
Consolidation back pressure = 4.122 tsf
Consolidation effective confining stress = 3.033 tsf
Peak Stress = 1.728 tsf **at reading no.** 6
Ult. Stress = 1.083 tsf **at reading no.** 20

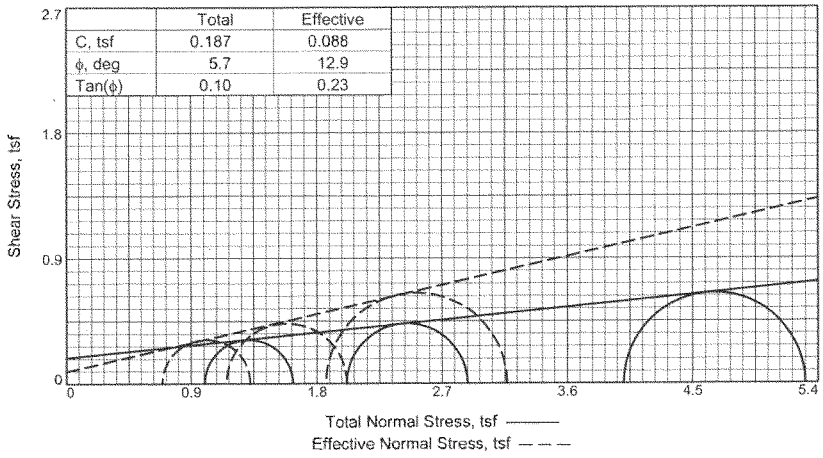
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0126	17.060	0.0	0.0	0.000	3.033	3.033	1.00	4.122	3.033	0.000
1	0.0147	21.510	4.5	0.1	0.201	2.976	3.177	1.07	4.179	3.077	0.101
2	0.0165	27.120	10.1	0.1	0.454	2.799	3.253	1.16	4.356	3.026	0.227
3	0.0295	43.700	26.6	0.6	1.197	2.246	3.443	1.53	4.909	2.845	0.599
4	0.0484	51.360	34.3	1.3	1.531	1.926	3.457	1.79	5.229	2.691	0.765
5	0.0703	55.720	38.7	2.1	1.712	1.759	3.471	1.97	5.396	2.615	0.856
6	0.0935	56.420	39.4	2.9	1.728	1.672	3.400	2.03	5.483	2.536	0.864
7	0.1172	52.030	35.0	3.8	1.522	1.705	3.227	1.89	5.450	2.466	0.761
8	0.1402	46.440	29.4	4.6	1.268	1.764	3.032	1.72	5.391	2.398	0.634
9	0.1629	46.900	29.8	5.4	1.276	1.754	3.030	1.73	5.401	2.392	0.638
10	0.1858	46.350	29.3	6.2	1.242	1.715	2.957	1.72	5.440	2.336	0.621
11	0.2086	46.600	29.5	7.0	1.242	1.688	2.930	1.74	5.467	2.309	0.621
12	0.2315	46.840	29.8	7.9	1.241	1.643	2.884	1.76	5.512	2.263	0.620
13	0.2554	46.810	29.8	8.7	1.228	1.606	2.834	1.76	5.549	2.220	0.614
14	0.2796	46.380	29.3	9.6	1.198	1.572	2.770	1.76	5.583	2.171	0.599
15	0.3044	46.050	29.0	10.5	1.173	1.542	2.715	1.76	5.613	2.129	0.587
16	0.3362	45.990	28.9	11.6	1.156	1.514	2.670	1.76	5.641	2.092	0.578
17	0.3531	44.800	27.7	12.2	1.101	1.502	2.603	1.73	5.653	2.052	0.550
18	0.3861	44.950	27.9	13.4	1.092	1.472	2.564	1.74	5.683	2.018	0.546
19	0.4110	45.100	28.0	14.3	1.086	1.441	2.527	1.75	5.714	1.984	0.543
20	0.4309	45.260	28.2	15.0	1.083	1.435	2.518	1.75	5.720	1.977	0.542

10-105 MW
4
45-47'
CU 1.5 +

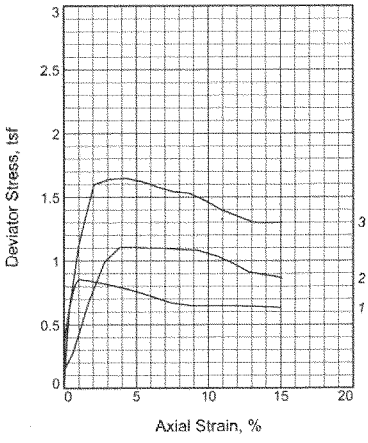
10-105 MW
4
45-47'
CU 3 +SC


10-105 MW
4
45-47'
CU 0.75 +


10-105 MW
Tube #
45-47'



	Total	Effective
C, tsf	0.187	0.088
ϕ, deg	5.7	12.9
Tan(ϕ)	0.10	0.23



Sample No.		1	2	3
Initial	Water Content, %	56.9	63.0	63.5
	Dry Density, pcf	66.4	61.9	61.5
	Saturation, %	99.9	98.8	98.7
	Void Ratio	1.5354	1.7193	1.7370
	Diameter, in.	1.41	1.41	1.39
	Height, in.	2.82	2.82	2.81
At Test	Water Content, %	55.9	61.6	61.1
	Dry Density, pcf	67.1	63.3	63.6
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.5085	1.6616	1.6498
	Diameter, in.	1.40	1.40	1.38
	Height, in.	2.81	2.80	2.78
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		1.00	2.01	4.00
Back Pressure, tsf		6.13	5.12	3.13
Cell Pressure, tsf		7.13	7.13	7.13
Peak Deviator Stress, tsf		0.85	1.11	1.65
Total Pore Pr., tsf		6.60	5.94	4.70
Ultimate Deviator Stress, tsf		0.63	0.86	1.30
Total Pore Pr., tsf		6.44	5.98	5.27
Maj. Eff. Stress at Ultimate, tsf		1.33	2.02	3.17
Min. Eff. Stress at Ultimate, tsf		0.69	1.15	1.86

Type of Test:
CU with Pore Pressures

Sample Type: 5" Thinwall, Middle of sample

Description: FAT CLAY, brown (CH)

LL= 91 **PL=** 25 **PI=** 66

Specific Gravity= 2.698

Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

Location: Maple River, Argusville Formation

Sample Number: Boring10-105MU, #5 **Depth:** 55-57'

Proj. No.: BL-10-10065 **Date Sampled:**

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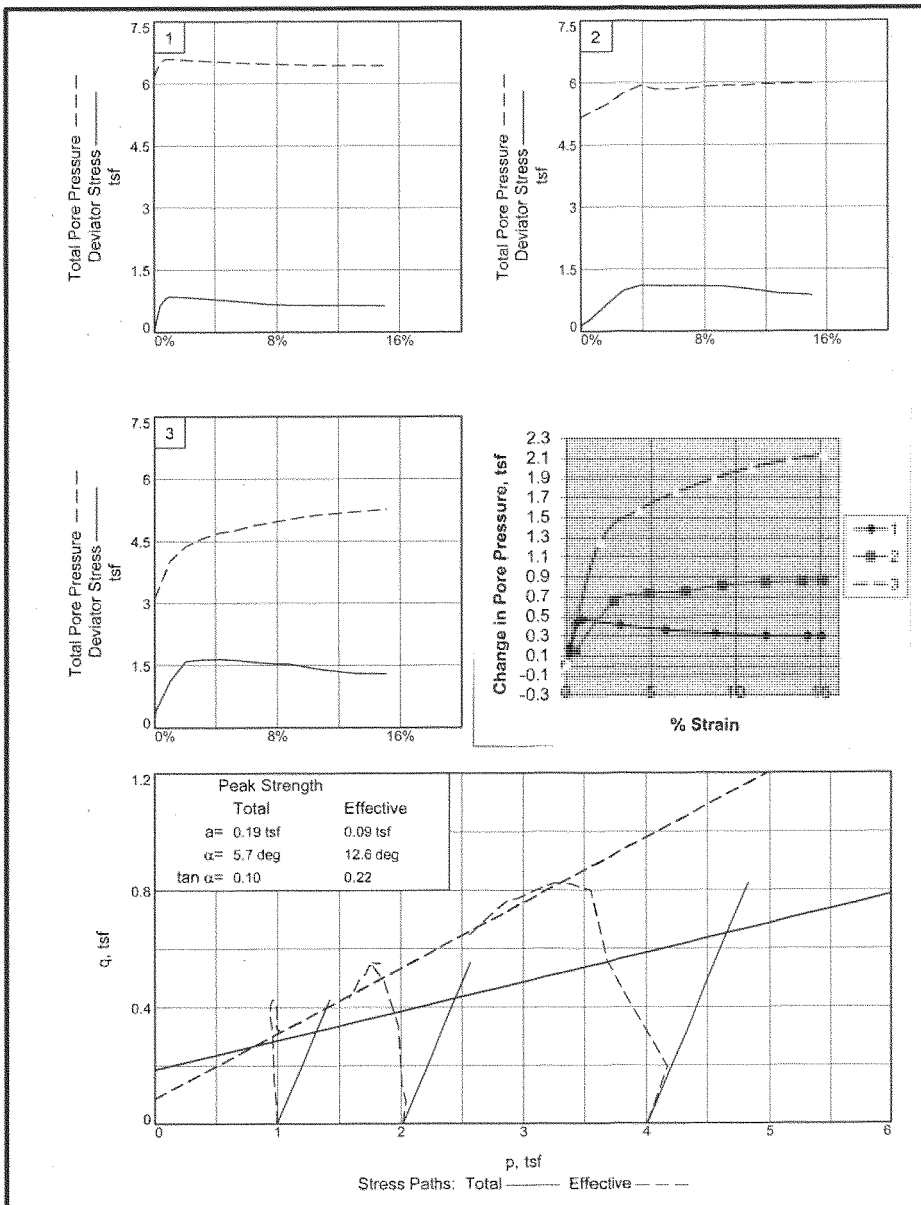
Figure Triaxial Test Results



Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Loc.: Maple River, Argusville Formation **Depth:** 55-57' **Sample No.:** Boring10-105MU, #5

Project No.: BI-18-11065 **Figure**

Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST 3/4/2011
CU with Pore Pressures 2:46 PM

Date:
Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project No.: BL-10-10065
Location: Maple River, Argusville Formation
Depth: 55-57' **Sample Number:** Boring10-105MU, #5
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.698 **LL=**91 **PL=**25 **PI=**66
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	108.780			149.920
Moisture content: Dry soil+tare, gms.	80.310			107.860
Moisture content: Tare, gms.	30.250			30.460
Moisture, %	56.9	56.9	55.9	54.3
Moist specimen weight, gms.	119.6			
Diameter, in.	1.41	1.41	1.40	
Area, in.^{2}	1.55	1.55	1.54	
Height, in.	2.82	2.82	2.81	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	104.2	104.2	104.7	
Dry density, pcf	66.4	66.4	67.1	
Void ratio	1.5354	1.5354	1.5085	
Saturation, %	99.9	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.130 tsf
Consolidation back pressure = 6.134 tsf
Consolidation effective confining stress = 0.996 tsf
Peak Stress = 0.855 tsf **at reading no.** 6
Ult. Stress = 0.633 tsf **at reading no.** 17

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	0.0110	19.770	0.0	0.0	0.000	0.996	0.996	1.00	6.134	0.996	0.000
1	0.0122	22.550	2.8	0.0	0.130	0.926	1.056	1.14	6.204	0.991	0.065
2	0.0154	26.390	6.6	0.2	0.309	0.815	1.124	1.38	6.315	0.970	0.155
3	0.0212	33.290	13.5	0.4	0.630	0.644	1.274	1.98	6.486	0.959	0.315
4	0.0271	35.640	15.9	0.6	0.738	0.571	1.309	2.29	6.559	0.940	0.369
5	0.0329	37.440	17.7	0.8	0.820	0.533	1.353	2.54	6.597	0.943	0.410
6	0.0390	38.230	18.5	1.0	0.855	0.531	1.386	2.61	6.599	0.958	0.427
7	0.0613	38.140	18.4	1.8	0.844	0.555	1.399	2.52	6.575	0.977	0.422
8	0.0997	37.680	17.9	3.2	0.811	0.584	1.395	2.39	6.546	0.990	0.406
9	0.1385	37.100	17.3	4.5	0.774	0.609	1.383	2.27	6.521	0.996	0.387
10	0.1774	36.280	16.5	5.9	0.726	0.631	1.357	2.15	6.499	0.994	0.363
11	0.2172	35.300	15.5	7.3	0.673	0.654	1.327	2.03	6.476	0.991	0.337
12	0.2582	35.000	15.2	8.8	0.650	0.668	1.318	1.97	6.462	0.993	0.325
13	0.2992	35.210	15.4	10.3	0.648	0.678	1.326	1.96	6.452	1.002	0.324
14	0.3399	35.430	15.7	11.7	0.647	0.689	1.336	1.94	6.441	1.012	0.323
15	0.3672	35.550	15.8	12.7	0.644	0.686	1.330	1.94	6.444	1.008	0.322
16	0.4087	35.670	15.9	14.2	0.638	0.693	1.331	1.92	6.437	1.012	0.319
17	0.4328	35.700	15.9	15.0	0.633	0.693	1.326	1.91	6.437	1.010	0.317

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	126.890			156.540
Moisture content: Dry soil+tare, gms.	89.720			110.000
Moisture content: Tare, gms.	30.680			30.290
Moisture, %	63.0	63.7	61.6	58.4
Moist specimen weight, gms.	115.9			
Diameter, in.	1.41	1.41	1.40	
Area, in.^{2}	1.55	1.55	1.53	
Height, in.	2.82	2.82	2.80	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	100.9	101.4	102.3	
Dry density, pcf	61.9	61.9	63.3	
Void ratio	1.7193	1.7193	1.6616	
Saturation, %	98.8	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.134 tsf

Consolidation back pressure = 5.118 tsf

Consolidation effective confining stress = 2.016 tsf

Peak Stress = 1.106 tsf at reading no. 5

Ult. Stress = 0.864 tsf at reading no. 16

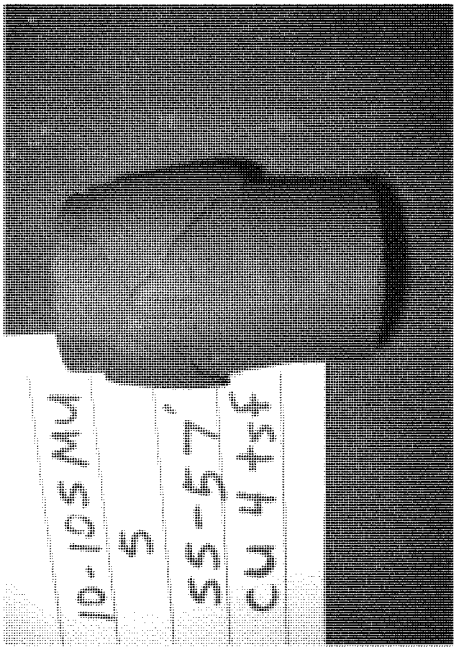
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0404	20.630	0.0	0.0	0.000	2.016	2.016	1.00	5.118	2.016	0.000
1	0.0423	23.980	3.4	0.1	0.157	1.961	2.118	1.08	5.173	2.040	0.079
2	0.0568	26.480	5.9	0.6	0.274	1.868	2.142	1.15	5.266	2.005	0.137
3	0.0874	35.170	14.5	1.7	0.672	1.643	2.315	1.41	5.491	1.979	0.336
4	0.1177	42.220	21.6	2.8	0.988	1.370	2.358	1.72	5.764	1.864	0.494
5	0.1479	45.070	24.4	3.8	1.106	1.198	2.304	1.92	5.936	1.751	0.553
6	0.1773	45.300	24.7	4.9	1.104	1.283	2.387	1.86	5.851	1.835	0.552
7	0.2076	45.480	24.8	6.0	1.099	1.286	2.385	1.85	5.848	1.836	0.550
8	0.2368	45.750	25.1	7.0	1.099	1.264	2.363	1.87	5.870	1.813	0.549
9	0.2671	45.770	25.1	8.1	1.087	1.231	2.318	1.88	5.903	1.774	0.543
10	0.2978	46.030	25.4	9.2	1.085	1.201	2.286	1.90	5.933	1.743	0.542
11	0.3379	45.220	24.6	10.6	1.034	1.199	2.233	1.86	5.935	1.716	0.517
12	0.3685	44.190	23.6	11.7	0.978	1.167	2.145	1.84	5.967	1.656	0.489
13	0.3985	42.810	22.2	12.8	0.910	1.162	2.072	1.78	5.972	1.617	0.455
14	0.4290	42.590	22.0	13.9	0.889	1.159	2.048	1.77	5.975	1.604	0.445
15	0.4494	42.500	21.9	14.6	0.878	1.150	2.028	1.76	5.984	1.589	0.439
16	0.4620	42.260	21.6	15.1	0.864	1.152	2.016	1.75	5.982	1.584	0.432

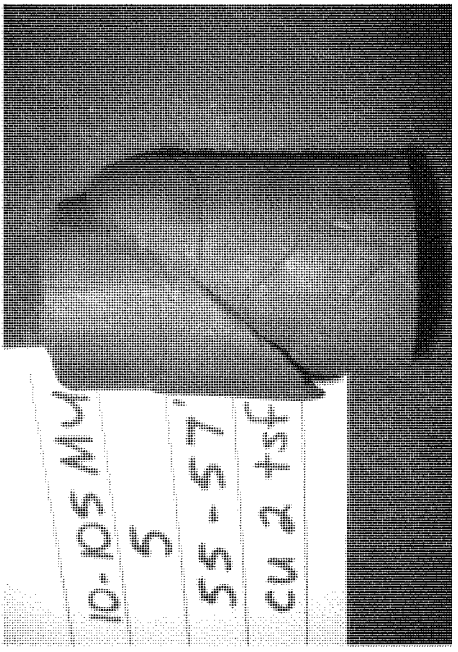
Parameters for Specimen No. 3				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	116.950			157.150
Moisture content: Dry soil+tare, gms.	83.290			110.510
Moisture content: Tare, gms.	30.310			30.270
Moisture, %	63.5	64.4	61.1	58.1
Moist specimen weight, gms.	113.1			
Diameter, in.	1.39	1.39	1.38	
Area, in.^{2}	1.53	1.53	1.49	
Height, in.	2.81	2.81	2.78	
Net decrease in height, in.		0.00	0.03	
Wet Density, pcf	100.6	101.2	102.4	
Dry density, pcf	61.5	61.5	63.6	
Void ratio	1.7370	1.7370	1.6498	
Saturation, %	98.7	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.132 tsf
Consolidation back pressure = 3.126 tsf
Consolidation effective confining stress = 4.006 tsf
Peak Stress = 1.647 tsf **at reading no.** 6
Ult. Stress = 1.302 tsf **at reading no.** 16

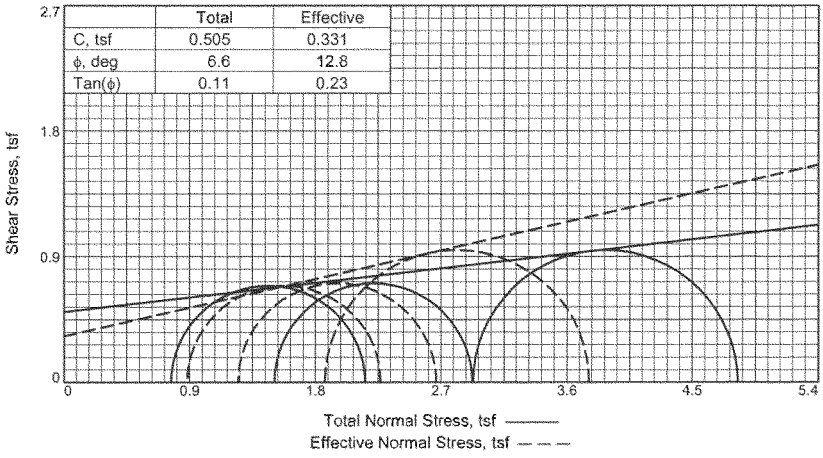
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0304	17.650	0.0	0.0	0.000	4.006	4.006	1.00	3.126	4.006	0.000
1	0.0305	22.500	4.9	0.0	0.234	3.987	4.221	1.06	3.145	4.104	0.117
2	0.0318	25.810	8.2	0.1	0.393	3.973	4.366	1.10	3.159	4.170	0.197
3	0.0580	41.170	23.5	1.0	1.123	3.112	4.235	1.36	4.020	3.673	0.561
4	0.0870	51.470	33.8	2.0	1.597	2.755	4.352	1.58	4.377	3.554	0.799
5	0.1175	52.790	35.1	3.1	1.641	2.563	4.204	1.64	4.569	3.383	0.820
6	0.1490	53.350	35.7	4.3	1.647	2.431	4.078	1.68	4.701	3.255	0.824
7	0.1792	53.190	35.5	5.4	1.621	2.364	3.985	1.69	4.768	3.175	0.811
8	0.2106	52.690	35.0	6.5	1.579	2.250	3.829	1.70	4.882	3.040	0.790
9	0.2408	52.270	34.6	7.6	1.542	2.190	3.732	1.70	4.942	2.961	0.771
10	0.2714	52.440	34.8	8.7	1.531	2.111	3.642	1.73	5.021	2.877	0.766
11	0.3018	51.470	33.8	9.8	1.471	2.044	3.515	1.72	5.088	2.779	0.735
12	0.3323	50.220	32.6	10.9	1.399	1.997	3.396	1.70	5.135	2.697	0.700
13	0.3615	49.470	31.8	11.9	1.351	1.960	3.311	1.69	5.172	2.635	0.675
14	0.3938	48.670	31.0	13.1	1.300	1.922	3.222	1.68	5.210	2.572	0.650
15	0.4262	49.030	31.4	14.3	1.297	1.892	3.189	1.69	5.240	2.540	0.648
16	0.4500	49.480	31.8	15.1	1.302	1.864	3.166	1.70	5.268	2.515	0.651


10-10.5 MH
S
55-57'
CH 4 tsf

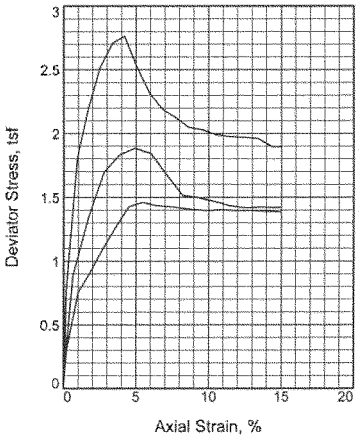

10-10.5 MH
S
55-57'
CH 2 tsf

10-10.5MH
S
55-57'
CH 1 tsf

10-10.5 MH
S
55-57'
CH



	Total	Effective
C, tsf	0.505	0.331
ϕ, deg	6.6	12.8
Tan(ϕ)	0.11	0.23



Sample No.		1	2	3
Initial	Water Content, %	32.6	35.8	36.1
	Dry Density, pcf	88.5	84.5	85.0
	Saturation, %	97.9	98.0	99.8
	Void Ratio	0.8917	0.9797	0.9695
	Diameter, in.	1.40	1.38	1.40
	Height, in.	2.81	2.80	2.80
At Test	Water Content, %	33.3	36.5	35.5
	Dry Density, pcf	88.5	84.5	85.7
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.8917	0.9797	0.9527
	Diameter, in.	1.40	1.38	1.39
	Height, in.	2.81	2.80	2.79
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.77	1.50	2.94
Back Pressure, tsf		6.37	5.66	4.15
Cell Pressure, tsf		7.14	7.16	7.09
Peak Deviator Stress, tsf		1.46	1.89	2.76
Total Pore Pr., tsf		6.51	6.38	5.32
Ultimate Deviator Stress, tsf		1.38	1.42	1.89
Total Pore Pr., tsf		6.26	5.92	5.22
Maj. Eff. Stress at Ultimate, tsf		2.27	2.66	3.76
Min. Eff. Stress at Ultimate, tsf		0.88	1.25	1.87

Type of Test:
CU with Pore Pressures

Sample Type: 5" Thinwall, Middle of sample

Description: FAT CLAY, brown (CH)

LL= 60 **PL=** 18 **PI=** 42

Specific Gravity= 2.681

Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Figure CUT-MOORHEAD METRO 4776

Client: USACE W912ES-11-P-0024

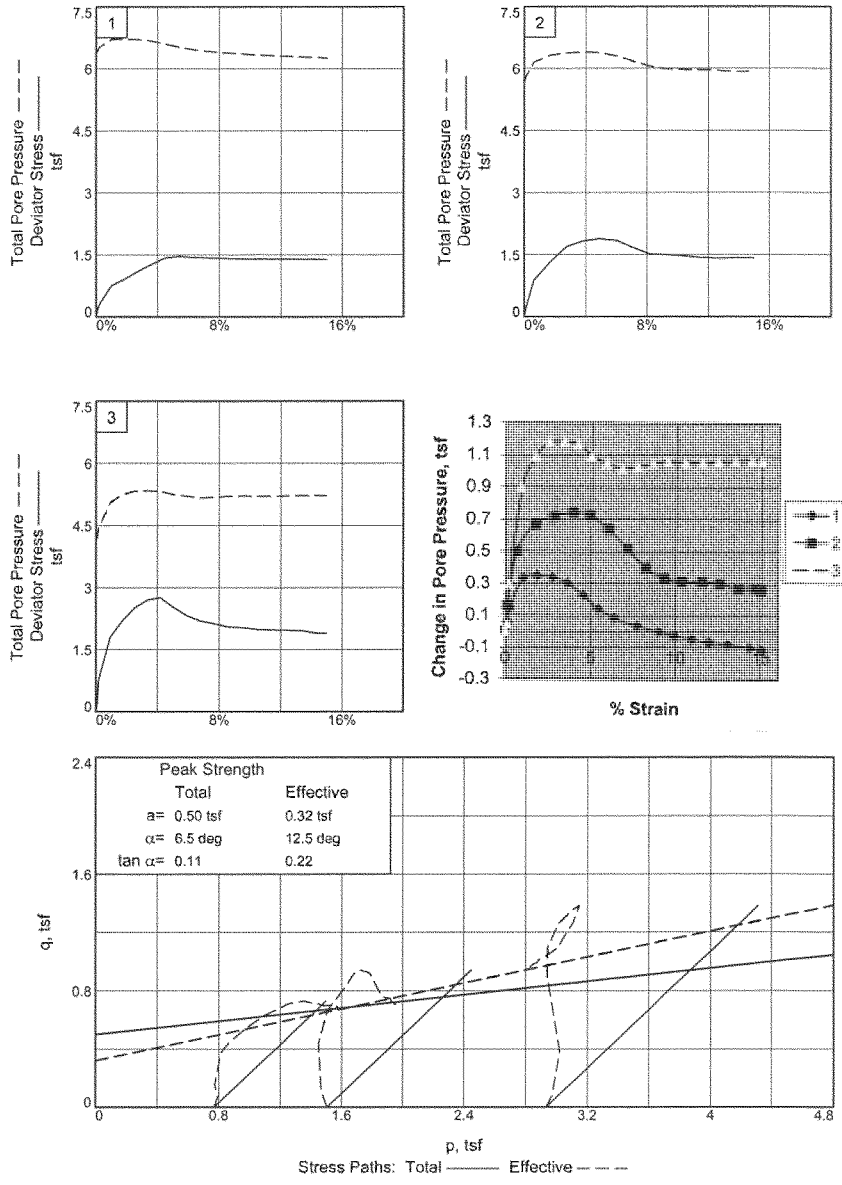
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3

Location: ND RRCS, MN, Argusville Formation

Sample Number: Boring11-107MU, #3 **Depth:** 40-42'

Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC



Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Loc.: ND RRCS, MN, Argusville Formation **Depth:** 40-42' **Sample No.:** Boring11-107MU, #3

Project No.: BL-10-10065 **Figure**

Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST 6/16/2011
CU with Pore Pressures 10:48 AM

Date:
Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Project No.: BL-10-10065
Location: ND RRCS, MN, Argusville Formation
Depth: 40-42' **Sample Number:** Boring11-107MU, #3
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.681 **LL=**60 **PL=**18 **PI=**42
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	127.800			165.710
Moisture content: Dry soil+tare, gms.	103.710			131.290
Moisture content: Tare, gms.	29.750			31.160
Moisture, %	32.6	33.3	33.3	34.4
Moist specimen weight, gms.	133.2			
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	117.3	117.9	117.9	
Dry density, pcf	88.5	88.5	88.5	
Void ratio	0.8917	0.8917	0.8917	
Saturation, %	97.9	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.141 tsf
Consolidation back pressure = 6.372 tsf
Consolidation effective confining stress = 0.769 tsf
Peak Stress = 1.460 tsf **at reading no.** 8
Ult. Stress = 1.385 tsf **at reading no.** 17

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	0.0127	21.840	0.0	0.0	0.000	0.769	0.769	1.00	6.372	0.769	0.000
1	0.0154	25.480	3.6	0.1	0.170	0.713	0.883	1.24	6.428	0.798	0.085
2	0.0183	28.280	6.4	0.2	0.300	0.623	0.923	1.48	6.518	0.773	0.150
3	0.0404	38.110	16.3	1.0	0.752	0.436	1.188	2.73	6.705	0.812	0.376
4	0.0633	41.530	19.7	1.8	0.903	0.422	1.325	3.14	6.719	0.874	0.452
5	0.0880	45.890	24.1	2.7	1.093	0.433	1.526	3.52	6.708	0.980	0.547
6	0.1141	50.010	28.2	3.6	1.268	0.468	1.736	3.71	6.673	1.102	0.634
7	0.1389	53.830	32.0	4.5	1.427	0.543	1.970	3.63	6.598	1.256	0.713
8	0.1648	54.900	33.1	5.4	1.460	0.626	2.086	3.33	6.515	1.356	0.730
9	0.1908	54.710	32.9	6.3	1.438	0.684	2.122	3.10	6.457	1.403	0.719
10	0.2275	54.840	33.0	7.7	1.423	0.735	2.158	2.94	6.406	1.447	0.712
11	0.2644	54.870	33.0	9.0	1.404	0.771	2.175	2.82	6.370	1.473	0.702
12	0.2913	55.020	33.2	9.9	1.396	0.797	2.193	2.75	6.344	1.495	0.698
13	0.3195	55.580	33.7	10.9	1.404	0.817	2.221	2.72	6.324	1.519	0.702
14	0.3471	55.790	34.0	11.9	1.397	0.834	2.231	2.67	6.307	1.532	0.698
15	0.3762	56.200	34.4	13.0	1.397	0.850	2.247	2.64	6.291	1.548	0.698
16	0.4149	56.580	34.7	14.3	1.390	0.869	2.259	2.60	6.272	1.564	0.695
17	0.4339	56.730	34.9	15.0	1.385	0.883	2.268	2.57	6.258	1.575	0.692

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	144.510			157.640
Moisture content: Dry soil+tare, gms.	114.410			122.550
Moisture content: Tare, gms.	30.390			30.310
Moisture, %	35.8	36.5	36.5	38.0
Moist specimen weight, gms.	126.8			
Diameter, in.	1.38	1.38	1.38	
Area, in.²	1.50	1.50	1.50	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	114.8	115.4	115.4	
Dry density, pcf	84.5	84.5	84.5	
Void ratio	0.9797	0.9797	0.9797	
Saturation, %	98.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.163 tsf
Consolidation back pressure = 5.657 tsf
Consolidation effective confining stress = 1.506 tsf
Peak Stress = 1.885 tsf **at reading no.** 6
Ult. Stress = 1.419 tsf **at reading no.** 16

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	0.0439	18.360	0.0	0.0	0.000	1.506	1.506	1.00	5.657	1.506	0.000
1	0.0477	23.430	5.1	0.1	0.243	1.346	1.589	1.18	5.817	1.467	0.121
2	0.0616	36.900	18.5	0.6	0.883	1.008	1.891	1.88	6.155	1.449	0.441
3	0.0918	46.780	28.4	1.7	1.339	0.842	2.181	2.59	6.321	1.511	0.669
4	0.1220	54.790	36.4	2.8	1.697	0.790	2.487	3.15	6.373	1.639	0.849
5	0.1525	58.140	39.8	3.9	1.833	0.764	2.597	3.40	6.399	1.680	0.916
6	0.1818	59.730	41.4	4.9	1.885	0.784	2.669	3.40	6.379	1.727	0.943
7	0.2131	59.250	40.9	6.0	1.841	0.866	2.707	3.13	6.297	1.787	0.921
8	0.2433	55.940	37.6	7.1	1.673	0.989	2.662	2.69	6.174	1.825	0.836
9	0.2736	52.810	34.5	8.2	1.516	1.108	2.624	2.37	6.055	1.866	0.758
10	0.3031	52.820	34.5	9.3	1.499	1.170	2.669	2.28	5.993	1.919	0.749
11	0.3335	52.570	34.2	10.3	1.470	1.193	2.663	2.23	5.970	1.928	0.735
12	0.3649	52.180	33.8	11.5	1.435	1.195	2.630	2.20	5.968	1.913	0.718
13	0.3950	52.190	33.8	12.5	1.418	1.205	2.623	2.18	5.958	1.914	0.709
14	0.4236	52.730	34.4	13.6	1.424	1.237	2.661	2.15	5.926	1.949	0.712
15	0.4540	53.080	34.7	14.6	1.420	1.234	2.654	2.15	5.929	1.944	0.710
16	0.4640	53.190	34.8	15.0	1.419	1.246	2.665	2.14	5.917	1.955	0.709

Parameters for Specimen No. 3

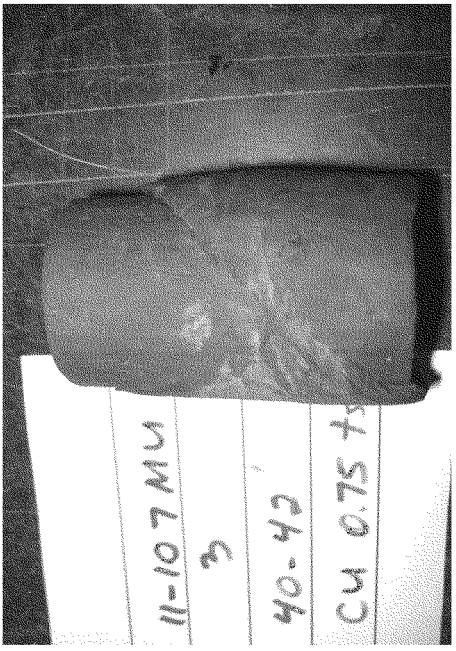
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	111.930			160.120
Moisture content: Dry soil+tare, gms.	90.320			126.830
Moisture content: Tare, gms.	30.460			30.420
Moisture, %	36.1	36.2	35.5	34.5
Moist specimen weight, gms.	130.6			
Diameter, in.	1.40	1.40	1.39	
Area, in.^{2}	1.53	1.53	1.53	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	115.7	115.7	116.2	
Dry density, pcf	85.0	85.0	85.7	
Void ratio	0.9695	0.9695	0.9527	
Saturation, %	99.8	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.086 tsf
Consolidation back pressure = 4.154 tsf
Consolidation effective confining stress = 2.932 tsf
Peak Stress = 2.763 tsf **at reading no.** 7
Ult. Stress = 1.894 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	0.0074	18.550	0.0	0.0	0.000	2.932	2.932	1.00	4.154	2.932	0.000
1	0.0094	22.000	3.4	0.1	0.163	2.889	3.052	1.06	4.197	2.970	0.081
2	0.0123	34.880	16.3	0.2	0.769	2.637	3.406	1.29	4.449	3.022	0.385
3	0.0332	57.070	38.5	0.9	1.800	2.037	3.837	1.88	5.049	2.937	0.900
4	0.0552	65.890	47.3	1.7	2.195	1.843	4.038	2.19	5.243	2.941	1.098
5	0.0780	73.360	54.8	2.5	2.520	1.754	4.274	2.44	5.332	3.014	1.260
6	0.1018	77.970	59.4	3.4	2.708	1.752	4.460	2.55	5.334	3.106	1.354
7	0.1249	79.680	61.1	4.2	2.763	1.765	4.528	2.57	5.321	3.146	1.381
8	0.1483	74.950	56.4	5.0	2.527	1.842	4.369	2.37	5.244	3.105	1.263
9	0.1731	70.740	52.2	5.9	2.316	1.885	4.201	2.23	5.201	3.043	1.158
10	0.1984	68.390	49.8	6.8	2.190	1.917	4.107	2.14	5.169	3.012	1.095
11	0.2235	67.380	48.8	7.7	2.125	1.903	4.028	2.12	5.183	2.966	1.063
12	0.2482	66.100	47.5	8.6	2.050	1.883	3.933	2.09	5.203	2.908	1.025
13	0.2742	66.130	47.6	9.5	2.030	1.873	3.903	2.08	5.213	2.888	1.015
14	0.3012	65.670	47.1	10.5	1.989	1.879	3.868	2.06	5.207	2.874	0.995
15	0.3281	65.860	47.3	11.5	1.976	1.877	3.853	2.05	5.209	2.865	0.988
16	0.3550	66.220	47.7	12.4	1.969	1.871	3.840	2.05	5.215	2.856	0.985
17	0.3821	66.560	48.0	13.4	1.961	1.868	3.829	2.05	5.218	2.849	0.981
18	0.4088	65.520	47.0	14.4	1.897	1.861	3.758	2.02	5.225	2.810	0.949
19	0.4268	65.790	47.2	15.0	1.894	1.867	3.761	2.01	5.219	2.814	0.947

11-107 MW
3
40-42'
Cu 1.5 +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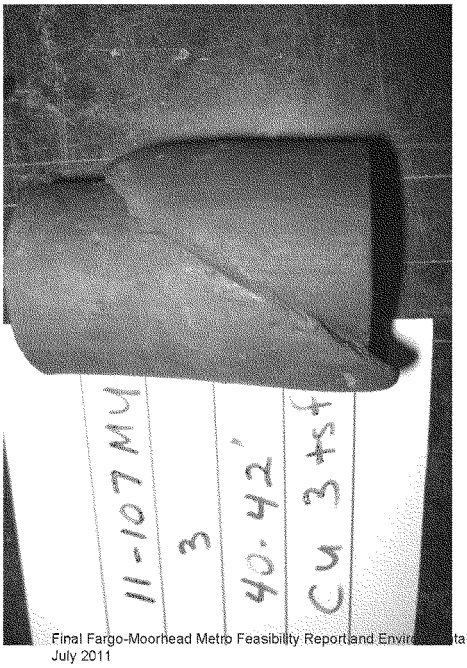
3
40-42'
Cu 0.75 +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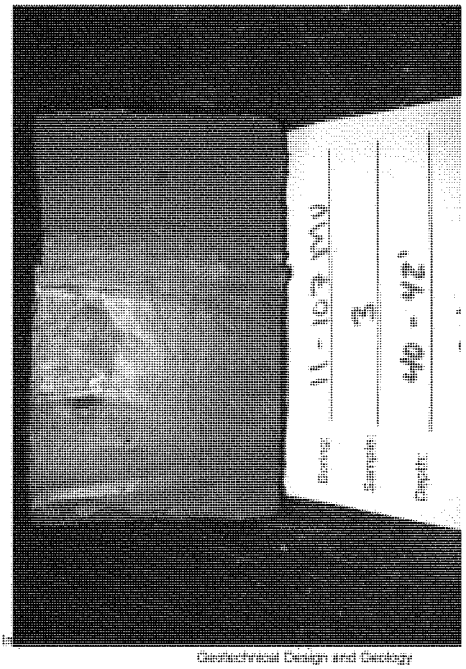
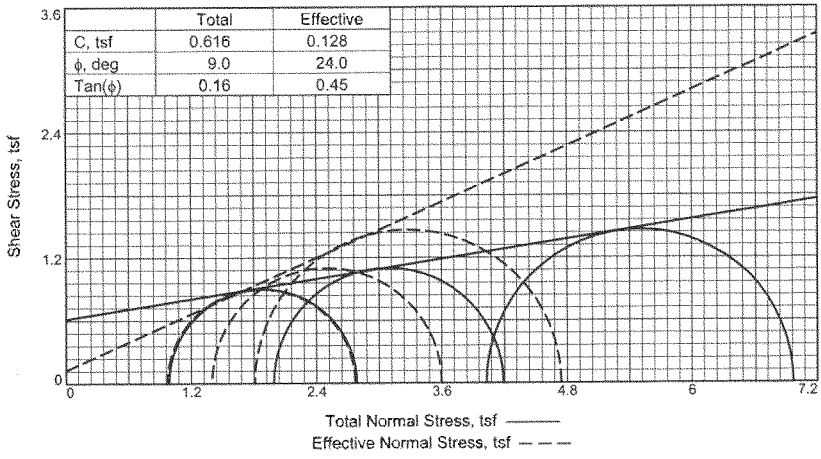
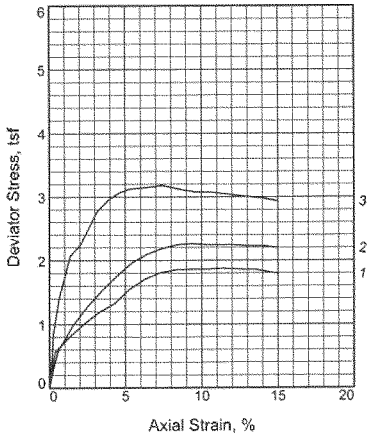
3
40-42'
Cu 3+


11 - 107 MW
3
40 - 42'



	Total	Effective
C, tsf	0.616	0.128
ϕ, deg	9.0	24.0
Tan(ϕ)	0.16	0.45



Sample No.		1	2	3
Initial	Water Content, %	36.8	37.0	37.3
	Dry Density, pcf	84.0	84.1	84.0
	Saturation, %	98.5	99.3	99.9
	Void Ratio	1.0100	1.0076	1.0099
	Diameter, in.	1.38	1.38	1.39
	Height, in.	2.80	2.80	2.80
At Test	Water Content, %	37.3	36.9	36.1
	Dry Density, pcf	84.0	84.6	85.4
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.0100	0.9968	0.9777
	Diameter, in.	1.38	1.38	1.38
	Height, in.	2.80	2.80	2.79
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.98	1.99	4.04
Back Pressure, tsf		6.13	5.15	3.09
Cell Pressure, tsf		7.11	7.14	7.13
Peak Deviator Stress, tsf		1.88	2.26	3.18
Total Pore Pr., tsf		6.25	5.80	5.14
Ultimate Deviator Stress, tsf		1.80	2.20	2.93
Total Pore Pr., tsf		6.14	5.74	5.32
Maj. Eff. Stress at Ultimate, tsf		2.77	3.60	4.74
Min. Eff. Stress at Ultimate, tsf		0.97	1.40	1.81

Type of Test:
CU with Pore Pressures

Sample Type: 5" Thinwall, Middle of sample

Description: FAT CLAY, brown (CH)

LL= 63 **PL=** 19 **PI=** 44

Specific Gravity= 2.705

Remarks:

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3

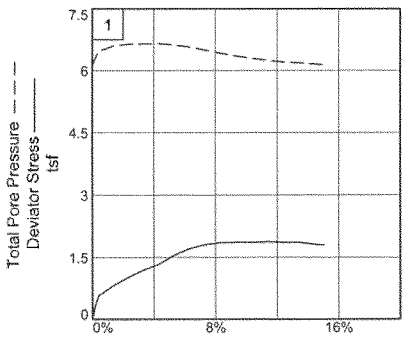
Location: ND RRCS, MN, Argusville Formation

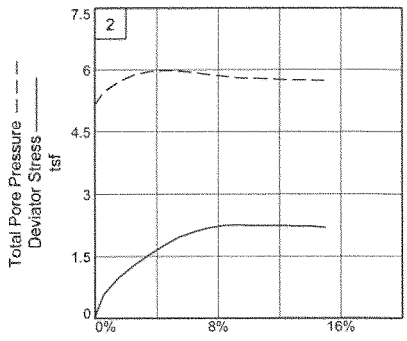
Sample Number: Boring11-107MU, #4 **Depth:** 50-52'

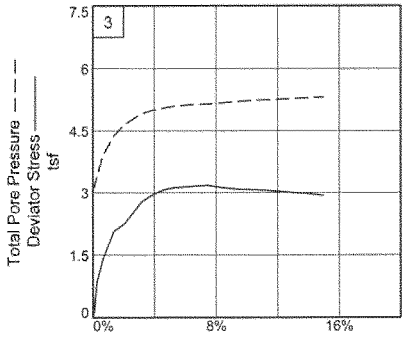
Proj. No.: BL-10-10065 **Date Sampled:**

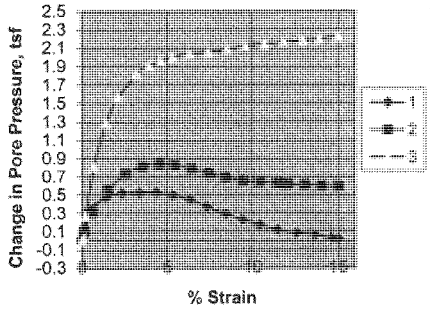
BRAUN INTERTEC

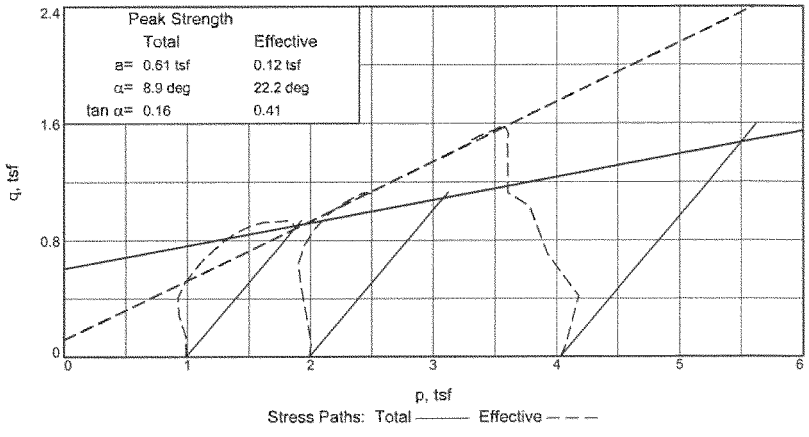
Figure CU Triax ASTM D 4767











Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Loc.: ND RRCS, MN, Argusville Formation **Depth:** 50-52' **Sample No.:** Boring11-107MU, #4

Project No.: [illegible]

Figure

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

6/16/2011
10:49 AM

Date:
Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Project No.: BL-10-10065
Location: ND RRCS, MN, Argusville Formation
Depth: 50-52' **Sample Number:** Boring11-107MU, #4
Description: FAT CLAY, brown (CH)
Remarks:
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.705 **LL=**63 **PL=**19 **PI=**44
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	125.620			155.650
Moisture content: Dry soil+tare, gms.	99.920			120.860
Moisture content: Tare, gms.	30.070			30.280
Moisture, %	36.8	37.3	37.3	38.4
Moist specimen weight, gms.	125.5			
Diameter, in.	1.38	1.38	1.38	
Area, in.^{2}	1.48	1.48	1.48	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	114.9	115.4	115.4	
Dry density, pcf	84.0	84.0	84.0	
Void ratio	1.0100	1.0100	1.0100	
Saturation, %	98.5	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.113 tsf
Consolidation back pressure = 6.125 tsf
Consolidation effective confining stress = 0.988 tsf
Peak Stress = 1.877 tsf **at reading no.** 13
Ult. Stress = 1.798 tsf **at reading no.** 17

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	0.0062	17.850	0.0	0.0	0.000	0.988	0.988	1.00	6.125	0.988	0.000
1	0.0103	23.740	5.9	0.1	0.285	0.844	1.129	1.34	6.269	0.987	0.143
2	0.0172	29.630	11.8	0.4	0.569	0.647	1.216	1.88	6.466	0.931	0.284
3	0.0442	34.820	17.0	1.4	0.812	0.515	1.327	2.58	6.598	0.921	0.406
4	0.0719	39.390	21.5	2.3	1.020	0.471	1.491	3.17	6.642	0.981	0.510
5	0.0988	43.270	25.4	3.3	1.192	0.462	1.654	3.58	6.651	1.058	0.596
6	0.1267	46.500	28.6	4.3	1.329	0.457	1.786	3.91	6.656	1.122	0.665
7	0.1536	51.450	33.6	5.3	1.543	0.489	2.032	4.16	6.624	1.261	0.772
8	0.1824	55.450	37.6	6.3	1.708	0.538	2.246	4.18	6.575	1.392	0.854
9	0.2115	58.070	40.2	7.3	1.807	0.617	2.424	3.93	6.496	1.521	0.904
10	0.2403	59.570	41.7	8.4	1.854	0.694	2.548	3.67	6.419	1.621	0.927
11	0.2681	60.150	42.3	9.4	1.859	0.759	2.618	3.45	6.354	1.689	0.930
12	0.2970	60.670	42.8	10.4	1.861	0.815	2.676	3.28	6.298	1.745	0.930
13	0.3259	61.550	43.7	11.4	1.877	0.868	2.745	3.16	6.245	1.807	0.939
14	0.3560	61.690	43.8	12.5	1.860	0.906	2.766	3.05	6.207	1.836	0.930
15	0.3858	62.120	44.3	13.6	1.856	0.925	2.781	3.01	6.188	1.853	0.928
16	0.4155	61.490	43.6	14.6	1.807	0.959	2.766	2.88	6.154	1.862	0.903
17	0.4277	61.490	43.6	15.0	1.798	0.972	2.770	2.85	6.141	1.871	0.899

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	137.990			156.310
Moisture content: Dry soil+tare, gms.	109.100			122.750
Moisture content: Tare, gms.	30.990			30.840
Moisture, %	37.0	37.2	36.9	36.5
Moist specimen weight, gms.	126.6			
Diameter, in.	1.38	1.38	1.38	
Area, in.²	1.49	1.49	1.49	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	115.2	115.4	115.7	
Dry density, pcf	84.1	84.1	84.6	
Void ratio	1.0076	1.0076	0.9968	
Saturation, %	99.3	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.137 tsf

Consolidation back pressure = 5.147 tsf

Consolidation effective confining stress = 1.990 tsf

Peak Stress = 2.260 tsf **at reading no.** 11

Ult. Stress = 2.199 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	0.0127	18.790	0.0	0.0	0.000	1.990	1.990	1.00	5.147	1.990	0.000
1	0.0167	22.480	3.7	0.1	0.178	1.916	2.094	1.09	5.221	2.005	0.089
2	0.0284	30.820	12.0	0.6	0.579	1.677	2.256	1.35	5.460	1.966	0.289
3	0.0553	39.360	20.6	1.5	0.980	1.432	2.412	1.68	5.705	1.922	0.490
4	0.0832	45.990	27.2	2.5	1.283	1.259	2.542	2.02	5.878	1.900	0.641
5	0.1111	51.880	33.1	3.5	1.545	1.179	2.724	2.31	5.958	1.951	0.772
6	0.1379	56.940	38.1	4.5	1.763	1.154	2.917	2.53	5.983	2.036	0.882
7	0.1648	61.700	42.9	5.4	1.963	1.166	3.129	2.68	5.971	2.148	0.982
8	0.1917	65.000	46.2	6.4	2.093	1.203	3.296	2.74	5.934	2.249	1.046
9	0.2195	67.560	48.8	7.4	2.185	1.254	3.439	2.74	5.883	2.347	1.093
10	0.2485	69.550	50.8	8.4	2.249	1.298	3.547	2.73	5.839	2.422	1.124
11	0.2753	70.340	51.6	9.4	2.260	1.335	3.595	2.69	5.802	2.465	1.130
12	0.3032	70.540	51.8	10.4	2.244	1.347	3.591	2.67	5.790	2.469	1.122
13	0.3314	71.140	52.4	11.4	2.244	1.361	3.605	2.65	5.776	2.483	1.122
14	0.3493	71.510	52.7	12.0	2.244	1.373	3.617	2.63	5.764	2.495	1.122
15	0.3771	71.770	53.0	13.0	2.229	1.381	3.610	2.61	5.756	2.496	1.115
16	0.4049	72.320	53.5	14.0	2.227	1.391	3.618	2.60	5.746	2.504	1.113
17	0.4318	72.260	53.5	15.0	2.199	1.398	3.597	2.57	5.739	2.498	1.100

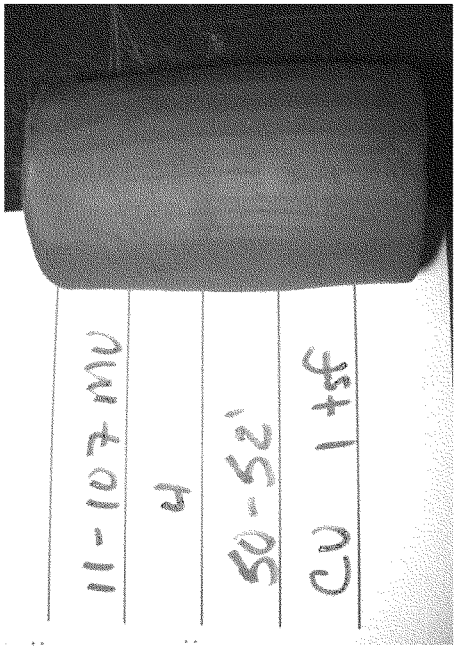
Parameters for Specimen No. 3

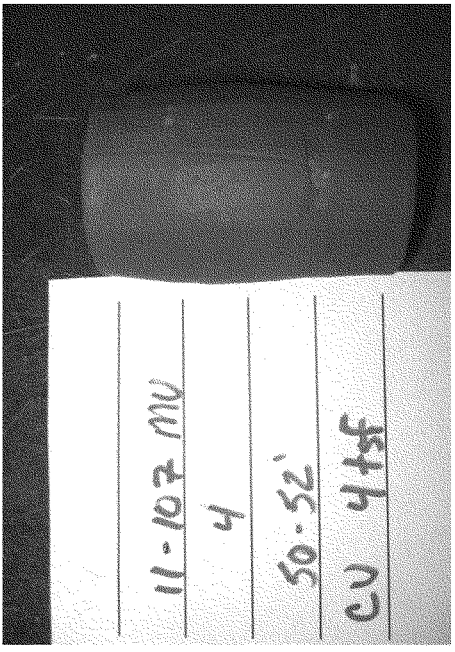
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	143.620			156.860
Moisture content: Dry soil+tare, gms.	112.930			123.940
Moisture content: Tare, gms.	30.660			30.620
Moisture, %	37.3	37.3	36.1	35.3
Moist specimen weight, gms.	128.7			
Diameter, in.	1.39	1.39	1.38	
Area, in.^{2}	1.52	1.52	1.50	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	115.4	115.4	116.2	
Dry density, pcf	84.0	84.0	85.4	
Void ratio	1.0099	1.0099	0.9777	
Saturation, %	99.9	100.0	100.0	

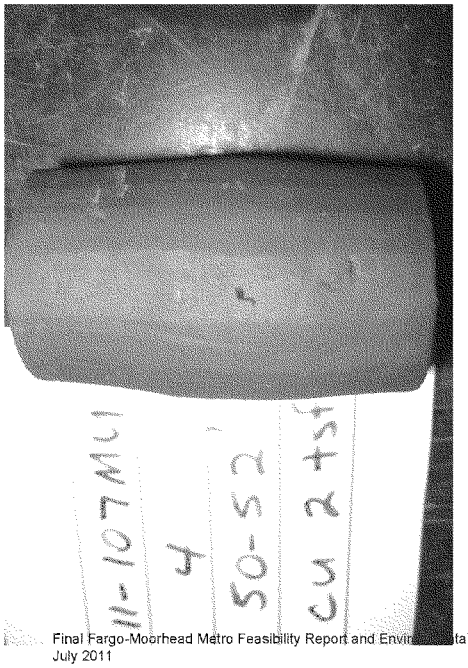
Test Readings for Specimen No. 3

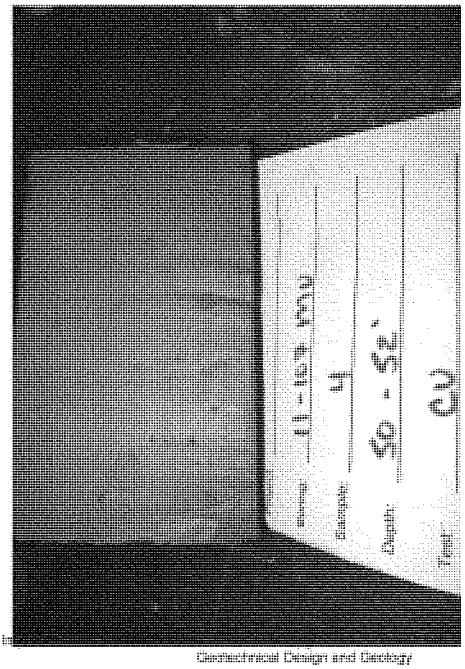
Consolidation cell pressure = 7.125 tsf
Consolidation back pressure = 3.093 tsf
Consolidation effective confining stress = 4.032 tsf
Peak Stress = 3.182 tsf **at reading no.** 11
Ult. Stress = 2.935 tsf **at reading no.** 18

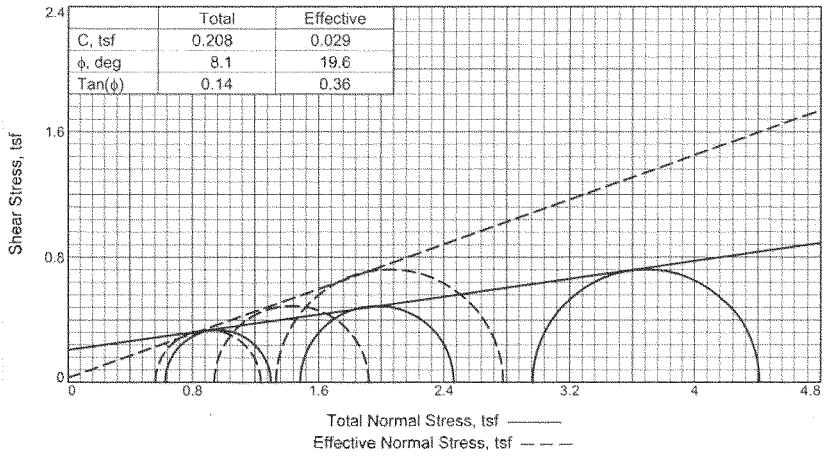
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0407	20.630	0.0	0.0	0.000	4.032	4.032	1.00	3.093	4.032	0.000
1	0.0434	23.800	3.2	0.1	0.152	3.997	4.149	1.04	3.128	4.073	0.076
2	0.0475	38.120	17.5	0.2	0.837	3.761	4.598	1.22	3.364	4.179	0.418
3	0.0589	50.310	29.7	0.7	1.414	3.218	4.632	1.44	3.907	3.925	0.707
4	0.0787	64.330	43.7	1.4	2.067	2.747	4.814	1.75	4.378	3.781	1.034
5	0.0981	68.660	48.0	2.1	2.256	2.474	4.730	1.91	4.651	3.602	1.128
6	0.1286	80.420	59.8	3.2	2.777	2.215	4.992	2.25	4.910	3.604	1.389
7	0.1490	84.690	64.1	3.9	2.953	2.125	5.078	2.39	5.000	3.601	1.476
8	0.1686	87.650	67.0	4.6	3.067	2.075	5.142	2.48	5.050	3.608	1.533
9	0.1873	89.400	68.8	5.3	3.125	2.028	5.153	2.54	5.097	3.590	1.562
10	0.2176	90.720	70.1	6.3	3.148	1.993	5.141	2.58	5.132	3.567	1.574
11	0.2478	92.300	71.7	7.4	3.182	1.980	5.162	2.61	5.145	3.571	1.591
12	0.2784	91.770	71.1	8.5	3.121	1.950	5.071	2.60	5.175	3.510	1.560
13	0.3079	91.660	71.0	9.6	3.080	1.910	4.990	2.61	5.215	3.450	1.540
14	0.3382	92.310	71.7	10.7	3.071	1.887	4.958	2.63	5.238	3.422	1.535
15	0.3686	92.500	71.9	11.8	3.041	1.872	4.913	2.62	5.253	3.393	1.521
16	0.3989	92.600	72.0	12.9	3.008	1.851	4.859	2.63	5.274	3.355	1.504
17	0.4284	92.870	72.2	13.9	2.983	1.832	4.815	2.63	5.293	3.323	1.491
18	0.4579	92.600	72.0	15.0	2.935	1.808	4.743	2.62	5.317	3.275	1.467

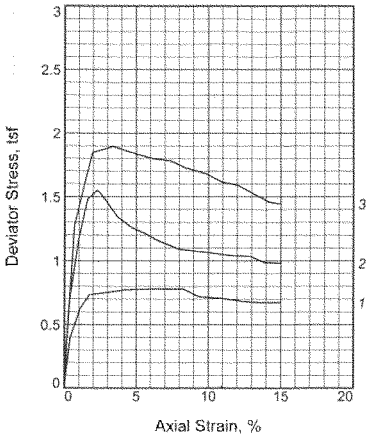

11-107 MW
4
50-52'
CU 1+4F


11-107 MW
4
50-52'
CU 4+4F


11-107 MW
4
50-52
CU 2+4F


11-107 MW
4
50 - 52'
CU





Sample No.		1	2	3
Initial	Water Content, %	52.4	52.5	50.5
	Dry Density, pcf	69.5	69.6	70.9
	Saturation, %	99.3	100.0	99.3
	Void Ratio	1.4194	1.4141	1.3705
	Diameter, in.	1.40	1.40	1.41
	Height, in.	2.80	2.80	2.80
At Test	Water Content, %	52.7	52.0	49.5
	Dry Density, pcf	69.5	70.0	72.1
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.4194	1.4012	1.3326
	Diameter, in.	1.40	1.40	1.40
	Height, in.	2.80	2.80	2.79
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.63	1.49	2.96
Back Pressure, tsf		6.50	5.64	4.17
Cell Pressure, tsf		7.13	7.13	7.13
Peak Deviator Stress, tsf		0.78	1.55	1.89
Total Pore Pr., tsf		6.61	6.38	5.41
Ultimate Deviator Stress, tsf		0.67	0.98	1.45
Total Pore Pr., tsf		6.56	6.19	5.80
Maj. Eff. Stress at Ultimate, tsf		1.24	1.92	2.78
Min. Eff. Stress at Ultimate, tsf		0.56	0.94	1.33

Type of Test:
CU with Pore Pressures
Sample Type: Undisturbed, 5" Thinwall, Middle
Description: FAT CLAY, brown (CH)

LL= 85 **PL=** 21 **PI=** 64
Specific Gravity= 2.693
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Sheyenne River, Argusville Formation
Sample Number: Boring11-110MU, #4 **Depth:** 55-57'
Proj. No.: BL-10-10065 **Date Sampled:**

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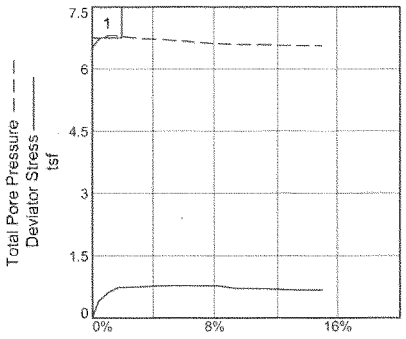
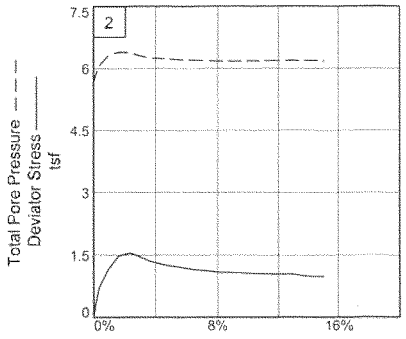
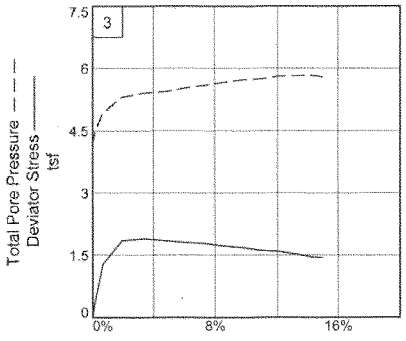
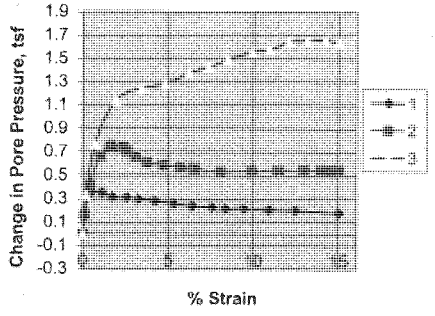
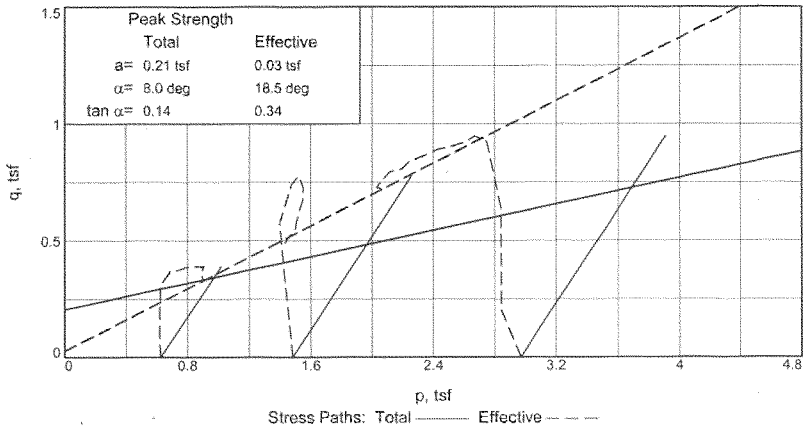
Figure C-Triaxial CU-Ma-K2











Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: Sheyenne River, Argusville Formation **Depth:** 55-57' **Sample No.:** Boring11-110MU, #4

TRIAXIAL COMPRESSION TEST 4/26/2011
CU with Pore Pressures 8:19 AM

Date:
Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project No.: BL-10-10065
Location: Sheyenne River, Argusville Formation
Depth: 55-57' **Sample Number:** Boring11-110MU, #4
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: Undisturbed, 5" Thinwall, Middle
Specific Gravity=2.693 **LL=**85 **PL=**21 **PI=**64
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	131.740			151.740
Moisture content: Dry soil+tare, gms.	96.940			109.960
Moisture content: Tare, gms.	30.480			31.110
Moisture, %	52.4	52.7	52.7	53.0
Moist specimen weight, gms.	120.1			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.54	1.54	1.54	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	105.9	106.1	106.1	
Dry density, pcf	69.5	69.5	69.5	
Void ratio	1.4194	1.4194	1.4194	
Saturation, %	99.3	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.126 tsf
Consolidation back pressure = 6.499 tsf
Consolidation effective confining stress = 0.627 tsf
Peak Stress = 0.781 tsf **at reading no.** 11
Ult. Stress = 0.674 tsf **at reading no.** 16

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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	0.0142	21.690	0.0	0.0	0.000	0.627	0.627	1.00	6.499	0.627	0.000
1	0.0172	24.410	2.7	0.1	0.127	0.556	0.683	1.23	6.570	0.619	0.063
2	0.0252	30.240	8.5	0.4	0.398	0.421	0.819	1.94	6.705	0.620	0.199
3	0.0441	35.120	13.4	1.1	0.621	0.315	0.936	2.97	6.811	0.625	0.310
4	0.0630	37.710	16.0	1.7	0.735	0.320	1.055	3.30	6.806	0.688	0.368
5	0.0839	38.050	16.4	2.5	0.745	0.356	1.101	3.09	6.770	0.729	0.373
6	0.1047	38.450	16.8	3.2	0.758	0.382	1.140	2.98	6.744	0.761	0.379
7	0.1326	39.000	17.3	4.2	0.774	0.405	1.179	2.91	6.721	0.792	0.387
8	0.1625	39.240	17.6	5.3	0.776	0.437	1.213	2.78	6.689	0.825	0.388
9	0.1934	39.530	17.8	6.4	0.780	0.467	1.247	2.67	6.659	0.857	0.390
10	0.2242	39.700	18.0	7.5	0.778	0.498	1.276	2.56	6.628	0.887	0.389
11	0.2463	39.910	18.2	8.3	0.781	0.514	1.295	2.52	6.612	0.904	0.390
12	0.2771	38.660	17.0	9.4	0.718	0.527	1.245	2.36	6.599	0.886	0.359
13	0.3190	38.660	17.0	10.9	0.706	0.538	1.244	2.31	6.588	0.891	0.353
14	0.3608	38.390	16.7	12.4	0.684	0.555	1.239	2.23	6.571	0.897	0.342
15	0.3948	38.360	16.7	13.6	0.673	0.560	1.233	2.20	6.566	0.896	0.336
16	0.4350	38.660	17.0	15.0	0.674	0.563	1.237	2.20	6.563	0.900	0.337

Parameters for Specimen No. 2				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	142.870			150.480
Moisture content: Dry soil+tare, gms.	104.280			109.790
Moisture content: Tare, gms.	30.780			30.340
Moisture, %	52.5	52.5	52.0	51.2
Moist specimen weight, gms.	120.6			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.54	1.54	1.54	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	106.2	106.2	106.4	
Dry density, pcf	69.6	69.6	70.0	
Void ratio	1.4141	1.4141	1.4012	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.127 tsf

Consolidation back pressure = 5.645 tsf

Consolidation effective confining stress = 1.482 tsf

Peak Stress = 1.551 tsf **at reading no.** 5

Ult. Stress = 0.983 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	0.0202	20.380	0.0	0.0	0.000	1.482	1.482	1.00	5.645	1.482	0.000
1	0.0232	26.330	5.9	0.1	0.278	1.321	1.599	1.21	5.806	1.460	0.139
2	0.0304	35.640	15.3	0.4	0.712	1.070	1.782	1.67	6.057	1.426	0.356
3	0.0469	45.220	24.8	1.0	1.152	0.820	1.972	2.40	6.307	1.396	0.576
4	0.0650	52.550	32.2	1.6	1.482	0.734	2.216	3.02	6.393	1.475	0.741
5	0.0840	54.290	33.9	2.3	1.551	0.743	2.294	3.09	6.384	1.518	0.775
6	0.0911	53.710	33.3	2.5	1.520	0.773	2.293	2.97	6.354	1.533	0.760
7	0.1028	52.430	32.0	3.0	1.456	0.824	2.280	2.77	6.303	1.552	0.728
8	0.1228	50.260	29.9	3.7	1.347	0.875	2.222	2.54	6.252	1.549	0.674
9	0.1507	48.610	28.2	4.7	1.260	0.897	2.157	2.40	6.230	1.527	0.630
10	0.1796	47.760	27.4	5.7	1.209	0.916	2.125	2.32	6.211	1.520	0.604
11	0.2024	46.810	26.4	6.5	1.156	0.926	2.082	2.25	6.201	1.504	0.578
12	0.2435	45.710	25.3	8.0	1.091	0.954	2.045	2.14	6.173	1.499	0.545
13	0.2982	45.680	25.3	9.9	1.066	0.946	2.012	2.13	6.181	1.479	0.533
14	0.3401	45.540	25.2	11.4	1.043	0.942	1.985	2.11	6.185	1.463	0.521
15	0.3809	45.800	25.4	12.9	1.036	0.938	1.974	2.10	6.189	1.456	0.518
16	0.4089	44.850	24.5	13.9	0.986	0.940	1.926	2.05	6.187	1.433	0.493
17	0.4229	44.950	24.6	14.4	0.984	0.938	1.922	2.05	6.189	1.430	0.492
18	0.4398	45.090	24.7	15.0	0.983	0.940	1.923	2.05	6.187	1.432	0.492

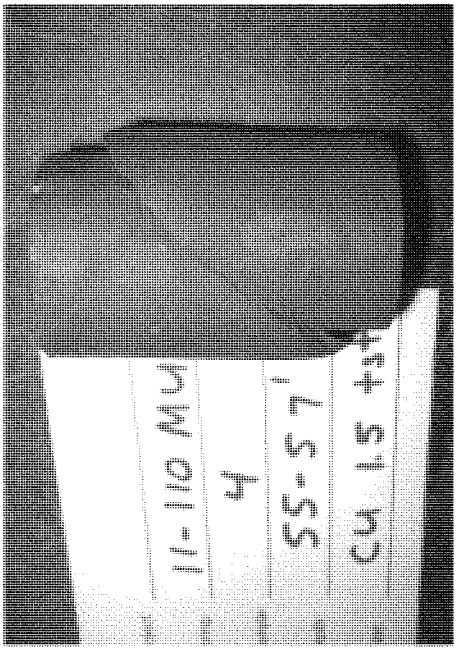
Parameters for Specimen No. 3

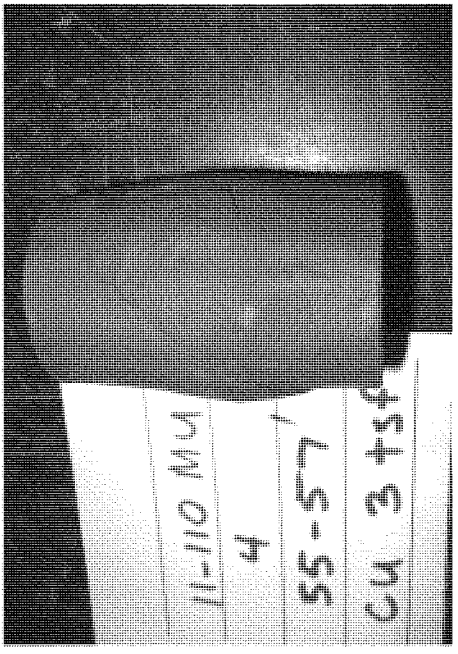
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	135.410			150.380
Moisture content: Dry soil+tare, gms.	100.160			111.420
Moisture content: Tare, gms.	30.400			30.500
Moisture, %	50.5	50.9	49.5	48.1
Moist specimen weight, gms.	122.0			
Diameter, in.	1.41	1.41	1.40	
Area, in.^{2}	1.55	1.55	1.54	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	106.8	107.0	107.7	
Dry density, pcf	70.9	70.9	72.1	
Void ratio	1.3705	1.3705	1.3326	
Saturation, %	99.3	100.0	100.0	

Test Readings for Specimen No. 3

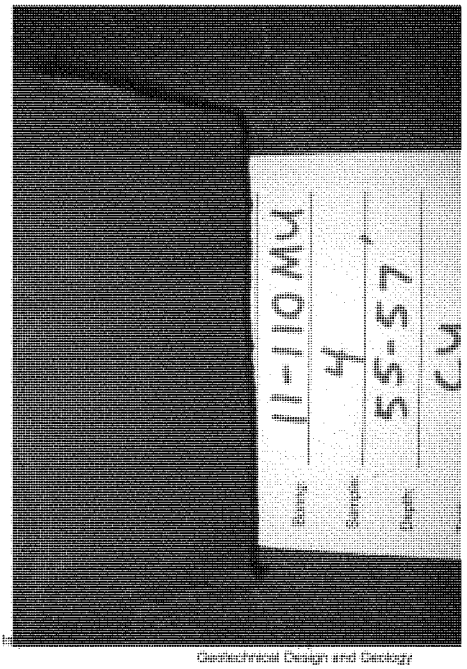
Consolidation cell pressure = 7.132 tsf
Consolidation back pressure = 4.166 tsf
Consolidation effective confining stress = 2.966 tsf
Peak Stress = 1.894 tsf **at reading no.** 4
Ult. Stress = 1.446 tsf **at reading no.** 14

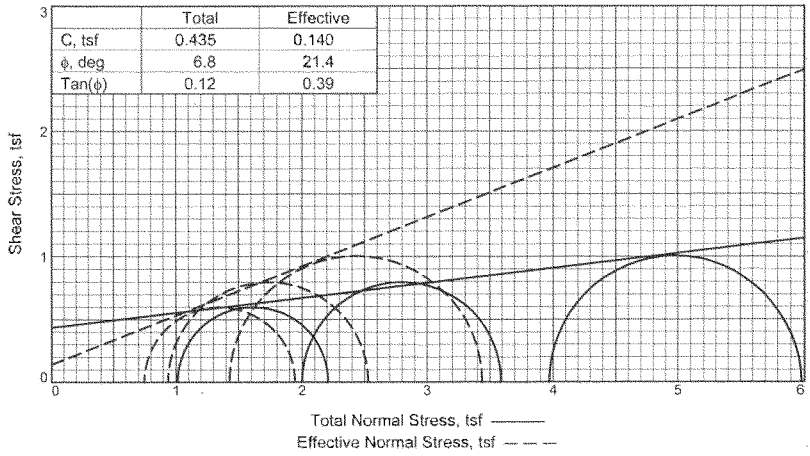
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0624	21.660	0.0	0.0	0.000	2.966	2.966	1.00	4.166	2.966	0.000
1	0.0673	30.440	8.8	0.2	0.410	2.637	3.047	1.16	4.495	2.842	0.205
2	0.0812	49.090	27.4	0.7	1.275	2.203	3.478	1.58	4.929	2.841	0.638
3	0.1166	61.890	40.2	1.9	1.846	1.825	3.671	2.01	5.307	2.748	0.923
4	0.1568	63.540	41.9	3.4	1.894	1.724	3.618	2.10	5.408	2.671	0.947
5	0.1963	62.990	41.3	4.8	1.842	1.687	3.529	2.09	5.445	2.608	0.921
6	0.2358	62.560	40.9	6.2	1.795	1.591	3.386	2.13	5.541	2.489	0.898
7	0.2664	62.770	41.1	7.3	1.783	1.541	3.324	2.16	5.591	2.433	0.892
8	0.2967	61.950	40.3	8.4	1.727	1.480	3.207	2.17	5.652	2.344	0.864
9	0.3368	61.460	39.8	9.9	1.679	1.408	3.087	2.19	5.724	2.248	0.840
10	0.3672	60.360	38.7	10.9	1.613	1.390	3.003	2.16	5.742	2.197	0.807
11	0.3977	60.250	38.6	12.0	1.589	1.323	2.912	2.20	5.809	2.117	0.794
12	0.4282	59.150	37.5	13.1	1.524	1.309	2.833	2.16	5.823	2.071	0.762
13	0.4587	57.930	36.3	14.2	1.456	1.302	2.758	2.12	5.830	2.030	0.728
14	0.4800	57.990	36.3	15.0	1.446	1.332	2.778	2.09	5.800	2.055	0.723

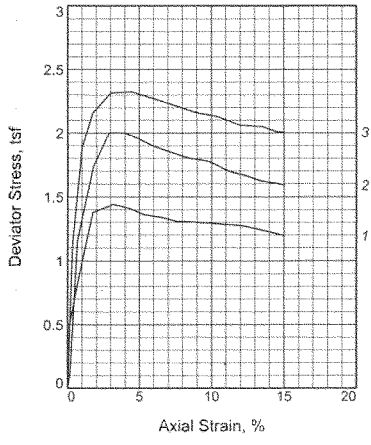

11-110 MU
4
55-57'
CU 1.5 tsf


11-110 MU
4
55-57'
CU 3 tsf

11-110 MU
4
55-57'
CU 0.75 t


11-110 MU
4
55-57'
CU





Sample No.		1	2	3
Initial	Water Content, %	46.4	44.9	45.9
	Dry Density, pcf	73.6	75.5	75.0
	Saturation, %	97.7	99.0	100.0
	Void Ratio	1.2725	1.2153	1.2297
	Diameter, in.	1.41	1.38	1.39
	Height, in.	2.80	2.81	2.80
At Test	Water Content, %	47.4	44.7	44.1
	Dry Density, pcf	73.7	76.1	76.6
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.2701	1.1964	1.1821
	Diameter, in.	1.41	1.38	1.38
	Height, in.	2.80	2.80	2.78
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		1.02	2.00	3.97
Back Pressure, tsf		6.10	5.15	3.16
Cell Pressure, tsf		7.12	7.15	7.13
Peak Deviator Stress, tsf		1.44	2.00	2.33
Total Pore Pr., tsf		6.58	5.97	5.10
Ultimate Deviator Stress, tsf		1.20	1.59	2.01
Total Pore Pr., tsf		6.37	6.21	5.70
Maj. Eff. Stress at Ultimate, tsf		1.94	2.53	3.44
Min. Eff. Stress at Ultimate, tsf		0.75	0.94	1.43

Type of Test:
CU with Pore Pressures

Sample Type: Undisturbed, 5" Thinwall, Middle

Description: FAT CLAY, brown (CH)

LL= 70 **PL=** 22 **PI=** 48

Specific Gravity= 2.679

Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

Location: Sheyenne River, Argusville Formation

Sample Number: Boring11-110MU, #5 **Depth:** 60-62'

Proj. No.: BL-10-10065 **Date Sampled:**

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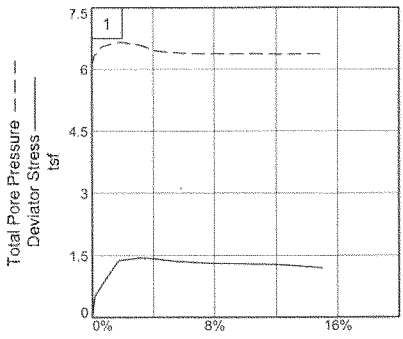
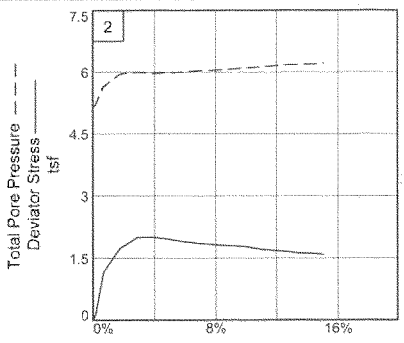
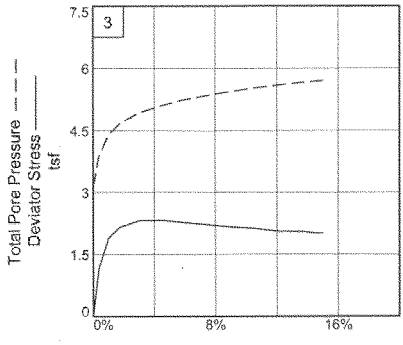
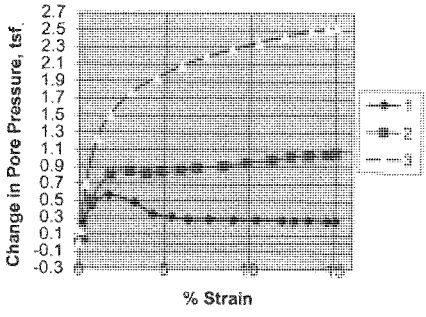
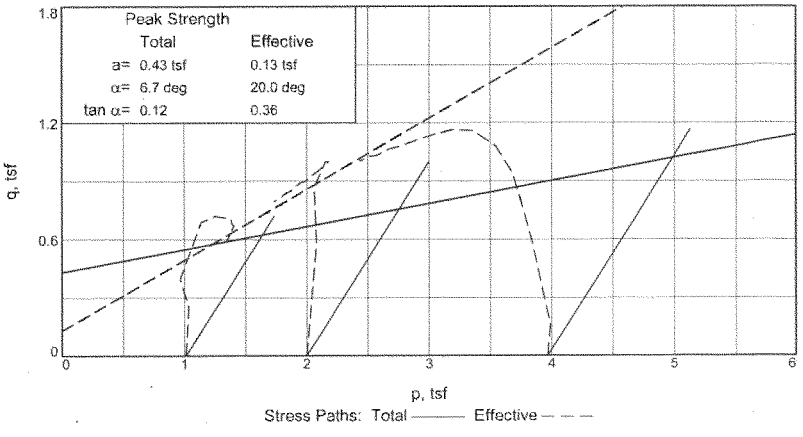
Figure A-1 Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement











Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: Sheyenne River, Argusville Formation **Depth:** 60-62' **Sample No.:** Boring11-110MU, #5
Project No.: Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement **Figure**
July 2011
Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST 4/26/2011
CU with Pore Pressures 8:19 AM

Date:
Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project No.: BL-10-10065
Location: Sheyenne River, Argusville Formation
Depth: 60-62' **Sample Number:** Boring11-110MU, #5
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: Undisturbed, 5" Thinwall, Middle
Specific Gravity=2.679 **LL**=70 **PL**=22 **PI**=48
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	142.110			153.830
Moisture content: Dry soil+tare, gms.	106.410			114.170
Moisture content: Tare, gms.	29.470			30.520
Moisture, %	46.4	47.5	47.4	47.4
Moist specimen weight, gms.	123.3			
Diameter, in.	1.41	1.41	1.41	
Area, in.^{2}	1.56	1.56	1.56	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	107.7	108.6	108.6	
Dry density, pcf	73.6	73.6	73.7	
Void ratio	1.2725	1.2725	1.2701	
Saturation, %	97.7	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.116 tsf
Consolidation back pressure = 6.104 tsf
Consolidation effective confining stress = 1.012 tsf
Strain rate, %/min. = 0.05
Peak Stress = 1.442 tsf **at reading no.** 4
Ult. Stress = 1.197 tsf **at reading no.** 15

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	0.0511	19.810	0.0	0.0	0.000	1.012	1.012	1.00	6.104	1.012	0.000
1	0.0557	30.810	11.0	0.2	0.507	0.781	1.288	1.65	6.335	1.035	0.254
2	0.0696	37.150	17.3	0.7	0.796	0.568	1.364	2.40	6.548	0.966	0.398
3	0.0997	50.150	30.3	1.7	1.378	0.447	1.825	4.08	6.669	1.136	0.689
4	0.1401	52.040	32.2	3.2	1.442	0.533	1.975	3.71	6.583	1.254	0.721
5	0.1703	51.720	31.9	4.3	1.412	0.673	2.085	3.10	6.443	1.379	0.706
6	0.2007	50.900	31.1	5.4	1.360	0.706	2.066	2.93	6.410	1.386	0.680
7	0.2310	50.850	31.0	6.4	1.342	0.735	2.077	2.83	6.381	1.406	0.671
8	0.2626	50.480	30.7	7.6	1.310	0.733	2.043	2.79	6.383	1.388	0.655
9	0.3028	50.770	31.0	9.0	1.302	0.740	2.042	2.76	6.376	1.391	0.651
10	0.3430	50.950	31.1	10.4	1.289	0.736	2.025	2.75	6.380	1.380	0.644
11	0.3833	51.160	31.3	11.9	1.277	0.747	2.024	2.71	6.369	1.385	0.638
12	0.4037	51.110	31.3	12.6	1.264	0.750	2.014	2.69	6.366	1.382	0.632
13	0.4262	50.870	31.1	13.4	1.243	0.746	1.989	2.67	6.370	1.367	0.621
14	0.4567	50.510	30.7	14.5	1.213	0.749	1.962	2.62	6.367	1.355	0.606
15	0.4700	50.280	30.5	15.0	1.197	0.747	1.944	2.60	6.369	1.346	0.599

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	149.370			150.370
Moisture content: Dry soil+tare, gms.	112.440			114.150
Moisture content: Tare, gms.	30.200			30.470
Moisture, %	44.9	45.4	44.7	43.3
Moist specimen weight, gms.	120.9			
Diameter, in.	1.38	1.38	1.38	
Area, in.²	1.50	1.50	1.49	
Height, in.	2.81	2.81	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	109.4	109.7	110.2	
Dry density, pcf	75.5	75.5	76.1	
Void ratio	1.2153	1.2153	1.1964	
Saturation, %	99.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.147 tsf
Consolidation back pressure = 5.148 tsf
Consolidation effective confining stress = 1.999 tsf
Peak Stress = 2.001 tsf **at reading no.** 5
Ult. Stress = 1.592 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	0.0442	19.500	0.0	0.0	0.000	1.999	1.999	1.00	5.148	1.999	0.000
1	0.0490	22.090	2.6	0.2	0.125	1.947	2.072	1.06	5.200	2.009	0.062
2	0.0637	43.670	24.2	0.7	1.160	1.498	2.658	1.77	5.649	2.078	0.580
3	0.0940	56.100	36.6	1.8	1.738	1.192	2.930	2.46	5.955	2.061	0.869
4	0.1251	62.110	42.6	2.9	2.000	1.151	3.151	2.74	5.996	2.151	1.000
5	0.1546	62.590	43.1	3.9	2.001	1.179	3.180	2.70	5.968	2.180	1.001
6	0.1790	62.180	42.7	4.8	1.964	1.162	3.126	2.69	5.985	2.144	0.982
7	0.2093	61.330	41.8	5.9	1.903	1.138	3.041	2.67	6.009	2.090	0.952
8	0.2388	60.800	41.3	6.9	1.858	1.112	2.970	2.67	6.035	2.041	0.929
9	0.2790	60.260	40.8	8.4	1.805	1.092	2.897	2.65	6.055	1.995	0.903
10	0.3198	60.270	40.8	9.8	1.777	1.049	2.826	2.69	6.098	1.938	0.889
11	0.3595	59.050	39.5	11.3	1.697	1.013	2.710	2.68	6.134	1.861	0.848
12	0.3908	58.800	39.3	12.4	1.665	0.979	2.644	2.70	6.168	1.811	0.832
13	0.4211	58.270	38.8	13.4	1.622	0.968	2.590	2.68	6.179	1.779	0.811
14	0.4517	58.340	38.8	14.5	1.605	0.950	2.555	2.69	6.197	1.752	0.802
15	0.4656	58.270	38.8	15.0	1.592	0.936	2.528	2.70	6.211	1.732	0.796

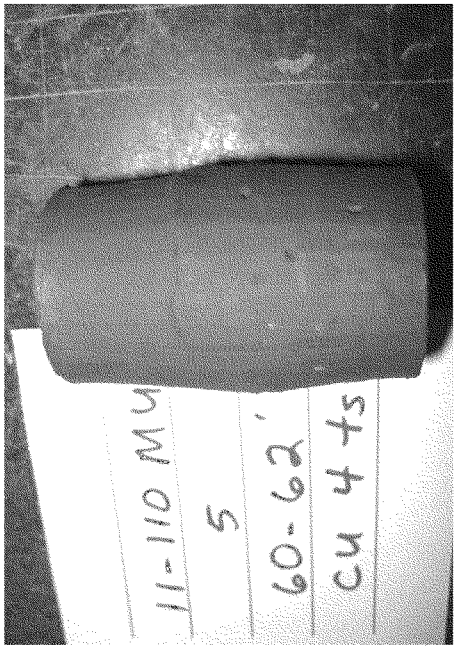
Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	160.530			149.680
Moisture content: Dry soil+tare, gms.	119.590			114.990
Moisture content: Tare, gms.	30.380			31.100
Moisture, %	45.9	45.9	44.1	41.4
Moist specimen weight, gms.	122.3			
Diameter, in.	1.39	1.39	1.38	
Area, in.²	1.52	1.52	1.50	
Height, in.	2.80	2.80	2.78	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	109.4	109.4	110.5	
Dry density, pcf	75.0	75.0	76.6	
Void ratio	1.2297	1.2297	1.1821	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 3

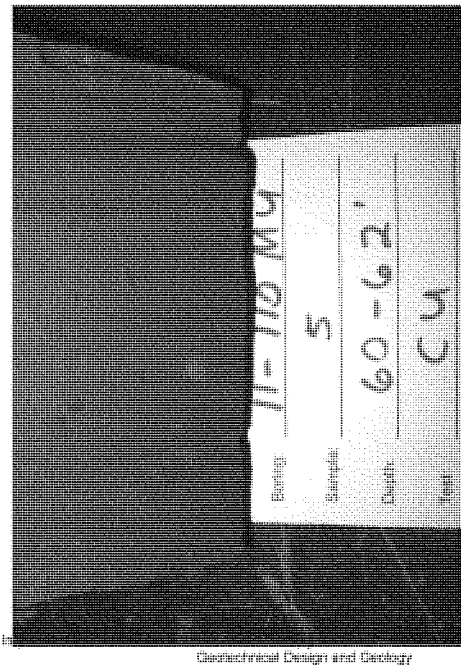
Consolidation cell pressure = 7.131 tsf
Consolidation back pressure = 3.162 tsf
Consolidation effective confining stress = 3.969 tsf
Peak Stress = 2.327 tsf **at reading no.** 6
Ult. Stress = 2.009 tsf **at reading no.** 14

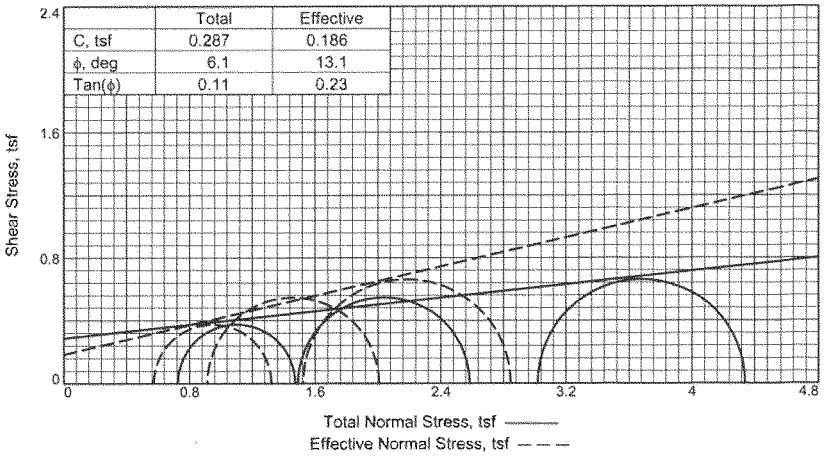
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0077	18.790	0.0	0.0	0.000	3.969	3.969	1.00	3.162	3.969	0.000
1	0.0105	25.720	6.9	0.1	0.332	3.825	4.157	1.09	3.306	3.991	0.166
2	0.0177	42.780	24.0	0.4	1.148	3.272	4.420	1.35	3.859	3.846	0.574
3	0.0359	58.500	39.7	1.0	1.887	2.737	4.624	1.69	4.394	3.681	0.944
4	0.0564	64.600	45.8	1.8	2.161	2.460	4.621	1.88	4.671	3.541	1.081
5	0.0920	68.570	49.8	3.0	2.318	2.199	4.517	2.05	4.932	3.358	1.159
6	0.1318	69.520	50.7	4.5	2.327	2.028	4.355	2.15	5.103	3.192	1.164
7	0.1735	69.150	50.4	6.0	2.274	1.888	4.162	2.20	5.243	3.025	1.137
8	0.2146	68.720	49.9	7.4	2.219	1.783	4.002	2.24	5.348	2.892	1.109
9	0.2563	68.240	49.4	8.9	2.162	1.694	3.856	2.28	5.437	2.775	1.081
10	0.2983	68.300	49.5	10.5	2.129	1.610	3.739	2.32	5.521	2.674	1.064
11	0.3401	67.560	48.8	12.0	2.062	1.539	3.601	2.34	5.592	2.570	1.031
12	0.3832	68.210	49.4	13.5	2.052	1.477	3.529	2.39	5.654	2.503	1.026
13	0.4110	67.750	49.0	14.5	2.010	1.442	3.452	2.39	5.689	2.447	1.005
14	0.4240	68.000	49.2	15.0	2.009	1.427	3.436	2.41	5.704	2.431	1.004


11-110 MH
S
60-62'
Cu 4 tsf

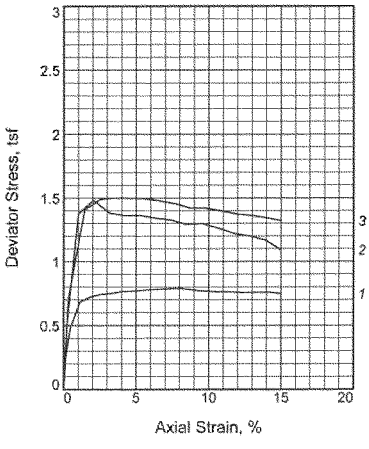
11-110 MH
S
60-62'
Cu 1 tsf

11-110 MH
S
60-62'
Cu 2 tsf


11-110 MH
S
60-62'
Cu



	Total	Effective
C, tsf	0.287	0.186
ϕ, deg	6.1	13.1
Tan(ϕ)	0.11	0.23



Sample No.		1	2	3
Initial	Water Content, %	45.0	44.7	49.1
	Dry Density, pcf	74.8	75.1	71.4
	Saturation, %	97.0	97.2	97.7
	Void Ratio	1.2484	1.2396	1.3543
	Diameter, in.	1.42	1.41	1.40
	Height, in.	2.79	2.81	2.80
At Test	Water Content, %	46.4	46.0	49.4
	Dry Density, pcf	74.8	75.1	72.2
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.2484	1.2396	1.3292
	Diameter, in.	1.42	1.41	1.39
	Height, in.	2.79	2.81	2.79
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.73	1.49	3.02
Back Pressure, tsf		6.41	5.64	4.11
Cell Pressure, tsf		7.14	7.13	7.13
Peak Deviator Stress, tsf		0.79	1.48	1.50
Total Pore Pr., tsf		6.64	6.20	5.13
Ultimate Deviator Stress, tsf		0.75	1.09	1.32
Total Pore Pr., tsf		6.57	6.22	5.61
Maj. Eff. Stress at Ultimate, tsf		1.32	2.01	2.85
Min. Eff. Stress at Ultimate, tsf		0.57	0.91	1.52

Type of Test:
CU with Pore Pressures
Sample Type: 5" Thinwall, Middle of sample
Description: FAT CLAY, brown (CH)

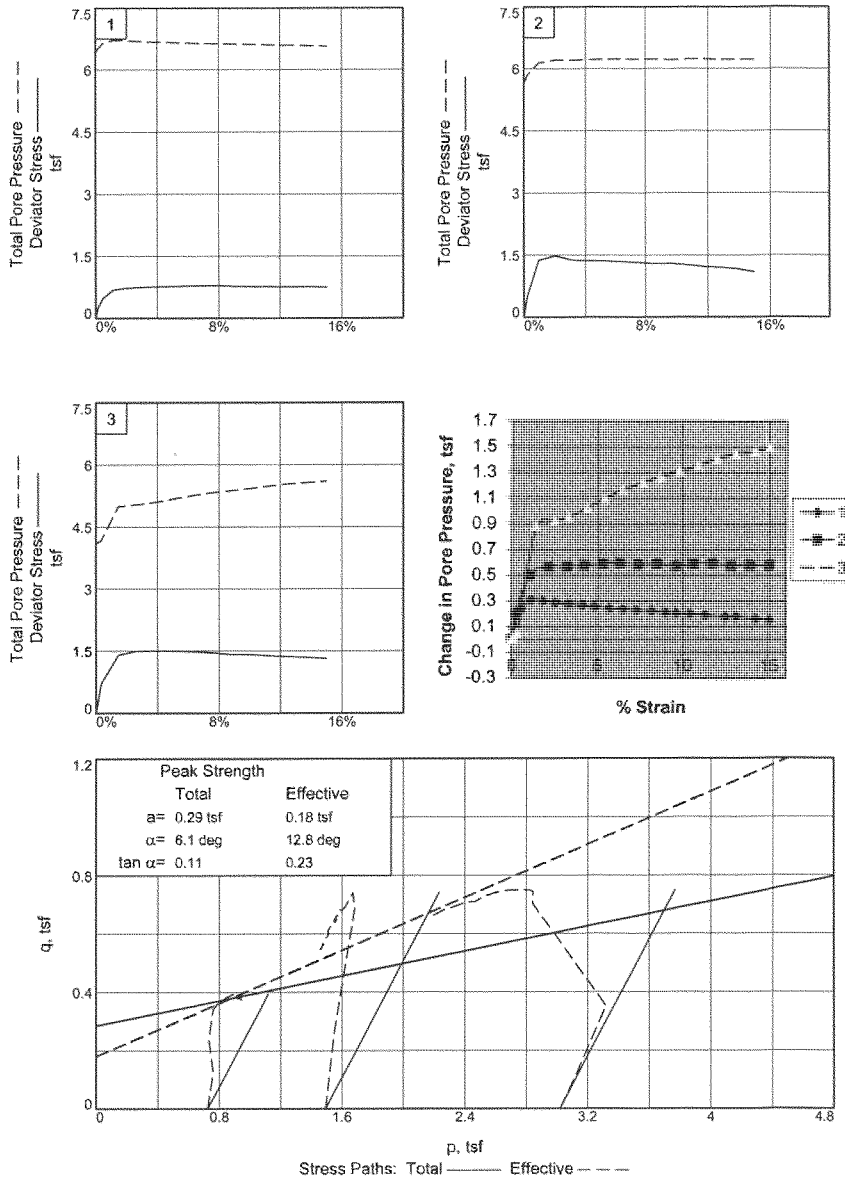
LL= 60 **PL=** 17 **PI=** 43
Specific Gravity= 2.693
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Location: Wild Rice, Argusville Formation
Sample Number: Boring11-118MU, #3 **Depth:** 45-47'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Figure Triaxial Test Results



Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Location: Wild Rice, Argusville Formation **Depth:** 45-47' **Sample Number:** Boring11-118MU, #3

Project No.: BL-10-10065 **Figure** **Braun Intertec**

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

5/15/2011
11:45 AM

Date:
Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Project No.: BL-10-10065
Location: Wild Rice, Argusville Formation
Depth: 45-47' **Sample Number:** Boring11-118MU, #3
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.693 **LL=**60 **PL=**17 **PI=**43
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	123.210			155.610
Moisture content: Dry soil+tare, gms.	94.210			113.610
Moisture content: Tare, gms.	29.720			29.460
Moisture, %	45.0	46.4	46.4	49.9
Moist specimen weight, gms.	126.1			
Diameter, in.	1.42	1.42	1.42	
Area, in.²	1.59	1.59	1.59	
Height, in.	2.79	2.79	2.79	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	108.4	109.4	109.4	
Dry density, pcf	74.8	74.8	74.8	
Void ratio	1.2484	1.2484	1.2484	
Saturation, %	97.0	100.0	100.0	

Test Reading for Specimen No. 1

Consolidation cell pressure = 7.138 tsf
Consolidation back pressure = 6.413 tsf
Consolidation effective confining stress = 0.725 tsf
Peak Stress = 0.789 tsf **at reading no.** 12
Ult. Stress = 0.750 tsf **at reading no.** 20

Results 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	0.0096	17.280	0.0	0.0	0.000	0.725	0.725	1.00	6.413	0.725	0.000
1	0.0135	22.790	5.5	0.1	0.250	0.635	0.885	1.39	6.503	0.760	0.125
2	0.0225	27.860	10.6	0.5	0.478	0.494	0.972	1.97	6.644	0.733	0.239
3	0.0412	32.470	15.2	1.1	0.682	0.420	1.102	2.62	6.718	0.761	0.341
4	0.0602	33.470	16.2	1.8	0.722	0.429	1.151	2.68	6.709	0.790	0.361
5	0.0802	34.060	16.8	2.5	0.743	0.443	1.186	2.68	6.695	0.814	0.371
6	0.1010	34.370	17.1	3.3	0.751	0.453	1.204	2.66	6.685	0.828	0.375
7	0.1229	34.840	17.6	4.1	0.765	0.462	1.227	2.66	6.676	0.844	0.382
8	0.1448	35.090	17.8	4.8	0.769	0.472	1.241	2.63	6.666	0.857	0.385
9	0.1676	35.430	18.1	5.7	0.777	0.484	1.261	2.61	6.654	0.873	0.389
10	0.1906	35.710	18.4	6.5	0.783	0.491	1.274	2.59	6.647	0.882	0.391
11	0.2146	36.000	18.7	7.3	0.788	0.496	1.284	2.59	6.642	0.890	0.394
12	0.2374	36.200	18.9	8.2	0.789	0.502	1.291	2.57	6.636	0.896	0.394
13	0.2613	36.050	18.8	9.0	0.775	0.514	1.289	2.51	6.624	0.902	0.388
14	0.2776	36.040	18.8	9.6	0.770	0.519	1.289	2.48	6.619	0.904	0.385
15	0.3012	36.050	18.8	10.4	0.763	0.524	1.287	2.46	6.614	0.906	0.382
16	0.3262	36.200	18.9	11.3	0.762	0.532	1.294	2.43	6.606	0.913	0.381
17	0.3590	36.350	19.1	12.5	0.758	0.545	1.303	2.39	6.593	0.924	0.379
18	0.3760	36.530	19.3	13.1	0.759	0.544	1.303	2.40	6.594	0.924	0.380
19	0.4059	36.740	19.5	14.2	0.758	0.561	1.319	2.35	6.577	0.940	0.379
20	0.4297	36.710	19.4	15.0	0.750	0.572	1.322	2.31	6.566	0.947	0.375

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	137.960			154.680
Moisture content: Dry soil+tare, gms.	104.570			115.480
Moisture content: Tare, gms.	29.930			31.000
Moisture, %	44.7	46.0	46.0	46.4
Moist specimen weight, gms.	124.5			
Diameter, in.	1.41	1.41	1.41	
Area, in.²	1.55	1.55	1.55	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	108.6	109.6	109.6	
Dry density, pcf	75.1	75.1	75.1	
Void ratio	1.2396	1.2396	1.2396	
Saturation, %	97.2	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.133 tsf
Consolidation back pressure = 5.641 tsf
Consolidation effective confining stress = 1.492 tsf
Peak Stress = 1.482 tsf **at reading no.** 3
Ult. Stress = 1.093 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	0.0483	20.810	0.0	0.0	0.000	1.492	1.492	1.00	5.641	1.492	0.000
1	0.0551	32.030	11.2	0.2	0.518	1.290	1.808	1.40	5.843	1.549	0.259
2	0.0764	50.790	30.0	1.0	1.374	0.995	2.369	2.38	6.138	1.682	0.687
3	0.1059	53.490	32.7	2.1	1.482	0.929	2.411	2.60	6.204	1.670	0.741
4	0.1372	51.630	30.8	3.2	1.382	0.928	2.310	2.49	6.205	1.619	0.691
5	0.1655	51.500	30.7	4.2	1.362	0.919	2.281	2.48	6.214	1.600	0.681
6	0.1957	51.870	31.1	5.3	1.363	0.903	2.266	2.51	6.230	1.584	0.681
7	0.2254	51.750	30.9	6.3	1.342	0.899	2.241	2.49	6.234	1.570	0.671
8	0.2558	51.750	30.9	7.4	1.327	0.908	2.235	2.46	6.225	1.571	0.663
9	0.2861	51.300	30.5	8.5	1.292	0.902	2.194	2.43	6.231	1.548	0.646
10	0.3165	51.800	31.0	9.6	1.298	0.918	2.216	2.41	6.215	1.567	0.649
11	0.3468	51.350	30.5	10.6	1.264	0.901	2.165	2.40	6.232	1.533	0.632
12	0.3775	50.660	29.8	11.7	1.220	0.897	2.117	2.36	6.236	1.507	0.610
13	0.4076	50.540	29.7	12.8	1.201	0.914	2.115	2.31	6.219	1.514	0.600
14	0.4386	50.140	29.3	13.9	1.169	0.909	2.078	2.29	6.224	1.494	0.585
15	0.4688	48.580	27.8	15.0	1.093	0.913	2.006	2.20	6.220	1.460	0.547

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	140.490			146.630
Moisture content: Dry soil+tare, gms.	104.220			108.420
Moisture content: Tare, gms.	30.400			30.200
Moisture, %	49.1	50.3	49.4	48.8
Moist specimen weight, gms.	119.8			
Diameter, in.	1.40	1.40	1.39	
Area, in.^{2}	1.53	1.53	1.52	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	106.5	107.3	107.8	
Dry density, pcf	71.4	71.4	72.2	
Void ratio	1.3543	1.3543	1.3292	
Saturation, %	97.7	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.131 tsf

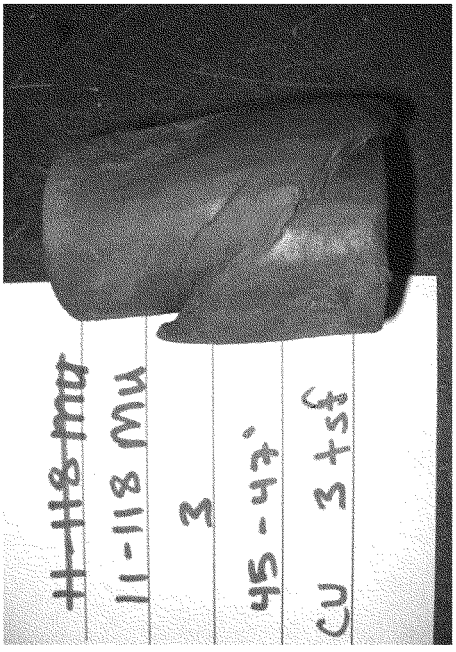
Consolidation back pressure = 4.112 tsf

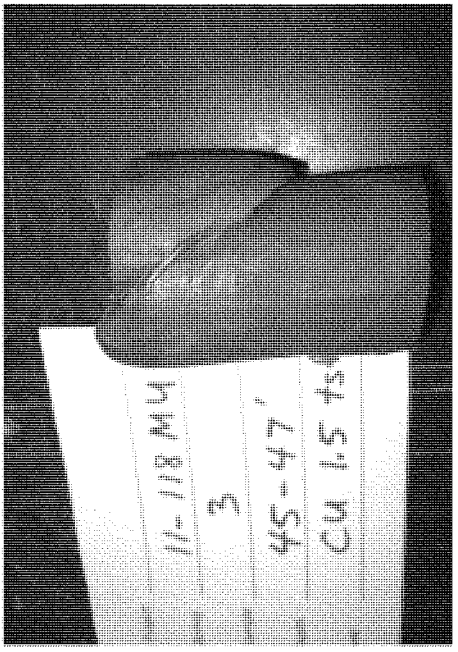
Consolidation effective confining stress = 3.019 tsf

Peak Stress = 1.499 tsf **at reading no.** 6

Ult. Stress = 1.322 tsf **at reading no.** 16

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	0.0294	17.600	0.0	0.0	0.000	3.019	3.019	1.00	4.112	3.019	0.000
1	0.0325	22.500	4.9	0.1	0.232	3.007	3.239	1.08	4.124	3.123	0.116
2	0.0385	32.520	14.9	0.3	0.705	2.969	3.674	1.24	4.162	3.321	0.352
3	0.0696	47.700	30.1	1.4	1.406	2.138	3.544	1.66	4.993	2.841	0.703
4	0.1000	49.860	32.3	2.5	1.490	2.099	3.589	1.71	5.032	2.844	0.745
5	0.1206	50.300	32.7	3.3	1.499	2.070	3.569	1.72	5.061	2.819	0.749
6	0.1509	50.680	33.1	4.4	1.499	1.999	3.498	1.75	5.132	2.749	0.750
7	0.1814	50.990	33.4	5.4	1.496	1.928	3.424	1.78	5.203	2.676	0.748
8	0.2114	51.020	33.4	6.5	1.480	1.857	3.337	1.80	5.274	2.597	0.740
9	0.2430	50.880	33.3	7.7	1.456	1.799	3.255	1.81	5.332	2.527	0.728
10	0.2734	50.440	32.8	8.7	1.420	1.757	3.177	1.81	5.374	2.467	0.710
11	0.3029	50.810	33.2	9.8	1.419	1.712	3.131	1.83	5.419	2.422	0.710
12	0.3334	50.730	33.1	10.9	1.399	1.664	3.063	1.84	5.467	2.363	0.699
13	0.3637	50.530	32.9	12.0	1.373	1.613	2.986	1.85	5.518	2.300	0.687
14	0.3942	50.630	33.0	13.1	1.360	1.575	2.935	1.86	5.556	2.255	0.680
15	0.4251	50.550	32.9	14.2	1.340	1.554	2.894	1.86	5.577	2.224	0.670
16	0.4472	50.430	32.8	15.0	1.322	1.523	2.845	1.87	5.608	2.184	0.661


~~11-118 MU~~
11-118 MU
3
45-47'
CU 3 tsf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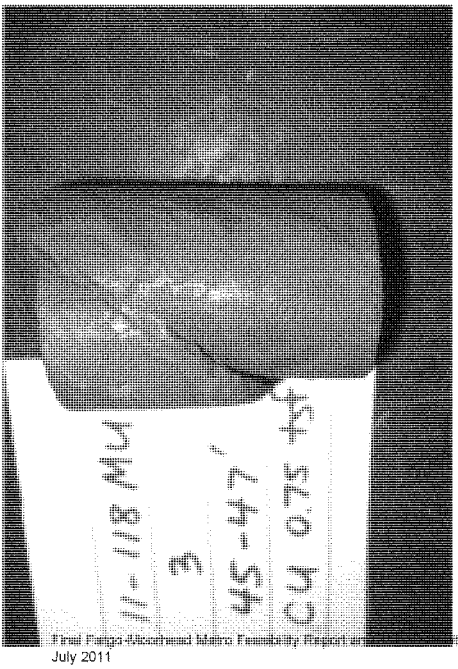
3
45-47'
CU 1.5 ts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3
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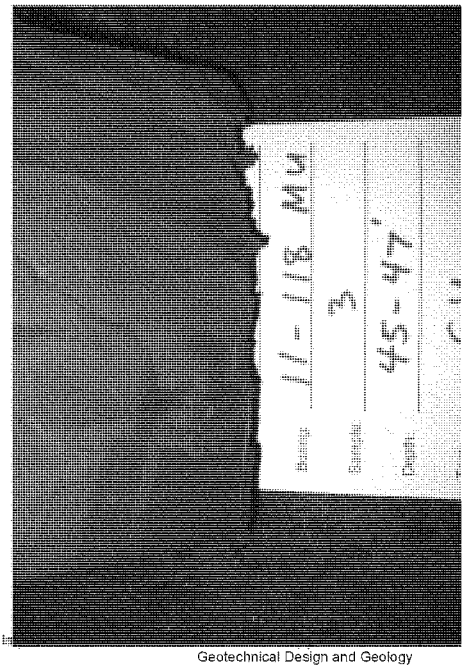
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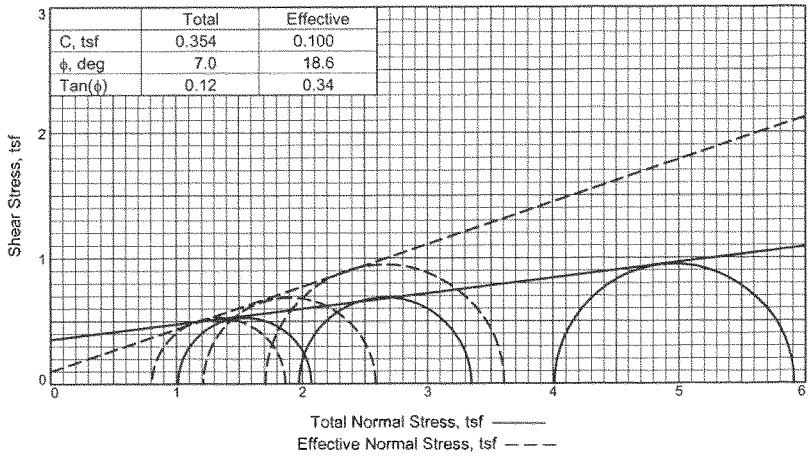
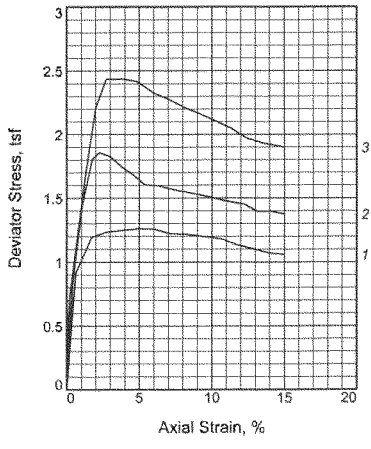
3
45-47'





Sample No.		1	2	3
Initial	Water Content, %	46.1	43.8	45.0
	Dry Density, pcf	74.4	76.9	74.9
	Saturation, %	98.9	99.7	97.5
	Void Ratio	1.2533	1.1803	1.2387
	Diameter, in.	1.39	1.39	1.41
	Height, in.	2.81	2.81	2.80
At Test	Water Content, %	46.6	43.1	44.8
	Dry Density, pcf	74.4	77.8	76.1
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.2533	1.1571	1.2029
	Diameter, in.	1.39	1.39	1.40
	Height, in.	2.81	2.80	2.79
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		1.01	1.98	4.01
Back Pressure, tsf		6.12	5.15	3.12
Cell Pressure, tsf		7.13	7.13	7.13
Peak Deviator Stress, tsf		1.26	1.86	2.44
Total Pore Pr., tsf		6.52	6.06	4.87
Ultimate Deviator Stress, tsf		1.06	1.38	1.90
Total Pore Pr., tsf		6.33	5.92	5.42
Maj. Eff. Stress at Ultimate, tsf		1.87	2.59	3.61
Min. Eff. Stress at Ultimate, tsf		0.81	1.21	1.71

Type of Test: CU with Pore Pressures

Sample Type: 5" Thinwall, Middle of sample

Description: FAT CLAY, brown (CH)

LL= 77 **PL=** 22 **PI=** 55

Specific Gravity= 2.687

Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2

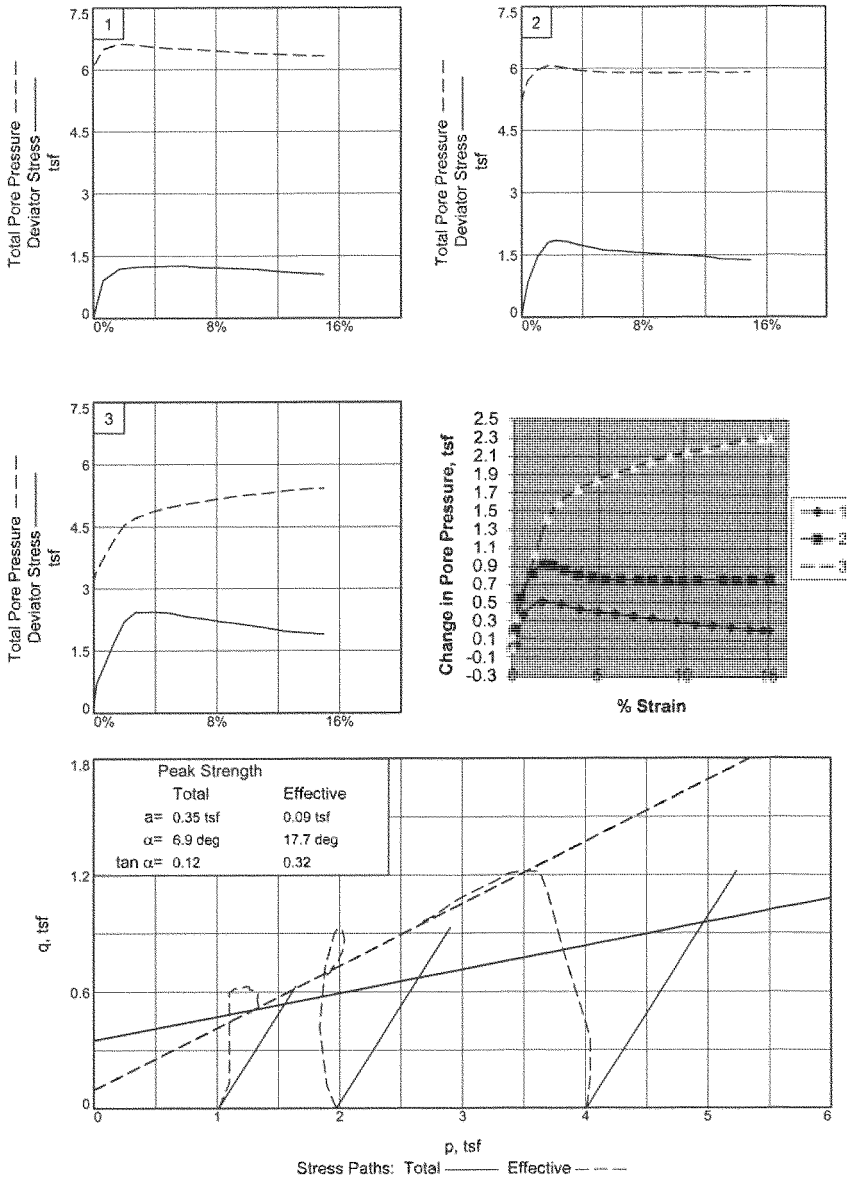
Location: Wild Rice, Argusvill Formation

Sample Number: Boring11-118MU, #4 **Depth:** 55-57'

Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Figure C-1, Triaxial ASTM D 4767



Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Location: Wild Rice, Argusvill Formation **Depth:** 55-57' **Sample Number:** Boring11-118MU, #4

Project No.: BI-10-10065 **Figure**

Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

5/15/2011
11:46 AM

Date:
Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Project No.: BL-10-10065
Location: Wild Rice, Argusvill Formation
Depth: 55-57' **Sample Number:** Boring11-118MU, #4
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.687 **LL=**77 **PL=**22 **PI=**55
Test Method: COE uniform strain

Parameter for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	154.590			152.920
Moisture content: Dry soil+tare, gms.	115.280			113.690
Moisture content: Tare, gms.	30.100			30.300
Moisture, %	46.1	46.6	46.6	47.0
Moist specimen weight, gms.	122.0			
Diameter, in.	1.39	1.39	1.39	
Area, in.^{2}	1.52	1.52	1.52	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	108.8	109.2	109.2	
Dry density, pcf	74.4	74.4	74.4	
Void ratio	1.2533	1.2533	1.2533	
Saturation, %	98.9	100.0	100.0	

Test Reading for Specimen No. 1

Consolidation cell pressure = 7.134 tsf
Consolidation back pressure = 6.122 tsf
Consolidation effective confining stress = 1.012 tsf
Peak Stress = 1.260 tsf **at reading no.** 6
Ult. Stress = 1.059 tsf **at reading no.** 16

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	0.0441	18.090	0.0	0.0	0.000	1.012	1.012	1.00	6.122	1.012	0.000
1	0.0490	23.670	5.6	0.2	0.264	0.968	1.232	1.27	6.166	1.100	0.132
2	0.0618	37.540	19.4	0.6	0.916	0.642	1.558	2.43	6.492	1.100	0.458
3	0.0922	43.740	25.7	1.7	1.194	0.503	1.697	3.37	6.631	1.100	0.597
4	0.1225	44.920	26.8	2.8	1.236	0.528	1.764	3.34	6.606	1.146	0.618
5	0.1528	45.510	27.4	3.9	1.249	0.582	1.831	3.15	6.552	1.206	0.624
6	0.1833	46.070	28.0	5.0	1.260	0.614	1.874	3.05	6.520	1.244	0.630
7	0.2136	46.350	28.3	6.0	1.258	0.632	1.890	2.99	6.502	1.261	0.629
8	0.2441	45.910	27.8	7.1	1.224	0.654	1.878	2.87	6.480	1.266	0.612
9	0.2743	46.120	28.0	8.2	1.219	0.682	1.901	2.79	6.452	1.292	0.610
10	0.3144	46.040	27.9	9.6	1.197	0.717	1.914	2.67	6.417	1.315	0.598
11	0.3441	45.970	27.9	10.7	1.180	0.745	1.925	2.58	6.389	1.335	0.590
12	0.3744	45.240	27.2	11.7	1.135	0.759	1.894	2.50	6.375	1.327	0.568
13	0.4046	44.840	26.8	12.8	1.105	0.777	1.882	2.42	6.357	1.329	0.552
14	0.4363	44.400	26.3	13.9	1.073	0.796	1.869	2.35	6.338	1.332	0.536
15	0.4559	44.370	26.3	14.6	1.063	0.803	1.866	2.32	6.331	1.334	0.531
16	0.4658	44.390	26.3	15.0	1.059	0.808	1.867	2.31	6.326	1.338	0.530

Parameters for Specimen No. 2				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	135.290			153.920
Moisture content: Dry soil+tare, gms.	103.340			117.040
Moisture content: Tare, gms.	30.410			29.760
Moisture, %	43.8	43.9	43.1	42.3
Moist specimen weight, gms.	124.5			
Diameter, in.	1.39	1.39	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	110.6	110.7	111.3	
Dry density, pcf	76.9	76.9	77.8	
Void ratio	1.1803	1.1803	1.1571	
Saturation, %	99.7	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.125 tsf

Consolidation back pressure = 5.152 tsf

Consolidation effective confining stress = 1.973 tsf

Peak Stress = 1.858 tsf **at reading no.** 5

Ult. Stress = 1.375 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	0.0075	20.500	0.0	0.0	0.000	1.973	1.973	1.00	5.152	1.973	0.000
1	0.0104	25.350	4.9	0.1	0.230	1.781	2.011	1.13	5.344	1.896	0.115
2	0.0191	38.140	17.6	0.4	0.835	1.419	2.254	1.59	5.706	1.836	0.417
3	0.0372	51.300	30.8	1.1	1.448	1.157	2.605	2.25	5.968	1.881	0.724
4	0.0571	59.200	38.7	1.8	1.806	1.056	2.862	2.71	6.069	1.959	0.903
5	0.0711	60.510	40.0	2.3	1.858	1.061	2.919	2.75	6.064	1.990	0.929
6	0.0920	60.060	39.6	3.0	1.823	1.113	2.936	2.64	6.012	2.024	0.911
7	0.1130	58.650	38.1	3.8	1.744	1.167	2.911	2.49	5.958	2.039	0.872
8	0.1358	57.610	37.1	4.6	1.682	1.195	2.877	2.41	5.930	2.036	0.841
9	0.1587	56.180	35.7	5.4	1.604	1.219	2.823	2.32	5.906	2.021	0.802
10	0.1828	56.390	35.9	6.3	1.598	1.218	2.816	2.31	5.907	2.017	0.799
11	0.2144	56.090	35.6	7.4	1.566	1.220	2.786	2.28	5.905	2.003	0.783
12	0.2375	56.000	35.5	8.2	1.548	1.222	2.770	2.27	5.903	1.996	0.774
13	0.2614	55.840	35.3	9.1	1.527	1.229	2.756	2.24	5.896	1.992	0.763
14	0.2852	55.680	35.2	9.9	1.506	1.233	2.739	2.22	5.892	1.986	0.753
15	0.3102	55.450	35.0	10.8	1.481	1.224	2.705	2.21	5.901	1.965	0.741
16	0.3511	55.260	34.8	12.3	1.449	1.213	2.662	2.19	5.912	1.937	0.724
17	0.3749	54.320	33.8	13.1	1.396	1.225	2.621	2.14	5.900	1.923	0.698
18	0.3990	54.710	34.2	14.0	1.398	1.218	2.616	2.15	5.907	1.917	0.699
19	0.4279	54.560	34.1	15.0	1.375	1.210	2.585	2.14	5.915	1.898	0.688

Parameters for Specimen No. 3

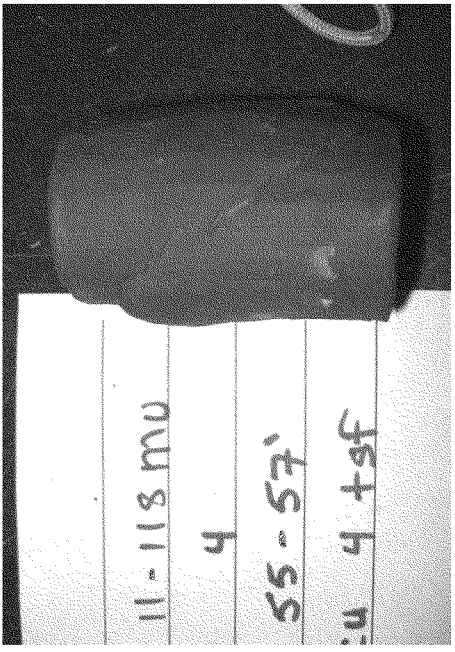
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	110.950			151.530
Moisture content: Dry soil+tare, gms.	85.870			114.750
Moisture content: Tare, gms.	30.080			29.910
Moisture, %	45.0	46.1	44.8	43.4
Moist specimen weight, gms.	124.3			
Diameter, in.	1.41	1.41	1.40	
Area, in.²	1.55	1.55	1.54	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	108.6	109.5	110.2	
Dry density, pcf	74.9	74.9	76.1	
Void ratio	1.2387	1.2387	1.2029	
Saturation, %	97.5	100.0	100.0	

Test Readings for Specimen No. 3

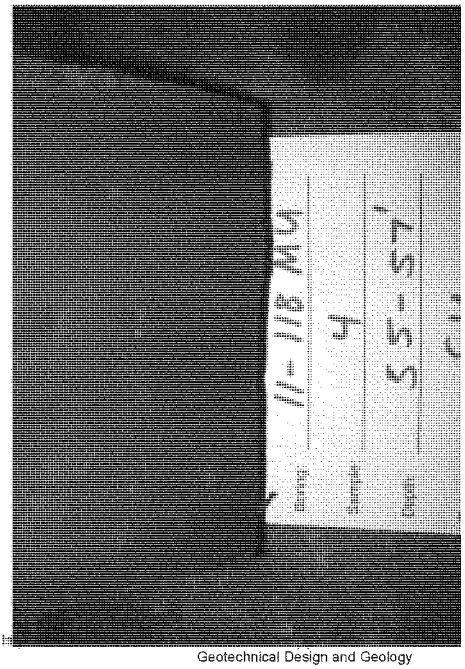
Consolidation cell pressure = 7.132 tsf
Consolidation back pressure = 3.120 tsf
Consolidation effective confining stress = 4.012 tsf
Peak Stress = 2.438 tsf **at reading no.** 6
Ult. Stress = 1.898 tsf **at reading no.** 17

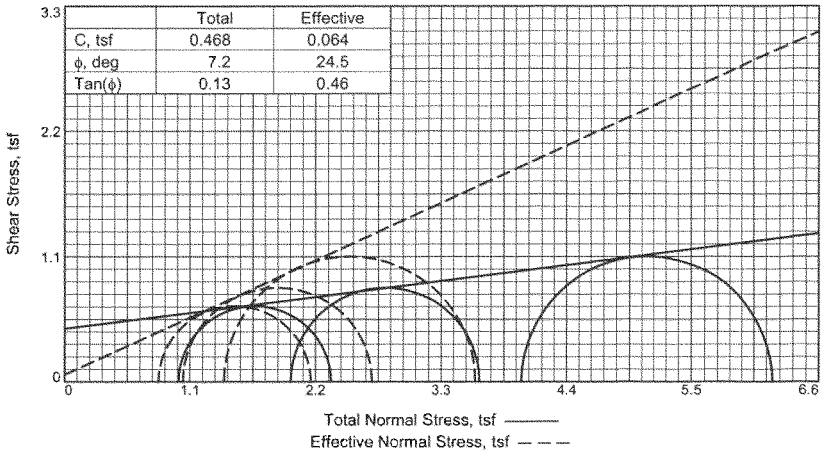
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0530	17.350	0.0	0.0	0.000	4.012	4.012	1.00	3.120	4.012	0.000
1	0.0540	24.100	6.8	0.0	0.316	3.882	4.198	1.08	3.250	4.040	0.158
2	0.0587	32.920	15.6	0.2	0.727	3.677	4.404	1.20	3.455	4.041	0.364
3	0.0884	53.480	36.1	1.3	1.670	2.975	4.645	1.56	4.157	3.810	0.835
4	0.1088	65.490	48.1	2.0	2.208	2.590	4.798	1.85	4.542	3.694	1.104
5	0.1293	70.850	53.5	2.7	2.436	2.412	4.848	2.01	4.720	3.630	1.218
6	0.1598	71.510	54.2	3.8	2.438	2.264	4.702	2.08	4.868	3.483	1.219
7	0.1892	71.600	54.2	4.9	2.415	2.170	4.585	2.11	4.962	3.378	1.208
8	0.2194	70.230	52.9	6.0	2.328	2.090	4.418	2.11	5.042	3.254	1.164
9	0.2498	69.710	52.4	7.1	2.278	2.028	4.306	2.12	5.104	3.167	1.139
10	0.2802	68.800	51.4	8.1	2.212	1.958	4.170	2.13	5.174	3.064	1.106
11	0.3088	68.240	50.9	9.2	2.164	1.905	4.069	2.14	5.227	2.987	1.082
12	0.3382	67.510	50.2	10.2	2.108	1.858	3.966	2.13	5.274	2.912	1.054
13	0.3685	66.690	49.3	11.3	2.048	1.825	3.873	2.12	5.307	2.849	1.024
14	0.3989	65.400	48.1	12.4	1.970	1.773	3.743	2.11	5.359	2.758	0.985
15	0.4294	65.080	47.7	13.5	1.933	1.734	3.667	2.11	5.398	2.700	0.966
16	0.4588	65.090	47.7	14.5	1.910	1.710	3.620	2.12	5.422	2.665	0.955
17	0.4707	65.030	47.7	15.0	1.898	1.708	3.606	2.11	5.424	2.657	0.949

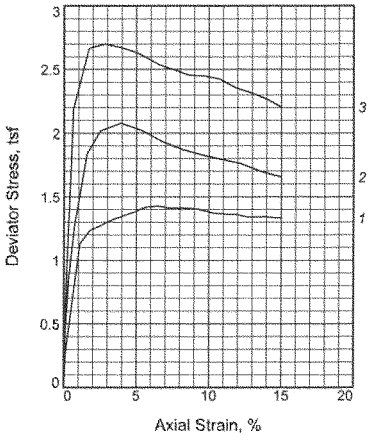
11-118 MU
4
55-57'
Cu 2 tsf


11-118 mu
4
55-57'
Cu 4 tsf

11-118MU
4
55-57'
Cu 1 tsf


11-118 MU
4
55-57'





Sample No.		1	2	3
Initial	Water Content, %	39.2	39.1	38.5
	Dry Density, pcf	81.5	81.6	82.1
	Saturation, %	99.2	99.3	98.9
	Void Ratio	1.0651	1.0611	1.0482
	Diameter, in.	1.38	1.38	1.39
	Height, in.	2.81	2.82	2.81
At Test	Water Content, %	38.7	38.7	37.3
	Dry Density, pcf	82.3	82.3	83.9
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.0431	1.0436	1.0046
	Diameter, in.	1.38	1.37	1.38
	Height, in.	2.80	2.82	2.79
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		1.00	1.98	4.01
Back Pressure, tsf		6.13	5.15	3.13
Cell Pressure, tsf		7.13	7.13	7.14
Peak Deviator Stress, tsf		1.43	2.08	2.70
Total Pore Pr., tsf		6.41	6.01	5.00
Ultimate Deviator Stress, tsf		1.33	1.66	2.21
Total Pore Pr., tsf		6.30	6.10	5.74
Maj. Eff. Stress at Ultimate, tsf		2.16	2.69	3.60
Min. Eff. Stress at Ultimate, tsf		0.82	1.04	1.40

Type of Test:
CU with Pore Pressures
Sample Type: 5" Thinwall, Middle of sample
Description: FAT CLAY, brown (CH)

LL= 61 **PL=** 20 **PI=** 41
Specific Gravity= 2.695
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Location: Wild Rice, Argusville Formation
Sample Number: Boring11-118, #5 **Depth:** 65-67'
Proj. No.: BL-10-10065 **Date Sampled:**

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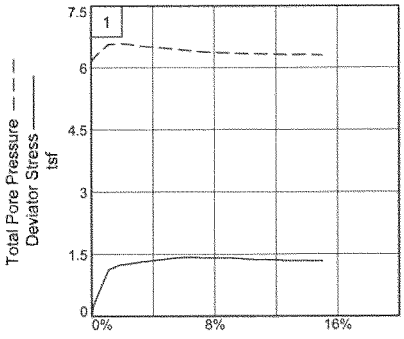
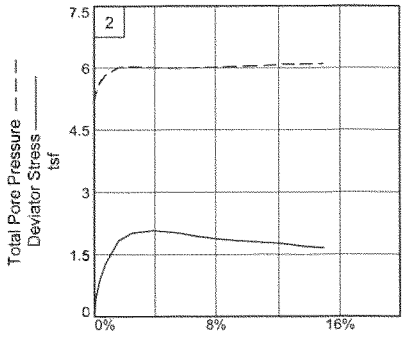
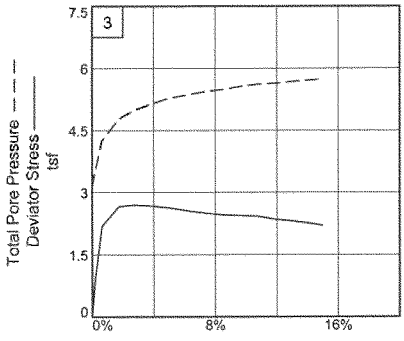
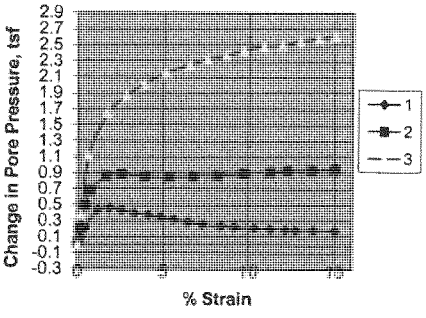
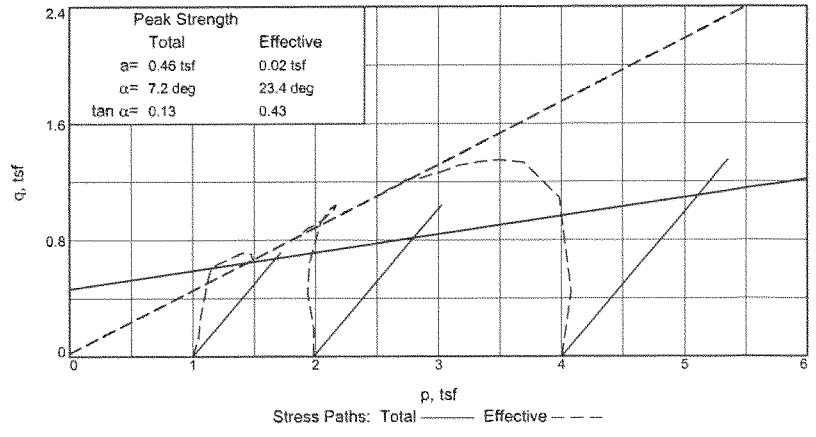
Figure CU Triaxial ASTM D4767











Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Location: Wild Rice, Argusville Formation **Depth:** 65-67' **Sample Number:** Boring11-118, #5
Project No.: 01-10-0065

Figure

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

5/15/2011
11:47 AM

Date:
Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Project No.: BL-10-10065
Location: Wild Rice, Argusville Formation
Depth: 65-67' **Sample Number:** Boring11-118, #5
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.695 **LL=**61 **PL=**20 **PI=**41
Test Method: COE uniform strain

Specimen Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	134.810			153.820
Moisture content: Dry soil+tare, gms.	105.490			120.620
Moisture content: Tare, gms.	30.710			30.500
Moisture, %	39.2	39.5	38.7	36.8
Moist specimen weight, gms.	126.0			
Diameter, in.	1.38	1.38	1.38	
Area, in.²	1.50	1.50	1.49	
Height, in.	2.81	2.81	2.80	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	113.4	113.7	114.2	
Dry density, pcf	81.5	81.5	82.3	
Void ratio	1.0651	1.0651	1.0431	
Saturation, %	99.2	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.129 tsf
Consolidation back pressure = 6.129 tsf
Consolidation effective confining stress = 1.000 tsf
Peak Stress = 1.429 tsf **at reading no.** 10
Ult. Stress = 1.334 tsf **at reading no.** 19

Test Readings for Specimen No. 2

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	0.0097	17.710	0.0	0.0	0.000	0.998	0.998	1.00	6.131	0.998	0.000
1	0.0125	22.970	5.3	0.1	0.253	0.920	1.173	1.28	6.209	1.047	0.127
2	0.0215	29.050	11.3	0.4	0.544	0.792	1.336	1.69	6.337	1.064	0.272
3	0.0403	41.400	23.7	1.1	1.129	0.568	1.697	2.99	6.561	1.133	0.565
4	0.0602	43.820	26.1	1.8	1.236	0.542	1.778	3.28	6.587	1.160	0.618
5	0.0811	44.830	27.1	2.5	1.274	0.568	1.842	3.24	6.561	1.205	0.637
6	0.1020	45.960	28.3	3.3	1.317	0.606	1.923	3.17	6.523	1.264	0.658
7	0.1238	46.900	29.2	4.1	1.350	0.625	1.975	3.16	6.504	1.300	0.675
8	0.1447	47.760	30.0	4.8	1.379	0.651	2.030	3.12	6.478	1.340	0.689
9	0.1670	48.890	31.2	5.6	1.419	0.681	2.100	3.08	6.448	1.390	0.709
10	0.1905	49.390	31.7	6.4	1.429	0.715	2.144	3.00	6.414	1.429	0.714
11	0.2136	49.290	31.6	7.3	1.412	0.746	2.158	2.89	6.383	1.452	0.706
12	0.2443	49.680	32.0	8.4	1.412	0.766	2.178	2.84	6.363	1.472	0.706
13	0.2672	49.780	32.1	9.2	1.404	0.775	2.179	2.81	6.354	1.477	0.702
14	0.2994	49.430	31.7	10.3	1.371	0.791	2.162	2.73	6.338	1.477	0.686
15	0.3244	49.590	31.9	11.2	1.364	0.800	2.164	2.71	6.329	1.482	0.682
16	0.3482	49.760	32.0	12.1	1.358	0.808	2.166	2.68	6.321	1.487	0.679
17	0.3651	49.560	31.9	12.7	1.341	0.814	2.155	2.65	6.315	1.484	0.670
18	0.3980	50.010	32.3	13.8	1.341	0.812	2.153	2.65	6.317	1.483	0.671
19	0.4310	50.270	32.6	15.0	1.334	0.824	2.158	2.62	6.305	1.491	0.667

Parameters for Specimen No. 2				
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	121.170			155.290
Moisture content: Dry soil+tare, gms.	95.620			120.760
Moisture content: Tare, gms.	30.300			30.540
Moisture, %	39.1	39.4	38.7	38.3
Moist specimen weight, gms.	125.5			
Diameter, in.	1.38	1.38	1.37	
Area, in.^{2}	1.49	1.49	1.48	
Height, in.	2.82	2.82	2.82	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	113.6	113.8	114.2	
Dry density, pcf	81.6	81.6	82.3	
Void ratio	1.0611	1.0611	1.0436	
Saturation, %	99.3	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.135 tsf
Consolidation back pressure = 5.152 tsf
Consolidation effective confining stress = 1.983 tsf
Peak Stress = 2.080 tsf **at reading no.** 6
Ult. Stress = 1.656 tsf **at reading no.** 14

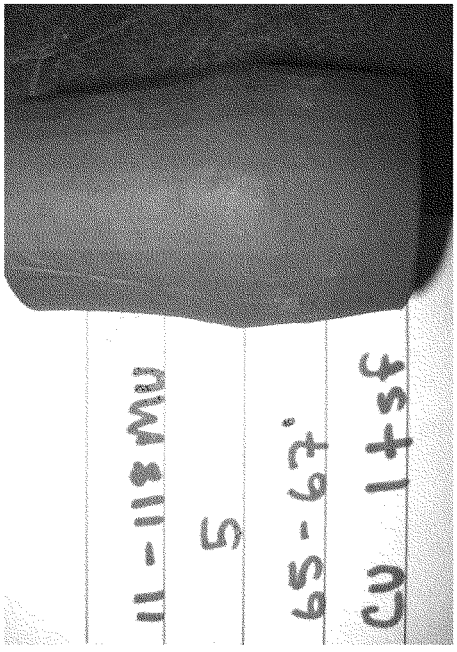
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0086	20.510	0.0	0.0	0.000	1.983	1.983	1.00	5.152	1.983	0.000
1	0.0107	28.500	8.0	0.1	0.388	1.791	2.179	1.22	5.344	1.985	0.194
2	0.0185	38.660	18.1	0.4	0.878	1.496	2.374	1.59	5.639	1.935	0.439
3	0.0294	47.180	26.7	0.7	1.285	1.307	2.592	1.98	5.828	1.950	0.643
4	0.0532	58.930	38.4	1.6	1.836	1.124	2.960	2.63	6.011	2.042	0.918
5	0.0792	63.140	42.6	2.5	2.018	1.101	3.119	2.83	6.034	2.110	1.009
6	0.1189	65.090	44.6	3.9	2.080	1.128	3.208	2.84	6.007	2.168	1.040
7	0.1587	64.510	44.0	5.3	2.022	1.137	3.159	2.78	5.998	2.148	1.011
8	0.1986	63.290	42.8	6.7	1.937	1.129	3.066	2.72	6.006	2.097	0.968
9	0.2396	62.470	42.0	8.2	1.870	1.118	2.988	2.67	6.017	2.053	0.935
10	0.2813	62.130	41.6	9.7	1.825	1.094	2.919	2.67	6.041	2.007	0.913
11	0.3231	61.920	41.4	11.2	1.786	1.076	2.862	2.66	6.059	1.969	0.893
12	0.3511	61.830	41.3	12.2	1.762	1.054	2.816	2.67	6.081	1.935	0.881
13	0.3930	60.970	40.5	13.7	1.696	1.046	2.742	2.62	6.089	1.894	0.848
14	0.4309	60.640	40.1	15.0	1.656	1.037	2.693	2.60	6.098	1.865	0.828

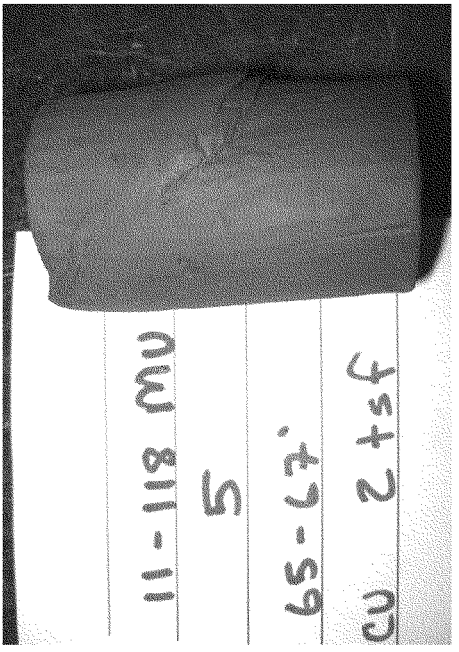
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	143.560			154.540
Moisture content: Dry soil+tare, gms.	112.060			121.740
Moisture content: Tare, gms.	30.140			30.390
Moisture, %	38.5	38.9	37.3	35.9
Moist specimen weight, gms.	127.3			
Diameter, in.	1.39	1.39	1.38	
Area, in.^{2}	1.52	1.52	1.50	
Height, in.	2.81	2.81	2.79	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	113.7	114.1	115.2	
Dry density, pcf	82.1	82.1	83.9	
Void ratio	1.0482	1.0482	1.0046	
Saturation, %	98.9	100.0	100.0	

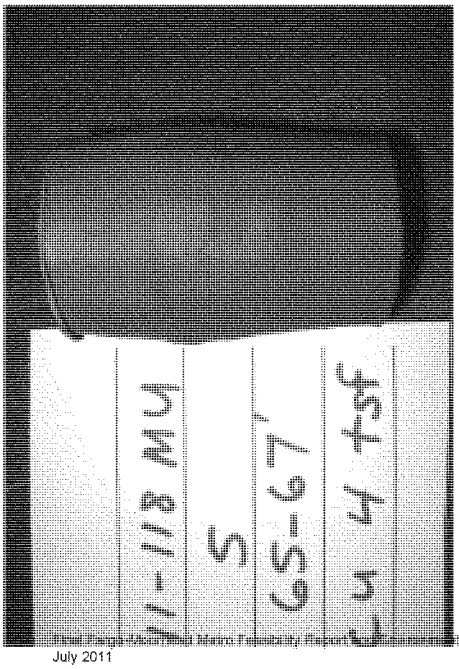
Test Reading for Specimen No. 3

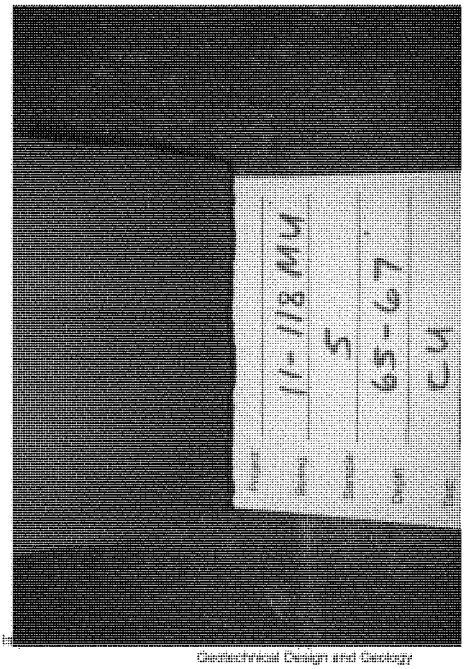
Consolidation cell pressure = 7.138 tsf
Consolidation back pressure = 3.133 tsf
Consolidation effective confining stress = 4.005 tsf
Peak Stress = 2.699 tsf **at reading no.** 4
Ult. Stress = 2.205 tsf **at reading no.** 15

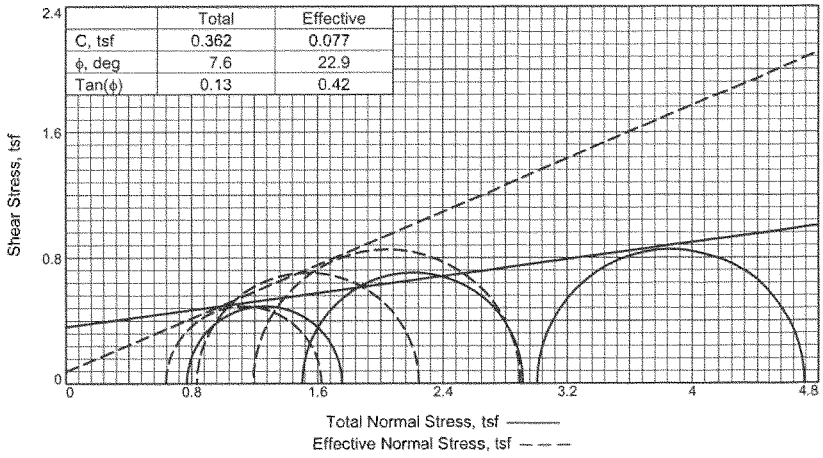
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0219	18.260	0.0	0.0	0.000	4.005	4.005	1.00	3.133	4.005	0.000
1	0.0270	36.840	18.6	0.2	0.891	3.634	4.525	1.25	3.504	4.080	0.446
2	0.0396	64.060	45.8	0.6	2.187	2.890	5.077	1.76	4.248	3.984	1.094
3	0.0700	74.680	56.4	1.7	2.665	2.361	5.026	2.13	4.777	3.693	1.332
4	0.1000	76.040	57.8	2.8	2.699	2.140	4.839	2.26	4.998	3.490	1.350
5	0.1305	76.150	57.9	3.9	2.674	1.993	4.667	2.34	5.145	3.330	1.337
6	0.1630	75.930	57.7	5.1	2.632	1.854	4.486	2.42	5.284	3.170	1.316
7	0.2031	74.800	56.5	6.5	2.541	1.758	4.299	2.45	5.380	3.028	1.270
8	0.2332	74.470	56.2	7.6	2.497	1.686	4.183	2.48	5.452	2.934	1.248
9	0.2635	74.180	55.9	8.7	2.455	1.638	4.093	2.50	5.500	2.865	1.227
10	0.2933	74.680	56.4	9.7	2.448	1.570	4.018	2.56	5.568	2.794	1.224
11	0.3224	74.790	56.5	10.8	2.424	1.521	3.945	2.59	5.617	2.733	1.212
12	0.3528	73.850	55.6	11.9	2.355	1.501	3.856	2.57	5.637	2.678	1.177
13	0.3843	73.580	55.3	13.0	2.313	1.454	3.767	2.59	5.684	2.611	1.157
14	0.4147	73.030	54.8	14.1	2.261	1.426	3.687	2.59	5.712	2.557	1.131
15	0.4393	72.220	54.0	15.0	2.205	1.397	3.602	2.58	5.741	2.500	1.103

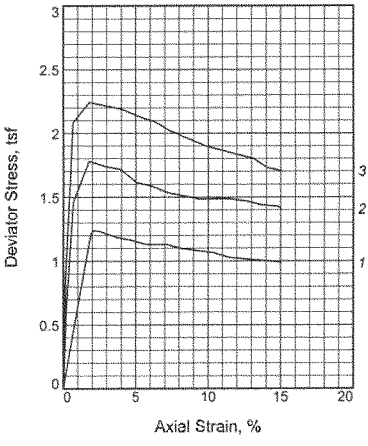

11-118 MU
S
65-67'
CU 1 tsf


11-118 MU
S
65-67'
CU 2 tsf


11-118 MU
S
65-67'
CU 4 tsf


11-118 MU
S
65-67
CU





Sample No.		1	2	3
Initial	Water Content, %	43.6	43.0	40.0
	Dry Density, pcf	77.3	78.0	81.0
	Saturation, %	99.9	100.0	100.0
	Void Ratio	1.1775	1.1596	1.0800
	Diameter, in.	1.39	1.40	1.40
	Height, in.	2.80	2.80	2.81
At Test	Water Content, %	42.8	41.7	38.6
	Dry Density, pcf	78.2	79.3	82.6
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.1543	1.1250	1.0402
	Diameter, in.	1.38	1.39	1.39
	Height, in.	2.79	2.79	2.79
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.77	1.50	3.00
Back Pressure, tsf		6.36	5.63	4.13
Cell Pressure, tsf		7.13	7.13	7.13
Peak Deviator Stress, tsf		1.24	1.78	2.24
Total Pore Pr., tsf		6.67	6.23	5.43
Ultimate Deviator Stress, tsf		0.99	1.41	1.70
Total Pore Pr., tsf		6.49	6.30	5.94
Maj. Eff. Stress at Ultimate, tsf		1.62	2.24	2.89
Min. Eff. Stress at Ultimate, tsf		0.64	0.83	1.19

Type of Test:
CU with Pore Pressures
Sample Type: 5" Thinwall, Middle of sample
Description: FAT CLAY, brown (CH)

LL= 56 **PL=** 22 **PI=** 34
Specific Gravity= 2.698
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: Fargo Pile Load Test, Argusville Formation
Sample Number: Boring11-119MU, #2 **Depth:** 40-42'
Proj. No.: BL-10-10065 **Date Sampled:**

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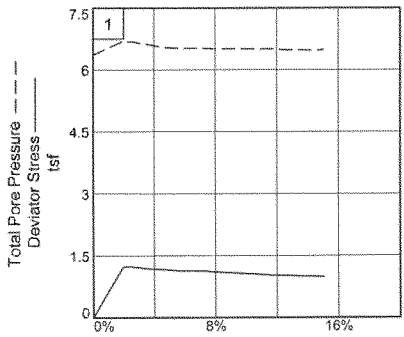
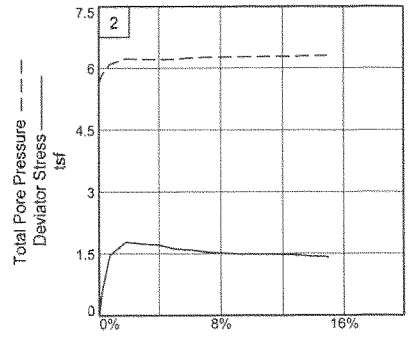
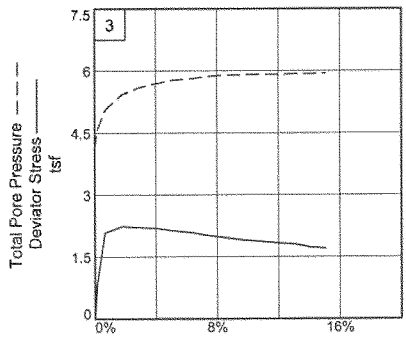
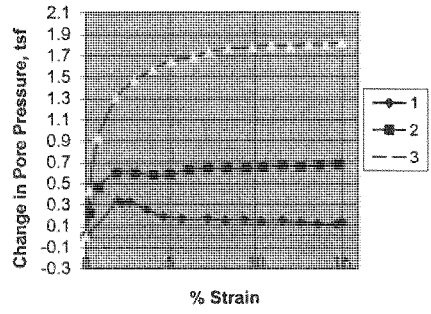
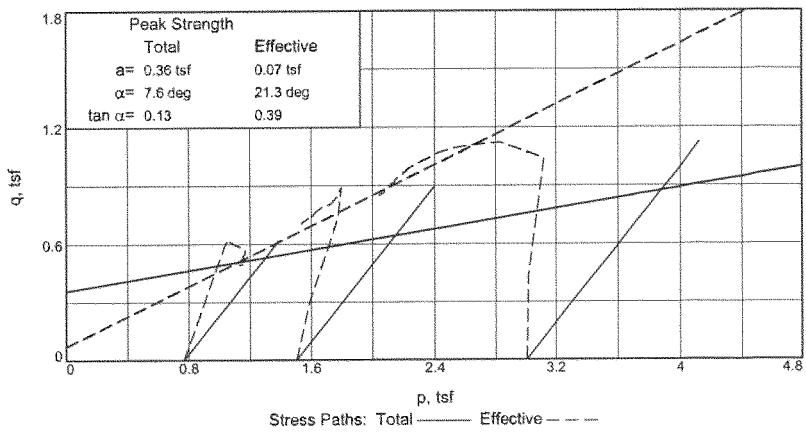
Figure C1 Tri-Axial ASTM D 4767











Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Loc.: Fargo Pile Load Test, Argusville Formation **Depth:** 40-42' **Sample No.:** Boring11-119MU, #2

Project No.: BI-10-10065 **Figure** **Braun Intertec**

Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST 5/30/2011
CU with Pore Pressures 12:18 PM

Date:
Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Project No.: BL-10-10065
Location: Fargo Pile Load Test, Argusville Formation
Depth: 40-42' **Sample Number:** Boring11-119MU, #2
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.698 **LL=**56 **PL=**22 **PI=**34
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	151.840			153.850
Moisture content: Dry soil+tare, gms.	114.940			117.170
Moisture content: Tare, gms.	30.310			30.490
Moisture, %	43.6	43.6	42.8	42.3
Moist specimen weight, gms.	123.5			
Diameter, in.	1.39	1.39	1.38	
Area, in.²	1.51	1.51	1.50	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	111.1	111.1	111.6	
Dry density, pcf	77.3	77.3	78.2	
Void ratio	1.1775	1.1775	1.1543	
Saturation, %	99.9	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.127 tsf
Consolidation back pressure = 6.358 tsf
Consolidation effective confining stress = 0.769 tsf
Peak Stress = 1.240 tsf **at reading no.** 2
Ult. Stress = 0.986 tsf **at reading no.** 15

Braun Intertec

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	0.0544	18.490	0.0	0.0	0.000	0.769	0.769	1.00	6.358	0.769	0.000
1	0.1080	44.350	25.9	1.9	1.216	0.434	1.650	3.80	6.693	1.042	0.608
2	0.1127	44.910	26.4	2.1	1.240	0.452	1.692	3.74	6.675	1.072	0.620
3	0.1264	44.850	26.4	2.6	1.231	0.445	1.676	3.77	6.682	1.060	0.615
4	0.1548	44.210	25.7	3.6	1.188	0.515	1.703	3.31	6.612	1.109	0.594
5	0.1841	43.970	25.5	4.6	1.164	0.584	1.748	2.99	6.543	1.166	0.582
6	0.2138	43.530	25.0	5.7	1.132	0.604	1.736	2.87	6.523	1.170	0.566
7	0.2541	43.870	25.4	7.2	1.129	0.603	1.732	2.87	6.524	1.168	0.565
8	0.2839	43.460	25.0	8.2	1.098	0.618	1.716	2.78	6.509	1.167	0.549
9	0.3138	43.340	24.9	9.3	1.080	0.613	1.693	2.76	6.514	1.153	0.540
10	0.3432	43.280	24.8	10.3	1.065	0.626	1.691	2.70	6.501	1.159	0.533
11	0.3743	42.700	24.2	11.5	1.027	0.621	1.648	2.65	6.506	1.135	0.514
12	0.4047	42.730	24.2	12.6	1.016	0.639	1.655	2.59	6.488	1.147	0.508
13	0.4350	42.760	24.3	13.6	1.005	0.652	1.657	2.54	6.475	1.154	0.502
14	0.4648	42.810	24.3	14.7	0.994	0.655	1.649	2.52	6.472	1.152	0.497
15	0.4735	42.700	24.2	15.0	0.986	0.637	1.623	2.55	6.490	1.130	0.493

Summary for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	137.010			155.590
Moisture content: Dry soil+tare, gms.	105.180			119.490
Moisture content: Tare, gms.	31.150			30.230
Moisture, %	43.0	43.0	41.7	40.4
Moist specimen weight, gms.	126.1			
Diameter, in.	1.40	1.40	1.39	
Area, in.²	1.54	1.54	1.52	
Height, in.	2.80	2.80	2.79	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	111.5	111.5	112.3	
Dry density, pcf	78.0	78.0	79.3	
Void ratio	1.1596	1.1596	1.1250	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.133 tsf
Consolidation back pressure = 5.630 tsf
Consolidation effective confining stress = 1.503 tsf
Peak Stress = 1.781 tsf **at reading no.** 3
Ult. Stress = 1.410 tsf **at reading no.** 16

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	0.0482	20.470	0.0	0.0	0.000	1.503	1.503	1.00	5.630	1.503	0.000
1	0.0540	33.180	12.7	0.2	0.601	1.289	1.890	1.47	5.844	1.589	0.300
2	0.0678	51.590	31.1	0.7	1.464	1.040	2.504	2.41	6.093	1.772	0.732
3	0.0980	58.740	38.3	1.8	1.781	0.907	2.688	2.96	6.226	1.797	0.890
4	0.1283	58.290	37.8	2.9	1.740	0.910	2.650	2.91	6.223	1.780	0.870
5	0.1587	58.150	37.7	4.0	1.715	0.926	2.641	2.85	6.207	1.783	0.857
6	0.1890	56.330	35.9	5.0	1.613	0.919	2.532	2.76	6.214	1.726	0.807
7	0.2195	56.140	35.7	6.1	1.586	0.881	2.467	2.80	6.252	1.674	0.793
8	0.2498	55.390	34.9	7.2	1.535	0.864	2.399	2.78	6.269	1.631	0.767
9	0.2802	55.240	34.8	8.3	1.510	0.862	2.372	2.75	6.271	1.617	0.755
10	0.3097	55.030	34.6	9.4	1.484	0.863	2.347	2.72	6.270	1.605	0.742
11	0.3390	55.470	35.0	10.4	1.485	0.856	2.341	2.74	6.277	1.599	0.743
12	0.3694	55.900	35.4	11.5	1.485	0.838	2.323	2.77	6.295	1.581	0.743
13	0.4009	55.980	35.5	12.6	1.470	0.849	2.319	2.73	6.284	1.584	0.735
14	0.4312	55.650	35.2	13.7	1.438	0.837	2.275	2.72	6.296	1.556	0.719
15	0.4615	55.850	35.4	14.8	1.428	0.825	2.253	2.73	6.308	1.539	0.714
16	0.4670	55.500	35.0	15.0	1.410	0.833	2.243	2.69	6.300	1.538	0.705

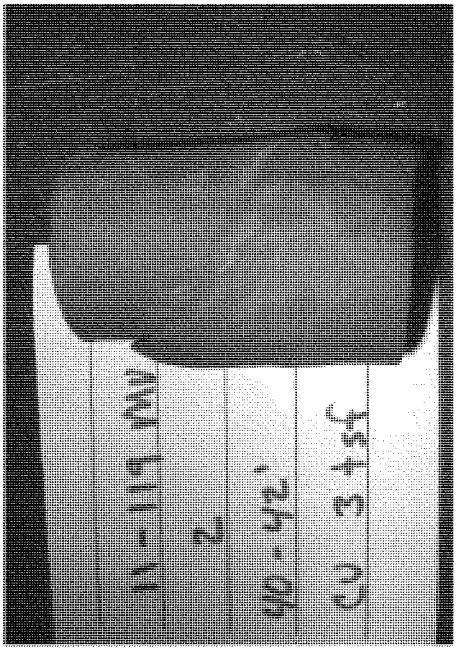
Test Results for Specimen No. 3

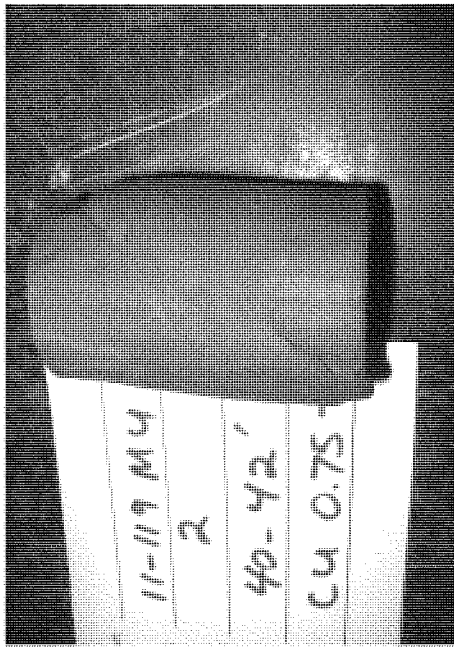
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	142.970			156.410
Moisture content: Dry soil+tare, gms.	110.800			122.200
Moisture content: Tare, gms.	30.410			30.480
Moisture, %	40.0	40.0	38.6	37.3
Moist specimen weight, gms.	128.6			
Diameter, in.	1.40	1.40	1.39	
Area, in.²	1.54	1.54	1.52	
Height, in.	2.81	2.81	2.79	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	113.4	113.4	114.4	
Dry density, pcf	81.0	81.0	82.6	
Void ratio	1.0800	1.0800	1.0402	
Saturation, %	100.0	100.0	100.0	

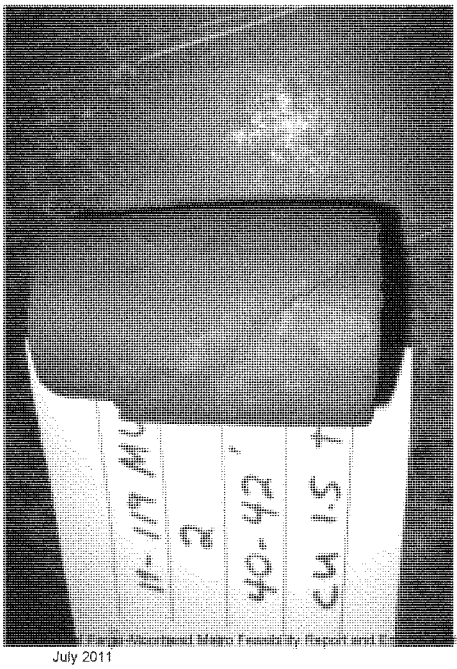
Test Readings for Specimen No. 3

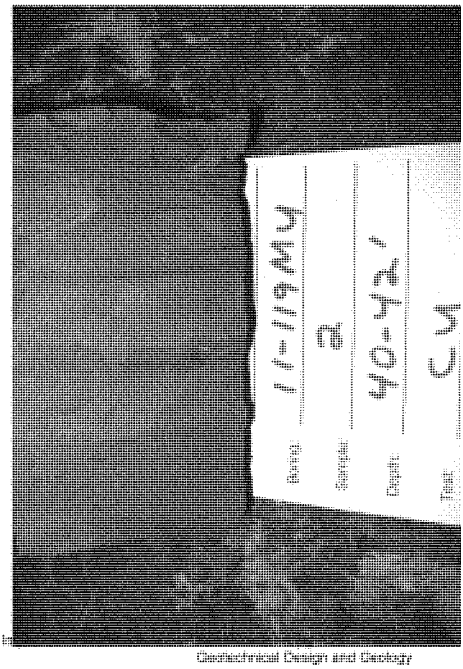
Consolidation cell pressure = 7.134 tsf
Consolidation back pressure = 4.126 tsf
Consolidation effective confining stress = 3.008 tsf
Peak Stress = 2.244 tsf **at reading no.** 3
Ult. Stress = 1.705 tsf **at reading no.** 15

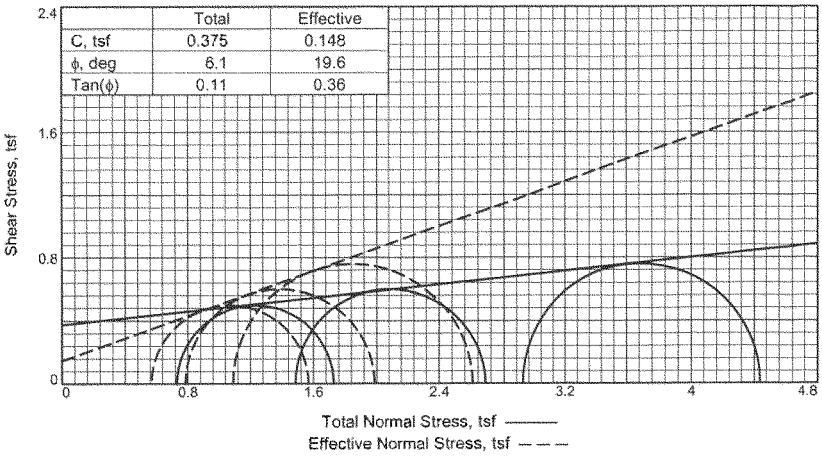
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0489	17.090	0.0	0.0	0.000	3.008	3.008	1.00	4.126	3.008	0.000
1	0.0532	35.500	18.4	0.2	0.871	2.580	3.451	1.34	4.554	3.015	0.435
2	0.0676	61.300	44.2	0.7	2.081	2.080	4.161	2.00	5.054	3.120	1.040
3	0.0989	65.310	48.2	1.8	2.244	1.704	3.948	2.32	5.430	2.826	1.122
4	0.1304	65.270	48.2	2.9	2.216	1.539	3.755	2.44	5.595	2.647	1.108
5	0.1618	65.230	48.1	4.0	2.189	1.437	3.626	2.52	5.697	2.531	1.094
6	0.1910	64.670	47.6	5.1	2.139	1.358	3.497	2.58	5.776	2.428	1.070
7	0.2281	64.090	47.0	6.4	2.084	1.319	3.403	2.58	5.815	2.361	1.042
8	0.2530	63.160	46.1	7.3	2.023	1.271	3.294	2.59	5.863	2.283	1.012
9	0.2830	62.470	45.4	8.4	1.970	1.242	3.212	2.59	5.892	2.227	0.985
10	0.3235	61.550	44.5	9.8	1.899	1.230	3.129	2.54	5.904	2.180	0.950
11	0.3539	61.330	44.2	10.9	1.867	1.215	3.082	2.54	5.919	2.148	0.933
12	0.3840	61.060	44.0	12.0	1.833	1.221	3.054	2.50	5.913	2.137	0.916
13	0.4147	60.870	43.8	13.1	1.802	1.207	3.009	2.49	5.927	2.108	0.901
14	0.4411	59.550	42.5	14.1	1.729	1.208	2.937	2.43	5.926	2.072	0.864
15	0.4686	59.440	42.3	15.0	1.705	1.190	2.895	2.43	5.944	2.042	0.852

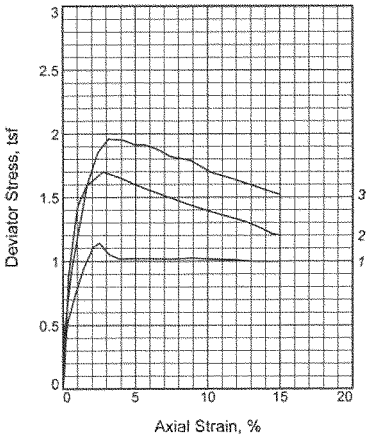

11-119 MW
2
40-42'
CU 3+54


11-119 MW
2
40-42'
CU 0.75


11-119 MW
2
40-42'
CU 1.5 +


Bore: 11-119MW
Sample: 2
Depth: 40-42'
Test: CU





Sample No.		1	2	3
Initial	Water Content, %	41.0	43.5	38.9
	Dry Density, pcf	79.3	77.6	82.0
	Saturation, %	98.2	99.8	99.1
	Void Ratio	1.1340	1.1826	1.0645
	Diameter, in.	1.40	1.39	1.39
	Height, in.	2.80	2.81	2.80
At Test	Water Content, %	41.8	43.1	37.6
	Dry Density, pcf	79.3	78.1	83.8
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.1340	1.1686	1.0205
	Diameter, in.	1.40	1.38	1.38
	Height, in.	2.80	2.81	2.78
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.73	1.48	2.92
Back Pressure, tsf		6.40	5.66	4.22
Cell Pressure, tsf		7.13	7.14	7.14
Peak Deviator Stress, tsf		1.14	1.70	1.96
Total Pore Pr., tsf		6.75	6.38	5.49
Ultimate Deviator Stress, tsf		1.00	1.20	1.52
Total Pore Pr., tsf		6.56	6.36	6.05
Maj. Eff. Stress at Ultimate, tsf		1.57	1.99	2.61
Min. Eff. Stress at Ultimate, tsf		0.57	0.79	1.09

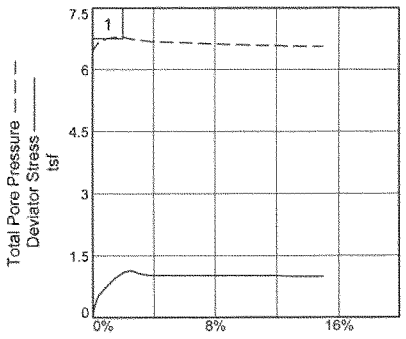
Type of Test:
CU with Pore Pressures
Sample Type: 5" Thinwall, Middle of sample
Description: FAT CLAY, brown (CH)

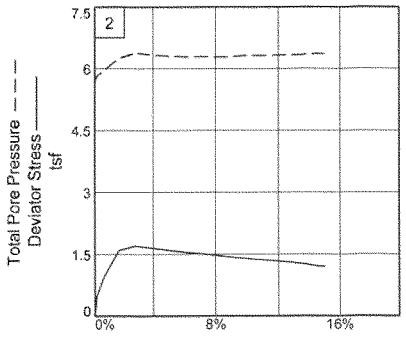
LL= 62 **PL=** 19 **PI=** 43
Specific Gravity= 2.712
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

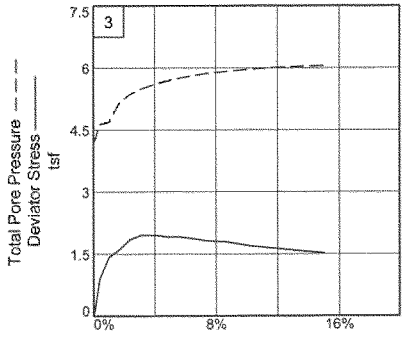
Client: USACE W912ES-11-P-0024

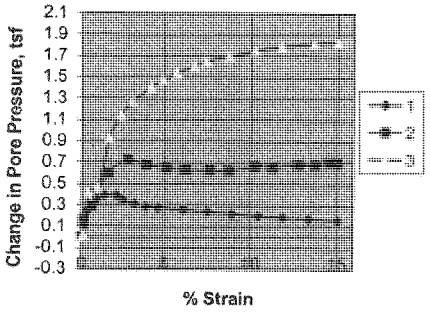
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: Fargo Pile Load Test, Argusville Formation
Sample Number: Boring11-119MU, #3 **Depth:** 50-52'
Proj. No.: BL-10-10065 **Date Sampled:**

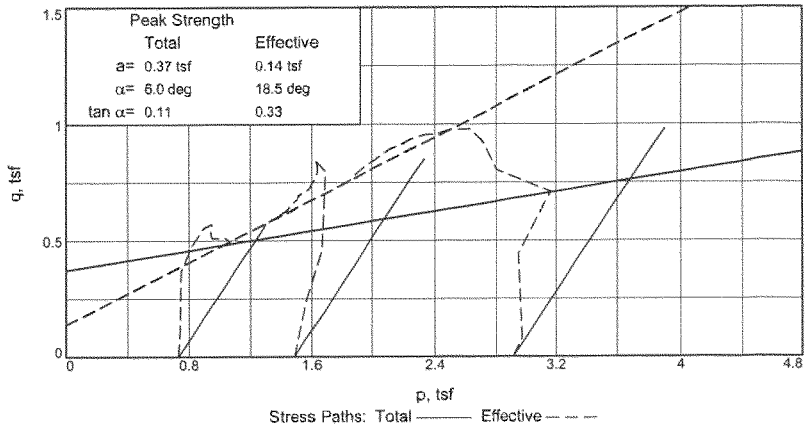
BRAUN INTERTEC











Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: Fargo Pile Load Test, Argusville Formation **Depth:** 50-52' **Sample No.:** Boring11-119MU, #3
Project Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2014

Figure

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

5/30/2011
12:18 PM

Date:
Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Project No.: BL-10-10065
Location: Fargo Pile Load Test, Argusville Formation
Depth: 50-52' **Sample Number:** Boring11-119MU, #3
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.712 **LL=**62 **PL=**19 **PI=**43
Test Method: COE uniform strain

Parameters of Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	150.030			156.590
Moisture content: Dry soil+tare, gms.	115.290			119.610
Moisture content: Tare, gms.	30.650			30.510
Moisture, %	41.0	41.8	41.8	41.5
Moist specimen weight, gms.	126.3			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.53	1.53	1.53	
Height, in.	2.80	2.80	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	111.9	112.5	112.5	
Dry density, pcf	79.3	79.3	79.3	
Void ratio	1.1340	1.1340	1.1340	
Saturation, %	98.2	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.128 tsf
Consolidation back pressure = 6.397 tsf
Consolidation effective confining stress = 0.731 tsf
Peak Stress = 1.142 tsf **at reading no.** 6
Ult. Stress = 0.998 tsf **at reading no.** 16

Test Reading 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	0.0077	18.550	0.0	0.0	0.000	0.731	0.731	1.00	6.397	0.731	0.000
1	0.0096	23.250	4.7	0.1	0.220	0.633	0.853	1.35	6.495	0.743	0.110
2	0.0170	29.630	11.1	0.3	0.518	0.488	1.006	2.06	6.640	0.747	0.259
3	0.0319	34.420	15.9	0.9	0.738	0.380	1.118	2.94	6.748	0.749	0.369
4	0.0480	39.120	20.6	1.4	0.951	0.342	1.293	3.78	6.786	0.817	0.475
5	0.0657	42.690	24.1	2.1	1.109	0.345	1.454	4.21	6.783	0.899	0.554
6	0.0787	43.540	25.0	2.5	1.142	0.381	1.523	4.00	6.747	0.952	0.571
7	0.0977	41.710	23.2	3.2	1.051	0.419	1.470	3.51	6.709	0.945	0.526
8	0.1168	41.130	22.6	3.9	1.018	0.447	1.465	3.28	6.681	0.956	0.509
9	0.1377	41.370	22.8	4.6	1.021	0.455	1.476	3.24	6.673	0.965	0.510
10	0.1775	41.710	23.2	6.1	1.020	0.474	1.494	3.15	6.654	0.984	0.510
11	0.2174	42.020	23.5	7.5	1.018	0.494	1.512	3.06	6.634	1.003	0.509
12	0.2580	42.550	24.0	8.9	1.025	0.511	1.536	3.01	6.617	1.024	0.513
13	0.2980	42.720	24.2	10.4	1.016	0.533	1.549	2.91	6.595	1.041	0.508
14	0.3391	43.010	24.5	11.8	1.012	0.544	1.556	2.86	6.584	1.050	0.506
15	0.3807	43.100	24.6	13.3	0.998	0.559	1.557	2.79	6.569	1.058	0.499
16	0.4277	43.570	25.0	15.0	0.998	0.570	1.568	2.75	6.558	1.069	0.499

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	142.710			153.940
Moisture content: Dry soil+tare, gms.	108.510			117.410
Moisture content: Tare, gms.	29.910			30.660
Moisture, %	43.5	43.6	43.1	42.1
Moist specimen weight, gms.	124.2			
Diameter, in.	1.39	1.39	1.38	
Area, in.²	1.51	1.51	1.50	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	111.3	111.4	111.7	
Dry density, pcf	77.6	77.6	78.1	
Void ratio	1.1826	1.1826	1.1686	
Saturation, %	99.8	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.143 tsf
Consolidation back pressure = 5.658 tsf
Consolidation effective confining stress = 1.485 tsf
Peak Stress = 1.701 tsf **at reading no.** 4
Ult. Stress = 1.200 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	0.0390	17.210	0.0	0.0	0.000	1.485	1.485	1.00	5.658	1.485	0.000
1	0.0431	27.330	10.1	0.1	0.484	1.325	1.809	1.36	5.818	1.567	0.242
2	0.0559	36.510	19.3	0.6	0.918	1.201	2.119	1.76	5.942	1.660	0.459
3	0.0852	51.080	33.9	1.6	1.594	0.889	2.483	2.79	6.254	1.686	0.797
4	0.1165	53.760	36.5	2.8	1.701	0.763	2.464	3.23	6.380	1.613	0.850
5	0.1489	53.140	35.9	3.9	1.652	0.807	2.459	3.05	6.336	1.633	0.826
6	0.1809	52.340	35.1	5.1	1.596	0.837	2.433	2.91	6.306	1.635	0.798
7	0.2121	51.650	34.4	6.2	1.547	0.853	2.400	2.81	6.290	1.626	0.773
8	0.2524	50.900	33.7	7.6	1.490	0.857	2.347	2.74	6.286	1.602	0.745
9	0.2827	50.240	33.0	8.7	1.443	0.862	2.305	2.67	6.281	1.584	0.722
10	0.3241	49.510	32.3	10.2	1.389	0.820	2.209	2.69	6.323	1.514	0.694
11	0.3541	49.060	31.9	11.2	1.353	0.827	2.180	2.64	6.316	1.504	0.677
12	0.3949	48.480	31.3	12.7	1.307	0.807	2.114	2.62	6.336	1.460	0.653
13	0.4241	47.620	30.4	13.7	1.256	0.805	2.061	2.56	6.338	1.433	0.628
14	0.4449	46.870	29.7	14.5	1.214	0.781	1.995	2.55	6.362	1.388	0.607
15	0.4606	46.720	29.5	15.0	1.200	0.785	1.985	2.53	6.358	1.385	0.600

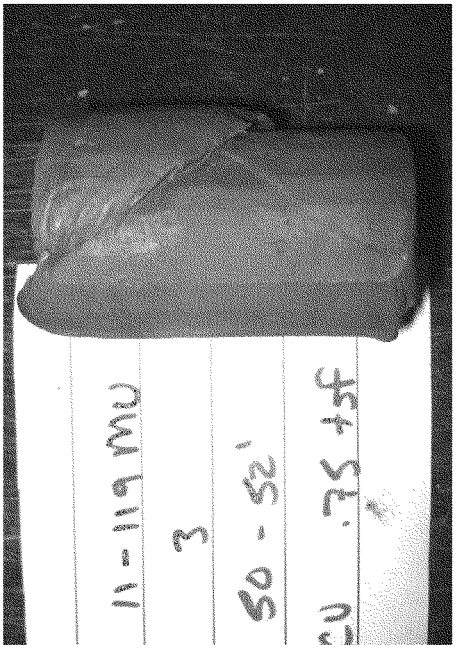
Parameters for Specimen No. 3

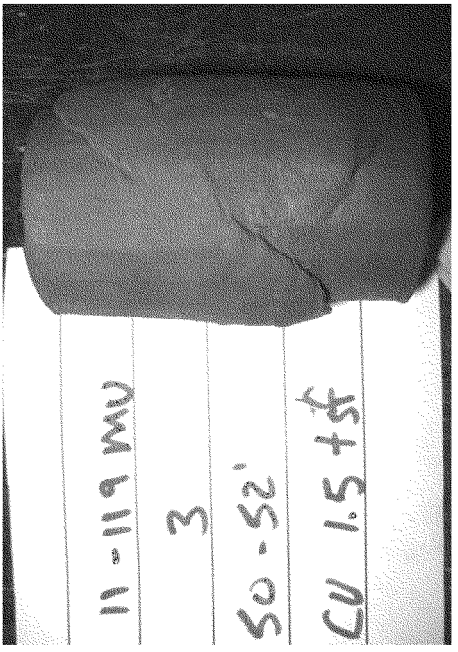
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	119.120			155.890
Moisture content: Dry soil+tare, gms.	94.020			123.300
Moisture content: Tare, gms.	29.520			31.170
Moisture, %	38.9	39.3	37.6	35.4
Moist specimen weight, gms.	127.7			
Diameter, in.	1.39	1.39	1.38	
Area, in.^{2}	1.52	1.52	1.50	
Height, in.	2.80	2.80	2.78	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	113.9	114.2	115.3	
Dry density, pcf	82.0	82.0	83.8	
Void ratio	1.0645	1.0645	1.0205	
Saturation, %	99.1	100.0	100.0	

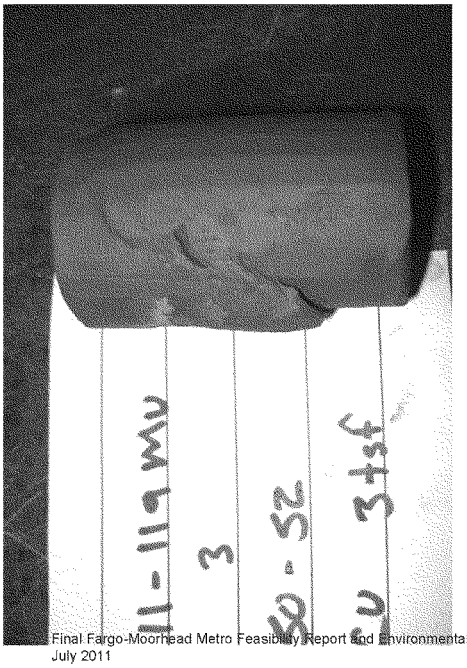
Test Readings for Specimen No. 3

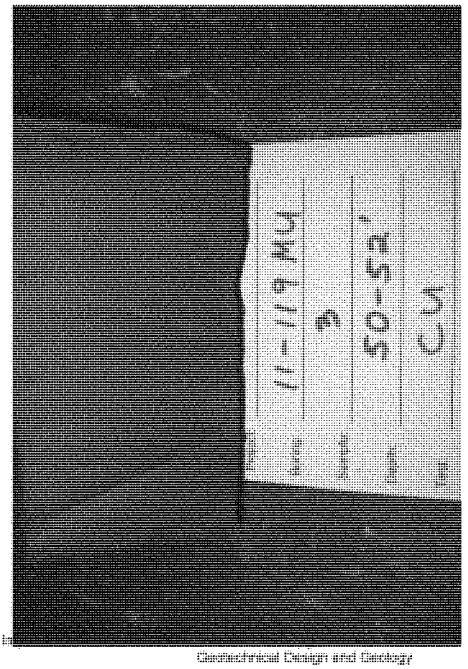
Consolidation cell pressure = 7.142 tsf
Consolidation back pressure = 4.222 tsf
Consolidation effective confining stress = 2.920 tsf
Peak Stress = 1.959 tsf at reading no. 6
Ult. Stress = 1.519 tsf at reading no. 16

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	0.0111	18.620	0.0	0.0	0.000	2.920	2.920	1.00	4.222	2.920	0.000
1	0.0141	21.970	3.3	0.1	0.160	2.896	3.056	1.06	4.246	2.976	0.080
2	0.0219	37.170	18.6	0.4	0.886	2.508	3.394	1.35	4.634	2.951	0.443
3	0.0390	48.620	30.0	1.0	1.423	2.456	3.879	1.58	4.686	3.168	0.712
4	0.0578	52.760	34.1	1.7	1.609	1.997	3.606	1.81	5.145	2.801	0.804
5	0.0778	58.220	39.6	2.4	1.852	1.779	3.631	2.04	5.363	2.705	0.926
6	0.0986	60.820	42.2	3.1	1.959	1.648	3.607	2.19	5.494	2.627	0.979
7	0.1266	61.060	42.4	4.2	1.950	1.516	3.466	2.29	5.626	2.491	0.975
8	0.1476	60.620	42.0	4.9	1.914	1.447	3.361	2.32	5.695	2.404	0.957
9	0.1686	60.910	42.3	5.7	1.912	1.385	3.297	2.38	5.757	2.341	0.956
10	0.1964	60.420	41.8	6.7	1.870	1.315	3.185	2.42	5.827	2.250	0.935
11	0.2182	59.660	41.0	7.4	1.820	1.271	3.091	2.43	5.871	2.181	0.910
12	0.2543	59.570	41.0	8.7	1.791	1.224	3.015	2.46	5.918	2.120	0.896
13	0.2961	58.010	39.4	10.2	1.694	1.172	2.866	2.45	5.970	2.019	0.847
14	0.3368	57.490	38.9	11.7	1.645	1.133	2.778	2.45	6.009	1.955	0.822
15	0.3900	56.610	38.0	13.6	1.573	1.102	2.675	2.43	6.040	1.888	0.786
16	0.4289	55.910	37.3	15.0	1.519	1.089	2.608	2.39	6.053	1.848	0.759


11-119 MU
3
50 - 52'
CU .75 +sf


11-119 MU
3
50-52'
CU 1.5 +sf

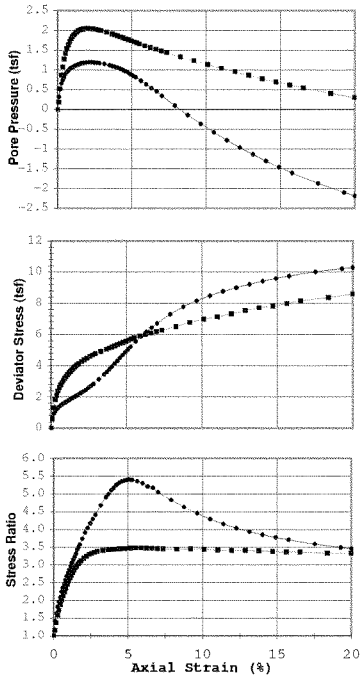

11-119 MU
3
50 - 52
CU 3+sf

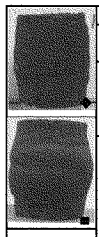

11-119 MU
3
50-52'
CU

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING
Boring #: 10-78MU Fargo Sample #: 4 Type: 5T Depth (ft): 70-71.2
Soil Type: Clayey Sand w/gravel (SC) Unit "A" Till





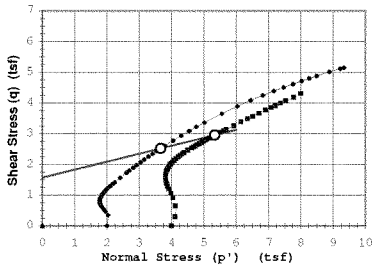
Failure Criterion:	Max. Stress Ratio
Angle of internal friction, ϕ' =	15.0 °
Apparent Cohesion, c' =	1.63 (tsf)
Test Date: 8/18/10	Liquid Limit: 29.5
Test Type: CU w/pp	Plastic Limit: 16.9
Strain Rate (in/min): 0.00285	Plasticity Index: 12.6
Strain Rate (%/min): 0.050	Spec. Gravity (Assumed): 2.69

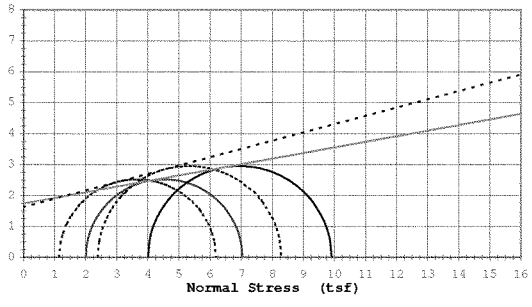
Before Consolidation	A	B	C	D	E
Diameter (in)	2.85	2.89			
Height (in)	5.78	5.49			
Water Content (%)	14.7	16.4			
Dry Density (pcf)	113.3	110.7			
Void Ratio	0.48	0.52			
After Consolidation					
Diameter (in)	2.83	2.86			
Height (in)	5.70	5.44			
Water Content (%)	16.5	17.5			
Dry Density (pcf)	116.3	114.3			
Void Ratio	0.44	0.47			
Back Pressure (tsf)	5.8	5.8			
Minor Principal Stress (tsf)	2.00	4.00			
Max. Deviator Stress (tsf)	10.29	8.61			
Ultimate Deviator Stress (tsf)	10.29	8.61			
Deviator Stress at Failure (tsf)	5.04	5.90			
Max. Pore Pressure Buildup (tsf)	1.20	2.05			
Pore Pressure Parameter "B"	1.0	1.0			
Pct. Axial Strain at Failure	5.1	5.9			

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.

*Height to diameter ratio of 2:1 no achieved for specimen B.





Rupture Envelope at Failure	
α = 14.5 °	a = 1.6 (tsf)

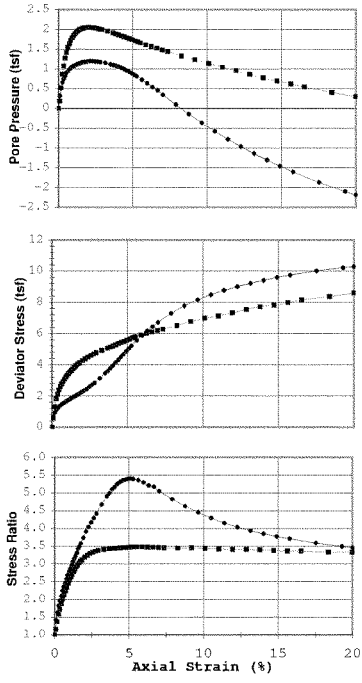
----------	Effective ϕ': 15.0 °	c'=	1.63 (tsf)
_____	Total ϕ': 10.3 °	c=	1.74 (tsf)

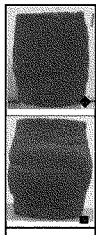
8301 Bryant Ave. South Suite #107
Bloomington, Minnesota 55420-3436

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING
Boring #: 10-78MU Fargo Sample #: 4 Type: 5T Depth (ft): 70-71.2
Soil Type: Clayey Sand w/gravel (SC) Unit "A" Till





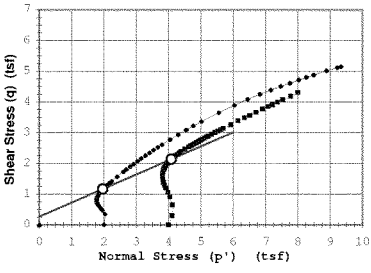
Failure Criterion:	Max. Pore Pressure
Angle of internal friction, ϕ' =	27.2 °
Apparent Cohesion, c' =	0.30 (tsf)
Test Date: 8/18/10	Liquid Limit: 29.5
Test Type: CU w/pp	Plastic Limit: 16.9
Strain Rate (in/min): 0.00285	Plasticity Index: 12.6
Strain Rate (%/min): 0.050	Spec. Gravity (Assumed): 2.69

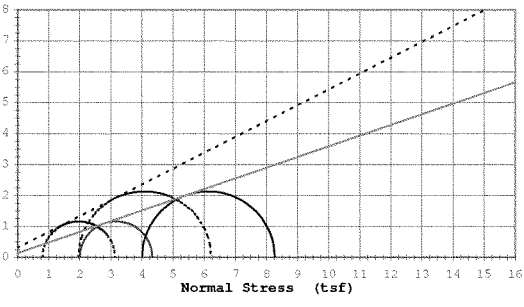
	A	B	C	D	E
Before Consolidation					
Diameter (in)	2.85	2.89			
Height (in)	5.78	5.49			
Water Content (%)	14.7	16.4			
Dry Density (pcf)	113.3	110.7			
Void Ratio	0.48	0.52			
After Consolidation					
Diameter (in)	2.83	2.86			
Height (in)	5.70	5.44			
Water Content (%)	16.5	17.5			
Dry Density (pcf)	116.3	114.3			
Void Ratio	0.44	0.47			
Back Pressure (tsf)	5.8	5.8			
Minor Principal Stress (tsf)	2.00	4.00			
Max. Deviator Stress (tsf)	10.29	8.61			
Ultimate Deviator Stress (tsf)	10.29	8.61			
Deviator Stress at Failure (tsf)	2.33	4.26			
Max. Pore Pressure Buildup (tsf)	1.20	2.05			
Pore Pressure Parameter "B"	1.0	1.0			
Pct. Axial Strain at Failure	2.1	2.0			

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.

*Height to diameter ratio of 2:1 no achieved for specimen B.





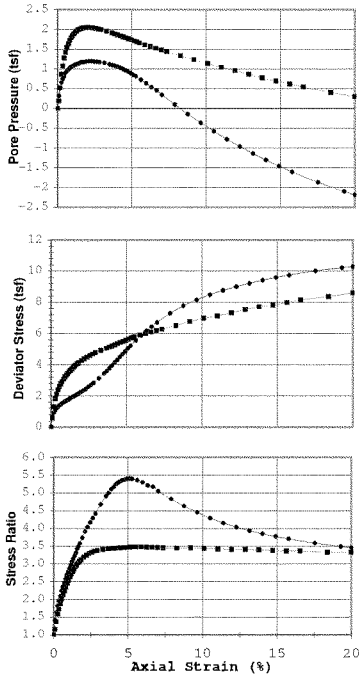
Rupture Envelope at Failure	
α = 24.6 °	a = 0.3 (tsf)

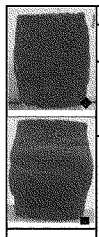
----------	Effective ϕ': 27.2 °	c'=	0.30 (tsf)
_____	Total ϕ': 19.0 °	c=	0.14 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING
Boring #: 10-78MU Fargo Sample #: 4 Type: 5T Depth (ft): 70-71.2
Soil Type: Clayey Sand w/gravel (SC) Unit "A" Till





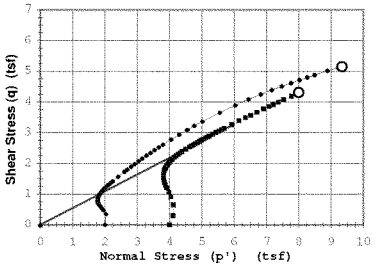
Failure Criterion:	Max. Deviator Stress
Angle of internal friction, ϕ' =	33.1 °
Apparent Cohesion, c' =	0.00 (tsf)
Test Date: 8/18/10	Liquid Limit: 29.5
Test Type: CU w/pp	Plastic Limit: 16.9
Strain Rate (in/min): 0.00285	Plasticity Index: 12.6
Strain Rate (%/min): 0.050	Spec. Gravity (Assumed): 2.69

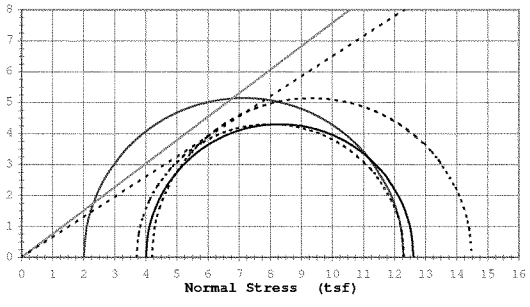
Before Consolidation	A	B	C	D	E
Diameter (in)	2.85	2.89			
Height (in)	5.78	5.49			
Water Content (%)	14.7	16.4			
Dry Density (pcf)	113.3	110.7			
Void Ratio	0.48	0.52			
After Consolidation					
Diameter (in)	2.83	2.86			
Height (in)	5.70	5.44			
Water Content (%)	16.5	17.5			
Dry Density (pcf)	116.3	114.3			
Void Ratio	0.44	0.47			
Back Pressure (tsf)	5.8	5.8			
Minor Principal Stress (tsf)	2.00	4.00			
Max. Deviator Stress (tsf)	10.29	8.61			
Ultimate Deviator Stress (tsf)	10.29	8.61			
Deviator Stress at Failure (tsf)	10.29	8.61			
Max. Pore Pressure Buildup (tsf)	1.20	2.05			
Pore Pressure Parameter "B"	1.0	1.0			
Pct. Axial Strain at Failure	20.0	20.0			

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen: Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.

*Height to diameter ratio of 2:1 no achieved for specimen B.





Rupture Envelope at Failure	
α = 28.6 °	a = 0.0 (tsf)

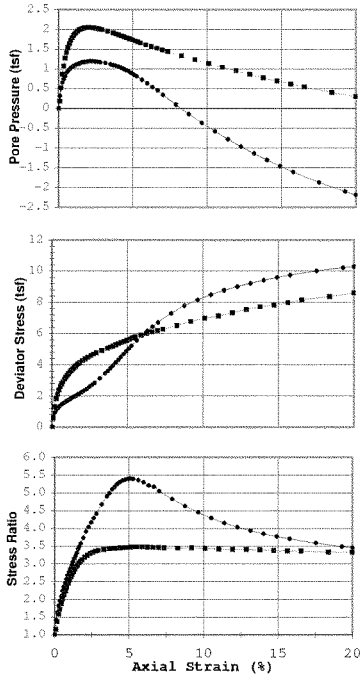
----------	Effective ϕ': 33.1 °	c'=	0.00 (tsf)
_____	Total ϕ': 37.2 °	c=	0.00 (tsf)

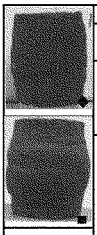
8301 Bryant Ave. South Suite #107 Bloomington, Minnesota 55420-3436
SOIL ENGINEERING TESTING, INC.

TRIAXIAL TEST ASTM: D 4767

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING
Boring #: 10-78MU Fargo Sample #: 4 Type: 5T Depth (ft): 70-71.2
Soil Type: Clayey Sand w/gravel (SC) Unit "A" Till





Failure Criterion: Given Strain of: 15%
Angle of internal friction, ϕ' = 34.3 °
Apparent Cohesion, c' = 0.00 (tsf)

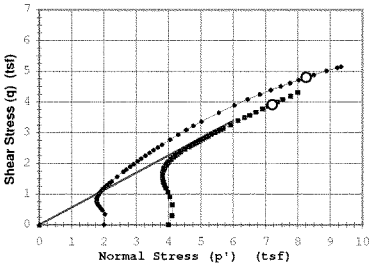
Test Date:	8/18/10	Liquid Limit:	29.5		
Test Type:	CU w/pp	Plastic Limit:	16.9		
Strain Rate (in/min):	0.00285	Plasticity Index:	12.6		
Strain Rate (%/min):	0.050	Spec. Gravity (Assumed):	2.69		

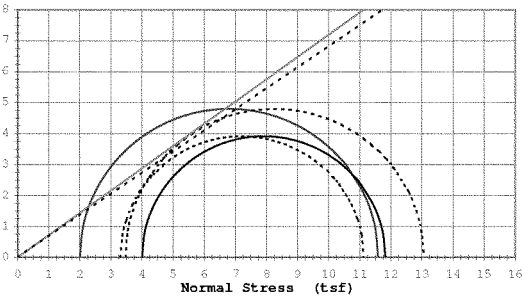
Before Consolidation	A	B	C	D	E
Diameter (in)	2.85	2.89			
Height (in)	5.78	5.49			
Water Content (%)	14.7	16.4			
Dry Density (pcf)	113.3	110.7			
Void Ratio	0.48	0.52			
After Consolidation					
Diameter (in)	2.83	2.86			
Height (in)	5.70	5.44			
Water Content (%)	16.5	17.5			
Dry Density (pcf)	116.3	114.3			
Void Ratio	0.44	0.47			
Back Pressure (tsf)	5.8	5.8			
Minor Principal Stress (tsf)	2.00	4.00			
Max. Deviator Stress (tsf)	10.29	8.61			
Ultimate Deviator Stress (tsf)	10.29	8.61			
Deviator Stress at Failure (tsf)	9.59	7.82			
Max. Pore Pressure Buildup (tsf)	1.20	2.05			
Pore Pressure Parameter "B"	1.0	1.0			
Pct. Axial Strain at Failure	15.0	15.0			

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.

*Height to diameter ratio of 2:1 no achieved for specimen B.





Rupture Envelope at Failure
α = 29.4 ° a = 0.0 (tsf)

---------- Effective ϕ': 34.3 ° c'= 0.00 (tsf)
_____ Total ϕ': 35.7 ° c= 0.00 (tsf)

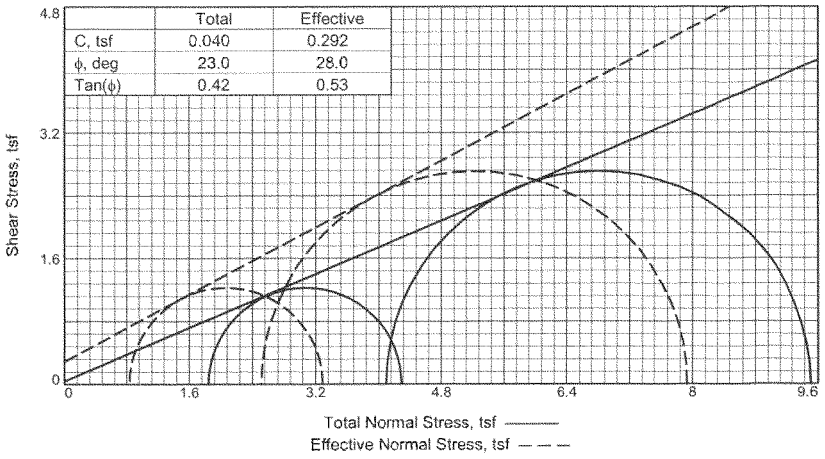
5 OIL ENGINEERING TESTING, INC. 9301 Bryant Ave. South Suite #107 Bloomington, Minnesota 55420-3436

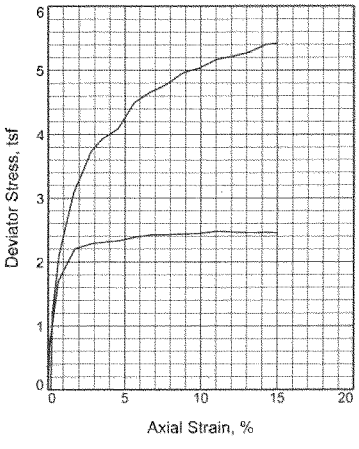
Date: 10/4/2010

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING Type: CU

Boring No.: 10-78MU, Sample No.: 4, Depth (ft.): 70-71.2

Sample 1			Sample 2			Sample 3			Sample 4			Sample 5		
Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)
0.00	0.00	0.00	0.00	0.00	0.00									
0.09	0.69	0.32	0.09	0.59	0.18									
0.18	0.93	0.51	0.18	1.30	0.53									
0.26	1.09	0.66	0.28	1.82	0.86									
0.35	1.19	0.75	0.37	2.11	1.08									
0.44	1.28	0.82	0.46	2.39	1.28									
0.53	1.37	0.89	0.55	2.59	1.42									
0.61	1.43	0.94	0.64	2.76	1.54									
0.70	1.49	0.98	0.74	2.93	1.64									
0.79	1.56	1.01	0.83	3.07	1.72									
0.88	1.61	1.04	0.92	3.21	1.79									
0.96	1.66	1.06	1.01	3.32	1.85									
1.05	1.71	1.08	1.11	3.43	1.89									
1.14	1.77	1.10	1.20	3.54	1.93									
1.23	1.82	1.12	1.29	3.63	1.96									
1.32	1.87	1.13	1.38	3.73	1.98									
1.40	1.92	1.14	1.47	3.83	2.00									
1.49	1.96	1.15	1.56	3.90	2.02									
1.58	2.01	1.17	1.66	4.00	2.03									
1.67	2.07	1.17	1.75	4.07	2.04									
1.75	2.11	1.18	1.84	4.13	2.04									
1.93	2.22	1.19	2.02	4.26	2.05									
2.10	2.33	1.20	2.21	4.38	2.05									
2.28	2.43	1.20	2.39	4.49	2.04									
2.46	2.56	1.19	2.57	4.59	2.03									
2.63	2.69	1.18	2.76	4.68	2.01									
2.81	2.82	1.17	2.94	4.77	1.99									
3.16	3.12	1.15	3.31	4.92	1.96									
3.51	3.43	1.12	3.68	5.06	1.91									
3.68	3.59	1.10	3.86	5.13	1.89									
3.86	3.77	1.08	4.05	5.20	1.86									
4.03	3.94	1.05	4.23	5.27	1.84									
4.21	4.13	1.03	4.41	5.35	1.81									
4.38	4.30	1.00	4.60	5.43	1.79									
4.56	4.49	0.97	4.78	5.50	1.76									
4.73	4.67	0.93	4.97	5.57	1.74									
4.91	4.86	0.89	5.15	5.65	1.71									
5.08	5.04	0.85	5.33	5.72	1.69									
5.26	5.21	0.81	5.52	5.78	1.66									
5.61	5.54	0.73	5.89	5.90	1.61									
5.96	5.86	0.64	6.26	6.01	1.57									
6.31	6.16	0.54	6.62	6.10	1.52									
6.66	6.43	0.46	6.99	6.19	1.48									
7.01	6.71	0.34	7.36	6.27	1.44									
7.89	7.29	0.10	8.28	6.51	1.33									
8.77	7.77	-0.14	9.20	6.77	1.24									
9.64	8.16	-0.36	10.12	6.98	1.14									
10.52	8.48	-0.58	11.04	7.13	1.05									
11.39	8.76	-0.78	11.96	7.33	0.96									
12.27	9.00	-0.97	12.87	7.54	0.86									
13.15	9.22	-1.14	13.79	7.71	0.78									
14.02	9.41	-1.31	14.71	7.82	0.70									
14.90	9.59	-1.46	15.63	7.98	0.62									
15.78	9.75	-1.61	16.55	8.16	0.55									
17.53	10.02	-1.87	18.39	8.37	0.41									
19.28	10.22	-2.11	20.00	8.61	0.30									
20.00	10.29	-2.19												





Sample No.		1	2
Initial	Water Content, %	18.9	17.0
	Dry Density, pcf	110.4	114.1
	Saturation, %	98.5	97.9
	Void Ratio	0.5131	0.4640
	Diameter, in.	1.38	1.40
	Height, in.	2.81	2.81
At Test	Water Content, %	19.2	17.3
	Dry Density, pcf	110.4	114.1
	Saturation, %	100.0	100.0
	Void Ratio	0.5131	0.4640
	Diameter, in.	1.38	1.40
	Height, in.	2.81	2.81
Pore Pressure Parameter B		1.0	1.0
Consolidation Pressure, tsf		1.85	4.09
Back Pressure, tsf		5.22	3.14
Cell Pressure, tsf		7.07	7.23
Peak Deviator Stress, tsf		2.48	5.42
	Total Pore Pr., tsf	6.27	4.72
Ultimate Deviator Stress, tsf		2.45	5.42
	Total Pore Pr., tsf	6.23	4.72
Maj. Eff. Stress at Ultimate, tsf		3.29	7.93
Min. Eff. Stress at Ultimate, tsf		0.84	2.51

Type of Test: CU with Pore Pressures

Sample Type: 3" Thinwall, Middle of sample

Description: SANDY LEAN CLAY, brown (CL)

LL= 31 **PL=** 15 **PI=** 16

Specific Gravity= 2.676

Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

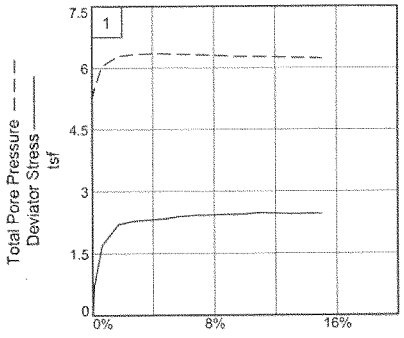
Location: Maple River, Till Formation

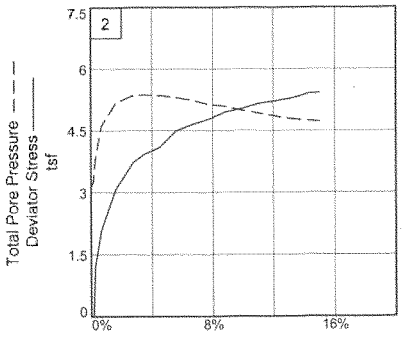
Sample Number: Boring10-105MU, #6 **Depth:** 67-69'

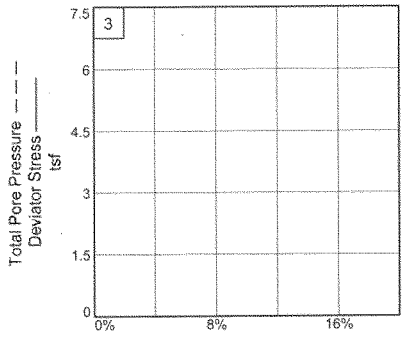
Proj. No.: BL-10-10065 **Date Sampled:**

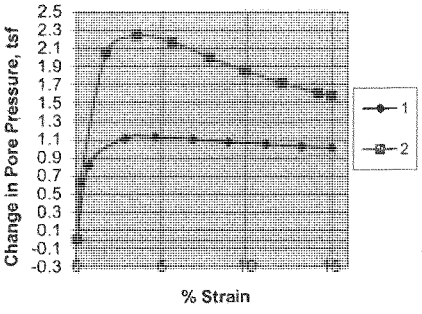
BRAUN INTERTEC

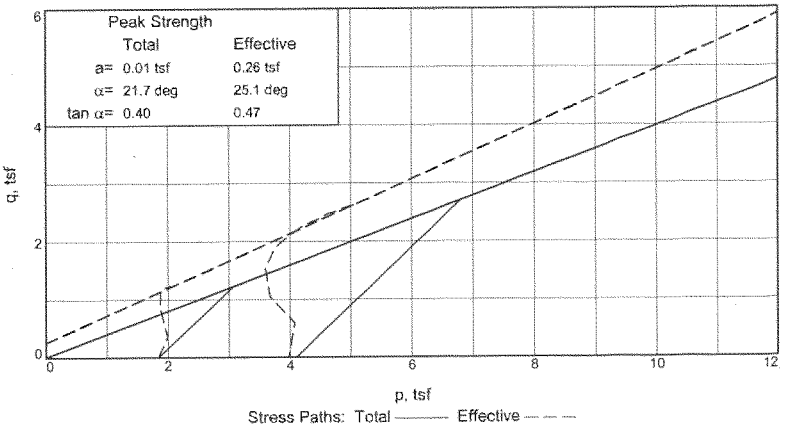
Figure C-T-Tom-NSTMMD-767











Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Location: Maple River, Till Formation **Depth:** 67-69' **Sample Number:** Boring10-105MU, #6
Project No. Fargo-Moorhead 00416 **Figure**

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

3/4/2011
2:31 PM

Date:
Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project No.: BL-10-10065
Location: Maple River, Till Formation
Depth: 67-69' **Sample Number:** Boring10-105MU, #6
Description: SANDY LEAN CLAY, brown (CL)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 3" Thinwall, Middle of sample
Specific Gravity=2.676 **LL=**31 **PL=**15 **PI=**16
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	154.860			174.130
Moisture content: Dry soil+tare, gms.	135.090			152.050
Moisture content: Tare, gms.	30.430			30.440
Moisture, %	18.9	19.2	19.2	18.2
Moist specimen weight, gms.	145.2			
Diameter, in.	1.38	1.38	1.38	
Area, in.²	1.50	1.50	1.50	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	131.3	131.6	131.6	
Dry density, pcf	110.4	110.4	110.4	
Void ratio	0.5131	0.5131	0.5131	
Saturation, %	98.5	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.068 tsf
Consolidation back pressure = 5.224 tsf
Consolidation effective confining stress = 1.844 tsf
Peak Stress = 2.481 tsf **at reading no.** 12
Ult. Stress = 2.452 tsf **at reading no.** 16

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	0.0443	12.840	0.0	0.0	0.000	1.844	1.844	1.00	5.224	1.844	0.000
1	0.0471	27.580	14.7	0.1	0.707	1.642	2.349	1.43	5.426	1.995	0.353
2	0.0628	48.420	35.6	0.7	1.697	1.029	2.726	2.65	6.039	1.877	0.848
3	0.0934	59.640	46.8	1.7	2.207	0.778	2.985	3.84	6.290	1.882	1.104
4	0.1235	61.830	49.0	2.8	2.285	0.736	3.021	4.10	6.332	1.879	1.143
5	0.1538	63.030	50.2	3.9	2.315	0.721	3.036	4.21	6.347	1.879	1.158
6	0.1740	63.730	50.9	4.6	2.330	0.718	3.048	4.24	6.350	1.883	1.165
7	0.2047	65.630	52.8	5.7	2.389	0.730	3.119	4.27	6.338	1.925	1.195
8	0.2351	66.990	54.1	6.8	2.423	0.743	3.166	4.26	6.325	1.954	1.211
9	0.2643	67.720	54.9	7.8	2.428	0.756	3.184	4.21	6.312	1.970	1.214
10	0.2951	68.600	55.8	8.9	2.437	0.773	3.210	4.15	6.295	1.992	1.219
11	0.3254	69.490	56.6	10.0	2.447	0.788	3.235	4.11	6.280	2.012	1.224
12	0.3556	70.980	58.1	11.1	2.481	0.798	3.279	4.11	6.270	2.039	1.241
13	0.3862	71.270	58.4	12.2	2.463	0.808	3.271	4.05	6.260	2.040	1.232
14	0.4157	71.760	58.9	13.2	2.454	0.822	3.276	3.99	6.246	2.049	1.227
15	0.4469	72.710	59.9	14.3	2.462	0.828	3.290	3.97	6.240	2.059	1.231
16	0.4665	72.960	60.1	15.0	2.452	0.837	3.289	3.93	6.231	2.063	1.226

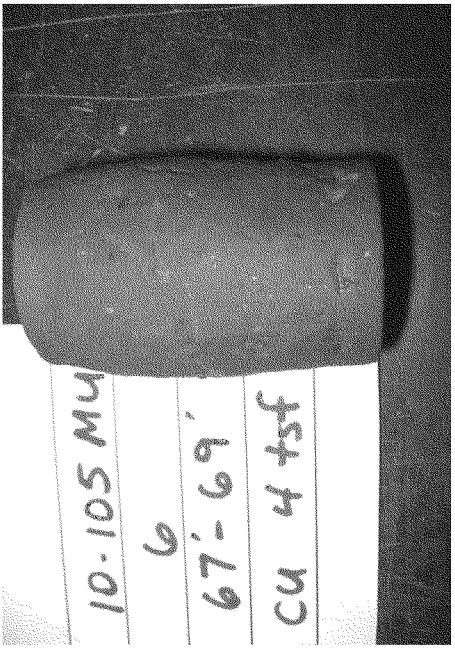
Parameters for Specimen No. 2

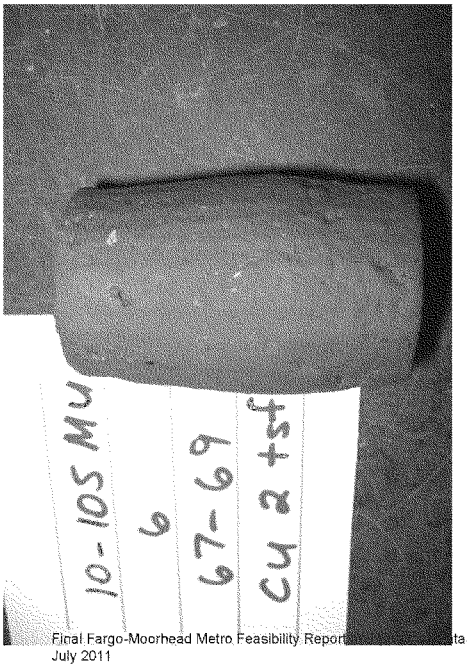
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	131.390			178.020
Moisture content: Dry soil+tare, gms.	116.630			158.450
Moisture content: Tare, gms.	29.720			30.270
Moisture, %	17.0	17.3	17.3	15.3
Moist specimen weight, gms.	150.5			
Diameter, in.	1.40	1.40	1.40	
Area, in.²	1.53	1.53	1.53	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	133.5	133.9	133.9	
Dry density, pcf	114.1	114.1	114.1	
Void ratio	0.4640	0.4640	0.4640	
Saturation, %	97.9	100.0	100.0	

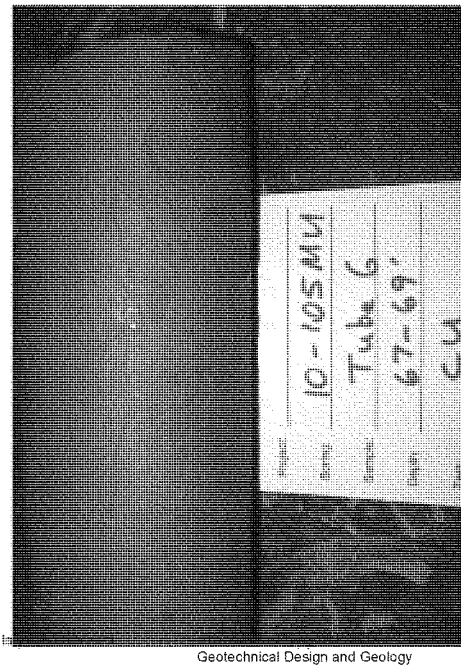
Test Readings for Specimen No. 2

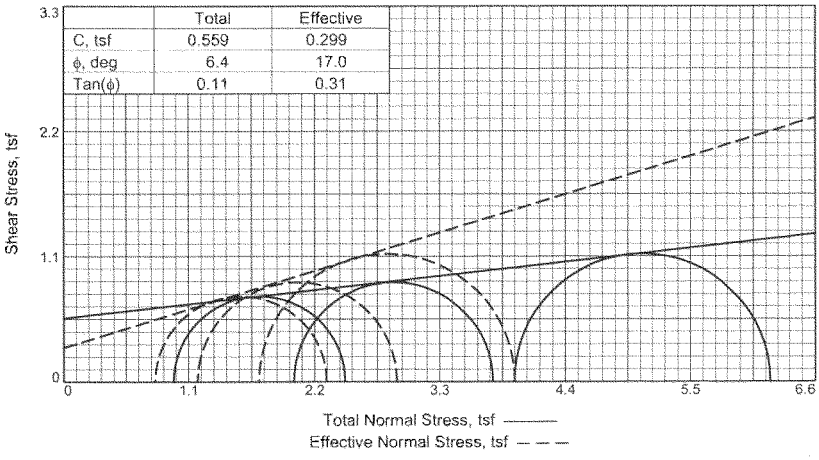
Consolidation cell pressure = 7.232 tsf
Consolidation back pressure = 3.136 tsf
Consolidation effective confining stress = 4.096 tsf
Peak Stress = 5.419 tsf **at reading no.** 17
Ult. Stress = 5.419 tsf **at reading no.** 17

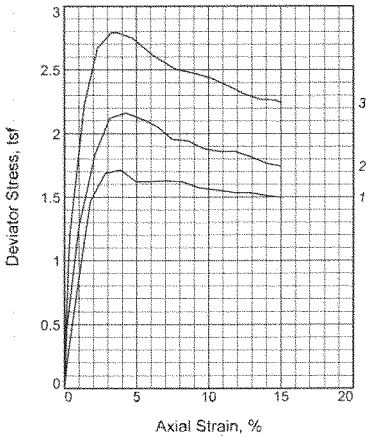
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0385	28.610	0.0	0.0	0.000	4.096	4.096	1.00	3.136	4.096	0.000
1	0.0434	28.610	0.0	0.2	0.000	3.976	3.976	1.00	3.256	3.976	0.000
2	0.0463	54.150	25.5	0.3	1.198	3.475	4.673	1.34	3.757	4.074	0.599
3	0.0584	73.470	44.9	0.7	2.095	2.622	4.717	1.80	4.610	3.670	1.048
4	0.0850	95.410	66.8	1.7	3.090	2.052	5.142	2.51	5.180	3.597	1.545
5	0.1155	110.160	81.5	2.7	3.731	1.874	5.605	2.99	5.358	3.739	1.865
6	0.1361	115.040	86.4	3.5	3.924	1.856	5.780	3.11	5.376	3.818	1.962
7	0.1654	119.670	91.1	4.5	4.090	1.875	5.965	3.18	5.357	3.920	2.045
8	0.1957	129.790	101.2	5.6	4.493	1.930	6.423	3.33	5.302	4.176	2.246
9	0.2262	134.790	106.2	6.7	4.661	2.000	6.661	3.33	5.232	4.330	2.330
10	0.2565	138.870	110.3	7.8	4.784	2.099	6.883	3.28	5.133	4.491	2.392
11	0.2871	144.360	115.8	8.9	4.963	2.144	7.107	3.31	5.088	4.625	2.481
12	0.3173	147.530	118.9	9.9	5.038	2.246	7.284	3.24	4.986	4.765	2.519
13	0.3477	152.040	123.4	11.0	5.167	2.315	7.482	3.23	4.917	4.898	2.583
14	0.3771	154.720	126.1	12.1	5.217	2.375	7.592	3.20	4.857	4.983	2.608
15	0.4075	157.890	129.3	13.1	5.282	2.443	7.725	3.16	4.789	5.084	2.641
16	0.4379	162.470	133.9	14.2	5.401	2.493	7.894	3.17	4.739	5.193	2.700
17	0.4584	164.080	135.5	15.0	5.419	2.514	7.933	3.16	4.718	5.224	2.710


10-105 MW
6
67'-69'
CH 4 tst


10-105 MW
6
67-69
CH 2 tst


10-105 MW
Tube 6
67-69'





Sample No.		1	2	3
Initial	Water Content, %	34.9	39.3	40.5
	Dry Density, pcf	85.1	81.6	80.3
	Saturation, %	96.7	100.0	100.0
	Void Ratio	0.9720	1.0579	1.0902
	Diameter, in.	1.40	1.38	1.39
	Height, in.	2.81	2.81	2.81
At Test	Water Content, %	36.1	39.0	38.9
	Dry Density, pcf	85.1	81.9	82.1
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.9720	1.0491	1.0458
	Diameter, in.	1.40	1.38	1.38
	Height, in.	2.81	2.80	2.79
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		0.97	2.02	3.96
Back Pressure, tsf		6.13	5.13	3.18
Cell Pressure, tsf		7.10	7.15	7.14
Peak Deviator Stress, tsf		1.71	2.16	2.79
Total Pore Pr., tsf		6.64	6.02	4.91
Ultimate Deviator Stress, tsf		1.50	1.74	2.24
Total Pore Pr., tsf		6.29	5.97	5.42
Maj. Eff. Stress at Ultimate, tsf		2.31	2.92	3.96
Min. Eff. Stress at Ultimate, tsf		0.81	1.18	1.72

Type of Test: CU with Pore Pressures

Sample Type: Undisturbed, 5" Thinwall, Middle

Description: FAT CLAY, brown (CH)

LL= 66 **PL=** 20 **PI=** 46

Specific Gravity= 2.689

Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

Location: Sheyenne River, Till Formation

Sample Number: Boring11-110, #6 **Depth:** 65-67'

Proj. No.: BL-10-10065 **Date Sampled:**

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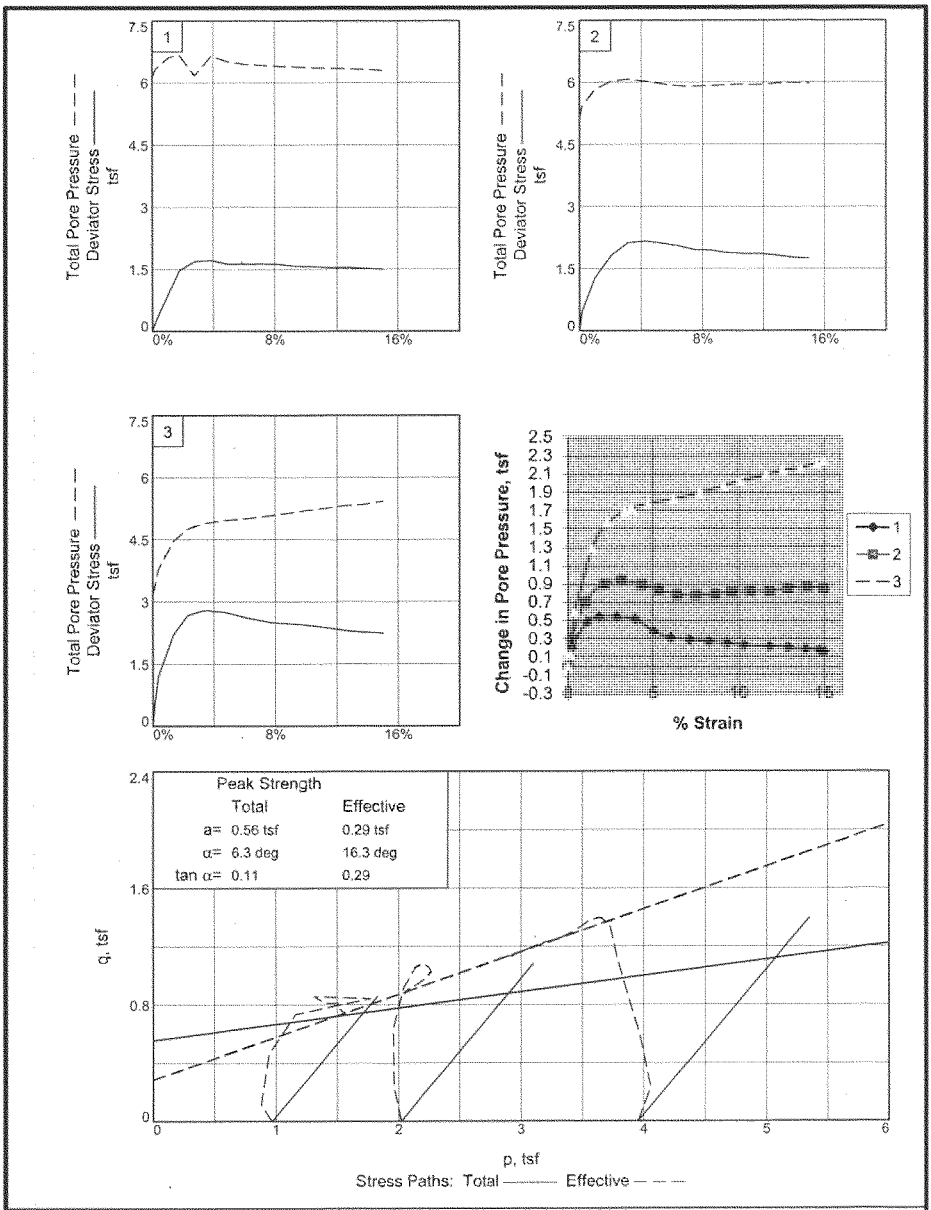
Figure C Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement



Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Location: Sheyenne River, Till Formation **Depth:** 65-67' **Sample Number:** Boring11-110, #6

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

4/26/2011
8:19 AM

Date:
Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project No.: BL-10-10065
Location: Sheyenne River, Till Formation
Depth: 65-67' **Sample Number:** Boring11-110MU, #6
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: Undisturbed, 5" Thinwall, Middle
Specific Gravity=2.689 **LL=**66 **PL=**20 **PI=**46
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	141.640			161.240
Moisture content: Dry soil+tare, gms.	112.790			125.650
Moisture content: Tare, gms.	30.240			30.980
Moisture, %	34.9	36.1	36.1	37.6
Moist specimen weight, gms.	129.9			
Diameter, in.	1.40	1.40	1.40	
Area, in.^{2}	1.53	1.53	1.53	
Height, in.	2.81	2.81	2.81	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	114.9	115.9	115.9	
Dry density, pcf	85.1	85.1	85.1	
Void ratio	0.9720	0.9720	0.9720	
Saturation, %	96.7	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.098 tsf
Consolidation back pressure = 6.130 tsf
Consolidation effective confining stress = 0.968 tsf
Peak Stress = 1.714 tsf **at reading no.** 5
Ult. Stress = 1.499 tsf **at reading no.** 16

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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	0.0560	20.000	0.0	0.0	0.000	0.968	0.968	1.00	6.130	0.968	0.000
1	0.0619	24.890	4.9	0.2	0.229	0.767	0.996	1.30	6.331	0.881	0.114
2	0.0863	39.950	20.0	1.1	0.926	0.481	1.407	2.92	6.617	0.944	0.463
3	0.1059	51.890	31.9	1.8	1.469	0.427	1.896	4.44	6.671	1.162	0.735
4	0.1353	57.000	37.0	2.8	1.686	0.926	2.613	2.82	6.171	1.770	0.843
5	0.1648	58.010	38.0	3.9	1.714	0.453	2.167	4.78	6.645	1.310	0.857
6	0.1950	56.360	36.4	5.0	1.621	0.589	2.210	3.75	6.509	1.400	0.811
7	0.2244	56.780	36.8	6.0	1.622	0.653	2.275	3.48	6.445	1.464	0.811
8	0.2547	57.320	37.3	7.1	1.627	0.676	2.303	3.41	6.422	1.489	0.813
9	0.2852	57.620	37.6	8.2	1.620	0.697	2.317	3.32	6.401	1.507	0.810
10	0.3164	56.990	37.0	9.3	1.574	0.715	2.289	3.20	6.383	1.502	0.787
11	0.3459	57.080	37.1	10.3	1.560	0.739	2.299	3.11	6.359	1.519	0.780
12	0.3859	57.110	37.1	11.8	1.536	0.750	2.286	3.05	6.348	1.518	0.768
13	0.4169	57.520	37.5	12.9	1.534	0.763	2.297	3.01	6.335	1.530	0.767
14	0.4471	57.490	37.5	13.9	1.513	0.780	2.293	2.94	6.318	1.537	0.757
15	0.4674	57.550	37.5	14.7	1.503	0.792	2.295	2.90	6.306	1.544	0.752
16	0.4773	57.610	37.6	15.0	1.499	0.806	2.305	2.86	6.292	1.556	0.750

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	136.490			155.500
Moisture content: Dry soil+tare, gms.	106.530			120.910
Moisture content: Tare, gms.	30.380			30.360
Moisture, %	39.3	39.3	39.0	38.2
Moist specimen weight, gms.	126.0			
Diameter, in.	1.38	1.38	1.38	
Area, in.²	1.51	1.51	1.50	
Height, in.	2.81	2.81	2.80	
Net decrease in height, in.		0.00	0.00	
Wet Density, pcf	113.7	113.7	113.9	
Dry density, pcf	81.6	81.6	81.9	
Void ratio	1.0579	1.0579	1.0491	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 7.149 tsf
Consolidation back pressure = 5.129 tsf
Consolidation effective confining stress = 2.020 tsf
Peak Stress = 2.162 tsf **at reading no.** 5
Ult. Stress = 1.745 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	0.0385	20.580	0.0	0.0	0.000	2.020	2.020	1.00	5.129	2.020	0.000
1	0.0433	30.440	9.9	0.2	0.472	1.726	2.198	1.27	5.423	1.962	0.236
2	0.0669	47.450	26.9	1.0	1.275	1.320	2.595	1.97	5.829	1.958	0.638
3	0.0969	59.640	39.1	2.1	1.834	1.123	2.957	2.63	6.026	2.040	0.917
4	0.1264	66.280	45.7	3.1	2.122	1.080	3.202	2.96	6.069	2.141	1.061
5	0.1578	67.680	47.1	4.3	2.162	1.129	3.291	2.91	6.020	2.210	1.081
6	0.1882	67.210	46.6	5.3	2.116	1.189	3.305	2.78	5.960	2.247	1.058
7	0.2184	66.400	45.8	6.4	2.056	1.239	3.295	2.66	5.910	2.267	1.028
8	0.2479	64.660	44.1	7.5	1.955	1.243	3.198	2.57	5.906	2.221	0.978
9	0.2784	64.900	44.3	8.6	1.943	1.236	3.179	2.57	5.913	2.207	0.971
10	0.3085	64.040	43.5	9.6	1.883	1.211	3.094	2.55	5.938	2.152	0.941
11	0.3392	64.040	43.5	10.7	1.860	1.200	3.060	2.55	5.949	2.130	0.930
12	0.3685	64.590	44.0	11.8	1.861	1.204	3.065	2.55	5.945	2.135	0.931
13	0.3997	64.110	43.5	12.9	1.818	1.175	2.993	2.55	5.974	2.084	0.909
14	0.4302	63.400	42.8	14.0	1.766	1.156	2.922	2.53	5.993	2.039	0.883
15	0.4580	63.390	42.8	15.0	1.745	1.179	2.924	2.48	5.970	2.051	0.872

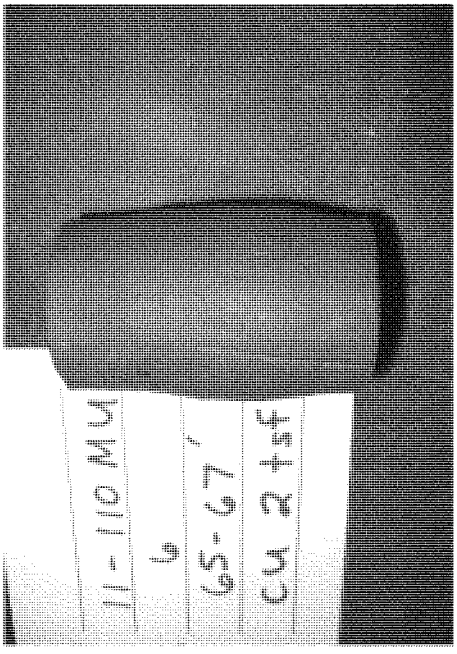
Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	128.450			153.900
Moisture content: Dry soil+tare, gms.	100.200			120.390
Moisture content: Tare, gms.	30.490			30.430
Moisture, %	40.5	40.5	38.9	37.2
Moist specimen weight, gms.	126.0			
Diameter, in.	1.39	1.39	1.38	
Area, in.^{2}	1.52	1.52	1.49	
Height, in.	2.81	2.81	2.79	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	112.9	112.9	114.0	
Dry density, pcf	80.3	80.3	82.1	
Void ratio	1.0902	1.0902	1.0458	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 3

Consolidation cell pressure = 7.138 tsf
Consolidation back pressure = 3.182 tsf
Consolidation effective confining stress = 3.956 tsf
Peak Stress = 2.790 tsf **at reading no.** 6
Ult. Stress = 2.244 tsf **at reading no.** 16

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	0.0096	18.500	0.0	0.0	0.000	3.956	3.956	1.00	3.182	3.956	0.000
1	0.0126	28.190	9.7	0.1	0.467	3.824	4.291	1.12	3.314	4.057	0.233
2	0.0196	43.300	24.8	0.4	1.191	3.373	4.564	1.35	3.765	3.969	0.596
3	0.0473	65.280	46.8	1.4	2.224	2.671	4.895	1.83	4.467	3.783	1.112
4	0.0732	75.160	56.7	2.3	2.669	2.391	5.060	2.12	4.747	3.725	1.334
5	0.1002	78.310	59.8	3.3	2.789	2.264	5.053	2.23	4.874	3.659	1.395
6	0.1130	78.610	60.1	3.7	2.790	2.232	5.022	2.25	4.906	3.627	1.395
7	0.1408	78.370	59.9	4.7	2.750	2.179	4.929	2.26	4.959	3.554	1.375
8	0.1817	76.260	57.8	6.2	2.612	2.132	4.744	2.23	5.006	3.438	1.306
9	0.2236	74.860	56.4	7.7	2.508	2.062	4.570	2.22	5.076	3.316	1.254
10	0.2644	74.890	56.4	9.1	2.470	1.990	4.460	2.24	5.148	3.225	1.235
11	0.2923	74.740	56.2	10.1	2.436	1.937	4.373	2.26	5.201	3.155	1.218
12	0.3333	73.940	55.4	11.6	2.362	1.870	4.232	2.26	5.268	3.051	1.181
13	0.3610	73.210	54.7	12.6	2.305	1.816	4.121	2.27	5.322	2.968	1.152
14	0.3891	73.030	54.5	13.6	2.270	1.795	4.065	2.26	5.343	2.930	1.135
15	0.4169	73.490	55.0	14.6	2.263	1.737	4.000	2.30	5.401	2.869	1.132
16	0.4280	73.270	54.8	15.0	2.244	1.716	3.960	2.31	5.422	2.838	1.122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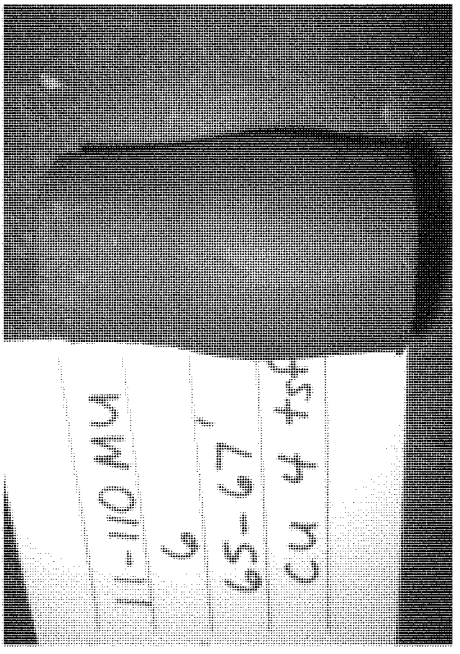
6
65-67'
cu 2 +sf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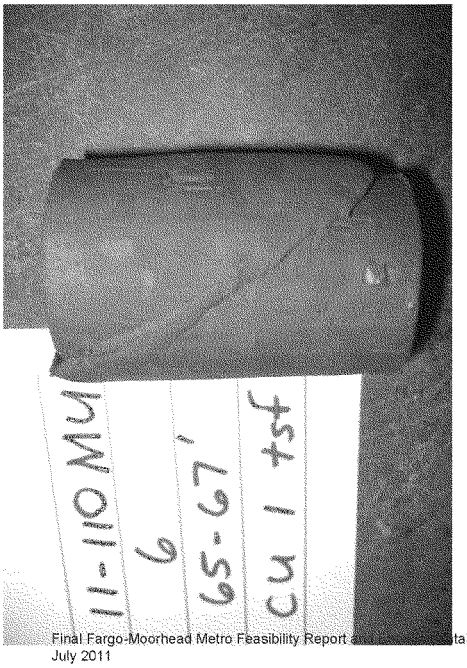
65-67'
cu 4 +sf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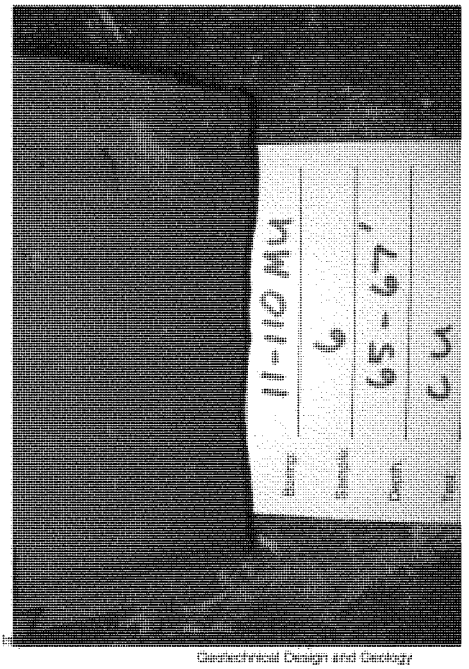
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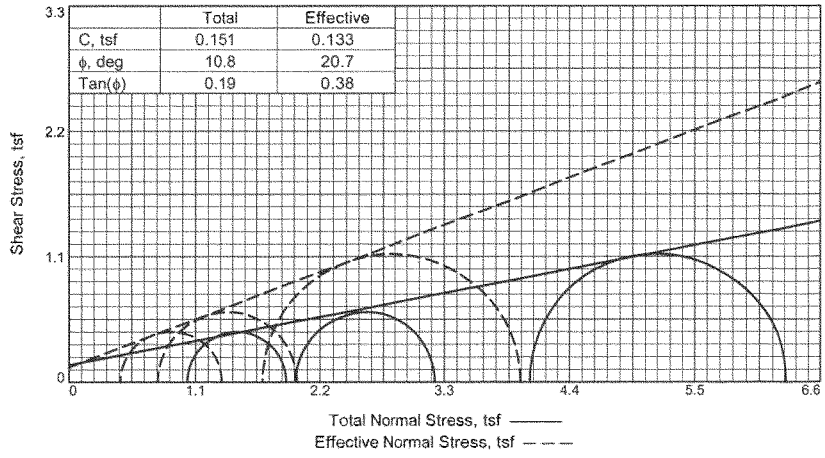
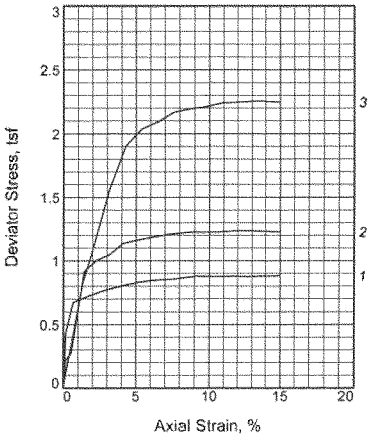
6
65-67'
cu





Sample No.		1	2	3
Initial	Water Content, %	50.9	51.3	47.5
	Dry Density, pcf	71.0	70.7	73.9
	Saturation, %	100.0	99.9	100.0
	Void Ratio	1.3761	1.3866	1.2828
	Diameter, in.	1.43	1.41	1.41
	Height, in.	2.80	2.80	2.80
At Test	Water Content, %	46.3	47.6	41.2
	Dry Density, pcf	75.0	73.8	79.8
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.2503	1.2853	1.1144
	Diameter, in.	1.40	1.39	1.37
	Height, in.	2.75	2.76	2.73
Pore Pressure Parameter B		1.0	1.0	1.0
Consolidation Pressure, tsf		1.03	2.00	4.04
Back Pressure, tsf		6.12	5.13	3.08
Cell Pressure, tsf		7.15	7.13	7.12
Peak Deviator Stress, tsf		0.88	1.24	2.26
Total Pore Pr., tsf		6.70	6.34	5.42
Ultimate Deviator Stress, tsf		0.88	1.23	2.25
Total Pore Pr., tsf		6.70	6.35	5.42
Maj. Eff. Stress at Ultimate, tsf		1.33	2.00	3.95
Min. Eff. Stress at Ultimate, tsf		0.45	0.78	1.70

Type of Test:
CU with Pore Pressures
Sample Type: 5" Thinwall, Middle of sample
Description: FAT CLAY, brown (CH)

LL= 66 **PL=** 19 **PI=** 47
Specific Gravity= 2.702
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: Fargo Pile Load Test, Till Formation
Sample Number: Boring11-119MU, #4 **Depth:** 61-64'
Proj. No.: BL-10-10065 **Date Sampled:**

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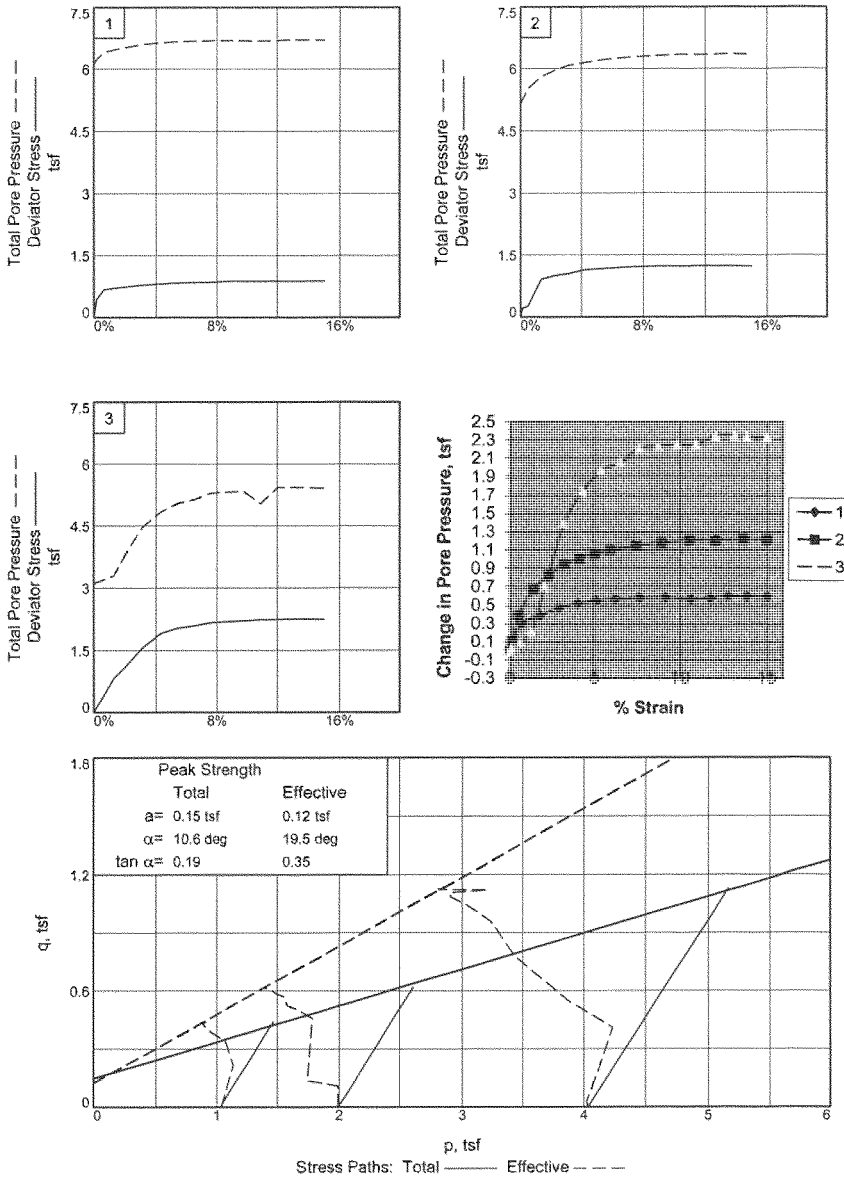
Figure 4 Triaxial ASTM D4767



Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Loc.: Fargo Pile Load Test, Till Formation **Depth:** 61-64' **Sample No.:** Boring11-119MU, #4

Project No.: BL-10-10065 **Figure**

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Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
CU with Pore Pressures

5/30/2011
12:18 PM

Date:
Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Project No.: BL-10-10065
Location: Fargo Pile Load Test, Till Formation
Depth: 61-64' **Sample Number:** Boring11-119MU, #4
Description: FAT CLAY, brown (CH)
Remarks: Rate of strain is 0.001 in/min. Failure criteria is based on the ultimate stress which occurs at 15% strain. Samples were saturated for 10 days and consolidated for 3 days.
Type of Sample: 5" Thinwall, Middle of sample
Specific Gravity=2.702 **LL=**66 **PL=**19 **PI=**47
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	123.950			144.960
Moisture content: Dry soil+tare, gms.	92.350			113.460
Moisture content: Tare, gms.	30.280			30.790
Moisture, %	50.9	50.9	46.3	38.1
Moist specimen weight, gms.	125.7			
Diameter, in.	1.43	1.43	1.40	
Area, in.²	1.60	1.60	1.54	
Height, in.	2.80	2.80	2.75	
Net decrease in height, in.		0.00	0.05	
Wet Density, pcf	107.1	107.1	109.6	
Dry density, pcf	71.0	71.0	75.0	
Void ratio	1.3761	1.3761	1.2503	
Saturation, %	100.0	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 7.151 tsf
Consolidation back pressure = 6.122 tsf
Consolidation effective confining stress = 1.029 tsf
Peak Stress = 0.882 tsf **at reading no.** 14
Ult. Stress = 0.882 tsf **at reading no.** 14

Test Results 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	0.0554	18.090	0.0	0.0	0.000	1.039	1.039	1.00	6.112	1.039	0.000
1	0.0602	27.390	9.3	0.2	0.434	0.925	1.359	1.47	6.226	1.142	0.217
2	0.0740	32.590	14.5	0.7	0.674	0.741	1.415	1.91	6.410	1.078	0.337
3	0.1040	33.890	15.8	1.8	0.726	0.649	1.375	2.12	6.502	1.012	0.363
4	0.1346	35.060	17.0	2.9	0.771	0.574	1.345	2.34	6.577	0.959	0.385
5	0.1641	35.930	17.8	4.0	0.801	0.523	1.324	2.53	6.628	0.924	0.401
6	0.1952	36.790	18.7	5.1	0.830	0.490	1.320	2.69	6.661	0.905	0.415
7	0.2255	37.390	19.3	6.2	0.847	0.473	1.320	2.79	6.678	0.896	0.423
8	0.2656	37.920	19.8	7.6	0.856	0.459	1.315	2.87	6.692	0.887	0.428
9	0.3059	38.770	20.7	9.1	0.879	0.456	1.335	2.93	6.695	0.896	0.440
10	0.3469	39.000	20.9	10.6	0.874	0.471	1.345	2.86	6.680	0.908	0.437
11	0.3764	39.350	21.3	11.7	0.878	0.463	1.341	2.90	6.688	0.902	0.439
12	0.4058	39.530	21.4	12.7	0.875	0.444	1.319	2.97	6.707	0.881	0.437
13	0.4362	39.920	21.8	13.8	0.880	0.445	1.325	2.98	6.706	0.885	0.440
14	0.4676	40.270	22.2	15.0	0.882	0.449	1.331	2.96	6.702	0.890	0.441

Test Results for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	134.200			138.260
Moisture content: Dry soil+tare, gms.	98.970			110.200
Moisture content: Tare, gms.	30.280			30.180
Moisture, %	51.3	51.3	47.6	35.1
Moist specimen weight, gms.	122.5			
Diameter, in.	1.41	1.41	1.39	
Area, in.²	1.56	1.56	1.51	
Height, in.	2.80	2.80	2.76	
Net decrease in height, in.		0.00	0.04	
Wet Density, pcf	106.9	106.9	108.9	
Dry density, pcf	70.7	70.7	73.8	
Void ratio	1.3866	1.3866	1.2853	
Saturation, %	99.9	100.0	100.0	

Test Reading for Specimen No. 2

Consolidation cell pressure = 7.127 tsf
Consolidation back pressure = 5.135 tsf
Consolidation effective confining stress = 1.992 tsf
Peak Stress = 1.237 tsf **at reading no.** 12
Ult. Stress = 1.227 tsf **at reading no.** 14

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	0.0066	17.600	0.0	0.0	0.000	1.992	1.992	1.00	5.135	1.992	0.000
1	0.0105	22.180	4.6	0.1	0.217	1.880	2.097	1.12	5.247	1.989	0.109
2	0.0215	23.400	5.8	0.5	0.274	1.603	1.877	1.17	5.524	1.740	0.137
3	0.0455	37.170	19.6	1.4	0.917	1.319	2.236	1.70	5.808	1.778	0.459
4	0.0694	39.180	21.6	2.3	1.002	1.167	2.169	1.86	5.960	1.668	0.501
5	0.0942	40.400	22.8	3.2	1.049	1.051	2.100	2.00	6.076	1.576	0.525
6	0.1200	42.540	24.9	4.1	1.137	0.987	2.124	2.15	6.140	1.555	0.568
7	0.1440	43.270	25.7	5.0	1.159	0.935	2.094	2.24	6.192	1.515	0.580
8	0.1688	44.000	26.4	5.9	1.181	0.889	2.070	2.33	6.238	1.480	0.591
9	0.2095	45.100	27.5	7.4	1.211	0.846	2.057	2.43	6.281	1.452	0.606
10	0.2523	45.920	28.3	8.9	1.226	0.815	2.041	2.50	6.312	1.428	0.613
11	0.2961	46.410	28.8	10.5	1.226	0.785	2.011	2.56	6.342	1.398	0.613
12	0.3391	47.180	29.6	12.0	1.237	0.788	2.025	2.57	6.339	1.406	0.618
13	0.3831	47.660	30.1	13.6	1.234	0.771	2.005	2.60	6.356	1.388	0.617
14	0.4200	47.950	30.4	15.0	1.227	0.777	2.004	2.58	6.350	1.390	0.613

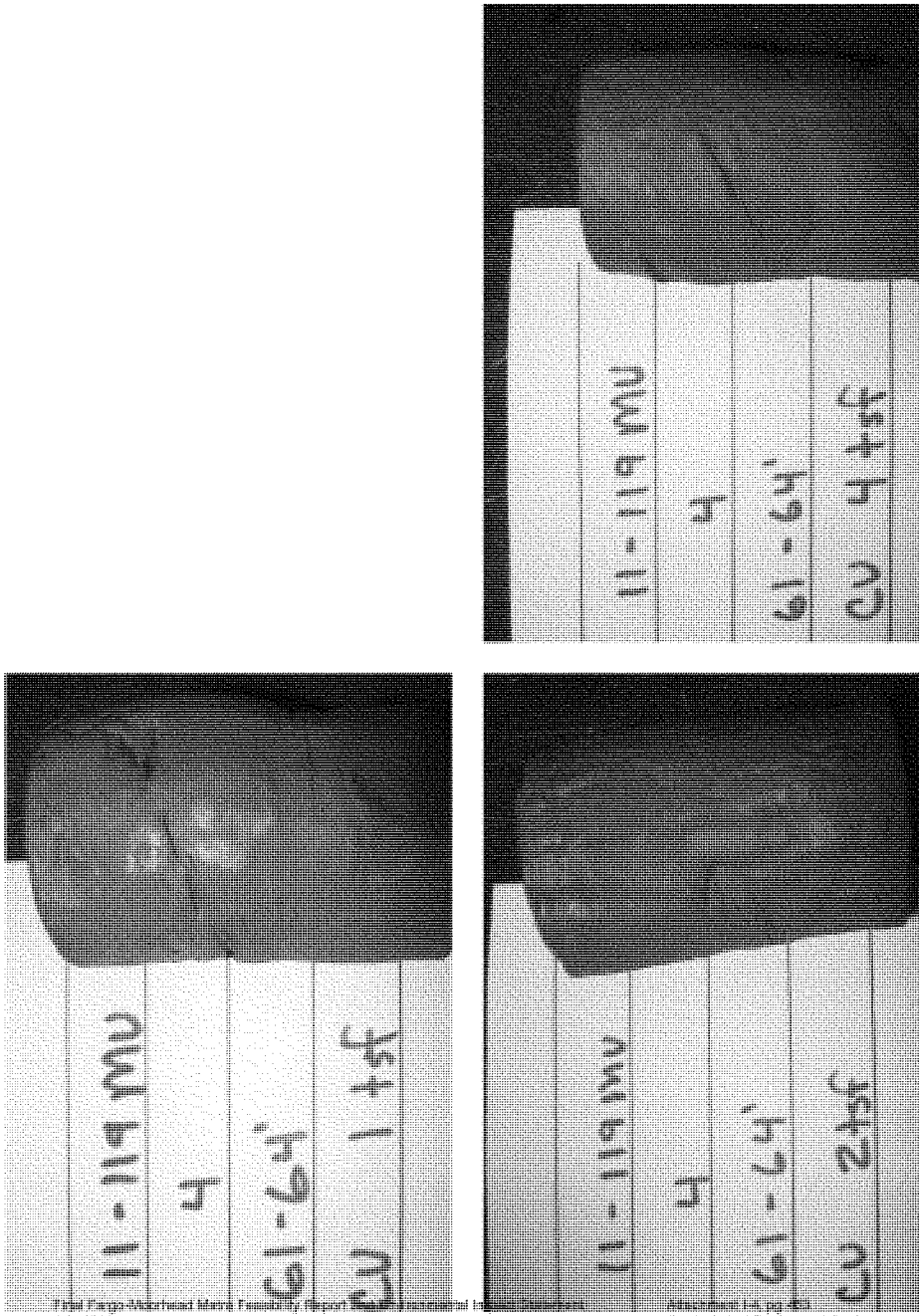
Test Results for Specimen No. 3

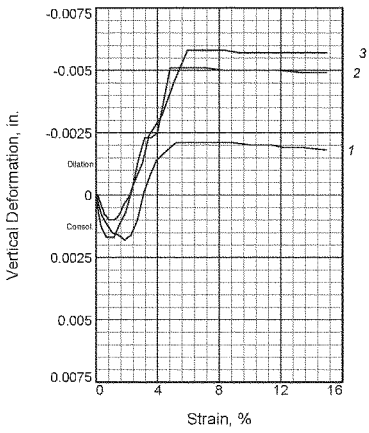
Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	144.410			139.130
Moisture content: Dry soil+tare, gms.	108.030			114.600
Moisture content: Tare, gms.	31.390			30.330
Moisture, %	47.5	47.5	41.2	29.1
Moist specimen weight, gms.	124.9			
Diameter, in.	1.41	1.41	1.37	
Area, in.²	1.56	1.56	1.48	
Height, in.	2.80	2.80	2.73	
Net decrease in height, in.		0.00	0.07	
Wet Density, pcf	109.0	109.0	112.7	
Dry density, pcf	73.9	73.9	79.8	
Void ratio	1.2828	1.2828	1.1144	
Saturation, %	100.0	100.0	100.0	

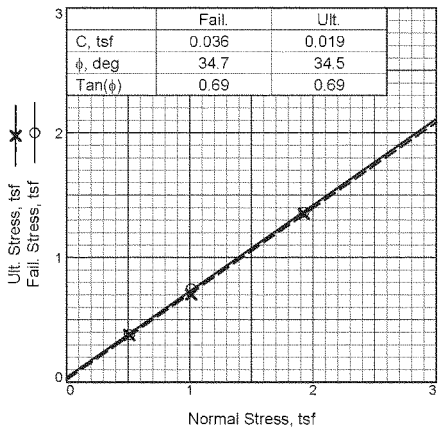
Test Readings for Specimen No. 3

Consolidation cell pressure = 7.119 tsf
Consolidation back pressure = 3.082 tsf
Consolidation effective confining stress = 4.037 tsf
Peak Stress = 2.256 tsf **at reading no.** 15
Ult. Stress = 2.249 tsf **at reading no.** 16

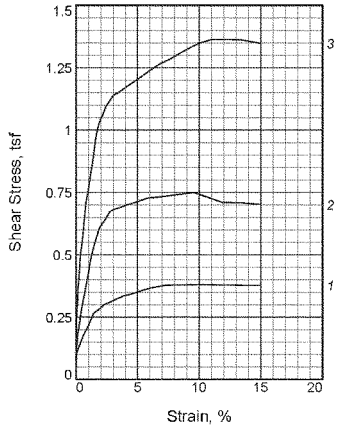
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Eff. Stress tsf	Major Eff. Stress tsf	1:3 Ratio	Pore Press. tsf	P tsf	Q tsf
0	0.0403	21.470	0.0	0.0	0.000	4.037	4.037	1.00	3.082	4.037	0.000
1	0.0423	22.640	1.2	0.1	0.057	3.995	4.052	1.01	3.124	4.023	0.028
2	0.0563	28.890	7.4	0.6	0.359	3.933	4.292	1.09	3.186	4.112	0.179
3	0.0761	38.630	17.2	1.3	0.823	3.824	4.647	1.22	3.295	4.236	0.412
4	0.0963	44.520	23.1	2.1	1.097	3.328	4.425	1.33	3.791	3.877	0.549
5	0.1267	54.760	33.3	3.2	1.567	2.646	4.213	1.59	4.473	3.429	0.783
6	0.1571	62.380	40.9	4.3	1.903	2.295	4.198	1.83	4.824	3.247	0.952
7	0.1875	65.790	44.3	5.4	2.038	2.073	4.111	1.98	5.046	3.092	1.019
8	0.2178	67.540	46.1	6.5	2.094	1.981	4.075	2.06	5.138	3.028	1.047
9	0.2479	69.740	48.3	7.6	2.168	1.824	3.992	2.19	5.295	2.908	1.084
10	0.2784	71.000	49.5	8.7	2.198	1.801	3.999	2.22	5.318	2.900	1.099
11	0.3080	71.960	50.5	9.8	2.214	1.786	4.000	2.24	5.333	2.893	1.107
12	0.3380	73.260	51.8	10.9	2.243	2.087	4.330	2.07	5.032	3.208	1.121
13	0.3685	74.030	52.6	12.0	2.248	1.691	3.939	2.33	5.428	2.815	1.124
14	0.3979	74.860	53.4	13.1	2.255	1.684	3.939	2.34	5.435	2.812	1.128
15	0.4175	75.320	53.8	13.8	2.256	1.694	3.950	2.33	5.425	2.822	1.128
16	0.4490	75.880	54.4	15.0	2.249	1.702	3.951	2.32	5.417	2.826	1.124


11-119 MU
4
61-64'
CU 4 tsf
11-119 MU
4
61-64'
CU 1 tsf
11-119 MU
4
61-64'
CU 2 tsf





	Fail.	Ult.
C, tsf	0.036	0.019
ϕ, deg	34.7	34.5
Tan(ϕ)	0.69	0.69



Sample No.		1	2	3
Initial	Water Content, %	27.6	27.1	24.7
	Dry Density, pcf	95.7	98.4	100.0
	Saturation, %	95.6	100.0	94.6
	Void Ratio	0.7934	0.7454	0.7176
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.00	1.01	1.00
At Test	Water Content, %	27.7	26.3	25.0
	Dry Density, pcf	97.3	99.6	101.6
	Saturation, %	99.5	100.0	99.6
	Void Ratio	0.7652	0.7237	0.6893
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.98	1.00	0.98
Normal Stress, tsf		0.509	1.011	1.926
Fail. Stress, tsf		0.380	0.748	1.363
Strain, %		10.2	9.6	11.1
Ult. Stress, tsf		0.377	0.701	1.347
Strain, %		15.0	15.0	15.0
Strain rate, in./min.		0.00	0.00	0.00

Sample Type: Thinwall, 5", Bottom of sample
Description: SILT, brown (ML)

LL= 31 **PL=** 23 **PI=** 8
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00064 in/min.

Figure DirectShear ASTM D3080

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Fargo
Location: SE-F-05, Poplar River/West Fargo Formation
Sample Number: Boring 09-23MU, #3 **Depth:** 20-22'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs

DIRECT SHEAR TEST

10/12/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL-09-03127
Location: SE-F-05, Poplar River/West Fargo Formation Fargo
Depth: 20-22' Sample Number: Boring 09-23MU, #3
Description: SILT, brown (ML)
Remarks: The rate of strain is 0.00064 in/min.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.75 LL=31 PL=23 PI=8

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	114.650		142.070
Moisture content: Dry soil+tare, gms.	96.600		117.810
Moisture content: Tare, gms.	31.150		30.150
Moisture, %	27.6	27.7	27.7
Moist specimen weight, gms.	146.5		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.98	
Net decrease in height, in.		0.02	
Wet Density, pcf	122.1	124.2	
Dry density, pcf	95.7	97.3	
Void ratio	0.7934	0.7652	
Saturation, %	95.6	99.5	

Test Readings for Specimen No. 1

Normal stress = .509 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.380 tsf at reading no. 23
Ult. Stress = 0.377 tsf at reading no. 27

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0248	0.000	0.0	0.0	0.000	0.1467
1	0.0252	3.400	3.4	0.0	0.054	0.1467
2	0.0260	6.600	6.6	0.0	0.104	0.1467
3	0.0280	7.400	7.4	0.1	0.117	0.1464
4	0.0335	9.100	9.1	0.4	0.143	0.1459
5	0.0400	11.300	11.3	0.6	0.178	0.1456
6	0.0500	13.800	13.8	1.0	0.217	0.1452
7	0.0600	16.900	16.9	1.5	0.266	0.1451
8	0.0700	17.800	17.8	1.9	0.280	0.1449
9	0.0800	19.000	19.0	2.3	0.299	0.1451
10	0.0900	19.500	19.5	2.7	0.307	0.1457
11	0.1000	20.200	20.2	3.1	0.318	0.1468
12	0.1100	20.700	20.7	3.5	0.326	0.1475
13	0.1200	21.300	21.3	3.9	0.336	0.1481

Braun Intertec

Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
14	0.1320	21.600	21.6	4.4	0.340	0.1484
15	0.1410	22.000	22.0	4.8	0.347	0.1486
16	0.1500	22.400	22.4	5.2	0.353	0.1488
17	0.1600	22.800	22.8	5.6	0.359	0.1488
18	0.1700	23.200	23.2	6.0	0.366	0.1488
19	0.1820	23.500	23.5	6.5	0.370	0.1488
20	0.2000	23.900	23.9	7.3	0.377	0.1488
21	0.2200	24.000	24.0	8.1	0.378	0.1488
22	0.2400	24.000	24.0	8.9	0.378	0.1488
23	0.2700	24.100	24.1	10.2	0.380	0.1487
24	0.3000	24.000	24.0	11.4	0.378	0.1487
25	0.3200	24.000	24.0	12.2	0.378	0.1486
26	0.3500	23.900	23.9	13.5	0.377	0.1486
27	0.3860	23.900	23.9	15.0	0.377	0.1485

Parameters for Specimen No. 2

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	142.370		108.720
Moisture content: Dry soil+tare, gms.	118.310		92.450
Moisture content: Tare, gms.	29.550		30.640
Moisture, %	27.1	26.3	26.3
Moist specimen weight, gms.	151.8		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.01	1.00	
Net decrease in height, in.		0.01	
Wet Density, pcf	125.0	125.8	
Dry density, pcf	98.4	99.6	
Void ratio	0.7454	0.7237	
Saturation, %	100.0	100.0	

Test Readings for Specimen No. 2

Normal stress = 1.011 tsf

Strain rate, in./min. = 0.00

Fail. Stress = 0.748 tsf at reading no. 20

Ult. Stress = 0.701 tsf at reading no. 23

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0236	0.000	0.0	0.0	0.000	0.1528
1	0.0240	5.000	5.0	0.0	0.079	0.1527
2	0.0250	8.000	8.0	0.1	0.126	0.1525
3	0.0270	11.100	11.1	0.1	0.175	0.1522
4	0.0310	14.400	14.4	0.3	0.227	0.1516
5	0.0340	17.500	17.5	0.4	0.276	0.1514
6	0.0400	21.300	21.3	0.7	0.336	0.1511
7	0.0470	26.200	26.2	1.0	0.413	0.1511
8	0.0520	30.100	30.1	1.2	0.474	0.1511
9	0.0600	34.500	34.5	1.5	0.544	0.1516

Test Readings for Specimen No. 2

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
10	0.0700	38.600	38.6	1.9	0.608	0.1521
11	0.0800	40.500	40.5	2.3	0.638	0.1530
12	0.0900	42.700	42.7	2.8	0.673	0.1542
13	0.1000	43.300	43.3	3.2	0.682	0.1551
14	0.1100	43.700	43.7	3.6	0.689	0.1551
15	0.1200	44.200	44.2	4.0	0.696	0.1553
16	0.1400	45.000	45.0	4.8	0.709	0.1579
17	0.1640	46.100	46.1	5.8	0.726	0.1579
18	0.1960	46.500	46.5	7.1	0.733	0.1579
19	0.2230	47.000	47.0	8.3	0.741	0.1578
20	0.2550	47.500	47.5	9.6	0.748	0.1578
21	0.3100	45.000	45.0	11.9	0.709	0.1578
22	0.3500	44.900	44.9	13.5	0.708	0.1577
23	0.3850	44.500	44.5	15.0	0.701	0.1577

Parameters for Specimen No. 3

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	136.690		95.910
Moisture content: Dry soil+tare, gms.	115.600		82.950
Moisture content: Tare, gms.	30.210		31.040
Moisture, %	24.7	25.0	25.0
Moist specimen weight, gms.	149.6		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.98	
Net decrease in height, in.		0.02	
Wet Density, pcf	124.6	127.0	
Dry density, pcf	100.0	101.6	
Void ratio	0.7176	0.6893	
Saturation, %	94.6	99.6	

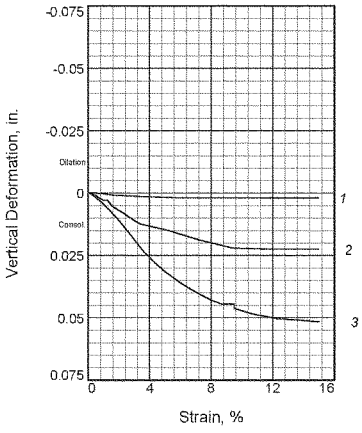
Test Readings for Specimen No. 3

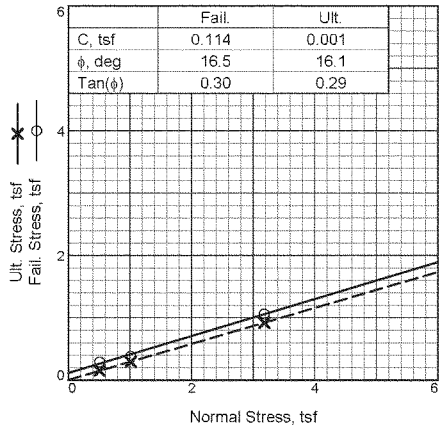
Normal stress = 1.926 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 1.363 tsf at reading no. 31
Ult. Stress = 1.347 tsf at reading no. 34

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0267	0.000	0.0	0.0	0.000	0.1294
1	0.0270	6.000	6.0	0.0	0.095	0.1294
2	0.0280	14.500	14.5	0.1	0.228	0.1294
3	0.0290	18.100	18.1	0.1	0.285	0.1294
4	0.0300	19.900	19.9	0.1	0.314	0.1294
5	0.0310	23.200	23.2	0.2	0.366	0.1293
6	0.0320	24.500	24.5	0.2	0.386	0.1292
7	0.0340	28.500	28.5	0.3	0.449	0.1291
8	0.0360	32.300	32.3	0.4	0.509	0.1289
9	0.0380	34.000	34.0	0.5	0.536	0.1288

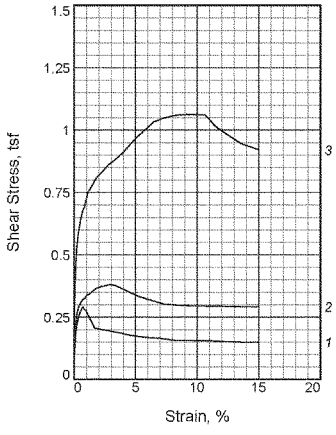
Test Readings for Specimen No. 3

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
10	0.0400	36.300	36.3	0.6	0.572	0.1286
11	0.0420	39.200	39.2	0.6	0.618	0.1286
12	0.0464	45.100	45.1	0.8	0.711	0.1284
13	0.0500	47.500	47.5	1.0	0.748	0.1284
14	0.0550	51.900	51.9	1.2	0.818	0.1284
15	0.0600	55.500	55.5	1.4	0.875	0.1285
16	0.0650	61.000	61.0	1.6	0.961	0.1287
17	0.0700	64.100	64.1	1.8	1.010	0.1290
18	0.0750	66.200	66.2	2.0	1.043	0.1292
19	0.0800	67.500	67.5	2.2	1.064	0.1294
20	0.0850	69.400	69.4	2.4	1.094	0.1298
21	0.1000	72.300	72.3	3.0	1.139	0.1307
22	0.1100	73.000	73.0	3.5	1.150	0.1318
23	0.1300	74.800	74.8	4.3	1.179	0.1326
24	0.1500	76.600	76.6	5.1	1.207	0.1340
25	0.1700	78.500	78.5	5.9	1.237	0.1352
26	0.1900	80.200	80.2	6.8	1.264	0.1352
27	0.2100	81.400	81.4	7.6	1.283	0.1352
28	0.2300	83.000	83.0	8.4	1.308	0.1352
29	0.2500	84.400	84.4	9.3	1.330	0.1351
30	0.2700	85.600	85.6	10.1	1.349	0.1351
31	0.2940	86.500	86.5	11.1	1.363	0.1351
32	0.3170	86.500	86.5	12.0	1.363	0.1351
33	0.3500	86.400	86.4	13.4	1.361	0.1351
34	0.3880	85.500	85.5	15.0	1.347	0.1351





	Fail.	Ult.
C, tsf	0.114	0.001
ϕ, deg	16.5	16.1
Tan(ϕ)	0.30	0.29



Sample No.		1	2	3
Initial	Water Content, %	64.3	59.5	66.4
	Dry Density, pcf	61.7	65.1	60.7
	Saturation, %	99.3	99.9	100.0
	Void Ratio	1.7814	1.6372	1.8260
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.99	1.00	1.00
At Test	Water Content, %	63.0	56.5	47.4
	Dry Density, pcf	62.8	67.2	74.5
	Saturation, %	99.9	99.9	100.0
	Void Ratio	1.7331	1.5538	1.3048
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.97	0.96	0.82
Normal Stress, tsf		0.509	1.011	3.181
Fail. Stress, tsf		0.292	0.380	1.062
Strain, %		0.7	3.0	9.5
Ult. Stress, tsf		0.150	0.292	0.920
Strain, %		15.0	15.0	15.0
Strain rate, in./min.		0.00	0.00	0.00

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, gray (CH)

LL= 100 **PL=** 22 **PI=** 78
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min.

Figure DirectShear ASTM D3080

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Moorhead
Location: East Diversion, SE-ED-15, Brenna Formation
Sample Number: Boring 09-14MU, #3 **Depth:** 38-40'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: js **Checked By:** rs

DIRECT SHEAR TEST

10/12/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL-09-03127
Location: East Diversion, SE-ED-15, Brenna Formation
Depth: 38-40' Sample Number: Boring 09-14MU, #3
Description: FAT CLAY, gray (CH)
Remarks: The rate of strain is 0.00096 in/min.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.75 LL=100 PL=22 PI=78

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	100.270		149.540
Moisture content: Dry soil+tare, gms.	72.770		103.420
Moisture content: Tare, gms.	30.020		30.200
Moisture, %	64.3	63.0	63.0
Moist specimen weight, gms.	120.6		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	0.99	0.97	
Net decrease in height, in.		0.02	
Wet Density, pcf	101.4	102.4	
Dry density, pcf	61.7	62.8	
Void ratio	1.7814	1.7331	
Saturation, %	99.3	99.9	

Test Readings for Specimen No. 1

Normal stress = .509 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.292 tsf at reading no. 9
Ult. Stress = 0.150 tsf at reading no. 24

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0246	0.000	0.0	0.0	0.000	0.1359
1	0.0248	4.000	4.0	0.0	0.063	0.1359
2	0.0255	6.500	6.5	0.0	0.102	0.1359
3	0.0270	9.500	9.5	0.1	0.150	0.1359
4	0.0280	11.500	11.5	0.1	0.181	0.1359
5	0.0300	13.500	13.5	0.2	0.213	0.1359
6	0.0340	16.000	16.0	0.4	0.252	0.1359
7	0.0380	17.500	17.5	0.6	0.276	0.1359
8	0.0400	18.000	18.0	0.6	0.284	0.1358
9	0.0420	18.500	18.5	0.7	0.292	0.1357
10	0.0440	18.000	18.0	0.8	0.284	0.1356
11	0.0480	17.500	17.5	1.0	0.276	0.1356
12	0.0651	13.100	13.1	1.7	0.206	0.1351
13	0.0730	12.800	12.8	2.0	0.202	0.1349

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Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
14	0.0801	12.600	12.6	2.3	0.199	0.1349
15	0.0900	12.400	12.4	2.7	0.195	0.1347
16	0.1203	11.600	11.6	4.0	0.183	0.1344
17	0.1390	11.100	11.1	4.7	0.175	0.1342
18	0.1652	10.700	10.7	5.8	0.169	0.1340
19	0.1933	10.400	10.4	7.0	0.164	0.1340
20	0.2230	9.900	9.9	8.2	0.156	0.1340
21	0.2947	9.800	9.8	11.2	0.154	0.1340
22	0.3200	9.600	9.6	12.2	0.151	0.1339
23	0.3500	9.500	9.5	13.5	0.150	0.1339
24	0.3854	9.500	9.5	15.0	0.150	0.1339

Parameters for Specimen No. 2

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	118.920		149.600
Moisture content: Dry soil+tare, gms.	86.100		107.020
Moisture content: Tare, gms.	30.910		31.610
Moisture, %	59.5	56.5	56.5
Moist specimen weight, gms.	124.0		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.96	
Net decrease in height, in.		0.03	
Wet Density, pcf	103.8	105.2	
Dry density, pcf	65.1	67.2	
Void ratio	1.6372	1.5538	
Saturation, %	99.9	99.9	

Test Readings for Specimen No. 2

Normal stress = 1.011 tsf

Strain rate, in./min. = 0.00

Fail. Stress = 0.380 tsf at reading no. 21

Ult. Stress = 0.292 tsf at reading no. 28

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0237	0.000	0.0	0.0	0.000	0.1350
1	0.0240	3.500	3.5	0.0	0.055	0.1350
2	0.0245	7.000	7.0	0.0	0.110	0.1350
3	0.0250	9.000	9.0	0.1	0.142	0.1350
4	0.0260	11.500	11.5	0.1	0.181	0.1350
5	0.0270	13.000	13.0	0.1	0.205	0.1350
6	0.0290	16.000	16.0	0.2	0.252	0.1348
7	0.0310	17.500	17.5	0.3	0.276	0.1345
8	0.0330	18.500	18.5	0.4	0.292	0.1343
9	0.0350	19.000	19.0	0.5	0.299	0.1340
10	0.0370	19.500	19.5	0.6	0.307	0.1338
11	0.0390	20.000	20.0	0.6	0.315	0.1335
12	0.0410	20.300	20.3	0.7	0.320	0.1331

Test Readings for Specimen No. 2

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
13	0.0430	20.500	20.5	0.8	0.323	0.1328
14	0.0460	20.700	20.7	0.9	0.326	0.1324
15	0.0480	21.300	21.3	1.0	0.336	0.1321
16	0.0540	21.700	21.7	1.3	0.342	0.1321
17	0.0610	22.500	22.5	1.5	0.355	0.1299
18	0.0670	23.100	23.1	1.8	0.364	0.1289
19	0.0768	23.600	23.6	2.2	0.372	0.1274
20	0.0820	23.700	23.7	2.4	0.373	0.1265
21	0.0960	24.100	24.1	3.0	0.380	0.1241
22	0.1060	23.800	23.8	3.4	0.375	0.1226
23	0.1500	21.100	21.1	5.2	0.332	0.1200
24	0.2000	19.100	19.1	7.3	0.301	0.1160
25	0.2500	18.700	18.7	9.4	0.295	0.1130
26	0.3138	18.600	18.6	12.0	0.293	0.1125
27	0.3500	18.500	18.5	13.5	0.292	0.1125
28	0.3850	18.500	18.5	15.0	0.292	0.1125

Parameters for Specimen No. 3			
Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	104.860		133.600
Moisture content: Dry soil+tare, gms.	75.270		100.330
Moisture content: Tare, gms.	30.700		30.190
Moisture, %	66.4	47.4	47.4
Moist specimen weight, gms.	121.6		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.82	
Net decrease in height, in.		0.19	
Wet Density, pcf	101.1	109.8	
Dry density, pcf	60.7	74.5	
Void ratio	1.8260	1.3048	
Saturation, %	100.0	100.0	

Test Readings for Specimen No. 3

Normal stress = 3.181 tsf

Strain rate, in./min. = 0.00

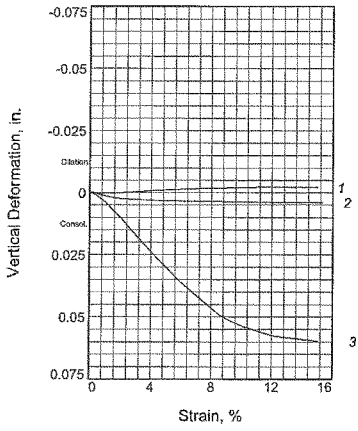
Fail. Stress = 1.062 tsf at reading no. 26

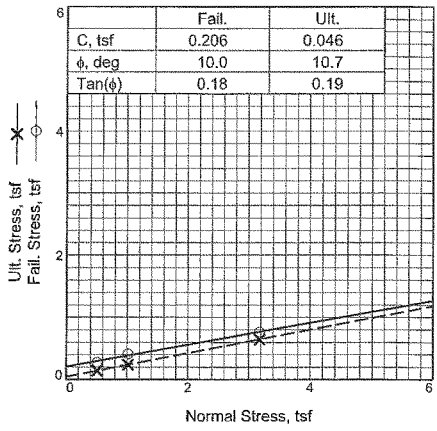
Ult. Stress = 0.920 tsf at reading no. 32

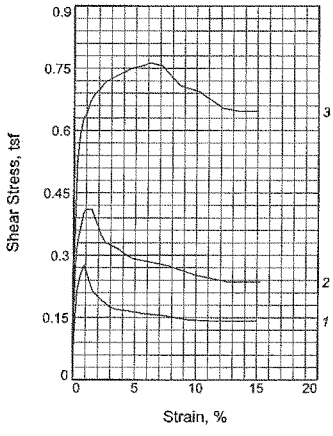
No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0231	0.000	0.0	0.0	0.000	0.1696
1	0.0232	4.100	4.1	0.0	0.065	0.1696
2	0.0236	9.400	9.4	0.0	0.148	0.1696
3	0.0243	18.200	18.2	0.0	0.287	0.1696
4	0.0255	25.500	25.5	0.1	0.402	0.1695
5	0.0285	33.200	33.2	0.2	0.523	0.1692
6	0.0320	37.400	37.4	0.4	0.589	0.1686
7	0.0360	40.500	40.5	0.5	0.638	0.1678
8	0.0400	42.800	42.8	0.7	0.674	0.1669
9	0.0440	44.000	44.0	0.9	0.693	0.1660
10	0.0505	47.600	47.6	1.1	0.750	0.1643
11	0.0550	48.500	48.5	1.3	0.764	0.1632
12	0.0600	49.600	49.6	1.5	0.782	0.1618
13	0.0665	51.200	51.2	1.8	0.807	0.1600
14	0.0800	53.000	53.0	2.4	0.835	0.1560
15	0.0900	54.500	54.5	2.8	0.859	0.1528
16	0.1020	55.700	55.7	3.3	0.878	0.1487
17	0.1103	56.600	56.6	3.6	0.892	0.1462
18	0.1200	57.800	57.8	4.0	0.911	0.1436
19	0.1300	59.300	59.3	4.4	0.934	0.1412
20	0.1450	61.500	61.5	5.1	0.969	0.1379
21	0.1670	64.000	64.0	6.0	1.008	0.1338
22	0.1793	65.500	65.5	6.5	1.032	0.1318
23	0.2003	66.500	66.5	7.3	1.048	0.1287
24	0.2180	67.100	67.1	8.1	1.057	0.1265
25	0.2333	67.300	67.3	8.7	1.060	0.1251
26	0.2520	67.400	67.4	9.5	1.062	0.1251
27	0.2520	67.400	67.4	9.5	1.062	0.1233

Test Readings for Specimen No. 3

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
28	0.2800	67.300	67.3	10.7	1.060	0.1212
29	0.2990	64.500	64.5	11.4	1.016	0.1202
30	0.3200	62.600	62.6	12.3	0.986	0.1192
31	0.3500	60.000	60.0	13.6	0.945	0.1187
32	0.3850	58.400	58.4	15.0	0.920	0.1180







Sample No.		1	2	3
Initial	Water Content, %	69.3	72.5	72.2
	Dry Density, pcf	57.5	56.6	56.6
	Saturation, %	96.0	98.1	97.7
	Void Ratio	1.9852	2.0310	2.0335
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	70.2	71.7	62.6
	Dry Density, pcf	58.5	57.7	62.6
	Saturation, %	99.8	99.9	98.9
	Void Ratio	1.9347	1.9754	1.7413
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.98	0.99	0.91
Normal Stress, tsf		0.509	1.011	3.181
Fail. Stress, tsf		0.276	0.410	0.763
Strain, %		0.8	1.0	6.1
Ult. Stress, tsf		0.142	0.236	0.646
Strain, %		15.0	15.3	15.0
Strain rate, in./min.		0.00	0.00	0.00

Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, gray (CH)

LL= 111 **PL=** 25 **PI=** 86
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00064 in/min.

Figure DirectShear ASTM D3080

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Fargo
Sample Number: Boring 09-23MU, #5 **Depth:** 38-40'
Brenna

Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: jrs **Checked By:** rs

DIRECT SHEAR TEST

9/22/2009

Date:			
Client:	US Army Corps of Engineers		
Project:	Fargo-Moorhead Metro Feasibility Study		
Project No.:	BL-09-03127		Fargo
Depth:	38-40'	**Sample Number:**	Boring 09-23MU, #5
Description:	FAT CLAY, gray (CH)		Brenna
Remarks:	The rate of strain is 0.00064 in/min.		
Type of Sample:	Thinwall, 5", Middle of sample		

Assumed Specific Gravity=2.75 **LL=111** **PL=25** **PI=86**

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	86.990		147.700
Moisture content: Dry soil+tare, gms.	64.170		99.600
Moisture content: Tare, gms.	31.240		31.060
Moisture, %	69.3	70.2	70.2
Moist specimen weight, gms.	116.7		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.98	
Net decrease in height, in.		0.02	
Wet Density, pcf	97.4	99.6	
Dry density, pcf	57.5	58.5	
Void ratio	1.9852	1.9347	
Saturation, %	96.0	99.8	

Test Readings for Specimen No. 1

Normal stress = .509 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.276 tsf **at reading no.** 5
Ult. Stress = 0.142 tsf **at reading no.** 17

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0255	0.000	0.0	0.0	0.000	0.0245
1	0.0260	4.000	4.0	0.0	0.063	0.0246
2	0.0270	6.500	6.5	0.1	0.102	0.0246
3	0.0323	13.500	13.5	0.3	0.213	0.0245
4	0.0393	16.000	16.0	0.6	0.252	0.0242
5	0.0459	17.500	17.5	0.8	0.276	0.0241
6	0.0632	13.500	13.5	1.6	0.213	0.0242
7	0.0761	12.500	12.5	2.1	0.197	0.0244
8	0.0956	11.200	11.2	2.9	0.176	0.0247
9	0.1069	10.800	10.8	3.4	0.170	0.0249
10	0.1252	10.600	10.6	4.1	0.167	0.0252
11	0.1640	10.100	10.1	5.7	0.159	0.0257
12	0.2042	9.800	9.8	7.4	0.154	0.0261
13	0.2503	9.200	9.2	9.3	0.145	0.0264
14	0.2768	9.100	9.1	10.4	0.143	0.0265

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Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
15	0.2934	9.000	9.0	11.1	0.142	0.0266
16	0.3024	9.000	9.0	11.5	0.142	0.0266
17	0.3870	9.000	9.0	15.0	0.142	0.0266

Parameters for Specimen No. 2

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	120.020		146.440
Moisture content: Dry soil+tare, gms.	82.400		97.970
Moisture content: Tare, gms.	30.480		30.410
Moisture, %	72.5	71.7	71.7
Moist specimen weight, gms.	117.6		
Diameter, in.	2.41	2.41	
Area, in.^{2}	4.57	4.57	
Height, in.	1.00	0.99	
Net decrease in height, in.		0.02	
Wet Density, pcf	97.7	99.1	
Dry density, pcf	56.6	57.7	
Void ratio	2.0310	1.9754	
Saturation, %	98.1	99.9	

Test Readings for Specimen No. 2

Normal stress = 1.011 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.410 tsf **at reading no.** 10
Ult. Stress = 0.236 tsf **at reading no.** 25

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0212	0.000	0.0	0.0	0.000	0.1785
1	0.0214	4.000	4.0	0.0	0.063	0.1785
2	0.0218	7.000	7.0	0.0	0.110	0.1785
3	0.0225	10.500	10.5	0.1	0.165	0.1785
4	0.0235	13.500	13.5	0.1	0.213	0.1785
5	0.0248	17.000	17.0	0.2	0.268	0.1784
6	0.0281	20.500	20.5	0.3	0.323	0.1783
7	0.0330	22.500	22.5	0.5	0.355	0.1779
8	0.0370	24.000	24.0	0.7	0.378	0.1777
9	0.0407	25.500	25.5	0.8	0.402	0.1774
10	0.0456	26.000	26.0	1.0	0.410	0.1772
11	0.0507	26.000	26.0	1.2	0.410	0.1768
12	0.0565	26.000	26.0	1.5	0.410	0.1765
13	0.0637	24.500	24.5	1.8	0.386	0.1762
14	0.0689	23.500	23.5	2.0	0.370	0.1760
15	0.0755	22.000	22.0	2.3	0.347	0.1759
16	0.0830	21.000	21.0	2.6	0.331	0.1758
17	0.0954	20.500	20.5	3.1	0.323	0.1756
18	0.1083	20.000	20.0	3.6	0.315	0.1755
19	0.1256	19.000	19.0	4.3	0.299	0.1753
20	0.1381	18.500	18.5	4.8	0.292	0.1752

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Test Readings for Specimen No. 2

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
21	0.1450	18.400	18.4	5.1	0.290	0.1751
22	0.2033	17.500	17.5	7.6	0.276	0.1749
23	0.2600	16.000	16.0	9.9	0.252	0.1747
24	0.3230	15.000	15.0	12.5	0.236	0.1745
25	0.3900	15.000	15.0	15.3	0.236	0.1745

Parameters for Specimen No. 3

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	100.110		136.960
Moisture content: Dry soil+tare, gms.	70.830		95.900
Moisture content: Tare, gms.	30.300		30.360
Moisture, %	72.2	62.6	62.6
Moist specimen weight, gms.	117.5		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.91	
Net decrease in height, in.		0.10	
Wet Density, pcf	97.5	101.9	
Dry density, pcf	56.6	62.6	
Void ratio	2.0335	1.7413	
Saturation, %	97.7	98.9	

Test Readings for Specimen No. 3

Normal stress = 3.181 tsf

Strain rate, in./min. = 0.00

Fail. Stress = 0.763 tsf at reading no. 18

Ult. Stress = 0.646 tsf at reading no. 26

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0209	0.000	0.0	0.0	0.000	0.0666
1	0.0210	6.000	6.0	0.0	0.095	0.0666
2	0.0220	16.000	16.0	0.0	0.252	0.0665
3	0.0276	33.500	33.5	0.3	0.528	0.0660
4	0.0329	37.500	37.5	0.5	0.591	0.0652
5	0.0396	40.000	40.0	0.8	0.630	0.0639
6	0.0440	40.500	40.5	1.0	0.638	0.0630
7	0.0483	41.500	41.5	1.1	0.654	0.0619
8	0.0525	42.500	42.5	1.3	0.670	0.0608
9	0.0597	43.500	43.5	1.6	0.685	0.0589
10	0.0649	44.000	44.0	1.8	0.693	0.0576
11	0.0714	44.500	44.5	2.1	0.701	0.0558
12	0.0810	45.500	45.5	2.5	0.717	0.0529
13	0.0925	46.000	46.0	3.0	0.725	0.0497
14	0.1047	46.500	46.5	3.5	0.733	0.0461
15	0.1182	47.000	47.0	4.0	0.741	0.0425
16	0.1294	47.500	47.5	4.5	0.748	0.0395
17	0.1562	48.000	48.0	5.6	0.756	0.0326
18	0.1691	48.400	48.4	6.1	0.763	0.0296

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Test Readings for Specimen No. 3

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
19	0.1924	48.000	48.0	7.1	0.756	0.0246
20	0.2275	45.000	45.0	8.6	0.709	0.0174
21	0.2462	44.500	44.5	9.3	0.701	0.0148
22	0.2673	44.000	44.0	10.2	0.693	0.0125
23	0.3053	42.000	42.0	11.8	0.662	0.0095
24	0.3126	41.500	41.5	12.1	0.654	0.0089
25	0.3500	41.000	41.0	13.6	0.646	0.0079
26	0.3830	41.000	41.0	15.0	0.646	0.0068

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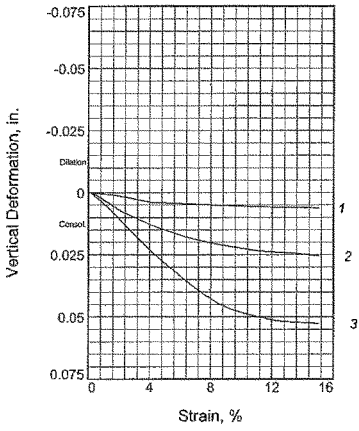
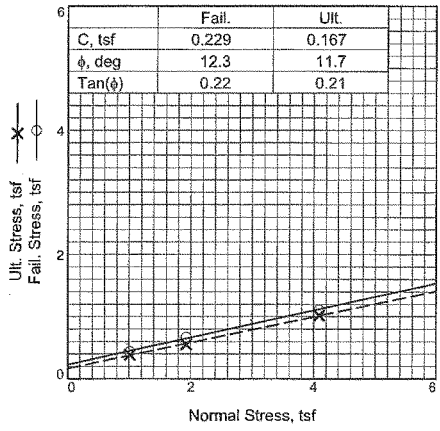
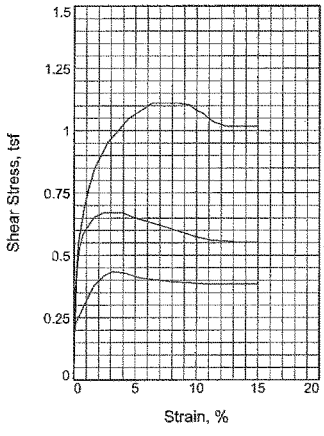




	Fail.	Ult.
C, tsf	0.229	0.167
ϕ, deg	12.3	11.7
Tan(ϕ)	0.22	0.21



Sample No.		1	2	3
Initial	Water Content, %	52.2	54.2	57.2
	Dry Density, pcf	70.5	68.8	66.7
	Saturation, %	99.9	99.6	99.9
	Void Ratio	1.4358	1.4962	1.5753
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.01	1.00	1.01
At Test	Water Content, %	49.8	51.0	43.8
	Dry Density, pcf	72.3	71.4	77.9
	Saturation, %	99.7	99.9	100.0
	Void Ratio	1.3735	1.4030	1.2036
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.98	0.96	0.86
Normal Stress, tsf		1.011	1.926	4.084
Fail. Stress, tsf		0.433	0.670	1.111
Strain, %		3.2	2.4	6.4
Ult. Stress, tsf		0.386	0.552	1.016
Strain, %		15.0	15.0	15.0
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, gray (CH)

LL= 92 **PL=** 22 **PI=** 70
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00064 in/min.

Figure DirectShear ASTM D3080

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Fargo

Sample Number: Boring 09-23MU, #6 **Depth:** 80-82'

Brenna

Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: jrs **Checked By:** rs

DIRECT SHEAR TEST

9/22/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL-09-03127
Depth: 80-82'
Sample Number: Boring 09-23MU, #6
Description: FAT CLAY, gray (CH)
Remarks: The rate of strain is 0.00064 in/min.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.75 **LL=92** **PL=22** **PI=70**

Fargo
Brenna

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	76.970		157.930
Moisture content: Dry soil+tare, gms.	61.170		115.600
Moisture content: Tare, gms.	30.890		30.610
Moisture, %	52.2	49.8	49.8
Moist specimen weight, gms.	129.7		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.01	0.98	
Net decrease in height, in.		0.03	
Wet Density, pcf	107.3	108.4	
Dry density, pcf	70.5	72.3	
Void ratio	1.4358	1.3735	
Saturation, %	99.9	99.7	

Test Readings for Specimen No. 1

Normal stress = 1.011 tsf
Fail. Stress = 0.433 tsf **at reading no.** 5
Ult. Stress = 0.386 tsf **at reading no.** 11

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0208	0.000	0.0	0.0	0.000	0.0970
1	0.0213	6.000	6.0	0.0	0.095	0.0970
2	0.0230	14.000	14.0	0.1	0.221	0.0970
3	0.0600	24.000	24.0	1.6	0.378	0.0960
4	0.0800	26.500	26.5	2.5	0.418	0.0950
5	0.0970	27.500	27.5	3.2	0.433	0.0942
6	0.1200	27.200	27.2	4.1	0.429	0.0930
7	0.1480	26.000	26.0	5.3	0.410	0.0928
8	0.2100	25.000	25.0	7.8	0.394	0.0920
9	0.2780	24.500	24.5	10.7	0.386	0.0914
10	0.3190	24.500	24.5	12.4	0.386	0.0911
11	0.3830	24.500	24.5	15.0	0.386	0.0908

Braun Intertec

Parameters for Specimen No. 2			
Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	100.630		152.850
Moisture content: Dry soil+tare, gms.	76.310		111.520
Moisture content: Tare, gms.	31.440		30.420
Moisture, %	54.2	51.0	51.0
Moist specimen weight, gms.	126.8		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.96	
Net decrease in height, in.		0.04	
Wet Density, pcf	106.1	107.9	
Dry density, pcf	68.8	71.4	
Void ratio	1.4962	1.4030	
Saturation, %	99.6	99.9	

Test Readings for Specimen No. 2

Normal stress = 1.926 tsf

Fail. Stress = 0.670 tsf at reading no. 7

Ult. Stress = 0.552 tsf at reading no. 15

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0209	0.000	0.0	0.0	0.000	0.1392
1	0.0213	6.500	6.5	0.0	0.102	0.1392
2	0.0270	28.000	28.0	0.3	0.441	0.1389
3	0.0327	34.000	34.0	0.5	0.536	0.1383
4	0.0387	37.000	37.0	0.7	0.583	0.1373
5	0.0554	40.500	40.5	1.4	0.638	0.1345
6	0.0616	41.500	41.5	1.7	0.654	0.1335
7	0.0778	42.500	42.5	2.4	0.670	0.1310
8	0.1174	42.500	42.5	4.0	0.670	0.1264
9	0.1353	41.500	41.5	4.7	0.654	0.1246
10	0.1744	40.000	40.0	6.4	0.630	0.1213
11	0.2110	38.500	38.5	7.9	0.607	0.1191
12	0.2581	36.500	36.5	9.8	0.575	0.1169
13	0.2900	35.600	35.6	11.2	0.561	0.1157
14	0.3500	35.000	35.0	13.6	0.552	0.1147
15	0.3830	35.000	35.0	15.0	0.552	0.1137

Parameters for Specimen No. 3

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	99.420		143.510
Moisture content: Dry soil+tare, gms.	74.370		109.400
Moisture content: Tare, gms.	30.600		31.440
Moisture, %	57.2	43.8	43.8
Moist specimen weight, gms.	126.5		
Diameter, in.	2.41	2.41	
Area, in.^{2}	4.57	4.57	
Height, in.	1.01	0.86	
Net decrease in height, in.		0.15	
Wet Density, pcf	104.8	112.0	
Dry density, pcf	66.7	77.9	
Void ratio	1.5753	1.2036	
Saturation, %	99.9	100.0	

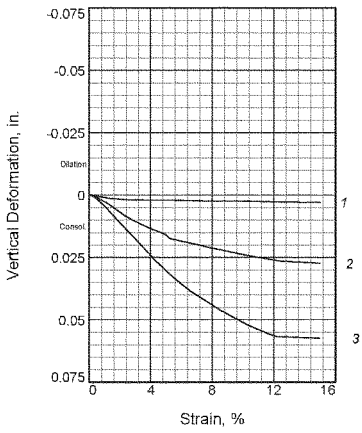
Test Readings for Specimen No. 3

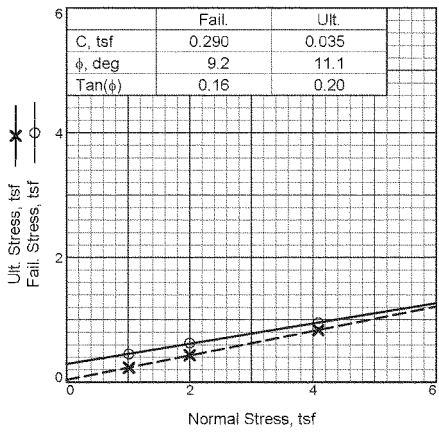
Normal stress = 4.084 tsf

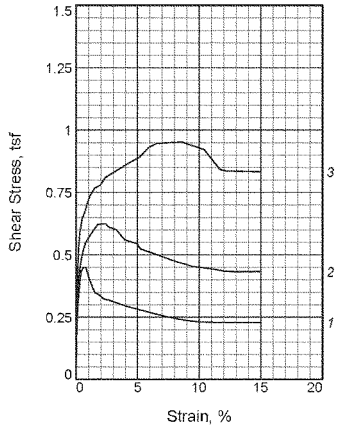
Fail. Stress = 1.111 tsf **at reading no.** 11

Ult. Stress = 1.016 tsf **at reading no.** 22

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0187	0.000	0.0	0.0	0.000	0.1048
1	0.0223	25.000	25.0	0.2	0.394	0.1046
2	0.0276	35.000	35.0	0.4	0.552	0.1037
3	0.0389	43.500	43.5	0.8	0.685	0.1012
4	0.0483	49.000	49.0	1.2	0.772	0.0991
5	0.0528	51.000	51.0	1.4	0.804	0.0979
6	0.0579	53.500	53.5	1.6	0.843	0.0966
7	0.0670	56.000	56.0	2.0	0.882	0.0942
8	0.0850	60.500	60.5	2.8	0.953	0.0894
9	0.1089	64.000	64.0	3.7	1.008	0.0833
10	0.1250	66.500	66.5	4.4	1.048	0.0795
11	0.1720	70.500	70.5	6.4	1.111	0.0694
12	0.1988	70.500	70.5	7.5	1.111	0.0643
13	0.2240	70.500	70.5	8.5	1.111	0.0601
14	0.2450	70.000	70.0	9.4	1.103	0.0577
15	0.2608	68.500	68.5	10.0	1.079	0.0565
16	0.2708	68.000	68.0	10.5	1.072	0.0558
17	0.2844	66.500	66.5	11.0	1.048	0.0549
18	0.2955	65.500	65.5	11.5	1.032	0.0544
19	0.3080	65.000	65.0	12.0	1.024	0.0536
20	0.3183	64.500	64.5	12.4	1.016	0.0532
21	0.3400	64.500	64.5	13.3	1.016	0.0528
22	0.3810	64.500	64.5	15.0	1.016	0.0522







Sample No.		1	2	3
Initial	Water Content, %	61.1	58.8	60.4
	Dry Density, pcf	63.2	64.2	63.9
	Saturation, %	98.0	96.5	98.5
	Void Ratio	1.7155	1.6759	1.6871
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	59.9	57.5	51.0
	Dry Density, pcf	64.7	66.5	71.4
	Saturation, %	99.7	99.9	99.8
	Void Ratio	1.6542	1.5820	1.4040
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.98	0.97	0.90
Normal Stress, tsf		1.011	2.000	4.084
Fail. Stress, tsf		0.449	0.624	0.952
Strain, %		0.6	2.4	8.6
Ult. Stress, tsf		0.228	0.432	0.832
Strain, %		15.0	15.0	15.0
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, gray (CH)

LL= 108 **PL=** 22 **PI=** 86
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min.

Figure DirectShear ASTM D3080

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Location: SE-F-13, Fargo, Brenna Formation
Sample Number: Boring 09-25MU, #4 **Depth:** 50-52'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: ts **Checked By:** js

DIRECT SHEAR TEST

11/9/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-F-13, Fargo, Brenna Formation
Depth: 50-52' Sample Number: Boring 09-25MU, #4
Description: FAT CLAY, gray (CH)
Remarks: The rate of strain is 0.00096 in/min.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.75 LL=108 PL=22 PI=86

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	113.660		151.740
Moisture content: Dry soil+tare, gms.	82.520		106.370
Moisture content: Tare, gms.	31.570		30.690
Moisture, %	61.1	59.9	59.9
Moist specimen weight, gms.	121.9		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.98	
Net decrease in height, in.		0.02	
Wet Density, pcf	101.9	103.5	
Dry density, pcf	63.2	64.7	
Void ratio	1.7155	1.6542	
Saturation, %	98.0	99.7	

Test Readings for Specimen No. 1

Normal stress = 1.011 tsf
Fail. Stress = 0.449 tsf at reading no. 6
Ult. Stress = 0.228 tsf at reading no. 21

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0208	0.000	0.0	0.0	0.000	0.1505
1	0.0227	11.500	11.5	0.1	0.181	0.1505
2	0.0234	15.000	15.0	0.1	0.236	0.1505
3	0.0248	19.500	19.5	0.2	0.307	0.1505
4	0.0280	24.150	24.2	0.3	0.381	0.1504
5	0.0310	27.500	27.5	0.4	0.433	0.1501
6	0.0358	28.500	28.5	0.6	0.449	0.1499
7	0.0400	28.500	28.5	0.8	0.449	0.1498
8	0.0470	25.500	25.5	1.1	0.402	0.1495
9	0.0530	23.500	23.5	1.3	0.370	0.1492
10	0.0580	22.000	22.0	1.5	0.347	0.1491
11	0.0650	21.600	21.6	1.8	0.340	0.1489
12	0.0760	20.400	20.4	2.3	0.321	0.1487
13	0.0863	20.100	20.1	2.7	0.317	0.1486

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Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
14	0.1228	18.500	18.5	4.2	0.292	0.1484
15	0.1550	17.400	17.4	5.6	0.274	0.1484
16	0.1984	15.900	15.9	7.4	0.251	0.1482
17	0.2320	15.100	15.1	8.8	0.238	0.1481
18	0.2620	14.600	14.6	10.0	0.230	0.1481
19	0.2893	14.500	14.5	11.1	0.228	0.1479
20	0.3180	14.500	14.5	12.3	0.228	0.1478
21	0.3830	14.500	14.5	15.0	0.228	0.1476

Parameters for Specimen No. 2

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	100.570		149.150
Moisture content: Dry soil+tare, gms.	74.700		105.650
Moisture content: Tare, gms.	30.720		29.960
Moisture, %	58.8	57.5	57.5
Moist specimen weight, gms.	122.6		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.97	
Net decrease in height, in.		0.04	
Wet Density, pcf	101.9	104.7	
Dry density, pcf	64.2	66.5	
Void ratio	1.6759	1.5820	
Saturation, %	96.5	99.9	

Test Readings for Specimen No. 2

Normal stress = 2 tsf

Fail. Stress = 0.624 tsf at reading no. 10

Ult. Stress = 0.432 tsf at reading no. 21

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0215	0.000	0.0	0.0	0.000	0.1520
1	0.0218	8.500	8.5	0.0	0.134	0.1521
2	0.0230	15.100	15.1	0.1	0.238	0.1521
3	0.0253	23.400	23.4	0.2	0.369	0.1520
4	0.0280	26.900	26.9	0.3	0.424	0.1517
5	0.0310	29.500	29.5	0.4	0.465	0.1514
6	0.0350	32.300	32.3	0.6	0.509	0.1508
7	0.0400	34.700	34.7	0.8	0.547	0.1501
8	0.0485	36.500	36.5	1.1	0.575	0.1490
9	0.0639	39.400	39.4	1.8	0.621	0.1463
10	0.0789	39.600	39.6	2.4	0.624	0.1436
11	0.0862	38.700	38.7	2.7	0.610	0.1425
12	0.1000	38.100	38.1	3.3	0.600	0.1407
13	0.1160	35.600	35.6	3.9	0.561	0.1388
14	0.1412	34.500	34.5	5.0	0.544	0.1362
15	0.1480	33.200	33.2	5.2	0.523	0.1346
16	0.2133	30.131	30.1	8.0	0.475	0.1308

Test Readings for Specimen No. 2

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
17	0.2507	28.700	28.7	9.5	0.452	0.1288
18	0.2820	28.200	28.2	10.8	0.444	0.1272
19	0.3104	27.600	27.6	12.0	0.435	0.1260
20	0.3210	27.400	27.4	12.4	0.432	0.1255
21	0.3830	27.400	27.4	15.0	0.432	0.1247

Parameters for Specimen No. 3

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	124.600		142.500
Moisture content: Dry soil+tare, gms.	89.120		104.510
Moisture content: Tare, gms.	30.380		29.960
Moisture, %	60.4	51.0	51.0
Moist specimen weight, gms.	123.5		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.90	
Net decrease in height, in.		0.11	
Wet Density, pcf	102.5	107.8	
Dry density, pcf	63.9	71.4	
Void ratio	1.6871	1.4040	
Saturation, %	98.5	99.8	

Test Readings for Specimen No. 3

Normal stress = 4.084 tsf

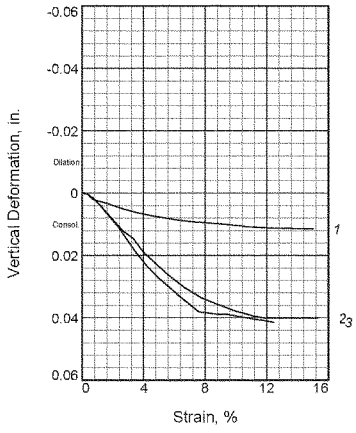
Fail. Stress = 0.952 tsf at reading no. 20

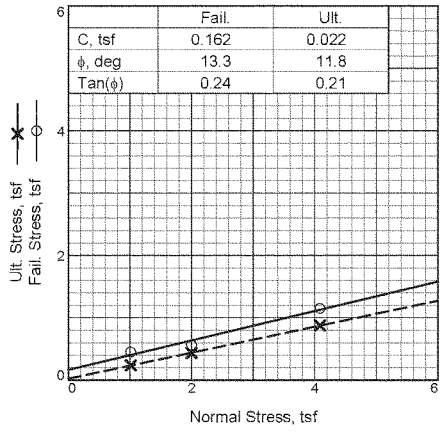
Ult. Stress = 0.832 tsf at reading no. 24

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0244	0.000	0.0	0.0	0.000	0.0766
1	0.0246	7.400	7.4	0.0	0.117	0.0765
2	0.0250	12.700	12.7	0.0	0.200	0.0765
3	0.0260	21.200	21.2	0.1	0.334	0.0765
4	0.0275	27.300	27.3	0.1	0.430	0.0764
5	0.0297	33.500	33.5	0.2	0.528	0.0762
6	0.0320	37.400	37.4	0.3	0.589	0.0759
7	0.0340	39.000	39.0	0.4	0.615	0.0756
8	0.0360	40.700	40.7	0.5	0.641	0.0752
9	0.0413	42.400	42.4	0.7	0.668	0.0740
10	0.0450	44.000	44.0	0.9	0.693	0.0731
11	0.0520	46.700	46.7	1.1	0.736	0.0713
12	0.0606	48.600	48.6	1.5	0.766	0.0688
13	0.0720	49.400	49.4	2.0	0.778	0.0657
14	0.0820	51.400	51.4	2.4	0.810	0.0630
15	0.0961	52.500	52.5	3.0	0.827	0.0592
16	0.1230	54.700	54.7	4.1	0.862	0.0518
17	0.1482	56.500	56.5	5.1	0.890	0.0456
18	0.1670	59.000	59.0	5.9	0.930	0.0414
19	0.1830	60.000	60.0	6.6	0.945	0.0382

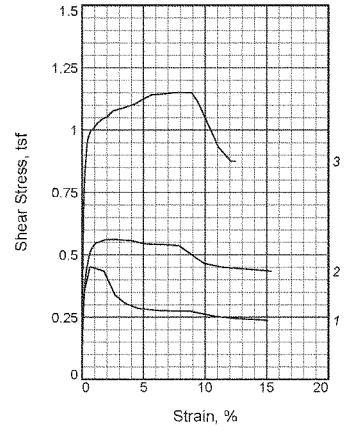
Test Readings for Specimen No. 3

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
20	0.2310	60.400	60.4	8.6	0.952	0.0303
21	0.2753	58.500	58.5	10.4	0.922	0.0242
22	0.3056	53.400	53.4	11.7	0.841	0.0209
23	0.3186	53.000	53.0	12.2	0.835	0.0199
24	0.3850	52.800	52.8	15.0	0.832	0.0192





	Fail.	Ult.
C, tsf	0.162	0.022
ϕ, deg	13.3	11.8
Tan(ϕ)	0.24	0.21



Sample No.		1	2	3
Initial	Water Content, %	72.3	73.6	73.5
	Dry Density, pcf	57.1	56.4	55.6
	Saturation, %	99.1	99.1	96.9
	Void Ratio	2.0064	2.0428	2.0850
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.00	1.00	1.03
At Test	Water Content, %	70.9	69.7	63.6
	Dry Density, pcf	58.2	58.8	62.3
	Saturation, %	100.0	100.0	99.7
	Void Ratio	1.9497	1.9178	1.7549
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.98	0.96	0.92
Normal Stress, tsf		1.011	2.000	4.084
Fail. Stress, tsf		0.451	0.561	1.150
Strain, %		0.7	2.4	7.6
Ult. Stress, tsf		0.236	0.433	0.875
Strain, %		15.0	15.3	12.5
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, gray (CH)

Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min.

Figure DirectShear ASTM D3080

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Moorhead
Location: SE-ED-29, East Diversion, Brenna Formation
Sample Number: Boring 09-26MU, #3 **Depth:** 28-30'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: JS **Checked By:** IS

DIRECT SHEAR TEST

11/9/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-ED-29, East Diversion, Brenna Formation
Depth: 28-30' Sample Number: Boring 09-26MU, #3
Description: FAT CLAY, gray (CH)
Remarks: The rate of strain is 0.00096 in/min.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.75 LL= PL= PI=

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	116.840		146.120
Moisture content: Dry soil+tare, gms.	80.550		98.510
Moisture content: Tare, gms.	30.360		31.380
Moisture, %	72.3	70.9	70.9
Moist specimen weight, gms.	117.5		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.98	
Net decrease in height, in.		0.02	
Wet Density, pcf	98.4	99.5	
Dry density, pcf	57.1	58.2	
Void ratio	2.0064	1.9497	
Saturation, %	99.1	100.0	

Test Readings for Specimen No. 1

Normal stress = 1.011 tsf
Fail. Stress = 0.451 tsf at reading no. 6
Ult. Stress = 0.236 tsf at reading no. 16

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0220	0.000	0.0	0.0	0.000	0.1515
1	0.0226	6.600	6.6	0.0	0.104	0.1515
2	0.0235	11.400	11.4	0.1	0.180	0.1515
3	0.0253	18.500	18.5	0.1	0.292	0.1515
4	0.0270	22.500	22.5	0.2	0.355	0.1514
5	0.0297	24.000	24.0	0.3	0.378	0.1513
6	0.0377	28.600	28.6	0.7	0.451	0.1496
7	0.0652	27.500	27.5	1.8	0.433	0.1479
8	0.0863	21.500	21.5	2.7	0.339	0.1464
9	0.1069	19.300	19.3	3.5	0.304	0.1453
10	0.1327	18.000	18.0	4.6	0.284	0.1442
11	0.1737	17.500	17.5	6.3	0.276	0.1428
12	0.2020	17.400	17.4	7.5	0.274	0.1422
13	0.2347	17.300	17.3	8.8	0.273	0.1417

Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
14	0.2827	16.000	16.0	10.8	0.252	0.1407
15	0.3200	15.500	15.5	12.4	0.244	0.1403
16	0.3850	15.000	15.0	15.0	0.236	0.1400

Parameters for Specimen No. 2

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	77.740		142.070
Moisture content: Dry soil+tare, gms.	57.810		96.330
Moisture content: Tare, gms.	30.730		30.730
Moisture, %	73.6	69.7	69.7
Moist specimen weight, gms.	117.2		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.96	
Net decrease in height, in.		0.04	
Wet Density, pcf	97.9	99.9	
Dry density, pcf	56.4	58.8	
Void ratio	2.0428	1.9178	
Saturation, %	99.1	100.0	

Test Readings for Specimen No. 2

Normal stress = 2 tsf

Fail. Stress = 0.561 tsf at reading no. 12

Ult. Stress = 0.433 tsf at reading no. 23

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0149	0.000	0.0	0.0	0.000	0.1440
1	0.0152	5.500	5.5	0.0	0.087	0.1440
2	0.0163	12.200	12.2	0.1	0.192	0.1440
3	0.0175	17.400	17.4	0.1	0.274	0.1440
4	0.0207	24.300	24.3	0.2	0.383	0.1439
5	0.0236	27.500	27.5	0.4	0.433	0.1436
6	0.0270	30.100	30.1	0.5	0.474	0.1432
7	0.0310	32.500	32.5	0.7	0.512	0.1426
8	0.0360	33.700	33.7	0.9	0.531	0.1416
9	0.0410	34.600	34.6	1.1	0.545	0.1406
10	0.0502	35.000	35.0	1.5	0.552	0.1385
11	0.0606	35.500	35.5	1.9	0.559	0.1361
12	0.0718	35.600	35.6	2.4	0.561	0.1336
13	0.0795	35.600	35.6	2.7	0.561	0.1318
14	0.0945	35.400	35.4	3.3	0.558	0.1296
15	0.1099	35.300	35.3	3.9	0.556	0.1253
16	0.1369	34.500	34.5	5.1	0.544	0.1202
17	0.1508	34.400	34.4	5.6	0.542	0.1177
18	0.1750	34.300	34.3	6.6	0.540	0.1138
19	0.2050	34.000	34.0	7.9	0.536	0.1101
20	0.2540	29.500	29.5	9.9	0.465	0.1062
21	0.2861	28.600	28.6	11.2	0.451	0.1044

Test Readings for Specimen No. 2

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
22	0.3000	28.400	28.4	11.8	0.448	0.1039
23	0.3850	27.500	27.5	15.3	0.433	0.1039

Parameters for Specimen No. 3

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	116.510		138.280
Moisture content: Dry soil+tare, gms.	80.070		96.460
Moisture content: Tare, gms.	30.470		30.750
Moisture, %	73.5	63.6	63.6
Moist specimen weight, gms.	119.1		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.03	0.92	
Net decrease in height, in.		0.11	
Wet Density, pcf	96.5	102.0	
Dry density, pcf	55.6	62.3	
Void ratio	2.0850	1.7549	
Saturation, %	96.9	99.7	

Test Readings for Specimen No. 3

Normal stress = 4.084 tsf

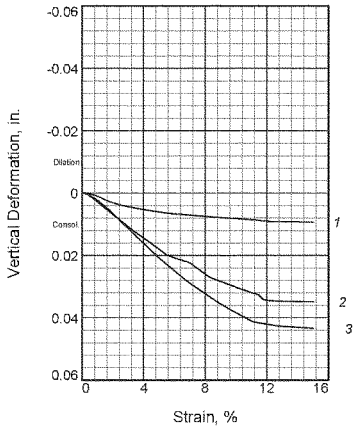
Fail. Stress = 1.150 tsf at reading no. 19

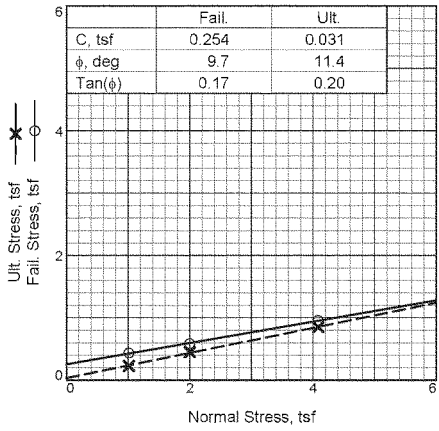
Ult. Stress = 0.875 tsf at reading no. 24

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0095	0.000	0.0	0.0	0.000	0.0389
1	0.0107	23.500	23.5	0.0	0.370	0.0389
2	0.0124	41.700	41.7	0.1	0.657	0.0388
3	0.0135	47.400	47.4	0.2	0.747	0.0387
4	0.0153	52.500	52.5	0.2	0.827	0.0386
5	0.0175	56.600	56.6	0.3	0.892	0.0385
6	0.0200	60.500	60.5	0.4	0.953	0.0385
7	0.0230	61.900	61.9	0.6	0.975	0.0378
8	0.0270	63.300	63.3	0.7	0.997	0.0372
9	0.0304	63.500	63.5	0.9	1.001	0.0366
10	0.0391	65.100	65.1	1.2	1.026	0.0346
11	0.0490	66.200	66.2	1.6	1.043	0.0322
12	0.0600	66.900	66.9	2.1	1.054	0.0295
13	0.0700	68.300	68.3	2.5	1.076	0.0269
14	0.0925	69.100	69.1	3.4	1.089	0.0202
15	0.1112	69.900	69.9	4.2	1.101	0.0154
16	0.1280	71.200	71.2	4.9	1.122	0.0120
17	0.1466	72.400	72.4	5.7	1.141	0.0087
18	0.1603	72.500	72.5	6.3	1.142	0.0062
19	0.1930	73.000	73.0	7.6	1.150	0.0008
20	0.2240	73.000	73.0	8.9	1.150	0.0000
21	0.2370	70.500	70.5	9.4	1.111	0.0000
22	0.2770	59.000	59.0	11.1	0.930	-0.0015

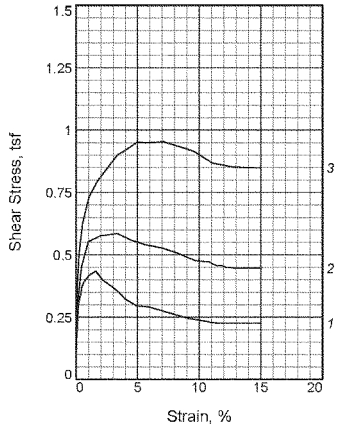
Test Readings for Specimen No. 3

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
23	0.3005	55.500	55.5	12.1	0.875	-0.0022
24	0.3100	55.500	55.5	12.5	0.875	-0.0025





	Fail.	Ult.
C, tsf	0.254	0.031
ϕ, deg	9.7	11.4
Tan(ϕ)	0.17	0.20



Sample No.		1	2	3
Initial	Water Content, %	64.8	65.3	66.2
	Dry Density, pcf	61.3	60.8	60.2
	Saturation, %	99.0	98.4	98.4
	Void Ratio	1.8014	1.8233	1.8517
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	63.9	62.0	54.0
	Dry Density, pcf	62.3	63.2	69.1
	Saturation, %	100.0	99.4	100.0
	Void Ratio	1.7576	1.7156	1.4840
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.98	0.96	0.87
Normal Stress, tsf		1.011	2.000	4.084
Fail. Stress, tsf		0.433	0.585	0.953
Strain, %		1.6	3.3	7.1
Ult. Stress, tsf		0.225	0.446	0.848
Strain, %		15.0	15.0	15.0
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 117 **PL=** 25 **PI=** 92
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min.

Figure DirectShear ASTM D3080

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Location: SE-F-19, Fargo, Brenna Formation
Sample Number: Boring 09-27MU, #3 **Depth:** 32-34'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs

DIRECT SHEAR TEST

11/9/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-F-19, Fargo, Brenna Formation
Depth: 32-34' Sample Number: Boring 09-27MU, #3
Description: FAT CLAY, brown (CH)
Remarks: The rate of strain is 0.00096 in/min.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.75 LL=117 PL=25 PI=92

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	127.270		150.270
Moisture content: Dry soil+tare, gms.	89.220		103.920
Moisture content: Tare, gms.	30.540		31.390
Moisture, %	64.8	63.9	63.9
Moist specimen weight, gms.	120.9		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.98	
Net decrease in height, in.		0.02	
Wet Density, pcf	101.0	102.0	
Dry density, pcf	61.3	62.3	
Void ratio	1.8014	1.7576	
Saturation, %	99.0	100.0	

Test Readings for Specimen No. 1

Normal stress = 1.011 tsf
Fail. Stress = 0.433 tsf at reading no. 10
Ult. Stress = 0.225 tsf at reading no. 23

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0177	0.000	0.0	0.0	0.000	0.1531
1	0.0180	5.100	5.1	0.0	0.080	0.1531
2	0.0186	7.600	7.6	0.0	0.120	0.1531
3	0.0193	10.700	10.7	0.1	0.169	0.1531
4	0.0207	14.000	14.0	0.1	0.221	0.1531
5	0.0229	19.400	19.4	0.2	0.306	0.1531
6	0.0270	21.600	21.6	0.4	0.340	0.1529
7	0.0296	23.500	23.5	0.5	0.370	0.1528
8	0.0331	24.700	24.7	0.6	0.389	0.1526
9	0.0434	26.500	26.5	1.1	0.418	0.1520
10	0.0565	27.500	27.5	1.6	0.433	0.1507
11	0.0690	25.400	25.4	2.1	0.400	0.1498
12	0.0811	24.300	24.3	2.6	0.383	0.1491
13	0.0982	22.600	22.6	3.3	0.356	0.1484

Braun Intertec

Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
14	0.1133	20.500	20.5	4.0	0.323	0.1478
15	0.1370	18.700	18.7	4.9	0.295	0.1471
16	0.1587	18.500	18.5	5.8	0.292	0.1465
17	0.2375	15.500	15.5	9.1	0.244	0.1452
18	0.2593	15.100	15.1	10.0	0.238	0.1449
19	0.2862	14.400	14.4	11.1	0.227	0.1445
20	0.2950	14.300	14.3	11.5	0.225	0.1443
21	0.3046	14.300	14.3	11.9	0.225	0.1441
22	0.3120	14.300	14.3	12.2	0.225	0.1440
23	0.3800	14.300	14.3	15.0	0.225	0.1438

Parameters for Specimen No. 2

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	122.680		146.600
Moisture content: Dry soil+tare, gms.	86.190		102.500
Moisture content: Tare, gms.	30.280		31.420
Moisture, %	65.3	62.0	62.0
Moist specimen weight, gms.	120.1		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.96	
Net decrease in height, in.		0.04	
Wet Density, pcf	100.5	102.4	
Dry density, pcf	60.8	63.2	
Void ratio	1.8233	1.7156	
Saturation, %	98.4	99.4	

Test Readings for Specimen No. 2

Normal stress = 2 tsf

Fail. Stress = 0.585 tsf at reading no. 7

Ult. Stress = 0.446 tsf at reading no. 18

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0160	0.000	0.0	0.0	0.000	0.1354
1	0.0162	5.300	5.3	0.0	0.084	0.1354
2	0.0168	9.700	9.7	0.0	0.153	0.1354
3	0.0191	18.700	18.7	0.1	0.295	0.1354
4	0.0267	28.400	28.4	0.4	0.448	0.1347
5	0.0400	35.000	35.0	1.0	0.552	0.1327
6	0.0643	36.500	36.5	2.0	0.575	0.1286
7	0.0966	37.100	37.1	3.3	0.585	0.1233
8	0.1235	35.500	35.5	4.5	0.559	0.1194
9	0.1510	34.300	34.3	5.6	0.540	0.1153
10	0.1850	33.400	33.4	7.0	0.526	0.1130
11	0.2160	32.000	32.0	8.3	0.504	0.1084
12	0.2500	30.200	30.2	9.7	0.476	0.1057
13	0.2765	29.900	29.9	10.8	0.471	0.1038
14	0.2922	28.900	28.9	11.5	0.455	0.1028

Test Readings for Specimen No. 2

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
15	0.2999	29.000	29.0	11.8	0.457	0.1013
16	0.3084	28.500	28.5	12.1	0.449	0.1009
17	0.3300	28.300	28.3	13.0	0.446	0.1007
18	0.3789	28.300	28.3	15.0	0.446	0.1005

Parameters for Specimen No. 3

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	127.430		128.220
Moisture content: Dry soil+tare, gms.	88.690		93.940
Moisture content: Tare, gms.	30.200		30.420
Moisture, %	66.2	54.0	54.0
Moist specimen weight, gms.	119.6		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.87	
Net decrease in height, in.		0.13	
Wet Density, pcf	100.1	106.4	
Dry density, pcf	60.2	69.1	
Void ratio	1.8517	1.4840	
Saturation, %	98.4	100.0	

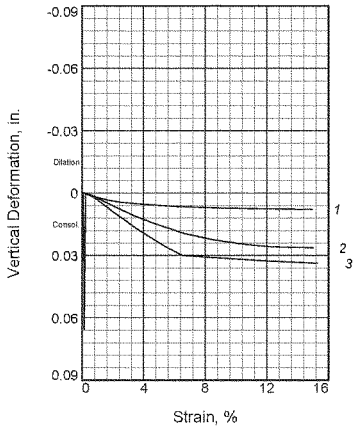
Test Readings for Specimen No. 3

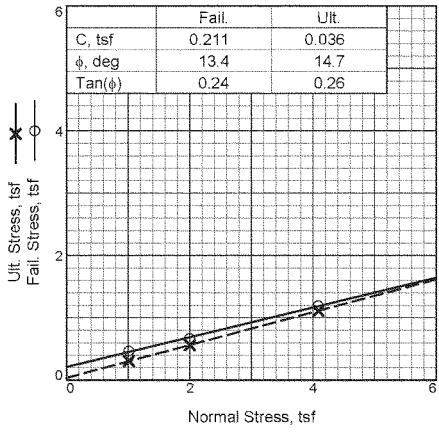
Normal stress = 4.084 tsf

Fail. Stress = 0.953 tsf at reading no. 12

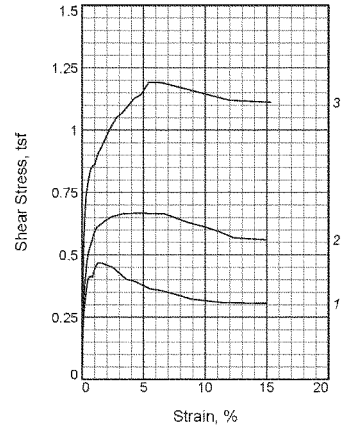
Ult. Stress = 0.848 tsf at reading no. 17

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0130	0.000	0.0	0.0	0.000	0.1159
1	0.0134	7.700	7.7	0.0	0.121	0.1159
2	0.0143	14.900	14.9	0.1	0.235	0.1158
3	0.0160	24.100	24.1	0.1	0.380	0.1158
4	0.0192	31.900	31.9	0.3	0.503	0.1156
5	0.0260	39.600	39.6	0.5	0.624	0.1150
6	0.0387	46.500	46.5	1.1	0.733	0.1134
7	0.0553	50.500	50.5	1.8	0.796	0.1106
8	0.0947	57.200	57.2	3.4	0.901	0.1027
9	0.1060	58.000	58.0	3.9	0.914	0.1005
10	0.1312	60.200	60.2	4.9	0.949	0.0956
11	0.1687	60.300	60.3	6.5	0.950	0.0891
12	0.1834	60.500	60.5	7.1	0.953	0.0868
13	0.2280	58.700	58.7	8.9	0.925	0.0806
14	0.2446	58.000	58.0	9.6	0.914	0.0786
15	0.2809	55.000	55.0	11.1	0.867	0.0746
16	0.3200	54.000	54.0	12.7	0.851	0.0732
17	0.3750	53.800	53.8	15.0	0.848	0.0725





	Fail.	Ult.
C, tsf	0.211	0.036
ϕ, deg	13.4	14.7
Tan(ϕ)	0.24	0.26



Sample No.		1	2	3
Initial	Water Content, %	51.0	52.4	51.4
	Dry Density, pcf	70.3	69.5	70.6
	Saturation, %	98.5	99.3	99.8
	Void Ratio	1.4001	1.4275	1.3924
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.00	1.00	1.01
At Test	Water Content, %	50.9	49.8	40.4
	Dry Density, pcf	71.0	72.0	80.6
	Saturation, %	99.9	100.0	100.0
	Void Ratio	1.3784	1.3452	1.0934
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.99	0.97	0.88
Normal Stress, tsf		1.011	2.000	4.084
Fail. Stress, tsf		0.466	0.667	1.191
Strain, %		1.3	4.6	5.4
Ult. Stress, tsf		0.304	0.559	1.111
Strain, %		15.0	15.0	15.3
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: Thinwall, 5", Top of sample
Description: FAT CLAY, gray (CH)

LL= 89 **PL=** 20 **PI=** 69
Assumed Specific Gravity= 2.704
Remarks: The rate of strain is 0.00096 in/min.

Figure DirectShear ASTM D3080

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Location: SE-F-19, Fargo, ~~Argusville Formation~~ Brenna
Sample Number: Boring 09-27MU, #4 **Depth:** 64-66'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs

DIRECT SHEAR TEST

11/9/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-F-19, Fargo, ~~Argusville Formation~~ Brenna
Depth: 64-66' Sample Number: Boring 09-27MU, #4
Description: FAT CLAY, gray (CH)
Remarks: The rate of strain is 0.00096 in/min.
Type of Sample: Thinwall, 5", Top of sample
Assumed Specific Gravity=2.704 LL=89 PL=20 PI=69

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	118.480		154.950
Moisture content: Dry soil+tare, gms.	88.550		112.760
Moisture content: Tare, gms.	29.860		29.920
Moisture, %	51.0	50.9	50.9
Moist specimen weight, gms.	126.9		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.99	
Net decrease in height, in.		0.01	
Wet Density, pcf	106.2	107.1	
Dry density, pcf	70.3	71.0	
Void ratio	1.4001	1.3784	
Saturation, %	98.5	99.9	

Test Readings for Specimen No. 1

Normal stress = 1.011 tsf
Fail. Stress = 0.466 tsf at reading no. 11
Ult. Stress = 0.304 tsf at reading no. 21

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0243	0.000	0.0	0.0	0.000	0.1706
1	0.0245	4.500	4.5	0.0	0.071	0.1706
2	0.0254	10.100	10.1	0.0	0.159	0.1706
3	0.0266	13.400	13.4	0.1	0.211	0.1706
4	0.0280	16.800	16.8	0.2	0.265	0.1050
5	0.0300	19.300	19.3	0.2	0.304	0.1702
6	0.0330	23.000	23.0	0.4	0.362	0.1698
7	0.0360	25.500	25.5	0.5	0.402	0.1696
8	0.0400	26.200	26.2	0.7	0.413	0.1693
9	0.0450	26.000	26.0	0.9	0.410	0.1688
10	0.0500	28.500	28.5	1.1	0.449	0.1684
11	0.0553	29.600	29.6	1.3	0.466	0.1680
12	0.0644	29.500	29.5	1.7	0.465	0.1672
13	0.0856	28.400	28.4	2.5	0.448	0.1661

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Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
14	0.1110	25.500	25.5	3.6	0.402	0.1654
15	0.1240	25.100	25.1	4.1	0.396	0.1651
16	0.1575	23.000	23.0	5.5	0.362	0.1644
17	0.1780	22.600	22.6	6.4	0.356	0.1641
18	0.2160	21.300	21.3	7.9	0.336	0.1637
19	0.2380	20.400	20.4	8.9	0.321	0.1635
20	0.2990	19.500	19.5	11.4	0.307	0.1631
21	0.3850	19.300	19.3	15.0	0.304	0.1628

Parameters for Specimen No. 2

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	94.380		153.000
Moisture content: Dry soil+tare, gms.	72.420		112.250
Moisture content: Tare, gms.	30.550		30.360
Moisture, %	52.4	49.8	49.8
Moist specimen weight, gms.	127.5		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.97	
Net decrease in height, in.		0.03	
Wet Density, pcf	106.0	107.8	
Dry density, pcf	69.5	72.0	
Void ratio	1.4275	1.3452	
Saturation, %	99.3	100.0	

Test Readings for Specimen No. 2

Normal stress = 2 tsf

Fail. Stress = 0.667 tsf at reading no. 17

Ult. Stress = 0.559 tsf at reading no. 23

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0231	0.000	0.0	0.0	0.000	0.1508
1	0.0242	5.500	5.5	0.0	0.087	0.1508
2	0.0247	10.200	10.2	0.1	0.161	0.1508
3	0.0262	17.400	17.4	0.1	0.274	0.1508
4	0.0274	21.500	21.5	0.2	0.339	0.1508
5	0.0294	25.200	25.2	0.3	0.397	0.1507
6	0.0311	27.400	27.4	0.3	0.432	0.1506
7	0.0332	30.200	30.2	0.4	0.476	0.1504
8	0.0360	32.300	32.3	0.5	0.509	0.1501
9	0.0390	33.600	33.6	0.7	0.529	0.1497
10	0.0432	35.500	35.5	0.8	0.559	0.1491
11	0.0470	37.200	37.2	1.0	0.586	0.1485
12	0.0525	38.700	38.7	1.2	0.610	0.1476
13	0.0615	39.600	39.6	1.6	0.624	0.1462
14	0.0700	40.500	40.5	1.9	0.638	0.1449
15	0.0816	41.400	41.4	2.4	0.652	0.1432
16	0.1041	42.100	42.1	3.4	0.663	0.1400

Test Readings for Specimen No. 2

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
17	0.1330	42.300	42.3	4.6	0.667	0.1365
18	0.1840	42.100	42.1	6.7	0.663	0.1313
19	0.2290	40.000	40.0	8.5	0.630	0.1283
20	0.2654	38.700	38.7	10.0	0.610	0.1266
21	0.2934	37.500	37.5	11.2	0.591	0.1257
22	0.3200	36.000	36.0	12.3	0.567	0.1250
23	0.3850	35.500	35.5	15.0	0.559	0.1245

Parameters for Specimen No. 3

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	98.630		146.020
Moisture content: Dry soil+tare, gms.	75.300		112.930
Moisture content: Tare, gms.	29.920		31.090
Moisture, %	51.4	40.4	40.4
Moist specimen weight, gms.	129.2		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.01	0.88	
Net decrease in height, in.		0.13	
Wet Density, pcf	106.8	113.2	
Dry density, pcf	70.6	80.6	
Void ratio	1.3924	1.0934	
Saturation, %	99.8	100.0	

Test Readings for Specimen No. 3

Normal stress = 4.084 tsf

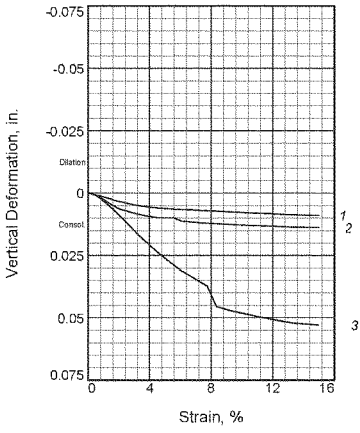
Fail. Stress = 1.191 tsf at reading no. 22

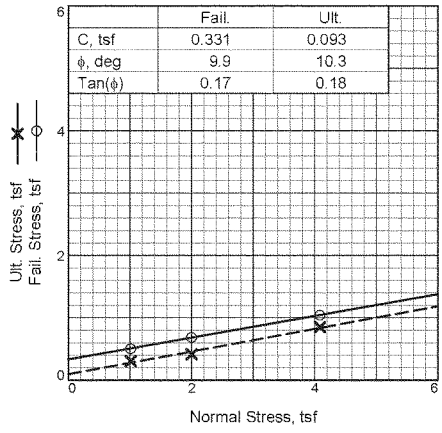
Ult. Stress = 1.111 tsf at reading no. 26

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0160	0.000	0.0	0.0	0.000	0.0392
1	0.0164	7.400	7.4	0.0	0.117	0.0393
2	0.0173	19.400	19.4	0.1	0.306	0.0393
3	0.0181	25.500	25.5	0.1	0.402	0.0392
4	0.0190	32.000	32.0	0.1	0.504	0.0392
5	0.0202	36.500	36.5	0.2	0.575	0.0391
6	0.0222	42.500	42.5	0.3	0.670	0.0390
7	0.0240	46.600	46.6	0.3	0.734	0.0388
8	0.0266	49.000	49.0	0.4	0.772	0.0384
9	0.0287	50.600	50.6	0.5	0.797	0.0381
10	0.0336	53.600	53.6	0.7	0.845	0.0373
11	0.0379	54.400	54.4	0.9	0.857	0.0364
12	0.0406	54.500	54.5	1.0	0.859	0.0359
13	0.0480	57.600	57.6	1.3	0.908	0.0342
14	0.0540	59.000	59.0	1.6	0.930	0.0328
15	0.0612	61.000	61.0	1.9	0.961	0.0311
16	0.0700	63.600	63.6	2.2	1.002	0.0291
17	0.0840	66.700	66.7	2.8	1.051	0.0261

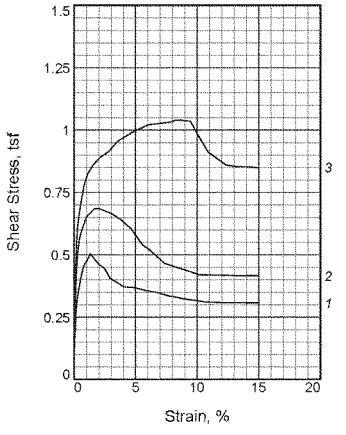
Test Readings for Specimen No. 3

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
18	0.0950	67.800	67.8	3.3	1.068	0.0236
19	0.1056	69.500	69.5	3.7	1.095	0.0214
20	0.1180	71.400	71.4	4.2	1.125	0.0189
21	0.1320	72.500	72.5	4.8	1.142	0.0162
22	0.1470	75.600	75.6	5.4	1.191	0.0135
23	0.1690	75.500	75.5	6.3	1.190	0.0099
24	0.1744	75.400	75.4	6.6	1.188	0.0091
25	0.3056	71.000	71.0	12.0	1.119	0.0065
26	0.3850	70.500	70.5	15.3	1.111	0.0054





	Fail.	Ult.
C, tsf	0.331	0.093
ϕ, deg	9.9	10.3
Tan(ϕ)	0.17	0.18



Sample No.		1	2	3
Initial	Water Content, %	60.3	59.3	59.4
	Dry Density, pcf	63.9	65.0	64.6
	Saturation, %	98.4	99.5	98.6
	Void Ratio	1.6851	1.6400	1.6580
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	59.3	56.6	50.0
	Dry Density, pcf	65.2	67.1	72.2
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.6317	1.5580	1.3762
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.98	0.97	0.90
Normal Stress, tsf		1.011	2.000	4.084
Fail. Stress, tsf		0.503	0.685	1.040
Strain, %		1.3	2.0	8.4
Ult. Stress, tsf		0.306	0.414	0.849
Strain, %		15.0	15.0	15.0
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, brown (CH)

Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min.

Figure DirectShear ASTM D3080

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Moorhead

Location: SE-M-18, Moorhead, Brenna Formation

Sample Number: Boring 09-34MU, #3 **Depth:** 28-30'

Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: js **Checked By:** rs

DIRECT SHEAR TEST

11/16/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-M-18, Moorhead, Brenna Formation
Depth: 28-30' Sample Number: Boring 09-34MU, #3
Description: FAT CLAY, brown (CH)
Remarks: The rate of strain is 0.00096 in/min.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.75 LL= PL= PI=

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	122.420		152.080
Moisture content: Dry soil+tare, gms.	88.000		106.750
Moisture content: Tare, gms.	30.920		30.330
Moisture, %	60.3	59.3	59.3
Moist specimen weight, gms.	123.5		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.98	
Net decrease in height, in.		0.02	
Wet Density, pcf	102.5	103.9	
Dry density, pcf	63.9	65.2	
Void ratio	1.6851	1.6317	
Saturation, %	98.4	100.0	

Test Readings for Specimen No. 1

Normal stress = 1.011 tsf
Fail. Stress = 0.503 tsf at reading no. 10
Ult. Stress = 0.306 tsf at reading no. 23

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0134	0.000	0.0	0.0	0.000	0.1513
1	0.0137	4.500	4.5	0.0	0.071	0.1514
2	0.0147	9.600	9.6	0.1	0.151	0.1513
3	0.0163	13.300	13.3	0.1	0.210	0.1511
4	0.0176	17.000	17.0	0.2	0.268	0.1510
5	0.0199	20.700	20.7	0.3	0.326	0.1508
6	0.0237	23.400	23.4	0.4	0.369	0.1506
7	0.0279	26.500	26.5	0.6	0.418	0.1504
8	0.0325	28.800	28.8	0.8	0.454	0.1501
9	0.0373	29.900	29.9	1.0	0.471	0.1498
10	0.0458	31.900	31.9	1.3	0.503	0.1492
11	0.0600	29.500	29.5	1.9	0.465	0.1480
12	0.0728	28.300	28.3	2.5	0.446	0.1473
13	0.0837	25.800	25.8	2.9	0.407	0.1467

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Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
14	0.1115	23.500	23.5	4.1	0.370	0.1456
15	0.1294	23.400	23.4	4.8	0.369	0.1452
16	0.1576	22.500	22.5	6.0	0.355	0.1447
17	0.1769	22.100	22.1	6.8	0.348	0.1445
18	0.2002	21.200	21.2	7.7	0.334	0.1442
19	0.2270	20.500	20.5	8.9	0.323	0.1439
20	0.2702	19.700	19.7	10.6	0.310	0.1433
21	0.2986	19.500	19.5	11.8	0.307	0.1430
22	0.3200	19.500	19.5	12.7	0.307	0.1427
23	0.3750	19.400	19.4	15.0	0.306	0.1423

Parameters for Specimen No. 2

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	123.430		151.150
Moisture content: Dry soil+tare, gms.	89.180		107.620
Moisture content: Tare, gms.	31.470		30.750
Moisture, %	59.3	56.6	56.6
Moist specimen weight, gms.	124.1		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.97	
Net decrease in height, in.		0.03	
Wet Density, pcf	103.6	105.1	
Dry density, pcf	65.0	67.1	
Void ratio	1.6400	1.5580	
Saturation, %	99.5	100.0	

Test Readings for Specimen No. 2

Normal stress = 2 tsf

Fail. Stress = 0.685 tsf at reading no. 12

Ult. Stress = 0.414 tsf at reading no. 22

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0146	0.000	0.0	0.0	0.000	0.1253
1	0.0149	6.100	6.1	0.0	0.096	0.1253
2	0.0154	10.300	10.3	0.0	0.162	0.1253
3	0.0162	14.400	14.4	0.1	0.227	0.1253
4	0.0170	19.300	19.3	0.1	0.304	0.1253
5	0.0182	23.200	23.2	0.2	0.366	0.1253
6	0.0200	28.200	28.2	0.2	0.444	0.1252
7	0.0220	32.100	32.1	0.3	0.506	0.1250
8	0.0250	35.600	35.6	0.4	0.561	0.1247
9	0.0300	38.000	38.0	0.6	0.599	0.1241
10	0.0400	41.500	41.5	1.1	0.654	0.1226
11	0.0550	43.400	43.4	1.7	0.684	0.1202
12	0.0630	43.500	43.5	2.0	0.685	0.1190
13	0.0890	42.100	42.1	3.1	0.663	0.1170
14	0.1060	40.700	40.7	3.8	0.641	0.1161

Test Readings for Specimen No. 2

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
15	0.1257	38.400	38.4	4.6	0.605	0.1153
16	0.1483	34.300	34.3	5.5	0.540	0.1154
17	0.1610	33.100	33.1	6.1	0.522	0.1141
18	0.1927	29.500	29.5	7.4	0.465	0.1133
19	0.2605	26.600	26.6	10.2	0.419	0.1124
20	0.3037	26.500	26.5	12.0	0.418	0.1120
21	0.3310	26.400	26.4	13.1	0.416	0.1117
22	0.3760	26.300	26.3	15.0	0.414	0.1115

Parameters for Specimen No. 3

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	134.850		138.490
Moisture content: Dry soil+tare, gms.	96.240		102.580
Moisture content: Tare, gms.	31.290		30.830
Moisture, %	59.4	50.0	50.0
Moist specimen weight, gms.	123.9		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.90	
Net decrease in height, in.		0.11	
Wet Density, pcf	103.0	108.4	
Dry density, pcf	64.6	72.2	
Void ratio	1.6580	1.3762	
Saturation, %	98.6	100.0	

Test Readings for Specimen No. 3

Normal stress = 4.084 tsf

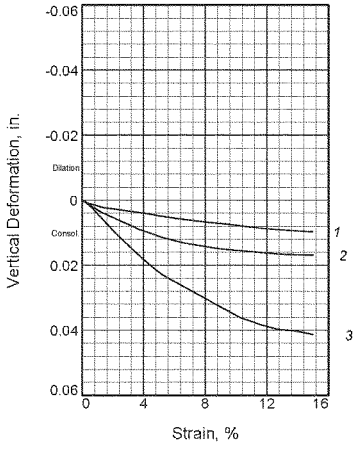
Fail. Stress = 1.040 tsf at reading no. 19

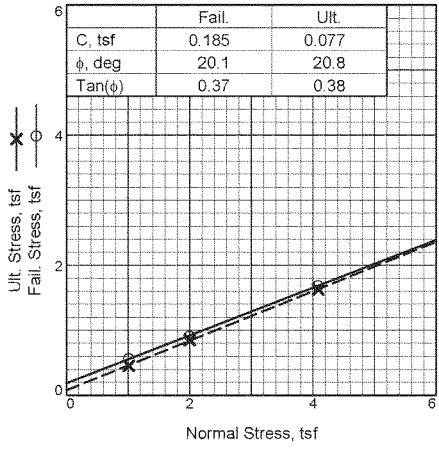
Ult. Stress = 0.849 tsf at reading no. 25

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0151	0.000	0.0	0.0	0.000	0.0616
1	0.0153	6.500	6.5	0.0	0.102	0.0616
2	0.0159	13.700	13.7	0.0	0.216	0.0616
3	0.0169	19.900	19.9	0.1	0.314	0.0615
4	0.0177	25.200	25.2	0.1	0.397	0.0615
5	0.0188	29.400	29.4	0.2	0.463	0.0615
6	0.0206	34.700	34.7	0.2	0.547	0.0614
7	0.0220	38.500	38.5	0.3	0.607	0.0612
8	0.0250	41.600	41.6	0.4	0.656	0.0609
9	0.0290	45.000	45.0	0.6	0.709	0.0604
10	0.0350	49.300	49.3	0.8	0.777	0.0594
11	0.0423	52.300	52.3	1.1	0.824	0.0579
12	0.0532	54.600	54.6	1.6	0.860	0.0554
13	0.0666	56.500	56.5	2.1	0.890	0.0519
14	0.0839	58.100	58.1	2.9	0.916	0.0475
15	0.0995	60.500	60.5	3.5	0.953	0.0436
16	0.1272	62.700	62.7	4.6	0.988	0.0373

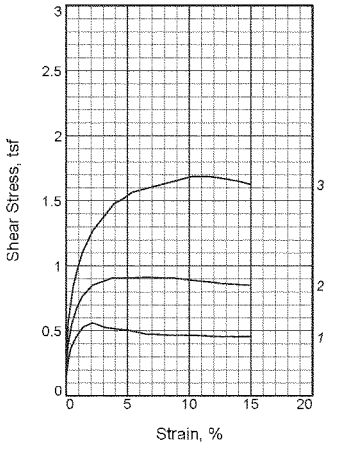
Test Readings for Specimen No. 3

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
17	0.1609	64.800	64.8	6.0	1.021	0.0305
18	0.2018	65.400	65.4	7.7	1.031	0.0243
19	0.2166	66.000	66.0	8.4	1.040	0.0160
20	0.2428	65.700	65.7	9.4	1.035	0.0142
21	0.2596	61.800	61.8	10.1	0.974	0.0133
22	0.2777	57.900	57.9	10.9	0.912	0.0122
23	0.3130	54.500	54.5	12.4	0.859	0.0105
24	0.3350	54.100	54.1	13.3	0.852	0.0095
25	0.3760	53.900	53.9	15.0	0.849	0.0087





	Fail.	Ult.
C, tsf	0.185	0.077
ϕ, deg	20.1	20.8
Tan(ϕ)	0.37	0.38



Sample No.		1	2	3
Initial	Water Content, %	39.6	39.4	39.0
	Dry Density, pcf	81.5	82.1	81.6
	Saturation, %	98.4	99.3	97.3
	Void Ratio	1.1076	1.0905	1.1030
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	38.7	37.3	34.4
	Dry Density, pcf	83.1	84.8	88.2
	Saturation, %	99.9	99.9	99.9
	Void Ratio	1.0656	1.0254	0.9460
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.98	0.96	0.93
Normal Stress, tsf		1.011	2.000	4.084
Fail. Stress, tsf		0.561	0.912	1.686
Strain, %		2.2	6.5	10.3
Ult. Stress, tsf		0.454	0.849	1.626
Strain, %		15.0	15.0	15.0
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 64 **PL=** 17 **PI=** 47
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min.

Figure DirectShear ASTM D3080

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Fargo Brenna / Argusville Transition
Location: WD-28, ND Div, ~~Brenna Formation~~
Sample Number: Boring 09-59MU, #3 **Depth:** 35-37'
Proj. No.: BL09-03127A **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs

DIRECT SHEAR TEST

3/2/2010

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL09-03127A
Location: WD-28, ND Div, ~~Brenna Formation~~ Brenna / Argusville Transition
Depth: 35-37' Sample Number: Boring 09-59MU, #3
Description: FAT CLAY, brown (CH)
Remarks: The rate of strain is 0.00096 in/min.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.75 LL=64 PL=17 PI=47

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	155.200		165.410
Moisture content: Dry soil+tare, gms.	119.590		127.650
Moisture content: Tare, gms.	29.700		30.130
Moisture, %	39.6	38.7	38.7
Moist specimen weight, gms.	136.9		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.98	
Net decrease in height, in.		0.02	
Wet Density, pcf	113.7	115.3	
Dry density, pcf	81.5	83.1	
Void ratio	1.1076	1.0656	
Saturation, %	98.4	99.9	

Test Readings for Specimen No. 1

Normal stress = 1.011 tsf
Fail. Stress = 0.561 tsf at reading no. 7
Ult. Stress = 0.454 tsf at reading no. 17

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0141	0.000	0.0	0.0	0.000	0.1361
1	0.0152	10.300	10.3	0.0	0.162	0.1361
2	0.0175	15.100	15.1	0.1	0.238	0.1358
3	0.0200	19.000	19.0	0.2	0.299	0.1355
4	0.0240	23.400	23.4	0.4	0.369	0.1351
5	0.0342	28.700	28.7	0.8	0.452	0.1346
6	0.0475	33.500	33.5	1.4	0.528	0.1338
7	0.0668	35.600	35.6	2.2	0.561	0.1333
8	0.0897	33.400	33.4	3.1	0.526	0.1327
9	0.1182	32.400	32.4	4.3	0.511	0.1319
10	0.1342	32.100	32.1	5.0	0.506	0.1313
11	0.1684	30.200	30.2	6.4	0.476	0.1303
12	0.2127	29.600	29.6	8.2	0.466	0.1293
13	0.2463	29.500	29.5	9.6	0.465	0.1286
14	0.2750	29.400	29.4	10.8	0.463	0.1279

Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
15	0.3040	29.000	29.0	12.0	0.457	0.1273
16	0.3400	28.900	28.9	13.5	0.455	0.1268
17	0.3750	28.800	28.8	15.0	0.454	0.1264

Parameters for Specimen No. 2

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	169.900		163.570
Moisture content: Dry soil+tare, gms.	130.600		127.340
Moisture content: Tare, gms.	30.800		30.110
Moisture, %	39.4	37.3	37.3
Moist specimen weight, gms.	136.6		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.96	
Net decrease in height, in.		0.03	
Wet Density, pcf	114.5	116.3	
Dry density, pcf	82.1	84.8	
Void ratio	1.0905	1.0254	
Saturation, %	99.3	99.9	

Test Readings for Specimen No. 2

Normal stress = 2 tsf

Fail. Stress = 0.912 tsf at reading no. 11

Ult. Stress = 0.849 tsf at reading no. 18

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0171	0.000	0.0	0.0	0.000	0.1272
1	0.0175	6.800	6.8	0.0	0.107	0.1272
2	0.0190	16.900	16.9	0.1	0.266	0.1270
3	0.0210	24.600	24.6	0.2	0.388	0.1268
4	0.0280	34.500	34.5	0.5	0.544	0.1259
5	0.0330	38.700	38.7	0.7	0.610	0.1252
6	0.0382	42.600	42.6	0.9	0.671	0.1246
7	0.0488	48.400	48.4	1.3	0.763	0.1234
8	0.0684	53.800	53.8	2.1	0.848	0.1216
9	0.1069	57.400	57.4	3.7	0.904	0.1182
10	0.1455	57.500	57.5	5.3	0.906	0.1156
11	0.1744	57.900	57.9	6.5	0.912	0.1142
12	0.2054	57.500	57.5	7.8	0.906	0.1131
13	0.2320	57.400	57.4	8.9	0.904	0.1123
14	0.2650	56.300	56.3	10.3	0.887	0.1117
15	0.2992	55.500	55.5	11.7	0.875	0.1111
16	0.3187	54.900	54.9	12.5	0.865	0.1108
17	0.3348	54.600	54.6	13.2	0.860	0.1105
18	0.3790	53.900	53.9	15.0	0.849	0.1103

Parameters for Specimen No. 3			
Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	141.900		158.590
Moisture content: Dry soil+tare, gms.	110.820		125.860
Moisture content: Tare, gms.	31.200		30.630
Moisture, %	39.0	34.4	34.4
Moist specimen weight, gms.	136.2		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.93	
Net decrease in height, in.		0.07	
Wet Density, pcf	113.5	118.5	
Dry density, pcf	81.6	88.2	
Void ratio	1.1030	0.9460	
Saturation, %	97.3	99.9	

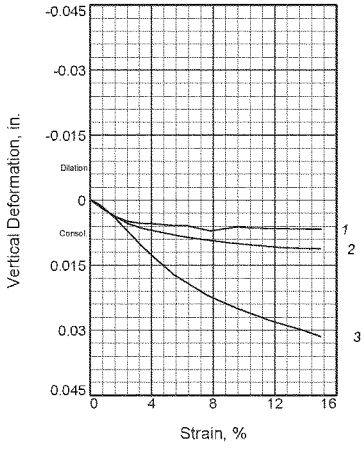
Test Readings for Specimen No. 3

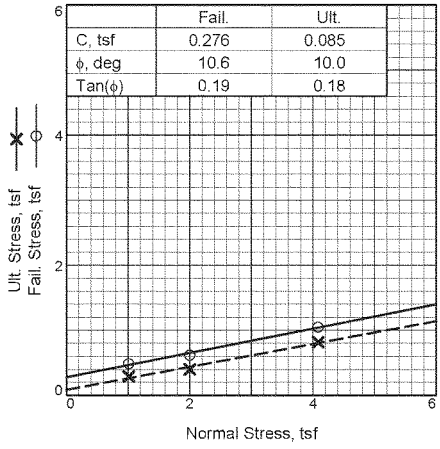
Normal stress = 4.084 tsf

Fail. Stress = 1.686 tsf at reading no. 13

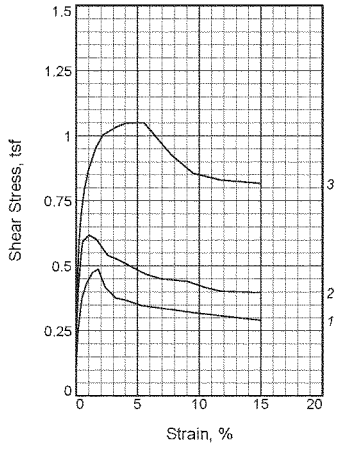
Ult. Stress = 1.626 tsf at reading no. 17

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0147	0.000	0.0	0.0	0.000	0.0783
1	0.0149	6.300	6.3	0.0	0.099	0.0783
2	0.0156	14.400	14.4	0.0	0.227	0.0783
3	0.0165	22.500	22.5	0.1	0.355	0.0782
4	0.0178	29.900	29.9	0.1	0.471	0.0781
5	0.0190	35.800	35.8	0.2	0.564	0.0780
6	0.0290	53.500	53.5	0.6	0.843	0.0762
7	0.0390	63.400	63.4	1.0	0.999	0.0741
8	0.0466	69.600	69.6	1.3	1.097	0.0725
9	0.0667	80.500	80.5	2.2	1.268	0.0683
10	0.1087	93.700	93.7	3.9	1.476	0.0605
11	0.1280	96.300	96.3	4.7	1.517	0.0573
12	0.1434	99.200	99.2	5.3	1.563	0.0551
13	0.2625	107.000	107.0	10.3	1.686	0.0422
14	0.2964	106.900	106.9	11.7	1.684	0.0399
15	0.3204	106.100	106.1	12.7	1.672	0.0386
16	0.3510	104.700	104.7	13.9	1.650	0.0380
17	0.3760	103.200	103.2	15.0	1.626	0.0370





	Fail.	Ult.
C, tsf	0.276	0.085
ϕ, deg	10.6	10.0
Tan(ϕ)	0.19	0.18



Sample No.		1	2	3
Initial	Water Content, %	64.5	67.9	41.3
	Dry Density, pcf	61.0	59.0	71.5
	Saturation, %	97.7	97.8	81.1
	Void Ratio	1.8152	1.9076	1.3999
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	64.4	65.6	47.4
	Dry Density, pcf	61.9	61.2	74.5
	Saturation, %	99.8	100.0	100.0
	Void Ratio	1.7745	1.8057	1.3039
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.99	0.97	0.96
Normal Stress, tsf		1.011	2.000	4.084
Fail. Stress, tsf		0.487	0.618	1.049
Strain, %		1.8	1.1	5.5
Ult. Stress, tsf		0.290	0.397	0.816
Strain, %		15.0	15.0	15.0
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, gray (CH)

LL= 111 **PL=** 26 **PI=** 85
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min.

Figure DirectShear ASTM D3080

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Fargo
Location: WD-05, ND Div, Brenna Formation
Sample Number: Boring 09-60MU, #3 **Depth:** 35-37'
Proj. No.: BL09-03127A **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs

DIRECT SHEAR TEST

3/2/2010

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL09-03127A
Location: WD-05, ND Div, Brenna Formation
Depth: 35-37' Sample Number: Boring 09-60MU, #3
Description: FAT CLAY, gray (CH)
Remarks: The rate of strain is 0.00096 in/min.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.75 LL=111 PL=26 PI=85

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	139.390		149.510
Moisture content: Dry soil+tare, gms.	96.940		102.870
Moisture content: Tare, gms.	31.100		30.440
Moisture, %	64.5	64.4	64.4
Moist specimen weight, gms.	120.6		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.99	
Net decrease in height, in.		0.01	
Wet Density, pcf	100.3	101.7	
Dry density, pcf	61.0	61.9	
Void ratio	1.8152	1.7745	
Saturation, %	97.7	99.8	

Test Readings for Specimen No. 1

Normal stress = 1.011 tsf
Fail. Stress = 0.487 tsf at reading no. 7
Ult. Stress = 0.290 tsf at reading no. 18

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0186	0.000	0.0	0.0	0.000	0.1059
1	0.0190	5.400	5.4	0.0	0.085	0.1059
2	0.0200	9.500	9.5	0.1	0.150	0.1059
3	0.0220	15.200	15.2	0.1	0.240	0.1057
4	0.0305	23.900	23.9	0.5	0.377	0.1048
5	0.0400	27.600	27.6	0.9	0.435	0.1038
6	0.0510	30.000	30.0	1.3	0.473	0.1028
7	0.0620	30.900	30.9	1.8	0.487	0.1019
8	0.0760	26.500	26.5	2.4	0.418	0.1011
9	0.0965	23.800	23.8	3.2	0.375	0.1006
10	0.1140	23.400	23.4	4.0	0.369	0.1005
11	0.1468	22.000	22.0	5.3	0.347	0.1001
12	0.1710	21.600	21.6	6.3	0.340	0.1000
13	0.2072	21.000	21.0	7.8	0.331	0.0988
14	0.2484	20.300	20.3	9.5	0.320	0.0997

Braun Intertec

Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
15	0.2748	19.900	19.9	10.6	0.314	0.0995
16	0.2956	19.600	19.6	11.5	0.309	0.0994
17	0.3310	19.100	19.1	13.0	0.301	0.0993
18	0.3808	18.400	18.4	15.0	0.290	0.0992

Parameters for Specimen No. 2

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	148.290		146.790
Moisture content: Dry soil+tare, gms.	100.590		100.630
Moisture content: Tare, gms.	30.300		30.310
Moisture, %	67.9	65.6	65.6
Moist specimen weight, gms.	119.4		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.97	
Net decrease in height, in.		0.04	
Wet Density, pcf	99.1	101.4	
Dry density, pcf	59.0	61.2	
Void ratio	1.9076	1.8057	
Saturation, %	97.8	100.0	

Test Readings for Specimen No. 2

Normal stress = 2 tsf

Fail. Stress = 0.618 tsf at reading no. 6

Ult. Stress = 0.397 tsf at reading no. 17

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0140	0.000	0.0	0.0	0.000	0.1106
1	0.0142	7.500	7.5	0.0	0.118	0.1106
2	0.0157	18.100	18.1	0.1	0.285	0.1106
3	0.0183	25.400	25.4	0.2	0.400	0.1104
4	0.0244	35.000	35.0	0.4	0.552	0.1099
5	0.0276	37.700	37.7	0.6	0.594	0.1096
6	0.0399	39.200	39.2	1.1	0.618	0.1082
7	0.0528	38.300	38.3	1.6	0.604	0.1069
8	0.0756	34.300	34.3	2.6	0.540	0.1051
9	0.0986	33.100	33.1	3.5	0.522	0.1040
10	0.1520	29.600	29.6	5.7	0.466	0.1024
11	0.1810	28.500	28.5	6.9	0.449	0.1017
12	0.2325	27.900	27.9	9.1	0.440	0.1008
13	0.2676	26.400	26.4	10.5	0.416	0.1003
14	0.2976	25.500	25.5	11.8	0.402	0.0999
15	0.3128	25.400	25.4	12.4	0.400	0.0997
16	0.3398	25.300	25.3	13.5	0.399	0.0995
17	0.3748	25.200	25.2	15.0	0.397	0.0994

Parameters for Specimen No. 3			
Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	164.910		141.160
Moisture content: Dry soil+tare, gms.	125.710		105.410
Moisture content: Tare, gms.	30.700		30.020
Moisture, %	41.3	47.4	47.4
Moist specimen weight, gms.	121.2		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.96	
Net decrease in height, in.		0.04	
Wet Density, pcf	101.0	109.9	
Dry density, pcf	71.5	74.5	
Void ratio	1.3999	1.3039	
Saturation, %	81.1	100.0	

Test Readings for Specimen No. 3

Normal stress = 4.084 tsf

Fail. Stress = 1.049 tsf at reading no. 13

Ult. Stress = 0.816 tsf at reading no. 18

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0176	0.000	0.0	0.0	0.000	0.0535
1	0.0180	9.500	9.5	0.0	0.150	0.0535
2	0.0187	15.900	15.9	0.0	0.251	0.0535
3	0.0200	24.300	24.3	0.1	0.383	0.0535
4	0.0215	31.000	31.0	0.2	0.488	0.0534
5	0.0240	38.100	38.1	0.3	0.600	0.0532
6	0.0282	44.700	44.7	0.4	0.704	0.0528
7	0.0341	50.200	50.2	0.7	0.791	0.0523
8	0.0420	55.000	55.0	1.0	0.867	0.0513
9	0.0568	60.600	60.6	1.6	0.955	0.0494
10	0.0702	63.600	63.6	2.2	1.002	0.0473
11	0.0944	65.400	65.4	3.2	1.031	0.0436
12	0.1158	66.500	66.5	4.1	1.048	0.0406
13	0.1505	66.600	66.6	5.5	1.049	0.0362
14	0.2027	59.000	59.0	7.7	0.930	0.0315
15	0.2470	54.300	54.3	9.5	0.856	0.0286
16	0.3003	52.600	52.6	11.7	0.829	0.0257
17	0.3510	52.100	52.1	13.8	0.821	0.0235
18	0.3790	51.800	51.8	15.0	0.816	0.0220

Direct Shear Test

ASTM: D3080

Job No.: 7577

Project: **Fargo-Moorhead Metro Feasibility Project - # W912ES-10-T-0095**

Boring No.: **10-80MU** Sample No. **2** Depth: **35 - 37 (Top)**

Location: Fargo **ND Sheyenne** Sample Type: **5T**

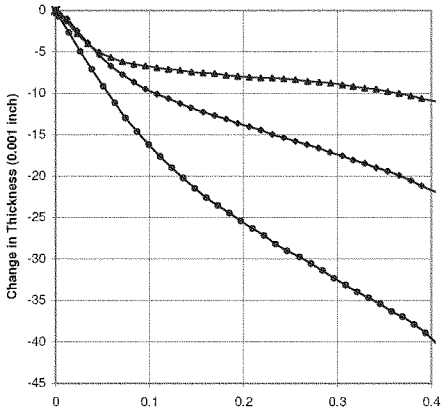
Soil Type: **Fat Clay w/Laminations of Silt (CH)** Brenna

Test Date:	8/18/2010
Date Reported:	8/23/2010
Shear Rate	
0.000378 (in/min)	

Remarks: Specimens trimmed to given sizes; Inundated after applying normal load; Allowed to consolidate for about 3-6 Hrs.; Sheared to given displacements at constant rate of 0.000378"/min..

Liquid Limit:	90.7
Plastic Limit:	29.1
Plasticity Index:	61.6
Specific Gravity (*):	2.78

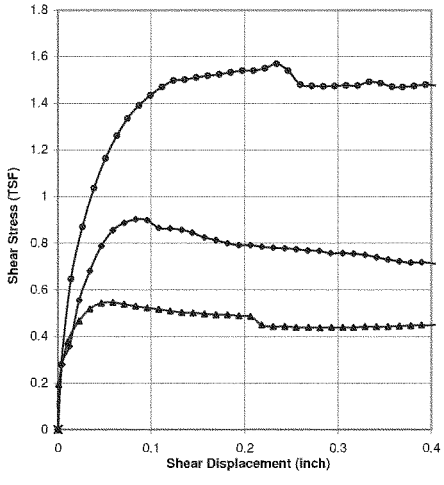
(*) = Assumed Specific Gravity

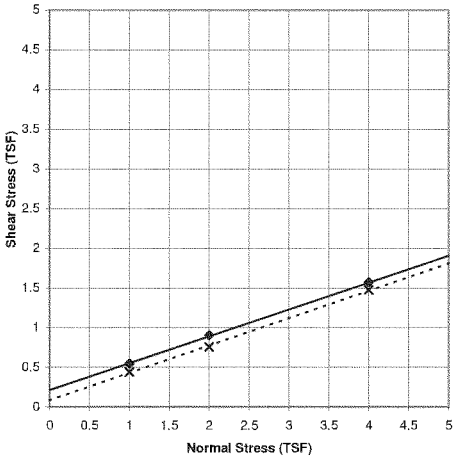


Failure Criterion:				
Max. Shear Stress	A	B	C	D
Initial	▲	◇	○	X
Diameter (In.)	2.50	2.50	2.50	
Thickness (In.)	0.72	0.72	0.72	
Water Content (%)	49.4	51.9	48.0	
Dry Density (pcf)	71.3	70.8	74.8	
Before Shear				
Thickness (In.)	0.68	0.67	0.65	
Water Content (%)	46.7	46.4	39.4	
Dry Density (pcf)	75.5	75.8	82.8	
Normal Stress	1.00	2.00	4.00	
Shear Stress	0.55	0.90	1.57	

"These tests are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design."

Peak Conditions		At Given Shear Disp. Of: 0.3	
Friction Angle:	ϕ= 18.7 deg.	Friction Angle:	ϕ= 19.1 deg.
Apparent Cohesion	0.212 TSF	Apparent Cohesion	0.080 TSF





Direct Shear Test Data

Job No.: 7577

ASTM: D3080

Project: **Fargo-Moorhead Metro Feasibility Project - # W912ES-10-T-0095**

Boring No.: **10-80MU** Sample No. **2** Depth: **35 - 37 (Top)**

Location: Fargo **ND Sheyenne** Samp. Type: **5T**

Soil Type: **Fat Clay w/Laminations of Silt (CH)** Brenna

Test Date: **8/18/2010**

Date Reported: **8/23/2010**

Shear Rate

Normal Load: 1 tsf				Normal Load: 2 tsf				Normal Load: 4 tsf				Normal Load: 0 tsf			
Rdg. #	Load lbs	Shear in	Vert. in	Rdg. #	Load lbs	Shear in	Vert. in	Rdg. #	Load lbs	Shear in	Vert. in	Rdg. #	Load lbs	Shear in	Vert. in
1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0
2	13.2	9E-04	-0.31	2	19	0.004	-0.516	2	19	0.004	-0.723	2			
3	25.6	0.011	-1.239	3	24.4	0.012	-1.033	3	44.1	0.014	-2.686	3			
4	31.8	0.023	-2.789	4	37.8	0.023	-2.479	4	59.3	0.026	-4.958	4			
5	35.3	0.034	-4.028	5	46.4	0.034	-3.925	5	70.6	0.039	-7.127	5			
6	37	0.046	-5.061	6	53.7	0.046	-5.371	6	79.3	0.051	-9.193	6			
7	37.2	0.059	-5.681	7	58.3	0.059	-6.714	7	86	0.063	-11.16	7			
8	36.7	0.071	-6.197	8	60.4	0.071	-7.747	8	91	0.075	-13.01	8			
9	36.1	0.083	-6.507	9	61.5	0.083	-8.676	9	94.8	0.087	-14.67	9			
10	35.6	0.096	-6.714	10	61.3	0.096	-9.503	10	97.8	0.099	-16.22	10			
11	35.2	0.108	-6.92	11	59	0.108	-10.12	11	100.2	0.111	-17.66	11			
12	34.7	0.12	-7.127	12	58.8	0.12	-10.64	12	102.1	0.124	-19.01	12			
13	34.3	0.132	-7.23	13	58.4	0.132	-11.26	13	102.4	0.136	-20.24	13			
14	34.1	0.145	-7.437	14	57.6	0.144	-11.78	14	103	0.148	-21.48	14			
15	33.8	0.157	-7.54	15	56.2	0.157	-12.29	15	103.5	0.16	-22.62	15			
16	33.6	0.169	-7.643	16	55.4	0.169	-12.7	16	103.9	0.173	-23.55	16			
17	33.6	0.182	-7.85	17	54.5	0.182	-13.12	17	104.5	0.185	-24.48	17			
18	33.3	0.194	-7.953	18	53.9	0.194	-13.63	18	105	0.197	-25.41	18			
19	33.1	0.206	-8.057	19	53.9	0.206	-14.05	19	105	0.21	-26.34	19			
20	30.6	0.218	-8.16	20	53.5	0.218	-14.46	20	105.7	0.222	-27.17	20			
21	30.1	0.231	-8.16	21	53.2	0.231	-14.98	21	107	0.234	-28.2	21			
22	30.2	0.243	-8.263	22	53	0.243	-15.39	22	105	0.246	-29.02	22			
23	29.9	0.255	-8.366	23	52.8	0.255	-15.8	23	100.9	0.26	-29.75	23			
24	29.9	0.268	-8.573	24	52.4	0.267	-16.22	24	100.5	0.272	-30.57	24			
25	29.8	0.281	-8.676	25	52.3	0.28	-16.63	25	100.4	0.284	-31.4	25			
26	29.9	0.293	-8.78	26	51.6	0.292	-17.15	26	100.5	0.296	-32.33	26			
27	29.9	0.305	-8.986	27	51.6	0.305	-17.56	27	100.7	0.309	-33.16	27			
28	29.9	0.317	-9.193	28	51.4	0.317	-18.08	28	100.6	0.321	-33.98	28			
29	30.1	0.329	-9.399	29	51.1	0.329	-18.49	29	101.7	0.333	-34.71	29			
30	30.1	0.341	-9.503	30	50.4	0.341	-19.01	30	101.3	0.345	-35.43	30			
31	30.1	0.353	-9.813	31	49.7	0.353	-19.42	31	100.3	0.358	-36.36	31			
32	30.3	0.366	-10.02	32	49.2	0.366	-19.93	32	100.2	0.369	-36.98	32			
33	30.4	0.378	-10.33	33	48.8	0.378	-20.55	33	100.5	0.381	-37.91	33			
34	30.6	0.389	-10.64	34	48.9	0.389	-21.17	34	100.9	0.394	-38.94	34			
35	30.6	0.402	-10.95	35	48.6	0.402	-21.79	35	100.7	0.405	-40.18	35			
36	30.7	0.413	-11.16	36	48.2	0.413	-22.21	36	100.7	0.417	-41.21	36			
37	30.7	0.424	-11.47	37	48.3	0.425	-22.83	37	100.9	0.429	-42.25	37			
38	30.7	0.436	-11.78	38	48.2	0.437	-23.45	38	100.5	0.44	-43.28	38			
39	30.5	0.447	-12.08	39	47.7	0.448	-24.17	39	100.3	0.451	-44.21	39			
40	30.5	0.455	-12.5	40	48.2	0.459	-24.89	40				40			
41				41				41				41			
42				42				42				42			
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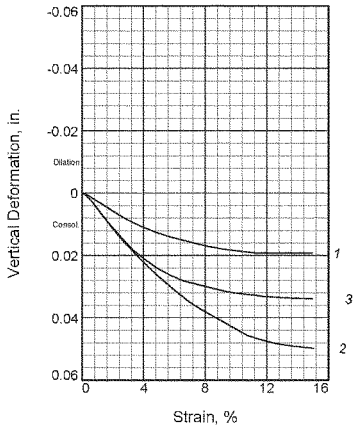
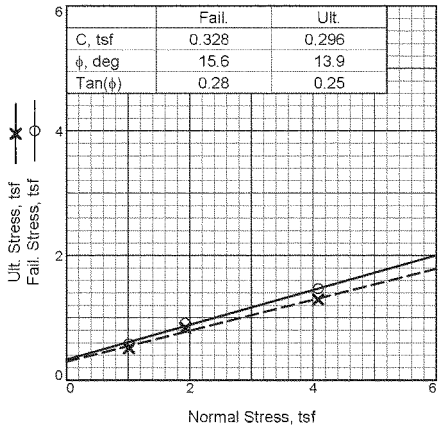
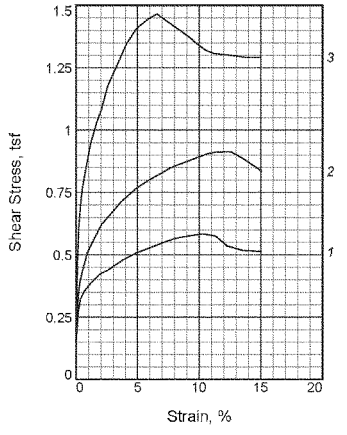




	Fail.	Ult.
C, tsf	0.328	0.296
ϕ, deg	15.6	13.9
Tan(ϕ)	0.28	0.25



Sample No.		1	2	3
Initial	Water Content, %	38.0	41.5	43.2
	Dry Density, pcf	82.8	80.2	77.0
	Saturation, %	97.5	100.0	96.6
	Void Ratio	1.0725	1.1419	1.2299
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	36.0	37.1	33.6
	Dry Density, pcf	86.1	85.0	89.1
	Saturation, %	99.4	100.0	99.7
	Void Ratio	0.9950	1.0204	0.9274
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.96	0.94	0.86
Normal Stress, tsf		1.011	1.926	4.084
Fail. Stress, tsf		0.583	0.912	1.465
Strain, %		10.3	12.6	6.6
Ult. Stress, tsf		0.512	0.835	1.292
Strain, %		15.0	15.0	15.0
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, gray (CH)

LL= 53 **PL=** 17 **PI=** 36
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min.

Figure DirectShear ASTM D3080

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Moorhead
Location: East Diversion, SE-ED-15, Argusville Formation
Sample Number: Boring 09-14MU, #4 **Depth:** 58-60'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs

DIRECT SHEAR TEST

10/12/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL-09-03127
Location: East Diversion, SE-ED-15, Argusville Formation
Depth: 58-60' Sample Number: Boring 09-14MU, #4
Description: FAT CLAY, gray (CH)
Remarks: The rate of strain is 0.00096 in/min.
Type of Sample: Thinwall, 5", Middle of sample
Assumed Specific Gravity=2.75 LL=53 PL=17 PI=36

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	103.020		163.210
Moisture content: Dry soil+tare, gms.	82.980		127.940
Moisture content: Tare, gms.	30.250		29.890
Moisture, %	38.0	36.0	36.0
Moist specimen weight, gms.	137.2		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.96	
Net decrease in height, in.		0.04	
Wet Density, pcf	114.3	117.0	
Dry density, pcf	82.8	86.1	
Void ratio	1.0725	0.9950	
Saturation, %	97.5	99.4	

Test Readings for Specimen No. 1

Normal stress = 1.011 tsf
Fail. Stress = 0.583 tsf at reading no. 17
Ult. Stress = 0.512 tsf at reading no. 21

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0240	0.000	0.0	0.0	0.000	0.1513
1	0.0241	5.000	5.0	0.0	0.079	0.1513
2	0.0246	9.200	9.2	0.0	0.145	0.1513
3	0.0263	13.400	13.4	0.1	0.211	0.1512
4	0.0290	17.300	17.3	0.2	0.273	0.1510
5	0.0330	20.500	20.5	0.4	0.323	0.1507
6	0.0400	22.400	22.4	0.7	0.353	0.1498
7	0.0540	24.600	24.6	1.2	0.388	0.1480
8	0.0713	26.800	26.8	2.0	0.422	0.1457
9	0.0882	27.900	27.9	2.7	0.440	0.1436
10	0.1008	29.100	29.1	3.2	0.459	0.1422
11	0.1160	30.400	30.4	3.8	0.479	0.1407
12	0.1400	32.000	32.0	4.8	0.504	0.1387
13	0.1633	33.200	33.2	5.8	0.523	0.1372
14	0.2020	35.100	35.1	7.4	0.553	0.1351

Braun Intertec

Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
15	0.2200	35.900	35.9	8.1	0.566	0.1343
16	0.2460	36.500	36.5	9.2	0.575	0.1333
17	0.2730	37.000	37.0	10.3	0.583	0.1326
18	0.2980	36.400	36.4	11.4	0.574	0.1320
19	0.3200	33.900	33.9	12.3	0.534	0.1320
20	0.3500	32.800	32.8	13.5	0.517	0.1320
21	0.3850	32.500	32.5	15.0	0.512	0.1320

Parameters for Specimen No. 2

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	112.180		155.770
Moisture content: Dry soil+tare, gms.	88.100		121.700
Moisture content: Tare, gms.	30.100		29.890
Moisture, %	41.5	37.1	37.1
Moist specimen weight, gms.	135.5		
Diameter, in.	2.41	2.41	
Area, in.^{2}	4.57	4.57	
Height, in.	1.00	0.94	
Net decrease in height, in.		0.06	
Wet Density, pcf	113.4	116.5	
Dry density, pcf	80.2	85.0	
Void ratio	1.1419	1.0204	
Saturation, %	100.0	100.0	

Test Readings for Specimen No. 2

Normal stress = 1.926 tsf

Fail. Stress = 0.912 tsf at reading no. 17

Ult. Stress = 0.835 tsf at reading no. 19

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0201	0.000	0.0	0.0	0.000	0.1293
1	0.0202	5.400	5.4	0.0	0.085	0.1293
2	0.0207	9.100	9.1	0.0	0.143	0.1293
3	0.0247	21.200	21.2	0.2	0.334	0.1290
4	0.0280	24.700	24.7	0.3	0.389	0.1283
5	0.0330	27.600	27.6	0.5	0.435	0.1272
6	0.0430	32.500	32.5	1.0	0.512	0.1246
7	0.0530	35.100	35.1	1.4	0.553	0.1219
8	0.0700	39.400	39.4	2.1	0.621	0.1174
9	0.0850	41.600	41.6	2.7	0.656	0.1138
10	0.1086	45.200	45.2	3.7	0.712	0.1087
11	0.1393	48.700	48.7	4.9	0.767	0.1027
12	0.1630	50.700	50.7	5.9	0.799	0.0985
13	0.1890	52.600	52.6	7.0	0.829	0.0943
14	0.2044	53.800	53.8	7.6	0.848	0.0923
15	0.2775	57.400	57.4	10.7	0.904	0.0838
16	0.2947	57.800	57.8	11.4	0.911	0.0826
17	0.3235	57.900	57.9	12.6	0.912	0.0810

Test Readings for Specimen No. 2

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
18	0.3500	56.000	56.0	13.7	0.882	0.0802
19	0.3830	53.000	53.0	15.0	0.835	0.0795

Parameters for Specimen No. 3

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	96.360		145.630
Moisture content: Dry soil+tare, gms.	76.690		116.600
Moisture content: Tare, gms.	31.180		30.280
Moisture, %	43.2	33.6	33.6
Moist specimen weight, gms.	131.6		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.86	
Net decrease in height, in.		0.14	
Wet Density, pcf	110.3	119.0	
Dry density, pcf	77.0	89.1	
Void ratio	1.2299	0.9274	
Saturation, %	96.6	99.7	

Test Readings for Specimen No. 3

Normal stress = 4.084 tsf

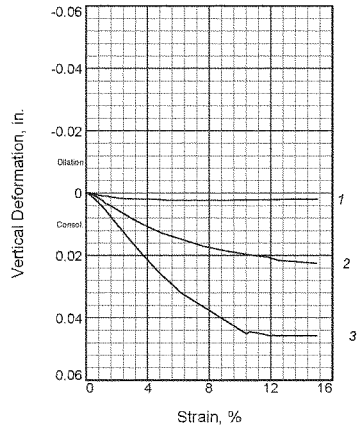
Fail. Stress = 1.465 tsf at reading no. 21

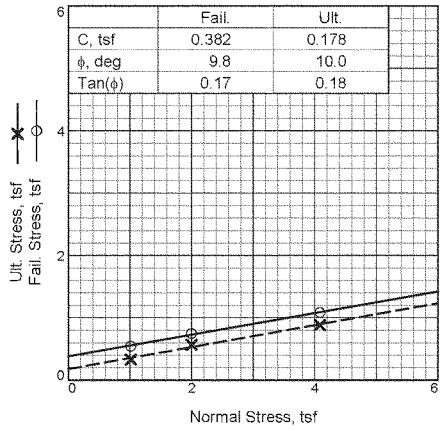
Ult. Stress = 1.292 tsf at reading no. 29

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0214	0.000	0.0	0.0	0.000	0.0356
1	0.0215	5.600	5.6	0.0	0.088	0.0356
2	0.0220	12.200	12.2	0.0	0.192	0.0356
3	0.0226	17.400	17.4	0.1	0.274	0.0355
4	0.0234	23.600	23.6	0.1	0.372	0.0354
5	0.0244	29.000	29.0	0.1	0.457	0.0353
6	0.0256	33.300	33.3	0.2	0.525	0.0352
7	0.0270	38.700	38.7	0.2	0.610	0.0349
8	0.0290	42.100	42.1	0.3	0.663	0.0346
9	0.0320	46.400	46.4	0.4	0.731	0.0340
10	0.0350	49.500	49.5	0.6	0.780	0.0333
11	0.0380	51.500	51.5	0.7	0.812	0.0326
12	0.0430	55.200	55.2	0.9	0.870	0.0313
13	0.0500	59.900	59.9	1.2	0.944	0.0294
14	0.0622	65.400	65.4	1.7	1.031	0.0262
15	0.0710	68.500	68.5	2.1	1.079	0.0241
16	0.0840	74.700	74.7	2.6	1.177	0.0211
17	0.1000	79.300	79.3	3.3	1.250	0.0176
18	0.1210	85.500	85.5	4.1	1.347	0.0142
19	0.1403	89.300	89.3	4.9	1.407	0.0114
20	0.1620	91.600	91.6	5.8	1.443	0.0090
21	0.1800	93.000	93.0	6.6	1.465	0.0074
22	0.2442	87.000	87.0	9.2	1.371	0.0041

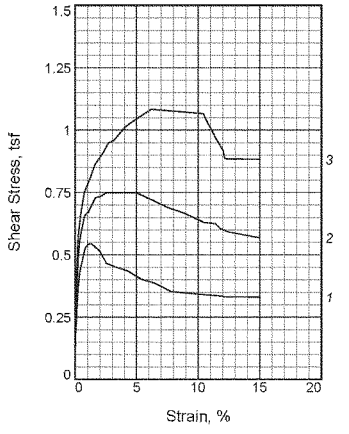
Test Readings for Specimen No. 3

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
23	0.2577	85.500	85.5	9.8	1.347	0.0036
24	0.2746	83.800	83.8	10.5	1.320	0.0032
25	0.2900	83.000	83.0	11.1	1.308	0.0029
26	0.3030	82.700	82.7	11.7	1.303	0.0025
27	0.3200	82.500	82.5	12.4	1.300	0.0022
28	0.3500	82.000	82.0	13.6	1.292	0.0019
29	0.3820	82.000	82.0	15.0	1.292	0.0017





	Fail.	Ult.
C, tsf	0.382	0.178
ϕ, deg	9.8	10.0
Tan(ϕ)	0.17	0.18



Sample No.		1	2	3
Initial	Water Content, %	47.5	47.3	54.4
	Dry Density, pcf	73.7	74.1	68.4
	Saturation, %	99.2	99.9	100.0
	Void Ratio	1.3003	1.2850	1.4760
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.99	1.00	1.00
At Test	Water Content, %	46.7	45.0	45.3
	Dry Density, pcf	74.7	76.3	76.0
	Saturation, %	99.9	99.9	100.0
	Void Ratio	1.2679	1.2213	1.2299
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.98	0.98	0.90
Normal Stress, tsf		1.011	2.000	4.084
Fail. Stress, tsf		0.544	0.748	1.083
Strain, %		1.4	2.6	6.2
Ult. Stress, tsf		0.329	0.567	0.882
Strain, %		15.0	15.0	15.0
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, gray (CH)

LL= 81 **PL=** 20 **PI=** 61
Assumed Specific Gravity= 2.714
Remarks: The rate of strain is 0.00096 in/min.

Figure DirectShear ASTM D3080

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Location: SE-F-13, Fargo, Argusville Formation
Sample Number: Boring 09-25MU, #5 **Depth:** 66-68'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: JS **Checked By:** IS

DIRECT SHEAR TEST

11/9/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-F-13, Fargo, Argusville Formation
Depth: 66-68' Sample Number: Boring 09-25MU, #5
Description: FAT CLAY, gray (CH)
Remarks: The rate of strain is 0.00096 in/min.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.714 LL=81 PL=20 PI=61

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	126.330		158.430
Moisture content: Dry soil+tare, gms.	95.390		117.900
Moisture content: Tare, gms.	30.270		31.040
Moisture, %	47.5	46.7	46.7
Moist specimen weight, gms.	129.4		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	0.99	0.98	
Net decrease in height, in.		0.01	
Wet Density, pcf	108.6	109.6	
Dry density, pcf	73.7	74.7	
Void ratio	1.3003	1.2679	
Saturation, %	99.2	99.9	

Test Readings for Specimen No. 1

Normal stress = 1.011 tsf
Fail. Stress = 0.544 tsf at reading no. 8
Ult. Stress = 0.329 tsf at reading no. 22

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0172	0.000	0.0	0.0	0.000	0.1078
1	0.0179	6.400	6.4	0.0	0.101	0.1078
2	0.0187	10.800	10.8	0.1	0.170	0.1078
3	0.0235	23.300	23.3	0.3	0.367	0.1078
4	0.0270	27.400	27.4	0.4	0.432	0.1077
5	0.0320	30.500	30.5	0.6	0.481	0.1074
6	0.0370	33.300	33.3	0.8	0.525	0.1071
7	0.0430	34.400	34.4	1.1	0.542	0.1069
8	0.0500	34.500	34.5	1.4	0.544	0.1068
9	0.0660	32.600	32.6	2.0	0.514	0.1063
10	0.0783	29.500	29.5	2.5	0.465	0.1060
11	0.1000	28.400	28.4	3.4	0.448	0.1059
12	0.1213	27.600	27.6	4.3	0.435	0.1059
13	0.1470	25.500	25.5	5.4	0.402	0.1055

Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
14	0.1752	24.400	24.4	6.6	0.384	0.1055
15	0.2060	22.300	22.3	7.8	0.351	0.1055
16	0.2240	22.100	22.1	8.6	0.348	0.1055
17	0.2715	21.500	21.5	10.5	0.339	0.1056
18	0.2960	21.300	21.3	11.6	0.336	0.1057
19	0.3037	21.200	21.2	11.9	0.334	0.1056
20	0.3101	21.000	21.0	12.1	0.331	0.1057
21	0.3300	21.000	21.0	13.0	0.331	0.1058
22	0.3800	20.900	20.9	15.0	0.329	0.1059

Parameters for Specimen No. 2

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	108.830		159.380
Moisture content: Dry soil+tare, gms.	83.750		119.390
Moisture content: Tare, gms.	30.750		30.460
Moisture, %	47.3	45.0	45.0
Moist specimen weight, gms.	131.6		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.98	
Net decrease in height, in.		0.03	
Wet Density, pcf	109.2	110.6	
Dry density, pcf	74.1	76.3	
Void ratio	1.2850	1.2213	
Saturation, %	99.9	99.9	

Test Readings for Specimen No. 2

Normal stress = 2 tsf

Fail. Stress = 0.748 tsf at reading no. 16

Ult. Stress = 0.567 tsf at reading no. 26

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0145	0.000	0.0	0.0	0.000	0.1386
1	0.0147	4.500	4.5	0.0	0.071	0.1386
2	0.0155	10.600	10.6	0.0	0.167	0.1386
3	0.0163	15.200	15.2	0.1	0.240	0.1387
4	0.0171	19.900	19.9	0.1	0.314	0.1386
5	0.0190	24.900	24.9	0.2	0.392	0.1385
6	0.0212	31.000	31.0	0.3	0.488	0.1385
7	0.0240	35.200	35.2	0.4	0.555	0.1382
8	0.0270	37.600	37.6	0.5	0.592	0.1379
9	0.0300	39.400	39.4	0.6	0.621	0.1375
10	0.0330	41.500	41.5	0.8	0.654	0.1372
11	0.0370	42.200	42.2	0.9	0.665	0.1367
12	0.0410	42.600	42.6	1.1	0.671	0.1362
13	0.0440	43.500	43.5	1.2	0.685	0.1354
14	0.0544	46.200	46.2	1.7	0.728	0.1344
15	0.0640	46.500	46.5	2.1	0.733	0.1332

Test Readings for Specimen No. 2

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
16	0.0770	47.500	47.5	2.6	0.748	0.1316
17	0.0880	47.500	47.5	3.0	0.748	0.1303
18	0.1145	47.500	47.5	4.1	0.748	0.1275
19	0.1340	47.500	47.5	5.0	0.748	0.1257
20	0.1987	43.600	43.6	7.6	0.687	0.1215
21	0.2303	42.200	42.2	8.9	0.665	0.1202
22	0.2670	39.900	39.9	10.5	0.629	0.1189
23	0.2893	39.600	39.6	11.4	0.624	0.1183
24	0.3000	38.300	38.3	11.8	0.604	0.1181
25	0.3153	37.500	37.5	12.5	0.591	0.1170
26	0.3760	36.000	36.0	15.0	0.567	0.1161

Parameters for Specimen No. 3

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	104.540		145.840
Moisture content: Dry soil+tare, gms.	78.550		109.590
Moisture content: Tare, gms.	30.770		29.570
Moisture, %	54.4	45.3	45.3
Moist specimen weight, gms.	126.6		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.90	
Net decrease in height, in.		0.10	
Wet Density, pcf	105.6	110.4	
Dry density, pcf	68.4	76.0	
Void ratio	1.4760	1.2299	
Saturation, %	100.0	100.0	

Test Readings for Specimen No. 3

Normal stress = 4.084 tsf

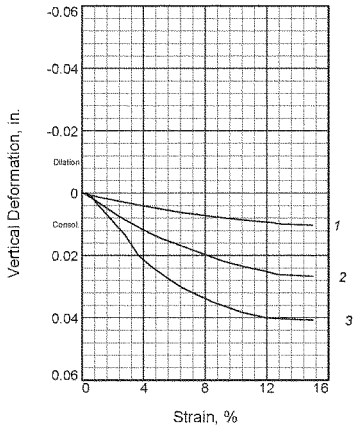
Fail. Stress = 1.083 tsf at reading no. 17

Ult. Stress = 0.882 tsf at reading no. 24

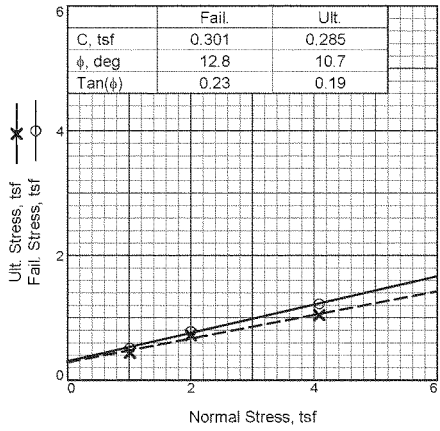
No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0148	0.000	0.0	0.0	0.000	0.1229
1	0.0150	6.500	6.5	0.0	0.102	0.1229
2	0.0157	12.400	12.4	0.0	0.195	0.1228
3	0.0164	18.900	18.9	0.1	0.298	0.1229
4	0.0181	26.600	26.6	0.1	0.419	0.1226
5	0.0200	33.700	33.7	0.2	0.531	0.1224
6	0.0215	36.400	36.4	0.3	0.574	0.1222
7	0.0260	42.000	42.0	0.5	0.662	0.1215
8	0.0330	47.400	47.4	0.8	0.747	0.1202
9	0.0453	51.500	51.5	1.3	0.812	0.1174
10	0.0540	54.600	54.6	1.6	0.860	0.1151
11	0.0700	57.700	57.7	2.3	0.909	0.1113
12	0.0800	60.100	60.1	2.7	0.947	0.1088
13	0.0903	60.700	60.7	3.1	0.956	0.1063

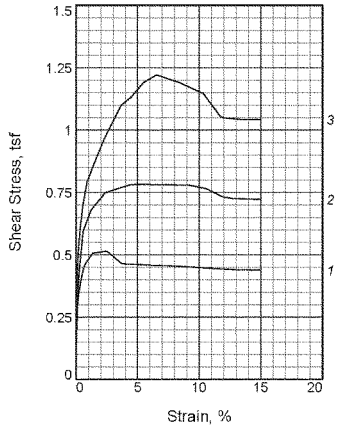
Test Readings for Specimen No. 3

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
14	0.1020	62.500	62.5	3.6	0.985	0.1035
15	0.1130	64.200	64.2	4.1	1.012	0.1010
16	0.1263	65.500	65.5	4.6	1.032	0.0981
17	0.1640	68.700	68.7	6.2	1.083	0.0909
18	0.2662	67.600	67.6	10.4	1.065	0.0778
19	0.2720	65.900	65.9	10.7	1.038	0.0784
20	0.2907	61.300	61.3	11.4	0.966	0.0778
21	0.3050	58.200	58.2	12.0	0.917	0.0770
22	0.3084	56.300	56.3	12.2	0.887	0.0773
23	0.3122	56.100	56.1	12.3	0.884	0.0771
24	0.3760	56.000	56.0	15.0	0.882	0.0771



	Fail.	Ult.
C, tsf	0.301	0.285
ϕ, deg	12.8	10.7
Tan(ϕ)	0.23	0.19





Sample No.		1	2	3
Initial	Water Content, %	44.8	46.3	49.7
	Dry Density, pcf	76.9	75.0	71.2
	Saturation, %	100.0	98.7	96.8
	Void Ratio	1.2314	1.2886	1.4113
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.00	1.00	0.99
At Test	Water Content, %	43.0	42.8	41.1
	Dry Density, pcf	78.5	78.5	80.5
	Saturation, %	99.6	99.3	99.8
	Void Ratio	1.1859	1.1863	1.1321
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.98	0.96	0.88
Normal Stress, tsf		1.011	2.000	4.084
Fail. Stress, tsf		0.514	0.782	1.221
Strain, %		2.5	5.1	6.5
Ult. Stress, tsf		0.438	0.722	1.042
Strain, %		15.0	15.0	15.0
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, gray (CH)

LL= 79 **PL=** 21 **PI=** 58
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min.

Figure DirectShear ASTMD3080

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Location: SE-M-18, Moorhead, Argusville Formation
Sample Number: Boring 09-34MU, #4 **Depth:** 56-58'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs

DIRECT SHEAR TEST

11/9/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-M-18, Moorhead, Argusville Formation
Depth: 56-58' Sample Number: Boring 09-34MU, #4
Description: FAT CLAY, gray (CH)
Remarks: The rate of strain is 0.00096 in/min.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.75 LL=79 PL=21 PI=58

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	136.510		161.690
Moisture content: Dry soil+tare, gms.	103.810		122.200
Moisture content: Tare, gms.	30.800		30.260
Moisture, %	44.8	43.0	43.0
Moist specimen weight, gms.	133.6		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.98	
Net decrease in height, in.		0.02	
Wet Density, pcf	111.4	112.3	
Dry density, pcf	76.9	78.5	
Void ratio	1.2314	1.1859	
Saturation, %	100.0	99.6	

Test Readings for Specimen No. 1

Normal stress = 1.011 tsf
Fail. Stress = 0.514 tsf at reading no. 11
Ult. Stress = 0.438 tsf at reading no. 19

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0091	0.000	0.0	0.0	0.000	0.1569
1	0.0092	3.400	3.4	0.0	0.054	0.1570
2	0.0098	8.600	8.6	0.0	0.136	0.1570
3	0.0104	11.500	11.5	0.1	0.181	0.1570
4	0.0115	15.100	15.1	0.1	0.238	0.1569
5	0.0125	18.900	18.9	0.1	0.298	0.1568
6	0.0147	22.000	22.0	0.2	0.347	0.1567
7	0.0194	25.400	25.4	0.4	0.400	0.1564
8	0.0240	28.300	28.3	0.6	0.446	0.1561
9	0.0287	29.600	29.6	0.8	0.466	0.1559
10	0.0420	32.100	32.1	1.4	0.506	0.1553
11	0.0701	32.600	32.6	2.5	0.514	0.1542
12	0.0993	29.400	29.4	3.7	0.463	0.1530
13	0.1624	29.000	29.0	6.4	0.457	0.1507

Braun Intertec

Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
14	0.1893	28.900	28.9	7.5	0.455	0.1500
15	0.2305	28.600	28.6	9.2	0.451	0.1489
16	0.2760	28.200	28.2	11.1	0.444	0.1480
17	0.3090	28.000	28.0	12.4	0.441	0.1474
18	0.3200	27.900	27.9	12.9	0.440	0.1470
19	0.3700	27.800	27.8	15.0	0.438	0.1466

Parameters for Specimen No. 2

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	126.490		156.510
Moisture content: Dry soil+tare, gms.	96.170		118.820
Moisture content: Tare, gms.	30.620		30.830
Moisture, %	46.3	42.8	42.8
Moist specimen weight, gms.	131.6		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.96	
Net decrease in height, in.		0.04	
Wet Density, pcf	109.7	112.2	
Dry density, pcf	75.0	78.5	
Void ratio	1.2886	1.1863	
Saturation, %	98.7	99.3	

Test Readings for Specimen No. 2

Normal stress = 2 tsf

Fail. Stress = 0.782 tsf at reading no. 10

Ult. Stress = 0.722 tsf at reading no. 15

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0140	0.000	0.0	0.0	0.000	0.1482
1	0.0142	3.400	3.4	0.0	0.054	0.1481
2	0.0152	12.700	12.7	0.0	0.200	0.1481
3	0.0170	20.300	20.3	0.1	0.320	0.1481
4	0.0204	27.500	27.5	0.3	0.433	0.1478
5	0.0280	37.700	37.7	0.6	0.594	0.1468
6	0.0440	43.100	43.1	1.2	0.679	0.1446
7	0.0709	47.400	47.4	2.4	0.747	0.1409
8	0.1061	48.900	48.9	3.8	0.771	0.1369
9	0.1207	49.500	49.5	4.4	0.780	0.1353
10	0.1360	49.600	49.6	5.1	0.782	0.1338
11	0.2358	49.400	49.4	9.2	0.778	0.1263
12	0.2694	48.500	48.5	10.6	0.764	0.1245
13	0.3012	46.400	46.4	11.9	0.731	0.1231
14	0.3200	46.000	46.0	12.7	0.725	0.1221
15	0.3760	45.800	45.8	15.0	0.722	0.1215

Parameters for Specimen No. 3			
Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	113.770		147.150
Moisture content: Dry soil+tare, gms.	86.010		113.350
Moisture content: Tare, gms.	30.120		31.120
Moisture, %	49.7	41.1	41.1
Moist specimen weight, gms.	127.0		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	0.99	0.88	
Net decrease in height, in.		0.12	
Wet Density, pcf	106.6	113.6	
Dry density, pcf	71.2	80.5	
Void ratio	1.4113	1.1321	
Saturation, %	96.8	99.8	

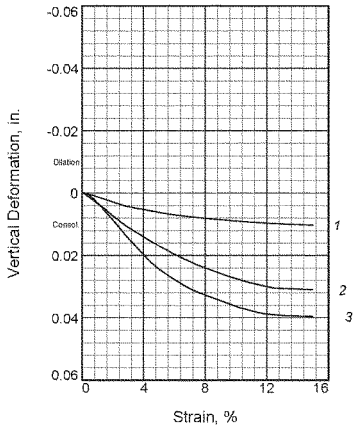
Test Readings for Specimen No. 3

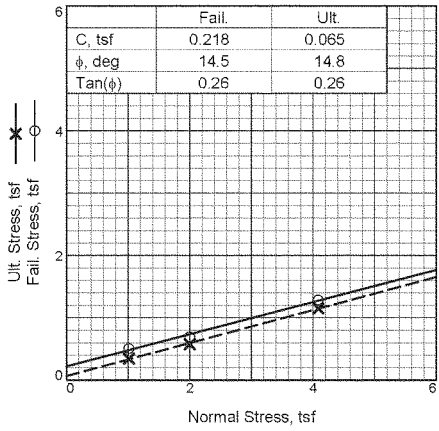
Normal stress = 4.084 tsf

Fail. Stress = 1.221 tsf at reading no. 13

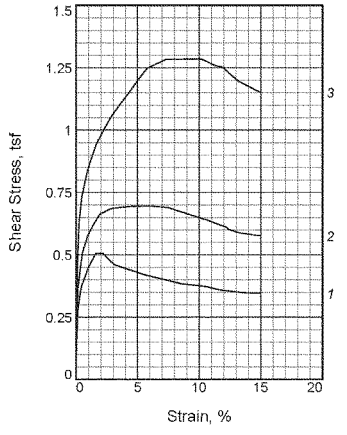
Ult. Stress = 1.042 tsf at reading no. 19

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0207	0.000	0.0	0.0	0.000	0.0423
1	0.0217	13.900	13.9	0.0	0.219	0.0423
2	0.0230	23.700	23.7	0.1	0.373	0.0422
3	0.0252	32.300	32.3	0.2	0.509	0.0420
4	0.0293	38.500	38.5	0.4	0.607	0.0416
5	0.0342	44.000	44.0	0.6	0.693	0.0415
6	0.0427	50.200	50.2	0.9	0.791	0.0392
7	0.0581	55.500	55.5	1.6	0.875	0.0357
8	0.0769	61.300	61.3	2.3	0.966	0.0314
9	0.0883	64.400	64.4	2.8	1.015	0.0288
10	0.1089	69.700	69.7	3.7	1.098	0.0223
11	0.1287	71.800	71.8	4.5	1.131	0.0189
12	0.1526	75.500	75.5	5.5	1.190	0.0153
13	0.1784	77.500	77.5	6.5	1.221	0.0118
14	0.2250	75.400	75.4	8.5	1.188	0.0074
15	0.2703	72.700	72.7	10.3	1.146	0.0041
16	0.3030	66.900	66.9	11.7	1.054	0.0025
17	0.3105	66.500	66.5	12.0	1.048	0.0022
18	0.3410	66.200	66.2	13.3	1.043	0.0019
19	0.3820	66.100	66.1	15.0	1.042	0.0015





	Fail.	Ult.
C, tsf	0.218	0.065
ϕ, deg	14.5	14.8
Tan(ϕ)	0.26	0.26



Sample No.		1	2	3
Initial	Water Content, %	47.9	47.3	48.9
	Dry Density, pcf	74.0	73.3	72.4
	Saturation, %	99.8	96.9	98.0
	Void Ratio	1.3194	1.3435	1.3725
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	46.2	44.8	40.6
	Dry Density, pcf	75.5	76.5	80.9
	Saturation, %	99.7	98.9	99.7
	Void Ratio	1.2734	1.2454	1.1213
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.98	0.96	0.89
Normal Stress, tsf		1.011	2.000	4.084
Fail. Stress, tsf		0.506	0.695	1.284
Strain, %		2.2	6.1	10.2
Ult. Stress, tsf		0.345	0.575	1.150
Strain, %		15.0	15.0	15.0
Strain rate, in./min.		N/A	N/A	N/A

Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY with a trace of gravel, brown (CH)
LL= 76 **PL=** 20 **PI=** 56
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min.

Figure DirectShear ASTM D3080

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Location: SE-M-11, Moorhead, Argusville Formation
Sample Number: Boring 09-53MU, #3 **Depth:** 68-70'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs

DIRECT SHEAR TEST

11/16/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-M-11, Moorhead, Argusville Formation
Depth: 68-70' Sample Number: Boring 09-53MU, #3
Description: FAT CLAY with a trace of gravel, brown (CH)
Remarks: The rate of strain is 0.00096 in/min.
Type of Sample: Thinwall, 5", Middle of sample
Assumed Specific Gravity=2.75 LL=76 PL=20 PI=56

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	139.810		160.240
Moisture content: Dry soil+tare, gms.	104.500		119.550
Moisture content: Tare, gms.	30.740		31.430
Moisture, %	47.9	46.2	46.2
Moist specimen weight, gms.	130.9		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.98	
Net decrease in height, in.		0.02	
Wet Density, pcf	109.4	110.4	
Dry density, pcf	74.0	75.5	
Void ratio	1.3194	1.2734	
Saturation, %	99.8	99.7	

Test Readings for Specimen No. 1

Normal stress = 1.011 tsf
Fail. Stress = 0.506 tsf at reading no. 10
Ult. Stress = 0.345 tsf at reading no. 19

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0112	0.000	0.0	0.0	0.000	0.1033
1	0.0119	5.500	5.5	0.0	0.087	0.1033
2	0.0126	9.100	9.1	0.1	0.143	0.1033
3	0.0138	12.900	12.9	0.1	0.203	0.1033
4	0.0149	17.300	17.3	0.2	0.273	0.1033
5	0.0182	20.600	20.6	0.3	0.325	0.1032
6	0.0222	23.700	23.7	0.5	0.373	0.1029
7	0.0275	25.500	25.5	0.7	0.402	0.1026
8	0.0369	28.900	28.9	1.1	0.455	0.1020
9	0.0500	32.000	32.0	1.6	0.504	0.1011
10	0.0640	32.100	32.1	2.2	0.506	0.1001
11	0.0798	29.900	29.9	2.8	0.471	0.0991
12	0.0900	29.000	29.0	3.3	0.457	0.0987
13	0.1485	26.500	26.5	5.7	0.418	0.0965

Braun Intertec

Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
14	0.1844	25.400	25.4	7.2	0.400	0.0956
15	0.2185	24.300	24.3	8.6	0.383	0.0949
16	0.2663	23.600	23.6	10.6	0.372	0.0941
17	0.2943	22.700	22.7	11.7	0.358	0.0937
18	0.3340	22.100	22.1	13.4	0.348	0.0933
19	0.3730	21.900	21.9	15.0	0.345	0.0930

Parameters for Specimen No. 2

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	101.110		155.910
Moisture content: Dry soil+tare, gms.	78.670		116.990
Moisture content: Tare, gms.	31.270		30.130
Moisture, %	47.3	44.8	44.8
Moist specimen weight, gms.	129.6		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.96	
Net decrease in height, in.		0.04	
Wet Density, pcf	107.9	110.7	
Dry density, pcf	73.3	76.5	
Void ratio	1.3435	1.2454	
Saturation, %	96.9	98.9	

Test Readings for Specimen No. 2

Normal stress = 2 tsf

Fail. Stress = 0.695 tsf at reading no. 13

Ult. Stress = 0.575 tsf at reading no. 22

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0122	0.000	0.0	0.0	0.000	0.1240
1	0.0124	4.400	4.4	0.0	0.069	0.1240
2	0.0130	9.900	9.9	0.0	0.156	0.1240
3	0.0140	15.100	15.1	0.1	0.238	0.1240
4	0.0150	19.500	19.5	0.1	0.307	0.1239
5	0.0165	23.400	23.4	0.2	0.369	0.1238
6	0.0200	27.200	27.2	0.3	0.429	0.1232
7	0.0250	32.300	32.3	0.5	0.509	0.1225
8	0.0357	36.700	36.7	1.0	0.578	0.1208
9	0.0463	39.400	39.4	1.4	0.621	0.1192
10	0.0589	42.000	42.0	1.9	0.662	0.1170
11	0.0820	43.500	43.5	2.9	0.685	0.1134
12	0.1193	44.000	44.0	4.4	0.693	0.1087
13	0.1582	44.100	44.1	6.1	0.695	0.1043
14	0.1930	43.700	43.7	7.5	0.689	0.1009
15	0.2419	41.600	41.6	9.5	0.656	0.0973
16	0.2703	40.500	40.5	10.7	0.638	0.0955
17	0.2950	39.200	39.2	11.7	0.618	0.0943
18	0.3009	39.000	39.0	12.0	0.615	0.0940

Test Readings for Specimen No. 2

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
19	0.3065	38.700	38.7	12.2	0.610	0.0938
20	0.3117	38.100	38.1	12.4	0.600	0.0935
21	0.3350	37.200	37.2	13.4	0.586	0.0933
22	0.3730	36.500	36.5	15.0	0.575	0.0930

Parameters for Specimen No. 3

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	120.060		149.050
Moisture content: Dry soil+tare, gms.	90.520		114.750
Moisture content: Tare, gms.	30.140		30.350
Moisture, %	48.9	40.6	40.6
Moist specimen weight, gms.	129.3		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.89	
Net decrease in height, in.		0.11	
Wet Density, pcf	107.8	113.8	
Dry density, pcf	72.4	80.9	
Void ratio	1.3725	1.1213	
Saturation, %	98.0	99.7	

Test Readings for Specimen No. 3

Normal stress = 4.084 tsf

Fail. Stress = 1.284 tsf at reading no. 23

Ult. Stress = 1.150 tsf at reading no. 27

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0136	0.000	0.0	0.0	0.000	0.1330
1	0.0137	4.900	4.9	0.0	0.077	0.1330
2	0.0140	10.400	10.4	0.0	0.164	0.1330
3	0.0145	14.400	14.4	0.0	0.227	0.1330
4	0.0150	19.600	19.6	0.1	0.309	0.1330
5	0.0159	25.000	25.0	0.1	0.394	0.1330
6	0.0169	30.100	30.1	0.1	0.474	0.1329
7	0.0185	35.700	35.7	0.2	0.563	0.1329
8	0.0197	39.800	39.8	0.3	0.627	0.1327
9	0.0222	42.700	42.7	0.4	0.673	0.1325
10	0.0250	46.300	46.3	0.5	0.730	0.1322
11	0.0300	49.500	49.5	0.7	0.780	0.1314
12	0.0350	52.400	52.4	0.9	0.826	0.1304
13	0.0400	54.600	54.6	1.1	0.860	0.1294
14	0.0540	60.000	60.0	1.7	0.945	0.1262
15	0.0690	63.800	63.8	2.3	1.005	0.1227
16	0.0829	66.900	66.9	2.9	1.054	0.1192
17	0.0995	69.900	69.9	3.6	1.101	0.1155
18	0.1200	73.400	73.4	4.4	1.157	0.1111
19	0.1362	76.400	76.4	5.1	1.204	0.1083
20	0.1524	79.100	79.1	5.8	1.246	0.1061

Test Readings for Specimen No. 3

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
21	0.1740	80.400	80.4	6.7	1.267	0.1033
22	0.1905	81.400	81.4	7.3	1.283	0.1015
23	0.2592	81.500	81.5	10.2	1.284	0.0963
24	0.2870	79.800	79.8	11.3	1.257	0.0948
25	0.3003	79.500	79.5	11.9	1.253	0.0942
26	0.3310	75.900	75.9	13.2	1.196	0.0937
27	0.3750	73.000	73.0	15.0	1.150	0.0934

Direct Shear Test

ASTM: D3080

Job No.: 7577

Project: **Fargo-Moorhead Metro Feasibility Project - # W912ES-10-T-0095**

Boring No.: **10-78MU** Sample No. **3** Depth: **55 - 57 (Bot)**

Location: Fargo **ND Wild Rice** Sample Type: **5T**

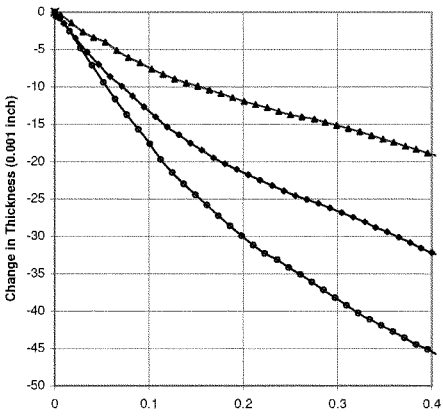
Soil Type: **Fat Clay w/a few pockets of Silt (CH)** Argusville

Test Date:	8/13/2010
Date Reported:	8/19/2010
Shear Rate	
0.000378 (in/min)	

Remarks: Specimens trimmed to given sizes; Inundated after applying normal load; Allowed to consolidate for about 3-16 Hrs.; Sheared to given displacements at constant rate of 0.000378"/min..

Liquid Limit:	63.8
Plastic Limit:	23.1
Plasticity Index:	40.7
Specific Gravity (*):	2.78

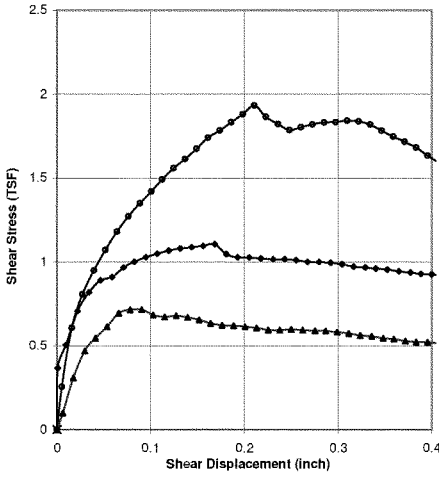
(*) = Assumed Specific Gravity

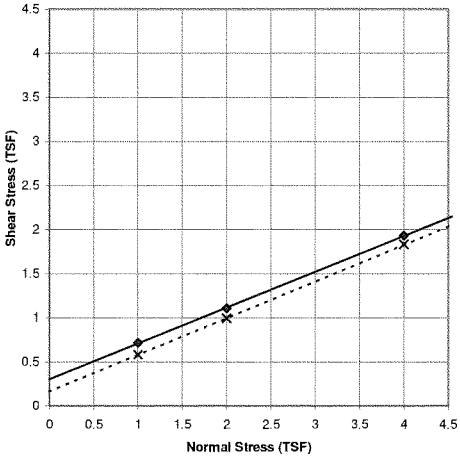


Failure Criterion:				
Max. Shear Stress	A	B	C	D
Initial	▲	◇	○	X
Diameter (In.)	2.50	2.50	2.50	
Thickness (In.)	0.72	0.72	0.72	
Water Content (%)	43.3	42.3	46.6	
Dry Density (pcf)	76.2	77.9	75.4	
Before Shear				
Thickness (In.)	0.69	0.68	0.65	
Water Content (%)	42.9	39.8	38.4	
Dry Density (pcf)	79.1	82.4	83.9	
Normal Stress	1.00	2.00	4.00	
Shear Stress	0.72	1.11	1.93	

"These tests are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design."

Peak Conditions		At Given Shear Disp. Of:	0.3
Friction Angle:	ϕ= 22.1 deg.	Friction Angle:	ϕ= 22.6 deg.
Apparent Cohesion	0.303 TSF	Apparent Cohesion	0.161 TSF





Direct Shear Test Data

Job No.: 7577

ASTM: D3080

Project: **Fargo-Moorhead Metro Feasibility Project - # W912ES-10-T-0095**

Boring No.: **10-78MU** Sample No. **3** Depth: **55 - 57 (Bot)**

Location: Fargo **ND Wild Rice** Samp. Type: **5T**

Soil Type: **Fat Clay w/a few pockets of Silt (CH)** Argusville

Test Date: **8/13/2010**

Date Reported: **8/19/2010**

Shear Rate

Normal Load: 1 tsf				Normal Load: 2 tsf				Normal Load: 4 tsf				Normal Load: 0 tsf			
Rdg. #	Load lbs	Shear in	Vert. in	Rdg. #	Load lbs	Shear in	Vert. in	Rdg. #	Load lbs	Shear in	Vert. in	Rdg. #	Load lbs	Shear in	Vert. in
1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0
2	6.8	0.006	-0.413	2	25	9E-04	-0.62	2	17.4	0.005	-0.826	2			
3	21	0.018	-1.446	3	34.4	0.01	-1.549	3	41.4	0.016	-2.582	3			
4	32	0.03	-2.686	4	48.2	0.022	-3.512	4	55	0.027	-4.855	4			
5	37.2	0.041	-3.409	5	55.8	0.034	-5.371	5	64.7	0.039	-7.127	5			
6	41.8	0.053	-4.028	6	60.7	0.046	-7.024	6	73	0.052	-9.399	6			
7	47.3	0.066	-5.165	7	62	0.059	-8.676	7	80.4	0.064	-11.67	7			
8	48.7	0.078	-6.094	8	65.9	0.071	-9.916	8	86.7	0.076	-13.74	8			
9	48.8	0.09	-6.817	9	68.2	0.082	-11.26	9	92	0.089	-15.7	9			
10	46.6	0.103	-7.643	10	70	0.095	-12.7	10	96.8	0.101	-17.66	10			
11	45.8	0.115	-8.366	11	71.5	0.107	-14.05	11	101.6	0.112	-19.73	11			
12	46.3	0.127	-8.986	12	72.8	0.119	-15.39	12	106.2	0.125	-21.48	12			
13	45.6	0.139	-9.503	13	73.6	0.132	-16.42	13	109.9	0.137	-23.03	13			
14	44.6	0.152	-9.916	14	74.1	0.144	-17.56	14	114.1	0.149	-24.48	14			
15	43.2	0.164	-10.43	15	74.7	0.156	-18.49	15	118.6	0.161	-25.82	15			
16	42.4	0.176	-10.95	16	75.4	0.168	-19.52	16	121.6	0.174	-27.27	16			
17	42.2	0.189	-11.47	17	71.3	0.181	-20.35	17	124.9	0.186	-28.61	17			
18	41.8	0.201	-11.98	18	70	0.193	-21.07	18	128.1	0.198	-29.95	18			
19	41.3	0.213	-12.39	19	69.9	0.205	-21.79	19	131.7	0.21	-31.19	19			
20	40.5	0.225	-12.81	20	69.5	0.217	-22.52	20	127.1	0.223	-32.33	20			
21	40.4	0.238	-13.32	21	69.2	0.231	-23.24	21	124.2	0.236	-33.16	21			
22	40.7	0.25	-13.74	22	69.2	0.243	-23.96	22	121.7	0.248	-34.19	22			
23	40.4	0.262	-14.05	23	68.9	0.255	-24.58	23	122.9	0.26	-35.12	23			
24	40.2	0.275	-14.36	24	68.2	0.267	-25.1	24	124	0.273	-36.15	24			
25	40.1	0.287	-14.77	25	68.1	0.28	-25.62	25	124.8	0.285	-37.18	25			
26	39.6	0.299	-15.18	26	67.8	0.292	-26.24	26	125	0.297	-38.22	26			
27	39.1	0.311	-15.6	27	67.2	0.304	-26.86	27	125.5	0.31	-39.25	27			
28	38.3	0.324	-16.01	28	66.2	0.317	-27.48	28	125.2	0.322	-40.28	28			
29	37.9	0.336	-16.53	29	65.9	0.329	-28.09	29	123.9	0.334	-41.11	29			
30	37.1	0.348	-17.04	30	65.4	0.34	-28.82	30	121.5	0.346	-41.94	30			
31	36.8	0.36	-17.46	31	65	0.353	-29.44	31	119	0.359	-42.76	31			
32	36	0.372	-17.97	32	64.3	0.365	-30.16	32	117	0.371	-43.59	32			
33	35.6	0.383	-18.39	33	63.8	0.377	-30.88	33	114.6	0.383	-44.52	33			
34	35.5	0.395	-18.9	34	63.3	0.388	-31.61	34	111.4	0.395	-45.14	34			
35	35	0.407	-19.32	35	63.1	0.4	-32.23	35	108.6	0.407	-45.96	35			
36	34.7	0.418	-19.73	36	62.3	0.412	-32.85	36	105.9	0.419	-46.79	36			
37	34.5	0.43	-20.24	37	61.8	0.424	-33.47	37	103.3	0.431	-47.62	37			
38	34.9	0.44	-20.76	38	61.5	0.434	-34.19	38	101.7	0.442	-48.55	38			
39	35.2	0.451	-21.48	39	61.5	0.445	-34.81	39	101.9	0.453	-49.58	39			
40	34.6	0.458	-21.79	40				40	101.8	0.465	-50.51	40			
41				41				41	102.4	0.475	-51.54	41			
42				42				42	101	0.484	-52.37	42			
43				43				43				43			
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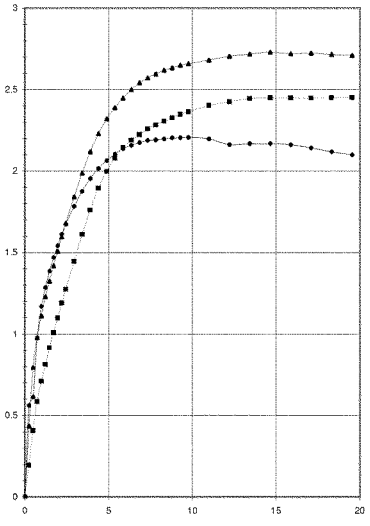
TRIAXIAL TEST ASTM: D 2850

Job No. 7577
Date: 8/24/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-79MU Fargo Sample #: 1 Type: 5T Depth (ft): 20 - 22 (Mid.)
Soil Type: Fat Clay w/a few pieces of Gravel & a few Laminations of Silt, Slightly Blocky (CH) Alluvium



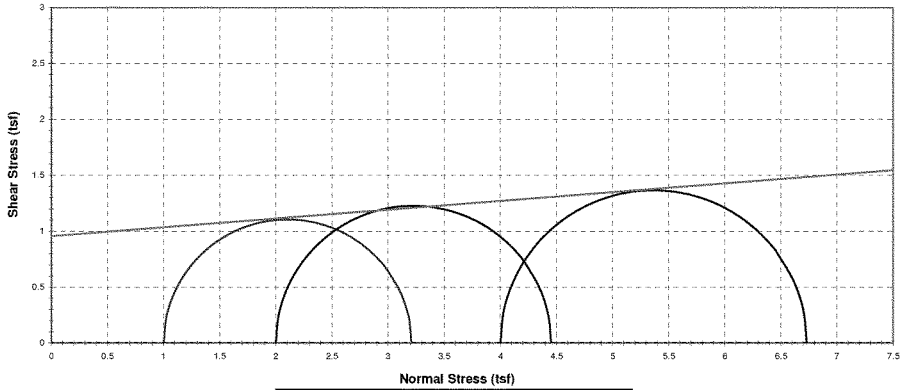
Failure Criterion: Max. Deviator Stress
Angle of internal friction, ϕ_u = 4.5 °
Apparent Cohesion, c_u = 0.96 (tsf)

Test Date:	8/19/10		Liquid Limit:		51.8
Test Type:	U-U		Plastic Limit:		20.5
Strain Rate (in/min):	0.05		Plasticity Index:		31.3
Strain Rate (%/min):	1.221		Spec. Gravity (Assumed):		2.78

Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	27.5	28.2	29.1		
Dry Density (pcf)	96.1	95.0	93.8		
Void Ratio	0.81	0.83	0.85		
After Consolidation					
Diameter (in)					
Height (in)					
Water Content (%)					
Dry Density (pcf)					
Void Ratio					
Back Pressure (tsf)					
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	2.21	2.45	2.73		
Ultimate Deviator Stress (tsf)	2.10	2.45	2.71		
Deviator Stress at Failure (tsf)	2.21	2.45	2.73		
Max. Pore Pressure Buildup (tsf)	--------	--------	--------		
Pore Pressure Parameter "B"	--------	--------	--------		
Pct. Axial Strain at Failure	9.8	19.5	14.7		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Specimens trimmed to given sizes; Allowed to adjust under applied confining pressures for about 10 minutes.



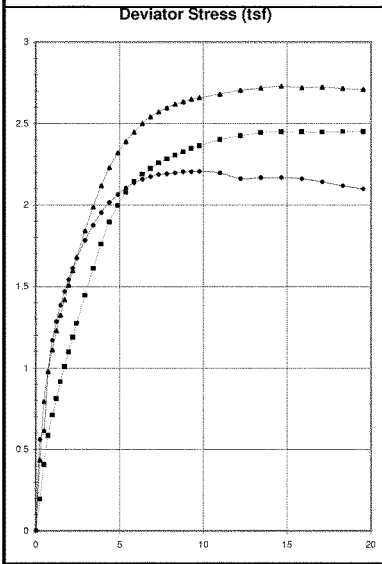
Total ϕ_u: 4.5 ° c_u= 0.96 (tsf)

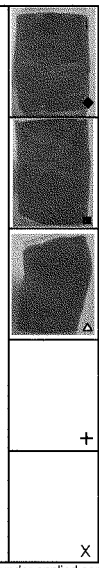
OIL ENGINEERING TESTING, INC.

TRIAXIAL TEST ASTM: D 2850

Job No. 7577
Date: 8/24/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-79MU Fargo Sample #: 1 Type: 5T Depth (ft): 20 - 22 (Mid.)
Soil Type: Fat Clay w/a few pieces of Gravel & a few Laminations of Silt, Slightly Blocky (CH) Alluvium





Failure Criterion: Given Strain of: 15%

Angle of internal friction, ϕ_u = 4.8 °

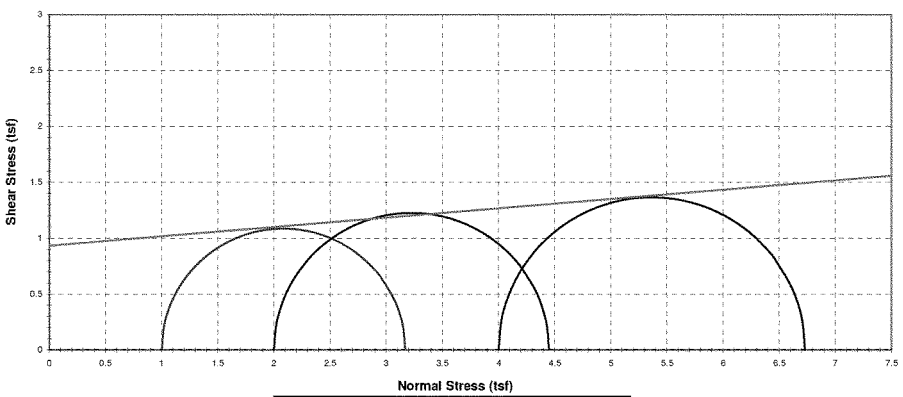
Apparent Cohesion, c_u = 0.93 (tsf)

Test Date:	8/19/10	Liquid Limit:	51.8
Test Type:	U-U	Plastic Limit:	20.5
Strain Rate (in/min):	0.05	Plasticity Index:	31.3
Strain Rate (%/min):	1.221	Spec. Gravity (Assumed):	2.78

Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	27.5	28.2	29.1		
Dry Density (pcf)	96.1	95.0	93.8		
Void Ratio	0.81	0.83	0.85		
After Consolidation					
Diameter (in)					
Height (in)					
Water Content (%)					
Dry Density (pcf)					
Void Ratio					
Back Pressure (tsf)					
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	2.21	2.45	2.73		
Ultimate Deviator Stress (tsf)	2.10	2.45	2.71		
Deviator Stress at Failure (tsf)	2.17	2.45	2.73		
Max. Pore Pressure Buildup (tsf)	--------	--------	--------		
Pore Pressure Parameter "B"	--------	--------	--------		
Pct. Axial Strain at Failure	15.0	15.0	15.0		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Specimens trimmed to given sizes; Allowed to adjust under applied confining pressures for about 10 minutes.



Total ϕ_u: 4.8 ° c_u= 0.93 (tsf)

SOIL ENGINEERING TESTING, INC.

Job No.: 7577
Test Type: U-U

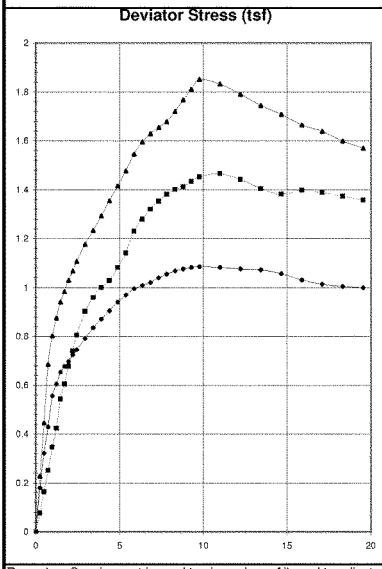
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring No.: 10-79MU, Sample No.: 1, Depth (ft.): 20 - 22 (Mid.)

Sample 1		Sample 2		Sample 3	
Strain (%)	Deviator Stress (tsf)	Strain (%)	Deviator Stress (tsf)	Strain (%)	Deviator Stress (tsf)
0.00	0.00	0.00	0.00	0.00	0.00
0.24	0.56	0.24	0.20	0.24	0.43
0.49	0.61	0.49	0.41	0.49	0.79
0.73	0.98	0.73	0.59	0.73	0.98
0.98	1.17	0.98	0.71	0.98	1.11
1.22	1.29	1.22	0.81	1.22	1.23
1.47	1.39	1.47	0.92	1.47	1.33
1.71	1.47	1.71	1.01	1.71	1.42
1.95	1.54	1.95	1.10	1.95	1.51
2.20	1.61	2.20	1.19	2.20	1.60
2.44	1.67	2.44	1.27	2.44	1.68
2.93	1.78	2.93	1.45	2.93	1.84
3.42	1.88	3.42	1.61	3.42	1.99
3.91	1.95	3.91	1.76	3.91	2.12
4.40	2.02	4.40	1.90	4.40	2.23
4.88	2.06	4.88	2.00	4.88	2.32
5.37	2.10	5.37	2.08	5.37	2.39
5.86	2.14	5.86	2.14	5.86	2.45
6.35	2.16	6.35	2.19	6.35	2.50
6.84	2.17	6.84	2.22	6.84	2.54
7.33	2.19	7.33	2.26	7.33	2.57
7.81	2.19	7.81	2.28	7.81	2.60
8.30	2.20	8.30	2.31	8.30	2.62
8.79	2.20	8.79	2.33	8.79	2.63
9.28	2.20	9.28	2.35	9.28	2.65
9.77	2.21	9.77	2.36	9.77	2.66
10.99	2.20	10.99	2.40	10.99	2.68
12.21	2.16	12.21	2.43	12.21	2.70
13.43	2.17	13.43	2.45	13.43	2.72
14.65	2.17	14.65	2.45	14.65	2.73
15.87	2.16	15.87	2.45	15.87	2.72
17.09	2.14	17.09	2.45	17.09	2.72
18.32	2.12	18.32	2.45	18.32	2.72
19.54	2.10	19.54	2.45	19.54	2.71

TRIAXIAL TEST ASTM: D 2850

Job No. 7577
Date: 10/4/10

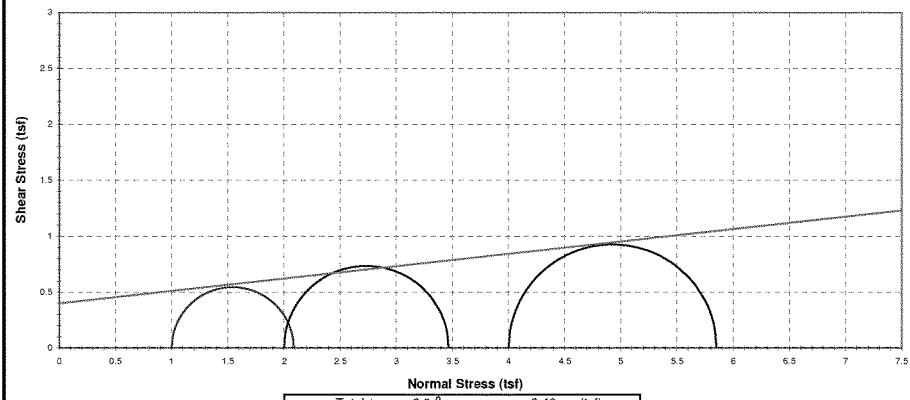
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 1 Type: ST Depth (ft): 23 - 25
Soil Type: Silty Clay w/a few pockets of Silty Sand (CL-ML) Alluvium



Failure Criterion:	Max. Deviator Stress				
Angle of internal friction, ϕ_u =	6.3 °				
Apparent Cohesion, c_u =	0.40 (tsf)				
Test Date: 8/24/10		Liquid Limit:	28.2		
Test Type: U-U		Plastic Limit:	17.1		
Strain Rate (in/min): 0.05		Plasticity Index:	11.1		
Strain Rate (%/min): 1.221		Spec. Gravity (Assumed):	2.67		
Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	27.7	26.7	25.9		
Dry Density (pcf)	94.9	96.8	98.1		
Void Ratio	0.76	0.72	0.70		
After Consolidation					
Diameter (in)					
Height (in)					
Water Content (%)					
Dry Density (pcf)					
Void Ratio					
Back Pressure (tsf)					
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	1.09	1.47	1.85		
Ultimate Deviator Stress (tsf)	1.00	1.36	1.57		
Deviator Stress at Failure (tsf)	1.09	1.47	1.85		
Max. Pore Pressure Buildup (tsf)	-------	-------	-------		
Pore Pressure Parameter "B"	-------	-------	-------		
Pct. Axial Strain at Failure	9.8	11.0	9.8		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Specimens trimmed to given sizes; Allowed to adjust under applied confining pressures for about 10 minutes.



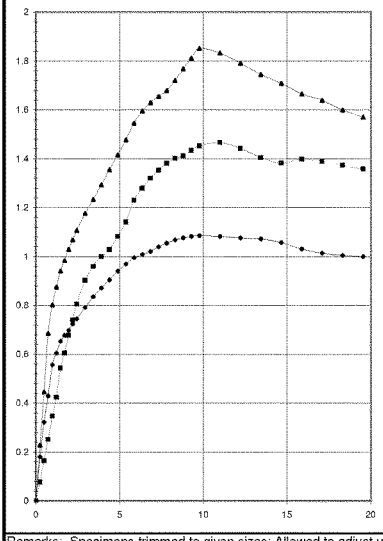
Total ϕ_u: 6.3 ° c_u= 0.40 (tsf)

OIL ENGINEERING TESTING, INC.
8301 Bryant Ave South, Suite #107 Bloomington, Minnesota 55420-3435
Geotechnical Design and Geology

TRIAXIAL TEST ASTM: D 2850

Job No. 7577
Date: 10/4/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 1 Type: 5T Depth (ft): 23 - 25
Soil Type: Silty Clay w/a few pockets of Silty Sand (CL-ML) Alluvium



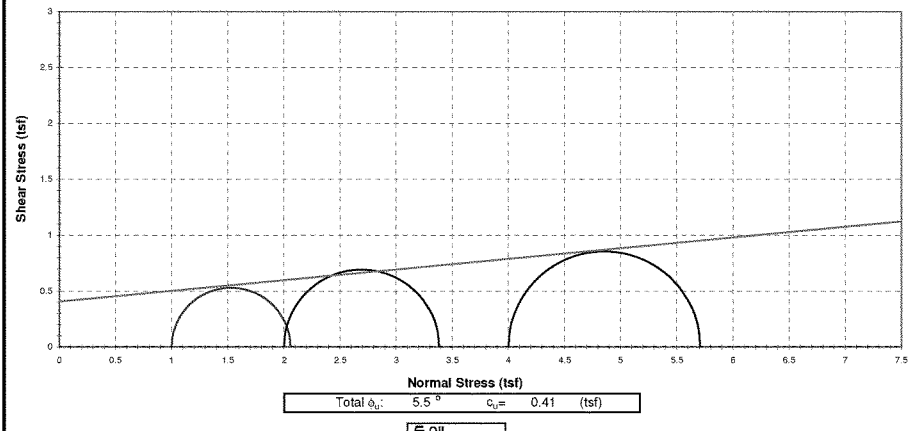
Failure Criterion: Given Strain of: 15%
Angle of internal friction, ϕ_u = 5.5 °
Apparent Cohesion, c_u = 0.41 (tsf)

Test Date: 8/24/10			Liquid Limit:		28.2
Test Type: U-U			Plastic Limit:		17.1
Strain Rate (in/min): 0.05			Plasticity Index:		11.1
Strain Rate (%/min): 1.221			Spec. Gravity (Assumed):		2.67

Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	27.7	26.7	25.9		
Dry Density (pcf)	94.9	96.8	98.1		
Void Ratio	0.76	0.72	0.70		
After Consolidation					
Diameter (in)					
Height (in)					
Water Content (%)					
Dry Density (pcf)					
Void Ratio					
Back Pressure (tsf)					
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	1.09	1.47	1.85		
Ultimate Deviator Stress (tsf)	1.00	1.36	1.57		
Deviator Stress at Failure (tsf)	1.06	1.38	1.71		
Max. Pore Pressure Buildup (tsf)	--------	--------	--------		
Pore Pressure Parameter "B"	--------	--------	--------		
Pct. Axial Strain at Failure	15.0	15.0	15.0		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Specimens trimmed to given sizes; Allowed to adjust under applied confining pressures for about 10 minutes.



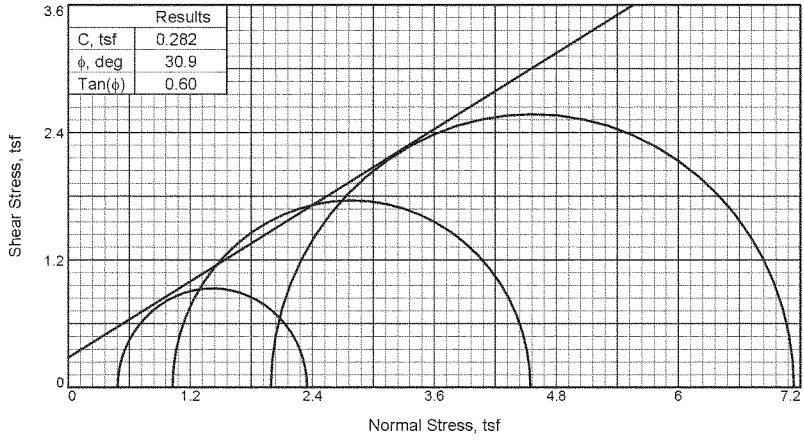
Total ϕ_u: 5.5 ° c_u= 0.41 (tsf)

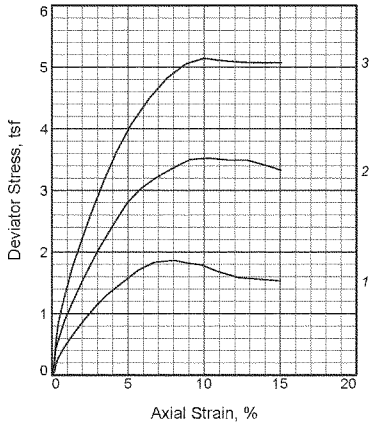
SOIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55420-3436
Geotechnical Design and Geology

Job No.: 7577
Test Type: U-U

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring No.: 10-80MU, Sample No.: 1, Depth (ft.): 23 - 25

Sample 1		Sample 2		Sample 3	
Strain (%)	Deviator Stress (tsf)	Strain (%)	Deviator Stress (tsf)	Strain (%)	Deviator Stress (tsf)
0.00	0.00	0.00	0.00	0.00	0.00
0.24	0.18	0.24	0.08	0.24	0.23
0.49	0.32	0.49	0.16	0.49	0.45
0.73	0.43	0.73	0.25	0.73	0.69
0.98	0.56	0.98	0.35	0.98	0.80
1.22	0.60	1.22	0.42	1.22	0.88
1.47	0.65	1.47	0.54	1.47	0.94
1.71	0.68	1.71	0.61	1.71	0.98
1.95	0.70	1.95	0.68	1.95	1.03
2.20	0.72	2.20	0.74	2.20	1.07
2.44	0.74	2.44	0.81	2.44	1.11
2.93	0.79	2.93	0.90	2.93	1.18
3.42	0.83	3.42	0.96	3.42	1.23
3.91	0.87	3.91	1.00	3.91	1.29
4.40	0.90	4.40	1.03	4.40	1.35
4.88	0.94	4.88	1.08	4.88	1.42
5.37	0.97	5.37	1.14	5.37	1.48
5.86	0.99	5.86	1.23	5.86	1.55
6.35	1.01	6.35	1.28	6.35	1.60
6.84	1.02	6.84	1.32	6.84	1.63
7.33	1.04	7.33	1.35	7.33	1.65
7.81	1.05	7.81	1.38	7.81	1.68
8.30	1.07	8.30	1.40	8.30	1.72
8.79	1.08	8.79	1.41	8.79	1.77
9.28	1.08	9.28	1.43	9.28	1.81
9.77	1.09	9.77	1.45	9.77	1.85
10.99	1.08	10.99	1.47	10.99	1.83
12.21	1.08	12.21	1.44	12.21	1.79
13.43	1.07	13.43	1.40	13.43	1.74
14.65	1.06	14.65	1.38	14.65	1.71
15.87	1.03	15.87	1.40	15.87	1.67
17.09	1.01	17.09	1.39	17.09	1.64
18.32	1.00	18.32	1.37	18.32	1.60
19.54	1.00	19.54	1.36	19.54	1.57





Sample No.		1	2	3
Initial	Water Content, %	29.4	30.6	29.5
	Dry Density, pcf	94.4	92.7	94.8
	Saturation, %	98.9	98.9	100.0
	Void Ratio	0.8183	0.8513	0.8116
	Diameter, in.	1.43	1.43	1.43
	Height, in.	2.80	2.80	2.80
At Test	Water Content, %	29.8	31.0	29.5
	Dry Density, pcf	94.4	92.7	94.8
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.8183	0.8513	0.8116
	Diameter, in.	1.43	1.43	1.43
	Height, in.	2.80	2.80	2.80
Strain rate, in./min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.49	1.03	1.99
Fail. Stress, tsf		1.86	3.52	5.14
Ult. Stress, tsf		1.53	3.33	5.08
σ_1 Failure, tsf		2.35	4.55	7.14
σ_3 Failure, tsf		0.49	1.03	1.99

Type of Test: Unconsolidated Undrained
Sample Type: Thinwall, 5", Bottom of sample
Description: SILT, brown (ML)

LL= 31 **PL=** 23 **PI=** 8
Assumed Specific Gravity= 2.75
Remarks:

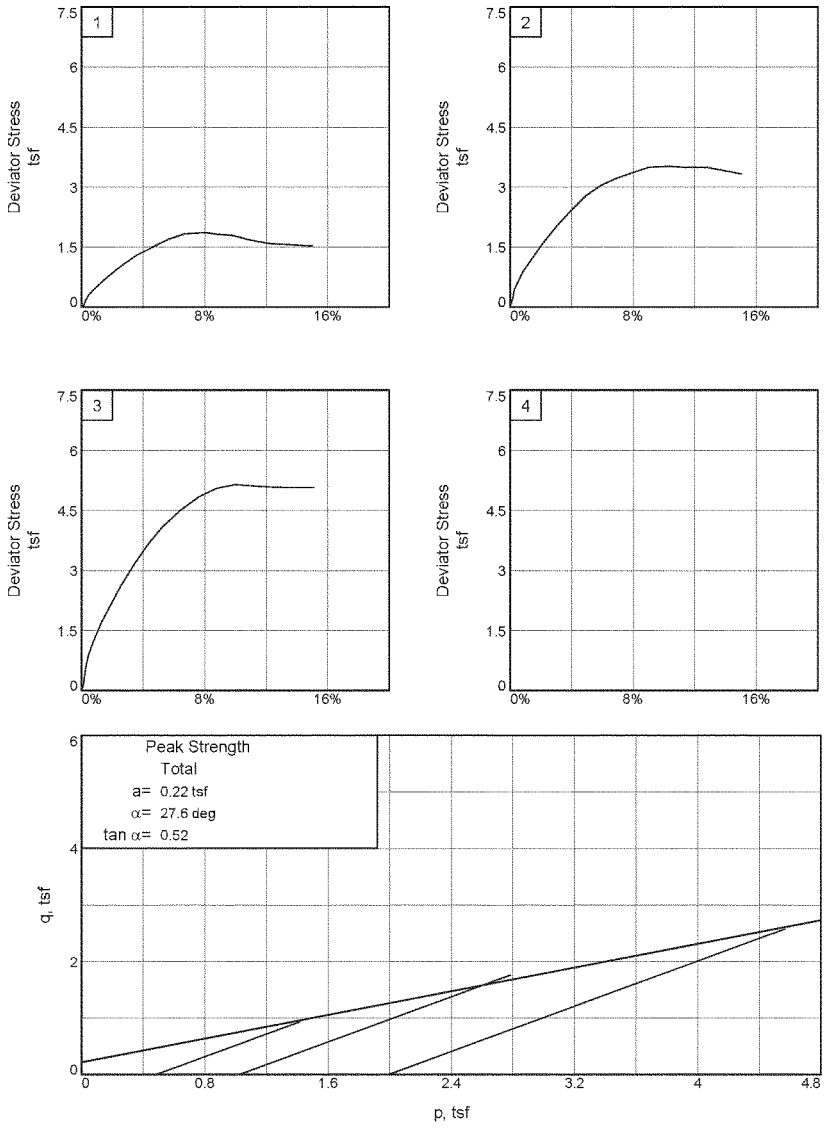
Figure UU Triax ASTM D2850

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Fargo
Sample Number: Boring 09-23MU, #3 **Depth:** 20-22'
Poplar River - West Fargo
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Fargo
Depth: 20-22' **Sample Number:** Boring 09-23MU, #3
Project No.: BL-09-03127 **Figure** _____

Poplar River - West Fargo
Braun Intertec

Tested By: rs **Checked By:** rs

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

9/16/2009
9:48 AM

Date:			
Client:	US Army Corps of Engineers		
Project:	Fargo-Moorhead Metro Feasibility Study		
Project No.:	BL-09-03127		Fargo
Depth:	20-22'	**Sample Number:**	Boring 09-23MU, #3
Description:	SILT, brown (ML)		Poplar River - West Fargo
Remarks:			
Type of Sample:	Thinwall, 5", Bottom of sample		

Assumed Specific Gravity=2.75 LL=31 PL=23 PI=8

Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	105.030		172.980
Moisture content: Dry soil+tare, gms.	88.020		142.280
Moisture content: Tare, gms.	30.190		30.880
Moisture, %	29.4	29.8	27.6
Moist specimen weight, gms.	144.3		
Diameter, in.	1.43	1.43	
Area, in.²	1.61	1.61	
Height, in.	2.80	2.80	
Net decrease in height, in.		0.00	
Wet Density, pcf	122.2	122.5	
Dry density, pcf	94.4	94.4	
Void ratio	0.8183	0.8183	
Saturation, %	98.9	100.0	

Test Readings for Specimen No. 1

Cell pressure = 0.486 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 1.863 tsf **at reading no.** 12
Ult. Stress = 1.529 tsf **at reading no.** 18

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.6050	-0.310	0.0	0.0	0.000	0.486	0.486	1.00	0.486	0.000
1	-1.6000	1.100	1.4	0.2	0.063	0.486	0.549	1.13	0.518	0.032
2	-1.5970	3.900	4.2	0.3	0.188	0.486	0.674	1.39	0.580	0.094
3	-1.5930	6.060	6.4	0.4	0.284	0.486	0.770	1.59	0.628	0.142
4	-1.5830	9.640	10.0	0.8	0.443	0.486	0.929	1.91	0.707	0.221
5	-1.5630	15.400	15.7	1.5	0.694	0.486	1.180	2.43	0.833	0.347
6	-1.5440	20.550	20.9	2.2	0.915	0.486	1.401	2.88	0.943	0.457
7	-1.5250	25.200	25.5	2.9	1.111	0.486	1.597	3.29	1.041	0.555
8	-1.5050	29.600	29.9	3.6	1.293	0.486	1.779	3.66	1.133	0.647
9	-1.4760	34.700	35.0	4.6	1.497	0.486	1.983	4.08	1.235	0.749
10	-1.4460	39.900	40.2	5.7	1.700	0.486	2.186	4.50	1.336	0.850
11	-1.4170	43.500	43.8	6.7	1.832	0.486	2.318	4.77	1.402	0.916
12	-1.3790	44.900	45.2	8.1	1.863	0.486	2.349	4.83	1.418	0.932
13	-1.3575	44.300	44.6	8.8	1.823	0.486	2.309	4.75	1.398	0.912
14	-1.3300	44.000	44.3	9.8	1.791	0.486	2.277	4.69	1.382	0.896
15	-1.3000	41.800	42.1	10.9	1.682	0.486	2.168	4.46	1.327	0.841
16	-1.2610	40.000	40.3	12.3	1.585	0.486	2.071	4.26	1.279	0.793
17	-1.2120	39.900	40.2	14.0	1.550	0.486	2.036	4.19	1.261	0.775
18	-1.1850	39.800	40.1	15.0	1.529	0.486	2.015	4.15	1.250	0.764

Parameters for Specimen No. 2			
Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	80.800		169.360
Moisture content: Dry soil+tare, gms.	68.980		139.790
Moisture content: Tare, gms.	30.390		30.230
Moisture, %	30.6	31.0	27.0
Moist specimen weight, gms.	143.1		
Diameter, in.	1.43	1.43	
Area, in.²	1.61	1.61	
Height, in.	2.80	2.80	
Net decrease in height, in.		0.00	
Wet Density, pcf	121.1	121.4	
Dry density, pcf	92.7	92.7	
Void ratio	0.8513	0.8513	
Saturation, %	98.9	100.0	

Test Readings for Specimen No. 2

Cell pressure = 1.026 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 3.521 tsf at reading no. 13
Ult. Stress = 3.327 tsf at reading no. 17

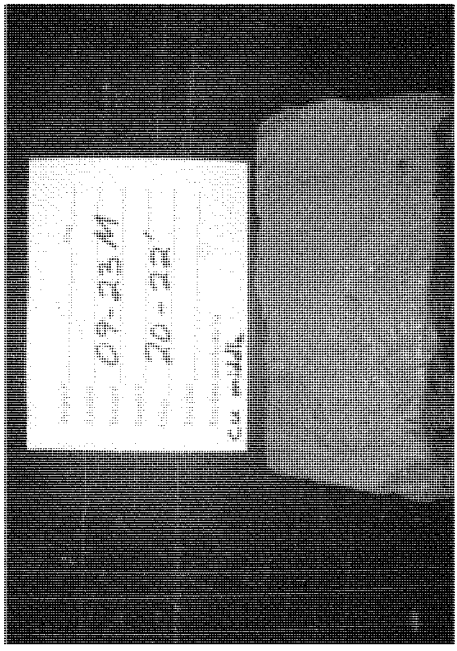
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.3065	1.250	0.0	0.0	0.000	1.026	1.026	1.00	1.026	0.000
1	-1.3010	6.900	5.7	0.2	0.253	1.026	1.279	1.25	1.152	0.126
2	-1.2990	10.900	9.7	0.3	0.431	1.026	1.457	1.42	1.242	0.216
3	-1.2830	21.200	20.0	0.8	0.887	1.026	1.913	1.86	1.469	0.443
4	-1.2650	29.500	28.3	1.5	1.248	1.026	2.274	2.22	1.650	0.624
5	-1.2470	37.500	36.3	2.1	1.591	1.026	2.617	2.55	1.821	0.795
6	-1.2210	48.200	47.0	3.1	2.041	1.026	3.067	2.99	2.046	1.020
7	-1.1940	57.900	56.7	4.0	2.438	1.026	3.464	3.38	2.245	1.219
8	-1.1680	66.800	65.6	4.9	2.793	1.026	3.819	3.72	2.423	1.397
9	-1.1420	73.200	72.0	5.9	3.036	1.026	4.062	3.96	2.544	1.518
10	-1.1150	78.000	76.8	6.8	3.206	1.026	4.232	4.12	2.629	1.603
11	-1.0890	81.900	80.7	7.8	3.335	1.026	4.361	4.25	2.693	1.667
12	-1.0530	87.000	85.7	9.0	3.496	1.026	4.522	4.41	2.774	1.748
13	-1.0180	88.800	87.5	10.3	3.521	1.026	4.547	4.43	2.786	1.760
14	-0.9820	89.300	88.1	11.6	3.490	1.026	4.516	4.40	2.771	1.745
15	-0.9470	90.600	89.3	12.8	3.492	1.026	4.518	4.40	2.772	1.746
16	-0.9020	89.300	88.1	14.4	3.377	1.026	4.403	4.29	2.715	1.689
17	-0.8850	88.600	87.4	15.0	3.327	1.026	4.353	4.24	2.689	1.663

Parameters for Specimen No. 3			
Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	101.940		170.190
Moisture content: Dry soil+tare, gms.	85.750		141.450
Moisture content: Tare, gms.	30.890		30.260
Moisture, %	29.5	29.5	25.8
Moist specimen weight, gms.	145.8		
Diameter, in.	1.43	1.43	
Area, in.²	1.62	1.62	
Height, in.	2.80	2.80	
Net decrease in height, in.		0.00	
Wet Density, pcf	122.7	122.7	
Dry density, pcf	94.8	94.8	
Void ratio	0.8116	0.8116	
Saturation, %	100.0	100.0	

Test Readings for Specimen No. 3

Cell pressure = 1.994 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 5.144 tsf at reading no. 14
Ult. Stress = 5.076 tsf at reading no. 19

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.4990	3.900	0.0	0.0	0.000	1.994	1.994	1.00	1.994	0.000
1	-1.4950	7.400	3.5	0.1	0.156	1.994	2.150	1.08	2.072	0.078
2	-1.4920	15.200	11.3	0.2	0.503	1.994	2.497	1.25	2.245	0.251
3	-1.4870	23.100	19.2	0.4	0.852	1.994	2.846	1.43	2.420	0.426
4	-1.4780	30.900	27.0	0.7	1.195	1.994	3.189	1.60	2.591	0.597
5	-1.4620	43.200	39.3	1.3	1.729	1.994	3.723	1.87	2.858	0.864
6	-1.4450	53.500	49.6	1.9	2.169	1.994	4.163	2.09	3.078	1.084
7	-1.4280	63.700	59.8	2.5	2.598	1.994	4.592	2.30	3.293	1.299
8	-1.4030	77.200	73.3	3.4	3.156	1.994	5.150	2.58	3.572	1.578
9	-1.3780	89.600	85.7	4.3	3.656	1.994	5.650	2.83	3.822	1.828
10	-1.3530	100.200	96.3	5.2	4.069	1.994	6.063	3.04	4.029	2.035
11	-1.3190	111.800	107.9	6.4	4.501	1.994	6.495	3.26	4.245	2.251
12	-1.2860	121.200	117.3	7.6	4.832	1.994	6.826	3.42	4.410	2.416
13	-1.2520	128.200	124.3	8.8	5.053	1.994	7.047	3.53	4.520	2.526
14	-1.2190	132.100	128.2	10.0	5.144	1.994	7.138	3.58	4.566	2.572
15	-1.1850	132.900	129.0	11.2	5.106	1.994	7.100	3.56	4.547	2.553
16	-1.1510	134.000	130.1	12.4	5.080	1.994	7.074	3.55	4.534	2.540
17	-1.1180	135.500	131.6	13.6	5.069	1.994	7.063	3.54	4.529	2.535
18	-1.0930	137.000	133.1	14.5	5.074	1.994	7.068	3.54	4.531	2.537
19	-1.0760	138.000	134.1	15.1	5.076	1.994	7.070	3.55	4.532	2.538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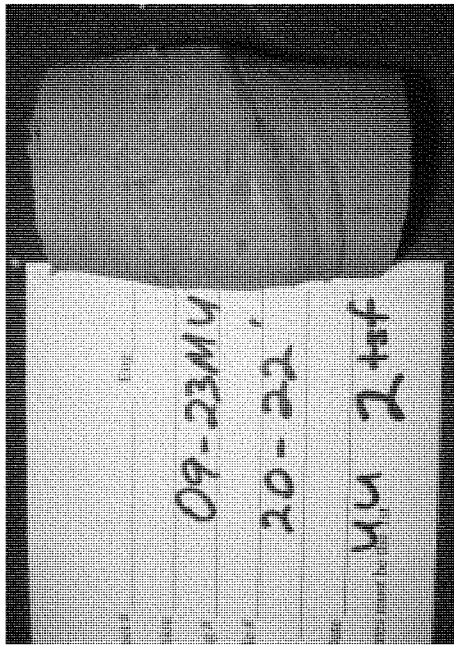
20-22'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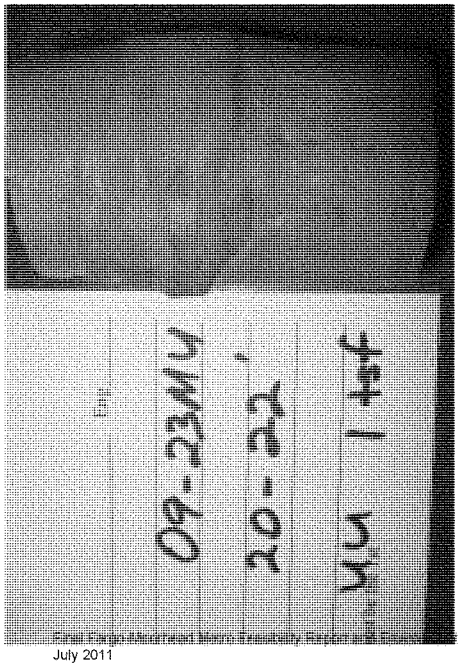
20-22'
WW 2 tsf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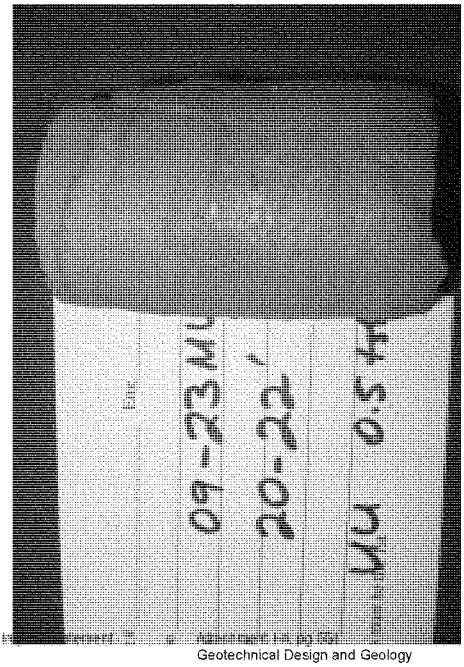
20-22'
WW 1 tsf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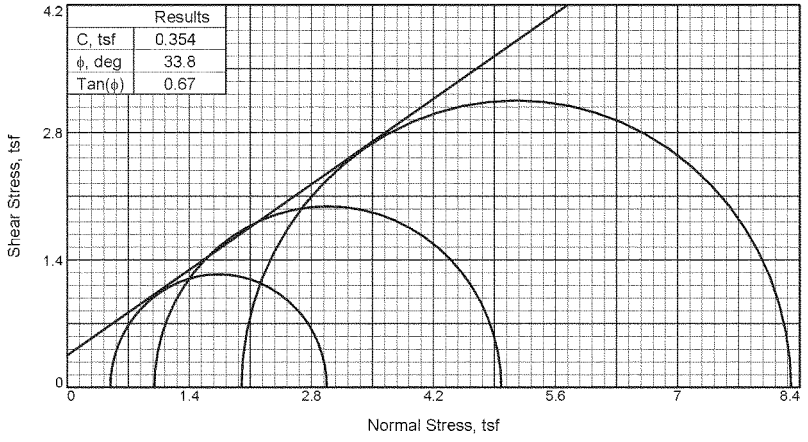
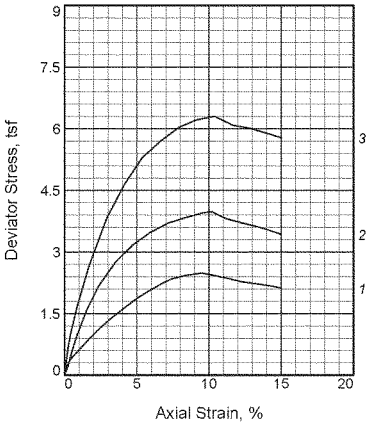
WW 0.5 tsf





Sample No.		1	2	3
Initial	Water Content, %	30.8	30.1	28.5
	Dry Density, pcf	92.6	93.4	94.3
	Saturation, %	99.3	98.8	95.3
	Void Ratio	0.8543	0.8383	0.8213
	Diameter, in.	1.42	1.43	1.42
	Height, in.	2.80	2.81	2.80
At Test	Water Content, %	31.1	30.5	29.9
	Dry Density, pcf	92.6	93.4	94.3
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.8543	0.8383	0.8213
	Diameter, in.	1.42	1.43	1.42
	Height, in.	2.80	2.81	2.80
Strain rate, in./min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.50	1.00	2.00
Fail. Stress, tsf		2.48	3.98	6.30
Ult. Stress, tsf		2.12	3.43	5.78
σ_1 Failure, tsf		2.98	4.98	8.30
σ_3 Failure, tsf		0.50	1.00	2.00

Type of Test:
Unconsolidated Undrained
Sample Type: Thinwall, 5", Top of sample
Description: SILT with layers of Clay, gray-brown (ML)
LL= 30 **PL=** 24 **PI=** 6
Assumed Specific Gravity= 2.75
Remarks:

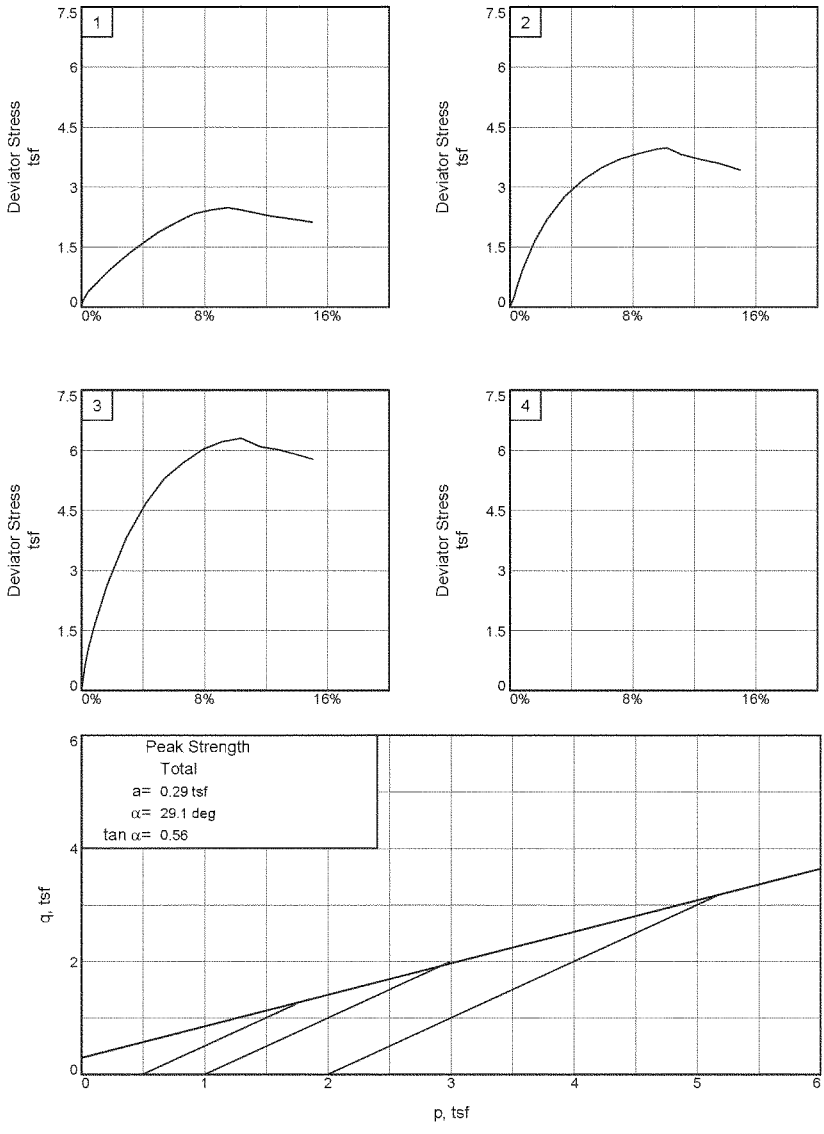
Figure UU Triax ASTM D2850

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Moorhead
Sample Number: Boring 09-25MU, #2 **Depth:** 21-23'
Poplar River - West Fargo
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Moorhead
Depth: 21-23' **Sample Number:** Boring 09-25MU, #2
Project No.: BL-09-03127 **Figure** _____
Poplar River - West Fargo
Braun Intertec

Tested By: rs **Checked By:** rs

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

9/16/2009
9:44 AM

Date:			
Client:	US Army Corps of Engineers		
Project:	Fargo-Moorhead Metro Feasibility Study		
Project No.:	BL-09-03127		Moorhead
Depth:	21-23'	**Sample Number:**	Boring 09-25MU, #2
Description:	SILT with layers of Clay, gray-brown (ML)		Poplar River - West Fargo
Remarks:			
Type of Sample:	Thinwall, 5", Top of sample		
Assumed Specific Gravity=2.75	**LL=30**	**PL=24**	**PI=6**
Test Method:	COE uniform strain		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	95.240		172.420
Moisture content: Dry soil+tare, gms.	79.880		141.140
Moisture content: Tare, gms.	30.080		31.270
Moisture, %	30.8	31.1	28.5
Moist specimen weight, gms.	141.1		
Diameter, in.	1.42	1.42	
Area, in.²	1.58	1.58	
Height, in.	2.80	2.80	
Net decrease in height, in.		0.00	
Wet Density, pcf	121.1	121.3	
Dry density, pcf	92.6	92.6	
Void ratio	0.8543	0.8543	
Saturation, %	99.3	100.0	

Test Readings for Specimen No. 1

Cell pressure = 0.495 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 2.483 tsf **at reading no.** 14
Ult. Stress = 2.124 tsf **at reading no.** 20

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.5450	0.600	0.0	0.0	0.000	0.495	0.495	1.00	0.495	0.000
1	-1.5430	3.600	3.0	0.1	0.136	0.495	0.631	1.28	0.563	0.068
2	-1.5330	9.300	8.7	0.4	0.394	0.495	0.889	1.80	0.692	0.197
3	-1.5230	12.300	11.7	0.8	0.527	0.495	1.022	2.07	0.759	0.264
4	-1.5130	15.500	14.9	1.1	0.669	0.495	1.164	2.35	0.830	0.335
5	-1.4940	21.400	20.8	1.8	0.928	0.495	1.423	2.87	0.959	0.464
6	-1.4740	27.000	26.4	2.5	1.169	0.495	1.664	3.36	1.079	0.584
7	-1.4550	32.100	31.5	3.2	1.385	0.495	1.880	3.80	1.188	0.693
8	-1.4350	36.800	36.2	3.9	1.580	0.495	2.075	4.19	1.285	0.790
9	-1.4060	43.700	43.1	5.0	1.861	0.495	2.356	4.76	1.425	0.930
10	-1.3860	47.700	47.1	5.7	2.018	0.495	2.513	5.08	1.504	1.009
11	-1.3570	53.100	52.5	6.7	2.225	0.495	2.720	5.49	1.608	1.113
12	-1.3380	56.200	55.6	7.4	2.339	0.495	2.834	5.73	1.665	1.170
13	-1.3080	59.100	58.5	8.5	2.433	0.495	2.928	5.91	1.711	1.216
14	-1.2790	61.000	60.4	9.5	2.483	0.495	2.978	6.02	1.737	1.242
15	-1.2600	60.400	59.8	10.2	2.440	0.495	2.935	5.93	1.715	1.220
16	-1.2300	59.200	58.6	11.2	2.363	0.495	2.858	5.77	1.676	1.181
17	-1.2010	57.700	57.1	12.3	2.275	0.495	2.770	5.60	1.633	1.138
18	-1.1710	57.000	56.4	13.4	2.220	0.495	2.715	5.49	1.605	1.110
19	-1.1420	56.200	55.6	14.4	2.162	0.495	2.657	5.37	1.576	1.081
20	-1.1250	55.600	55.0	15.0	2.124	0.495	2.619	5.29	1.557	1.062

Parameters for Specimen No. 2			
Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	107.800		173.760
Moisture content: Dry soil+tare, gms.	89.880		142.120
Moisture content: Tare, gms.	30.380		31.230
Moisture, %	30.1	30.5	28.5
Moist specimen weight, gms.	143.2		
Diameter, in.	1.43	1.43	
Area, in.²	1.60	1.60	
Height, in.	2.81	2.81	
Net decrease in height, in.		0.00	
Wet Density, pcf	121.5	121.9	
Dry density, pcf	93.4	93.4	
Void ratio	0.8383	0.8383	
Saturation, %	98.8	100.0	

Test Readings for Specimen No. 2

Cell pressure = 1.000 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 3.978 tsf at reading no. 12
Ult. Stress = 3.430 tsf at reading no. 17

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.6380	1.300	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	-1.6300	7.000	5.7	0.3	0.256	1.000	1.256	1.26	1.128	0.128
2	-1.6260	11.800	10.5	0.4	0.471	1.000	1.471	1.47	1.235	0.235
3	-1.6150	22.100	20.8	0.8	0.929	1.000	1.929	1.93	1.464	0.464
4	-1.5930	38.400	37.1	1.6	1.643	1.000	2.643	2.64	1.822	0.822
5	-1.5710	51.000	49.7	2.4	2.184	1.000	3.184	3.18	2.092	1.092
6	-1.5380	65.100	63.8	3.6	2.770	1.000	3.770	3.77	2.385	1.385
7	-1.5040	75.600	74.3	4.8	3.185	1.000	4.185	4.19	2.593	1.593
8	-1.4710	83.500	82.2	6.0	3.480	1.000	4.480	4.48	2.740	1.740
9	-1.4370	89.800	88.5	7.2	3.699	1.000	4.699	4.70	2.849	1.849
10	-1.4040	94.100	92.8	8.3	3.829	1.000	4.829	4.83	2.915	1.915
11	-1.3700	98.300	97.0	9.5	3.950	1.000	4.950	4.95	2.975	1.975
12	-1.3520	99.700	98.4	10.2	3.978	1.000	4.978	4.98	2.989	1.989
13	-1.3250	96.700	95.4	11.2	3.816	1.000	4.816	4.82	2.908	1.908
14	-1.2920	95.000	93.7	12.3	3.698	1.000	4.698	4.70	2.849	1.849
15	-1.2580	93.700	92.4	13.5	3.597	1.000	4.597	4.60	2.798	1.798
16	-1.2360	92.300	91.0	14.3	3.510	1.000	4.510	4.51	2.755	1.755
17	-1.2180	90.900	89.6	15.0	3.430	1.000	4.430	4.43	2.715	1.715

Parameters for Specimen No. 3			
Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	124.800		169.740
Moisture content: Dry soil+tare, gms.	103.850		138.960
Moisture content: Tare, gms.	30.260		30.650
Moisture, %	28.5	29.9	28.4
Moist specimen weight, gms.	141.1		
Diameter, in.	1.42	1.42	
Area, in.²	1.58	1.58	
Height, in.	2.80	2.80	
Net decrease in height, in.		0.00	
Wet Density, pcf	121.1	122.4	
Dry density, pcf	94.3	94.3	
Void ratio	0.8213	0.8213	
Saturation, %	95.3	100.0	

Test Readings for Specimen No. 3

Cell pressure = 2.000 tsf

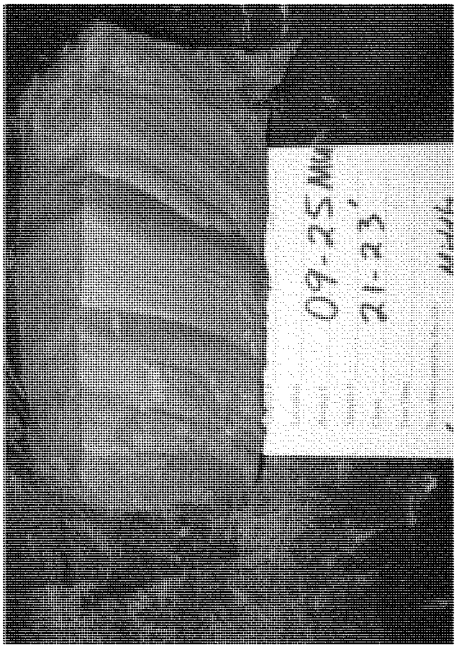
Back pressure = 0.000 tsf

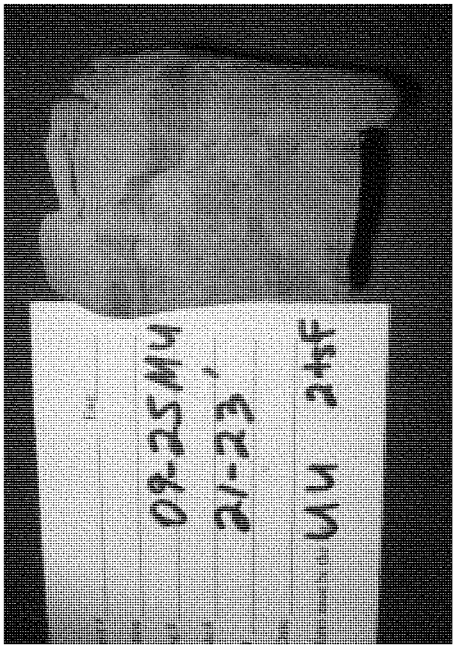
Strain rate, in./min. = 0.03

Fail. Stress = 6.303 tsf at reading no. 11

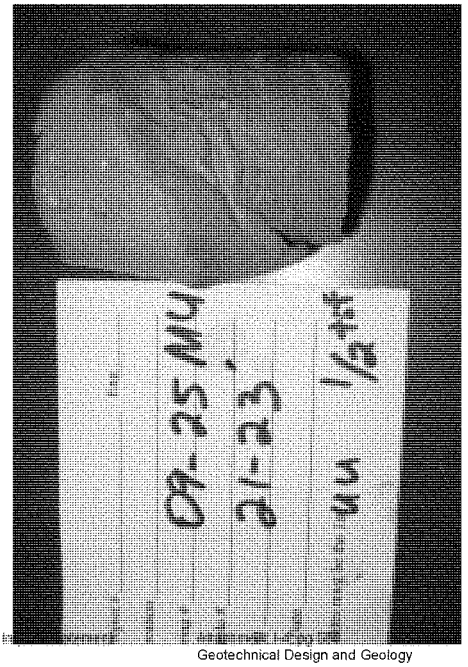
Ult. Stress = 5.780 tsf at reading no. 15

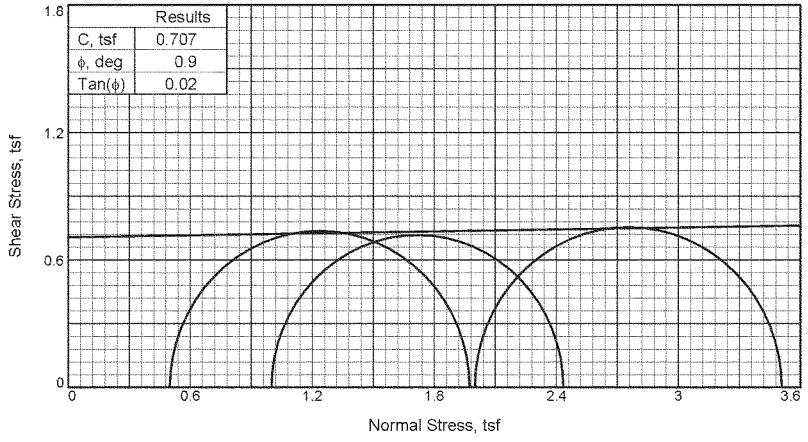
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.6160	4.400	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	-1.6090	19.200	14.8	0.2	0.671	2.000	2.671	1.34	2.336	0.336
2	-1.6040	26.800	22.4	0.4	1.014	2.000	3.014	1.51	2.507	0.507
3	-1.5920	40.800	36.4	0.9	1.641	2.000	3.641	1.82	2.820	0.820
4	-1.5690	63.400	59.0	1.7	2.637	2.000	4.637	2.32	3.319	1.319
5	-1.5340	91.200	86.8	2.9	3.831	2.000	5.831	2.92	3.915	1.915
6	-1.4990	111.600	107.2	4.2	4.670	2.000	6.670	3.34	4.335	2.335
7	-1.4650	127.600	123.2	5.4	5.299	2.000	7.299	3.65	4.650	2.650
8	-1.4300	138.600	134.2	6.6	5.696	2.000	7.696	3.85	4.848	2.848
9	-1.3950	148.300	143.9	7.9	6.026	2.000	8.026	4.01	5.013	3.013
10	-1.3600	154.800	150.4	9.1	6.213	2.000	8.213	4.11	5.107	3.107
11	-1.3250	159.100	154.7	10.4	6.303	2.000	8.303	4.15	5.152	3.152
12	-1.2900	156.000	151.6	11.6	6.091	2.000	8.091	4.05	5.045	3.045
13	-1.2550	156.100	151.7	12.9	6.009	2.000	8.009	4.00	5.004	3.004
14	-1.2200	155.000	150.6	14.1	5.880	2.000	7.880	3.94	4.940	2.940
15	-1.1950	154.000	149.6	15.0	5.780	2.000	7.780	3.89	4.890	2.890

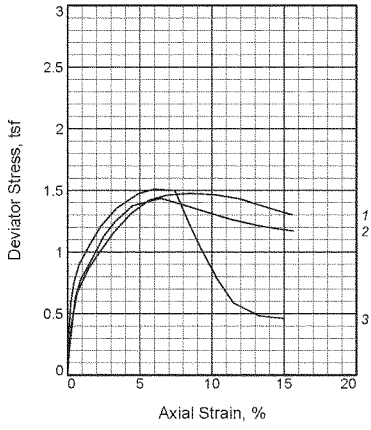

09-25MW4
21-23'


09-25MW4
21-23'
UW 2+5F

09-25MW4
21-23'
UW 1+5F


09-25MW4
21-23'
UW 1+5F





Sample No.		1	2	3
Initial	Water Content, %	37.8	37.3	37.6
	Dry Density, pcf	82.9	83.8	83.6
	Saturation, %	96.9	97.9	98.2
	Void Ratio	1.0715	1.0474	1.0545
	Diameter, in.	1.40	1.40	1.41
	Height, in.	2.81	2.82	2.80
At Test	Water Content, %	36.6	36.4	36.8
	Dry Density, pcf	82.9	83.8	83.6
	Saturation, %	93.9	95.6	95.8
	Void Ratio	1.0715	1.0474	1.0545
	Diameter, in.	1.40	1.40	1.41
	Height, in.	2.81	2.82	2.80
Strain rate, in./min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.50	1.00	2.00
Fail. Stress, tsf		1.47	1.43	1.51
Ult. Stress, tsf		1.32	1.18	0.46
σ_1 Failure, tsf		1.97	2.43	3.51
σ_3 Failure, tsf		0.50	1.00	2.00

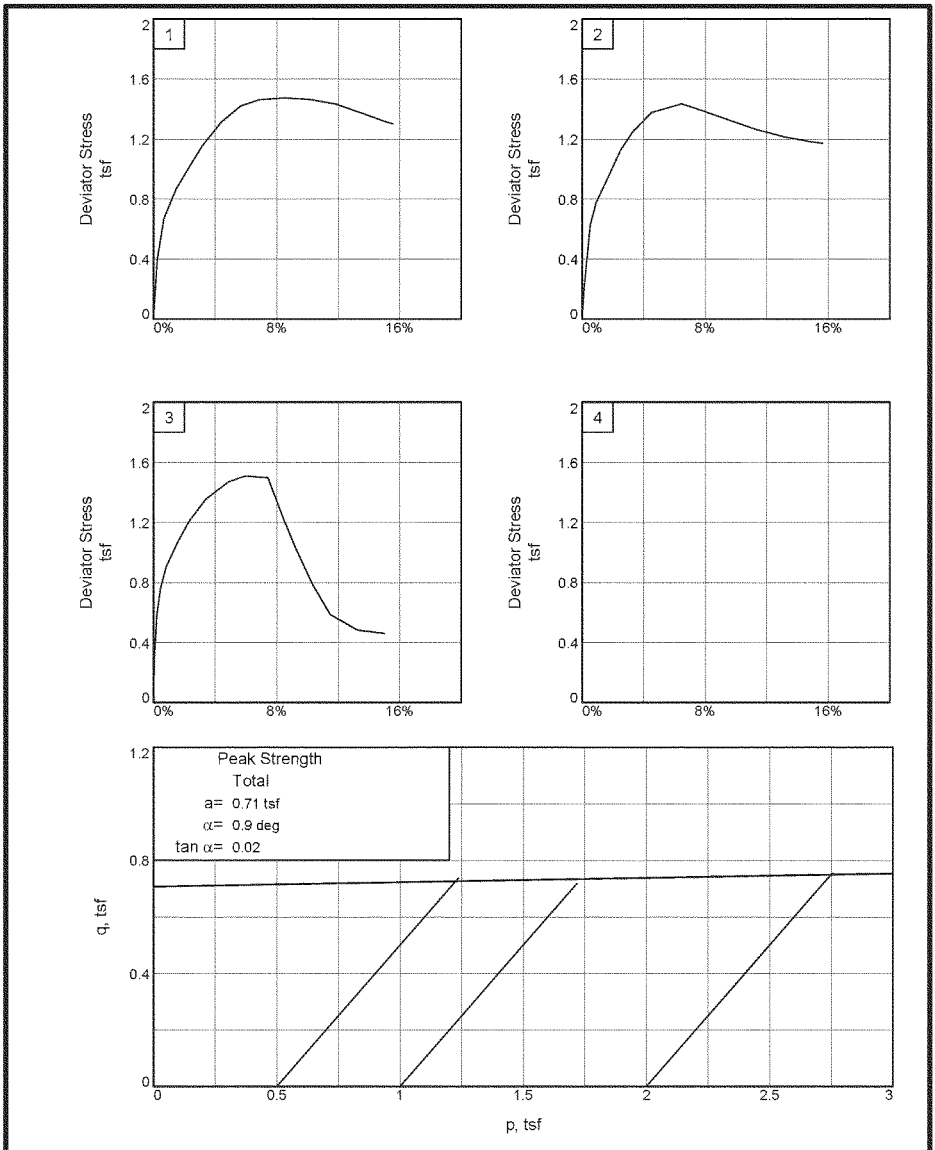
Type of Test: Unconsolidated Undrained
Sample Type: Thinwall, 5"
Description: FAT CLAY with layers of Silt, brown (CH)
LL= 83 **PL=** 20 **PI=** 63
Assumed Specific Gravity= 2.75
Remarks: Tested bottom portion of 5" thinwall.

Figure UU Triax ASTM D 2850

Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Fargo
Sample Number: Boring 09-23MU, #4 **Depth:** 28-30'
Poplar River - Harwood
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Fargo
Depth: 28-30' **Sample Number:** Boring 09-23MU, #4
Project No.: BL-09-03127 **Figure** _____
Poplar River - Harwood
Braun Intertec

Tested By: rs **Checked By:** rs

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

9/16/2009
9:42 AM

Date:			
Client:	US Army Corps of Engineers		
Project:	Fargo-Moorhead Metro Feasibility Study		
Project No.:	BL-09-03127		Fargo
Depth:	28-30'	**Sample Number:**	Boring 09-23MU, #4
Description:	FAT CLAY with layers of Silt, brown (CH)		Poplar River - Harwood
Remarks:	Tested bottom portion of 5" thinwall.		
Type of Sample:	Thinwall, 5"		
Assumed Specific Gravity=2.75	**LL=83**	**PL=20**	**PI=63**
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	112.760	160.460
Moisture content: Dry soil+tare, gms.	90.510	125.640
Moisture content: Tare, gms.	31.580	30.500
Moisture, %	37.8	36.6
Moist specimen weight, gms.	130.4	
Diameter, in.	1.40	
Area, in.²	1.55	
Height, in.	2.81	
Wet Density, pcf	114.2	
Dry density, pcf	82.9	
Void ratio	1.0715	
Saturation, %	96.9	

Test Readings for Specimen No. 1

Cell pressure = 0.500 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 1.474 tsf **at reading no.** 9
Ult. Stress = 1.318 tsf **at reading no.** 13

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.7280	1.099	0.0	0.0	0.000	0.500	0.500	1.00	0.500	0.000
1	-1.7210	9.700	8.6	0.2	0.400	0.500	0.900	1.80	0.700	0.200
2	-1.7090	15.600	14.5	0.7	0.671	0.500	1.171	2.34	0.835	0.335
3	-1.6860	20.100	19.0	1.5	0.872	0.500	1.372	2.74	0.936	0.436
4	-1.6620	23.500	22.4	2.3	1.019	0.500	1.519	3.04	1.009	0.509
5	-1.6390	26.700	25.6	3.2	1.155	0.500	1.655	3.31	1.077	0.577
6	-1.6040	30.600	29.5	4.4	1.313	0.500	1.813	3.63	1.157	0.657
7	-1.5690	33.400	32.3	5.6	1.419	0.500	1.919	3.84	1.210	0.710
8	-1.5340	34.800	33.7	6.9	1.461	0.500	1.961	3.92	1.231	0.731
9	-1.4880	35.700	34.6	8.5	1.474	0.500	1.974	3.95	1.237	0.737
10	-1.4410	36.100	35.0	10.2	1.464	0.500	1.964	3.93	1.232	0.732
11	-1.3930	36.000	34.9	11.9	1.432	0.500	1.932	3.86	1.216	0.716
12	-1.3480	35.200	34.1	13.5	1.374	0.500	1.874	3.75	1.187	0.687
13	-1.3050	34.400	33.3	15.0	1.318	0.500	1.818	3.64	1.159	0.659
14	-1.2900	34.200	33.1	15.6	1.302	0.500	1.802	3.60	1.151	0.651

Parameters for Specimen No. 2		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	100.570	161.300
Moisture content: Dry soil+tare, gms.	81.520	126.520
Moisture content: Tare, gms.	30.450	30.990
Moisture, %	37.3	36.4
Moist specimen weight, gms.	130.9	
Diameter, in.	1.40	
Area, in.^{2}	1.53	
Height, in.	2.82	
Wet Density, pcf	115.1	
Dry density, pcf	83.8	
Void ratio	1.0474	
Saturation, %	97.9	

Test Readings for Specimen No. 2

Cell pressure = 1.000 tsf

Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

Fail. Stress = 1.435 tsf at reading no. 8

Ult. Stress = 1.181 tsf at reading no. 13

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.7329	2.790	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	-1.7290	7.300	4.5	0.1	0.211	1.000	1.211	1.21	1.106	0.106
2	-1.7180	16.200	13.4	0.5	0.626	1.000	1.626	1.63	1.313	0.313
3	-1.7070	19.500	16.7	0.9	0.777	1.000	1.777	1.78	1.388	0.388
4	-1.6840	23.500	20.7	1.7	0.955	1.000	1.955	1.95	1.477	0.477
5	-1.6620	27.500	24.7	2.5	1.130	1.000	2.130	2.13	1.565	0.565
6	-1.6400	30.300	27.5	3.3	1.248	1.000	2.248	2.25	1.624	0.624
7	-1.6060	33.500	30.7	4.5	1.376	1.000	2.376	2.38	1.688	0.688
8	-1.5500	35.500	32.7	6.5	1.435	1.000	2.435	2.43	1.717	0.717
9	-1.5050	34.800	32.0	8.1	1.380	1.000	2.380	2.38	1.690	0.690
10	-1.4720	34.200	31.4	9.2	1.337	1.000	2.337	2.34	1.669	0.669
11	-1.4160	33.200	30.4	11.2	1.266	1.000	2.266	2.27	1.633	0.633
12	-1.3600	32.600	29.8	13.2	1.213	1.000	2.213	2.21	1.607	0.607
13	-1.3100	32.400	29.6	15.0	1.181	1.000	2.181	2.18	1.590	0.590
14	-1.2920	32.400	29.6	15.6	1.172	1.000	2.172	2.17	1.586	0.586

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	135.510	163.010
Moisture content: Dry soil+tare, gms.	106.750	127.390
Moisture content: Tare, gms.	30.360	30.470
Moisture, %	37.6	36.8
Moist specimen weight, gms.	132.7	
Diameter, in.	1.41	
Area, in.²	1.57	
Height, in.	2.80	
Wet Density, pcf	115.0	
Dry density, pcf	83.6	
Void ratio	1.0545	
Saturation, %	98.2	

Test Readings for Specimen No. 3

Cell pressure = 2.000 tsf

Back pressure = 0.000 tsf

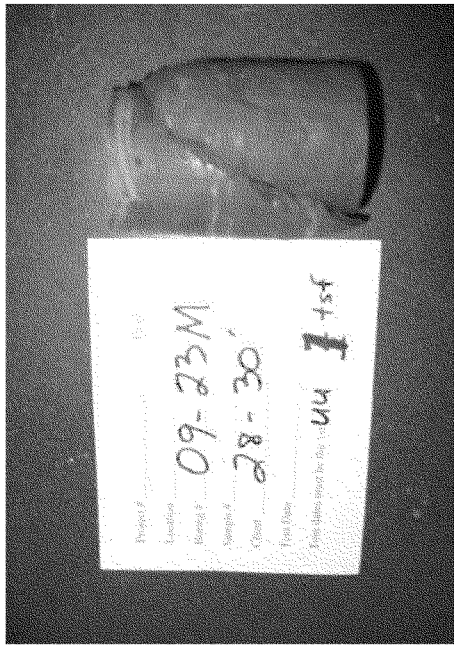
Strain rate, in./min. = 0.03

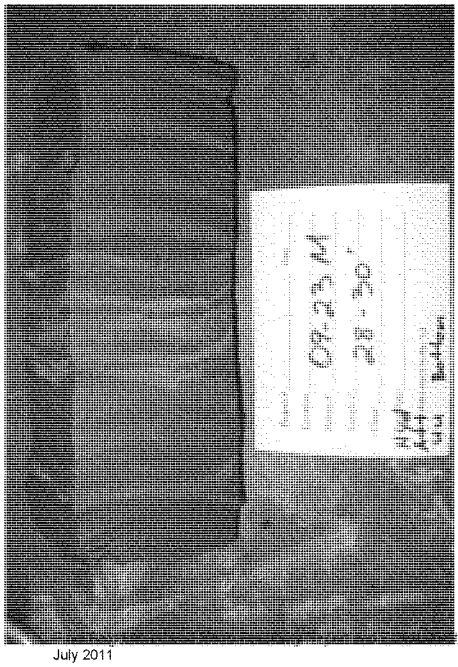
Fail. Stress = 1.509 tsf at reading no. 9

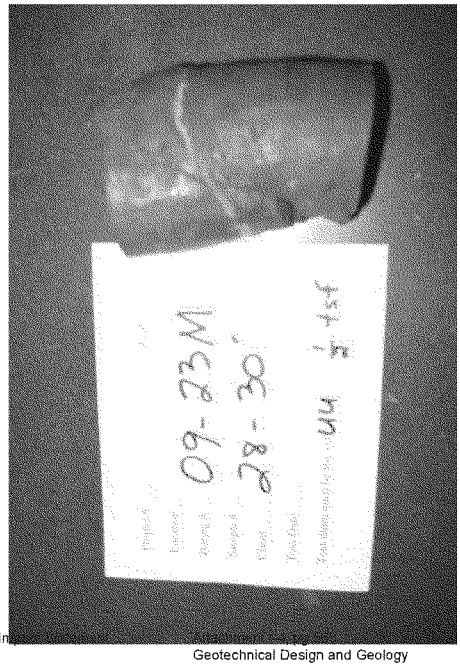
Ult. Stress = 0.460 tsf at reading no. 16

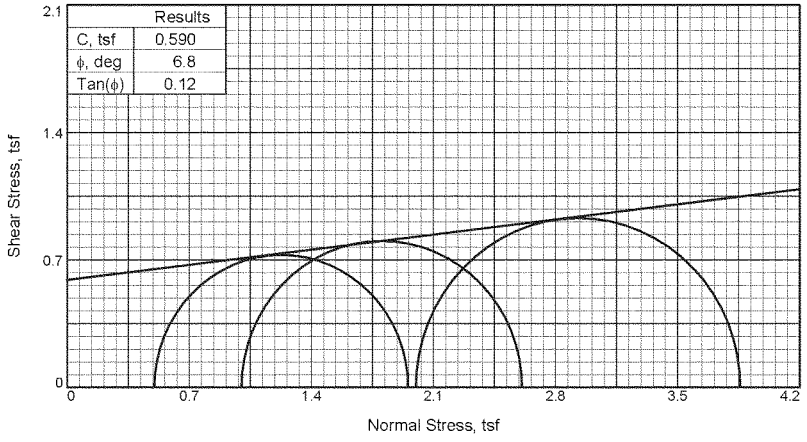
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.6980	5.300	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	-1.6960	11.900	6.6	0.1	0.302	2.000	2.302	1.15	2.151	0.151
2	-1.6920	18.100	12.8	0.2	0.586	2.000	2.586	1.29	2.293	0.293
3	-1.6850	22.100	16.8	0.5	0.767	2.000	2.767	1.38	2.383	0.383
4	-1.6750	25.200	19.9	0.8	0.905	2.000	2.905	1.45	2.452	0.452
5	-1.6540	28.980	23.7	1.6	1.069	2.000	3.069	1.53	2.534	0.534
6	-1.6340	32.200	26.9	2.3	1.205	2.000	3.205	1.60	2.603	0.603
7	-1.6030	35.900	30.6	3.4	1.355	2.000	3.355	1.68	2.678	0.678
8	-1.5620	39.000	33.7	4.9	1.470	2.000	3.470	1.74	2.735	0.735
9	-1.5310	40.300	35.0	6.0	1.509	2.000	3.509	1.75	2.755	0.755
10	-1.4900	40.600	35.3	7.4	1.498	2.000	3.498	1.75	2.749	0.749
11	-1.4600	34.100	28.8	8.5	1.208	2.000	3.208	1.60	2.604	0.604
12	-1.4390	29.900	24.6	9.3	1.024	2.000	3.024	1.51	2.512	0.512
13	-1.4080	24.300	19.0	10.4	0.781	2.000	2.781	1.39	2.390	0.390
14	-1.3770	19.800	14.5	11.5	0.589	2.000	2.589	1.29	2.294	0.294
15	-1.3264	17.400	12.1	13.3	0.481	2.000	2.481	1.24	2.241	0.241
16	-1.2780	17.100	11.8	15.0	0.460	2.000	2.460	1.23	2.230	0.230

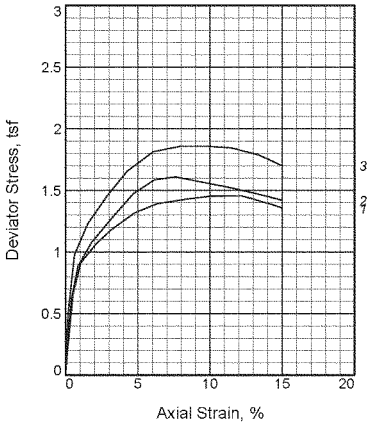
09-23M
28-30'
UU 2 tsf


09-23M
28-30'
UU 1 tsf


09-23M
28-30'
UU Bottom


09-23M
28-30'
UU 1.5 tsf





Sample No.		1	2	3
Initial	Water Content, %	37.2	36.9	36.8
	Dry Density, pcf	84.4	83.9	84.4
	Saturation, %	98.9	96.9	97.9
	Void Ratio	1.0349	1.0472	1.0336
	Diameter, in.	1.39	1.40	1.38
	Height, in.	2.64	2.71	2.77
At Test	Water Content, %	37.6	38.1	37.6
	Dry Density, pcf	84.4	83.9	84.4
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.0349	1.0472	1.0336
	Diameter, in.	1.39	1.40	1.38
	Height, in.	2.64	2.71	2.77
Strain rate, in./min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.50	1.00	2.00
Fail. Stress, tsf		1.46	1.61	1.86
Ult. Stress, tsf		1.36	1.42	1.70
σ_1 Failure, tsf		1.96	2.61	3.86
σ_3 Failure, tsf		0.50	1.00	2.00

Type of Test:
Unconsolidated Undrained
Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 80 **PL=** 21 **PI=** 59
Assumed Specific Gravity= 2.75
Remarks:

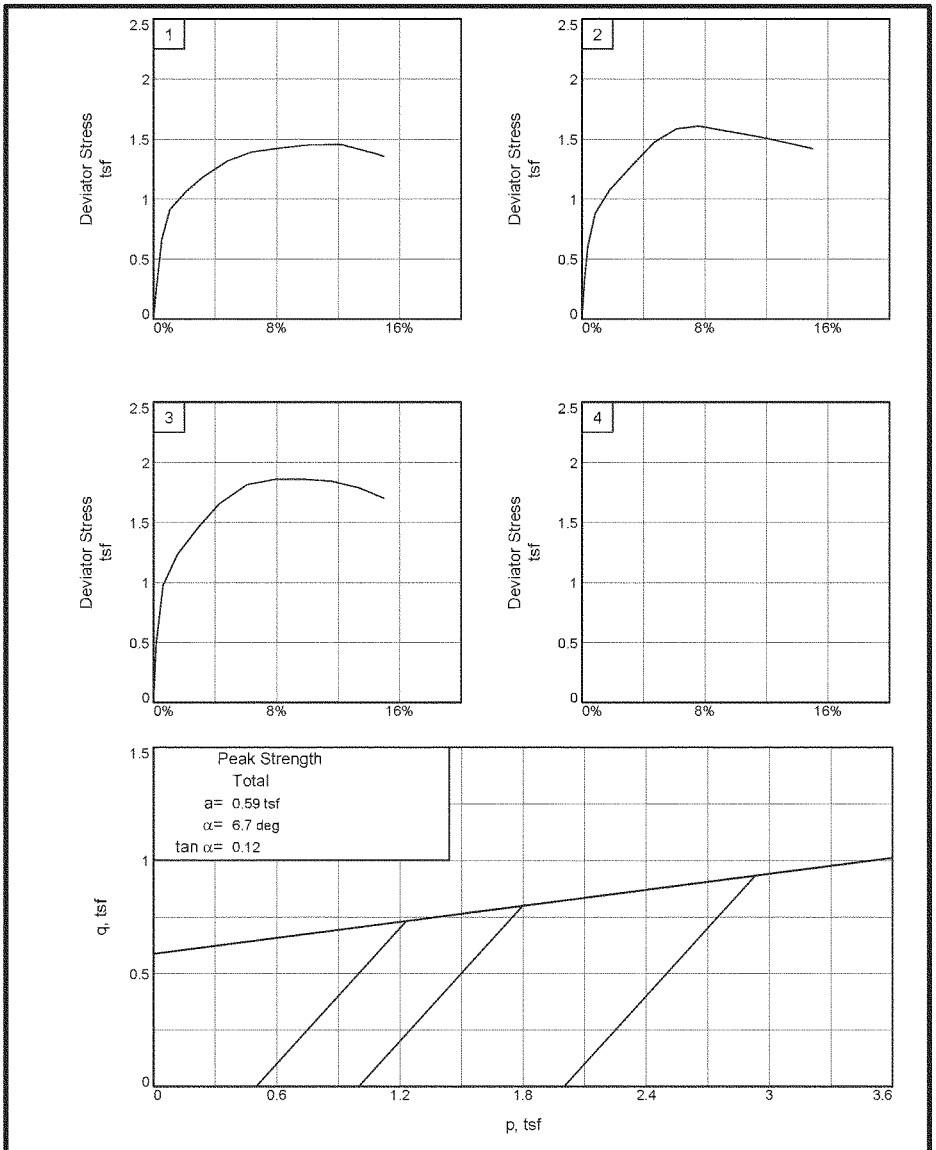
Figure UU Triax ASTM D2850

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Moorhead
Sample Number: Boring 09-25MU, #3 **Depth:** 25-27'
Poplar River - Harwood
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Moorhead
Depth: 25-27' **Sample Number:** Boring 09-25MU, #3
Project No.: BL-09-03127 **Figure** _____
Poplar River - Harwood
Braun Intertec

Tested By: rs **Checked By:** rs

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

9/16/2009
9:49 AM

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project No.: BL-09-03127 Moorhead
Depth: 25-27' Sample Number: Boring 09-25MU, #3
Description: FAT CLAY, brown (CH) Poplar River - Harwood
Remarks:
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.75 LL=80 PL=21 PI=59
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	99.980		152.290
Moisture content: Dry soil+tare, gms.	81.210		119.980
Moisture content: Tare, gms.	30.760		30.490
Moisture, %	37.2	37.6	36.1
Moist specimen weight, gms.	121.8		
Diameter, in.	1.39	1.39	
Area, in.²	1.52	1.52	
Height, in.	2.64	2.64	
Net decrease in height, in.		0.00	
Wet Density, pcf	115.8	116.1	
Dry density, pcf	84.4	84.4	
Void ratio	1.0349	1.0349	
Saturation, %	98.9	100.0	

Test Readings for Specimen No. 1

Cell pressure = 0.500 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 1.455 tsf at reading no. 10
Ult. Stress = 1.357 tsf at reading no. 12

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.5330	0.820	0.0	0.0	0.000	0.500	0.500	1.00	0.500	0.000
1	-1.5290	5.200	4.4	0.2	0.207	0.500	0.707	1.41	0.604	0.104
2	-1.5190	14.900	14.1	0.5	0.664	0.500	1.164	2.33	0.832	0.332
3	-1.5050	20.300	19.5	1.1	0.913	0.500	1.413	2.83	0.957	0.457
4	-1.4770	23.800	23.0	2.1	1.066	0.500	1.566	3.13	1.033	0.533
5	-1.4490	26.600	25.8	3.2	1.183	0.500	1.683	3.37	1.091	0.591
6	-1.4070	29.980	29.2	4.8	1.316	0.500	1.816	3.63	1.158	0.658
7	-1.3650	32.200	31.4	6.4	1.392	0.500	1.892	3.78	1.196	0.696
8	-1.3090	33.800	33.0	8.5	1.430	0.500	1.930	3.86	1.215	0.715
9	-1.2670	34.900	34.1	10.1	1.452	0.500	1.952	3.90	1.226	0.726
10	-1.2110	35.800	35.0	12.2	1.455	0.500	1.955	3.91	1.228	0.728
11	-1.1550	34.900	34.1	14.3	1.383	0.500	1.883	3.77	1.192	0.692
12	-1.1380	34.500	33.7	15.0	1.357	0.500	1.857	3.71	1.178	0.678

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	88.040		155.150
Moisture content: Dry soil+tare, gms.	72.680		122.350
Moisture content: Tare, gms.	31.060		30.580
Moisture, %	36.9	38.1	35.7
Moist specimen weight, gms.	124.6		
Diameter, in.	1.40	1.40	
Area, in.²	1.53	1.53	
Height, in.	2.71	2.71	
Net decrease in height, in.		0.00	
Wet Density, pcf	114.8	115.8	
Dry density, pcf	83.9	83.9	
Void ratio	1.0472	1.0472	
Saturation, %	96.9	100.0	

Test Readings for Specimen No. 2

Cell pressure = 1.000 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 1.609 tsf at reading no. 8
Ult. Stress = 1.420 tsf at reading no. 11

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.5736	2.045	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	-1.5690	8.800	6.8	0.2	0.318	1.000	1.318	1.32	1.159	0.159
2	-1.5630	15.000	13.0	0.4	0.608	1.000	1.608	1.61	1.304	0.304
3	-1.5500	21.000	19.0	0.9	0.885	1.000	1.885	1.89	1.443	0.443
4	-1.5250	25.300	23.3	1.8	1.076	1.000	2.076	2.08	1.538	0.538
5	-1.4850	30.200	28.2	3.3	1.283	1.000	2.283	2.28	1.641	0.641
6	-1.4460	34.900	32.9	4.7	1.475	1.000	2.475	2.47	1.737	0.737
7	-1.4070	37.900	35.9	6.2	1.585	1.000	2.585	2.59	1.793	0.793
8	-1.3680	39.000	37.0	7.6	1.609	1.000	2.609	2.61	1.804	0.804
9	-1.2640	38.500	36.5	11.4	1.521	1.000	2.521	2.52	1.760	0.760

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
10	-1.1980	37.900	35.9	13.9	1.455	1.000	2.455	2.45	1.727	0.727
11	-1.1680	37.500	35.5	15.0	1.420	1.000	2.420	2.42	1.710	0.710

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	118.460		155.620
Moisture content: Dry soil+tare, gms.	94.940		122.750
Moisture content: Tare, gms.	31.030		30.090
Moisture, %	36.8	37.6	35.5
Moist specimen weight, gms.	125.8		
Diameter, in.	1.38	1.38	
Area, in.²	1.50	1.50	
Height, in.	2.77	2.77	
Net decrease in height, in.		0.00	
Wet Density, pcf	115.5	116.2	
Dry density, pcf	84.4	84.4	
Void ratio	1.0336	1.0336	
Saturation, %	97.9	100.0	

Test Readings for Specimen No. 3

Cell pressure = 2.000 tsf

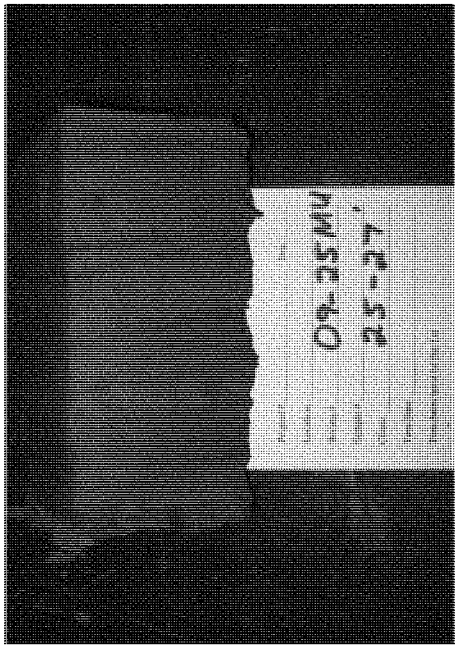
Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

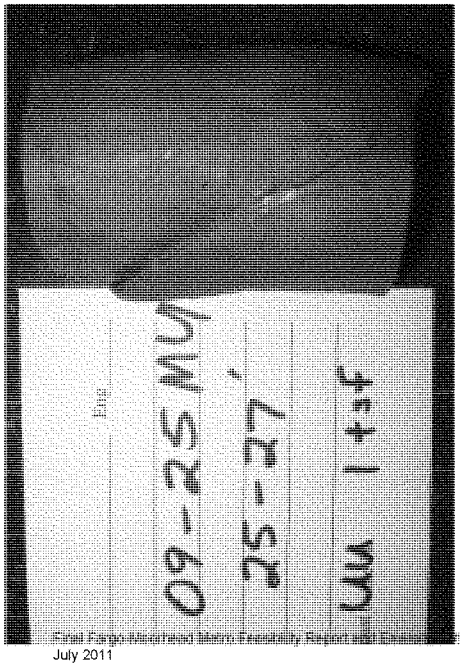
Fail. Stress = 1.860 tsf at reading no. 9

Ult. Stress = 1.703 tsf at reading no. 12

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.6370	4.780	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	-1.6340	10.900	6.1	0.1	0.293	2.000	2.293	1.15	2.147	0.147
2	-1.6320	15.100	10.3	0.2	0.494	2.000	2.494	1.25	2.247	0.247
3	-1.6200	25.200	20.4	0.6	0.974	2.000	2.974	1.49	2.487	0.487
4	-1.5940	30.900	26.1	1.6	1.234	2.000	3.234	1.62	2.617	0.617
5	-1.5570	36.000	31.2	2.9	1.455	2.000	3.455	1.73	2.728	0.728
6	-1.5190	40.800	36.0	4.3	1.655	2.000	3.655	1.83	2.828	0.828
7	-1.4690	45.000	40.2	6.1	1.813	2.000	3.813	1.91	2.907	0.907
8	-1.4180	46.800	42.0	7.9	1.857	2.000	3.857	1.93	2.929	0.929
9	-1.3680	47.700	42.9	9.7	1.860	2.000	3.860	1.93	2.930	0.930
10	-1.3180	48.200	43.4	11.5	1.844	2.000	3.844	1.92	2.922	0.922
11	-1.2680	47.800	43.0	13.3	1.790	2.000	3.790	1.89	2.895	0.895
12	-1.2230	46.500	41.7	15.0	1.703	2.000	3.703	1.85	2.851	0.851


09-25MU
25-27'

09-25MU
25-27'
UU 2+3f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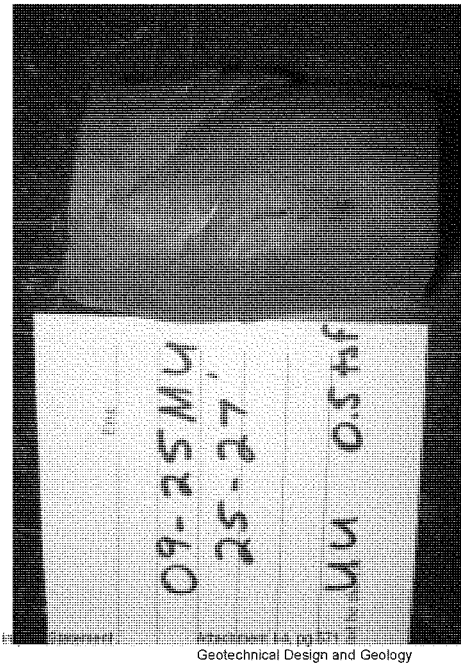
25-27'
UU 1+3f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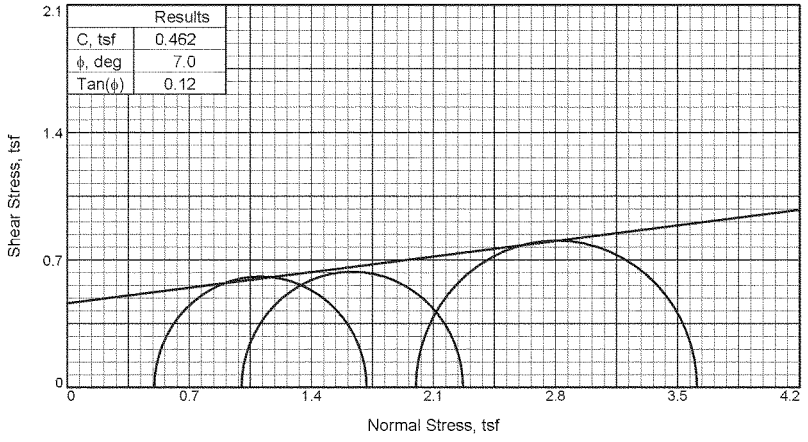
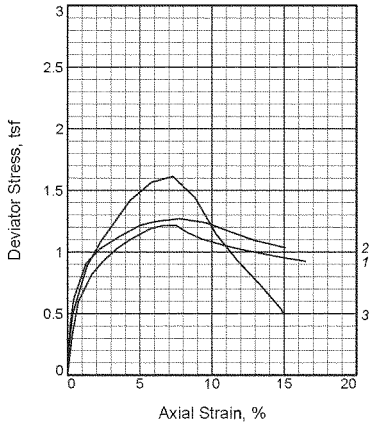
UU 0.5+3f





Sample No.		1	2	3
Initial	Water Content, %	37.3	36.4	37.9
	Dry Density, pcf	83.4	83.5	81.5
	Saturation, %	97.1	94.7	94.0
	Void Ratio	1.0574	1.0566	1.1072
	Diameter, in.	1.40	1.39	1.41
	Height, in.	2.80	2.81	2.81
At Test	Water Content, %	36.6	36.1	38.2
	Dry Density, pcf	83.4	83.5	81.5
	Saturation, %	95.3	93.8	94.9
	Void Ratio	1.0574	1.0566	1.1072
	Diameter, in.	1.40	1.39	1.41
	Height, in.	2.80	2.81	2.81
Strain rate, in./min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.50	1.00	2.00
Fail. Stress, tsf		1.22	1.27	1.61
Ult. Stress, tsf		0.95	1.04	0.49
σ_1 Failure, tsf		1.72	2.27	3.61
σ_3 Failure, tsf		0.50	1.00	2.00

Type of Test: Unconsolidated Undrained
Sample Type: Thinwall, 5"
Description: FAT CLAY with layers of Silt, brown (CH)
LL= 84 **PL=** 20 **PI=** 64
Assumed Specific Gravity= 2.75
Remarks:

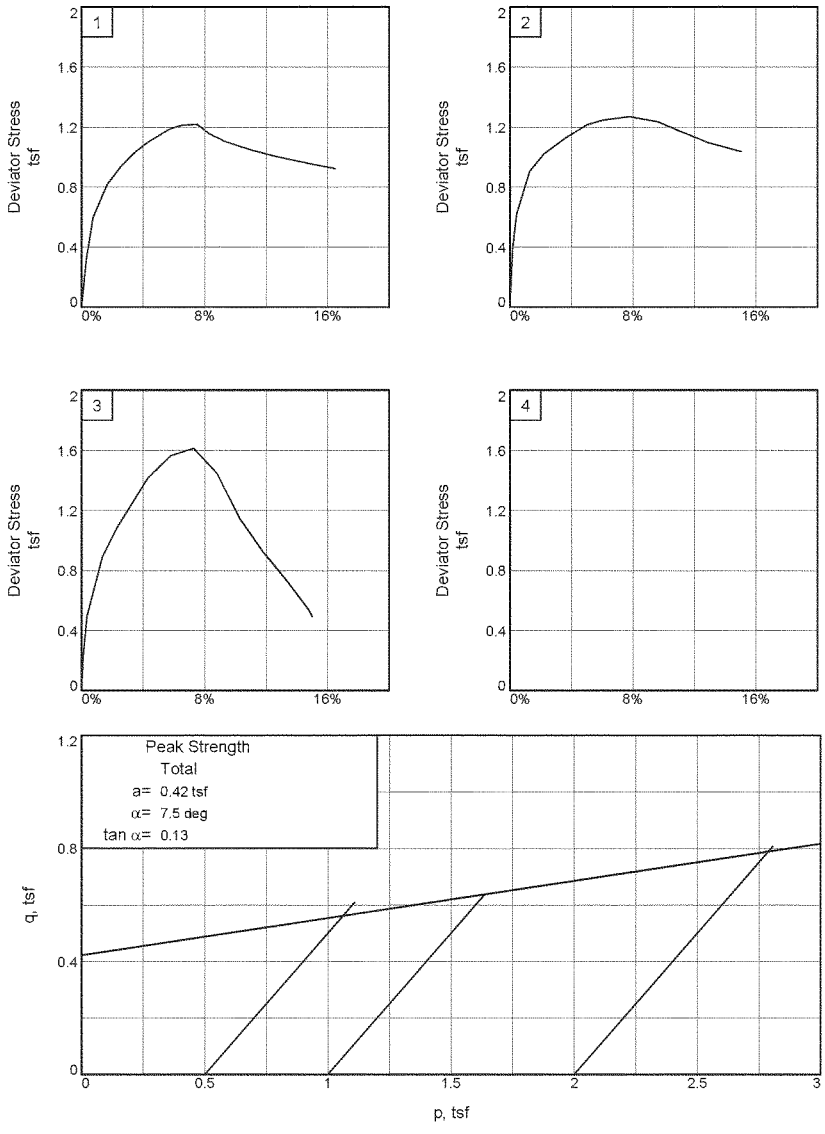
Figure UU Triax ASTM D 2850

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Fargo
Sample Number: Boring 09-23MU, #2 **Depth:** 10-12'
Sherack
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Fargo
Depth: 10-12' **Sample Number:** Boring 09-23MU, #2
Project No.: BL-09-03127 **Figure** _____

Sherack
Braun Intertec

Tested By: rs **Checked By:** rs

TRIAXIAL COMPRESSION TEST 9/16/2009
Unconsolidated Undrained 9:41 AM

Date:			
Client:	US Army Corps of Engineers		
Project:	Fargo-Moorhead Metro Feasibility Study		
Project No.:	BL-09-03127		Fargo
Depth:	10-12'	**Sample Number:**	Boring 09-23MU, #2
Description:	FAT CLAY with layers of Silt, brown (CH)		Sherack
Remarks:			
Type of Sample:	Thinwall, 5"		
Assumed Specific Gravity=2.75	**LL=84**	**PL=20**	**PI=64**
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	111.010	160.390
Moisture content: Dry soil+tare, gms.	89.250	125.420
Moisture content: Tare, gms.	30.990	29.940
Moisture, %	37.3	36.6
Moist specimen weight, gms.	130.6	
Diameter, in.	1.40	
Area, in.²	1.55	
Height, in.	2.80	
Wet Density, pcf	114.6	
Dry density, pcf	83.4	
Void ratio	1.0574	
Saturation, %	97.1	

Test Readings for Specimen No. 1

Cell pressure = 0.500 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 1.217 tsf **at reading no.** 10
Ult. Stress = 0.952 tsf **at reading no.** 16

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.7280	1.700	0.0	0.0	0.000	0.500	0.500	1.00	0.500	0.000
1	-1.7245	4.270	2.6	0.1	0.119	0.500	0.619	1.24	0.560	0.060
2	-1.7190	8.600	6.9	0.3	0.320	0.500	0.820	1.64	0.660	0.160
3	-1.7070	14.600	12.9	0.7	0.595	0.500	1.095	2.19	0.798	0.298
4	-1.6810	19.600	17.9	1.7	0.819	0.500	1.319	2.64	0.909	0.409
5	-1.6570	22.300	20.6	2.5	0.934	0.500	1.434	2.87	0.967	0.467
6	-1.6320	24.600	22.9	3.4	1.029	0.500	1.529	3.06	1.014	0.514
7	-1.6070	26.400	24.7	4.3	1.099	0.500	1.599	3.20	1.050	0.550
8	-1.5690	28.700	27.0	5.7	1.184	0.500	1.684	3.37	1.092	0.592
9	-1.5440	29.600	27.9	6.6	1.212	0.500	1.712	3.42	1.106	0.606
10	-1.5170	30.000	28.3	7.5	1.217	0.500	1.717	3.43	1.109	0.609
11	-1.4940	28.800	27.1	8.3	1.155	0.500	1.655	3.31	1.078	0.578
12	-1.4670	27.900	26.2	9.3	1.105	0.500	1.605	3.21	1.053	0.553
13	-1.4170	27.000	25.3	11.1	1.046	0.500	1.546	3.09	1.023	0.523
14	-1.3790	26.500	24.8	12.4	1.010	0.500	1.510	3.02	1.005	0.505
15	-1.3290	26.000	24.3	14.2	0.969	0.500	1.469	2.94	0.985	0.485
16	-1.3070	25.800	24.1	15.0	0.952	0.500	1.452	2.90	0.976	0.476
17	-1.2660	25.500	23.8	16.5	0.924	0.500	1.424	2.85	0.962	0.462

Parameters for Specimen No. 2		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	123.660	157.650
Moisture content: Dry soil+tare, gms.	98.730	123.910
Moisture content: Tare, gms.	30.180	30.320
Moisture, %	36.4	36.1
Moist specimen weight, gms.	127.6	
Diameter, in.	1.39	
Area, in.²	1.52	
Height, in.	2.81	
Wet Density, pcf	113.8	
Dry density, pcf	83.5	
Void ratio	1.0566	
Saturation, %	94.7	

Test Readings for Specimen No. 2

Cell pressure = 1.000 tsf

Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

Fail. Stress = 1.270 tsf at reading no. 8

Ult. Stress = 1.037 tsf at reading no. 13

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.7070	0.000	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	-1.7020	8.300	8.3	0.2	0.392	1.000	1.392	1.39	1.196	0.196
2	-1.6950	13.100	13.1	0.4	0.617	1.000	1.617	1.62	1.309	0.309
3	-1.6710	19.400	19.4	1.3	0.906	1.000	1.906	1.91	1.453	0.453
4	-1.6450	22.100	22.1	2.2	1.022	1.000	2.022	2.02	1.511	0.511
5	-1.6060	24.700	24.7	3.6	1.127	1.000	2.127	2.13	1.563	0.563
6	-1.5670	27.000	27.0	5.0	1.214	1.000	2.214	2.21	1.607	0.607
7	-1.5380	28.000	28.0	6.0	1.245	1.000	2.245	2.24	1.622	0.622
8	-1.4890	29.100	29.1	7.8	1.270	1.000	2.270	2.27	1.635	0.635
9	-1.4370	28.900	28.9	9.6	1.236	1.000	2.236	2.24	1.618	0.618
10	-1.3980	27.900	27.9	11.0	1.175	1.000	2.175	2.17	1.587	0.587
11	-1.3450	26.600	26.6	12.9	1.096	1.000	2.096	2.10	1.548	0.548
12	-1.2930	25.900	25.9	14.8	1.045	1.000	2.045	2.04	1.522	0.522
13	-1.2850	25.800	25.8	15.0	1.037	1.000	2.037	2.04	1.519	0.519

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	115.160	158.620
Moisture content: Dry soil+tare, gms.	92.060	123.190
Moisture content: Tare, gms.	31.050	30.480
Moisture, %	37.9	38.2
Moist specimen weight, gms.	128.6	
Diameter, in.	1.41	
Area, in.²	1.55	
Height, in.	2.81	
Wet Density, pcf	112.3	
Dry density, pcf	81.5	
Void ratio	1.1072	
Saturation, %	94.0	

Test Readings for Specimen No. 3

Cell pressure = 2.000 tsf

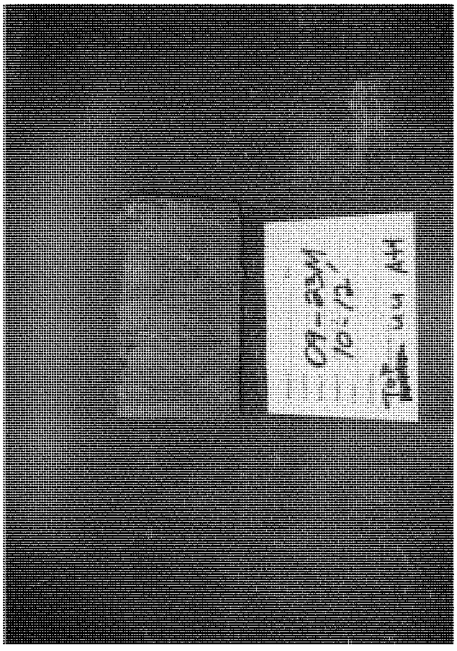
Back pressure = 0.000 tsf

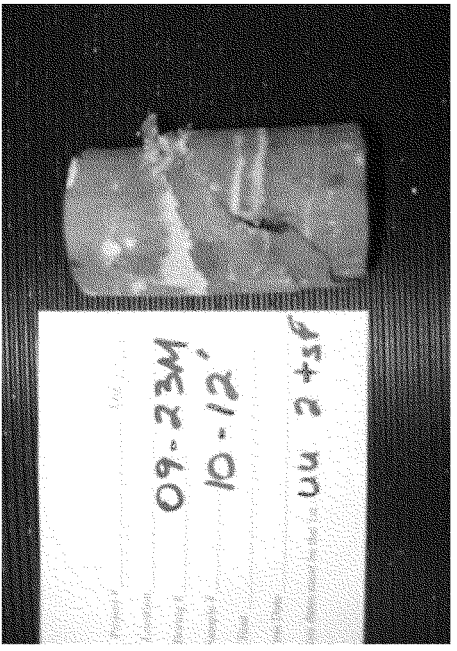
Strain rate, in./min. = 0.03

Fail. Stress = 1.612 tsf at reading no. 8

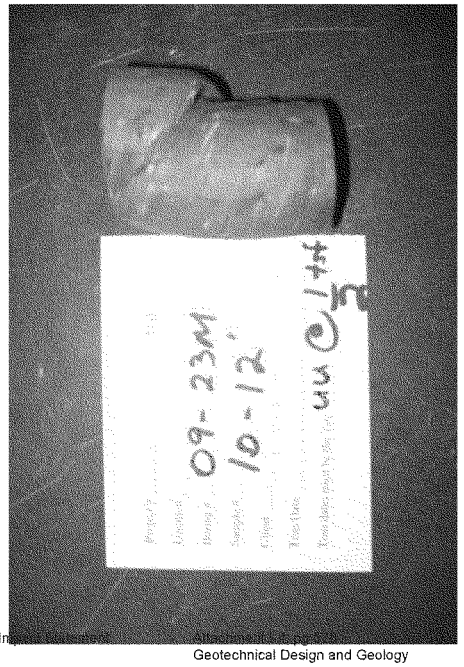
Ult. Stress = 0.493 tsf at reading no. 14

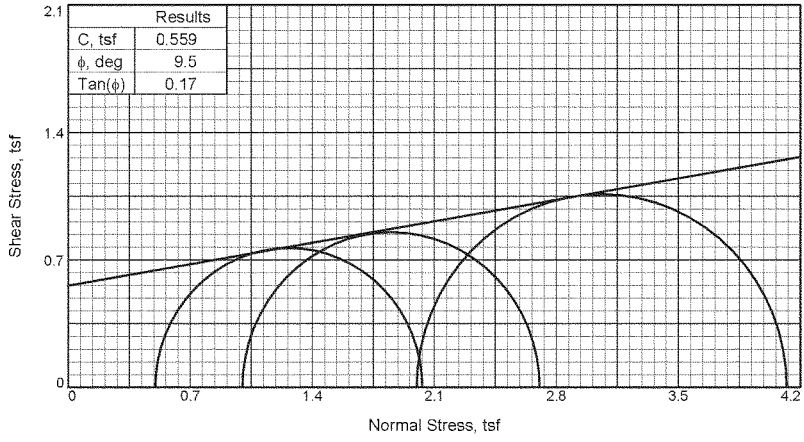
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.6940	5.500	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	-1.6910	10.300	4.8	0.1	0.222	2.000	2.222	1.11	2.111	0.111
2	-1.6840	16.200	10.7	0.4	0.494	2.000	2.494	1.25	2.247	0.247
3	-1.6560	24.900	19.4	1.4	0.887	2.000	2.887	1.44	2.444	0.444
4	-1.6290	29.500	24.0	2.3	1.087	2.000	3.087	1.54	2.544	0.544
5	-1.6010	33.400	27.9	3.3	1.251	2.000	3.251	1.63	2.625	0.625
6	-1.5730	37.400	31.9	4.3	1.416	2.000	3.416	1.71	2.708	0.708
7	-1.5310	41.300	35.8	5.8	1.564	2.000	3.564	1.78	2.782	0.782
8	-1.4890	43.000	37.5	7.3	1.612	2.000	3.612	1.81	2.806	0.806
9	-1.4470	39.700	34.2	8.8	1.446	2.000	3.446	1.72	2.723	0.723
10	-1.4050	33.000	27.5	10.3	1.144	2.000	3.144	1.57	2.572	0.572
11	-1.3630	28.100	22.6	11.8	0.925	2.000	2.925	1.46	2.462	0.462
12	-1.3210	23.900	18.4	13.3	0.740	2.000	2.740	1.37	2.370	0.370
13	-1.2790	19.100	13.6	14.8	0.537	2.000	2.537	1.27	2.269	0.269
14	-1.2730	18.000	12.5	15.0	0.493	2.000	2.493	1.25	2.246	0.246

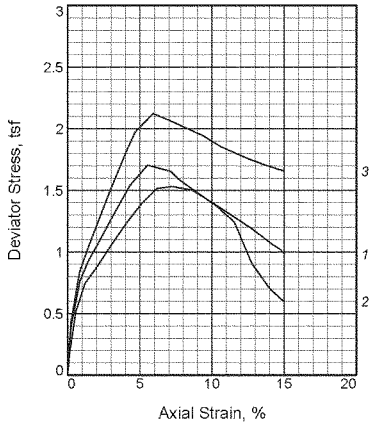

09-23M
10-12'


09-23M
10-12'

09-23M
10-12'


09-23M
10-12'





Sample No.		1	2	3
Initial	Water Content, %	37.4	37.9	37.8
	Dry Density, pcf	82.1	81.7	82.0
	Saturation, %	94.1	94.7	95.0
	Void Ratio	1.0923	1.1012	1.0930
	Diameter, in.	1.39	1.39	1.41
	Height, in.	2.79	2.82	2.81
At Test	Water Content, %	38.4	37.6	36.5
	Dry Density, pcf	82.1	81.7	82.0
	Saturation, %	96.8	94.0	91.7
	Void Ratio	1.0923	1.1012	1.0930
	Diameter, in.	1.39	1.39	1.41
	Height, in.	2.79	2.82	2.81
Strain rate, in./min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.50	1.00	2.00
Fail. Stress, tsf		1.53	1.70	2.12
Ult. Stress, tsf		0.99	0.60	1.66
σ_1 Failure, tsf		2.03	2.70	4.12
σ_3 Failure, tsf		0.50	1.00	2.00

Type of Test: Unconsolidated Undrained
Sample Type: Thinwall, 5"
Description: FAT CLAY with layers of Silt, brown (CH)
LL= 82 **PL=** 20 **PI=** 62
Assumed Specific Gravity= 2.75
Remarks: Tested bottom portion of 5" thinwall.

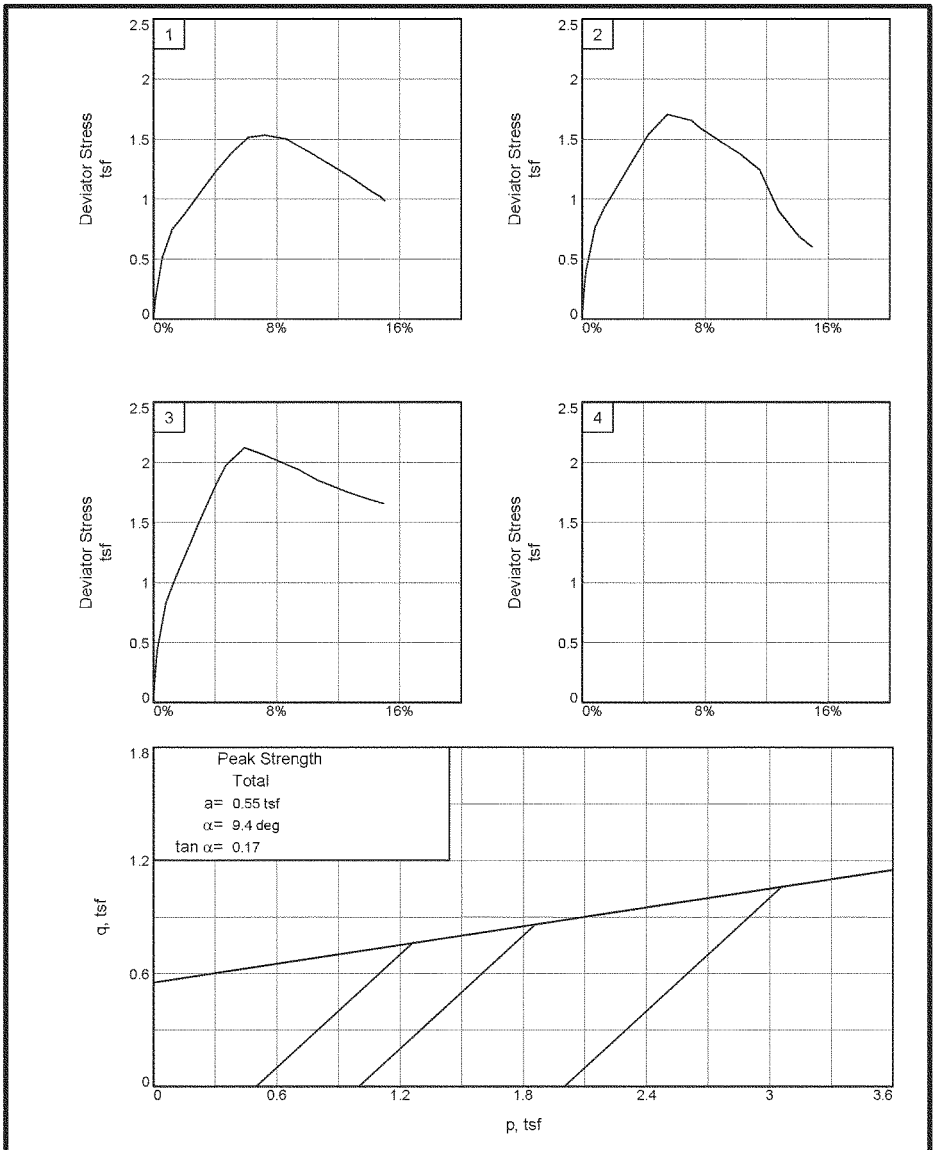
Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Moorhead
Sample Number: Boring 09-25MU, #1 **Depth:** 8-10'
Sherack
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Figure UU Triax ASTM D 2850

Tested By: rs **Checked By:** rs



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Moorhead
Depth: 8-10' **Sample Number:** Boring 09-25MU, #1
Project No.: BL-09-03127 **Figure** _____

Sherack
Braun Intertec

Tested By: ts **Checked By:** ts

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

9/16/2009
9:41 AM

Date:			
Client:	US Army Corps of Engineers		
Project:	Fargo-Moorhead Metro Feasibility Study		
Project No.:	BL-09-03127		Moorhead
Depth:	8-10'	**Sample Number:**	Boring 09-25MU, #1
Description:	FAT CLAY with layers of Silt, brown (CH)		Sherack
Remarks:	Tested bottom portion of 5" thinwall.		
Type of Sample:	Thinwall, 5"		
Assumed Specific Gravity=2.75	**LL=82**	**PL=20**	**PI=62**
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	94.120	156.280
Moisture content: Dry soil+tare, gms.	76.780	121.470
Moisture content: Tare, gms.	30.410	30.920
Moisture, %	37.4	38.4
Moist specimen weight, gms.	125.9	
Diameter, in.	1.39	
Area, in.²	1.52	
Height, in.	2.79	
Wet Density, pcf	112.7	
Dry density, pcf	82.1	
Void ratio	1.0923	
Saturation, %	94.1	

Test Readings for Specimen No. 1

Cell pressure = 0.500 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 1.532 tsf **at reading no.** 9
Ult. Stress = 0.986 tsf **at reading no.** 16

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.7040	1.450	0.0	0.0	0.000	0.500	0.500	1.00	0.500	0.000
1	-1.7000	5.200	3.8	0.1	0.177	0.500	0.677	1.35	0.588	0.088
2	-1.6880	12.400	11.0	0.6	0.514	0.500	1.014	2.03	0.757	0.257
3	-1.6700	17.500	16.1	1.2	0.749	0.500	1.249	2.50	0.875	0.375
4	-1.6490	20.200	18.8	2.0	0.868	0.500	1.368	2.74	0.934	0.434
5	-1.6200	24.400	23.0	3.0	1.052	0.500	1.552	3.10	1.026	0.526
6	-1.5910	28.600	27.2	4.0	1.231	0.500	1.731	3.46	1.115	0.615
7	-1.5610	32.500	31.1	5.1	1.392	0.500	1.892	3.78	1.196	0.696
8	-1.5320	35.600	34.2	6.2	1.514	0.500	2.014	4.03	1.257	0.757
9	-1.5020	36.400	34.9	7.2	1.532	0.500	2.032	4.06	1.266	0.766
10	-1.4630	36.200	34.8	8.6	1.500	0.500	2.000	4.00	1.250	0.750
11	-1.4240	34.400	32.9	10.0	1.400	0.500	1.900	3.80	1.200	0.700
12	-1.3840	32.300	30.9	11.5	1.290	0.500	1.790	3.58	1.145	0.645
13	-1.3460	30.200	28.8	12.8	1.184	0.500	1.684	3.37	1.092	0.592
14	-1.3070	27.600	26.2	14.2	1.060	0.500	1.560	3.12	1.030	0.530
15	-1.2937	26.900	25.5	14.7	1.026	0.500	1.526	3.05	1.013	0.513
16	-1.2850	26.000	24.6	15.0	0.986	0.500	1.486	2.97	0.993	0.493

Parameters for Specimen No. 2		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	125.880	156.400
Moisture content: Dry soil+tare, gms.	99.610	121.920
Moisture content: Tare, gms.	30.360	30.280
Moisture, %	37.9	37.6
Moist specimen weight, gms.	126.9	
Diameter, in.	1.39	
Area, in.²	1.52	
Height, in.	2.82	
Wet Density, pcf	112.7	
Dry density, pcf	81.7	
Void ratio	1.1012	
Saturation, %	94.7	

Test Readings for Specimen No. 2

Cell pressure = 1.000 tsf

Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

Fail. Stress = 1.705 tsf at reading no. 8

Ult. Stress = 0.603 tsf at reading no. 16

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.7110	2.300	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	-1.7070	7.700	5.4	0.1	0.255	1.000	1.255	1.25	1.127	0.127
2	-1.7040	10.700	8.4	0.2	0.396	1.000	1.396	1.40	1.198	0.198
3	-1.6870	18.600	16.3	0.9	0.764	1.000	1.764	1.76	1.382	0.382
4	-1.6700	22.300	20.0	1.5	0.931	1.000	1.931	1.93	1.466	0.466
5	-1.6520	25.300	23.0	2.1	1.064	1.000	2.064	2.06	1.532	0.532
6	-1.6250	30.100	27.8	3.1	1.273	1.000	2.273	2.27	1.637	0.637
7	-1.5900	36.300	34.0	4.3	1.537	1.000	2.537	2.54	1.769	0.769
8	-1.5550	40.500	38.2	5.5	1.705	1.000	2.705	2.70	1.852	0.852
9	-1.5100	40.000	37.7	7.1	1.654	1.000	2.654	2.65	1.827	0.827
10	-1.4930	38.700	36.4	7.7	1.587	1.000	2.587	2.59	1.793	0.793
11	-1.4570	36.700	34.4	9.0	1.479	1.000	2.479	2.48	1.739	0.739
12	-1.4220	34.800	32.5	10.3	1.378	1.000	2.378	2.38	1.689	0.689
13	-1.3860	32.100	29.8	11.5	1.245	1.000	2.245	2.25	1.623	0.623
14	-1.3510	24.100	21.8	12.8	0.898	1.000	1.898	1.90	1.449	0.449
15	-1.3160	19.500	17.2	14.0	0.699	1.000	1.699	1.70	1.349	0.349
16	-1.2900	17.300	15.0	15.0	0.603	1.000	1.603	1.60	1.301	0.301

Parameters for Specimen No. 3

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	81.240	160.790
Moisture content: Dry soil+tare, gms.	67.440	125.990
Moisture content: Tare, gms.	30.890	30.540
Moisture, %	37.8	36.5
Moist specimen weight, gms.	130.8	
Diameter, in.	1.41	
Area, in.²	1.57	
Height, in.	2.81	
Wet Density, pcf	113.0	
Dry density, pcf	82.0	
Void ratio	1.0930	
Saturation, %	95.0	

Test Readings for Specimen No. 3

Cell pressure = 2.000 tsf

Back pressure = 0.000 tsf

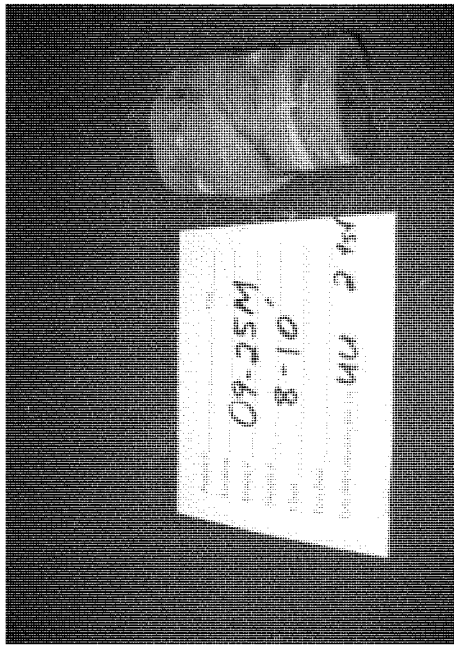
Strain rate, in./min. = 0.03

Fail. Stress = 2.123 tsf at reading no. 9

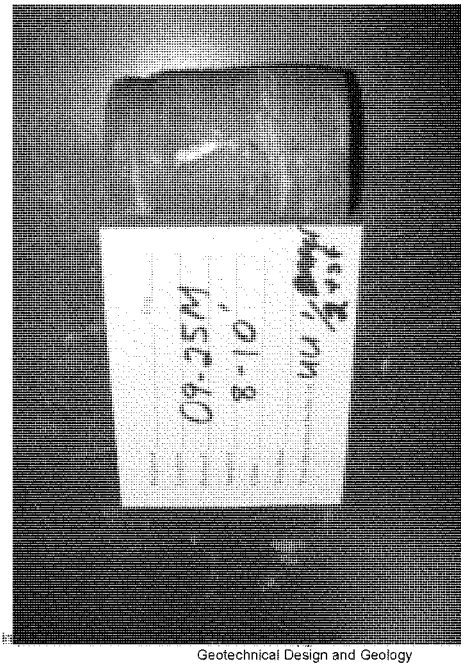
Ult. Stress = 1.657 tsf at reading no. 16

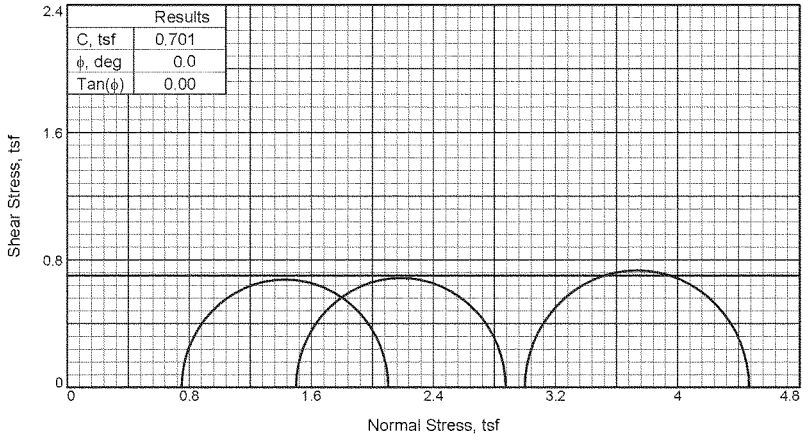
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.7000	5.300	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	-1.6980	9.000	3.7	0.1	0.170	2.000	2.170	1.08	2.085	0.085
2	-1.6930	14.900	9.6	0.2	0.439	2.000	2.439	1.22	2.220	0.220
3	-1.6770	23.600	18.3	0.8	0.832	2.000	2.832	1.42	2.416	0.416
4	-1.6600	28.200	22.9	1.4	1.035	2.000	3.035	1.52	2.518	0.518
5	-1.6350	34.400	29.1	2.3	1.303	2.000	3.303	1.65	2.652	0.652
6	-1.6180	38.700	33.4	2.9	1.487	2.000	3.487	1.74	2.743	0.743
7	-1.5840	47.000	41.7	4.1	1.833	2.000	3.833	1.92	2.916	0.916
8	-1.5680	50.500	45.2	4.7	1.975	2.000	3.975	1.99	2.988	0.988
9	-1.5340	54.500	49.2	5.9	2.123	2.000	4.123	2.06	3.061	1.061
10	-1.5010	53.800	48.5	7.1	2.066	2.000	4.066	2.03	3.033	1.033
11	-1.4670	52.900	47.6	8.3	2.001	2.000	4.001	2.00	3.001	1.001
12	-1.4340	52.000	46.7	9.5	1.938	2.000	3.938	1.97	2.969	0.969
13	-1.4000	50.500	45.2	10.7	1.851	2.000	3.851	1.93	2.926	0.926
14	-1.3490	49.100	43.8	12.5	1.757	2.000	3.757	1.88	2.879	0.879
15	-1.3160	48.400	43.1	13.7	1.706	2.000	3.706	1.85	2.853	0.853
16	-1.2800	47.800	42.5	15.0	1.657	2.000	3.657	1.83	2.829	0.829

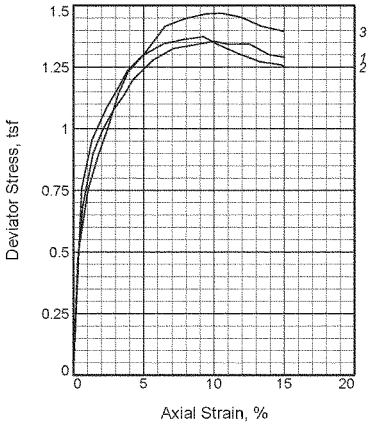
09-25M
8-10'


09-25M
8-10'

09-25M
8-10'


09-25M
8-10'





Sample No.		1	2	3
Initial	Water Content, %	40.3	40.1	38.7
	Dry Density, pcf	81.4	81.7	83.1
	Saturation, %	99.9	100.0	100.0
	Void Ratio	1.1097	1.1018	1.0650
	Diameter, in.	1.40	1.39	1.40
	Height, in.	2.80	2.81	2.81
At Test	Water Content, %	40.1	39.0	37.8
	Dry Density, pcf	81.4	81.7	83.1
	Saturation, %	99.3	97.2	97.6
	Void Ratio	1.1097	1.1018	1.0650
	Diameter, in.	1.40	1.39	1.40
	Height, in.	2.80	2.81	2.81
Strain rate, in./min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.75	1.50	3.00
Fail. Stress, tsf		1.35	1.37	1.47
Ult. Stress, tsf		1.29	1.25	1.39
σ_1 Failure, tsf		2.10	2.87	4.47
σ_3 Failure, tsf		0.75	1.50	3.00

Type of Test:
Unconsolidated Undrained
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, brown (CH)

LL= 89 **PL=** 21 **PI=** 68
Assumed Specific Gravity= 2.75
Remarks:

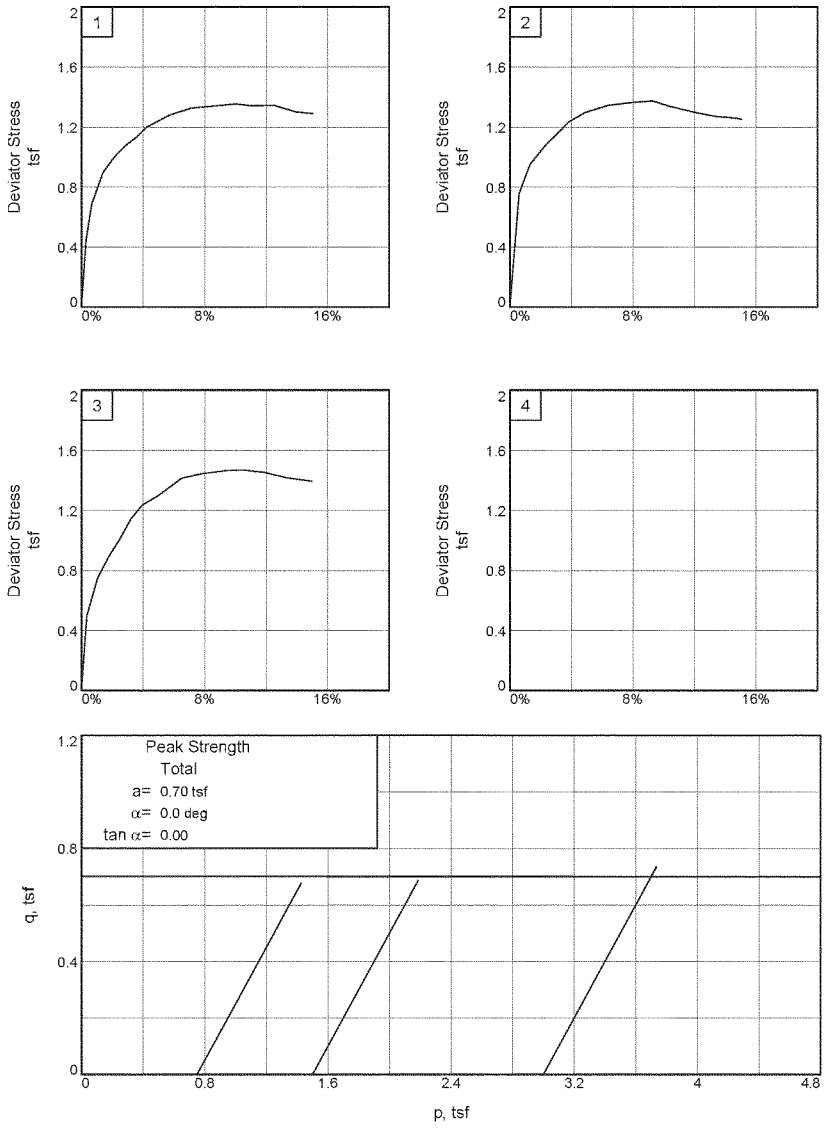
Figure UU Triax ASTM D 2850

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Fargo
Location: WD-28, ND Div Oxidized Brenna
Sample Number: Boring 09-59MU, #1 **Depth:** 10-12'
Proj. No.: BL0903127A **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Fargo Oxidized Brenna
Location: WD-28, ND Div **Depth:** 10-12' **Sample Number:** Boring 09-59MU, #1
Project No.: BL0903127A **Figure** _____ **Braun Intertec**

Tested By: rs **Checked By:** rs

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

2/23/2010
11:26 AM

Date:			
Client:	US Army Corps of Engineers		
Project:	Fargo-Moorhead Metro Feasibility Study		
Project No.:	BL0903127A		
Location:	WD-28, ND Div		Fargo
Depth:	10-12'	**Sample Number:**	Boring 09-59MU, #1
Description:	FAT CLAY, brown (CH)		Oxidized Brenna
Remarks:			
Type of Sample:	Thinwall, 5", Middle of sample		
Assumed Specific Gravity=2.75	**LL=89**	**PL=21**	**PI=68**
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	176.600	158.910
Moisture content: Dry soil+tare, gms.	134.620	122.100
Moisture content: Tare, gms.	30.500	30.200
Moisture, %	40.3	40.1
Moist specimen weight, gms.	129.1	
Diameter, in.	1.40	
Area, in.²	1.54	
Height, in.	2.80	
Wet Density, pcf	114.2	
Dry density, pcf	81.4	
Void ratio	1.1097	
Saturation, %	99.9	

Test Readings for Specimen No. 1

Cell pressure = 0.750 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 1.354 tsf **at reading no.** 11
Ult. Stress = 1.290 tsf **at reading no.** 15

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0061	0.630	0.0	0.0	0.000	0.750	0.750	1.00	0.750	0.000
1	0.0147	10.340	9.7	0.3	0.453	0.750	1.203	1.60	0.977	0.227
2	0.0248	15.370	14.7	0.7	0.686	0.750	1.436	1.91	1.093	0.343
3	0.0456	20.130	19.5	1.4	0.900	0.750	1.650	2.20	1.200	0.450
4	0.0664	22.520	21.9	2.2	1.003	0.750	1.753	2.34	1.252	0.502
5	0.0866	24.350	23.7	2.9	1.079	0.750	1.829	2.44	1.290	0.540
6	0.1062	25.740	25.1	3.6	1.134	0.750	1.884	2.51	1.317	0.567
7	0.1251	27.390	26.8	4.2	1.200	0.750	1.950	2.60	1.350	0.600
8	0.1652	29.570	28.9	5.7	1.279	0.750	2.029	2.70	1.389	0.639
9	0.2060	31.120	30.5	7.1	1.326	0.750	2.076	2.77	1.413	0.663
10	0.2469	31.930	31.3	8.6	1.340	0.750	2.090	2.79	1.420	0.670
11	0.2866	32.760	32.1	10.0	1.354	0.750	2.104	2.81	1.427	0.677
12	0.3166	32.860	32.2	11.1	1.342	0.750	2.092	2.79	1.421	0.671
13	0.3572	33.440	32.8	12.5	1.344	0.750	2.094	2.79	1.422	0.672
14	0.3974	32.890	32.3	14.0	1.300	0.750	2.050	2.73	1.400	0.650
15	0.4270	33.050	32.4	15.0	1.290	0.750	2.040	2.72	1.395	0.645

Parameters for Specimen No. 2		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	154.900	158.010
Moisture content: Dry soil+tare, gms.	119.550	122.200
Moisture content: Tare, gms.	31.300	30.280
Moisture, %	40.1	39.0
Moist specimen weight, gms.	128.1	
Diameter, in.	1.39	
Area, in.²	1.52	
Height, in.	2.81	
Wet Density, pcf	114.4	
Dry density, pcf	81.7	
Void ratio	1.1018	
Saturation, %	100.0	

Test Readings for Specimen No. 2

Cell pressure = 1.500 tsf

Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

Fail. Stress = 1.374 tsf at reading no. 10

Ult. Stress = 1.251 tsf at reading no. 15

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0061	2.010	0.0	0.0	0.000	1.500	1.500	1.00	1.500	0.000
1	0.0228	18.060	16.0	0.6	0.757	1.500	2.257	1.50	1.879	0.379
2	0.0430	22.360	20.4	1.3	0.953	1.500	2.453	1.64	1.976	0.476
3	0.0635	24.500	22.5	2.0	1.045	1.500	2.545	1.70	2.023	0.523
4	0.0736	25.550	23.5	2.4	1.090	1.500	2.590	1.73	2.045	0.545
5	0.0935	27.230	25.2	3.1	1.159	1.500	2.659	1.77	2.080	0.580
6	0.1135	29.050	27.0	3.8	1.234	1.500	2.734	1.82	2.117	0.617
7	0.1442	30.760	28.8	4.9	1.297	1.500	2.797	1.86	2.149	0.649
8	0.1860	32.290	30.3	6.4	1.345	1.500	2.845	1.90	2.172	0.672
9	0.2266	33.170	31.2	7.8	1.362	1.500	2.862	1.91	2.181	0.681
10	0.2668	33.930	31.9	9.3	1.374	1.500	2.874	1.92	2.187	0.687
11	0.2977	33.500	31.5	10.4	1.339	1.500	2.839	1.89	2.170	0.670
12	0.3395	33.140	31.1	11.9	1.302	1.500	2.802	1.87	2.151	0.651
13	0.3793	32.920	30.9	13.3	1.272	1.500	2.772	1.85	2.136	0.636
14	0.4203	33.160	31.2	14.7	1.260	1.500	2.760	1.84	2.130	0.630
15	0.4290	33.050	31.0	15.0	1.251	1.500	2.751	1.83	2.126	0.626

Parameters for Specimen No. 3

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	132.300	160.680
Moisture content: Dry soil+tare, gms.	103.850	124.900
Moisture content: Tare, gms.	30.410	30.280
Moisture, %	38.7	37.8
Moist specimen weight, gms.	130.9	
Diameter, in.	1.40	
Area, in.²	1.54	
Height, in.	2.81	
Wet Density, pcf	115.3	
Dry density, pcf	83.1	
Void ratio	1.0650	
Saturation, %	100.0	

Test Readings for Specimen No. 3

Cell pressure = 3.000 tsf

Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

Fail. Stress = 1.469 tsf at reading no. 11

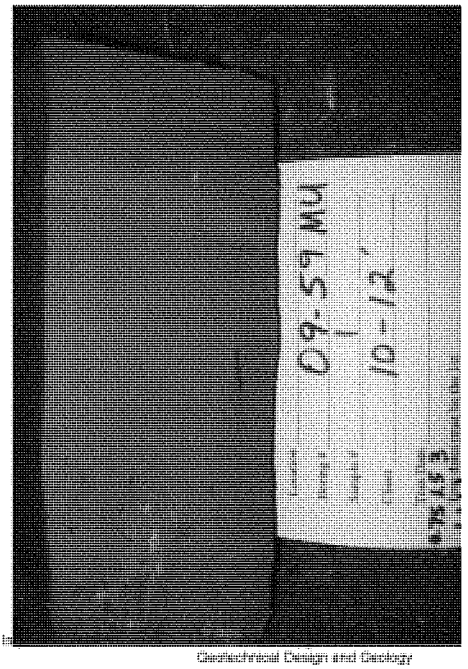
Ult. Stress = 1.395 tsf at reading no. 14

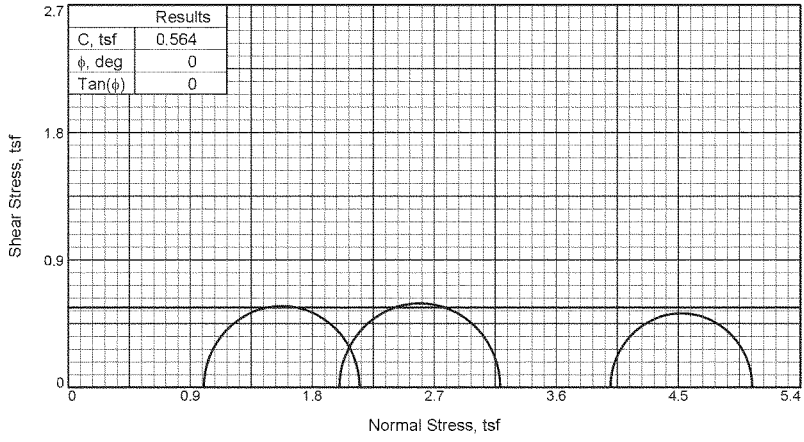
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0061	8.450	0.0	0.0	0.000	3.000	3.000	1.00	3.000	0.000
1	0.0159	19.070	10.6	0.3	0.496	3.000	3.496	1.17	3.248	0.248
2	0.0356	24.660	16.2	1.0	0.751	3.000	3.751	1.25	3.376	0.376
3	0.0559	27.830	19.4	1.8	0.892	3.000	3.892	1.30	3.446	0.446
4	0.0760	30.510	22.1	2.5	1.008	3.000	4.008	1.34	3.504	0.504
5	0.0964	33.660	25.2	3.2	1.143	3.000	4.143	1.38	3.571	0.571
6	0.1165	35.850	27.4	3.9	1.233	3.000	4.233	1.41	3.617	0.617
7	0.1479	37.750	29.3	5.0	1.303	3.000	4.303	1.43	3.652	0.652
8	0.1890	40.760	32.3	6.5	1.415	3.000	4.415	1.47	3.707	0.707
9	0.2289	41.970	33.5	7.9	1.446	3.000	4.446	1.48	3.723	0.723
10	0.2707	42.990	34.5	9.4	1.466	3.000	4.466	1.49	3.733	0.733
11	0.3005	43.480	35.0	10.5	1.469	3.000	4.469	1.49	3.735	0.735
12	0.3413	43.670	35.2	11.9	1.453	3.000	4.453	1.48	3.727	0.727
13	0.3814	43.360	34.9	13.3	1.417	3.000	4.417	1.47	3.708	0.708
14	0.4275	43.480	35.0	15.0	1.395	3.000	4.395	1.46	3.697	0.697

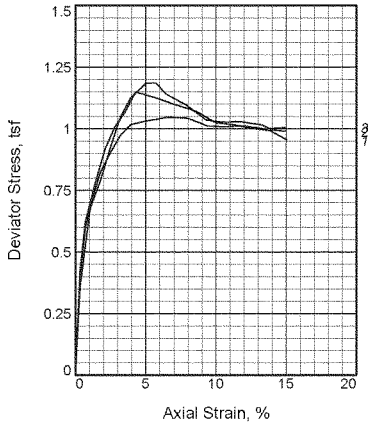
09-59MU
10-12'
UU 3 tsf

09-59MU
10-12'
UU 1.5 t

09-59MU
10-12'
UU 0.75 tsf


09-59MU
10-12'





Sample No.		1	2	3
Initial	Water Content, %	46.4	46.5	47.3
	Dry Density, pcf	75.4	75.3	73.8
	Saturation, %	100.0	100.0	98.0
	Void Ratio	1.2756	1.2795	1.3268
	Diameter, in.	1.40	1.40	1.40
	Height, in.	2.80	2.81	2.81
At Test	Water Content, %	44.6	46.2	48.2
	Dry Density, pcf	75.4	75.3	73.8
	Saturation, %	96.2	99.4	99.9
	Void Ratio	1.2756	1.2795	1.3268
	Diameter, in.	1.40	1.40	1.40
	Height, in.	2.80	2.81	2.81
Strain rate, in./min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		1.00	2.00	4.00
Fail. Stress, tsf		1.15	1.19	1.05
Ult. Stress, tsf		0.96	0.99	1.01
σ_1 Failure, tsf		2.15	3.19	5.05
σ_3 Failure, tsf		1.00	2.00	4.00

Type of Test: Unconsolidated Undrained
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, brown (CH)

LL= 92 **PL=** 19 **PI=** 73
Assumed Specific Gravity= 2.75
Remarks:

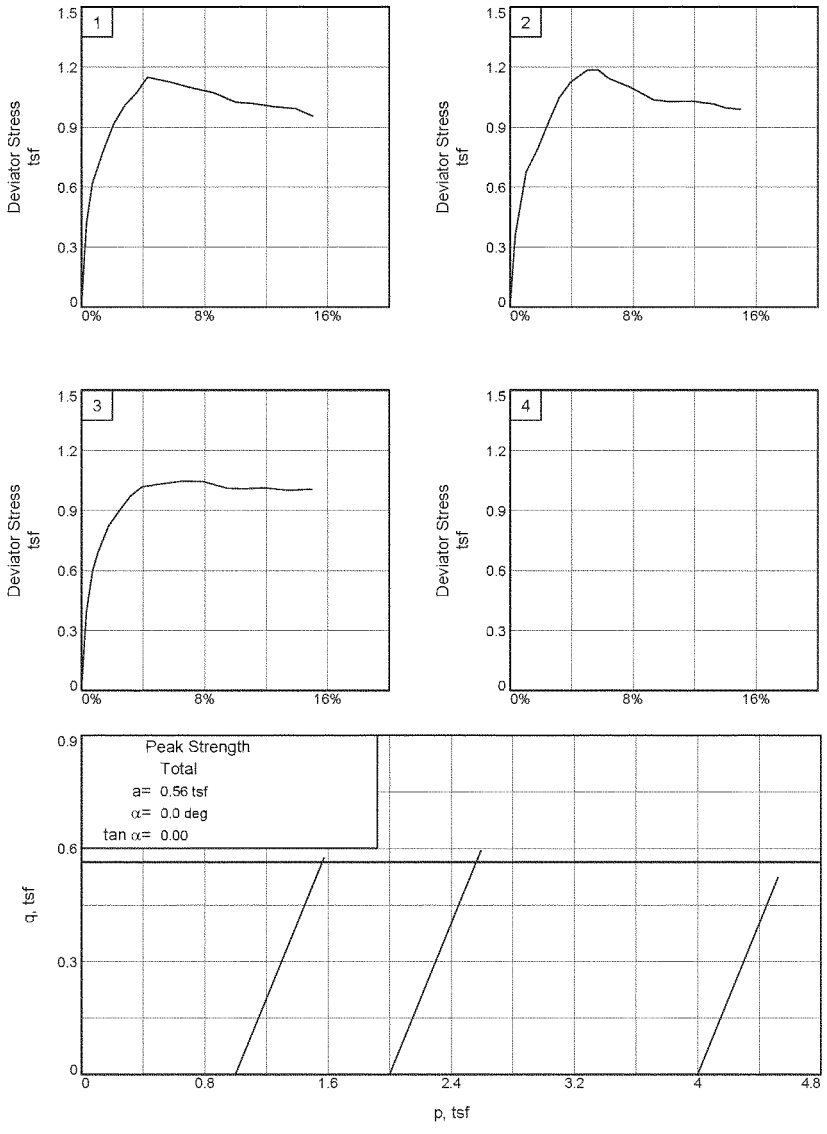
Figure UU Triax ASTM D 2850

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Fargo
Location: WD-28, ND Div Oxidized Brenna
Sample Number: Boring 09-59MU, #2 **Depth:** 20-22'
Proj. No.: BL0903127A **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Fargo Oxidized Brenna
Location: WD-28, ND Div **Depth:** 20-22' **Sample Number:** Boring 09-59MU, #2
Project No.: BL0903127A **Figure** _____ **Braun Intertec**

Tested By: rs **Checked By:** rs

TRIAXIAL COMPRESSION TEST 2/23/2010
Unconsolidated Undrained 11:24 AM

Date:			
Client:	US Army Corps of Engineers		
Project:	Fargo-Moorhead Metro Feasibility Study		
Project No.:	BL0903127A		
Location:	WD-28, ND Div		Fargo
Depth:	20-22'	**Sample Number:**	Boring 09-59MU, #2
Description:	FAT CLAY, brown (CH)		Oxidized Brenna
Remarks:			
Type of Sample:	Thinwall, 5", Middle of sample		
Assumed Specific Gravity=2.75	**LL=92**	**PL=19**	**PI=73**
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	124.110	155.200
Moisture content: Dry soil+tare, gms.	94.350	116.910
Moisture content: Tare, gms.	30.200	31.100
Moisture, %	46.4	44.6
Moist specimen weight, gms.	124.6	
Diameter, in.	1.40	
Area, in.²	1.53	
Height, in.	2.80	
Wet Density, pcf	110.4	
Dry density, pcf	75.4	
Void ratio	1.2756	
Saturation, %	100.0	

Test Readings for Specimen No. 1

Cell pressure = 1.000 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 1.149 tsf **at reading no.** 7
Ult. Stress = 0.956 tsf **at reading no.** 15

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0060	0.970	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	0.0152	10.030	9.1	0.3	0.424	1.000	1.424	1.42	1.212	0.212
2	0.0255	14.240	13.3	0.7	0.618	1.000	1.618	1.62	1.309	0.309
3	0.0457	17.880	16.9	1.4	0.782	1.000	1.782	1.78	1.391	0.391
4	0.0653	20.980	20.0	2.1	0.919	1.000	1.919	1.92	1.459	0.459
5	0.0851	23.130	22.2	2.8	1.010	1.000	2.010	2.01	1.505	0.505
6	0.1053	24.590	23.6	3.5	1.069	1.000	2.069	2.07	1.534	0.534
7	0.1260	26.570	25.6	4.3	1.149	1.000	2.149	2.15	1.575	0.575
8	0.1668	26.420	25.5	5.7	1.125	1.000	2.125	2.13	1.563	0.563
9	0.2058	26.150	25.2	7.1	1.097	1.000	2.097	2.10	1.548	0.548
10	0.2469	25.960	25.0	8.6	1.071	1.000	2.071	2.07	1.536	0.536
11	0.2866	25.230	24.3	10.0	1.024	1.000	2.024	2.02	1.512	0.512
12	0.3173	25.380	24.4	11.1	1.018	1.000	2.018	2.02	1.509	0.509
13	0.3564	25.380	24.4	12.5	1.002	1.000	2.002	2.00	1.501	0.501
14	0.3955	25.540	24.6	13.9	0.992	1.000	1.992	1.99	1.496	0.496
15	0.4270	24.950	24.0	15.0	0.956	1.000	1.956	1.96	1.478	0.478

Parameters for Specimen No. 2		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	178.590	154.470
Moisture content: Dry soil+tare, gms.	131.530	115.170
Moisture content: Tare, gms.	30.410	30.190
Moisture, %	46.5	46.2
Moist specimen weight, gms.	124.8	
Diameter, in.	1.40	
Area, in.²	1.53	
Height, in.	2.81	
Wet Density, pcf	110.4	
Dry density, pcf	75.3	
Void ratio	1.2795	
Saturation, %	100.0	

Test Readings for Specimen No. 2

Cell pressure = 2.000 tsf

Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

Fail. Stress = 1.187 tsf at reading no. 8

Ult. Stress = 0.990 tsf at reading no. 16

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0082	4.080	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	0.0177	11.740	7.7	0.3	0.359	2.000	2.359	1.18	2.179	0.179
2	0.0378	18.670	14.6	1.1	0.678	2.000	2.678	1.34	2.339	0.339
3	0.0582	21.200	17.1	1.8	0.790	2.000	2.790	1.39	2.395	0.395
4	0.0793	24.380	20.3	2.5	0.929	2.000	2.929	1.46	2.465	0.465
5	0.0985	27.150	23.1	3.2	1.049	2.000	3.049	1.52	2.524	0.524
6	0.1189	29.020	24.9	3.9	1.125	2.000	3.125	1.56	2.563	0.563
7	0.1492	30.630	26.5	5.0	1.185	2.000	3.185	1.59	2.592	0.592
8	0.1690	30.880	26.8	5.7	1.187	2.000	3.187	1.59	2.593	0.593
9	0.1885	30.080	26.0	6.4	1.143	2.000	3.143	1.57	2.571	0.571
10	0.2291	29.440	25.4	7.9	1.098	2.000	3.098	1.55	2.549	0.549
11	0.2707	28.410	24.3	9.3	1.036	2.000	3.036	1.52	2.518	0.518
12	0.2998	28.480	24.4	10.4	1.027	2.000	3.027	1.51	2.514	0.514
13	0.3397	28.920	24.8	11.8	1.029	2.000	3.029	1.51	2.515	0.515
14	0.3814	28.990	24.9	13.3	1.015	2.000	3.015	1.51	2.507	0.507
15	0.4019	28.720	24.6	14.0	0.995	2.000	2.995	1.50	2.498	0.498
16	0.4290	28.860	24.8	15.0	0.990	2.000	2.990	1.49	2.495	0.495

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	123.490	152.010
Moisture content: Dry soil+tare, gms.	93.600	112.340
Moisture content: Tare, gms.	30.380	30.050
Moisture, %	47.3	48.2
Moist specimen weight, gms.	122.4	
Diameter, in.	1.40	
Area, in.²	1.53	
Height, in.	2.81	
Wet Density, pcf	108.7	
Dry density, pcf	73.8	
Void ratio	1.3268	
Saturation, %	98.0	

Test Readings for Specimen No. 3

Cell pressure = 4.000 tsf

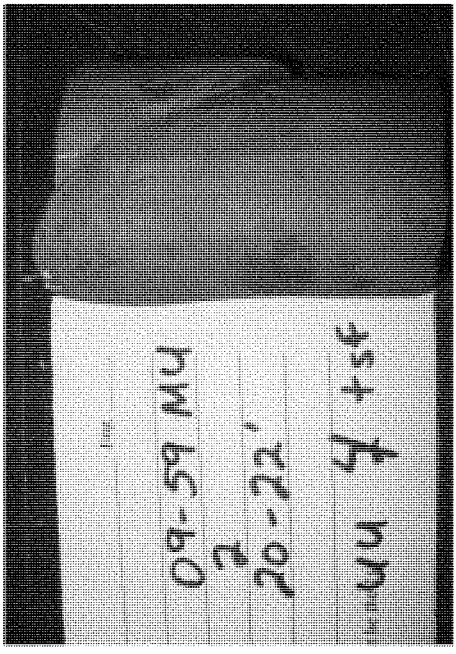
Back pressure = 0.000 tsf

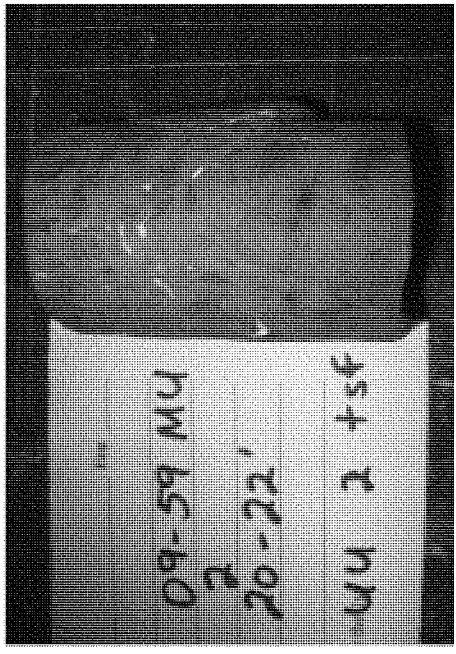
Strain rate, in./min. = 0.03

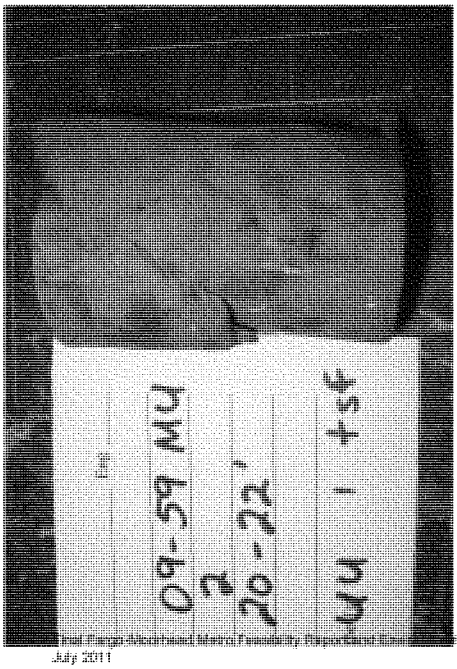
Fail. Stress = 1.046 tsf at reading no. 9

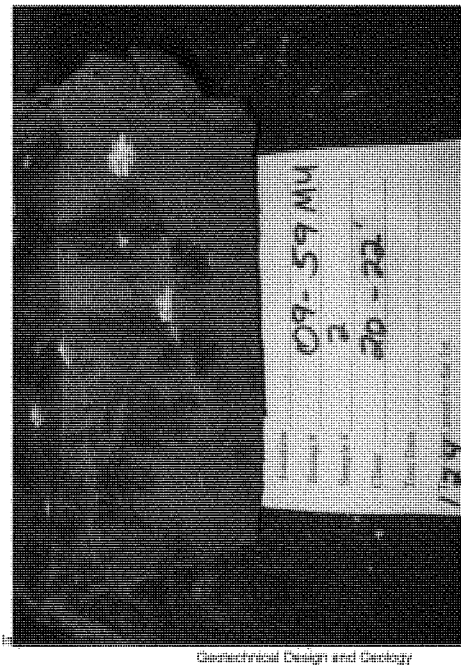
Ult. Stress = 1.005 tsf at reading no. 15

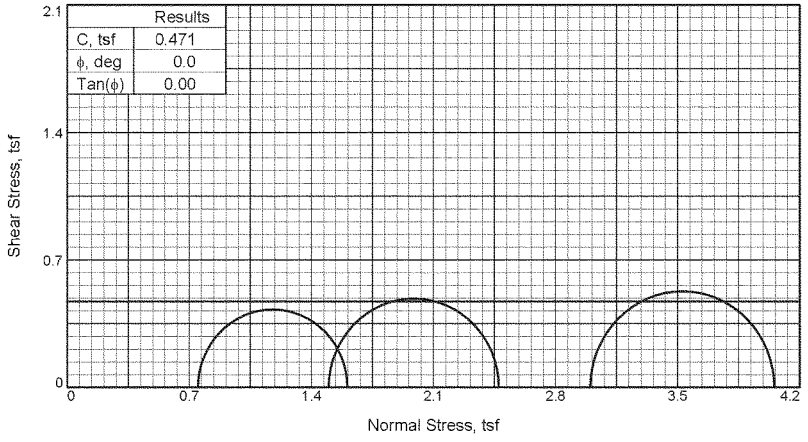
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0079	9.450	0.0	0.0	0.000	4.000	4.000	1.00	4.000	0.000
1	0.0169	17.750	8.3	0.3	0.390	4.000	4.390	1.10	4.195	0.195
2	0.0279	22.210	12.8	0.7	0.597	4.000	4.597	1.15	4.298	0.298
3	0.0377	24.220	14.8	1.1	0.688	4.000	4.688	1.17	4.344	0.344
4	0.0577	27.230	17.8	1.8	0.823	4.000	4.823	1.21	4.411	0.411
5	0.0777	29.080	19.6	2.5	0.902	4.000	4.902	1.23	4.451	0.451
6	0.0976	30.790	21.3	3.2	0.973	4.000	4.973	1.24	4.487	0.487
7	0.1182	31.920	22.5	3.9	1.017	4.000	5.017	1.25	4.508	0.508
8	0.1497	32.500	23.1	5.1	1.031	4.000	5.031	1.26	4.515	0.515
9	0.1913	33.210	23.8	6.5	1.046	4.000	5.046	1.26	4.523	0.523
10	0.2311	33.510	24.1	8.0	1.043	4.000	5.043	1.26	4.522	0.522
11	0.2728	33.140	23.7	9.4	1.011	4.000	5.011	1.25	4.505	0.505
12	0.3039	33.370	23.9	10.5	1.008	4.000	5.008	1.25	4.504	0.504
13	0.3447	33.860	24.4	12.0	1.012	4.000	5.012	1.25	4.506	0.506
14	0.3852	33.970	24.5	13.4	1.000	4.000	5.000	1.25	4.500	0.500
15	0.4280	34.540	25.1	15.0	1.005	4.000	5.005	1.25	4.503	0.503

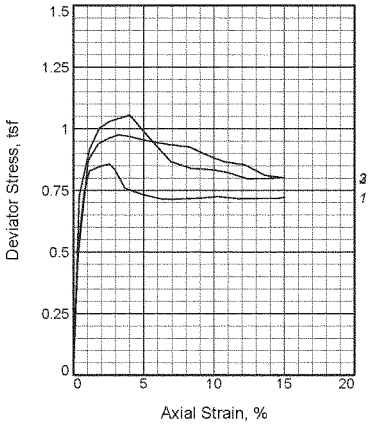

09-59 MU
2
20-22'
UU 4 +sf


09-59 MU
2
20-22'
UU 2 +sf


09-59 MU
2
20-22'
UU 1 +sf


09-59 MU
2
20-22'





Sample No.		1	2	3
Initial	Water Content, %	59.8	59.4	60.0
	Dry Density, pcf	64.0	64.4	64.3
	Saturation, %	98.9	99.2	100.0
	Void Ratio	1.6328	1.6167	1.6205
	Diameter, in.	1.41	1.39	1.39
	Height, in.	2.79	2.80	2.81
At Test	Water Content, %	58.0	57.0	59.7
	Dry Density, pcf	64.0	64.4	64.3
	Saturation, %	95.9	95.1	99.4
	Void Ratio	1.6328	1.6167	1.6205
	Diameter, in.	1.41	1.39	1.39
	Height, in.	2.79	2.80	2.81
Strain rate, in./min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.75	1.50	3.00
Fail. Stress, tsf		0.86	0.98	1.06
Ult. Stress, tsf		0.72	0.80	0.80
σ_1 Failure, tsf		1.61	2.48	4.06
σ_3 Failure, tsf		0.75	1.50	3.00

Type of Test:
Unconsolidated Undrained
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, brown (CH)

LL= 113 **PL=** 26 **PI=** 87
Assumed Specific Gravity= 2.70
Remarks:

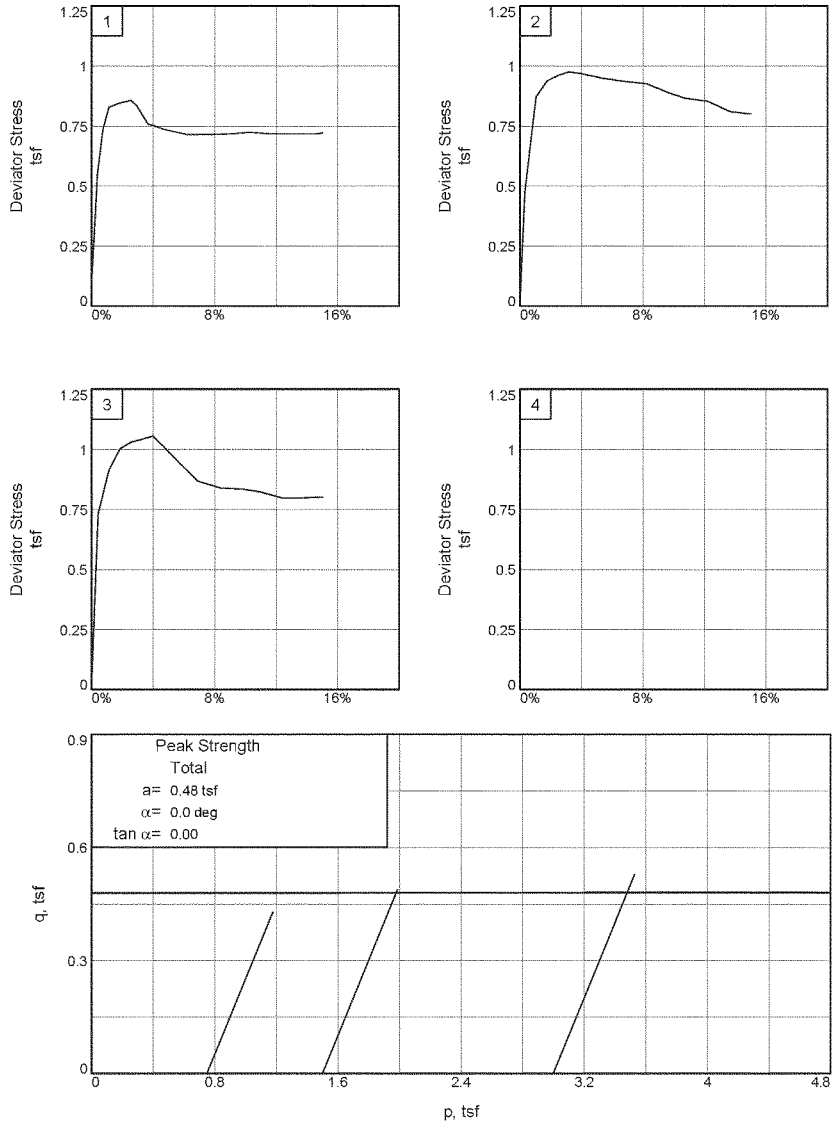
Figure UU Triax ASTM D 2850

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Fargo Oxidized Brenna
Location: WD-05, ND Div, ~~Sherack Formation~~
Sample Number: Boring 09-60MU, #1 **Depth:** 15-17'
Proj. No.: BL0903127A **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Fargo Oxidized Brenna
Loc.: WD-05, ND Div, Sherack Formation **Depth:** 15-17' **Sample No.:** Boring 09-60MU, #1
Project No.: BL0903127A **Figure** _____ **Braun Intertec**

Tested By: rs **Checked By:** rs

TRIAXIAL COMPRESSION TEST 2/23/2010
Unconsolidated Undrained 11:23 AM

Date:			
Client:	US Army Corps of Engineers		
Project:	Fargo-Moorhead Metro Feasibility Study		
Project No.:	BL0903127A		
Location:	WD-05, ND Div, Sherack Formation		Fargo
Depth:	15-17'	**Sample Number:**	Boring 09-60MU, #1
Description:	FAT CLAY, brown (CH)		Oxidized Brenna
Remarks:			
Type of Sample:	Thinwall, 5", Middle of sample		
Assumed Specific Gravity=2.70	**LL=**113	**PL=**26	**PI=**87
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	125.500	147.000
Moisture content: Dry soil+tare, gms.	89.790	104.350
Moisture content: Tare, gms.	30.100	30.800
Moisture, %	59.8	58.0
Moist specimen weight, gms.	116.8	
Diameter, in.	1.41	
Area, in.²	1.56	
Height, in.	2.79	
Wet Density, pcf	102.3	
Dry density, pcf	64.0	
Void ratio	1.6328	
Saturation, %	98.9	

Test Readings for Specimen No. 1

Cell pressure = 0.750 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 0.857 tsf **at reading no.** 6
Ult. Stress = 0.722 tsf **at reading no.** 17

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	-0.220	0.0	0.0	0.000	0.750	0.750	1.00	0.750	0.000
1	0.0072	2.340	2.6	0.0	0.118	0.750	0.868	1.16	0.809	0.059
2	0.0174	11.740	12.0	0.4	0.549	0.750	1.299	1.73	1.025	0.275
3	0.0275	15.860	16.1	0.8	0.736	0.750	1.486	1.98	1.118	0.368
4	0.0381	17.940	18.2	1.1	0.828	0.750	1.578	2.10	1.164	0.414
5	0.0574	18.450	18.7	1.8	0.845	0.750	1.595	2.13	1.173	0.423
6	0.0780	18.850	19.1	2.6	0.857	0.750	1.607	2.14	1.178	0.428
7	0.0878	18.470	18.7	2.9	0.837	0.750	1.587	2.12	1.168	0.418
8	0.1087	16.860	17.1	3.7	0.759	0.750	1.509	2.01	1.129	0.379
9	0.1395	16.530	16.8	4.8	0.736	0.750	1.486	1.98	1.118	0.368
10	0.1805	16.310	16.5	6.2	0.715	0.750	1.465	1.95	1.107	0.357
11	0.2202	16.570	16.8	7.7	0.715	0.750	1.465	1.95	1.107	0.357
12	0.2612	16.930	17.2	9.1	0.719	0.750	1.469	1.96	1.109	0.359
13	0.2920	17.290	17.5	10.2	0.725	0.750	1.475	1.97	1.112	0.362
14	0.3320	17.390	17.6	11.7	0.717	0.750	1.467	1.96	1.109	0.359
15	0.3725	17.680	17.9	13.1	0.717	0.750	1.467	1.96	1.108	0.358
16	0.4136	18.010	18.2	14.6	0.718	0.750	1.468	1.96	1.109	0.359
17	0.4250	18.200	18.4	15.0	0.722	0.750	1.472	1.96	1.111	0.361

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	139.600	144.800
Moisture content: Dry soil+tare, gms.	99.240	103.170
Moisture content: Tare, gms.	31.300	30.100
Moisture, %	59.4	57.0
Moist specimen weight, gms.	115.1	
Diameter, in.	1.39	
Area, in.²	1.53	
Height, in.	2.80	
Wet Density, pcf	102.7	
Dry density, pcf	64.4	
Void ratio	1.6167	
Saturation, %	99.2	

Test Readings for Specimen No. 2

Cell pressure = 1.500 tsf

Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

Fail. Stress = 0.975 tsf at reading no. 5

Ult. Stress = 0.801 tsf at reading no. 14

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0065	0.230	0.0	0.0	0.000	1.500	1.500	1.00	1.500	0.000
1	0.0154	10.280	10.0	0.3	0.473	1.500	1.973	1.32	1.736	0.236
2	0.0361	18.910	18.7	1.1	0.872	1.500	2.372	1.58	1.936	0.436
3	0.0562	20.490	20.3	1.8	0.939	1.500	2.439	1.63	1.969	0.469
4	0.0771	21.140	20.9	2.5	0.962	1.500	2.462	1.64	1.981	0.481
5	0.0960	21.590	21.4	3.2	0.975	1.500	2.475	1.65	1.988	0.488
6	0.1160	21.620	21.4	3.9	0.970	1.500	2.470	1.65	1.985	0.485
7	0.1556	21.500	21.3	5.3	0.950	1.500	2.450	1.63	1.975	0.475
8	0.1971	21.510	21.3	6.8	0.936	1.500	2.436	1.62	1.968	0.468
9	0.2373	21.630	21.4	8.2	0.926	1.500	2.426	1.62	1.963	0.463
10	0.2779	21.080	20.9	9.7	0.888	1.500	2.388	1.59	1.944	0.444
11	0.3072	20.790	20.6	10.7	0.866	1.500	2.366	1.58	1.933	0.433
12	0.3477	20.840	20.6	12.2	0.854	1.500	2.354	1.57	1.927	0.427
13	0.3888	20.130	19.9	13.7	0.811	1.500	2.311	1.54	1.905	0.405
14	0.4266	20.200	20.0	15.0	0.801	1.500	2.301	1.53	1.900	0.400

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	127.700	145.500
Moisture content: Dry soil+tare, gms.	91.550	102.630
Moisture content: Tare, gms.	31.300	30.800
Moisture, %	60.0	59.7
Moist specimen weight, gms.	115.4	
Diameter, in.	1.39	
Area, in.²	1.52	
Height, in.	2.81	
Wet Density, pcf	102.9	
Dry density, pcf	64.3	
Void ratio	1.6205	
Saturation, %	100.0	

Test Readings for Specimen No. 3

Cell pressure = 3.000 tsf

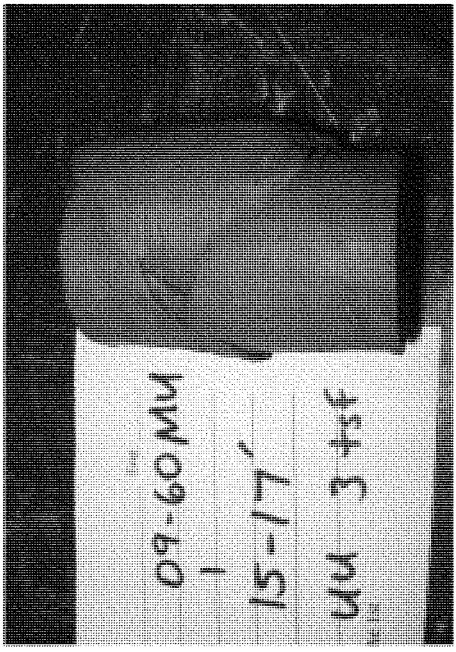
Back pressure = 0.000 tsf

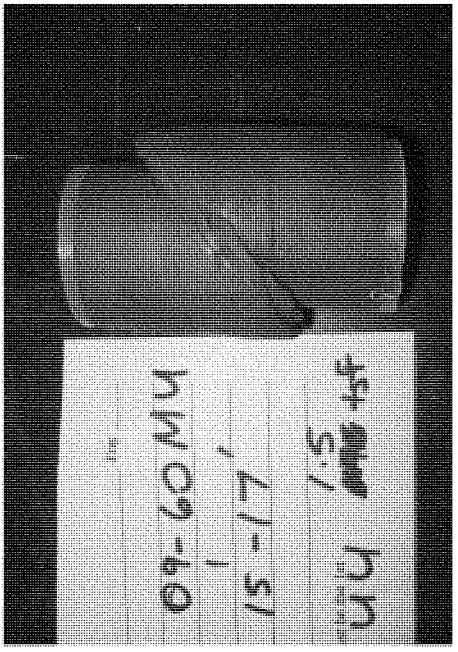
Strain rate, in./min. = 0.03

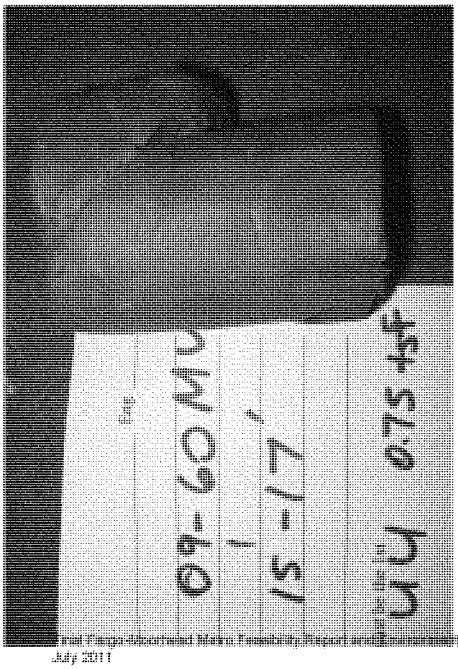
Fail. Stress = 1.055 tsf at reading no. 6

Ult. Stress = 0.801 tsf at reading no. 14

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0061	5.820	0.0	0.0	0.000	3.000	3.000	1.00	3.000	0.000
1	0.0180	21.290	15.5	0.4	0.730	3.000	3.730	1.24	3.365	0.365
2	0.0383	25.380	19.6	1.1	0.916	3.000	3.916	1.31	3.458	0.458
3	0.0582	27.370	21.6	1.9	1.002	3.000	4.002	1.33	3.501	0.501
4	0.0784	28.130	22.3	2.6	1.030	3.000	4.030	1.34	3.515	0.515
5	0.0980	28.550	22.7	3.3	1.042	3.000	4.042	1.35	3.521	0.521
6	0.1182	29.020	23.2	4.0	1.055	3.000	4.055	1.35	3.528	0.528
7	0.1603	27.220	21.4	5.5	0.958	3.000	3.958	1.32	3.479	0.479
8	0.2011	25.480	19.7	6.9	0.867	3.000	3.867	1.29	3.433	0.433
9	0.2422	25.140	19.3	8.4	0.838	3.000	3.838	1.28	3.419	0.419
10	0.2831	25.350	19.5	9.9	0.834	3.000	3.834	1.28	3.417	0.417
11	0.3138	25.320	19.5	10.9	0.823	3.000	3.823	1.27	3.411	0.411
12	0.3549	25.030	19.2	12.4	0.797	3.000	3.797	1.27	3.399	0.399
13	0.3956	25.380	19.6	13.9	0.798	3.000	3.798	1.27	3.399	0.399
14	0.4290	25.730	19.9	15.0	0.801	3.000	3.801	1.27	3.401	0.401


09-60MW
1
15-17'
UU 3 tsf


09-60MW
1
15-17'
UU 1.5 tsf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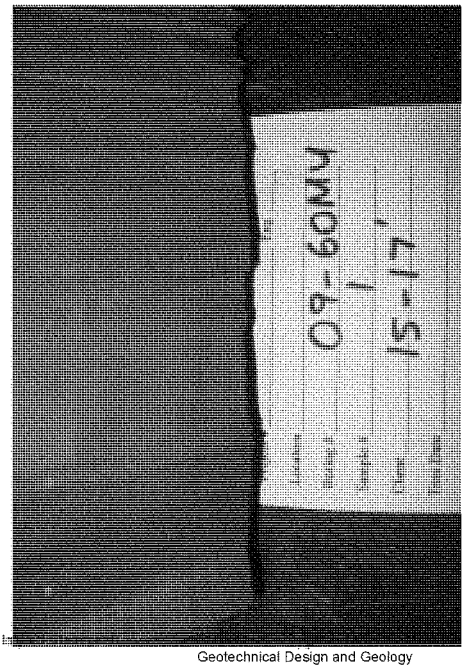
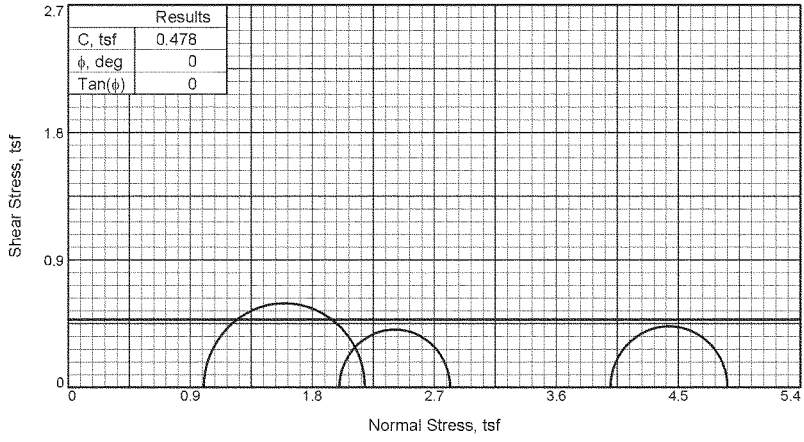
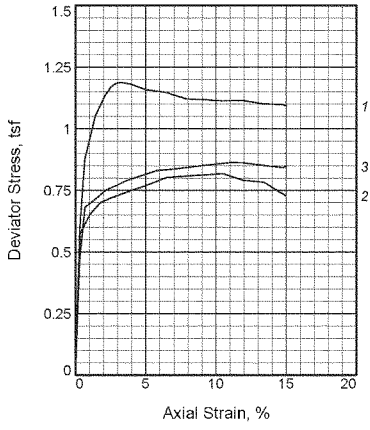
UU 0.75 tsf


09-60MW
1
15-17'





Sample No.		1	2	3
Initial	Water Content, %	55.7	57.0	57.9
	Dry Density, pcf	67.2	66.4	65.5
	Saturation, %	99.7	100.0	99.4
	Void Ratio	1.5080	1.5397	1.5727
	Diameter, in.	1.41	1.40	1.40
	Height, in.	2.81	2.80	2.80
At Test	Water Content, %	53.9	56.9	58.0
	Dry Density, pcf	67.2	66.4	65.5
	Saturation, %	96.6	99.7	99.5
	Void Ratio	1.5080	1.5397	1.5727
	Diameter, in.	1.41	1.40	1.40
	Height, in.	2.81	2.80	2.80
Strain rate, in./min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		1.00	2.00	4.00
Fail. Stress, tsf		1.19	0.82	0.86
Ult. Stress, tsf		1.09	0.73	0.85
σ_1 Failure, tsf		2.19	2.82	4.86
σ_3 Failure, tsf		1.00	2.00	4.00

Type of Test: Unconsolidated Undrained
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, brown (CH)

LL= 106 **PL=** 24 **PI=** 82
Assumed Specific Gravity= 2.70
Remarks:

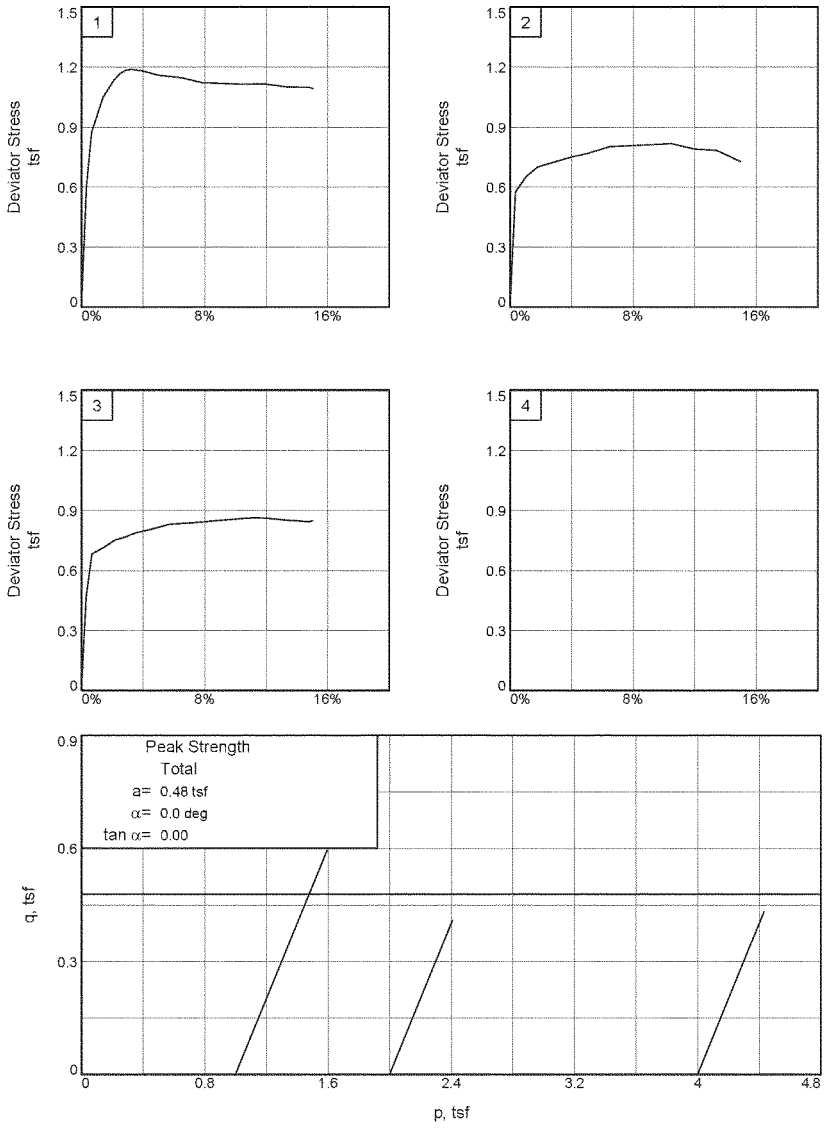
Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Fargo Oxidized Brenna
Location: WD-05, ND Div, ~~Sheyenne Formation~~
Sample Number: Boring 09-60MU, #2 **Depth:** 25-27'
Proj. No.: BL0903127A **Date Sampled:**

BRAUN INTERTEC

Figure UU Triax ASTM D 2850

Tested By: rs **Checked By:** rs



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Fargo Oxidized Brenna
Loc.: WD-05, ND Div, Sherack Formation **Depth:** 25-27' **Sample No.:** Boring 09-60MU, #2
Project No.: BL0903127A **Figure** _____ **Braun Intertec**

Tested By: rs **Checked By:** rs

TRIAXIAL COMPRESSION TEST 2/23/2010
Unconsolidated Undrained 11:26 AM

Date:			
Client:	US Army Corps of Engineers		
Project:	Fargo-Moorhead Metro Feasibility Study		
Project No.:	BL0903127A		
Location:	WD-05, ND Div, Sherack Formation		Fargo
Depth:	25-27'	**Sample Number:**	Boring 09-60MU, #2
Description:	FAT CLAY, brown (CH)		Oxidized Brenna
Remarks:			
Type of Sample:	Thinwall, 5", Middle of sample		

Assumed Specific Gravity=2.70 **LL**=106 **PL**=24 **PI**=82

Test Method: ASTM D 2850

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	159.490	151.290
Moisture content: Dry soil+tare, gms.	113.510	109.170
Moisture content: Tare, gms.	30.900	31.090
Moisture, %	55.7	53.9
Moist specimen weight, gms.	120.7	
Diameter, in.	1.41	
Area, in.²	1.57	
Height, in.	2.81	
Wet Density, pcf	104.6	
Dry density, pcf	67.2	
Void ratio	1.5080	
Saturation, %	99.7	

Test Readings for Specimen No. 1

Cell pressure = 1.000 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 1.189 tsf **at reading no.** 7
Ult. Stress = 1.094 tsf **at reading no.** 17

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0061	1.360	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	0.0150	14.430	13.1	0.3	0.599	1.000	1.599	1.60	1.300	0.300
2	0.0246	20.500	19.1	0.7	0.874	1.000	1.874	1.87	1.437	0.437
3	0.0457	24.530	23.2	1.4	1.050	1.000	2.050	2.05	1.525	0.525
4	0.0655	26.590	25.2	2.1	1.136	1.000	2.136	2.14	1.568	0.568
5	0.0766	27.430	26.1	2.5	1.169	1.000	2.169	2.17	1.584	0.584
6	0.0860	27.850	26.5	2.8	1.183	1.000	2.183	2.18	1.592	0.592
7	0.0965	28.070	26.7	3.2	1.189	1.000	2.189	2.19	1.594	0.594
8	0.1161	28.100	26.7	3.9	1.181	1.000	2.181	2.18	1.591	0.591
9	0.1463	27.890	26.5	5.0	1.159	1.000	2.159	2.16	1.579	0.579
10	0.1871	28.040	26.7	6.4	1.148	1.000	2.148	2.15	1.574	0.574
11	0.2279	27.830	26.5	7.9	1.121	1.000	2.121	2.12	1.560	0.560
12	0.2678	28.160	26.8	9.3	1.117	1.000	2.117	2.12	1.559	0.559
13	0.2983	28.380	27.0	10.4	1.113	1.000	2.113	2.11	1.557	0.557
14	0.3396	28.880	27.5	11.9	1.115	1.000	2.115	2.12	1.558	0.558
15	0.3806	28.990	27.6	13.3	1.101	1.000	2.101	2.10	1.550	0.550
16	0.4203	29.380	28.0	14.8	1.098	1.000	2.098	2.10	1.549	0.549
17	0.4280	29.350	28.0	15.0	1.094	1.000	2.094	2.09	1.547	0.547

Parameters for Specimen No. 2		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	148.600	148.810
Moisture content: Dry soil+tare, gms.	105.820	106.200
Moisture content: Tare, gms.	30.810	31.280
Moisture, %	57.0	56.9
Moist specimen weight, gms.	118.0	
Diameter, in.	1.40	
Area, in.²	1.54	
Height, in.	2.80	
Wet Density, pcf	104.2	
Dry density, pcf	66.4	
Void ratio	1.5397	
Saturation, %	100.0	

Test Readings for Specimen No. 2

Cell pressure = 2.000 tsf

Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

Fail. Stress = 0.817 tsf at reading no. 11

Ult. Stress = 0.729 tsf at reading no. 14

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0059	3.620	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	0.0156	15.980	12.4	0.3	0.576	2.000	2.576	1.29	2.288	0.288
2	0.0353	17.750	14.1	1.0	0.654	2.000	2.654	1.33	2.327	0.327
3	0.0557	18.850	15.2	1.8	0.700	2.000	2.700	1.35	2.350	0.350
4	0.0767	19.370	15.8	2.5	0.718	2.000	2.718	1.36	2.359	0.359
5	0.0964	19.820	16.2	3.2	0.733	2.000	2.733	1.37	2.367	0.367
6	0.1165	20.290	16.7	3.9	0.749	2.000	2.749	1.37	2.374	0.374
7	0.1468	20.930	17.3	5.0	0.769	2.000	2.769	1.38	2.384	0.384
8	0.1881	21.970	18.3	6.5	0.802	2.000	2.802	1.40	2.401	0.401
9	0.2291	22.390	18.8	8.0	0.808	2.000	2.808	1.40	2.404	0.404
10	0.2690	22.810	19.2	9.4	0.813	2.000	2.813	1.41	2.407	0.407
11	0.2996	23.140	19.5	10.5	0.817	2.000	2.817	1.41	2.409	0.409
12	0.3405	22.820	19.2	11.9	0.791	2.000	2.791	1.40	2.395	0.395
13	0.3824	22.970	19.3	13.4	0.783	2.000	2.783	1.39	2.392	0.392
14	0.4252	21.940	18.3	15.0	0.729	2.000	2.729	1.36	2.364	0.364

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	131.090	146.010
Moisture content: Dry soil+tare, gms.	93.940	103.250
Moisture content: Tare, gms.	29.800	29.490
Moisture, %	57.9	58.0
Moist specimen weight, gms.	117.0	
Diameter, in.	1.40	
Area, in.²	1.54	
Height, in.	2.80	
Wet Density, pcf	103.5	
Dry density, pcf	65.5	
Void ratio	1.5727	
Saturation, %	99.4	

Test Readings for Specimen No. 3

Cell pressure = 4.000 tsf

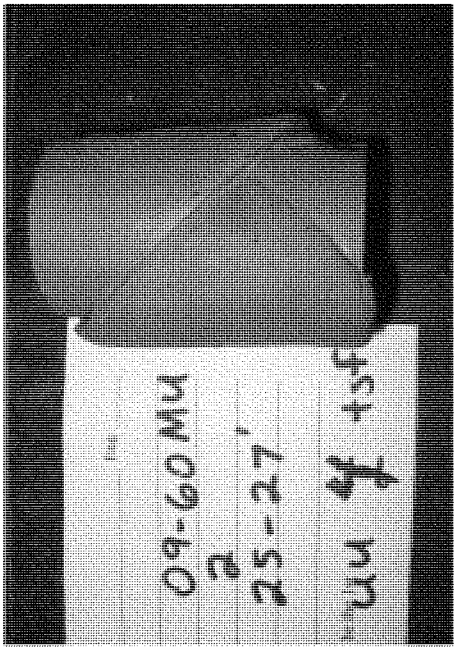
Back pressure = 0.000 tsf

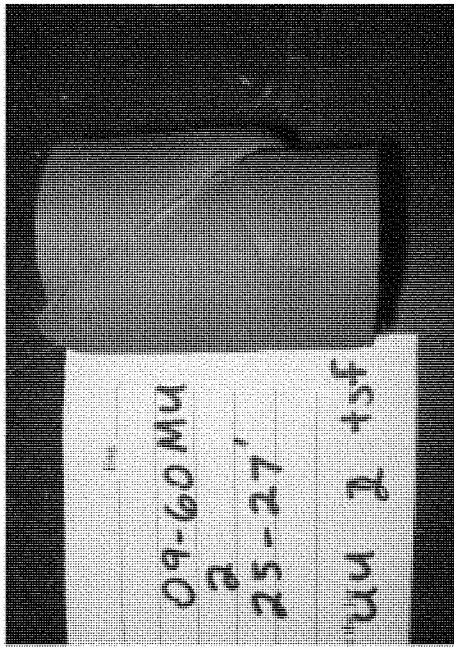
Strain rate, in./min. = 0.03

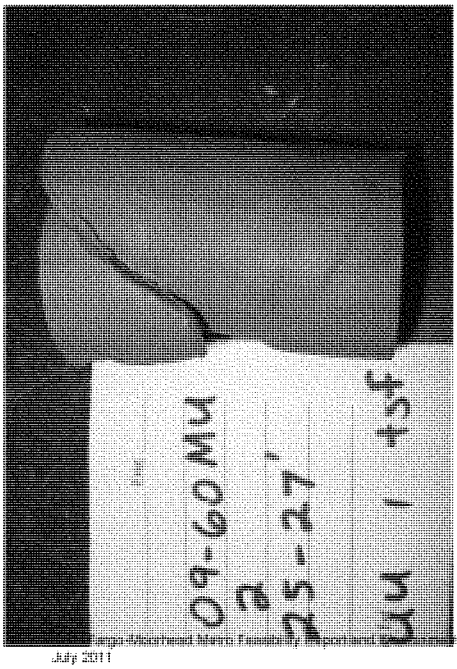
Fail. Stress = 0.864 tsf at reading no. 12

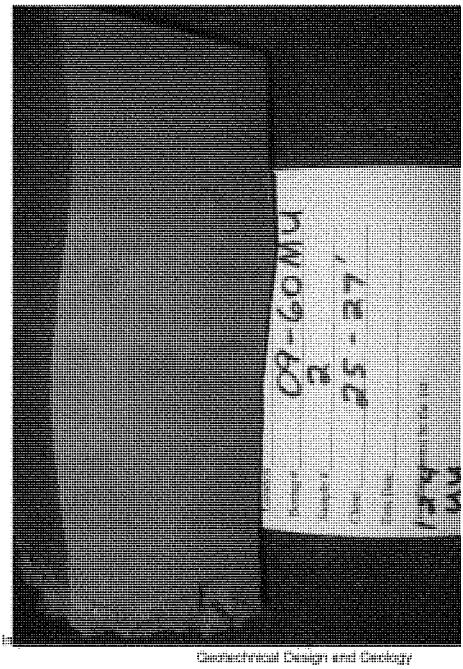
Ult. Stress = 0.847 tsf at reading no. 16

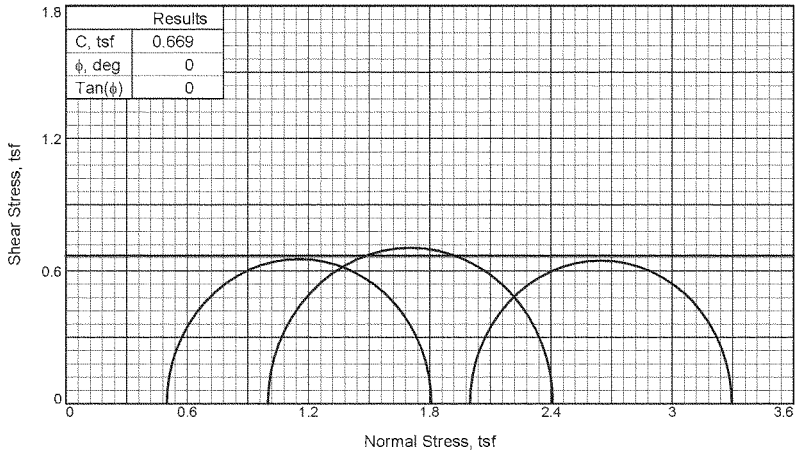
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0061	8.870	0.0	0.0	0.000	4.000	4.000	1.00	4.000	0.000
1	0.0145	18.850	10.0	0.3	0.466	4.000	4.466	1.12	4.233	0.233
2	0.0251	23.520	14.7	0.7	0.682	4.000	4.682	1.17	4.341	0.341
3	0.0464	24.350	15.5	1.4	0.715	4.000	4.715	1.18	4.357	0.357
4	0.0667	25.260	16.4	2.2	0.751	4.000	4.751	1.19	4.376	0.376
5	0.0859	25.730	16.9	2.8	0.767	4.000	4.767	1.19	4.384	0.384
6	0.1054	26.300	17.4	3.5	0.787	4.000	4.787	1.20	4.394	0.394
7	0.1263	26.740	17.9	4.3	0.801	4.000	4.801	1.20	4.401	0.401
8	0.1673	27.670	18.8	5.8	0.830	4.000	4.830	1.21	4.415	0.415
9	0.2086	28.150	19.3	7.2	0.838	4.000	4.838	1.21	4.419	0.419
10	0.2487	28.680	19.8	8.7	0.848	4.000	4.848	1.21	4.424	0.424
11	0.2892	29.230	20.4	10.1	0.857	4.000	4.857	1.21	4.429	0.429
12	0.3196	29.630	20.8	11.2	0.864	4.000	4.864	1.22	4.432	0.432
13	0.3406	29.750	20.9	11.9	0.861	4.000	4.861	1.22	4.431	0.431
14	0.3806	29.840	21.0	13.4	0.851	4.000	4.851	1.21	4.425	0.425
15	0.4204	29.990	21.1	14.8	0.843	4.000	4.843	1.21	4.421	0.421
16	0.4270	30.160	21.3	15.0	0.847	4.000	4.847	1.21	4.424	0.424

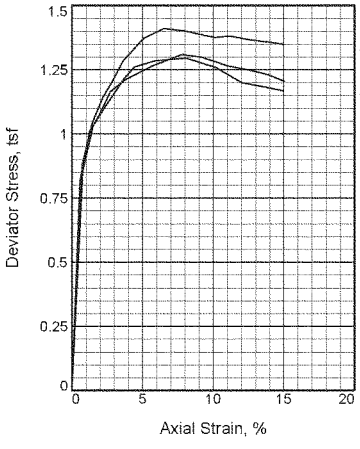

09-60MU
2
25-27'
UU 4 tsf


09-60MU
2
25-27'
UU 2 tsf


09-60MU
2
25-27'
UU 1 tsf


09-60MU
2
25-27'





Sample No.		1	2	3
Initial	Water Content, %	50.7	50.5	50.4
	Dry Density, pcf	70.9	71.5	71.8
	Saturation, %	97.6	98.3	98.8
	Void Ratio	1.4435	1.4260	1.4148
	Diameter, in.	1.41	1.41	1.40
	Height, in.	2.81	2.80	2.80
At Test	Water Content, %	50.7	50.5	50.4
	Dry Density, pcf	70.9	71.5	71.8
	Saturation, %	97.6	98.3	98.8
	Void Ratio	1.4435	1.4260	1.4148
	Diameter, in.	1.41	1.41	1.40
	Height, in.	2.81	2.80	2.80
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.50	1.00	2.00
Peak Stress, tsf		1.31	1.41	1.30
Ult. Stress, tsf		1.20	1.35	1.17
σ_1 Failure, tsf		1.81	2.41	3.30
σ_3 Failure, tsf		0.50	1.00	2.00

Type of Test:
Unconsolidated Undrained
Sample Type: 5" Thinwall, Bottom of sample
Description: FAT CLAY, brown (CH)

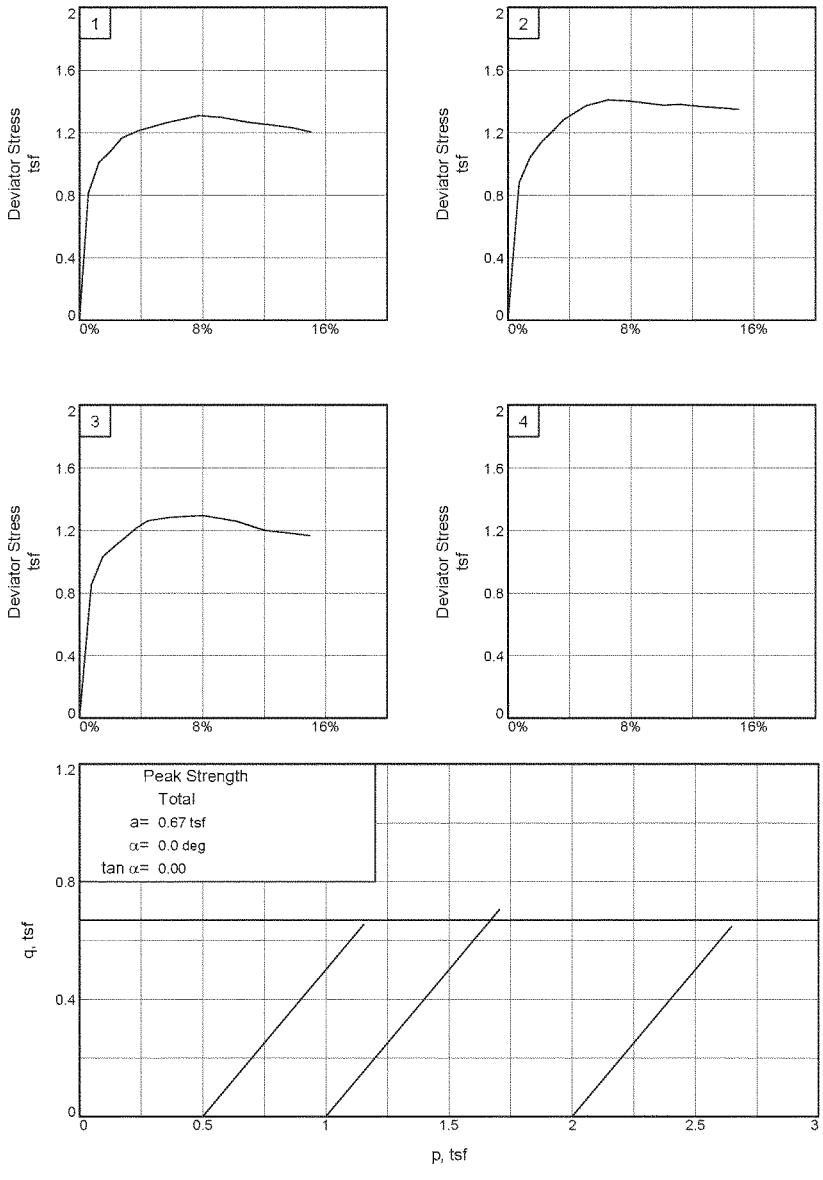
LL= 113 **PL=** 32 **PI=** 81
Specific Gravity= 2.777
Remarks:

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Maple River, Dessicated Brenna Formation
Sample Number: Boring10-105MU, #1 **Depth:** 15-17'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Figure Test Method: ASTM D 2850



Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Loc.: Maple River, Dessicated Brenna Formation **Depth:** 15-17' **Sample No.:** Boring10-105MU, #1

Project No.: 0-10-10065 **Figure** **Braun Intertec**

TRIAXIAL COMPRESSION TEST 3/4/2011
Unconsolidated Undrained 12:04 PM

Date:			
Client:	W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing		
Project No.:	BL-10-10065		
Location:	Maple River, Dessicated Brenna Formation		
Depth:	15-17'	**Sample Number:**	Boring10-105MU, #1
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	5" Thinwall, Bottom of sample		
Specific Gravity=2.777	**LL=**113	**PL=**32	**PI=**81
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	153.040	153.040
Moisture content: Dry soil+tare, gms.	111.800	111.800
Moisture content: Tare, gms.	30.520	30.520
Moisture, %	50.7	50.7
Moist specimen weight, gms.	123.3	
Diameter, in.	1.41	
Area, in.²	1.56	
Height, in.	2.81	
Wet Density, pcf	106.9	
Dry density, pcf	70.9	
Void ratio	1.4435	
Saturation, %	97.6	

Test Readings for Specimen No. 1

Cell pressure = 0.500 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 1.309 tsf **at reading no.** 7
Ult. Stress = 1.205 tsf **at reading no.** 12

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	0.000	0.0	0.0	0.000	0.500	0.500	1.00	0.500	0.000
1	0.0228	17.780	17.8	0.6	0.814	0.500	1.314	2.63	0.907	0.407
2	0.0423	22.210	22.2	1.3	1.010	0.500	1.510	3.02	1.005	0.505
3	0.0630	23.920	23.9	2.0	1.079	0.500	1.579	3.16	1.040	0.540
4	0.0831	25.990	26.0	2.7	1.164	0.500	1.664	3.33	1.082	0.582
5	0.1131	27.340	27.3	3.8	1.211	0.500	1.711	3.42	1.106	0.606
6	0.1648	29.050	29.1	5.6	1.262	0.500	1.762	3.52	1.131	0.631
7	0.2254	30.820	30.8	7.8	1.309	0.500	1.809	3.62	1.154	0.654
8	0.2652	31.060	31.1	9.2	1.298	0.500	1.798	3.60	1.149	0.649
9	0.3159	30.880	30.9	11.0	1.265	0.500	1.765	3.53	1.133	0.633
10	0.3563	31.000	31.0	12.5	1.250	0.500	1.750	3.50	1.125	0.625
11	0.3969	31.030	31.0	13.9	1.230	0.500	1.730	3.46	1.115	0.615
12	0.4290	30.800	30.8	15.0	1.205	0.500	1.705	3.41	1.102	0.602

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	151.980	151.980
Moisture content: Dry soil+tare, gms.	110.950	110.950
Moisture content: Tare, gms.	29.680	29.680
Moisture, %	50.5	50.5
Moist specimen weight, gms.	123.0	
Diameter, in.	1.41	
Area, in.²	1.55	
Height, in.	2.80	
Wet Density, pcf	107.5	
Dry density, pcf	71.5	
Void ratio	1.4260	
Saturation, %	98.3	

Test Readings for Specimen No. 2

Cell pressure = 1.000 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.410 tsf at reading no. 7

Ult. Stress = 1.348 tsf at reading no. 13

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0097	0.660	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	0.0303	19.800	19.1	0.7	0.880	1.000	1.880	1.88	1.440	0.440
2	0.0502	23.490	22.8	1.4	1.042	1.000	2.042	2.04	1.521	0.521
3	0.0708	25.840	25.2	2.2	1.141	1.000	2.141	2.14	1.570	0.570
4	0.0911	27.540	26.9	2.9	1.209	1.000	2.209	2.21	1.604	0.604
5	0.1111	29.410	28.8	3.6	1.283	1.000	2.283	2.28	1.642	0.642
6	0.1516	31.850	31.2	5.1	1.371	1.000	2.371	2.37	1.686	0.686
7	0.1925	33.230	32.6	6.5	1.410	1.000	2.410	2.41	1.705	0.705
8	0.2328	33.530	32.9	8.0	1.401	1.000	2.401	2.40	1.700	0.700
9	0.2930	33.690	33.0	10.1	1.375	1.000	2.375	2.37	1.687	0.687
10	0.3233	34.230	33.6	11.2	1.381	1.000	2.381	2.38	1.690	0.690

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
11	0.3644	34.420	33.8	12.7	1.365	1.000	2.365	2.37	1.683	0.683
12	0.4048	34.750	34.1	14.1	1.356	1.000	2.356	2.36	1.678	0.678
13	0.4300	34.910	34.3	15.0	1.348	1.000	2.348	2.35	1.674	0.674

Parameters for Specimen No. 3

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	151.870	151.870
Moisture content: Dry soil+tare, gms.	111.160	111.160
Moisture content: Tare, gms.	30.320	30.320
Moisture, %	50.4	50.4
Moist specimen weight, gms.	122.2	
Diameter, in.	1.40	
Area, in.²	1.54	
Height, in.	2.80	
Wet Density, pcf	107.9	
Dry density, pcf	71.8	
Void ratio	1.4148	
Saturation, %	98.8	

Test Readings for Specimen No. 3

Cell pressure = 2.000 tsf

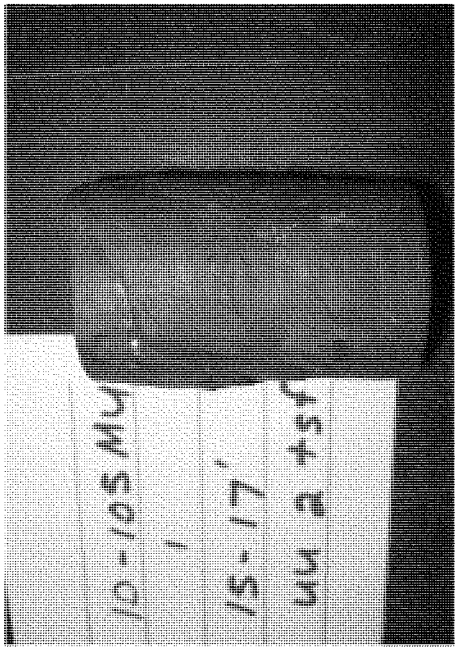
Back pressure = 0.000 tsf

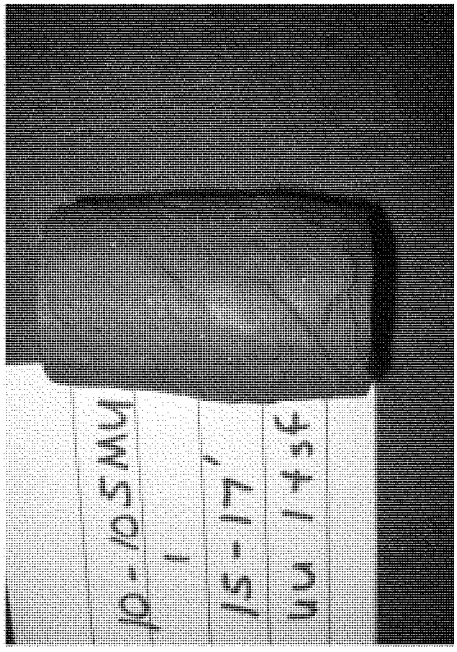
Strain rate, %/min. = 1.00

Peak Stress = 1.295 tsf at reading no. 8

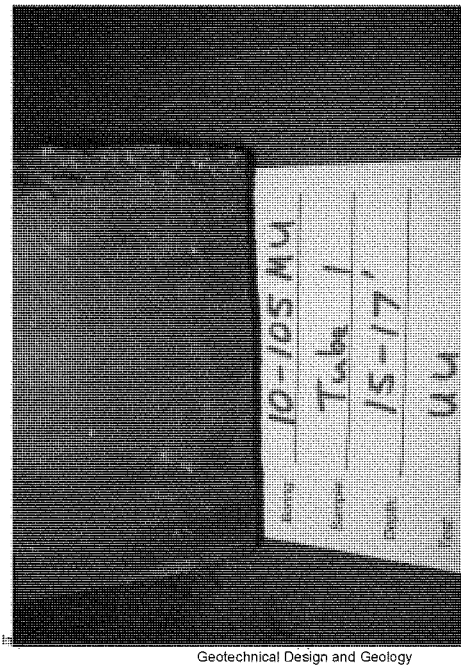
Ult. Stress = 1.167 tsf at reading no. 12

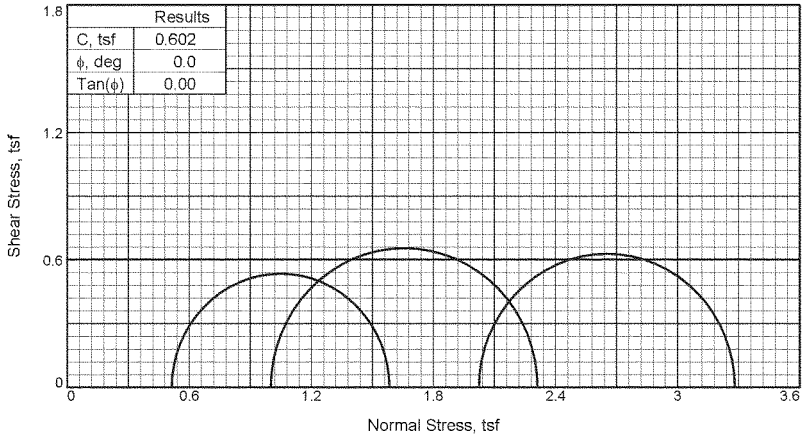
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0088	4.690	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	0.0305	23.100	18.4	0.8	0.853	2.000	2.853	1.43	2.427	0.427
2	0.0511	27.120	22.4	1.5	1.032	2.000	3.032	1.52	2.516	0.516
3	0.0720	28.740	24.0	2.3	1.098	2.000	3.098	1.55	2.549	0.549
4	0.0911	30.110	25.4	2.9	1.152	2.000	3.152	1.58	2.576	0.576
5	0.1121	31.700	27.0	3.7	1.215	2.000	3.215	1.61	2.607	0.607
6	0.1325	32.920	28.2	4.4	1.260	2.000	3.260	1.63	2.630	0.630
7	0.1735	33.900	29.2	5.9	1.284	2.000	3.284	1.64	2.642	0.642
8	0.2344	34.850	30.2	8.1	1.295	2.000	3.295	1.65	2.648	0.648
9	0.2950	34.690	30.0	10.2	1.258	2.000	3.258	1.63	2.629	0.629
10	0.3459	33.870	29.2	12.0	1.199	2.000	3.199	1.60	2.599	0.599
11	0.3861	33.990	29.3	13.5	1.184	2.000	3.184	1.59	2.592	0.592
12	0.4277	34.080	29.4	15.0	1.167	2.000	3.167	1.58	2.584	0.584

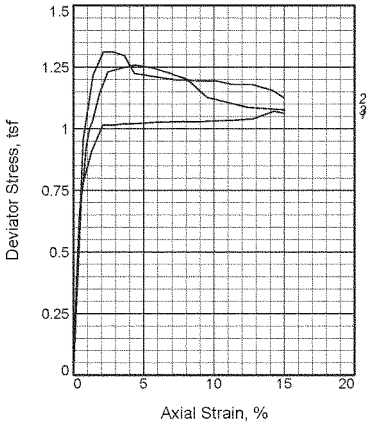

10-105 MU
1
15-17'
uu 2 tsf


10-105 MU
1
15-17'
uu 1 tsf

10-105 MU
1
15-17
uu 0.5 ts


10-105 MU
Tube 1
15-17'
uu





Sample No.		1	2	3
Initial	Water Content, %	43.4	44.0	43.0
	Dry Density, pcf	78.0	77.5	78.2
	Saturation, %	99.5	99.6	99.2
	Void Ratio	1.1968	1.2110	1.1894
	Diameter, in.	1.41	1.39	1.40
	Height, in.	2.81	2.81	2.81
At Test	Water Content, %	43.4	44.0	43.0
	Dry Density, pcf	78.0	77.5	78.2
	Saturation, %	99.5	99.6	99.2
	Void Ratio	1.1968	1.2110	1.1894
	Diameter, in.	1.41	1.39	1.40
	Height, in.	2.81	2.81	2.81
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.51	1.00	2.02
Peak Stress, tsf		1.07	1.31	1.26
Ult. Stress, tsf		1.06	1.13	1.08
σ_1 Failure, tsf		1.58	2.31	3.28
σ_3 Failure, tsf		0.51	1.00	2.02

Type of Test:
Unconsolidated Undrained
Sample Type: Undisturbed, 5" Thinwall, Bottom
Description: FAT CLAY, brown (CH)

LL= 82 **PL=** 23 **PI=** 59
Specific Gravity= 2.744
Remarks:

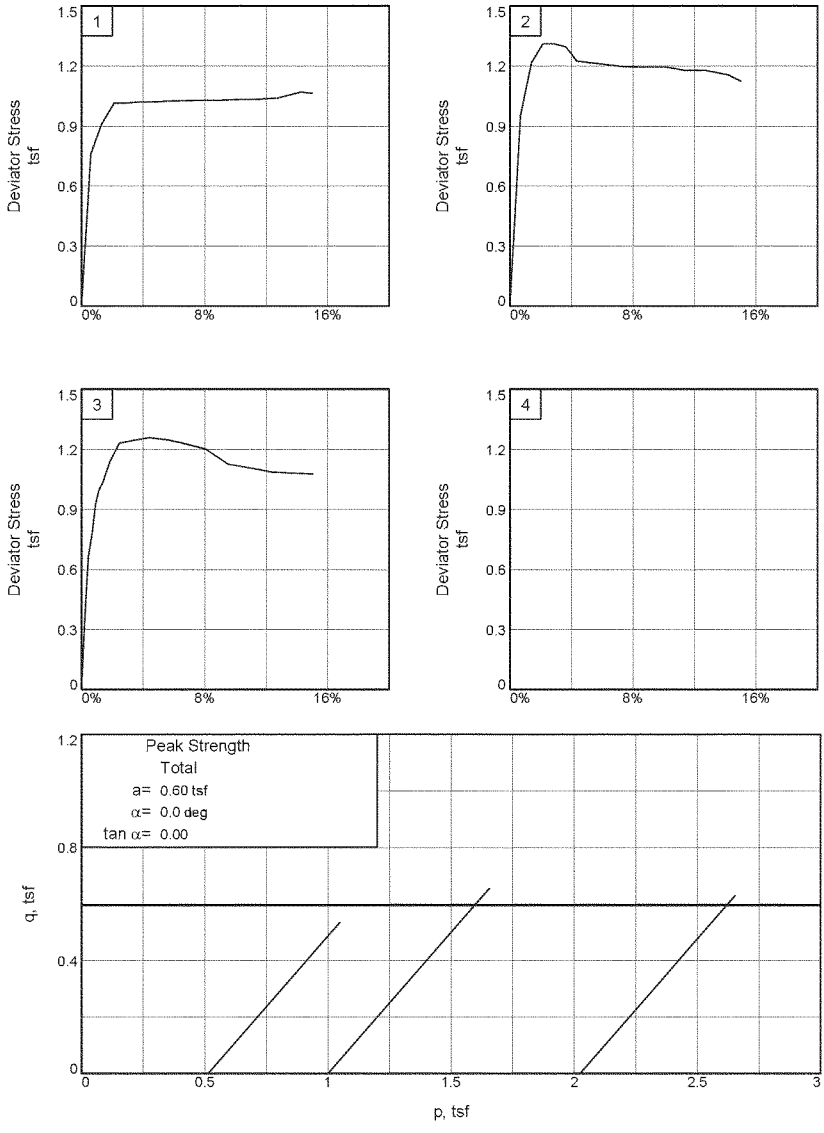
Figure UU Triax ASTM D 2850

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Sheyenne River, OX Brenna Formation
Sample Number: Boring11-110MU, #1 **Depth:** 25-27'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Tested By: JK **Checked By:** JS



Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: Sheyenne River, OX Brenna Formation **Depth:** 25-27' **Sample No.:** Boring11-110MU, #1
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JK **Checked By:** JS

TRIAXIAL COMPRESSION TEST 4/26/2011
Unconsolidated Undrained 8:10 AM

Date:			
Client:	W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing		
Project No.:	BL-10-10065		
Location:	Sheyenne River, OX Brenna Formation		
Depth:	25-27'	**Sample Number:**	Boring11-110MU, #1
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	Undisturbed, 5" Thinwall, Bottom		
Specific Gravity=2.744	**LL=**82	**PL=**23	**PI=**59
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	158.060	158.060
Moisture content: Dry soil+tare, gms.	119.370	119.370
Moisture content: Tare, gms.	30.210	30.210
Moisture, %	43.4	43.4
Moist specimen weight, gms.	128.1	
Diameter, in.	1.41	
Area, in.²	1.55	
Height, in.	2.81	
Wet Density, pcf	111.8	
Dry density, pcf	78.0	
Void ratio	1.1968	
Saturation, %	99.5	

Test Readings for Specimen No. 1

Cell pressure = 0.514 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 1.070 tsf **at reading no.** 13
Ult. Stress = 1.063 tsf **at reading no.** 14

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0075	0.000	0.0	0.0	0.000	0.514	0.514	1.00	0.514	0.000
1	0.0244	16.500	16.5	0.6	0.761	0.514	1.275	2.48	0.894	0.380
2	0.0443	19.890	19.9	1.3	0.910	0.514	1.424	2.77	0.969	0.455
3	0.0668	22.360	22.4	2.1	1.015	0.514	1.529	2.97	1.022	0.508
4	0.0882	22.520	22.5	2.9	1.014	0.514	1.528	2.97	1.021	0.507
5	0.1089	22.820	22.8	3.6	1.020	0.514	1.534	2.98	1.024	0.510
6	0.1298	23.000	23.0	4.4	1.020	0.514	1.534	2.98	1.024	0.510
7	0.1724	23.500	23.5	5.9	1.026	0.514	1.540	3.00	1.027	0.513
8	0.2134	23.930	23.9	7.3	1.028	0.514	1.542	3.00	1.028	0.514
9	0.2550	24.310	24.3	8.8	1.028	0.514	1.542	3.00	1.028	0.514
10	0.2959	24.810	24.8	10.3	1.032	0.514	1.546	3.01	1.030	0.516
11	0.3266	25.150	25.1	11.4	1.034	0.514	1.548	3.01	1.031	0.517
12	0.3669	25.720	25.7	12.8	1.040	0.514	1.554	3.02	1.034	0.520
13	0.4084	26.910	26.9	14.3	1.070	0.514	1.584	3.08	1.049	0.535
14	0.4289	26.970	27.0	15.0	1.063	0.514	1.577	3.07	1.046	0.532

Parameters for Specimen No. 2		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	154.570	154.570
Moisture content: Dry soil+tare, gms.	116.400	116.400
Moisture content: Tare, gms.	29.560	29.560
Moisture, %	44.0	44.0
Moist specimen weight, gms.	125.2	
Diameter, in.	1.39	
Area, in.²	1.52	
Height, in.	2.81	
Wet Density, pcf	111.5	
Dry density, pcf	77.5	
Void ratio	1.2110	
Saturation, %	99.6	

Test Readings for Specimen No. 2

Cell pressure = 1.001 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.311 tsf at reading no. 3

Ult. Stress = 1.125 tsf at reading no. 14

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	0.720	0.0	0.0	0.000	1.001	1.001	1.00	1.001	0.000
1	0.0263	21.020	20.3	0.7	0.954	1.001	1.955	1.95	1.478	0.477
2	0.0464	26.820	26.1	1.4	1.218	1.001	2.219	2.22	1.610	0.609
3	0.0668	29.020	28.3	2.1	1.311	1.001	2.312	2.31	1.657	0.656
4	0.0875	29.220	28.5	2.9	1.311	1.001	2.312	2.31	1.656	0.655
5	0.1085	29.140	28.4	3.6	1.297	1.001	2.298	2.30	1.649	0.648
6	0.1287	27.760	27.0	4.3	1.225	1.001	2.226	2.22	1.613	0.612
7	0.1713	27.890	27.2	5.9	1.211	1.001	2.212	2.21	1.607	0.606
8	0.2122	28.010	27.3	7.3	1.198	1.001	2.199	2.20	1.600	0.599
9	0.2529	28.370	27.7	8.8	1.194	1.001	2.195	2.19	1.598	0.597
10	0.2938	28.800	28.1	10.2	1.194	1.001	2.195	2.19	1.598	0.597
11	0.3250	28.810	28.1	11.3	1.179	1.001	2.180	2.18	1.591	0.590
12	0.3655	29.250	28.5	12.8	1.178	1.001	2.179	2.18	1.590	0.589
13	0.4057	29.170	28.5	14.2	1.156	1.001	2.157	2.15	1.579	0.578
14	0.4288	28.680	28.0	15.0	1.125	1.001	2.126	2.12	1.564	0.563

Parameters for Specimen No. 3

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	157.550	157.550
Moisture content: Dry soil+tare, gms.	119.260	119.260
Moisture content: Tare, gms.	30.230	30.230
Moisture, %	43.0	43.0
Moist specimen weight, gms.	127.6	
Diameter, in.	1.40	
Area, in.²	1.54	
Height, in.	2.81	
Wet Density, pcf	111.9	
Dry density, pcf	78.2	
Void ratio	1.1894	
Saturation, %	99.2	

Test Readings for Specimen No. 3

Cell pressure = 2.024 tsf

Back pressure = 0.000 tsf

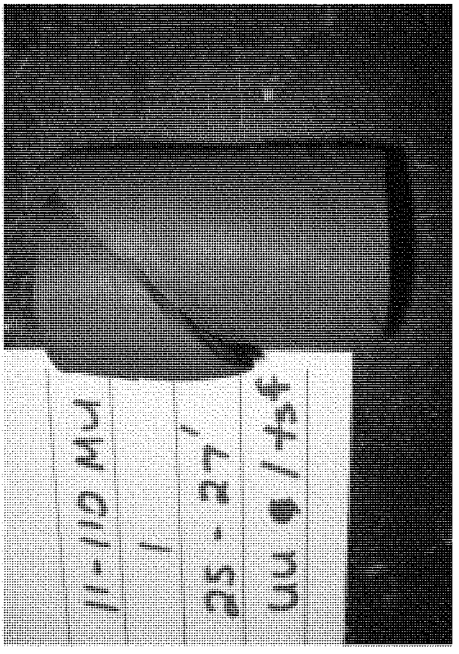
Strain rate, %/min. = 1.00

Peak Stress = 1.258 tsf at reading no. 10

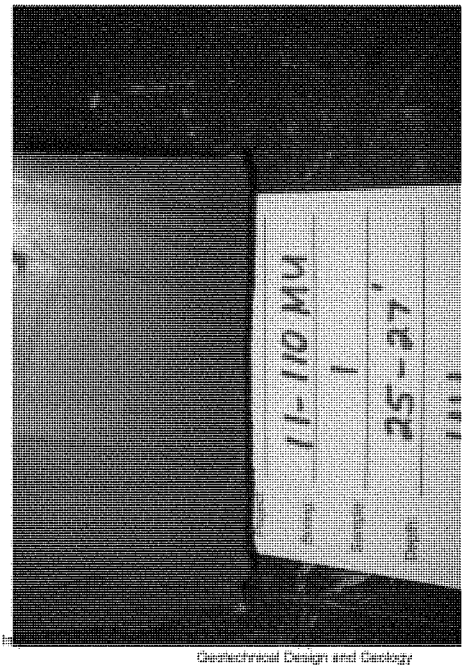
Ult. Stress = 1.077 tsf at reading no. 17

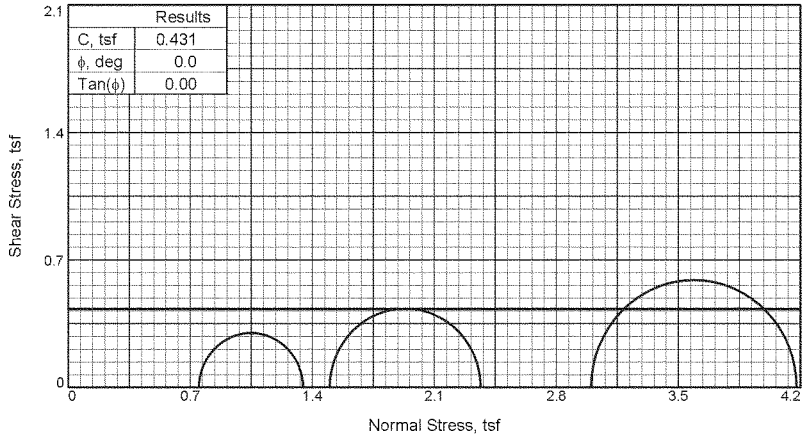
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0067	4.260	0.0	0.0	0.000	2.024	2.024	1.00	2.024	0.000
1	0.0132	12.410	8.2	0.2	0.379	2.024	2.403	1.19	2.214	0.190
2	0.0192	18.520	14.3	0.4	0.662	2.024	2.686	1.33	2.355	0.331
3	0.0261	21.080	16.8	0.7	0.779	2.024	2.803	1.38	2.414	0.390
4	0.0322	24.250	20.0	0.9	0.924	2.024	2.948	1.46	2.486	0.462
5	0.0390	25.960	21.7	1.1	1.000	2.024	3.024	1.49	2.524	0.500
6	0.0452	26.670	22.4	1.4	1.031	2.024	3.055	1.51	2.539	0.515
7	0.0590	29.230	25.0	1.9	1.143	2.024	3.167	1.56	2.595	0.571
8	0.0758	31.310	27.0	2.5	1.231	2.024	3.255	1.61	2.639	0.615
9	0.1035	31.920	27.7	3.4	1.246	2.024	3.270	1.62	2.647	0.623
10	0.1305	32.470	28.2	4.4	1.258	2.024	3.282	1.62	2.653	0.629
11	0.1661	32.590	28.3	5.7	1.246	2.024	3.270	1.62	2.647	0.623
12	0.1932	32.500	28.2	6.6	1.230	2.024	3.254	1.61	2.639	0.615
13	0.2342	32.280	28.0	8.1	1.201	2.024	3.225	1.59	2.625	0.601
14	0.2751	30.970	26.7	9.5	1.127	2.024	3.151	1.56	2.587	0.563
15	0.3164	30.910	26.7	11.0	1.106	2.024	3.130	1.55	2.577	0.553
16	0.3557	30.850	26.6	12.4	1.086	2.024	3.110	1.54	2.567	0.543
17	0.4300	31.430	27.2	15.0	1.077	2.024	3.101	1.53	2.562	0.538

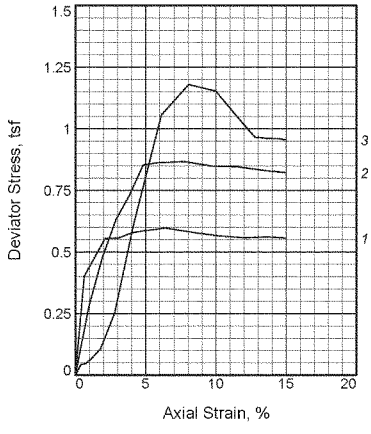
11-110 MW
1
25-27'
WW 0.5 tsf


11-110 MW
1
25-27'
WW 0.5 tsf

11-110 MW
1
25-27'
WW 2 tsf


11-110 MW
1
25-27'





Sample No.		1	2	3
Initial	Water Content, %	49.1	48.0	45.1
	Dry Density, pcf	71.8	73.9	76.2
	Saturation, %	96.7	99.3	98.6
	Void Ratio	1.4044	1.3373	1.2659
	Diameter, in.	1.40	1.39	1.39
	Height, in.	2.81	2.81	2.81
At Test	Water Content, %	49.1	48.0	45.1
	Dry Density, pcf	71.8	73.9	76.2
	Saturation, %	96.7	99.3	98.6
	Void Ratio	1.4044	1.3373	1.2659
	Diameter, in.	1.40	1.39	1.39
	Height, in.	2.81	2.81	2.81
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.75	1.50	3.00
Peak Stress, tsf		0.60	0.87	1.18
Ult. Stress, tsf		0.56	0.82	0.95
σ_1 Failure, tsf		1.35	2.37	4.18
σ_3 Failure, tsf		0.75	1.50	3.00

Type of Test: Unconsolidated Undrained
Sample Type: 5" Thinwall, Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 91 **PL=** 24 **PI=** 67
Specific Gravity= 2.767
Remarks:

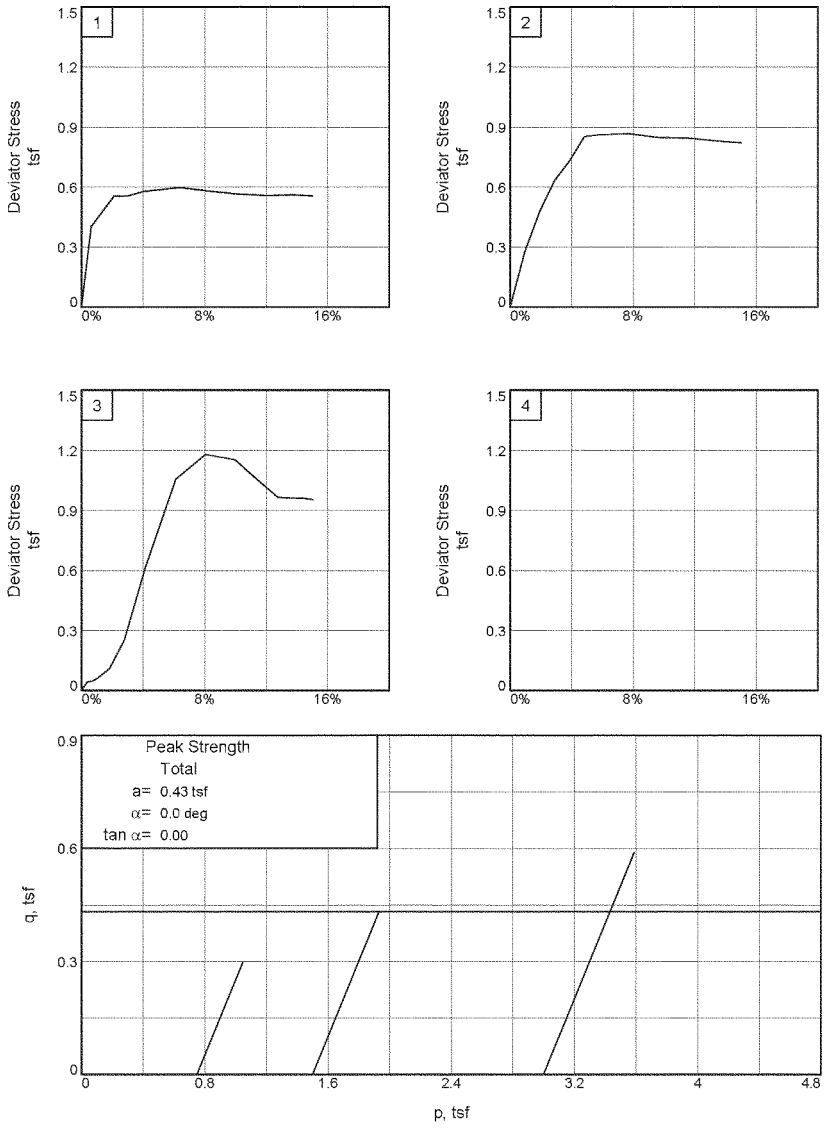
Figure UU Triax ASTM D 2850

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Location: Wild Rice, Ox Brenna Formation
Sample Number: Boring11-118MU, #1 **Depth:** 20-21'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Tested By: JK **Checked By:** JS



Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Location: Wild Rice, Ox Brenna Formation **Depth:** 20-21' **Sample Number:** Boring11-118MU, #1
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JK **Checked By:** JS

TRIAXIAL COMPRESSION TEST 5/15/2011
Unconsolidated Undrained 11:39 AM

Date:			
Client:	USACE W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing Request NO. 2		
Project No.:	BL-10-10065		
Location:	Wild Rice, Ox Brenna Formation		
Depth:	20-21'	**Sample Number:**	Boring11-118MU, #1
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	5" Thinwall, Bottom of sample		
Specific Gravity=2.767	**LL=**91	**PL=**24	**PI=**67
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	151.020	151.020
Moisture content: Dry soil+tare, gms.	111.200	111.200
Moisture content: Tare, gms.	30.090	30.090
Moisture, %	49.1	49.1
Moist specimen weight, gms.	121.7	
Diameter, in.	1.40	
Area, in.²	1.54	
Height, in.	2.81	
Wet Density, pcf	107.1	
Dry density, pcf	71.8	
Void ratio	1.4044	
Saturation, %	96.7	

Test Readings for Specimen No. 1

Cell pressure = 0.750 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 0.597 tsf **at reading no.** 6
Ult. Stress = 0.557 tsf **at reading no.** 11

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0065	2.370	0.0	0.0	0.000	0.750	0.750	1.00	0.750	0.000
1	0.0245	11.040	8.7	0.6	0.403	0.750	1.153	1.54	0.951	0.201
2	0.0655	14.460	12.1	2.1	0.554	0.750	1.304	1.74	1.027	0.277
3	0.0925	14.640	12.3	3.1	0.556	0.750	1.306	1.74	1.028	0.278
4	0.1203	15.250	12.9	4.0	0.578	0.750	1.328	1.77	1.039	0.289
5	0.1467	15.560	13.2	5.0	0.586	0.750	1.336	1.78	1.043	0.293
6	0.1864	16.010	13.6	6.4	0.597	0.750	1.347	1.80	1.049	0.299
7	0.2409	15.890	13.5	8.3	0.580	0.750	1.330	1.77	1.040	0.290
8	0.2946	15.830	13.5	10.2	0.565	0.750	1.315	1.75	1.033	0.283
9	0.3480	15.940	13.6	12.1	0.558	0.750	1.308	1.74	1.029	0.279
10	0.3896	16.270	13.9	13.6	0.562	0.750	1.312	1.75	1.031	0.281
11	0.4287	16.370	14.0	15.0	0.557	0.750	1.307	1.74	1.028	0.278

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	152.580	152.580
Moisture content: Dry soil+tare, gms.	112.950	112.950
Moisture content: Tare, gms.	30.400	30.400
Moisture, %	48.0	48.0
Moist specimen weight, gms.	122.8	
Diameter, in.	1.39	
Area, in.²	1.52	
Height, in.	2.81	
Wet Density, pcf	109.4	
Dry density, pcf	73.9	
Void ratio	1.3373	
Saturation, %	99.3	

Test Readings for Specimen No. 2

Cell pressure = 1.500 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 0.867 tsf at reading no. 7

Ult. Stress = 0.822 tsf at reading no. 11

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0103	4.840	0.0	0.0	0.000	1.500	1.500	1.00	1.500	0.000
1	0.0376	10.830	6.0	1.0	0.280	1.500	1.780	1.19	1.640	0.140
2	0.0642	15.160	10.3	1.9	0.478	1.500	1.978	1.32	1.739	0.239
3	0.0918	18.670	13.8	2.9	0.634	1.500	2.134	1.42	1.817	0.317
4	0.1182	20.900	16.1	3.8	0.730	1.500	2.230	1.49	1.865	0.365
5	0.1456	23.800	19.0	4.8	0.853	1.500	2.353	1.57	1.926	0.426
6	0.1723	24.190	19.4	5.8	0.861	1.500	2.361	1.57	1.931	0.431
7	0.2278	24.730	19.9	7.7	0.867	1.500	2.367	1.58	1.933	0.433
8	0.2819	24.720	19.9	9.7	0.848	1.500	2.348	1.57	1.924	0.424
9	0.3357	25.070	20.2	11.6	0.845	1.500	2.345	1.56	1.922	0.422
10	0.3914	25.170	20.3	13.6	0.830	1.500	2.330	1.55	1.915	0.415
11	0.4315	25.310	20.5	15.0	0.822	1.500	2.322	1.55	1.911	0.411

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	154.150	154.150
Moisture content: Dry soil+tare, gms.	115.640	115.640
Moisture content: Tare, gms.	30.280	30.280
Moisture, %	45.1	45.1
Moist specimen weight, gms.	124.6	
Diameter, in.	1.39	
Area, in.²	1.53	
Height, in.	2.81	
Wet Density, pcf	110.6	
Dry density, pcf	76.2	
Void ratio	1.2659	
Saturation, %	98.6	

Test Readings for Specimen No. 3

Cell pressure = 3.000 tsf

Back pressure = 0.000 tsf

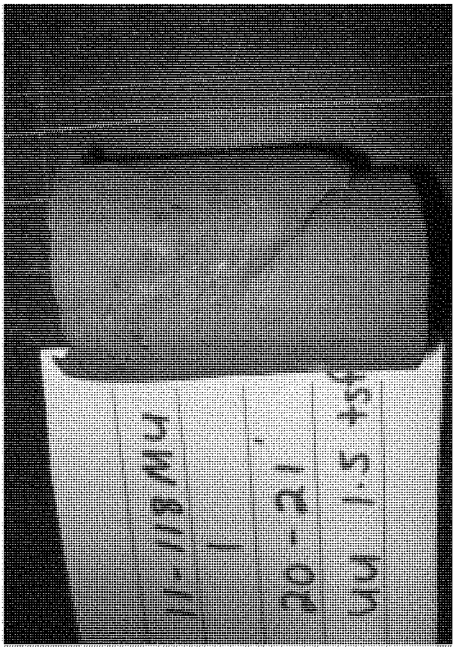
Strain rate, %/min. = 1.00

Peak Stress = 1.179 tsf at reading no. 8

Ult. Stress = 0.955 tsf at reading no. 14

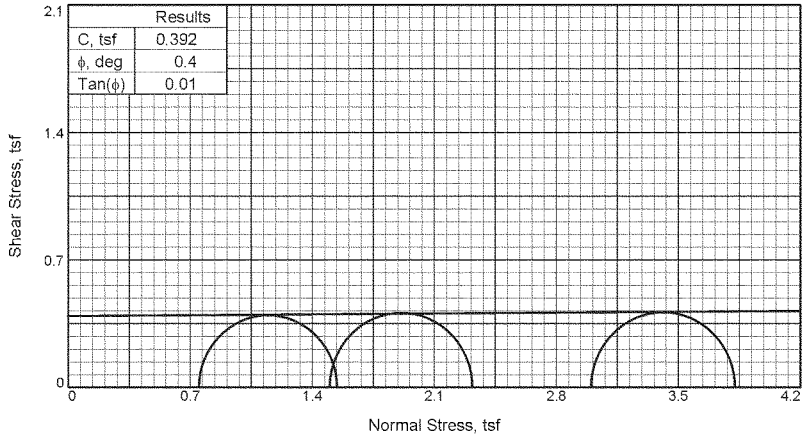
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0700	9.000	0.0	0.0	0.000	3.000	3.000	1.00	3.000	0.000
1	0.0800	9.880	0.9	0.4	0.041	3.000	3.041	1.01	3.021	0.021
2	0.0900	10.010	1.0	0.7	0.047	3.000	3.047	1.02	3.024	0.024
3	0.1000	10.360	1.4	1.1	0.063	3.000	3.063	1.02	3.032	0.032
4	0.1207	11.340	2.3	1.8	0.108	3.000	3.108	1.04	3.054	0.054
5	0.1485	14.520	5.5	2.8	0.253	3.000	3.253	1.08	3.127	0.127
6	0.1874	22.700	13.7	4.2	0.619	3.000	3.619	1.21	3.310	0.310
7	0.2422	32.860	23.9	6.1	1.057	3.000	4.057	1.35	3.528	0.528
8	0.2965	36.190	27.2	8.1	1.179	3.000	4.179	1.39	3.590	0.590
9	0.3507	36.160	27.2	10.0	1.153	3.000	4.153	1.38	3.577	0.577
10	0.3909	34.240	25.2	11.4	1.055	3.000	4.055	1.35	3.527	0.527
11	0.4291	32.470	23.5	12.8	0.966	3.000	3.966	1.32	3.483	0.483
12	0.4511	32.580	23.6	13.6	0.962	3.000	3.962	1.32	3.481	0.481
13	0.4761	32.790	23.8	14.4	0.960	3.000	3.960	1.32	3.480	0.480
14	0.4921	32.810	23.8	15.0	0.955	3.000	3.955	1.32	3.477	0.477

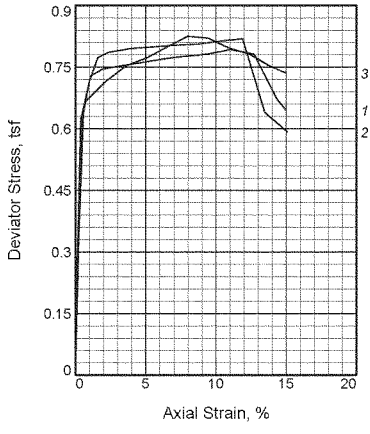
11-118 MU
1
20-21
UU 0.75 t


11-118 MU
1
20-21
UU 1.5 tsf

11-118 MU
1
20-21
UU 3 tsf

11-118 MU
1
20-21
UU





Sample No.		1	2	3
Initial	Water Content, %	70.2	71.2	73.7
	Dry Density, pcf	57.8	57.0	55.8
	Saturation, %	98.0	97.2	97.6
	Void Ratio	1.9693	2.0124	2.0750
	Diameter, in.	1.40	1.41	1.41
	Height, in.	2.82	2.82	2.81
At Test	Water Content, %	71.6	73.2	75.5
	Dry Density, pcf	57.8	57.0	55.8
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.9693	2.0124	2.0750
	Diameter, in.	1.40	1.41	1.41
	Height, in.	2.82	2.82	2.81
Strain rate, in./min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.75	1.50	3.00
Fail. Stress, tsf		0.79	0.82	0.83
Ult. Stress, tsf		0.65	0.59	0.73
σ_1 Failure, tsf		1.54	2.32	3.83
σ_3 Failure, tsf		0.75	1.50	3.00

Type of Test: Unconsolidated Undrained
Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, gray (CH)

LL= 111 **PL=** 25 **PI=** 86
Assumed Specific Gravity= 2.75
Remarks:

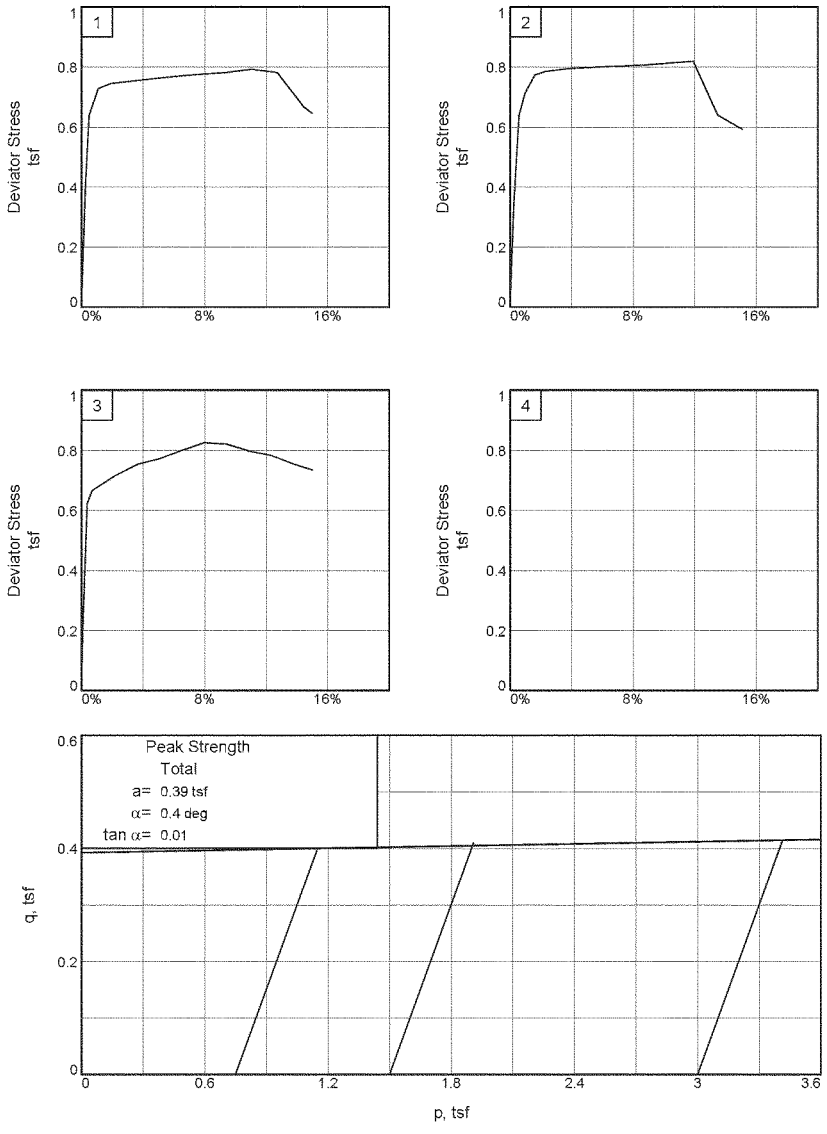
Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Fargo
Sample Number: Boring 09-23MU, #5 **Depth:** 38-40'
Brenna
Proj. No.: BL-09-03127 **Date Sampled:**

Figure UU Triax ASTM D2850

Tested By: rs **Checked By:** rs

BRAUN INTERTEC



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Fargo
Depth: 38-40' **Sample Number:** Boring 09-23MU, #5
Project No.: BL-09-03127 **Figure** _____

Brenna

Braun Intertec

Tested By: rs **Checked By:** rs

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

9/16/2009
10:17 AM

Date:			
Client:	US Army Corps of Engineers		
Project:	Fargo-Moorhead Metro Feasibility Study		
Project No.:	BL-09-03127		Fargo
Depth:	38-40'	**Sample Number:**	Boring 09-23MU, #5
Description:	FAT CLAY, gray (CH)		Brenna
Remarks:			
Type of Sample:	Thinwall, 5", Bottom of sample		
Assumed Specific Gravity=2.75	**LL=111**	**PL=25**	**PI=86**
Test Method:	COE uniform strain		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	109.770		141.590
Moisture content: Dry soil+tare, gms.	77.060		95.980
Moisture content: Tare, gms.	30.440		30.270
Moisture, %	70.2	71.6	69.4
Moist specimen weight, gms.	111.8		
Diameter, in.	1.40	1.40	
Area, in.²	1.54	1.54	
Height, in.	2.82	2.82	
Net decrease in height, in.		0.00	
Wet Density, pcf	98.4	99.2	
Dry density, pcf	57.8	57.8	
Void ratio	1.9693	1.9693	
Saturation, %	98.0	100.0	

Test Readings for Specimen No. 1

Cell pressure = 0.750 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 0.792 tsf **at reading no.** 9
Ult. Stress = 0.646 tsf **at reading no.** 12

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.2709	0.780	0.0	0.0	0.000	0.750	0.750	1.00	0.750	0.000
1	-1.2640	9.200	8.4	0.2	0.393	0.750	1.143	1.52	0.947	0.197
2	-1.2568	14.500	13.7	0.5	0.639	0.750	1.389	1.85	1.070	0.320
3	-1.2402	16.500	15.7	1.1	0.728	0.750	1.478	1.97	1.114	0.364
4	-1.2170	17.000	16.2	1.9	0.745	0.750	1.495	1.99	1.123	0.373
5	-1.1700	17.500	16.7	3.6	0.755	0.750	1.505	2.01	1.128	0.378
6	-1.1230	18.000	17.2	5.3	0.764	0.750	1.514	2.02	1.132	0.382
7	-1.0768	18.500	17.7	6.9	0.773	0.750	1.523	2.03	1.136	0.386
8	-1.0065	19.200	18.4	9.4	0.782	0.750	1.532	2.04	1.141	0.391
9	-0.9598	19.800	19.0	11.0	0.792	0.750	1.542	2.06	1.146	0.396
10	-0.9132	19.900	19.1	12.7	0.782	0.750	1.532	2.04	1.141	0.391
11	-0.8660	17.500	16.7	14.4	0.671	0.750	1.421	1.89	1.085	0.335
12	-0.8490	17.000	16.2	15.0	0.646	0.750	1.396	1.86	1.073	0.323

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	117.220		141.880
Moisture content: Dry soil+tare, gms.	81.040		95.880
Moisture content: Tare, gms.	30.190		30.620
Moisture, %	71.2	73.2	70.5
Moist specimen weight, gms.	112.2		
Diameter, in.	1.41	1.41	
Area, in.²	1.55	1.55	
Height, in.	2.82	2.82	
Net decrease in height, in.		0.00	
Wet Density, pcf	97.5	98.7	
Dry density, pcf	57.0	57.0	
Void ratio	2.0124	2.0124	
Saturation, %	97.2	100.0	

Test Readings for Specimen No. 2

Cell pressure = 1.500 tsf

Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

Fail. Stress = 0.819 tsf at reading no. 11

Ult. Stress = 0.593 tsf at reading no. 13

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.2653	2.420	0.0	0.0	0.000	1.500	1.500	1.00	1.500	0.000
1	-1.2585	9.700	7.3	0.2	0.336	1.500	1.836	1.22	1.668	0.168
2	-1.2490	16.300	13.9	0.6	0.639	1.500	2.139	1.43	1.820	0.320
3	-1.2377	18.000	15.6	1.0	0.714	1.500	2.214	1.48	1.857	0.357
4	-1.2200	19.400	17.0	1.6	0.774	1.500	2.274	1.52	1.887	0.387
5	-1.1990	19.800	17.4	2.4	0.786	1.500	2.286	1.52	1.893	0.393
6	-1.1540	20.300	17.9	4.0	0.795	1.500	2.295	1.53	1.898	0.398
7	-1.1090	20.700	18.3	5.5	0.800	1.500	2.300	1.53	1.900	0.400
8	-1.0646	21.100	18.7	7.1	0.803	1.500	2.303	1.54	1.902	0.402
9	-1.0190	21.500	19.1	8.7	0.806	1.500	2.306	1.54	1.903	0.403

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
10	-0.9750	22.000	19.6	10.3	0.813	1.500	2.313	1.54	1.907	0.407
11	-0.9299	22.500	20.1	11.9	0.819	1.500	2.319	1.55	1.910	0.410
12	-0.8854	18.400	16.0	13.5	0.640	1.500	2.140	1.43	1.820	0.320
13	-0.8401	17.500	15.1	15.1	0.593	1.500	2.093	1.40	1.796	0.296

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	127.150		140.760
Moisture content: Dry soil+tare, gms.	86.040		95.010
Moisture content: Tare, gms.	30.240		30.410
Moisture, %	73.7	75.5	70.8
Moist specimen weight, gms.	111.3		
Diameter, in.	1.41	1.41	
Area, in.²	1.56	1.56	
Height, in.	2.81	2.81	
Net decrease in height, in.		0.00	
Wet Density, pcf	97.0	98.0	
Dry density, pcf	55.8	55.8	
Void ratio	2.0750	2.0750	
Saturation, %	97.6	100.0	

Test Readings for Specimen No. 3

Cell pressure = 3.000 tsf

Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

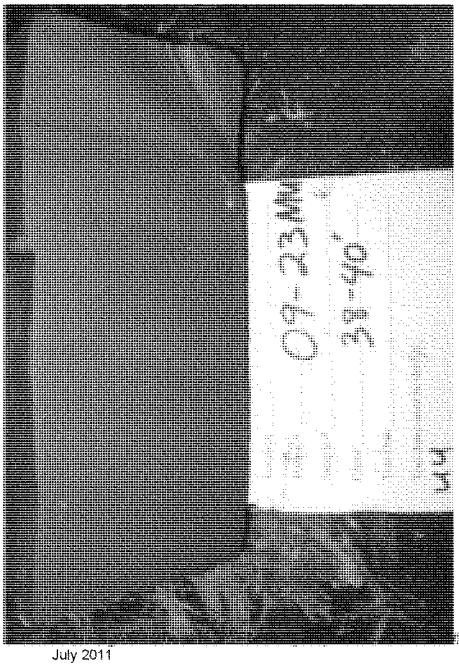
Fail. Stress = 0.825 tsf at reading no. 8

Ult. Stress = 0.735 tsf at reading no. 13

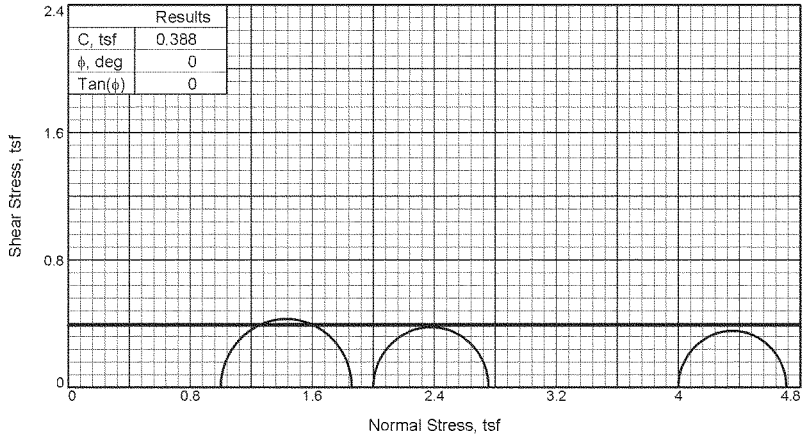
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.2595	6.500	0.0	0.0	0.000	3.000	3.000	1.00	3.000	0.000
1	-1.2567	11.300	4.8	0.1	0.222	3.000	3.222	1.07	3.111	0.111
2	-1.2490	20.000	13.5	0.4	0.622	3.000	3.622	1.21	3.311	0.311
3	-1.2400	21.000	14.5	0.7	0.666	3.000	3.666	1.22	3.333	0.333
4	-1.1990	22.300	15.8	2.2	0.715	3.000	3.715	1.24	3.357	0.357
5	-1.1580	23.400	16.9	3.6	0.753	3.000	3.753	1.25	3.377	0.377
6	-1.1170	24.100	17.6	5.1	0.773	3.000	3.773	1.26	3.386	0.386
7	-1.0760	25.000	18.5	6.5	0.800	3.000	3.800	1.27	3.400	0.400
8	-1.0349	25.900	19.4	8.0	0.825	3.000	3.825	1.28	3.413	0.413
9	-0.9940	26.100	19.6	9.5	0.821	3.000	3.821	1.27	3.410	0.410
10	-0.9525	25.848	19.3	10.9	0.797	3.000	3.797	1.27	3.398	0.398
11	-0.9115	25.800	19.3	12.4	0.782	3.000	3.782	1.26	3.391	0.391
12	-0.8704	25.400	18.9	13.9	0.753	3.000	3.753	1.25	3.376	0.376
13	-0.8380	25.200	18.7	15.0	0.735	3.000	3.735	1.24	3.367	0.367

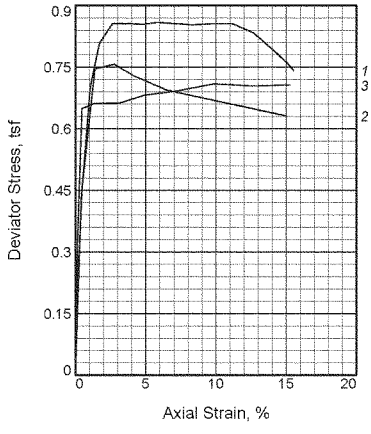
09-23MW
38-40'
UU 3+3f

09-23M
38-40
UU


09-23MW
38-40'
UU

09-23MW
38-40'
UU 0.75





Sample No.		1	2	3
Initial	Water Content, %	53.9	54.1	56.0
	Dry Density, pcf	68.5	67.5	65.2
	Saturation, %	98.4	96.3	94.3
	Void Ratio	1.5048	1.5448	1.6339
	Diameter, in.	1.39	1.42	1.40
	Height, in.	2.82	2.80	2.81
At Test	Water Content, %	53.3	56.8	61.8
	Dry Density, pcf	68.5	67.5	65.2
	Saturation, %	97.4	101.1	104.0
	Void Ratio	1.5048	1.5448	1.6339
	Diameter, in.	1.39	1.42	1.40
	Height, in.	2.82	2.80	2.81
Strain rate, in./min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		1.00	2.00	4.00
Fail. Stress, tsf		0.86	0.76	0.71
Ult. Stress, tsf		0.76	0.63	0.71
σ_1 Failure, tsf		1.86	2.76	4.71
σ_3 Failure, tsf		1.00	2.00	4.00

Type of Test: Unconsolidated Undrained
Sample Type: Thinwall, 5"
Description: FAT CLAY, gray (CH)

LL= 92 **PL=** 22 **PI=** 70
Assumed Specific Gravity= 2.75
Remarks: Tested bottom portion of 5" thinwall.

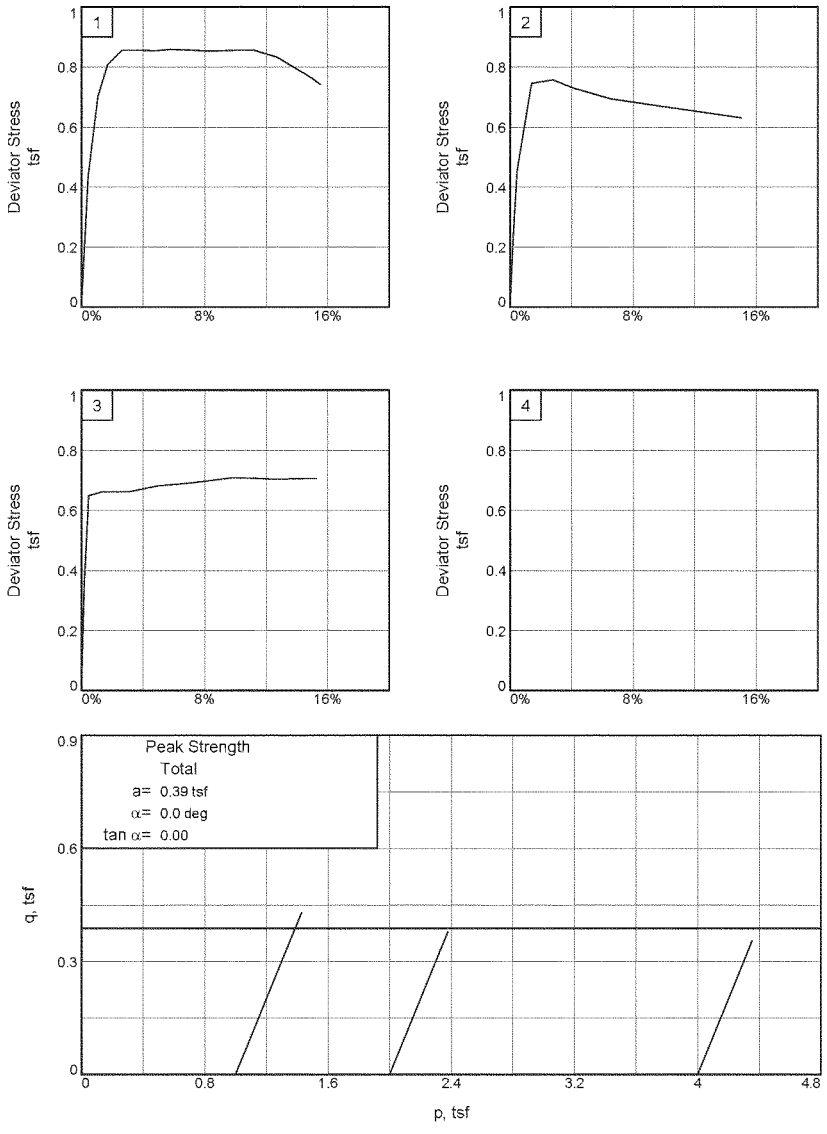
Figure UU Triax ASTM D 2850

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Fargo
Sample Number: Boring 09-23MU, #6 **Depth:** 80-82'
Brenna
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Fargo
Depth: 80-82' **Sample Number:** Boring 09-23MU, #6
Project No.: BL-09-03127 **Figure** _____

Brenna

Braun Intertec

Tested By: rs **Checked By:** rs

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

9/16/2009
9:43 AM

Date:			
Client:	US Army Corps of Engineers		
Project:	Fargo-Moorhead Metro Feasibility Study		
Project No.:	BL-09-03127		Fargo
Depth:	80-82'	**Sample Number:**	Boring 09-23MU, #6
Description:	FAT CLAY, gray (CH)		Brenna
Remarks:	Tested bottom portion of 5" thinwall.		
Type of Sample:	Thinwall, 5"		
Assumed Specific Gravity=2.75	**LL=92**	**PL=22**	**PI=70**
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	135.440	148.820
Moisture content: Dry soil+tare, gms.	98.770	107.650
Moisture content: Tare, gms.	30.690	30.420
Moisture, %	53.9	53.3
Moist specimen weight, gms.	118.8	
Diameter, in.	1.39	
Area, in.²	1.52	
Height, in.	2.82	
Wet Density, pcf	105.5	
Dry density, pcf	68.5	
Void ratio	1.5048	
Saturation, %	98.4	

Test Readings for Specimen No. 1

Cell pressure = 1.000 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 0.859 tsf **at reading no.** 8
Ult. Stress = 0.763 tsf **at reading no.** 15

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.7320	5.000	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	-1.7280	8.000	3.0	0.1	0.142	1.000	1.142	1.14	1.071	0.071
2	-1.7200	14.200	9.2	0.4	0.433	1.000	1.433	1.43	1.216	0.216
3	-1.7020	20.000	15.0	1.1	0.701	1.000	1.701	1.70	1.351	0.351
4	-1.6840	22.400	17.4	1.7	0.808	1.000	1.808	1.81	1.404	0.404
5	-1.6580	23.600	18.6	2.6	0.856	1.000	1.856	1.86	1.428	0.428
6	-1.6310	23.800	18.8	3.6	0.856	1.000	1.856	1.86	1.428	0.428
7	-1.5960	24.000	19.0	4.8	0.854	1.000	1.854	1.85	1.427	0.427
8	-1.5690	24.300	19.3	5.8	0.859	1.000	1.859	1.86	1.430	0.430
9	-1.5340	24.500	19.5	7.0	0.856	1.000	1.856	1.86	1.428	0.428
10	-1.4980	24.700	19.7	8.3	0.853	1.000	1.853	1.85	1.427	0.427
11	-1.4530	25.100	20.1	9.9	0.855	1.000	1.855	1.86	1.428	0.428
12	-1.4170	25.400	20.4	11.2	0.856	1.000	1.856	1.86	1.428	0.428
13	-1.3740	25.200	20.2	12.7	0.833	1.000	1.833	1.83	1.416	0.416
14	-1.3300	24.400	19.4	14.3	0.786	1.000	1.786	1.79	1.393	0.393
15	-1.3100	24.000	19.0	15.0	0.763	1.000	1.763	1.76	1.382	0.382
16	-1.2950	23.600	18.6	15.5	0.742	1.000	1.742	1.74	1.371	0.371

Parameters for Specimen No. 2		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	118.480	152.260
Moisture content: Dry soil+tare, gms.	87.510	108.310
Moisture content: Tare, gms.	30.260	30.960
Moisture, %	54.1	56.8
Moist specimen weight, gms.	121.5	
Diameter, in.	1.42	
Area, in.²	1.59	
Height, in.	2.80	
Wet Density, pcf	104.0	
Dry density, pcf	67.5	
Void ratio	1.5448	
Saturation, %	96.3	

Test Readings for Specimen No. 2

Cell pressure = 2.000 tsf

Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

Fail. Stress = 0.757 tsf at reading no. 4

Ult. Stress = 0.631 tsf at reading no. 10

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.7170	4.000	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	-1.7110	9.300	5.3	0.2	0.239	2.000	2.239	1.12	2.120	0.120
2	-1.7040	14.100	10.1	0.5	0.455	2.000	2.455	1.23	2.228	0.228
3	-1.6780	20.700	16.7	1.4	0.746	2.000	2.746	1.37	2.373	0.373
4	-1.6390	21.200	17.2	2.8	0.757	2.000	2.757	1.38	2.378	0.378
5	-1.5997	20.800	16.8	4.2	0.729	2.000	2.729	1.36	2.364	0.364
6	-1.5340	20.400	16.4	6.5	0.694	2.000	2.694	1.35	2.347	0.347
7	-1.4560	20.400	16.4	9.3	0.673	2.000	2.673	1.34	2.337	0.337
8	-1.3910	20.400	16.4	11.6	0.656	2.000	2.656	1.33	2.328	0.328
9	-1.3750	20.400	16.4	12.2	0.652	2.000	2.652	1.33	2.326	0.326
10	-1.2970	20.400	16.4	15.0	0.631	2.000	2.631	1.32	2.316	0.316

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	111.230	146.430
Moisture content: Dry soil+tare, gms.	82.220	102.510
Moisture content: Tare, gms.	30.420	31.420
Moisture, %	56.0	61.8
Moist specimen weight, gms.	115.8	
Diameter, in.	1.40	
Area, in.²	1.55	
Height, in.	2.81	
Wet Density, pcf	101.7	
Dry density, pcf	65.2	
Void ratio	1.6339	
Saturation, %	94.3	

Test Readings for Specimen No. 3

Cell pressure = 4.000 tsf

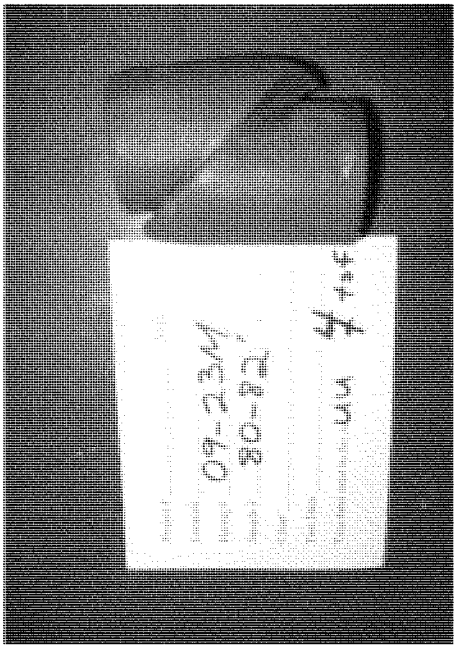
Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

Fail. Stress = 0.709 tsf at reading no. 7

Ult. Stress = 0.707 tsf at reading no. 9

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.7140	7.000	0.0	0.0	0.000	4.000	4.000	1.00	4.000	0.000
1	-1.7090	14.600	7.6	0.2	0.353	4.000	4.353	1.09	4.177	0.177
2	-1.7010	21.000	14.0	0.5	0.649	4.000	4.649	1.16	4.324	0.324
3	-1.6760	21.400	14.4	1.4	0.662	4.000	4.662	1.17	4.331	0.331
4	-1.6250	21.700	14.7	3.2	0.663	4.000	4.663	1.17	4.331	0.331
5	-1.5750	22.400	15.4	5.0	0.682	4.000	4.682	1.17	4.341	0.341
6	-1.5120	23.000	16.0	7.2	0.692	4.000	4.692	1.17	4.346	0.346
7	-1.4370	23.900	16.9	9.9	0.709	4.000	4.709	1.18	4.355	0.355
8	-1.3610	24.300	17.3	12.6	0.704	4.000	4.704	1.18	4.352	0.352
9	-1.2860	24.900	17.9	15.2	0.707	4.000	4.707	1.18	4.353	0.353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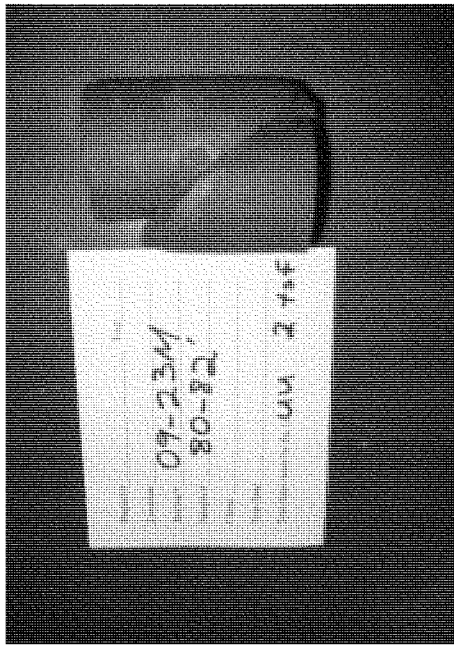
80-82'
4 ++f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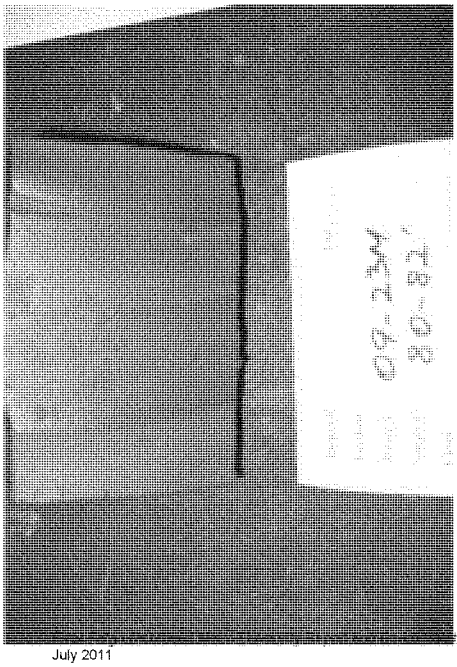
80-82'
2 ++f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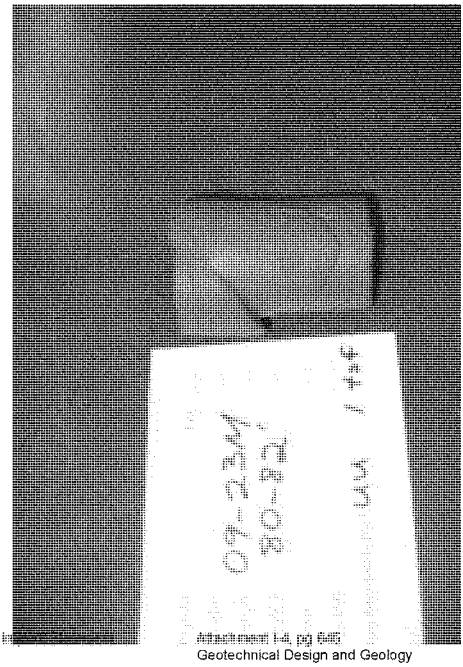
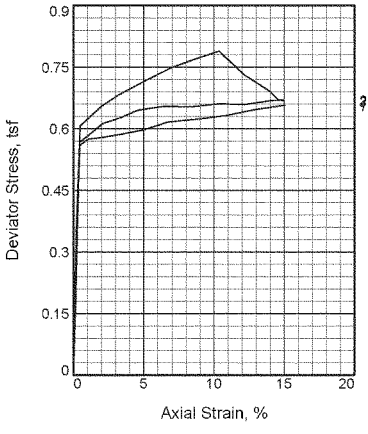

01-23W
80-82'
1 ++f



Sample No.		1	2	3
Initial	Water Content, %	70.1	70.2	70.0
	Dry Density, pcf	57.7	58.1	57.7
	Saturation, %	97.4	98.6	97.5
	Void Ratio	1.9776	1.9559	1.9728
	Diameter, in.	1.39	1.40	1.39
	Height, in.	2.82	2.80	2.81
At Test	Water Content, %	71.9	71.1	71.7
	Dry Density, pcf	57.7	58.1	57.7
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.9776	1.9559	1.9728
	Diameter, in.	1.39	1.40	1.39
	Height, in.	2.82	2.80	2.81
Strain rate, in./min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.75	1.50	3.00
Fail. Stress, tsf		0.66	0.67	0.79
Ult. Stress, tsf		0.66	0.67	0.67
σ_1 Failure, tsf		1.41	2.17	3.79
σ_3 Failure, tsf		0.75	1.50	3.00

Type of Test:
Unconsolidated Undrained
Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, gray (CH)

LL= 116 **PL=** 25 **PI=** 91
Assumed Specific Gravity= 2.75
Remarks:

Figure UU Triax ASTM D2850

Client: US Army Corps of Engineers

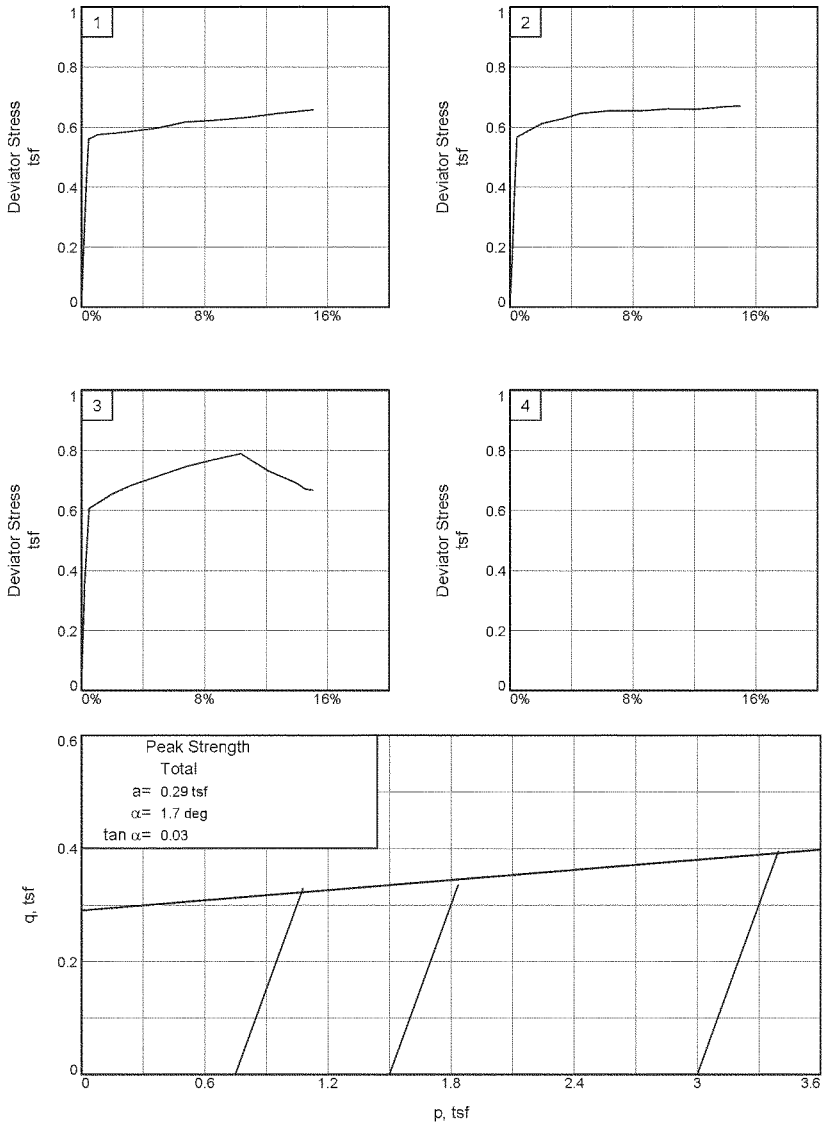
Project: Fargo-Moorhead Metro Feasibility Study
Moorhead

Sample Number: Boring 09-25MU, #4 **Depth:** 38-40'
Brenna

Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Moorhead
Depth: 38-40' **Sample Number:** Boring 09-25MU, #4
Project No.: BL-09-03127 **Figure** _____

Brenna

Braun Intertec

Tested By: rs **Checked By:** rs

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

9/16/2009
10:16 AM

Date:			
Client:	US Army Corps of Engineers		
Project:	Fargo-Moorhead Metro Feasibility Study		
Project No.:	BL-09-03127		Moorhead
Depth:	38-40'	**Sample Number:**	Boring 09-25MU, #4
Description:	FAT CLAY, gray (CH)		Brenna
Remarks:			
Type of Sample:	Thinwall, 5", Bottom of sample		
Assumed Specific Gravity=2.75	**LL=116**	**PL=25**	**PI=91**
Test Method:	COE uniform strain		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	116.060		139.190
Moisture content: Dry soil+tare, gms.	80.690		95.380
Moisture content: Tare, gms.	30.210		30.400
Moisture, %	70.1	71.9	67.4
Moist specimen weight, gms.	109.7		
Diameter, in.	1.39	1.39	
Area, in.²	1.51	1.51	
Height, in.	2.82	2.82	
Net decrease in height, in.		0.00	
Wet Density, pcf	98.1	99.1	
Dry density, pcf	57.7	57.7	
Void ratio	1.9776	1.9776	
Saturation, %	97.4	100.0	

Test Readings for Specimen No. 1

Cell pressure = 0.750 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 0.657 tsf **at reading no.** 13
Ult. Stress = 0.657 tsf **at reading no.** 13

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.2771	-0.214	0.0	0.0	0.000	0.750	0.750	1.00	0.750	0.000
1	-1.2717	5.400	5.6	0.2	0.267	0.750	1.017	1.36	0.883	0.133
2	-1.2680	8.900	9.1	0.3	0.432	0.750	1.182	1.58	0.966	0.216
3	-1.2640	11.600	11.8	0.5	0.560	0.750	1.310	1.75	1.030	0.280
4	-1.2600	11.700	11.9	0.6	0.563	0.750	1.313	1.75	1.032	0.282
5	-1.2470	12.000	12.2	1.1	0.575	0.750	1.325	1.77	1.037	0.287
6	-1.2200	12.200	12.4	2.0	0.579	0.750	1.329	1.77	1.039	0.289
7	-1.1760	12.600	12.8	3.6	0.588	0.750	1.338	1.78	1.044	0.294
8	-1.1360	13.000	13.2	5.0	0.597	0.750	1.347	1.80	1.049	0.299
9	-1.0880	13.670	13.9	6.7	0.616	0.750	1.366	1.82	1.058	0.308
10	-1.0230	14.200	14.4	9.0	0.624	0.750	1.374	1.83	1.062	0.312
11	-0.9707	14.700	14.9	10.9	0.632	0.750	1.382	1.84	1.066	0.316
12	-0.9120	15.400	15.6	13.0	0.647	0.750	1.397	1.86	1.073	0.323
13	-0.8530	16.050	16.3	15.1	0.657	0.750	1.407	1.88	1.079	0.329

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	75.650		142.410
Moisture content: Dry soil+tare, gms.	57.200		98.120
Moisture content: Tare, gms.	30.900		31.020
Moisture, %	70.2	71.1	66.0
Moist specimen weight, gms.	112.6		
Diameter, in.	1.40	1.40	
Area, in.²	1.55	1.55	
Height, in.	2.80	2.80	
Net decrease in height, in.		0.00	
Wet Density, pcf	98.8	99.4	
Dry density, pcf	58.1	58.1	
Void ratio	1.9559	1.9559	
Saturation, %	98.6	100.0	

Test Readings for Specimen No. 2

Cell pressure = 1.500 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 0.670 tsf at reading no. 13
Ult. Stress = 0.670 tsf at reading no. 13

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.4696	1.950	0.0	0.0	0.000	1.500	1.500	1.00	1.500	0.000
1	-1.4650	5.700	3.8	0.2	0.174	1.500	1.674	1.12	1.587	0.087
2	-1.4620	9.260	7.3	0.3	0.339	1.500	1.839	1.23	1.670	0.170
3	-1.4567	14.200	12.3	0.5	0.567	1.500	2.067	1.38	1.784	0.284
4	-1.4300	14.900	13.0	1.4	0.594	1.500	2.094	1.40	1.797	0.297
5	-1.4110	15.400	13.5	2.1	0.612	1.500	2.112	1.41	1.806	0.306
6	-1.3750	15.900	14.0	3.4	0.627	1.500	2.127	1.42	1.813	0.313
7	-1.3400	16.500	14.6	4.6	0.645	1.500	2.145	1.43	1.823	0.323
8	-1.2870	17.000	15.1	6.5	0.654	1.500	2.154	1.44	1.827	0.327

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
9	-1.2330	17.300	15.4	8.4	0.654	1.500	2.154	1.44	1.827	0.327
10	-1.1800	17.800	15.9	10.3	0.661	1.500	2.161	1.44	1.830	0.330
11	-1.1270	18.100	16.2	12.2	0.659	1.500	2.159	1.44	1.830	0.330
12	-1.0730	18.700	16.8	14.1	0.669	1.500	2.169	1.45	1.834	0.334
13	-1.0500	18.900	17.0	15.0	0.670	1.500	2.170	1.45	1.835	0.335

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	78.160		140.060
Moisture content: Dry soil+tare, gms.	58.490		96.810
Moisture content: Tare, gms.	30.380		30.930
Moisture, %	70.0	71.7	65.6
Moist specimen weight, gms.	109.8		
Diameter, in.	1.39	1.39	
Area, in.²	1.52	1.52	
Height, in.	2.81	2.81	
Net decrease in height, in.		0.00	
Wet Density, pcf	98.2	99.2	
Dry density, pcf	57.7	57.7	
Void ratio	1.9728	1.9728	
Saturation, %	97.5	100.0	

Test Readings for Specimen No. 3

Cell pressure = 3.000 tsf

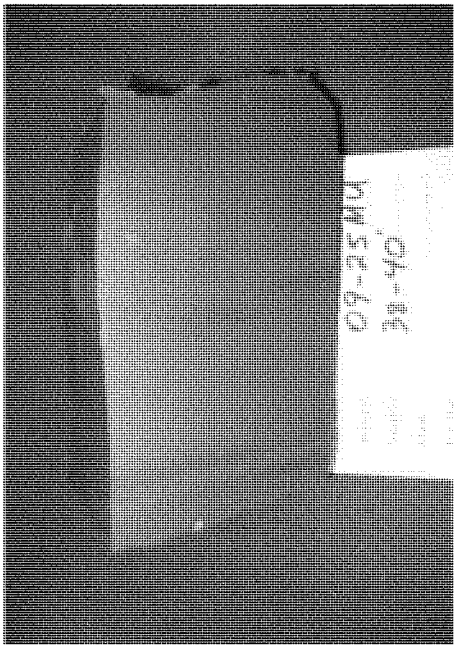
Back pressure = 0.000 tsf

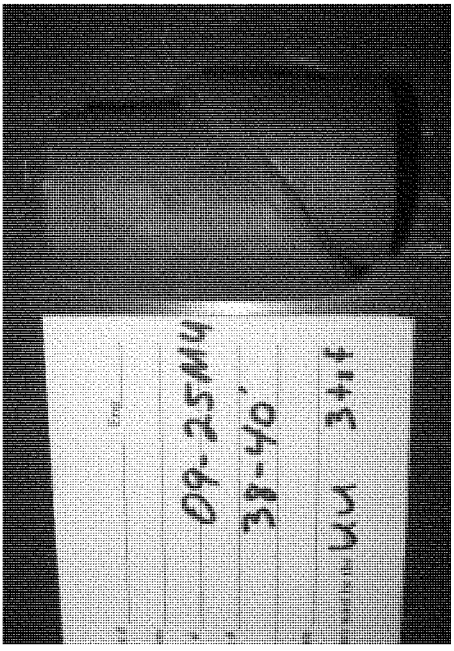
Strain rate, in./min. = 0.03

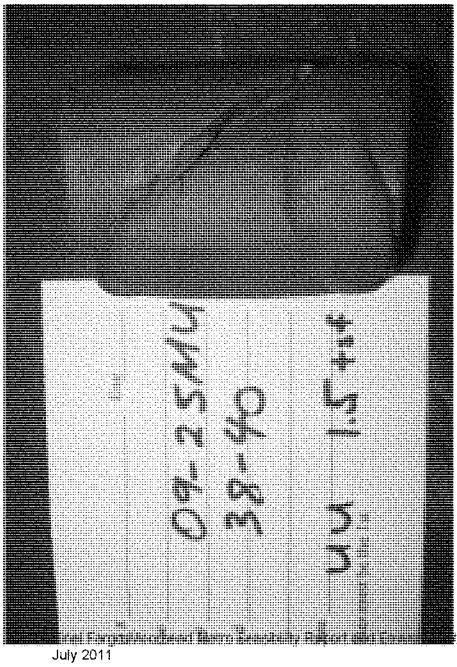
Fail. Stress = 0.789 tsf at reading no. 9

Ult. Stress = 0.667 tsf at reading no. 13

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.2518	6.150	0.0	0.0	0.000	3.000	3.000	1.00	3.000	0.000
1	-1.2490	9.800	3.7	0.1	0.173	3.000	3.173	1.06	3.087	0.087
2	-1.2460	13.700	7.5	0.2	0.357	3.000	3.357	1.12	3.179	0.179
3	-1.2380	19.000	12.9	0.5	0.607	3.000	3.607	1.20	3.303	0.303
4	-1.1970	20.200	14.1	2.0	0.654	3.000	3.654	1.22	3.327	0.327
5	-1.1620	21.000	14.9	3.2	0.682	3.000	3.682	1.23	3.341	0.341
6	-1.1118	22.000	15.9	5.0	0.715	3.000	3.715	1.24	3.357	0.357
7	-1.0620	23.000	16.9	6.8	0.745	3.000	3.745	1.25	3.373	0.373
8	-1.0090	23.900	17.8	8.6	0.769	3.000	3.769	1.26	3.385	0.385
9	-0.9606	24.700	18.5	10.4	0.789	3.000	3.789	1.26	3.394	0.394
10	-0.9102	23.700	17.5	12.2	0.731	3.000	3.731	1.24	3.366	0.366
11	-0.8600	23.100	17.0	13.9	0.692	3.000	3.692	1.23	3.346	0.346
12	-0.8419	22.700	16.5	14.6	0.671	3.000	3.671	1.22	3.335	0.335
13	-0.8300	22.700	16.5	15.0	0.667	3.000	3.667	1.22	3.334	0.334


09-25MW
38-40'


09-25MW
38-40'
UU 3+ft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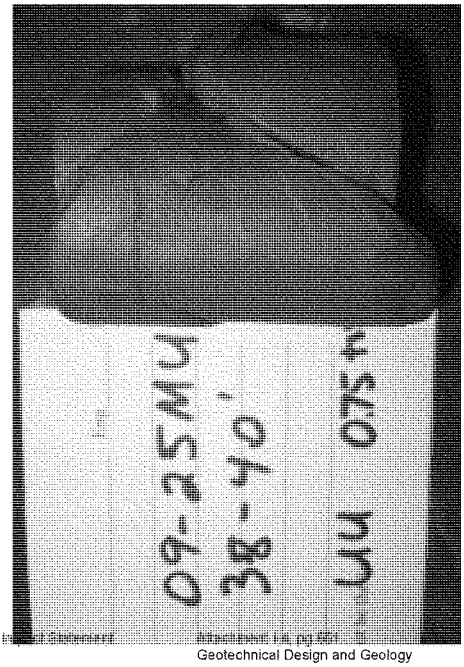
38-40'
UU 1.5+ft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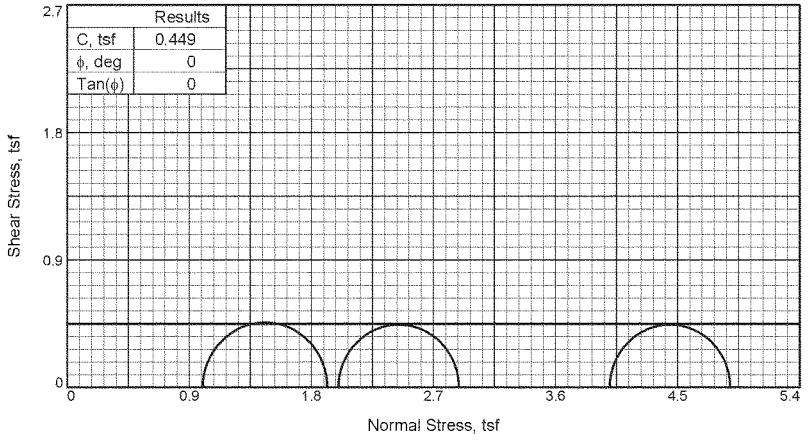
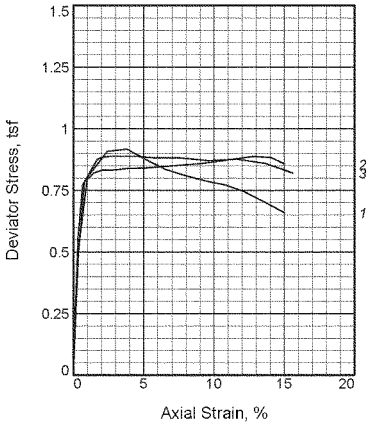
38-40'
UU 0.75+ft





Sample No.		1	2	3
Initial	Water Content, %	53.8	57.6	57.0
	Dry Density, pcf	69.2	66.2	66.0
	Saturation, %	99.9	99.4	97.7
	Void Ratio	1.4802	1.5937	1.6025
	Diameter, in.	1.40	1.40	1.41
	Height, in.	2.80	2.81	2.81
At Test	Water Content, %	53.8	58.0	58.3
	Dry Density, pcf	69.2	66.2	66.0
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.4802	1.5937	1.6025
	Diameter, in.	1.40	1.40	1.41
	Height, in.	2.80	2.81	2.81
Strain rate, in./min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		1.00	2.00	4.00
Fail. Stress, tsf		0.92	0.89	0.89
Ult. Stress, tsf		0.66	0.86	0.82
σ_1 Failure, tsf		1.92	2.89	4.89
σ_3 Failure, tsf		1.00	2.00	4.00

Type of Test:
Unconsolidated Undrained
Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, gray (CH)

LL= 87 **PL=** 22 **PI=** 65
Assumed Specific Gravity= 2.75
Remarks:

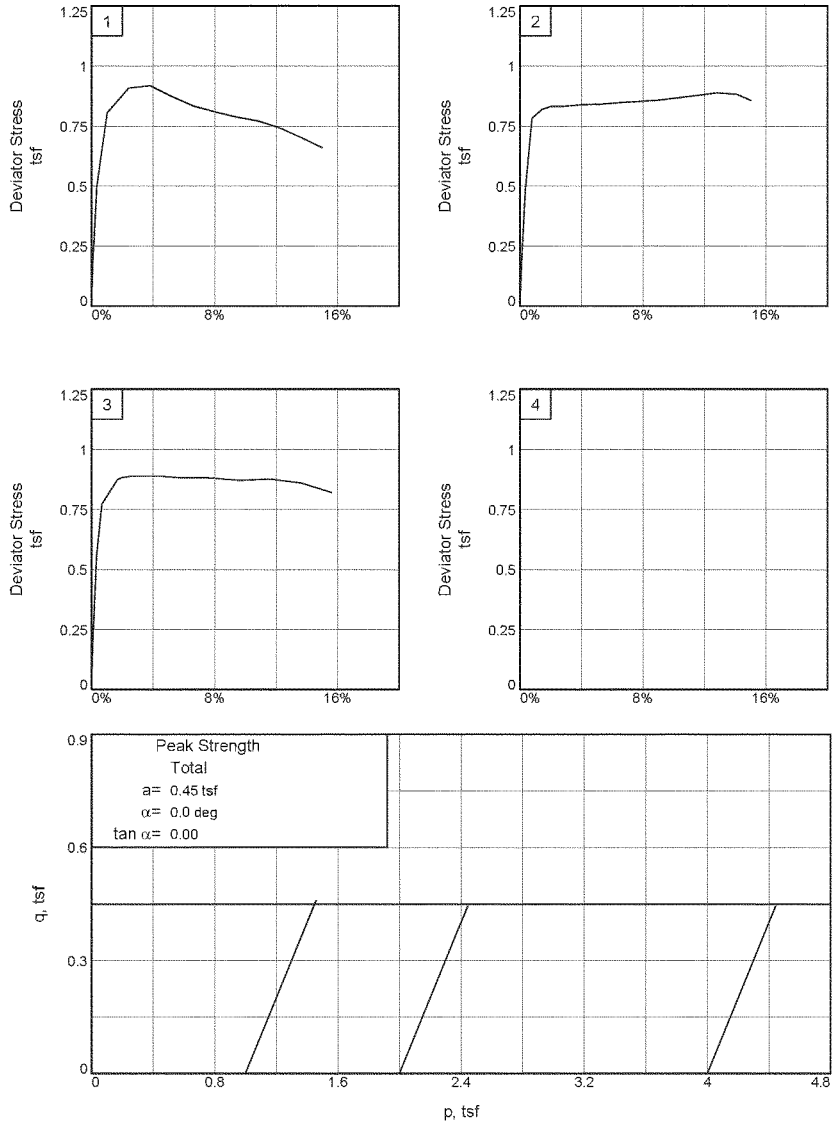
Figure UU Triax ASTM D2850

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Moorhead
Sample Number: Boring 09-25MU, #5 **Depth:** 68-70'
Brenna / Argusville Transition
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Moorhead
Depth: 68-70' **Sample Number:** Boring 09-25MU, #5
Project No.: BL-09-03127 **Figure** _____
Brenna / Argusville Transition
Braun Intertec

Tested By: rs **Checked By:** rs

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

9/16/2009
10:18 AM

Date:			
Client:	US Army Corps of Engineers		
Project:	Fargo-Moorhead Metro Feasibility Study		
Project No.:	BL-09-03127		Moorhead
Depth:	68-70'	**Sample Number:**	Boring 09-25MU, #5
Description:	FAT CLAY, gray (CH)		Brenna / Argusville Transition
Remarks:			
Type of Sample:	Thinwall, 5", Bottom of sample		
Assumed Specific Gravity=2.75	**LL=87**	**PL=22**	**PI=65**
Test Method:	COE uniform strain		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	148.670		150.350
Moisture content: Dry soil+tare, gms.	107.600		109.010
Moisture content: Tare, gms.	31.220		30.020
Moisture, %	53.8	53.8	52.3
Moist specimen weight, gms.	120.6		
Diameter, in.	1.40	1.40	
Area, in.²	1.54	1.54	
Height, in.	2.80	2.80	
Net decrease in height, in.		0.00	
Wet Density, pcf	106.4	106.5	
Dry density, pcf	69.2	69.2	
Void ratio	1.4802	1.4802	
Saturation, %	99.9	100.0	

Test Readings for Specimen No. 1

Cell pressure = 1.000 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 0.918 tsf **at reading no.** 5
Ult. Stress = 0.660 tsf **at reading no.** 13

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.2675	0.900	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	-1.2650	4.970	4.1	0.1	0.190	1.000	1.190	1.19	1.095	0.095
2	-1.2580	11.600	10.7	0.3	0.499	1.000	1.499	1.50	1.249	0.249
3	-1.2390	18.300	17.4	1.0	0.806	1.000	1.806	1.81	1.403	0.403
4	-1.1996	20.800	19.9	2.4	0.908	1.000	1.908	1.91	1.454	0.454
5	-1.1605	21.300	20.4	3.8	0.918	1.000	1.918	1.92	1.459	0.459
6	-1.1212	20.600	19.7	5.2	0.873	1.000	1.873	1.87	1.437	0.437
7	-1.0823	20.000	19.1	6.6	0.834	1.000	1.834	1.83	1.417	0.417
8	-1.0430	19.700	18.8	8.0	0.809	1.000	1.809	1.81	1.404	0.404
9	-1.0040	19.500	18.6	9.4	0.788	1.000	1.788	1.79	1.394	0.394
10	-0.9644	19.400	18.5	10.8	0.772	1.000	1.772	1.77	1.386	0.386
11	-0.9250	19.000	18.1	12.2	0.743	1.000	1.743	1.74	1.372	0.372
12	-0.8860	18.300	17.4	13.6	0.703	1.000	1.703	1.70	1.352	0.352
13	-0.8467	17.500	16.6	15.0	0.660	1.000	1.660	1.66	1.330	0.330

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	108.070		148.740
Moisture content: Dry soil+tare, gms.	79.660		107.550
Moisture content: Tare, gms.	30.320		31.040
Moisture, %	57.6	58.0	53.8
Moist specimen weight, gms.	118.4		
Diameter, in.	1.40	1.40	
Area, in.²	1.54	1.54	
Height, in.	2.81	2.81	
Net decrease in height, in.		0.00	
Wet Density, pcf	104.3	104.5	
Dry density, pcf	66.2	66.2	
Void ratio	1.5937	1.5937	
Saturation, %	99.4	100.0	

Test Readings for Specimen No. 2

Cell pressure = 2.000 tsf

Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

Fail. Stress = 0.888 tsf at reading no. 13

Ult. Stress = 0.857 tsf at reading no. 15

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.2577	3.800	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	-1.2532	8.900	5.1	0.2	0.238	2.000	2.238	1.12	2.119	0.119
2	-1.2480	14.100	10.3	0.3	0.479	2.000	2.479	1.24	2.240	0.240
3	-1.2355	20.700	16.9	0.8	0.783	2.000	2.783	1.39	2.392	0.392
4	-1.2175	21.600	17.8	1.4	0.819	2.000	2.819	1.41	2.410	0.410
5	-1.1998	22.000	18.2	2.1	0.832	2.000	2.832	1.42	2.416	0.416
6	-1.1820	22.100	18.3	2.7	0.832	2.000	2.832	1.42	2.416	0.416
7	-1.1467	22.500	18.7	4.0	0.839	2.000	2.839	1.42	2.419	0.419
8	-1.1110	22.800	19.0	5.2	0.841	2.000	2.841	1.42	2.420	0.420

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
9	-1.0757	23.200	19.4	6.5	0.847	2.000	2.847	1.42	2.424	0.424
10	-1.0400	23.600	19.8	7.8	0.853	2.000	2.853	1.43	2.427	0.427
11	-1.0048	24.000	20.2	9.0	0.858	2.000	2.858	1.43	2.429	0.429
12	-0.9690	24.500	20.7	10.3	0.867	2.000	2.867	1.43	2.434	0.434
13	-0.8983	25.600	21.8	12.8	0.888	2.000	2.888	1.44	2.444	0.444
14	-0.8630	25.800	22.0	14.1	0.883	2.000	2.883	1.44	2.441	0.441
15	-0.8364	25.400	21.6	15.0	0.857	2.000	2.857	1.43	2.429	0.429

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	90.880		149.060
Moisture content: Dry soil+tare, gms.	68.980		107.120
Moisture content: Tare, gms.	30.530		31.490
Moisture, %	57.0	58.3	55.5
Moist specimen weight, gms.	118.7		
Diameter, in.	1.41	1.41	
Area, in.²	1.55	1.55	
Height, in.	2.81	2.81	
Net decrease in height, in.		0.00	
Wet Density, pcf	103.5	104.4	
Dry density, pcf	66.0	66.0	
Void ratio	1.6025	1.6025	
Saturation, %	97.7	100.0	

Test Readings for Specimen No. 3

Cell pressure = 4.000 tsf

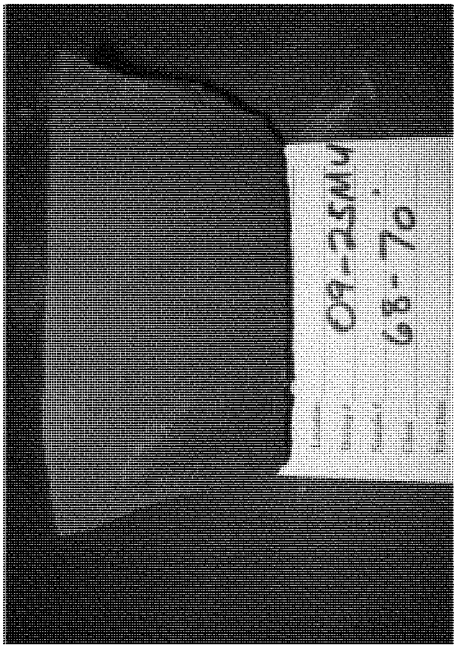
Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

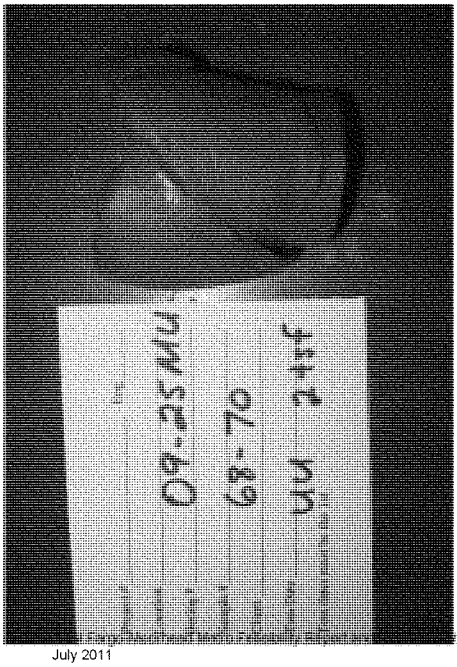
Fail. Stress = 0.888 tsf at reading no. 6

Ult. Stress = 0.821 tsf at reading no. 15

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	-1.4493	9.300	0.0	0.0	0.000	4.000	4.000	1.00	4.000	0.000
1	-1.4465	13.800	4.5	0.1	0.208	4.000	4.208	1.05	4.104	0.104
2	-1.4399	21.400	12.1	0.3	0.558	4.000	4.558	1.14	4.279	0.279
3	-1.4304	26.100	16.8	0.7	0.773	4.000	4.773	1.19	4.386	0.386
4	-1.4020	28.500	19.2	1.7	0.874	4.000	4.874	1.22	4.437	0.437
5	-1.3930	28.760	19.5	2.0	0.883	4.000	4.883	1.22	4.442	0.442
6	-1.3750	29.000	19.7	2.6	0.888	4.000	4.888	1.22	4.444	0.444
7	-1.3750	29.000	19.7	2.6	0.888	4.000	4.888	1.22	4.444	0.444
8	-1.3470	29.200	19.9	3.6	0.888	4.000	4.888	1.22	4.444	0.444
9	-1.3185	29.400	20.1	4.7	0.887	4.000	4.887	1.22	4.444	0.444
10	-1.2905	29.500	20.2	5.7	0.883	4.000	4.883	1.22	4.441	0.441
11	-1.2350	29.900	20.6	7.6	0.881	4.000	4.881	1.22	4.441	0.441
12	-1.1785	30.100	20.8	9.6	0.870	4.000	4.870	1.22	4.435	0.435
13	-1.1230	30.700	21.4	11.6	0.876	4.000	4.876	1.22	4.438	0.438
14	-1.0665	30.800	21.5	13.6	0.860	4.000	4.860	1.21	4.430	0.430
15	-1.0106	30.300	21.0	15.6	0.821	4.000	4.821	1.21	4.410	0.410


09-25MW-
68-70'

09-25MW-
68-70'
UW 4 +sf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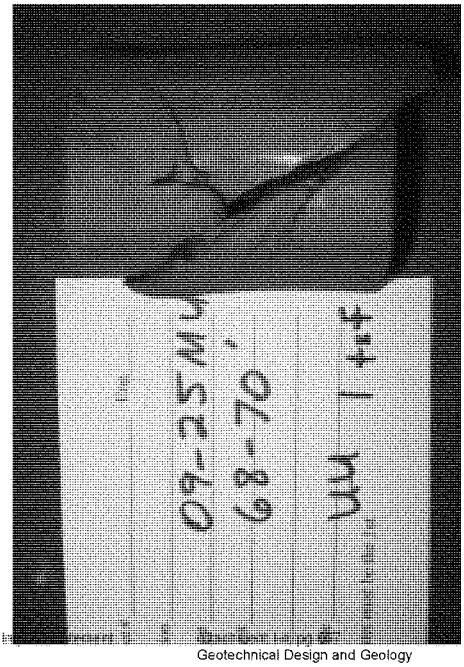
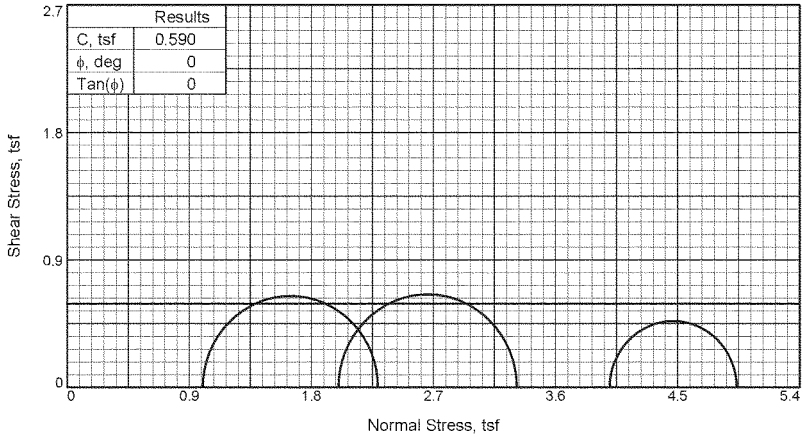
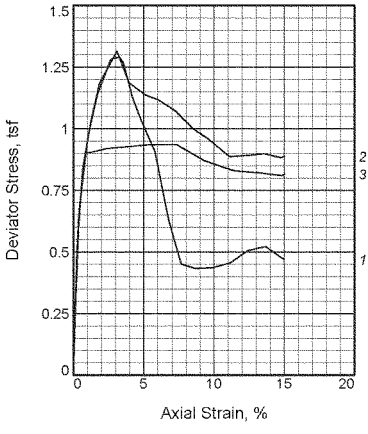
68-70'
UW 2 +sf


09-25MW-
68-70'
UW 1 +sf





Sample No.		1	2	3
Initial	Water Content, %	54.2	53.6	54.4
	Dry Density, pcf	68.8	68.9	68.5
	Saturation, %	99.7	98.8	99.1
	Void Ratio	1.4957	1.4928	1.5080
	Diameter, in.	1.40	1.40	1.41
	Height, in.	2.80	2.80	2.80
At Test	Water Content, %	54.7	54.8	66.7
	Dry Density, pcf	68.8	68.9	68.5
	Saturation, %	100.5	100.9	121.6
	Void Ratio	1.4957	1.4928	1.5080
	Diameter, in.	1.40	1.40	1.41
	Height, in.	2.80	2.80	2.80
Strain rate, %/min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		1.00	2.00	4.00
Peak Stress, tsf		1.29	1.32	0.94
Ult. Stress, tsf		0.43	0.88	0.81
σ_1 Failure, tsf		2.29	3.32	4.94
σ_3 Failure, tsf		1.00	2.00	4.00

Type of Test:
Unconsolidated Undrained
Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 110 **PL=** 24 **PI=** 86
Assumed Specific Gravity= 2.75
Remarks:

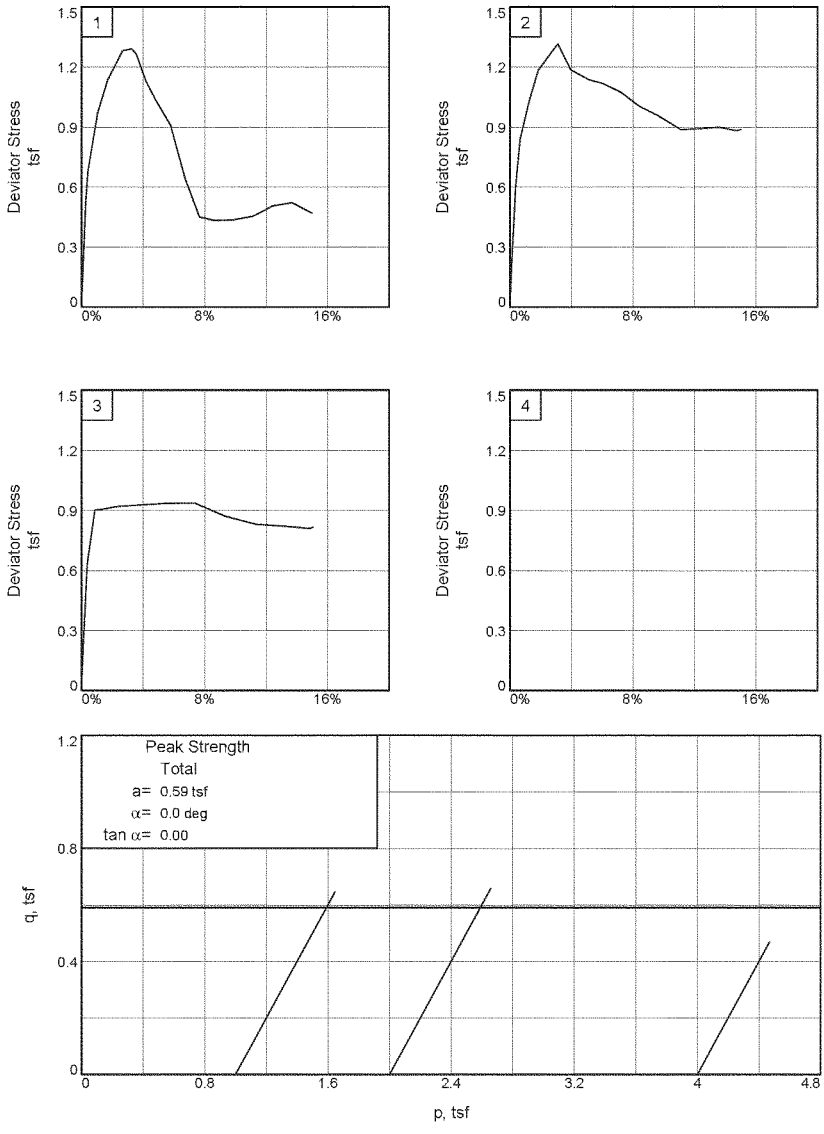
Figure UU Triax ASTM D 2850

Client: US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Location: SE-F-15, Fargo, Brenna Formation
Sample Number: Boring 09-26MU, #3 **Depth:** 28-30'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs



Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
Loc.: SE-F-15, Fargo, Brenna Formation **Depth:** 28-30' **Sample No.:** Boring 09-26MU, #3
Project No.: BL-09-03127 **Figure** _____ **Braun Intertec**

Tested By: rs **Checked By:** rs

TRIAXIAL COMPRESSION TEST 11/16/2009
Unconsolidated Undrained 3:07 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-15, Fargo, Brenna Formation		
Depth:	28-30'	**Sample Number:**	Boring 09-26MU, #3
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	Thinwall, 5", Bottom of sample		
Assumed Specific Gravity=2.75	**LL=110**	**PL=24**	**PI=86**
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	108.460	148.300
Moisture content: Dry soil+tare, gms.	81.270	106.530
Moisture content: Tare, gms.	31.130	30.130
Moisture, %	54.2	54.7
Moist specimen weight, gms.	120.6	
Diameter, in.	1.40	
Area, in.^{2}	1.55	
Height, in.	2.80	
Wet Density, pcf	106.1	
Dry density, pcf	68.8	
Void ratio	1.4957	
Saturation, %	99.7	

Test Readings for Specimen No. 1

Cell pressure = 1.000 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 0.03
Peak Stress = 1.291 tsf at reading no. 7
Ult. Stress = 0.433 tsf at reading no. 14

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.2653	1.900	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	0.2682	6.300	4.4	0.1	0.204	1.000	1.204	1.20	1.102	0.102
2	0.2727	12.900	11.0	0.3	0.510	1.000	1.510	1.51	1.255	0.255
3	0.2770	16.500	14.6	0.4	0.676	1.000	1.676	1.68	1.338	0.338
4	0.2947	23.000	21.1	1.1	0.971	1.000	1.971	1.97	1.485	0.485
5	0.3130	26.800	24.9	1.7	1.138	1.000	2.138	2.14	1.569	0.569
6	0.3397	30.200	28.3	2.7	1.281	1.000	2.281	2.28	1.641	0.641
7	0.3566	30.600	28.7	3.3	1.291	1.000	2.291	2.29	1.646	0.646
8	0.3651	30.100	28.2	3.6	1.265	1.000	2.265	2.26	1.632	0.632
9	0.3828	27.200	25.3	4.2	1.127	1.000	2.127	2.13	1.564	0.564
10	0.4009	25.200	23.3	4.8	1.031	1.000	2.031	2.03	1.516	0.516
11	0.4276	22.600	20.7	5.8	0.907	1.000	1.907	1.91	1.453	0.453
12	0.4540	16.600	14.7	6.7	0.637	1.000	1.637	1.64	1.319	0.319
13	0.4797	12.400	10.5	7.7	0.451	1.000	1.451	1.45	1.225	0.225
14	0.5062	12.100	10.2	8.6	0.433	1.000	1.433	1.43	1.217	0.217
15	0.5416	12.300	10.4	9.9	0.436	1.000	1.436	1.44	1.218	0.218
16	0.5768	12.900	11.0	11.1	0.455	1.000	1.455	1.45	1.227	0.227
17	0.6122	14.300	12.4	12.4	0.505	1.000	1.505	1.51	1.253	0.253
18	0.6480	14.900	13.0	13.7	0.522	1.000	1.522	1.52	1.261	0.261
19	0.6843	13.800	11.9	15.0	0.470	1.000	1.470	1.47	1.235	0.235

Parameters for Specimen No. 2		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	135.840	148.960
Moisture content: Dry soil+tare, gms.	99.150	106.990
Moisture content: Tare, gms.	30.710	30.340
Moisture, %	53.6	54.8
Moist specimen weight, gms.	120.1	
Diameter, in.	1.40	
Area, in.²	1.54	
Height, in.	2.80	
Wet Density, pcf	105.8	
Dry density, pcf	68.9	
Void ratio	1.4928	
Saturation, %	98.8	

Test Readings for Specimen No. 2

Cell pressure = 2.000 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 0.03

Peak Stress = 1.315 tsf at reading no. 7

Ult. Stress = 0.883 tsf at reading no. 17

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.2643	4.300	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	0.2686	10.100	5.8	0.2	0.270	2.000	2.270	1.14	2.135	0.135
2	0.2747	17.300	13.0	0.4	0.604	2.000	2.604	1.30	2.302	0.302
3	0.2828	22.400	18.1	0.7	0.839	2.000	2.839	1.42	2.419	0.419
4	0.2996	26.700	22.4	1.3	1.032	2.000	3.032	1.52	2.516	0.516
5	0.3163	30.200	25.9	1.9	1.186	2.000	3.186	1.59	2.593	0.593
6	0.3414	32.500	28.2	2.8	1.279	2.000	3.279	1.64	2.640	0.640
7	0.3514	33.400	29.1	3.1	1.315	2.000	3.315	1.66	2.658	0.658
8	0.3752	30.800	26.5	4.0	1.187	2.000	3.187	1.59	2.594	0.594
9	0.4084	30.000	25.7	5.1	1.137	2.000	3.137	1.57	2.568	0.568
10	0.4340	29.800	25.5	6.1	1.117	2.000	3.117	1.56	2.559	0.559
11	0.4673	29.100	24.8	7.2	1.073	2.000	3.073	1.54	2.536	0.536
12	0.5010	27.800	23.5	8.4	1.003	2.000	3.003	1.50	2.502	0.502
13	0.5349	27.000	22.7	9.7	0.956	2.000	2.956	1.48	2.478	0.478
14	0.5764	25.700	21.4	11.1	0.887	2.000	2.887	1.44	2.443	0.443
15	0.6099	26.100	21.8	12.3	0.891	2.000	2.891	1.45	2.446	0.446
16	0.6451	26.600	22.3	13.6	0.899	2.000	2.899	1.45	2.449	0.449
17	0.6780	26.500	22.2	14.8	0.883	2.000	2.883	1.44	2.441	0.441
18	0.6850	26.700	22.4	15.0	0.888	2.000	2.888	1.44	2.444	0.444

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	126.100	150.190
Moisture content: Dry soil+tare, gms.	92.380	102.210
Moisture content: Tare, gms.	30.350	30.240
Moisture, %	54.4	66.7
Moist specimen weight, gms.	120.8	
Diameter, in.	1.41	
Area, in.^{2}	1.55	
Height, in.	2.80	
Wet Density, pcf	105.7	
Dry density, pcf	68.5	
Void ratio	1.5080	
Saturation, %	99.1	

Test Readings for Specimen No. 3

Cell pressure = 4.000 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 0.03

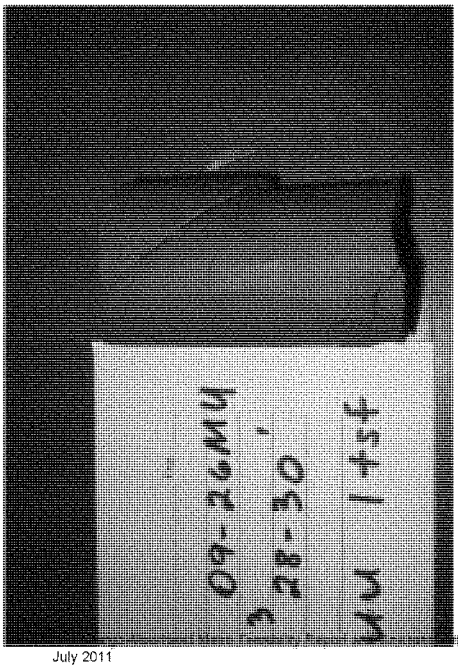
Peak Stress = 0.937 tsf at reading no. 8

Ult. Stress = 0.810 tsf at reading no. 12

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.2660	10.700	0.0	0.0	0.000	4.000	4.000	1.00	4.000	0.000
1	0.2694	15.700	5.0	0.1	0.232	4.000	4.232	1.06	4.116	0.116
2	0.2764	24.400	13.7	0.4	0.633	4.000	4.633	1.16	4.316	0.316
3	0.2903	30.300	19.6	0.9	0.901	4.000	4.901	1.23	4.451	0.451
4	0.3042	30.500	19.8	1.4	0.906	4.000	4.906	1.23	4.453	0.453
5	0.3323	31.000	20.3	2.4	0.919	4.000	4.919	1.23	4.460	0.460
6	0.3740	31.500	20.8	3.9	0.927	4.000	4.927	1.23	4.464	0.464
7	0.4161	32.000	21.3	5.4	0.935	4.000	4.935	1.23	4.467	0.467
8	0.4720	32.500	21.8	7.3	0.937	4.000	4.937	1.23	4.468	0.468
9	0.5280	31.400	20.7	9.3	0.870	4.000	4.870	1.22	4.435	0.435
10	0.5841	30.900	20.2	11.3	0.830	4.000	4.830	1.21	4.415	0.415
11	0.6400	31.100	20.4	13.3	0.820	4.000	4.820	1.20	4.410	0.410
12	0.6820	31.200	20.5	14.8	0.810	4.000	4.810	1.20	4.405	0.405
13	0.6880	31.400	20.7	15.0	0.815	4.000	4.815	1.20	4.408	0.408

09-26MW
3 28-30
WW 4+5f

09-26MW
3 28-30
WW 7+5f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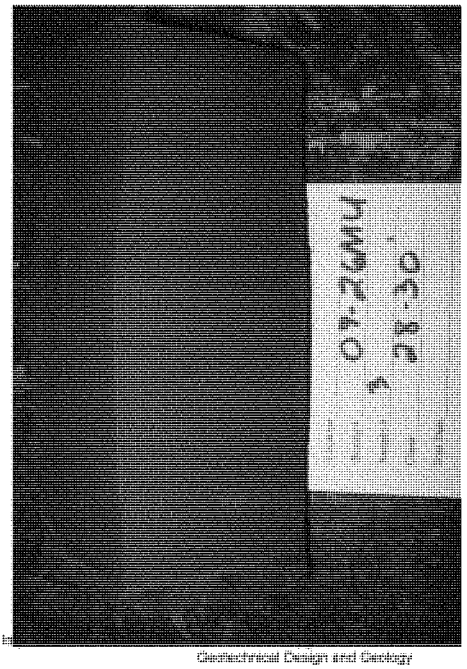
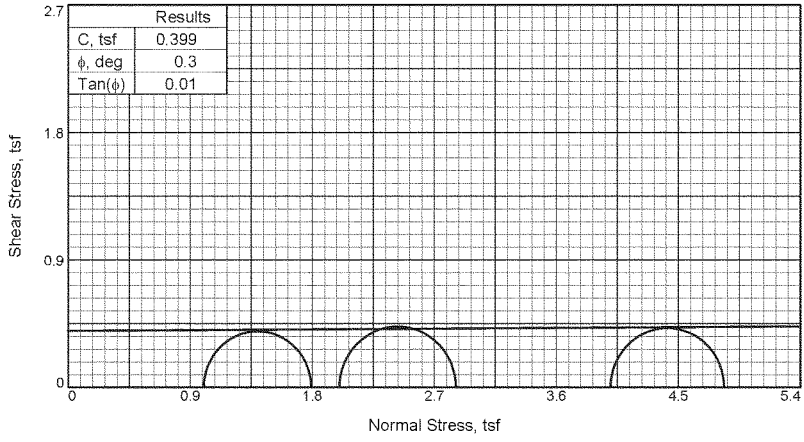
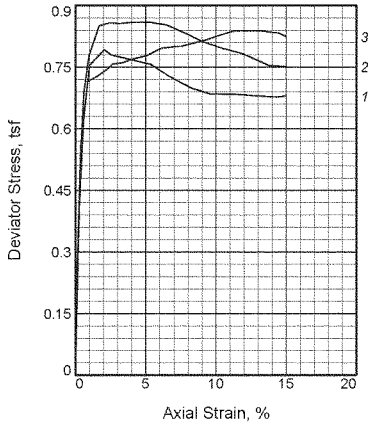
3 28-30
WW 1+5f


09-26MW
3 28-30





Sample No.		1	2	3
Initial	Water Content, %	55.4	56.6	58.6
	Dry Density, pcf	67.1	65.4	64.4
	Saturation, %	98.9	96.7	97.7
	Void Ratio	1.5145	1.5822	1.6208
	Diameter, in.	1.40	1.40	1.40
	Height, in.	2.80	2.80	2.80
At Test	Water Content, %	57.2	58.7	49.1
	Dry Density, pcf	67.1	65.4	64.4
	Saturation, %	102.2	100.4	81.8
	Void Ratio	1.5145	1.5822	1.6208
	Diameter, in.	1.40	1.40	1.40
	Height, in.	2.80	2.80	2.80
Strain rate, %/min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		1.00	2.00	4.00
Peak Stress, tsf		0.79	0.86	0.84
Ult. Stress, tsf		0.68	0.75	0.82
σ_1 Failure, tsf		1.79	2.86	4.84
σ_3 Failure, tsf		1.00	2.00	4.00

Type of Test: Unconsolidated Undrained
Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, gray (CH)

LL= 89 **PL=** 20 **PI=** 69
Assumed Specific Gravity= 2.704
Remarks:

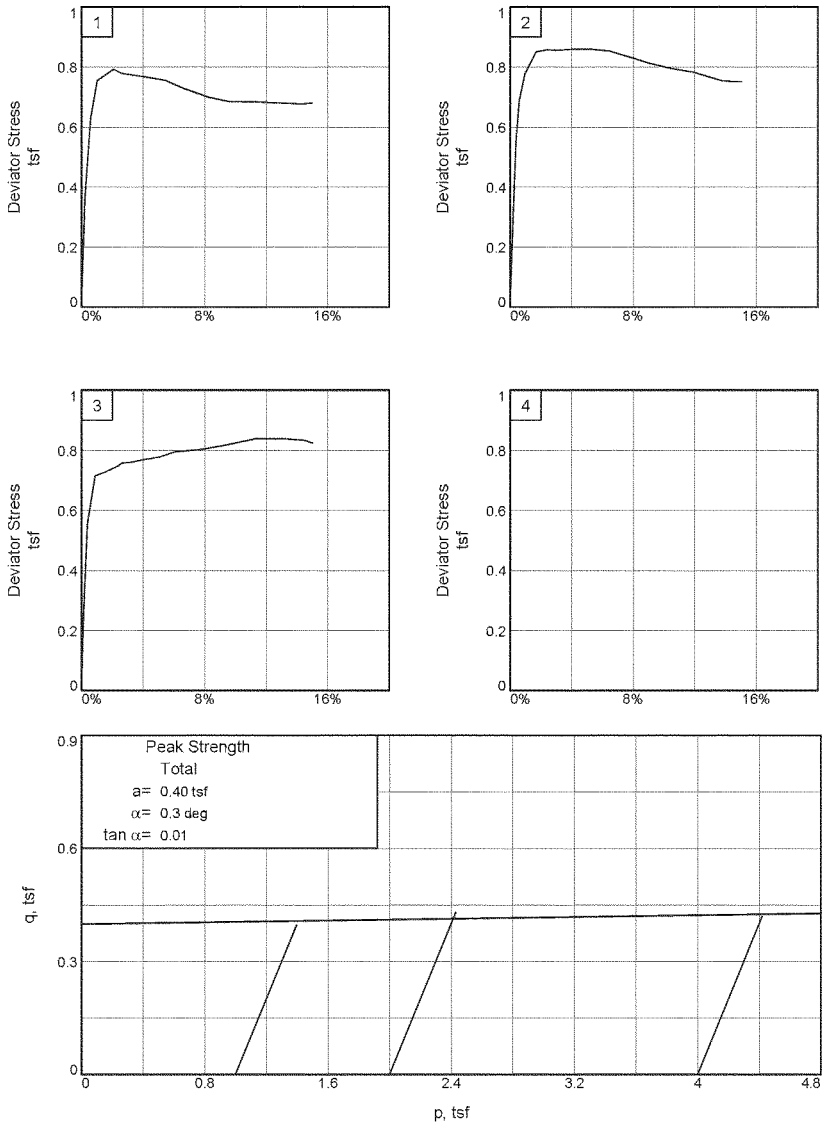
Figure UU Triax ASTM D 2850

Client: US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115 Brenna
Location: SE-F-19, Fargo, ~~Argusville Formation~~
Sample Number: Boring 09-27MU, #4 **Depth:** 64-66'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs



Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
Loc.: SE-F-19, Fargo, ~~Argusville Formation~~ Brenna
Project No.: BL-09-03127
Depth: 64-66'
Figure _____
Sample No.: Boring 09-27MU, #4

Braun Intertec

Tested By: rs **Checked By:** rs

TRIAXIAL COMPRESSION TEST 11/16/2009
Unconsolidated Undrained 3:06 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, ~~Argusville Formation~~		
Depth:	64-66'	**Sample Number:**	Boring 09-27MU, #4
Description:	FAT CLAY, gray (CH)		Brenna
Remarks:			
Type of Sample:	Thinwall, 5", Bottom of sample		
Assumed Specific Gravity=2.704	**LL=89**	**PL=20**	**PI=69**
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	133.610	147.290
Moisture content: Dry soil+tare, gms.	97.060	105.130
Moisture content: Tare, gms.	31.080	31.480
Moisture, %	55.4	57.2
Moist specimen weight, gms.	118.4	
Diameter, in.	1.40	
Area, in.²	1.54	
Height, in.	2.80	
Wet Density, pcf	104.3	
Dry density, pcf	67.1	
Void ratio	1.5145	
Saturation, %	98.9	

Test Readings for Specimen No. 1

Cell pressure = 1.000 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 0.03
Peak Stress = 0.792 tsf **at reading no.** 4
Ult. Stress = 0.680 tsf **at reading no.** 14

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.2672	1.950	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	0.2733	9.700	7.7	0.2	0.361	1.000	1.361	1.36	1.180	0.180
2	0.2839	15.500	13.6	0.6	0.628	1.000	1.628	1.63	1.314	0.314
3	0.2957	18.300	16.4	1.0	0.755	1.000	1.755	1.75	1.377	0.377
4	0.3250	19.300	17.4	2.1	0.792	1.000	1.792	1.79	1.396	0.396
5	0.3402	19.100	17.2	2.6	0.779	1.000	1.779	1.78	1.390	0.390
6	0.3757	19.100	17.2	3.9	0.769	1.000	1.769	1.77	1.384	0.384
7	0.4186	19.100	17.2	5.4	0.757	1.000	1.757	1.76	1.378	0.378
8	0.4520	18.700	16.8	6.6	0.730	1.000	1.730	1.73	1.365	0.365
9	0.4979	18.300	16.4	8.2	0.700	1.000	1.700	1.70	1.350	0.350
10	0.5355	18.200	16.3	9.6	0.685	1.000	1.685	1.69	1.343	0.343
11	0.5864	18.500	16.6	11.4	0.684	1.000	1.684	1.68	1.342	0.342
12	0.6311	18.700	16.8	13.0	0.680	1.000	1.680	1.68	1.340	0.340
13	0.6680	18.900	17.0	14.3	0.677	1.000	1.677	1.68	1.339	0.339
14	0.6870	19.100	17.2	15.0	0.680	1.000	1.680	1.68	1.340	0.340

Parameters for Specimen No. 2		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	135.960	144.330
Moisture content: Dry soil+tare, gms.	98.040	101.950
Moisture content: Tare, gms.	31.020	29.780
Moisture, %	56.6	58.7
Moist specimen weight, gms.	116.0	
Diameter, in.	1.40	
Area, in.²	1.54	
Height, in.	2.80	
Wet Density, pcf	102.4	
Dry density, pcf	65.4	
Void ratio	1.5822	
Saturation, %	96.7	

Test Readings for Specimen No. 2

Cell pressure = 2.000 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 0.03

Peak Stress = 0.860 tsf at reading no. 8

Ult. Stress = 0.751 tsf at reading no. 16

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.2646	4.700	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	0.2701	11.100	6.4	0.2	0.299	2.000	2.299	1.15	2.149	0.149
2	0.2756	16.600	11.9	0.4	0.554	2.000	2.554	1.28	2.277	0.277
3	0.2815	19.500	14.8	0.6	0.688	2.000	2.688	1.34	2.344	0.344
4	0.2919	21.500	16.8	1.0	0.778	2.000	2.778	1.39	2.389	0.389
5	0.3121	23.200	18.5	1.7	0.851	2.000	2.851	1.43	2.425	0.425
6	0.3328	23.500	18.8	2.4	0.858	2.000	2.858	1.43	2.429	0.429
7	0.3531	23.600	18.9	3.2	0.856	2.000	2.856	1.43	2.428	0.428
8	0.3840	23.900	19.2	4.3	0.860	2.000	2.860	1.43	2.430	0.430
9	0.4148	24.100	19.4	5.4	0.859	2.000	2.859	1.43	2.429	0.429
10	0.4453	24.200	19.5	6.4	0.853	2.000	2.853	1.43	2.427	0.427
11	0.4872	24.000	19.3	7.9	0.831	2.000	2.831	1.42	2.416	0.416
12	0.5173	23.800	19.1	9.0	0.813	2.000	2.813	1.41	2.406	0.406
13	0.5582	23.700	19.0	10.5	0.796	2.000	2.796	1.40	2.398	0.398
14	0.5994	23.700	19.0	11.9	0.783	2.000	2.783	1.39	2.391	0.391
15	0.6510	23.400	18.7	13.8	0.754	2.000	2.754	1.38	2.377	0.377
16	0.6860	23.600	18.9	15.0	0.751	2.000	2.751	1.38	2.376	0.376

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	141.830	145.330
Moisture content: Dry soil+tare, gms.	100.670	107.700
Moisture content: Tare, gms.	30.420	30.990
Moisture, %	58.6	49.1
Moist specimen weight, gms.	115.6	
Diameter, in.	1.40	
Area, in.²	1.54	
Height, in.	2.80	
Wet Density, pcf	102.1	
Dry density, pcf	64.4	
Void ratio	1.6208	
Saturation, %	97.7	

Test Readings for Specimen No. 3

Cell pressure = 4.000 tsf

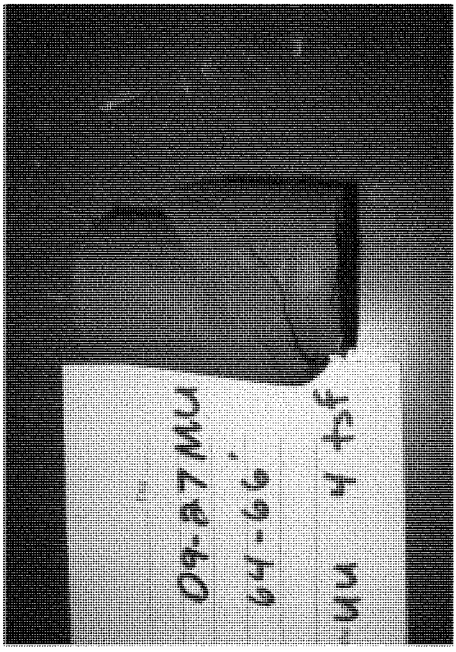
Back pressure = 0.000 tsf

Strain rate, %/min. = 0.03

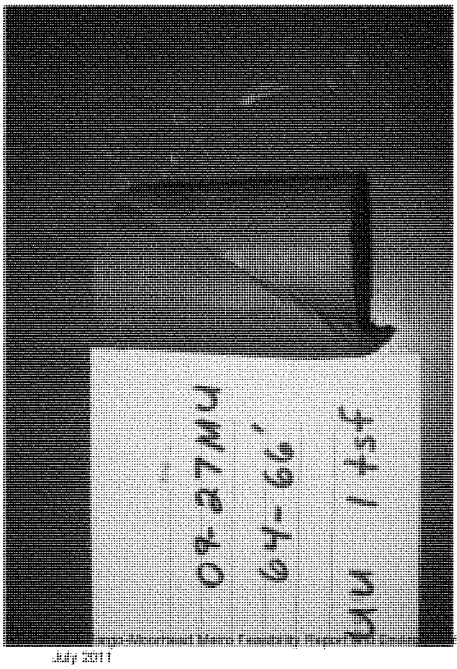
Peak Stress = 0.839 tsf at reading no. 15

Ult. Stress = 0.824 tsf at reading no. 18

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.2670	10.600	0.0	0.0	0.000	4.000	4.000	1.00	4.000	0.000
1	0.2708	16.100	5.5	0.1	0.257	4.000	4.257	1.06	4.129	0.129
2	0.2778	22.500	11.9	0.4	0.555	4.000	4.555	1.14	4.278	0.278
3	0.2917	26.000	15.4	0.9	0.715	4.000	4.715	1.18	4.357	0.357
4	0.3110	26.400	15.8	1.6	0.728	4.000	4.728	1.18	4.364	0.364
5	0.3317	26.900	16.3	2.3	0.746	4.000	4.746	1.19	4.373	0.373
6	0.3405	27.200	16.6	2.6	0.757	4.000	4.757	1.19	4.379	0.379
7	0.3602	27.400	16.8	3.3	0.761	4.000	4.761	1.19	4.380	0.380
8	0.3796	27.700	17.1	4.0	0.769	4.000	4.769	1.19	4.384	0.384
9	0.4090	28.100	17.5	5.1	0.778	4.000	4.778	1.19	4.389	0.389
10	0.4385	28.700	18.1	6.1	0.796	4.000	4.796	1.20	4.398	0.398
11	0.4676	29.000	18.4	7.2	0.800	4.000	4.800	1.20	4.400	0.400
12	0.4792	29.100	18.5	7.6	0.801	4.000	4.801	1.20	4.400	0.400
13	0.5264	29.800	19.2	9.3	0.816	4.000	4.816	1.20	4.408	0.408
14	0.5558	30.300	19.7	10.3	0.828	4.000	4.828	1.21	4.414	0.414
15	0.5853	30.800	20.2	11.4	0.839	4.000	4.839	1.21	4.419	0.419
16	0.6344	31.200	20.6	13.1	0.838	4.000	4.838	1.21	4.419	0.419
17	0.6737	31.400	20.8	14.5	0.833	4.000	4.833	1.21	4.416	0.416
18	0.6880	31.300	20.7	15.0	0.824	4.000	4.824	1.21	4.412	0.412


09-27MJ
64-66'
UU 4 tsf

09-27MJ
64-66'
UU 2 tsf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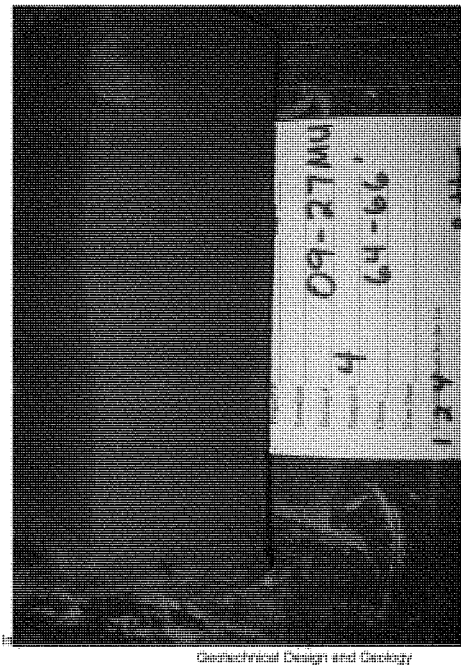
UU 1 tsf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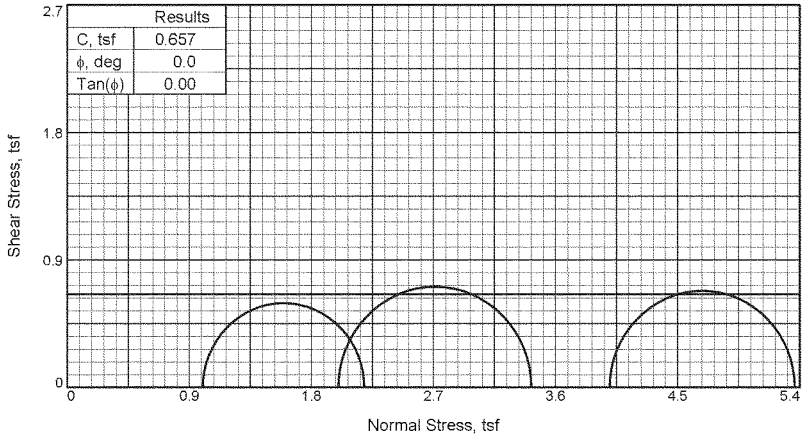
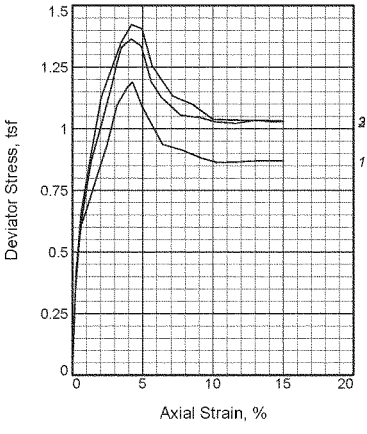
64-66'





Sample No.		1	2	3
Initial	Water Content, %	57.2	57.0	56.8
	Dry Density, pcf	66.2	65.8	66.0
	Saturation, %	99.9	98.6	98.9
	Void Ratio	1.5461	1.5600	1.5522
	Diameter, in.	1.39	1.40	1.39
	Height, in.	2.80	2.81	2.82
At Test	Water Content, %	56.9	56.5	56.5
	Dry Density, pcf	66.2	65.8	66.0
	Saturation, %	99.3	97.7	98.3
	Void Ratio	1.5461	1.5600	1.5522
	Diameter, in.	1.39	1.40	1.39
	Height, in.	2.80	2.81	2.82
Strain rate, in./min.		0.03	0.03	0.03
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		1.00	2.00	4.00
Fail. Stress, tsf		1.19	1.42	1.36
Ult. Stress, tsf		0.87	1.03	1.03
σ_1 Failure, tsf		2.19	3.42	5.36
σ_3 Failure, tsf		1.00	2.00	4.00

Type of Test:
Unconsolidated Undrained
Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, gray (CH)

LL= 111 **PL=** 26 **PI=** 85
Assumed Specific Gravity= 2.70
Remarks:

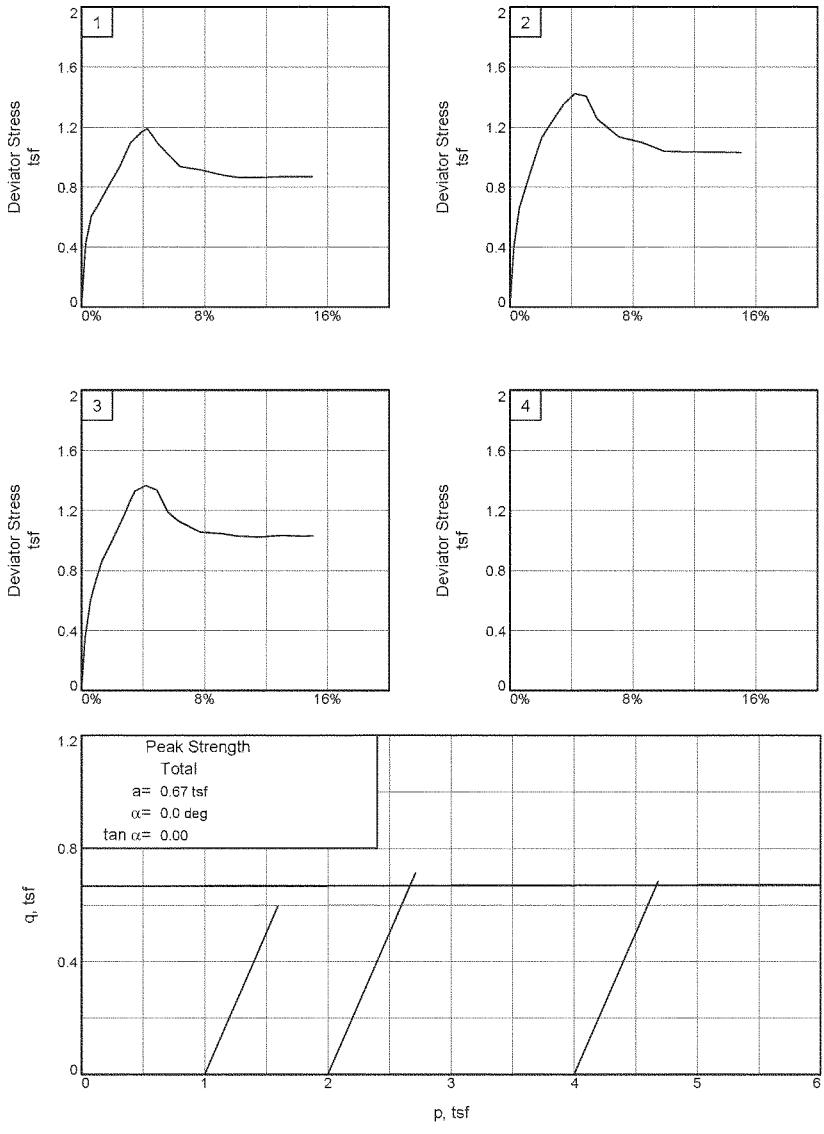
Figure UU Triax ASTM D 2850

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Fargo
Location: WD-05, ND Div, Brenna Formation
Sample Number: Boring 09-60MU, #3 **Depth:** 35-37'
Proj. No.: BL0903127A **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs



Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study Fargo
Loc.: WD-05, ND Div, Brenna Formation **Depth:** 35-37' **Sample No.:** Boring 09-60MU, #3
Project No.: BL0903127A **Figure** _____ **Braun Intertec**

Tested By: rs **Checked By:** rs

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

2/23/2010
11:25 AM

Date:			
Client:	US Army Corps of Engineers		
Project:	Fargo-Moorhead Metro Feasibility Study		
Project No.:	BL0903127A		
Location:	WD-05, ND Div, Brenna Formation		Fargo
Depth:	35-37'	Sample Number:	Boring 09-60MU, #3
Description:	FAT CLAY, gray (CH)		
Remarks:			
Type of Sample:	Thinwall, 5", Middle of sample		
Assumed Specific Gravity=2.70	LL=111	PL=26	PI=85
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	178.810	147.320
Moisture content: Dry soil+tare, gms.	124.820	105.220
Moisture content: Tare, gms.	30.400	31.200
Moisture, %	57.2	56.9
Moist specimen weight, gms.	116.4	
Diameter, in.	1.39	
Area, in.²	1.52	
Height, in.	2.80	
Wet Density, pcf	104.1	
Dry density, pcf	66.2	
Void ratio	1.5461	
Saturation, %	99.9	

Test Readings for Specimen No. 1

Cell pressure = 1.000 tsf
Back pressure = 0.000 tsf
Strain rate, in./min. = 0.03
Fail. Stress = 1.190 tsf at reading no. 8
Ult. Stress = 0.869 tsf at reading no. 16

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0070	1.240	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	0.0147	10.280	9.0	0.3	0.427	1.000	1.427	1.43	1.214	0.214
2	0.0250	14.210	13.0	0.6	0.611	1.000	1.611	1.61	1.305	0.305
3	0.0348	15.440	14.2	1.0	0.666	1.000	1.666	1.67	1.333	0.333
4	0.0556	18.530	17.3	1.7	0.805	1.000	1.805	1.80	1.402	0.402
5	0.0766	21.510	20.3	2.5	0.937	1.000	1.937	1.94	1.468	0.468
6	0.0963	25.140	23.9	3.2	1.096	1.000	2.096	2.10	1.548	0.548
7	0.1169	26.920	25.7	3.9	1.169	1.000	2.169	2.17	1.585	0.585
8	0.1272	27.480	26.2	4.3	1.190	1.000	2.190	2.19	1.595	0.595
9	0.1471	25.370	24.1	5.0	1.086	1.000	2.086	2.09	1.543	0.543
10	0.1868	22.360	21.1	6.4	0.936	1.000	1.936	1.94	1.468	0.468
11	0.2262	22.150	20.9	7.8	0.913	1.000	1.913	1.91	1.457	0.457
12	0.2664	21.690	20.5	9.2	0.879	1.000	1.879	1.88	1.440	0.440
13	0.2954	21.540	20.3	10.3	0.863	1.000	1.863	1.86	1.431	0.431
14	0.3366	21.920	20.7	11.8	0.865	1.000	1.865	1.86	1.432	0.432
15	0.3772	22.400	21.2	13.2	0.870	1.000	1.870	1.87	1.435	0.435
16	0.4280	22.820	21.6	15.0	0.869	1.000	1.869	1.87	1.434	0.434

Parameters for Specimen No. 2		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	142.490	146.790
Moisture content: Dry soil+tare, gms.	101.900	104.850
Moisture content: Tare, gms.	30.680	30.590
Moisture, %	57.0	56.5
Moist specimen weight, gms.	116.7	
Diameter, in.	1.40	
Area, in.²	1.53	
Height, in.	2.81	
Wet Density, pcf	103.4	
Dry density, pcf	65.8	
Void ratio	1.5600	
Saturation, %	98.6	

Test Readings for Specimen No. 2

Cell pressure = 2.000 tsf

Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

Fail. Stress = 1.423 tsf at reading no. 8

Ult. Stress = 1.029 tsf at reading no. 18

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0061	3.470	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	0.0135	12.140	8.7	0.3	0.407	2.000	2.407	1.20	2.203	0.203
2	0.0234	17.570	14.1	0.6	0.659	2.000	2.659	1.33	2.330	0.330
3	0.0446	23.100	19.6	1.4	0.911	2.000	2.911	1.46	2.455	0.455
4	0.0641	27.950	24.5	2.1	1.128	2.000	3.128	1.56	2.564	0.564
5	0.0842	30.660	27.2	2.8	1.243	2.000	3.243	1.62	2.622	0.622
6	0.1044	33.290	29.8	3.5	1.354	2.000	3.354	1.68	2.677	0.677
7	0.1145	34.160	30.7	3.9	1.388	2.000	3.388	1.69	2.694	0.694
8	0.1245	35.050	31.6	4.2	1.423	2.000	3.423	1.71	2.711	0.711
9	0.1456	34.910	31.4	5.0	1.406	2.000	3.406	1.70	2.703	0.703
10	0.1655	31.760	28.3	5.7	1.255	2.000	3.255	1.63	2.628	0.628
11	0.2062	29.410	25.9	7.1	1.133	2.000	3.133	1.57	2.567	0.567
12	0.2468	29.020	25.6	8.6	1.099	2.000	3.099	1.55	2.549	0.549
13	0.2877	28.000	24.5	10.0	1.038	2.000	3.038	1.52	2.519	0.519
14	0.3177	28.240	24.8	11.1	1.036	2.000	3.036	1.52	2.518	0.518
15	0.3575	28.590	25.1	12.5	1.034	2.000	3.034	1.52	2.517	0.517
16	0.3988	29.010	25.5	14.0	1.034	2.000	3.034	1.52	2.517	0.517
17	0.4199	29.200	25.7	14.7	1.032	2.000	3.032	1.52	2.516	0.516
18	0.4280	29.200	25.7	15.0	1.029	2.000	3.029	1.51	2.514	0.514

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	148.290	144.810
Moisture content: Dry soil+tare, gms.	105.670	103.130
Moisture content: Tare, gms.	30.690	29.400
Moisture, %	56.8	56.5
Moist specimen weight, gms.	116.0	
Diameter, in.	1.39	
Area, in.²	1.51	
Height, in.	2.82	
Wet Density, pcf	103.6	
Dry density, pcf	66.0	
Void ratio	1.5522	
Saturation, %	98.9	

Test Readings for Specimen No. 3

Cell pressure = 4.000 tsf

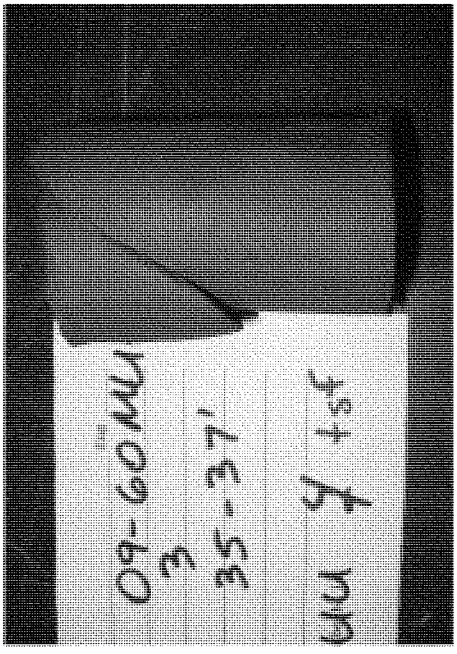
Back pressure = 0.000 tsf

Strain rate, in./min. = 0.03

Fail. Stress = 1.364 tsf at reading no. 10

Ult. Stress = 1.030 tsf at reading no. 20

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0061	9.730	0.0	0.0	0.000	4.000	4.000	1.00	4.000	0.000
1	0.0125	17.140	7.4	0.2	0.352	4.000	4.352	1.09	4.176	0.176
2	0.0228	22.520	12.8	0.6	0.605	4.000	4.605	1.15	4.302	0.302
3	0.0329	25.380	15.6	1.0	0.738	4.000	4.738	1.18	4.369	0.369
4	0.0437	28.190	18.5	1.3	0.867	4.000	4.867	1.22	4.433	0.433
5	0.0647	31.580	21.8	2.1	1.018	4.000	5.018	1.25	4.509	0.509
6	0.0855	35.210	25.5	2.8	1.178	4.000	5.178	1.29	4.589	0.589
7	0.0945	37.010	27.3	3.1	1.257	4.000	5.257	1.31	4.629	0.629
8	0.1041	38.660	28.9	3.5	1.329	4.000	5.329	1.33	4.664	0.664
9	0.1142	39.180	29.5	3.8	1.348	4.000	5.348	1.34	4.674	0.674
10	0.1241	39.650	29.9	4.2	1.364	4.000	5.364	1.34	4.682	0.682
11	0.1443	39.240	29.5	4.9	1.335	4.000	5.335	1.33	4.668	0.668
12	0.1643	36.220	26.5	5.6	1.190	4.000	5.190	1.30	4.595	0.595
13	0.1842	35.060	25.3	6.3	1.129	4.000	5.129	1.28	4.565	0.565
14	0.2238	33.740	24.0	7.7	1.054	4.000	5.054	1.26	4.527	0.527
15	0.2627	33.900	24.2	9.1	1.045	4.000	5.045	1.26	4.523	0.523
16	0.2929	33.770	24.0	10.2	1.028	4.000	5.028	1.26	4.514	0.514
17	0.3336	34.030	24.3	11.6	1.022	4.000	5.022	1.26	4.511	0.511
18	0.3745	34.730	25.0	13.1	1.034	4.000	5.034	1.26	4.517	0.517
19	0.4144	34.970	25.2	14.5	1.027	4.000	5.027	1.26	4.514	0.514
20	0.4300	35.210	25.5	15.0	1.030	4.000	5.030	1.26	4.515	0.515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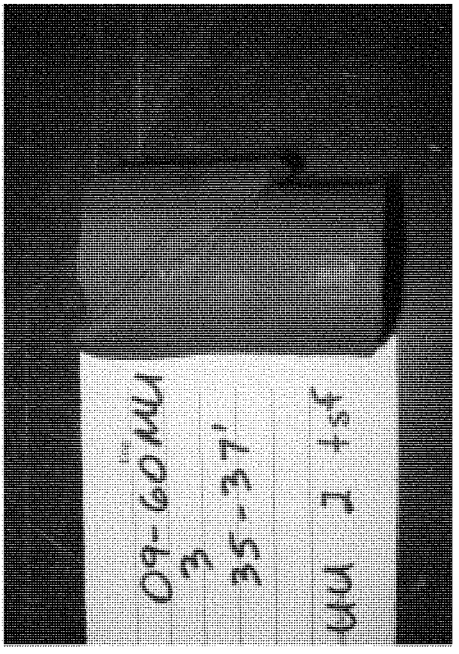
B3
35-37'
Unit 4 tst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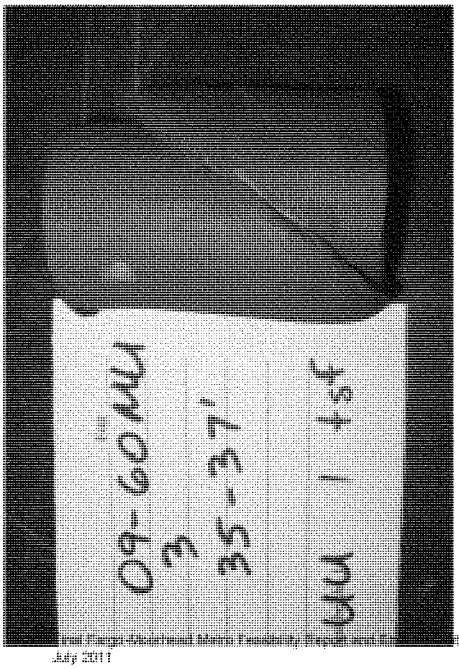
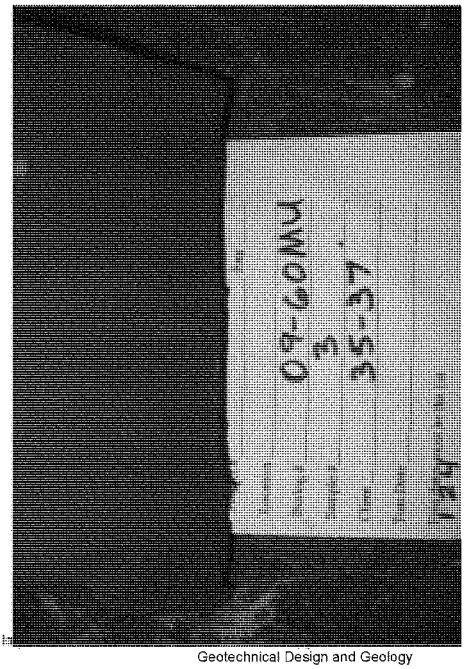
B3
35-37'
Unit 2 tst

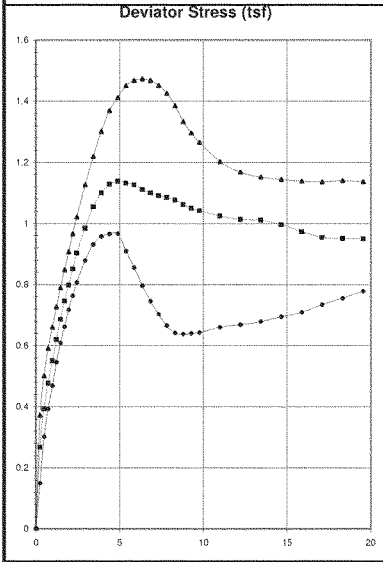

09-60MW
B3
35-37'
Unit 1 tst


09-60MW
35-37'

TRIAXIAL TEST ASTM: D 2850

Job No. 7577
Date: 8/24/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-78MU Fargo Sample #: 2 Type: 5T Depth (ft): 25 - 27 (Mid-Top)
Soil Type: Fat Clay (CH) Brenna



Failure Criterion: Max. Deviator Stress

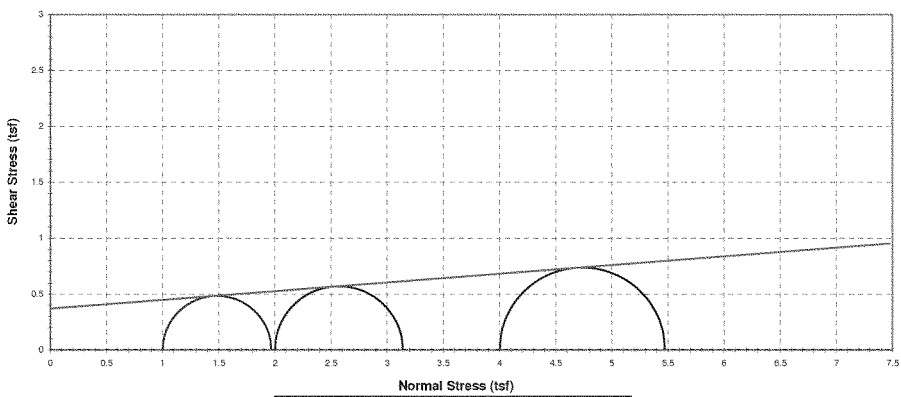
Angle of internal friction, ϕ_u = 4.5 °
Apparent Cohesion, c_u = 0.37 (tsf)

Test Date:	8/18/10	Liquid Limit:	63.8
Test Type:	U-U	Plastic Limit:	23.1
Strain Rate (in/min):	0.05	Plasticity Index:	40.7
Strain Rate (%/min):	1.221	Spec. Gravity (Assumed):	2.76

Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	41.6	42.9	42.6		
Dry Density (pcf)	79.3	78.5	78.3		
Void Ratio	1.17	1.20	1.20		
After Consolidation					
Diameter (in)					
Height (in)					
Water Content (%)					
Dry Density (pcf)					
Void Ratio					
Back Pressure (tsf)					
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	0.97	1.14	1.47		
Ultimate Deviator Stress (tsf)	0.78	0.95	1.14		
Deviator Stress at Failure (tsf)	0.97	1.14	1.47		
Max. Pore Pressure Buildup (tsf)	--------	--------	--------		
Pore Pressure Parameter "B"	--------	--------	--------		
Pct. Axial Strain at Failure	4.9	4.9	6.3		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Specimens trimmed to given sizes; Allowed to adjust under applied confining pressures for about 10 minutes.



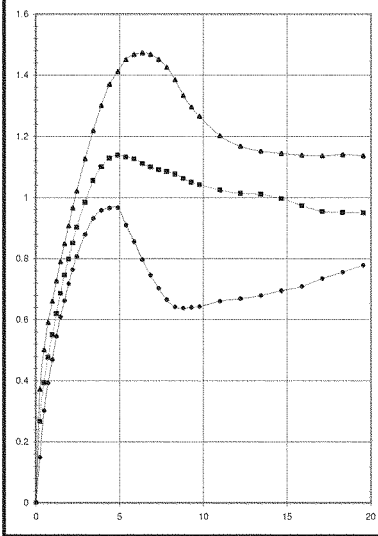
Total ϕ_u: 4.5 ° c_u= 0.37 (tsf)

SOIL ENGINEERING TESTING, INC.

TRIAXIAL TEST ASTM: D 2850

Job No. 7577
Date: 8/24/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-78MU Fargo Sample #: 2 Type: 5T Depth (ft): 25 - 27 (Mid-Top)
Soil Type: Fat Clay (CH) Brenna



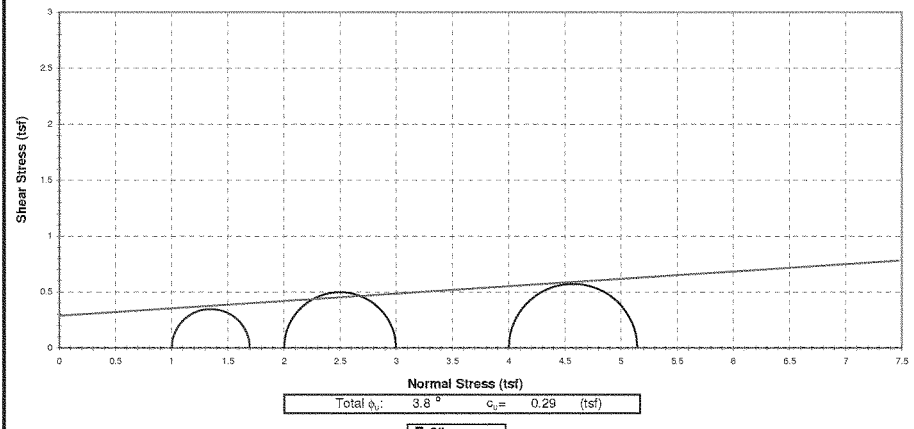
Failure Criterion: Given Strain of: 15%
Angle of internal friction, ϕ_u = 3.8 °
Apparent Cohesion, c_u = 0.29 (tsf)

Test Date:	8/18/10		Liquid Limit:		63.8
Test Type:	U-U		Plastic Limit:		23.1
Strain Rate (in/min):	0.05		Plasticity Index:		40.7
Strain Rate (%/min):	1.221		Spec. Gravity (Assumed):		2.76

Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	41.6	42.9	42.6		
Dry Density (pcf)	79.3	78.5	78.3		
Void Ratio	1.17	1.20	1.20		
After Consolidation					
Diameter (in)					
Height (in)					
Water Content (%)					
Dry Density (pcf)					
Void Ratio					
Back Pressure (tsf)					
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	0.97	1.14	1.47		
Ultimate Deviator Stress (tsf)	0.78	0.95	1.14		
Deviator Stress at Failure (tsf)	0.69	1.00	1.14		
Max. Pore Pressure Buildup (tsf)	-------	-------	-------		
Pore Pressure Parameter "B"	-------	-------	-------		
Pct. Axial Strain at Failure	15.0	15.0	15.0		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Specimens trimmed to given sizes; Allowed to adjust under applied confining pressures for about 10 minutes.



Total ϕ_u: 3.8 ° c_u= 0.29 (tsf)

OIL ENGINEERING & TESTING, INC.
8301 Bryant Ave. South, Suite #107 Bloomington, Minnesota 55420-3436
Geotechnical Design and Geology

Job No.: 7577
Test Type: U-U

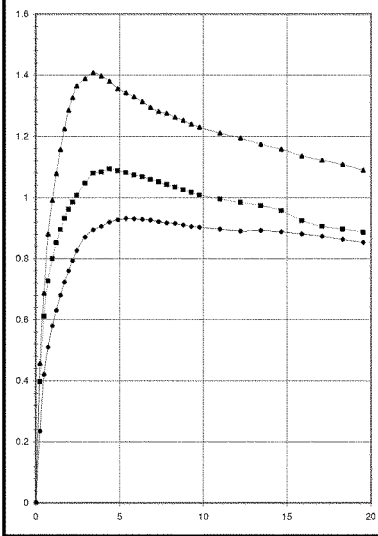
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring No.: 10-78MU, Sample No.: 2, Depth (ft.): 25 - 27 (Mid-Top)

Sample 1		Sample 2		Sample 3	
Strain (%)	Deviator Stress (tsf)	Strain (%)	Deviator Stress (tsf)	Strain (%)	Deviator Stress (tsf)
0.00	0.00	0.00	0.00	0.00	0.00
0.24	0.15	0.24	0.27	0.24	0.37
0.49	0.30	0.49	0.39	0.49	0.50
0.73	0.39	0.73	0.48	0.73	0.59
0.98	0.47	0.98	0.55	0.98	0.66
1.22	0.55	1.22	0.62	1.22	0.73
1.47	0.61	1.47	0.69	1.47	0.79
1.71	0.66	1.71	0.75	1.71	0.85
1.95	0.72	1.95	0.80	1.95	0.91
2.20	0.76	2.20	0.85	2.20	0.97
2.44	0.81	2.44	0.90	2.44	1.02
2.93	0.88	2.93	0.98	2.93	1.13
3.42	0.93	3.42	1.05	3.42	1.22
3.91	0.96	3.91	1.10	3.91	1.30
4.40	0.97	4.40	1.13	4.40	1.37
4.88	0.97	4.88	1.14	4.88	1.41
5.37	0.91	5.37	1.13	5.37	1.45
5.86	0.86	5.86	1.13	5.86	1.47
6.35	0.80	6.35	1.11	6.35	1.47
6.84	0.75	6.84	1.10	6.84	1.47
7.33	0.70	7.33	1.09	7.33	1.45
7.81	0.67	7.81	1.08	7.81	1.43
8.30	0.64	8.30	1.08	8.30	1.38
8.79	0.64	8.79	1.06	8.79	1.33
9.28	0.64	9.28	1.05	9.28	1.30
9.77	0.64	9.77	1.04	9.77	1.27
10.99	0.66	10.99	1.02	10.99	1.20
12.21	0.67	12.21	1.01	12.21	1.17
13.43	0.68	13.43	1.01	13.43	1.15
14.65	0.69	14.65	1.00	14.65	1.14
15.87	0.71	15.87	0.97	15.87	1.14
17.09	0.73	17.09	0.95	17.09	1.14
18.32	0.76	18.32	0.95	18.32	1.14
19.54	0.78	19.54	0.95	19.54	1.14

TRIAXIAL TEST ASTM: D 2850

Job No. 7577
Date: 8/24/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 2 Type: 5T Depth (ft): 35 - 37 (Mid.)
Soil Type: Fat Clay w/Laminations of Silt (CH) Brenna



Failure Criterion: Max. Deviator Stress

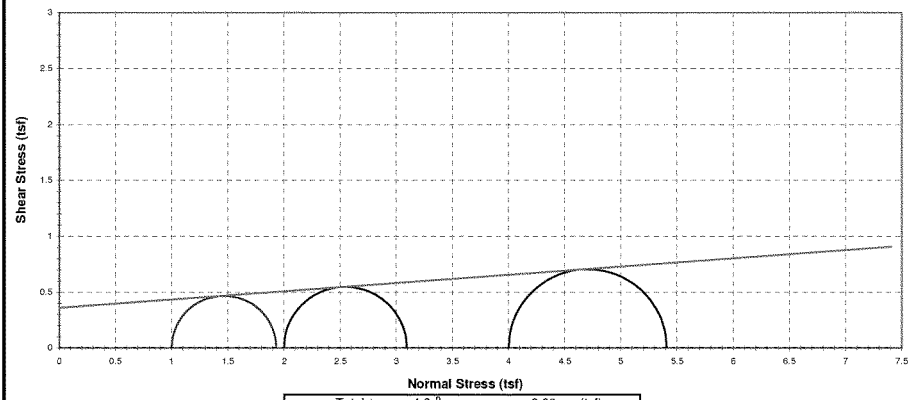
Angle of internal friction, ϕ_u = 4.2 °
Apparent Cohesion, c_u = 0.36 (tsf)

Test Date:	8/20/10	Liquid Limit:	90.7
Test Type:	U-U	Plastic Limit:	29.1
Strain Rate (in/min):	0.05	Plasticity Index:	61.6
Strain Rate (%/min):	1.221	Spec. Gravity (Assumed):	2.78

Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	36.3	36.4	37.9		
Dry Density (pcf)	84.6	84.5	83.1		
Void Ratio	1.05	1.05	1.09		
After Consolidation					
Diameter (in)					
Height (in)					
Water Content (%)					
Dry Density (pcf)					
Void Ratio					
Back Pressure (tsf)					
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	0.93	1.09	1.41		
Ultimate Deviator Stress (tsf)	0.85	0.89	1.09		
Deviator Stress at Failure (tsf)	0.93	1.09	1.41		
Max. Pore Pressure Buildup (tsf)	--------	--------	--------		
Pore Pressure Parameter "B"	--------	--------	--------		
Pct. Axial Strain at Failure	5.4	4.4	3.4		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Specimens trimmed to given sizes; Allowed to adjust under applied confining pressures for about 10 minutes.



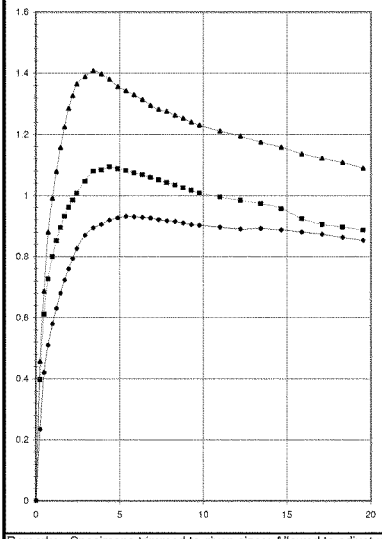
Total ϕ_u: 4.2 ° c_u= 0.36 (tsf)

Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Geotechnical Design and Geology
8301 Bryant Ave. South Suite #107 Bloomington, Minnesota 55420-3436
Attachment 4, pg 362

TRIAXIAL TEST ASTM: D 2850

Job No. 7577
Date: 8/24/10

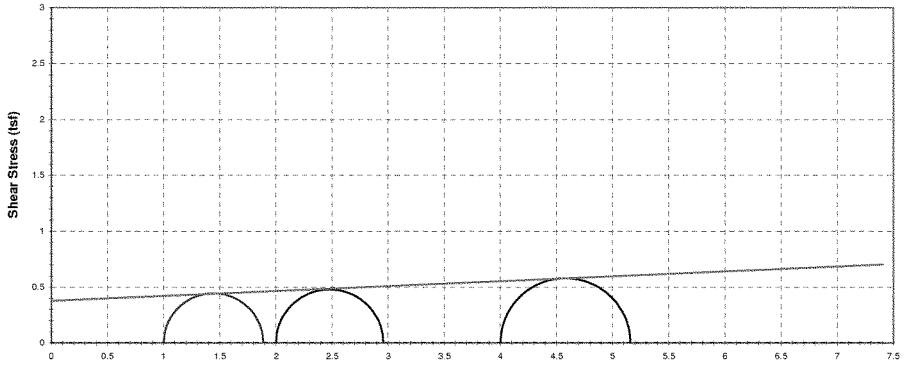
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 2 Type: 5T Depth (ft): 35 - 37 (Mid.)
Soil Type: Fat Clay w/Laminations of Silt (CH) Brenna



Failure Criterion:	Given Strain of: 15%					
Angle of internal friction, ϕ_u =	2.5 °					
Apparent Cohesion, c_u =	0.38 (tsf)					
Test Date: 8/20/10			Liquid Limit:		90.7	
Test Type: U-U			Plastic Limit:		29.1	
Strain Rate (in/min): 0.05			Plasticity Index:		61.6	
Strain Rate (%/min): 1.221			Spec. Gravity (Assumed):		2.78	
Before Consolidation	A	B	C	D	E	
Diameter (in)	1.94	1.94	1.94			
Height (in)	4.10	4.10	4.10			
Water Content (%)	36.3	36.4	37.9			
Dry Density (pcf)	84.6	84.5	83.1			
Void Ratio	1.05	1.05	1.09			
After Consolidation						
Diameter (in)						
Height (in)						
Water Content (%)						
Dry Density (pcf)						
Void Ratio						
Back Pressure (tsf)						
Minor Principal Stress (tsf)	1.00	2.00	4.00			
Max. Deviator Stress (tsf)	0.93	1.09	1.41			
Ultimate Deviator Stress (tsf)	0.85	0.89	1.09			
Deviator Stress at Failure (tsf)	0.89	0.96	1.16			
Max. Pore Pressure Buildup (tsf)	--------	--------	--------			
Pore Pressure Parameter "B"	--------	--------	--------			
Pct. Axial Strain at Failure	15.0	15.0	15.0			

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Specimens trimmed to given sizes; Allowed to adjust under applied confining pressures for about 10 minutes.



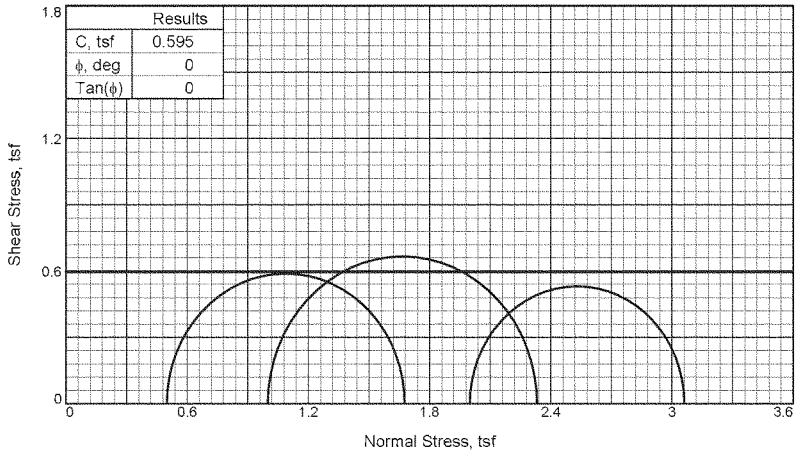
Total ϕ_u: 2.5 ° c_u= 0.38 (tsf)

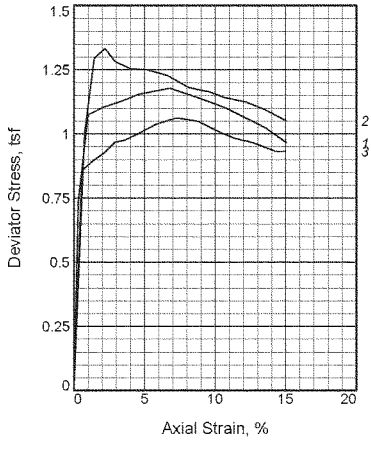
3070 Bryant Ave. South, Suite #107, Bloomington, Minnesota 55420-3403
Geotechnical Design and Geology

Job No.: 7577
Test Type: U-U

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring No.: 10-80MU, Sample No.: 2, Depth (ft.): 35 - 37 (Mid.)

Sample 1		Sample 2		Sample 3	
Strain (%)	Deviator Stress (tsf)	Strain (%)	Deviator Stress (tsf)	Strain (%)	Deviator Stress (tsf)
0.00	0.00	0.00	0.00	0.00	0.00
0.24	0.23	0.24	0.40	0.24	0.46
0.49	0.42	0.49	0.61	0.49	0.69
0.73	0.51	0.73	0.73	0.73	0.88
0.98	0.58	0.98	0.80	0.98	0.99
1.22	0.63	1.22	0.85	1.22	1.08
1.47	0.68	1.47	0.90	1.47	1.16
1.71	0.72	1.71	0.93	1.71	1.22
1.95	0.76	1.95	0.96	1.95	1.29
2.20	0.79	2.20	0.98	2.20	1.33
2.44	0.83	2.44	1.01	2.44	1.37
2.93	0.87	2.93	1.05	2.93	1.39
3.42	0.89	3.42	1.08	3.42	1.41
3.91	0.90	3.91	1.08	3.91	1.40
4.40	0.92	4.40	1.09	4.40	1.38
4.88	0.93	4.88	1.09	4.88	1.36
5.37	0.93	5.37	1.08	5.37	1.34
5.86	0.93	5.86	1.07	5.86	1.33
6.35	0.93	6.35	1.07	6.35	1.31
6.84	0.93	6.84	1.06	6.84	1.29
7.33	0.92	7.33	1.05	7.33	1.28
7.81	0.92	7.81	1.04	7.81	1.27
8.30	0.91	8.30	1.03	8.30	1.26
8.79	0.91	8.79	1.03	8.79	1.25
9.28	0.90	9.28	1.02	9.28	1.24
9.77	0.90	9.77	1.01	9.77	1.23
10.99	0.90	10.99	0.99	10.99	1.21
12.21	0.89	12.21	0.98	12.21	1.19
13.43	0.89	13.43	0.97	13.43	1.17
14.65	0.89	14.65	0.96	14.65	1.16
15.87	0.88	15.87	0.92	15.87	1.14
17.09	0.87	17.09	0.90	17.09	1.12
18.32	0.86	18.32	0.90	18.32	1.11
19.54	0.85	19.54	0.89	19.54	1.09





Sample No.		1	2	3
Initial	Water Content, %	57.2	55.6	56.8
	Dry Density, pcf	66.1	67.2	66.1
	Saturation, %	99.2	99.0	98.5
	Void Ratio	1.5685	1.5257	1.5672
	Diameter, in.	1.40	1.42	1.41
	Height, in.	2.81	2.80	2.80
At Test	Water Content, %	57.2	55.6	56.8
	Dry Density, pcf	66.1	67.2	66.1
	Saturation, %	99.2	99.0	98.5
	Void Ratio	1.5685	1.5257	1.5672
	Diameter, in.	1.40	1.42	1.41
	Height, in.	2.81	2.80	2.80
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.50	1.00	2.00
Peak Stress, tsf		1.18	1.33	1.06
Ult. Stress, tsf		0.97	1.05	0.93
σ_1 Failure, tsf		1.68	2.33	3.06
σ_3 Failure, tsf		0.50	1.00	2.00

Type of Test:
Unconsolidated Undrained
Sample Type: 5" Thinwall, Bottom of sample
Description: FAT CLAY, brown (CH)

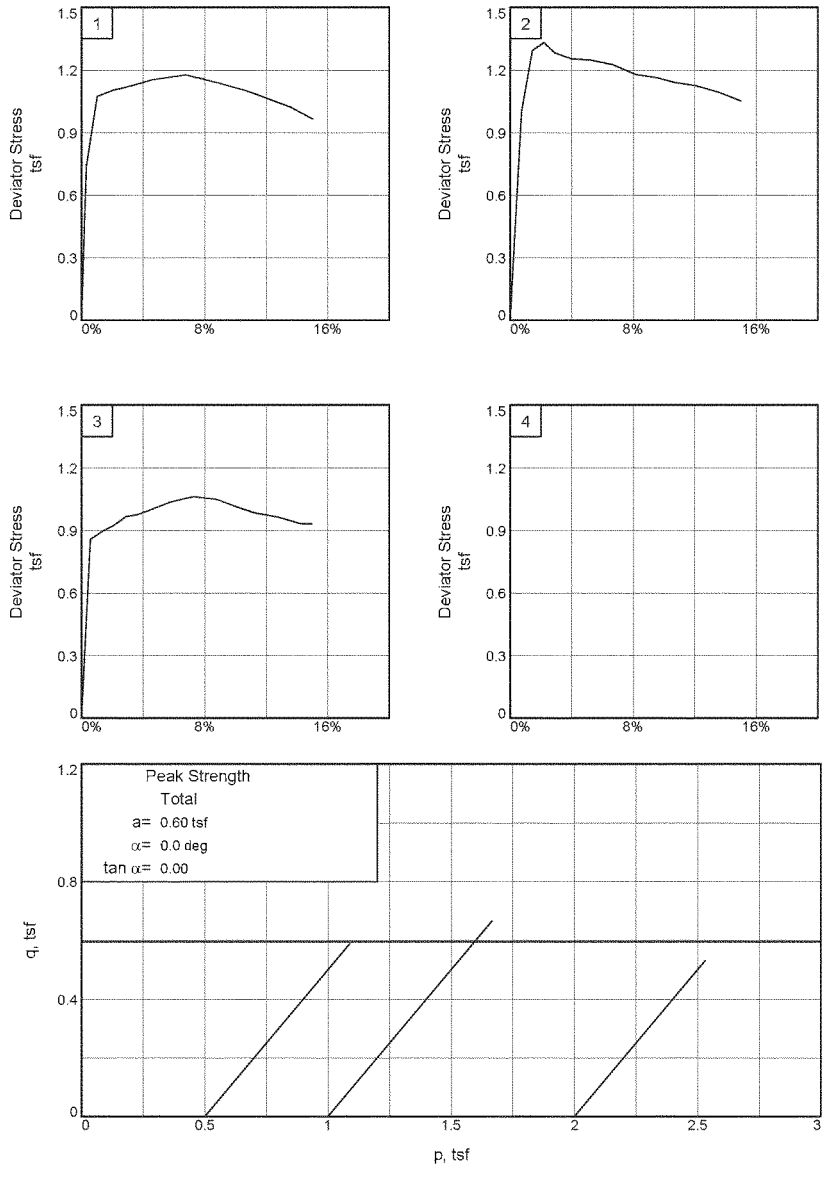
LL= 119 **PL=** 32 **PI=** 87
Specific Gravity= 2.720
Remarks:

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Maple River, Brenna Formation
Sample Number: Boring10-105MU, #2 **Depth:** 25-27'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Figure Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement Attachment I-4, pg 685
July 2011 Geotechnical Design and Geology



Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Location: Maple River, Brenna Formation **Depth:** 25-27' **Sample Number:** Boring10-105MU, #2
Project No: Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement **Figure**
July 2011

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST 3/4/2011
Unconsolidated Undrained 12:04 PM

Date:			
Client:	W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing		
Project No.:	BL-10-10065		
Location:	Maple River, Brenna Formation		
Depth:	25-27'	**Sample Number:**	Boring10-105MU, #2
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	5" Thinwall, Bottom of sample		
Specific Gravity=2.720	**LL=**119	**PL=**32	**PI=**87
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	148.270	148.270
Moisture content: Dry soil+tare, gms.	105.800	105.800
Moisture content: Tare, gms.	31.590	31.590
Moisture, %	57.2	57.2
Moist specimen weight, gms.	117.5	
Diameter, in.	1.40	
Area, in.²	1.53	
Height, in.	2.81	
Wet Density, pcf	103.9	
Dry density, pcf	66.1	
Void ratio	1.5685	
Saturation, %	99.2	

Test Readings for Specimen No. 1

Cell pressure = 0.500 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 1.177 tsf **at reading no.** 7
Ult. Stress = 0.965 tsf **at reading no.** 11

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0062	1.000	0.0	0.0	0.000	0.500	0.500	1.00	0.500	0.000
1	0.0150	16.790	15.8	0.3	0.739	0.500	1.239	2.48	0.870	0.370
2	0.0347	24.090	23.1	1.0	1.074	0.500	1.574	3.15	1.037	0.537
3	0.0648	25.000	24.0	2.1	1.104	0.500	1.604	3.21	1.052	0.552
4	0.0851	25.450	24.5	2.8	1.116	0.500	1.616	3.23	1.058	0.558
5	0.1054	25.940	24.9	3.5	1.130	0.500	1.630	3.26	1.065	0.565
6	0.1359	26.760	25.8	4.6	1.154	0.500	1.654	3.31	1.077	0.577
7	0.1965	27.880	26.9	6.8	1.177	0.500	1.677	3.35	1.089	0.589
8	0.2566	27.600	26.6	8.9	1.138	0.500	1.638	3.28	1.069	0.569
9	0.3074	27.260	26.3	10.7	1.101	0.500	1.601	3.20	1.051	0.551
10	0.3887	26.170	25.2	13.6	1.021	0.500	1.521	3.04	1.011	0.511
11	0.4286	25.190	24.2	15.0	0.965	0.500	1.465	2.93	0.983	0.483

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	150.600	150.600
Moisture content: Dry soil+tare, gms.	107.620	107.620
Moisture content: Tare, gms.	30.260	30.260
Moisture, %	55.6	55.6
Moist specimen weight, gms.	121.1	
Diameter, in.	1.42	
Area, in.²	1.57	
Height, in.	2.80	
Wet Density, pcf	104.6	
Dry density, pcf	67.2	
Void ratio	1.5257	
Saturation, %	99.0	

Test Readings for Specimen No. 2

Cell pressure = 1.000 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.332 tsf at reading no. 3

Ult. Stress = 1.052 tsf at reading no. 13

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0094	1.520	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	0.0304	23.550	22.0	0.7	1.001	1.000	2.001	2.00	1.501	0.501
2	0.0501	30.210	28.7	1.5	1.295	1.000	2.295	2.29	1.647	0.647
3	0.0711	31.270	29.8	2.2	1.332	1.000	2.332	2.33	1.666	0.666
4	0.0911	30.360	28.8	2.9	1.282	1.000	2.282	2.28	1.641	0.641
5	0.1219	30.050	28.5	4.0	1.254	1.000	2.254	2.25	1.627	0.627
6	0.1547	30.290	28.8	5.2	1.249	1.000	2.249	2.25	1.625	0.625
7	0.1964	30.210	28.7	6.7	1.226	1.000	2.226	2.23	1.613	0.613
8	0.2378	29.570	28.1	8.1	1.180	1.000	2.180	2.18	1.590	0.590
9	0.2783	29.620	28.1	9.6	1.163	1.000	2.163	2.16	1.582	0.582
10	0.3089	29.410	27.9	10.7	1.141	1.000	2.141	2.14	1.570	0.570
11	0.3499	29.470	28.0	12.1	1.124	1.000	2.124	2.12	1.562	0.562

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
12	0.3908	29.140	27.6	13.6	1.093	1.000	2.093	2.09	1.546	0.546
13	0.4300	28.560	27.0	15.0	1.052	1.000	2.052	2.05	1.526	0.526

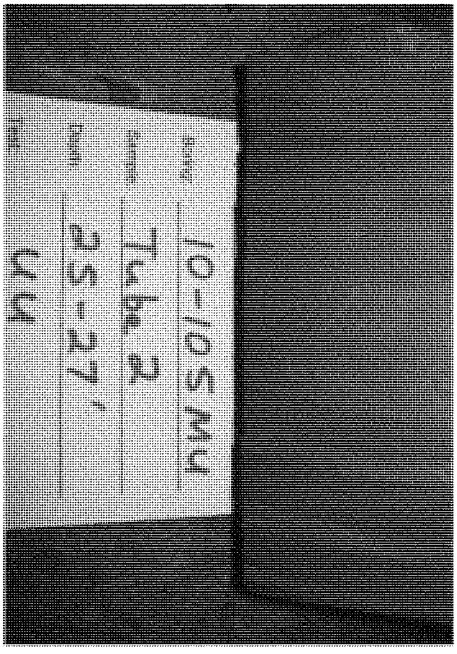
Parameters for Specimen No. 3

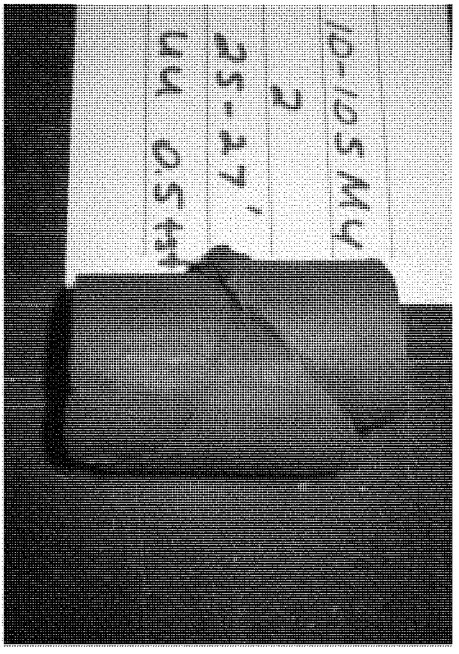
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	149.820	149.820
Moisture content: Dry soil+tare, gms.	106.960	106.960
Moisture content: Tare, gms.	31.450	31.450
Moisture, %	56.8	56.8
Moist specimen weight, gms.	119.1	
Diameter, in.	1.41	
Area, in.^{2}	1.56	
Height, in.	2.80	
Wet Density, pcf	103.7	
Dry density, pcf	66.1	
Void ratio	1.5672	
Saturation, %	98.5	

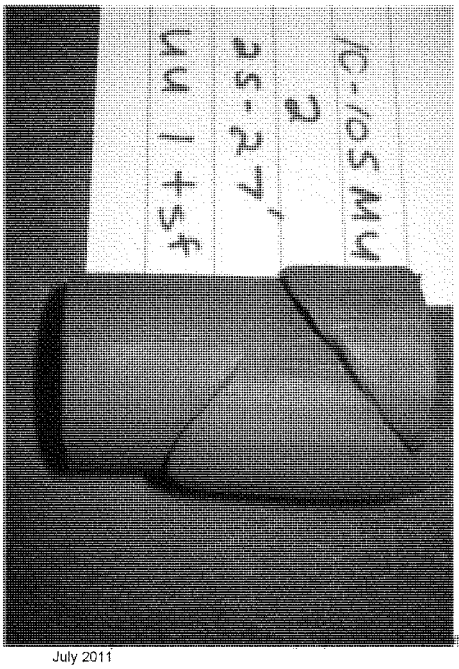
Test Readings for Specimen No. 3

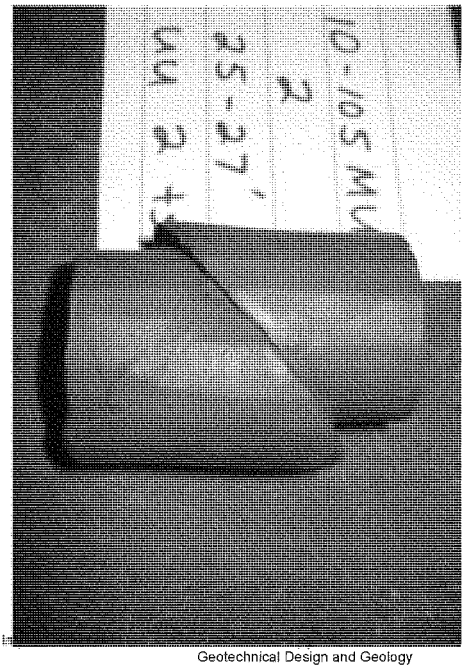
Cell pressure = 2.000 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 1.062 tsf **at reading no.** 8
Ult. Stress = 0.932 tsf **at reading no.** 14

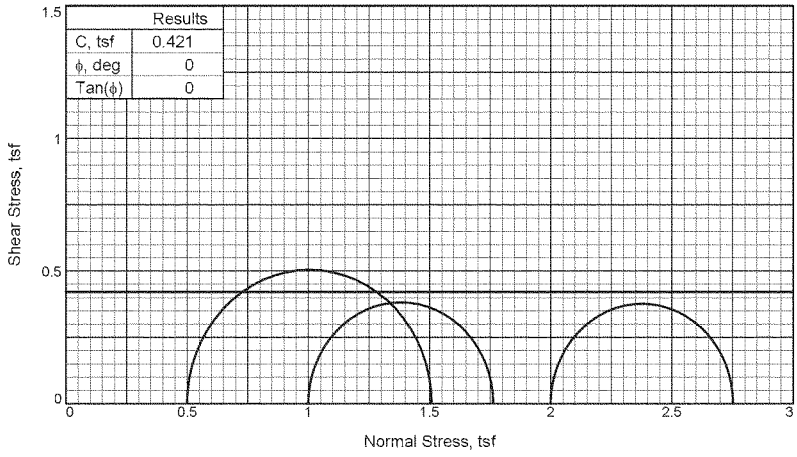
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0067	3.990	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	0.0228	22.700	18.7	0.6	0.857	2.000	2.857	1.43	2.428	0.428
2	0.0443	23.670	19.7	1.3	0.894	2.000	2.894	1.45	2.447	0.447
3	0.0666	24.530	20.5	2.1	0.926	2.000	2.926	1.46	2.463	0.463
4	0.0871	25.590	21.6	2.9	0.966	2.000	2.966	1.48	2.483	0.483
5	0.1075	25.950	22.0	3.6	0.975	2.000	2.975	1.49	2.487	0.487
6	0.1279	26.570	22.6	4.3	0.995	2.000	2.995	1.50	2.497	0.497
7	0.1699	27.910	23.9	5.8	1.037	2.000	3.037	1.52	2.519	0.519
8	0.2106	28.860	24.9	7.3	1.062	2.000	3.062	1.53	2.531	0.531
9	0.2520	28.960	25.0	8.8	1.049	2.000	3.049	1.52	2.524	0.524
10	0.2926	28.410	24.4	10.2	1.010	2.000	3.010	1.50	2.505	0.505
11	0.3230	28.070	24.1	11.3	0.983	2.000	2.983	1.49	2.492	0.492
12	0.3640	27.980	24.0	12.8	0.964	2.000	2.964	1.48	2.482	0.482
13	0.4052	27.600	23.6	14.2	0.932	2.000	2.932	1.47	2.466	0.466
14	0.4257	27.800	23.8	15.0	0.932	2.000	2.932	1.47	2.466	0.466

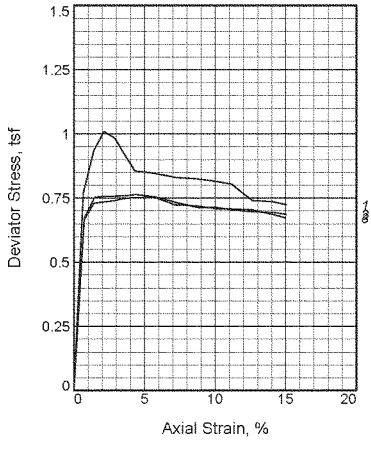

10-105MU
Tube 2
25-27'
UU


10-105MU
2
25-27'
UU 0.5tsf


10-105MU
2
25-27'
UU 1tsf


10-105MU
2
25-27'
UU 2 ts





Sample No.		1	2	3
Initial	Water Content, %	62.6	63.3	63.9
	Dry Density, pcf	62.5	62.6	62.1
	Saturation, %	98.3	99.7	99.2
	Void Ratio	1.7616	1.7555	1.7801
	Diameter, in.	1.42	1.41	1.40
	Height, in.	2.80	2.81	2.82
At Test	Water Content, %	62.6	63.3	63.9
	Dry Density, pcf	62.5	62.6	62.1
	Saturation, %	98.3	99.7	99.2
	Void Ratio	1.7616	1.7555	1.7801
	Diameter, in.	1.42	1.41	1.40
	Height, in.	2.80	2.81	2.82
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.50	1.00	2.00
Peak Stress, tsf		1.01	0.76	0.75
Ult. Stress, tsf		0.72	0.69	0.67
σ_1 Failure, tsf		1.51	1.76	2.75
σ_3 Failure, tsf		0.50	1.00	2.00

Type of Test:
Unconsolidated Undrained
Sample Type: 5" Thinwall, Bottom of sample
Description: FAT CLAY, brown (CH)

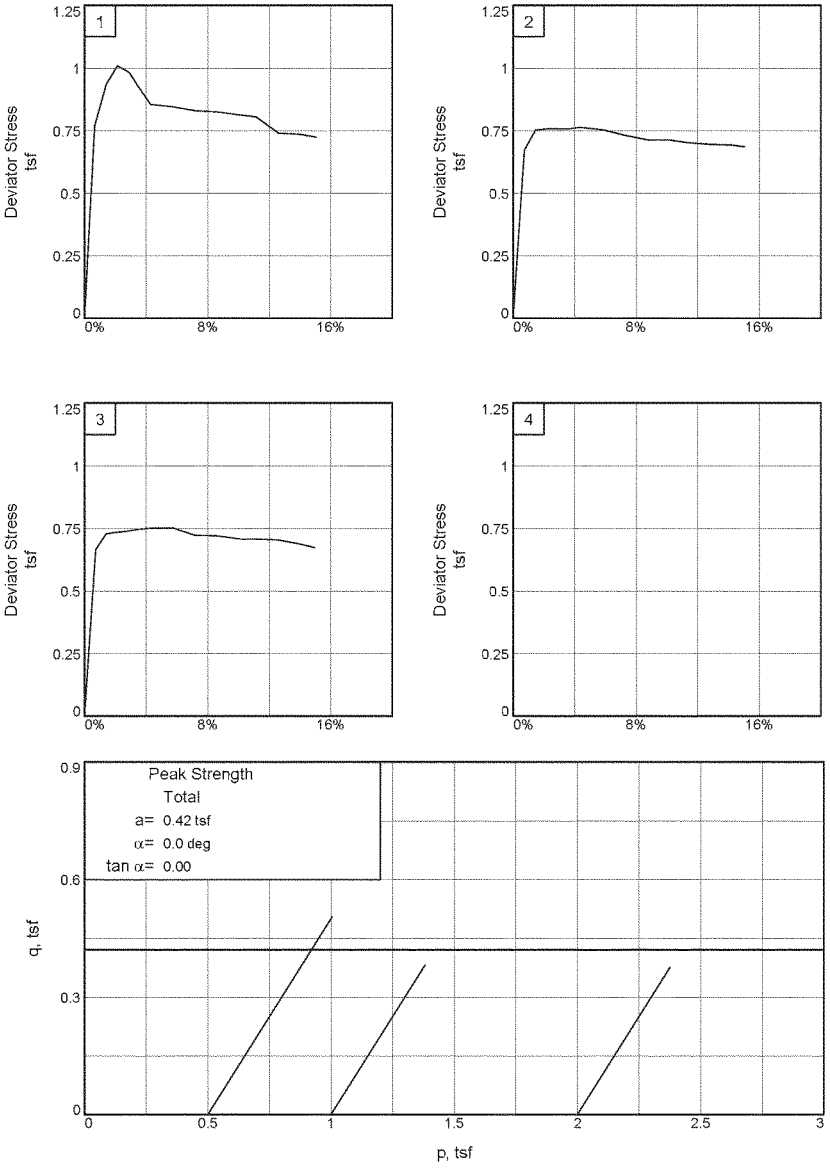
LL= 106 **PL=** 29 **PI=** 77
Specific Gravity= 2.764
Remarks:

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Maple River, Brenna Formation
Sample Number: Boring10-105MU, #3 **Depth:** 35-37'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Figure Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement Attachment I-4, pg 691
July 2014 Geotechnical Design and Geology



Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study

Location: Maple River, Brenna Formation **Depth:** 35-37' **Sample Number:** Boring10-105MU, #3

Project No.: BI-10-10045 **Figure**

Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST 3/4/2011
Unconsolidated Undrained 1:19 PM

Date:			
Client:	W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing		
Project No.:	BL-10-10065		
Location:	Maple River, Brenna Formation		
Depth:	35-37'	**Sample Number:**	Boring10-105MU, #3
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	5" Thinwall, Bottom of sample		
Specific Gravity=2.764	**LL=**106	**PL=**29	**PI=**77
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	147.440	147.440
Moisture content: Dry soil+tare, gms.	102.320	102.320
Moisture content: Tare, gms.	30.290	30.290
Moisture, %	62.6	62.6
Moist specimen weight, gms.	117.5	
Diameter, in.	1.42	
Area, in.²	1.57	
Height, in.	2.80	
Wet Density, pcf	101.6	
Dry density, pcf	62.5	
Void ratio	1.7616	
Saturation, %	98.3	

Test Readings for Specimen No. 1

Cell pressure = 0.500 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 1.009 tsf **at reading no.** 3
Ult. Stress = 0.724 tsf **at reading no.** 14

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0063	0.000	0.0	0.0	0.000	0.500	0.500	1.00	0.500	0.000
1	0.0250	16.900	16.9	0.7	0.769	0.500	1.269	2.54	0.884	0.384
2	0.0461	20.750	20.8	1.4	0.937	0.500	1.437	2.87	0.968	0.468
3	0.0662	22.520	22.5	2.1	1.009	0.500	1.509	3.02	1.005	0.505
4	0.0870	22.120	22.1	2.9	0.984	0.500	1.484	2.97	0.992	0.492
5	0.1067	20.810	20.8	3.6	0.919	0.500	1.419	2.84	0.959	0.459
6	0.1268	19.510	19.5	4.3	0.855	0.500	1.355	2.71	0.927	0.427
7	0.1674	19.590	19.6	5.7	0.845	0.500	1.345	2.69	0.923	0.423
8	0.2084	19.520	19.5	7.2	0.829	0.500	1.329	2.66	0.915	0.415
9	0.2482	19.710	19.7	8.6	0.825	0.500	1.325	2.65	0.912	0.412
10	0.2892	19.760	19.8	10.1	0.813	0.500	1.313	2.63	0.907	0.407
11	0.3191	19.770	19.8	11.2	0.804	0.500	1.304	2.61	0.902	0.402
12	0.3600	18.500	18.5	12.6	0.740	0.500	1.240	2.48	0.870	0.370
13	0.4005	18.690	18.7	14.1	0.735	0.500	1.235	2.47	0.868	0.368
14	0.4280	18.610	18.6	15.0	0.724	0.500	1.224	2.45	0.862	0.362

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	146.540	146.540
Moisture content: Dry soil+tare, gms.	101.340	101.340
Moisture content: Tare, gms.	29.950	29.950
Moisture, %	63.3	63.3
Moist specimen weight, gms.	117.1	
Diameter, in.	1.41	
Area, in.²	1.55	
Height, in.	2.81	
Wet Density, pcf	102.3	
Dry density, pcf	62.6	
Void ratio	1.7555	
Saturation, %	99.7	

Test Readings for Specimen No. 2

Cell pressure = 1.000 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 0.763 tsf at reading no. 6

Ult. Stress = 0.686 tsf at reading no. 14

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0079	1.520	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	0.0285	16.140	14.6	0.7	0.673	1.000	1.673	1.67	1.337	0.337
2	0.0488	17.970	16.5	1.5	0.752	1.000	1.752	1.75	1.376	0.376
3	0.0699	18.210	16.7	2.2	0.757	1.000	1.757	1.76	1.378	0.378
4	0.0900	18.330	16.8	2.9	0.757	1.000	1.757	1.76	1.378	0.378
5	0.1103	18.490	17.0	3.6	0.758	1.000	1.758	1.76	1.379	0.379
6	0.1313	18.730	17.2	4.4	0.763	1.000	1.763	1.76	1.382	0.382
7	0.1728	18.760	17.2	5.9	0.753	1.000	1.753	1.75	1.376	0.376
8	0.2135	18.520	17.0	7.3	0.731	1.000	1.731	1.73	1.365	0.365
9	0.2545	18.370	16.9	8.8	0.713	1.000	1.713	1.71	1.356	0.356
10	0.2943	18.610	17.1	10.2	0.712	1.000	1.712	1.71	1.356	0.356
11	0.3248	18.610	17.1	11.3	0.703	1.000	1.703	1.70	1.352	0.352
12	0.3660	18.700	17.2	12.7	0.695	1.000	1.695	1.70	1.348	0.348
13	0.4067	18.930	17.4	14.2	0.693	1.000	1.693	1.69	1.346	0.346
14	0.4298	18.930	17.4	15.0	0.686	1.000	1.686	1.69	1.343	0.343

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	145.940	145.940
Moisture content: Dry soil+tare, gms.	100.950	100.950
Moisture content: Tare, gms.	30.500	30.500
Moisture, %	63.9	63.9
Moist specimen weight, gms.	115.9	
Diameter, in.	1.40	
Area, in.²	1.54	
Height, in.	2.82	
Wet Density, pcf	101.7	
Dry density, pcf	62.1	
Void ratio	1.7801	
Saturation, %	99.2	

Test Readings for Specimen No. 3

Cell pressure = 2.000 tsf

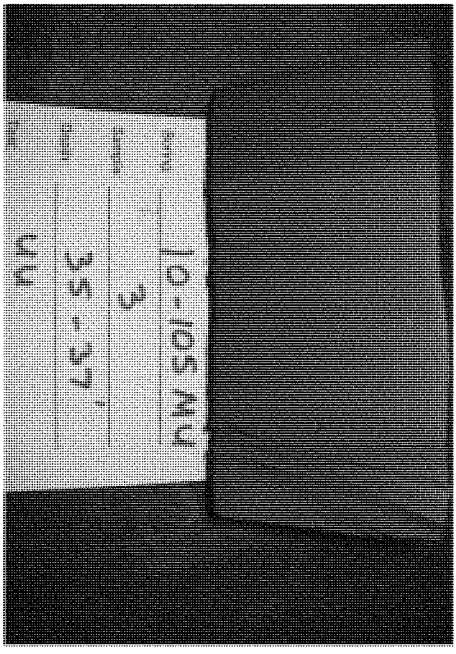
Back pressure = 0.000 tsf

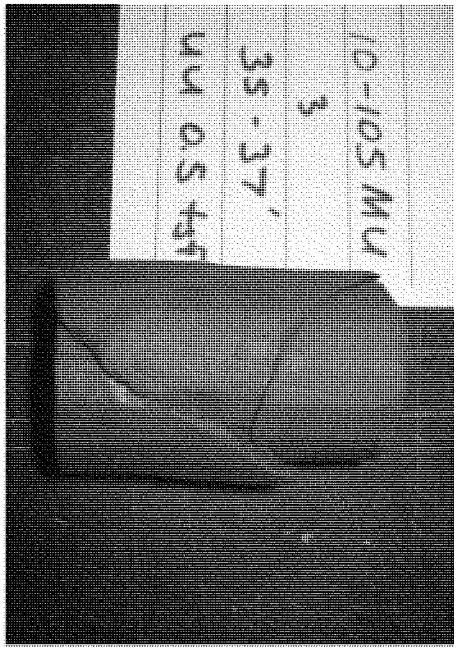
Strain rate, %/min. = 1.00

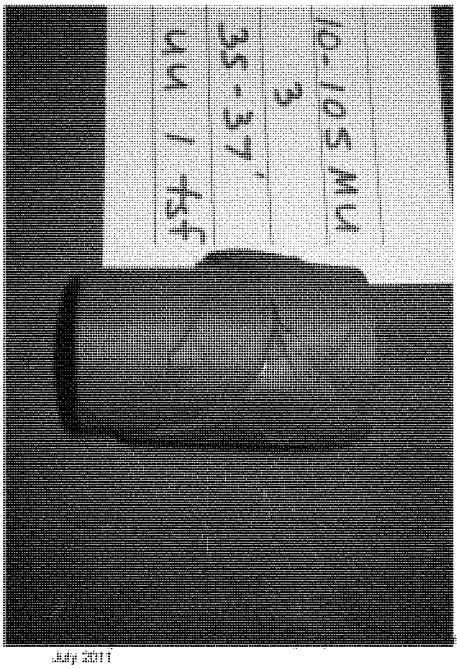
Peak Stress = 0.753 tsf at reading no. 7

Ult. Stress = 0.673 tsf at reading no. 14

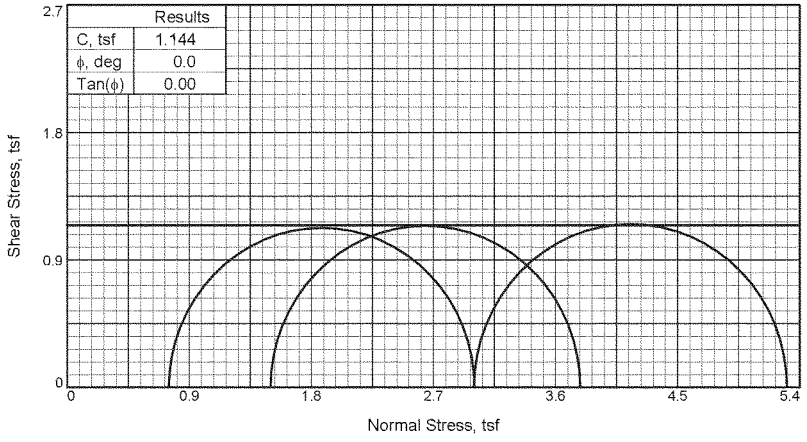
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0100	4.540	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	0.0305	18.900	14.4	0.7	0.666	2.000	2.666	1.33	2.333	0.333
2	0.0495	20.360	15.8	1.4	0.729	2.000	2.729	1.36	2.364	0.364
3	0.0695	20.600	16.1	2.1	0.734	2.000	2.734	1.37	2.367	0.367
4	0.0891	20.810	16.3	2.8	0.739	2.000	2.739	1.37	2.369	0.369
5	0.1085	21.100	16.6	3.5	0.746	2.000	2.746	1.37	2.373	0.373
6	0.1289	21.320	16.8	4.2	0.751	2.000	2.751	1.38	2.375	0.375
7	0.1710	21.630	17.1	5.7	0.753	2.000	2.753	1.38	2.376	0.376
8	0.2115	21.200	16.7	7.2	0.722	2.000	2.722	1.36	2.361	0.361
9	0.2525	21.400	16.9	8.6	0.720	2.000	2.720	1.36	2.360	0.360
10	0.2932	21.390	16.9	10.1	0.708	2.000	2.708	1.35	2.354	0.354
11	0.3237	21.570	17.0	11.1	0.707	2.000	2.707	1.35	2.353	0.353
12	0.3651	21.780	17.2	12.6	0.704	2.000	2.704	1.35	2.352	0.352
13	0.4068	21.630	17.1	14.1	0.686	2.000	2.686	1.34	2.343	0.343
14	0.4310	21.480	16.9	15.0	0.673	2.000	2.673	1.34	2.336	0.336

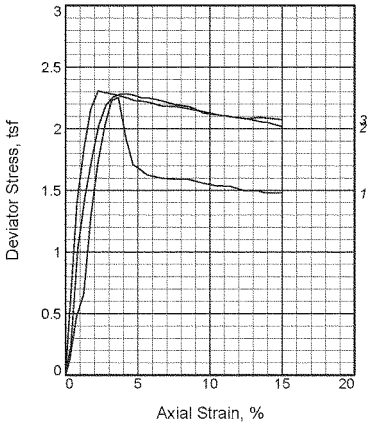

10-105 MU
3
35-37'
UU


10-105 MU
3
35-37'
UU 0.5 tsf


10-105 MU
3
35-37'
UU 1 tsf

10-105 MU
3
35-37'
UU 2 tsf





Sample No.		1	2	3
Initial	Water Content, %	37.3	37.5	37.4
	Dry Density, pcf	78.5	83.9	84.1
	Saturation, %	86.6	98.8	99.2
	Void Ratio	1.1802	1.0405	1.0340
	Diameter, in.	1.43	1.39	1.40
	Height, in.	2.81	2.80	2.81
At Test	Water Content, %	37.3	37.5	37.4
	Dry Density, pcf	78.5	83.9	84.1
	Saturation, %	86.6	98.8	99.2
	Void Ratio	1.1802	1.0405	1.0340
	Diameter, in.	1.43	1.39	1.40
	Height, in.	2.81	2.80	2.81
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.75	1.50	3.00
Peak Stress, tsf		2.25	2.28	2.31
Ult. Stress, tsf		1.48	2.02	2.08
σ_1 Failure, tsf		3.00	3.78	5.31
σ_3 Failure, tsf		0.75	1.50	3.00

Type of Test:
Unconsolidated Undrained
Sample Type: 5" Thinwall, Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 71 **PL=** 19 **PI=** 52
Specific Gravity= 2.741
Remarks:

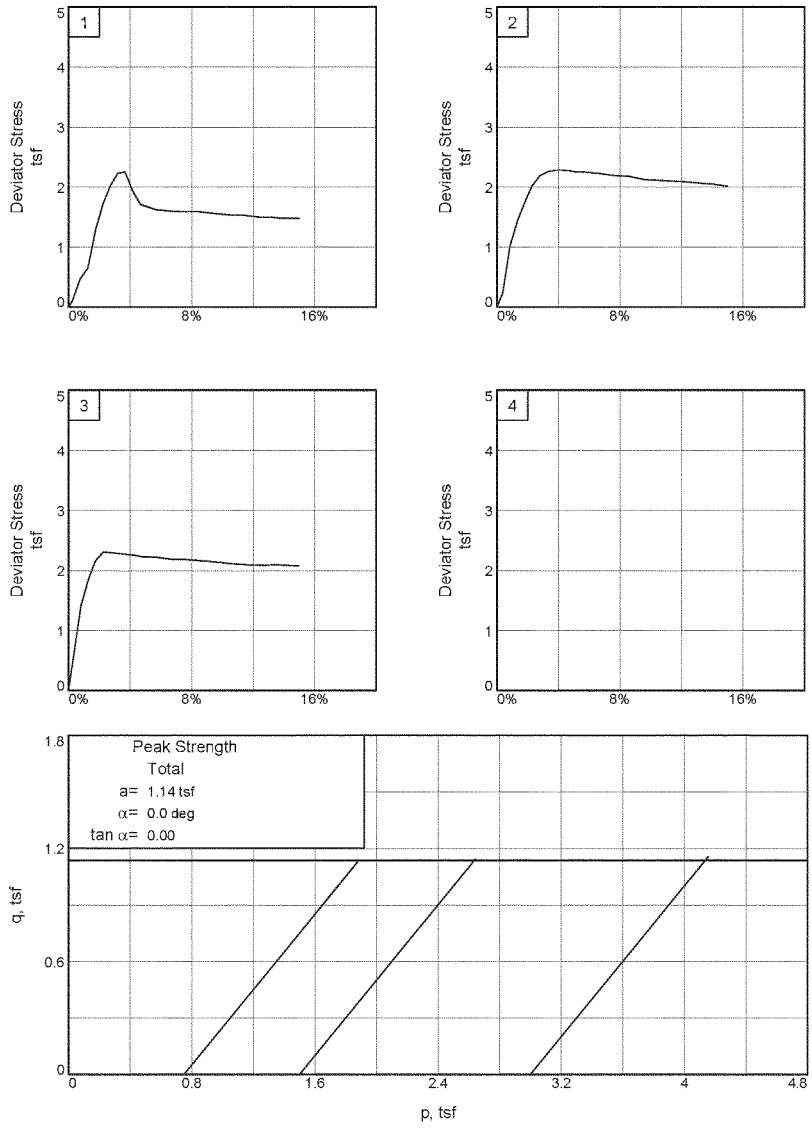
Figure UU Triax ASTM D 2850

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: ND RRCS, MN, Brenna Formation
Sample Number: Boring11-107MU, #1 **Depth:** 20-22'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Tested By: JK **Checked By:** JFS



Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: ND RRCS, MN, Brenna Formation **Depth:** 20-22' **Sample No.:** Boring11-107MU, #1
Project No.: BL-10-10065 **Figure** _____

Braun Intertec

Tested By: JK **Checked By:** jts

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

5/30/2011
12:13 PM

Date:			
Client:	USACE W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing Request NO. 3		
Project No.:	BL-10-10065		
Location:	ND RRCS, MN, Brenna Formation		
Depth:	20-22'	**Sample Number:**	Boring11-107MU, #1
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	5" Thinwall, Bottom of sample		
Specific Gravity=2.741	**LL=**71	**PL=**19	**PI=**52
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	157.860	157.860
Moisture content: Dry soil+tare, gms.	123.290	123.290
Moisture content: Tare, gms.	30.600	30.600
Moisture, %	37.3	37.3
Moist specimen weight, gms.	127.6	
Diameter, in.	1.43	
Area, in.^{2}	1.61	
Height, in.	2.81	
Wet Density, pcf	107.8	
Dry density, pcf	78.5	
Void ratio	1.1802	
Saturation, %	86.6	

Test Readings for Specimen No. 1

Cell pressure = 0.750 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 2.253 tsf **at reading no.** 8
Ult. Stress = 1.479 tsf **at reading no.** 22

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0067	2.130	0.0	0.0	0.000	0.750	0.750	1.00	0.750	0.000
1	0.0148	4.970	2.8	0.3	0.127	0.750	0.877	1.17	0.813	0.063
2	0.0280	12.810	10.7	0.8	0.474	0.750	1.224	1.63	0.987	0.237
3	0.0422	17.050	14.9	1.3	0.659	0.750	1.409	1.88	1.080	0.330
4	0.0560	31.270	29.1	1.8	1.282	0.750	2.032	2.71	1.391	0.641
5	0.0690	41.130	39.0	2.2	1.707	0.750	2.457	3.28	1.604	0.854
6	0.0829	48.610	46.5	2.7	2.024	0.750	2.774	3.70	1.762	1.012
7	0.0963	53.560	51.4	3.2	2.229	0.750	2.979	3.97	1.864	1.114
8	0.1096	54.380	52.2	3.7	2.253	0.750	3.003	4.00	1.877	1.127
9	0.1241	46.990	44.9	4.2	1.924	0.750	2.674	3.57	1.712	0.962
10	0.1378	42.210	40.1	4.7	1.710	0.750	2.460	3.28	1.605	0.855
11	0.1511	41.490	39.4	5.1	1.671	0.750	2.421	3.23	1.586	0.836
12	0.1653	40.620	38.5	5.7	1.626	0.750	2.376	3.17	1.563	0.813
13	0.1924	40.380	38.3	6.6	1.599	0.750	2.349	3.13	1.549	0.799
14	0.2187	40.560	38.4	7.6	1.590	0.750	2.340	3.12	1.545	0.795
15	0.2456	40.940	38.8	8.5	1.589	0.750	2.339	3.12	1.545	0.795
16	0.2728	40.620	38.5	9.5	1.560	0.750	2.310	3.08	1.530	0.780
17	0.3001	40.460	38.3	10.5	1.536	0.750	2.286	3.05	1.518	0.768
18	0.3259	40.770	38.6	11.4	1.533	0.750	2.283	3.04	1.516	0.766
19	0.3529	40.350	38.2	12.3	1.500	0.750	2.250	3.00	1.500	0.750
20	0.3800	40.720	38.6	13.3	1.498	0.750	2.248	3.00	1.499	0.749
21	0.3939	40.500	38.4	13.8	1.481	0.750	2.231	2.97	1.490	0.740
22	0.4275	40.990	38.9	15.0	1.479	0.750	2.229	2.97	1.489	0.739

Parameters for Specimen No. 2		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	159.300	159.300
Moisture content: Dry soil+tare, gms.	124.430	124.430
Moisture content: Tare, gms.	31.440	31.440
Moisture, %	37.5	37.5
Moist specimen weight, gms.	128.2	
Diameter, in.	1.39	
Area, in.²	1.51	
Height, in.	2.80	
Wet Density, pcf	115.3	
Dry density, pcf	83.9	
Void ratio	1.0405	
Saturation, %	98.8	

Test Readings for Specimen No. 2

Cell pressure = 1.500 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 2.283 tsf at reading no. 9

Ult. Stress = 2.018 tsf at reading no. 22

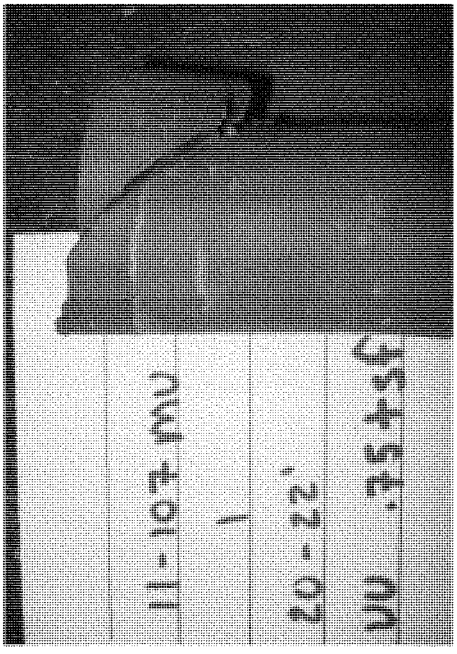
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	2.340	0.0	0.0	0.000	1.500	1.500	1.00	1.500	0.000
1	0.0171	7.220	4.9	0.4	0.231	1.500	1.731	1.15	1.616	0.116
2	0.0306	24.130	21.8	0.9	1.028	1.500	2.528	1.69	2.014	0.514
3	0.0441	33.010	30.7	1.3	1.440	1.500	2.940	1.96	2.220	0.720
4	0.0578	39.940	37.6	1.8	1.756	1.500	3.256	2.17	2.378	0.878
5	0.0710	45.890	43.5	2.3	2.025	1.500	3.525	2.35	2.512	1.012
6	0.0849	49.680	47.3	2.8	2.190	1.500	3.690	2.46	2.595	1.095
7	0.0980	51.300	49.0	3.3	2.254	1.500	3.754	2.50	2.627	1.127
8	0.1123	52.150	49.8	3.8	2.281	1.500	3.781	2.52	2.640	1.140
9	0.1261	52.460	50.1	4.3	2.283	1.500	3.783	2.52	2.642	1.142
10	0.1387	52.490	50.2	4.7	2.274	1.500	3.774	2.52	2.637	1.137
11	0.1526	52.270	49.9	5.2	2.252	1.500	3.752	2.50	2.626	1.126
12	0.1664	52.510	50.2	5.7	2.251	1.500	3.751	2.50	2.626	1.126
13	0.1933	52.460	50.1	6.7	2.226	1.500	3.726	2.48	2.613	1.113
14	0.2195	52.270	49.9	7.6	2.195	1.500	3.695	2.46	2.598	1.098
15	0.2472	52.430	50.1	8.6	2.179	1.500	3.679	2.45	2.589	1.089
16	0.2750	51.780	49.4	9.6	2.127	1.500	3.627	2.42	2.564	1.064
17	0.3028	51.970	49.6	10.6	2.112	1.500	3.612	2.41	2.556	1.056
18	0.3299	52.150	49.8	11.5	2.097	1.500	3.597	2.40	2.548	1.048
19	0.3567	52.360	50.0	12.5	2.083	1.500	3.583	2.39	2.541	1.041
20	0.3845	52.340	50.0	13.5	2.058	1.500	3.558	2.37	2.529	1.029
21	0.3980	52.460	50.1	14.0	2.052	1.500	3.552	2.37	2.526	1.026
22	0.4257	52.210	49.9	15.0	2.018	1.500	3.518	2.35	2.509	1.009

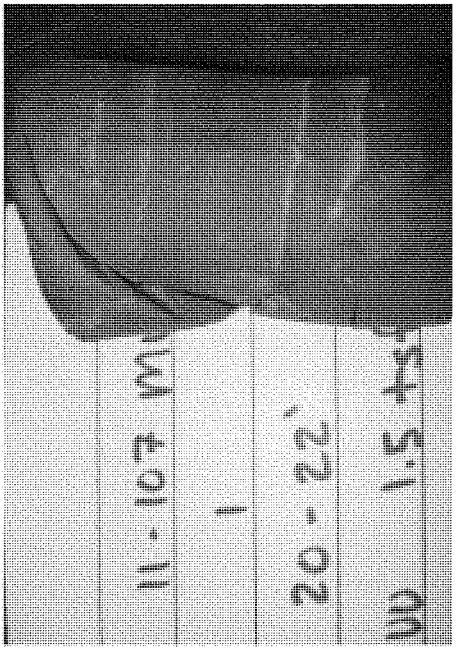
Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	161.210	161.210
Moisture content: Dry soil+tare, gms.	125.520	125.520
Moisture content: Tare, gms.	30.180	30.180
Moisture, %	37.4	37.4
Moist specimen weight, gms.	131.1	
Diameter, in.	1.40	
Area, in.^{2}	1.54	
Height, in.	2.81	
Wet Density, pcf	115.6	
Dry density, pcf	84.1	
Void ratio	1.0340	
Saturation, %	99.2	

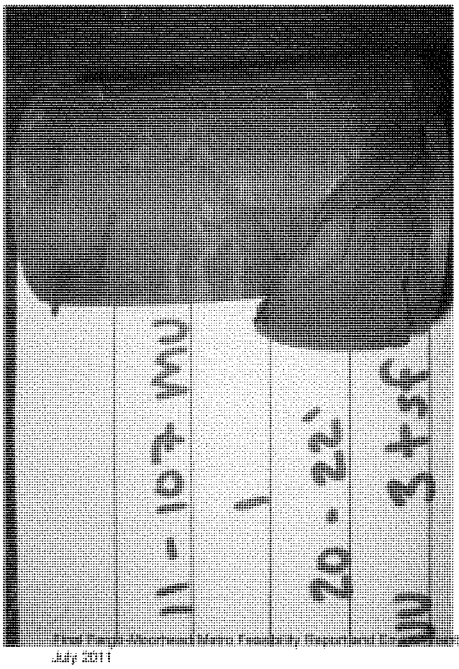
Test Readings for Specimen No. 3

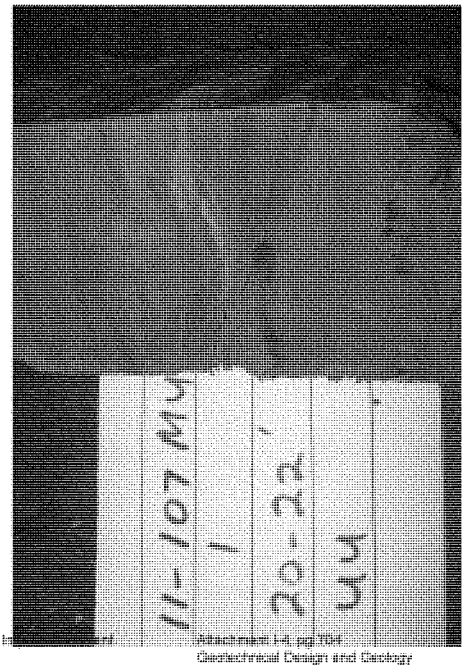
Cell pressure = 3.000 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 2.308 tsf **at reading no.** 5
Ult. Stress = 2.075 tsf **at reading no.** 22

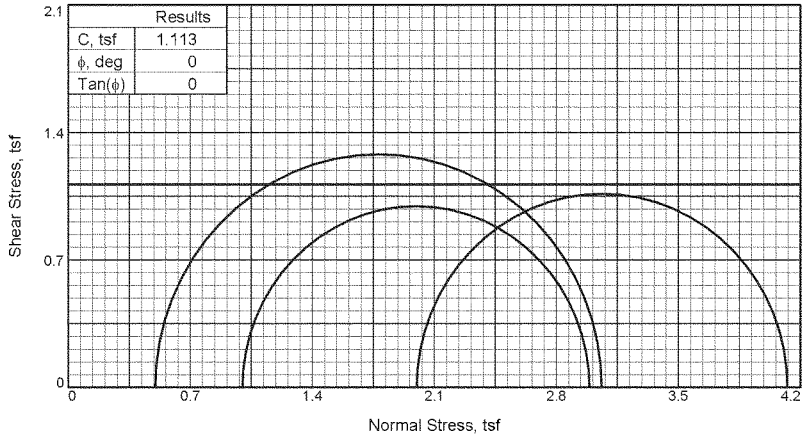
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0065	6.400	0.0	0.0	0.000	3.000	3.000	1.00	3.000	0.000
1	0.0161	19.070	12.7	0.3	0.591	3.000	3.591	1.20	3.295	0.295
2	0.0289	36.550	30.2	0.8	1.399	3.000	4.399	1.47	3.699	0.699
3	0.0430	46.540	40.1	1.3	1.853	3.000	4.853	1.62	3.927	0.927
4	0.0557	53.400	47.0	1.8	2.160	3.000	5.160	1.72	4.080	1.080
5	0.0701	56.880	50.5	2.3	2.308	3.000	5.308	1.77	4.154	1.154
6	0.0844	56.820	50.4	2.8	2.293	3.000	5.293	1.76	4.146	1.146
7	0.0993	56.830	50.4	3.3	2.281	3.000	5.281	1.76	4.140	1.140
8	0.1135	56.750	50.4	3.8	2.265	3.000	5.265	1.76	4.133	1.133
9	0.1268	56.690	50.3	4.3	2.251	3.000	5.251	1.75	4.126	1.126
10	0.1406	56.420	50.0	4.8	2.228	3.000	5.228	1.74	4.114	1.114
11	0.1539	56.590	50.2	5.3	2.224	3.000	5.224	1.74	4.112	1.112
12	0.1676	56.650	50.3	5.7	2.215	3.000	5.215	1.74	4.108	1.108
13	0.1950	56.440	50.0	6.7	2.183	3.000	5.183	1.73	4.092	1.092
14	0.2216	56.870	50.5	7.7	2.180	3.000	5.180	1.73	4.090	1.090
15	0.2492	56.940	50.5	8.7	2.159	3.000	5.159	1.72	4.080	1.080
16	0.2762	56.960	50.6	9.6	2.137	3.000	5.137	1.71	4.069	1.069
17	0.3032	56.870	50.5	10.6	2.111	3.000	5.111	1.70	4.055	1.055
18	0.3304	57.050	50.6	11.5	2.095	3.000	5.095	1.70	4.048	1.048
19	0.3576	57.250	50.9	12.5	2.081	3.000	5.081	1.69	4.040	1.040
20	0.3856	58.130	51.7	13.5	2.093	3.000	5.093	1.70	4.046	1.046
21	0.3988	58.230	51.8	14.0	2.085	3.000	5.085	1.70	4.043	1.043
22	0.4264	58.580	52.2	15.0	2.075	3.000	5.075	1.69	4.038	1.038

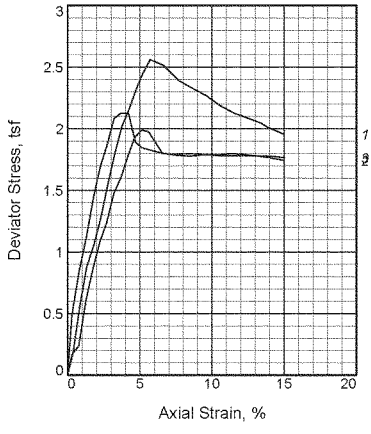

11-107 MU
1
20-22'
UU .75 tsf


11-107 MU
1
20-22'
UU 1.5 tsf


11-107 MU
1
20-22'
UU 3 tsf


11-107 MU
1
20-22'
UU





Sample No.		1	2	3
Initial	Water Content, %	36.9	39.5	40.1
	Dry Density, pcf	84.5	81.9	80.7
	Saturation, %	97.9	98.9	97.6
	Void Ratio	1.0393	1.1037	1.1347
	Diameter, in.	1.40	1.40	1.39
	Height, in.	2.80	2.81	2.80
At Test	Water Content, %	36.9	39.5	40.1
	Dry Density, pcf	84.5	81.9	80.7
	Saturation, %	97.9	98.9	97.6
	Void Ratio	1.0393	1.1037	1.1347
	Diameter, in.	1.40	1.40	1.39
	Height, in.	2.80	2.81	2.80
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.50	1.00	2.00
Peak Stress, tsf		2.56	1.99	2.13
Ult. Stress, tsf		1.96	1.75	1.77
σ_1 Failure, tsf		3.06	2.99	4.13
σ_3 Failure, tsf		0.50	1.00	2.00

Type of Test:
Unconsolidated Undrained
Sample Type: 5" Thinwall, Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 52 **PL=** 21 **PI=** 31
Specific Gravity= 2.760
Remarks:

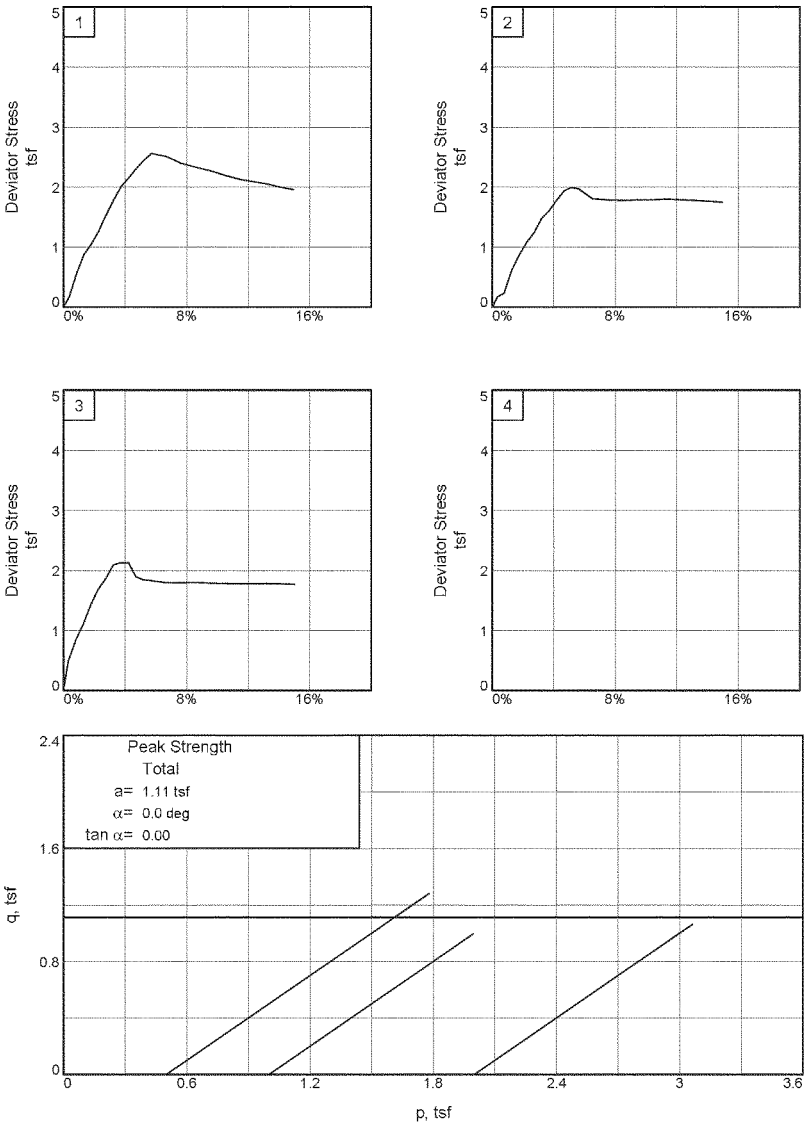
Figure UU Triax ASTM D 2850

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: ND RRCS, MN, Brenna Formation
Sample Number: Boring11-107MU, #2 **Depth:** 30-32'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Tested By: JK **Checked By:** jfs



Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: ND RRCS, MN, Brenna Formation **Depth:** 30-32' **Sample No.:** Boring11-107MU, #2
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JK **Checked By:** jrs

TRIAXIAL COMPRESSION TEST 5/30/2011
Unconsolidated Undrained 12:14 PM

Date:			
Client:	USACE W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing Request NO. 3		
Project No.:	BL-10-10065		
Location:	ND RRCS, MN, Brenna Formation		
Depth:	30-32'	**Sample Number:**	Boring11-107MU, #2
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	5" Thinwall, Bottom of sample		
Specific Gravity=2.760	**LL=**52	**PL=**21	**PI=**31
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	161.360	161.360
Moisture content: Dry soil+tare, gms.	126.140	126.140
Moisture content: Tare, gms.	30.570	30.570
Moisture, %	36.9	36.9
Moist specimen weight, gms.	131.2	
Diameter, in.	1.40	
Area, in.^{2}	1.54	
Height, in.	2.80	
Wet Density, pcf	115.6	
Dry density, pcf	84.5	
Void ratio	1.0393	
Saturation, %	97.9	

Test Readings for Specimen No. 1

Cell pressure = 0.500 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 2.561 tsf **at reading no.** 12
Ult. Stress = 1.958 tsf **at reading no.** 22

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0063	0.780	0.0	0.0	0.000	0.500	0.500	1.00	0.500	0.000
1	0.0170	4.690	3.9	0.4	0.182	0.500	0.682	1.36	0.591	0.091
2	0.0300	12.690	11.9	0.8	0.552	0.500	1.052	2.10	0.776	0.276
3	0.0436	19.800	19.0	1.3	0.877	0.500	1.377	2.75	0.938	0.438
4	0.0573	23.860	23.1	1.8	1.058	0.500	1.558	3.12	1.029	0.529
5	0.0710	28.800	28.0	2.3	1.278	0.500	1.778	3.56	1.139	0.639
6	0.0839	34.600	33.8	2.8	1.536	0.500	2.036	4.07	1.268	0.768
7	0.0983	40.680	39.9	3.3	1.802	0.500	2.302	4.60	1.401	0.901
8	0.1118	45.680	44.9	3.8	2.018	0.500	2.518	5.04	1.509	1.009
9	0.1254	48.980	48.2	4.2	2.156	0.500	2.656	5.31	1.578	1.078
10	0.1392	52.790	52.0	4.7	2.314	0.500	2.814	5.63	1.657	1.157
11	0.1530	56.180	55.4	5.2	2.452	0.500	2.952	5.90	1.726	1.226
12	0.1666	58.930	58.2	5.7	2.561	0.500	3.061	6.12	1.780	1.280
13	0.1930	58.440	57.7	6.7	2.514	0.500	3.014	6.03	1.757	1.257
14	0.2202	56.390	55.6	7.6	2.399	0.500	2.899	5.80	1.700	1.200
15	0.2476	55.390	54.6	8.6	2.331	0.500	2.831	5.66	1.666	1.166
16	0.2751	54.590	53.8	9.6	2.272	0.500	2.772	5.54	1.636	1.136
17	0.3019	53.220	52.4	10.5	2.191	0.500	2.691	5.38	1.596	1.096
18	0.3289	52.270	51.5	11.5	2.128	0.500	2.628	5.26	1.564	1.064
19	0.3566	51.780	51.0	12.5	2.084	0.500	2.584	5.17	1.542	1.042
20	0.3834	51.300	50.5	13.4	2.042	0.500	2.542	5.08	1.521	1.021
21	0.3976	50.690	49.9	14.0	2.006	0.500	2.506	5.01	1.503	1.003
22	0.4257	50.080	49.3	15.0	1.958	0.500	2.458	4.92	1.479	0.979

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	159.030	159.030
Moisture content: Dry soil+tare, gms.	122.660	122.660
Moisture content: Tare, gms.	30.680	30.680
Moisture, %	39.5	39.5
Moist specimen weight, gms.	128.9	
Diameter, in.	1.40	
Area, in.²	1.53	
Height, in.	2.81	
Wet Density, pcf	114.3	
Dry density, pcf	81.9	
Void ratio	1.1037	
Saturation, %	98.9	

Test Readings for Specimen No. 2

Cell pressure = 1.000 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.990 tsf at reading no. 11

Ult. Stress = 1.746 tsf at reading no. 22

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0063	1.940	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	0.0155	5.580	3.6	0.3	0.171	1.000	1.171	1.17	1.085	0.085
2	0.0283	7.040	5.1	0.8	0.238	1.000	1.238	1.24	1.119	0.119
3	0.0421	15.100	13.2	1.3	0.611	1.000	1.611	1.61	1.306	0.306
4	0.0558	20.680	18.7	1.8	0.866	1.000	1.866	1.87	1.433	0.433
5	0.0690	25.410	23.5	2.2	1.079	1.000	2.079	2.08	1.540	0.540
6	0.0822	28.960	27.0	2.7	1.237	1.000	2.237	2.24	1.618	0.618
7	0.0964	34.330	32.4	3.2	1.475	1.000	2.475	2.47	1.737	0.737
8	0.1100	37.320	35.4	3.7	1.603	1.000	2.603	2.60	1.801	0.801
9	0.1236	41.350	39.4	4.2	1.776	1.000	2.776	2.78	1.888	0.888
10	0.1370	44.980	43.0	4.7	1.930	1.000	2.930	2.93	1.965	0.965
11	0.1503	46.540	44.6	5.1	1.990	1.000	2.990	2.99	1.995	0.995
12	0.1638	46.410	44.5	5.6	1.974	1.000	2.974	2.97	1.987	0.987
13	0.1901	42.960	41.0	6.6	1.803	1.000	2.803	2.80	1.902	0.902
14	0.2170	42.990	41.1	7.5	1.786	1.000	2.786	2.79	1.893	0.893
15	0.2445	43.210	41.3	8.5	1.777	1.000	2.777	2.78	1.888	0.888
16	0.2711	43.940	42.0	9.4	1.789	1.000	2.789	2.79	1.895	0.895
17	0.2984	44.360	42.4	10.4	1.788	1.000	2.788	2.79	1.894	0.894
18	0.3255	45.120	43.2	11.4	1.800	1.000	2.800	2.80	1.900	0.900
19	0.3526	45.310	43.4	12.3	1.788	1.000	2.788	2.79	1.894	0.894
20	0.3796	45.500	43.6	13.3	1.776	1.000	2.776	2.78	1.888	0.888
21	0.3933	45.550	43.6	13.8	1.769	1.000	2.769	2.77	1.884	0.884
22	0.4258	45.590	43.7	15.0	1.746	1.000	2.746	2.75	1.873	0.873

Parameters for Specimen No. 3

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	155.840	155.840
Moisture content: Dry soil+tare, gms.	119.890	119.890
Moisture content: Tare, gms.	30.290	30.290
Moisture, %	40.1	40.1
Moist specimen weight, gms.	126.3	
Diameter, in.	1.39	
Area, in.²	1.52	
Height, in.	2.80	
Wet Density, pcf	113.1	
Dry density, pcf	80.7	
Void ratio	1.1347	
Saturation, %	97.6	

Test Readings for Specimen No. 3

Cell pressure = 2.000 tsf

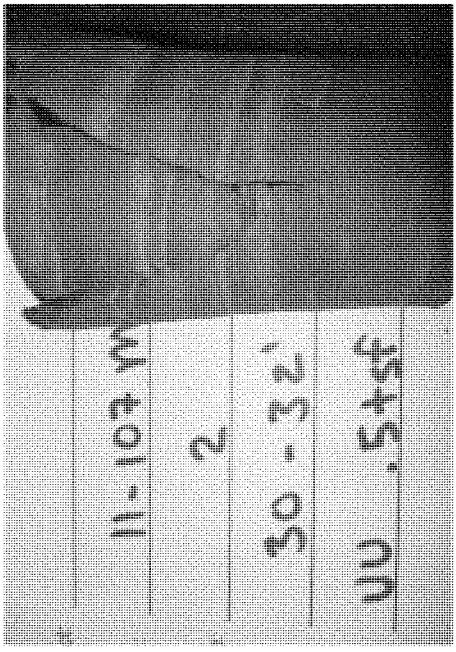
Back pressure = 0.000 tsf

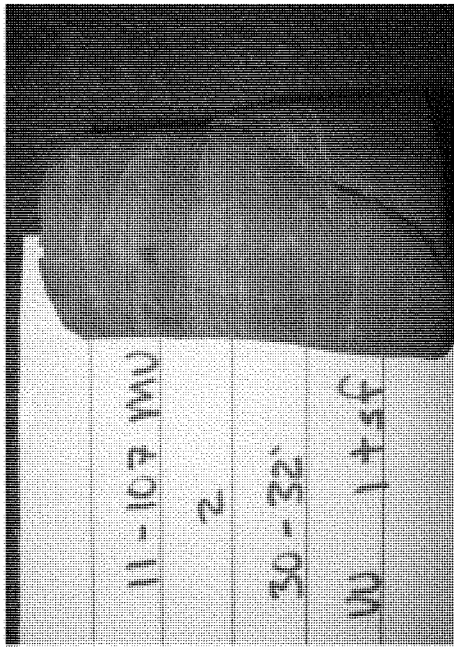
Strain rate, %/min. = 1.00

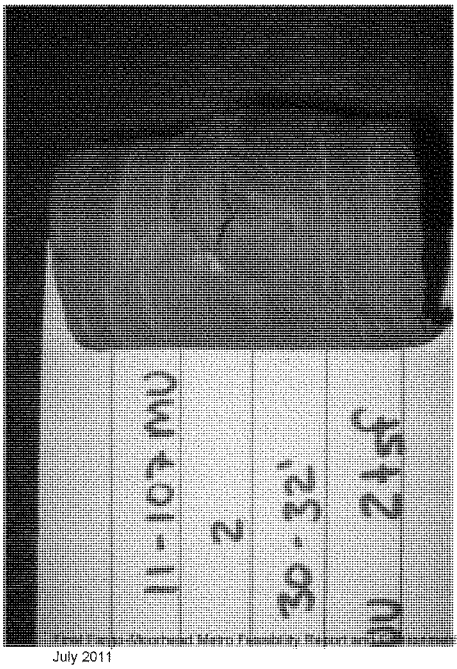
Peak Stress = 2.127 tsf at reading no. 8

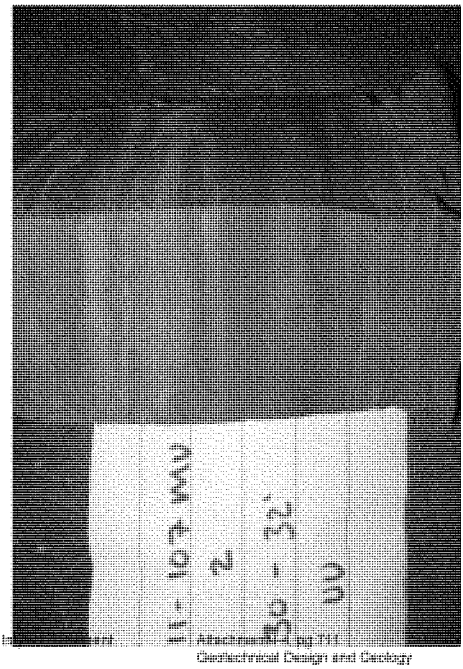
Ult. Stress = 1.766 tsf at reading no. 22

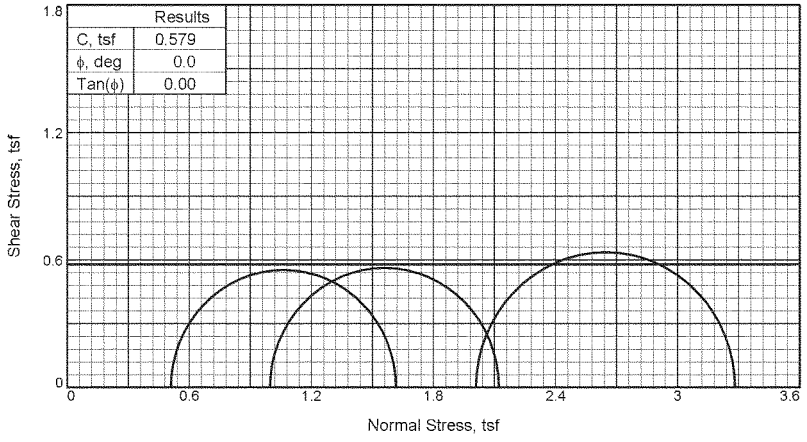
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0064	3.870	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	0.0152	14.270	10.4	0.3	0.492	2.000	2.492	1.25	2.246	0.246
2	0.0288	21.690	17.8	0.8	0.839	2.000	2.839	1.42	2.419	0.419
3	0.0427	27.640	23.8	1.3	1.113	2.000	3.113	1.56	2.557	0.557
4	0.0560	34.420	30.6	1.8	1.424	2.000	3.424	1.71	2.712	0.712
5	0.0695	40.190	36.3	2.3	1.684	2.000	3.684	1.84	2.842	0.842
6	0.0833	44.340	40.5	2.7	1.868	2.000	3.868	1.93	2.934	0.934
7	0.0967	49.250	45.4	3.2	2.084	2.000	4.084	2.04	3.042	1.042
8	0.1101	50.410	46.5	3.7	2.127	2.000	4.127	2.06	3.063	1.063
9	0.1247	50.630	46.8	4.2	2.125	2.000	4.125	2.06	3.063	1.063
10	0.1381	45.740	41.9	4.7	1.893	2.000	3.893	1.95	2.947	0.947
11	0.1510	44.900	41.0	5.2	1.846	2.000	3.846	1.92	2.923	0.923
12	0.1645	44.740	40.9	5.6	1.830	2.000	3.830	1.91	2.915	0.915
13	0.1911	44.480	40.6	6.6	1.800	2.000	3.800	1.90	2.900	0.900
14	0.2171	44.730	40.9	7.5	1.793	2.000	3.793	1.90	2.896	0.896
15	0.2442	45.300	41.4	8.5	1.799	2.000	3.799	1.90	2.899	0.899
16	0.2715	45.490	41.6	9.5	1.788	2.000	3.788	1.89	2.894	0.894
17	0.2988	45.800	41.9	10.4	1.782	2.000	3.782	1.89	2.891	0.891
18	0.3258	46.230	42.4	11.4	1.781	2.000	3.781	1.89	2.890	0.890
19	0.3520	46.720	42.9	12.3	1.782	2.000	3.782	1.89	2.891	0.891
20	0.3798	47.120	43.3	13.3	1.779	2.000	3.779	1.89	2.889	0.889
21	0.3936	47.420	43.6	13.8	1.781	2.000	3.781	1.89	2.890	0.890
22	0.4273	47.660	43.8	15.0	1.766	2.000	3.766	1.88	2.883	0.883

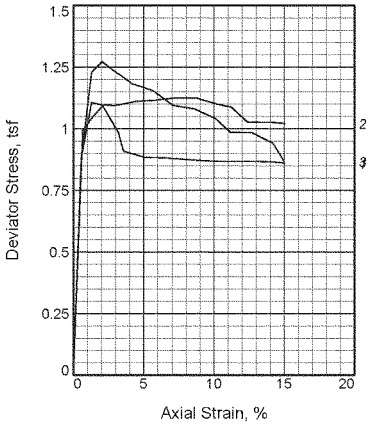

11-107 MU
2
30-32'
UU .5+sf


11-107 MU
2
30-32'
UU 1+sf


11-107 MU
2
30-32'
UU 2+sf


11-107 MU
2
30-32'
UU





Sample No.		1	2	3
Initial	Water Content, %	53.3	51.6	53.2
	Dry Density, pcf	68.5	69.6	68.5
	Saturation, %	98.1	97.5	97.9
	Void Ratio	1.4759	1.4381	1.4774
	Diameter, in.	1.41	1.41	1.41
	Height, in.	2.80	2.82	2.81
At Test	Water Content, %	54.3	52.9	54.4
	Dry Density, pcf	68.5	69.6	68.5
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.4759	1.4381	1.4774
	Diameter, in.	1.41	1.41	1.41
	Height, in.	2.80	2.82	2.81
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.51	1.00	2.01
Peak Stress, tsf		1.11	1.13	1.27
Ult. Stress, tsf		0.86	1.02	0.87
σ_1 Failure, tsf		1.62	2.12	3.28
σ_3 Failure, tsf		0.51	1.00	2.01

Type of Test:
Unconsolidated Undrained
Sample Type: Undisturbed, 5" Thinwall, Bottom
Description: FAT CLAY, brown (CH)

LL= 95 **PL=** 28 **PI=** 67
Specific Gravity= 2.718
Remarks:

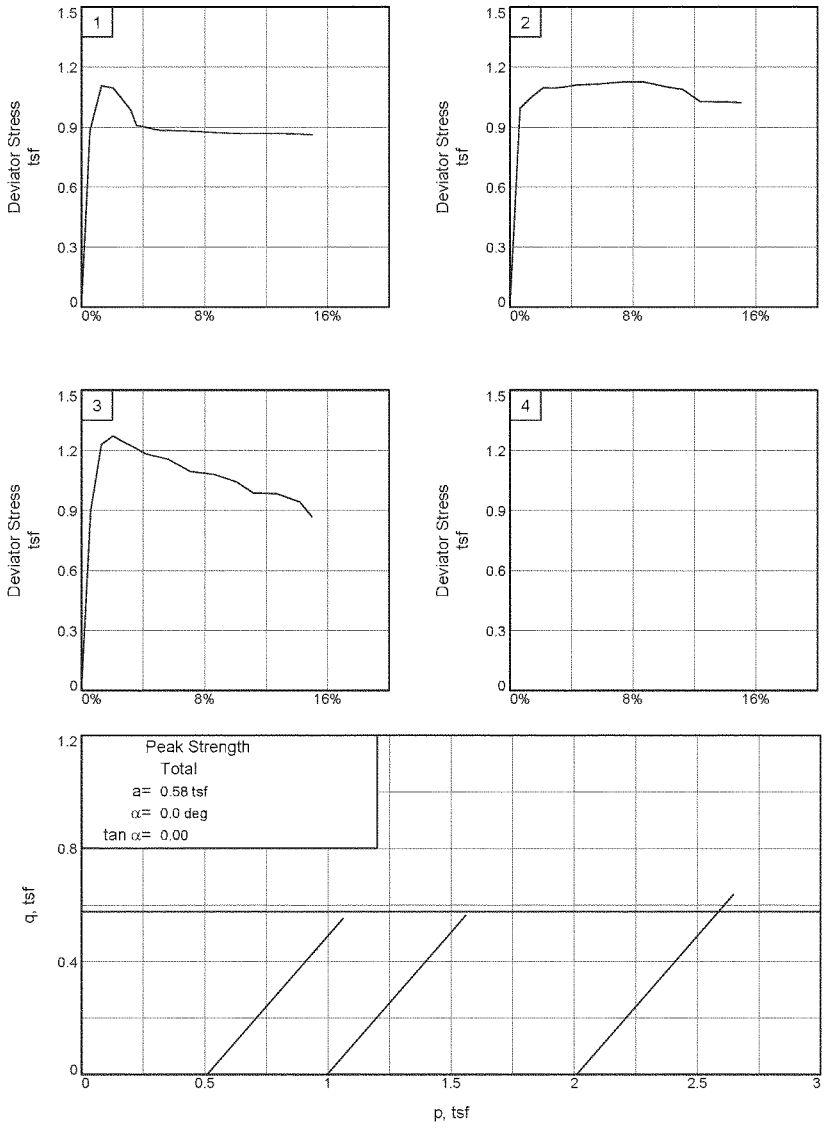
Figure UU Triax ASTM D 2850

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Sheyenne River, Brenna Formation
Sample Number: Boring11-110MU, #2 **Depth:** 35-37'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Tested By: JK **Checked By:** JS



Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: Sheyenne River, Brenna Formation **Depth:** 35-37' **Sample No.:** Boring11-110MU, #2
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JK **Checked By:** JS

TRIAXIAL COMPRESSION TEST 4/26/2011
Unconsolidated Undrained 8:12 AM

Date:			
Client:	W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing		
Project No.:	BL-10-10065		
Location:	Sheyenne River, Brenna Formation		
Depth:	35-37'	**Sample Number:**	Boring11-110MU, #2
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	Undisturbed, 5" Thinwall, Bottom		
Specific Gravity=2.718	**LL=**95	**PL=**28	**PI=**67
Test Method:	COE uniform strain		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	152.140		152.140
Moisture content: Dry soil+tare, gms.	110.130		110.130
Moisture content: Tare, gms.	31.260		31.260
Moisture, %	53.3	54.3	53.3
Moist specimen weight, gms.	121.1		
Diameter, in.	1.41	1.41	
Area, in.²	1.57	1.57	
Height, in.	2.80	2.80	
Net decrease in height, in.		0.00	
Wet Density, pcf	105.0	105.7	
Dry density, pcf	68.5	68.5	
Void ratio	1.4759	1.4759	
Saturation, %	98.1	100.0	

Test Readings for Specimen No. 1

Cell pressure = 0.510 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 1.106 tsf **at reading no.** 2
Ult. Stress = 0.860 tsf **at reading no.** 13

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0076	0.000	0.0	0.0	0.000	0.510	0.510	1.00	0.510	0.000
1	0.0232	19.340	19.3	0.6	0.882	0.510	1.392	2.73	0.951	0.441
2	0.0440	24.440	24.4	1.3	1.106	0.510	1.616	3.17	1.063	0.553
3	0.0650	24.400	24.4	2.1	1.096	0.510	1.606	3.15	1.058	0.548
4	0.0975	22.150	22.2	3.2	0.983	0.510	1.493	2.93	1.001	0.491
5	0.1077	20.560	20.6	3.6	0.909	0.510	1.419	2.78	0.964	0.454
6	0.1498	20.320	20.3	5.1	0.884	0.510	1.394	2.73	0.952	0.442
7	0.1915	20.580	20.6	6.6	0.882	0.510	1.392	2.73	0.951	0.441
8	0.2532	20.850	20.9	8.8	0.872	0.510	1.382	2.71	0.946	0.436
9	0.2946	21.090	21.1	10.3	0.868	0.510	1.378	2.70	0.944	0.434
10	0.3259	21.350	21.4	11.4	0.868	0.510	1.378	2.70	0.944	0.434
11	0.3663	21.710	21.7	12.8	0.868	0.510	1.378	2.70	0.944	0.434
12	0.4074	22.020	22.0	14.3	0.865	0.510	1.375	2.70	0.943	0.433
13	0.4276	22.080	22.1	15.0	0.860	0.510	1.370	2.69	0.940	0.430

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	151.720		151.720
Moisture content: Dry soil+tare, gms.	110.630		110.630
Moisture content: Tare, gms.	30.950		30.950
Moisture, %	51.6	52.9	51.6
Moist specimen weight, gms.	121.1		
Diameter, in.	1.41	1.41	
Area, in.²	1.55	1.55	
Height, in.	2.82	2.82	
Net decrease in height, in.		0.00	
Wet Density, pcf	105.5	106.4	
Dry density, pcf	69.6	69.6	
Void ratio	1.4381	1.4381	
Saturation, %	97.5	100.0	

Test Readings for Specimen No. 2

Cell pressure = 0.997 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.125 tsf at reading no. 9

Ult. Stress = 1.022 tsf at reading no. 14

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0067	1.060	0.0	0.0	0.000	0.997	0.997	1.00	0.997	0.000
1	0.0255	22.640	21.6	0.7	0.994	0.997	1.991	2.00	1.494	0.497
2	0.0461	24.010	23.0	1.4	1.049	0.997	2.046	2.05	1.522	0.525
3	0.0673	25.230	24.2	2.2	1.097	0.997	2.094	2.10	1.545	0.548
4	0.0885	25.370	24.3	2.9	1.095	0.997	2.092	2.10	1.544	0.547
5	0.1095	25.710	24.7	3.6	1.101	0.997	2.098	2.10	1.548	0.551
6	0.1302	26.110	25.1	4.4	1.111	0.997	2.108	2.11	1.552	0.555
7	0.1712	26.610	25.6	5.8	1.116	0.997	2.113	2.12	1.555	0.558
8	0.2111	27.220	26.2	7.3	1.125	0.997	2.122	2.13	1.560	0.563

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
9	0.2522	27.640	26.6	8.7	1.125	0.997	2.122	2.13	1.560	0.563
10	0.2939	27.480	26.4	10.2	1.100	0.997	2.097	2.10	1.547	0.550
11	0.3240	27.490	26.4	11.3	1.088	0.997	2.085	2.09	1.541	0.544
12	0.3556	26.340	25.3	12.4	1.027	0.997	2.024	2.03	1.511	0.514
13	0.4063	26.820	25.8	14.2	1.025	0.997	2.022	2.03	1.510	0.513
14	0.4300	27.000	25.9	15.0	1.022	0.997	2.019	2.03	1.508	0.511

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	149.930		149.930
Moisture content: Dry soil+tare, gms.	108.380		108.380
Moisture content: Tare, gms.	30.320		30.320
Moisture, %	53.2	54.4	53.2
Moist specimen weight, gms.	120.0		
Diameter, in.	1.41	1.41	
Area, in.²	1.55	1.55	
Height, in.	2.81	2.81	
Net decrease in height, in.		0.00	
Wet Density, pcf	104.9	105.7	
Dry density, pcf	68.5	68.5	
Void ratio	1.4774	1.4774	
Saturation, %	97.9	100.0	

Test Readings for Specimen No. 3

Cell pressure = 2.010 tsf

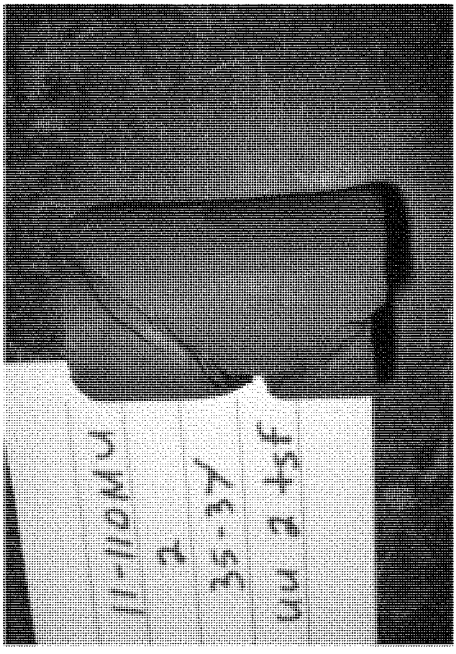
Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.272 tsf at reading no. 3

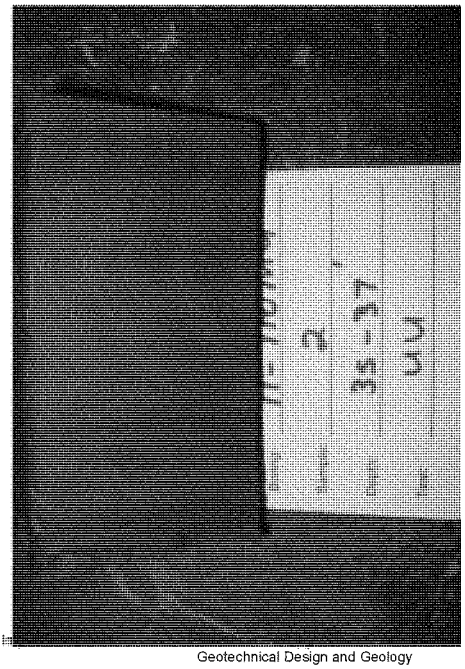
Ult. Stress = 0.868 tsf at reading no. 14

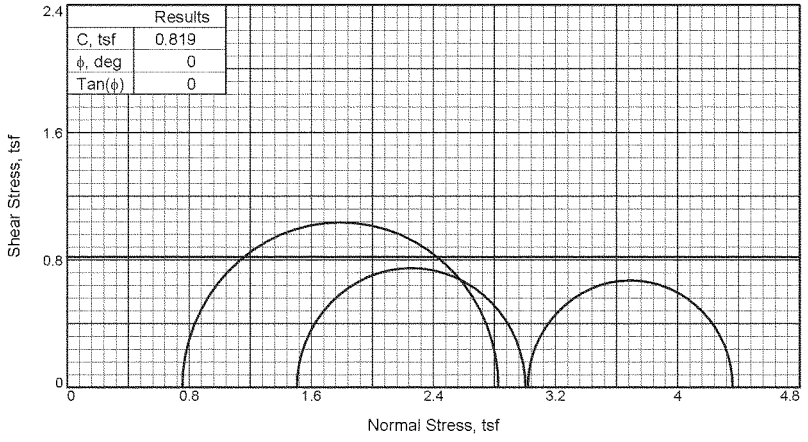
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0064	4.170	0.0	0.0	0.000	2.010	2.010	1.00	2.010	0.000
1	0.0232	23.610	19.4	0.6	0.896	2.010	2.906	1.45	2.458	0.448
2	0.0430	31.030	26.9	1.3	1.229	2.010	3.239	1.61	2.625	0.615
3	0.0637	32.180	28.0	2.0	1.272	2.010	3.282	1.63	2.646	0.636
4	0.0839	31.690	27.5	2.8	1.241	2.010	3.251	1.62	2.630	0.620
5	0.1036	31.270	27.1	3.5	1.213	2.010	3.223	1.60	2.617	0.607
6	0.1236	30.790	26.6	4.2	1.183	2.010	3.193	1.59	2.601	0.591
7	0.1655	30.570	26.4	5.7	1.155	2.010	3.165	1.57	2.587	0.577
8	0.2060	29.570	25.4	7.1	1.094	2.010	3.104	1.54	2.557	0.547
9	0.2480	29.660	25.5	8.6	1.080	2.010	3.090	1.54	2.550	0.540
10	0.2903	29.170	25.0	10.1	1.042	2.010	3.052	1.52	2.531	0.521
11	0.3204	28.110	23.9	11.2	0.986	2.010	2.996	1.49	2.503	0.493
12	0.3629	28.470	24.3	12.7	0.984	2.010	2.994	1.49	2.502	0.492
13	0.4047	27.830	23.7	14.2	0.941	2.010	2.951	1.47	2.481	0.471
14	0.4268	26.180	22.0	15.0	0.868	2.010	2.878	1.43	2.444	0.434

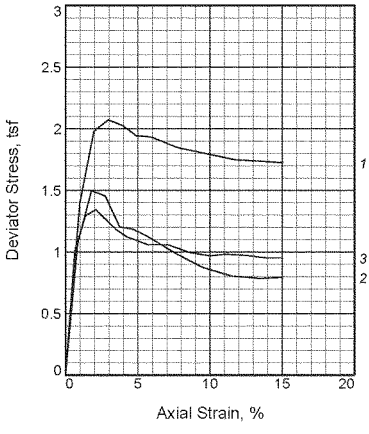

11-110MJ
2
35-37'
UU 2 tsf

11-110MJ
2
35-37'
UU 1 tsf

11-110MJ
2
35-37'
UU 0.5 tsf


11-110MJ
2
35-37'
UU





Sample No.		1	2	3
Initial	Water Content, %	40.8	55.1	59.2
	Dry Density, pcf	80.3	67.4	64.6
	Saturation, %	100.0	98.9	99.1
	Void Ratio	1.1059	1.5087	1.6180
	Diameter, in.	1.40	1.41	1.41
	Height, in.	2.80	2.80	2.80
At Test	Water Content, %	40.8	55.1	59.2
	Dry Density, pcf	80.3	67.4	64.6
	Saturation, %	100.0	98.9	99.1
	Void Ratio	1.1059	1.5087	1.6180
	Diameter, in.	1.40	1.41	1.41
	Height, in.	2.80	2.80	2.80
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.76	1.51	3.02
Peak Stress, tsf		2.07	1.50	1.34
Ult. Stress, tsf		1.72	0.78	0.95
σ_1 Failure, tsf		2.83	3.00	4.36
σ_3 Failure, tsf		0.76	1.51	3.02

Type of Test:
Unconsolidated Undrained
Sample Type: Undisturbed, 5" Thinwall, Bottom
Description: FAT CLAY, brown (CH)

LL= 86 **PL=** 22 **PI=** 64
Specific Gravity= 2.71
Remarks:

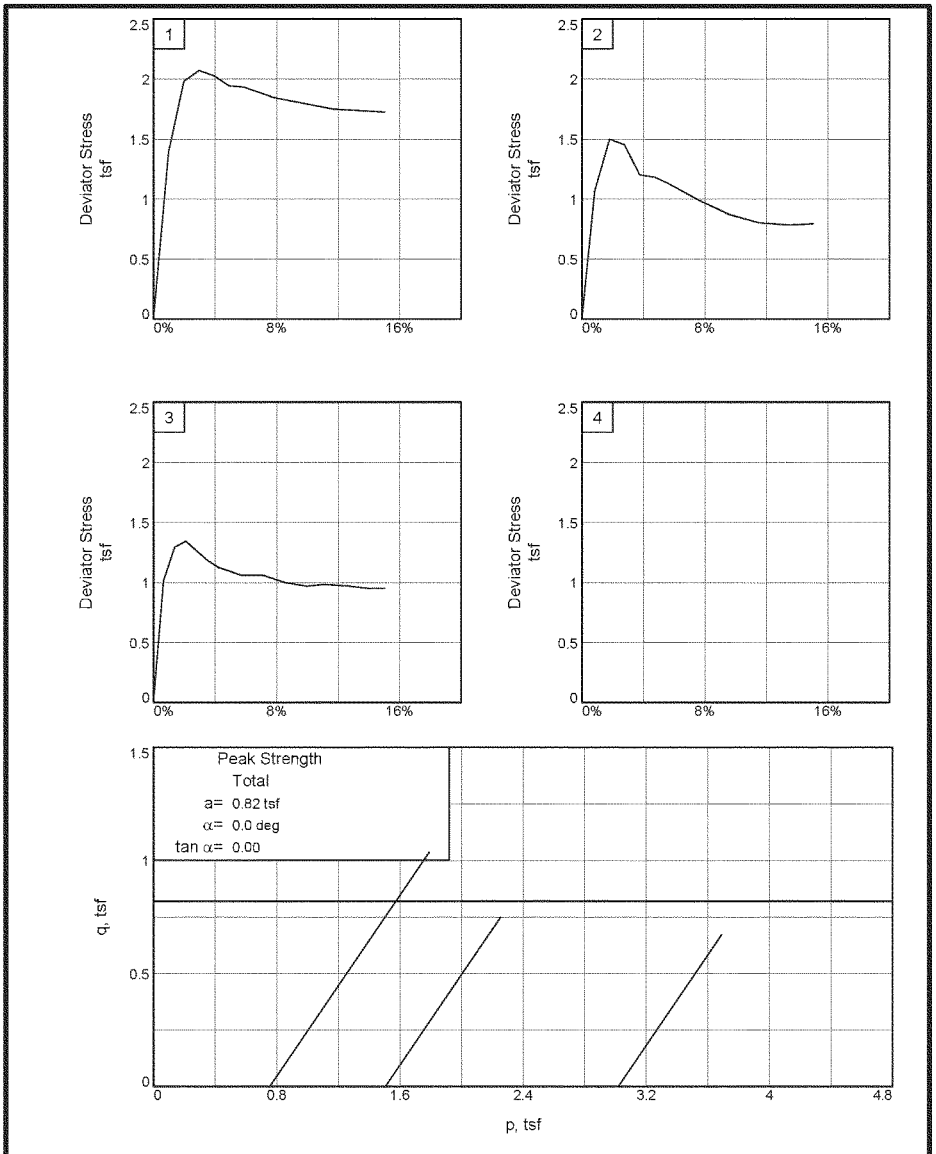
Figure UU Triax ASTM D 2850

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Sheyenne River, Brenna Formation
Sample Number: Boring11-110MU, #3 **Depth:** 48-50'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Tested By: JK **Checked By:** JS



Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: Sheyenne River, Brenna Formation **Depth:** 48-50' **Sample No.:** Boring11-110MU, #3
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JK **Checked By:** JS

TRIAXIAL COMPRESSION TEST 4/26/2011
Unconsolidated Undrained 8:13 AM

Date:			
Client:	W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing		
Project No.:	BL-10-10065		
Location:	Sheyenne River, Brenna Formation		
Depth:	48-50'	**Sample Number:**	Boring11-110MU, #3
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	Undisturbed, 5" Thinwall, Bottom		
Specific Gravity=2.71	**LL=86**	**PL=22**	**PI=64**
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	156.960	156.960
Moisture content: Dry soil+tare, gms.	120.220	120.220
Moisture content: Tare, gms.	30.230	30.230
Moisture, %	40.8	40.8
Moist specimen weight, gms.	127.5	
Diameter, in.	1.40	
Area, in.^{2}	1.53	
Height, in.	2.80	
Wet Density, pcf	113.1	
Dry density, pcf	80.3	
Void ratio	1.1059	
Saturation, %	100.0	

Test Readings for Specimen No. 1

Cell pressure = 0.755 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 2.072 tsf **at reading no.** 3
Ult. Stress = 1.725 tsf **at reading no.** 11

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0085	0.630	0.0	0.0	0.000	0.755	0.755	1.00	0.755	0.000
1	0.0360	30.600	30.0	1.0	1.392	0.755	2.147	2.84	1.451	0.696
2	0.0637	43.730	43.1	2.0	1.982	0.755	2.737	3.62	1.746	0.991
3	0.0911	46.140	45.5	3.0	2.072	0.755	2.827	3.74	1.791	1.036
4	0.1187	45.620	45.0	3.9	2.027	0.755	2.782	3.68	1.769	1.014
5	0.1457	44.220	43.6	4.9	1.944	0.755	2.699	3.58	1.727	0.972
6	0.1726	44.430	43.8	5.9	1.934	0.755	2.689	3.56	1.722	0.967
7	0.2275	43.300	42.7	7.8	1.845	0.755	2.600	3.44	1.677	0.922
8	0.2818	43.090	42.5	9.8	1.797	0.755	2.552	3.38	1.654	0.899
9	0.3356	42.870	42.2	11.7	1.750	0.755	2.505	3.32	1.630	0.875
10	0.3900	43.480	42.8	13.6	1.736	0.755	2.491	3.30	1.623	0.868
11	0.4290	43.910	43.3	15.0	1.725	0.755	2.480	3.28	1.617	0.862

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	149.130	149.130
Moisture content: Dry soil+tare, gms.	107.190	107.190
Moisture content: Tare, gms.	31.030	31.030
Moisture, %	55.1	55.1
Moist specimen weight, gms.	119.3	
Diameter, in.	1.41	
Area, in.^{2}	1.55	
Height, in.	2.80	
Wet Density, pcf	104.6	
Dry density, pcf	67.4	
Void ratio	1.5087	
Saturation, %	98.9	

Test Readings for Specimen No. 2

Cell pressure = 1.506 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.498 tsf at reading no. 2

Ult. Stress = 0.785 tsf at reading no. 10

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	2.860	0.0	0.0	0.000	1.506	1.506	1.00	1.506	0.000
1	0.0301	26.030	23.2	0.8	1.067	1.506	2.573	1.71	2.039	0.533
2	0.0570	35.700	32.8	1.8	1.498	1.506	3.004	1.99	2.255	0.749
3	0.0839	35.060	32.2	2.8	1.454	1.506	2.960	1.97	2.233	0.727
4	0.1120	29.750	26.9	3.8	1.202	1.506	2.708	1.80	2.107	0.601
5	0.1390	29.600	26.7	4.7	1.183	1.506	2.689	1.79	2.098	0.592
6	0.1659	28.590	25.7	5.7	1.127	1.506	2.633	1.75	2.069	0.563
7	0.2207	25.930	23.1	7.6	0.990	1.506	2.496	1.66	2.001	0.495
8	0.2746	23.610	20.8	9.6	0.871	1.506	2.377	1.58	1.942	0.436
9	0.3290	22.420	19.6	11.5	0.804	1.506	2.310	1.53	1.908	0.402
10	0.3836	22.380	19.5	13.5	0.785	1.506	2.291	1.52	1.898	0.392
11	0.4280	23.000	20.1	15.0	0.795	1.506	2.301	1.53	1.903	0.397

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	147.910	147.910
Moisture content: Dry soil+tare, gms.	104.490	104.490
Moisture content: Tare, gms.	31.130	31.130
Moisture, %	59.2	59.2
Moist specimen weight, gms.	117.4	
Diameter, in.	1.41	
Area, in.²	1.55	
Height, in.	2.80	
Wet Density, pcf	102.9	
Dry density, pcf	64.6	
Void ratio	1.6180	
Saturation, %	99.1	

Test Readings for Specimen No. 3

Cell pressure = 3.019 tsf

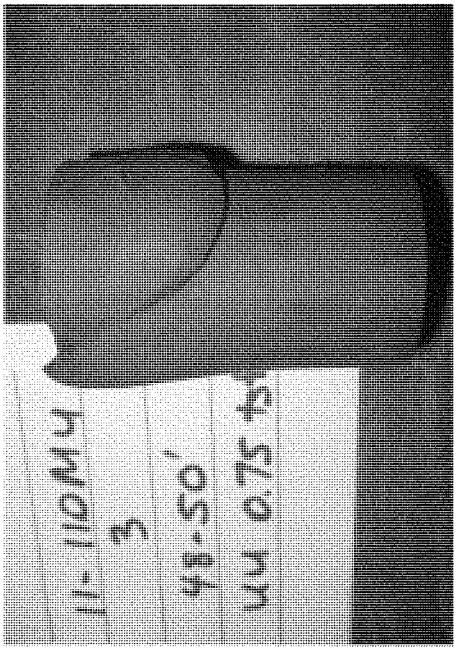
Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.343 tsf at reading no. 3

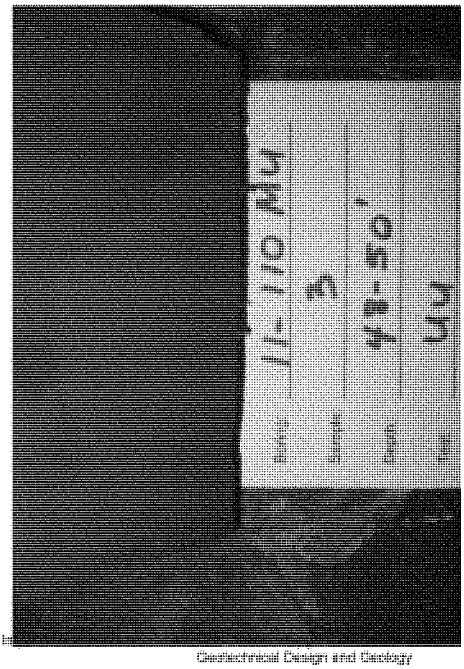
Ult. Stress = 0.952 tsf at reading no. 14

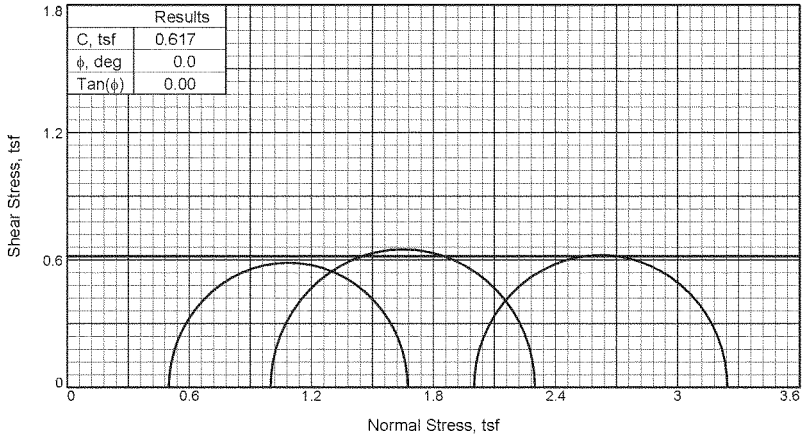
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0063	6.460	0.0	0.0	0.000	3.019	3.019	1.00	3.019	0.000
1	0.0244	28.410	22.0	0.6	1.011	3.019	4.030	1.33	3.525	0.506
2	0.0450	34.750	28.3	1.4	1.294	3.019	4.313	1.43	3.666	0.647
3	0.0650	36.040	29.6	2.1	1.343	3.019	4.362	1.44	3.690	0.671
4	0.0851	34.480	28.0	2.8	1.263	3.019	4.282	1.42	3.650	0.631
5	0.1049	32.890	26.4	3.5	1.183	3.019	4.202	1.39	3.610	0.591
6	0.1252	31.760	25.3	4.2	1.123	3.019	4.142	1.37	3.581	0.562
7	0.1655	30.690	24.2	5.7	1.060	3.019	4.079	1.35	3.549	0.530
8	0.2052	31.060	24.6	7.1	1.060	3.019	4.079	1.35	3.549	0.530
9	0.2458	29.990	23.5	8.6	0.998	3.019	4.017	1.33	3.518	0.499
10	0.2857	29.660	23.2	10.0	0.969	3.019	3.988	1.32	3.503	0.484
11	0.3161	30.270	23.8	11.1	0.982	3.019	4.001	1.33	3.510	0.491
12	0.3567	30.420	24.0	12.5	0.972	3.019	3.991	1.32	3.505	0.486
13	0.3969	30.300	23.8	13.9	0.951	3.019	3.970	1.32	3.495	0.476
14	0.4270	30.610	24.2	15.0	0.952	3.019	3.971	1.32	3.495	0.476

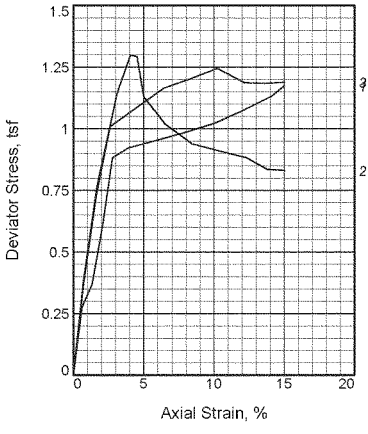

11-110 MW
3
48-50'
WW 0.75 +5

11-110 MW
3
48-50'
WW 1.5 +5

11-110 MW
3
48-50'
WW 3 +5


11-110 MW
3
48-50'
WW





Sample No.		1	2	3
Initial	Water Content, %	48.5	51.6	49.6
	Dry Density, pcf	72.9	70.4	71.8
	Saturation, %	99.7	100.0	99.4
	Void Ratio	1.3118	1.3939	1.3487
	Diameter, in.	1.40	1.39	1.41
	Height, in.	2.80	2.80	2.81
At Test	Water Content, %	48.5	51.6	49.6
	Dry Density, pcf	72.9	70.4	71.8
	Saturation, %	99.7	100.0	99.4
	Void Ratio	1.3118	1.3939	1.3487
	Diameter, in.	1.40	1.39	1.41
	Height, in.	2.80	2.80	2.81
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.50	1.00	2.00
Peak Stress, tsf		1.17	1.30	1.25
Ult. Stress, tsf		1.17	0.83	1.19
σ_1 Failure, tsf		1.67	2.30	3.25
σ_3 Failure, tsf		0.50	1.00	2.00

Type of Test:
Unconsolidated Undrained
Sample Type: 5" Thinwall, Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 72 **PL=** 19 **PI=** 53
Specific Gravity= 2.70
Remarks:

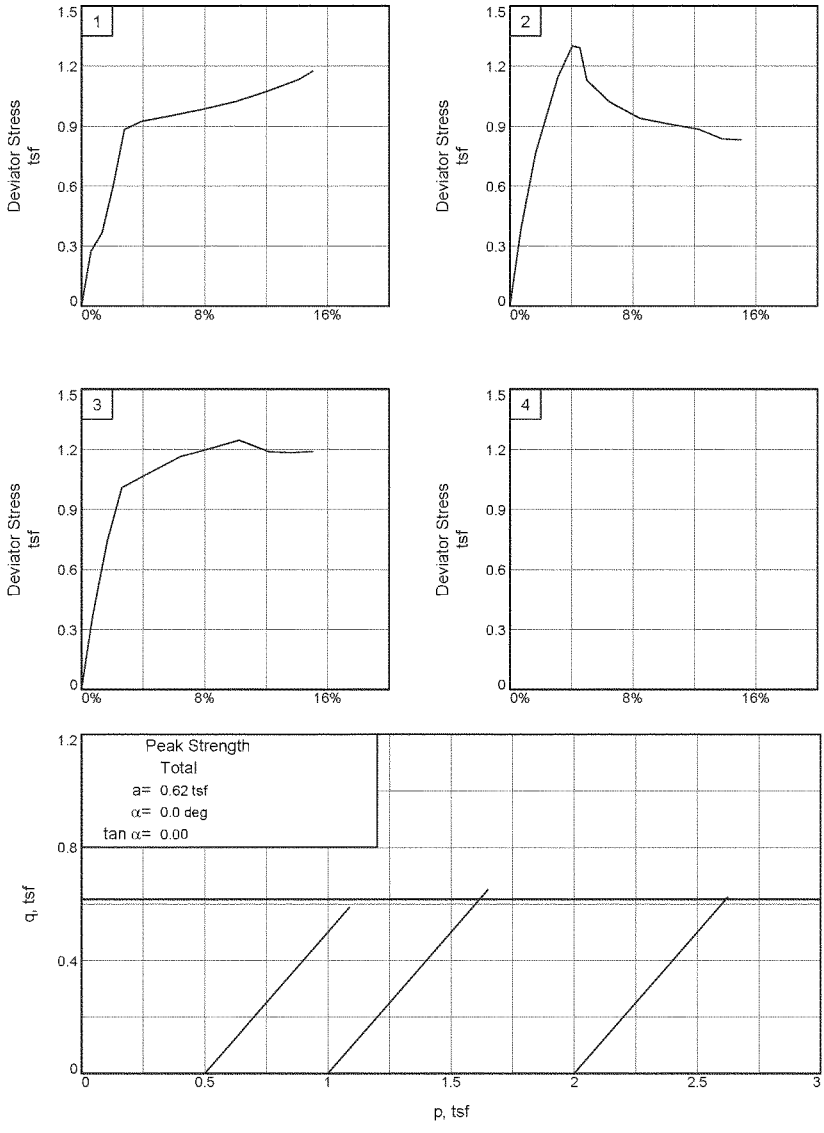
Figure UU Traix ASTM D 2850

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Location: Wild Rice, Brenna Formation
Sample Number: Boring11-118MU, #2 **Depth:** 33-35'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Tested By: JK **Checked By:** JS



Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Location: Wild Rice, Brenna Formation **Depth:** 33-35' **Sample Number:** Boring11-118MU, #2
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JK **Checked By:** JS

TRIAXIAL COMPRESSION TEST 5/15/2011
Unconsolidated Undrained 11:39 AM

Date:			
Client:	USACE W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing Request NO. 2		
Project No.:	BL-10-10065		
Location:	Wild Rice, Brenna Formation		
Depth:	33-35'	**Sample Number:**	Boring11-118MU, #2
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	5" Thinwall, Bottom of sample		
Specific Gravity=2.70	**LL=72**	**PL=19**	**PI=53**
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	152.890	152.890
Moisture content: Dry soil+tare, gms.	113.010	113.010
Moisture content: Tare, gms.	30.710	30.710
Moisture, %	48.5	48.5
Moist specimen weight, gms.	122.5	
Diameter, in.	1.40	
Area, in.^{2}	1.54	
Height, in.	2.80	
Wet Density, pcf	108.2	
Dry density, pcf	72.9	
Void ratio	1.3118	
Saturation, %	99.7	

Test Readings for Specimen No. 1

Cell pressure = 0.500 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 1.174 tsf at reading no. 11
Ult. Stress = 1.174 tsf at reading no. 11

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0065	0.630	0.0	0.0	0.000	0.500	0.500	1.00	0.500	0.000
1	0.0239	6.580	6.0	0.6	0.276	0.500	0.776	1.55	0.638	0.138
2	0.0438	8.600	8.0	1.3	0.367	0.500	0.867	1.73	0.684	0.184
3	0.0650	13.970	13.3	2.1	0.610	0.500	1.110	2.22	0.805	0.305
4	0.0845	20.070	19.4	2.8	0.883	0.500	1.383	2.77	0.941	0.441
5	0.1160	21.200	20.6	3.9	0.923	0.500	1.423	2.85	0.962	0.462
6	0.1666	22.200	21.6	5.7	0.950	0.500	1.450	2.90	0.975	0.475
7	0.2276	23.500	22.9	7.9	0.984	0.500	1.484	2.97	0.992	0.492
8	0.2882	24.980	24.4	10.1	1.023	0.500	1.523	3.05	1.011	0.511
9	0.3391	26.610	26.0	11.9	1.069	0.500	1.569	3.14	1.035	0.535
10	0.4007	28.830	28.2	14.1	1.131	0.500	1.631	3.26	1.066	0.566
11	0.4265	30.210	29.6	15.0	1.174	0.500	1.674	3.35	1.087	0.587

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	148.190	148.190
Moisture content: Dry soil+tare, gms.	108.050	108.050
Moisture content: Tare, gms.	30.270	30.270
Moisture, %	51.6	51.6
Moist specimen weight, gms.	119.8	
Diameter, in.	1.39	
Area, in.²	1.53	
Height, in.	2.80	
Wet Density, pcf	106.7	
Dry density, pcf	70.4	
Void ratio	1.3939	
Saturation, %	100.0	

Test Readings for Specimen No. 2

Cell pressure = 1.000 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.300 tsf at reading no. 4

Ult. Stress = 0.831 tsf at reading no. 12

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	2.980	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	0.0270	11.220	8.2	0.7	0.386	1.000	1.386	1.39	1.193	0.193
2	0.0536	19.490	16.5	1.7	0.766	1.000	1.766	1.77	1.383	0.383
3	0.0941	28.040	25.1	3.1	1.145	1.000	2.145	2.15	1.573	0.573
4	0.1207	31.700	28.7	4.1	1.300	1.000	2.300	2.30	1.650	0.650
5	0.1339	31.670	28.7	4.5	1.292	1.000	2.292	2.29	1.646	0.646
6	0.1469	28.190	25.2	5.0	1.130	1.000	2.130	2.13	1.565	0.565
7	0.1884	26.120	23.1	6.5	1.021	1.000	2.021	2.02	1.510	0.510
8	0.2440	24.710	21.7	8.5	0.938	1.000	1.938	1.94	1.469	0.469
9	0.2979	24.500	21.5	10.4	0.910	1.000	1.910	1.91	1.455	0.455
10	0.3520	24.320	21.3	12.3	0.883	1.000	1.883	1.88	1.441	0.441
11	0.3931	23.540	20.6	13.8	0.836	1.000	1.836	1.84	1.418	0.418

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
12	0.4279	23.710	20.7	15.0	0.831	1.000	1.831	1.83	1.415	0.415

Parameters for Specimen No. 3

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	152.490	152.490
Moisture content: Dry soil+tare, gms.	111.990	111.990
Moisture content: Tare, gms.	30.410	30.410
Moisture, %	49.6	49.6
Moist specimen weight, gms.	123.1	
Diameter, in.	1.41	
Area, in.^{2}	1.56	
Height, in.	2.81	
Wet Density, pcf	107.4	
Dry density, pcf	71.8	
Void ratio	1.3487	
Saturation, %	99.4	

Test Readings for Specimen No. 3

Cell pressure = 2.000 tsf

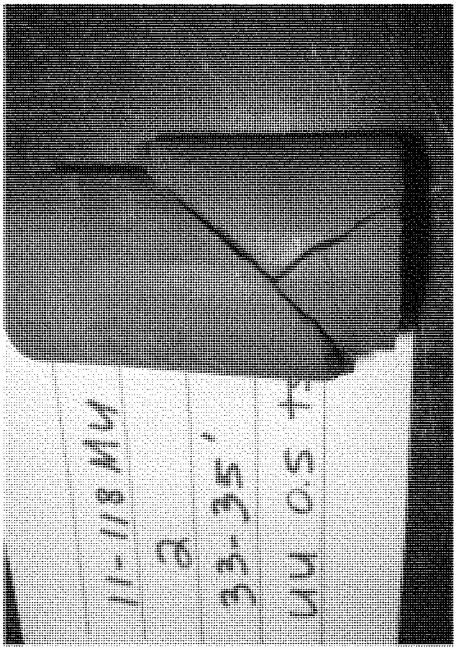
Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

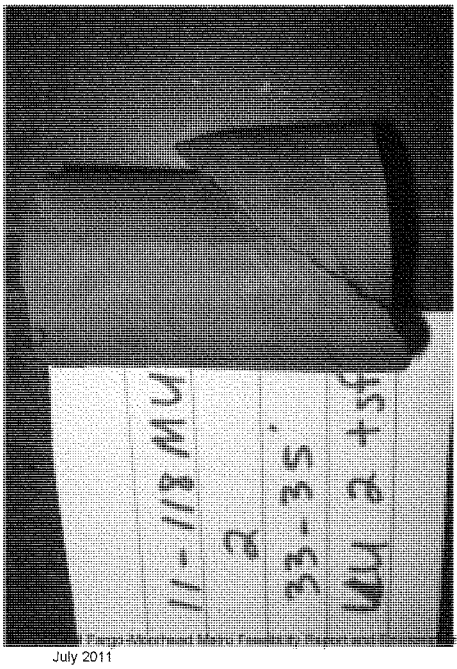
Peak Stress = 1.245 tsf at reading no. 7

Ult. Stress = 1.190 tsf at reading no. 10

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0061	4.660	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	0.0265	12.720	8.1	0.7	0.370	2.000	2.370	1.19	2.185	0.185
2	0.0530	20.930	16.3	1.7	0.740	2.000	2.740	1.37	2.370	0.370
3	0.0797	27.060	22.4	2.6	1.009	2.000	3.009	1.50	2.504	0.504
4	0.1067	28.190	23.5	3.6	1.049	2.000	3.049	1.52	2.525	0.525
5	0.1861	31.560	26.9	6.4	1.164	2.000	3.164	1.58	2.582	0.582
6	0.2401	33.040	28.4	8.3	1.203	2.000	3.203	1.60	2.601	0.601
7	0.2939	34.670	30.0	10.3	1.245	2.000	3.245	1.62	2.623	0.623
8	0.3475	33.900	29.2	12.2	1.188	2.000	3.188	1.59	2.594	0.594
9	0.3883	34.300	29.6	13.6	1.184	2.000	3.184	1.59	2.592	0.592
10	0.4281	34.940	30.3	15.0	1.190	2.000	3.190	1.59	2.595	0.595


11-118 MW4
B
33-35'
WH 0.5 +

11-118 MW4
B
33-35'
WH 1 +5#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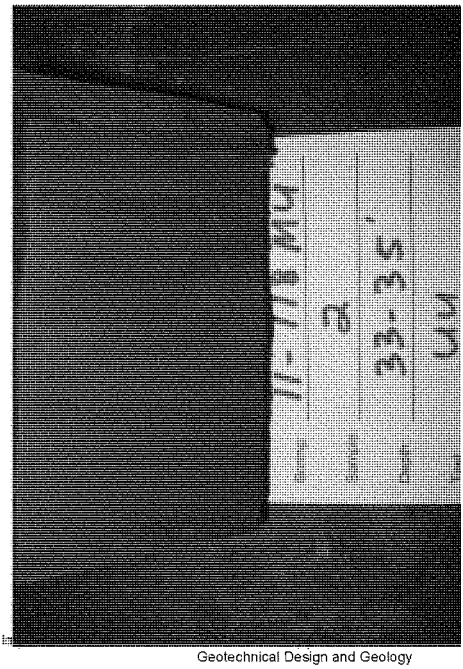
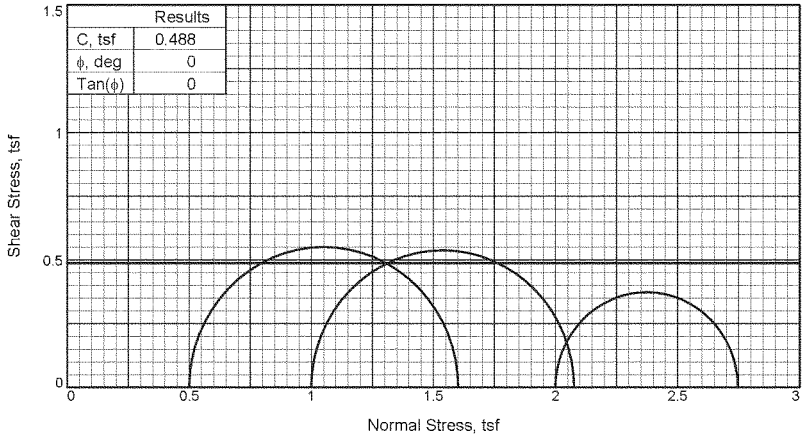
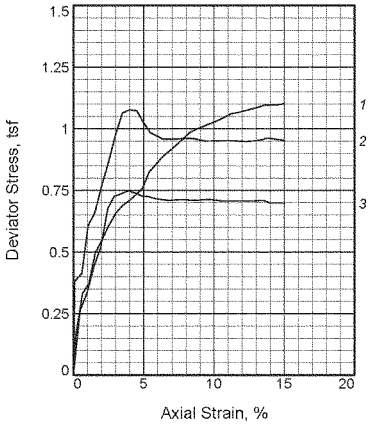
B
33-35'
WH 2 +5#


11-118 MW4
B
33-35'
WH





Sample No.		1	2	3
Initial	Water Content, %	45.2	45.8	47.1
	Dry Density, pcf	75.9	75.0	74.0
	Saturation, %	99.9	98.9	99.4
	Void Ratio	1.2235	1.2521	1.2819
	Diameter, in.	1.42	1.41	1.38
	Height, in.	2.80	2.80	2.81
At Test	Water Content, %	45.2	45.8	47.1
	Dry Density, pcf	75.9	75.0	74.0
	Saturation, %	99.9	98.9	99.4
	Void Ratio	1.2235	1.2521	1.2819
	Diameter, in.	1.42	1.41	1.38
	Height, in.	2.80	2.80	2.81
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.50	1.00	2.00
Peak Stress, tsf		1.10	1.08	0.75
Ult. Stress, tsf		1.10	0.95	0.70
σ_1 Failure, tsf		1.60	2.08	2.75
σ_3 Failure, tsf		0.50	1.00	2.00

Type of Test:
Unconsolidated Undrained
Sample Type: 5" Thinwall, Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 56 **PL=** 19 **PI=** 37
Specific Gravity= 2.704
Remarks:

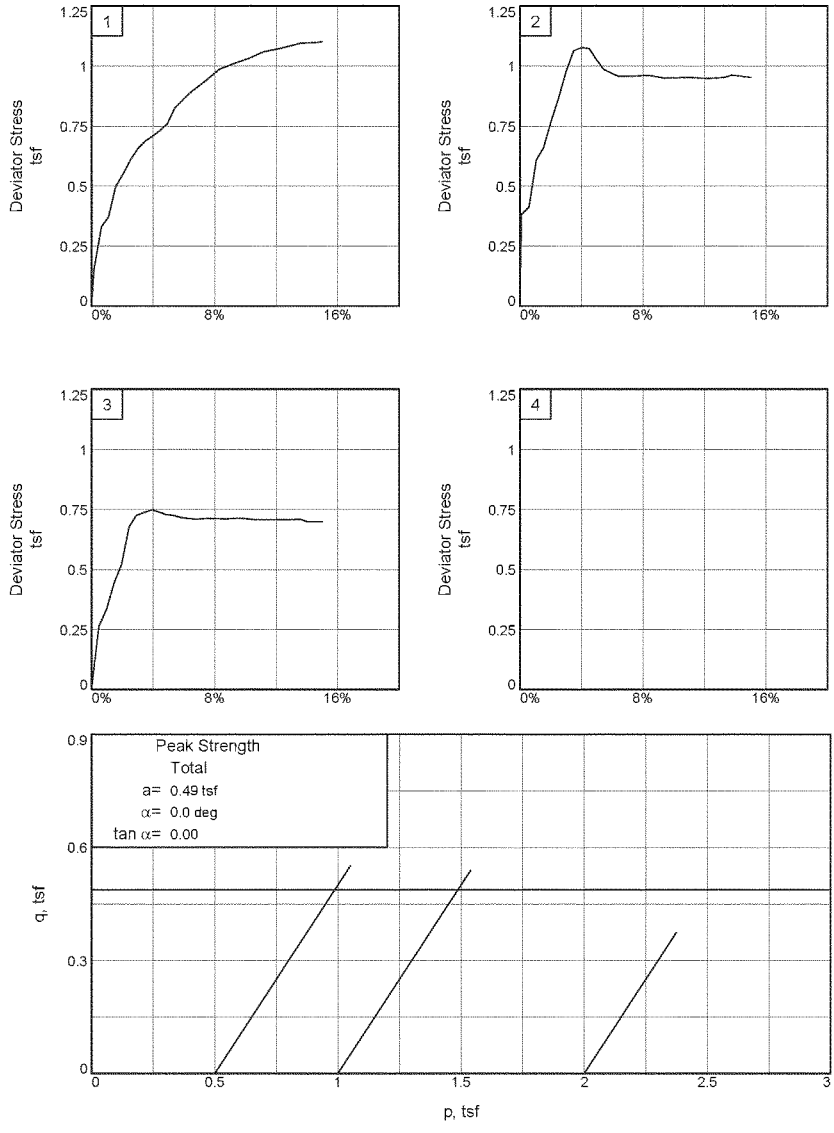
Figure UU Triax ASTM D 2850

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: Fargo Pile Load Test, Brenna Formation
Sample Number: Boring11-119MU, #1 **Depth:** 30-32'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Tested By: JK **Checked By:** jrs



Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: Fargo Pile Load Test, Brenna Formation **Depth:** 30-32' **Sample No.:** Boring11-119MU, #1
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JK **Checked By:** jrs

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

5/30/2011
12:10 PM

Date:			
Client:	USACE W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing Request NO. 3		
Project No.:	BL-10-10065		
Location:	Fargo Pile Load Test, Brenna Formation		
Depth:	30-32'	**Sample Number:**	Boring11-119MU, #1
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	5" Thinwall, Bottom of sample		
Specific Gravity=2.704	**LL=**56	**PL=**19	**PI=**37
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	157.300	157.300
Moisture content: Dry soil+tare, gms.	117.710	117.710
Moisture content: Tare, gms.	30.160	30.160
Moisture, %	45.2	45.2
Moist specimen weight, gms.	127.7	
Diameter, in.	1.42	
Area, in.^{2}	1.58	
Height, in.	2.80	
Wet Density, pcf	110.3	
Dry density, pcf	75.9	
Void ratio	1.2235	
Saturation, %	99.9	

Test Readings for Specimen No. 1

Cell pressure = 0.500 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 1.102 tsf **at reading no.** 23
Ult. Stress = 1.102 tsf **at reading no.** 23

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0061	0.360	0.0	0.0	0.000	0.500	0.500	1.00	0.500	0.000
1	0.0105	3.740	3.4	0.2	0.154	0.500	0.654	1.31	0.577	0.077
2	0.0243	7.680	7.3	0.7	0.332	0.500	0.832	1.66	0.666	0.166
3	0.0370	8.600	8.2	1.1	0.372	0.500	0.872	1.74	0.686	0.186
4	0.0499	11.470	11.1	1.6	0.499	0.500	0.999	2.00	0.749	0.249
5	0.0635	12.720	12.4	2.1	0.552	0.500	1.052	2.10	0.776	0.276
6	0.0775	14.130	13.8	2.6	0.612	0.500	1.112	2.22	0.806	0.306
7	0.0908	15.250	14.9	3.0	0.658	0.500	1.158	2.32	0.829	0.329
8	0.1044	16.020	15.7	3.5	0.689	0.500	1.189	2.38	0.844	0.344
9	0.1181	16.580	16.2	4.0	0.710	0.500	1.210	2.42	0.855	0.355
10	0.1314	17.210	16.9	4.5	0.734	0.500	1.234	2.47	0.867	0.367
11	0.1441	17.900	17.5	4.9	0.760	0.500	1.260	2.52	0.880	0.380
12	0.1573	19.500	19.1	5.4	0.825	0.500	1.325	2.65	0.913	0.413
13	0.1842	21.150	20.8	6.4	0.887	0.500	1.387	2.77	0.944	0.444
14	0.2108	22.470	22.1	7.3	0.934	0.500	1.434	2.87	0.967	0.467
15	0.2381	23.940	23.6	8.3	0.986	0.500	1.486	2.97	0.993	0.493
16	0.2650	24.770	24.4	9.3	1.010	0.500	1.510	3.02	1.005	0.505
17	0.2925	25.580	25.2	10.2	1.032	0.500	1.532	3.06	1.016	0.516
18	0.3191	26.540	26.2	11.2	1.060	0.500	1.560	3.12	1.030	0.530
19	0.3462	27.120	26.8	12.2	1.072	0.500	1.572	3.14	1.036	0.536
20	0.3729	27.800	27.4	13.1	1.087	0.500	1.587	3.17	1.043	0.543
21	0.3858	28.160	27.8	13.6	1.095	0.500	1.595	3.19	1.048	0.548
22	0.4136	28.540	28.2	14.6	1.097	0.500	1.597	3.19	1.049	0.549
23	0.4250	28.780	28.4	15.0	1.102	0.500	1.602	3.20	1.051	0.551

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	155.530	155.530
Moisture content: Dry soil+tare, gms.	116.180	116.180
Moisture content: Tare, gms.	30.290	30.290
Moisture, %	45.8	45.8
Moist specimen weight, gms.	125.7	
Diameter, in.	1.41	
Area, in.²	1.57	
Height, in.	2.80	
Wet Density, pcf	109.3	
Dry density, pcf	75.0	
Void ratio	1.2521	
Saturation, %	98.9	

Test Readings for Specimen No. 2

Cell pressure = 1.000 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.076 tsf at reading no. 9

Ult. Stress = 0.952 tsf at reading no. 22

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0067	38.000	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	0.0096	46.320	8.3	0.1	0.382	1.000	1.382	1.38	1.191	0.191
2	0.0235	47.050	9.0	0.6	0.414	1.000	1.414	1.41	1.207	0.207
3	0.0364	51.390	13.4	1.1	0.609	1.000	1.609	1.61	1.305	0.305
4	0.0496	52.580	14.6	1.5	0.660	1.000	1.660	1.66	1.330	0.330
5	0.0639	55.170	17.2	2.0	0.773	1.000	1.773	1.77	1.387	0.387
6	0.0772	57.340	19.3	2.5	0.867	1.000	1.867	1.87	1.433	0.433
7	0.0908	59.900	21.9	3.0	0.977	1.000	1.977	1.98	1.488	0.488
8	0.1047	61.980	24.0	3.5	1.064	1.000	2.064	2.06	1.532	0.532
9	0.1188	62.380	24.4	4.0	1.076	1.000	2.076	2.08	1.538	0.538
10	0.1327	62.440	24.4	4.5	1.073	1.000	2.073	2.07	1.537	0.537
11	0.1457	61.510	23.5	5.0	1.027	1.000	2.027	2.03	1.514	0.514
12	0.1595	60.660	22.7	5.5	0.985	1.000	1.985	1.99	1.493	0.493
13	0.1862	60.250	22.3	6.4	0.957	1.000	1.957	1.96	1.479	0.479
14	0.2138	60.500	22.5	7.4	0.958	1.000	1.958	1.96	1.479	0.479
15	0.2413	60.830	22.8	8.4	0.962	1.000	1.962	1.96	1.481	0.481
16	0.2694	60.800	22.8	9.4	0.950	1.000	1.950	1.95	1.475	0.475
17	0.2970	61.090	23.1	10.4	0.952	1.000	1.952	1.95	1.476	0.476
18	0.3230	61.340	23.3	11.3	0.952	1.000	1.952	1.95	1.476	0.476
19	0.3502	61.500	23.5	12.3	0.948	1.000	1.948	1.95	1.474	0.474
20	0.3787	61.900	23.9	13.3	0.953	1.000	1.953	1.95	1.476	0.476
21	0.3925	62.280	24.3	13.8	0.962	1.000	1.962	1.96	1.481	0.481
22	0.4270	62.370	24.4	15.0	0.952	1.000	1.952	1.95	1.476	0.476

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	150.520	150.520
Moisture content: Dry soil+tare, gms.	112.110	112.110
Moisture content: Tare, gms.	30.620	30.620
Moisture, %	47.1	47.1
Moist specimen weight, gms.	120.4	
Diameter, in.	1.38	
Area, in.²	1.50	
Height, in.	2.81	
Wet Density, pcf	108.8	
Dry density, pcf	74.0	
Void ratio	1.2819	
Saturation, %	99.4	

Test Readings for Specimen No. 3

Cell pressure = 2.000 tsf

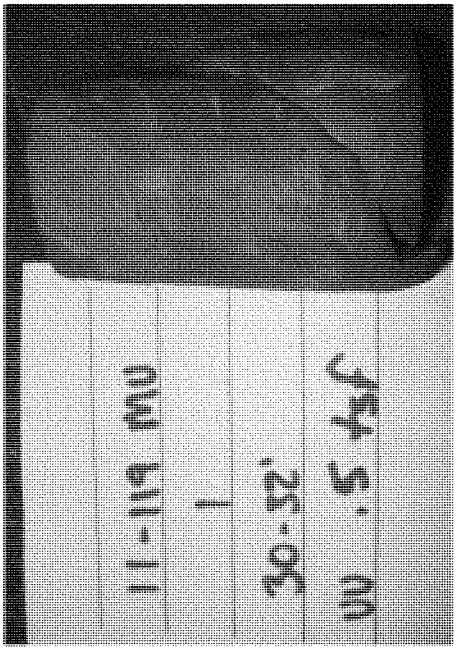
Back pressure = 0.000 tsf

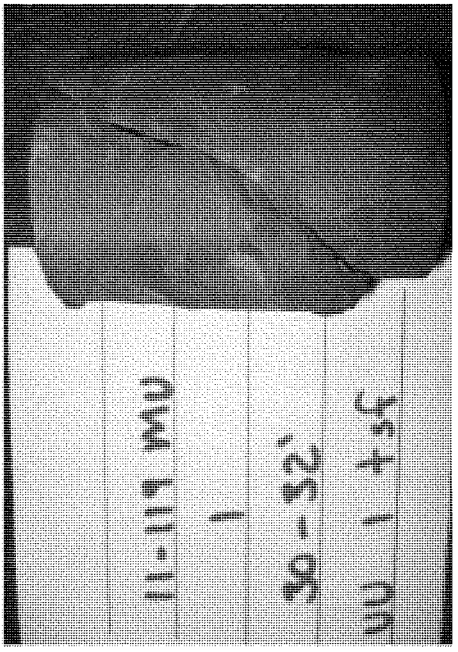
Strain rate, %/min. = 1.00

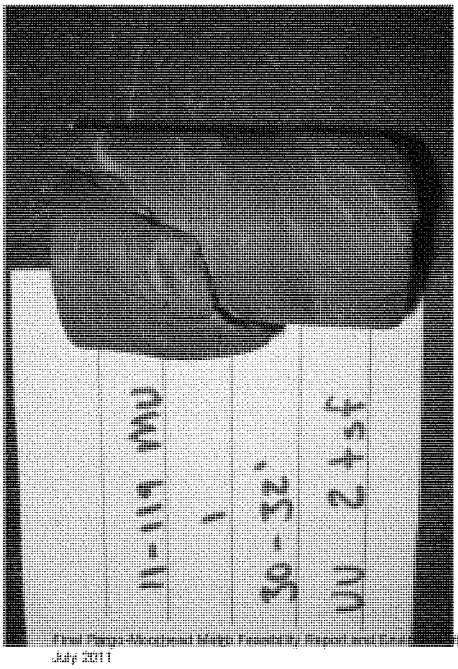
Peak Stress = 0.747 tsf at reading no. 8

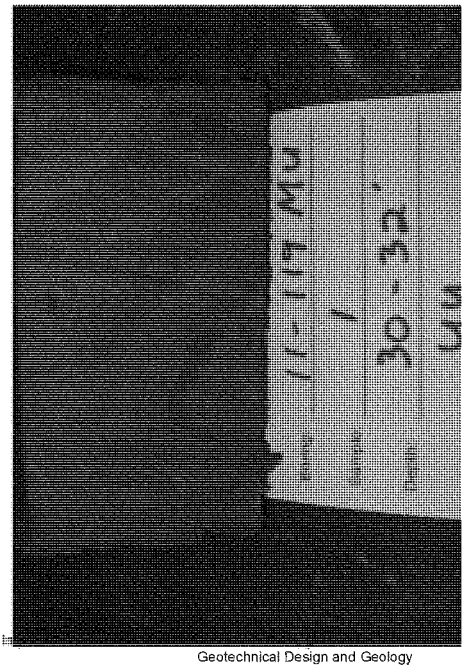
Ult. Stress = 0.698 tsf at reading no. 22

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	1.430	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	0.0203	6.950	5.5	0.5	0.263	2.000	2.263	1.13	2.132	0.132
2	0.0340	8.480	7.1	1.0	0.335	2.000	2.335	1.17	2.167	0.167
3	0.0480	10.860	9.4	1.5	0.445	2.000	2.445	1.22	2.223	0.223
4	0.0613	12.470	11.0	2.0	0.519	2.000	2.519	1.26	2.259	0.259
5	0.0753	15.920	14.5	2.4	0.677	2.000	2.677	1.34	2.339	0.339
6	0.0878	16.990	15.6	2.9	0.724	2.000	2.724	1.36	2.362	0.362
7	0.1027	17.350	15.9	3.4	0.737	2.000	2.737	1.37	2.368	0.368
8	0.1165	17.660	16.2	3.9	0.747	2.000	2.747	1.37	2.374	0.374
9	0.1298	17.560	16.1	4.4	0.739	2.000	2.739	1.37	2.370	0.370
10	0.1433	17.380	16.0	4.9	0.727	2.000	2.727	1.36	2.364	0.364
11	0.1566	17.400	16.0	5.3	0.724	2.000	2.724	1.36	2.362	0.362
12	0.1703	17.300	15.9	5.8	0.716	2.000	2.716	1.36	2.358	0.358
13	0.1973	17.300	15.9	6.8	0.709	2.000	2.709	1.35	2.354	0.354
14	0.2232	17.530	16.1	7.7	0.712	2.000	2.712	1.36	2.356	0.356
15	0.2505	17.640	16.2	8.7	0.709	2.000	2.709	1.35	2.355	0.355
16	0.2772	17.900	16.5	9.6	0.713	2.000	2.713	1.36	2.357	0.357
17	0.3050	17.930	16.5	10.6	0.707	2.000	2.707	1.35	2.353	0.353
18	0.3317	18.130	16.7	11.6	0.708	2.000	2.708	1.35	2.354	0.354
19	0.3591	18.280	16.9	12.6	0.706	2.000	2.706	1.35	2.353	0.353
20	0.3867	18.540	17.1	13.6	0.709	2.000	2.709	1.35	2.354	0.354
21	0.3999	18.390	17.0	14.0	0.699	2.000	2.699	1.35	2.349	0.349
22	0.4275	18.570	17.1	15.0	0.698	2.000	2.698	1.35	2.349	0.349


11-119 MU
1
30-32'
UU .5 tsf


11-119 MU
1
30-32'
UU 1 tsf

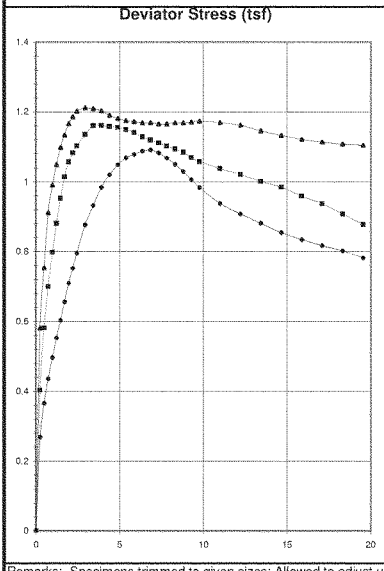

11-119 MU
1
30-32'
UU 2 tsf


11-119 MU
1
30-32'
UU

TRIAXIAL TEST ASTM: D 2850

Job No. 7577
Date: 8/24/10

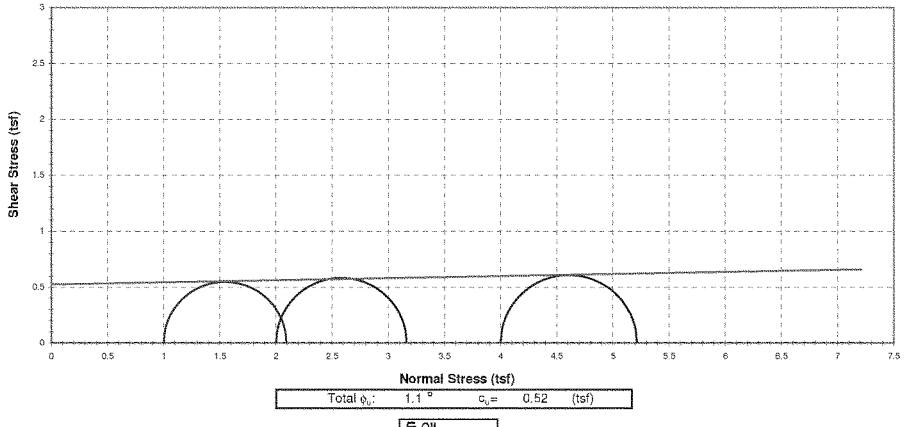
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-78MU Fargo Sample #: 3 Type: 5T Depth (ft): 55 - 57 (Mid-Bot)
Soil Type: Fat Clay w/a few pockets of Silt (CH) Argusville



Failure Criterion:	Max. Deviator Stress					
Angle of internal friction, ϕ_u =	1.1 °					
Apparent Cohesion, c_u =	0.52 (tsf)					
Test Date: 8/18/10			Liquid Limit:	71.8		
Test Type: U-U			Plastic Limit:	22.4		
Strain Rate (in/min): 0.05			Plasticity Index:	49.4		
Strain Rate (%/min): 1.221			Spec. Gravity (Assumed):	2.77		
Before Consolidation	A	B	C	D	E	
Diameter (in)	1.94	1.94	1.94			
Height (in)	4.10	4.10	4.10			
Water Content (%)	44.8	46.0	46.6			
Dry Density (pcf)	75.9	75.0	74.4			
Void Ratio	1.28	1.30	1.32			
After Consolidation						
Diameter (in)						
Height (in)						
Water Content (%)						
Dry Density (pcf)						
Void Ratio						
Back Pressure (tsf)						
Minor Principal Stress (tsf)	1.00	2.00	4.00			
Max. Deviator Stress (tsf)	1.09	1.16	1.21			
Ultimate Deviator Stress (tsf)	0.78	0.88	1.10			
Deviator Stress at Failure (tsf)	1.09	1.16	1.21			
Max. Pore Pressure Buildup (tsf)	-------	-------	-------			
Pore Pressure Parameter "B"	-------	-------	-------			
Pct. Axial Strain at Failure	6.8	3.9	2.9			

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Specimens trimmed to given sizes; Allowed to adjust under applied confining pressures for about 10 minutes.



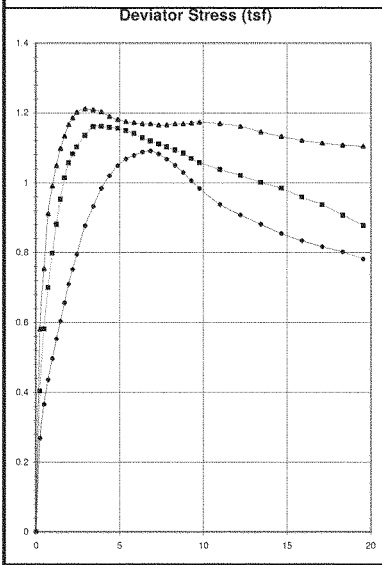
Total ϕ_u: 1.1 ° c_u = 0.52 (tsf)

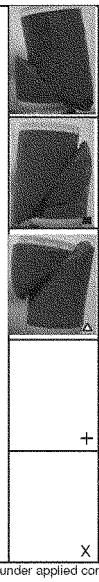
SOIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55420-3437
Geotechnical Design and Geology

TRIAXIAL TEST ASTM: D 2850

Job No. 7577
Date: 8/24/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-78MU Fargo Sample #: 3 Type: ST Depth (ft): 55 - 57 (Mid-Bot)
Soil Type: Fat Clay w/a few pockets of Silt (CH) Argusville





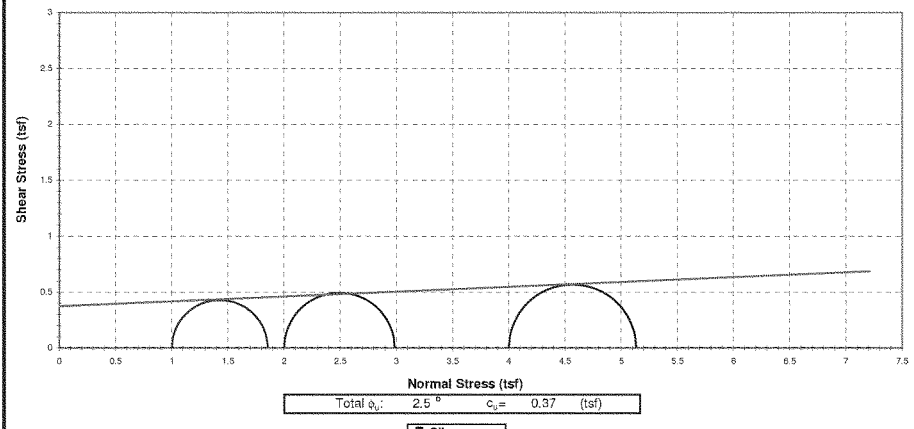
Failure Criterion: Given Strain of: 15%
Angle of internal friction, ϕ_u = 2.5 °
Apparent Cohesion, c_u = 0.37 (tsf)

Test Date:	8/18/10		Liquid Limit:		71.8
Test Type:	U-U		Plastic Limit:		22.4
Strain Rate (in/min):	0.05		Plasticity Index:		49.4
Strain Rate (%/min):	1.221		Spec. Gravity (Assumed):		2.77

Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	44.8	46.0	46.6		
Dry Density (pcf)	75.9	75.0	74.4		
Void Ratio	1.28	1.30	1.32		
After Consolidation					
Diameter (in)					
Height (in)					
Water Content (%)					
Dry Density (pcf)					
Void Ratio					
Back Pressure (tsf)					
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	1.09	1.16	1.21		
Ultimate Deviator Stress (tsf)	0.78	0.88	1.10		
Deviator Stress at Failure (tsf)	0.85	0.98	1.13		
Max. Pore Pressure Buildup (tsf)	-------	-------	-------		
Pore Pressure Parameter "B"	-------	-------	-------		
Pct. Axial Strain at Failure	15.0	15.0	15.0		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Specimens trimmed to given sizes; Allowed to adjust under applied confining pressures for about 10 minutes.



Total ϕ_u: 2.5 ° c_u= 0.37 (tsf)

OIL ENGINEERING TESTING, INC.

Job No.: 7577
Test Type: U-U

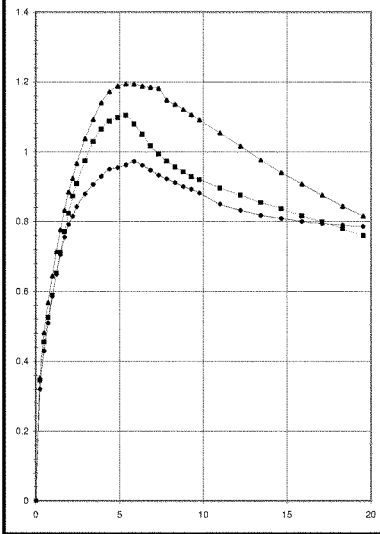
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring No.: 10-78MU, Sample No.: 3, Depth (ft.): 55 - 57 (Mid-Bot)

Sample 1		Sample 2		Sample 3	
Strain (%)	Deviator Stress (tsf)	Strain (%)	Deviator Stress (tsf)	Strain (%)	Deviator Stress (tsf)
0.00	0.00	0.00	0.00	0.00	0.00
0.24	0.27	0.24	0.40	0.24	0.58
0.49	0.37	0.49	0.58	0.49	0.75
0.73	0.44	0.73	0.70	0.73	0.91
0.98	0.50	0.98	0.80	0.98	0.99
1.22	0.55	1.22	0.88	1.22	1.05
1.47	0.60	1.47	0.95	1.47	1.10
1.71	0.66	1.71	1.01	1.71	1.13
1.95	0.71	1.95	1.06	1.95	1.17
2.20	0.75	2.20	1.08	2.20	1.19
2.44	0.79	2.44	1.10	2.44	1.20
2.93	0.88	2.93	1.14	2.93	1.21
3.42	0.93	3.42	1.16	3.42	1.21
3.91	0.98	3.91	1.16	3.91	1.20
4.40	1.02	4.40	1.16	4.40	1.19
4.88	1.05	4.88	1.16	4.88	1.18
5.37	1.07	5.37	1.15	5.37	1.18
5.86	1.08	5.86	1.14	5.86	1.17
6.35	1.09	6.35	1.13	6.35	1.17
6.84	1.09	6.84	1.12	6.84	1.17
7.33	1.08	7.33	1.11	7.33	1.17
7.81	1.07	7.81	1.10	7.81	1.17
8.30	1.05	8.30	1.09	8.30	1.17
8.79	1.03	8.79	1.08	8.79	1.17
9.28	1.01	9.28	1.07	9.28	1.17
9.77	0.98	9.77	1.06	9.77	1.17
10.99	0.94	10.99	1.04	10.99	1.17
12.21	0.91	12.21	1.02	12.21	1.16
13.43	0.88	13.43	1.00	13.43	1.15
14.65	0.85	14.65	0.98	14.65	1.13
15.87	0.83	15.87	0.96	15.87	1.12
17.09	0.82	17.09	0.94	17.09	1.11
18.32	0.80	18.32	0.91	18.32	1.11
19.54	0.78	19.54	0.88	19.54	1.10

TRIAXIAL TEST ASTM: D 2850

Job No. 7577
Date: 8/24/10

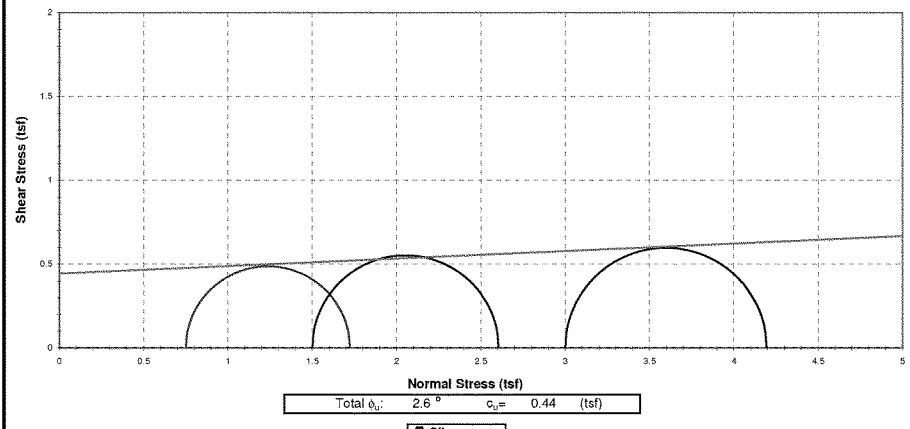
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-79MU Fargo Sample #: 2 Type: 5T Depth (ft): 40 - 42 (Mid.)
Soil Type: Fat Clay w/a few pieces of Gravel & a few pockets of Silt (CH) Argsuville



Failure Criterion:	Max. Deviator Stress				
Angle of internal friction, ϕ_u =	2.6 °				
Apparent Cohesion, c_u =	0.44 (tsf)				
Test Date: 8/19/10			Liquid Limit:		83.0
Test Type: U-U			Plastic Limit:		25.2
Strain Rate (in/min): 0.05			Plasticity Index:		57.8
Strain Rate (%/min): 1.221			Spec. Gravity (Assumed):		2.78
Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	42.0	42.4	43.7		
Dry Density (pcf)	78.8	78.3	77.0		
Void Ratio	1.20	1.22	1.25		
After Consolidation					
Diameter (in)					
Height (in)					
Water Content (%)					
Dry Density (pcf)					
Void Ratio					
Back Pressure (tsf)					
Minor Principal Stress (tsf)	0.75	1.50	3.00		
Max. Deviator Stress (tsf)	0.97	1.10	1.19		
Ultimate Deviator Stress (tsf)	0.79	0.76	0.82		
Deviator Stress at Failure (tsf)	0.97	1.10	1.19		
Max. Pore Pressure Buildup (tsf)	--------	--------	--------		
Pore Pressure Parameter "B"	--------	--------	--------		
Pct. Axial Strain at Failure	5.9	5.4	5.4		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Specimens trimmed to given sizes; Allowed to adjust under applied confining pressures for about 10 minutes.



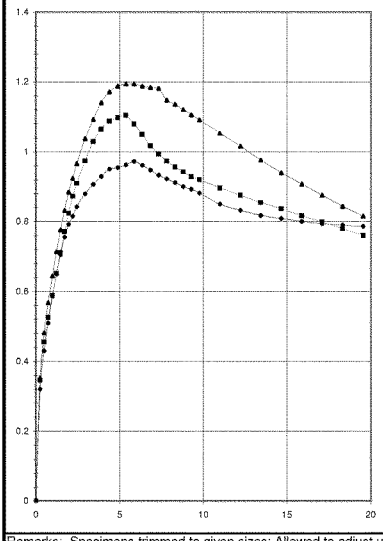
Total ϕ_u: 2.6 ° c_u= 0.44 (tsf)

OIL ENGINEERING TESTING, INC.

TRIAXIAL TEST ASTM: D 2850

Job No. 7577
Date: 8/24/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-79MU Fargo Sample #: 2 Type: 5T Depth (ft): 40 - 42 (Mid.)
Soil Type: Fat Clay w/a few pieces of Gravel & a few pockets of Silt (CH) Argsuville



Failure Criterion: Given Strain of: 15%

Angle of internal friction, ϕ_u = 1.7 °

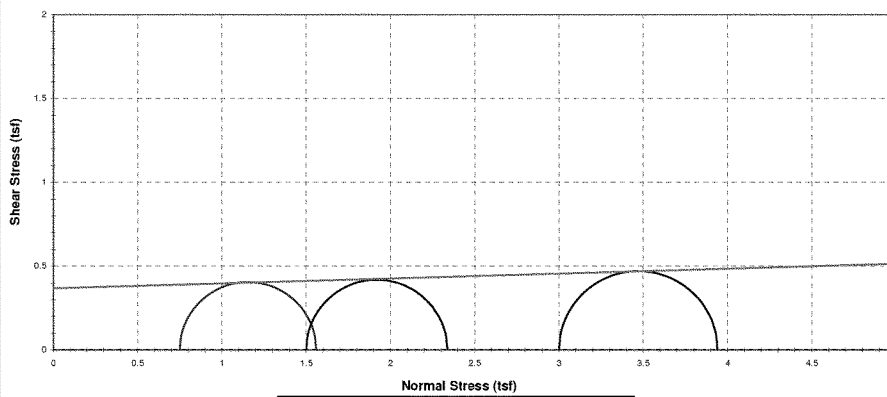
Apparent Cohesion, c_u = 0.37 (tsf)

Test Date:	8/19/10	Liquid Limit:	83.0
Test Type:	U-U	Plastic Limit:	25.2
Strain Rate (in/min):	0.05	Plasticity Index:	57.8
Strain Rate (%/min):	1.221	Spec. Gravity (Assumed):	2.78

Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	42.0	42.4	43.7		
Dry Density (pcf)	78.8	78.3	77.0		
Void Ratio	1.20	1.22	1.25		
After Consolidation					
Diameter (in)					
Height (in)					
Water Content (%)					
Dry Density (pcf)					
Void Ratio					
Back Pressure (tsf)					
Minor Principal Stress (tsf)	0.75	1.50	3.00		
Max. Deviator Stress (tsf)	0.97	1.10	1.19		
Ultimate Deviator Stress (tsf)	0.79	0.76	0.82		
Deviator Stress at Failure (tsf)	0.81	0.84	0.94		
Max. Pore Pressure Buildup (tsf)	--------	--------	--------		
Pore Pressure Parameter "B"	--------	--------	--------		
Pct. Axial Strain at Failure	15.0	15.0	15.0		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Specimens trimmed to given sizes; Allowed to adjust under applied confining pressures for about 10 minutes.



Total ϕ_u: 1.7 ° c_u= 0.37 (tsf)

Job No.: 7577
Test Type: U-U

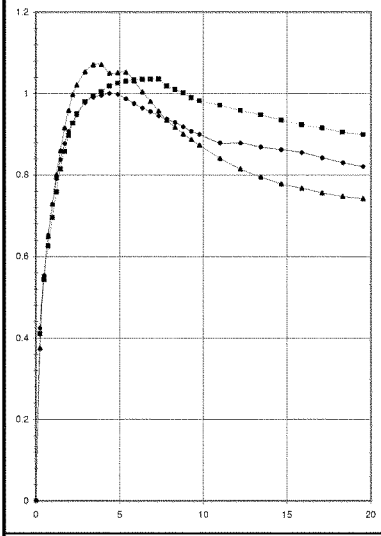
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring No.: 10-79MU, Sample No.: 2, Depth (ft.): 40 - 42 (Mid.)

Sample 1		Sample 2		Sample 3	
Strain (%)	Deviator Stress (tsf)	Strain (%)	Deviator Stress (tsf)	Strain (%)	Deviator Stress (tsf)
0.00	0.00	0.00	0.00	0.00	0.00
0.24	0.32	0.24	0.35	0.24	0.35
0.49	0.43	0.49	0.46	0.49	0.48
0.73	0.51	0.73	0.53	0.73	0.57
0.98	0.59	0.98	0.59	0.98	0.64
1.22	0.65	1.22	0.65	1.22	0.71
1.47	0.71	1.47	0.71	1.47	0.78
1.71	0.76	1.71	0.77	1.71	0.83
1.95	0.79	1.95	0.82	1.95	0.88
2.20	0.82	2.20	0.87	2.20	0.92
2.44	0.84	2.44	0.91	2.44	0.97
2.93	0.88	2.93	0.97	2.93	1.04
3.42	0.91	3.42	1.03	3.42	1.09
3.91	0.93	3.91	1.06	3.91	1.14
4.40	0.95	4.40	1.09	4.40	1.17
4.88	0.95	4.88	1.10	4.88	1.19
5.37	0.96	5.37	1.10	5.37	1.19
5.86	0.97	5.86	1.08	5.86	1.19
6.35	0.96	6.35	1.05	6.35	1.19
6.84	0.95	6.84	1.02	6.84	1.18
7.33	0.93	7.33	0.99	7.33	1.18
7.81	0.92	7.81	0.97	7.81	1.15
8.30	0.91	8.30	0.96	8.30	1.14
8.79	0.90	8.79	0.94	8.79	1.12
9.28	0.89	9.28	0.93	9.28	1.11
9.77	0.88	9.77	0.92	9.77	1.09
10.99	0.85	10.99	0.90	10.99	1.05
12.21	0.83	12.21	0.88	12.21	1.02
13.43	0.82	13.43	0.85	13.43	0.98
14.65	0.81	14.65	0.84	14.65	0.94
15.87	0.80	15.87	0.82	15.87	0.91
17.09	0.79	17.09	0.80	17.09	0.88
18.32	0.79	18.32	0.78	18.32	0.84
19.54	0.79	19.54	0.76	19.54	0.82

TRIAXIAL TEST ASTM: D 2850

Job No. 7577
Date: 8/24/10

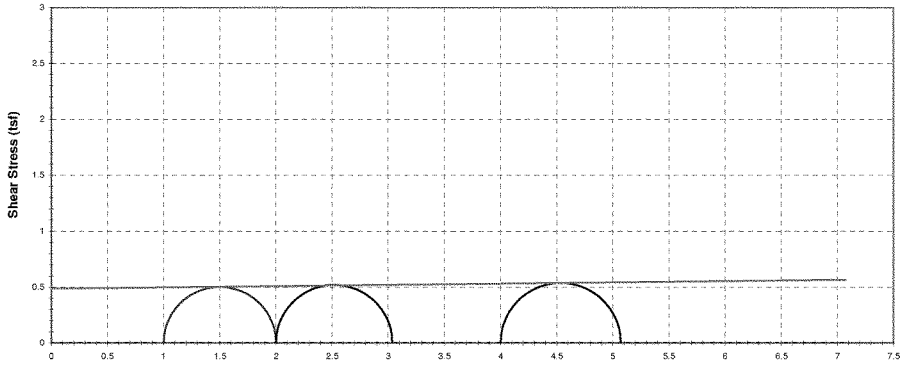
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 3 Type: 5T Depth (ft): 55 - 57
Soil Type: Fat Clay w/a few pieces of Gravel & a few pockets of Silt (CH) Argusville



Failure Criterion:	Max. Deviator Stress					
Angle of internal friction, ϕ_u =	0.6 °					
Apparent Cohesion, c_u =	0.49 (tsf)					
Test Date: 8/20/10		Liquid Limit:		78.1		
Test Type: U-U		Plastic Limit:		26.8		
Strain Rate (in/min): 0.05		Plasticity Index:		51.3		
Strain Rate (%/min): 1.221		Spec. Gravity (Assumed):		2.78		
Before Consolidation	A	B	C	D	E	
Diameter (in)	1.94	1.94	1.94			
Height (in)	4.10	4.10	4.10			
Water Content (%)	46.0	47.0	46.9			
Dry Density (pcf)	74.4	73.8	73.8			
Void Ratio	1.33	1.35	1.35			
After Consolidation						
Diameter (in)						
Height (in)						
Water Content (%)						
Dry Density (pcf)						
Void Ratio						
Back Pressure (tsf)						
Minor Principal Stress (tsf)	1.00	2.00	4.00			
Max. Deviator Stress (tsf)	1.00	1.04	1.07			
Ultimate Deviator Stress (tsf)	0.82	0.90	0.74			
Deviator Stress at Failure (tsf)	1.00	1.04	1.07			
Max. Pore Pressure Buildup (tsf)	-------	-------	-------			
Pore Pressure Parameter "B"	-------	-------	-------			
Pct. Axial Strain at Failure	4.4	7.3	3.9			

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Specimens trimmed to given sizes; Allowed to adjust under applied confining pressures for about 10 minutes.



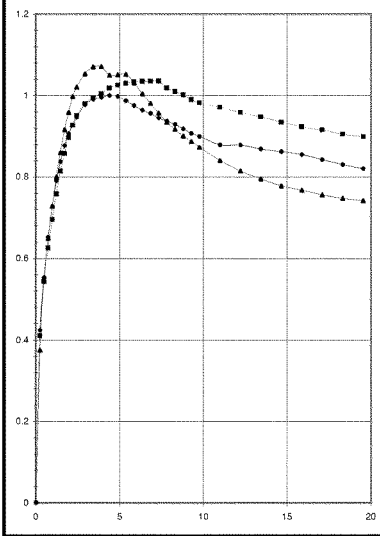
Total ϕ_u: 0.6 ° c_u= 0.49 (tsf)

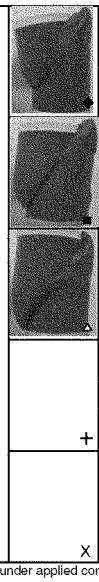
SOIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55420-3435
Geotechnical Design and Geology

TRIAXIAL TEST ASTM: D 2850

Job No. 7577
Date: 8/24/10

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring #: 10-80MU Fargo Sample #: 3 Type: 5T Depth (ft): 55 - 57
Soil Type: Fat Clay w/a few pieces of Gravel & a few pockets of Silt (CH) Argusville





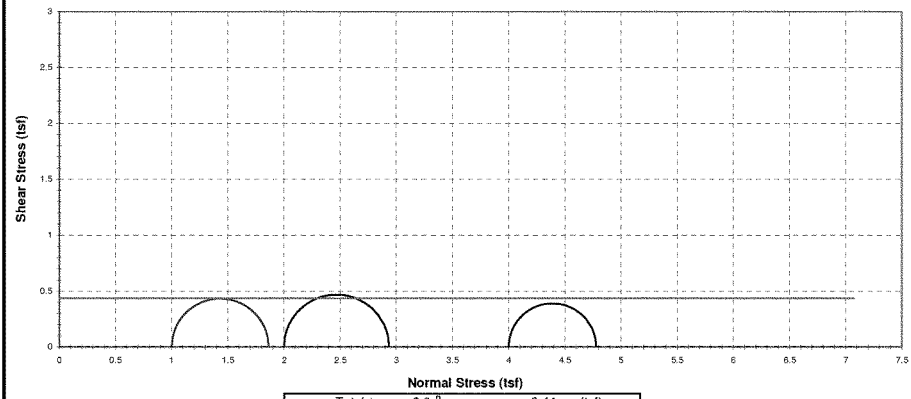
Failure Criterion: Given Strain of: 15%
Angle of internal friction, ϕ_u = 0.0 °
Apparent Cohesion, c_u = 0.44 (tsf)

Test Date:	8/20/10	Liquid Limit:			78.1
Test Type:	U-U	Plastic Limit:			26.8
Strain Rate (in/min):	0.05	Plasticity Index:			51.3
Strain Rate (%/min):	1.221	Spec. Gravity (Assumed):			2.78

Before Consolidation	A	B	C	D	E
Diameter (in)	1.94	1.94	1.94		
Height (in)	4.10	4.10	4.10		
Water Content (%)	46.0	47.0	46.9		
Dry Density (pcf)	74.4	73.8	73.8		
Void Ratio	1.33	1.35	1.35		
After Consolidation					
Diameter (in)					
Height (in)					
Water Content (%)					
Dry Density (pcf)					
Void Ratio					
Back Pressure (tsf)					
Minor Principal Stress (tsf)	1.00	2.00	4.00		
Max. Deviator Stress (tsf)	1.00	1.04	1.07		
Ultimate Deviator Stress (tsf)	0.82	0.90	0.74		
Deviator Stress at Failure (tsf)	0.86	0.93	0.78		
Max. Pore Pressure Buildup (tsf)	--------	--------	--------		
Pore Pressure Parameter "B"	--------	--------	--------		
Pct. Axial Strain at Failure	15.0	15.0	15.0		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Specimens trimmed to given sizes; Allowed to adjust under applied confining pressures for about 10 minutes.



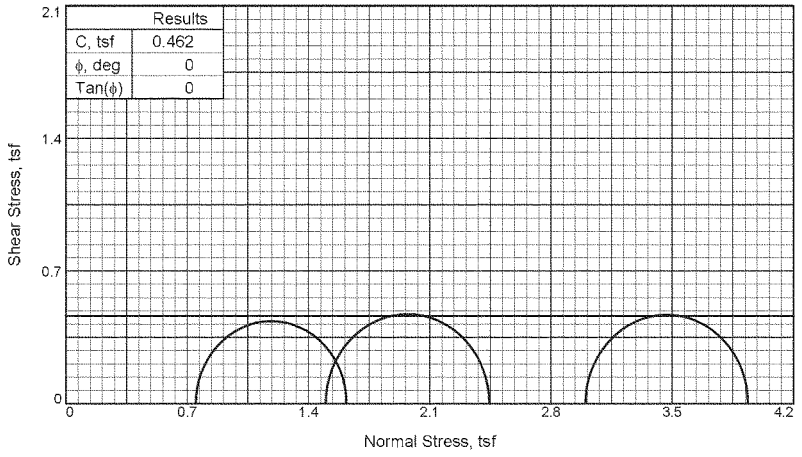
Total ϕ_u: 0.0 ° c_u= 0.44 (tsf)

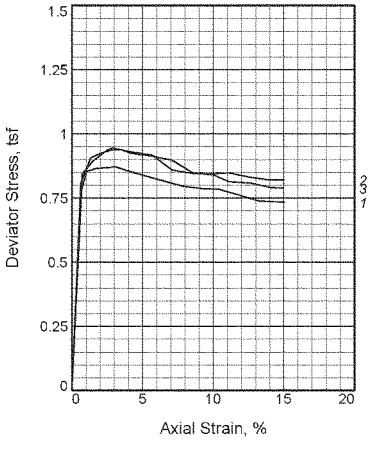
9301 Bryant Ave. South, Suite #107 Bloomington, Minnesota 55420-3435
Telephone 952-884-0441 FAX 952-884-0444
Geotechnical Design and Geology

Job No.: 7577
Test Type: U-U

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - # W912ES-10-T-0095
Boring No.: 10-80MU, Sample No.: 3, Depth (ft.): 55 - 57

Sample 1		Sample 2		Sample 3	
Strain (%)	Deviator Stress (tsf)	Strain (%)	Deviator Stress (tsf)	Strain (%)	Deviator Stress (tsf)
0.00	0.00	0.00	0.00	0.00	0.00
0.24	0.42	0.24	0.41	0.24	0.38
0.49	0.55	0.49	0.54	0.49	0.55
0.73	0.65	0.73	0.63	0.73	0.65
0.98	0.73	0.98	0.70	0.98	0.73
1.22	0.79	1.22	0.76	1.22	0.80
1.47	0.84	1.47	0.81	1.47	0.86
1.71	0.88	1.71	0.86	1.71	0.92
1.95	0.91	1.95	0.90	1.95	0.96
2.20	0.93	2.20	0.93	2.20	1.00
2.44	0.95	2.44	0.95	2.44	1.02
2.93	0.98	2.93	0.98	2.93	1.05
3.42	0.99	3.42	0.99	3.42	1.07
3.91	1.00	3.91	1.01	3.91	1.07
4.40	1.00	4.40	1.02	4.40	1.05
4.88	1.00	4.88	1.03	4.88	1.05
5.37	0.99	5.37	1.03	5.37	1.05
5.86	0.98	5.86	1.03	5.86	1.03
6.35	0.96	6.35	1.03	6.35	1.00
6.84	0.96	6.84	1.04	6.84	0.98
7.33	0.95	7.33	1.04	7.33	0.96
7.81	0.94	7.81	1.02	7.81	0.93
8.30	0.93	8.30	1.01	8.30	0.92
8.79	0.92	8.79	1.00	8.79	0.90
9.28	0.91	9.28	0.99	9.28	0.89
9.77	0.90	9.77	0.98	9.77	0.87
10.99	0.88	10.99	0.97	10.99	0.84
12.21	0.88	12.21	0.96	12.21	0.82
13.43	0.87	13.43	0.95	13.43	0.80
14.65	0.86	14.65	0.93	14.65	0.78
15.87	0.86	15.87	0.92	15.87	0.77
17.09	0.84	17.09	0.92	17.09	0.76
18.32	0.83	18.32	0.91	18.32	0.75
19.54	0.82	19.54	0.90	19.54	0.74





Sample No.		1	2	3
Initial	Water Content, %	70.4	70.8	66.2
	Dry Density, pcf	57.9	57.5	60.1
	Saturation, %	99.2	98.8	99.0
	Void Ratio	1.9222	1.9432	1.8131
	Diameter, in.	1.40	1.41	1.39
	Height, in.	2.81	2.81	2.81
At Test	Water Content, %	70.4	70.8	66.2
	Dry Density, pcf	57.9	57.5	60.1
	Saturation, %	99.2	98.8	99.0
	Void Ratio	1.9222	1.9432	1.8131
	Diameter, in.	1.40	1.40	1.39
	Height, in.	2.81	2.81	2.81
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.75	1.50	3.00
Peak Stress, tsf		0.87	0.94	0.94
Ult. Stress, tsf		0.73	0.82	0.79
σ_1 Failure, tsf		1.62	2.44	3.94
σ_3 Failure, tsf		0.75	1.50	3.00

Type of Test:
Unconsolidated Undrained
Sample Type: 5" Thinwall, Bottom of sample
Description: FAT CLAY, brown (CH)

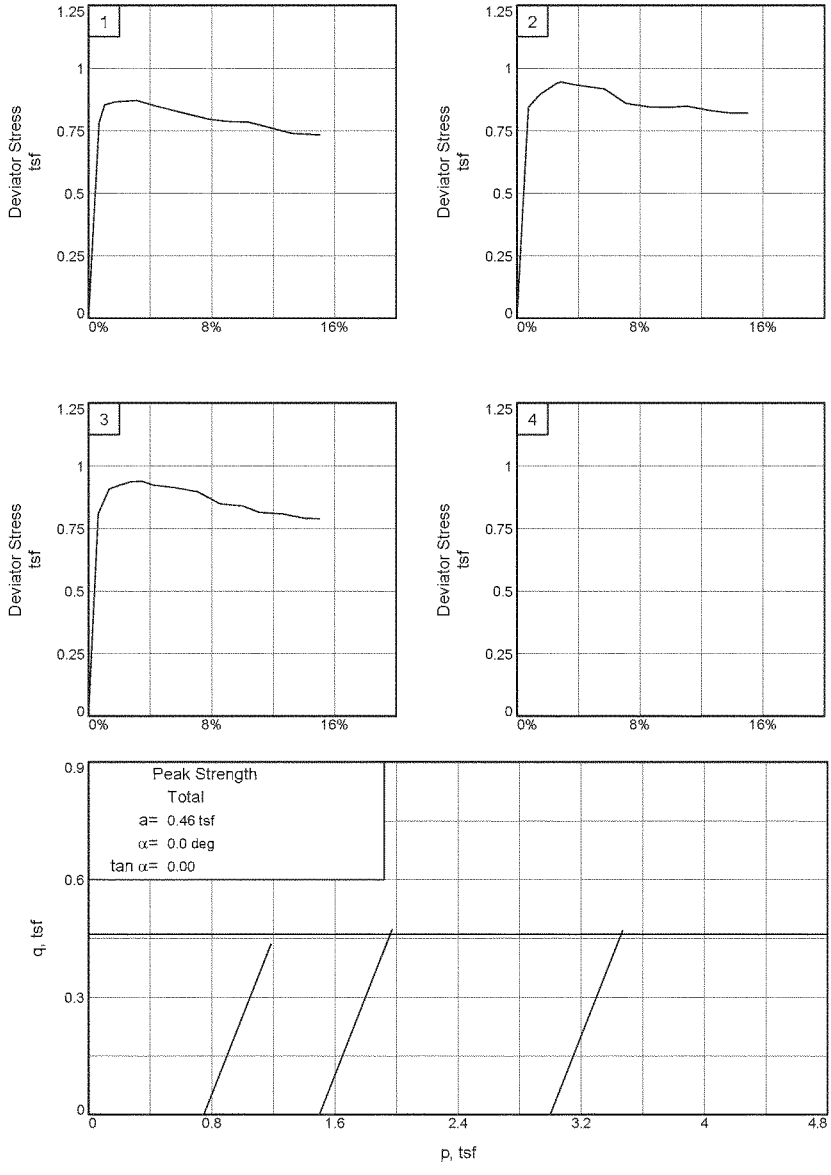
LL= 90 **PL=** 27 **PI=** 63
Specific Gravity= 2.709
Remarks:

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Maple River, Argusville Formation
Sample Number: Boring10-105MU, #4 **Depth:** 45-47'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Figure Triaxial Test (ASTM D 2850)



Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: Maple River, Argusville Formation **Depth:** 45-47' **Sample No.:** Boring10-105MU, #4
Project No.: Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement **Figure**

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

3/4/2011
12:05 PM

Date:			
Client:	W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing		
Project No.:	BL-10-10065		
Location:	Maple River, Argusville Formation		
Depth:	45-47'	**Sample Number:**	Boring10-105MU, #4
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	5" Thinwall, Bottom of sample		
Specific Gravity=2.709	**LL=**90	**PL=**27	**PI=**63
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	142.120	142.120
Moisture content: Dry soil+tare, gms.	96.060	96.060
Moisture content: Tare, gms.	30.630	30.630
Moisture, %	70.4	70.4
Moist specimen weight, gms.	112.1	
Diameter, in.	1.40	
Area, in.²	1.54	
Height, in.	2.81	
Wet Density, pcf	98.6	
Dry density, pcf	57.9	
Void ratio	1.9222	
Saturation, %	99.2	

Test Readings for Specimen No. 1

Cell pressure = 0.750 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 0.871 tsf **at reading no.** 5
Ult. Stress = 0.733 tsf **at reading no.** 13

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0062	0.066	0.0	0.0	0.000	0.750	0.750	1.00	0.750	0.000
1	0.0255	16.900	16.8	0.7	0.782	0.750	1.532	2.04	1.141	0.391
2	0.0356	18.490	18.4	1.0	0.853	0.750	1.603	2.14	1.176	0.426
3	0.0550	18.880	18.8	1.7	0.865	0.750	1.615	2.15	1.182	0.432
4	0.0742	19.080	19.0	2.4	0.868	0.750	1.618	2.16	1.184	0.434
5	0.0938	19.280	19.2	3.1	0.871	0.750	1.621	2.16	1.185	0.435
6	0.1245	19.070	19.0	4.2	0.851	0.750	1.601	2.14	1.176	0.426
7	0.1861	18.730	18.7	6.4	0.817	0.750	1.567	2.09	1.158	0.408
8	0.2272	18.530	18.5	7.9	0.796	0.750	1.546	2.06	1.148	0.398
9	0.2670	18.580	18.5	9.3	0.786	0.750	1.536	2.05	1.143	0.393
10	0.2980	18.780	18.7	10.4	0.784	0.750	1.534	2.05	1.142	0.392
11	0.3390	18.520	18.5	11.8	0.761	0.750	1.511	2.01	1.130	0.380
12	0.3793	18.260	18.2	13.3	0.738	0.750	1.488	1.98	1.119	0.369
13	0.4290	18.520	18.5	15.0	0.733	0.750	1.483	1.98	1.117	0.367

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	142.100	142.100
Moisture content: Dry soil+tare, gms.	95.940	95.940
Moisture content: Tare, gms.	30.780	30.780
Moisture, %	70.8	70.8
Moist specimen weight, gms.	112.1	
Diameter, in.	1.41	
Area, in.²	1.55	
Height, in.	2.81	
Wet Density, pcf	98.2	
Dry density, pcf	57.5	
Void ratio	1.9432	
Saturation, %	98.8	

Test Readings for Specimen No. 2

Cell pressure = 1.500 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 0.945 tsf **at reading no.** 4
Ult. Stress = 0.821 tsf **at reading no.** 14

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0073	2.070	0.0	0.0	0.000	1.500	1.500	1.00	1.500	0.000
1	0.0282	20.380	18.3	0.7	0.844	1.500	2.344	1.56	1.922	0.422
2	0.0487	21.600	19.5	1.5	0.894	1.500	2.394	1.60	1.947	0.447
3	0.0786	22.790	20.7	2.5	0.938	1.500	2.438	1.63	1.969	0.469
4	0.0882	23.020	20.9	2.9	0.945	1.500	2.445	1.63	1.972	0.472
5	0.1087	22.970	20.9	3.6	0.936	1.500	2.436	1.62	1.968	0.468
6	0.1293	22.970	20.9	4.3	0.928	1.500	2.428	1.62	1.964	0.464
7	0.1674	23.000	20.9	5.7	0.917	1.500	2.417	1.61	1.958	0.458
8	0.2066	21.970	19.9	7.1	0.859	1.500	2.359	1.57	1.929	0.429
9	0.2471	21.980	19.9	8.5	0.846	1.500	2.346	1.56	1.923	0.423

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
10	0.2873	22.240	20.2	10.0	0.843	1.500	2.343	1.56	1.922	0.422
11	0.3180	22.600	20.5	11.1	0.848	1.500	2.348	1.57	1.924	0.424
12	0.3585	22.530	20.5	12.5	0.831	1.500	2.331	1.55	1.916	0.416
13	0.3993	22.590	20.5	14.0	0.820	1.500	2.320	1.55	1.910	0.410
14	0.4280	22.860	20.8	15.0	0.821	1.500	2.321	1.55	1.910	0.410

Parameters for Specimen No. 3

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	142.020	142.020
Moisture content: Dry soil+tare, gms.	97.520	97.520
Moisture content: Tare, gms.	30.330	30.330
Moisture, %	66.2	66.2
Moist specimen weight, gms.	112.4	
Diameter, in.	1.39	
Area, in.^{2}	1.52	
Height, in.	2.81	
Wet Density, pcf	99.9	
Dry density, pcf	60.1	
Void ratio	1.8131	
Saturation, %	99.0	

Test Readings for Specimen No. 3

Cell pressure = 3.000 tsf

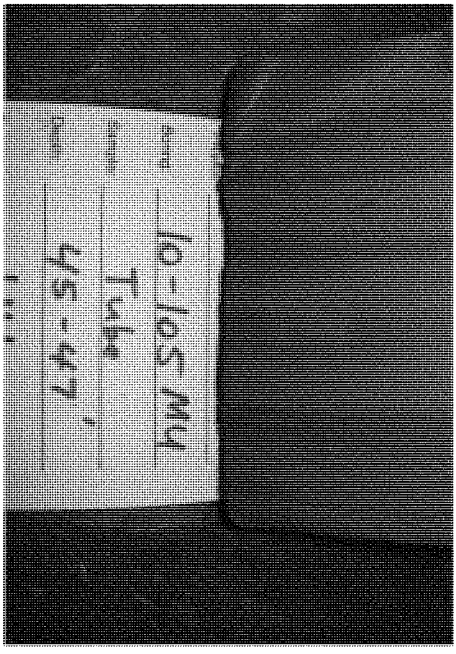
Back pressure = 0.000 tsf

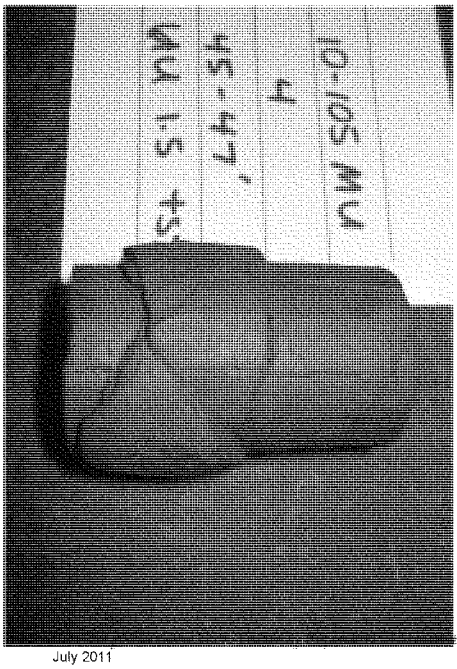
Strain rate, %/min. = 1.00

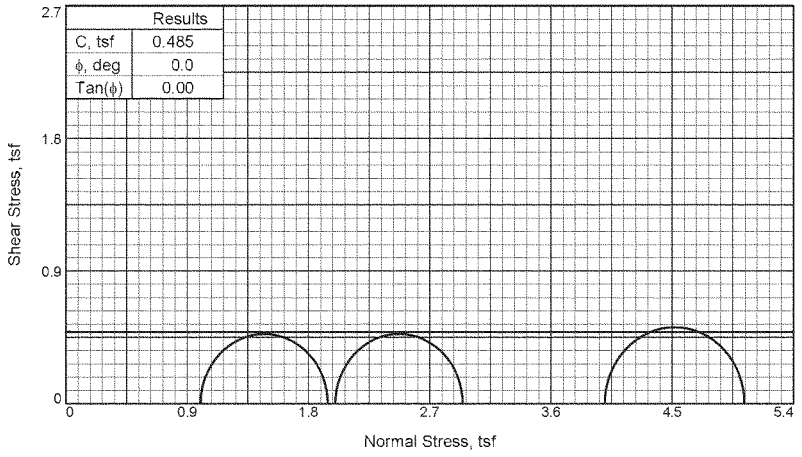
Peak Stress = 0.938 tsf at reading no. 5

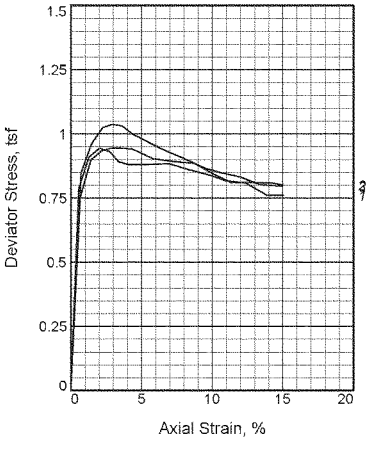
Ult. Stress = 0.788 tsf at reading no. 14

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0064	6.980	0.0	0.0	0.000	3.000	3.000	1.00	3.000	0.000
1	0.0242	24.190	17.2	0.6	0.808	3.000	3.808	1.27	3.404	0.404
2	0.0442	26.430	19.5	1.3	0.907	3.000	3.907	1.30	3.453	0.453
3	0.0646	26.950	20.0	2.1	0.924	3.000	3.924	1.31	3.462	0.462
4	0.0846	27.370	20.4	2.8	0.936	3.000	3.936	1.31	3.468	0.468
5	0.1045	27.550	20.6	3.5	0.938	3.000	3.938	1.31	3.469	0.469
6	0.1248	27.370	20.4	4.2	0.923	3.000	3.923	1.31	3.461	0.461
7	0.1653	27.460	20.5	5.7	0.913	3.000	3.913	1.30	3.456	0.456
8	0.2061	27.410	20.4	7.1	0.897	3.000	3.897	1.30	3.448	0.448
9	0.2472	26.610	19.6	8.6	0.848	3.000	3.848	1.28	3.424	0.424
10	0.2883	26.730	19.8	10.0	0.840	3.000	3.840	1.28	3.420	0.420
11	0.3190	26.340	19.4	11.1	0.813	3.000	3.813	1.27	3.406	0.406
12	0.3600	26.540	19.6	12.6	0.808	3.000	3.808	1.27	3.404	0.404
13	0.4015	26.450	19.5	14.1	0.791	3.000	3.791	1.26	3.395	0.395
14	0.4280	26.610	19.6	15.0	0.788	3.000	3.788	1.26	3.394	0.394









Sample No.		1	2	3
Initial	Water Content, %	53.8	57.4	54.5
	Dry Density, pcf	68.9	66.1	68.3
	Saturation, %	100.4	100.1	100.1
	Void Ratio	1.4443	1.5465	1.4674
	Diameter, in.	1.40	1.39	1.40
	Height, in.	2.80	2.80	2.80
At Test	Water Content, %	53.8	57.4	54.5
	Dry Density, pcf	68.9	66.1	68.3
	Saturation, %	100.4	100.1	100.1
	Void Ratio	1.4443	1.5465	1.4674
	Diameter, in.	1.40	1.39	1.40
	Height, in.	2.80	2.80	2.80
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		1.00	2.00	4.00
Peak Stress, tsf		0.94	0.94	1.04
Ult. Stress, tsf		0.76	0.80	0.80
σ_1 Failure, tsf		1.94	2.94	5.04
σ_3 Failure, tsf		1.00	2.00	4.00

Type of Test:
Unconsolidated Undrained

Sample Type: 5" Thinwall, Bottom of sample

Description: FAT CLAY, brown (CH)

LL= 91 **PL=** 25 **PI=** 66

Specific Gravity= 2.698

Remarks:

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

Location: Maple River, Argusville Formation

Sample Number: Boring10-105MU, #5 **Depth:** 55-57'

Proj. No.: BL-10-10065 **Date Sampled:**

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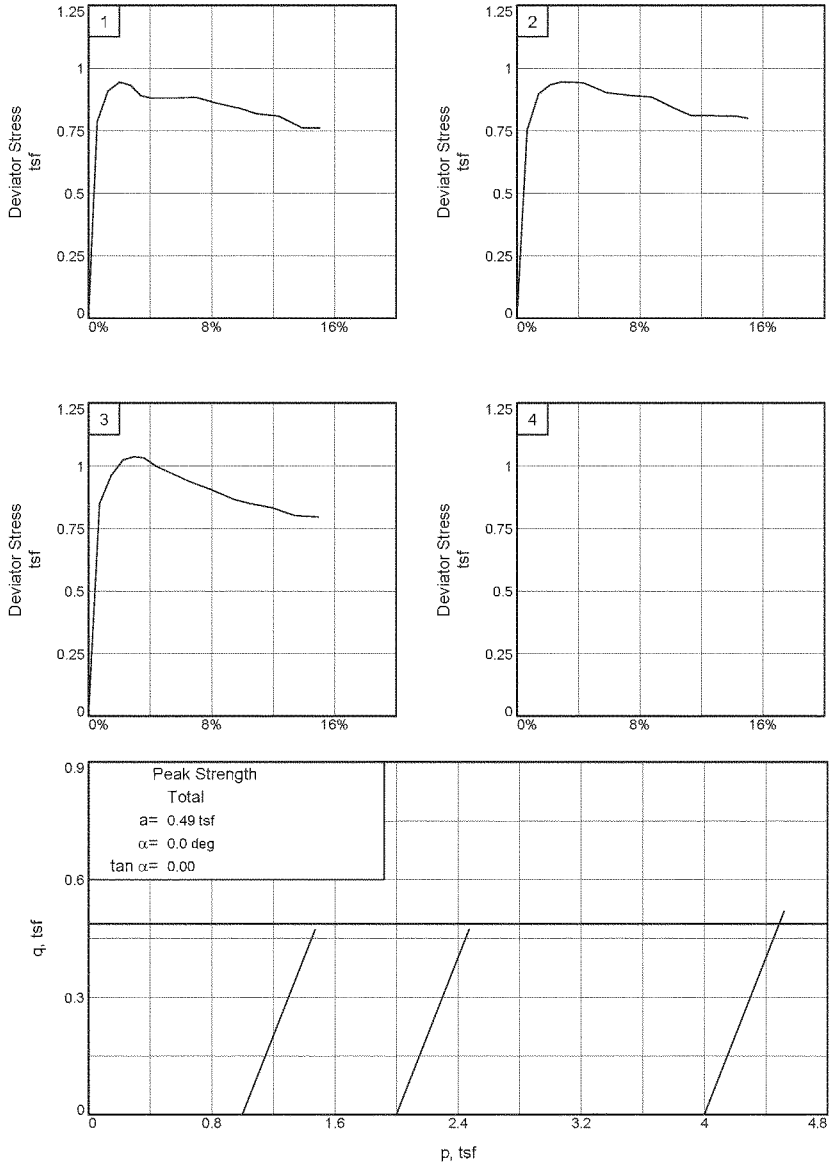
Figure Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement Attachment I-4, pg 752
July 2011 Geotechnical Design and Geology



Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: Maple River, Argusville Formation **Depth:** 55-57' **Sample No.:** Boring10-105MU, #5
Project No.: Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement **Figure**

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST 3/4/2011
Unconsolidated Undrained 12:06 PM

Date:			
Client:	W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing		
Project No.:	BL-10-10065		
Location:	Maple River, Argusville Formation		
Depth:	55-57'	**Sample Number:**	Boring10-105MU, #5
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	5" Thinwall, Bottom of sample		

Specific Gravity=2.698 **LL**=91 **PL**=25 **PI**=66
Test Method: ASTM D 2850

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	149.320	149.320
Moisture content: Dry soil+tare, gms.	107.720	107.720
Moisture content: Tare, gms.	30.330	30.330
Moisture, %	53.8	53.8
Moist specimen weight, gms.	119.5	
Diameter, in.	1.40	
Area, in.^{2}	1.53	
Height, in.	2.80	
Wet Density, pcf	105.9	
Dry density, pcf	68.9	
Void ratio	1.4443	
Saturation, %	100.4	

Test Readings for Specimen No. 1

Cell pressure = 1.000 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 0.944 tsf **at reading no.** 3
Ult. Stress = 0.761 tsf **at reading no.** 14

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	1.970	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	0.0224	18.790	16.8	0.6	0.786	1.000	1.786	1.79	1.393	0.393
2	0.0423	21.570	19.6	1.3	0.909	1.000	1.909	1.91	1.454	0.454
3	0.0630	22.480	20.5	2.0	0.944	1.000	1.944	1.94	1.472	0.472
4	0.0830	22.360	20.4	2.7	0.932	1.000	1.932	1.93	1.466	0.466
5	0.1014	21.590	19.6	3.4	0.890	1.000	1.890	1.89	1.445	0.445
6	0.1199	21.500	19.5	4.0	0.880	1.000	1.880	1.88	1.440	0.440
7	0.1606	21.800	19.8	5.5	0.880	1.000	1.880	1.88	1.440	0.440
8	0.2015	22.180	20.2	7.0	0.883	1.000	1.883	1.88	1.442	0.442
9	0.2423	21.940	20.0	8.4	0.859	1.000	1.859	1.86	1.430	0.430
10	0.2824	21.780	19.8	9.8	0.839	1.000	1.839	1.84	1.420	0.420
11	0.3130	21.500	19.5	10.9	0.817	1.000	1.817	1.82	1.409	0.409
12	0.3540	21.600	19.6	12.4	0.808	1.000	1.808	1.81	1.404	0.404
13	0.3959	20.780	18.8	13.9	0.761	1.000	1.761	1.76	1.380	0.380
14	0.4280	21.030	19.1	15.0	0.761	1.000	1.761	1.76	1.380	0.380

Parameters for Specimen No. 2		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	146.420	146.420
Moisture content: Dry soil+tare, gms.	103.950	103.950
Moisture content: Tare, gms.	29.940	29.940
Moisture, %	57.4	57.4
Moist specimen weight, gms.	117.0	
Diameter, in.	1.39	
Area, in.²	1.53	
Height, in.	2.80	
Wet Density, pcf	104.1	
Dry density, pcf	66.1	
Void ratio	1.5465	
Saturation, %	100.1	

Test Readings for Specimen No. 2

Cell pressure = 2.000 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 0.945 tsf at reading no. 4

Ult. Stress = 0.800 tsf at reading no. 14

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0067	4.420	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	0.0253	20.470	16.0	0.7	0.752	2.000	2.752	1.38	2.376	0.376
2	0.0462	23.710	19.3	1.4	0.897	2.000	2.897	1.45	2.449	0.449
3	0.0678	24.650	20.2	2.2	0.934	2.000	2.934	1.47	2.467	0.467
4	0.0881	25.050	20.6	2.9	0.945	2.000	2.945	1.47	2.472	0.472
5	0.1080	25.170	20.8	3.6	0.944	2.000	2.944	1.47	2.472	0.472
6	0.1289	25.260	20.8	4.4	0.940	2.000	2.940	1.47	2.470	0.470
7	0.1701	24.730	20.3	5.8	0.902	2.000	2.902	1.45	2.451	0.451
8	0.2113	24.800	20.4	7.3	0.891	2.000	2.891	1.45	2.446	0.446
9	0.2526	24.960	20.5	8.8	0.884	2.000	2.884	1.44	2.442	0.442
10	0.2937	24.250	19.8	10.2	0.840	2.000	2.840	1.42	2.420	0.420
11	0.3247	23.800	19.4	11.3	0.811	2.000	2.811	1.41	2.405	0.405
12	0.3656	24.100	19.7	12.8	0.810	2.000	2.810	1.40	2.405	0.405
13	0.4070	24.400	20.0	14.3	0.808	2.000	2.808	1.40	2.404	0.404
14	0.4275	24.360	19.9	15.0	0.800	2.000	2.800	1.40	2.400	0.400

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	148.370	148.370
Moisture content: Dry soil+tare, gms.	106.710	106.710
Moisture content: Tare, gms.	30.200	30.200
Moisture, %	54.5	54.5
Moist specimen weight, gms.	118.8	
Diameter, in.	1.40	
Area, in.²	1.53	
Height, in.	2.80	
Wet Density, pcf	105.4	
Dry density, pcf	68.3	
Void ratio	1.4674	
Saturation, %	100.1	

Test Readings for Specimen No. 3

Cell pressure = 4.000 tsf

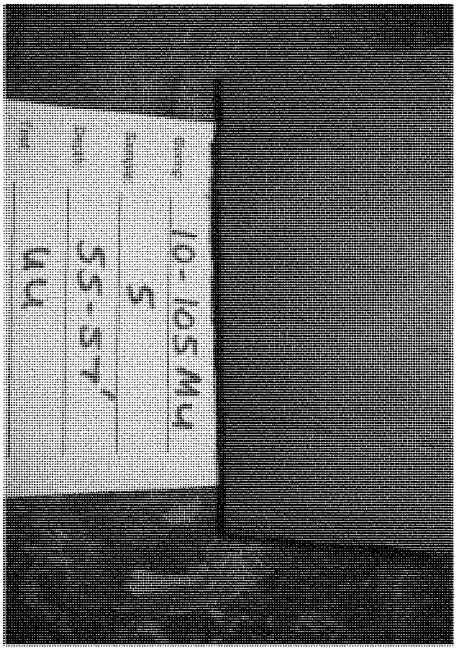
Back pressure = 0.000 tsf

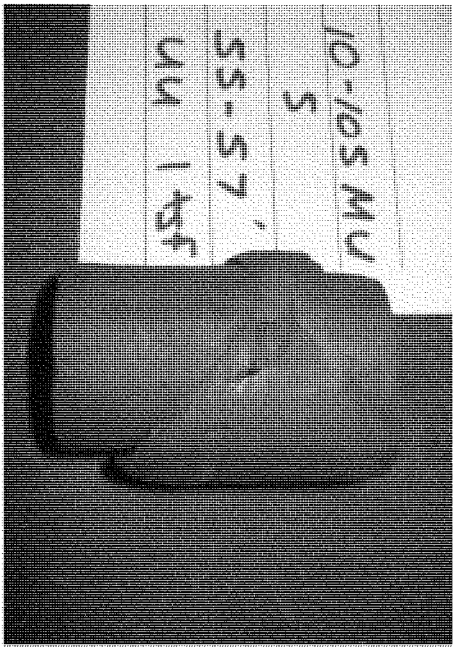
Strain rate, %/min. = 1.00

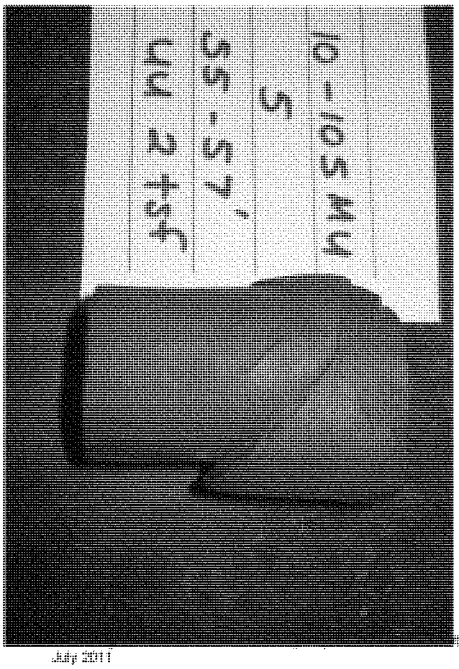
Peak Stress = 1.037 tsf at reading no. 4

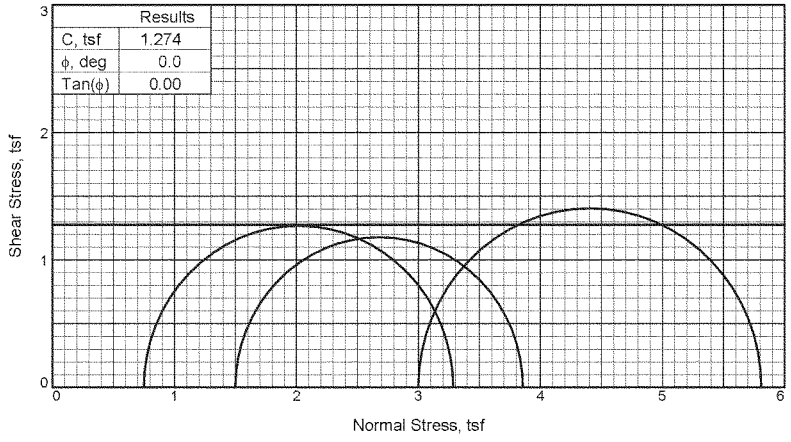
Ult. Stress = 0.796 tsf at reading no. 13

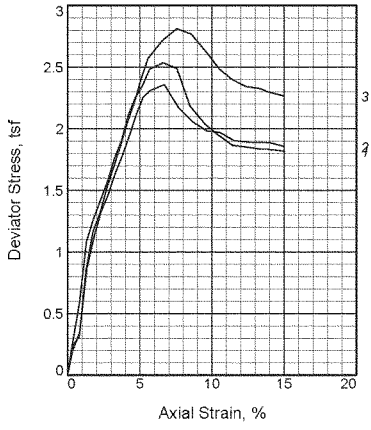
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0082	10.520	0.0	0.0	0.000	4.000	4.000	1.00	4.000	0.000
1	0.0284	28.680	18.2	0.7	0.848	4.000	4.848	1.21	4.424	0.424
2	0.0498	31.270	20.8	1.5	0.962	4.000	4.962	1.24	4.481	0.481
3	0.0710	32.770	22.3	2.2	1.023	4.000	5.023	1.26	4.512	0.512
4	0.0911	33.230	22.7	3.0	1.037	4.000	5.037	1.26	4.518	0.518
5	0.1108	33.253	22.7	3.7	1.030	4.000	5.030	1.26	4.515	0.515
6	0.1312	32.710	22.2	4.4	0.998	4.000	4.998	1.25	4.499	0.499
7	0.1926	31.850	21.3	6.6	0.937	4.000	4.937	1.23	4.469	0.469
8	0.2324	31.400	20.9	8.0	0.904	4.000	4.904	1.23	4.452	0.452
9	0.2738	30.850	20.3	9.5	0.866	4.000	4.866	1.22	4.433	0.433
10	0.3031	30.690	20.2	10.5	0.849	4.000	4.849	1.21	4.425	0.425
11	0.3437	30.600	20.1	12.0	0.832	4.000	4.832	1.21	4.416	0.416
12	0.3837	30.180	19.7	13.4	0.801	4.000	4.801	1.20	4.400	0.400
13	0.4275	30.410	19.9	15.0	0.796	4.000	4.796	1.20	4.398	0.398


10-105 MU
5
55-57'
UU


10-105 MU
5
55-57'
UU 1 tsf


10-105 MU
5
55-57'
UU 2 tsf





Sample No.		1	2	3
Initial	Water Content, %	39.3	40.1	36.2
	Dry Density, pcf	81.4	80.5	84.8
	Saturation, %	99.8	99.5	99.8
	Void Ratio	1.0555	1.0791	0.9734
	Diameter, in.	1.39	1.39	1.40
	Height, in.	2.80	2.80	2.81
At Test	Water Content, %	39.3	40.1	36.2
	Dry Density, pcf	81.4	80.5	84.8
	Saturation, %	99.8	99.5	99.8
	Void Ratio	1.0555	1.0791	0.9734
	Diameter, in.	1.39	1.39	1.40
	Height, in.	2.80	2.80	2.81
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.75	1.50	3.00
Peak Stress, tsf		2.54	2.36	2.81
Ult. Stress, tsf		1.82	1.86	2.27
σ_1 Failure, tsf		3.29	3.86	5.81
σ_3 Failure, tsf		0.75	1.50	3.00

Type of Test:
Unconsolidated Undrained
Sample Type: 5" Thinwall, Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 60 **PL=** 18 **PI=** 42
Specific Gravity= 2.681
Remarks:

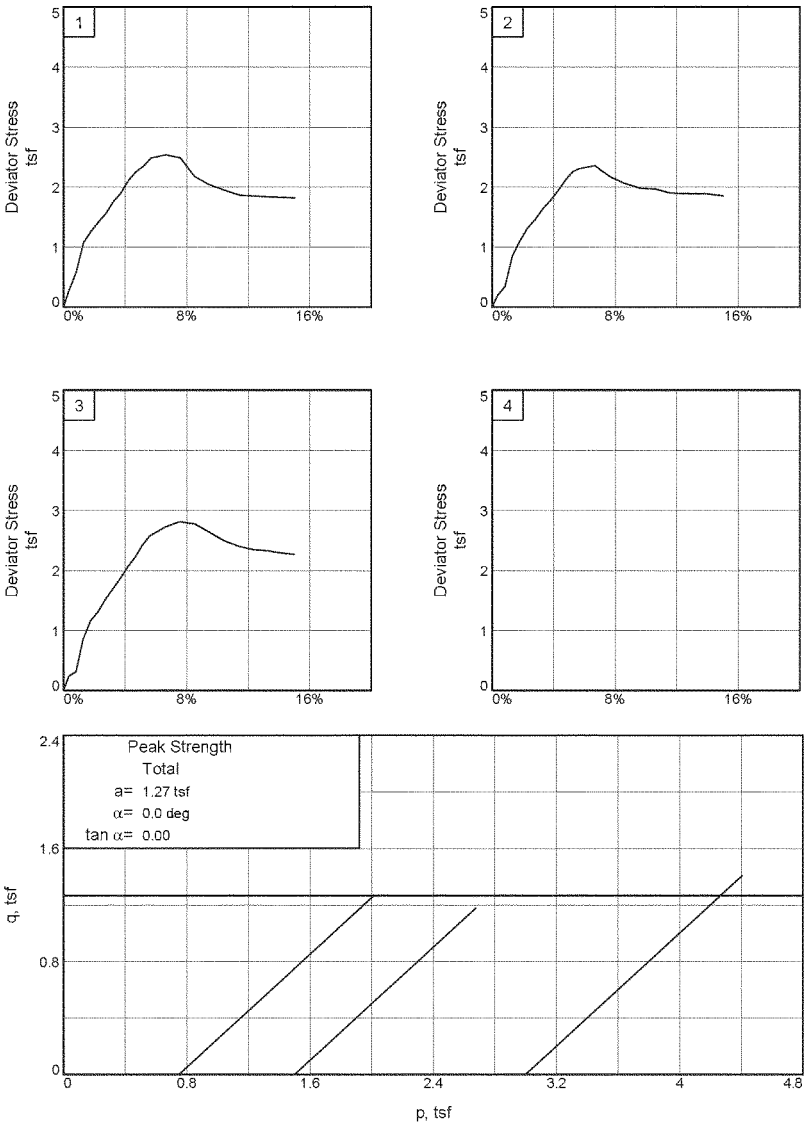
Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: ND RRCS, MN, Argusville Formation
Sample Number: Boring11-107MU, #3 **Depth:** 40-42'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Figure UU Triax ASTM D 2850

Tested By: JK **Checked By:** jrs



Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: ND RRCS, MN, Argusville Formation **Depth:** 40-42' **Sample No.:** Boring11-107MU, #3
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JK **Checked By:** jrs

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

5/30/2011
12:15 PM

Date:	
Client:	USACE W912ES-11-P-0024
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing Request NO. 3
Project No.:	BL-10-10065
Location:	ND RRCS, MN, Argusville Formation
Depth:	40-42' **Sample Number:** Boring11-107MU, #3
Description:	FAT CLAY, brown (CH)
Remarks:	
Type of Sample:	5" Thinwall, Bottom of sample
Specific Gravity=2.681	**LL=**60 **PL=**18 **PI=**42
Test Method:	ASTM D 2850

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	157.130	157.130
Moisture content: Dry soil+tare, gms.	121.370	121.370
Moisture content: Tare, gms.	30.390	30.390
Moisture, %	39.3	39.3
Moist specimen weight, gms.	126.9	
Diameter, in.	1.39	
Area, in.²	1.52	
Height, in.	2.80	
Wet Density, pcf	113.4	
Dry density, pcf	81.4	
Void ratio	1.0555	
Saturation, %	99.8	

Test Readings for Specimen No. 1

Cell pressure = 0.750 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 2.536 tsf **at reading no.** 13
Ult. Stress = 1.819 tsf **at reading no.** 22

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0065	1.060	0.0	0.0	0.000	0.750	0.750	1.00	0.750	0.000
1	0.0163	6.670	5.6	0.3	0.264	0.750	1.014	1.35	0.882	0.132
2	0.0295	13.480	12.4	0.8	0.583	0.750	1.333	1.78	1.041	0.291
3	0.0432	24.250	23.2	1.3	1.083	0.750	1.833	2.44	1.291	0.541
4	0.0567	28.340	27.3	1.8	1.268	0.750	2.018	2.69	1.384	0.634
5	0.0697	31.580	30.5	2.3	1.411	0.750	2.161	2.88	1.456	0.706
6	0.0838	35.090	34.0	2.8	1.566	0.750	2.316	3.09	1.533	0.783
7	0.0975	39.550	38.5	3.2	1.762	0.750	2.512	3.35	1.631	0.881
8	0.1107	42.720	41.7	3.7	1.898	0.750	2.648	3.53	1.699	0.949
9	0.1245	47.600	46.5	4.2	2.109	0.750	2.859	3.81	1.805	1.055
10	0.1381	51.050	50.0	4.7	2.254	0.750	3.004	4.01	1.877	1.127
11	0.1518	53.400	52.3	5.2	2.348	0.750	3.098	4.13	1.924	1.174
12	0.1655	56.700	55.6	5.7	2.483	0.750	3.233	4.31	1.991	1.241
13	0.1926	58.470	57.4	6.6	2.536	0.750	3.286	4.38	2.018	1.268
14	0.2189	57.950	56.9	7.6	2.487	0.750	3.237	4.32	1.994	1.244
15	0.2445	51.450	50.4	8.5	2.181	0.750	2.931	3.91	1.841	1.091
16	0.2720	48.760	47.7	9.5	2.043	0.750	2.793	3.72	1.771	1.021
17	0.3001	46.990	45.9	10.5	1.945	0.750	2.695	3.59	1.723	0.973
18	0.3271	45.580	44.5	11.4	1.865	0.750	2.615	3.49	1.683	0.933
19	0.3548	45.720	44.7	12.4	1.850	0.750	2.600	3.47	1.675	0.925
20	0.3809	45.830	44.8	13.4	1.835	0.750	2.585	3.45	1.668	0.918
21	0.3948	46.060	45.0	13.9	1.834	0.750	2.584	3.45	1.667	0.917
22	0.4273	46.300	45.2	15.0	1.819	0.750	2.569	3.43	1.659	0.909

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	155.880	155.880
Moisture content: Dry soil+tare, gms.	119.820	119.820
Moisture content: Tare, gms.	29.810	29.810
Moisture, %	40.1	40.1
Moist specimen weight, gms.	126.3	
Diameter, in.	1.39	
Area, in.²	1.52	
Height, in.	2.80	
Wet Density, pcf	112.8	
Dry density, pcf	80.5	
Void ratio	1.0791	
Saturation, %	99.5	

Test Readings for Specimen No. 2

Cell pressure = 1.500 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 2.357 tsf at reading no. 13

Ult. Stress = 1.855 tsf at reading no. 22

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0064	3.470	0.0	0.0	0.000	1.500	1.500	1.00	1.500	0.000
1	0.0165	7.680	4.2	0.4	0.198	1.500	1.698	1.13	1.599	0.099
2	0.0300	10.890	7.4	0.8	0.348	1.500	1.848	1.23	1.674	0.174
3	0.0438	22.000	18.5	1.3	0.864	1.500	2.364	1.58	1.932	0.432
4	0.0571	27.370	23.9	1.8	1.109	1.500	2.609	1.74	2.054	0.554
5	0.0707	32.010	28.5	2.3	1.317	1.500	2.817	1.88	2.159	0.659
6	0.0844	35.120	31.7	2.8	1.454	1.500	2.954	1.97	2.227	0.727
7	0.0986	39.300	35.8	3.3	1.637	1.500	3.137	2.09	2.318	0.818
8	0.1125	42.570	39.1	3.8	1.777	1.500	3.277	2.18	2.389	0.889
9	0.1257	46.200	42.7	4.3	1.933	1.500	3.433	2.29	2.466	0.966
10	0.1398	50.560	47.1	4.8	2.119	1.500	3.619	2.41	2.559	1.059
11	0.1533	53.890	50.4	5.2	2.257	1.500	3.757	2.50	2.629	1.129
12	0.1663	55.330	51.9	5.7	2.310	1.500	3.810	2.54	2.655	1.155
13	0.1939	56.940	53.5	6.7	2.357	1.500	3.857	2.57	2.678	1.178
14	0.2211	53.280	49.8	7.7	2.173	1.500	3.673	2.45	2.586	1.086
15	0.2484	51.170	47.7	8.6	2.059	1.500	3.559	2.37	2.529	1.029
16	0.2762	49.920	46.5	9.6	1.983	1.500	3.483	2.32	2.492	0.992
17	0.3033	50.050	46.6	10.6	1.967	1.500	3.467	2.31	2.484	0.984
18	0.3301	49.010	45.5	11.6	1.903	1.500	3.403	2.27	2.451	0.951
19	0.3576	49.220	45.8	12.5	1.890	1.500	3.390	2.26	2.445	0.945
20	0.3855	49.770	46.3	13.5	1.891	1.500	3.391	2.26	2.446	0.946
21	0.3989	49.940	46.5	14.0	1.888	1.500	3.388	2.26	2.444	0.944
22	0.4266	49.680	46.2	15.0	1.855	1.500	3.355	2.24	2.428	0.928

Parameters for Specimen No. 3

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	161.200	161.200
Moisture content: Dry soil+tare, gms.	126.460	126.460
Moisture content: Tare, gms.	30.580	30.580
Moisture, %	36.2	36.2
Moist specimen weight, gms.	130.8	
Diameter, in.	1.40	
Area, in.²	1.54	
Height, in.	2.81	
Wet Density, pcf	115.5	
Dry density, pcf	84.8	
Void ratio	0.9734	
Saturation, %	99.8	

Test Readings for Specimen No. 3

Cell pressure = 3.000 tsf

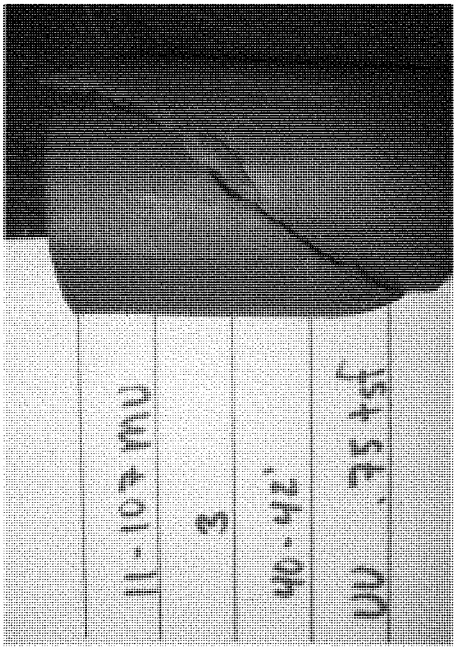
Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

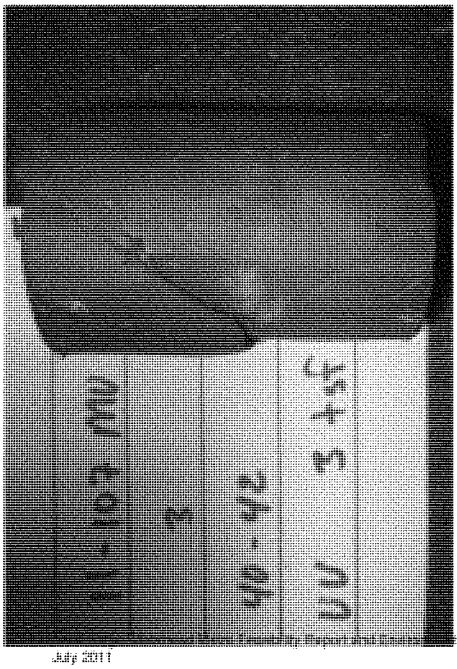
Peak Stress = 2.811 tsf at reading no. 14

Ult. Stress = 2.266 tsf at reading no. 22

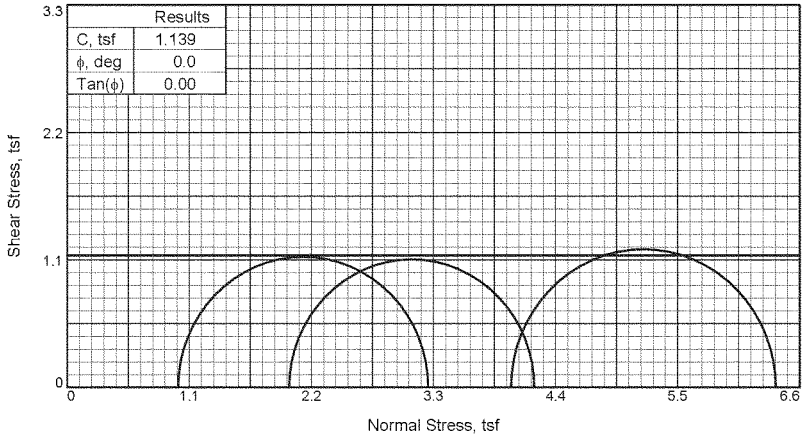
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0064	6.860	0.0	0.0	0.000	3.000	3.000	1.00	3.000	0.000
1	0.0163	12.020	5.2	0.4	0.241	3.000	3.241	1.08	3.120	0.120
2	0.0292	13.570	6.7	0.8	0.312	3.000	3.312	1.10	3.156	0.156
3	0.0422	25.260	18.4	1.3	0.851	3.000	3.851	1.28	3.425	0.425
4	0.0560	32.190	25.3	1.8	1.165	3.000	4.165	1.39	3.583	0.583
5	0.0690	35.490	28.6	2.2	1.311	3.000	4.311	1.44	3.656	0.656
6	0.0827	40.190	33.3	2.7	1.519	3.000	4.519	1.51	3.759	0.759
7	0.0965	44.220	37.4	3.2	1.694	3.000	4.694	1.56	3.847	0.847
8	0.1096	48.180	41.3	3.7	1.864	3.000	4.864	1.62	3.932	0.932
9	0.1235	52.760	45.9	4.2	2.060	3.000	5.060	1.69	4.030	1.030
10	0.1365	56.490	49.6	4.6	2.217	3.000	5.217	1.74	4.108	1.108
11	0.1496	61.060	54.2	5.1	2.409	3.000	5.409	1.80	4.205	1.205
12	0.1635	65.090	58.2	5.6	2.575	3.000	5.575	1.86	4.287	1.287
13	0.1911	68.970	62.1	6.6	2.718	3.000	5.718	1.91	4.359	1.359
14	0.2182	71.780	64.9	7.5	2.811	3.000	5.811	1.94	4.406	1.406
15	0.2463	71.530	64.7	8.5	2.770	3.000	5.770	1.92	4.385	1.385
16	0.2740	68.970	62.1	9.5	2.632	3.000	5.632	1.88	4.316	1.316
17	0.3003	66.190	59.3	10.5	2.488	3.000	5.488	1.83	4.244	1.244
18	0.3264	64.700	57.8	11.4	2.400	3.000	5.400	1.80	4.200	1.200
19	0.3536	63.930	57.1	12.4	2.342	3.000	5.342	1.78	4.171	1.171
20	0.3803	64.150	57.3	13.3	2.326	3.000	5.326	1.78	4.163	1.163
21	0.3938	63.900	57.0	13.8	2.303	3.000	5.303	1.77	4.151	1.151
22	0.4270	63.780	56.9	15.0	2.266	3.000	5.266	1.76	4.133	1.133

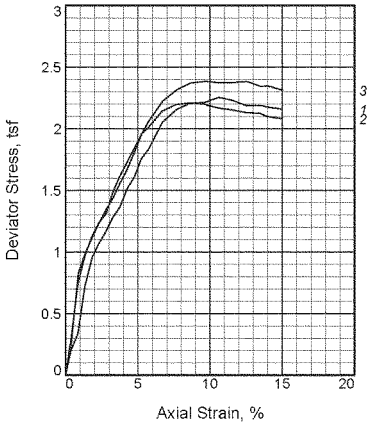

11-107 MU
3
40-42'
UU .75 tsf

11-107 MU
3
40-42'
UU 1.5 tsf


11-107 MU
3
40-42
UU 3 tsf

Boring 11-107 MU
Sample 3
Depth 40-42'





Sample No.		1	2	3
Initial	Water Content, %	34.0	34.1	33.2
	Dry Density, pcf	87.6	87.8	89.0
	Saturation, %	99.4	99.9	99.8
	Void Ratio	0.9267	0.9227	0.8984
	Diameter, in.	1.39	1.39	1.38
	Height, in.	2.80	2.81	2.80
At Test	Water Content, %	34.0	34.1	33.2
	Dry Density, pcf	87.6	87.8	89.0
	Saturation, %	99.4	99.9	99.8
	Void Ratio	0.9267	0.9227	0.8984
	Diameter, in.	1.39	1.39	1.38
	Height, in.	2.80	2.81	2.80
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		1.00	2.00	4.00
Peak Stress, tsf		2.25	2.21	2.39
Ult. Stress, tsf		2.16	2.08	2.31
σ_1 Failure, tsf		3.25	4.21	6.39
σ_3 Failure, tsf		1.00	2.00	4.00

Type of Test:
Unconsolidated Undrained
Sample Type: 5" Thinwall, Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 63 **PL=** 19 **PI=** 44
Specific Gravity= 2.705
Remarks:

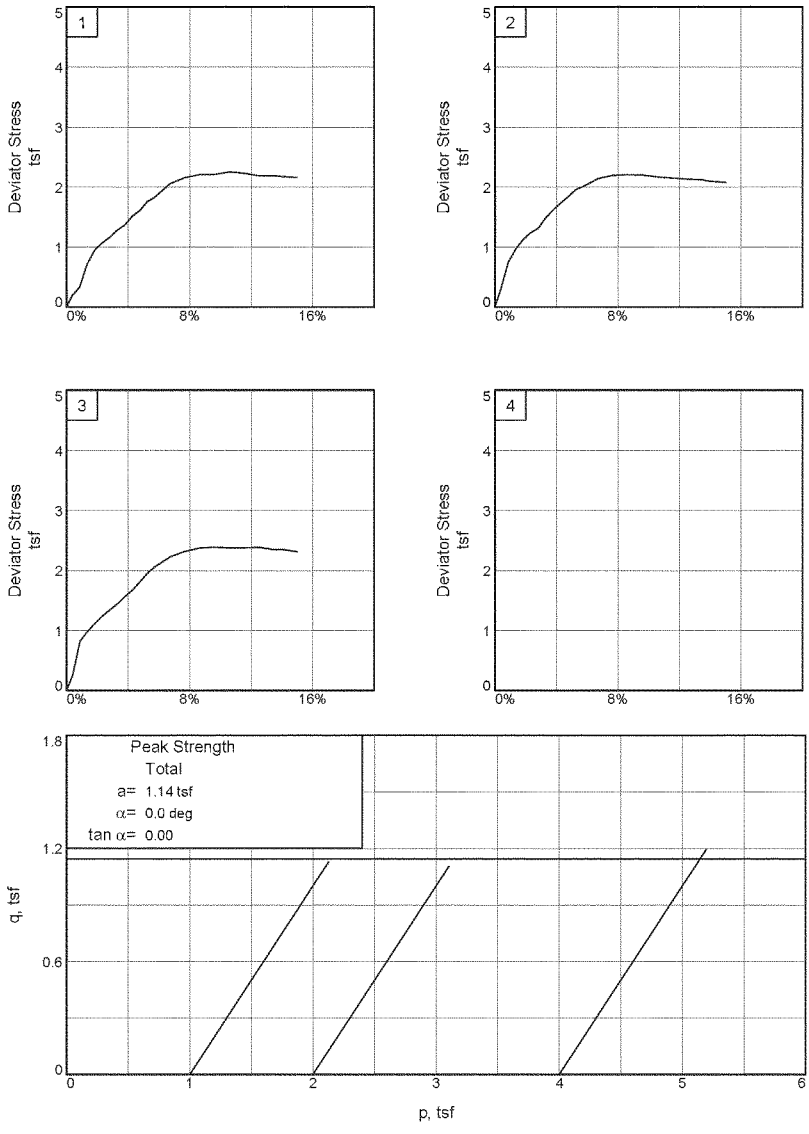
Figure UU Triax ASTM D 2850

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: ND RRCS, MN, Argusville Formation
Sample Number: Boring11-107MU, #4 **Depth:** 50-52'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Tested By: JK **Checked By:** JTS



Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: ND RRCS, MN, Argusville Formation **Depth:** 50-52' **Sample No.:** Boring11-107MU, #4
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JK **Checked By:** jrs

TRIAXIAL COMPRESSION TEST 5/30/2011
Unconsolidated Undrained 12:16 PM

Date:			
Client:	USACE W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing Request NO. 3		
Project No.:	BL-10-10065		
Location:	ND RRCS, MN, Argusville Formation		
Depth:	50-52'	**Sample Number:**	Boring11-107MU, #4
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	5" Thinwall, Bottom of sample		

Specific Gravity=2.705 **LL=63** **PL=19** **PI=44**

Test Method: ASTM D 2850

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	161.080	161.080
Moisture content: Dry soil+tare, gms.	127.870	127.870
Moisture content: Tare, gms.	30.300	30.300
Moisture, %	34.0	34.0
Moist specimen weight, gms.	131.0	
Diameter, in.	1.39	
Area, in.²	1.52	
Height, in.	2.80	
Wet Density, pcf	117.5	
Dry density, pcf	87.6	
Void ratio	0.9267	
Saturation, %	99.4	

Test Readings for Specimen No. 1

Cell pressure = 1.000 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 2.254 tsf **at reading no.** 17
Ult. Stress = 2.160 tsf **at reading no.** 22

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0063	0.940	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	0.0168	5.090	4.2	0.4	0.196	1.000	1.196	1.20	1.098	0.098
2	0.0303	8.050	7.1	0.9	0.335	1.000	1.335	1.33	1.167	0.167
3	0.0441	16.440	15.5	1.3	0.727	1.000	1.727	1.73	1.363	0.363
4	0.0579	21.390	20.5	1.8	0.954	1.000	1.954	1.95	1.477	0.477
5	0.0711	23.980	23.0	2.3	1.069	1.000	2.069	2.07	1.535	0.535
6	0.0849	26.180	25.2	2.8	1.166	1.000	2.166	2.17	1.583	0.583
7	0.0985	28.830	27.9	3.3	1.282	1.000	2.282	2.28	1.641	0.641
8	0.1125	30.880	29.9	3.8	1.369	1.000	2.369	2.37	1.684	0.684
9	0.1263	34.300	33.4	4.3	1.517	1.000	2.517	2.52	1.759	0.759
10	0.1398	36.520	35.6	4.8	1.610	1.000	2.610	2.61	1.805	0.805
11	0.1536	39.970	39.0	5.3	1.757	1.000	2.757	2.76	1.879	0.879
12	0.1667	41.800	40.9	5.7	1.830	1.000	2.830	2.83	1.915	0.915
13	0.1940	47.240	46.3	6.7	2.053	1.000	3.053	3.05	2.026	1.026
14	0.2211	50.050	49.1	7.7	2.155	1.000	3.155	3.15	2.077	1.077
15	0.2481	51.780	50.8	8.6	2.207	1.000	3.207	3.21	2.104	1.104
16	0.2763	52.460	51.5	9.6	2.212	1.000	3.212	3.21	2.106	1.106
17	0.3039	54.010	53.1	10.6	2.254	1.000	3.254	3.25	2.127	1.127
18	0.3309	54.010	53.1	11.6	2.230	1.000	3.230	3.23	2.115	1.115
19	0.3578	53.560	52.6	12.5	2.187	1.000	3.187	3.19	2.093	1.093
20	0.3852	54.260	53.3	13.5	2.191	1.000	3.191	3.19	2.096	1.096
21	0.3990	54.190	53.3	14.0	2.176	1.000	3.176	3.18	2.088	1.088
22	0.4261	54.410	53.5	15.0	2.160	1.000	3.160	3.16	2.080	1.080

Parameters for Specimen No. 2		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	162.370	162.370
Moisture content: Dry soil+tare, gms.	129.000	129.000
Moisture content: Tare, gms.	31.050	31.050
Moisture, %	34.1	34.1
Moist specimen weight, gms.	131.5	
Diameter, in.	1.39	
Area, in.²	1.52	
Height, in.	2.81	
Wet Density, pcf	117.8	
Dry density, pcf	87.8	
Void ratio	0.9227	
Saturation, %	99.9	

Test Readings for Specimen No. 2

Cell pressure = 2.000 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 2.209 tsf at reading no. 15

Ult. Stress = 2.082 tsf at reading no. 22

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0065	3.380	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	0.0172	9.480	6.1	0.4	0.289	2.000	2.289	1.14	2.144	0.144
2	0.0309	19.310	15.9	0.9	0.750	2.000	2.750	1.38	2.375	0.375
3	0.0450	24.220	20.8	1.4	0.977	2.000	2.977	1.49	2.488	0.488
4	0.0583	27.580	24.2	1.8	1.129	2.000	3.129	1.56	2.564	0.564
5	0.0719	30.110	26.7	2.3	1.241	2.000	3.241	1.62	2.620	0.620
6	0.0857	31.850	28.5	2.8	1.315	2.000	3.315	1.66	2.657	0.657
7	0.0988	35.730	32.3	3.3	1.487	2.000	3.487	1.74	2.743	0.743
8	0.1128	38.840	35.5	3.8	1.621	2.000	3.621	1.81	2.811	0.811
9	0.1266	41.500	38.1	4.3	1.734	2.000	3.734	1.87	2.867	0.867
10	0.1400	44.030	40.6	4.8	1.840	2.000	3.840	1.92	2.920	0.920
11	0.1540	46.840	43.5	5.3	1.957	2.000	3.957	1.98	2.978	0.978
12	0.1674	48.240	44.9	5.7	2.009	2.000	4.009	2.00	3.005	1.005
13	0.1943	51.690	48.3	6.7	2.142	2.000	4.142	2.07	3.071	1.071
14	0.2212	53.400	50.0	7.6	2.195	2.000	4.195	2.10	3.097	1.097
15	0.2482	54.260	50.9	8.6	2.209	2.000	4.209	2.10	3.105	1.105
16	0.2761	54.590	51.2	9.6	2.200	2.000	4.200	2.10	3.100	1.100
17	0.3031	54.380	51.0	10.6	2.167	2.000	4.167	2.08	3.084	1.084
18	0.3300	54.590	51.2	11.5	2.153	2.000	4.153	2.08	3.076	1.076
19	0.3567	54.650	51.3	12.5	2.132	2.000	4.132	2.07	3.066	1.066
20	0.3847	55.050	51.7	13.5	2.124	2.000	4.124	2.06	3.062	1.062
21	0.3978	54.710	51.3	13.9	2.099	2.000	4.099	2.05	3.049	1.049
22	0.4277	54.930	51.5	15.0	2.082	2.000	4.082	2.04	3.041	1.041

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	159.980	159.980
Moisture content: Dry soil+tare, gms.	127.650	127.650
Moisture content: Tare, gms.	30.140	30.140
Moisture, %	33.2	33.2
Moist specimen weight, gms.	130.0	
Diameter, in.	1.38	
Area, in.^{2}	1.49	
Height, in.	2.80	
Wet Density, pcf	118.4	
Dry density, pcf	89.0	
Void ratio	0.8984	
Saturation, %	99.8	

Test Readings for Specimen No. 3

Cell pressure = 4.000 tsf

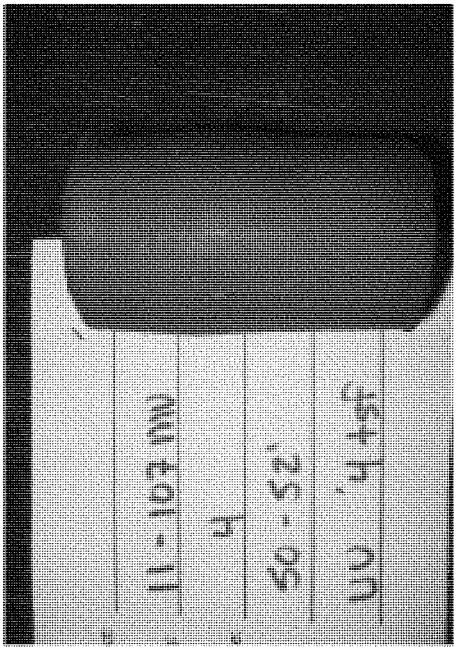
Back pressure = 0.000 tsf

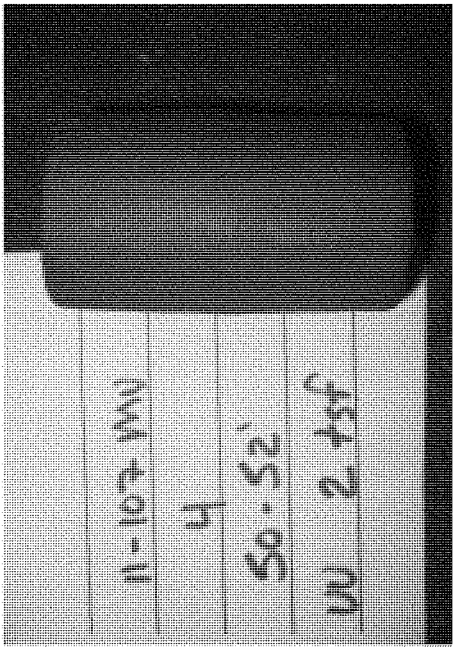
Strain rate, %/min. = 1.00

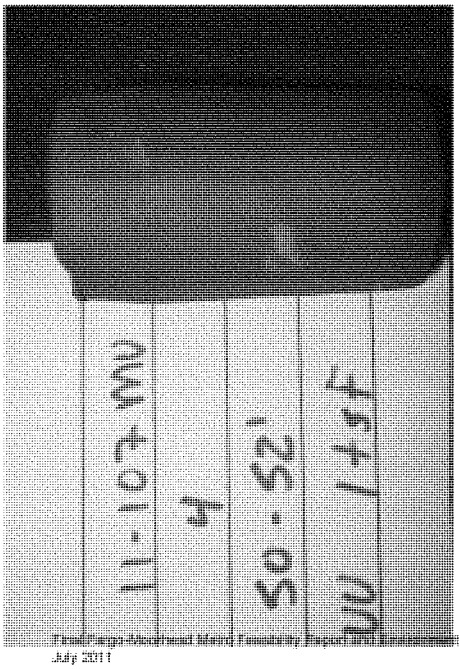
Peak Stress = 2.385 tsf at reading no. 16

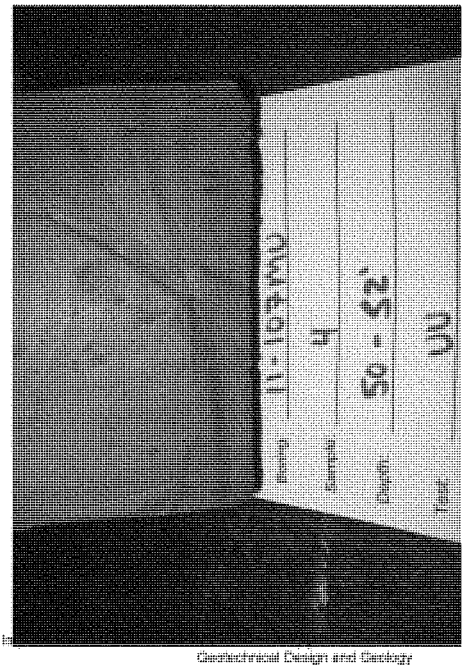
Ult. Stress = 2.312 tsf at reading no. 22

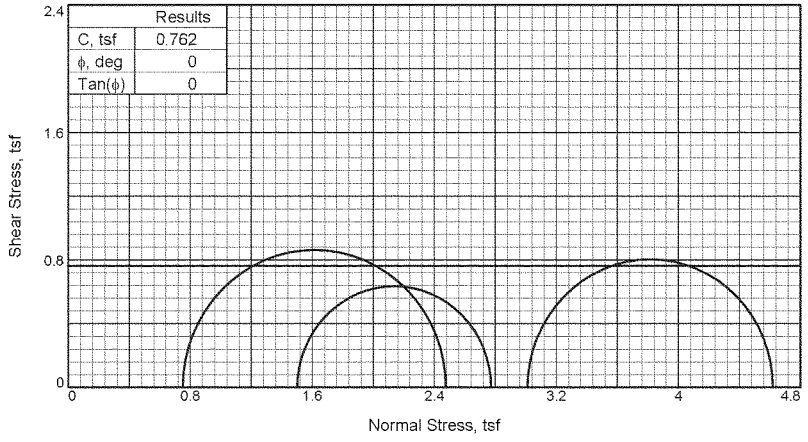
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0065	9.850	0.0	0.0	0.000	4.000	4.000	1.00	4.000	0.000
1	0.0178	15.100	5.3	0.4	0.252	4.000	4.252	1.06	4.126	0.126
2	0.0312	27.120	17.3	0.9	0.825	4.000	4.825	1.21	4.413	0.413
3	0.0450	30.630	20.8	1.4	0.988	4.000	4.988	1.25	4.494	0.494
4	0.0579	33.410	23.6	1.8	1.115	4.000	5.115	1.28	4.557	0.557
5	0.0720	36.160	26.3	2.3	1.239	4.000	5.239	1.31	4.619	0.619
6	0.0860	38.690	28.8	2.8	1.351	4.000	5.351	1.34	4.675	0.675
7	0.0997	40.920	31.1	3.3	1.448	4.000	5.448	1.36	4.724	0.724
8	0.1135	43.760	33.9	3.8	1.572	4.000	5.572	1.39	4.786	0.786
9	0.1266	46.140	36.3	4.3	1.674	4.000	5.674	1.42	4.837	0.837
10	0.1407	49.430	39.6	4.8	1.817	4.000	5.817	1.45	4.908	0.908
11	0.1545	52.790	42.9	5.3	1.961	4.000	5.961	1.49	4.980	0.980
12	0.1676	55.230	45.4	5.8	2.062	4.000	6.062	1.52	5.031	1.031
13	0.1950	59.320	49.5	6.7	2.224	4.000	6.224	1.56	5.112	1.112
14	0.2220	61.920	52.1	7.7	2.317	4.000	6.317	1.58	5.158	1.158
15	0.2493	63.710	53.9	8.7	2.371	4.000	6.371	1.59	5.186	1.186
16	0.2772	64.630	54.8	9.7	2.385	4.000	6.385	1.60	5.193	1.193
17	0.3046	64.930	55.1	10.6	2.373	4.000	6.373	1.59	5.186	1.186
18	0.3313	65.580	55.7	11.6	2.375	4.000	6.375	1.59	5.187	1.187
19	0.3585	66.400	56.6	12.6	2.383	4.000	6.383	1.60	5.192	1.192
20	0.3851	66.070	56.2	13.5	2.344	4.000	6.344	1.59	5.172	1.172
21	0.3998	66.480	56.6	14.0	2.347	4.000	6.347	1.59	5.173	1.173
22	0.4268	66.280	56.4	15.0	2.312	4.000	6.312	1.58	5.156	1.156

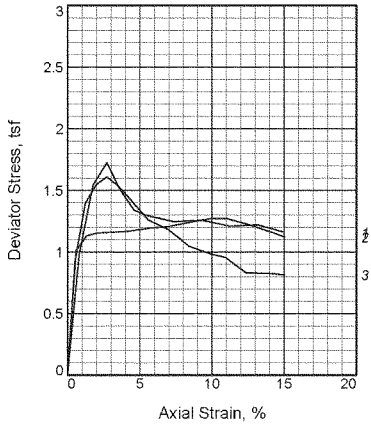

11-107 MW
4
50-52'
UU 4 tsf


11-107 MW
4
50-52'
UU 2 tsf


11-107 MW
4
50-52'
UU 1 tsf


11-107 MW
4
50-52'
UU





Sample No.		1	2	3
Initial	Water Content, %	51.3	50.3	52.7
	Dry Density, pcf	70.1	70.8	69.3
	Saturation, %	98.7	98.5	99.4
	Void Ratio	1.3990	1.3738	1.4260
	Diameter, in.	1.40	1.40	1.40
	Height, in.	2.81	2.81	2.81
At Test	Water Content, %	51.3	50.3	52.7
	Dry Density, pcf	70.1	70.8	69.3
	Saturation, %	98.7	98.5	99.4
	Void Ratio	1.3990	1.3738	1.4260
	Diameter, in.	1.40	1.40	1.40
	Height, in.	2.81	2.81	2.81
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.75	1.50	3.01
Peak Stress, tsf		1.73	1.27	1.61
Ult. Stress, tsf		1.16	1.12	0.81
σ_1 Failure, tsf		2.48	2.77	4.62
σ_3 Failure, tsf		0.75	1.50	3.01

Type of Test: Unconsolidated Undrained
Sample Type: Undisturbed, 5" Thinwall, Bottom
Description: FAT CLAY, brown (CH)

LL= 85 **PL=** 21 **PI=** 64
Specific Gravity= 2.693
Remarks:

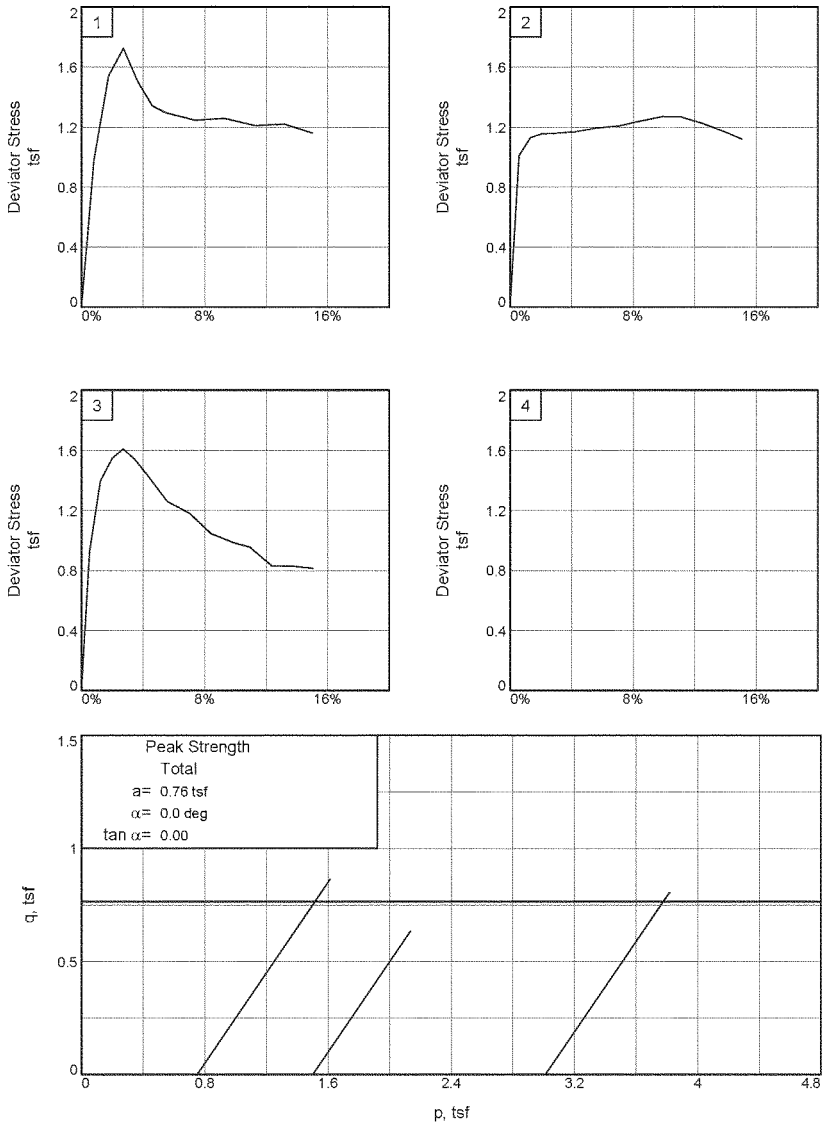
Figure UU Triax ASTM D 2850

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Sheyenne River, Argusville Formation
Sample Number: Boring11-110MU, #4 **Depth:** 55-57'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Tested By: JK **Checked By:** JS



Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: Sheyenne River, Argusville Formation **Depth:** 55-57' **Sample No.:** Boring11-110MU, #4
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JK **Checked By:** JS

TRIAXIAL COMPRESSION TEST 4/26/2011
Unconsolidated Undrained 8:14 AM

Date:			
Client:	W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing		
Project No.:	BL-10-10065		
Location:	Sheyenne River, Argusville Formation		
Depth:	55-57'	**Sample Number:**	Boring11-110MU, #4
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	Undisturbed, 5" Thinwall, Bottom		
Specific Gravity=2.693	**LL=**85	**PL=**21	**PI=**64
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	149.710	149.710
Moisture content: Dry soil+tare, gms.	109.300	109.300
Moisture content: Tare, gms.	30.480	30.480
Moisture, %	51.3	51.3
Moist specimen weight, gms.	119.6	
Diameter, in.	1.40	
Area, in.²	1.53	
Height, in.	2.81	
Wet Density, pcf	106.0	
Dry density, pcf	70.1	
Void ratio	1.3990	
Saturation, %	98.7	

Test Readings for Specimen No. 1

Cell pressure = 0.751 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 1.726 tsf **at reading no.** 3
Ult. Stress = 1.160 tsf **at reading no.** 11

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0065	0.000	0.0	0.0	0.000	0.751	0.751	1.00	0.751	0.000
1	0.0292	21.080	21.1	0.8	0.984	0.751	1.735	2.31	1.243	0.492
2	0.0561	33.410	33.4	1.8	1.544	0.751	2.295	3.06	1.523	0.772
3	0.0829	37.710	37.7	2.7	1.726	0.751	2.477	3.30	1.614	0.863
4	0.1092	33.140	33.1	3.7	1.502	0.751	2.253	3.00	1.502	0.751
5	0.1357	29.870	29.9	4.6	1.340	0.751	2.091	2.78	1.421	0.670
6	0.1608	29.140	29.1	5.5	1.295	0.751	2.046	2.72	1.399	0.648
7	0.2138	28.590	28.6	7.4	1.246	0.751	1.997	2.66	1.374	0.623
8	0.2674	29.470	29.5	9.3	1.258	0.751	2.009	2.67	1.380	0.629
9	0.3229	28.990	29.0	11.3	1.210	0.751	1.961	2.61	1.356	0.605
10	0.3764	29.870	29.9	13.2	1.220	0.751	1.971	2.62	1.361	0.610
11	0.4280	29.020	29.0	15.0	1.160	0.751	1.911	2.54	1.331	0.580

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	151.160	151.160
Moisture content: Dry soil+tare, gms.	110.750	110.750
Moisture content: Tare, gms.	30.360	30.360
Moisture, %	50.3	50.3
Moist specimen weight, gms.	121.2	
Diameter, in.	1.40	
Area, in.²	1.55	
Height, in.	2.81	
Wet Density, pcf	106.4	
Dry density, pcf	70.8	
Void ratio	1.3738	
Saturation, %	98.5	

Test Readings for Specimen No. 2

Cell pressure = 1.502 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.271 tsf at reading no. 10

Ult. Stress = 1.121 tsf at reading no. 14

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	2.980	0.0	0.0	0.000	1.502	1.502	1.00	1.502	0.000
1	0.0231	24.800	21.8	0.6	1.010	1.502	2.512	1.67	2.007	0.505
2	0.0435	27.550	24.6	1.3	1.129	1.502	2.631	1.75	2.067	0.565
3	0.0640	28.280	25.3	2.0	1.154	1.502	2.656	1.77	2.079	0.577
4	0.0840	28.540	25.6	2.8	1.158	1.502	2.660	1.77	2.081	0.579
5	0.1047	28.860	25.9	3.5	1.163	1.502	2.665	1.77	2.084	0.582
6	0.1249	29.170	26.2	4.2	1.168	1.502	2.670	1.78	2.086	0.584
7	0.1646	30.110	27.1	5.6	1.192	1.502	2.694	1.79	2.098	0.596
8	0.2052	30.880	27.9	7.1	1.207	1.502	2.709	1.80	2.106	0.604
9	0.2462	32.130	29.2	8.5	1.242	1.502	2.744	1.83	2.123	0.621
10	0.2861	33.290	30.3	10.0	1.271	1.502	2.773	1.85	2.138	0.636
11	0.3168	33.620	30.6	11.1	1.269	1.502	2.771	1.85	2.137	0.635

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
12	0.3578	33.010	30.0	12.5	1.224	1.502	2.726	1.81	2.114	0.612
13	0.3979	32.130	29.2	13.9	1.168	1.502	2.670	1.78	2.086	0.584
14	0.4290	31.310	28.3	15.0	1.121	1.502	2.623	1.75	2.062	0.560

Parameters for Specimen No. 3

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	150.030	150.030
Moisture content: Dry soil+tare, gms.	109.070	109.070
Moisture content: Tare, gms.	31.280	31.280
Moisture, %	52.7	52.7
Moist specimen weight, gms.	119.2	
Diameter, in.	1.40	
Area, in.²	1.53	
Height, in.	2.81	
Wet Density, pcf	105.8	
Dry density, pcf	69.3	
Void ratio	1.4260	
Saturation, %	99.4	

Test Readings for Specimen No. 3

Cell pressure = 3.012 tsf

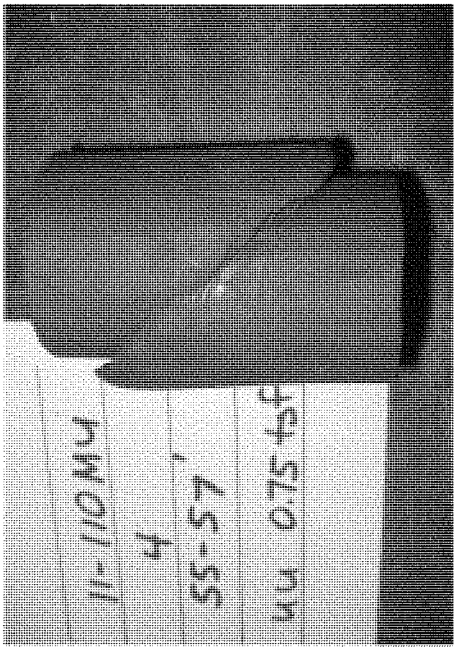
Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

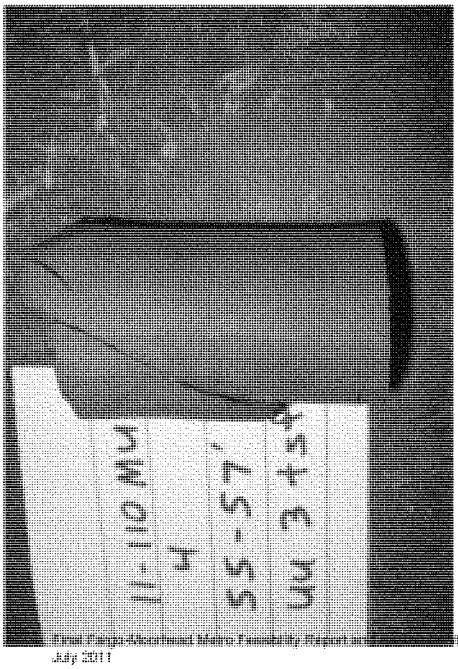
Peak Stress = 1.609 tsf at reading no. 4

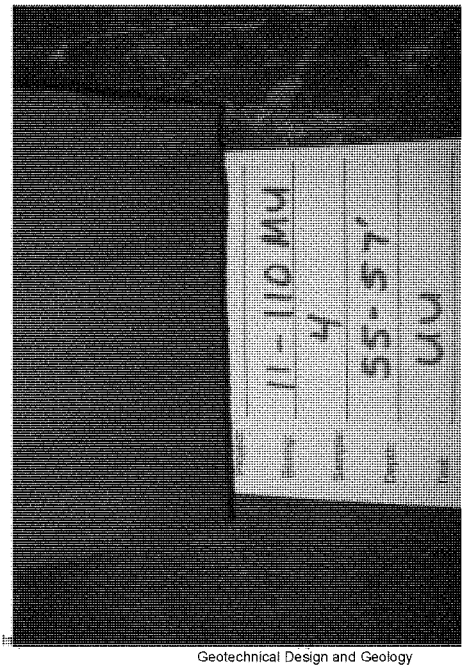
Ult. Stress = 0.814 tsf at reading no. 14

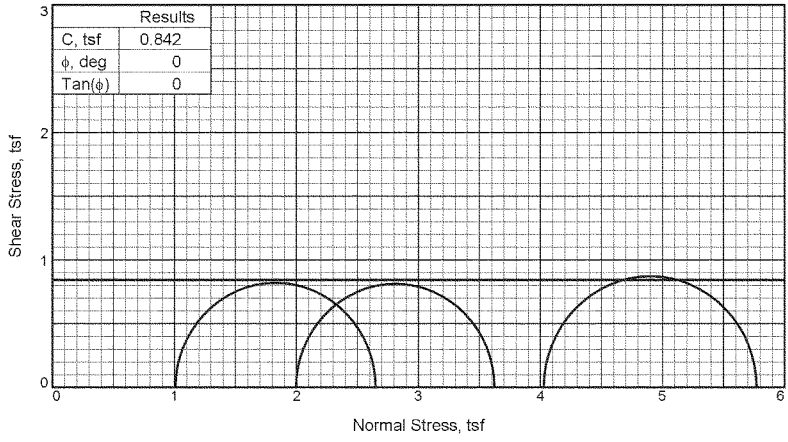
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0067	7.040	0.0	0.0	0.000	3.012	3.012	1.00	3.012	0.000
1	0.0212	26.790	19.8	0.5	0.924	3.012	3.936	1.31	3.474	0.462
2	0.0412	37.100	30.1	1.2	1.397	3.012	4.409	1.46	3.710	0.698
3	0.0628	40.640	33.6	2.0	1.549	3.012	4.561	1.51	3.786	0.774
4	0.0829	42.200	35.2	2.7	1.609	3.012	4.621	1.53	3.817	0.805
5	0.1024	41.070	34.0	3.4	1.546	3.012	4.558	1.51	3.785	0.773
6	0.1227	39.270	32.2	4.1	1.453	3.012	4.465	1.48	3.739	0.727
7	0.1626	35.430	28.4	5.6	1.261	3.012	4.273	1.42	3.643	0.631
8	0.2030	34.050	27.0	7.0	1.182	3.012	4.194	1.39	3.603	0.591
9	0.2431	31.310	24.3	8.4	1.045	3.012	4.057	1.35	3.535	0.523
10	0.2839	30.270	23.2	9.9	0.985	3.012	3.997	1.33	3.504	0.492
11	0.3142	29.840	22.8	11.0	0.955	3.012	3.967	1.32	3.489	0.477
12	0.3540	27.190	20.2	12.4	0.831	3.012	3.843	1.28	3.427	0.415
13	0.3948	27.430	20.4	13.8	0.826	3.012	3.838	1.27	3.425	0.413
14	0.4280	27.400	20.4	15.0	0.814	3.012	3.826	1.27	3.419	0.407

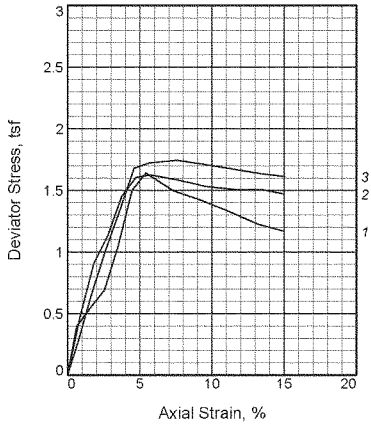

11-110 MW
4
55-57'
UU 075 tsf

11-110 MW
4
55-57'
UU 1.5 tsf


11-110 MW
4
55-57'
UU 3 tsf


11-110 MW
4
55-57'
UU





Sample No.		1	2	3
Initial	Water Content, %	46.9	45.3	43.5
	Dry Density, pcf	73.9	75.4	76.4
	Saturation, %	99.3	99.7	98.1
	Void Ratio	1.2646	1.2180	1.1897
	Diameter, in.	1.39	1.39	1.40
	Height, in.	2.80	2.79	2.80
At Test	Water Content, %	47.2	45.5	44.4
	Dry Density, pcf	73.9	75.4	76.4
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.2646	1.2180	1.1897
	Diameter, in.	1.39	1.39	1.40
	Height, in.	2.80	2.79	2.80
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		1.01	2.00	4.03
Peak Stress, tsf		1.64	1.63	1.74
Ult. Stress, tsf		1.17	1.47	1.61
σ_1 Failure, tsf		2.65	3.62	5.77
σ_3 Failure, tsf		1.01	2.00	4.03

Type of Test: Unconsolidated Undrained
Sample Type: Undisturbed, 5" Thinwall, Bottom
Description: FAT CLAY, brown (CH)

LL= 70 **PL=** 22 **PI=** 48
Specific Gravity= 2.679
Remarks:

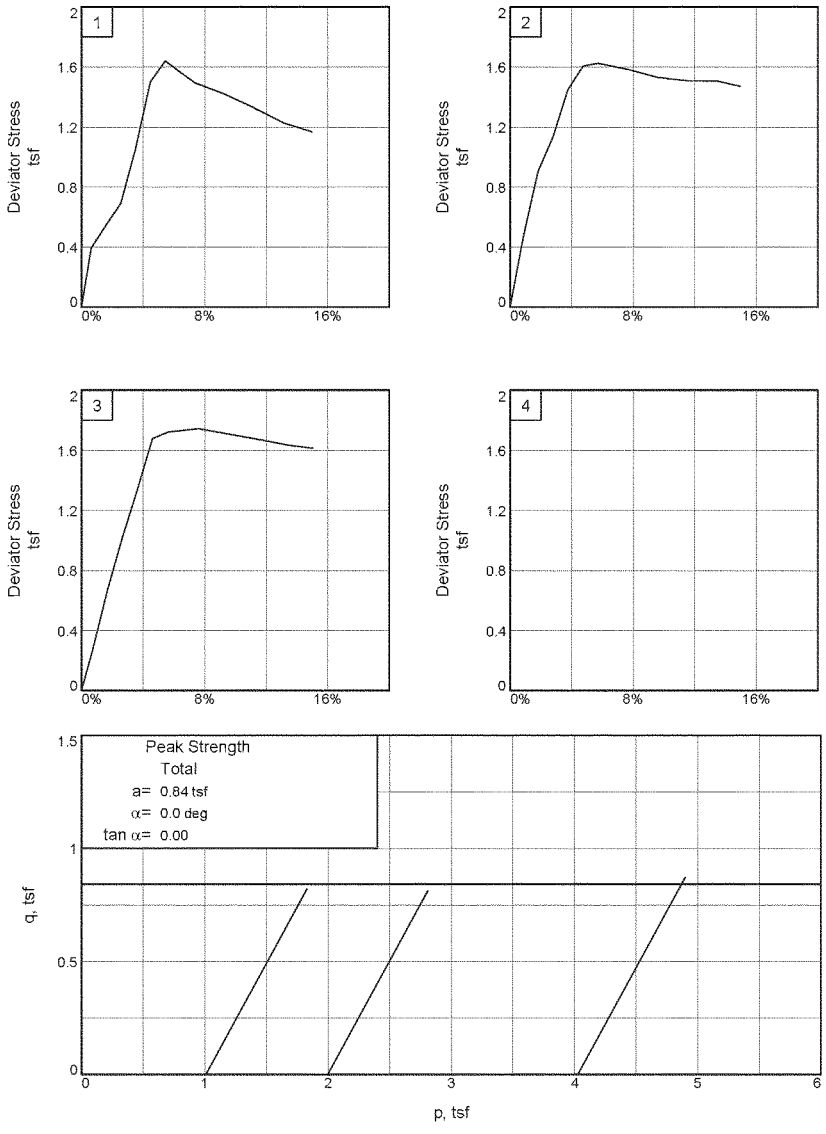
Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Sheyenne River, Argusville Formation
Sample Number: Boring11-110MU, #5 **Depth:** 60-62'
Proj. No.: BL-10-10065 **Date Sampled:**

Figure UU Triax ASTM D 2850

BRAUN INTERTEC

Tested By: JK **Checked By:** JS



Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: Sheyenne River, Argusville Formation **Depth:** 60-62' **Sample No.:** Boring11-110MU, #5
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JK **Checked By:** JS

TRIAXIAL COMPRESSION TEST 4/26/2011
Unconsolidated Undrained 8:14 AM

Date:			
Client:	W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing		
Project No.:	BL-10-10065		
Location:	Sheyenne River, Argusville Formation		
Depth:	60-62'	**Sample Number:**	Boring11-110MU, #5
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	Undisturbed, 5" Thinwall, Bottom		
Specific Gravity=2.679	**LL=**70	**PL=**22	**PI=**48
Test Method:	COE uniform strain		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	153.830		153.830
Moisture content: Dry soil+tare, gms.	115.330		115.330
Moisture content: Tare, gms.	33.170		33.170
Moisture, %	46.9	47.2	46.9
Moist specimen weight, gms.	121.4		
Diameter, in.	1.39	1.39	
Area, in.^{2}	1.52	1.52	
Height, in.	2.80	2.80	
Net decrease in height, in.		0.00	
Wet Density, pcf	108.5	108.7	
Dry density, pcf	73.9	73.9	
Void ratio	1.2646	1.2646	
Saturation, %	99.3	100.0	

Test Readings for Specimen No. 1

Cell pressure = 1.009 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 1.640 tsf **at reading no.** 6
Ult. Stress = 1.170 tsf **at reading no.** 11

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0064	2.010	0.0	0.0	0.000	1.009	1.009	1.00	1.009	0.000
1	0.0243	10.430	8.4	0.6	0.395	1.009	1.404	1.39	1.207	0.198
2	0.0515	13.860	11.9	1.6	0.551	1.009	1.560	1.55	1.284	0.275
3	0.0780	17.050	15.0	2.6	0.692	1.009	1.701	1.69	1.355	0.346
4	0.1047	25.110	23.1	3.5	1.053	1.009	2.062	2.04	1.535	0.526
5	0.1318	35.300	33.3	4.5	1.502	1.009	2.511	2.49	1.760	0.751
6	0.1585	38.720	36.7	5.4	1.640	1.009	2.649	2.63	1.829	0.820
7	0.2129	36.160	34.2	7.4	1.494	1.009	2.503	2.48	1.756	0.747
8	0.2665	35.120	33.1	9.3	1.419	1.009	2.428	2.41	1.718	0.709
9	0.3208	33.660	31.7	11.2	1.327	1.009	2.336	2.32	1.673	0.664
10	0.3756	31.890	29.9	13.2	1.225	1.009	2.234	2.21	1.622	0.613
11	0.4250	31.120	29.1	15.0	1.170	1.009	2.179	2.16	1.594	0.585

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	152.320		152.320
Moisture content: Dry soil+tare, gms.	114.310		114.310
Moisture content: Tare, gms.	30.430		30.430
Moisture, %	45.3	45.5	45.3
Moist specimen weight, gms.	122.7		
Diameter, in.	1.39	1.39	
Area, in.^{2}	1.53	1.53	
Height, in.	2.79	2.79	
Net decrease in height, in.		0.00	
Wet Density, pcf	109.6	109.7	
Dry density, pcf	75.4	75.4	
Void ratio	1.2180	1.2180	
Saturation, %	99.7	100.0	

Test Readings for Specimen No. 2

Cell pressure = 1.998 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.625 tsf at reading no. 6

Ult. Stress = 1.472 tsf at reading no. 11

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	6.000	0.0	0.0	0.000	1.998	1.998	1.00	1.998	0.000
1	0.0310	16.140	10.1	0.9	0.474	1.998	2.472	1.24	2.235	0.237
2	0.0571	25.480	19.5	1.8	0.902	1.998	2.900	1.45	2.449	0.451
3	0.0847	30.760	24.8	2.8	1.135	1.998	3.133	1.57	2.566	0.568
4	0.1116	37.960	32.0	3.8	1.451	1.998	3.449	1.73	2.724	0.726
5	0.1391	41.740	35.7	4.7	1.606	1.998	3.604	1.80	2.801	0.803
6	0.1664	42.540	36.5	5.7	1.625	1.998	3.623	1.81	2.811	0.813
7	0.2208	42.350	36.4	7.7	1.583	1.998	3.581	1.79	2.790	0.792
8	0.2745	41.900	35.9	9.6	1.531	1.998	3.529	1.77	2.764	0.766
9	0.3288	42.140	36.1	11.5	1.508	1.998	3.506	1.75	2.752	0.754
10	0.3837	42.890	36.9	13.5	1.505	1.998	3.503	1.75	2.751	0.753

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
11	0.4245	42.690	36.7	15.0	1.472	1.998	3.470	1.74	2.734	0.736

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	153.630		153.630
Moisture content: Dry soil+tare, gms.	116.500		116.500
Moisture content: Tare, gms.	31.240		31.240
Moisture, %	43.5	44.4	43.5
Moist specimen weight, gms.	123.3		
Diameter, in.	1.40	1.40	
Area, in.²	1.53	1.53	
Height, in.	2.80	2.80	
Net decrease in height, in.		0.00	
Wet Density, pcf	109.6	110.3	
Dry density, pcf	76.4	76.4	
Void ratio	1.1897	1.1897	
Saturation, %	98.1	100.0	

Test Readings for Specimen No. 3

Cell pressure = 4.028 tsf

Back pressure = 0.000 tsf

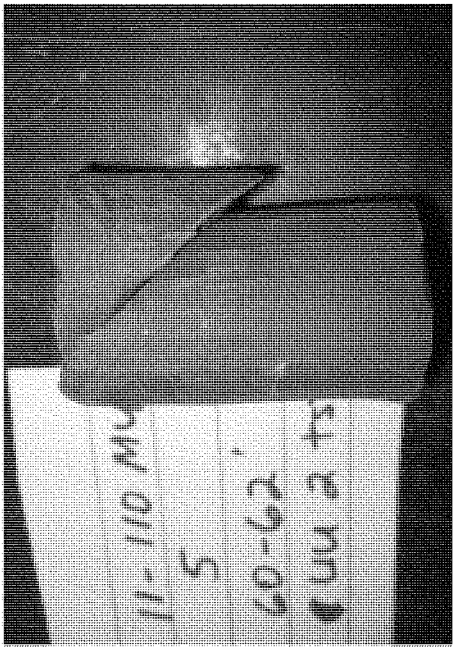
Strain rate, %/min. = 1.00

Peak Stress = 1.744 tsf at reading no. 7

Ult. Stress = 1.613 tsf at reading no. 11

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	9.790	0.0	0.0	0.000	4.028	4.028	1.00	4.028	0.000
1	0.0267	15.500	5.7	0.7	0.266	4.028	4.294	1.07	4.161	0.133
2	0.0534	24.130	14.3	1.7	0.662	4.028	4.690	1.16	4.359	0.331
3	0.0802	31.920	22.1	2.6	1.012	4.028	5.040	1.25	4.534	0.506
4	0.1080	39.330	29.5	3.6	1.337	4.028	5.365	1.33	4.697	0.669
5	0.1355	47.240	37.5	4.6	1.678	4.028	5.706	1.42	4.867	0.839
6	0.1641	48.610	38.8	5.6	1.721	4.028	5.749	1.43	4.888	0.860
7	0.2193	49.980	40.2	7.6	1.744	4.028	5.772	1.43	4.900	0.872
8	0.2730	50.000	40.2	9.5	1.709	4.028	5.737	1.42	4.882	0.854
9	0.3286	50.000	40.2	11.5	1.671	4.028	5.699	1.41	4.864	0.836
10	0.3836	50.000	40.2	13.5	1.634	4.028	5.662	1.41	4.845	0.817
11	0.4270	50.210	40.4	15.0	1.613	4.028	5.641	1.40	4.835	0.807

11+110 MW
S
60-62'
WW 4 +5f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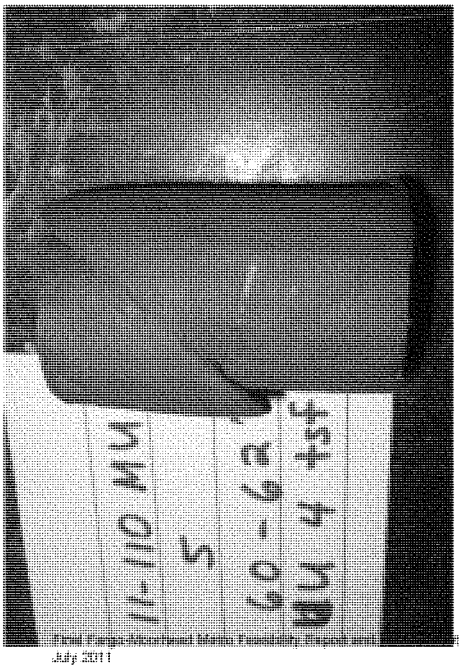
S
60-62'
WW 4 +5f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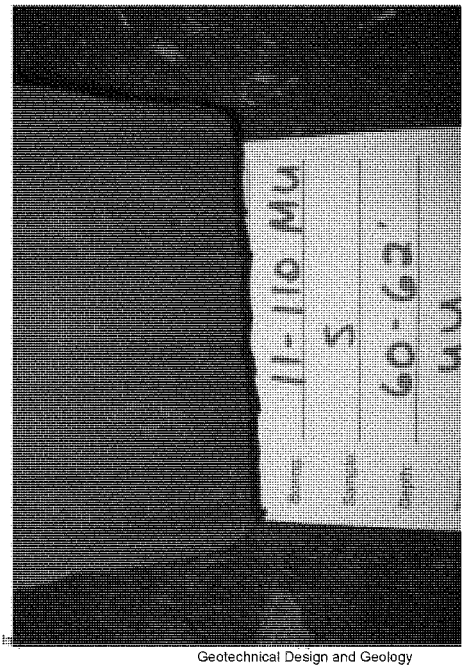
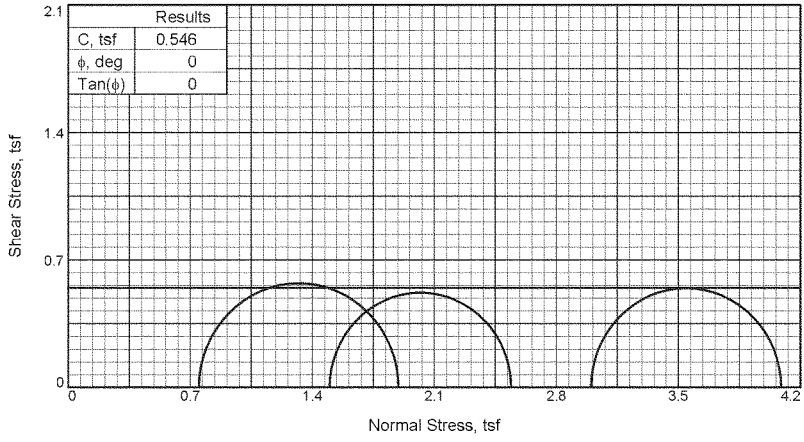
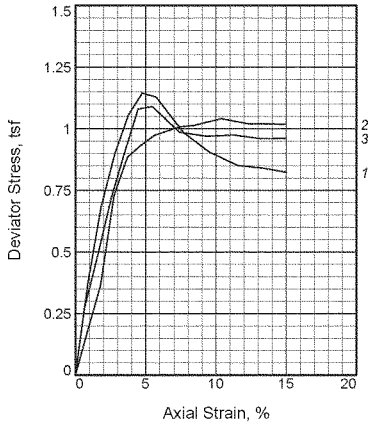
WW 4 +5f


11+110 MW
S
60-62'
WW





Sample No.		1	2	3
Initial	Water Content, %	43.3	46.7	45.8
	Dry Density, pcf	77.6	74.5	75.2
	Saturation, %	100.0	100.0	99.9
	Void Ratio	1.1658	1.2581	1.2347
	Diameter, in.	1.39	1.39	1.39
	Height, in.	2.81	2.81	2.81
At Test	Water Content, %	43.3	46.7	45.8
	Dry Density, pcf	77.6	74.5	75.2
	Saturation, %	100.0	100.0	99.9
	Void Ratio	1.1658	1.2581	1.2347
	Diameter, in.	1.39	1.39	1.39
	Height, in.	2.81	2.81	2.81
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.75	1.50	3.00
Peak Stress, tsf		1.14	1.04	1.09
Ult. Stress, tsf		0.82	1.02	0.96
σ_1 Failure, tsf		1.89	2.54	4.09
σ_3 Failure, tsf		0.75	1.50	3.00

Type of Test: Unconsolidated Undrained
Sample Type: 5" Thinwall, Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 60 **PL=** 17 **PI=** 43
Specific Gravity= 2.693
Remarks:

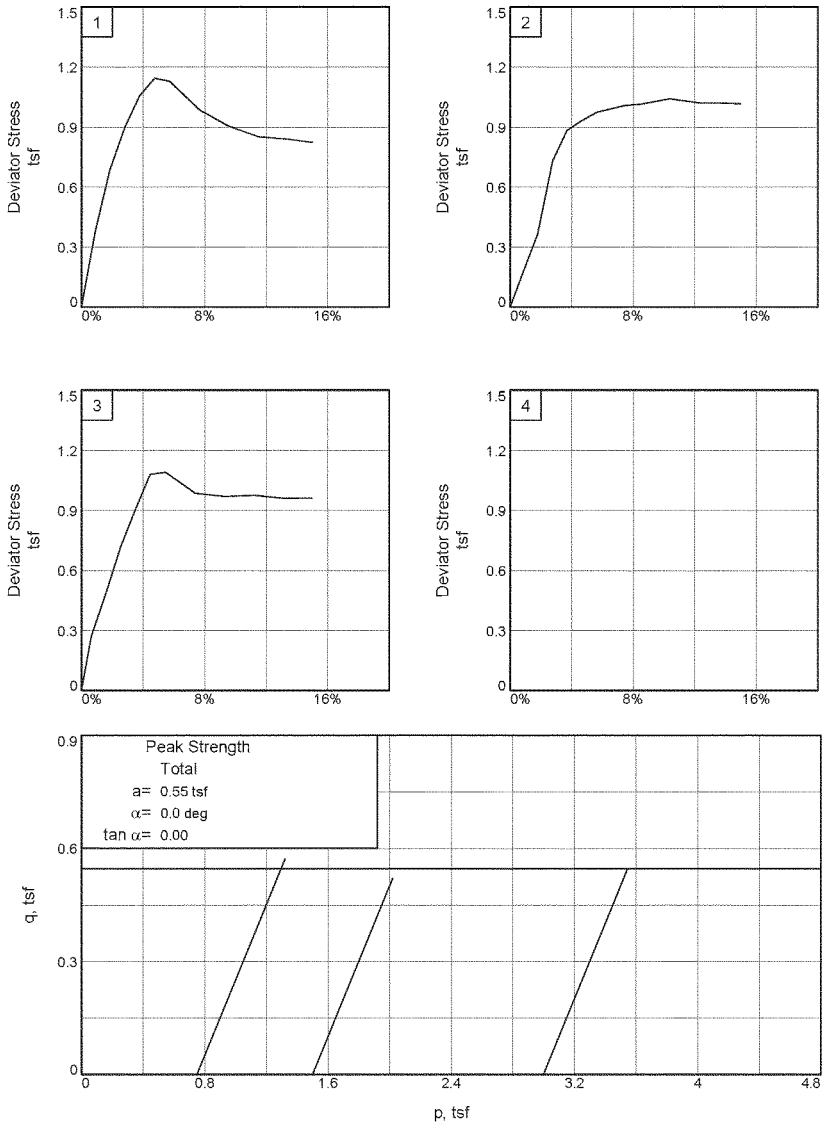
Figure UU Triax ASTM D 2850

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Location: Wild Rice, Argusville Formation
Sample Number: Boring11-118MU, #3 **Depth:** 45-47'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Tested By: JK **Checked By:** JS



Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Location: Wild Rice, Argusville Formation **Depth:** 45-47' **Sample Number:** Boring11-118MU, #3
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JK **Checked By:** JS

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

5/15/2011
11:40 AM

Date:			
Client:	USACE W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing Request NO. 2		
Project No.:	BL-10-10065		
Location:	Wild Rice, Argusville Formation		
Depth:	45-47'	**Sample Number:**	Boring11-118MU, #3
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	5" Thinwall, Bottom of sample		
Specific Gravity=2.693	**LL=**60	**PL=**17	**PI=**43
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	155.280	155.280
Moisture content: Dry soil+tare, gms.	117.750	117.750
Moisture content: Tare, gms.	31.070	31.070
Moisture, %	43.3	43.3
Moist specimen weight, gms.	124.4	
Diameter, in.	1.39	
Area, in.²	1.52	
Height, in.	2.81	
Wet Density, pcf	111.2	
Dry density, pcf	77.6	
Void ratio	1.1658	
Saturation, %	100.0	

Test Readings for Specimen No. 1

Cell pressure = 0.750 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 1.144 tsf **at reading no.** 5
Ult. Stress = 0.823 tsf **at reading no.** 11

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	0.085	0.0	0.0	0.000	0.750	0.750	1.00	0.750	0.000
1	0.0319	8.170	8.1	0.9	0.380	0.750	1.130	1.51	0.940	0.190
2	0.0582	14.760	14.7	1.8	0.683	0.750	1.433	1.91	1.092	0.342
3	0.0855	19.590	19.5	2.8	0.899	0.750	1.649	2.20	1.200	0.450
4	0.1129	23.240	23.2	3.8	1.057	0.750	1.807	2.41	1.279	0.529
5	0.1401	25.410	25.3	4.8	1.144	0.750	1.894	2.53	1.322	0.572
6	0.1677	25.320	25.2	5.7	1.129	0.750	1.879	2.50	1.314	0.564
7	0.2215	22.610	22.5	7.7	0.987	0.750	1.737	2.32	1.243	0.493
8	0.2752	21.170	21.1	9.6	0.905	0.750	1.655	2.21	1.202	0.452
9	0.3307	20.370	20.3	11.5	0.851	0.750	1.601	2.14	1.176	0.426
10	0.3843	20.530	20.4	13.5	0.840	0.750	1.590	2.12	1.170	0.420
11	0.4275	20.500	20.4	15.0	0.823	0.750	1.573	2.10	1.162	0.412

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	152.270	152.270
Moisture content: Dry soil+tare, gms.	113.180	113.180
Moisture content: Tare, gms.	29.540	29.540
Moisture, %	46.7	46.7
Moist specimen weight, gms.	123.1	
Diameter, in.	1.39	
Area, in.²	1.53	
Height, in.	2.81	
Wet Density, pcf	109.2	
Dry density, pcf	74.5	
Void ratio	1.2581	
Saturation, %	100.0	

Test Readings for Specimen No. 2

Cell pressure = 1.500 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.041 tsf at reading no. 9

Ult. Stress = 1.017 tsf at reading no. 12

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0064	2.650	0.0	0.0	0.000	1.500	1.500	1.00	1.500	0.000
1	0.0295	6.250	3.6	0.8	0.168	1.500	1.668	1.11	1.584	0.084
2	0.0566	10.490	7.8	1.8	0.363	1.500	1.863	1.24	1.682	0.182
3	0.0840	18.560	15.9	2.8	0.730	1.500	2.230	1.49	1.865	0.365
4	0.1107	22.120	19.5	3.7	0.884	1.500	2.384	1.59	1.942	0.442
5	0.1366	23.350	20.7	4.6	0.931	1.500	2.431	1.62	1.966	0.466
6	0.1642	24.500	21.9	5.6	0.973	1.500	2.473	1.65	1.986	0.486
7	0.2172	25.750	23.1	7.5	1.008	1.500	2.508	1.67	2.004	0.504
8	0.2443	26.120	23.5	8.5	1.014	1.500	2.514	1.68	2.007	0.507
9	0.2982	27.270	24.6	10.4	1.041	1.500	2.541	1.69	2.020	0.520
10	0.3525	27.320	24.7	12.3	1.021	1.500	2.521	1.68	2.010	0.510
11	0.3930	27.720	25.1	13.8	1.020	1.500	2.520	1.68	2.010	0.510

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
12	0.4273	28.010	25.4	15.0	1.017	1.500	2.517	1.68	2.009	0.509

Parameters for Specimen No. 3

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	153.430	153.430
Moisture content: Dry soil+tare, gms.	114.780	114.780
Moisture content: Tare, gms.	30.410	30.410
Moisture, %	45.8	45.8
Moist specimen weight, gms.	123.3	
Diameter, in.	1.39	
Area, in.^{2}	1.53	
Height, in.	2.81	
Wet Density, pcf	109.7	
Dry density, pcf	75.2	
Void ratio	1.2347	
Saturation, %	99.9	

Test Readings for Specimen No. 3

Cell pressure = 3.000 tsf

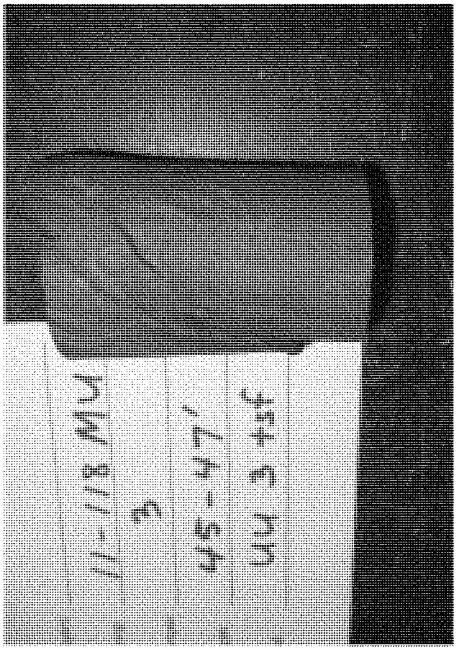
Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

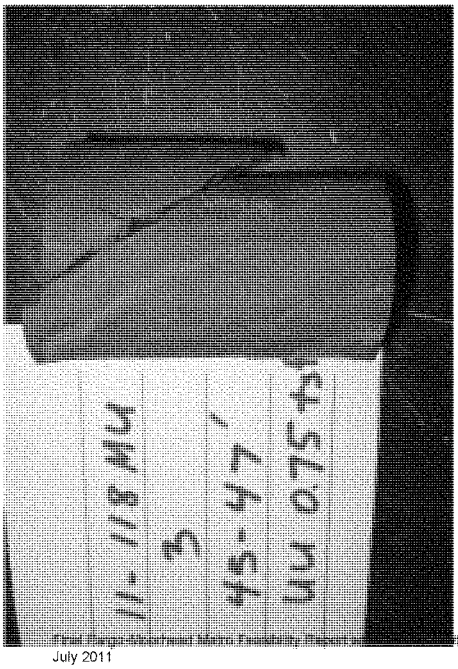
Peak Stress = 1.090 tsf at reading no. 6

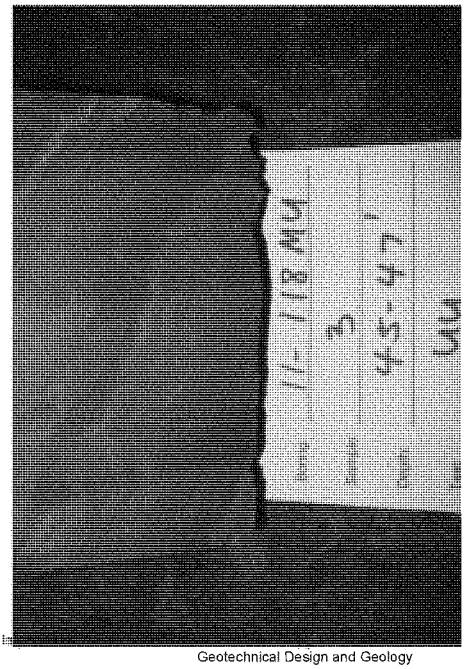
Ult. Stress = 0.962 tsf at reading no. 11

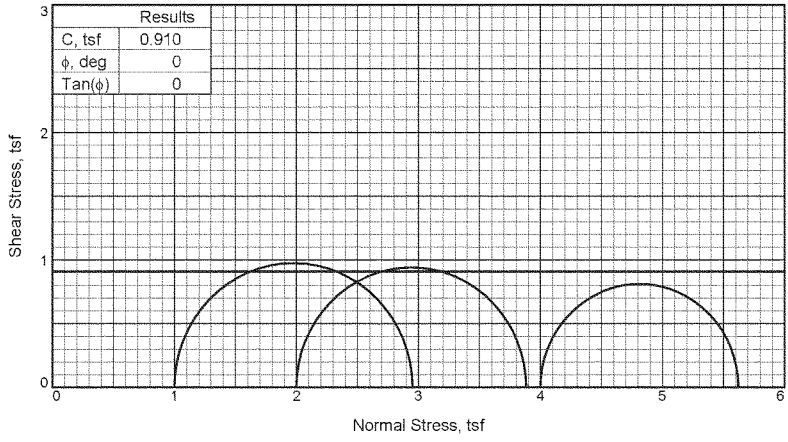
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0065	6.310	0.0	0.0	0.000	3.000	3.000	1.00	3.000	0.000
1	0.0243	12.080	5.8	0.6	0.270	3.000	3.270	1.09	3.135	0.135
2	0.0513	16.840	10.5	1.6	0.489	3.000	3.489	1.16	3.244	0.244
3	0.0781	21.970	15.7	2.6	0.720	3.000	3.720	1.24	3.360	0.360
4	0.1048	26.180	19.9	3.5	0.905	3.000	3.905	1.30	3.452	0.452
5	0.1318	30.270	24.0	4.5	1.080	3.000	4.080	1.36	3.540	0.540
6	0.1601	30.760	24.5	5.5	1.090	3.000	4.090	1.36	3.545	0.545
7	0.2144	28.870	22.6	7.4	0.985	3.000	3.985	1.33	3.493	0.493
8	0.2679	28.970	22.7	9.3	0.969	3.000	3.969	1.32	3.485	0.485
9	0.3227	29.600	23.3	11.3	0.975	3.000	3.975	1.32	3.487	0.487
10	0.3767	29.750	23.4	13.2	0.960	3.000	3.960	1.32	3.480	0.480
11	0.4268	30.290	24.0	15.0	0.962	3.000	3.962	1.32	3.481	0.481

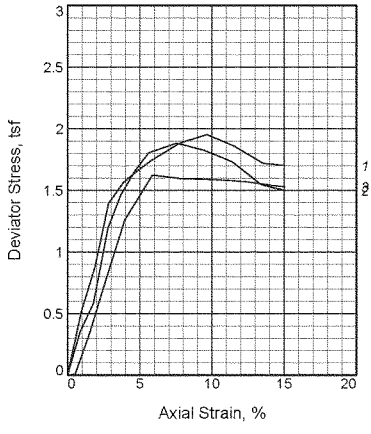

11-118 MW
3
45-47'
UU 3 tsf

11-118 MW
3
45-47'
UU 1.5 tsf


11-118 MW
3
45-47'
UU 0.75 tsf


11-118 MW
3
45-47'
UU





Sample No.		1	2	3
Initial	Water Content, %	46.1	45.4	46.7
	Dry Density, pcf	75.0	75.6	74.4
	Saturation, %	100.0	99.9	100.0
	Void Ratio	1.2378	1.2201	1.2543
	Diameter, in.	1.39	1.39	1.38
	Height, in.	2.81	2.80	2.81
At Test	Water Content, %	46.1	45.4	46.7
	Dry Density, pcf	75.0	75.6	74.4
	Saturation, %	100.0	99.9	100.0
	Void Ratio	1.2378	1.2201	1.2543
	Diameter, in.	1.39	1.39	1.38
	Height, in.	2.81	2.80	2.81
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		1.00	2.00	4.00
Peak Stress, tsf		1.95	1.88	1.62
Ult. Stress, tsf		1.70	1.50	
σ_1 Failure, tsf		2.95	3.88	5.62
σ_3 Failure, tsf		1.00	2.00	4.00

Type of Test: Unconsolidated Undrained
Sample Type: 5" Thinwall, Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 77 **PL=** 22 **PI=** 55
Specific Gravity= 2.687
Remarks:

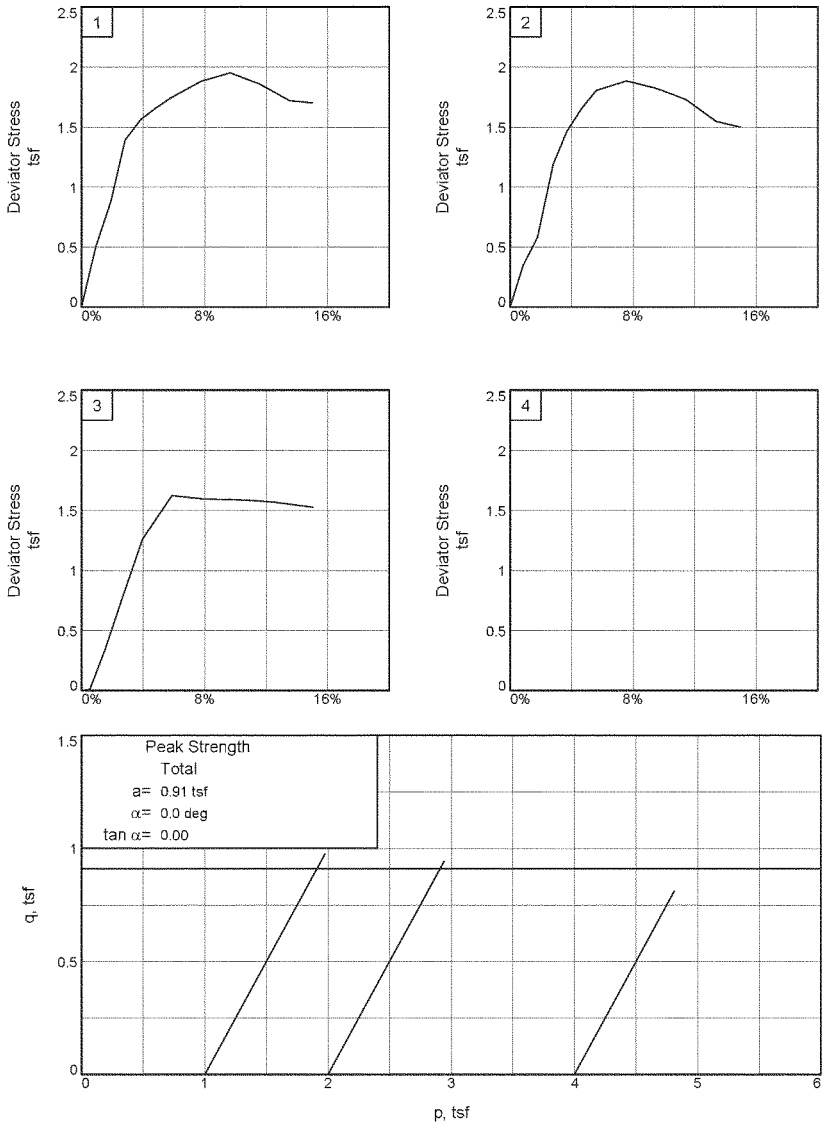
Figure UU Triax ASTM D 2850

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Location: Wild Rice, Argusville Formation
Sample Number: Boring11-118MU, #4 **Depth:** 55-57'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Tested By: JK **Checked By:** JS



Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Location: Wild Rice, Argusville Formation **Depth:** 55-57' **Sample Number:** Boring11-118MU, #4
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JK **Checked By:** JS

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

5/15/2011
11:41 AM

Date:			
Client:	USACE W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing Request NO. 2		
Project No.:	BL-10-10065		
Location:	Wild Rice, Argusville Formation		
Depth:	55-57'	**Sample Number:**	Boring11-118MU, #4
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	5" Thinwall, Bottom of sample		
Specific Gravity=2.687	**LL=**77	**PL=**22	**PI=**55
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	152.610	152.610
Moisture content: Dry soil+tare, gms.	114.360	114.360
Moisture content: Tare, gms.	31.310	31.310
Moisture, %	46.1	46.1
Moist specimen weight, gms.	121.6	
Diameter, in.	1.39	
Area, in.²	1.51	
Height, in.	2.81	
Wet Density, pcf	109.5	
Dry density, pcf	75.0	
Void ratio	1.2378	
Saturation, %	100.0	

Test Readings for Specimen No. 1

Cell pressure = 1.000 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 1.952 tsf **at reading no.** 8
Ult. Stress = 1.702 tsf **at reading no.** 11

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0212	1.640	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	0.0480	12.530	10.9	1.0	0.515	1.000	1.515	1.52	1.258	0.258
2	0.0746	20.350	18.7	1.9	0.877	1.000	1.877	1.88	1.439	0.439
3	0.1009	31.640	30.0	2.8	1.393	1.000	2.393	2.39	1.697	0.697
4	0.1294	35.670	34.0	3.9	1.564	1.000	2.564	2.56	1.782	0.782
5	0.1566	38.080	36.4	4.8	1.658	1.000	2.658	2.66	1.829	0.829
6	0.1845	40.400	38.8	5.8	1.745	1.000	2.745	2.74	1.872	0.872
7	0.2388	44.310	42.7	7.7	1.881	1.000	2.881	2.88	1.941	0.941
8	0.2923	46.840	45.2	9.7	1.952	1.000	2.952	2.95	1.976	0.976
9	0.3472	45.590	44.0	11.6	1.857	1.000	2.857	2.86	1.928	0.928
10	0.4015	43.270	41.6	13.5	1.720	1.000	2.720	2.72	1.860	0.860
11	0.4425	43.540	41.9	15.0	1.702	1.000	2.702	2.70	1.851	0.851

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	152.240	152.240
Moisture content: Dry soil+tare, gms.	114.240	114.240
Moisture content: Tare, gms.	30.470	30.470
Moisture, %	45.4	45.4
Moist specimen weight, gms.	122.0	
Diameter, in.	1.39	
Area, in.²	1.51	
Height, in.	2.80	
Wet Density, pcf	109.8	
Dry density, pcf	75.6	
Void ratio	1.2201	
Saturation, %	99.9	

Test Readings for Specimen No. 2

Cell pressure = 2.000 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.884 tsf at reading no. 7

Ult. Stress = 1.500 tsf at reading no. 11

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	3.840	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	0.0308	11.280	7.4	0.9	0.351	2.000	2.351	1.18	2.176	0.176
2	0.0567	16.320	12.5	1.8	0.584	2.000	2.584	1.29	2.292	0.292
3	0.0851	29.570	25.7	2.8	1.192	2.000	3.192	1.60	2.596	0.596
4	0.1105	35.850	32.0	3.7	1.469	2.000	3.469	1.73	2.734	0.734
5	0.1372	40.340	36.5	4.7	1.658	2.000	3.658	1.83	2.829	0.829
6	0.1635	43.940	40.1	5.6	1.804	2.000	3.804	1.90	2.902	0.902
7	0.2184	46.600	42.8	7.6	1.884	2.000	3.884	1.94	2.942	0.942
8	0.2727	46.110	42.3	9.5	1.823	2.000	3.823	1.91	2.911	0.911
9	0.3268	44.830	41.0	11.4	1.730	2.000	3.730	1.86	2.865	0.865
10	0.3825	41.320	37.5	13.4	1.546	2.000	3.546	1.77	2.773	0.773
11	0.4256	40.860	37.0	15.0	1.500	2.000	3.500	1.75	2.750	0.750

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	150.990	150.990
Moisture content: Dry soil+tare, gms.	112.610	112.610
Moisture content: Tare, gms.	30.380	30.380
Moisture, %	46.7	46.7
Moist specimen weight, gms.	120.9	
Diameter, in.	1.38	
Area, in.²	1.50	
Height, in.	2.81	
Wet Density, pcf	109.1	
Dry density, pcf	74.4	
Void ratio	1.2543	
Saturation, %	100.0	

Test Readings for Specimen No. 3

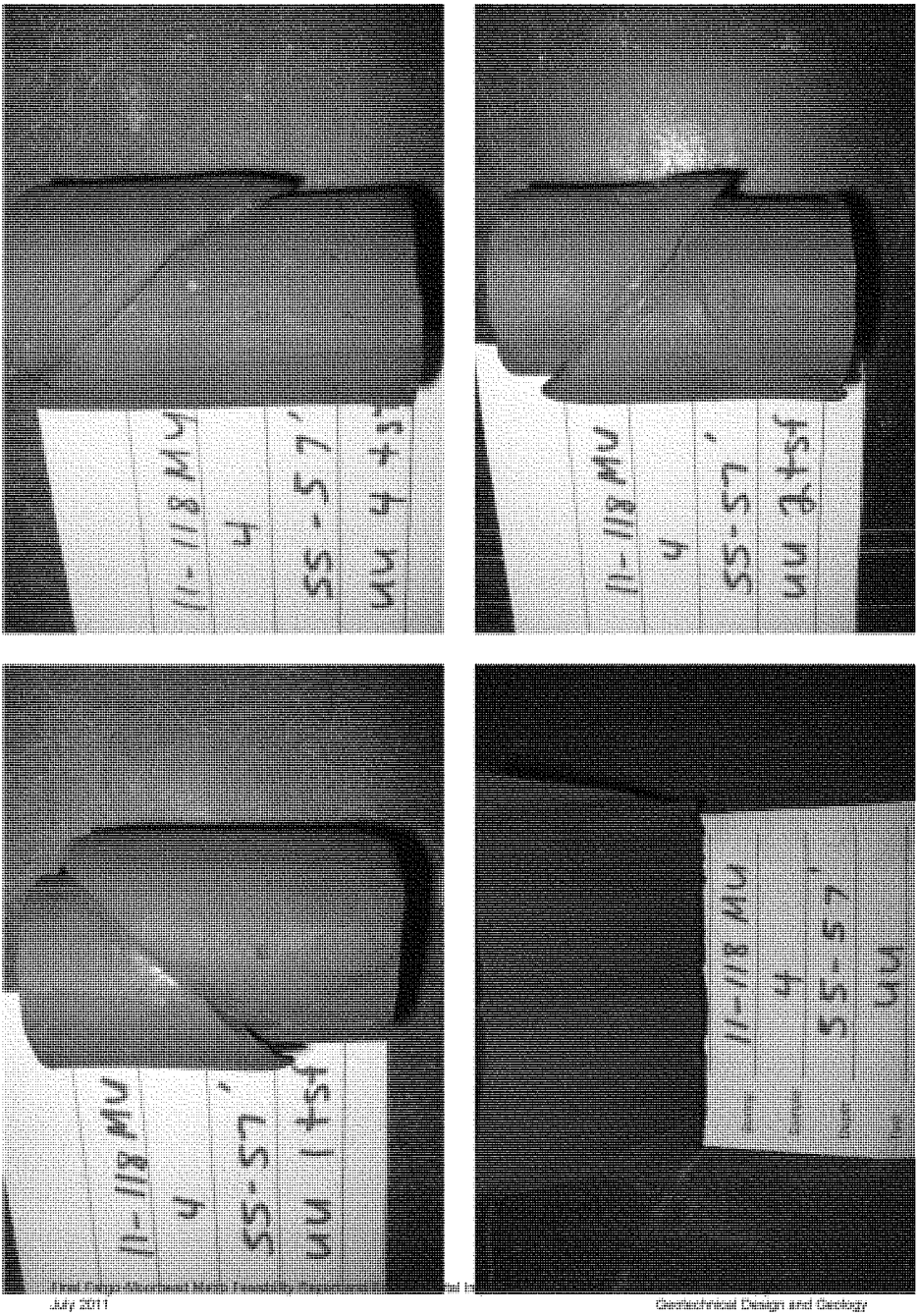
Cell pressure = 4.000 tsf

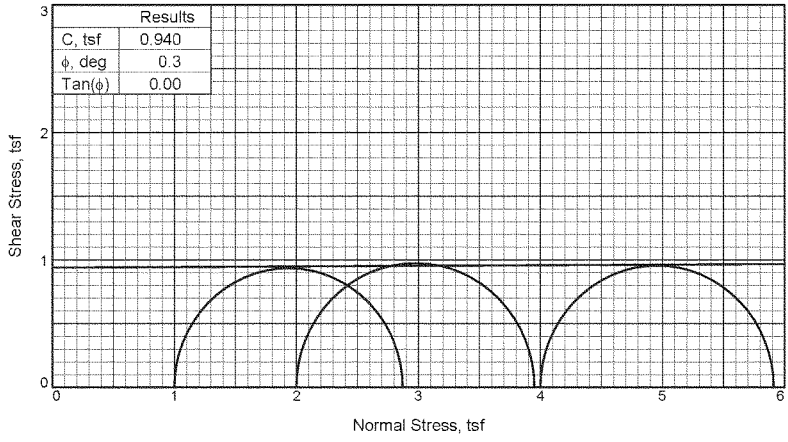
Back pressure = 0.000 tsf

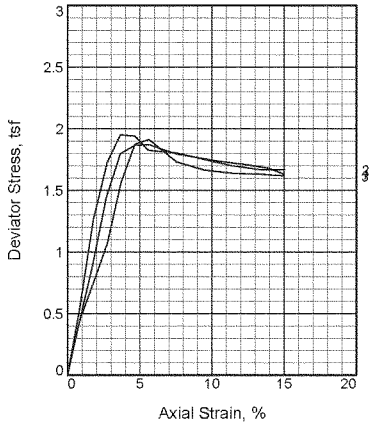
Strain rate, %/min. = 1.00

Peak Stress = 1.623 tsf at reading no. 7

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0750	13.820	0.0	0.0	0.000	4.000	4.000	1.00	4.000	0.000
1	0.0800	13.820	0.0	0.2	0.000	4.000	4.000	1.00	4.000	0.000
2	0.0900	14.030	0.2	0.5	0.010	4.000	4.010	1.00	4.005	0.005
3	0.0909	14.180	0.4	0.6	0.017	4.000	4.017	1.00	4.009	0.009
4	0.1178	21.020	7.2	1.5	0.340	4.000	4.340	1.08	4.170	0.170
5	0.1456	29.230	15.4	2.5	0.719	4.000	4.719	1.18	4.360	0.360
6	0.1865	41.290	27.5	4.0	1.263	4.000	5.263	1.32	4.632	0.632
7	0.2399	49.830	36.0	5.9	1.623	4.000	5.623	1.41	4.812	0.812
8	0.2949	49.970	36.2	7.8	1.596	4.000	5.596	1.40	4.798	0.798
9	0.3490	50.590	36.8	9.8	1.589	4.000	5.589	1.40	4.795	0.795
10	0.3901	50.990	37.2	11.2	1.580	4.000	5.580	1.40	4.790	0.790
11	0.4272	51.240	37.4	12.6	1.567	4.000	5.567	1.39	4.784	0.784
12	0.4511	51.270	37.5	13.4	1.553	4.000	5.553	1.39	4.777	0.777
13	0.4791	51.290	37.5	14.4	1.536	4.000	5.536	1.38	4.768	0.768
14	0.4967	51.370	37.6	15.0	1.528	4.000	5.528	1.38	4.764	0.764


11-118 MU
4
55-57'
UU 4 tsf
11-118 MU
4
55-57'
UU 2 tsf
11-118 MU
4
55-57'
UU 1 tsf
11-118 MU
4
55-57'
UU





Sample No.		1	2	3
Initial	Water Content, %	36.6	36.8	36.7
	Dry Density, pcf	84.2	83.7	84.5
	Saturation, %	98.8	98.1	99.7
	Void Ratio	0.9992	1.0107	0.9913
	Diameter, in.	1.39	1.43	1.41
	Height, in.	2.80	2.81	2.81
At Test	Water Content, %	36.6	36.8	36.7
	Dry Density, pcf	84.2	83.7	84.5
	Saturation, %	98.8	98.1	99.7
	Void Ratio	0.9992	1.0107	0.9913
	Diameter, in.	1.39	1.43	1.41
	Height, in.	2.80	2.81	2.81
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		1.00	2.00	4.00
Peak Stress, tsf		1.87	1.95	1.91
Ult. Stress, tsf		1.63	1.67	1.62
σ_1 Failure, tsf		2.87	3.95	5.91
σ_3 Failure, tsf		1.00	2.00	4.00

Type of Test: Unconsolidated Undrained
Sample Type: 5" Thinwall, Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 61 **PL=** 20 **PI=** 41
Specific Gravity= 2.695
Remarks:

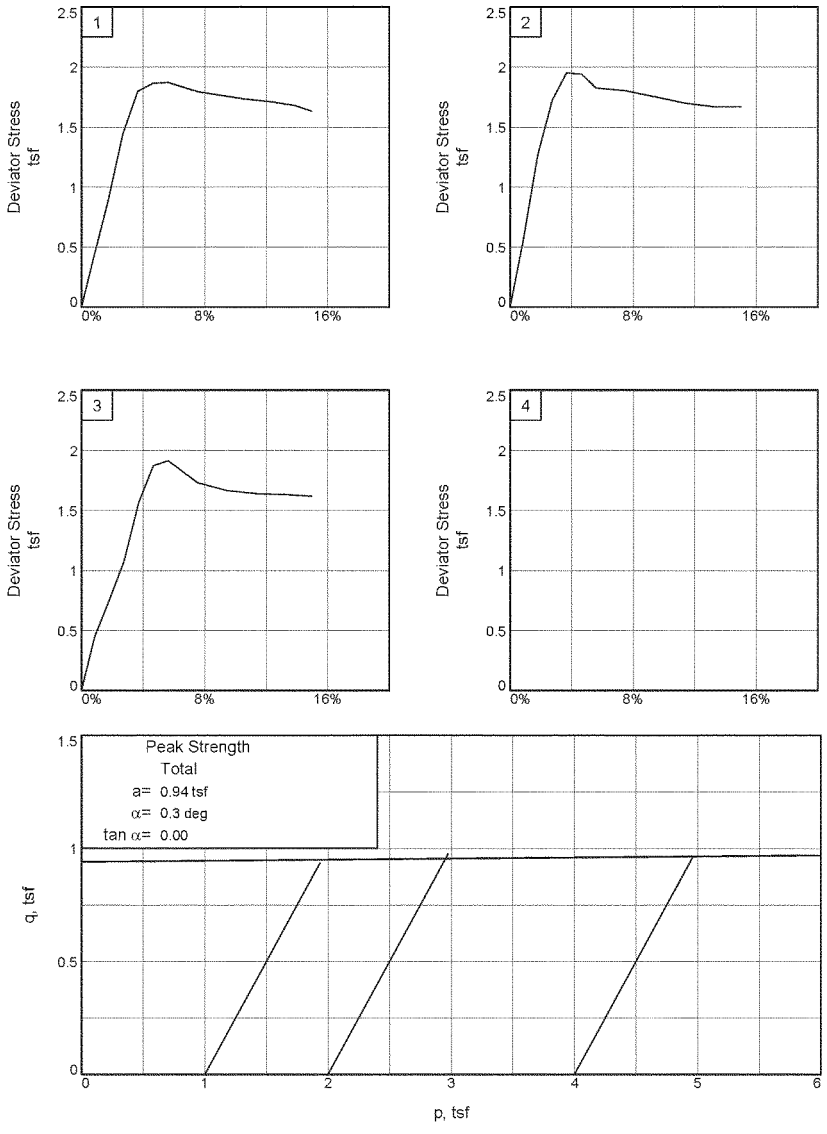
Figure UU Triax ASTM D 2850

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Location: Wild Rice, Argusville Formation
Sample Number: Boring11-118MU, #5 **Depth:** 65-67'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Tested By: JK **Checked By:** js



Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Location: Wild Rice, Argusville Formation **Depth:** 65-67' **Sample Number:** Boring11-118MU, #5
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JR **Checked By:** JS

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

5/15/2011
11:41 AM

Date:			
Client:	USACE W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing Request NO. 2		
Project No.:	BL-10-10065		
Location:	Wild Rice, Argusville Formation		
Depth:	65-67'	**Sample Number:**	Boring11-118MU, #5
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	5" Thinwall, Bottom of sample		
Specific Gravity=2.695	**LL=**61	**PL=**20	**PI=**41
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	157.320	157.320
Moisture content: Dry soil+tare, gms.	123.170	123.170
Moisture content: Tare, gms.	29.910	29.910
Moisture, %	36.6	36.6
Moist specimen weight, gms.	127.8	
Diameter, in.	1.39	
Area, in.²	1.51	
Height, in.	2.80	
Wet Density, pcf	115.0	
Dry density, pcf	84.2	
Void ratio	0.9992	
Saturation, %	98.8	

Test Readings for Specimen No. 1

Cell pressure = 1.000 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 1.871 tsf **at reading no.** 6
Ult. Stress = 1.633 tsf **at reading no.** 11

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0065	1.360	0.0	0.0	0.000	1.000	1.000	1.00	1.000	0.000
1	0.0276	9.730	8.4	0.8	0.396	1.000	1.396	1.40	1.198	0.198
2	0.0548	20.230	18.9	1.7	0.884	1.000	1.884	1.88	1.442	0.442
3	0.0819	32.530	31.2	2.7	1.445	1.000	2.445	2.45	1.723	0.723
4	0.1091	40.550	39.2	3.7	1.799	1.000	2.799	2.80	1.900	0.900
5	0.1367	42.380	41.0	4.6	1.864	1.000	2.864	2.86	1.932	0.932
6	0.1641	42.960	41.6	5.6	1.871	1.000	2.871	2.87	1.935	0.935
7	0.2186	42.080	40.7	7.6	1.794	1.000	2.794	2.79	1.897	0.897
8	0.3011	42.050	40.7	10.5	1.735	1.000	2.735	2.74	1.868	0.868
9	0.3545	42.290	40.9	12.4	1.708	1.000	2.708	2.71	1.854	0.854
10	0.3958	42.290	40.9	13.9	1.679	1.000	2.679	2.68	1.840	0.840
11	0.4254	41.650	40.3	15.0	1.633	1.000	2.633	2.63	1.816	0.816

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	164.120	164.120
Moisture content: Dry soil+tare, gms.	127.930	127.930
Moisture content: Tare, gms.	29.550	29.550
Moisture, %	36.8	36.8
Moist specimen weight, gms.	135.0	
Diameter, in.	1.43	
Area, in.²	1.60	
Height, in.	2.81	
Wet Density, pcf	114.5	
Dry density, pcf	83.7	
Void ratio	1.0107	
Saturation, %	98.1	

Test Readings for Specimen No. 2

Cell pressure = 2.000 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.951 tsf at reading no. 4

Ult. Stress = 1.669 tsf at reading no. 11

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0065	4.200	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	0.0295	16.040	11.8	0.8	0.529	2.000	2.529	1.26	2.264	0.264
2	0.0569	32.860	28.7	1.8	1.267	2.000	3.267	1.63	2.634	0.634
3	0.0838	43.670	39.5	2.8	1.728	2.000	3.728	1.86	2.864	0.864
4	0.1096	49.190	45.0	3.7	1.951	2.000	3.951	1.98	2.976	0.976
5	0.1375	49.400	45.2	4.7	1.940	2.000	3.940	1.97	2.970	0.970
6	0.1634	47.150	43.0	5.6	1.826	2.000	3.826	1.91	2.913	0.913
7	0.2173	47.510	43.3	7.5	1.803	2.000	3.803	1.90	2.902	0.902
8	0.2719	47.150	43.0	9.4	1.751	2.000	3.751	1.88	2.875	0.875
9	0.3250	46.810	42.6	11.3	1.701	2.000	3.701	1.85	2.850	0.850
10	0.3802	46.920	42.7	13.3	1.667	2.000	3.667	1.83	2.834	0.834
11	0.4285	47.820	43.6	15.0	1.669	2.000	3.669	1.83	2.834	0.834

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	163.380	163.380
Moisture content: Dry soil+tare, gms.	127.620	127.620
Moisture content: Tare, gms.	30.140	30.140
Moisture, %	36.7	36.7
Moist specimen weight, gms.	133.6	
Diameter, in.	1.41	
Area, in.²	1.57	
Height, in.	2.81	
Wet Density, pcf	115.5	
Dry density, pcf	84.5	
Void ratio	0.9913	
Saturation, %	99.7	

Test Readings for Specimen No. 3

Cell pressure = 4.000 tsf

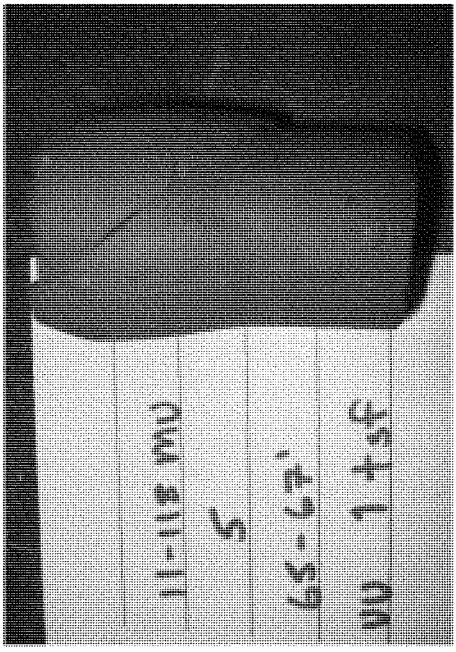
Back pressure = 0.000 tsf

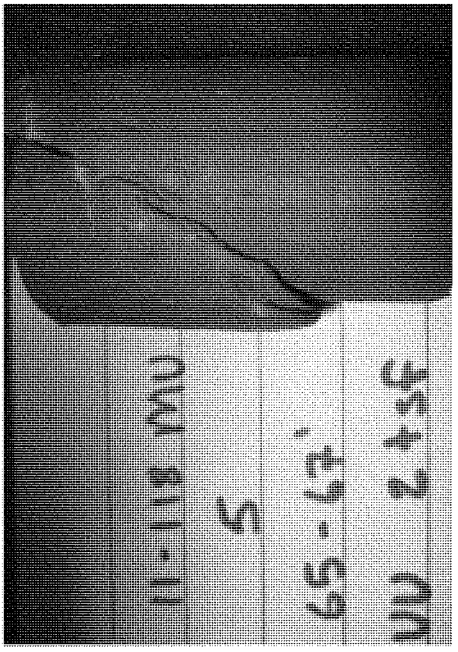
Strain rate, %/min. = 1.00

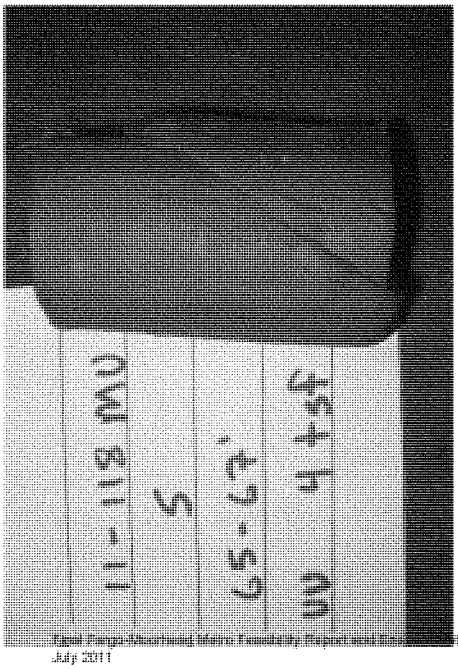
Peak Stress = 1.912 tsf at reading no. 6

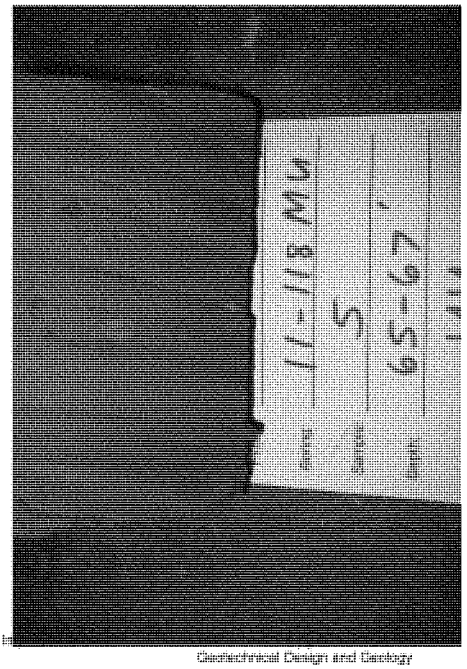
Ult. Stress = 1.617 tsf at reading no. 11

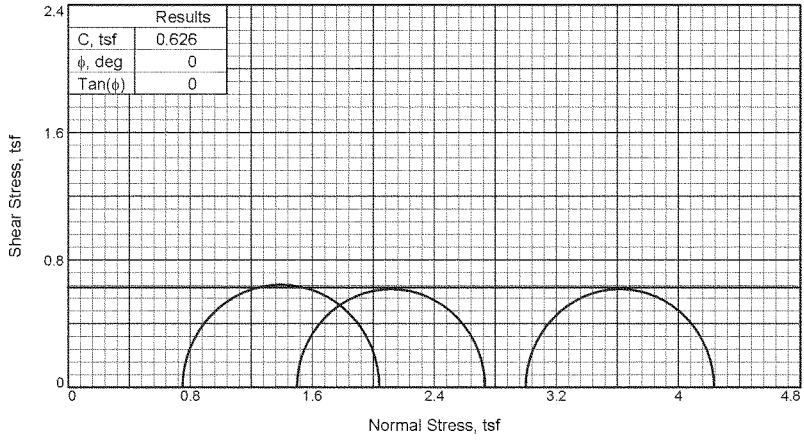
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0064	1.180	0.0	0.0	0.000	4.000	4.000	1.00	4.000	0.000
1	0.0303	11.010	9.8	0.9	0.447	4.000	4.447	1.11	4.223	0.223
2	0.0569	17.820	16.6	1.8	0.749	4.000	4.749	1.19	4.375	0.375
3	0.0835	25.140	24.0	2.7	1.068	4.000	5.068	1.27	4.534	0.534
4	0.1105	36.620	35.4	3.7	1.565	4.000	5.565	1.39	4.782	0.782
5	0.1374	44.030	42.9	4.7	1.873	4.000	5.873	1.47	4.937	0.937
6	0.1650	45.380	44.2	5.7	1.912	4.000	5.912	1.48	4.956	0.956
7	0.2189	41.990	40.8	7.6	1.730	4.000	5.730	1.43	4.865	0.865
8	0.2719	41.290	40.1	9.5	1.665	4.000	5.665	1.42	4.833	0.833
9	0.3260	41.530	40.4	11.4	1.639	4.000	5.639	1.41	4.820	0.820
10	0.3791	42.200	41.0	13.3	1.631	4.000	5.631	1.41	4.816	0.816
11	0.4266	42.660	41.5	15.0	1.617	4.000	5.617	1.40	4.809	0.809

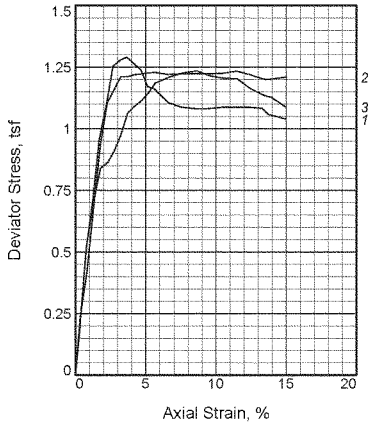

11-118 MU
5
65-67'
UU 1 tsf


11-118 MU
5
65-67'
UU 2 tsf


11-118 MU
5
65-67'
UU 4 tsf


11-118 MU
5
65-67'





Sample No.		1	2	3
Initial	Water Content, %	43.7	44.1	44.1
	Dry Density, pcf	76.9	76.6	76.8
	Saturation, %	99.0	99.3	99.9
	Void Ratio	1.1915	1.1988	1.1923
	Diameter, in.	1.39	1.37	1.38
	Height, in.	2.80	2.80	2.80
At Test	Water Content, %	43.7	44.1	44.1
	Dry Density, pcf	76.9	76.6	76.8
	Saturation, %	99.0	99.3	99.9
	Void Ratio	1.1915	1.1988	1.1923
	Diameter, in.	1.39	1.37	1.38
	Height, in.	2.80	2.80	2.80
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.75	1.50	3.00
Peak Stress, tsf		1.29	1.23	1.23
Ult. Stress, tsf		1.04	1.21	1.09
σ_1 Failure, tsf		2.04	2.73	4.23
σ_3 Failure, tsf		0.75	1.50	3.00

Type of Test: Unconsolidated Undrained
Sample Type: 5" Thinwall, Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 56 **PL=** 22 **PI=** 34
Specific Gravity= 2.698
Remarks:

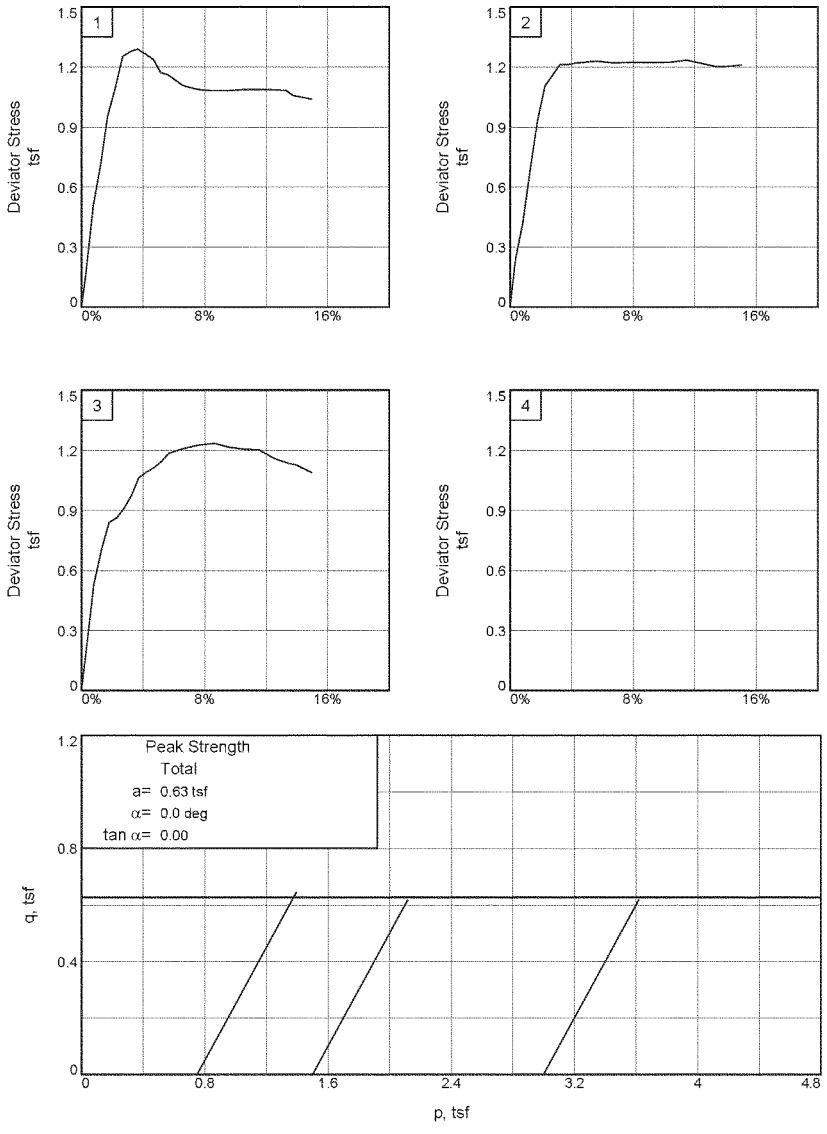
Figure UU Triax ASTM D 2850

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: Fargo Pile Load Test, Argusville Formation
Sample Number: Boring11-119MU, #2 **Depth:** 40-42'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Tested By: JK **Checked By:** jfs



Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: Fargo Pile Load Test, Argusville Formation **Depth:** 40-42' **Sample No.:** Boring11-119MU, #2
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JK **Checked By:** JFS

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

5/30/2011
12:11 PM

Date:			
Client:	USACE W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing Request NO. 3		
Project No.:	BL-10-10065		
Location:	Fargo Pile Load Test, Argusville Formation		
Depth:	40-42'	**Sample Number:**	Boring11-119MU, #2
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	5" Thinwall, Bottom of sample		
Specific Gravity=2.698	**LL=**56	**PL=**22	**PI=**34
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	153.410	153.410
Moisture content: Dry soil+tare, gms.	116.180	116.180
Moisture content: Tare, gms.	31.040	31.040
Moisture, %	43.7	43.7
Moist specimen weight, gms.	122.8	
Diameter, in.	1.39	
Area, in.²	1.51	
Height, in.	2.80	
Wet Density, pcf	110.5	
Dry density, pcf	76.9	
Void ratio	1.1915	
Saturation, %	99.0	

Test Readings for Specimen No. 1

Cell pressure = 0.750 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 1.290 tsf **at reading no.** 8
Ult. Stress = 1.040 tsf **at reading no.** 22

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	1.120	0.0	0.0	0.000	0.750	0.750	1.00	0.750	0.000
1	0.0143	4.450	3.3	0.3	0.158	0.750	0.908	1.21	0.829	0.079
2	0.0279	11.830	10.7	0.8	0.506	0.750	1.256	1.67	1.003	0.253
3	0.0415	16.260	15.1	1.2	0.711	0.750	1.461	1.95	1.106	0.356
4	0.0541	21.540	20.4	1.7	0.955	0.750	1.705	2.27	1.228	0.478
5	0.0679	24.650	23.5	2.2	1.095	0.750	1.845	2.46	1.298	0.548
6	0.0815	28.190	27.1	2.7	1.254	0.750	2.004	2.67	1.377	0.627
7	0.0957	28.860	27.7	3.2	1.278	0.750	2.028	2.70	1.389	0.639
8	0.1091	29.260	28.1	3.7	1.290	0.750	2.040	2.72	1.395	0.645
9	0.1229	28.860	27.7	4.2	1.265	0.750	2.015	2.69	1.383	0.633
10	0.1370	28.440	27.3	4.7	1.239	0.750	1.989	2.65	1.370	0.620
11	0.1505	27.070	25.9	5.1	1.171	0.750	1.921	2.56	1.336	0.586
12	0.1637	27.000	25.9	5.6	1.162	0.750	1.912	2.55	1.331	0.581
13	0.1913	26.020	24.9	6.6	1.107	0.750	1.857	2.48	1.303	0.553
14	0.2176	25.840	24.7	7.5	1.088	0.750	1.838	2.45	1.294	0.544
15	0.2445	25.960	24.8	8.5	1.081	0.750	1.831	2.44	1.291	0.541
16	0.2707	26.210	25.1	9.4	1.081	0.750	1.831	2.44	1.291	0.541
17	0.2983	26.610	25.5	10.4	1.086	0.750	1.836	2.45	1.293	0.543
18	0.3245	26.900	25.8	11.4	1.087	0.750	1.837	2.45	1.294	0.544
19	0.3514	27.180	26.1	12.3	1.087	0.750	1.837	2.45	1.294	0.544
20	0.3785	27.380	26.3	13.3	1.083	0.750	1.833	2.44	1.292	0.542
21	0.3921	26.890	25.8	13.8	1.057	0.750	1.807	2.41	1.279	0.529
22	0.4250	26.830	25.7	15.0	1.040	0.750	1.790	2.39	1.270	0.520

Parameters for Specimen No. 2		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	149.300	149.300
Moisture content: Dry soil+tare, gms.	112.770	112.770
Moisture content: Tare, gms.	30.000	30.000
Moisture, %	44.1	44.1
Moist specimen weight, gms.	119.9	
Diameter, in.	1.37	
Area, in.²	1.48	
Height, in.	2.80	
Wet Density, pcf	110.4	
Dry density, pcf	76.6	
Void ratio	1.1988	
Saturation, %	99.3	

Test Readings for Specimen No. 2

Cell pressure = 1.500 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.234 tsf at reading no. 18

Ult. Stress = 1.210 tsf at reading no. 22

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	2.130	0.0	0.0	0.000	1.500	1.500	1.00	1.500	0.000
1	0.0162	7.010	4.9	0.3	0.236	1.500	1.736	1.16	1.618	0.118
2	0.0300	10.920	8.8	0.8	0.424	1.500	1.924	1.28	1.712	0.212
3	0.0439	16.690	14.6	1.3	0.699	1.500	2.199	1.47	1.849	0.349
4	0.0567	21.750	19.6	1.8	0.937	1.500	2.437	1.62	1.969	0.469
5	0.0702	25.410	23.3	2.3	1.106	1.500	2.606	1.74	2.053	0.553
6	0.0838	26.670	24.5	2.8	1.160	1.500	2.660	1.77	2.080	0.580
7	0.0970	27.890	25.8	3.2	1.212	1.500	2.712	1.81	2.106	0.606
8	0.1110	28.020	25.9	3.7	1.212	1.500	2.712	1.81	2.106	0.606
9	0.1248	28.320	26.2	4.2	1.220	1.500	2.720	1.81	2.110	0.610
10	0.1387	28.520	26.4	4.7	1.223	1.500	2.723	1.82	2.111	0.611
11	0.1528	28.760	26.6	5.2	1.227	1.500	2.727	1.82	2.114	0.614
12	0.1658	28.930	26.8	5.7	1.229	1.500	2.729	1.82	2.115	0.615
13	0.1926	29.020	26.9	6.7	1.221	1.500	2.721	1.81	2.110	0.610
14	0.2191	29.354	27.2	7.6	1.223	1.500	2.723	1.82	2.112	0.612
15	0.2454	29.640	27.5	8.5	1.224	1.500	2.724	1.82	2.112	0.612
16	0.2720	29.910	27.8	9.5	1.223	1.500	2.723	1.82	2.111	0.611
17	0.3001	30.280	28.2	10.5	1.225	1.500	2.725	1.82	2.113	0.613
18	0.3271	30.790	28.7	11.5	1.234	1.500	2.734	1.82	2.117	0.617
19	0.3544	30.760	28.6	12.4	1.219	1.500	2.719	1.81	2.110	0.610
20	0.3818	30.660	28.5	13.4	1.201	1.500	2.701	1.80	2.101	0.601
21	0.3955	30.820	28.7	13.9	1.201	1.500	2.701	1.80	2.101	0.601
22	0.4265	31.400	29.3	15.0	1.210	1.500	2.710	1.81	2.105	0.605

Parameters for Specimen No. 3

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	152.120	152.120
Moisture content: Dry soil+tare, gms.	114.850	114.850
Moisture content: Tare, gms.	30.400	30.400
Moisture, %	44.1	44.1
Moist specimen weight, gms.	122.0	
Diameter, in.	1.38	
Area, in.²	1.50	
Height, in.	2.80	
Wet Density, pcf	110.7	
Dry density, pcf	76.8	
Void ratio	1.1923	
Saturation, %	99.9	

Test Readings for Specimen No. 3

Cell pressure = 3.000 tsf

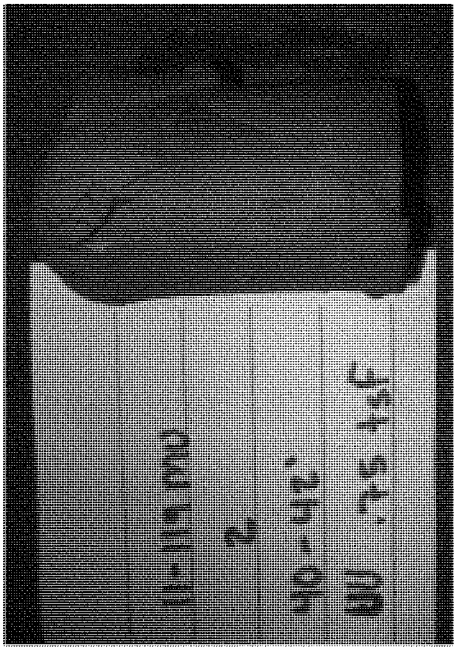
Back pressure = 0.000 tsf

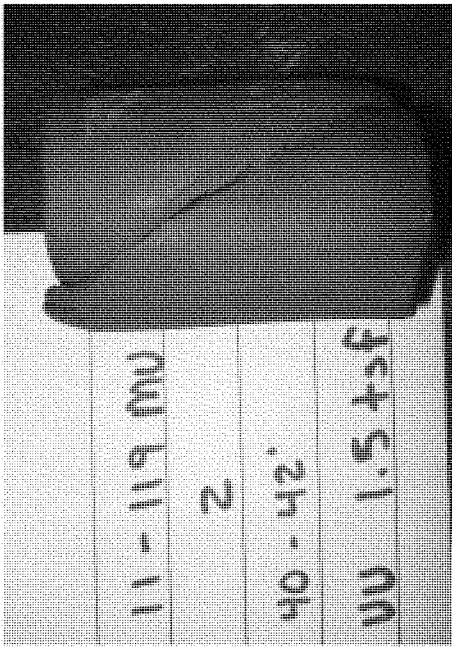
Strain rate, %/min. = 1.00

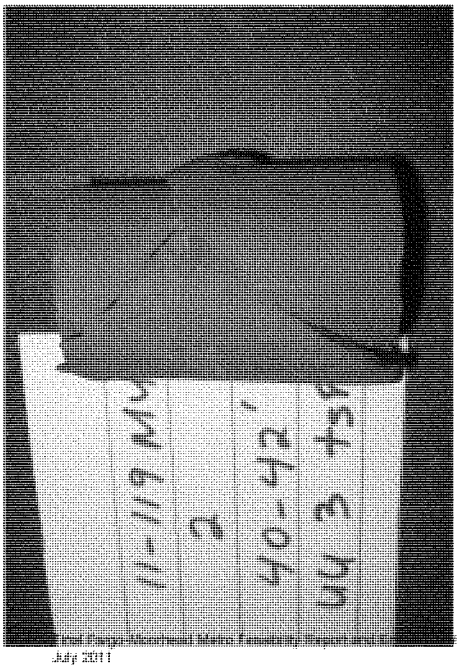
Peak Stress = 1.234 tsf at reading no. 15

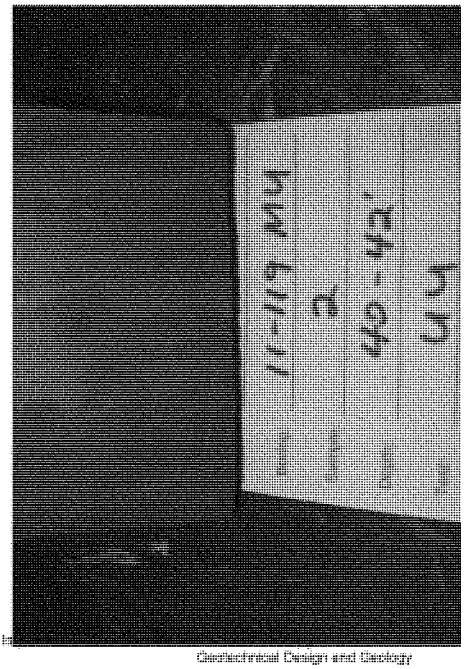
Ult. Stress = 1.089 tsf at reading no. 22

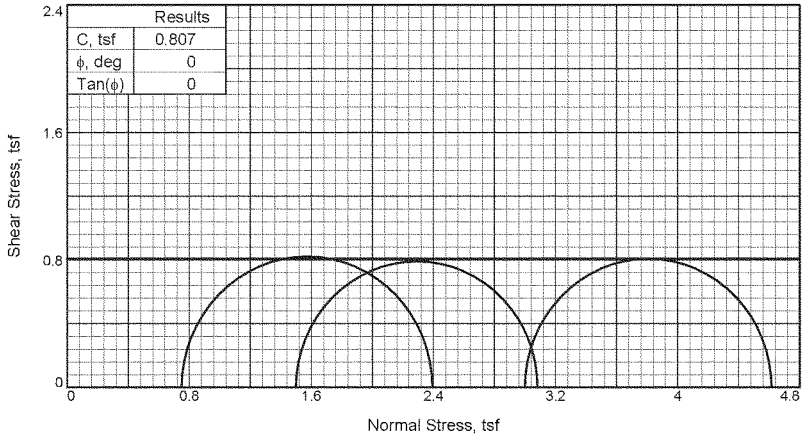
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0067	6.640	0.0	0.0	0.000	3.000	3.000	1.00	3.000	0.000
1	0.0168	11.500	4.9	0.4	0.233	3.000	3.233	1.08	3.116	0.116
2	0.0293	17.750	11.1	0.8	0.530	3.000	3.530	1.18	3.265	0.265
3	0.0433	21.540	14.9	1.3	0.707	3.000	3.707	1.24	3.353	0.353
4	0.0569	24.440	17.8	1.8	0.840	3.000	3.840	1.28	3.420	0.420
5	0.0710	25.020	18.4	2.3	0.863	3.000	3.863	1.29	3.432	0.432
6	0.0842	26.130	19.5	2.8	0.911	3.000	3.911	1.30	3.455	0.455
7	0.0976	27.600	21.0	3.2	0.975	3.000	3.975	1.32	3.487	0.487
8	0.1111	29.630	23.0	3.7	1.064	3.000	4.064	1.35	3.532	0.532
9	0.1251	30.360	23.7	4.2	1.092	3.000	4.092	1.36	3.546	0.546
10	0.1385	30.960	24.3	4.7	1.114	3.000	4.114	1.37	3.557	0.557
11	0.1515	31.700	25.1	5.2	1.142	3.000	4.142	1.38	3.571	0.571
12	0.1655	32.770	26.1	5.7	1.185	3.000	4.185	1.39	3.592	0.592
13	0.1936	33.590	27.0	6.7	1.209	3.000	4.209	1.40	3.605	0.605
14	0.2208	34.270	27.6	7.6	1.227	3.000	4.227	1.41	3.613	0.613
15	0.2487	34.750	28.1	8.6	1.234	3.000	4.234	1.41	3.617	0.617
16	0.2750	34.600	28.0	9.6	1.215	3.000	4.215	1.41	3.608	0.608
17	0.3027	34.670	28.0	10.6	1.205	3.000	4.205	1.40	3.603	0.603
18	0.3300	34.940	28.3	11.5	1.203	3.000	4.203	1.40	3.602	0.602
19	0.3576	34.240	27.6	12.5	1.161	3.000	4.161	1.39	3.580	0.580
20	0.3849	33.910	27.3	13.5	1.134	3.000	4.134	1.38	3.567	0.567
21	0.3987	33.900	27.3	14.0	1.127	3.000	4.127	1.38	3.564	0.564
22	0.4258	33.290	26.7	15.0	1.089	3.000	4.089	1.36	3.545	0.545

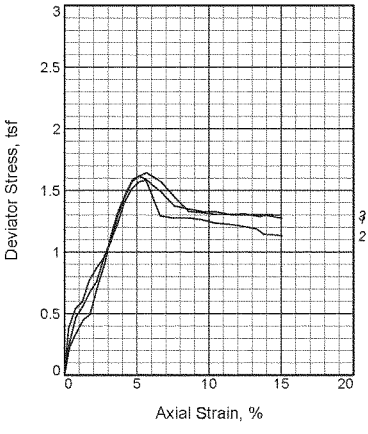

11-119 MM
2
40-42'
UU 1.5+F


11-119 MM
2
40-42'
UU 1.5+F


11-119 MM
2
40-42'
UU 3 +F


11-119 MM
2
40-42'
UU





Sample No.		1	2	3
Initial	Water Content, %	48.3	49.8	50.9
	Dry Density, pcf	73.1	72.0	71.0
	Saturation, %	99.6	100.0	99.8
	Void Ratio	1.3171	1.3508	1.3838
	Diameter, in.	1.37	1.37	1.38
	Height, in.	2.80	2.80	2.80
At Test	Water Content, %	48.3	49.8	50.9
	Dry Density, pcf	73.1	72.0	71.0
	Saturation, %	99.6	100.0	99.8
	Void Ratio	1.3171	1.3508	1.3838
	Diameter, in.	1.37	1.37	1.38
	Height, in.	2.80	2.80	2.80
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		0.75	1.50	3.00
Peak Stress, tsf		1.64	1.58	1.62
Ult. Stress, tsf		1.27	1.13	1.30
σ_1 Failure, tsf		2.39	3.08	4.62
σ_3 Failure, tsf		0.75	1.50	3.00

Type of Test:
Unconsolidated Undrained
Sample Type: 5" Thinwall, Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 62 **PL=** 19 **PI=** 43
Specific Gravity= 2.712
Remarks:

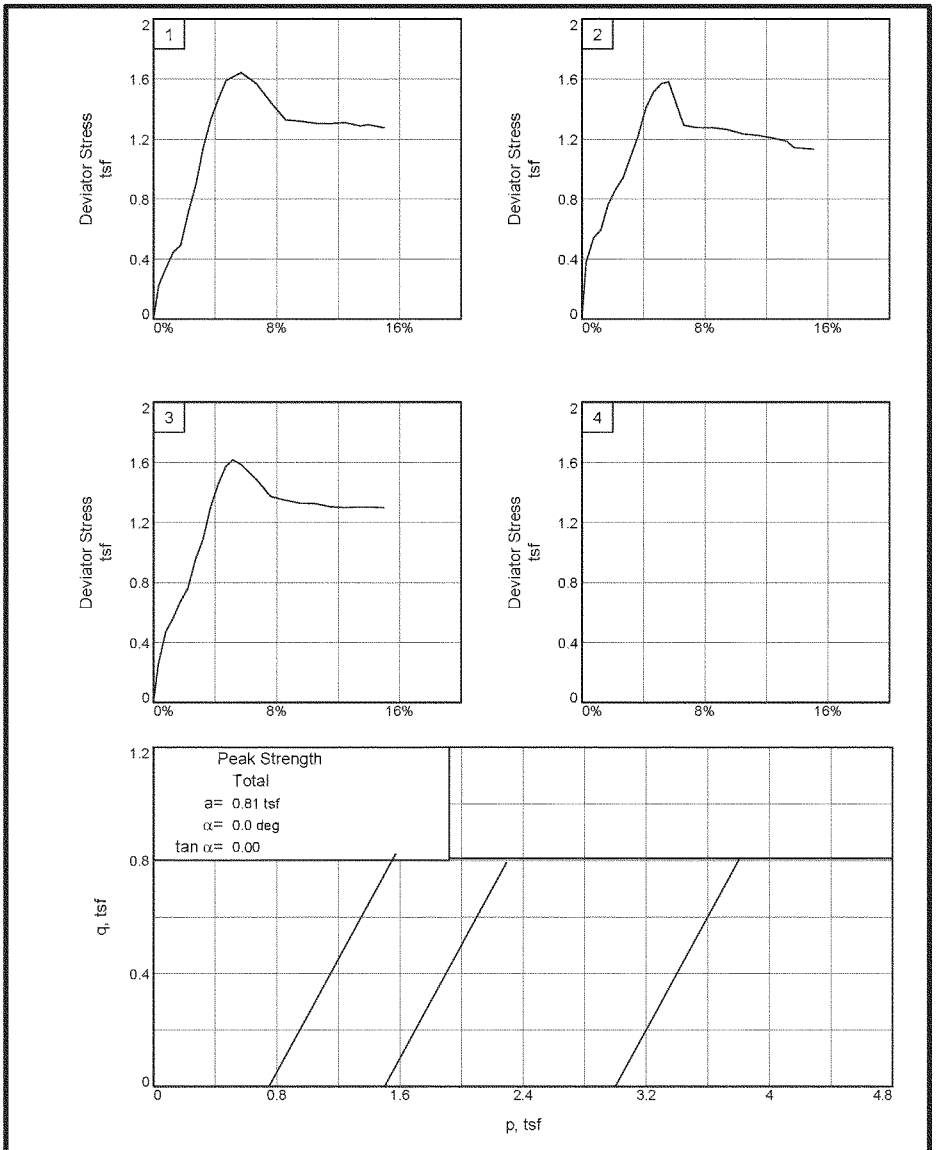
Figure UU Triax ASTM D 2850

Client: USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: Fargo Pile Load Test, Argusville Formation
Sample Number: Boring11-119MU, #3 **Depth:** 50-52'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Tested By: JK **Checked By:** jrs



Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Loc.: Fargo Pile Load Test, Argusville Formation **Depth:** 50-52' **Sample No.:** Boring11-119MU, #3
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JK **Checked By:** JFS

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

5/30/2011
12:12 PM

Date:			
Client:	USACE W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing Request NO. 3		
Project No.:	BL-10-10065		
Location:	Fargo Pile Load Test, Argusville Formation		
Depth:	50-52'	**Sample Number:**	Boring11-119MU, #3
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	5" Thinwall, Bottom of sample		
Specific Gravity=2.712	**LL=**62	**PL=**19	**PI=**43
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	147.880	147.880
Moisture content: Dry soil+tare, gms.	109.710	109.710
Moisture content: Tare, gms.	30.760	30.760
Moisture, %	48.3	48.3
Moist specimen weight, gms.	117.4	
Diameter, in.	1.37	
Area, in.^{2}	1.47	
Height, in.	2.80	
Wet Density, pcf	108.4	
Dry density, pcf	73.1	
Void ratio	1.3171	
Saturation, %	99.6	

Test Readings for Specimen No. 1

Cell pressure = 0.750 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 1.643 tsf **at reading no.** 12
Ult. Stress = 1.275 tsf **at reading no.** 22

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0067	1.760	0.0	0.0	0.000	0.750	0.750	1.00	0.750	0.000
1	0.0165	6.400	4.6	0.4	0.226	0.750	0.976	1.30	0.863	0.113
2	0.0295	8.810	7.1	0.8	0.342	0.750	1.092	1.46	0.921	0.171
3	0.0429	11.070	9.3	1.3	0.449	0.750	1.199	1.60	0.974	0.224
4	0.0561	12.020	10.3	1.8	0.492	0.750	1.242	1.66	0.996	0.246
5	0.0705	16.780	15.0	2.3	0.717	0.750	1.467	1.96	1.108	0.358
6	0.0844	20.810	19.0	2.8	0.905	0.750	1.655	2.21	1.202	0.452
7	0.0973	25.930	24.2	3.2	1.142	0.750	1.892	2.52	1.321	0.571
8	0.1113	30.180	28.4	3.7	1.336	0.750	2.086	2.78	1.418	0.668
9	0.1257	33.320	31.6	4.3	1.476	0.750	2.226	2.97	1.488	0.738
10	0.1390	35.940	34.2	4.7	1.591	0.750	2.341	3.12	1.545	0.795
11	0.1528	36.710	35.0	5.2	1.618	0.750	2.368	3.16	1.559	0.809
12	0.1661	37.440	35.7	5.7	1.643	0.750	2.393	3.19	1.572	0.822
13	0.1933	36.220	34.5	6.7	1.571	0.750	2.321	3.09	1.535	0.785
14	0.2200	33.750	32.0	7.6	1.443	0.750	2.193	2.92	1.472	0.722
15	0.2469	31.490	29.7	8.6	1.327	0.750	2.077	2.77	1.414	0.664
16	0.2741	31.610	29.9	9.6	1.319	0.750	2.069	2.76	1.409	0.659
17	0.3017	31.610	29.9	10.5	1.304	0.750	2.054	2.74	1.402	0.652
18	0.3281	31.910	30.2	11.5	1.304	0.750	2.054	2.74	1.402	0.652
19	0.3559	32.370	30.6	12.5	1.309	0.750	2.059	2.74	1.404	0.654
20	0.3836	32.200	30.4	13.5	1.287	0.750	2.037	2.72	1.393	0.643
21	0.3974	32.620	30.9	14.0	1.297	0.750	2.047	2.73	1.398	0.648
22	0.4269	32.470	30.7	15.0	1.275	0.750	2.025	2.70	1.387	0.637

Parameters for Specimen No. 2		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	146.490	146.490
Moisture content: Dry soil+tare, gms.	107.950	107.950
Moisture content: Tare, gms.	30.550	30.550
Moisture, %	49.8	49.8
Moist specimen weight, gms.	116.3	
Diameter, in.	1.37	
Area, in.²	1.47	
Height, in.	2.80	
Wet Density, pcf	107.9	
Dry density, pcf	72.0	
Void ratio	1.3508	
Saturation, %	100.0	

Test Readings for Specimen No. 2

Cell pressure = 1.500 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.583 tsf at reading no. 12

Ult. Stress = 1.134 tsf at reading no. 22

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0067	4.200	0.0	0.0	0.000	1.500	1.500	1.00	1.500	0.000
1	0.0145	11.950	7.7	0.3	0.379	1.500	1.879	1.25	1.690	0.190
2	0.0280	15.340	11.1	0.8	0.542	1.500	2.042	1.36	1.771	0.271
3	0.0413	16.500	12.3	1.2	0.596	1.500	2.096	1.40	1.798	0.298
4	0.0546	20.130	15.9	1.7	0.768	1.500	2.268	1.51	1.884	0.384
5	0.0681	22.240	18.0	2.2	0.866	1.500	2.366	1.58	1.933	0.433
6	0.0820	24.040	19.8	2.7	0.947	1.500	2.447	1.63	1.974	0.474
7	0.0951	26.970	22.8	3.2	1.082	1.500	2.582	1.72	2.041	0.541
8	0.1089	29.990	25.8	3.7	1.219	1.500	2.719	1.81	2.109	0.609
9	0.1229	34.050	29.9	4.2	1.404	1.500	2.904	1.94	2.202	0.702
10	0.1369	36.550	32.3	4.7	1.513	1.500	3.013	2.01	2.257	0.757
11	0.1507	37.900	33.7	5.1	1.568	1.500	3.068	2.05	2.284	0.784
12	0.1644	38.390	34.2	5.6	1.583	1.500	3.083	2.06	2.291	0.791
13	0.1919	32.400	28.2	6.6	1.292	1.500	2.792	1.86	2.146	0.646
14	0.2174	32.310	28.1	7.5	1.275	1.500	2.775	1.85	2.138	0.638
15	0.2440	32.640	28.4	8.5	1.277	1.500	2.777	1.85	2.138	0.638
16	0.2715	32.650	28.4	9.5	1.264	1.500	2.764	1.84	2.132	0.632
17	0.2993	32.290	28.1	10.5	1.234	1.500	2.734	1.82	2.117	0.617
18	0.3263	32.400	28.2	11.4	1.225	1.500	2.725	1.82	2.113	0.613
19	0.3529	32.280	28.1	12.4	1.207	1.500	2.707	1.80	2.104	0.604
20	0.3794	32.100	27.9	13.3	1.186	1.500	2.686	1.79	2.093	0.593
21	0.3930	31.240	27.0	13.8	1.143	1.500	2.643	1.76	2.072	0.572
22	0.4276	31.400	27.2	15.0	1.134	1.500	2.634	1.76	2.067	0.567

Parameters for Specimen No. 3		
Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	147.220	147.220
Moisture content: Dry soil+tare, gms.	107.810	107.810
Moisture content: Tare, gms.	30.430	30.430
Moisture, %	50.9	50.9
Moist specimen weight, gms.	117.1	
Diameter, in.	1.38	
Area, in.²	1.49	
Height, in.	2.80	
Wet Density, pcf	107.2	
Dry density, pcf	71.0	
Void ratio	1.3838	
Saturation, %	99.8	

Test Readings for Specimen No. 3

Cell pressure = 3.000 tsf

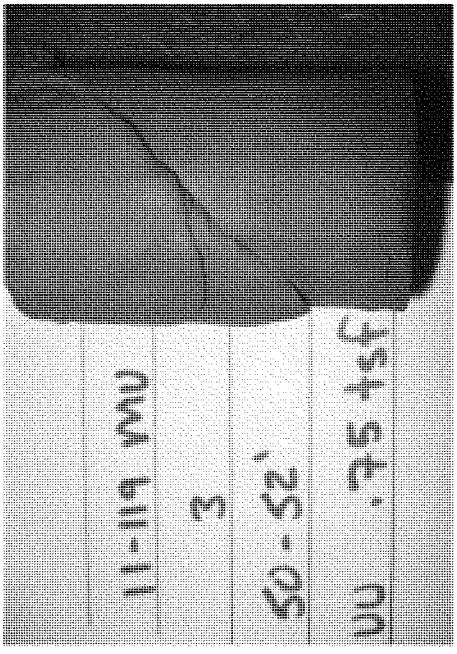
Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 1.616 tsf **at reading no.** 11

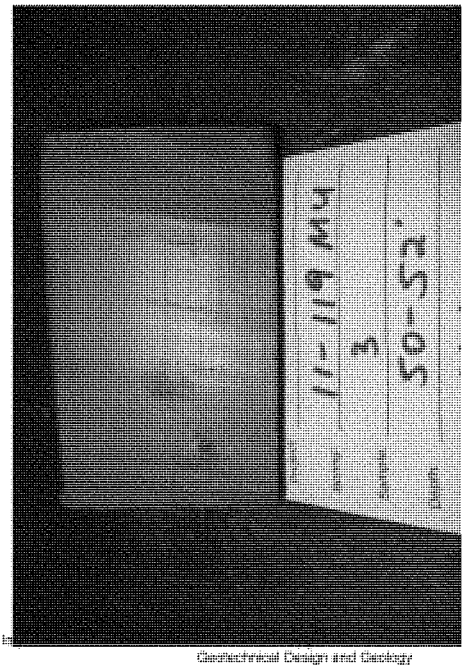
Ult. Stress = 1.299 tsf **at reading no.** 22

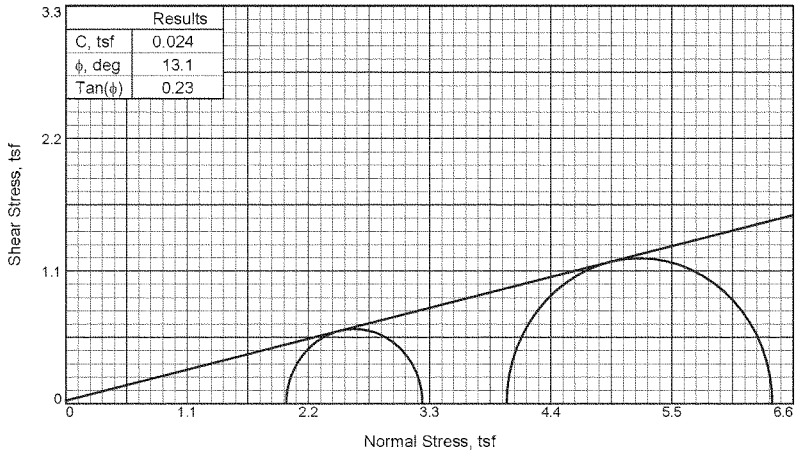
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0067	7.320	0.0	0.0	0.000	3.000	3.000	1.00	3.000	0.000
1	0.0156	12.600	5.3	0.3	0.255	3.000	3.255	1.08	3.127	0.127
2	0.0291	17.170	9.9	0.8	0.473	3.000	3.473	1.16	3.237	0.237
3	0.0428	19.130	11.8	1.3	0.564	3.000	3.564	1.19	3.282	0.282
4	0.0562	21.550	14.2	1.8	0.677	3.000	3.677	1.23	3.338	0.338
5	0.0693	23.420	16.1	2.2	0.762	3.000	3.762	1.25	3.381	0.381
6	0.0833	27.580	20.3	2.7	0.954	3.000	3.954	1.32	3.477	0.477
7	0.0964	30.410	23.1	3.2	1.082	3.000	4.082	1.36	3.541	0.541
8	0.1102	35.150	27.8	3.7	1.298	3.000	4.298	1.43	3.649	0.649
9	0.1238	38.540	31.2	4.2	1.448	3.000	4.448	1.48	3.724	0.724
10	0.1380	41.410	34.1	4.7	1.573	3.000	4.573	1.52	3.787	0.787
11	0.1509	42.510	35.2	5.2	1.616	3.000	4.616	1.54	3.808	0.808
12	0.1652	42.080	34.8	5.7	1.588	3.000	4.588	1.53	3.794	0.794
13	0.1926	40.340	33.0	6.6	1.493	3.000	4.493	1.50	3.746	0.746
14	0.2194	38.020	30.7	7.6	1.373	3.000	4.373	1.46	3.687	0.687
15	0.2464	37.780	30.5	8.6	1.349	3.000	4.349	1.45	3.674	0.674
16	0.2733	37.650	30.3	9.5	1.329	3.000	4.329	1.44	3.664	0.664
17	0.3011	37.900	30.6	10.5	1.325	3.000	4.325	1.44	3.662	0.662
18	0.3282	37.730	30.4	11.5	1.303	3.000	4.303	1.43	3.652	0.652
19	0.3551	37.950	30.6	12.4	1.298	3.000	4.298	1.43	3.649	0.649
20	0.3818	38.390	31.1	13.4	1.303	3.000	4.303	1.43	3.651	0.651
21	0.3952	38.550	31.2	13.9	1.302	3.000	4.302	1.43	3.651	0.651
22	0.4258	38.870	31.6	15.0	1.299	3.000	4.299	1.43	3.649	0.649

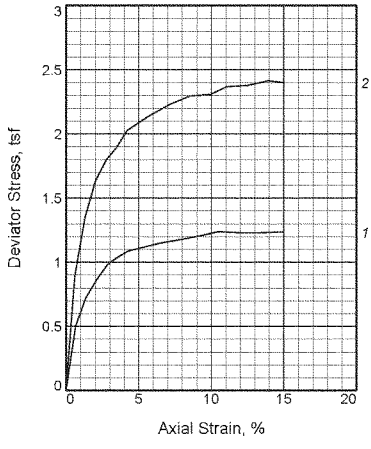

11-119 MU
3
50-52'
UU .75 tsf

11-119 MU
3
50-52'
UU 1.5 tsf

11-119 MU
3
50-52'
UU 3tsf


11-119 MU
3
50-52'





Sample No.		1	2
Initial	Water Content, %	19.8	16.9
	Dry Density, pcf	108.8	113.6
	Saturation, %	99.1	96.2
	Void Ratio	0.5357	0.4706
	Diameter, in.	1.39	1.40
	Height, in.	2.80	2.80
At Test	Water Content, %	19.8	16.9
	Dry Density, pcf	108.8	113.6
	Saturation, %	99.1	96.2
	Void Ratio	0.5357	0.4706
	Diameter, in.	1.39	1.40
	Height, in.	2.80	2.80
Strain rate, %/min.		1.00	1.00
Back Pressure, tsf		0.00	0.00
Cell Pressure, tsf		2.00	4.00
Peak Stress, tsf		1.24	2.41
Ult. Stress, tsf		1.23	2.40
σ_1 Failure, tsf		3.24	6.41
σ_3 Failure, tsf		2.00	4.00

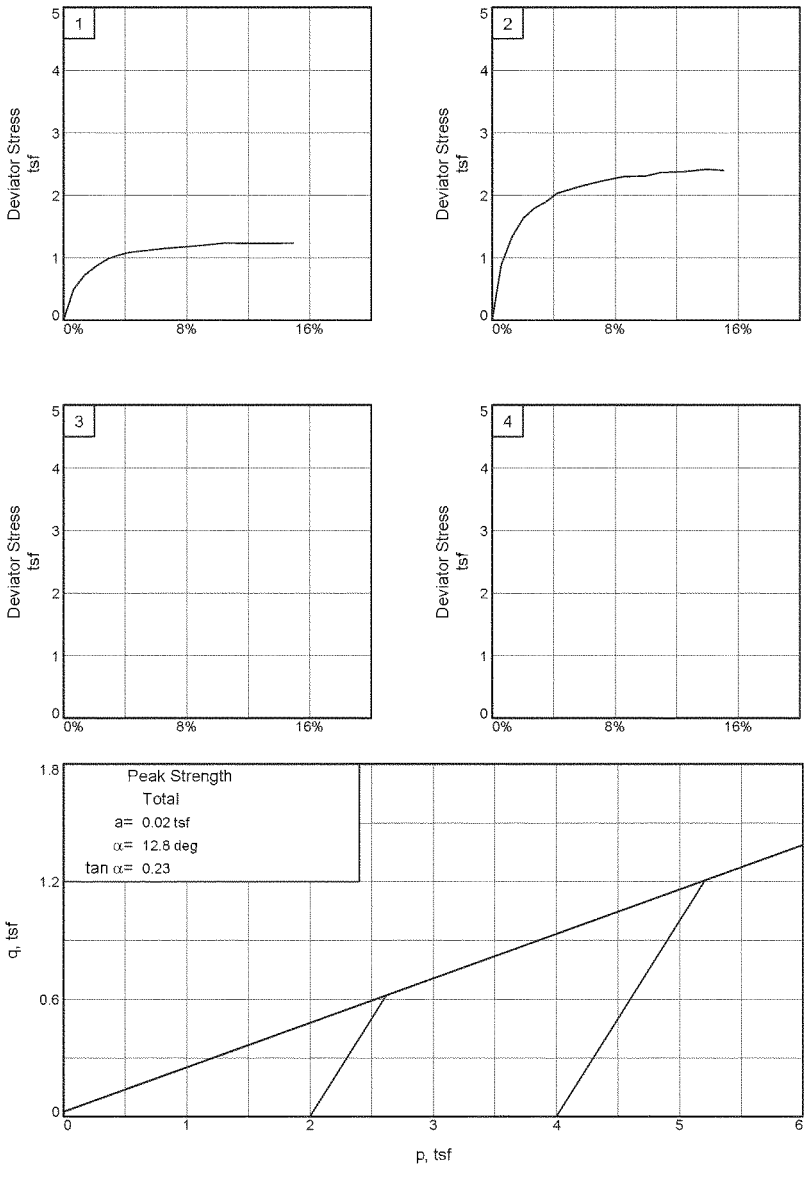
Type of Test:
Unconsolidated Undrained
Sample Type: 3" Thinwall, Top and Middle
Description: SANDY LEAN CLAY, brown (CL)
LL= 31 **PL=** 15 **PI=** 16
Specific Gravity= 2.676
Remarks:

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Maple River, Till Formation
Sample Number: Boring10-105MU, #6 **Depth:** 67-69'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Figure Tri-Axial ASTM D2850



Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Location: Maple River, Till Formation **Depth:** 67-69' **Sample Number:** Boring10-105MU, #6
Project No. Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement **Figure**
July 2011

Braun Intertec
Geotechnical Design and Geology

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

3/4/2011
12:06 PM

Date:			
Client:	W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing		
Project No.:	BL-10-10065		
Location:	Maple River, Till Formation		
Depth:	67-69'	**Sample Number:**	Boring10-105MU, #6
Description:	SANDY LEAN CLAY, brown (CL)		
Remarks:			
Type of Sample:	3" Thinwall, Top and Middle		
Specific Gravity=2.676	**LL=**31	**PL=**15	**PI=**16
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	176.600	176.600
Moisture content: Dry soil+tare, gms.	152.540	152.540
Moisture content: Tare, gms.	31.250	31.250
Moisture, %	19.8	19.8
Moist specimen weight, gms.	145.8	
Diameter, in.	1.39	
Area, in.²	1.52	
Height, in.	2.80	
Wet Density, pcf	130.4	
Dry density, pcf	108.8	
Void ratio	0.5357	
Saturation, %	99.1	

Test Readings for Specimen No. 1

Cell pressure = 2.000 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 1.237 tsf **at reading no.** 10
Ult. Stress = 1.235 tsf **at reading no.** 13

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0065	4.450	0.0	0.0	0.000	2.000	2.000	1.00	2.000	0.000
1	0.0252	15.070	10.6	0.7	0.500	2.000	2.500	1.25	2.250	0.250
2	0.0453	19.980	15.5	1.4	0.726	2.000	2.726	1.36	2.363	0.363
3	0.0659	23.100	18.7	2.1	0.865	2.000	2.865	1.43	2.432	0.432
4	0.0862	25.720	21.3	2.8	0.979	2.000	2.979	1.49	2.490	0.490
5	0.1061	27.150	22.7	3.6	1.037	2.000	3.037	1.52	2.519	0.519
6	0.1267	28.410	24.0	4.3	1.087	2.000	3.087	1.54	2.543	0.543
7	0.1886	30.360	25.9	6.5	1.148	2.000	3.148	1.57	2.574	0.574
8	0.2288	31.400	27.0	7.9	1.176	2.000	3.176	1.59	2.588	0.588
9	0.2703	32.590	28.1	9.4	1.208	2.000	3.208	1.60	2.604	0.604
10	0.3010	33.620	29.2	10.5	1.237	2.000	3.237	1.62	2.618	0.618
11	0.3420	33.900	29.5	12.0	1.228	2.000	3.228	1.61	2.614	0.614
12	0.3827	34.390	29.9	13.4	1.228	2.000	3.228	1.61	2.614	0.614
13	0.4257	35.090	30.6	15.0	1.235	2.000	3.235	1.62	2.617	0.617

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	179.440	179.440
Moisture content: Dry soil+tare, gms.	157.820	157.820
Moisture content: Tare, gms.	30.030	30.030
Moisture, %	16.9	16.9
Moist specimen weight, gms.	150.0	
Diameter, in.	1.40	
Area, in.²	1.54	
Height, in.	2.80	
Wet Density, pcf	132.8	
Dry density, pcf	113.6	
Void ratio	0.4706	
Saturation, %	96.2	

Test Readings for Specimen No. 2

Cell pressure = 4.000 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

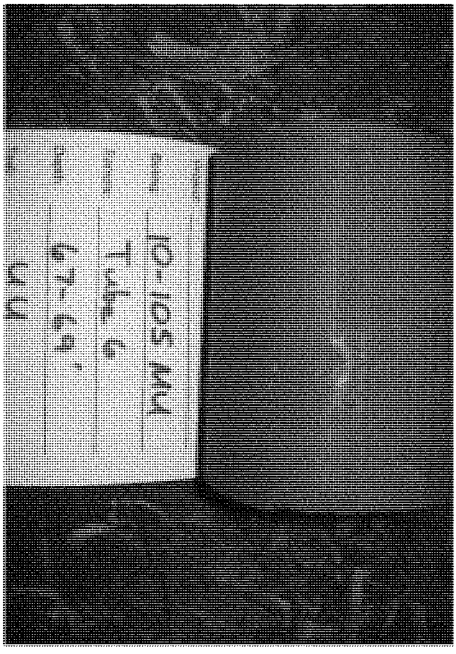
Peak Stress = 2.412 tsf at reading no. 13

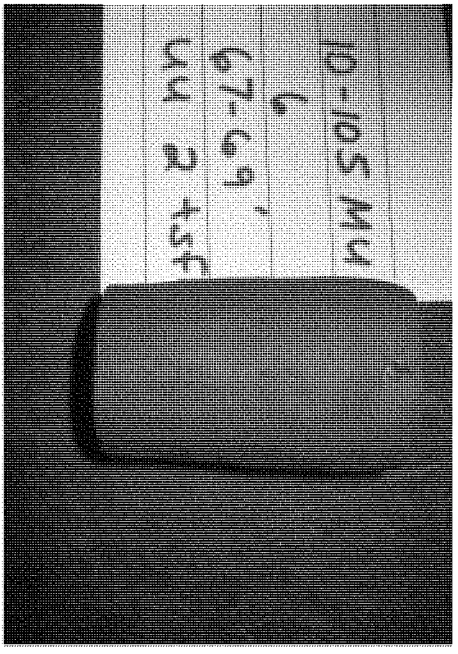
Ult. Stress = 2.398 tsf at reading no. 14

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	9.180	0.0	0.0	0.000	4.000	4.000	1.00	4.000	0.000
1	0.0234	28.220	19.0	0.6	0.886	4.000	4.886	1.22	4.443	0.443
2	0.0433	38.290	29.1	1.3	1.346	4.000	5.346	1.34	4.673	0.673
3	0.0637	44.830	35.7	2.0	1.636	4.000	5.636	1.41	4.818	0.818
4	0.0840	48.640	39.5	2.8	1.797	4.000	5.797	1.45	4.899	0.899
5	0.1038	51.020	41.8	3.5	1.892	4.000	5.892	1.47	4.946	0.946
6	0.1243	54.320	45.1	4.2	2.025	4.000	6.025	1.51	5.013	1.013
7	0.1653	57.520	48.3	5.7	2.136	4.000	6.136	1.53	5.068	1.068
8	0.2049	60.300	51.1	7.1	2.225	4.000	6.225	1.56	5.112	1.112
9	0.2452	62.710	53.5	8.5	2.294	4.000	6.294	1.57	5.147	1.147

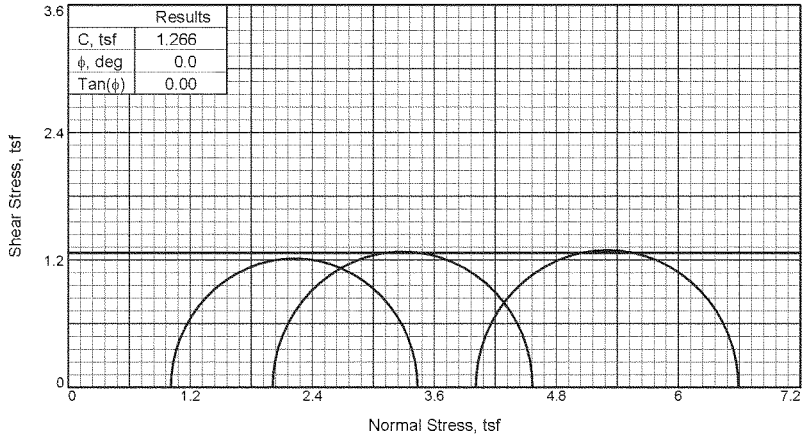
Test Readings for Specimen No. 2

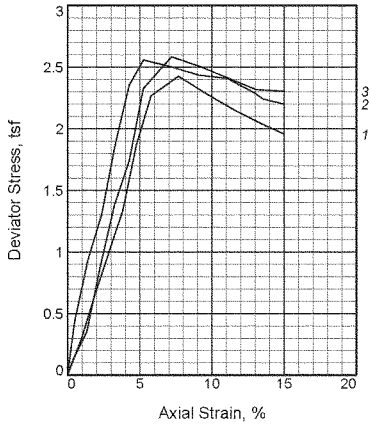
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
10	0.2858	63.870	54.7	10.0	2.306	4.000	6.306	1.58	5.153	1.153
11	0.3159	65.980	56.8	11.1	2.366	4.000	6.366	1.59	5.183	1.183
12	0.3564	67.170	58.0	12.5	2.377	4.000	6.377	1.59	5.188	1.188
13	0.3969	69.030	59.9	13.9	2.412	4.000	6.412	1.60	5.206	1.206
14	0.4276	69.430	60.3	15.0	2.398	4.000	6.398	1.60	5.199	1.199


10-105 MU
Tube 6
67-69'
UU


10-105 MU
6
67-69'
UU 2 tsf

10-105MU
6
67-69
CU 4 tsf





Sample No.		1	2	3
Initial	Water Content, %	21.5	24.4	22.9
	Dry Density, pcf	104.1	100.3	102.3
	Saturation, %	94.1	97.6	96.2
	Void Ratio	0.6133	0.6735	0.6404
	Diameter, in.	1.40	1.38	1.39
	Height, in.	2.81	2.81	2.81
At Test	Water Content, %	21.5	24.4	22.9
	Dry Density, pcf	104.1	100.3	102.3
	Saturation, %	94.1	97.6	96.2
	Void Ratio	0.6133	0.6735	0.6404
	Diameter, in.	1.40	1.38	1.39
	Height, in.	2.81	2.81	2.81
Strain rate, %/min.		1.00	1.00	1.00
Back Pressure, tsf		0.00	0.00	0.00
Cell Pressure, tsf		1.01	2.01	4.01
Peak Stress, tsf		2.43	2.56	2.58
Ult. Stress, tsf		1.96	2.20	2.31
σ_1 Failure, tsf		3.44	4.57	6.59
σ_3 Failure, tsf		1.01	2.01	4.01

Type of Test: Unconsolidated Undrained
Sample Type: Undisturbed, 5" Thinwall, Bottom
Description: FAT CLAY, brown (CH)

LL= 66 **PL=** 20 **PI=** 46
Specific Gravity= 2.689
Remarks:

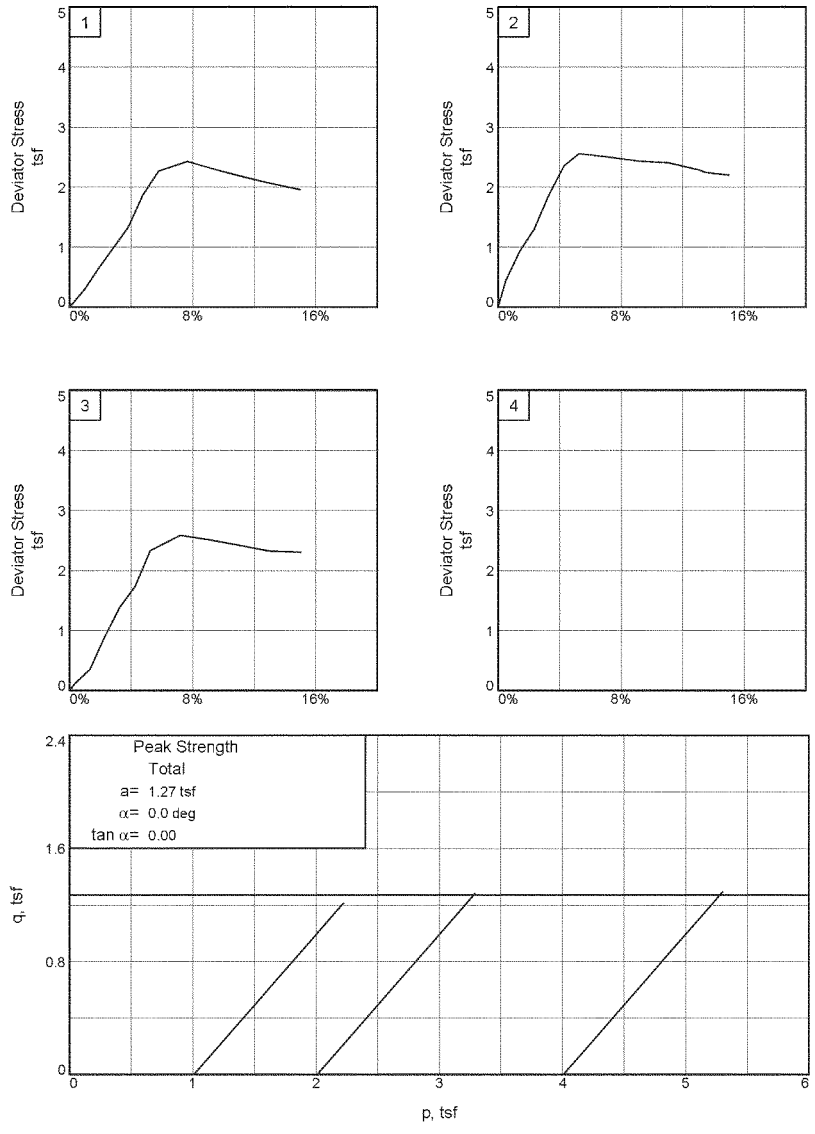
Figure UU Triax ASTM D 2850

Client: W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Sheyenne River, Till Formation
Sample Number: Boring11-110MU, #6 **Depth:** 65-67'
Proj. No.: BL-10-10065 **Date Sampled:**

BRAUN INTERTEC

Tested By: JK **Checked By:** JS



Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Location: Sheyenne River, Till Formation **Depth:** 65-67' **Sample Number:** Boring11-110MU, #6
Project No.: BL-10-10065 **Figure** _____ **Braun Intertec**

Tested By: JK **Checked By:** JS

TRIAXIAL COMPRESSION TEST 4/26/2011
Unconsolidated Undrained 8:15 AM

Date:			
Client:	W912ES-11-P-0024		
Project:	Fargo-Moorhead Metro Feasibility Study Phase 4 Undisturbed Testing		
Project No.:	BL-10-10065		
Location:	Sheyenne River, Till Formation		
Depth:	65-67'	**Sample Number:**	Boring11-110MU, #6
Description:	FAT CLAY, brown (CH)		
Remarks:			
Type of Sample:	Undisturbed, 5" Thinwall, Bottom		
Specific Gravity=2.689	**LL=**66	**PL=**20	**PI=**46
Test Method:	ASTM D 2850		

Parameters for Specimen No. 1

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	172.890	172.890
Moisture content: Dry soil+tare, gms.	147.770	147.770
Moisture content: Tare, gms.	30.720	30.720
Moisture, %	21.5	21.5
Moist specimen weight, gms.	142.9	
Diameter, in.	1.40	
Area, in.²	1.53	
Height, in.	2.81	
Wet Density, pcf	126.4	
Dry density, pcf	104.1	
Void ratio	0.6133	
Saturation, %	94.1	

Test Readings for Specimen No. 1

Cell pressure = 1.010 tsf
Back pressure = 0.000 tsf
Strain rate, %/min. = 1.00
Peak Stress = 2.427 tsf **at reading no.** 7
Ult. Stress = 1.958 tsf **at reading no.** 11

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0087	2.310	0.0	0.0	0.000	1.010	1.010	1.00	1.010	0.000
1	0.0361	8.720	6.4	1.0	0.298	1.010	1.308	1.29	1.159	0.149
2	0.0628	16.750	14.4	1.9	0.664	1.010	1.674	1.66	1.342	0.332
3	0.0886	23.980	21.7	2.8	0.988	1.010	1.998	1.98	1.504	0.494
4	0.1160	31.920	29.6	3.8	1.336	1.010	2.346	2.32	1.678	0.668
5	0.1429	44.280	42.0	4.8	1.875	1.010	2.885	2.86	1.947	0.937
6	0.1710	53.620	51.3	5.8	2.268	1.010	3.278	3.25	2.144	1.134
7	0.2242	58.350	56.0	7.7	2.427	1.010	3.437	3.40	2.223	1.213
8	0.2792	56.180	53.9	9.6	2.283	1.010	3.293	3.26	2.152	1.142
9	0.3339	54.170	51.9	11.6	2.151	1.010	3.161	3.13	2.085	1.075
10	0.3860	52.580	50.3	13.4	2.041	1.010	3.051	3.02	2.030	1.020
11	0.4293	51.420	49.1	15.0	1.958	1.010	2.968	2.94	1.989	0.979

Parameters for Specimen No. 2

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	166.930	166.930
Moisture content: Dry soil+tare, gms.	140.010	140.010
Moisture content: Tare, gms.	29.890	29.890
Moisture, %	24.4	24.4
Moist specimen weight, gms.	137.8	
Diameter, in.	1.38	
Area, in.²	1.50	
Height, in.	2.81	
Wet Density, pcf	124.8	
Dry density, pcf	100.3	
Void ratio	0.6735	
Saturation, %	97.6	

Test Readings for Specimen No. 2

Cell pressure = 2.011 tsf

Back pressure = 0.000 tsf

Strain rate, %/min. = 1.00

Peak Stress = 2.557 tsf at reading no. 6

Ult. Stress = 2.201 tsf at reading no. 12

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0066	4.420	0.0	0.0	0.000	2.011	2.011	1.00	2.011	0.000
1	0.0203	13.450	9.0	0.5	0.433	2.011	2.444	1.22	2.227	0.216
2	0.0463	24.130	19.7	1.4	0.935	2.011	2.946	1.47	2.479	0.468
3	0.0731	32.250	27.8	2.4	1.308	2.011	3.319	1.65	2.665	0.654
4	0.1002	44.920	40.5	3.3	1.885	2.011	3.896	1.94	2.953	0.942
5	0.1269	55.570	51.2	4.3	2.357	2.011	4.368	2.17	3.189	1.178
6	0.1543	60.480	56.1	5.3	2.557	2.011	4.568	2.27	3.289	1.278
7	0.2086	60.420	56.0	7.2	2.502	2.011	4.513	2.24	3.262	1.251
8	0.2625	60.060	55.6	9.1	2.435	2.011	4.446	2.21	3.228	1.217
9	0.3182	60.670	56.3	11.1	2.408	2.011	4.419	2.20	3.215	1.204
10	0.3721	59.080	54.7	13.0	2.289	2.011	4.300	2.14	3.156	1.145
11	0.3867	58.290	53.9	13.5	2.243	2.011	4.254	2.12	3.132	1.121

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
12	0.4280	58.210	53.8	15.0	2.201	2.011	4.212	2.09	3.112	1.101

Parameters for Specimen No. 3

Specimen Parameter	Initial	Final
Moisture content: Moist soil+tare, gms.	170.900	170.900
Moisture content: Dry soil+tare, gms.	144.680	144.680
Moisture content: Tare, gms.	30.280	30.250
Moisture, %	22.9	22.9
Moist specimen weight, gms.	141.2	
Diameter, in.	1.39	
Area, in.^{2}	1.52	
Height, in.	2.81	
Wet Density, pcf	125.8	
Dry density, pcf	102.3	
Void ratio	0.6404	
Saturation, %	96.2	

Test Readings for Specimen No. 3

Cell pressure = 4.009 tsf

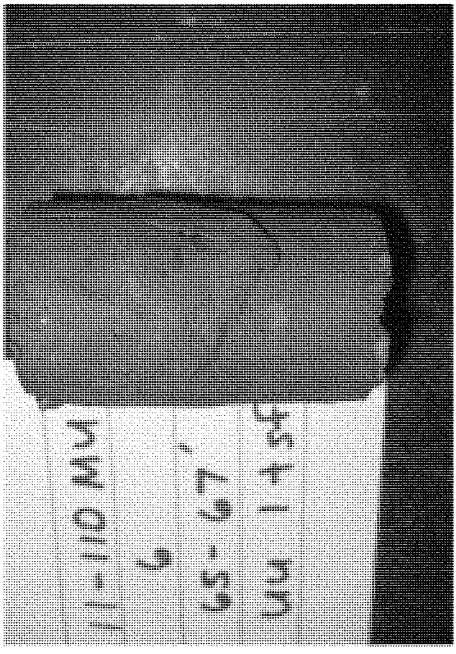
Back pressure = 0.000 tsf

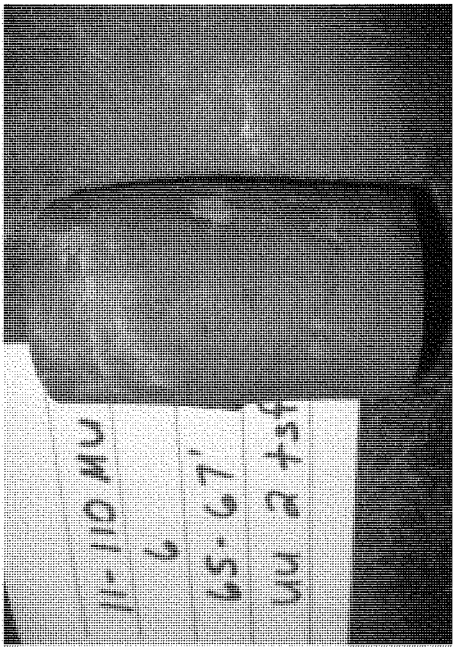
Strain rate, %/min. = 1.00

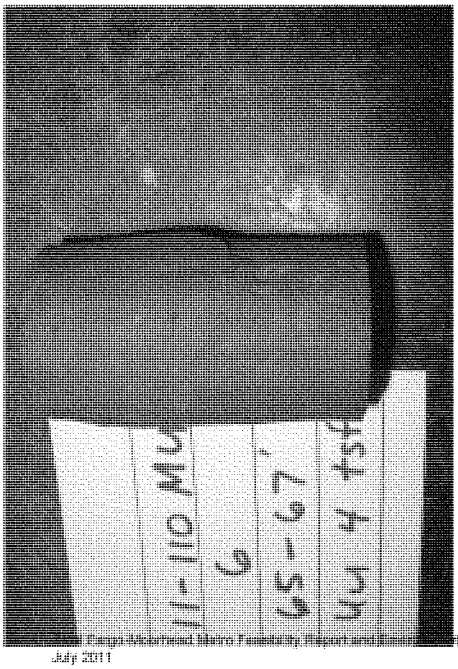
Peak Stress = 2.584 tsf at reading no. 7

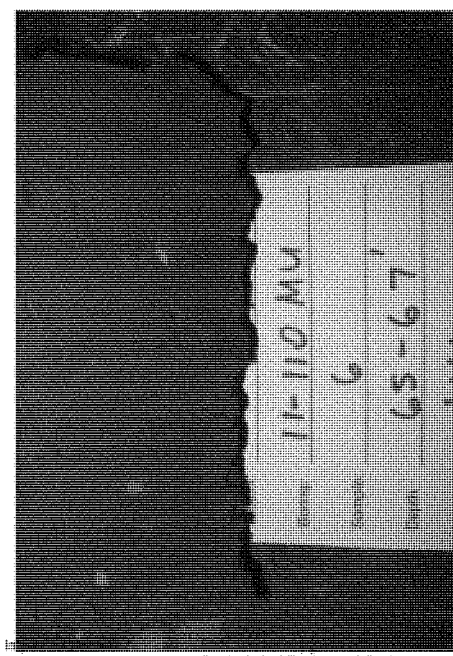
Ult. Stress = 2.305 tsf at reading no. 11

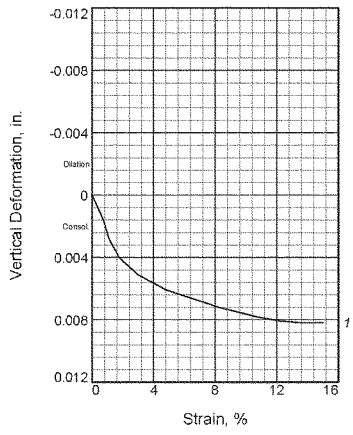
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress tsf	Minor Princ. Stress tsf	Major Princ. Stress tsf	1:3 Ratio	P tsf	Q tsf
0	0.0067	8.900	0.0	0.0	0.000	4.009	4.009	1.00	4.009	0.000
1	0.0172	11.470	2.6	0.4	0.121	4.009	4.130	1.03	4.069	0.060
2	0.0443	16.500	7.6	1.3	0.354	4.009	4.363	1.09	4.186	0.177
3	0.0711	28.340	19.4	2.3	0.897	4.009	4.906	1.22	4.458	0.449
4	0.0981	39.180	30.3	3.3	1.384	4.009	5.393	1.35	4.701	0.692
5	0.1265	47.300	38.4	4.3	1.737	4.009	5.746	1.43	4.877	0.868
6	0.1541	60.910	52.0	5.3	2.328	4.009	6.337	1.58	5.173	1.164
7	0.2086	67.840	58.9	7.2	2.584	4.009	6.593	1.64	5.301	1.292
8	0.2638	67.290	58.4	9.2	2.506	4.009	6.515	1.63	5.262	1.253
9	0.3182	66.370	57.5	11.1	2.414	4.009	6.423	1.60	5.216	1.207
10	0.3729	65.340	56.4	13.1	2.318	4.009	6.327	1.58	5.168	1.159
11	0.4280	66.310	57.4	15.0	2.305	4.009	6.314	1.57	5.162	1.153

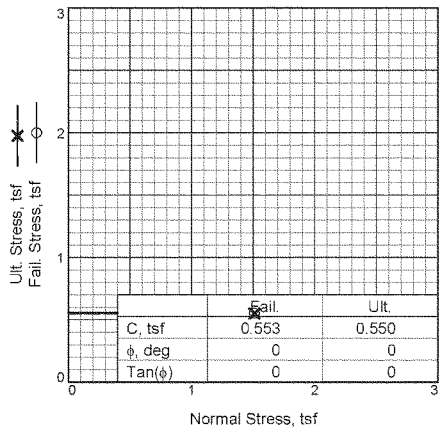

11-110 MU
6
65-67'
uu 1 tsf


11-110 MU
6
65-67'
uu 2 tsf

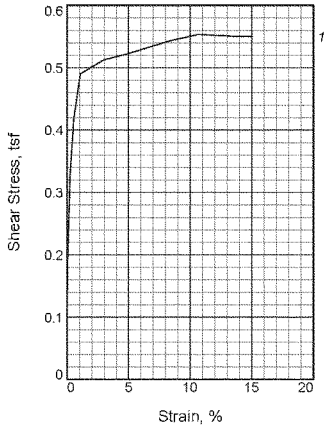

11-110 MU
6
65-67'
uu 4 tsf


11-110 MU
6
65-67'





	Fail.	Ult.
C, tsf	0.553	0.550
ϕ, deg	0	0
Tan(ϕ)	0	0



		Sample No. 1
Initial	Water Content, %	31.6
	Dry Density, pcf	88.2
	Saturation, %	91.7
	Void Ratio	0.9471
	Diameter, in.	2.41
	Height, in.	1.00
At Test	Water Content, %	32.2
	Dry Density, pcf	91.0
	Saturation, %	99.9
	Void Ratio	0.8866
	Diameter, in.	2.41
	Height, in.	0.97
Normal Stress, tsf		1.511
Fail. Stress, tsf		0.553
Strain, %		10.6
Ult. Stress, tsf		0.550
Strain, %		15.0
Strain rate, in./min.		0.00

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, brown (CH)

Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.

Figure Residual Direct Shear

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro 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

Tested By: JS **Checked By:** JS

DIRECT SHEAR TEST

11/9/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro 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: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.75 LL= PL= PI=

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	119.000		167.670
Moisture content: Dry soil+tare, gms.	97.780		134.300
Moisture content: Tare, gms.	30.610		30.720
Moisture, %	31.6	32.2	32.2
Moist specimen weight, gms.	139.2		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.97	
Net decrease in height, in.		0.03	
Wet Density, pcf	116.0	120.3	
Dry density, pcf	88.2	91.0	
Void ratio	0.9471	0.8866	
Saturation, %	91.7	99.9	

Test Readings for Specimen No. 1

Normal stress = 1.511 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.553 tsf at reading no. 11
Ult. Stress = 0.550 tsf at reading no. 15

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0056	0.000	0.0	0.0	0.000	0.1389
1	0.0058	5.900	5.9	0.0	0.093	0.1389
2	0.0073	12.400	12.4	0.1	0.195	0.1388
3	0.0115	20.700	20.7	0.2	0.326	0.1384
4	0.0190	26.500	26.5	0.6	0.418	0.1377
5	0.0244	28.500	28.5	0.8	0.449	0.1372
6	0.0319	31.100	31.1	1.1	0.490	0.1361
7	0.0480	31.600	31.6	1.8	0.498	0.1349
8	0.0774	32.500	32.5	3.0	0.512	0.1338
9	0.1226	33.100	33.1	4.9	0.522	0.1328
10	0.2045	34.400	34.4	8.2	0.542	0.1317
11	0.2617	35.100	35.1	10.6	0.553	0.1311
12	0.3025	35.000	35.0	12.3	0.552	0.1308

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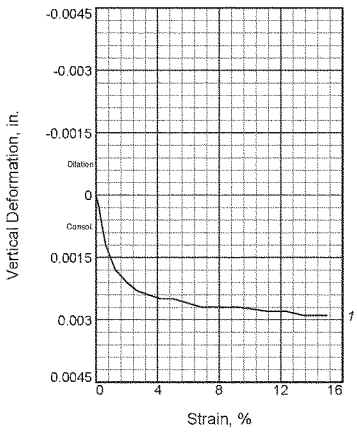
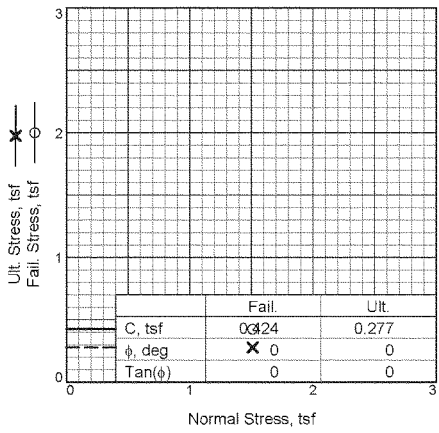
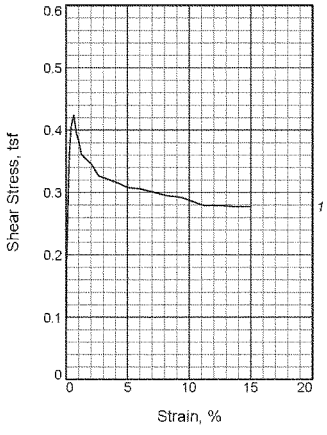
Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
13	0.3085	35.000	35.0	12.6	0.552	0.1308
14	0.3300	34.900	34.9	13.5	0.550	0.1307
15	0.3680	34.900	34.9	15.0	0.550	0.1307







Sample No.		1
Initial	Water Content, %	29.7
	Dry Density, pcf	91.6
	Saturation, %	94.9
	Void Ratio	0.8492
	Diameter, in.	2.41
	Height, in.	1.01
At Test	Water Content, %	29.4
	Dry Density, pcf	94.2
	Saturation, %	100.0
	Void Ratio	0.7982
	Diameter, in.	2.41
	Height, in.	0.98
Normal Stress, tsf		1.511
Fail. Stress, tsf		0.424
Strain, %		0.6
Ult. Stress, tsf		0.277
Strain, %		15.0
Strain rate, in./min.		0.00

Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, brown (CH)

LL= 75 **PL=** 18 **PI=** 57
Assumed Specific Gravity= 2.712
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.

Figure Residual Direct Shear

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro 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

Tested By: rs **Checked By:** rs

DIRECT SHEAR TEST

11/9/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro 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: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.
Type of Sample: Thinwall, 5", Middle of sample
Assumed Specific Gravity=2.712 LL=75 PL=18 PI=57

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	107.520		172.450
Moisture content: Dry soil+tare, gms.	89.750		140.110
Moisture content: Tare, gms.	29.950		30.250
Moisture, %	29.7	29.4	29.4
Moist specimen weight, gms.	143.2		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.01	0.98	
Net decrease in height, in.		0.03	
Wet Density, pcf	118.8	121.9	
Dry density, pcf	91.6	94.2	
Void ratio	0.8492	0.7982	
Saturation, %	94.9	100.0	

Test Readings for Specimen No. 1

Normal stress = 1.511 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.424 tsf at reading no. 5
Ult. Stress = 0.277 tsf at reading no. 20

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0197	0.000	0.0	0.0	0.000	0.1397
1	0.0213	12.400	12.4	0.1	0.195	0.1396
2	0.0245	19.500	19.5	0.2	0.307	0.1394
3	0.0266	23.100	23.1	0.3	0.364	0.1392
4	0.0300	25.700	25.7	0.4	0.405	0.1389
5	0.0350	26.900	26.9	0.6	0.424	0.1385
6	0.0400	25.100	25.1	0.8	0.396	0.1383
7	0.0450	24.200	24.2	1.0	0.381	0.1381
8	0.0500	22.900	22.9	1.3	0.361	0.1379
9	0.0682	22.000	22.0	2.0	0.347	0.1376
10	0.0839	20.700	20.7	2.7	0.326	0.1374
11	0.1204	20.000	20.0	4.2	0.315	0.1372
12	0.1410	19.500	19.5	5.0	0.307	0.1372

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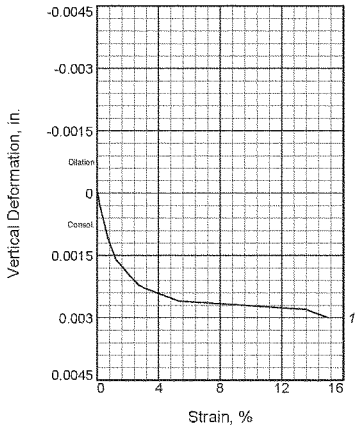
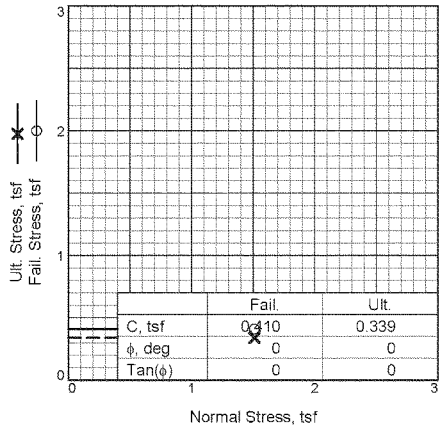
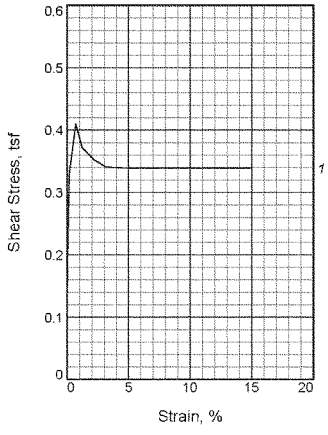
Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
13	0.1631	19.400	19.4	5.9	0.306	0.1371
14	0.1860	19.100	19.1	6.9	0.301	0.1370
15	0.2164	18.700	18.7	8.2	0.295	0.1370
16	0.2460	18.500	18.5	9.4	0.292	0.1370
17	0.2885	17.700	17.7	11.1	0.279	0.1369
18	0.3185	17.700	17.7	12.4	0.279	0.1369
19	0.3450	17.600	17.6	13.5	0.277	0.1368
20	0.3820	17.600	17.6	15.0	0.277	0.1368







Sample No.		1
Initial	Water Content, %	34.8
	Dry Density, pcf	86.3
	Saturation, %	97.2
	Void Ratio	0.9807
	Diameter, in.	2.41
	Height, in.	1.00
At Test	Water Content, %	33.4
	Dry Density, pcf	89.3
	Saturation, %	100.0
	Void Ratio	0.9143
	Diameter, in.	2.41
	Height, in.	0.97
Normal Stress, tsf		1.511
Fail. Stress, tsf		0.410
Strain, %		0.7
Ult. Stress, tsf		0.339
Strain, %		15.0
Strain rate, in./min.		0.00

Sample Type: Thinwall, 5", Top of sample
Description: FAT CLAY, gray (CH)

LL= 67 **PL=** 17 **PI=** 50
Assumed Specific Gravity= 2.738
Remarks: The rate of strain is 0.00096 in/min. The test spemcimen was precut before testing. ASTM D 3080.

Figure Residual Direct Shear

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Location: SE-F-15, Fargo, Sherack Formation
Sample Number: Boring 09-26MU, #1 **Depth:** 8-10'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: js **Checked By:** js

DIRECT SHEAR TEST

11/9/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-F-15, Fargo, Sherack Formation
Depth: 8-10' Sample Number: Boring 09-26MU, #1
Description: FAT CLAY, gray (CH)
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.
Type of Sample: Thinwall, 5", Top of sample
Assumed Specific Gravity=2.738 LL=67 PL=17 PI=50

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	127.730		167.120
Moisture content: Dry soil+tare, gms.	102.610		133.150
Moisture content: Tare, gms.	30.480		31.440
Moisture, %	34.8	33.4	33.4
Moist specimen weight, gms.	139.3		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.97	
Net decrease in height, in.		0.03	
Wet Density, pcf	116.3	119.1	
Dry density, pcf	86.3	89.3	
Void ratio	0.9807	0.9143	
Saturation, %	97.2	100.0	

Test Readings for Specimen No. 1

Normal stress = 1.511 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.410 tsf at reading no. 4
Ult. Stress = 0.339 tsf at reading no. 11

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0229	0.000	0.0	0.0	0.000	0.1107
1	0.0231	5.000	5.0	0.0	0.079	0.1107
2	0.0242	12.200	12.2	0.1	0.192	0.1107
3	0.0275	20.900	20.9	0.2	0.329	0.1104
4	0.0404	26.000	26.0	0.7	0.410	0.1096
5	0.0525	23.600	23.6	1.2	0.372	0.1091
6	0.0747	22.400	22.4	2.1	0.353	0.1087
7	0.0874	22.000	22.0	2.7	0.347	0.1085
8	0.0997	21.600	21.6	3.2	0.340	0.1084
9	0.1510	21.500	21.5	5.3	0.339	0.1081
10	0.3500	21.500	21.5	13.6	0.339	0.1079
11	0.3850	21.500	21.5	15.0	0.339	0.1077

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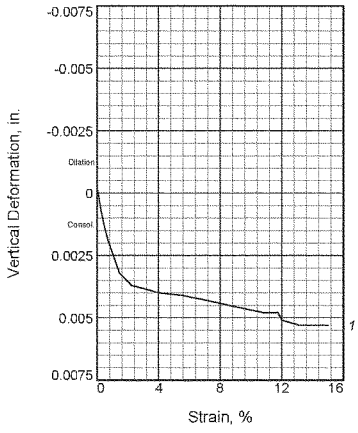
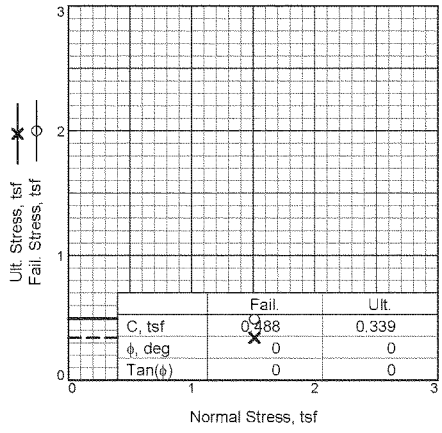
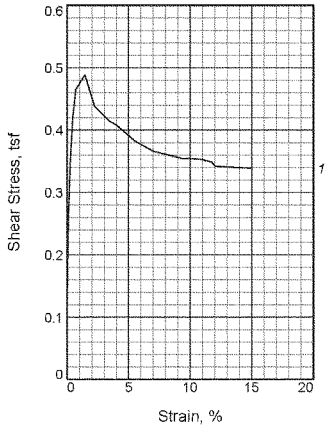






Sample No.		1
Initial	Water Content, %	40.5
	Dry Density, pcf	79.2
	Saturation, %	95.4
	Void Ratio	1.1669
	Diameter, in.	2.41
	Height, in.	1.00
At Test	Water Content, %	38.9
	Dry Density, pcf	83.0
	Saturation, %	100.0
	Void Ratio	1.0687
	Diameter, in.	2.41
	Height, in.	0.95
Normal Stress, tsf		1.511
Fail. Stress, tsf		0.488
Strain, %		1.5
Ult. Stress, tsf		0.339
Strain, %		15.0
Strain rate, in./min.		0.00

Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY with layers of silt, brown-gray (CH)

Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.

Figure Residual Direct Shear

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Location: SE-M-18, Moorhead, Sherack Formation
Sample Number: Boring 09-34MU, #1 **Depth:** 8-10'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: JS **Checked By:** rs

DIRECT SHEAR TEST

11/9/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-M-18, Moorhead, Sherack Formation
Depth: 8-10' Sample Number: Boring 09-34MU, #1
Description: FAT CLAY with layers of silt, brown-gray (CH)
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.
Type of Sample: Thinwall, 5", Middle of sample
Assumed Specific Gravity=2.75 LL= PL= PI=

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	153.200		160.280
Moisture content: Dry soil+tare, gms.	118.070		123.750
Moisture content: Tare, gms.	31.270		29.750
Moisture, %	40.5	38.9	38.9
Moist specimen weight, gms.	133.4		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.95	
Net decrease in height, in.		0.05	
Wet Density, pcf	111.3	115.2	
Dry density, pcf	79.2	83.0	
Void ratio	1.1669	1.0687	
Saturation, %	95.4	100.0	

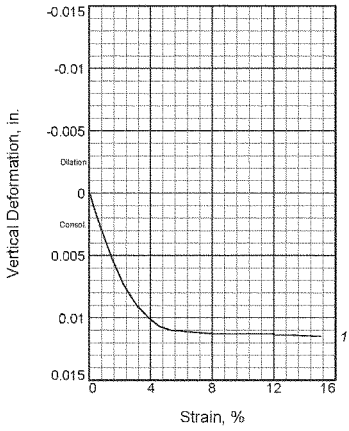
Test Readings for Specimen No. 1

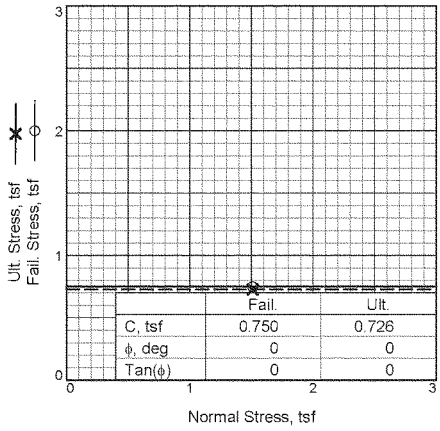
Normal stress = 1.511 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.488 tsf at reading no. 6
Ult. Stress = 0.339 tsf at reading no. 17

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0128	0.000	0.0	0.0	0.000	0.0647
1	0.0138	9.500	9.5	0.0	0.150	0.0648
2	0.0156	16.400	16.4	0.1	0.258	0.0646
3	0.0193	22.100	22.1	0.3	0.348	0.0640
4	0.0242	26.600	26.6	0.5	0.419	0.0634
5	0.0304	29.500	29.5	0.7	0.465	0.0628
6	0.0479	31.000	31.0	1.5	0.488	0.0615
7	0.0670	27.800	27.8	2.2	0.438	0.0610
8	0.0959	26.300	26.3	3.4	0.414	0.0608
9	0.1095	25.900	25.9	4.0	0.408	0.0607
10	0.1450	24.300	24.3	5.5	0.383	0.0606
11	0.1830	23.200	23.2	7.1	0.366	0.0604
12	0.2370	22.500	22.5	9.3	0.355	0.0601

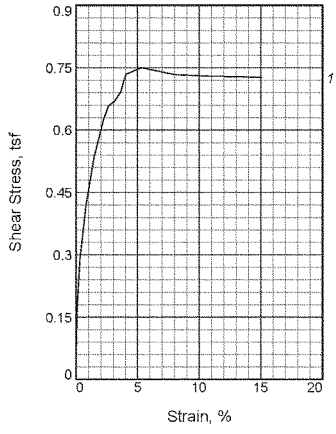
Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
13	0.2753	22.400	22.4	10.9	0.353	0.0599
14	0.2960	22.100	22.1	11.7	0.348	0.0599
15	0.3026	21.700	21.7	12.0	0.342	0.0596
16	0.3300	21.600	21.6	13.2	0.340	0.0594
17	0.3750	21.500	21.5	15.0	0.339	0.0594





	Fail.	Ult.
C, tsf	0.750	0.726
ϕ, deg	0	0
Tan(ϕ)	0	0



Sample No.		1
Initial	Water Content, %	40.3
	Dry Density, pcf	80.4
	Saturation, %	97.8
	Void Ratio	1.1343
	Diameter, in.	2.41
	Height, in.	1.00
At Test	Water Content, %	37.6
	Dry Density, pcf	84.2
	Saturation, %	99.6
	Void Ratio	1.0385
	Diameter, in.	2.41
	Height, in.	0.96
Normal Stress, tsf		1.511
Fail. Stress, tsf		0.750
Strain, %		5.3
Ult. Stress, tsf		0.726
Strain, %		15.0
Strain rate, in./min.		0.00

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, gray (CH)

LL= 55 **PL=** 21 **PI=** 34
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.

Figure Residual Direct Shear

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115 Sherack
Location: SE-M-11, Moorhead, ~~PL-Sherack-Formation~~
Sample Number: Boring 09-53MU, #1 **Depth:** 18-20'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs

DIRECT SHEAR TEST

11/9/2009

Date:	
Client:	US Army Corps of Engineers
Project:	Fargo-Moorhead Metro Feasibility Study W912ES-09-P-0115
Project No.:	BL-09-03127
Location:	SE-M-11, Moorhead, ~~PL-Sherack Formation~~
Depth:	18-20'
Sample Number:	Boring 09-53MU, #1
Description:	FAT CLAY, gray (CH) Sherack
Remarks:	The rate of strain is 0.00096 in/min. The test spemcimen was precut before testing. ASTM D 3080.
Type of Sample:	Thinwall, 5", Bottom of sample

Assumed Specific Gravity=2.75 LL=55 PL=21 PI=34

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	148.590		163.120
Moisture content: Dry soil+tare, gms.	114.910		126.940
Moisture content: Tare, gms.	31.420		30.790
Moisture, %	40.3	37.6	37.6
Moist specimen weight, gms.	135.6		
Diameter, in.	2.41	2.41	
Area, in.^{2}	4.57	4.57	
Height, in.	1.00	0.96	
Net decrease in height, in.		0.05	
Wet Density, pcf	112.9	115.9	
Dry density, pcf	80.4	84.2	
Void ratio	1.1343	1.0385	
Saturation, %	97.8	99.6	

Test Readings for Specimen No. 1

Normal stress = 1.511 tsf

Strain rate, in./min. = 0.00

Fail. Stress = 0.750 tsf at reading no. 12

Ult. Stress = 0.726 tsf at reading no. 18

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0120	0.000	0.0	0.0	0.000	0.1424
1	0.0124	4.100	4.1	0.0	0.065	0.1424
2	0.0148	11.600	11.6	0.1	0.183	0.1422
3	0.0201	18.500	18.5	0.3	0.292	0.1412
4	0.0319	26.600	26.6	0.8	0.419	0.1394
5	0.0477	33.900	33.9	1.5	0.534	0.1372
6	0.0658	39.500	39.5	2.2	0.622	0.1351
7	0.0751	41.700	41.7	2.6	0.657	0.1343
8	0.0868	42.400	42.4	3.1	0.668	0.1334
9	0.0998	43.900	43.9	3.6	0.692	0.1327
10	0.1100	46.600	46.6	4.1	0.734	0.1322
11	0.1229	47.000	47.0	4.6	0.741	0.1317

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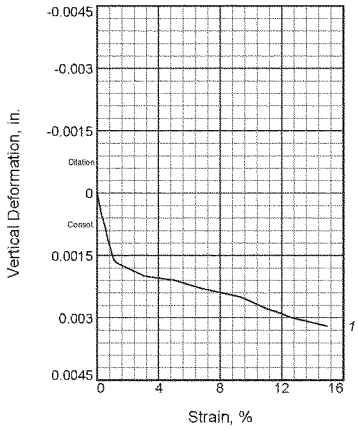
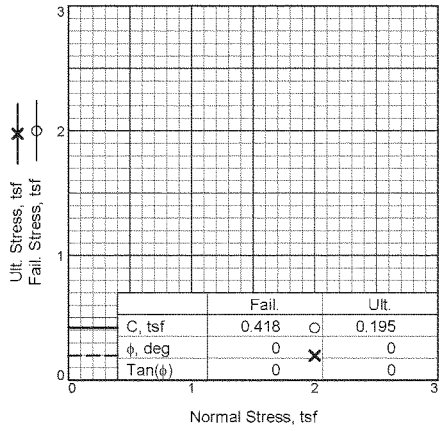
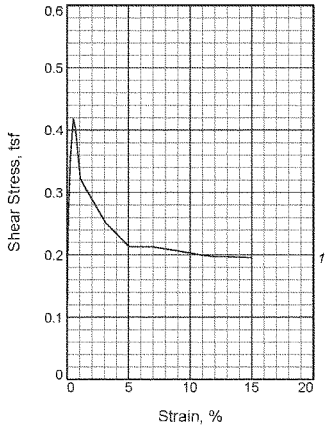
Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
12	0.1400	47.600	47.6	5.3	0.750	0.1314
13	0.2071	46.500	46.5	8.1	0.733	0.1311
14	0.2710	46.300	46.3	10.7	0.730	0.1311
15	0.3000	46.300	46.3	11.9	0.730	0.1311
16	0.3033	46.200	46.2	12.1	0.728	0.1310
17	0.3300	46.200	46.2	13.2	0.728	0.1310
18	0.3750	46.100	46.1	15.0	0.726	0.1309







Sample No.		1
Initial	Water Content, %	62.5
	Dry Density, pcf	62.7
	Saturation, %	99.8
	Void Ratio	1.6925
	Diameter, in.	2.41
	Height, in.	1.00
At Test	Water Content, %	60.2
	Dry Density, pcf	64.2
	Saturation, %	100.0
	Void Ratio	1.6295
	Diameter, in.	2.41
	Height, in.	0.98
Normal Stress, tsf		2.000
Fail. Stress, tsf		0.418
Strain, %		0.5
Ult. Stress, tsf		0.195
Strain, %		15.0
Strain rate, in./min.		0.00

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 114 **PL=** 24 **PI=** 90
Assumed Specific Gravity= 2.704
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.

Figure Residual Direct Shear

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115 Oxidized Brenna
Location: SE-M-18, Moorhead, ~~PL Sheyenh Formation~~
Sample Number: Boring 09-34MU, #2 **Depth:** 16-18'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: JS **Checked By:** JS

DIRECT SHEAR TEST

11/9/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-M-18, Moorhead, ~~PL-Sheyenne Formation~~
Depth: 16-18' Sample Number: Boring 09-34MU, #2
Description: FAT CLAY, brown (CH) Oxidized Brenna
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.704 LL=114 PL=24 PI=90

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	85.650		150.320
Moisture content: Dry soil+tare, gms.	64.880		105.190
Moisture content: Tare, gms.	31.630		30.280
Moisture, %	62.5	60.2	60.2
Moist specimen weight, gms.	122.8		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.98	
Net decrease in height, in.		0.02	
Wet Density, pcf	101.9	102.9	
Dry density, pcf	62.7	64.2	
Void ratio	1.6925	1.6295	
Saturation, %	99.8	100.0	

Test Readings for Specimen No. 1

Normal stress = 2 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.418 tsf at reading no. 6
Ult. Stress = 0.195 tsf at reading no. 17

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0253	0.000	0.0	0.0	0.000	0.1223
1	0.0255	4.500	4.5	0.0	0.071	0.1223
2	0.0260	8.100	8.1	0.0	0.128	0.1223
3	0.0270	13.100	13.1	0.1	0.206	0.1222
4	0.0283	16.900	16.9	0.1	0.266	0.1221
5	0.0320	22.700	22.7	0.3	0.358	0.1218
6	0.0380	26.500	26.5	0.5	0.418	0.1215
7	0.0420	25.600	25.6	0.7	0.403	0.1212
8	0.0514	20.400	20.4	1.1	0.321	0.1207
9	0.0588	19.700	19.7	1.4	0.310	0.1206
10	0.1000	16.000	16.0	3.1	0.252	0.1203
11	0.1466	13.500	13.5	5.0	0.213	0.1202
12	0.1900	13.500	13.5	6.8	0.213	0.1200

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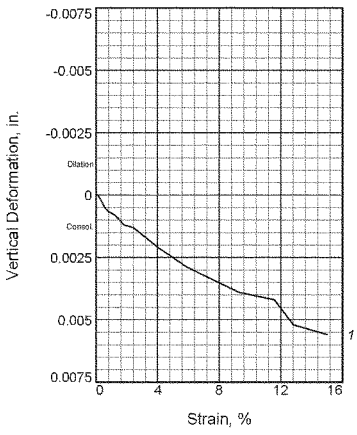
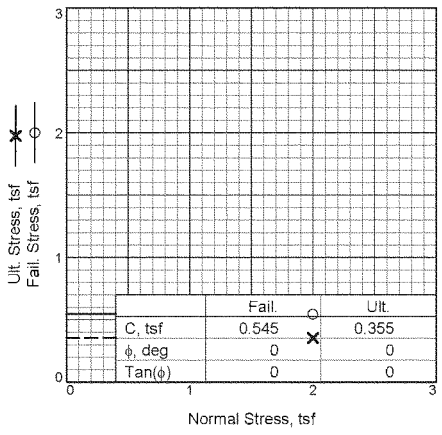
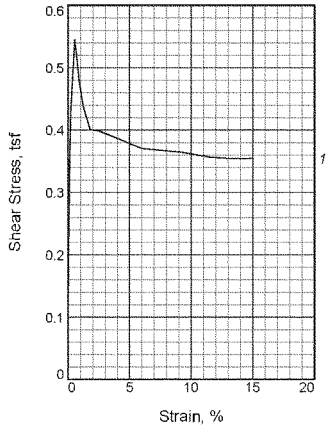
Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
13	0.2500	13.000	13.0	9.3	0.205	0.1198
14	0.2940	12.600	12.6	11.1	0.199	0.1195
15	0.3140	12.500	12.5	12.0	0.197	0.1194
16	0.3300	12.500	12.5	12.6	0.197	0.1193
17	0.3860	12.400	12.4	15.0	0.195	0.1191







Sample No.		1
Initial	Water Content, %	57.7
	Dry Density, pcf	66.0
	Saturation, %	99.1
	Void Ratio	1.6016
	Diameter, in.	2.41
	Height, in.	1.00
At Test	Water Content, %	55.0
	Dry Density, pcf	68.0
	Saturation, %	99.1
	Void Ratio	1.5262
	Diameter, in.	2.41
	Height, in.	0.97
Normal Stress, tsf		2.000
Fail. Stress, tsf		0.545
Strain, %		0.6
Ult. Stress, tsf		0.355
Strain, %		15.0
Strain rate, in./min.		0.00

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, gray (CH)

LL= 108 **PL=** 22 **PI=** 86
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min. The test spemcimen was precut before testing. ASTM D 3080.

Figure Residual Direct Shear

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Location: SE-F-13, Fargo, Brenna Formation
Sample Number: Boring 09-25MU, #4 **Depth:** 50-52'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs

DIRECT SHEAR TEST

11/9/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-F-13, Fargo, Brenna Formation
Depth: 50-52' Sample Number: Boring 09-25MU, #4
Description: FAT CLAY, gray (CH)
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.75 LL=108 PL=22 PI=86

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	116.580		151.960
Moisture content: Dry soil+tare, gms.	84.990		108.930
Moisture content: Tare, gms.	30.270		30.670
Moisture, %	57.7	55.0	55.0
Moist specimen weight, gms.	125.1		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.97	
Net decrease in height, in.		0.03	
Wet Density, pcf	104.1	105.3	
Dry density, pcf	66.0	68.0	
Void ratio	1.6016	1.5262	
Saturation, %	99.1	99.1	

Test Readings for Specimen No. 1

Normal stress = 2 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.545 tsf at reading no. 5
Ult. Stress = 0.355 tsf at reading no. 16

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0208	0.000	0.0	0.0	0.000	0.1266
1	0.0210	4.500	4.5	0.0	0.071	0.1266
2	0.0225	14.500	14.5	0.1	0.228	0.1266
3	0.0240	21.400	21.4	0.1	0.337	0.1266
4	0.0265	27.400	27.4	0.2	0.432	0.1265
5	0.0343	34.600	34.6	0.6	0.545	0.1261
6	0.0380	33.000	33.0	0.7	0.520	0.1260
7	0.0434	30.100	30.1	0.9	0.474	0.1259
8	0.0506	27.800	27.8	1.2	0.438	0.1258
9	0.0644	25.400	25.4	1.8	0.400	0.1254
10	0.0799	25.300	25.3	2.4	0.399	0.1253
11	0.1185	24.500	24.5	4.0	0.386	0.1245

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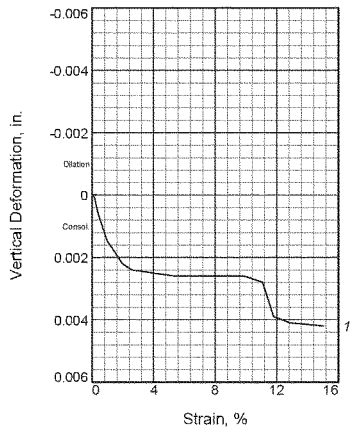
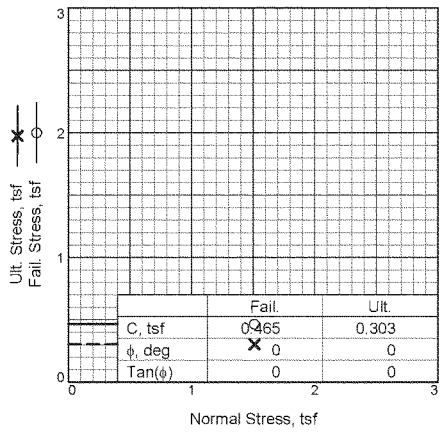
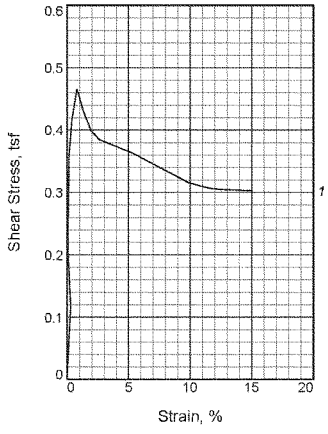
Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
12	0.1646	23.500	23.5	6.0	0.370	0.1237
13	0.2447	23.100	23.1	9.3	0.364	0.1227
14	0.3000	22.600	22.6	11.6	0.356	0.1224
15	0.3300	22.500	22.5	12.8	0.355	0.1214
16	0.3830	22.500	22.5	15.0	0.355	0.1210







Sample No.		1
Initial	Water Content, %	52.1
	Dry Density, pcf	70.0
	Saturation, %	98.6
	Void Ratio	1.4523
	Diameter, in.	2.41
	Height, in.	1.00
At Test	Water Content, %	50.2
	Dry Density, pcf	72.0
	Saturation, %	99.7
	Void Ratio	1.3838
	Diameter, in.	2.41
	Height, in.	0.97
Normal Stress, tsf		1.511
Fail. Stress, tsf		0.465
Strain, %		0.8
Ult. Stress, tsf		0.303
Strain, %		15.0
Strain rate, in./min.		0.00

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, gray (CH)

LL= 110 **PL=** 24 **PI=** 86
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.

Figure Residual Direct Shear

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Location: SE-F-15, Fargo, Brenna Formation
Sample Number: Boring 09-26MU **Depth:** 28-30'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: JS **Checked By:** JS

DIRECT SHEAR TEST

11/24/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-F-15, Fargo, Brenna Formation
Depth: 28-30' Sample Number: Boring 09-26MU
Description: FAT CLAY, gray (CH)
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.75 LL=110 PL=24 PI=86

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	105.340		157.500
Moisture content: Dry soil+tare, gms.	79.720		115.050
Moisture content: Tare, gms.	30.520		30.460
Moisture, %	52.1	50.2	50.2
Moist specimen weight, gms.	127.5		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.97	
Net decrease in height, in.		0.03	
Wet Density, pcf	106.5	108.2	
Dry density, pcf	70.0	72.0	
Void ratio	1.4523	1.3838	
Saturation, %	98.6	99.7	

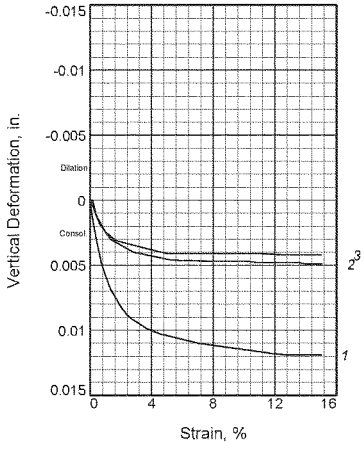
Test Readings for Specimen No. 1

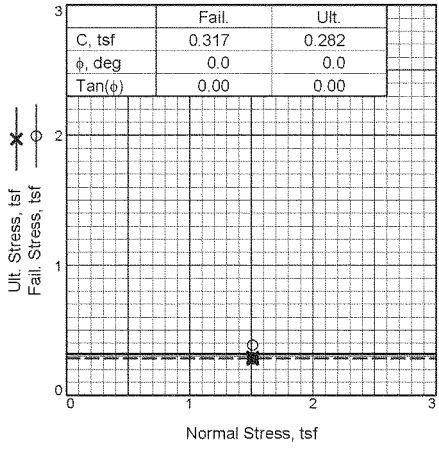
Normal stress = 1.511 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.465 tsf at reading no. 5
Ult. Stress = 0.303 tsf at reading no. 15

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0204	0.000	0.0	0.0	0.000	0.1714
1	0.0277	7.400	7.4	0.3	0.117	0.1714
2	0.0220	13.600	13.6	0.1	0.214	0.1714
3	0.0246	22.700	22.7	0.2	0.358	0.1713
4	0.0300	26.400	26.4	0.4	0.416	0.1708
5	0.0398	29.500	29.5	0.8	0.465	0.1702
6	0.0450	28.700	28.7	1.0	0.452	0.1699
7	0.0520	27.400	27.4	1.3	0.432	0.1697
8	0.0676	25.300	25.3	2.0	0.399	0.1692
9	0.0832	24.400	24.4	2.6	0.384	0.1690
10	0.1500	23.000	23.0	5.4	0.362	0.1688
11	0.2590	20.000	20.0	9.9	0.315	0.1688
12	0.2875	19.600	19.6	11.1	0.309	0.1686

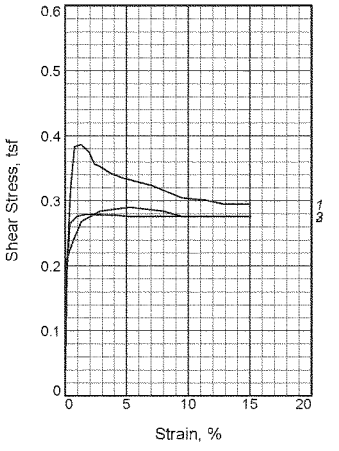
Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
13	0.3050	19.400	19.4	11.8	0.306	0.1675
14	0.3300	19.300	19.3	12.8	0.304	0.1673
15	0.3830	19.200	19.2	15.0	0.303	0.1672





	Fail.	Ult.
C, tsf	0.317	0.282
ϕ, deg	0.0	0.0
Tan(ϕ)	0.00	0.00



Sample No.		1	2	3
Initial	Water Content, %	52.2	52.2	52.2
	Dry Density, pcf	70.3	70.3	70.3
	Saturation, %	99.6	99.6	99.6
	Void Ratio	1.4406	1.4406	1.4406
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	50.3	50.3	50.3
	Dry Density, pcf	72.0	72.0	72.0
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.3835	1.3835	1.3835
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.98	0.98	0.98
Normal Stress, tsf		1.511	1.511	1.511
Fail. Stress, tsf		0.386	0.290	0.279
Strain, %		1.3	5.3	1.7
Ult. Stress, tsf		0.295	0.276	0.276
Strain, %		15.0	15.0	15.0
Strain rate, in./min.		0.00	0.00	0.00

Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, gray (CH)

LL= 110 **PL=** 24 **PI=** 86
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing then run 2 additional times after re-setting the sample in the shear box. ASTM D 3080
Figure Residual Direct Shear

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study W912ES-09-P-0115
Location: SE-F-15, Fargo, Brenna Formation
Sample Number: Boring 09-26MU, #3 **Depth:** 28-30'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs

DIRECT SHEAR TEST

12/3/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-F-15, Fargo, Brenna Formation
Depth: 28-30' Sample Number: Boring 09-26MU, #3
Description: FAT CLAY, gray (CH)
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing then run 2 additional times after re-setting the sample in the shear box. ASTM D 3080
Type of Sample: Thinwall, 5", Middle of sample
Assumed Specific Gravity=2.75 LL=110 PL=24 PI=86

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	141.050		151.900
Moisture content: Dry soil+tare, gms.	103.190		111.500
Moisture content: Tare, gms.	30.600		31.230
Moisture, %	52.2	50.3	50.3
Moist specimen weight, gms.	128.4		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.98	
Net decrease in height, in.		0.02	
Wet Density, pcf	107.0	108.3	
Dry density, pcf	70.3	72.0	
Void ratio	1.4406	1.3835	
Saturation, %	99.6	100.0	

Test Readings for Specimen No. 1

Normal stress = 1.511 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.386 tsf at reading no. 7
Ult. Stress = 0.295 tsf at reading no. 19

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0125	0.000	0.0	0.0	0.000	0.1562
1	0.0128	3.300	3.3	0.0	0.052	0.1561
2	0.0135	6.400	6.4	0.0	0.101	0.1558
3	0.0154	10.700	10.7	0.1	0.169	0.1552
4	0.0182	14.300	14.3	0.2	0.225	0.1543
5	0.0234	20.200	20.2	0.5	0.318	0.1530
6	0.0314	24.300	24.3	0.8	0.383	0.1512
7	0.0443	24.500	24.5	1.3	0.386	0.1494
8	0.0596	23.800	23.8	2.0	0.375	0.1481
9	0.0700	22.600	22.6	2.4	0.356	0.1474
10	0.0807	22.400	22.4	2.8	0.353	0.1470
11	0.1029	21.700	21.7	3.7	0.342	0.1463

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Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
12	0.1227	21.300	21.3	4.6	0.336	0.1459
13	0.1825	20.500	20.5	7.0	0.323	0.1452
14	0.2418	19.300	19.3	9.5	0.304	0.1448
15	0.2878	19.100	19.1	11.4	0.301	0.1445
16	0.2966	19.000	19.0	11.8	0.299	0.1444
17	0.3230	18.700	18.7	12.9	0.295	0.1443
18	0.3530	18.700	18.7	14.1	0.295	0.1443
19	0.3750	18.700	18.7	15.0	0.295	0.1443

Parameters for Specimen No. 2

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	141.050		151.900
Moisture content: Dry soil+tare, gms.	103.190		111.500
Moisture content: Tare, gms.	30.600		31.230
Moisture, %	52.2	50.3	50.3
Moist specimen weight, gms.	128.4		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.98	
Net decrease in height, in.		0.02	
Wet Density, pcf	107.0	108.3	
Dry density, pcf	70.3	72.0	
Void ratio	1.4406	1.3835	
Saturation, %	99.6	100.0	

Test Readings for Specimen No. 2

Normal stress = 1.511 tsf

Strain rate, in./min. = 0.00

Fail. Stress = 0.290 tsf at reading no. 5

Ult. Stress = 0.276 tsf at reading no. 13

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0320	0.000	0.0	0.0	0.000	0.1374
1	0.0335	13.000	13.0	0.1	0.205	0.1373
2	0.0470	15.000	15.0	0.6	0.236	0.1356
3	0.0641	17.000	17.0	1.3	0.268	0.1344
4	0.1001	18.000	18.0	2.8	0.284	0.1334
5	0.1591	18.400	18.4	5.3	0.290	0.1328
6	0.2250	18.000	18.0	8.0	0.284	0.1327
7	0.2600	17.500	17.5	9.5	0.276	0.1327
8	0.2780	17.500	17.5	10.2	0.276	0.1327
9	0.2940	17.500	17.5	10.9	0.276	0.1326
10	0.3340	17.500	17.5	12.5	0.276	0.1326
11	0.3590	17.500	17.5	13.6	0.276	0.1326
12	0.3710	17.500	17.5	14.1	0.276	0.1325
13	0.3950	17.500	17.5	15.0	0.276	0.1325

Parameters for Specimen No. 3			
Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	141.050		151.900
Moisture content: Dry soil+tare, gms.	103.190		111.500
Moisture content: Tare, gms.	30.600		31.230
Moisture, %	52.2	50.3	50.3
Moist specimen weight, gms.	128.4		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.98	
Net decrease in height, in.		0.02	
Wet Density, pcf	107.0	108.3	
Dry density, pcf	70.3	72.0	
Void ratio	1.4406	1.3835	
Saturation, %	99.6	100.0	

Test Readings for Specimen No. 3

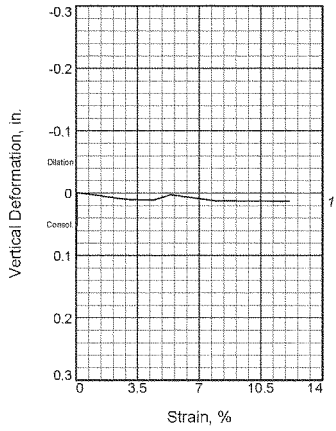
Normal stress = 1.511 tsf

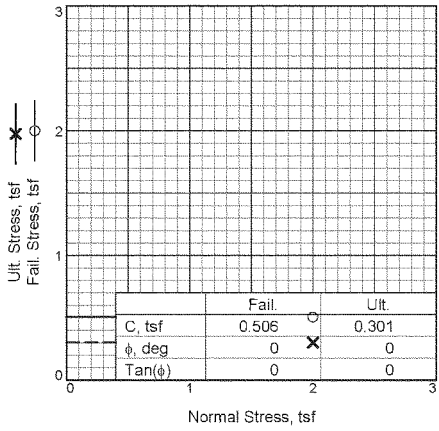
Strain rate, in./min. = 0.00

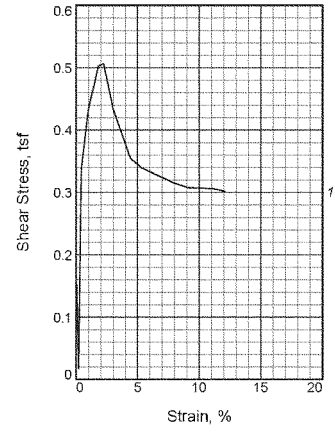
Fail. Stress = 0.279 tsf at reading no. 5

Ult. Stress = 0.276 tsf at reading no. 13

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0310	0.000	0.0	0.0	0.000	0.1054
1	0.0330	4.900	4.9	0.1	0.077	0.1054
2	0.0350	12.000	12.0	0.2	0.189	0.1054
3	0.0409	16.800	16.8	0.4	0.265	0.1042
4	0.0546	17.500	17.5	1.0	0.276	0.1030
5	0.0710	17.700	17.7	1.7	0.279	0.1023
6	0.1338	17.600	17.6	4.3	0.277	0.1015
7	0.1515	17.500	17.5	5.0	0.276	0.1013
8	0.1990	17.500	17.5	7.0	0.276	0.1013
9	0.2710	17.500	17.5	10.0	0.276	0.1013
10	0.3023	17.500	17.5	11.2	0.276	0.1013
11	0.3342	17.500	17.5	12.6	0.276	0.1012
12	0.3591	17.500	17.5	13.6	0.276	0.1012
13	0.3930	17.500	17.5	15.0	0.276	0.1012







Sample No.		1
Initial	Water Content, %	65.0
	Dry Density, pcf	60.7
	Saturation, %	97.9
	Void Ratio	1.8271
	Diameter, in.	2.41
	Height, in.	1.00
At Test	Water Content, %	62.1
	Dry Density, pcf	63.4
	Saturation, %	99.9
	Void Ratio	1.7095
	Diameter, in.	2.41
	Height, in.	0.96
Normal Stress, tsf		2.000
Fail. Stress, tsf		0.506
Strain, %		2.3
Ult. Stress, tsf		0.301
Strain, %		12.1
Strain rate, in./min.		0.00

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, brown (CH)

LL= 117 **PL=** 25 **PI=** 92
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.

Figure Residual Direct Shear

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Location: SE-F-19, Fargo, Brenna Formation
Sample Number: Boring 09-27MU, #3 **Depth:** 32-34'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs

DIRECT SHEAR TEST

11/9/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-F-19, Fargo, Brenna Formation
Depth: 32-34' Sample Number: Boring 09-27MU, #3
Description: FAT CLAY, brown (CH)
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.75 LL=117 PL=25 PI=92

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	110.120		145.310
Moisture content: Dry soil+tare, gms.	78.770		101.350
Moisture content: Tare, gms.	30.560		30.560
Moisture, %	65.0	62.1	62.1
Moist specimen weight, gms.	120.6		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.96	
Net decrease in height, in.		0.04	
Wet Density, pcf	100.2	102.7	
Dry density, pcf	60.7	63.4	
Void ratio	1.8271	1.7095	
Saturation, %	97.9	99.9	

Test Readings for Specimen No. 1

Normal stress = 2 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.506 tsf at reading no. 9
Ult. Stress = 0.301 tsf at reading no. 16

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0085	0.000	0.0	0.0	0.000	0.1463
1	0.0087	4.000	4.0	0.0	0.063	0.0146
2	0.0101	9.600	9.6	0.1	0.151	0.1463
3	0.0136	1.100	1.1	0.2	0.017	0.1463
4	0.0190	21.400	21.4	0.4	0.337	0.1457
5	0.0327	27.400	27.4	1.0	0.432	0.1437
6	0.0370	28.500	28.5	1.2	0.449	0.1430
7	0.0442	30.000	30.0	1.5	0.473	0.1417
8	0.0525	31.900	31.9	1.8	0.503	0.1401
9	0.0628	32.100	32.1	2.3	0.506	0.1383
10	0.0812	27.500	27.5	3.0	0.433	0.1359
11	0.1150	22.500	22.5	4.4	0.355	0.1349
12	0.1380	21.500	21.5	5.4	0.339	0.1436

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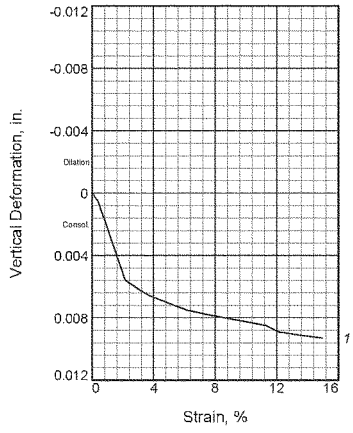
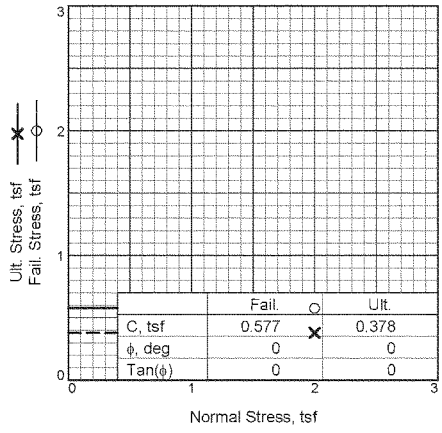
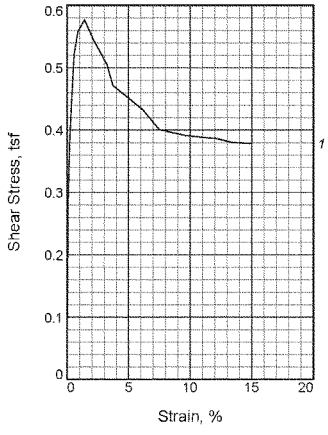
Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
13	0.1990	20.000	20.0	7.9	0.315	0.1340
14	0.2280	19.500	19.5	9.1	0.307	0.1337
15	0.2770	19.400	19.4	11.1	0.306	0.1334
16	0.3004	19.100	19.1	12.1	0.301	0.1330







Sample No.		1
Initial	Water Content, %	52.2
	Dry Density, pcf	69.5
	Saturation, %	98.9
	Void Ratio	1.4271
	Diameter, in.	2.41
	Height, in.	1.00
At Test	Water Content, %	49.7
	Dry Density, pcf	72.1
	Saturation, %	100.0
	Void Ratio	1.3423
	Diameter, in.	2.41
	Height, in.	0.97
Normal Stress, tsf		2.000
Fail. Stress, tsf		0.577
Strain, %		1.4
Ult. Stress, tsf		0.378
Strain, %		15.0
Strain rate, in./min.		0.00

Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, gray (CH)

LL= 111 **PL=** 25 **PI=** 86
Assumed Specific Gravity= 2.704
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.

Figure Residual Direct Shear

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115 Brenna / Argusville Transition
Location: SE-F-19, Fargo, ~~Argusville Formation~~
Sample Number: Boring 09-27MU, #4 **Depth:** 64-66'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: JS **Checked By:** IS

DIRECT SHEAR TEST

11/9/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-F-19, Fargo, ~~Argusvill Formation~~
Depth: 64-66' Sample Number: Boring 09-27MU, #4
Description: FAT CLAY, gray (CH) Brenna / Argusville Transition
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.
Type of Sample: Thinwall, 5", Middle of sample
Assumed Specific Gravity=2.704 LL=111 PL=25 PI=86

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	93.660		155.020
Moisture content: Dry soil+tare, gms.	72.310		114.000
Moisture content: Tare, gms.	31.420		31.410
Moisture, %	52.2	49.7	49.7
Moist specimen weight, gms.	127.3		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.97	
Net decrease in height, in.		0.04	
Wet Density, pcf	105.9	107.9	
Dry density, pcf	69.5	72.1	
Void ratio	1.4271	1.3423	
Saturation, %	98.9	100.0	

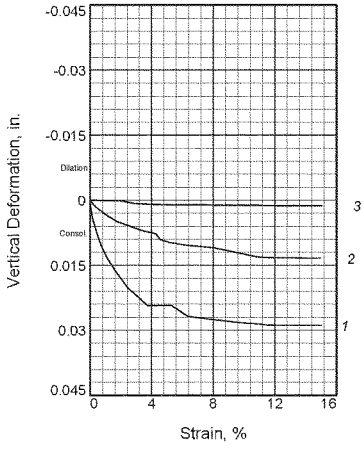
Test Readings for Specimen No. 1

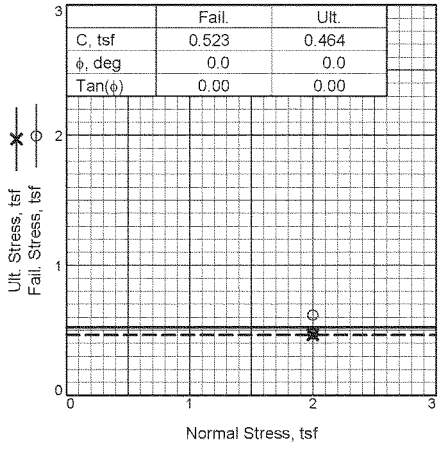
Normal stress = 2 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.577 tsf at reading no. 6
Ult. Stress = 0.378 tsf at reading no. 16

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0276	0.000	0.0	0.0	0.000	0.1086
1	0.0302	18.500	18.5	0.1	0.292	0.1085
2	0.0330	24.000	24.0	0.2	0.378	0.1083
3	0.0370	28.500	28.5	0.4	0.449	0.1081
4	0.0420	33.100	33.1	0.6	0.522	0.1075
5	0.0490	35.400	35.4	0.9	0.558	0.1067
6	0.0620	36.600	36.6	1.4	0.577	0.1051
7	0.0800	34.500	34.5	2.2	0.544	0.1030
8	0.1060	32.000	32.0	3.2	0.504	0.1023
9	0.1180	29.900	29.9	3.7	0.471	0.1020
10	0.1750	27.500	27.5	6.1	0.433	0.1011
11	0.2083	25.400	25.4	7.5	0.400	0.1008
12	0.2610	24.800	24.8	9.7	0.391	0.1004

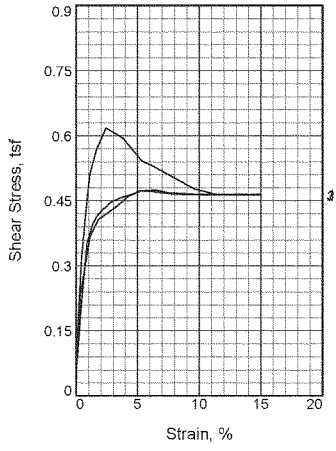
Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
13	0.3000	24.600	24.6	11.3	0.388	0.1001
14	0.3200	24.500	24.5	12.1	0.386	0.0997
15	0.3510	24.100	24.1	13.4	0.380	0.0995
16	0.3890	24.000	24.0	15.0	0.378	0.0993





	Fail.	Ult.
C, tsf	0.523	0.464
ϕ, deg	0.0	0.0
Tan(ϕ)	0.00	0.00



Sample No.		1	2	3
Initial	Water Content, %	49.8	49.8	49.8
	Dry Density, pcf	71.9	71.9	71.9
	Saturation, %	99.9	99.9	99.9
	Void Ratio	1.3482	1.3482	1.3482
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	45.9	45.9	45.9
	Dry Density, pcf	75.3	75.3	75.3
	Saturation, %	100.0	100.0	100.0
	Void Ratio	1.2412	1.2412	1.2412
	Diameter, in.	2.41	2.41	2.41
	Height, in.	0.95	0.95	0.95
Normal Stress, tsf		2.000	2.000	2.000
Fail. Stress, tsf		0.618	0.473	0.474
Strain, %		2.4	5.1	6.5
Ult. Stress, tsf		0.465	0.463	0.463
Strain, %		15.0	15.0	15.0
Strain rate, in./min.		0.00	0.00	0.00

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, gray (CH)

LL= 111 **PL=** 25 **PI=** 86
Assumed Specific Gravity= 2.704
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing then run 2 additional times after re-setting the sample in the shear box. ASTM D 3080
Figure Residual Direct Shear

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115 Brenna / Argusville Transition
Location: SE-F-19, Fargo, ~~Argusville Formation~~
Sample Number: Boring 09-27MU, #4 **Depth:** 64-66'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs

DIRECT SHEAR TEST

12/3/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-F-19, Fargo, ~~Argusville Formation~~
Depth: 64-66' Sample Number: Boring 09-27MU, #4
Description: FAT CLAY, gray (CH) Brenna / Argusville Transition
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing then run 2 additional times after re-setting the sample in the shear box. ASTM D 3080
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.704 LL=111 PL=25 PI=86

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	130.750		152.380
Moisture content: Dry soil+tare, gms.	97.420		113.810
Moisture content: Tare, gms.	30.490		29.780
Moisture, %	49.8	45.9	45.9
Moist specimen weight, gms.	129.0		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.95	
Net decrease in height, in.		0.05	
Wet Density, pcf	107.7	109.9	
Dry density, pcf	71.9	75.3	
Void ratio	1.3482	1.2412	
Saturation, %	99.9	100.0	

Test Readings for Specimen No. 1

Normal stress = 2 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.618 tsf at reading no. 7
Ult. Stress = 0.465 tsf at reading no. 17

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0157	0.000	0.0	0.0	0.000	0.1687
1	0.0182	7.400	7.4	0.1	0.117	0.1656
2	0.0200	10.700	10.7	0.2	0.169	0.1643
3	0.0266	20.100	20.1	0.5	0.317	0.1610
4	0.0335	25.900	25.9	0.7	0.408	0.1582
5	0.0425	32.300	32.3	1.1	0.509	0.1554
6	0.0556	36.000	36.0	1.7	0.567	0.1523
7	0.0743	39.200	39.2	2.4	0.618	0.1486
8	0.1064	37.800	37.8	3.8	0.596	0.1444
9	0.1438	34.400	34.4	5.3	0.542	0.1444
10	0.1695	33.500	33.5	6.4	0.528	0.1419
11	0.2474	30.300	30.3	9.6	0.477	0.1405

Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
12	0.2823	29.600	29.6	11.1	0.466	0.1401
13	0.2931	29.500	29.5	11.5	0.465	0.1399
14	0.3210	29.500	29.5	12.7	0.465	0.1398
15	0.3432	29.500	29.5	13.6	0.465	0.1398
16	0.3673	29.500	29.5	14.6	0.465	0.1398
17	0.3780	29.500	29.5	15.0	0.465	0.1398

Parameters for Specimen No. 2

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	130.750		152.380
Moisture content: Dry soil+tare, gms.	97.420		113.810
Moisture content: Tare, gms.	30.490		29.780
Moisture, %	49.8	45.9	45.9
Moist specimen weight, gms.	129.0		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.95	
Net decrease in height, in.		0.05	
Wet Density, pcf	107.7	109.9	
Dry density, pcf	71.9	75.3	
Void ratio	1.3482	1.2412	
Saturation, %	99.9	100.0	

Test Readings for Specimen No. 2

Normal stress = 2 tsf

Strain rate, in./min. = 0.00

Fail. Stress = 0.473 tsf **at reading no.** 8

Ult. Stress = 0.463 tsf **at reading no.** 15

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0285	0.000	0.0	0.0	0.000	0.1348
1	0.0293	3.500	3.5	0.0	0.055	0.1347
2	0.0369	14.700	14.7	0.3	0.232	0.1333
3	0.0560	23.300	23.3	1.1	0.367	0.1312
4	0.0724	25.800	25.8	1.8	0.407	0.1298
5	0.1099	27.800	27.8	3.4	0.438	0.1278
6	0.1310	29.200	29.2	4.2	0.460	0.1271
7	0.1380	29.400	29.4	4.5	0.463	0.1257
8	0.1520	30.000	30.0	5.1	0.473	0.1251
9	0.1765	29.900	29.9	6.1	0.471	0.1245
10	0.2236	29.500	29.5	8.1	0.465	0.1238
11	0.2912	29.400	29.4	10.9	0.463	0.1217
12	0.3220	29.400	29.4	12.2	0.463	0.1215
13	0.3510	29.400	29.4	13.4	0.463	0.1215
14	0.3710	29.400	29.4	14.2	0.463	0.1214
15	0.3895	29.400	29.4	15.0	0.463	0.1214

Parameters for Specimen No. 3			
Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	130.750		152.380
Moisture content: Dry soil+tare, gms.	97.420		113.810
Moisture content: Tare, gms.	30.490		29.780
Moisture, %	49.8	45.9	45.9
Moist specimen weight, gms.	129.0		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.95	
Net decrease in height, in.		0.05	
Wet Density, pcf	107.7	109.9	
Dry density, pcf	71.9	75.3	
Void ratio	1.3482	1.2412	
Saturation, %	99.9	100.0	

Test Readings for Specimen No. 3

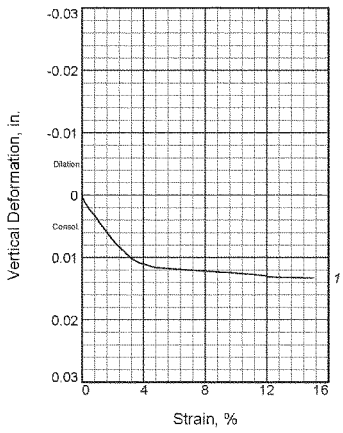
Normal stress = 2 tsf

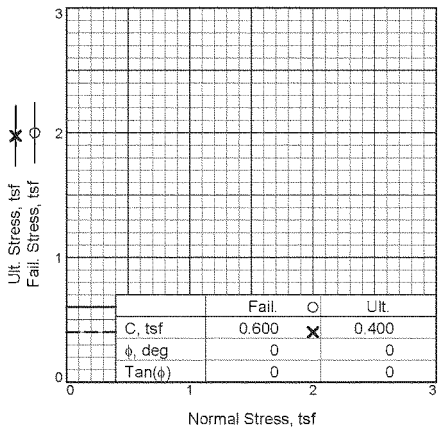
Strain rate, in./min. = 0.00

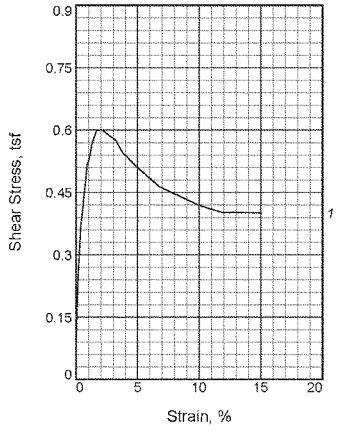
Fail. Stress = 0.474 tsf at reading no. 12

Ult. Stress = 0.463 tsf at reading no. 18

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0151	0.000	0.0	0.0	0.000	0.0616
1	0.0153	3.100	3.1	0.0	0.049	0.0616
2	0.0259	13.700	13.7	0.4	0.216	0.0616
3	0.0369	22.300	22.3	0.9	0.351	0.0615
4	0.0478	25.100	25.1	1.4	0.396	0.0615
5	0.0561	26.300	26.3	1.7	0.414	0.0615
6	0.0677	27.300	27.3	2.2	0.430	0.0614
7	0.0724	27.500	27.5	2.4	0.433	0.0612
8	0.0825	28.300	28.3	2.8	0.446	0.0609
9	0.1031	29.000	29.0	3.6	0.457	0.0607
10	0.1252	29.500	29.5	4.6	0.465	0.0606
11	0.1436	30.000	30.0	5.3	0.473	0.0605
12	0.1712	30.100	30.1	6.5	0.474	0.0605
13	0.1973	29.700	29.7	7.6	0.468	0.0605
14	0.2230	29.600	29.6	8.6	0.466	0.0604
15	0.2510	29.500	29.5	9.8	0.465	0.0604
16	0.2830	29.500	29.5	11.1	0.465	0.0604
17	0.3324	29.400	29.4	13.2	0.463	0.0603
18	0.3780	29.400	29.4	15.0	0.463	0.0603







Sample No.		1
Initial	Water Content, %	52.1
	Dry Density, pcf	70.2
	Saturation, %	100.0
	Void Ratio	1.4127
	Diameter, in.	2.41
	Height, in.	1.00
At Test	Water Content, %	49.5
	Dry Density, pcf	72.3
	Saturation, %	100.0
	Void Ratio	1.3441
	Diameter, in.	2.41
	Height, in.	0.97
Normal Stress, tsf		2.000
Fail. Stress, tsf		0.600
Strain, %		2.1
Ult. Stress, tsf		0.400
Strain, %		15.0
Strain rate, in./min.		0.00

Sample Type: Thinwall, 5", Bottom of sample
Description: FAT CLAY, gray (CH)

LL= 81 **PL=** 20 **PI=** 61
Assumed Specific Gravity= 2.714
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.

Figure Residual Direct Shear

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Location: SE-F-13, Fargo, Argusvill Formation
Sample Number: Boring 09-25MU, #5 **Depth:** 66-68'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: rs **Checked By:** rs

DIRECT SHEAR TEST

11/9/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-F-13, Fargo, Argusvill Formation
Depth: 66-68' Sample Number: Boring 09-25MU, #5
Description: FAT CLAY, gray (CH)
Remarks: The rate of strain is 0.00096 in/min. The test spemcimen was precut before testing. ASTM D 3080.
Type of Sample: Thinwall, 5", Bottom of sample
Assumed Specific Gravity=2.714 LL=81 PL=20 PI=61

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	115.380		155.680
Moisture content: Dry soil+tare, gms.	86.100		114.290
Moisture content: Tare, gms.	29.850		30.720
Moisture, %	52.1	49.5	49.5
Moist specimen weight, gms.	127.4		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	1.00	0.97	
Net decrease in height, in.		0.03	
Wet Density, pcf	106.8	108.1	
Dry density, pcf	70.2	72.3	
Void ratio	1.4127	1.3441	
Saturation, %	100.0	100.0	

Test Readings for Specimen No. 1

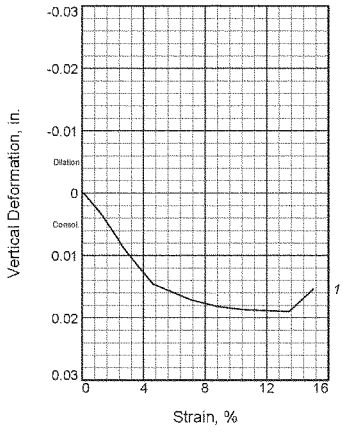
Normal stress = 2 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.600 tsf at reading no. 12
Ult. Stress = 0.400 tsf at reading no. 21

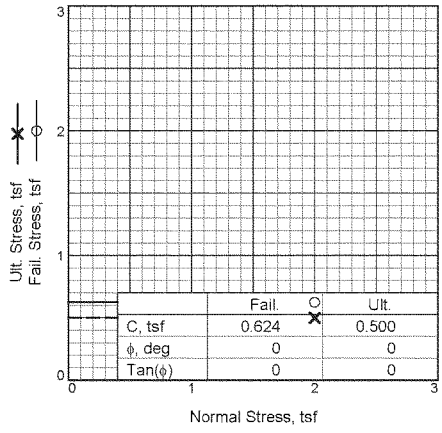
No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0191	0.000	0.0	0.0	0.000	0.1045
1	0.0194	4.700	4.7	0.0	0.074	0.1044
2	0.0203	8.100	8.1	0.1	0.128	0.1041
3	0.0236	16.000	16.0	0.2	0.252	0.1033
4	0.0290	23.700	23.7	0.4	0.373	0.1024
5	0.0325	25.900	25.9	0.6	0.408	0.1020
6	0.0350	28.100	28.1	0.7	0.443	0.1017
7	0.0380	30.300	30.3	0.8	0.477	0.1013
8	0.0410	32.700	32.7	0.9	0.515	0.1009
9	0.0450	33.600	33.6	1.1	0.529	0.1003
10	0.0506	36.000	36.0	1.3	0.567	0.0995
11	0.0598	38.000	38.0	1.7	0.599	0.0983

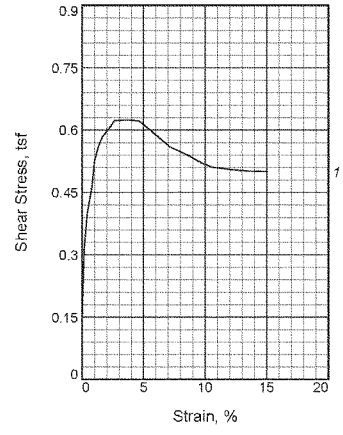
Braun Intertec

Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
12	0.0694	38.100	38.1	2.1	0.600	0.0970
13	0.0970	36.500	36.5	3.2	0.575	0.0943
14	0.1096	34.700	34.7	3.8	0.547	0.0936
15	0.1330	32.800	32.8	4.7	0.517	0.0929
16	0.1830	29.400	29.4	6.8	0.463	0.0925
17	0.2590	26.600	26.6	9.9	0.419	0.0920
18	0.3048	25.500	25.5	11.8	0.402	0.0916
19	0.3100	25.500	25.5	12.1	0.402	0.0914
20	0.3300	25.500	25.5	12.9	0.402	0.0913
21	0.3820	25.400	25.4	15.0	0.400	0.0912







Sample No.		1
Initial	Water Content, %	48.5
	Dry Density, pcf	72.6
	Saturation, %	97.6
	Void Ratio	1.3652
	Diameter, in.	2.41
	Height, in.	0.99
At Test	Water Content, %	47.0
	Dry Density, pcf	74.8
	Saturation, %	99.8
	Void Ratio	1.2937
	Diameter, in.	2.41
	Height, in.	0.96
Normal Stress, tsf		2.000
Fail. Stress, tsf		0.624
Strain, %		3.6
Ult. Stress, tsf		0.500
Strain, %		15.0
Strain rate, in./min.		0.00

Sample Type: Thinwall, 5", Middle of sample
Description: FAT CLAY, gray (CH)

LL= 79 **PL=** 21 **PI=** 58
Assumed Specific Gravity= 2.75
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.

Figure Residual Direct Shear

Client: US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Location: SE-M-18, Moorhead, Argusville
Sample Number: Boring 09-34MU, #4 **Depth:** 56-58'
Proj. No.: BL-09-03127 **Date Sampled:**

BRAUN INTERTEC

Tested By: JS **Checked By:** rs

DIRECT SHEAR TEST

11/9/2009

Date:
Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
W912ES-09-P-0115
Project No.: BL-09-03127
Location: SE-M-18, Moorhead, Argusville
Depth: 56-58' Sample Number: Boring 09-34MU, #4
Description: FAT CLAY, gray (CH)
Remarks: The rate of strain is 0.00096 in/min. The test specimen was precut before testing. ASTM D 3080.
Type of Sample: Thinwall, 5", Middle of sample
Assumed Specific Gravity=2.75 LL=79 PL=21 PI=58

Parameters for Specimen No. 1

Specimen Parameter	Initial	Consolidated	Final
Moisture content: Moist soil+tare, gms.	129.930		155.280
Moisture content: Dry soil+tare, gms.	97.340		115.650
Moisture content: Tare, gms.	30.100		31.260
Moisture, %	48.5	47.0	47.0
Moist specimen weight, gms.	128.2		
Diameter, in.	2.41	2.41	
Area, in.²	4.57	4.57	
Height, in.	0.99	0.96	
Net decrease in height, in.		0.03	
Wet Density, pcf	107.8	110.0	
Dry density, pcf	72.6	74.8	
Void ratio	1.3652	1.2937	
Saturation, %	97.6	99.8	

Test Readings for Specimen No. 1

Normal stress = 2 tsf
Strain rate, in./min. = 0.00
Fail. Stress = 0.624 tsf at reading no. 12
Ult. Stress = 0.500 tsf at reading no. 20

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
0	0.0154	0.000	0.0	0.0	0.000	0.1405
1	0.0156	4.700	4.7	0.0	0.074	0.1405
2	0.0161	8.700	8.7	0.0	0.137	0.1405
3	0.0170	12.700	12.7	0.1	0.200	0.1405
4	0.0200	20.000	20.0	0.2	0.315	0.1403
5	0.0260	25.400	25.4	0.4	0.400	0.1395
6	0.0350	29.300	29.3	0.8	0.462	0.1384
7	0.0404	33.500	33.5	1.0	0.528	0.1378
8	0.0476	35.500	35.5	1.3	0.559	0.1368
9	0.0554	37.000	37.0	1.7	0.583	0.1356
10	0.0703	38.500	38.5	2.3	0.607	0.1334
11	0.0793	39.500	39.5	2.6	0.622	0.1319
12	0.1017	39.600	39.6	3.6	0.624	0.1290

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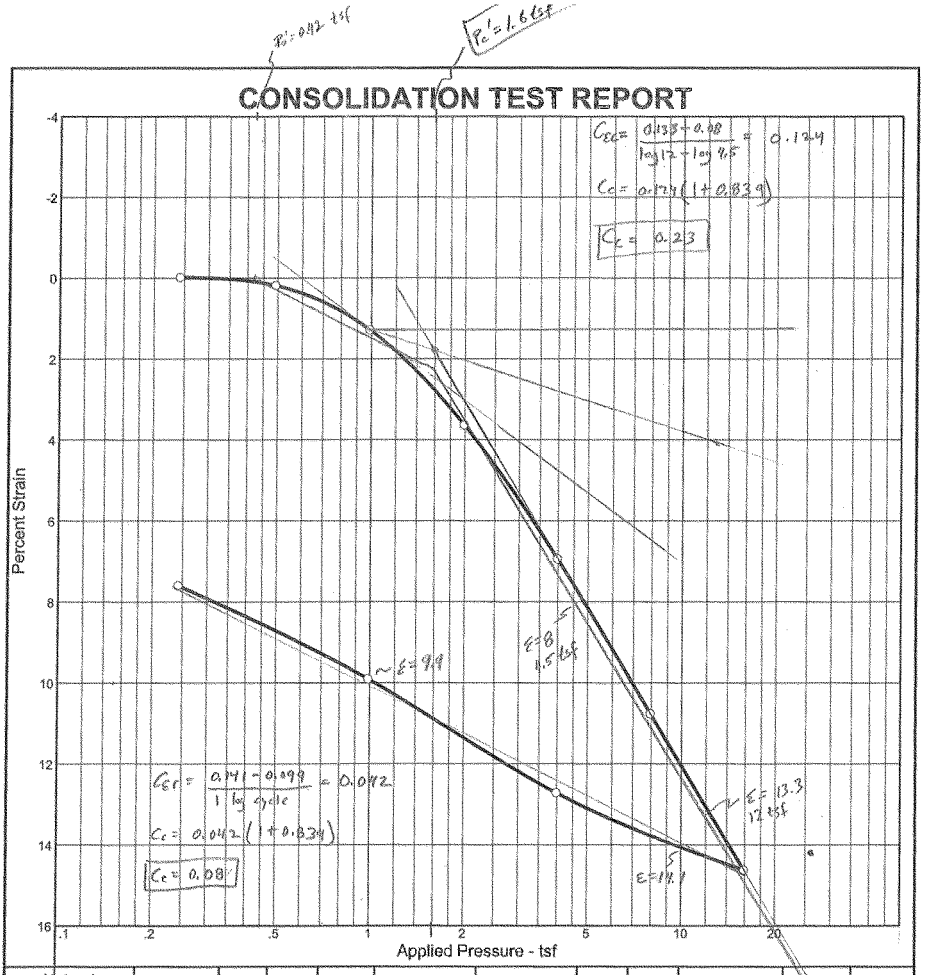
Test Readings for Specimen No. 1

No.	Horizontal Def. Dial in.	Load Dial	Load lbs.	Strain %	Shear Stress tsf	Vertical Def. Dial in.
13	0.1270	39.500	39.5	4.6	0.622	0.1259
14	0.1876	35.500	35.5	7.1	0.559	0.1233
15	0.2282	34.000	34.0	8.8	0.536	0.1223
16	0.2510	33.000	33.0	9.8	0.520	0.1220
17	0.2700	32.400	32.4	10.6	0.511	0.1218
18	0.3100	32.000	32.0	12.2	0.504	0.1216
19	0.3400	31.800	31.8	13.5	0.501	0.1215
20	0.3780	31.700	31.7	15.0	0.500	0.1251



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
95.9 %	29.7 %	92.1	75	57	2.712		1.40	0.24	0.07			0.839

	MATERIAL DESCRIPTION	USCS	AASHTO
20	Boring 09-27MU, Bottom of sample, FAT CLAY, brown (CH), ASTM D2435	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineer

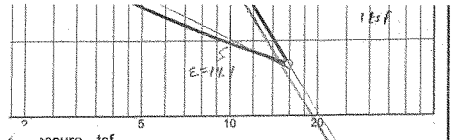
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115

Location: SE-F-19, Fargo, Alluvium Formation, #1, 6-8'

Remarks:
Fargo
09-27MU, #1, 6' - 8'
Alluvium

BRAUN INTERTEC

Figure



ssure - tsf

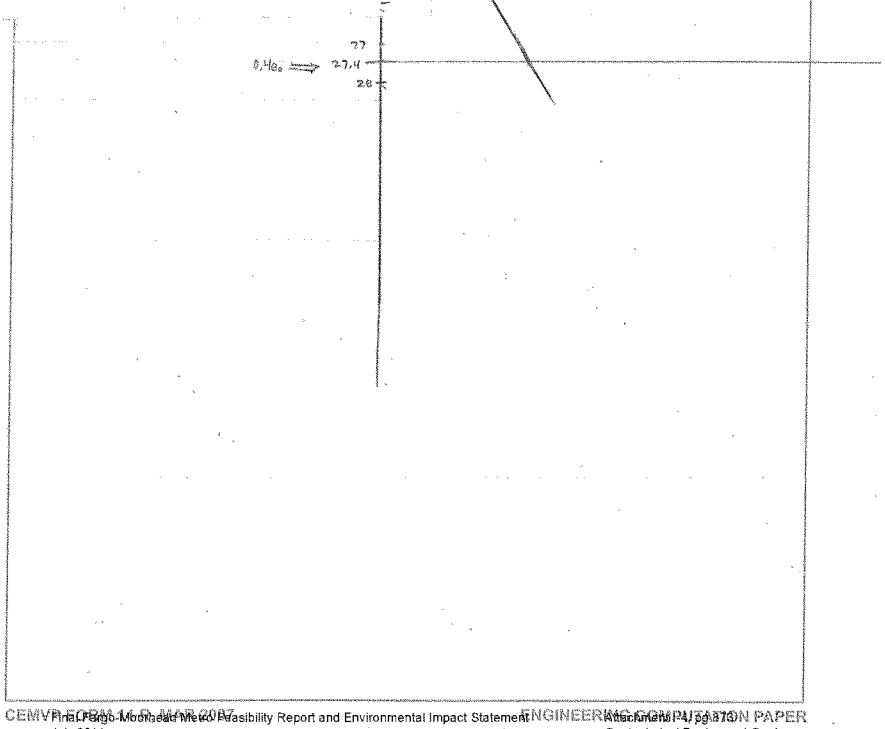
den	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
	1.40	0.24	0.07			0.839

N	USCS	AASHTO
own (CH), ASTM D2435	CH	

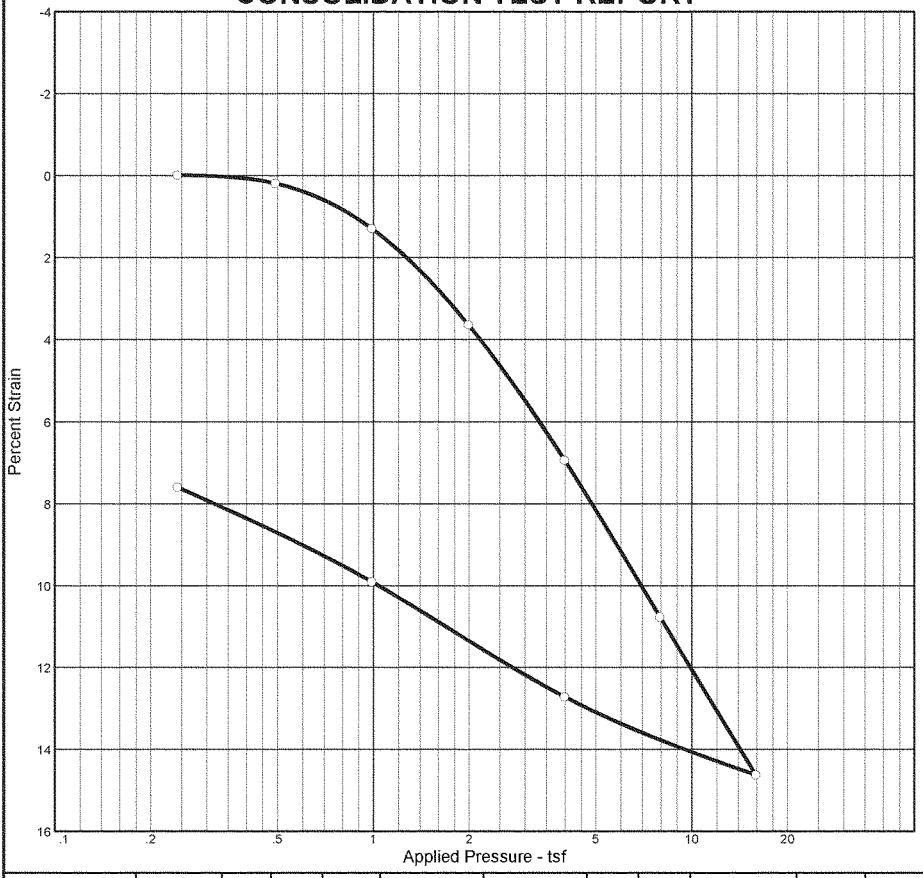
ineer	Remarks:

Figure

COMPUTED BY:	DATE:	SHEET
CHECKED BY:	DATE:	CONTRACT NO.:



CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
95.9 %	29.7 %	92.1	75	57	2.712		1.40	0.24	0.07			0.839

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-27MU, Bottom of sample, FAT CLAY, brown (CH), ASTM D2435	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115

Location: SE-F-19, Fargo, Alluvium Formation, #1, 6-8'

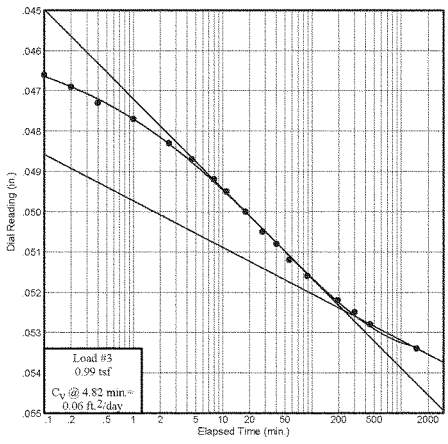
Remarks:

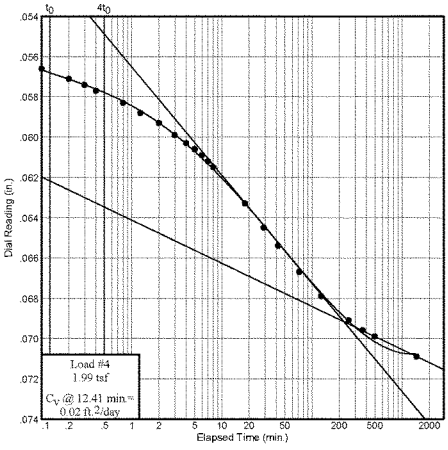
BRAUN INTERTEC

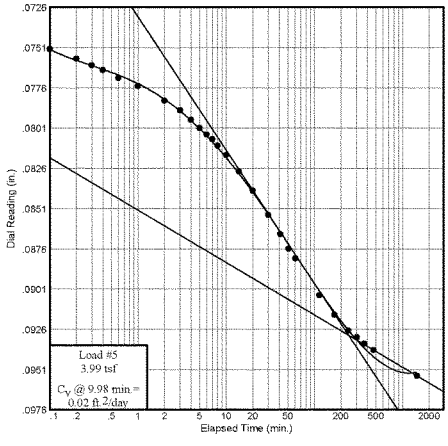
Figure

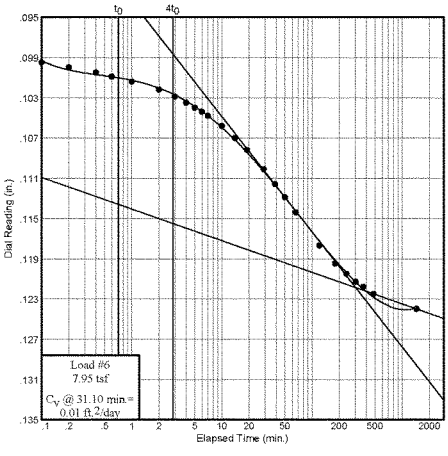
Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Location: SE-F-19, Fargo, Alluvium Formation, #1, 6-8'







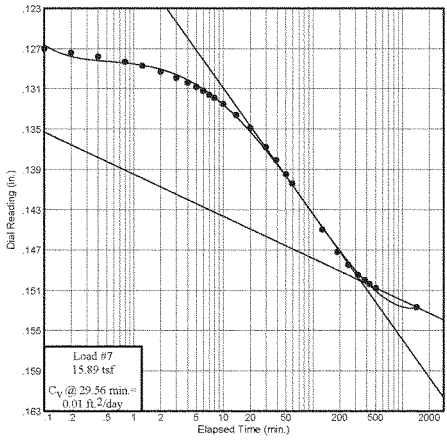


BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Location: SE-F-19, Fargo, Alluvium Formation, #1, 6-8'



BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Project Number: BL-09-03127

Sample Data

Source:
Sample No.: #1
Elev. or Depth: 6-8' **Sample Length(in./cm.):**
Location: SE-F-19, Fargo, Alluvium Formation, #1, 6-8'
Description: Boring 09-27MU, Bottom of sample, FAT CLAY, brown (CH), ASTM D2435
Liquid Limit: 75 **Plasticity Index:** 57
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST		AFTER TEST	
Wet w+t	= 122.62 g.	Consolidometer #	= 3	Wet w+t	=
Dry w+t	= 101.45 g.			Dry w+t	=
Tare Wt.	= 30.11 g.	Spec. Gravity	= 2.712	Tare Wt.	=
Height	= .74 in.	Height	= .74 in.		
Diameter	= 2.50 in.	Diameter	= 2.50 in.		
Weight	= 114.37 g.	Defl. Table	= #3-2008		
Moisture	= 29.7 %	Ht. Solids	= 0.4049 in.	Moisture	= %
Wet Den.	= 119.4 pcf	Dry Wt.	= 88.20 g.*	Dry Wt.	= n/a
Dry Den.	= 92.1 pcf	Void Ratio	= 0.839	Void Ratio	= 0.699
		Saturation	= 95.9 %		

* Initial dry weight used in calculations

End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.04380				0.839	
0.24	0.04400	0.00030			0.839	0.0 Swell
0.49	0.04570	0.00050			0.836	0.2 Comprs.
0.99	0.05410	0.00070	0.06	0.002	0.815	1.3 Comprs.
1.99	0.07190	0.00100	0.02	0.003	0.772	3.6 Comprs.
3.99	0.09700	0.00150	0.02	0.005	0.711	6.9 Comprs.
7.95	0.12600	0.00200	0.01	0.005	0.641	10.8 Comprs.
15.89	0.15560	0.00290	0.01	0.006	0.570	14.6 Comprs.
3.99	0.14000	0.00150			0.605	12.7 Comprs.
0.99	0.11830	0.00070			0.657	9.9 Comprs.
0.24	0.10070	0.00030			0.699	7.6 Comprs.

C_c = 0.24 P_c = 1.40 tsf C_r = 0.07

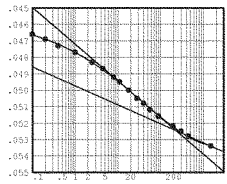
Pressure: 0.49 tsf — TEST READINGS — Load No. 2

No.	Elapsed Time	Dial Reading
1	0.00	0.04400
2	1.00	0.04430
3	5.00	0.04460
4	24.00	0.04490
5	66.00	0.04520
6	301.00	0.04550
7	1392.00	0.04570

Void Ratio = 0.836 Compression = 0.2 %

Pressure: 0.99 tsf — TEST READINGS — Load No. 3

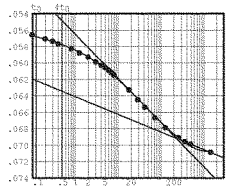
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.04570	11	28.00	0.05120
2	0.10	0.04730	12	40.00	0.05150
3	0.20	0.04760	13	56.00	0.05190
4	0.40	0.04800	14	89.00	0.05230
5	1.00	0.04840	15	195.00	0.05290
6	2.50	0.04900	16	301.00	0.05320
7	4.50	0.04940	17	450.00	0.05350
8	8.00	0.04990	18	1487.00	0.05410
9	11.00	0.05020			
10	18.00	0.05070			



Void Ratio = 0.815 Compression = 1.3 %
D_0 = 0.04520 D_{50} = 0.04883 D_{100} = 0.05246
C_v at 4.8 min. = 0.06 ft.^{2}/day C_α = 0.002

Pressure: 1.99 tsf — TEST READINGS — Load No. 4

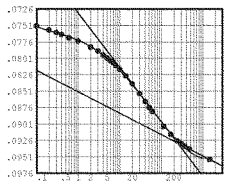
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.05410	13	7.00	0.06220
2	0.10	0.05760	14	8.00	0.06250
3	0.20	0.05810	15	18.00	0.06430
4	0.30	0.05840	16	29.00	0.06550
5	0.40	0.05870	17	42.00	0.06640
6	0.80	0.05930	18	72.00	0.06770
7	1.25	0.05980	19	126.00	0.06890
8	2.00	0.06030	20	255.00	0.07010
9	3.00	0.06090	21	364.00	0.07060
10	4.00	0.06130	22	492.50	0.07090
11	5.00	0.06160	23	1440.00	0.07190
12	6.00	0.06190			



Void Ratio = 0.772 Compression = 3.6 %
D_0 = 0.05581 D_{50} = 0.06249 D_{100} = 0.06917
C_v at 12.4 min. = 0.02 ft.^{2}/day C_α = 0.003

Pressure: 3.99 tsf | TEST READINGS | Load No. 5

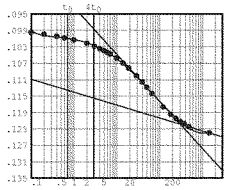
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.07190	15	10.00	0.08330
2	0.10	0.07670	16	14.00	0.08430
3	0.20	0.07730	17	20.00	0.08550
4	0.30	0.07770	18	30.00	0.08700
5	0.40	0.07800	19	41.20	0.08820
6	0.60	0.07850	20	51.00	0.08910
7	1.00	0.07900	21	61.00	0.08970
8	2.00	0.07990	22	114.00	0.09200
9	3.00	0.08050	23	169.00	0.09320
10	4.00	0.08110	24	243.00	0.09420
11	5.00	0.08160	25	303.00	0.09460
12	6.00	0.08200	26	369.00	0.09500
13	7.00	0.08230	27	469.00	0.09540
14	8.00	0.08270	28	1455.00	0.09700



Void Ratio = 0.711 Compression = 6.9 %
D_0 = 0.07090 D_{50} = 0.08194 D_{100} = 0.09298
C_v at 10.0 min. = 0.02 ft.^{2}/day C_α = 0.005

Pressure: 7.95 tsf | TEST READINGS | Load No. 6

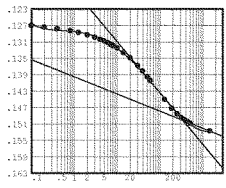
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.09700	14	14.00	0.10900
2	0.10	0.10150	15	19.00	0.11020
3	0.20	0.10200	16	29.00	0.11210
4	0.40	0.10250	17	39.00	0.11360
5	0.60	0.10290	18	50.00	0.11490
6	1.00	0.10340	19	66.00	0.11640
7	2.00	0.10420	20	121.00	0.11970
8	3.00	0.10490	21	180.00	0.12150
9	4.00	0.10550	22	240.00	0.12250
10	5.00	0.10600	23	304.00	0.12330
11	6.00	0.10640	24	369.00	0.12380
12	7.00	0.10680	25	480.00	0.12450
13	10.00	0.10780	26	1440.00	0.12600



Void Ratio = 0.641 Compression = 10.8 %
D_0 = 0.09940 D_{50} = 0.11064 D_{100} = 0.12187
C_v at 31.1 min. = 0.01 ft.^{2}/day C_α = 0.005

Pressure: 15.89 tsf | TEST READINGS | Load No. 7

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.12600	15	14.00	0.13650
2	0.10	0.12990	16	20.00	0.13780
3	0.20	0.13030	17	30.00	0.13970
4	0.40	0.13070	18	39.00	0.14100
5	0.80	0.13120	19	50.50	0.14240
6	1.25	0.13160	20	59.00	0.14330
7	2.00	0.13220	21	128.00	0.14790
8	3.00	0.13280	22	188.00	0.15010
9	4.00	0.13330	23	249.00	0.15140
10	5.00	0.13370	24	319.00	0.15240
11	6.00	0.13410	25	380.00	0.15290
12	7.00	0.13450	26	431.00	0.15330
13	8.00	0.13480	27	507.00	0.15370
14	10.00	0.13540	28	1442.00	0.15560



Void Ratio = 0.570 Compression = 14.6 %

D_0 = 0.12400 D_{50} = 0.13704 D_{100} = 0.15008

C_v at 29.6 min. = 0.01 ft.^{2}/day C_α = 0.006

Constant Rate of Strain Consolidation Test

Date: 10/27/10
Job: 7577

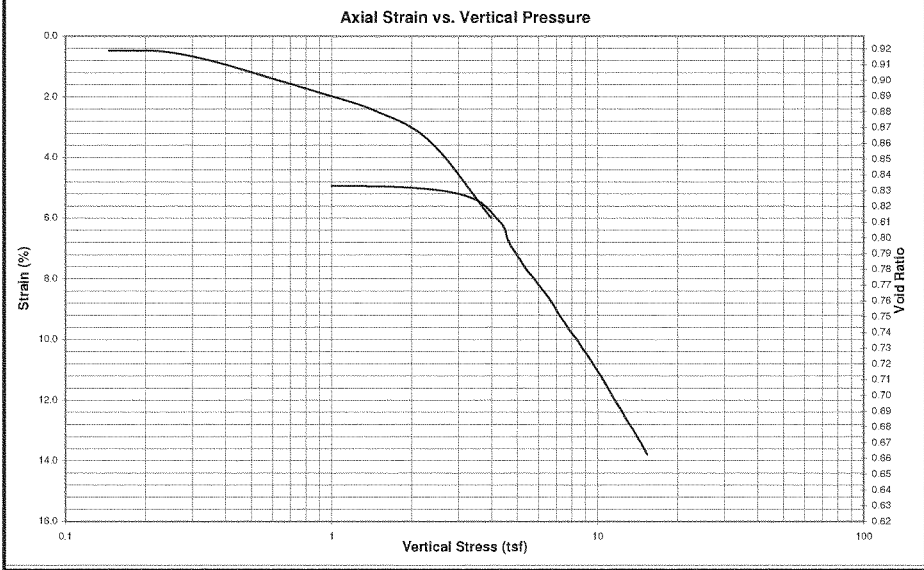
Project: FARGOMOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING

Specimen Information

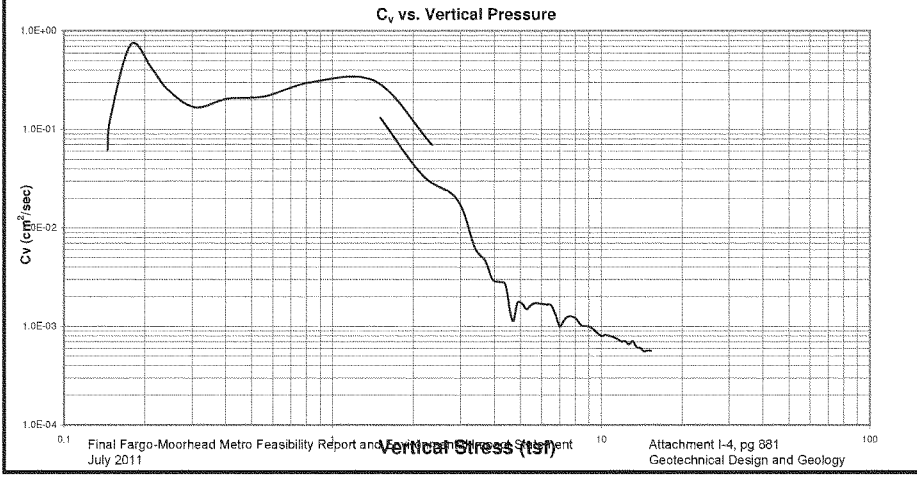
Boring: FAR 10-78MU Sample: 1 Depth: 13-15 Type: 5T

Soil Type: Fat Clay w/a few laminations of silt (CH) Alluvium

Initial Conditions: Dry Density (pcf): 89.5 Moisture Content (%): 29.8% e_o 0.926



Calculated Consolidation Coefficients	Pc	3.0 tsf	Cc	0.28	Cr	0.03



Constant Rate of Strain Consolidation Test

Date: 10/27/10
Job: 7577

Project: FARGOMOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING

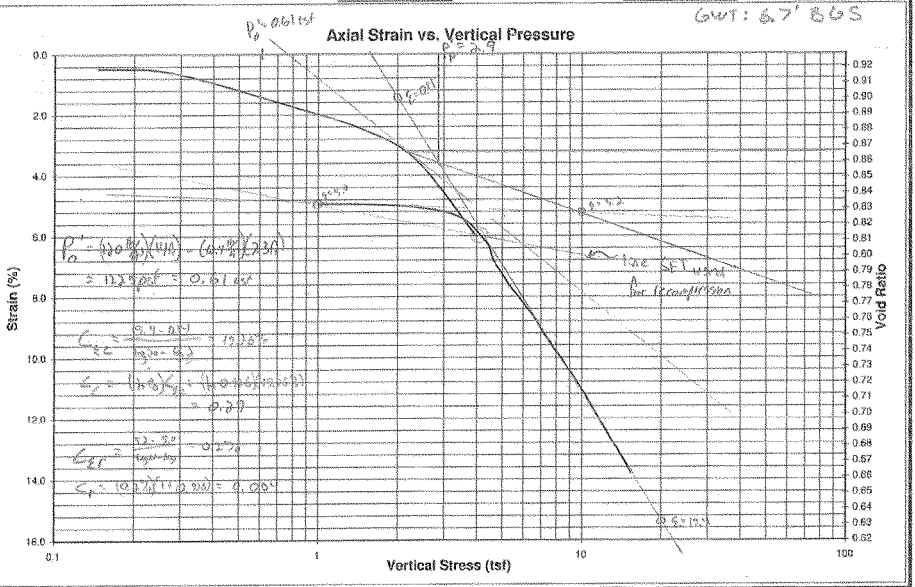
Specimen Information

Boring: FAR 10-78MU Sample: 1 Depth: 13-15 Type: 5T

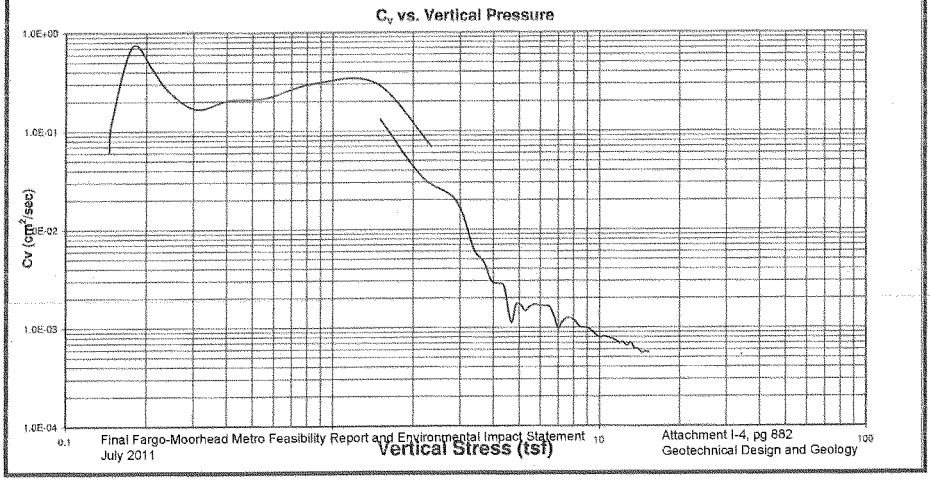
Soil Type: Fat Clay w/a few laminations of silt (CH) Alluvium

Initial Conditions: Dry Density (pcf): 89.5 Moisture Content (%): 29.8% e_o 0.926

GWT: 67' BGS



Calculated Consolidation Coefficients	Pc	3.0 tsf	Cc	0.28	Cr	0.03



Constant Rate of Strain Data Table

Project: OORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL Date: 10/27/10

Boring: 10-78MU Sample 1 Depth: 13-15 Job: 7577

Axial Strain	Vert. Stress (tsf)	Excess Pressure (tsf)	Pressure Ratio	Eff. Stress (tsf)	Cv (cm^2/sec)	K (cm/sec)	Void Ratio
0.48%	0.177	0.002	0.011	0.175	7.20E-01	8.18E-07	0.917
1.79%	0.847	0.007	0.008	0.842	3.04E-01	4.18E-06	0.892
2.46%	1.454	0.014	0.010	1.444	3.04E-01	3.06E-06	0.879
3.48%	2.345	0.070	0.030	2.298	6.91E-02	9.01E-07	0.859
6.00%	3.979	0.612	0.154	3.560			0.811
4.94%	0.999	-0.048	-0.048	1.031			0.831
5.02%	2.159	0.110	0.051	2.085	3.42E-02	4.83E-08	0.830
5.35%	3.396	0.228	0.067	3.242	6.16E-03	3.38E-08	0.823
5.54%	3.690	0.284	0.077	3.498	4.67E-03	3.52E-08	0.820
5.77%	3.939	0.323	0.082	3.721	2.98E-03	3.60E-08	0.815
6.43%	4.500	0.414	0.092	4.219	1.91E-03	2.14E-08	0.802
6.69%	4.579	0.454	0.099	4.271	1.39E-03	3.20E-08	0.797
7.57%	5.271	0.557	0.106	4.893	1.49E-03	1.99E-08	0.780
8.39%	6.230	0.695	0.112	5.758	1.66E-03	1.35E-08	0.765
9.25%	7.238	0.934	0.129	6.601	1.13E-03	8.05E-09	0.748
9.87%	8.126	1.082	0.133	7.388	1.16E-03	5.13E-09	0.736
10.67%	9.389	1.425	0.152	8.414	9.24E-04	6.37E-09	0.721
11.27%	10.382	1.666	0.160	9.239	8.16E-04	5.54E-09	0.709
12.15%	11.871	2.065	0.174	10.452	6.98E-04	2.99E-09	0.692
12.79%	13.112	2.424	0.185	11.441	7.06E-04	2.35E-09	0.680
13.58%	14.886	2.957	0.199	12.843	5.70E-04	3.42E-09	0.665
13.80%	15.362	3.081	0.201	13.232	5.63E-04	2.04E-09	0.660

Constant Rate of Strain Consolidation Test

Date: 10/26/10
Job: 7577

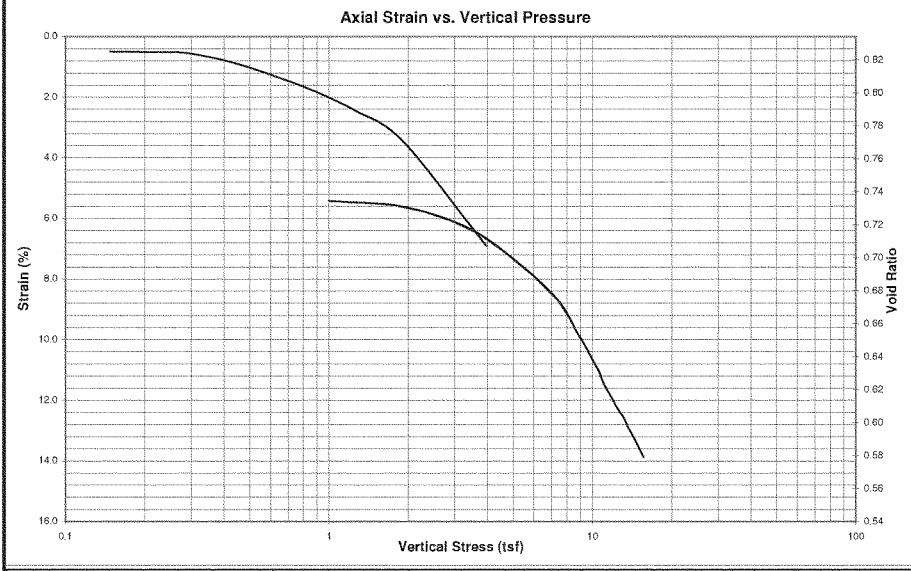
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING

Specimen Information

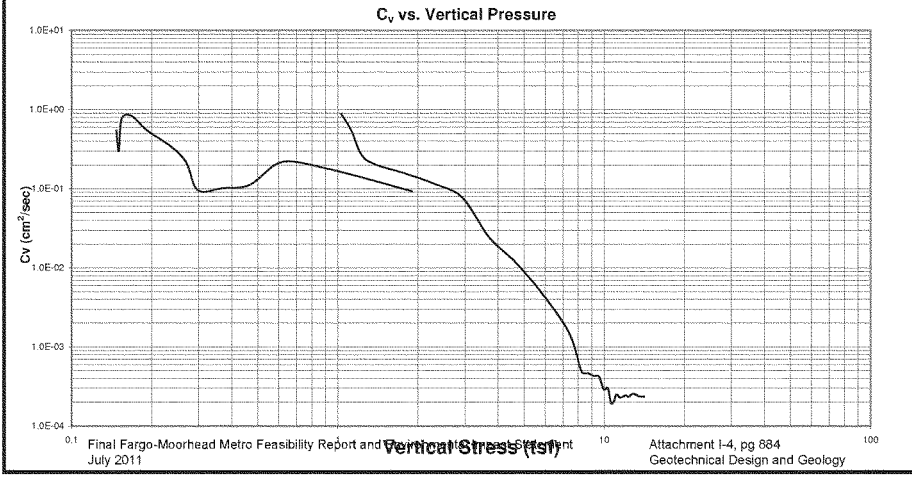
Boring: FAR 10-79MU Sample: 1 Depth: 20-22 (Top) Type: 5T

Soil Type: Fat Clay w/a few laminations of silt (CH) Alluvium

Initial Conditions: Dry Density (pcf): 91.7 Moisture Content (%): 30.3% e_o 0.839



Calculated Consolidation Coefficients	Pc	4.0 tsf	Cc	0.31	Cr	0.05



Constant Rate of Strain Consolidation Test

Date: 10/26/10
Job: 7577

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING

Specimen Information

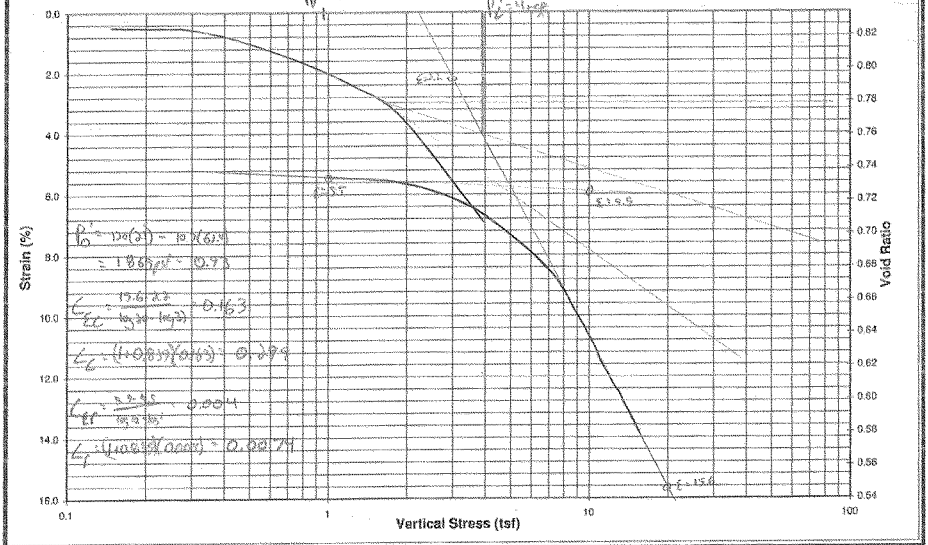
Boring: FAR 10-79MU Sample: 1 Depth: 20-22 (Top) Type: 5T

Soil Type: Fat Clay w/a few laminations of silt (CH) Alluvium

Initial Conditions: Dry Density (pcf): 91.7 Moisture Content (%): 30.3% e_o 0.839

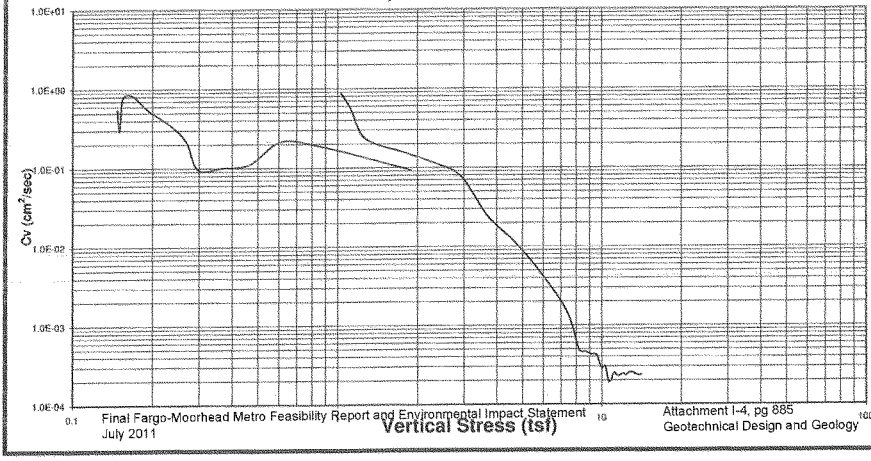
GWT: 10.7' BGS

Axial Strain vs. Vertical Pressure



Calculated Consolidation Coefficients	Pc	4.0 tsf	Cc	0.31	Cr	0.05

C_v vs. Vertical Pressure



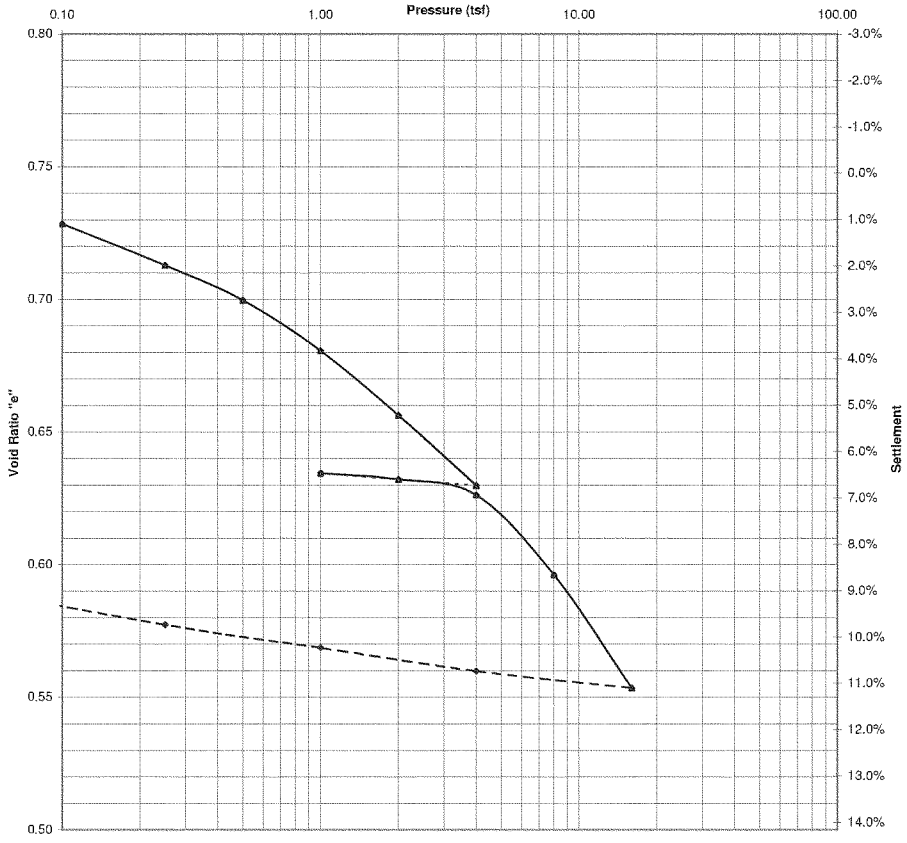
Constant Rate of Strain Data Table

Project: MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL Date: 10/26/10

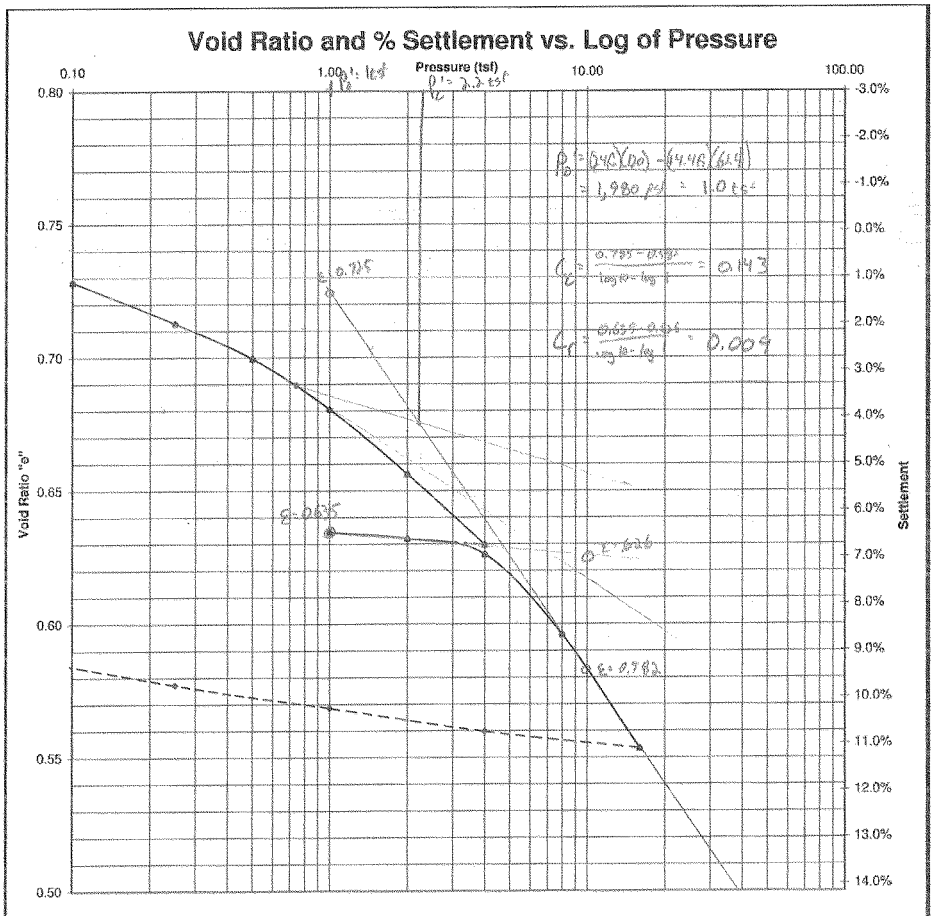
Boring: 10-79MU Sample 1 Depth: 20-22 (Top) Job: 7577

Axial Strain	Vert. Stress (tsf)	Excess Pressure (tsf)	Pressure Ratio	Eff. Stress (tsf)	Cv (cm^2/sec)	K (cm/sec)	Void Ratio
0.51%	0.167	0.002	0.012	0.166	8.40E-01	3.96E-06	0.829
1.29%	0.614	0.003	0.006	0.611	2.16E-01	4.86E-06	0.815
1.77%	0.861	0.006	0.007	0.857	1.87E-01	3.35E-06	0.806
2.44%	1.251	0.013	0.010	1.242	1.36E-01	2.36E-06	0.794
3.44%	1.898	0.032	0.017	1.876	9.25E-02	1.38E-06	0.775
5.43%	1.028	0.001	0.001	1.027	8.88E-01	1.05E-07	0.739
5.78%	2.298	0.017	0.007	2.287	1.15E-01	6.60E-07	0.732
6.09%	2.927	0.031	0.010	2.906	7.73E-02	3.34E-07	0.727
6.50%	3.696	0.117	0.032	3.618	2.43E-02	1.58E-07	0.719
7.14%	4.690	0.327	0.070	4.469	1.13E-02	7.60E-08	0.707
7.95%	6.058	1.179	0.195	5.244	4.03E-03	2.24E-08	0.692
8.73%	7.429	2.194	0.295	5.883	1.43E-03	8.78E-09	0.678
9.33%	8.230	2.518	0.306	6.452	4.83E-04	5.57E-09	0.667
9.73%	8.683	2.590	0.298	6.857	4.64E-04	3.20E-09	0.660
10.34%	9.571	2.851	0.298	7.561	4.18E-04	2.71E-09	0.649
11.06%	10.600	3.152	0.297	8.378	1.94E-04	1.88E-09	0.635
11.86%	11.719	3.325	0.284	9.382	2.32E-04	1.36E-09	0.621
12.39%	12.684	3.551	0.280	10.190	2.51E-04	1.16E-09	0.611
13.12%	14.125	3.952	0.280	11.350	2.35E-04	1.42E-09	0.597
13.70%	15.246	4.255	0.279	12.258	2.24E-04	1.51E-09	0.587
13.88%	15.632	4.362	0.279	12.569	2.18E-04	6.89E-10	0.583

Void Ratio and % Settlement vs. Log of Pressure



Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING			Date: 10/26/10
Sample #: 1	Boring #: 10-80MU FAR	Depth ft: 23-25	Job #: 7577
Soil Type: Sandy Lean Clay w/lenses and pockets of Silty Sand (CL & SM) Alluvium			
Initial W/C (%): 28.7	Dry Density (pcf): 95.3	LL: 28.2 PL: 17.1 PI: 11.1	Gs: 2.67
Organic Content (%):	Initial Height (in.): 0.746	Diameter (in.): 2.507	e_o= 0.748
Preconsolidation Pressure (Pc): 2.0 tsf	Compression Index (Cc): 0.14	Recompression Index (Cr): 0.015	
Remarks:			



Project:	FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING							Date:	10/26/10
Sample #: 1	Boring #: 10-60MU FAR			Depth ft: 23-25				Job #:	7577
Soil Type: Sandy Lean Clay w/lenses and pockets of Silty Sand (CL & SM) Alluvium									
Initial W/C (%): 28.7	Dry Density (pcf): 95.3		LL: 28.2	PL: 17.1	PI: 11.1		Gs: 2.67		
Organic Content (%):	Initial Height (in.): 0.746		Diameter (in.): 2.507			e_o= 0.748			
Preconsolidation Pressure (Pc): 2.0 tsf	Compression Index (Cc): 0.14		Recompression Index (Cr): 0.015						
Remarks: GWT= 7.6' BGS									

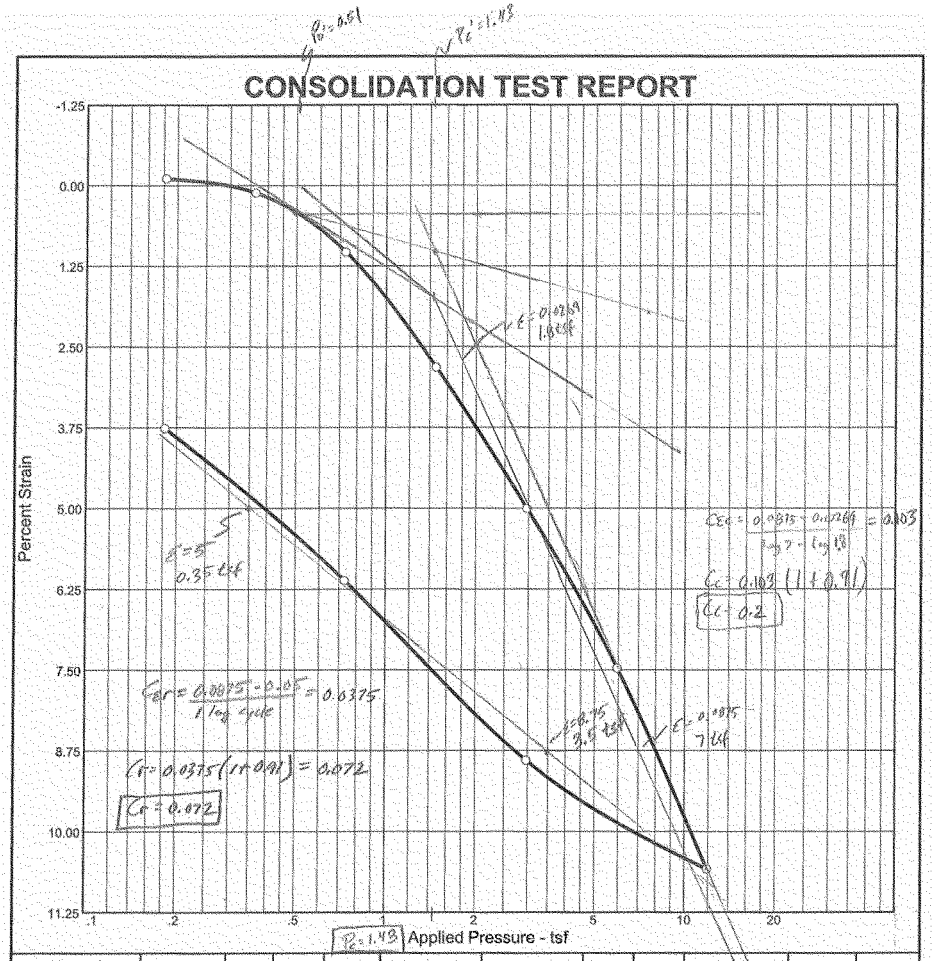
Hydraulic Conductivity Test Data

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING Date: 10/4/2010

Reported To: USACE -Geotech. & Geology Section Job No.: 7577

Boring No.:	10-80MU						
Sample No.:	1						
Depth (ft)	23-25 Bottom						
Location:	ND Sheyenne						
Sample Type:	5" Tube						
Soil Type:	Sandy Lean Clay with a few pockets of silty sand (CL)						
Atterberg Limits							
LL	28.2						
PL	17.1						
PI	11.1						
Permeability Test	Undisturbed						
Before Test Conditions: Saturation %:							
Porosity:							
Ht. (in):	3.17						
Dia. (in):	4.02						
Dry Density (pcf):	87.2						
Water Content:	34.9%						
Test Type:	Falling						
Max Head (ft):	5.0						
Confining press. (Effective-psi):	2.0						
Trial No.:	16-20						
Water Temp °C:	20.0						
% Compaction							
% Saturation (After Test)	95.7%						
Coefficient of Permeability							
K @ 20 °C (cm/sec)	**1.6 x 10 $^{-7}$**						
K @ 20 °C (ft/min)	**3.2 x 10 $^{-7}$**						
Notes:							

9384 Bryant Ave South, Suite 107 SOIL ENGINEERING TESTING, INC. Bloomington, Minnesota 55420-3436



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
97.5 %	32.4 %	89.5	67	50	2.738		1.52	0.20	0.07			0.910

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-26MU, Bottom of sample, FAT CLAY with silt layers, brown (CH), ASTM D2435	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115

Location: SE-F-15, Fargo, Sherack Formation, #1, 8-10'

Remarks:
Fargo
09-26MU, #1, 8' - 10'
Sherack

BRAUN INTERTEC

Figure

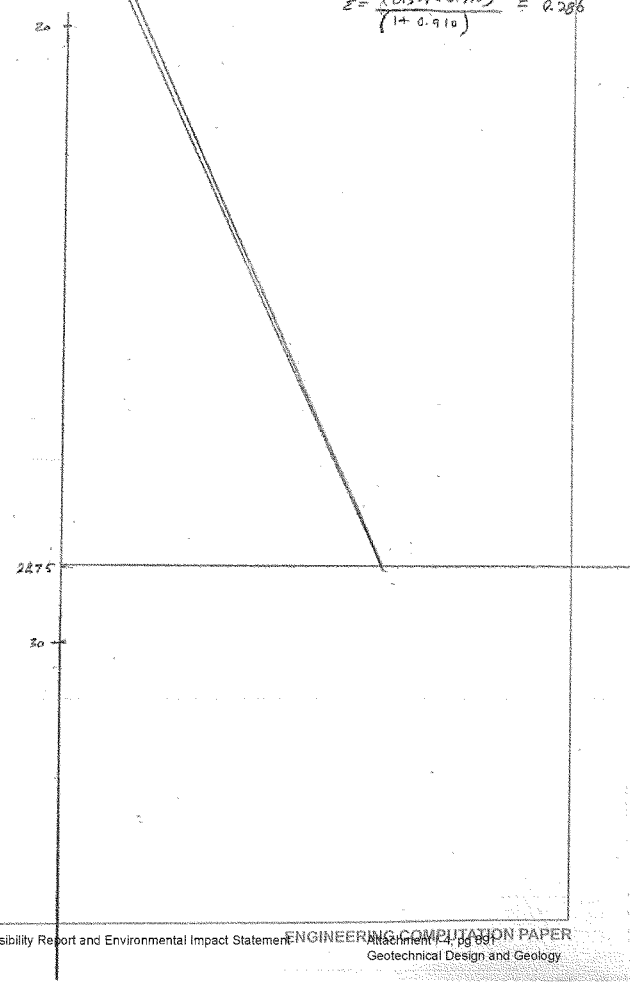
Figure

COMPUTED BY:	DATE:	SHEET:
CHECKED BY:	DATE:	CONTRACT NO.

Correcting for disturbance

$0.460 = 0.4(0.910) = 0.364$

$$\varepsilon = \frac{(0.364 - 0.910)}{(1 + 0.910)} = 0.286$$



CEMVP FORM 1-R, MAR 2007
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
ENGINEERING COMPUTATION PAPER
Attachment I-4, pg 891
Geotechnical Design and Geology

CONSOLIDATION TEST REPORT

Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
97.5 %	32.4 %	89.5	67	50	2.738		1.52	0.20	0.07			0.910

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-26MU, Bottom of sample, FAT CLAY with silt layers, brown (CH), ASTM D2435	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115

Location: SE-F-15, Fargo, Sherack Formation, #1, 8-10'

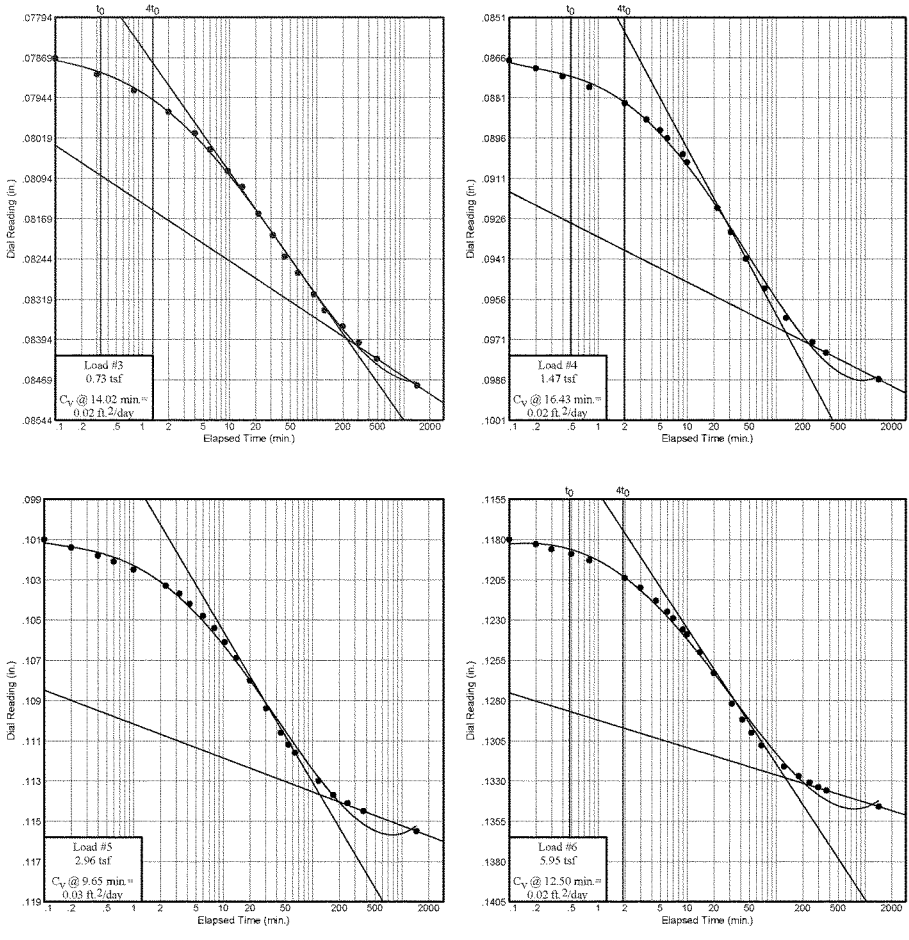
Remarks:

BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Location: SE-F-15, Fargo, Sherack Formation, #1, 8-10'

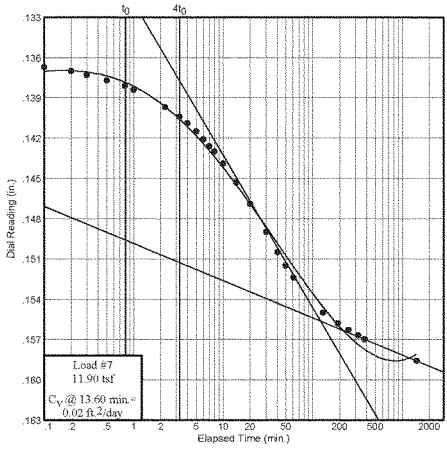


BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Location: SE-F-15, Fargo, Sherack Formation, #1, 8-10'



BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Project Number: BL-09-03127

Sample Data

Source:
Sample No.: #1
Elev. or Depth: 8-10' **Sample Length(in./cm.):**
Location: SE-F-15, Fargo, Sherack Formation, #1, 8-10'
Description: Boring 09-26MU, Bottom of sample, FAT CLAY with silt layers, brown (CH), ASTM D2435
Liquid Limit: 67 **Plasticity Index:** 50
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST		AFTER TEST	
Wet w+t	= 116.24 g.	Consolidometer #	= 6	Wet w+t	=
Dry w+t	= 95.08 g.			Dry w+t	=
Tare Wt.	= 29.79 g.	Spec. Gravity	= 2.738	Tare Wt.	=
Height	= .77 in.	Height	= .77 in.		
Diameter	= 2.50 in.	Diameter	= 2.50 in.		
Weight	= 118.19 g.	Defl. Table	= #6-2008		
Moisture	= 32.4 %	Ht. Solids	= 0.4046 in.	Moisture	= %
Wet Den.	= 118.5 pcf	Dry Wt.	= 89.26 g.*	Dry Wt.	= n/a
Dry Den.	= 89.5 pcf	Void Ratio	= 0.910	Void Ratio	= 0.838
		Saturation	= 97.5 %		

* Initial dry weight used in calculations

End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.07680				0.910	
0.18	0.07700	0.00100			0.912	0.1 Swell
0.36	0.07920	0.00150			0.908	0.1 Comprs.
0.73	0.08700	0.00220	0.02	0.001	0.891	1.0 Comprs.
1.47	0.10190	0.00330	0.02	0.002	0.856	2.8 Comprs.
2.96	0.12010	0.00460	0.03	0.002	0.815	5.0 Comprs.
5.95	0.14080	0.00620	0.02	0.002	0.768	7.5 Comprs.
11.90	0.16680	0.00820	0.02	0.004	0.708	10.6 Comprs.
2.96	0.15020	0.00460			0.740	8.9 Comprs.
0.73	0.12630	0.00220			0.793	6.1 Comprs.
0.18	0.10690	0.00100			0.838	3.8 Comprs.

C_c = 0.20 P_c = 1.52 tsf C_r = 0.07

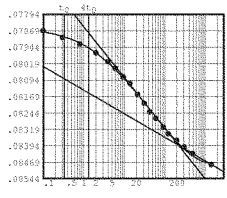
Pressure: 0.36 tsf — TEST READINGS — Load No. 2

No.	Elapsed Time	Dial Reading
1	0.00	0.07700
2	0.10	0.07750
3	2.00	0.07780
4	9.00	0.07810
5	27.00	0.07840
6	145.00	0.07880
7	511.00	0.07900
8	1394.00	0.07920

Void Ratio = 0.908 Compression = 0.1 %

Pressure: 0.73 tsf — TEST READINGS — Load No. 3

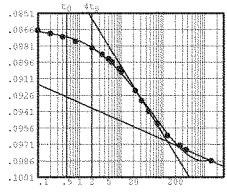
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.07920	11	31.50	0.08420
2	0.10	0.08090	12	43.00	0.08460
3	0.30	0.08120	13	61.00	0.08490
4	0.80	0.08150	14	93.00	0.08530
5	2.00	0.08190	15	123.50	0.08560
6	4.00	0.08230	16	199.00	0.08590
7	6.00	0.08260	17	306.00	0.08620
8	9.50	0.08300	18	490.50	0.08650
9	14.00	0.08330	19	1428.00	0.08700
10	21.50	0.08380			



Void Ratio = 0.891 Compression = 1.0 %
D_0 = 0.07845 D_{50} = 0.08119 D_{100} = 0.08393
C_v at 14.0 min. = 0.02 ft.^{2}/day C_α = 0.001

Pressure: 1.47 tsf — TEST READINGS — Load No. 4

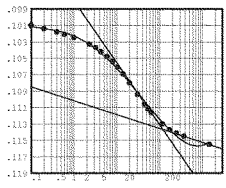
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08700	11	10.00	0.09380
2	0.10	0.09000	12	22.00	0.09550
3	0.20	0.09030	13	31.10	0.09640
4	0.40	0.09060	14	46.00	0.09740
5	0.80	0.09100	15	75.00	0.09850
6	2.00	0.09160	16	130.00	0.09960
7	3.50	0.09220	17	258.00	0.10050
8	5.00	0.09260	18	367.00	0.10090
9	6.00	0.09290	19	1441.00	0.10190
10	9.00	0.09350			



Void Ratio = 0.856 Compression = 2.8 %
D_0 = 0.08633 D_{50} = 0.09158 D_{100} = 0.09684
C_v at 16.4 min. = 0.02 ft.^{2}/day C_α = 0.002

Pressure: 2.96 tsf | TEST READINGS | Load No. 5

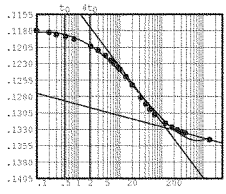
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10190	13	14.00	0.11150
2	0.10	0.10560	14	20.00	0.11260
3	0.20	0.10600	15	30.50	0.11400
4	0.40	0.10640	16	44.50	0.11520
5	0.60	0.10670	17	54.00	0.11580
6	1.00	0.10710	18	64.00	0.11620
7	2.30	0.10790	19	117.00	0.11760
8	3.25	0.10830	20	172.00	0.11830
9	4.25	0.10880	21	247.00	0.11870
10	6.00	0.10940	22	372.00	0.11910
11	8.00	0.11000	23	1458.00	0.12010
12	10.50	0.11070			



Void Ratio = 0.815 Compression = 5.0 %
D_0 = 0.09860 D_{50} = 0.10614 D_{100} = 0.11368
C_v at 9.7 min. = 0.03 ft.^{2}/day C_α = 0.002

Pressure: 5.95 tsf | TEST READINGS | Load No. 6

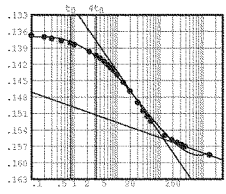
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.12010	14	14.00	0.13120
2	0.10	0.12420	15	20.00	0.13250
3	0.20	0.12450	16	32.00	0.13440
4	0.30	0.12480	17	42.00	0.13540
5	0.50	0.12510	18	53.00	0.13620
6	0.80	0.12550	19	69.00	0.13700
7	2.00	0.12660	20	124.00	0.13830
8	3.00	0.12720	21	181.00	0.13890
9	4.50	0.12800	22	240.00	0.13930
10	6.00	0.12870	23	300.00	0.13960
11	7.00	0.12910	24	372.00	0.13980
12	9.00	0.12980	25	1441.00	0.14080
13	10.00	0.13010			



Void Ratio = 0.768 Compression = 7.5 %
D_0 = 0.11690 D_{50} = 0.12485 D_{100} = 0.13281
C_v at 12.5 min. = 0.02 ft.^{2}/day C_α = 0.002

Pressure: 11.90 tsf | TEST READINGS | Load No. 7

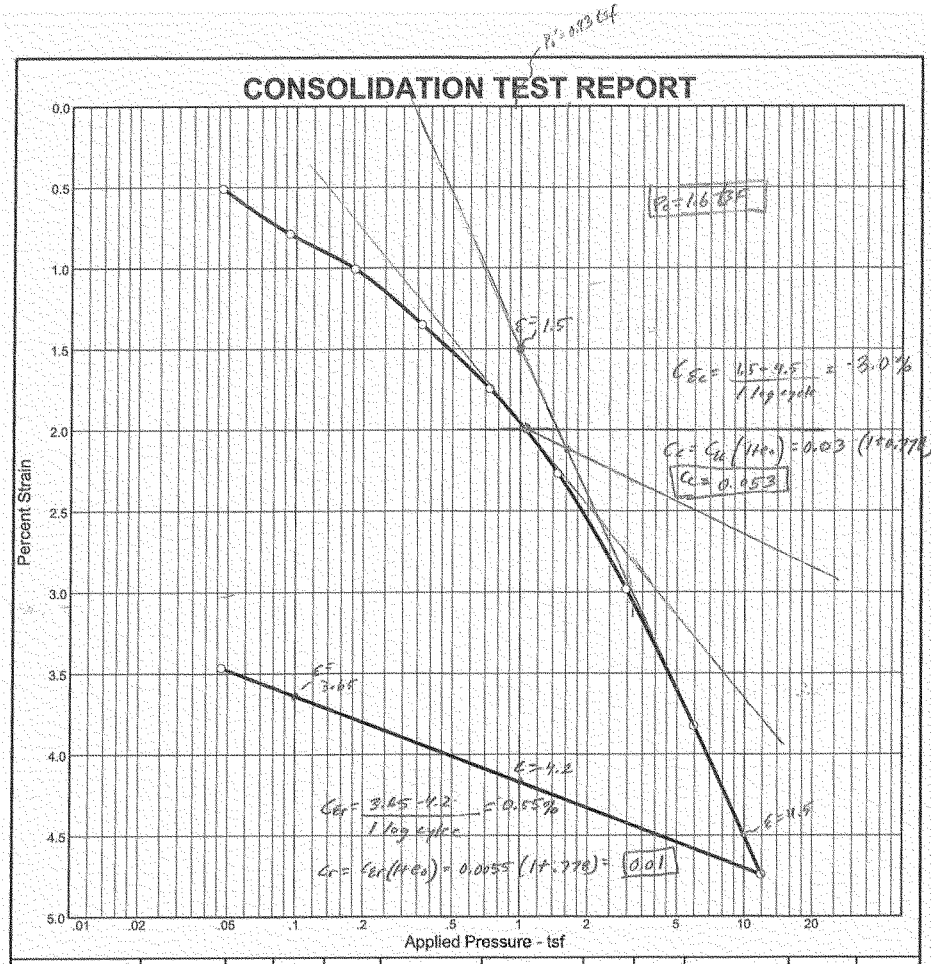
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.14080	15	10.00	0.15210
2	0.10	0.14490	16	14.00	0.15350
3	0.20	0.14520	17	20.00	0.15510
4	0.30	0.14550	18	30.30	0.15720
5	0.50	0.14590	19	40.50	0.15870
6	0.80	0.14630	20	50.00	0.15970
7	1.00	0.14660	21	61.00	0.16060
8	2.25	0.14790	22	130.00	0.16320
9	3.25	0.14860	23	190.00	0.16400
10	4.00	0.14910	24	251.00	0.16450
11	5.00	0.14970	25	321.00	0.16490
12	6.00	0.15030	26	382.00	0.16520
13	7.00	0.15080	27	1444.00	0.16680
14	8.00	0.15120			



Void Ratio = 0.708 Compression = 10.6 %

D_0 = 0.13512 D_{50} = 0.14537 D_{100} = 0.15563

C_v at 13.6 min. = 0.02 ft.^{2}/day C_α = 0.004



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
100.1 %	28.3 %	96.6	30	6	2.75		1.70	0.05	0.01			0.778

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-25MU, Bottom of sample, SILT, layers of clay, gray-brown (ML), ASTM D2435	ML	

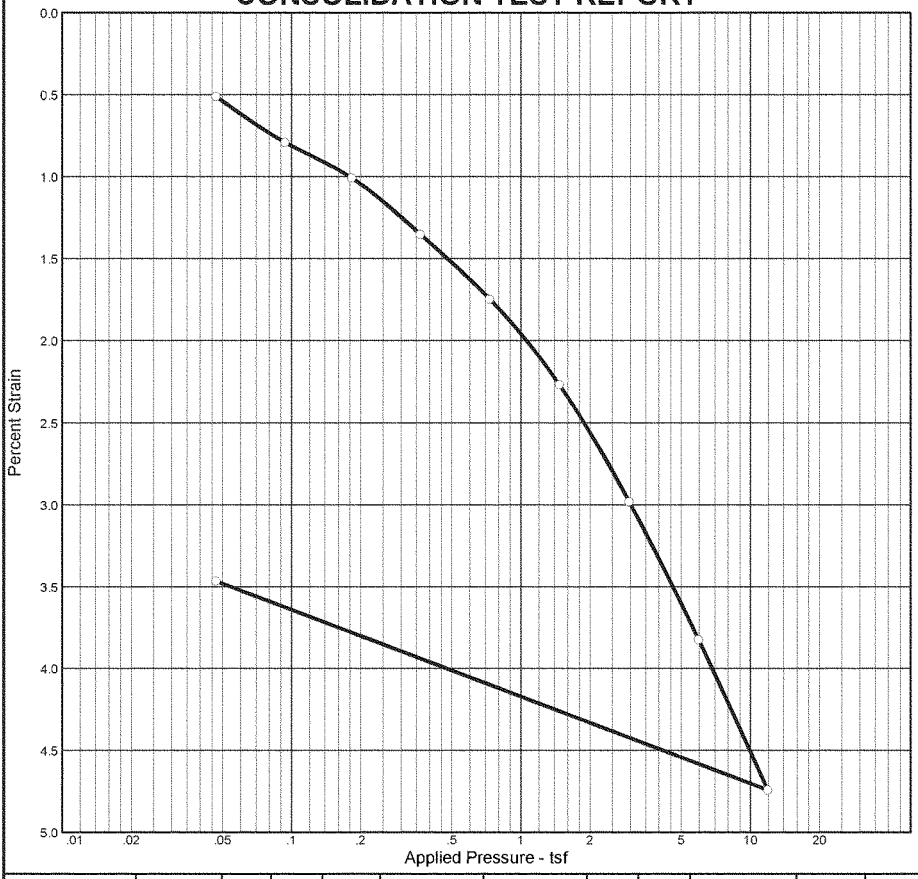
Project No. BL-09-03127 **Client:** US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Source: **Sample No.:** #2 **Elev./Depth:** 21-23'

BRAUN INTERTEC

Remarks:
Moorhead
09-25MU, #2, 21' - 23'
Poplar River - West
Fargo

Figure

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
100.1 %	28.3 %	96.6	30	6	2.75		1.70	0.05	0.01			0.778

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-25MU, Bottom of sample, SILT, layers of clay, gray-brown (ML), ASTM D2435	ML	

Project No. BL-09-03127 **Client:** US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Source: **Sample No.:** #2 **Elev./Depth:** 21-23'

BRAUN INTERTEC

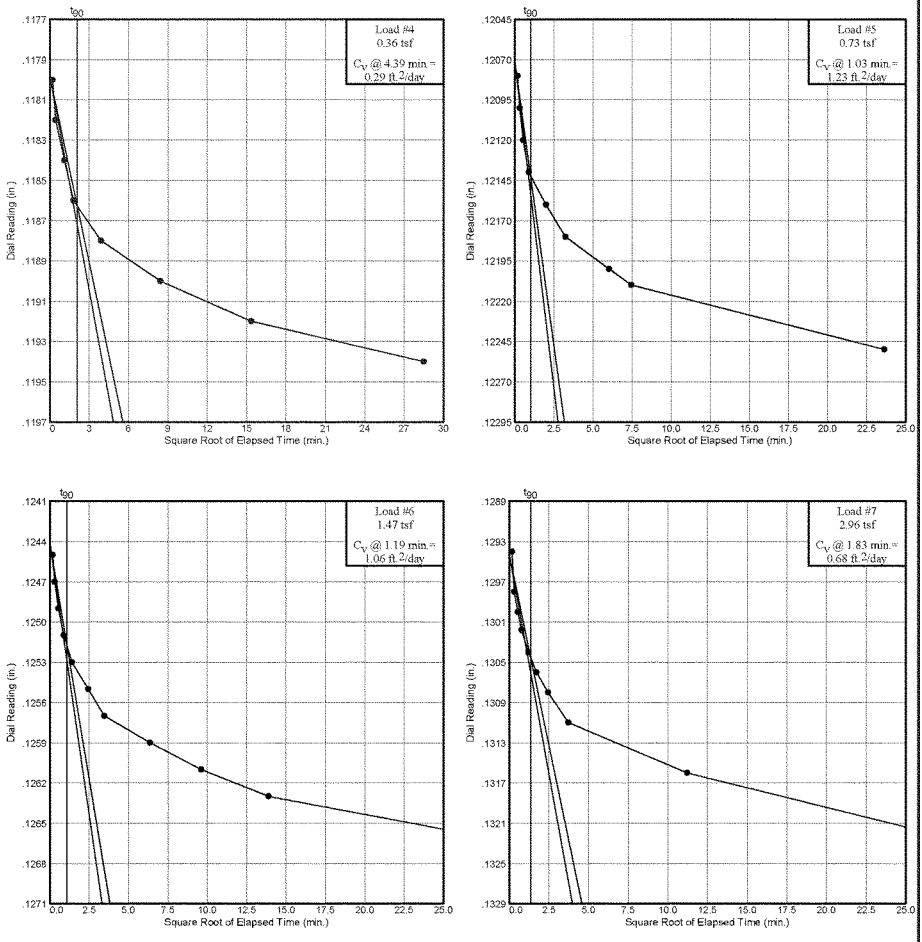
Remarks:

Moorhead
09-25MU, #2, 21' - 23'
Poplar River - West
Fargo

Figure

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Metro Feasibility Study
Poplar River - West Fargo
Source: Moorhead 09-25MU Sample No.: #2 Elev./Depth: 21-23'

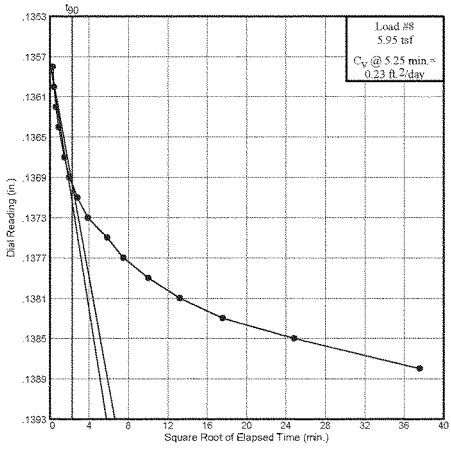


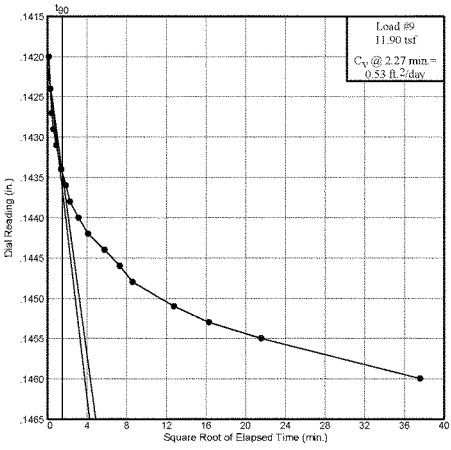
BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Metro Feasibility Study
Poplar River - West Fargo
Source: Moorhead 09-25MU Sample No.: #2 Elev./Depth: 21-23'





BRAUN INTERTEC

Figure

CONSOLIDATION TEST DATA

Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project Number: BL-09-03127

Sample Data

Source:
Sample No.: #2
Elev. or Depth: 21-23' **Sample Length(in./cm.):**
Location:
Description: Boring 09-25MU, Bottom of sample, SILT, layers of clay, gray-brown (ML), ASTM D2435
Poplar River - West Fargo
Liquid Limit: 30 **Plasticity Index:** 6
USCS: ML **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	170.77 g.	Consolidometer # = 6	Wet w+t =
Dry w+t =	139.96 g.		Dry w+t =
Tare Wt. =	31.15 g.	Spec. Gravity = 2.75	Tare Wt. =
Height =	.78 in.	Height = .78 in.	
Diameter =	2.50 in.	Diameter = 2.50 in.	
Weight =	125.44 g.	Defl. Table = #6-2008	
Moisture =	28.3 %	Ht. Solids = 0.4412 in.	Moisture = %
Wet Den. =	123.9 pcf	Dry Wt. = 97.76 g.*	Dry Wt. = n/a
Dry Den. =	96.6 pcf	Void Ratio = 0.778	Void Ratio = 0.716
		Saturation = 100.1 %	

* Initial dry weight used in calculations

End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.10880				0.778	
0.05	0.11310	0.00030			0.769	0.5 Comprs.
0.09	0.11500	0.00000			0.764	0.8 Comprs.
0.18	0.11770	0.00100			0.760	1.0 Comprs.
0.36	0.12090	0.00150	0.29		0.754	1.4 Comprs.
0.73	0.12470	0.00220	1.23		0.747	1.7 Comprs.
1.47	0.12990	0.00330	1.06		0.738	2.3 Comprs.
2.96	0.13680	0.00460	0.68		0.725	3.0 Comprs.
5.95	0.14500	0.00620	0.23		0.710	3.8 Comprs.
11.90	0.15420	0.00820	0.53		0.694	4.7 Comprs.
0.05	0.13630	0.00030			0.716	3.5 Comprs.

C_c = 0.05 P_c = 1.70 tsf C_r = 0.01

Pressure: 0.05 tsf | TEST READINGS | Load No. 1

No.	Elapsed Time	Dial Reading
1	0.00	0.10880
2	0.10	0.11220
3	5.50	0.11250
4	972.00	0.11310

Void Ratio = 0.769 Compression = 0.5 %

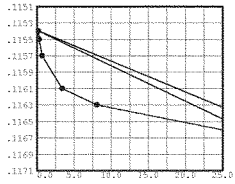
Pressure: 0.09 tsf | TEST READINGS | Load No. 2

No.	Elapsed Time	Dial Reading
1	0.00	0.11310
2	0.10	0.11400
3	0.80	0.11420
4	8.50	0.11440
5	67.50	0.11460
6	289.00	0.11480
7	473.00	0.11490
8	750.00	0.11500

Void Ratio = 0.764 Compression = 0.8 %

Pressure: 0.18 tsf | TEST READINGS | Load No. 3

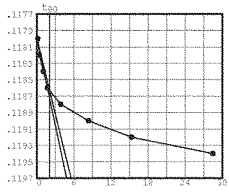
No.	Elapsed Time	Dial Reading
1	0.00	0.11510
2	0.05	0.11640
3	0.10	0.11650
4	0.50	0.11670
5	11.75	0.11710
6	65.50	0.11730
7	921.00	0.11770



Void Ratio = 0.760 Compression = 1.0 %

Pressure: 0.36 tsf — TEST READINGS — Load No. 4

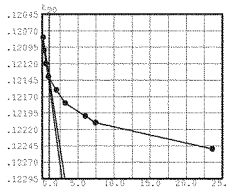
No.	Elapsed Time	Dial Reading
1	0.00	0.11770
2	0.05	0.11950
3	0.20	0.11970
4	1.25	0.11990
5	3.25	0.12010
6	15.30	0.12030
7	71.00	0.12050
8	236.00	0.12070
9	812.00	0.12090



Void Ratio = 0.754 Compression = 1.4 %
D_0 = 0.11798 D_{90} = 0.11863 D_{100} = 0.11870
C_v at 4.4 min. = 0.29 ft.^{2}/day

Pressure: 0.73 tsf — TEST READINGS — Load No. 5

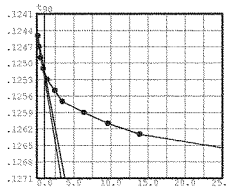
No.	Elapsed Time	Dial Reading
1	0.00	0.12090
2	0.03	0.12300
3	0.10	0.12320
4	0.30	0.12340
5	0.80	0.12360
6	4.00	0.12380
7	10.50	0.12400
8	36.30	0.12420
9	55.50	0.12430
10	558.50	0.12470



Void Ratio = 0.747 Compression = 1.7 %
D_0 = 0.12071 D_{90} = 0.12142 D_{100} = 0.12150
C_v at 1.0 min. = 1.23 ft.^{2}/day

Pressure: 1.47 tsf — TEST READINGS — Load No. 6

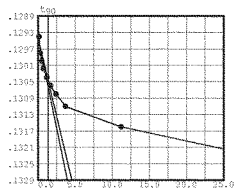
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.12470	11	193.00	0.12960
2	0.03	0.12780	12	754.00	0.12990
3	0.10	0.12800			
4	0.30	0.12820			
5	0.80	0.12840			
6	2.00	0.12860			
7	6.00	0.12880			
8	12.00	0.12900			
9	40.50	0.12920			
10	92.50	0.12940			



Void Ratio = 0.738 Compression = 2.3 %
D_0 = 0.12441 D_{90} = 0.12517 D_{100} = 0.12526
C_v at 1.2 min. = 1.06 ft.^{2}/day

Pressure: 2.96 tsf — TEST READINGS — Load No. 7

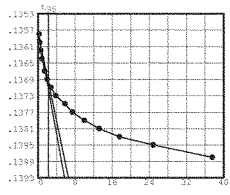
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.12990	11	707.00	0.13680
2	0.03	0.13400			
3	0.10	0.13440			
4	0.30	0.13460			
5	0.60	0.13478			
6	1.50	0.13500			
7	3.00	0.13520			
8	6.00	0.13540			
9	14.00	0.13570			
10	126.10	0.13620			



Void Ratio = 0.725 Compression = 3.0 %
D_0 = 0.12943 D_{90} = 0.13045 D_{100} = 0.13056
C_v at 1.8 min. = 0.68 ft.^{2}/day

Pressure: 5.95 tsf — TEST READINGS — Load No. 8

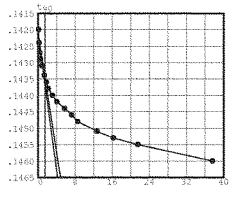
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.13680	11	56.00	0.14390
2	0.10	0.14200	12	100.50	0.14410
3	0.20	0.14220	13	175.00	0.14430
4	0.40	0.14240	14	309.00	0.14450
5	0.80	0.14260	15	616.50	0.14470
6	2.25	0.14290	16	1413.00	0.14500
7	4.00	0.14310			
8	8.00	0.14330			
9	15.00	0.14350			
10	34.00	0.14370			



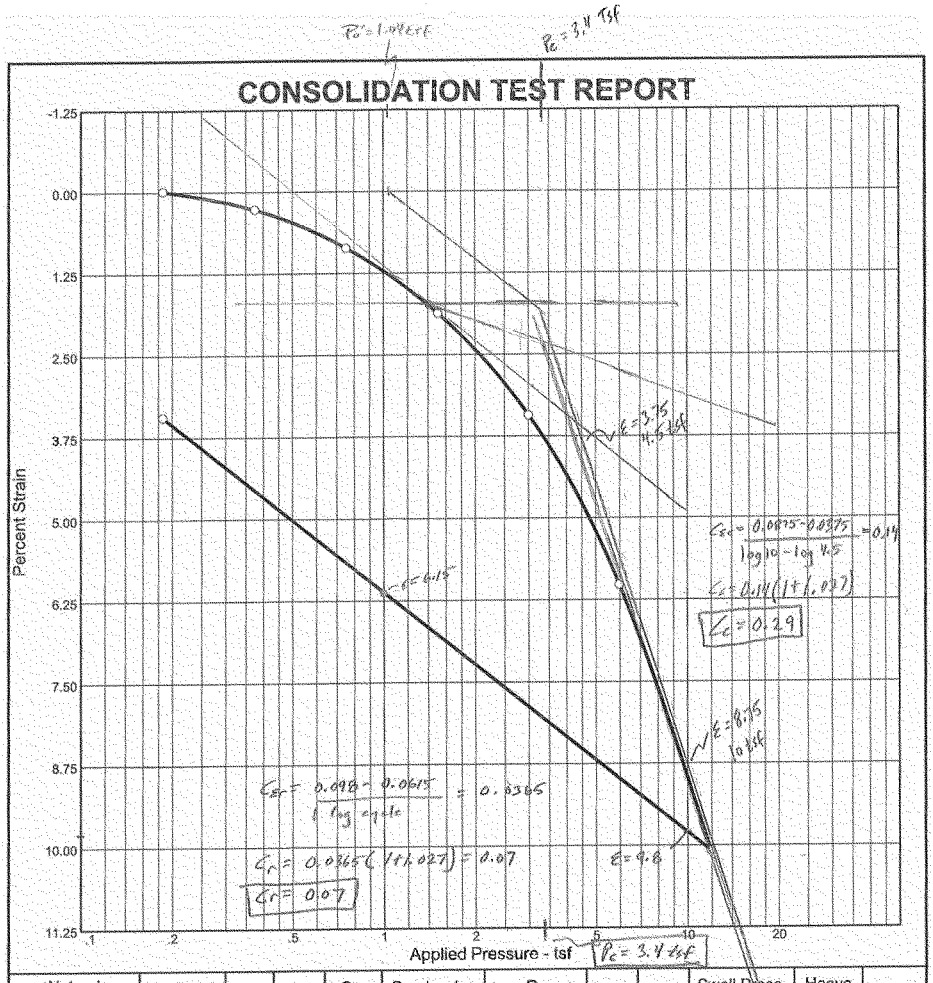
Void Ratio = 0.710 Compression = 3.8 %
D_0 = 0.13573 D_{90} = 0.13697 D_{100} = 0.13711
C_v at 5.2 min. = 0.23 ft.^{2}/day

Pressure: 11.90 tsf — TEST READINGS — Load No. 9

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.14500	11	17.00	0.15240
2	0.03	0.15020	12	33.30	0.15260
3	0.10	0.15060	13	53.50	0.15280
4	0.20	0.15090	14	73.80	0.15300
5	0.40	0.15110	15	163.00	0.15330
6	0.80	0.15130	16	266.00	0.15350
7	2.00	0.15160	17	465.00	0.15370
8	3.50	0.15180	18	1414.00	0.15420
9	5.25	0.15200			
10	10.00	0.15220			



Void Ratio = 0.694 Compression = 4.7 %
D_0 = 0.14208 D_{90} = 0.14344 D_{100} = 0.14359
C_v at 2.3 min. = 0.53 ft.^{2}/day



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
97.0 %	36.3 %	84.7	80	54	2.75		2.68	0.28	0.07			1.027

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-25MU, Bottom of sample, FAT CLAY, brown (CH), ASTM D2435	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Source: **Sample No.:** #3 **Elev./Depth:** 25-27'

BRAUN INTERTEC

Remarks:
Boring 09-25MU, Bottom of sample
Moorhead
09-25MU, #3, 25' - 27'
Poplar River - Harwood

Figure ASTM2435

	2.68	0.28	0.07			1.027

SCRIPTION	USCS	AASHTO
T CLAY, brown (CH), ASTM D2435	CH	

orps of Engineers

Elev./Depth: 25-27'

Remarks:
Boring 09-25MU, Bottom of sample

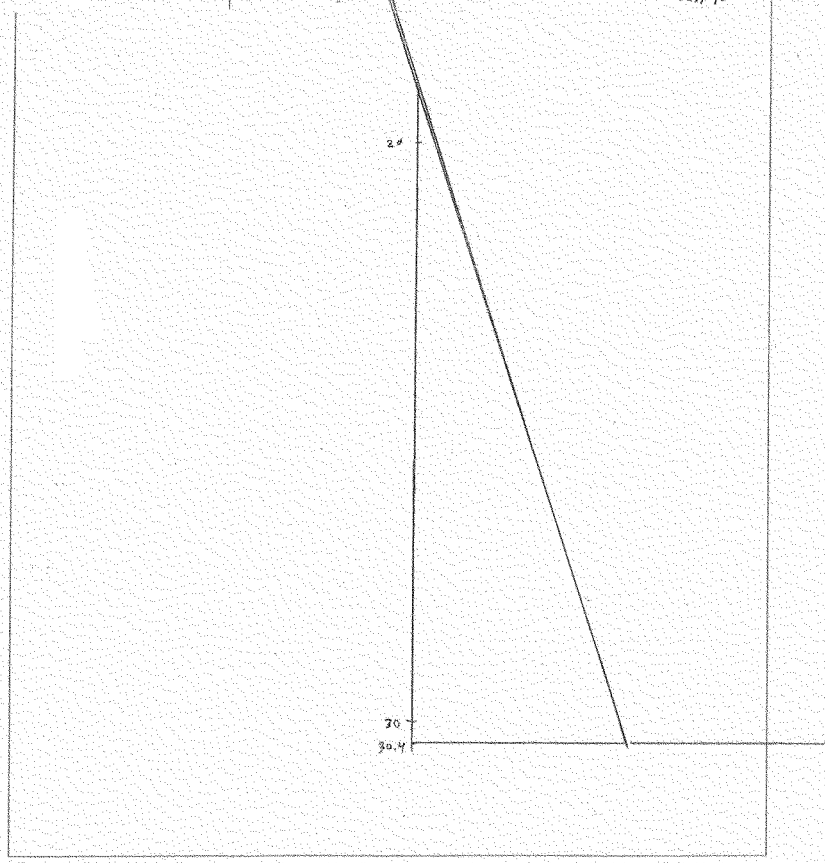
Figure ASTM2435

COMPUTED BY:	DATE:	SHEET:
CHECKED BY:	DATE:	CONTRACT NO.:

$0.7e_0 = 0.4(1.027) = 0.4108$

$\varepsilon = \left(\frac{e - e_0}{1 + e_0}\right) = \frac{0.4108 - 1.027}{1 + 1.027}$

$\varepsilon = 0.304 = 30.4\%$



CONSOLIDATION TEST REPORT

Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
97.0 %	36.3 %	84.7			2.75		2.68	0.28	0.07			1.027

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-25MU, Bottom of sample, FAT CLAY, brown (CH), ASTM D2435	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Source: **Sample No.:** #3 **Elev./Depth:** 25-27'

BRAUN INTERTEC

Remarks:

Boring 09-25MU, Bottom of sample

Moorhead

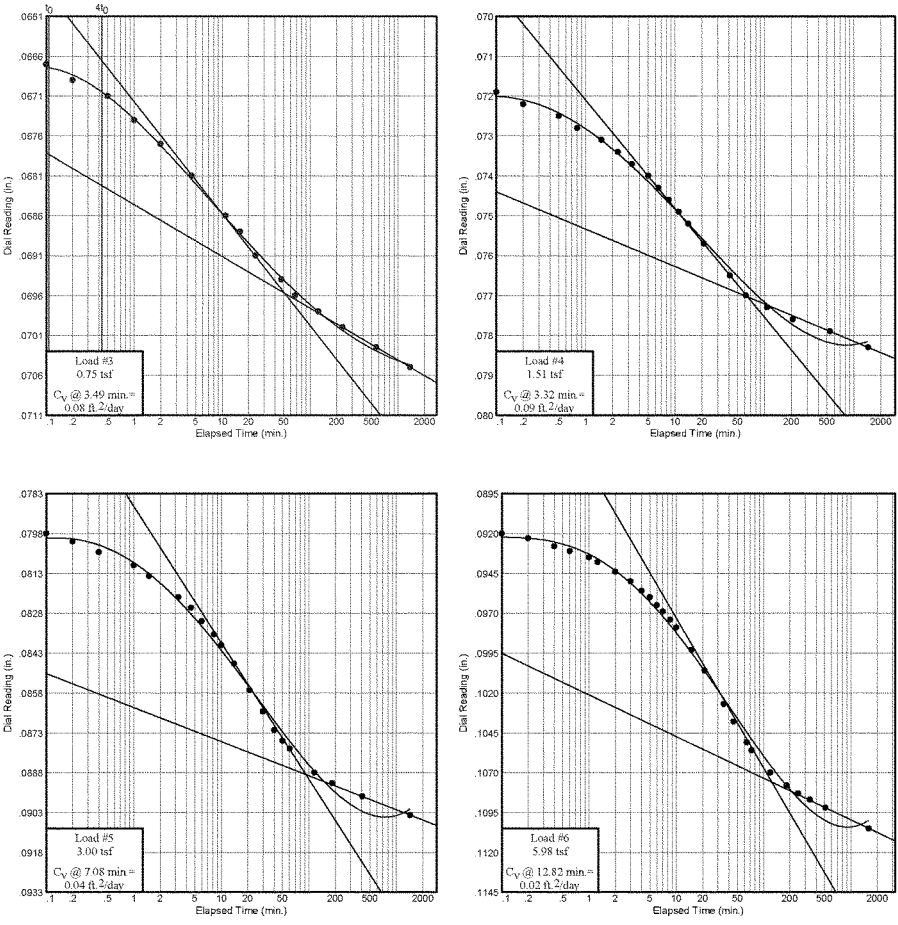
09-25MU, #3, 25' - 27'

Poplar River - Harwood

Figure ASTM2435

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Metro Feasibility Study
Poplar River - Harwood
Source: Moorhead 09-25MU Sample No.: #3 Elev./Depth: 25-27'

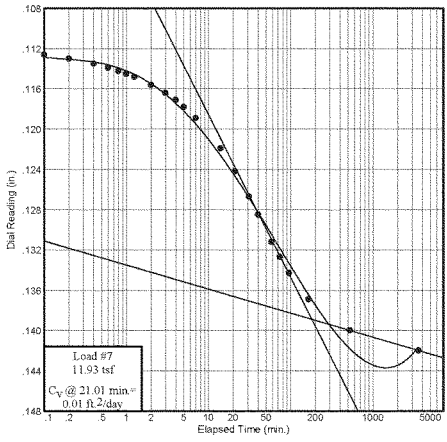


BRAUN INTERTEC

Figure AST2436

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Metro Feasibility Study
Poplar River - Harwood
Source: Moorhead 09-25MU Sample No.: #3 Elev./Depth: 25-27'



BRAUN INTERTEC

Figure AS2437

SWELL/CONSOLIDATION TEST DATA

Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project Number: BL-09-03127

Sample Data

Source:
Sample No.: #3
Elev. or Depth: 25-27' **Sample Length(in./cm.):**
Location: Poplar River - Harwood
Description: Boring 09-25MU, Bottom of sample, FAT CLAY, brown (CH), ASTM D2435
Liquid Limit: **Plasticity Index:**
USCS: CH **AASHTO:** **Figure No.:** ASTM2435
Testing Remarks: Boring 09-25MU, Bottom of sample

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	121.84 g.	Consolidometer # = 5	Wet w+t =
Dry w+t =	97.53 g.		Dry w+t =
Tare Wt. =	30.47 g.	Spec. Gravity = 2.75	Tare Wt. =
Height =	.78 in.	Height = .78 in.	
Diameter =	2.50 in.	Diameter = 2.50 in.	
Weight =	115.39 g.	Defl. Table = #5-2008	
Moisture =	36.3 %	Ht. Solids = 0.3825 in.	Moisture = %
Wet Den. =	115.4 pcf	Dry Wt. = 84.69 g.*	Dry Wt. = n/a
Dry Den. =	84.7 pcf	Void Ratio = 1.027	Void Ratio = 0.957
		Saturation = 97.0 %	

* Initial dry weight used in calculations

End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.06380				1.027	
0.19	0.06440	0.00070			1.028	0.0 Swell
0.38	0.06700	0.00110			1.022	0.3 Comprs.
0.75	0.07240	0.00190	0.08	0.001	1.010	0.9 Comprs.
1.51	0.08130	0.00300	0.09	0.001	0.989	1.9 Comprs.
3.00	0.09470	0.00430	0.04	0.002	0.958	3.4 Comprs.
5.98	0.11650	0.00600	0.02	0.003	0.905	6.0 Comprs.
11.93	0.15030	0.00830	0.01	0.003	0.823	10.1 Comprs.
0.19	0.09120	0.00070			0.957	3.4 Comprs.

C_c = 0.28 P_c = 2.68 tsf C_r = 0.07

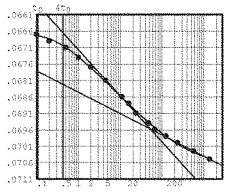
Pressure: 0.38 tsf — TEST READINGS — Load No. 2

No.	Elapsed Time	Dial Reading
1	0.00	0.06440
2	0.10	0.06550
3	0.80	0.06580
4	3.00	0.06600
5	6.00	0.06620
6	17.00	0.06640
7	46.00	0.06660
8	242.00	0.06680
9	1440.00	0.06700

Void Ratio = 1.022 Compression = 0.3 %

Pressure: 0.75 tsf — TEST READINGS — Load No. 3

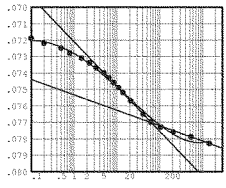
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.06700	11	47.30	0.07130
2	0.10	0.06860	12	67.50	0.07150
3	0.20	0.06880	13	124.00	0.07170
4	0.50	0.06900	14	235.00	0.07190
5	1.00	0.06930	15	566.00	0.07215
6	2.00	0.06960	16	1373.50	0.07240
7	4.50	0.07000			
8	11.00	0.07050			
9	16.00	0.07070			
10	24.00	0.07100			



Void Ratio = 1.010 Compression = 0.9 %
D_0 = 0.06644 D_{50} = 0.06801 D_{100} = 0.06958
C_v at 3.5 min. = 0.08 ft.^{2}/day C_α = 0.001

Pressure: 1.51 tsf — TEST READINGS — Load No. 4

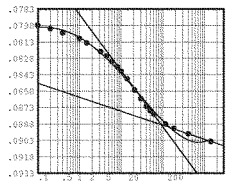
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.07240	11	8.50	0.07760
2	0.10	0.07490	12	11.00	0.07790
3	0.20	0.07520	13	14.00	0.07820
4	0.50	0.07550	14	21.00	0.07870
5	0.80	0.07580	15	41.00	0.07950
6	1.50	0.07610	16	62.00	0.08000
7	2.30	0.07640	17	107.00	0.08030
8	3.30	0.07670	18	207.00	0.08060
9	5.00	0.07700	19	539.50	0.08090
10	6.50	0.07730	20	1440.00	0.08130



Void Ratio = 0.989 Compression = 1.9 %
D_0 = 0.07050 D_{50} = 0.07377 D_{100} = 0.07704
C_v at 3.3 min. = 0.09 ft.^{2}/day C_α = 0.001

Pressure: 3.00 tsf — TEST READINGS — Load No. 5

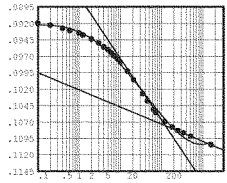
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08130	12	14.00	0.08900
2	0.10	0.08410	13	21.00	0.09000
3	0.20	0.08440	14	30.00	0.09080
4	0.40	0.08480	15	40.30	0.09150
5	1.00	0.08530	16	50.10	0.09190
6	1.50	0.08570	17	60.50	0.09220
7	3.25	0.08650	18	116.00	0.09310
8	4.50	0.08690	19	184.50	0.09350
9	6.00	0.08740	20	410.00	0.09400
10	8.25	0.08790	21	1440.00	0.09470
11	10.00	0.08830			



Void Ratio = 0.958 Compression = 3.4 %
D_0 = 0.07830 D_{50} = 0.08358 D_{100} = 0.08887
C_v at 7.1 min. = 0.04 ft.^{2}/day C_α = 0.002

Pressure: 5.98 tsf — TEST READINGS — Load No. 6

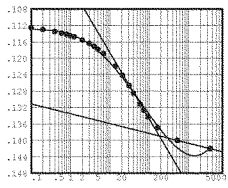
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.09470	15	10.00	0.10390
2	0.10	0.09800	16	15.00	0.10530
3	0.20	0.09830	17	21.00	0.10660
4	0.40	0.09880	18	35.00	0.10870
5	0.60	0.09910	19	45.50	0.10980
6	1.00	0.09950	20	64.30	0.11110
7	1.25	0.09980	21	73.00	0.11160
8	2.00	0.10040	22	120.00	0.11300
9	3.00	0.10100	23	184.00	0.11380
10	4.00	0.10160	24	249.00	0.11430
11	5.00	0.10200	25	341.00	0.11470
12	6.00	0.10250	26	510.00	0.11520
13	7.00	0.10290	27	1605.00	0.11650
14	8.50	0.10340			



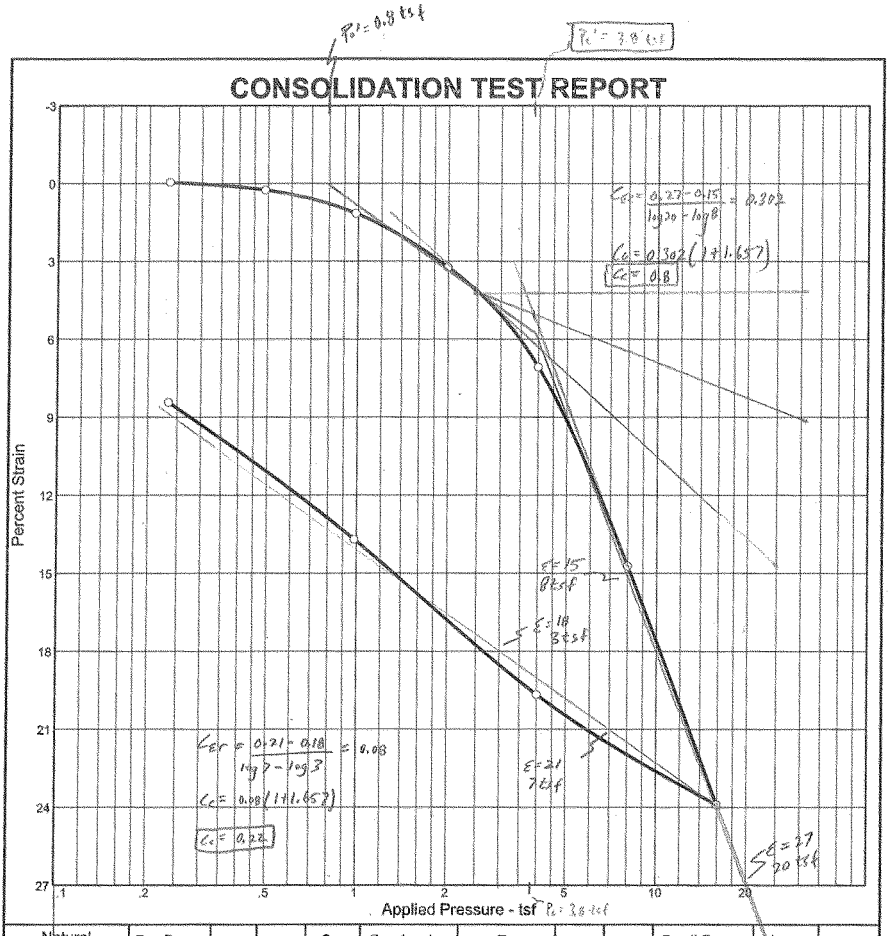
Void Ratio = 0.905 Compression = 6.0 %
D_0 = 0.09040 D_{50} = 0.09900 D_{100} = 0.10760
C_v at 12.8 min. = 0.02 ft.^{2}/day C_α = 0.003

Pressure: 11.93 tsf | TEST READINGS | Load No. 7

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.11650	13	7.00	0.12720
2	0.10	0.12090	14	14.00	0.13020
3	0.20	0.12130	15	21.00	0.13250
4	0.40	0.12180	16	31.00	0.13500
5	0.60	0.12220	17	40.00	0.13680
6	0.80	0.12250	18	58.50	0.13950
7	1.00	0.12280	19	73.50	0.14100
8	1.25	0.12310	20	95.00	0.14260
9	2.00	0.12390	21	165.00	0.14520
10	3.00	0.12470	22	525.00	0.14830
11	4.00	0.12540	23	3613.00	0.15030
12	5.00	0.12610			



Void Ratio = 0.823 Compression = 10.1 %
D_0 = 0.11050 D_{50} = 0.12470 D_{100} = 0.13889
C_v at 21.0 min. = 0.01 ft.^{2}/day C_α = 0.003



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
99.1 %	60.7 %	63.5	114	90	2.704		4.10	0.82	0.22			1.657

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-34MU, Bottom of sample, FAT CLAY, brown (CH), ASTM D2435	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115

Location: SE-M-18, Moorhead, ~~PL-Sherack-Formation~~, #2, 16-18'

BRAUN INTERTEC

Remarks:

Moorhead
09-34MU, #2, 16' - 18'
Oxidized Brenna

Figure

CONSOLIDATION TEST REPORT

Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
99.1 %	60.7 %	63.5	114	90	2.704		4.10	0.82	0.22			1.657

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-34MU, Bottom of sample, FAT CLAY, brown (CH), ASTM D2435	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115

Location: SE-M-18, Moorhead, ~~Pk Shenack Formation~~ #2, 16-18'

BRAUN INTERTEC

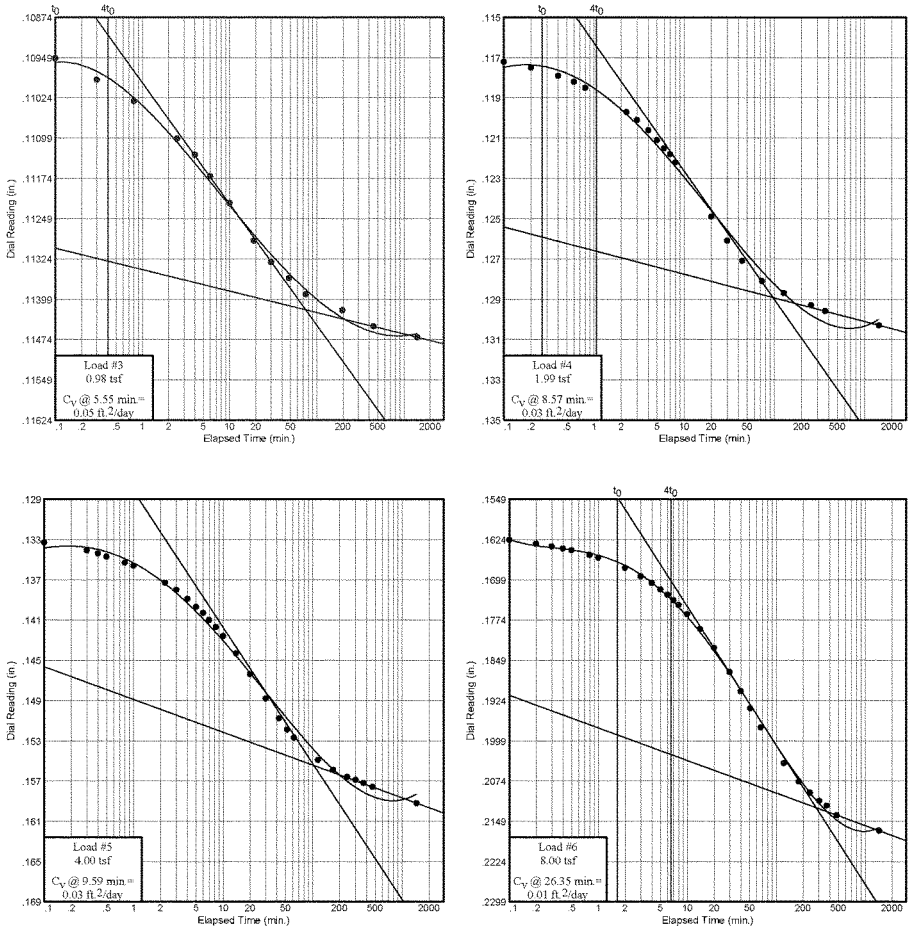
Remarks:

Moorhead
09-34MU, #2, 16' - 18'
Oxidized Brenna

Figure

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Location: SE-M-18, Moorhead, ~~PL Sheyenne Formation~~, #2, 16-18' Oxidized Brenna

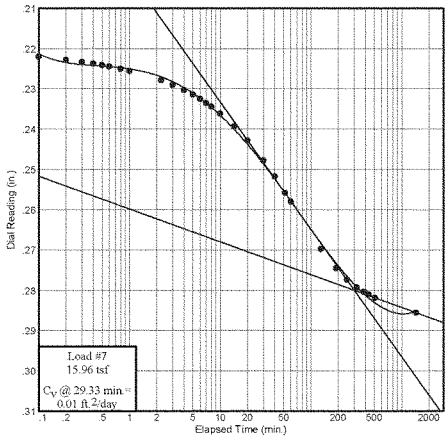


BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Location: SE-M-18, Moorhead, ~~PL Sheyenne Formation~~, #2, 16-18' Oxidized Brenna



BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Project Number: BL-09-03127

Sample Data

Source:
Sample No.: #2
Elev. or Depth: 16-18' **Sample Length(in./cm.):**
Location: SE-M-18, Moorhead, ~~BL Sherack Formation~~, #2, 16-18' Oxidized Brenna
Description: Boring 09-34MU, Bottom of sample, FAT CLAY, brown (CH), ASTM D2435
Liquid Limit: 114 **Plasticity Index:** 90
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE	BEFORE TEST	AFTER TEST
Wet w+t = 123.25 g.	Consolidometer # = 4	Wet w+t =
Dry w+t = 88.25 g.		Dry w+t =
Tare Wt. = 30.61 g.	Spec. Gravity = 2.704	Tare Wt. =
Height = .75 in.	Height = .75 in.	
Diameter = 2.49 in.	Diameter = 2.49 in.	
Weight = 98.47 g.	Defl. Table = #4-2008	
Moisture = 60.7 %	Ht. Solids = 0.2828 in.	Moisture = %
Wet Den. = 102.1 pcf	Dry Wt. = 61.27 g.*	Dry Wt. = n/a
Dry Den. = 63.5 pcf	Void Ratio = 1.657	Void Ratio = 1.433
	Saturation = 99.1 %	

* Initial dry weight used in calculations

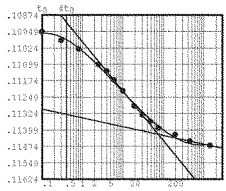
End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.10600				1.657	
0.23	0.10620	0.00050			1.658	0.0 Swell
0.49	0.10870	0.00080			1.651	0.3 Comprs.
0.98	0.11570	0.00100	0.05	0.001	1.627	1.2 Comprs.
1.99	0.13180	0.00150	0.03	0.002	1.571	3.2 Comprs.
4.00	0.16120	0.00200	0.03	0.004	1.469	7.1 Comprs.
8.00	0.21940	0.00270	0.01	0.009	1.266	14.7 Comprs.
15.96	0.28920	0.00360	0.01	0.013	1.022	23.9 Comprs.
4.00	0.25580	0.00200			1.135	19.7 Comprs.
0.98	0.21000	0.00100			1.293	13.7 Comprs.
0.23	0.16990	0.00050			1.433	8.4 Comprs.

C_c = 0.82 P_c = 4.10 tsf C_r = 0.22

Pressure: 0.98 tsf | TEST READINGS | Load No. 3

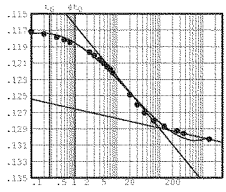
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10870	11	48.00	0.11460
2	0.10	0.11050	12	75.00	0.11490
3	0.30	0.11090	13	197.00	0.11520
4	0.80	0.11130	14	451.00	0.11550
5	2.50	0.11200	15	1426.00	0.11570
6	4.00	0.11230			
7	6.00	0.11270			
8	10.00	0.11320			
9	19.00	0.11390			
10	30.00	0.11430			



Void Ratio = 1.627 Compression = 1.2 %
D_0 = 0.10929 D_{50} = 0.11174 D_{100} = 0.11419
C_v at 5.5 min. = 0.05 ft.^{2}/day C_α = 0.001

Pressure: 1.99 tsf | TEST READINGS | Load No. 4

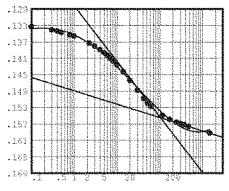
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.11570	12	7.00	0.12330
2	0.10	0.11870	13	8.00	0.12370
3	0.20	0.11900	14	20.00	0.12640
4	0.40	0.11940	15	30.00	0.12760
5	0.60	0.11970	16	44.00	0.12860
6	0.80	0.12000	17	73.00	0.12960
7	2.30	0.12120	18	127.00	0.13020
8	3.00	0.12160	19	256.00	0.13080
9	4.00	0.12210	20	365.00	0.13110
10	5.00	0.12260	21	1440.00	0.13180
11	6.00	0.12300			



Void Ratio = 1.571 Compression = 3.2 %
D_0 = 0.11624 D_{50} = 0.12258 D_{100} = 0.12892
C_v at 8.6 min. = 0.03 ft.^{2}/day C_α = 0.002

Pressure: 4.00 tsf — TEST READINGS — Load No. 5

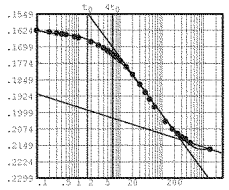
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.13180	15	10.00	0.14460
2	0.10	0.13530	16	14.00	0.14630
3	0.30	0.13610	17	20.00	0.14840
4	0.40	0.13640	18	30.00	0.15080
5	0.50	0.13670	19	42.00	0.15280
6	0.80	0.13730	20	52.00	0.15390
7	1.00	0.13760	21	62.00	0.15470
8	2.25	0.13930	22	115.00	0.15690
9	3.00	0.14000	23	170.00	0.15790
10	4.00	0.14090	24	244.00	0.15860
11	5.00	0.14170	25	304.00	0.15890
12	6.00	0.14230	26	370.00	0.15920
13	7.00	0.14300	27	470.00	0.15960
14	8.30	0.14370	28	1456.00	0.16120



Void Ratio = 1.469 Compression = 7.1 %
D_0 = 0.13030 D_{50} = 0.14288 D_{100} = 0.15546
C_v at 9.6 min. = 0.03 ft.^{2}/day C_α = 0.004

Pressure: 8.00 tsf — TEST READINGS — Load No. 6

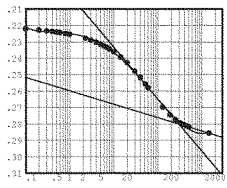
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.16120	16	10.00	0.17900
2	0.10	0.16520	17	14.00	0.18180
3	0.20	0.16590	18	20.00	0.18530
4	0.30	0.16640	19	30.00	0.18980
5	0.40	0.16680	20	40.00	0.19340
6	0.50	0.16710	21	51.00	0.19660
7	0.80	0.16800	22	67.00	0.20010
8	1.00	0.16850	23	122.00	0.20680
9	2.00	0.17040	24	180.00	0.21020
10	3.00	0.17200	25	240.00	0.21230
11	4.00	0.17320	26	305.00	0.21380
12	5.00	0.17440	27	370.00	0.21470
13	6.00	0.17540	28	480.00	0.21650
14	7.00	0.17640	29	1441.00	0.21940
15	8.00	0.17730			



Void Ratio = 1.266 Compression = 14.7 %
D_0 = 0.15958 D_{50} = 0.18599 D_{100} = 0.21239
C_v at 26.3 min. = 0.01 ft.^{2}/day C_α = 0.009

Pressure: 15.96 tsf | TEST READINGS | Load No. 7

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.21940	17	10.00	0.23970
2	0.10	0.22560	18	14.30	0.24290
3	0.20	0.22640	19	20.00	0.24640
4	0.30	0.22690	20	30.00	0.25140
5	0.40	0.22730	21	40.00	0.25540
6	0.50	0.22770	22	52.00	0.25940
7	0.60	0.22800	23	60.00	0.26160
8	0.80	0.22860	24	129.00	0.27340
9	1.00	0.22910	25	189.00	0.27820
10	2.25	0.23140	26	250.00	0.28100
11	3.00	0.23260	27	320.00	0.28290
12	4.00	0.23390	28	381.00	0.28400
13	5.00	0.23500	29	432.00	0.28470
14	6.00	0.23610	30	508.00	0.28550
15	7.00	0.23710	31	1443.00	0.28920
16	8.00	0.23800			

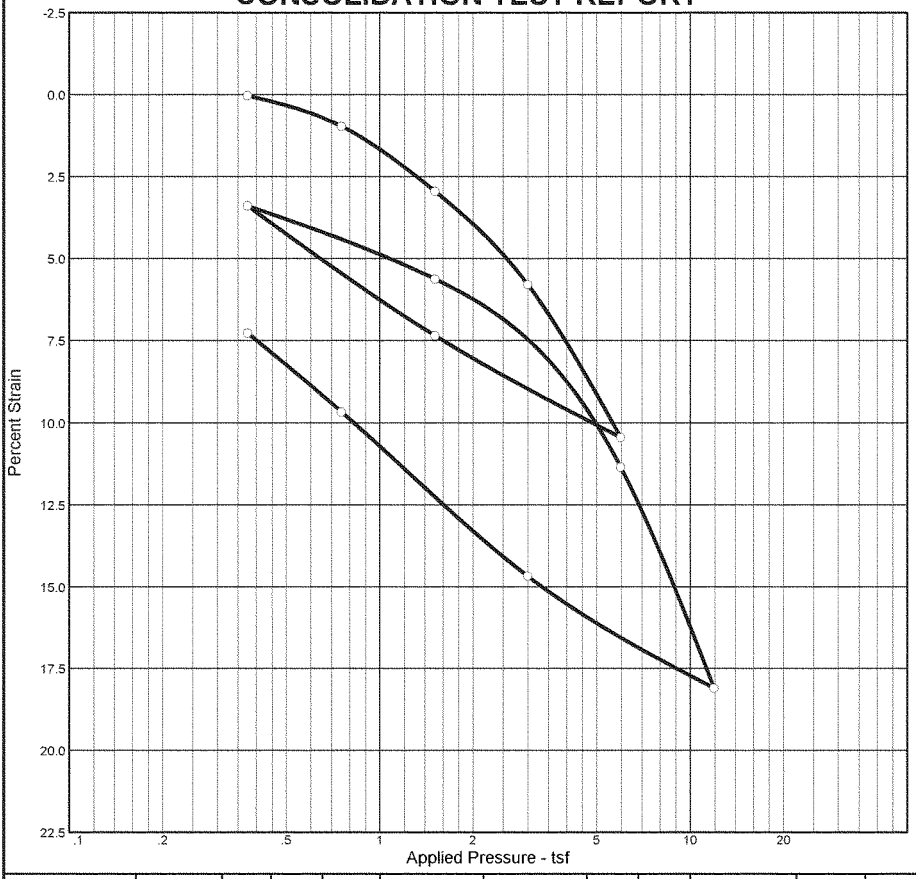


Void Ratio = 1.022 Compression = 23.9 %

D_0 = 0.21670 D_{50} = 0.24838 D_{100} = 0.28006

C_v at 29.3 min. = 0.01 ft.^{2}/day C_α = 0.013

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
97.7 %	53.3 %	68.6	92	73	2.75		3.01	0.65	0.17			1.501

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH)	CH	

Project No. BL0903127A **Client:** US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Location: Boring 09-59MU, #2, 20-22', WD-28, ND Div

BRAUN INTERTEC

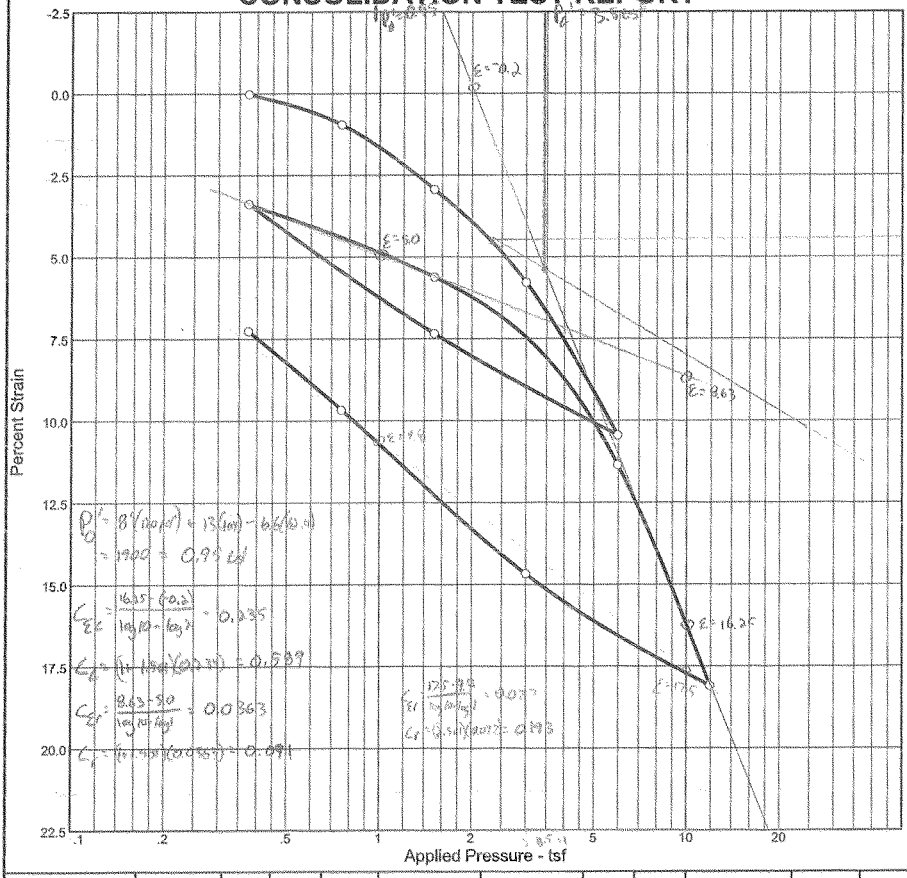
Remarks:

5" Thinwall, Bottom of sample

Fargo
09-59MU, #2, 20' - 22'
Oxidized Brenna

Figure

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
97.7 %	53.3 %	68.6	92	73	2.75		3.01	0.65	0.17			1.501

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH)	CH	

Project No. BL0903127A **Client:** US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

FAR

Location: Boring 09-59MU, #2, 20-22', WD-28, ND Div

Remarks:

5" Thinwall, Bottom of sample

Des, Brenna

GWT= 14.4' BGS

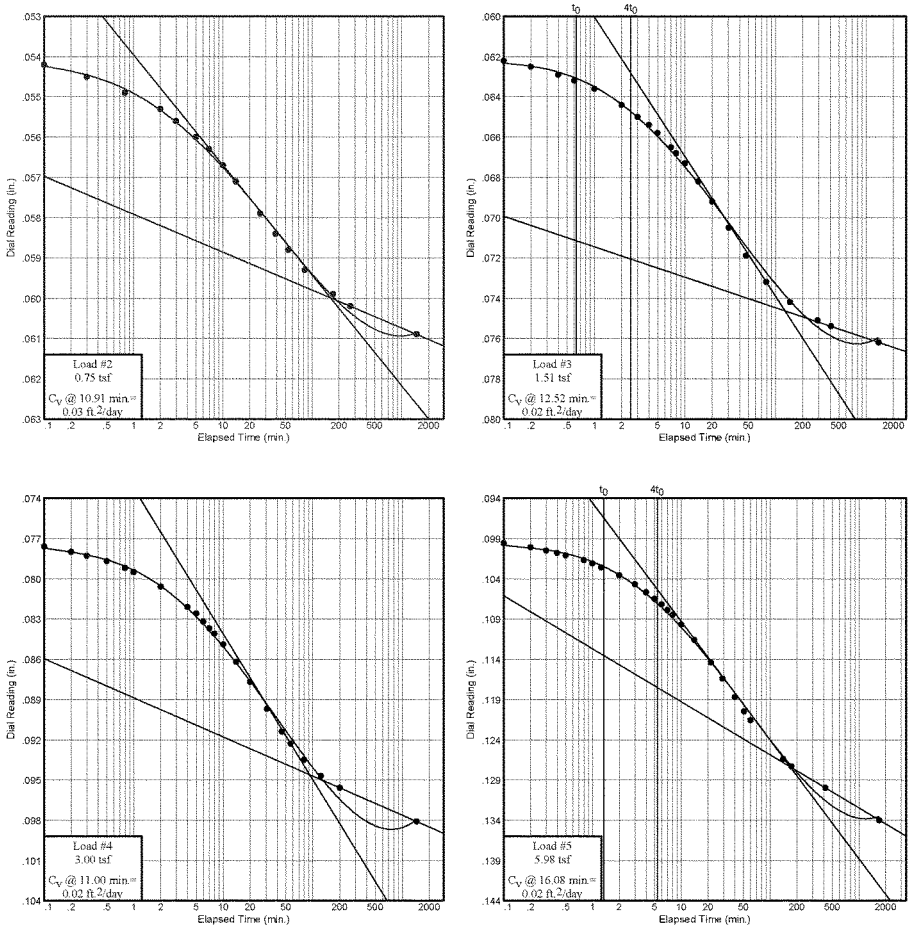
BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL0903127A
Project: Fargo-Moorhead Metro Feasibility Study

Location: Boring 09-59MU, #2, 20-22', WD-28, ND Div Oxidized Brenna



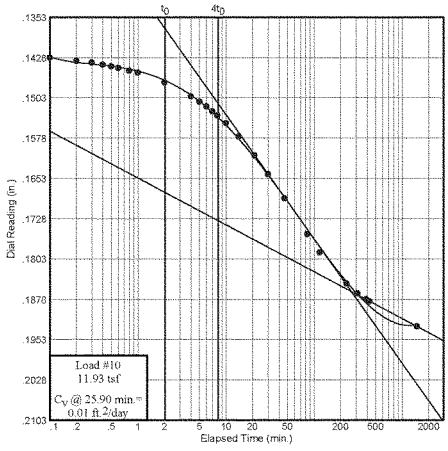
BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL0903127A
Project: Fargo-Moorhead Metro Feasibility Study

Location: Boring 09-59MU, #2, 20-22', WD-28, ND Div Oxidized Brenna



BRAUN INTERTEC

Figure

CONSOLIDATION TEST DATA

Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project Number: BL0903127A

Sample Data

Source:
Sample No.: Boring 09-59MU, #2
Elev. or Depth: 20-22' **Sample Length(in./cm.):**
Location: Boring 09-59MU, #2, 20-22', WD-28, ND Div Oxidized Brenna
Description: FAT CLAY, brown (CH)
Liquid Limit: 92 **Plasticity Index:** 73
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks: 5" Thinwall, Bottom of sample

Test Specimen Data

TOTAL SAMPLE	BEFORE TEST	AFTER TEST
Wet w+t = 138.61 g.	Consolidometer # = 5	Wet w+t =
Dry w+t = 101.00 g.		Dry w+t =
Tare Wt. = 30.49 g.	Spec. Gravity = 2.75	Tare Wt. =
Height = .77 in.	Height = .77 in.	
Diameter = 2.50 in.	Diameter = 2.50 in.	
Weight = 104.55 g.	Defl. Table = Machine5-2009	
Moisture = 53.3 %	Ht. Solids = 0.3080 in.	Moisture = %
Wet Den. = 105.3 pcf	Dry Wt. = 68.18 g.*	Dry Wt. = n/a
Dry Den. = 68.6 pcf	Void Ratio = 1.501	Void Ratio = 1.319
	Saturation = 97.7 %	

* Initial dry weight used in calculations

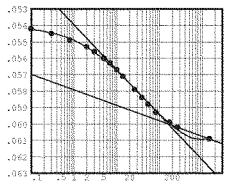
End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v ($ft.^2$/day)	C_α	Void Ratio	% Compression /Swell
start	0.05350				1.501	
0.38	0.05480	0.00110			1.500	0.0 Comprs.
0.75	0.06280	0.00190	0.03	0.001	1.477	1.0 Comprs.
1.51	0.07920	0.00300	0.02	0.002	1.427	2.9 Comprs.
3.00	0.10240	0.00430	0.02	0.004	1.356	5.8 Comprs.
5.98	0.14000	0.00600	0.02	0.009	1.240	10.5 Comprs.
1.51	0.11310	0.00300			1.317	7.3 Comprs.
0.38	0.08070	0.00110			1.416	3.4 Comprs.
1.51	0.09980	0.00300			1.360	5.6 Comprs.
5.98	0.14700	0.00600			1.217	11.4 Comprs.
11.93	0.20120	0.00830	0.01	0.013	1.048	18.1 Comprs.
3.00	0.17090	0.00430			1.134	14.7 Comprs.
0.75	0.12990	0.00190			1.259	9.7 Comprs.
0.38	0.11060	0.00110			1.319	7.3 Comprs.

C_c = 0.65 P_c = 3.01 tsf C_r = 0.17

Pressure: 0.75 tsf | TEST READINGS | Load No. 2

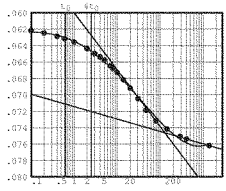
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.05480	11	26.20	0.05980
2	0.10	0.05610	12	39.00	0.06030
3	0.30	0.05640	13	54.00	0.06070
4	0.80	0.05680	14	82.50	0.06120
5	2.00	0.05720	15	171.50	0.06180
6	3.00	0.05750	16	266.50	0.06210
7	5.00	0.05790	17	1473.00	0.06280
8	7.00	0.05820			
9	10.00	0.05860			
10	14.00	0.05900			



Void Ratio = 1.477 Compression = 1.0 %
D_0 = 0.05370 D_{50} = 0.05685 D_{100} = 0.05999
C_v at 10.9 min. = 0.03 ft.^{2}/day C_α = 0.001

Pressure: 1.51 tsf | TEST READINGS | Load No. 3

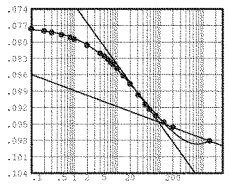
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.06280	12	8.00	0.06980
2	0.10	0.06520	13	10.00	0.07030
3	0.20	0.06550	14	14.00	0.07120
4	0.40	0.06590	15	20.00	0.07220
5	0.60	0.06620	16	30.50	0.07350
6	1.00	0.06660	17	47.50	0.07490
7	2.00	0.06740	18	79.00	0.07620
8	3.00	0.06800	19	144.50	0.07720
9	4.00	0.06840	20	291.00	0.07810
10	5.00	0.06880	21	409.00	0.07840
11	7.00	0.06950	22	1379.50	0.07920



Void Ratio = 1.427 Compression = 2.9 %
D_0 = 0.06141 D_{50} = 0.06802 D_{100} = 0.07463
C_v at 12.5 min. = 0.02 ft.^{2}/day C_α = 0.002

Pressure: 3.00 tsf | TEST READINGS | Load No. 4

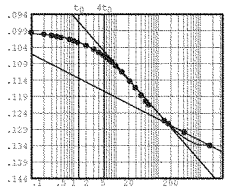
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.07920	13	8.00	0.08840
2	0.10	0.08190	14	10.00	0.08920
3	0.20	0.08230	15	14.00	0.09050
4	0.30	0.08260	16	20.00	0.09200
5	0.50	0.08300	17	31.00	0.09400
6	0.80	0.08350	18	45.00	0.09570
7	1.00	0.08380	19	56.50	0.09660
8	2.00	0.08490	20	80.00	0.09780
9	4.00	0.08640	21	123.00	0.09900
10	5.00	0.08690	22	201.00	0.09990
11	6.00	0.08750	23	1443.00	0.10240
12	7.00	0.08800			



Void Ratio = 1.356 Compression = 5.8 %
D_0 = 0.07620 D_{50} = 0.08541 D_{100} = 0.09461
C_v at 11.0 min. = 0.02 ft.^{2}/day C_α = 0.004

Pressure: 5.98 tsf | TEST READINGS | Load No. 5

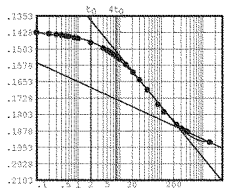
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10240	15	7.00	0.11390
2	0.10	0.10560	16	8.00	0.11450
3	0.20	0.10610	17	10.00	0.11570
4	0.30	0.10650	18	14.00	0.11760
5	0.40	0.10680	19	21.50	0.12040
6	0.50	0.10710	20	29.00	0.12240
7	0.80	0.10770	21	40.00	0.12470
8	1.00	0.10810	22	51.00	0.12650
9	1.25	0.10860	23	60.00	0.12760
10	2.00	0.10960	24	140.50	0.13240
11	3.00	0.11070	25	174.00	0.13330
12	4.00	0.11170	26	420.00	0.13600
13	5.00	0.11250	27	1699.00	0.14000
14	6.00	0.11320			



Void Ratio = 1.240 Compression = 10.5 %
D_0 = 0.09792 D_{50} = 0.11265 D_{100} = 0.12739
C_v at 16.1 min. = 0.02 ft.^{2}/day C_α = 0.009

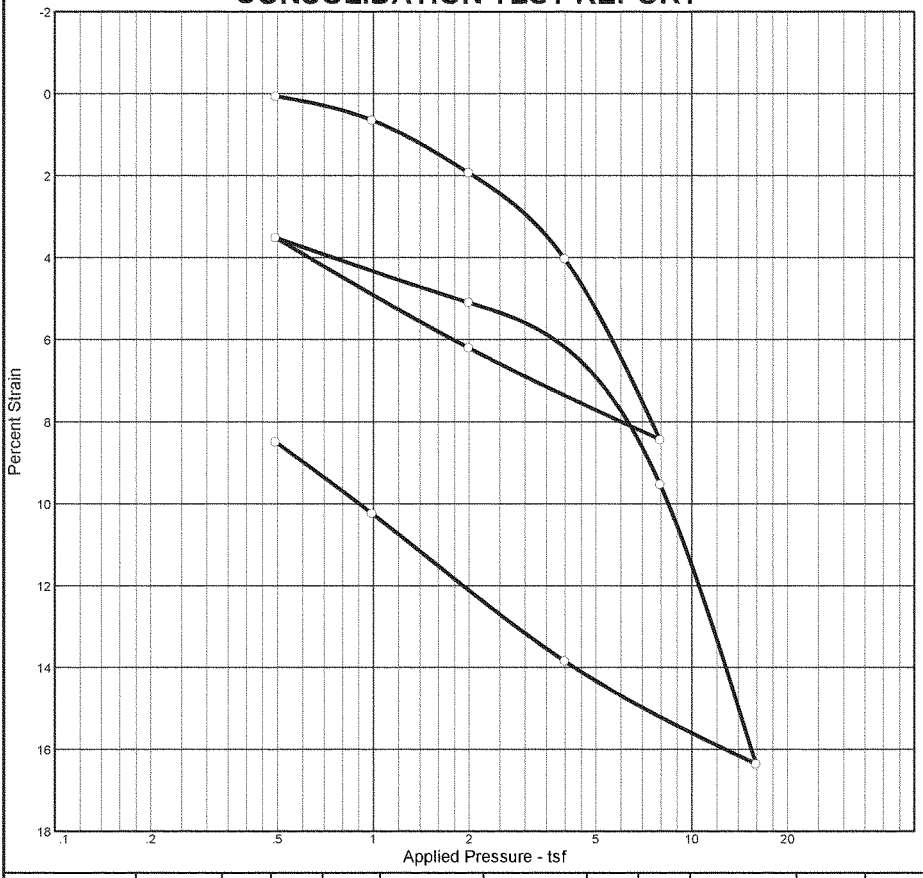
Pressure: 11.93 tsf | TEST READINGS | Load No. 10

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.14700	15	8.00	0.16190
2	0.10	0.15110	16	10.00	0.16330
3	0.20	0.15170	17	14.00	0.16580
4	0.30	0.15200	18	21.00	0.16930
5	0.40	0.15240	19	30.00	0.17280
6	0.50	0.15270	20	46.00	0.17730
7	0.60	0.15300	21	84.00	0.18400
8	0.80	0.15350	22	116.00	0.18740
9	1.00	0.15390	23	234.30	0.19320
10	2.00	0.15570	24	311.50	0.19500
11	4.00	0.15830	25	390.50	0.19610
12	5.00	0.15930	26	426.00	0.19650
13	6.00	0.16020	27	1471.00	0.20120
14	7.00	0.16110			



Void Ratio = 1.048 Compression = 18.1 %
D_0 = 0.14016 D_{50} = 0.16328 D_{100} = 0.18641
C_v at 25.9 min. = 0.01 ft.^{2}/day C_α = 0.013

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
93.6 %	49.1 %	69.8	106	82	2.70		5.58	0.65	0.12			1.416

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH)	CH	

Project No. BL0903127A **Client:** US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Location: Boring 09-60MU, #2, 25-27', WD-05, ND Div, ~~Sheyenne Formation~~

BRAUN INTERTEC

Remarks:

5" Thinwall, Bottom of sample

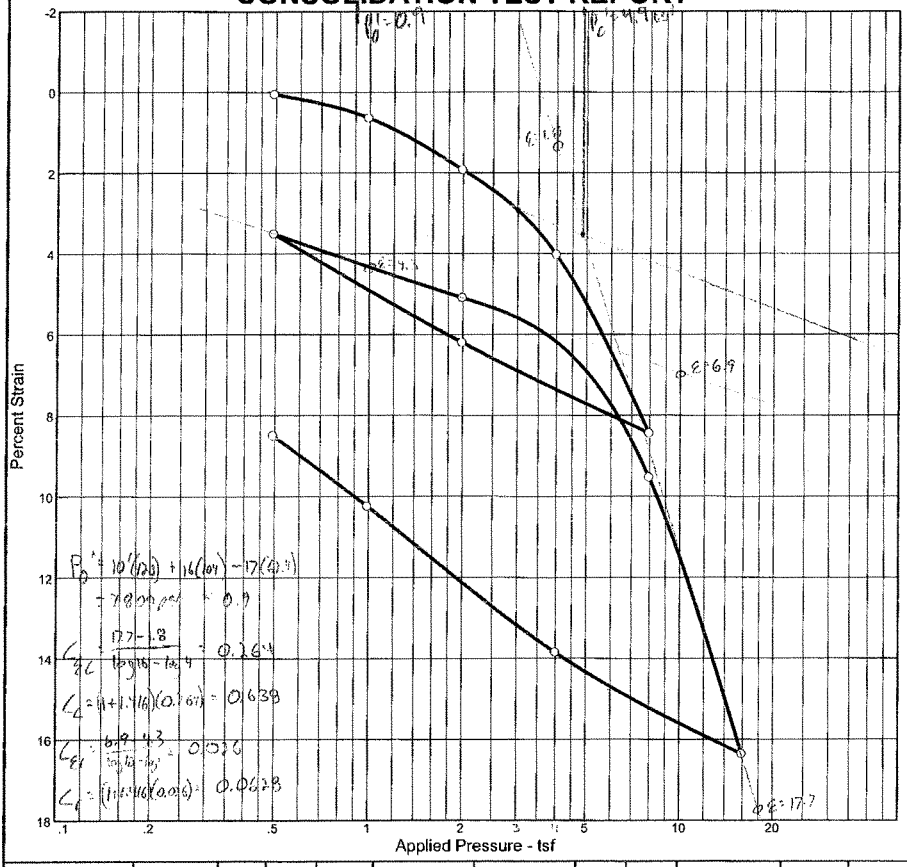
Fargo

09-60MU, #2, 25' - 27'

Oxidized Brenna

Figure

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
93.6 %	49.1 %	69.8	106	82	2.70		5.58	0.65	0.12			1.416

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH)	CH	

Project No. BL0903127A **Client:** US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Location: Boring 09-60MU, #2, 25-27', WD-05, ND Div, ~~Sheyenne~~ Formation

Remarks:
5" Thinwall, Bottom of sample

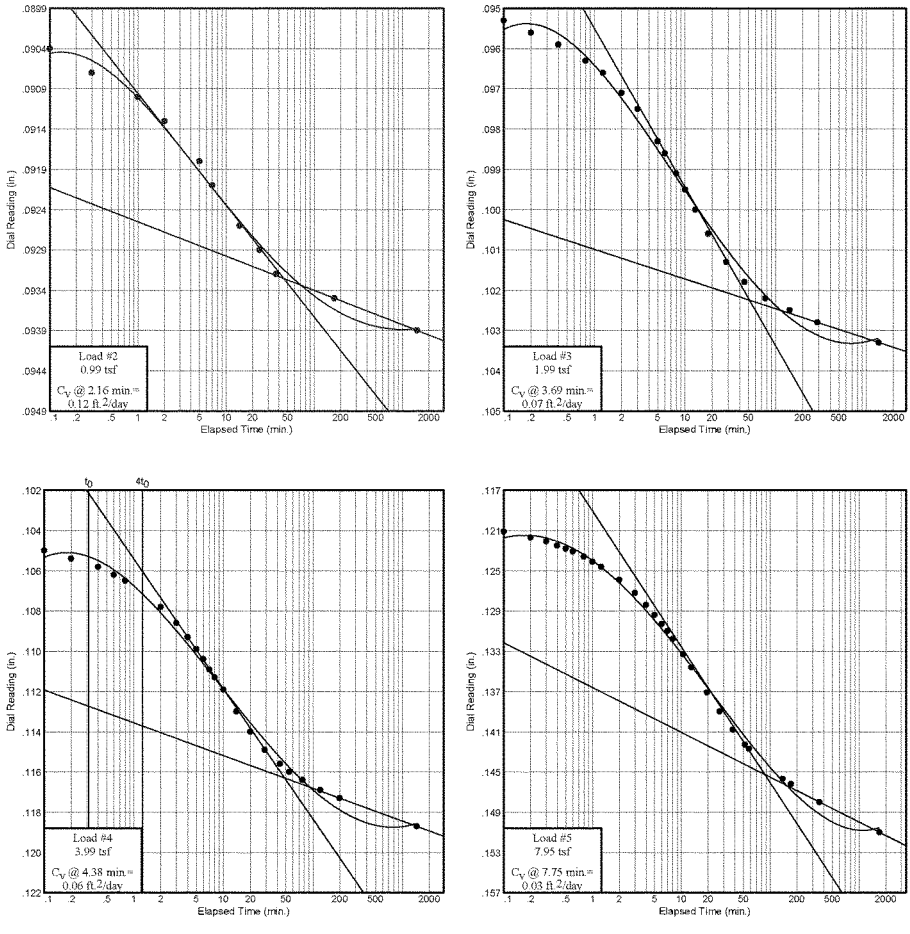
BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL0903127A
Project: Fargo-Moorhead Metro Feasibility Study

Location: Boring 09-60MU, #2, 25-27', WD-05, ND Div, ~~Sheyenne Formation~~ Oxidized Brenna



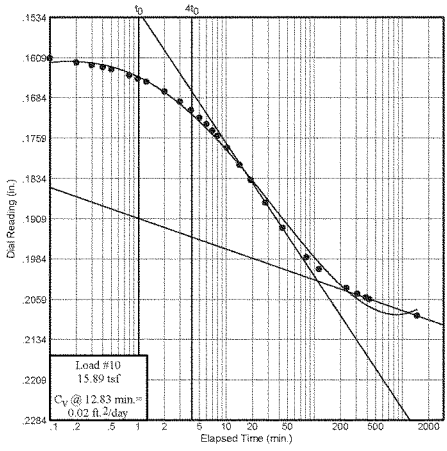
BRAUN™ INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL0903127A
Project: Fargo-Moorhead Metro Feasibility Study

Location: Boring 09-60MU, #2, 25-27', WD-05, ND Div, ~~Sheyenne Formation~~ Oxidized Brenna



BRAUN INTERTEC

Figure

CONSOLIDATION TEST DATA

Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project Number: BL0903127A

Sample Data

Source:
Sample No.: Boring 09-60MU, #2
Elev. or Depth: 25-27' **Sample Length(in./cm.):**
Location: Boring 09-60MU, #2, 25-27', WD-05, ND Div, ~~Sherack Formation~~ Oxidized Brenna
Description: FAT CLAY, brown (CH)
Liquid Limit: 106 **Plasticity Index:** 82
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks: 5" Thinwall, Bottom of sample

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST		AFTER TEST	
Wet w+t	= 154.86 g.	Consolidometer #	= 3	Wet w+t	=
Dry w+t	= 114.23 g.			Dry w+t	=
Tare Wt.	= 31.41 g.	Spec. Gravity	= 2.70	Tare Wt.	=
Height	= .73 in.	Height	= .73 in.		
Diameter	= 2.50 in.	Diameter	= 2.50 in.		
Weight	= 98.00 g.	Defl. Table	= Machine3-2009		
Moisture	= 49.1 %	Ht. Solids	= 0.3032 in.	Moisture	= %
Wet Den.	= 104.0 pcf	Dry Wt.	= 65.75 g.*	Dry Wt.	= n/a
Dry Den.	= 69.8 pcf	Void Ratio	= 1.416	Void Ratio	= 1.211
		Saturation	= 93.6 %		

* Initial dry weight used in calculations

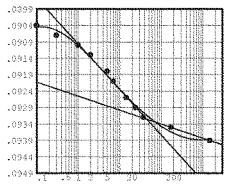
End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v ($ft.^2$/day)	C_α	Void Ratio	% Compression /Swell
start	0.08920				1.416	
0.49	0.09010	0.00050			1.415	0.1 Comprs.
0.99	0.09460	0.00070	0.12	0.001	1.400	0.6 Comprs.
1.99	0.10430	0.00100	0.07	0.001	1.369	1.9 Comprs.
3.99	0.12020	0.00150	0.06	0.002	1.319	4.0 Comprs.
7.95	0.15300	0.00200	0.03	0.006	1.212	8.4 Comprs.
1.99	0.13560	0.00100			1.266	6.2 Comprs.
0.49	0.11540	0.00050			1.331	3.5 Comprs.
1.99	0.12750	0.00100			1.293	5.1 Comprs.
7.95	0.16100	0.00200			1.186	9.5 Comprs.
15.89	0.21190	0.00290	0.02	0.009	1.021	16.4 Comprs.
3.99	0.19210	0.00150			1.081	13.8 Comprs.
0.99	0.16490	0.00070			1.169	10.2 Comprs.
0.49	0.15190	0.00050			1.211	8.5 Comprs.

C_c = 0.65 P_c = 5.58 tsf C_r = 0.12

Pressure: 0.99 tsf | TEST READINGS | Load No. 2

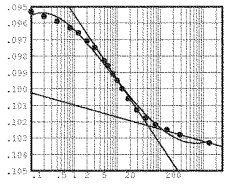
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.09010	11	169.50	0.09420
2	0.10	0.09110	12	1472.00	0.09460
3	0.30	0.09140			
4	1.00	0.09170			
5	2.00	0.09200			
6	5.00	0.09250			
7	7.00	0.09280			
8	14.30	0.09330			
9	24.00	0.09360			
10	37.00	0.09390			



Void Ratio = 1.400 Compression = 0.6 %
D_0 = 0.08960 D_{50} = 0.09143 D_{100} = 0.09326
C_v at 2.2 min. = 0.12 ft.^{2}/day C_α = 0.001

Pressure: 1.99 tsf | TEST READINGS | Load No. 3

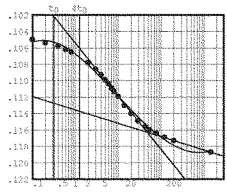
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.09460	11	8.00	0.10010
2	0.10	0.09630	12	10.00	0.10050
3	0.20	0.09660	13	13.00	0.10100
4	0.40	0.09690	14	18.00	0.10160
5	0.80	0.09730	15	28.50	0.10230
6	1.25	0.09760	16	45.50	0.10280
7	2.00	0.09810	17	77.00	0.10320
8	3.00	0.09850	18	142.50	0.10350
9	5.00	0.09930	19	289.00	0.10380
10	6.00	0.09960	20	1378.00	0.10430



Void Ratio = 1.369 Compression = 1.9 %
D_0 = 0.09390 D_{50} = 0.09807 D_{100} = 0.10225
C_v at 3.7 min. = 0.07 ft.^{2}/day C_α = 0.001

Pressure: 3.99 tsf | TEST READINGS | Load No. 4

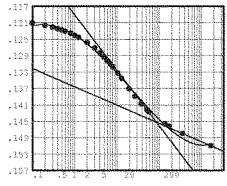
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10430	13	8.00	0.11280
2	0.10	0.10650	14	10.00	0.11340
3	0.20	0.10690	15	14.00	0.11450
4	0.40	0.10730	16	20.00	0.11550
5	0.60	0.10770	17	29.00	0.11640
6	0.80	0.10800	18	43.00	0.11710
7	2.00	0.10930	19	54.50	0.11750
8	3.00	0.11010	20	77.00	0.11790
9	4.00	0.11080	21	121.00	0.11840
10	5.00	0.11140	22	199.00	0.11880
11	6.00	0.11190	23	1441.00	0.12020
12	7.00	0.11240			



Void Ratio = 1.319 Compression = 4.0 %
D_0 = 0.10344 D_{50} = 0.10987 D_{100} = 0.11630
C_v at 4.4 min. = 0.06 ft.^{2}/day C_α = 0.002

Pressure: 7.95 tsf | TEST READINGS | Load No. 5

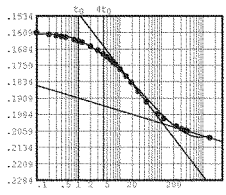
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.12020	15	6.00	0.13230
2	0.10	0.12310	16	7.00	0.13300
3	0.20	0.12370	17	8.00	0.13380
4	0.30	0.12410	18	10.50	0.13530
5	0.40	0.12450	19	13.00	0.13660
6	0.50	0.12480	20	19.50	0.13910
7	0.60	0.12510	21	27.00	0.14100
8	0.80	0.12560	22	38.00	0.14280
9	1.00	0.12610	23	52.00	0.14430
10	1.25	0.12660	24	58.00	0.14470
11	2.00	0.12790	25	138.50	0.14770
12	3.00	0.12920	26	172.00	0.14820
13	4.00	0.13040	27	360.00	0.15000
14	5.00	0.13140	28	1697.00	0.15300



Void Ratio = 1.212 Compression = 8.4 %
D_0 = 0.11870 D_{50} = 0.13198 D_{100} = 0.14525
C_v at 7.7 min. = 0.03 ft.^{2}/day C_α = 0.006

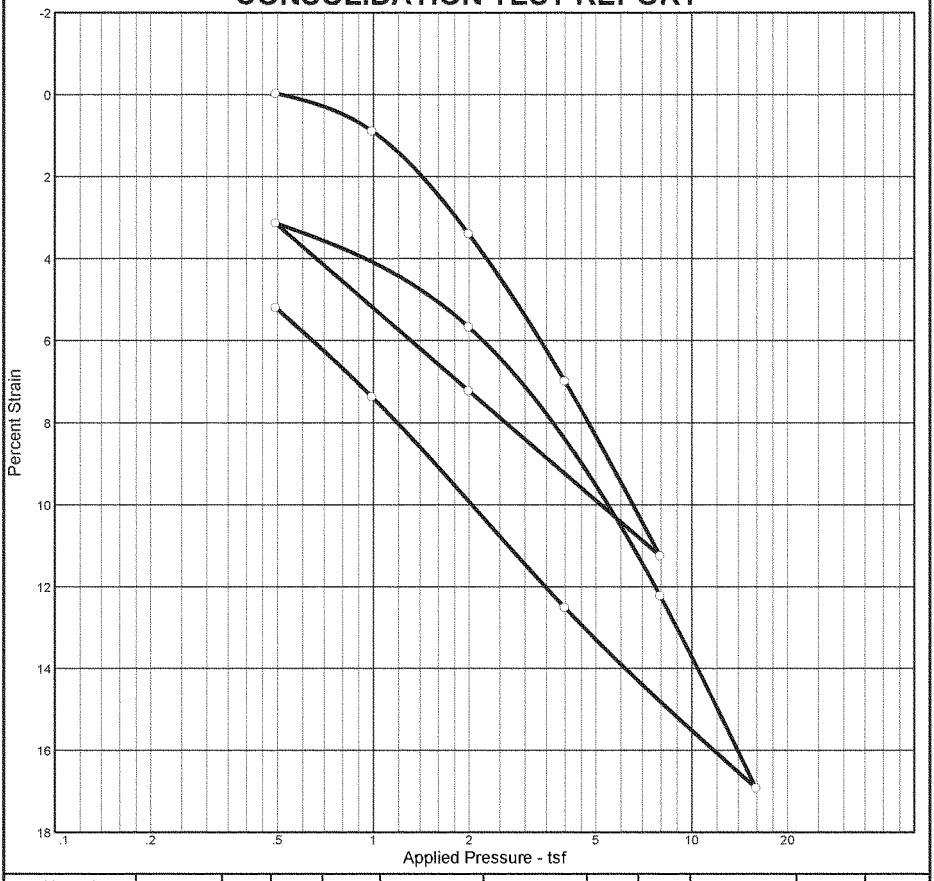
Pressure: 15.89 tsf | TEST READINGS | Load No. 10

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.16100	15	7.00	0.17740
2	0.10	0.16390	16	8.00	0.17840
3	0.20	0.16470	17	10.25	0.18060
4	0.30	0.16520	18	14.30	0.18380
5	0.40	0.16560	19	19.00	0.18660
6	0.50	0.16600	20	28.00	0.19080
7	0.80	0.16710	21	44.00	0.19550
8	1.00	0.16770	22	82.00	0.20100
9	1.25	0.16830	23	114.00	0.20320
10	2.00	0.17010	24	232.30	0.20670
11	3.00	0.17200	25	309.50	0.20780
12	4.00	0.17360	26	388.50	0.20850
13	5.00	0.17500	27	424.00	0.20880
14	6.00	0.17620	28	1469.00	0.21190



Void Ratio = 1.021 Compression = 16.4 %
D_0 = 0.15756 D_{50} = 0.18005 D_{100} = 0.20253
C_v at 12.8 min. = 0.02 ft.^{2}/day C_α = 0.009

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
99.0 %	48.0 %	73.9	113	81	2.777		1.69	0.37	0.17			1.346

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2850		

Project No. BL-10-10065 **Client:** W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

Location: Boring 10-105MU, #1, 15-17', Maple River, Dessicated Brenna

BRAUN INTERTEC

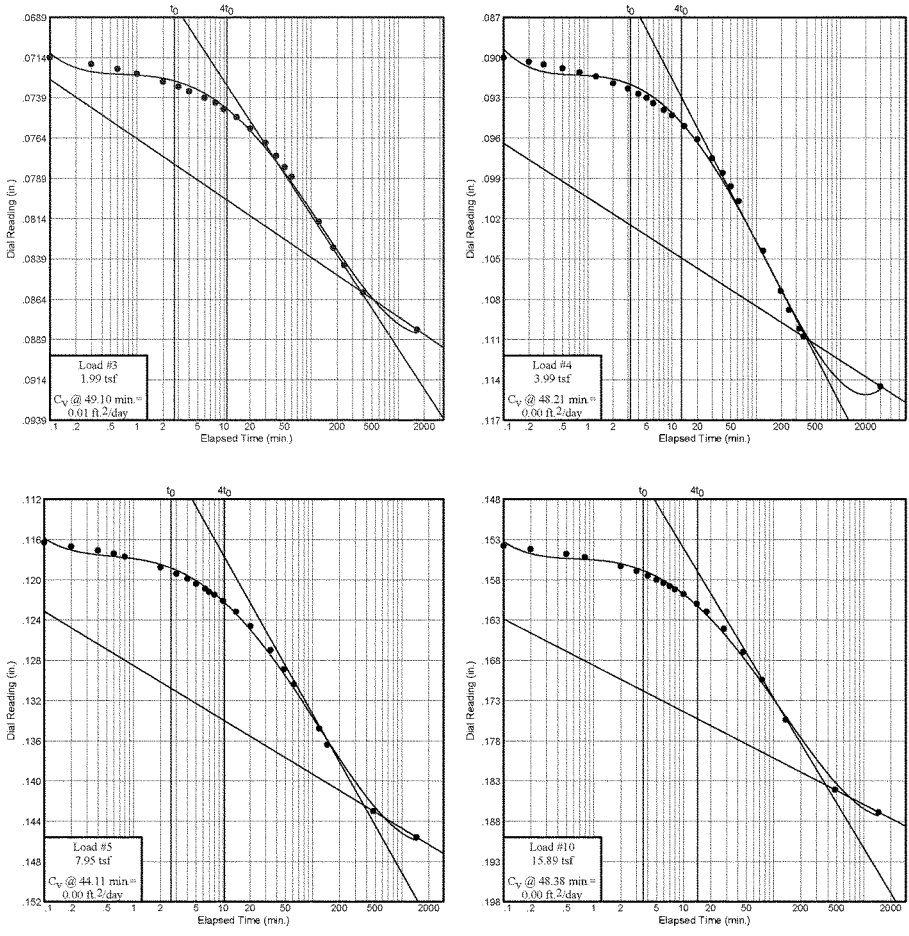
Remarks:

Load #3 Cv = 0.0050 ft2/day
Load #4 Cv = 0.0047 ft2/day
Load #5 Cv = 0.0047 ft2/day
Load #10 Cv = 0.0037 ft2/day

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Boring 10-105MU, #1, 15-17', Maple River, Dessicated Brenna



BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: Boring 10-105MU, #1
Elev. or Depth: 15-17' **Sample Length(in./cm.):**
Location: Boring 10-105MU, #1, 15-17', Maple River, Dessicated Brenna
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2850
Liquid Limit: 113 **Plasticity Index:** 81
USCS: **AASHTO:** **Figure No.:**
Testing Remarks: Load #3 Cv = 0.0050 ft2/day
Load #4 Cv = 0.0047 ft2/day
Load #5 Cv = 0.0047 ft2/day
Load #10 Cv = 0.0037 ft2/day

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	143.26 g.	Consolidometer # = 3	Wet w+t =
Dry w+t =	106.79 g.		Dry w+t =
Tare Wt. =	30.80 g.	Spec. Gravity = 2.777	Tare Wt. =
Height =	.73 in.	Height = .73 in.	
Diameter =	2.50 in.	Diameter = 2.50 in.	
Weight =	102.56 g.	Defl. Table = Machine3-2009	
Moisture =	48.0 %	Ht. Solids = 0.3107 in.	Moisture = %
Wet Den. =	109.4 pcf	Dry Wt. = 69.30 g.*	Dry Wt. = n/a
Dry Den. =	73.9 pcf	Void Ratio = 1.346	Void Ratio = 1.224
		Saturation = 99.0 %	

* Initial dry weight used in calculations

End-of-Load Summary

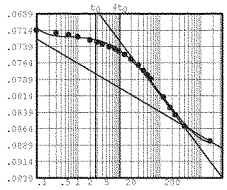
Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.06360				1.346	
0.49	0.06380	0.00050			1.347	0.0 Swell
0.99	0.07070	0.00070			1.325	0.9 Comprs.
1.99	0.08930	0.00100	0.01	0.005	1.267	3.4 Comprs.
3.99	0.11600	0.00150	0.00	0.006	1.182	7.0 Comprs.
7.95	0.14760	0.00200	0.00	0.008	1.082	11.2 Comprs.
1.99	0.11720	0.00100			1.177	7.2 Comprs.
0.49	0.08690	0.00050			1.273	3.1 Comprs.
1.99	0.10590	0.00100			1.213	5.7 Comprs.
7.95	0.15470	0.00200			1.059	12.2 Comprs.
15.89	0.18980	0.00290	0.00	0.009	0.949	16.9 Comprs.

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
3.99	0.15630	0.00150			1.053	12.5 Comprs.
0.99	0.11800	0.00070			1.173	7.4 Comprs.
0.49	0.10190	0.00050			1.224	5.2 Comprs.

C_c = 0.37 P_c = 1.69 tsf C_r = 0.17

Pressure: 1.99 tsf TEST READINGS **Load No. 3**

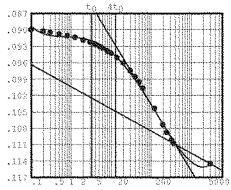
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.07070	12	14.00	0.07610
2	0.10	0.07240	13	20.00	0.07680
3	0.30	0.07280	14	30.00	0.07770
4	0.60	0.07310	15	40.00	0.07850
5	1.00	0.07340	16	50.00	0.07920
6	2.00	0.07390	17	60.00	0.07980
7	3.00	0.07420	18	123.00	0.08260
8	4.00	0.07450	19	180.00	0.08420
9	6.00	0.07490	20	240.00	0.08530
10	8.00	0.07520	21	395.00	0.08700
11	10.00	0.07560	22	1662.00	0.08930



Void Ratio = 1.267 Compression = 3.4 %
D_0 = 0.07111 D_{50} = 0.07851 D_{100} = 0.08591
C_v at 49.1 min. = 0.01 ft.^{2}/day C_α = 0.005

Pressure: 3.99 tsf TEST READINGS **Load No. 4**

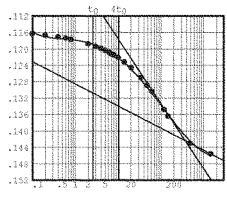
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08930	14	10.00	0.09580
2	0.10	0.09150	15	14.00	0.09660
3	0.20	0.09180	16	20.00	0.09760
4	0.30	0.09200	17	30.00	0.09900
5	0.50	0.09230	18	40.00	0.10010
6	0.80	0.09260	19	50.00	0.10110
7	1.25	0.09290	20	62.00	0.10220
8	2.00	0.09340	21	121.00	0.10590
9	3.00	0.09380	22	195.00	0.10890
10	4.00	0.09420	23	246.00	0.11030
11	5.00	0.09450	24	324.00	0.11170
12	6.00	0.09490	25	364.00	0.11230
13	8.00	0.09540	26	2985.00	0.11600



Void Ratio = 1.182 Compression = 7.0 %
D_0 = 0.08915 D_{50} = 0.10005 D_{100} = 0.11095
C_v at 48.2 min. = 0.00 ft.^{2}/day C_α = 0.006

Pressure: 7.95 tsf — TEST READINGS — Load No. 5

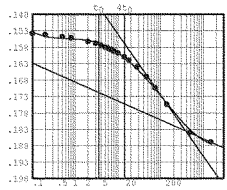
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.11600	13	8.00	0.12350
2	0.10	0.11830	14	10.00	0.12410
3	0.20	0.11870	15	14.00	0.12520
4	0.40	0.11910	16	20.30	0.12660
5	0.60	0.11940	17	34.00	0.12900
6	0.80	0.11970	18	48.00	0.13090
7	2.00	0.12080	19	62.00	0.13240
8	3.00	0.12140	20	119.00	0.13680
9	4.00	0.12190	21	146.50	0.13840
10	5.00	0.12240	22	480.00	0.14500
11	6.30	0.12290	23	1457.00	0.14760
12	7.00	0.12320			



Void Ratio = 1.082 Compression = 11.2 %
D_0 = 0.11537 D_{50} = 0.12890 D_{100} = 0.14244
C_v at 44.1 min. = 0.00 ft.^{2}/day C_α = 0.008

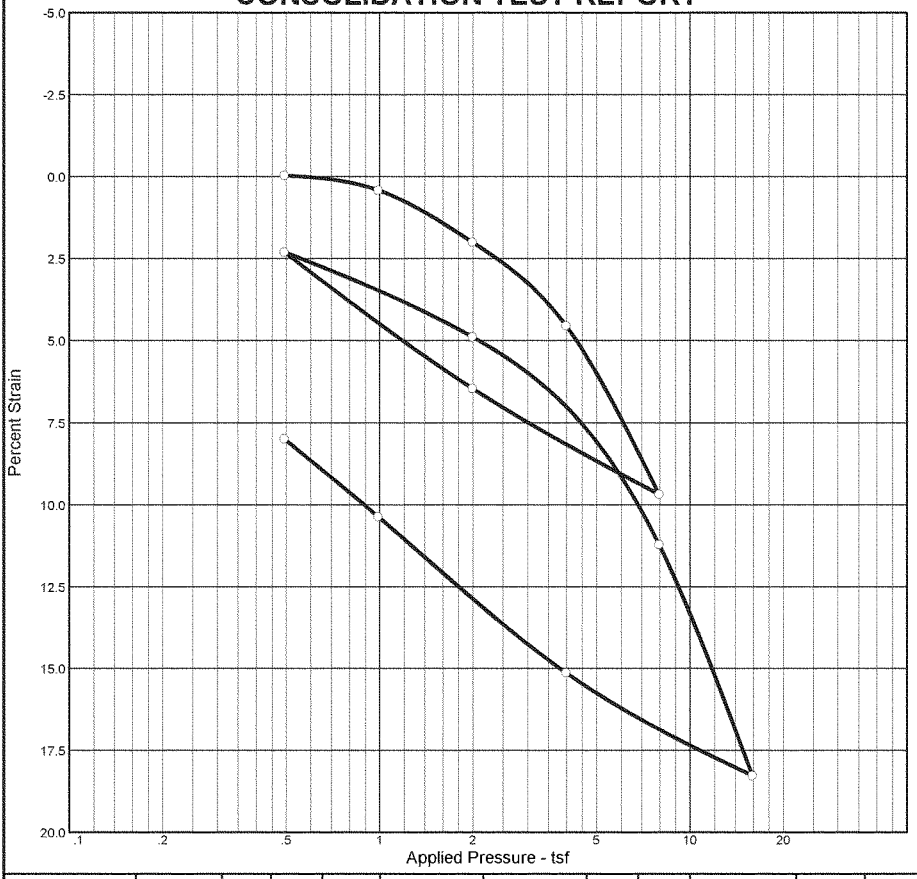
Pressure: 15.89 tsf — TEST READINGS — Load No. 10

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.15470	12	8.00	0.16210
2	0.10	0.15670	13	10.00	0.16270
3	0.20	0.15710	14	14.00	0.16390
4	0.50	0.15770	15	18.00	0.16490
5	0.80	0.15810	16	28.00	0.16700
6	2.00	0.15920	17	46.00	0.16990
7	3.00	0.15980	18	74.00	0.17330
8	4.00	0.16040	19	137.00	0.17830
9	5.00	0.16090	20	480.00	0.18700
10	6.00	0.16130	21	1469.00	0.18980
11	7.00	0.16170			



Void Ratio = 0.949 Compression = 16.9 %
D_0 = 0.15245 D_{50} = 0.16799 D_{100} = 0.18352
C_v at 48.4 min. = 0.00 ft.^{2}/day C_α = 0.009

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
Sat.	Moist.											
99.3 %	44.0 %	76.8	82	59	2.710		3.42	0.57	0.15			1.202

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2435	CH	

Project No. BL-10-10065 **Client:** W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

Location: Boring11-110MU, #1, 25-27', Sheyenne River, OX Brenna Formation

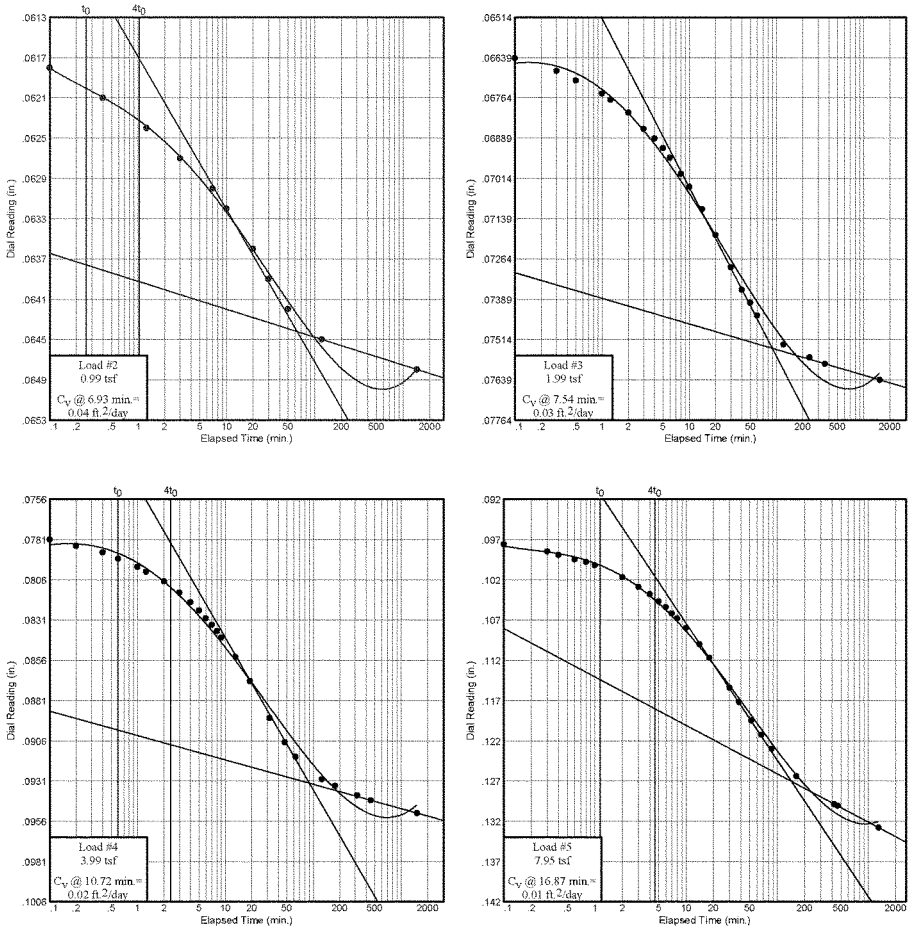
Remarks:

BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Boring11-110MU, #1, 25-27', Sheyenne River, OX Brenna Formation

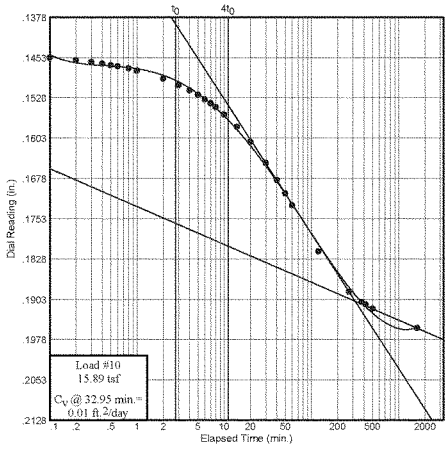


BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Boring11-110MU, #1, 25-27', Sheyenne River, OX Brenna Formation



BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: 11-110, #1
Elev. or Depth: 25-27 **Sample Length(in./cm.):**
Location: Boring11-110MU, #1, 25-27', Sheyenne River, OX Brenna Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2435
Liquid Limit: 82 **Plasticity Index:** 59
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	142.37 g.	Consolidometer # = 3	Wet w+t =
Dry w+t =	108.25 g.		Dry w+t =
Tare Wt. =	30.78 g.	Spec. Gravity = 2.710	Tare Wt. =
Height =	.73 in.	Height = .73 in.	
Diameter =	2.50 in.	Diameter = 2.50 in.	
Weight =	104.36 g.	Defl. Table = Machine3-2009	
Moisture =	44.0 %	Ht. Solids = 0.3329 in.	Moisture = %
Wet Den. =	110.7 pcf	Dry Wt. = 72.45 g.*	Dry Wt. = n/a
Dry Den. =	76.8 pcf	Void Ratio = 1.202	Void Ratio = 1.026
		Saturation = 99.3 %	

* Initial dry weight used in calculations

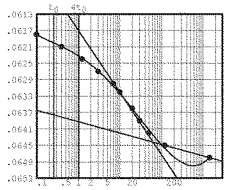
End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.06180				1.202	
0.49	0.06200	0.00050			1.203	0.0 Swell
0.99	0.06550	0.00070	0.04	0.000	1.193	0.4 Comprs.
1.99	0.07740	0.00100	0.03	0.001	1.158	2.0 Comprs.
3.99	0.09660	0.00150	0.02	0.002	1.102	4.5 Comprs.
7.95	0.13480	0.00200	0.01	0.009	0.989	9.7 Comprs.
1.99	0.11010	0.00100			1.060	6.5 Comprs.
0.49	0.07910	0.00050			1.151	2.3 Comprs.
1.99	0.09860	0.00100			1.094	4.9 Comprs.
7.95	0.14600	0.00200			0.955	11.2 Comprs.
15.89	0.19860	0.00290	0.01	0.011	0.800	18.3 Comprs.
3.99	0.17420	0.00150			0.869	15.1 Comprs.
0.99	0.13850	0.00070			0.974	10.4 Comprs.
0.49	0.12090	0.00050			1.026	8.0 Comprs.

C_c = 0.57 P_c = 3.42 tsf C_r = 0.15

Pressure: 0.99 tsf TEST READINGS Load No. 2

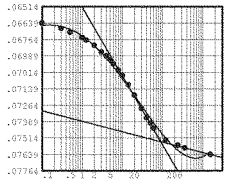
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.06200	11	120.00	0.06520
2	0.10	0.06250	12	1439.00	0.06550
3	0.40	0.06280			
4	1.25	0.06310			
5	3.00	0.06340			
6	7.00	0.06370			
7	10.00	0.06390			
8	20.00	0.06430			
9	30.00	0.06460			
10	50.00	0.06490			



Void Ratio = 1.193 Compression = 0.4 %
D_0 = 0.06168 D_{50} = 0.06305 D_{100} = 0.06442
C_v at 6.9 min. = 0.04 ft.^{2}/day C_α = 0.000

Pressure: 1.99 tsf TEST READINGS Load No. 3

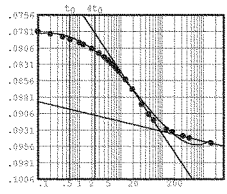
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.06550	13	10.00	0.07140
2	0.10	0.06740	14	14.00	0.07210
3	0.30	0.06780	15	20.00	0.07290
4	0.50	0.06810	16	30.00	0.07390
5	1.00	0.06850	17	40.00	0.07460
6	1.25	0.06870	18	50.00	0.07500
7	2.00	0.06910	19	60.00	0.07540
8	3.00	0.06960	20	120.00	0.07630
9	4.00	0.06990	21	240.00	0.07670
10	5.00	0.07020	22	360.00	0.07690
11	6.00	0.07050	23	1529.00	0.07740
12	8.00	0.07100			



Void Ratio = 1.158 Compression = 2.0 %
D_0 = 0.06480 D_{50} = 0.07011 D_{100} = 0.07542
C_v at 7.5 min. = 0.03 ft.^{2}/day C_α = 0.001

Pressure: 3.99 tsf — TEST READINGS — Load No. 4

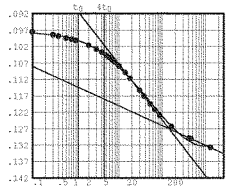
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.07740	14	8.00	0.08530
2	0.10	0.07960	15	9.00	0.08570
3	0.20	0.08000	16	13.00	0.08690
4	0.40	0.08040	17	19.00	0.08840
5	0.60	0.08080	18	32.00	0.09070
6	1.00	0.08130	19	47.30	0.09220
7	1.25	0.08160	20	63.00	0.09310
8	2.00	0.08220	21	126.00	0.09450
9	3.00	0.08290	22	177.00	0.09490
10	4.00	0.08350	23	317.00	0.09550
11	5.00	0.08400	24	452.00	0.09580
12	6.00	0.08450	25	1523.00	0.09660
13	7.00	0.08490			



Void Ratio = 1.102 Compression = 4.5 %
D_0 = 0.07681 D_{50} = 0.08503 D_{100} = 0.09324
C_v at 10.7 min. = 0.02 ft.^{2}/day C_α = 0.002

Pressure: 7.95 tsf — TEST READINGS — Load No. 5

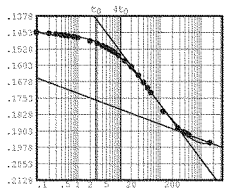
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.09660	14	8.00	0.10880
2	0.10	0.09960	15	10.00	0.11000
3	0.30	0.10050	16	14.00	0.11200
4	0.40	0.10090	17	18.00	0.11370
5	0.60	0.10150	18	30.00	0.11740
6	0.80	0.10180	19	38.00	0.11920
7	1.00	0.10220	20	52.00	0.12150
8	2.00	0.10370	21	67.00	0.12330
9	3.00	0.10490	22	87.00	0.12500
10	4.00	0.10580	23	163.00	0.12840
11	5.00	0.10670	24	421.00	0.13190
12	6.00	0.10740	25	462.00	0.13210
13	7.00	0.10820	26	1299.00	0.13480



Void Ratio = 0.989 Compression = 9.7 %
D_0 = 0.09586 D_{50} = 0.11145 D_{100} = 0.12704
C_v at 16.9 min. = 0.01 ft.^{2}/day C_α = 0.009

Pressure: 15.89 tsf | TEST READINGS | Load No. 10

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.14600	16	8.00	0.15740
2	0.10	0.14820	17	10.00	0.15880
3	0.20	0.14870	18	14.00	0.16110
4	0.30	0.14900	19	20.00	0.16390
5	0.40	0.14930	20	30.00	0.16780
6	0.50	0.14960	21	40.00	0.17100
7	0.60	0.14980	22	50.00	0.17350
8	0.80	0.15020	23	60.00	0.17570
9	1.00	0.15060	24	120.00	0.18430
10	2.00	0.15210	25	270.00	0.19180
11	3.00	0.15330	26	376.00	0.19370
12	4.00	0.15430	27	420.00	0.19420
13	5.00	0.15510	28	503.00	0.19500
14	6.00	0.15600	29	1629.00	0.19860
15	7.00	0.15670			

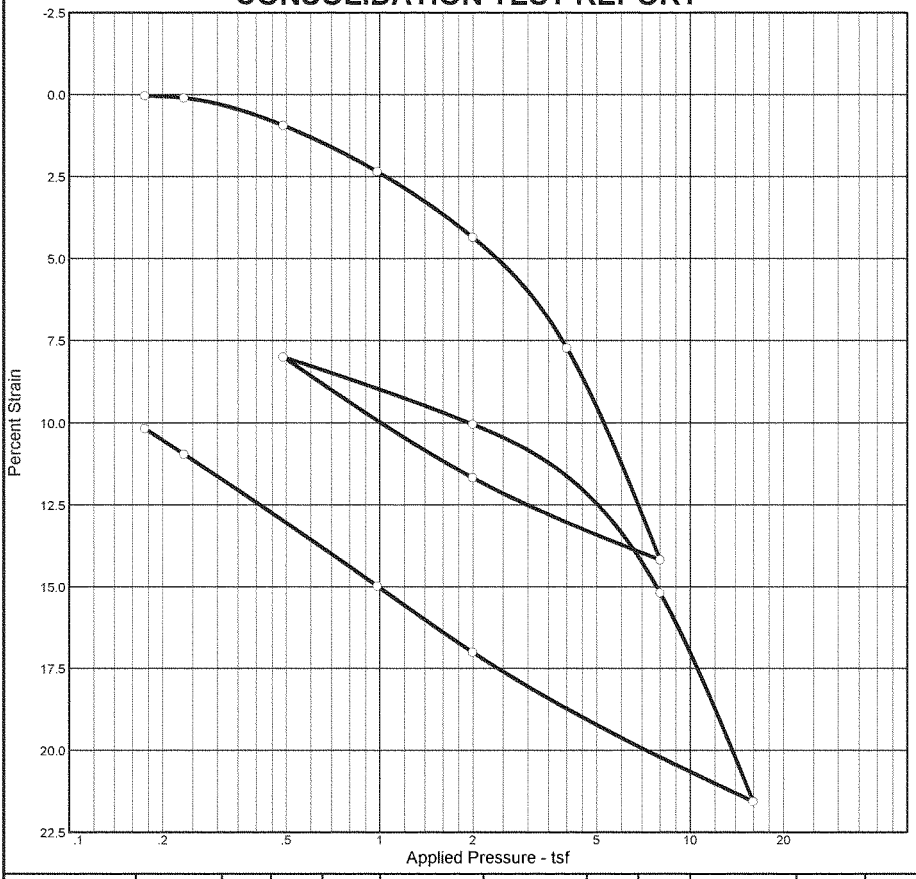


Void Ratio = 0.800 Compression = 18.3 %

D_0 = 0.14215 D_{50} = 0.16642 D_{100} = 0.19069

C_v at 32.9 min. = 0.01 ft.^{2}/day C_α = 0.011

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
99.4 %	47.8 %	74.1	91	67	2.767		3.61	0.57	0.14			1.332

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2435	CH	

Project No. BL-10-10065 **Client:** USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2

Location: Boring11-118MU, #1, 20-21', Wild Rice, OX Brenna Formation

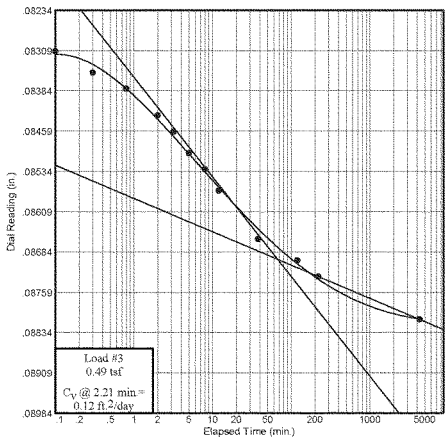
Remarks:

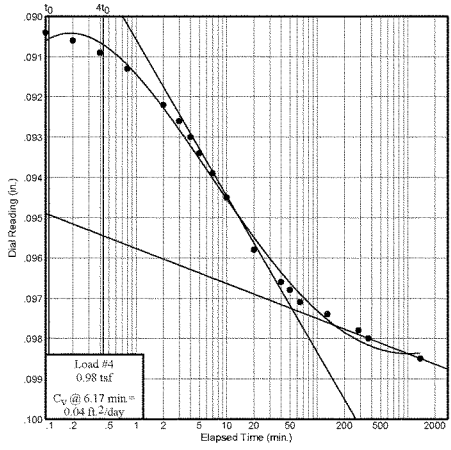
BRAUN INTERTEC

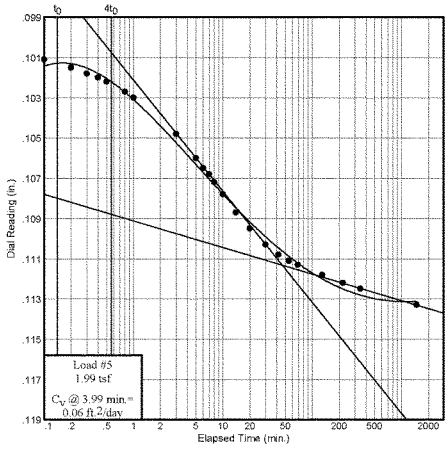
Figure

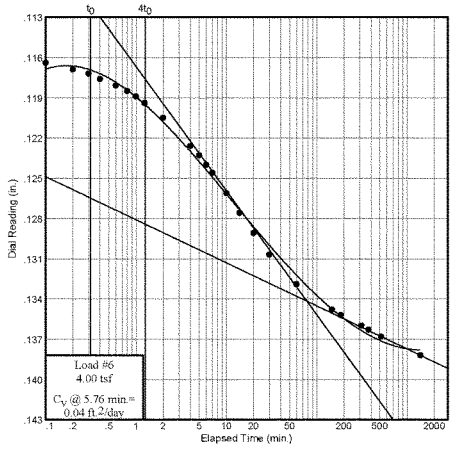
Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Location: Boring11-118MU, #1, 20-21', Wild Rice, OX Brenna Formation







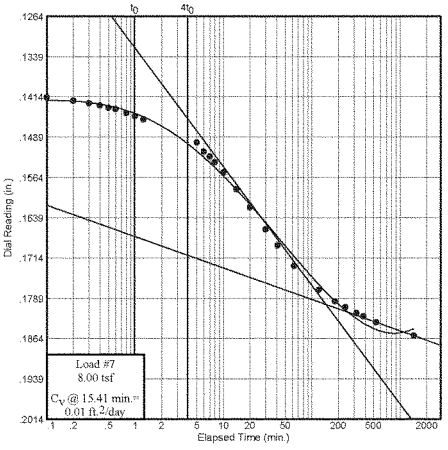


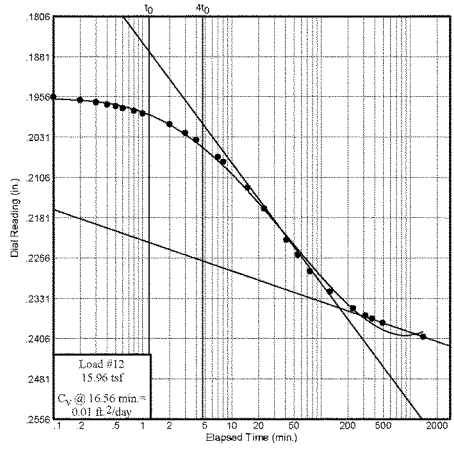
BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Location: Boring11-118MU, #1, 20-21', Wild Rice, OX Brenna Formation





BRAUN™ INTERTEC

Figure

CONSOLIDATION TEST DATA

Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: Boring11-118MU, #1
Elev. or Depth: 20-21' **Sample Length(in./cm.):**
Location: Boring11-118MU, #1, 20-21', Wild Rice, OX Brenna Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2435
Liquid Limit: 91 **Plasticity Index:** 67
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	166.81 g.	Consolidometer # = 4	Wet w+t =
Dry w+t =	122.73 g.		Dry w+t =
Tare Wt. =	30.56 g.	Spec. Gravity = 2.767	Tare Wt. =
Height =	.74 in.	Height = .74 in.	
Diameter =	2.49 in.	Diameter = 2.49 in.	
Weight =	103.73 g.	Defl. Table = Machine4-2009	
Moisture =	47.8 %	Ht. Solids = 0.3165 in.	Moisture = %
Wet Den. =	109.5 pcf	Dry Wt. = 70.17 g.*	Dry Wt. = n/a
Dry Den. =	74.1 pcf	Void Ratio = 1.332	Void Ratio = 1.094
		Saturation = 99.4 %	

* Initial dry weight used in calculations

End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.08120				1.332	
0.18	0.08140	0.00000			1.331	0.0 Comprs.
0.23	0.08240	0.00050			1.329	0.1 Comprs.
0.49	0.08890	0.00080	0.12	0.001	1.310	0.9 Comprs.
0.98	0.09950	0.00100	0.04	0.001	1.277	2.3 Comprs.
1.99	0.11480	0.00150	0.06	0.002	1.230	4.3 Comprs.
4.00	0.14020	0.00200	0.04	0.005	1.151	7.7 Comprs.
8.00	0.18860	0.00270	0.01	0.009	1.001	14.2 Comprs.
1.99	0.16890	0.00150			1.059	11.7 Comprs.
0.49	0.14100	0.00080			1.145	8.0 Comprs.
1.99	0.15690	0.00150			1.097	10.1 Comprs.
8.00	0.19600	0.00270			0.977	15.2 Comprs.
15.96	0.24390	0.00360	0.01	0.009	0.829	21.6 Comprs.
1.99	0.20820	0.00150			0.935	17.0 Comprs.

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v ($ft.^2$/day)	C_α	Void Ratio	% Compression /Swell
0.98	0.19280	0.00100			0.982	15.0 Comprs.
0.23	0.16260	0.00050			1.076	11.0 Comprs.
0.18	0.15630	0.00000			1.094	10.2 Comprs.

C_c = 0.57 P_c = 3.61 tsf C_r = 0.14

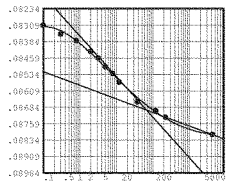
Pressure: 0.23 tsf TEST READINGS Load No. 2

No.	Elapsed Time	Dial Reading
1	0.00	0.08140
2	0.10	0.08170
3	13.50	0.08200
4	1348.00	0.08240

Void Ratio = 1.329 Compression = 0.1 %

Pressure: 0.49 tsf TEST READINGS Load No. 3

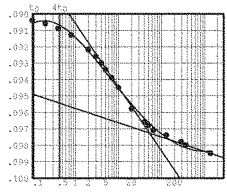
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08240	11	120.00	0.08780
2	0.10	0.08390	12	222.00	0.08810
3	0.30	0.08430	13	4312.00	0.08890
4	0.80	0.08460			
5	2.00	0.08510			
6	3.20	0.08540			
7	5.00	0.08580			
8	8.00	0.08610			
9	12.00	0.08650			
10	38.00	0.08740			



Void Ratio = 1.310 Compression = 0.9 %
D_0 = 0.08190 D_{50} = 0.08444 D_{100} = 0.08698
C_v at 2.2 min. = 0.12 $ft.^2$/day C_α = 0.001

Pressure: 0.98 tsf TEST READINGS Load No. 4

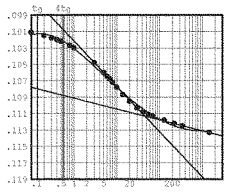
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08890	11	10.00	0.09550
2	0.10	0.09140	12	20.00	0.09680
3	0.20	0.09160	13	40.00	0.09760
4	0.40	0.09190	14	50.00	0.09780
5	0.80	0.09230	15	65.00	0.09810
6	2.00	0.09320	16	130.00	0.09840
7	3.00	0.09360	17	286.00	0.09880
8	4.00	0.09400	18	369.00	0.09900
9	5.00	0.09440	19	1385.00	0.09950
10	7.00	0.09490			



Void Ratio = 1.277 Compression = 2.3 %
D_0 = 0.09042 D_{50} = 0.09384 D_{100} = 0.09726
C_v at 6.2 min. = 0.04 $ft.^2$/day C_α = 0.001

Pressure: 1.99 tsf — TEST READINGS — Load No. 5

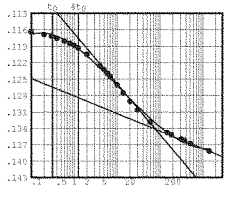
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.09950	13	8.00	0.10870
2	0.10	0.10260	14	10.00	0.10930
3	0.20	0.10300	15	14.00	0.11020
4	0.30	0.10330	16	20.00	0.11100
5	0.40	0.10350	17	30.00	0.11180
6	0.50	0.10370	18	42.00	0.11230
7	0.80	0.10420	19	55.00	0.11260
8	1.00	0.10450	20	69.00	0.11280
9	3.00	0.10630	21	130.00	0.11330
10	5.00	0.10750	22	221.00	0.11370
11	6.00	0.10800	23	346.00	0.11400
12	7.00	0.10830	24	1472.00	0.11480



Void Ratio = 1.230 Compression = 4.3 %
D_0 = 0.10037 D_{50} = 0.10584 D_{100} = 0.11132
C_v at 4.0 min. = 0.06 ft.^{2}/day C_α = 0.002

Pressure: 4.00 tsf — TEST READINGS — Load No. 6

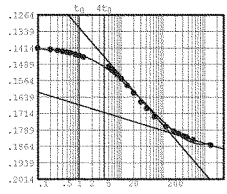
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.11480	14	7.00	0.12660
2	0.10	0.11840	15	10.00	0.12810
3	0.20	0.11890	16	14.00	0.12960
4	0.30	0.11920	17	20.00	0.13110
5	0.40	0.11960	18	30.00	0.13270
6	0.60	0.12010	19	60.00	0.13490
7	0.80	0.12050	20	148.00	0.13680
8	1.00	0.12090	21	185.00	0.13720
9	1.25	0.12140	22	313.00	0.13800
10	2.00	0.12250	23	376.00	0.13830
11	4.00	0.12460	24	517.00	0.13880
12	5.00	0.12530	25	1412.00	0.14020
13	6.00	0.12600			



Void Ratio = 1.151 Compression = 7.7 %
D_0 = 0.11433 D_{50} = 0.12425 D_{100} = 0.13416
C_v at 5.8 min. = 0.04 ft.^{2}/day C_α = 0.005

Pressure: 8.00 tsf | TEST READINGS | Load No. 7

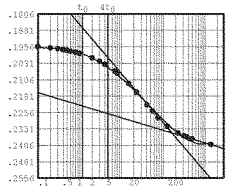
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.14020	15	10.00	0.15820
2	0.10	0.14420	16	14.00	0.16130
3	0.20	0.14480	17	20.00	0.16470
4	0.30	0.14530	18	30.00	0.16880
5	0.40	0.14570	19	41.00	0.17180
6	0.50	0.14610	20	63.00	0.17560
7	0.60	0.14640	21	120.00	0.18010
8	0.80	0.14710	22	183.00	0.18220
9	1.00	0.14770	23	240.00	0.18330
10	1.25	0.14830	24	321.00	0.18440
11	5.00	0.15260	25	384.00	0.18500
12	6.00	0.15430	26	536.00	0.18610
13	7.00	0.15520	27	1433.00	0.18860
14	8.00	0.15630			



Void Ratio = 1.001 Compression = 14.2 %
D_0 = 0.13873 D_{50} = 0.15940 D_{100} = 0.18007
C_v at 15.4 min. = 0.01 ft.^{2}/day C_α = 0.009

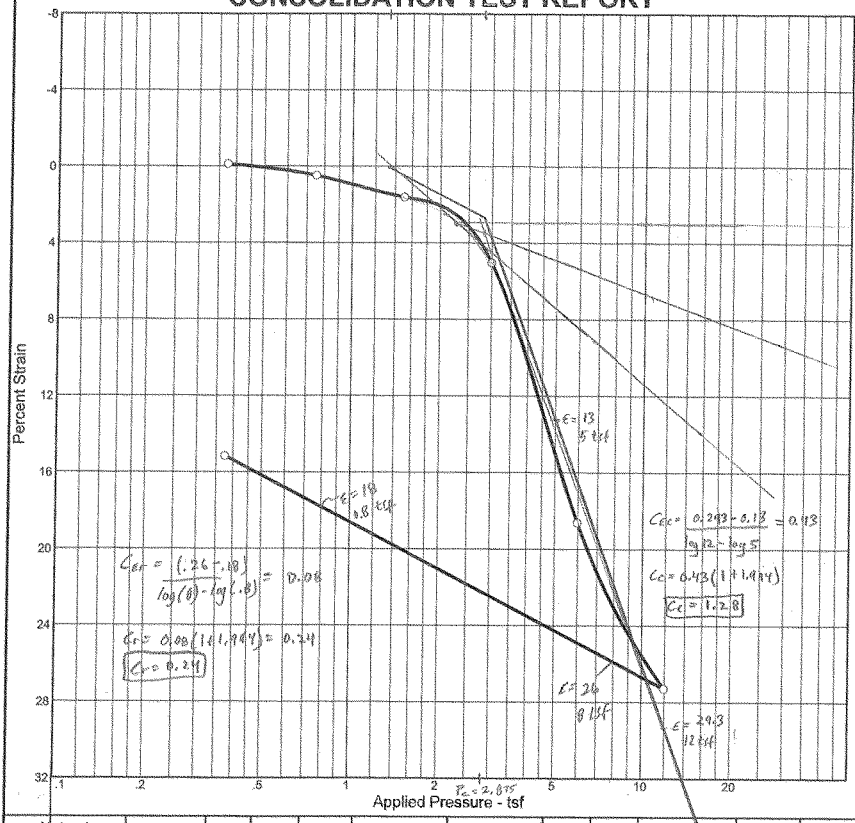
Pressure: 15.96 tsf | TEST READINGS | Load No. 12

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.19600	14	8.00	0.21130
2	0.10	0.19920	15	15.00	0.21610
3	0.20	0.19980	16	23.00	0.22000
4	0.30	0.20020	17	41.00	0.22580
5	0.40	0.20060	18	55.00	0.22860
6	0.50	0.20090	19	75.00	0.23170
7	0.60	0.20130	20	126.00	0.23550
8	0.80	0.20180	21	228.00	0.23860
9	1.00	0.20230	22	314.00	0.23990
10	2.00	0.20430	23	373.00	0.24050
11	3.00	0.20590	24	491.00	0.24130
12	4.00	0.20720	25	1397.00	0.24390
13	7.00	0.21040			



Void Ratio = 0.829 Compression = 21.6 %
D_0 = 0.19278 D_{50} = 0.21386 D_{100} = 0.23494
C_v at 16.6 min. = 0.01 ft.^{2}/day C_α = 0.009

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
97.2 %	70.5 %	57.3	116	91	2.75		2.85	1.28	0.24			1.994

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-25MU, Bottom of sample, FAT CLAY, gray (CH), ASTM D2435	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Source: **Sample No.:** #4 **Elev./Depth:** 38-40'

BRAUN INTERTEC

Remarks:
Load #5 Cv=0.004 ft2/day
Load #6 Cv=0.004 ft2/day
Moorhead
09-25MU, #4, 38' - 40'
Brenna

Figure

CONSOLIDATION TEST REPORT

Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
97.2 %	70.5 %	57.3	116	91	2.75		2.85	1.28	0.24			1.994

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-25MU, Bottom of sample, FAT CLAY, gray (CH), ASTM D2435	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Source: **Sample No.:** #4 **Elev./Depth:** 38-40'

BRAUN INTERTEC

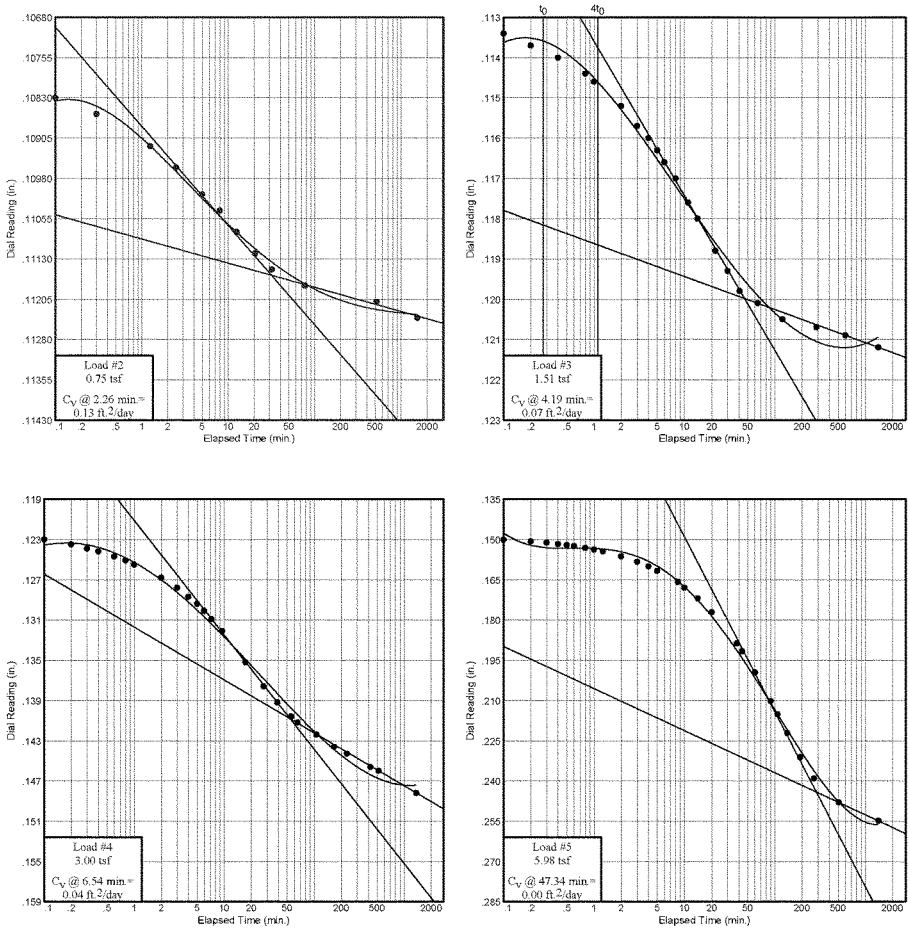
Remarks:

Load #5 Cv=0.004 ft2/day
Load #6 Cv=0.004 ft2/day
Moorhead
09-25MU, #4, 38' - 40'
Brenna

Figure

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Metro Feasibility Study
Source: Moorhead 09-25MU Sample No.: Brenna #4 Elev./Depth: 38-40'

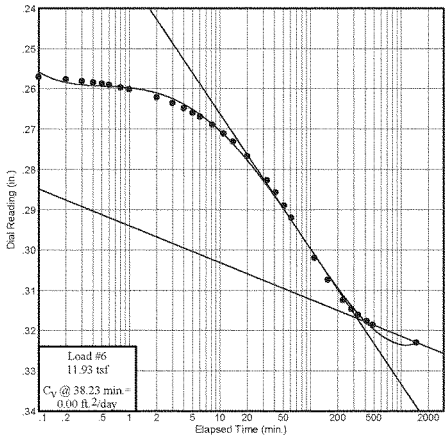


BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Metro Feasibility Study
Brenna
Source: Moorhead 09-25MU Sample No.: #4 Elev./Depth: 38-40'



BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project Number: BL-09-03127

Sample Data

Source:
Sample No.: #4
Elev. or Depth: 38-40' **Sample Length(in./cm.):**
Location: Brenna
Description: Boring 09-25MU, Bottom of sample, FAT CLAY, gray (CH), ASTM D2435
Liquid Limit: 116 **Plasticity Index:** 91
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks: Load #5 Cv=0.004 ft2/day
Load #6 Cv=0.004 ft2/day

Test Specimen Data

TOTAL SAMPLE	BEFORE TEST	AFTER TEST
Wet w+t = 94.07 g.	Consolidometer # = 5	Wet w+t = 119.98 g.
Dry w+t = 67.90 g.		Dry w+t = 87.49 g.
Tare Wt. = 30.76 g.	Spec. Gravity = 2.75	Tare Wt. = 30.43 g.
Height = .79 in.	Height = .79 in.	
Diameter = 2.50 in.	Diameter = 2.50 in.	
Weight = 99.07 g.	Defl. Table = #5-2008	
Moisture = 70.5 %	Ht. Solids = 0.2625 in.	Moisture = 56.9 %
Wet Den. = 97.7 pcf	Dry Wt. = 58.12 g.*	Dry Wt. = 57.06 g.
Dry Den. = 57.3 pcf	Void Ratio = 1.994	Void Ratio = 1.540
	Saturation = 97.2 %	

* Initial dry weight used in calculations

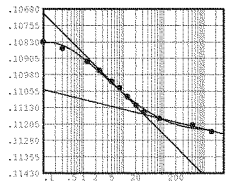
End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.10850				1.994	
0.38	0.10870	0.00110			1.997	0.1 Swell
0.75	0.11430	0.00190	0.13	0.001	1.979	0.5 Comprs.
1.51	0.12420	0.00300	0.07	0.001	1.946	1.6 Comprs.
3.00	0.15250	0.00430	0.04	0.007	1.843	5.1 Comprs.
5.98	0.26090	0.00600	0.00	0.021	1.436	18.6 Comprs.
11.93	0.33130	0.00830	0.00	0.014	1.177	27.3 Comprs.
0.38	0.22880	0.00110			1.540	15.2 Comprs.

C_c = 1.28 P_c = 2.85 tsf C_r = 0.24

Pressure: 0.75 tsf | TEST READINGS | Load No. 2

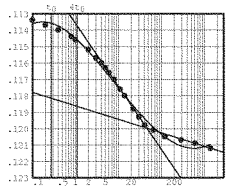
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10870	11	77.50	0.11370
2	0.10	0.11020	12	520.50	0.11400
3	0.30	0.11050	13	1543.00	0.11430
4	1.25	0.11110			
5	2.50	0.11150			
6	5.00	0.11200			
7	8.00	0.11230			
8	12.50	0.11270			
9	20.50	0.11310			
10	32.00	0.11340			



Void Ratio = 1.979 Compression = 0.5 %
D_0 = 0.10760 D_{50} = 0.10960 D_{100} = 0.11161
C_v at 2.3 min. = 0.13 ft.^{2}/day C_α = 0.001

Pressure: 1.51 tsf | TEST READINGS | Load No. 3

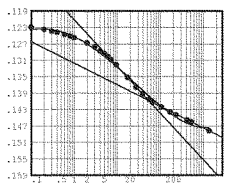
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.11430	12	8.00	0.12000
2	0.10	0.11640	13	11.00	0.12060
3	0.20	0.11670	14	14.00	0.12100
4	0.40	0.11700	15	22.00	0.12180
5	0.80	0.11740	16	30.00	0.12230
6	1.00	0.11760	17	41.00	0.12280
7	2.00	0.11820	18	65.00	0.12310
8	3.00	0.11870	19	122.00	0.12350
9	4.00	0.11900	20	288.50	0.12370
10	5.00	0.11930	21	605.00	0.12390
11	6.00	0.11960	22	1403.00	0.12420



Void Ratio = 1.946 Compression = 1.6 %
D_0 = 0.11257 D_{50} = 0.11628 D_{100} = 0.11998
C_v at 4.2 min. = 0.07 ft.^{2}/day C_α = 0.001

Pressure: 3.00 tsf — TEST READINGS — Load No. 4

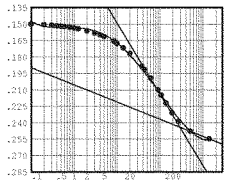
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.12420	14	7.25	0.13520
2	0.10	0.12730	15	9.50	0.13640
3	0.20	0.12780	16	17.30	0.13950
4	0.30	0.12820	17	27.50	0.14190
5	0.40	0.12850	18	39.00	0.14350
6	0.60	0.12900	19	55.50	0.14490
7	0.80	0.12940	20	65.30	0.14550
8	1.00	0.12980	21	106.00	0.14670
9	2.00	0.13110	22	167.50	0.14790
10	3.00	0.13210	23	231.00	0.14860
11	4.00	0.13300	24	421.30	0.14990
12	5.00	0.13370	25	521.20	0.15030
13	6.00	0.13440	26	1365.00	0.15250



Void Ratio = 1.843 Compression = 5.1 %
D_0 = 0.12120 D_{50} = 0.13102 D_{100} = 0.14083
C_v at 6.5 min. = 0.04 ft.^{2}/day C_α = 0.007

Pressure: 5.98 tsf — TEST READINGS — Load No. 5

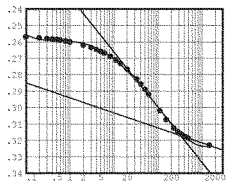
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.15250	15	8.50	0.17180
2	0.10	0.15610	16	10.00	0.17400
3	0.20	0.15670	17	14.00	0.17800
4	0.30	0.15720	18	20.00	0.18310
5	0.40	0.15770	19	38.00	0.19480
6	0.50	0.15810	20	43.50	0.19770
7	0.60	0.15850	21	60.50	0.20550
8	0.80	0.15920	22	90.00	0.21620
9	1.00	0.15980	23	107.00	0.22110
10	1.25	0.16050	24	137.00	0.22820
11	2.00	0.16230	25	191.00	0.23720
12	3.00	0.16430	26	272.00	0.24510
13	4.00	0.16610	27	509.00	0.25400
14	5.00	0.16770	28	1402.00	0.26090



Void Ratio = 1.436 Compression = 18.6 %
D_0 = 0.14820 D_{50} = 0.19616 D_{100} = 0.24413
C_v at 47.3 min. = 0.00 ft.^{2}/day C_α = 0.021

Pressure: 11.93 tsf | TEST READINGS | Load No. 6

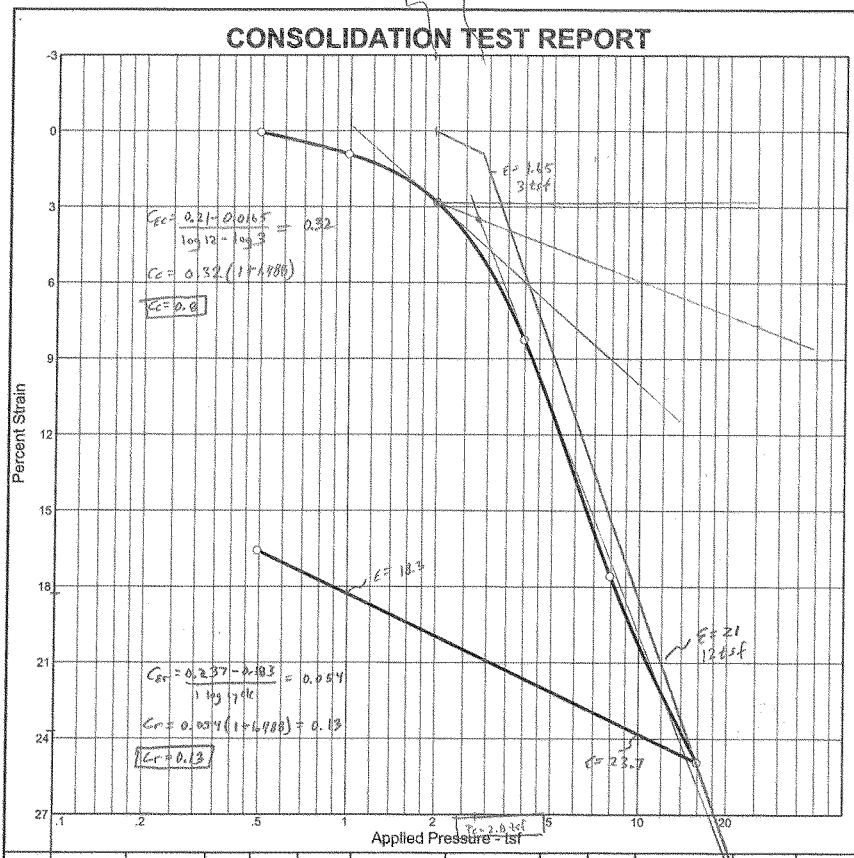
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.26090	16	11.00	0.27940
2	0.10	0.26530	17	14.00	0.28140
3	0.20	0.26590	18	20.00	0.28500
4	0.30	0.26640	19	33.00	0.29100
5	0.40	0.26670	20	41.00	0.29400
6	0.50	0.26700	21	51.00	0.29730
7	0.60	0.26730	22	61.30	0.30030
8	0.80	0.26790	23	110.30	0.31030
9	1.00	0.26840	24	155.00	0.31570
10	2.00	0.27040	25	228.00	0.32080
11	3.00	0.27180	26	282.00	0.32300
12	4.00	0.27310	27	334.00	0.32440
13	5.00	0.27420	28	416.00	0.32600
14	6.00	0.27520	29	485.00	0.32690
15	8.25	0.27720	30	1467.00	0.33130



Void Ratio = 1.177 Compression = 27.3 %

D_0 = 0.25490 D_{50} = 0.28597 D_{100} = 0.31704

C_v at 38.2 min. = 0.00 ft.^{2}/day C_α = 0.014



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
101.6 %	55.0 %	69.0	87	65	2.75		2.88	0.80	0.14			1.488

	MATERIAL DESCRIPTION	USCS	AASHTO
33	Boring 09-25MU, Bottom of sample, FAT CLAY, gray (CH), ASTM D2435	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Source: **Sample No.:** #5 **Elev./Depth:** 68-70'

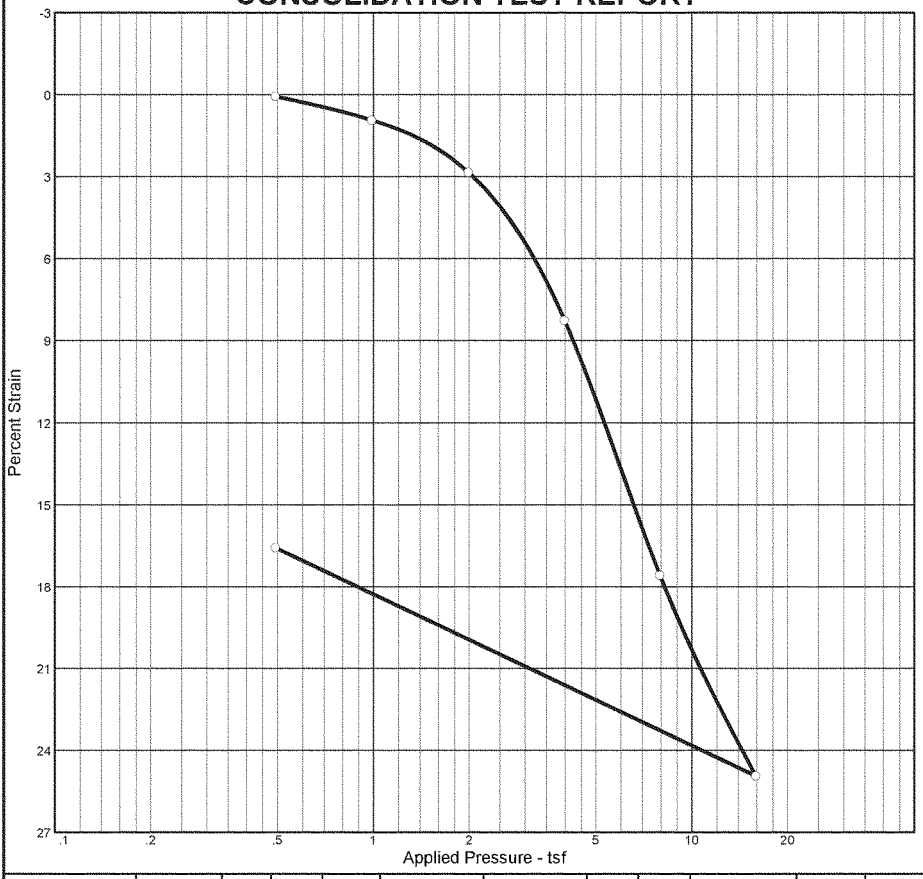
Remarks:

Moorhead
09-25MU, #5, 68' - 70'
Brenna / Argusville
Transition

BRAUN INTERTEC

Figure

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
101.6 %	55.0 %	69.0	87	65	2.75		2.88	0.80	0.14			1.488

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-25MU, Bottom of sample, FAT CLAY, gray (CH), ASTM D2435	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Source: **Sample No.:** #5 **Elev./Depth:** 68-70'

BRAUN INTERTEC

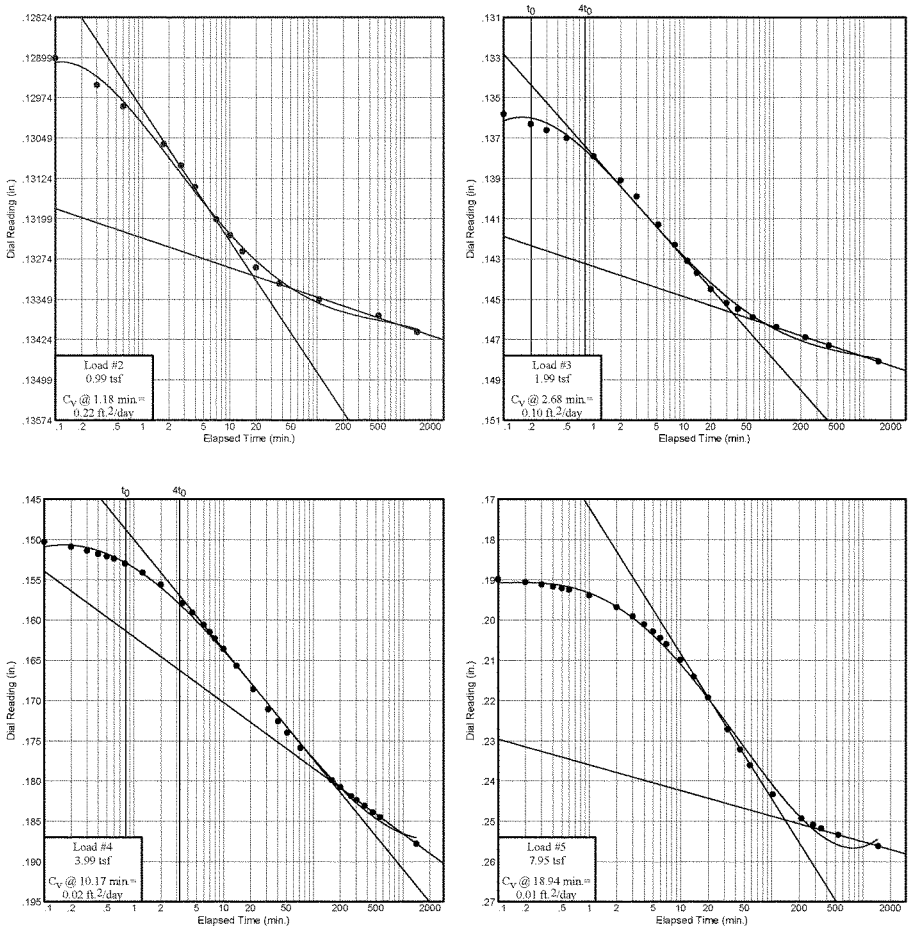
Remarks:

Moorhead
09-25MU, #5, 68' - 70'
Brenna / Argusville
Transition

Figure

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Metro Feasibility Study
Brenna / Argusville Transition
Source: Moorhead 09-25MU Sample No.: #5 Elev./Depth: 68-70'

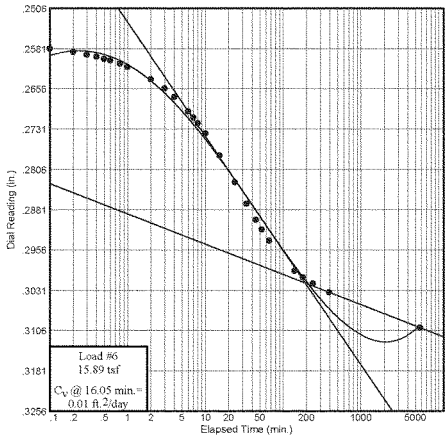


BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Metro Feasibility Study
Brenna / Argusville Transition
Source: Moorhead 09-25MU Sample No.: #5 Elev./Depth: 68-70'



BRAUN INTERTEC

Figure

CONSOLIDATION TEST DATA

Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project Number: BL-09-03127

Sample Data

Source:
Sample No.: #5
Elev. or Depth: 68-70'
Sample Length(in./cm.):
Location: Brenna / Argusville Transition
Description: Boring 09-25MU, Bottom of sample, FAT CLAY, gray (CH), ASTM D2435
Liquid Limit: 87 **Plasticity Index:** 65
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST		AFTER TEST	
Wet w+t	= 100.75 g.	Consolidometer #	= 3	Wet w+t	=
Dry w+t	= 75.71 g.			Dry w+t	=
Tare Wt.	= 30.17 g.	Spec. Gravity	= 2.75	Tare Wt.	=
Height	= .73 in.	Height	= .73 in.		
Diameter	= 2.50 in.	Diameter	= 2.50 in.		
Weight	= 100.84 g.	Defl. Table	= #3-2008		
Moisture	= 55.0 %	Ht. Solids	= 0.2946 in.	Moisture	= %
Wet Den.	= 106.9 pcf	Dry Wt.	= 65.06 g.*	Dry Wt.	= n/a
Dry Den.	= 69.0 pcf	Void Ratio	= 1.488	Void Ratio	= 1.076
		Saturation	= 101.6 %		

* Initial dry weight used in calculations

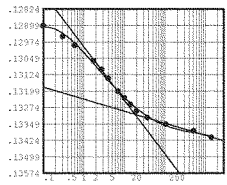
End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.12730				1.488	
0.49	0.12820	0.00050			1.487	0.1 Comprs.
0.99	0.13480	0.00070	0.22	0.001	1.465	0.9 Comprs.
1.99	0.14910	0.00100	0.10	0.002	1.417	2.8 Comprs.
3.99	0.18930	0.00150	0.02	0.011	1.283	8.3 Comprs.
7.95	0.25820	0.00200	0.01	0.009	1.051	17.6 Comprs.
15.89	0.31300	0.00290	0.01	0.009	0.868	24.9 Comprs.
0.49	0.24930	0.00050			1.076	16.6 Comprs.

C_c = 0.80 P_c = 2.88 tsf C_r = 0.14

Pressure: 0.99 tsf — TEST READINGS — Load No. 2

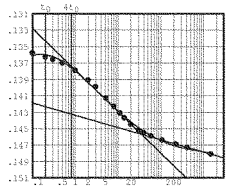
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.12820	11	20.00	0.13360
2	0.10	0.12970	12	37.00	0.13390
3	0.30	0.13020	13	106.00	0.13420
4	0.60	0.13060	14	508.00	0.13450
5	1.75	0.13130	15	1402.00	0.13480
6	2.75	0.13170			
7	4.00	0.13210			
8	7.00	0.13270			
9	10.00	0.13300			
10	14.00	0.13330			



Void Ratio = 1.465 Compression = 0.9 %
D_0 = 0.12770 D_{50} = 0.13037 D_{100} = 0.13305
C_v at 1.2 min. = 0.22 ft.^{2}/day C_α = 0.001

Pressure: 1.99 tsf — TEST READINGS — Load No. 3

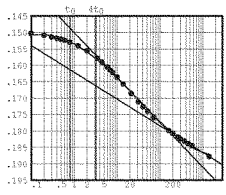
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.13480	11	11.00	0.14410
2	0.10	0.13680	12	14.00	0.14470
3	0.20	0.13730	13	20.00	0.14550
4	0.30	0.13760	14	30.00	0.14620
5	0.50	0.13800	15	40.00	0.14650
6	1.00	0.13890	16	58.50	0.14690
7	2.00	0.14010	17	107.00	0.14740
8	3.00	0.14090	18	225.00	0.14790
9	5.25	0.14230	19	413.00	0.14830
10	8.00	0.14330	20	1464.00	0.14910



Void Ratio = 1.417 Compression = 2.8 %
D_0 = 0.13440 D_{50} = 0.14004 D_{100} = 0.14569
C_v at 2.7 min. = 0.10 ft.^{2}/day C_α = 0.002

Pressure: 3.99 tsf | TEST READINGS | Load No. 4

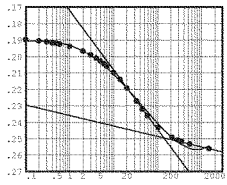
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.14910	16	10.00	0.16510
2	0.10	0.15180	17	14.00	0.16720
3	0.20	0.15240	18	21.50	0.17010
4	0.30	0.15290	19	31.50	0.17260
5	0.40	0.15330	20	40.50	0.17410
6	0.50	0.15360	21	51.50	0.17550
7	0.60	0.15390	22	72.00	0.17740
8	0.80	0.15450	23	161.00	0.18140
9	1.25	0.15560	24	201.00	0.18230
10	2.00	0.15710	25	264.00	0.18340
11	3.50	0.15940	26	304.00	0.18390
12	4.50	0.16060	27	375.00	0.18460
13	6.00	0.16210	28	462.00	0.18540
14	7.00	0.16300	29	557.00	0.18600
15	8.00	0.16380	30	1414.00	0.18930



Void Ratio = 1.283 Compression = 8.3 %
D_0 = 0.14777 D_{50} = 0.16390 D_{100} = 0.18004
C_v at 10.2 min. = 0.02 ft.^{2}/day C_α = 0.011

Pressure: 7.95 tsf | TEST READINGS | Load No. 5

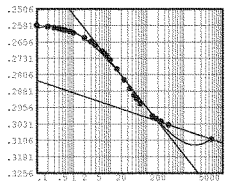
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.18930	14	7.00	0.20800
2	0.10	0.19190	15	10.00	0.21190
3	0.20	0.19260	16	14.00	0.21610
4	0.30	0.19320	17	20.00	0.22130
5	0.40	0.19370	18	33.00	0.22920
6	0.50	0.19410	19	45.00	0.23420
7	0.60	0.19450	20	58.00	0.23810
8	1.00	0.19590	21	103.00	0.24530
9	2.00	0.19880	22	212.00	0.25130
10	3.00	0.20110	23	285.00	0.25290
11	4.00	0.20310	24	349.00	0.25380
12	5.00	0.20490	25	537.00	0.25540
13	6.00	0.20650	26	1474.00	0.25820



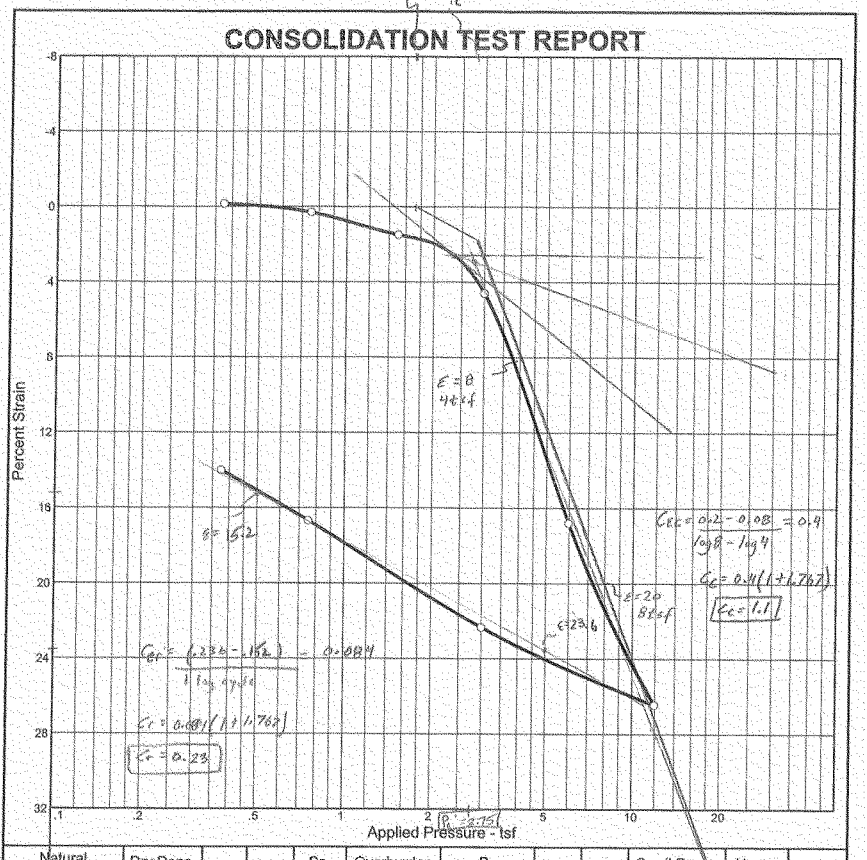
Void Ratio = 1.051 Compression = 17.6 %
D_0 = 0.18780 D_{50} = 0.21873 D_{100} = 0.24967
C_v at 18.9 min. = 0.01 ft.^{2}/day C_α = 0.009

Pressure: 15.89 tsf | TEST READINGS | Load No. 6

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.25820	15	8.00	0.27490
2	0.10	0.26100	16	10.00	0.27680
3	0.20	0.26160	17	15.25	0.28090
4	0.30	0.26210	18	24.00	0.28590
5	0.40	0.26250	19	34.00	0.28990
6	0.50	0.26290	20	44.50	0.29290
7	0.60	0.26320	21	53.00	0.29470
8	0.80	0.26380	22	66.00	0.29680
9	1.00	0.26440	23	140.00	0.30240
10	2.00	0.26670	24	179.00	0.30360
11	3.00	0.26840	25	241.00	0.30480
12	4.00	0.27000	26	390.00	0.30640
13	6.00	0.27270	27	5760.00	0.31300
14	7.00	0.27380			



Void Ratio = 0.868 Compression = 24.9 %
D_0 = 0.25620 D_{50} = 0.27899 D_{100} = 0.30178
C_v at 16.1 min. = 0.01 ft.^{2}/day C_α = 0.009



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
97.7 %	62.8 %	62.0	108	86	2.75		2.75	1.15	0.23			1.767

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-25MU, Bottom of sample, FAT CLAY, gray (CH), ASTM D2435	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115

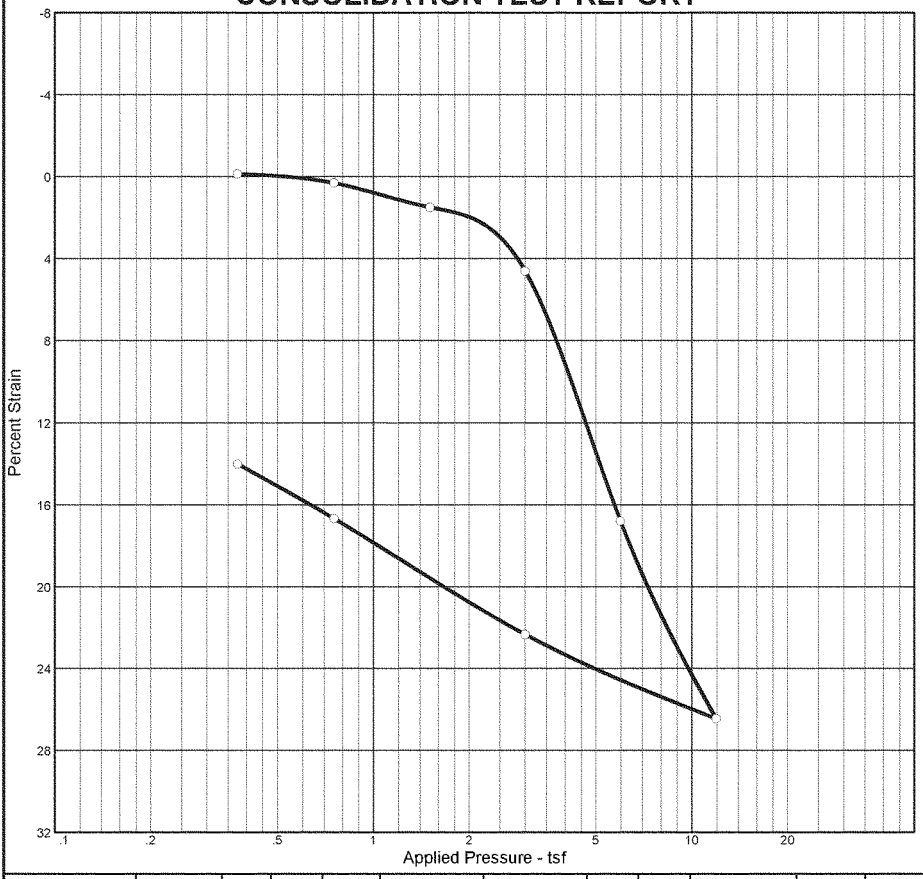
Location: SE-F-13, Fargo, Brenna Formation, #4, 50-52'

Remarks:
Load #5 Cv=0.005 ft2/day
Load #6 Cv=0.005 ft2/day
Fargo
09-25MU, #4, 50' - 52'
Brenna

BRAUN INTERTEC

Figure

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
97.7 %	62.8 %	62.0	108	86	2.75		2.75	1.15	0.23			1.767

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-25MU, Bottom of sample, FAT CLAY, gray (CH), ASTM D2435	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115

Location: SE-F-13, Fargo, Brenna Formation, #4, 50-52'

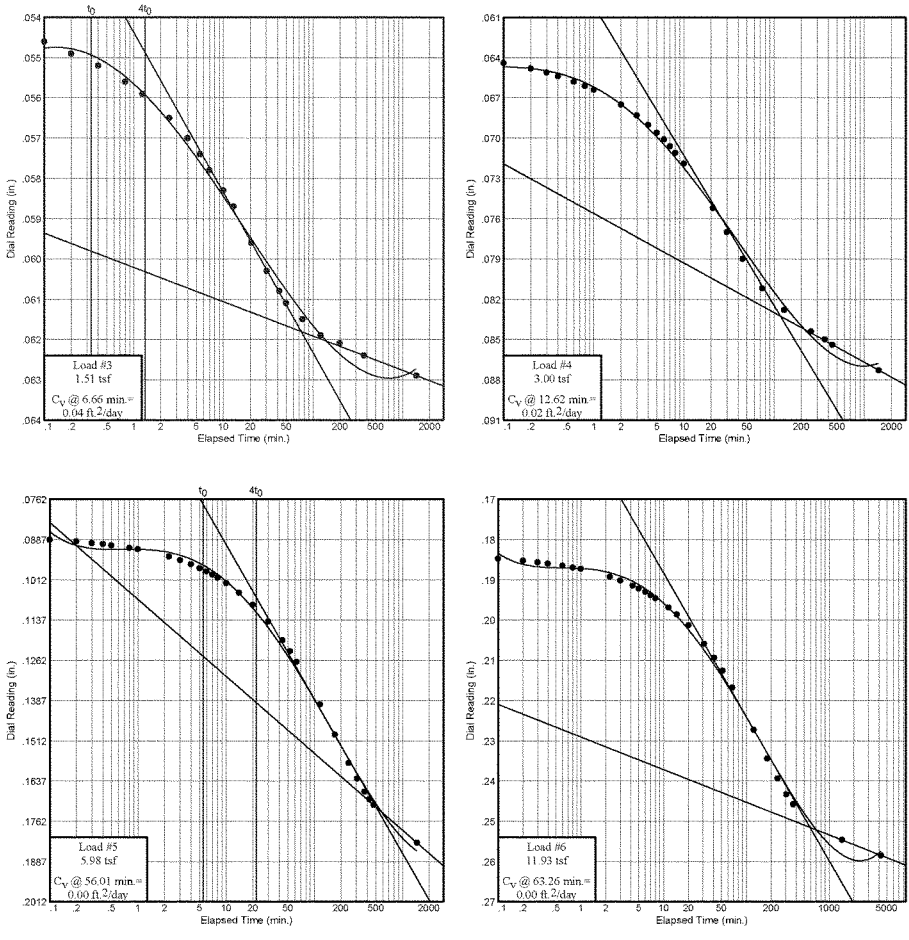
BRAUN INTERTEC

Remarks:
Load #5 Cv=0.005 ft2/day
Load #6 Cv=0.005 ft2/day

Figure

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Location: SE-F-13, Fargo, Brenna Formation, #4, 50-52'



BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Project Number: BL-09-03127

Sample Data

Source:
Sample No.: #4
Elev. or Depth: 50-52' **Sample Length(in./cm.):**
Location: SE-F-13, Fargo, Brenna Formation, #4, 50-52'
Description: Boring 09-25MU, Bottom of sample, FAT CLAY, gray (CH), ASTM D2435
Liquid Limit: 108 **Plasticity Index:** 86
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks: Load #5 Cv=0.005 ft2/day
Load #6 Cv=0.005 ft2/day

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	123.94 g.	Consolidometer # = 5	Wet w+t =
Dry w+t =	88.05 g.		Dry w+t =
Tare Wt. =	30.90 g.	Spec. Gravity = 2.75	Tare Wt. =
Height =	.78 in.	Height = .78 in.	
Diameter =	2.50 in.	Diameter = 2.50 in.	
Weight =	102.07 g.	Defl. Table = #5-2008	
Moisture =	62.8 %	Ht. Solids = 0.2832 in.	Moisture = %
Wet Den. =	101.0 pcf	Dry Wt. = 62.70 g.*	Dry Wt. = n/a
Dry Den. =	62.0 pcf	Void Ratio = 1.767	Void Ratio = 1.379
		Saturation = 97.7 %	

* Initial dry weight used in calculations

End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.05120				1.767	
0.38	0.05120	0.00110			1.771	0.1 Swell
0.75	0.05550	0.00190			1.759	0.3 Comprs.
1.51	0.06590	0.00300	0.04	0.001	1.726	1.5 Comprs.
3.00	0.09160	0.00430	0.02	0.005	1.640	4.6 Comprs.
5.98	0.18890	0.00600	0.00	0.032	1.302	16.8 Comprs.
11.93	0.26680	0.00830	0.00	0.012	1.035	26.4 Comprs.
3.00	0.23060	0.00430			1.149	22.3 Comprs.
0.75	0.18390	0.00190			1.306	16.7 Comprs.
0.38	0.16220	0.00110			1.379	14.0 Comprs.

C_c = 1.15 P_c = 2.75 tsf C_r = 0.23

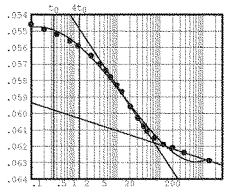
Pressure: 0.75 tsf | TEST READINGS | Load No. 2

No.	Elapsed Time	Dial Reading
1	0.00	0.05120
2	0.10	0.05350
3	1.00	0.05380
4	4.00	0.05410
5	8.00	0.05440
6	26.00	0.05480
7	144.00	0.05510
8	510.00	0.05530
9	1393.00	0.05550

Void Ratio = 1.759 Compression = 0.3 %

Pressure: 1.51 tsf | TEST READINGS | Load No. 3

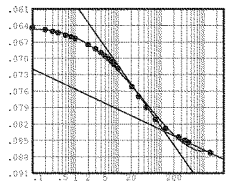
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.05550	12	13.00	0.06170
2	0.10	0.05760	13	20.50	0.06260
3	0.20	0.05790	14	30.50	0.06330
4	0.40	0.05820	15	42.00	0.06380
5	0.80	0.05860	16	50.00	0.06410
6	1.25	0.05890	17	76.50	0.06450
7	2.50	0.05950	18	122.00	0.06490
8	4.00	0.06000	19	198.00	0.06510
9	5.50	0.06040	20	369.50	0.06540
10	7.00	0.06080	21	1427.00	0.06590
11	10.00	0.06130			



Void Ratio = 1.726 Compression = 1.5 %
D_0 = 0.05394 D_{50} = 0.05787 D_{100} = 0.06180
C_v at 6.7 min. = 0.04 ft.^{2}/day C_α = 0.001

Pressure: 3.00 tsf | TEST READINGS | Load No. 4

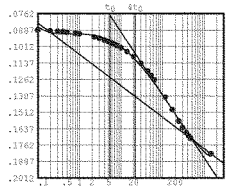
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.06590	14	7.00	0.07490
2	0.10	0.06870	15	8.00	0.07540
3	0.20	0.06910	16	10.00	0.07620
4	0.30	0.06940	17	21.00	0.07950
5	0.40	0.06970	18	30.00	0.08130
6	0.60	0.07010	19	45.00	0.08330
7	0.80	0.07040	20	74.00	0.08550
8	1.00	0.07070	21	129.00	0.08710
9	2.00	0.07180	22	257.00	0.08870
10	3.00	0.07260	23	366.00	0.08930
11	4.00	0.07330	24	441.50	0.08970
12	5.00	0.07390	25	1441.00	0.09160
13	6.00	0.07440			



Void Ratio = 1.640 Compression = 4.6 %
D_0 = 0.06290 D_{50} = 0.07309 D_{100} = 0.08328
C_v at 12.6 min. = 0.02 ft.^{2}/day C_α = 0.005

Pressure: 5.98 tsf | TEST READINGS | Load No. 5

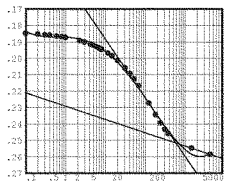
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.09160	16	10.00	0.10830
2	0.10	0.09480	17	14.00	0.11120
3	0.20	0.09530	18	20.00	0.11500
4	0.30	0.09580	19	30.00	0.12020
5	0.40	0.09610	20	43.50	0.12600
6	0.50	0.09650	21	53.00	0.12940
7	0.80	0.09730	22	63.00	0.13270
8	1.00	0.09770	23	116.00	0.14590
9	2.25	0.10000	24	171.00	0.15530
10	3.00	0.10110	25	245.00	0.16410
11	4.00	0.10240	26	305.00	0.16900
12	5.00	0.10360	27	371.00	0.17300
13	6.00	0.10460	28	423.00	0.17540
14	7.00	0.10560	29	472.00	0.17720
15	8.00	0.10660	30	1457.00	0.18890



Void Ratio = 1.302 Compression = 16.8 %
D_0 = 0.08203 D_{50} = 0.12695 D_{100} = 0.17187
C_v at 56.0 min. = 0.00 ft.^{2}/day C_α = 0.032

Pressure: 11.93 tsf | TEST READINGS | Load No. 6

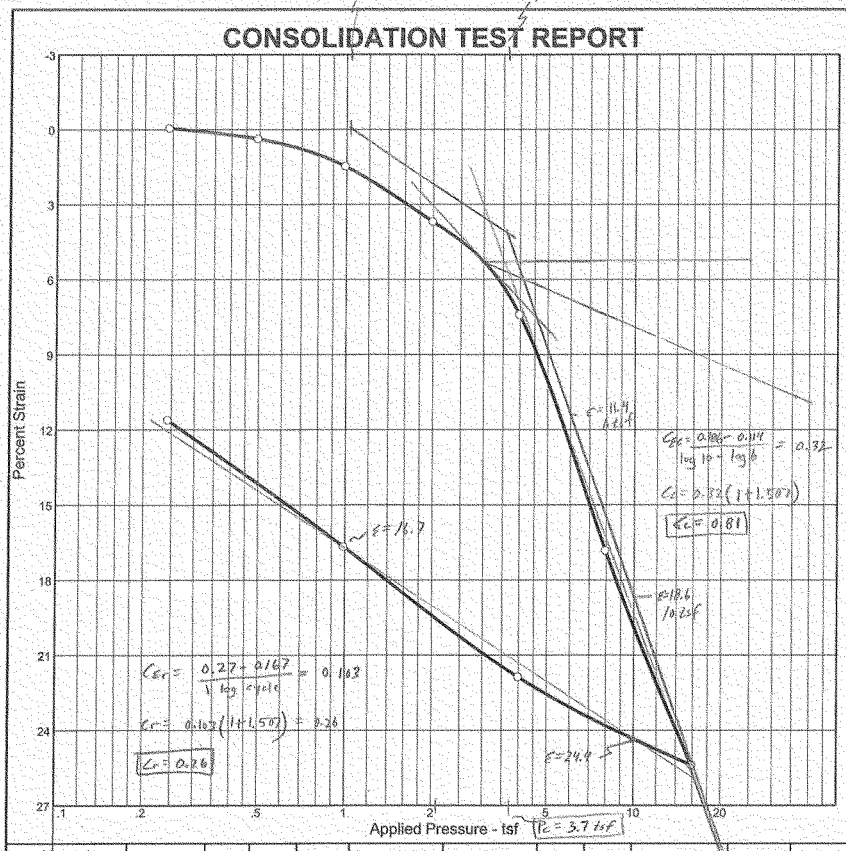
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.18890	16	11.50	0.20520
2	0.10	0.19310	17	14.50	0.20690
3	0.20	0.19360	18	20.00	0.20960
4	0.30	0.19400	19	31.00	0.21420
5	0.40	0.19430	20	41.00	0.21770
6	0.60	0.19480	21	52.00	0.22090
7	0.80	0.19530	22	68.00	0.22510
8	1.00	0.19560	23	123.00	0.23560
9	2.25	0.19760	24	180.00	0.24270
10	3.00	0.19850	25	240.00	0.24770
11	4.25	0.19980	26	306.00	0.25160
12	5.00	0.20050	27	371.00	0.25410
13	6.00	0.20130	28	1440.00	0.26300
14	7.00	0.20220	29	4236.00	0.26680
15	8.00	0.20290			



Void Ratio = 1.035 Compression = 26.4 %

D_0 = 0.18290 D_{50} = 0.21723 D_{100} = 0.25155

C_v at 63.3 min. = 0.00 ft.^{2}/day C_α = 0.012



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
99.0 %	54.2 %	68.5	110	86	2.75		3.98	0.78	0.19			1.507

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-26MU, Bottom of sample, FAT CLAY, brown (CH)	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study
~~W912ES-09-P-0115~~

Location: SE-F-15, Fargo, Brenna Formation, #3, 28-30'

Remarks:
Load #7 Cv=0.006 ft2/day

Fargo
09-26MU, #3, 28' - 30'
Brenna

BRAUN INTERTEC

Figure

CONSOLIDATION TEST REPORT

Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
99.0 %	54.2 %	68.5	110	86	2.75		3.98	0.78	0.19			1.507

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-26MU, Bottom of sample, FAT CLAY, brown (CH)	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115

Location: SE-F-15, Fargo, Brenna Formation, #3, 28-30'

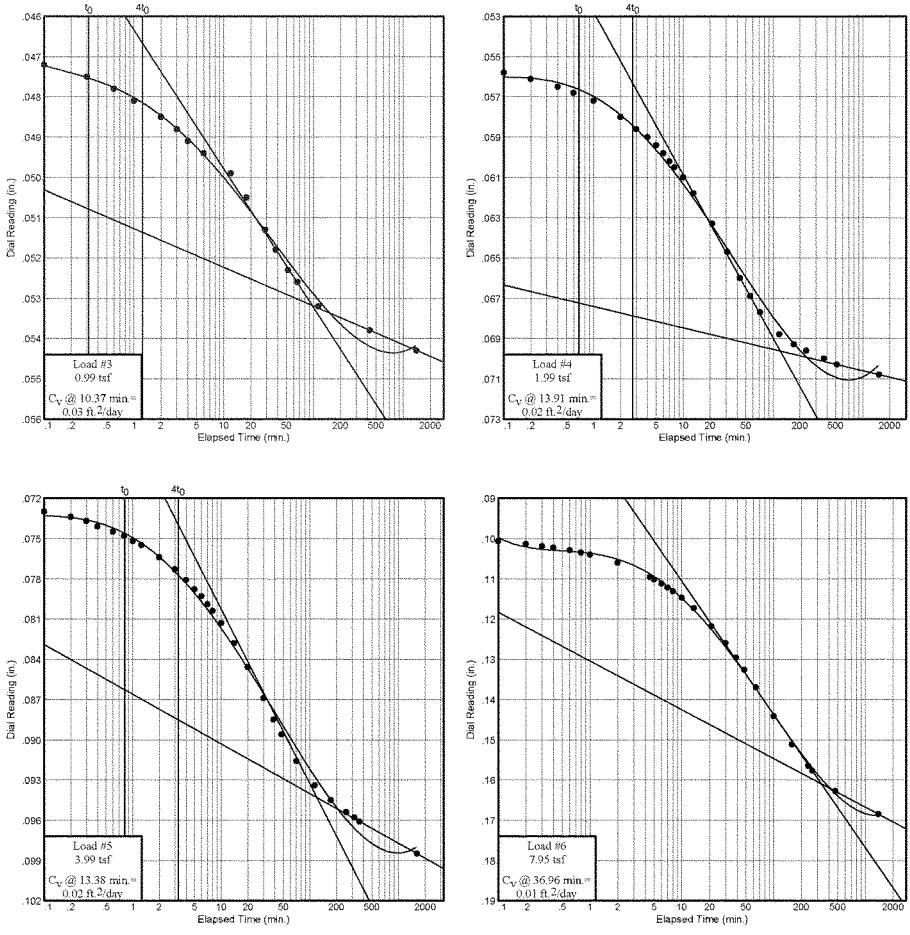
Remarks:
Load #7 Cv=0.006 ft2/day

BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Location: SE-F-15, Fargo, Brenna Formation, #3, 28-30'

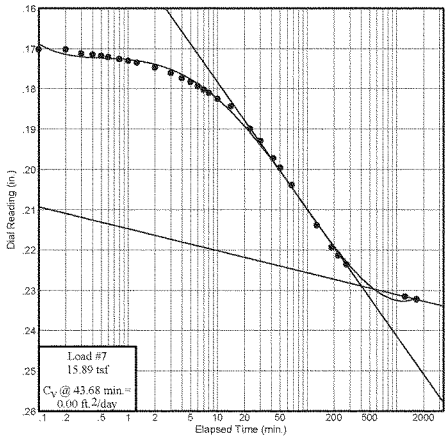


BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Location: SE-F-15, Fargo, Brenna Formation, #3, 28-30'



BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Project Number: BL-09-03127

Sample Data

Source:
Sample No.: #3
Elev. or Depth: 28-30' **Sample Length(in./cm.):**
Location: SE-F-15, Fargo, Brenna Formation, #3, 28-30'
Description: Boring 09-26MU, Bottom of sample, FAT CLAY, brown (CH)
Liquid Limit: 110 **Plasticity Index:** 86
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks: Load #7 Cv=0.006 ft2/day

Test Specimen Data

TOTAL SAMPLE	BEFORE TEST	AFTER TEST
Wet w+t = 96.30 g.	Consolidometer # = 3	Wet w+t =
Dry w+t = 73.20 g.		Dry w+t =
Tare Wt. = 30.60 g.	Spec. Gravity = 2.75	Tare Wt. =
Height = .74 in.	Height = .74 in.	
Diameter = 2.50 in.	Diameter = 2.50 in.	
Weight = 101.17 g.	Defl. Table = #3-2008	
Moisture = 54.2 %	Ht. Solids = 0.2970 in.	Moisture = %
Wet Den. = 105.6 pcf	Dry Wt. = 65.60 g.*	Dry Wt. = n/a
Dry Den. = 68.5 pcf	Void Ratio = 1.507	Void Ratio = 1.215
	Saturation = 99.0 %	

* Initial dry weight used in calculations

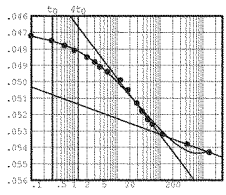
End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.04330				1.507	
0.24	0.04320	0.00030			1.508	0.1 Swell
0.49	0.04660	0.00050			1.497	0.4 Comprs.
0.99	0.05500	0.00070	0.03	0.001	1.470	1.5 Comprs.
1.99	0.07180	0.00100	0.02	0.001	1.414	3.7 Comprs.
3.99	0.10000	0.00150	0.02	0.005	1.321	7.4 Comprs.
7.95	0.17050	0.00200	0.01	0.018	1.085	16.8 Comprs.
15.89	0.23520	0.00290	0.00	0.009	0.870	25.4 Comprs.
3.99	0.20760	0.00150			0.958	21.9 Comprs.
0.99	0.16810	0.00070			1.089	16.7 Comprs.
0.24	0.13010	0.00030			1.215	11.6 Comprs.

C_c = 0.78 P_c = 3.98 tsf C_r = 0.19

Pressure: 0.99 tsf — TEST READINGS — Load No. 3

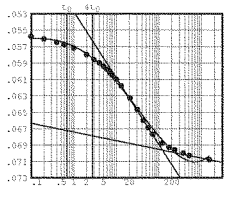
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.04660	11	18.00	0.05120
2	0.10	0.04790	12	29.00	0.05200
3	0.30	0.04820	13	38.00	0.05250
4	0.60	0.04850	14	52.00	0.05300
5	1.00	0.04880	15	66.50	0.05330
6	2.00	0.04920	16	114.00	0.05390
7	3.00	0.04950	17	425.50	0.05450
8	4.00	0.04980	18	1409.00	0.05500
9	6.00	0.05010			
10	12.00	0.05060			



Void Ratio = 1.470 Compression = 1.5 %
D_0 = 0.04691 D_{50} = 0.05005 D_{100} = 0.05318
C_v at 10.4 min. = 0.03 ft.^{2}/day C_α = 0.001

Pressure: 1.99 tsf — TEST READINGS — Load No. 4

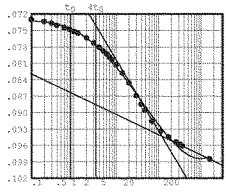
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.05500	14	10.00	0.06200
2	0.10	0.05680	15	13.00	0.06280
3	0.20	0.05710	16	21.00	0.06430
4	0.40	0.05750	17	31.00	0.06570
5	0.60	0.05780	18	43.00	0.06700
6	1.00	0.05820	19	56.00	0.06790
7	2.00	0.05900	20	72.00	0.06870
8	3.00	0.05960	21	118.00	0.06980
9	4.00	0.06000	22	172.00	0.07030
10	5.00	0.06040	23	236.00	0.07060
11	6.00	0.06080	24	372.00	0.07100
12	7.00	0.06120	25	517.00	0.07130
13	8.00	0.06150	26	1525.00	0.07180



Void Ratio = 1.414 Compression = 3.7 %
D_0 = 0.05483 D_{50} = 0.06223 D_{100} = 0.06963
C_v at 13.9 min. = 0.02 ft.^{2}/day C_α = 0.001

Pressure: 3.99 tsf — TEST READINGS — Load No. 5

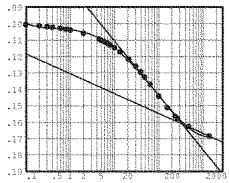
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.07180	16	8.00	0.08190
2	0.10	0.07450	17	10.00	0.08280
3	0.20	0.07490	18	14.00	0.08430
4	0.30	0.07520	19	20.00	0.08610
5	0.40	0.07560	20	30.00	0.08840
6	0.60	0.07600	21	39.00	0.09000
7	0.80	0.07630	22	48.00	0.09110
8	1.00	0.07670	23	70.50	0.09310
9	1.25	0.07700	24	114.00	0.09490
10	2.00	0.07790	25	173.00	0.09600
11	3.00	0.07880	26	258.00	0.09690
12	4.00	0.07960	27	320.00	0.09730
13	5.00	0.08030	28	364.00	0.09760
14	6.00	0.08080	29	1619.00	0.10000
15	7.00	0.08140			



Void Ratio = 1.321 Compression = 7.4 %
D_0 = 0.07153 D_{50} = 0.08292 D_{100} = 0.09432
C_v at 13.4 min. = 0.02 ft.^{2}/day C_α = 0.005

Pressure: 7.95 tsf — TEST READINGS — Load No. 6

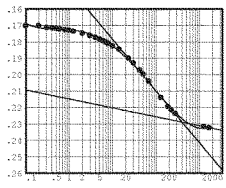
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10000	15	10.00	0.11670
2	0.10	0.10270	16	13.50	0.11930
3	0.20	0.10340	17	21.00	0.12380
4	0.30	0.10390	18	30.00	0.12800
5	0.40	0.10430	19	39.00	0.13160
6	0.60	0.10490	20	48.00	0.13460
7	0.80	0.10550	21	64.00	0.13900
8	1.00	0.10600	22	100.50	0.14620
9	2.00	0.10800	23	158.00	0.15320
10	4.50	0.11160	24	238.00	0.15850
11	5.00	0.11220	25	264.00	0.15970
12	6.00	0.11320	26	469.00	0.16480
13	7.00	0.11420	27	1386.00	0.17050
14	8.00	0.11510			



Void Ratio = 1.085 Compression = 16.8 %
D_0 = 0.09850 D_{50} = 0.12974 D_{100} = 0.16098
C_v at 37.0 min. = 0.01 ft.^{2}/day C_α = 0.018

Pressure: 15.89 tsf | TEST READINGS | Load No. 7

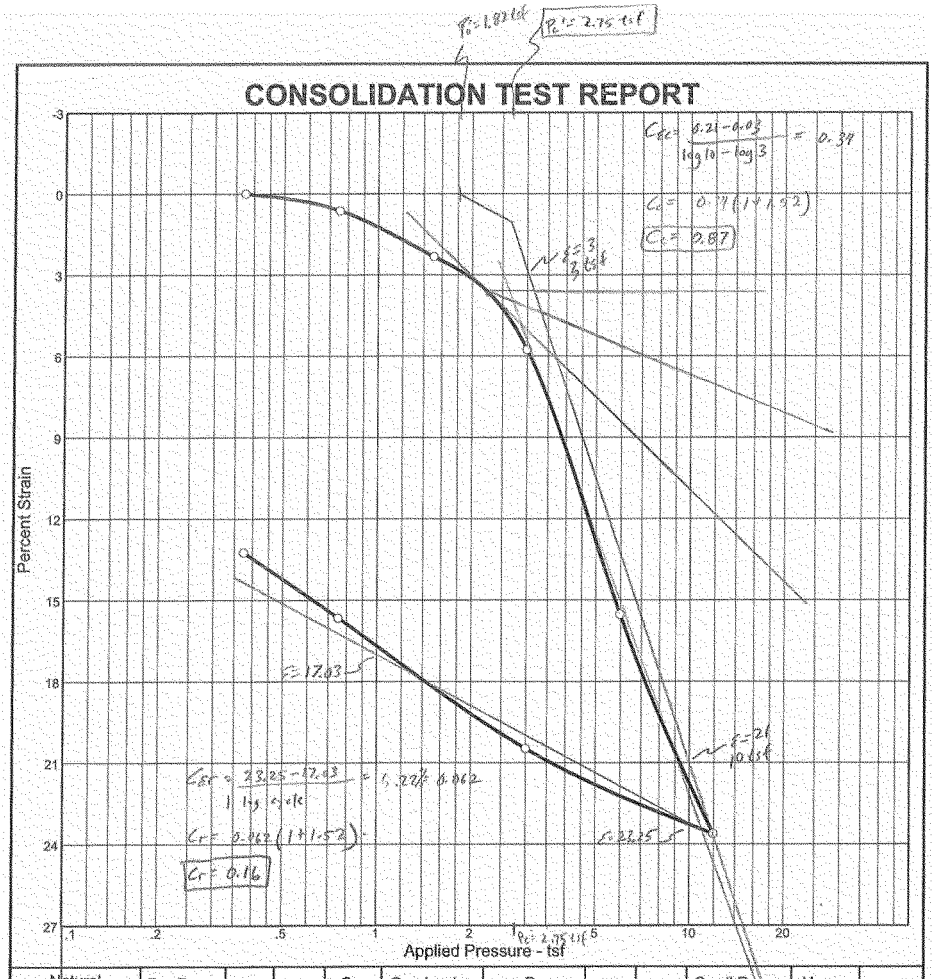
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.17050	16	7.00	0.18310
2	0.10	0.17310	17	8.00	0.18390
3	0.20	0.17310	18	10.00	0.18540
4	0.30	0.17410	19	14.00	0.18730
5	0.40	0.17440	20	23.00	0.19280
6	0.50	0.17470	21	30.00	0.19580
7	0.60	0.17500	22	42.00	0.20010
8	0.80	0.17550	23	50.00	0.20250
9	1.00	0.17590	24	67.00	0.20680
10	1.25	0.17640	25	128.00	0.21680
11	2.00	0.17760	26	188.00	0.22230
12	3.00	0.17900	27	223.00	0.22430
13	4.00	0.18020	28	275.00	0.22650
14	5.00	0.18120	29	1241.00	0.23450
15	6.00	0.18220	30	1668.00	0.23520



Void Ratio = 0.870 Compression = 25.4 %

D_0 = 0.16850 D_{50} = 0.19871 D_{100} = 0.22893

C_v at 43.7 min. = 0.00 $ft.^2/day$ C_α = 0.009



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
98.6 %	55.4 %	67.0	89	69	2.704		2.59	0.73	0.18			1.520

	MATERIAL DESCRIPTION	USCS	AASHTO
33	Boring 09-27MU, Bottom of sample, FAT CLAY, gray (CH), ASTM D2435	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study

~~W912ES-09-P-0115~~

Location: SE-F-19, Fargo, ~~Argusville Formation,~~ #4, 64-66'

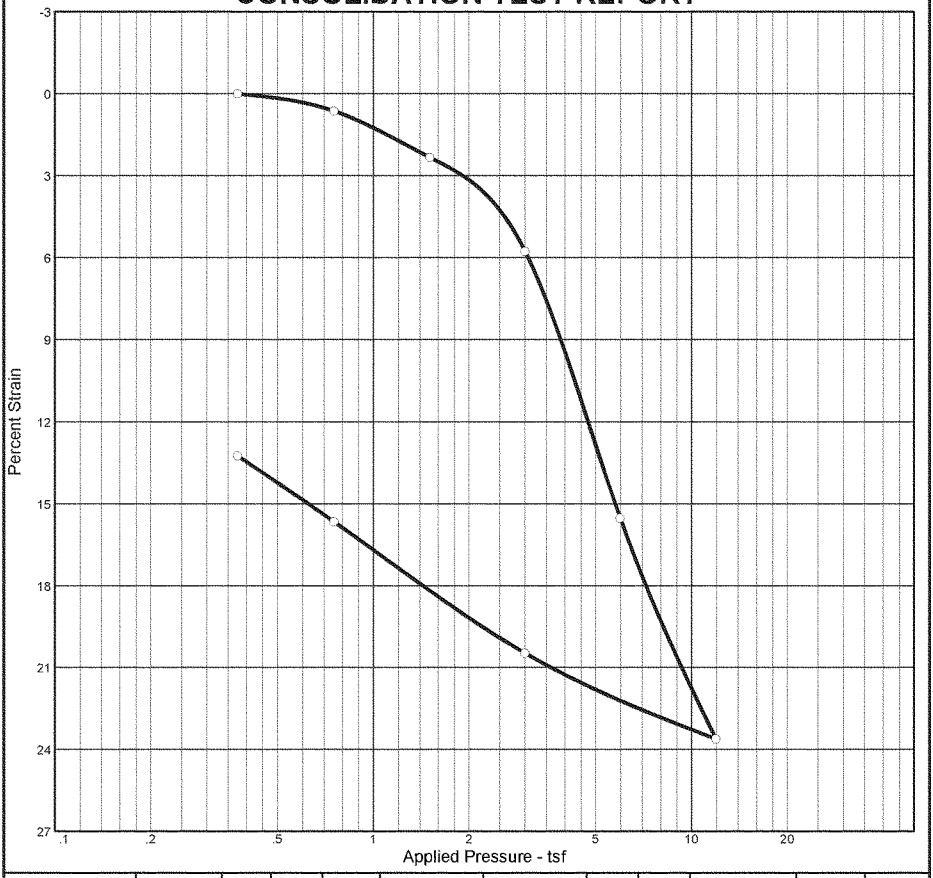
Remarks:

Fargo
09-27MU, #4, 64' - 66'
Brenna

BRAUN INTERTEC

Figure

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Heave %	e_o
98.6 %	55.4 %	67.0	89	69	2.704		2.59	0.73	0.18			1.520

MATERIAL DESCRIPTION	USCS	AASHTO
Boring 09-27MU, Bottom of sample, FAT CLAY, gray (CH), ASTM D2435	CH	

Project No. BL-09-03127 **Client:** US Army Corps of Engineer

Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115

Location: SE-F-19, Fargo, ~~Argusville Formation~~, #4, 64-66'

BRAUN INTERTEC

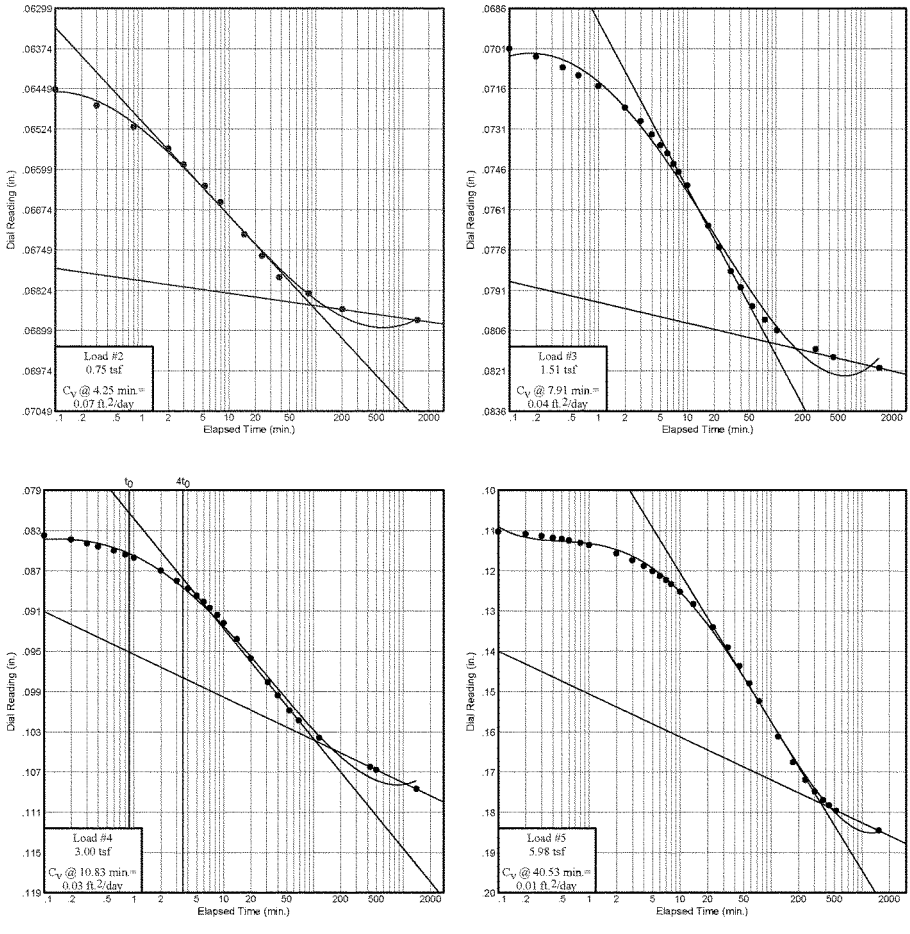
Remarks:

Fargo
09-27MU, #4, 64' - 66'
Brenna

Figure

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Location: SE-F-19, Fargo, ~~Argusville Formation~~, #4, 64-66' Brenna

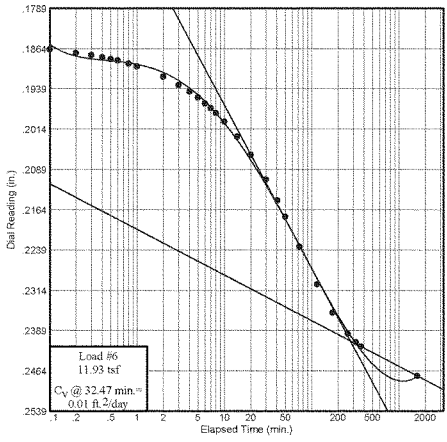


BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-09-03127
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Location: SE-F-19, Fargo, ~~Argusville Formation~~, #4, 64-66' Brenna



BRAUN INTERTEC

Figure

CONSOLIDATION TEST DATA

Client: US Army Corps of Engineer
Project: Fargo-Moorhead Feasibility Study
W912ES-09-P-0115
Project Number: BL-09-03127

Sample Data

Source:
Sample No.: #4
Elev. or Depth: 64-66' **Sample Length(in./cm.):**
Location: SE-F-19, Fargo, ~~Argusville Formation,~~ #4, 64-66' Brenna
Description: Boring 09-27MU, Bottom of sample, FAT CLAY, gray (CH), ASTM D2435
Liquid Limit: 89 **Plasticity Index:** 69
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	79.14 g.	Consolidometer # = 5	Wet w+t =
Dry w+t =	61.71 g.		Dry w+t =
Tare Wt. =	30.26 g.	Spec. Gravity = 2.704	Tare Wt. =
Height =	.78 in.	Height = .78 in.	
Diameter =	2.50 in.	Diameter = 2.50 in.	
Weight =	104.33 g.	Defl. Table = #5-2008	
Moisture =	55.4 %	Ht. Solids = 0.3084 in.	Moisture = %
Wet Den. =	104.1 pcf	Dry Wt. = 67.13 g.*	Dry Wt. = n/a
Dry Den. =	67.0 pcf	Void Ratio = 1.520	Void Ratio = 1.186
		Saturation = 98.6 %	

* Initial dry weight used in calculations

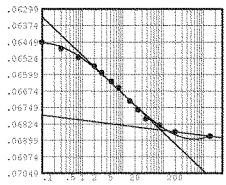
End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.06390				1.520	
0.38	0.06500	0.00110			1.520	0.0 Comprs.
0.75	0.07070	0.00190	0.07	0.000	1.504	0.6 Comprs.
1.51	0.08500	0.00300	0.04	0.001	1.461	2.3 Comprs.
3.00	0.11300	0.00430	0.03	0.006	1.374	5.8 Comprs.
5.98	0.19060	0.00600	0.01	0.015	1.128	15.5 Comprs.
11.93	0.25570	0.00830	0.01	0.013	0.925	23.6 Comprs.
3.00	0.22730	0.00430			1.004	20.5 Comprs.
0.75	0.18750	0.00190			1.125	15.7 Comprs.
0.38	0.16800	0.00110			1.186	13.3 Comprs.

C_c = 0.73 P_c = 2.59 tsf C_r = 0.18

Pressure: 0.75 tsf — TEST READINGS — Load No. 2

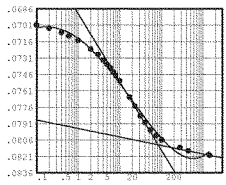
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.06500	11	38.00	0.06990
2	0.10	0.06640	12	82.30	0.07020
3	0.30	0.06670	13	202.00	0.07050
4	0.80	0.06710	14	1475.00	0.07070
5	2.00	0.06750			
6	3.00	0.06780			
7	5.30	0.06820			
8	8.00	0.06850			
9	15.00	0.06910			
10	24.00	0.06950			



Void Ratio = 1.504 Compression = 0.6 %
D_0 = 0.06390 D_{50} = 0.06621 D_{100} = 0.06852
C_v at 4.2 min. = 0.07 ft.^{2}/day C_α = 0.000

Pressure: 1.51 tsf — TEST READINGS — Load No. 3

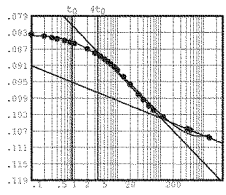
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.07070	14	10.00	0.07820
2	0.10	0.07310	15	17.30	0.07970
3	0.20	0.07340	16	23.00	0.08050
4	0.40	0.07380	17	31.00	0.08140
5	0.60	0.07410	18	40.00	0.08200
6	1.00	0.07450	19	54.00	0.08270
7	2.00	0.07530	20	75.00	0.08320
8	3.00	0.07580	21	102.00	0.08360
9	4.00	0.07630	22	0.00	0.00000
10	5.00	0.07670	23	279.00	0.08430
11	6.00	0.07700	24	441.50	0.08460
12	7.00	0.07740	25	1447.00	0.08500
13	8.00	0.07770			



Void Ratio = 1.461 Compression = 2.3 %
D_0 = 0.06880 D_{50} = 0.07492 D_{100} = 0.08104
C_v at 7.9 min. = 0.04 ft.^{2}/day C_α = 0.001

Pressure: 3.00 tsf — TEST READINGS — Load No. 4

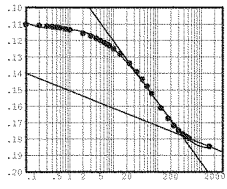
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08500	14	7.00	0.09500
2	0.10	0.08780	15	8.50	0.09570
3	0.20	0.08820	16	10.00	0.09650
4	0.30	0.08860	17	14.00	0.09810
5	0.40	0.08890	18	20.00	0.10000
6	0.60	0.08930	19	31.00	0.10240
7	0.80	0.08970	20	40.00	0.10370
8	1.00	0.09000	21	54.00	0.10520
9	2.00	0.09130	22	68.50	0.10620
10	3.00	0.09230	23	116.00	0.10790
11	4.00	0.09310	24	427.50	0.11080
12	5.00	0.09380	25	501.00	0.11110
13	6.00	0.09440	26	1401.00	0.11300



Void Ratio = 1.374 Compression = 5.8 %
D_0 = 0.08186 D_{50} = 0.09288 D_{100} = 0.10390
C_v at 10.8 min. = 0.03 ft.^{2}/day C_α = 0.006

Pressure: 5.98 tsf — TEST READINGS — Load No. 5

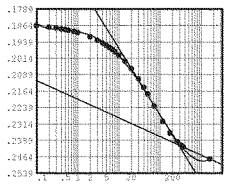
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.11300	17	10.00	0.13120
2	0.10	0.11630	18	14.00	0.13430
3	0.20	0.11690	19	23.00	0.14000
4	0.30	0.11740	20	33.50	0.14510
5	0.40	0.11780	21	45.00	0.14970
6	0.50	0.11810	22	58.00	0.15400
7	0.60	0.11850	23	74.00	0.15840
8	0.80	0.11910	24	120.00	0.16720
9	1.00	0.11960	25	175.00	0.17360
10	2.00	0.12170	26	238.00	0.17800
11	3.00	0.12340	27	303.00	0.18090
12	4.00	0.12480	28	374.50	0.18300
13	5.00	0.12610	29	436.50	0.18430
14	6.00	0.12730	30	519.00	0.18560
15	7.00	0.12830	31	1527.00	0.19060
16	8.00	0.12930			



Void Ratio = 1.128 Compression = 15.5 %
D_0 = 0.10870 D_{50} = 0.14327 D_{100} = 0.17784
C_v at 40.5 min. = 0.01 ft.^{2}/day C_α = 0.015

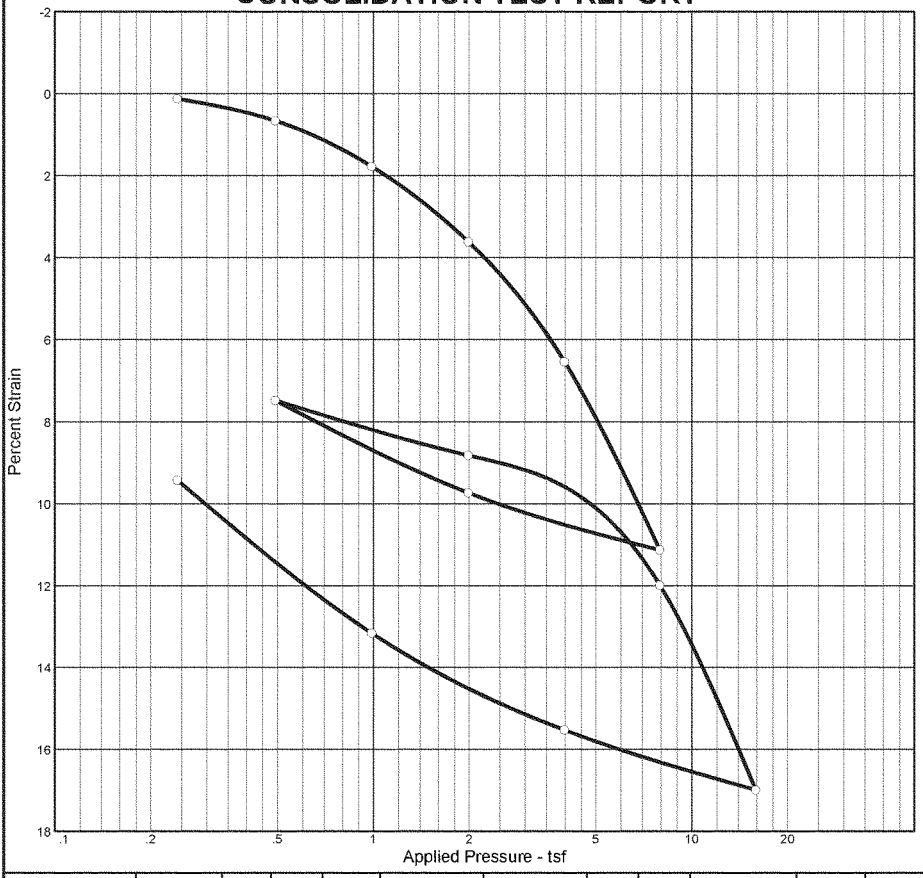
Pressure: 11.93 tsf | TEST READINGS | Load No. 6

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.19060	16	8.00	0.20670
2	0.10	0.19480	17	10.00	0.20830
3	0.20	0.19550	18	14.00	0.21110
4	0.30	0.19590	19	20.00	0.21450
5	0.40	0.19630	20	30.00	0.21910
6	0.50	0.19660	21	40.30	0.22300
7	0.60	0.19690	22	50.00	0.22600
8	0.80	0.19750	23	72.50	0.23160
9	1.00	0.19800	24	116.00	0.23860
10	2.00	0.19990	25	174.00	0.24390
11	3.00	0.20150	26	260.00	0.24780
12	4.00	0.20270	27	322.00	0.24940
13	5.00	0.20380	28	366.00	0.25020
14	6.00	0.20490	29	1620.00	0.25570
15	7.00	0.20580			



Void Ratio = 0.925 Compression = 23.6 %
D_0 = 0.18460 D_{50} = 0.21275 D_{100} = 0.24091
C_v at 32.5 min. = 0.01 ft.^{2}/day C_α = 0.013

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
97.7 %	38.3 %	82.6	64	47	2.75		2.81	0.41	0.08			1.079

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH)	CH	

Project No. BL0903127A **Client:** US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Location: Boring 09-59MU, #3, 35-37', WD-28, ND Div ~~Brenna Formation~~

BRAUN INTERTEC

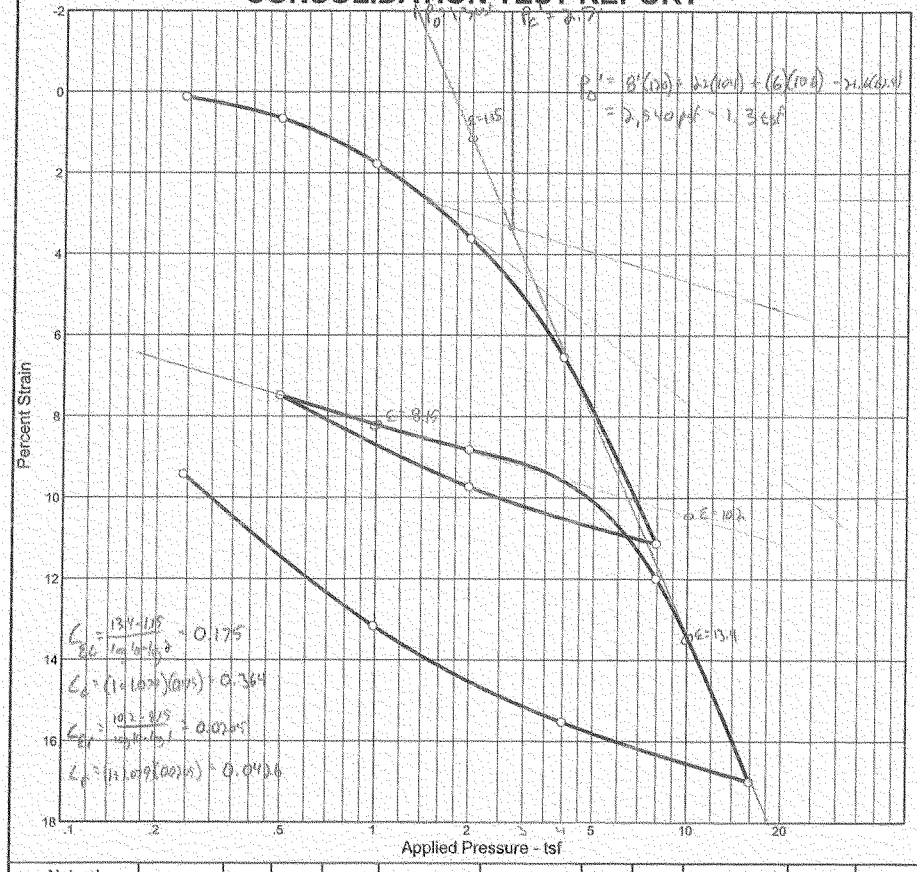
Remarks:

5" thinwall, Bottom of sample

Fargo
09-59MU, #3, 35' - 37'
Brenna / Argusville
Transition

Figure

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
97.7 %	38.3 %	82.6	64	47	2.75		2.81	0.41	0.08			1.079

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH)	CH	

Project No. BL0903127A **Client:** US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Location: Boring 09-59MU, #3, 35-37', WD-28, ND Div, Brenna Formation

BRAUN INTERTEC

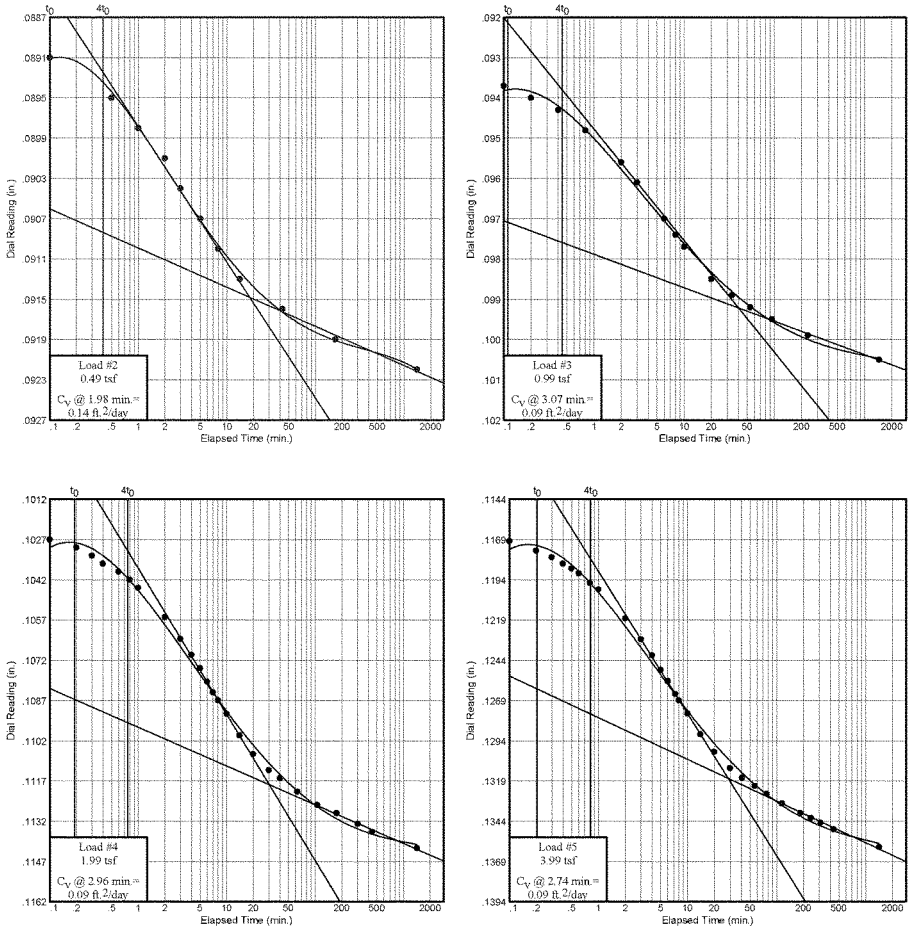
Remarks:
5" thinwall, Bottom of sample

Figure

Dial Reading vs. Time

Project No.: BL0903127A
Project: Fargo-Moorhead Metro Feasibility Study

Location: Boring 09-59MU, #3, 35-37', WD-28, ND Div, ~~Brenna Formation~~ Brenna / Argusville Transition



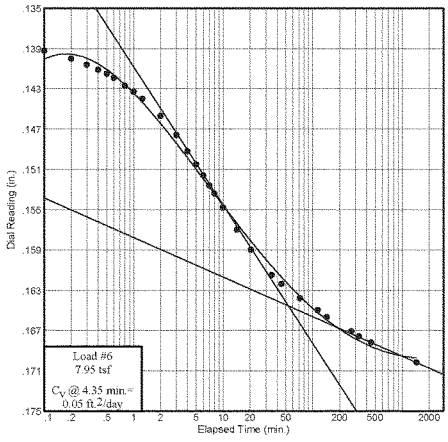
BRAUN INTERTEC

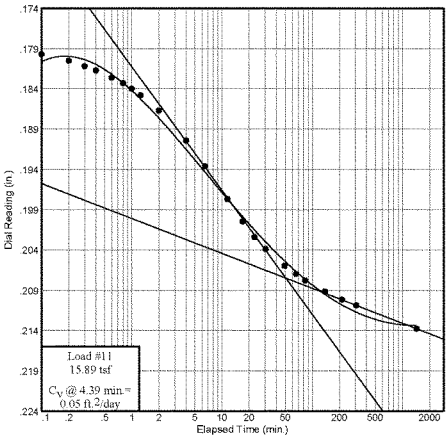
Figure

Dial Reading vs. Time

Project No.: BL0903127A
Project: Fargo-Moorhead Metro Feasibility Study

Location: Boring 09-59MU, #3, 35-37', WD-28, ND Div, ~~Brenna Formation~~ Brenna / Argusville Transition





BRAUN INTERTEC

Figure

CONSOLIDATION TEST DATA

Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project Number: BL0903127A

Sample Data

Source:
Sample No.: Boring 09-59MU, #3
Elev. or Depth: 35-37' **Sample Length(in./cm.):**
Location: Boring 09-59MU, #3, 35-37', WD-28, ND Div, ~~Brenna Formation~~ Brenna / Argusville Transition
Description: FAT CLAY, brown (CH)
Liquid Limit: 64 **Plasticity Index:** 47
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks: 5" thinwall, Bottom of sample

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	134.10 g.	Consolidometer # = 3	Wet w+t =
Dry w+t =	105.36 g.		Dry w+t =
Tare Wt. =	30.40 g.	Spec. Gravity = 2.75	Tare Wt. =
Height =	.74 in.	Height = .74 in.	
Diameter =	2.50 in.	Diameter = 2.50 in.	
Weight =	109.40 g.	Defl. Table = n/a	
Moisture =	38.3 %	Ht. Solids = 0.3581 in.	Moisture = %
Wet Den. =	114.2 pcf	Dry Wt. = 79.08 g.*	Dry Wt. = n/a
Dry Den. =	82.6 pcf	Void Ratio = 1.079	Void Ratio = 0.883
		Saturation = 97.7 %	

* Initial dry weight used in calculations

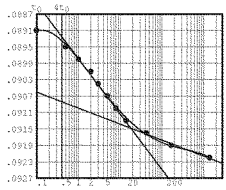
End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.08730				1.079	
0.24	0.08820	0.00000			1.077	0.1 Comprs.
0.49	0.09220	0.00000	0.14	0.001	1.066	0.7 Comprs.
0.99	0.10050	0.00000	0.09	0.001	1.042	1.8 Comprs.
1.99	0.11420	0.00000	0.09	0.002	1.004	3.6 Comprs.
3.99	0.13600	0.00000	0.09	0.004	0.943	6.5 Comprs.
7.95	0.17020	0.00000	0.05	0.006	0.848	11.1 Comprs.
1.99	0.15980	0.00000			0.877	9.7 Comprs.
0.49	0.14300	0.00000			0.924	7.5 Comprs.
1.99	0.15300	0.00000			0.896	8.8 Comprs.
7.95	0.17660	0.00000			0.830	12.0 Comprs.
15.89	0.21380	0.00000	0.05	0.007	0.726	17.0 Comprs.
3.99	0.20290	0.00000			0.756	15.5 Comprs.
0.99	0.18530	0.00000			0.806	13.2 Comprs.
0.24	0.15750	0.00000			0.883	9.4 Comprs.

C_c = 0.41 P_c = 2.81 tsf C_r = 0.08

Pressure: 0.49 tsf — TEST READINGS — Load No. 2

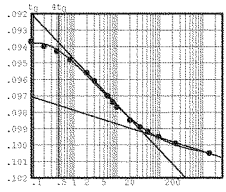
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08820	11	167.50	0.09190
2	0.10	0.08910	12	1399.00	0.09220
3	0.50	0.08950			
4	1.00	0.08980			
5	2.00	0.09010			
6	3.00	0.09040			
7	5.00	0.09070			
8	8.00	0.09100			
9	14.00	0.09130			
10	42.50	0.09160			



Void Ratio = 1.066 Compression = 0.7 %
D_0 = 0.08888 D_{50} = 0.09018 D_{100} = 0.09148
C_v at 2.0 min. = 0.14 ft.^{2}/day C_α = 0.001

Pressure: 0.99 tsf — TEST READINGS — Load No. 3

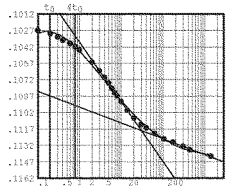
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.09220	11	20.00	0.09850
2	0.10	0.09370	12	34.00	0.09890
3	0.20	0.09400	13	54.00	0.09920
4	0.40	0.09430	14	94.00	0.09950
5	0.80	0.09480	15	235.00	0.09990
6	2.00	0.09560	16	1440.00	0.10050
7	3.00	0.09610			
8	6.00	0.09700			
9	8.00	0.09740			
10	10.00	0.09770			



Void Ratio = 1.042 Compression = 1.8 %
D_0 = 0.09332 D_{50} = 0.09627 D_{100} = 0.09922
C_v at 3.1 min. = 0.09 ft.^{2}/day C_α = 0.001

Pressure: 1.99 tsf | TEST READINGS | Load No. 4

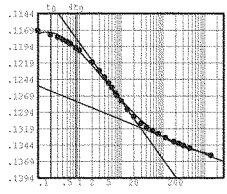
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10080	14	7.00	0.10840
2	0.10	0.10270	15	8.00	0.10870
3	0.20	0.10300	16	10.00	0.10920
4	0.30	0.10330	17	14.00	0.11000
5	0.40	0.10360	18	20.00	0.11070
6	0.60	0.10390	19	30.00	0.11130
7	0.80	0.10420	20	40.00	0.11160
8	1.00	0.10450	21	63.00	0.11210
9	2.00	0.10560	22	106.00	0.11260
10	3.00	0.10640	23	175.00	0.11290
11	4.00	0.10700	24	304.00	0.11330
12	5.00	0.10750	25	439.00	0.11360
13	6.00	0.10800	26	1417.00	0.11420



Void Ratio = 1.004 Compression = 3.6 %
D_0 = 0.10149 D_{50} = 0.10666 D_{100} = 0.11184
C_v at 3.0 min. = 0.09 ft.^{2}/day C_α = 0.002

Pressure: 3.99 tsf | TEST READINGS | Load No. 5

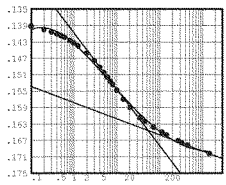
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.11420	16	8.00	0.12690
2	0.10	0.11700	17	10.00	0.12770
3	0.20	0.11760	18	14.00	0.12900
4	0.30	0.11800	19	20.00	0.13010
5	0.40	0.11840	20	30.00	0.13110
6	0.50	0.11870	21	41.00	0.13170
7	0.60	0.11900	22	56.50	0.13220
8	0.80	0.11960	23	77.00	0.13270
9	1.00	0.12000	24	115.00	0.13330
10	2.00	0.12180	25	185.00	0.13390
11	3.00	0.12310	26	242.00	0.13420
12	4.00	0.12410	27	311.00	0.13450
13	5.00	0.12500	28	438.00	0.13490
14	6.00	0.12570	29	1420.00	0.13600
15	7.25	0.12650			



Void Ratio = 0.943 Compression = 6.5 %
D_0 = 0.11490 D_{50} = 0.12332 D_{100} = 0.13173
C_v at 2.7 min. = 0.09 ft.^{2}/day C_α = 0.004

Pressure: 7.95 tsf — TEST READINGS — Load No. 6

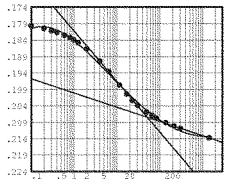
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.13600	16	7.00	0.15260
2	0.10	0.13920	17	8.00	0.15340
3	0.20	0.14000	18	10.00	0.15480
4	0.30	0.14060	19	14.30	0.15700
5	0.40	0.14110	20	20.50	0.15900
6	0.50	0.14150	21	35.00	0.16150
7	0.60	0.14190	22	45.00	0.16240
8	0.80	0.14270	23	72.00	0.16380
9	1.00	0.14330	24	114.00	0.16500
10	1.25	0.14400	25	144.00	0.16570
11	2.00	0.14570	26	270.30	0.16710
12	3.00	0.14760	27	330.00	0.16760
13	4.00	0.14920	28	449.00	0.16820
14	5.00	0.15050	29	1448.00	0.17020
15	6.00	0.15160			



Void Ratio = 0.848 Compression = 11.1 %
D_0 = 0.13600 D_{50} = 0.15029 D_{100} = 0.16458
C_v at 4.3 min. = 0.05 ft.^{2}/day C_α = 0.006

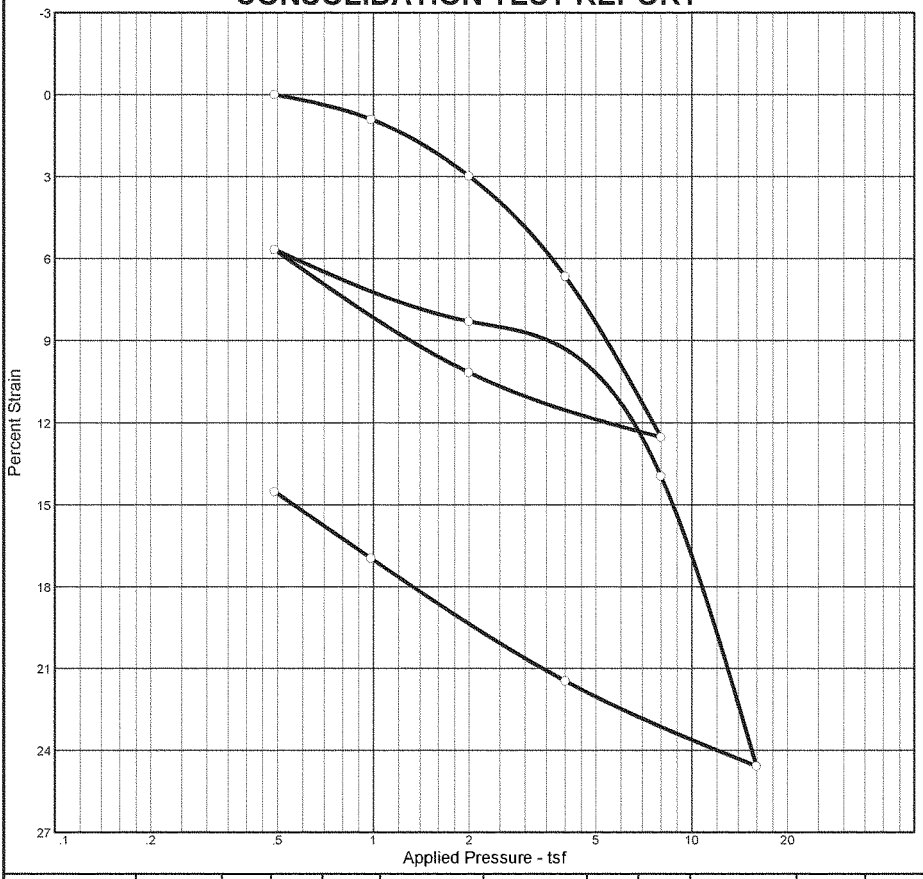
Pressure: 15.89 tsf — TEST READINGS — Load No. 11

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.17660	13	11.50	0.19770
2	0.10	0.17970	14	17.00	0.20050
3	0.20	0.18050	15	23.00	0.20240
4	0.30	0.18120	16	30.50	0.20390
5	0.40	0.18170	17	49.50	0.20600
6	0.60	0.18260	18	66.00	0.20700
7	0.80	0.18330	19	84.00	0.20780
8	1.00	0.18400	20	139.00	0.20920
9	1.25	0.18480	21	215.00	0.21020
10	2.00	0.18670	22	308.00	0.21090
11	4.00	0.19040	23	1435.00	0.21380
12	6.50	0.19360			



Void Ratio = 0.726 Compression = 17.0 %
D_0 = 0.17660 D_{50} = 0.19206 D_{100} = 0.20752
C_v at 4.4 min. = 0.05 ft.^{2}/day C_α = 0.007

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
100.0 %	57.5 %	66.0	111	85	2.70		4.67	1.06	0.17			1.554

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, gray (CH)	CH	

Project No. BL0903127A **Client:** US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Location: Boring 09-60MU, #3, 35-37', WD-05, ND Div, Brenna Formation

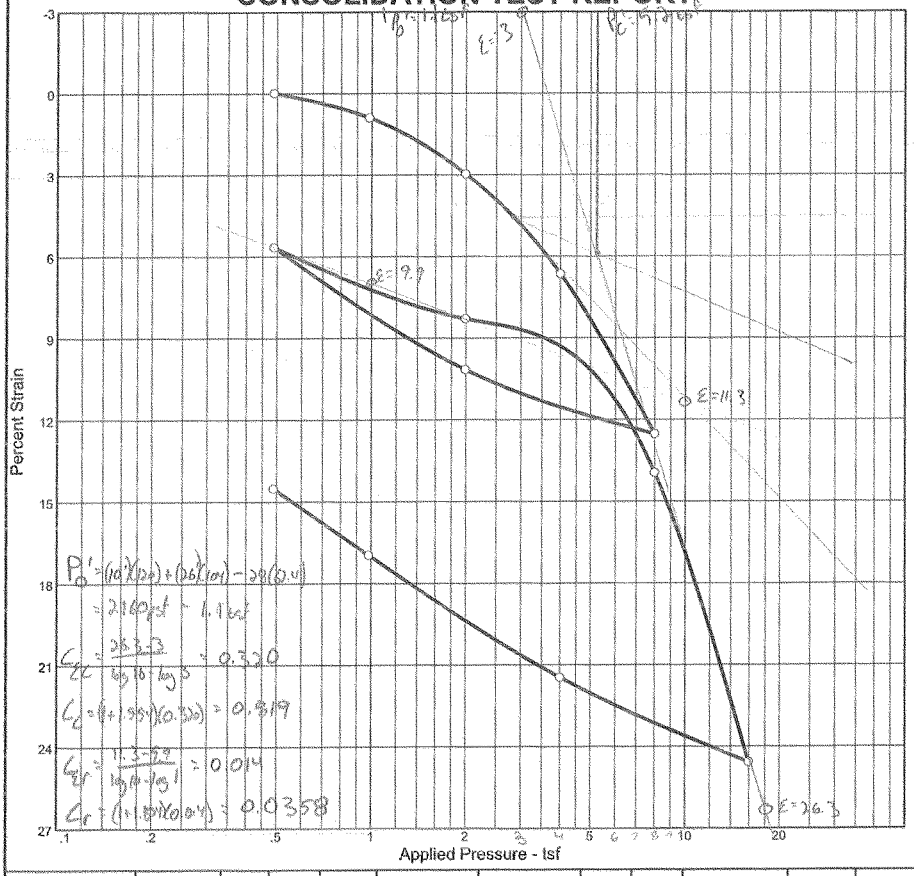
BRAUN INTERTEC

Remarks:

5" Thinwall, Bottom of sample
Fargo
09-60MU, #3, 35' - 37'
Brenna

Figure

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
100.0 %	57.5 %	66.0	111	85	2.70		4.67	1.06	0.17			1.554

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, gray (CH)	CH	

Project No. BL0903127A **Client:** US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Location: Boring 09-60MU, #3, 35-37', WD-05, ND Div, Brenna Formation

Remarks:

5" Thinwall, Bottom of sample

GWT ~ 8' BGS

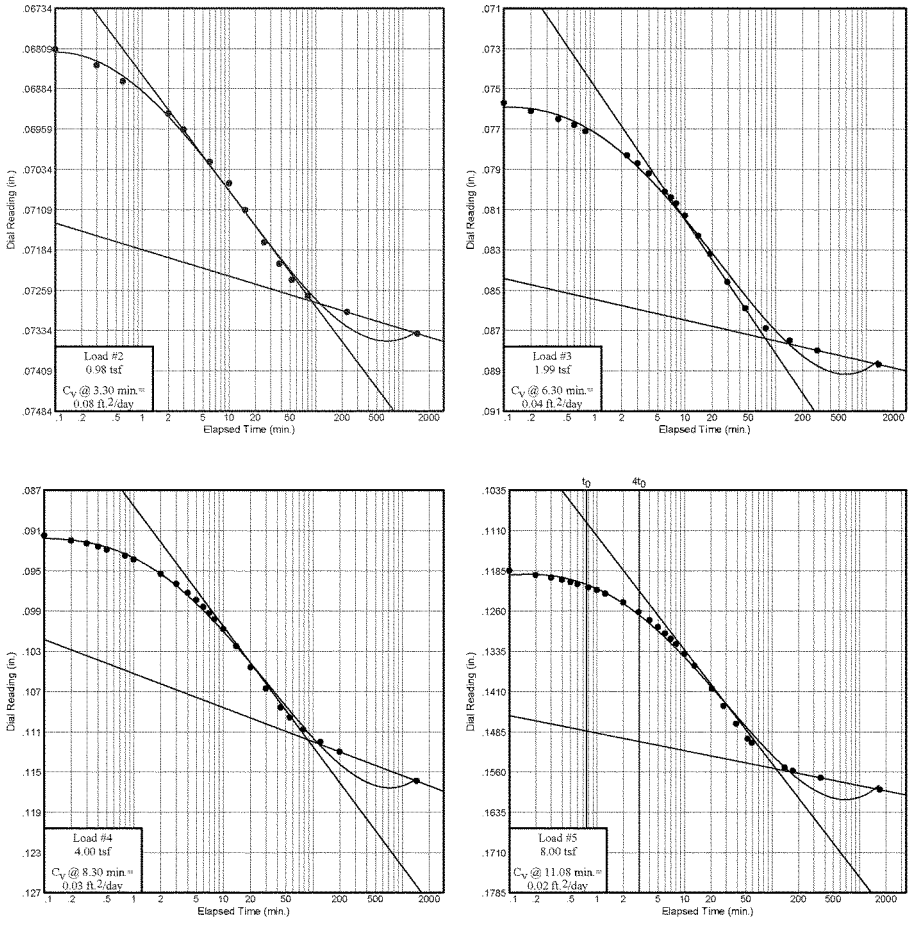
BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL0903127A
Project: Fargo-Moorhead Metro Feasibility Study

Location: Boring 09-60MU, #3, 35-37', WD-05, ND Div, Brenna Formation



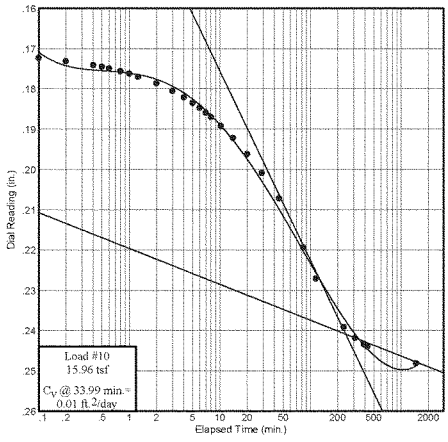
BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL0903127A
Project: Fargo-Moorhead Metro Feasibility Study

Location: Boring 09-60MU, #3, 35-37', WD-05, ND Div, Brenna Formation



BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: US Army Corps of Engineers
Project: Fargo-Moorhead Metro Feasibility Study
Project Number: BL0903127A

Sample Data

Source:
Sample No.: Boring 09-60MU, #3
Elev. or Depth: 35-37' **Sample Length(in./cm.):**
Location: Boring 09-60MU, #3, 35-37', WD-05, ND Div, Brenna Formation
Description: FAT CLAY, gray (CH)
Liquid Limit: 111 **Plasticity Index:** 85
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks: 5" Thinwall, Bottom of sample

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	157.92 g.	Consolidometer # = 4	Wet w+t =
Dry w+t =	111.50 g.		Dry w+t =
Tare Wt. =	30.81 g.	Spec. Gravity = 2.70	Tare Wt. =
Height =	.74 in.	Height = .74 in.	
Diameter =	2.49 in.	Diameter = 2.49 in.	
Weight =	98.50 g.	Defl. Table = Machine4-2009	
Moisture =	57.5 %	Ht. Solids = 0.2891 in.	Moisture = %
Wet Den. =	104.0 pcf	Dry Wt. = 62.53 g.*	Dry Wt. = n/a
Dry Den. =	66.0 pcf	Void Ratio = 1.554	Void Ratio = 1.183
		Saturation = 100.0 %	

* Initial dry weight used in calculations

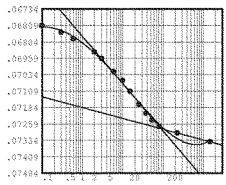
End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v ($ft.^2$/day)	C_α	Void Ratio	% Compression /Swell
start	0.06680				1.554	
0.49	0.06750	0.00080			1.554	0.0 Swell
0.98	0.07440	0.00100	0.08	0.001	1.531	0.9 Comprs.
1.99	0.09020	0.00150	0.04	0.001	1.478	3.0 Comprs.
4.00	0.11790	0.00200	0.03	0.005	1.384	6.7 Comprs.
8.00	0.16200	0.00270	0.02	0.005	1.234	12.5 Comprs.
1.99	0.14330	0.00150			1.294	10.2 Comprs.
0.49	0.10940	0.00080			1.409	5.7 Comprs.
1.99	0.12950	0.00150			1.342	8.3 Comprs.
8.00	0.17250	0.00270			1.198	14.0 Comprs.
15.96	0.25180	0.00360	0.01	0.014	0.926	24.6 Comprs.
4.00	0.22720	0.00200			1.006	21.5 Comprs.
0.98	0.19300	0.00100			1.121	17.0 Comprs.
0.49	0.17480	0.00080			1.183	14.5 Comprs.

C_c = 1.06 P_c = 4.67 tsf C_r = 0.17

Pressure: 0.98 tsf | TEST READINGS | Load No. 2

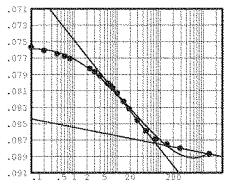
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.06750	11	38.00	0.07310
2	0.10	0.06910	12	53.00	0.07340
3	0.30	0.06940	13	81.00	0.07370
4	0.60	0.06970	14	228.00	0.07400
5	2.00	0.07030	15	1473.00	0.07440
6	3.00	0.07060			
7	6.00	0.07120			
8	10.00	0.07160			
9	15.30	0.07210			
10	25.30	0.07270			



Void Ratio = 1.531 Compression = 0.9 %
D_0 = 0.06670 D_{50} = 0.06975 D_{100} = 0.07280
C_v at 3.3 min. = 0.08 ft.^{2}/day C_α = 0.001

Pressure: 1.99 tsf | TEST READINGS | Load No. 3

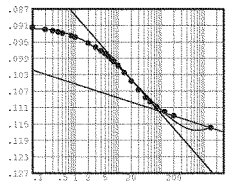
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.07440	12	8.00	0.08220
2	0.10	0.07720	13	10.00	0.08280
3	0.20	0.07760	14	14.00	0.08380
4	0.40	0.07800	15	19.00	0.08470
5	0.60	0.07830	16	29.50	0.08610
6	0.80	0.07860	17	46.50	0.08740
7	2.30	0.07980	18	78.00	0.08840
8	3.00	0.08020	19	143.50	0.08900
9	4.00	0.08070	20	290.00	0.08950
10	6.00	0.08160	21	1379.00	0.09020
11	7.00	0.08190			



Void Ratio = 1.478 Compression = 3.0 %
D_0 = 0.07340 D_{50} = 0.08040 D_{100} = 0.08741
C_v at 6.3 min. = 0.04 ft.^{2}/day C_α = 0.001

Pressure: 4.00 tsf — TEST READINGS — Load No. 4

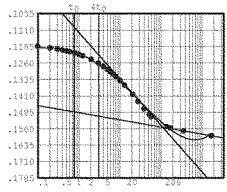
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.09020	14	7.00	0.10120
2	0.10	0.09350	15	8.00	0.10180
3	0.20	0.09400	16	10.00	0.10280
4	0.30	0.09430	17	14.00	0.10450
5	0.40	0.09460	18	20.30	0.10660
6	0.50	0.09490	19	30.00	0.10870
7	0.80	0.09550	20	44.00	0.11060
8	1.00	0.09590	21	55.50	0.11160
9	2.00	0.09730	22	78.00	0.11280
10	3.00	0.09830	23	122.00	0.11400
11	4.00	0.09920	24	200.00	0.11500
12	5.00	0.09990	25	1442.00	0.11790
13	6.00	0.10060			



Void Ratio = 1.384 Compression = 6.7 %
D_0 = 0.08870 D_{50} = 0.10025 D_{100} = 0.11179
C_v at 8.3 min. = 0.03 ft.^{2}/day C_α = 0.005

Pressure: 8.00 tsf — TEST READINGS — Load No. 5

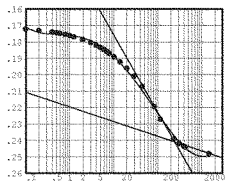
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.11790	15	6.00	0.13290
2	0.10	0.12120	16	7.00	0.13390
3	0.20	0.12200	17	8.00	0.13490
4	0.30	0.12250	18	10.00	0.13670
5	0.40	0.12290	19	13.00	0.13890
6	0.50	0.12330	20	20.50	0.14320
7	0.60	0.12370	21	28.00	0.14640
8	0.80	0.12430	22	39.00	0.14970
9	1.00	0.12480	23	53.00	0.15250
10	1.25	0.12550	24	59.00	0.15330
11	2.00	0.12710	25	139.50	0.15790
12	3.00	0.12890	26	173.00	0.15850
13	4.00	0.13040	27	360.00	0.15980
14	5.00	0.13170	28	1698.00	0.16200



Void Ratio = 1.234 Compression = 12.5 %
D_0 = 0.11533 D_{50} = 0.13538 D_{100} = 0.15544
C_v at 11.1 min. = 0.02 ft.^{2}/day C_α = 0.005

Pressure: 15.96 tsf | TEST READINGS | Load No. 10

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.17250	15	7.00	0.18950
2	0.10	0.17590	16	8.00	0.19060
3	0.20	0.17670	17	10.25	0.19280
4	0.40	0.17770	18	14.00	0.19580
5	0.50	0.17810	19	20.00	0.19980
6	0.60	0.17850	20	29.00	0.20450
7	0.80	0.17920	21	45.00	0.21080
8	1.00	0.17980	22	83.00	0.22300
9	1.25	0.18060	23	115.00	0.23070
10	2.00	0.18220	24	233.30	0.24280
11	3.00	0.18410	25	310.50	0.24550
12	4.00	0.18570	26	389.50	0.24710
13	5.00	0.18710	27	425.00	0.24760
14	6.00	0.18830	28	1470.00	0.25180



Void Ratio = 0.926 Compression = 24.6 %

D_0 = 0.16980 D_{50} = 0.20537 D_{100} = 0.24093

C_v at 34.0 min. = 0.01 ft.^{2}/day C_α = 0.014

Constant Rate of Strain Consolidation Test

Date: 10/27/10
Job: 7577

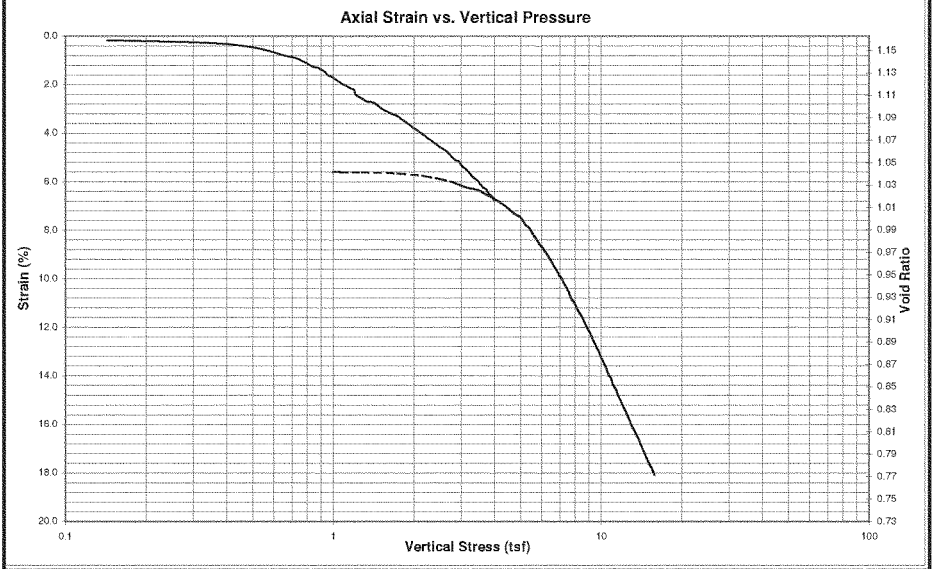
Project: FARGOMOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING

Specimen Information

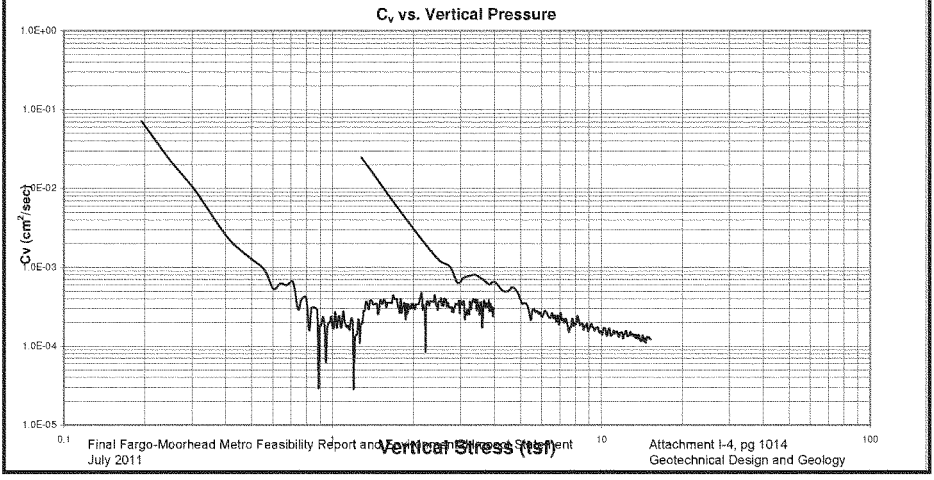
Boring: FAR 10-78MU Sample: 2 Depth: 25-27 Type: 5T

Soil Type: Fat Clay (CH) Brenna

Initial Conditions: Dry Density (pcf): 79.6 Moisture Content (%): 42.2% e_o 1.165



Calculated Consolidation Coefficients	Pc	4.0 tsf	Cc	0.54	Cr	0.04



Constant Rate of Strain Consolidation Test

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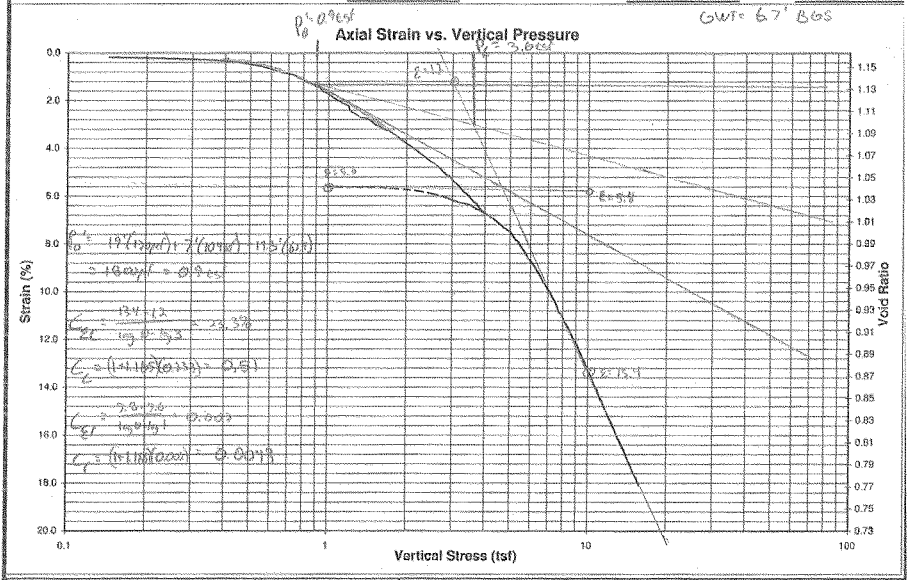

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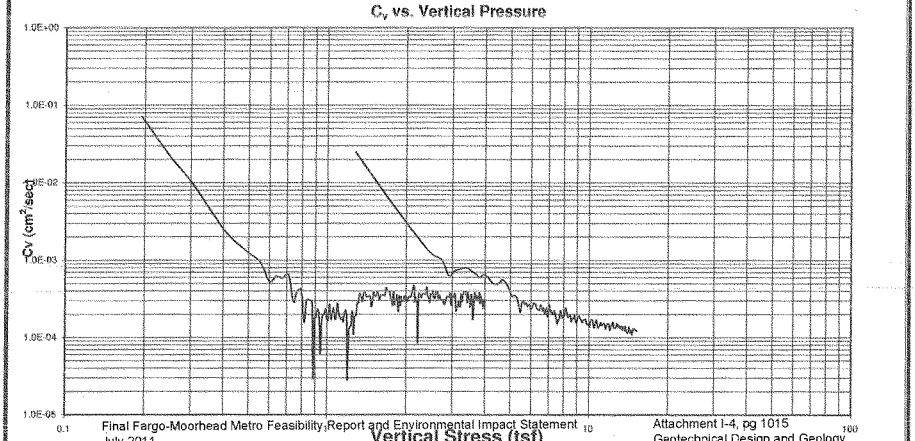


Constant Rate of Strain Data Table

Project: OORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL Date: 10/27/10

Boring: 10-78MU Sample 2 Depth: 25-27 Job: 7577

Axial Strain	Vert. Stress (tsf)	Excess Pressure (tsf)	Pressure Ratio	Eff. Stress (tsf)	Cv (cm^2/sec)	K (cm/sec)	Void Ratio
0.21%	0.194	0.025	0.126	0.178	7.11E-02	3.99E-07	1.160
0.45%	0.490	0.220	0.450	0.329	1.33E-03	2.59E-08	1.155
1.76%	1.009	0.262	0.260	0.825	1.68E-04	7.53E-09	1.126
3.83%	2.013	0.218	0.108	1.865	2.97E-04	3.66E-09	1.082
5.32%	3.004	0.243	0.081	2.840	3.37E-04	9.19E-09	1.049
6.77%	3.980	0.266	0.067	3.801	3.00E-04	4.36E-09	1.018
5.62%	1.280	0.126	0.099	1.194	2.48E-02	6.88E-09	1.043
5.90%	2.497	0.814	0.326	1.919	1.21E-03	4.69E-09	1.037
6.40%	3.548	0.868	0.245	2.943	7.27E-04	6.26E-09	1.026
7.14%	4.534	0.908	0.200	3.906	5.04E-04	3.50E-09	1.010
8.15%	5.531	1.119	0.202	4.757	2.78E-04	3.54E-09	0.988
9.35%	6.558	1.333	0.203	5.636	2.62E-04	3.13E-09	0.962
10.51%	7.515	1.524	0.203	6.461	1.69E-04	2.72E-09	0.937
11.26%	8.134	1.644	0.202	6.997	2.40E-04	2.30E-09	0.921
12.22%	9.075	1.852	0.204	7.794	1.73E-04	1.98E-09	0.900
13.31%	10.052	2.096	0.209	8.601	1.39E-04	1.40E-09	0.876
14.29%	11.000	2.350	0.214	9.371	1.41E-04	2.08E-09	0.855
15.25%	12.039	2.611	0.217	10.228	1.24E-04	1.41E-09	0.834
16.03%	12.939	2.836	0.219	10.971	1.38E-04	1.53E-09	0.818
16.71%	13.899	3.115	0.224	11.736	1.23E-04	1.08E-09	0.803
17.48%	14.871	3.365	0.226	12.533	1.26E-04	1.06E-09	0.786
18.10%	15.817	3.617	0.229	13.303	1.23E-04	1.20E-09	0.773

Constant Rate of Strain Consolidation Test

Date: 10/27/10
Job: 7577

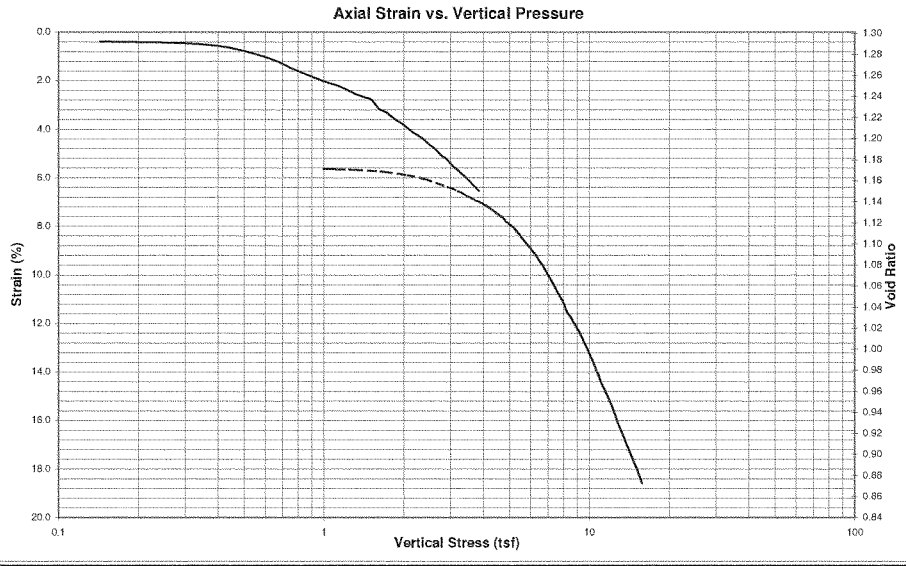
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING

Specimen Information

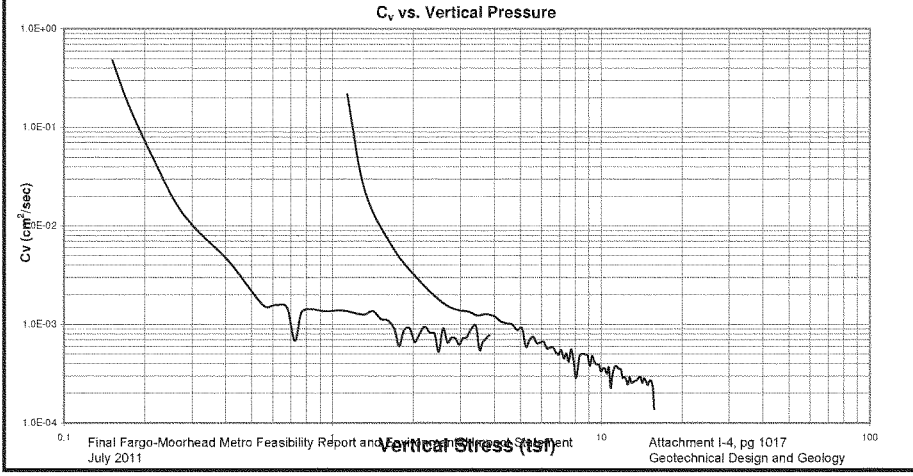
Boring: FAR 10-80MU Sample: 2 Depth: 35-37 (M-B) Type: 5T

Soil Type: Fat Clay w/laminations of silt (CH) Brenna

Initial Conditions: Dry Density (pcf): 75.3 Moisture Content (%): 46.1% e_o 1.306



Calculated Consolidation Coefficients	Pc	5.0 tsf	Cc	0.63	Cr	0.04



Constant Rate of Strain Consolidation Test

Date: 10/27/10
Job: 7577

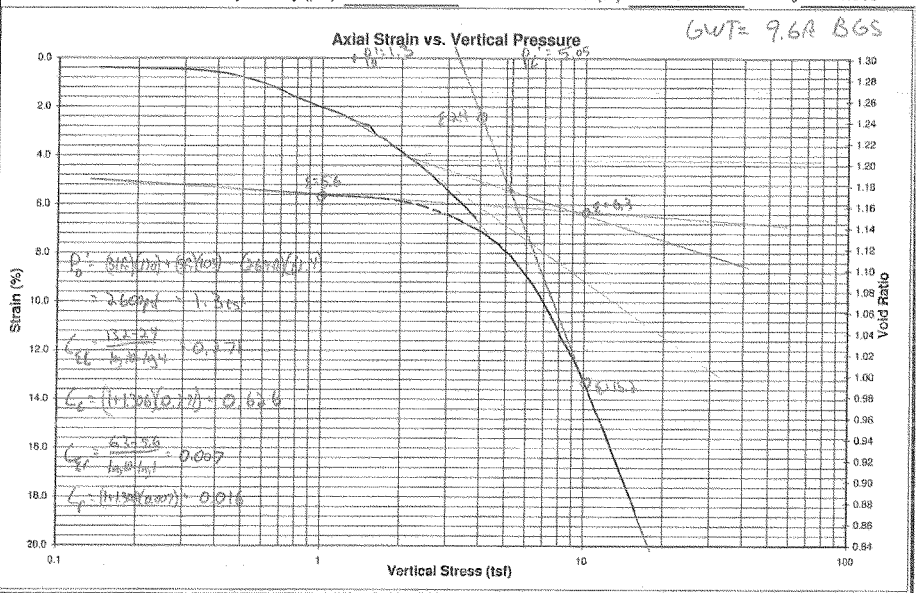
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING

Specimen Information

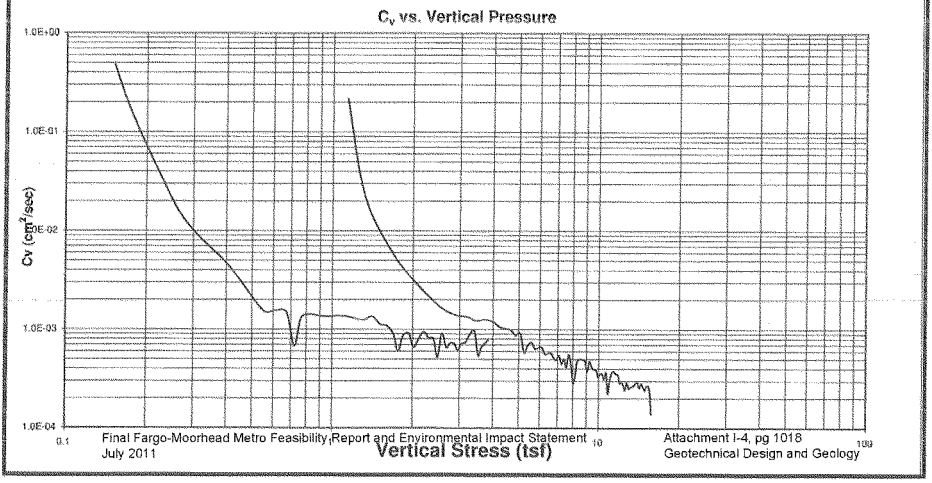
Boring: FAR 10-80MU Sample: 2 Depth: 35-37 (M-B) Type: 5T

Soil Type: Fat Clay w/laminations of silt (CH) Brenna

Initial Conditions: Dry Density (pcf): 75.3 Moisture Content (%): 46.1% e_o 1.306



Calculated Consolidation Coefficients	Pc	5.0 tsf	Cc	0.63	Cr	0.04



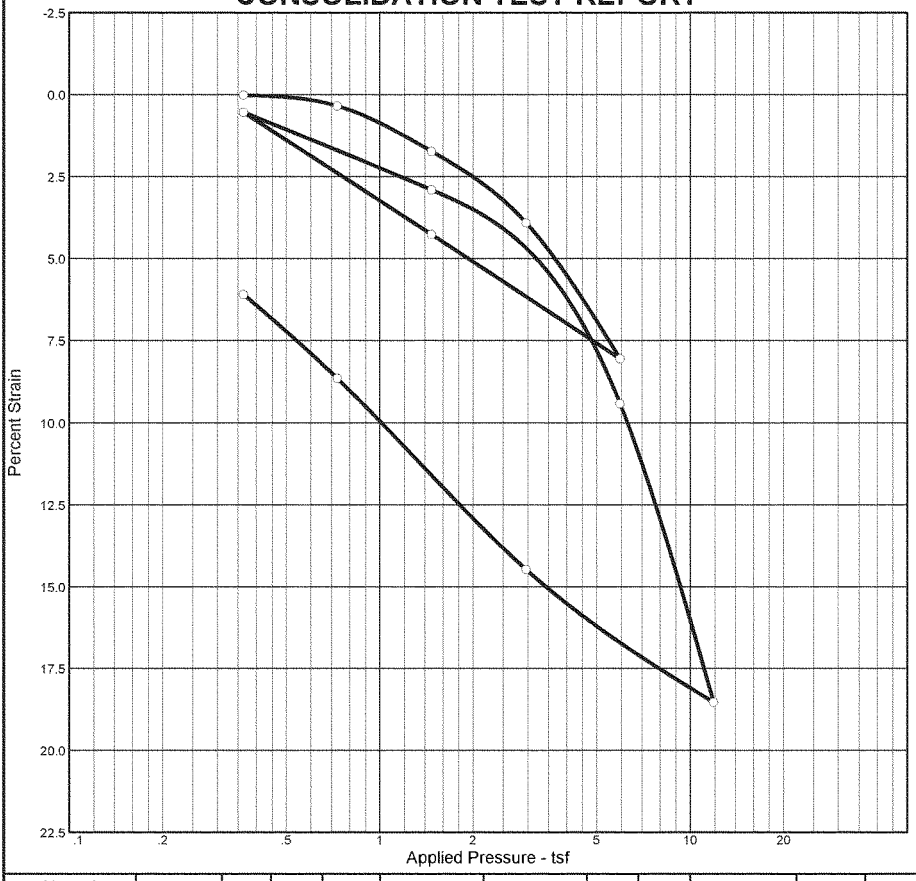
Constant Rate of Strain Data Table

Project: IOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL Date: 10/27/10

Boring: 10-80MU Sample 2 Depth: 35-37 (M-B) Job: 7577

Axial Strain	Vert. Stress (tsf)	Excess Pressure (tsf)	Pressure Ratio	Eff. Stress (tsf)	Cv (cm^2/sec)	K (cm/sec)	Void Ratio
0.39%	0.151	0.001	0.007	0.150	4.79E-01	2.59E-06	1.297
0.92%	0.558	0.157	0.281	0.448	1.52E-03	3.16E-08	1.285
2.10%	1.046	0.273	0.261	0.855	1.38E-03	2.05E-08	1.258
3.87%	2.018	0.479	0.237	1.685	6.62E-04	1.34E-08	1.217
5.51%	3.052	0.611	0.200	2.630	7.21E-04	8.64E-09	1.179
6.55%	3.837	0.679	0.177	3.369	7.79E-04	1.19E-08	1.155
5.66%	1.132	0.015	0.014	1.122	2.18E-01	2.19E-08	1.176
6.06%	2.385	0.616	0.258	1.955	1.97E-03	1.04E-08	1.166
6.55%	3.199	0.817	0.255	2.628	1.34E-03	1.27E-08	1.155
7.08%	3.981	0.870	0.219	3.378	1.21E-03	6.49E-09	1.143
7.98%	5.068	0.942	0.186	4.419	9.20E-04	4.35E-09	1.122
9.03%	6.106	1.101	0.180	5.348	6.63E-04	5.73E-09	1.098
10.14%	7.092	1.249	0.176	6.233	5.48E-04	6.11E-09	1.072
11.23%	8.030	1.456	0.181	7.027	2.85E-04	6.92E-09	1.047
12.29%	9.069	1.575	0.174	7.987	3.76E-04	3.24E-09	1.023
13.42%	10.149	1.833	0.181	8.887	3.57E-04	2.95E-09	0.997
14.36%	10.992	2.048	0.186	9.580	2.94E-04	4.55E-09	0.975
15.30%	12.021	2.209	0.184	10.499	2.86E-04	3.12E-09	0.953
16.25%	12.954	2.476	0.191	11.245	2.54E-04	1.65E-09	0.931
17.13%	13.988	2.664	0.190	12.150	2.92E-04	2.09E-09	0.911
17.85%	14.887	2.886	0.194	12.895	2.42E-04	1.65E-09	0.895
18.58%	15.751	2.984	0.189	13.692	1.38E-04	2.16E-09	0.878

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
101.7 %	61.6 %	64.1	119	87	2.720		3.15	0.83	0.20			1.649

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2850		

Project No. BL-10-10065 **Client:** W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

Location: Boring 10-105MU, #2, 25-27', Maple River, Brenna Formation

BRAUN INTERTEC

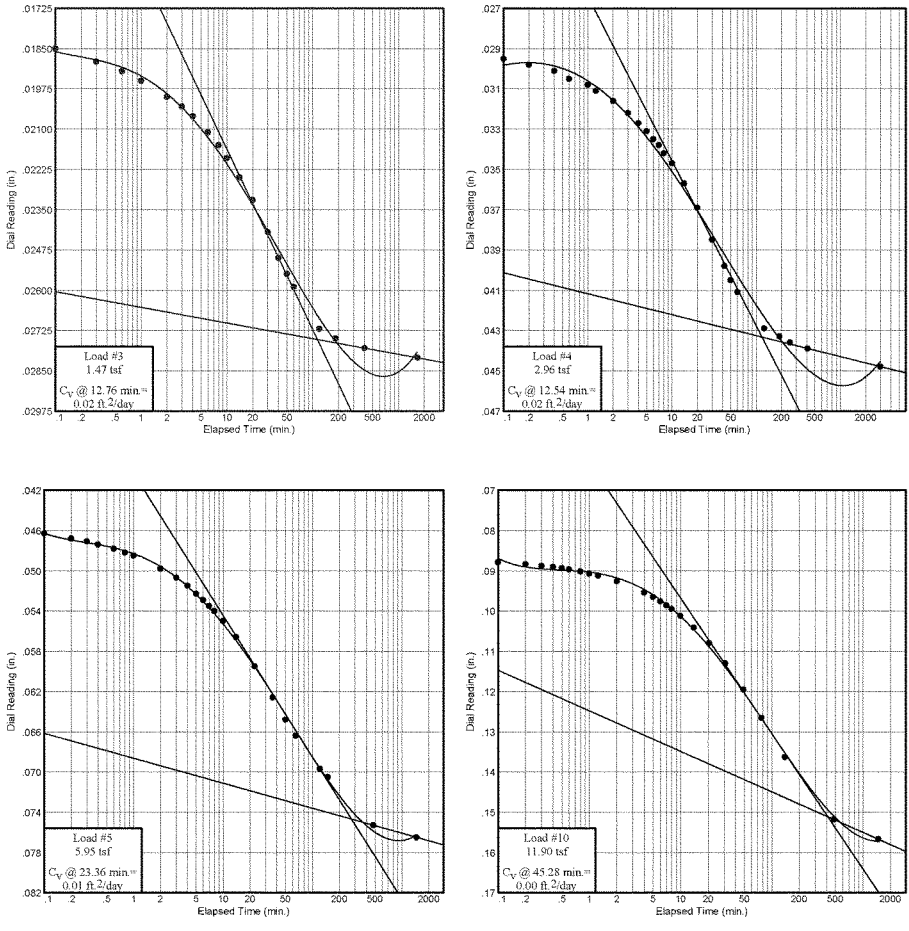
Remarks:

Load #3 Cv = 0.022 ft2/day
Load #4 Cv = 0.021 ft2/day
Load #5 Cv = 0.010 ft2/day
Load #10 Cv = 0.0042 ft2/day

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Boring 10-105MU, #2, 25-27', Maple River, Brenna Formation



BRAUN INTERTEC

Figure

CONSOLIDATION TEST DATA

Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: Boring 10-105MU, #2
Elev. or Depth: 25-27' **Sample Length(in./cm.):**
Location: Boring 10-105MU, #2, 25-27', Maple River, Brenna Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2850
Liquid Limit: 119 **Plasticity Index:** 87
USCS: **AASHTO:** **Figure No.:**
Testing Remarks: Load #3 Cv = 0.022 ft2/day
Load #4 Cv = 0.021 ft2/day
Load #5 Cv = 0.010 ft2/day
Load #10 Cv = 0.0042 ft2/day

Test Specimen Data

TOTAL SAMPLE	BEFORE TEST	AFTER TEST
Wet w+t = 105.75 g.	Consolidometer # = 6	Wet w+t =
Dry w+t = 76.95 g.		Dry w+t =
Tare Wt. = 30.23 g.	Spec. Gravity = 2.720	Tare Wt. =
Height = .76 in.	Height = .76 in.	
Diameter = 2.50 in.	Diameter = 2.50 in.	
Weight = 102.29 g.	Defl. Table = Machine6-2009	
Moisture = 61.6 %	Ht. Solids = 0.2888 in.	Moisture = %
Wet Den. = 103.6 pcf	Dry Wt. = 63.28 g.*	Dry Wt. = n/a
Dry Den. = 64.1 pcf	Void Ratio = 1.649	Void Ratio = 1.488
	Saturation = 101.7 %	

* Initial dry weight used in calculations

End-of-Load Summary

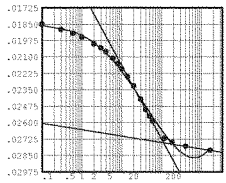
Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.01490				1.649	
0.36	0.01650	0.00150			1.649	0.0 Comprs.
0.73	0.01970	0.00220			1.640	0.3 Comprs.
1.47	0.03140	0.00330	0.02	0.001	1.604	1.7 Comprs.
2.96	0.04940	0.00460	0.02	0.001	1.546	3.9 Comprs.
5.95	0.08270	0.00620	0.01	0.003	1.436	8.1 Comprs.
1.47	0.05080	0.00330			1.536	4.3 Comprs.
0.36	0.02050	0.00150			1.635	0.5 Comprs.
1.47	0.04040	0.00330			1.572	2.9 Comprs.
5.95	0.09320	0.00620			1.400	9.4 Comprs.
11.90	0.16490	0.00820	0.00	0.015	1.158	18.5 Comprs.

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
2.96	0.13030	0.00460			1.266	14.5 Comprs.
0.73	0.08330	0.00220			1.420	8.7 Comprs.
0.36	0.06300	0.00150			1.488	6.1 Comprs.

C_c = 0.83 P_c = 3.15 tsf C_r = 0.20

Pressure: 1.47 tsf TEST READINGS **Load No. 3**

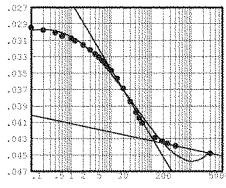
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.01970	12	14.00	0.02580
2	0.10	0.02180	13	20.00	0.02650
3	0.30	0.02220	14	30.00	0.02750
4	0.60	0.02250	15	40.00	0.02830
5	1.00	0.02280	16	50.00	0.02880
6	2.00	0.02330	17	60.00	0.02920
7	3.00	0.02360	18	120.00	0.03050
8	4.00	0.02390	19	184.00	0.03080
9	6.00	0.02440	20	403.00	0.03110
10	8.00	0.02480	21	1672.00	0.03140
11	10.00	0.02520			



Void Ratio = 1.604 Compression = 1.7 %
D_0 = 0.01750 D_{50} = 0.02252 D_{100} = 0.02753
C_v at 12.8 min. = 0.02 ft.^{2}/day C_α = 0.001

Pressure: 2.96 tsf TEST READINGS **Load No. 4**

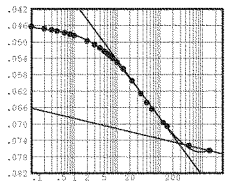
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.03140	14	8.00	0.03880
2	0.10	0.03410	15	10.00	0.03930
3	0.20	0.03440	16	14.00	0.04030
4	0.40	0.03470	17	20.00	0.04150
5	0.60	0.03510	18	30.00	0.04310
6	1.00	0.03540	19	42.00	0.04440
7	1.25	0.03570	20	50.00	0.04510
8	2.00	0.03620	21	60.00	0.04570
9	3.00	0.03680	22	125.00	0.04750
10	4.00	0.03730	23	189.00	0.04790
11	5.00	0.03770	24	253.00	0.04820
12	6.00	0.03810	25	410.00	0.04850
13	7.00	0.03840	26	2998.00	0.04940



Void Ratio = 1.546 Compression = 3.9 %
D_0 = 0.02810 D_{50} = 0.03572 D_{100} = 0.04334
C_v at 12.5 min. = 0.02 ft.^{2}/day C_α = 0.001

Pressure: 5.95 tsf — TEST READINGS — Load No. 5

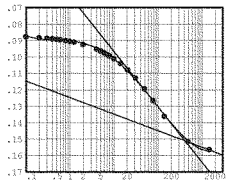
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.04940	14	7.00	0.05970
2	0.10	0.05250	15	8.00	0.06020
3	0.20	0.05300	16	10.00	0.06120
4	0.30	0.05330	17	14.00	0.06280
5	0.40	0.05360	18	22.50	0.06570
6	0.60	0.05400	19	36.00	0.06880
7	0.80	0.05440	20	50.00	0.07100
8	1.00	0.05470	21	65.00	0.07260
9	2.00	0.05600	22	121.00	0.07590
10	3.00	0.05690	23	148.50	0.07670
11	4.00	0.05770	24	480.00	0.08150
12	5.00	0.05850	25	1458.00	0.08270
13	6.00	0.05910			



Void Ratio = 1.436 Compression = 8.1 %
D_0 = 0.04480 D_{50} = 0.05975 D_{100} = 0.07469
C_v at 23.4 min. = 0.01 ft.^{2}/day C_α = 0.003

Pressure: 11.90 tsf — TEST READINGS — Load No. 10

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.09320	14	6.00	0.10580
2	0.10	0.09610	15	7.00	0.10680
3	0.20	0.09660	16	8.00	0.10770
4	0.30	0.09700	17	10.00	0.10940
5	0.40	0.09730	18	14.00	0.11230
6	0.50	0.09760	19	20.50	0.11620
7	0.60	0.09790	20	31.00	0.12120
8	0.80	0.09840	21	49.00	0.12770
9	1.00	0.09890	22	77.00	0.13480
10	1.25	0.09940	23	140.00	0.14450
11	2.00	0.10080	24	480.00	0.16000
12	4.00	0.10360	25	1471.00	0.16490
13	5.00	0.10470			



Void Ratio = 1.158 Compression = 18.5 %
D_0 = 0.08700 D_{50} = 0.11906 D_{100} = 0.15112
C_v at 45.3 min. = 0.00 ft.^{2}/day C_α = 0.015

Constant Rate of Strain Consolidation Test

Date: 5/12/11
Job: 7922

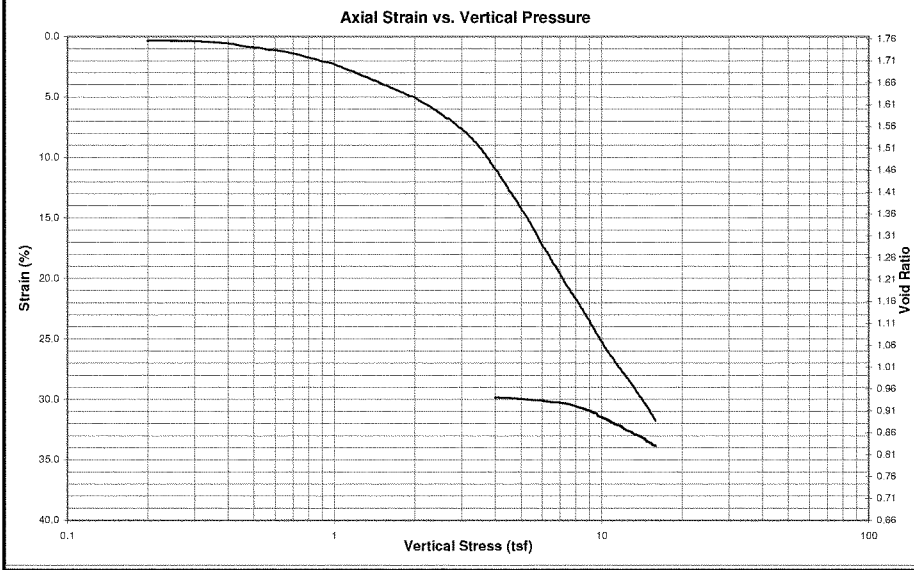
Project: Fargo Moorhead Metro Feasibility Project

Specimen Information

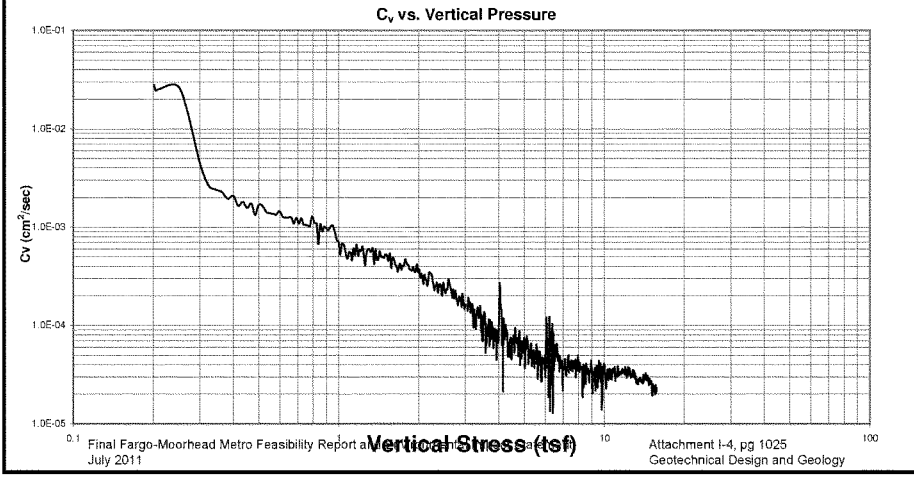
Boring: 10-105MU Sample: 3 Depth: 35-37 Type: 5T

Soil Type: Fat Clay (CH)

Initial Conditions: Dry Density (pcf): 62.1 Moisture Content (%): 62.1% e_o 1.765



Calculated Consolidation Coefficients	Pc	3.1 tsf	Cc	0.94	Cr	0.20

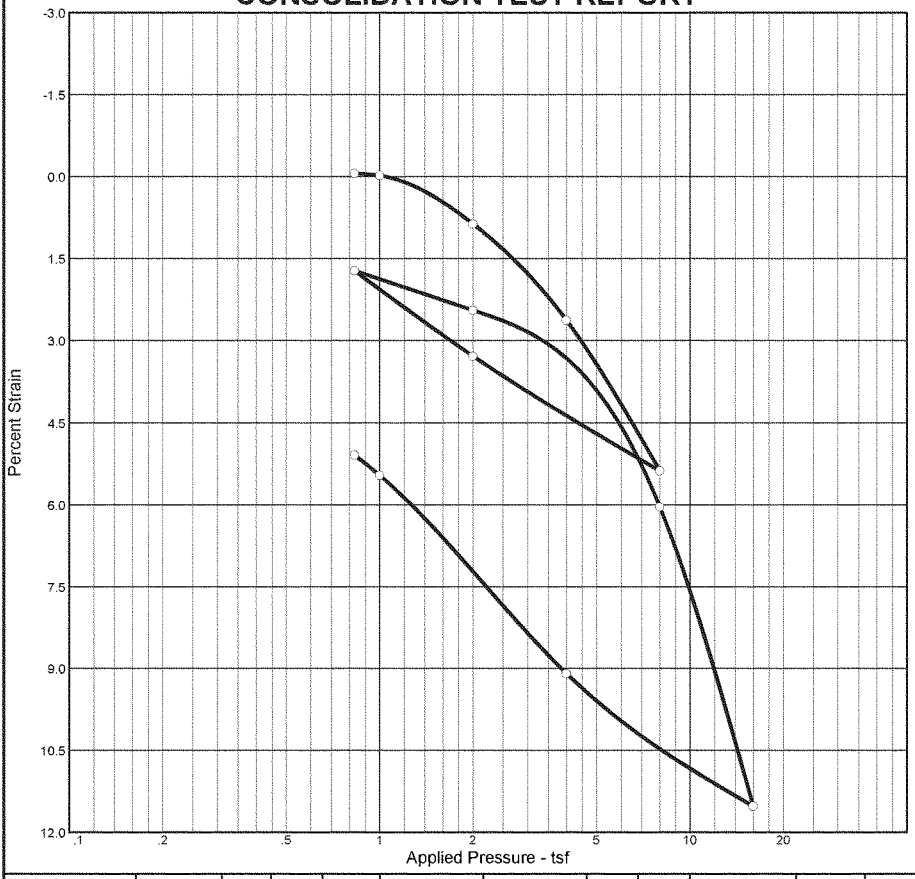


Constant Rate of Strain Data Table

Project: Fargo Moorhead Metro Feasibility Project Date: 5/12/11
Boring: 10-105MU Sample 3 Depth: 35-37 Job: 7922

Axial Strain	Vert. Stress (tsf)	Excess Pressure (tsf)	Pressure Ratio	Eff. Stress (tsf)	Cv (cm^2/sec)	K (cm/sec)	Void Ratio
0.36%	0.252	0.012	0.049	0.243	2.58E-02	9.45E-08	1.755
0.90%	0.499	0.044	0.088	0.470	1.69E-03	2.42E-08	1.740
2.36%	1.012	0.092	0.091	0.949	5.23E-04	3.87E-08	1.700
3.96%	1.518	0.149	0.098	1.417	5.15E-04	1.76E-08	1.655
5.08%	2.009	0.220	0.110	1.859	3.71E-04	1.17E-08	1.624
6.37%	2.490	0.296	0.119	2.288	2.43E-04	7.16E-09	1.589
7.66%	3.006	0.389	0.129	2.741	1.61E-04	8.02E-09	1.553
9.22%	3.504	0.487	0.139	3.171	9.68E-05	3.39E-09	1.510
10.97%	3.987	0.582	0.146	3.589	6.65E-05	2.73E-09	1.461
12.76%	4.508	0.678	0.150	4.044	7.28E-05	8.49E-10	1.412
14.32%	5.013	0.806	0.161	4.460	5.12E-05	2.36E-09	1.369
17.29%	6.002	1.109	0.185	5.238	2.95E-05	1.83E-09	1.287
19.68%	7.009	1.416	0.202	6.031	3.57E-05	9.60E-10	1.221
21.68%	7.982	1.675	0.210	6.823	4.29E-05	8.27E-10	1.165
23.37%	8.919	1.965	0.220	7.555	4.39E-05	7.20E-10	1.119
25.28%	10.060	2.250	0.224	8.498	3.26E-05	7.07E-10	1.066
26.65%	11.078	2.474	0.223	9.361	3.03E-05	4.91E-10	1.028
27.72%	11.943	2.677	0.224	10.084	3.17E-05	3.62E-10	0.998
28.78%	12.995	2.964	0.228	10.935	2.91E-05	3.82E-10	0.969
29.73%	13.865	3.204	0.231	11.636	2.61E-05	4.03E-10	0.943
30.70%	14.868	3.503	0.236	12.430	2.74E-05	4.09E-10	0.916
31.48%	15.635	3.687	0.236	13.069	2.35E-05	3.81E-10	0.894
31.76%	15.882	3.747	0.236	13.274	2.58E-05	3.94E-10	0.887

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
99.9 %	40.2 %	81.4	71	52	2.741		3.93	0.39	0.09			1.102

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2435	CH	

Project No. BL-10-10065 **Client:** USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3

Location: Boring11-107MU, #1, 20-22', ND RRCS, MN, Brenna Formation

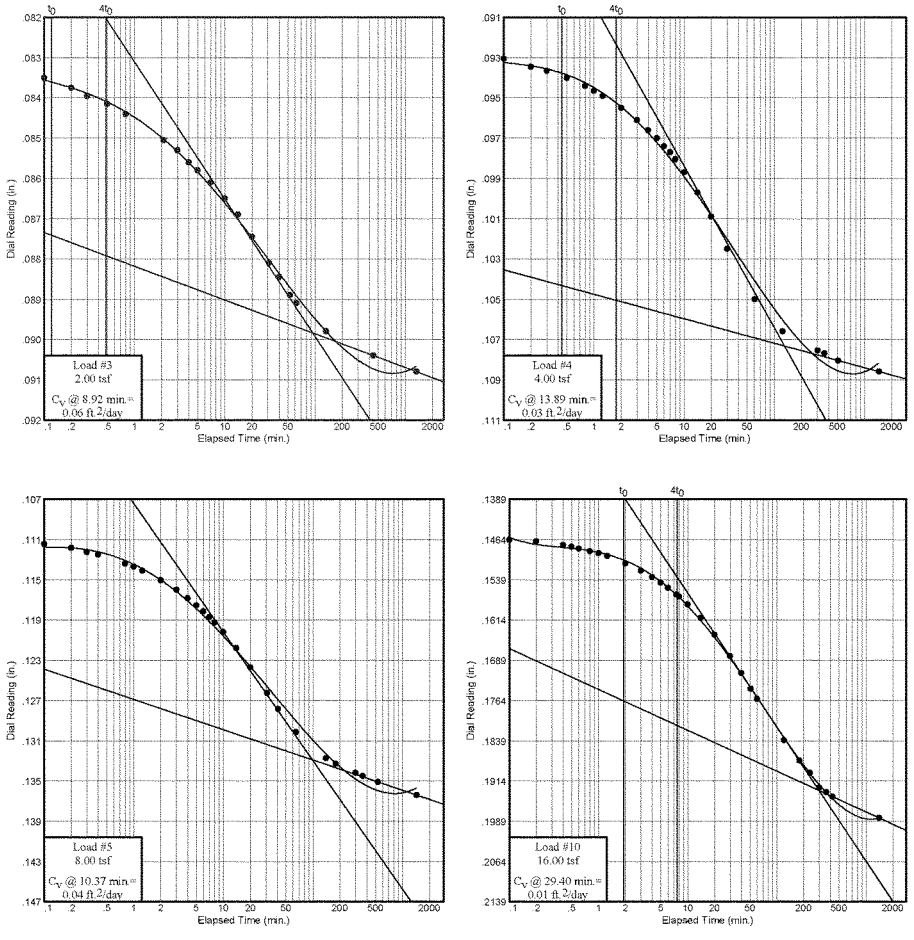
Remarks:

BRAUN™ INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: Boring11-107MU, #1, 20-22', ND RRCS, MN, Brenna Formation



BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: Boring11-107MU, #1
Elev. or Depth: 20-22' **Sample Length(in./cm.):**
Location: Boring11-107MU, #1, 20-22', ND RRCS, MN, Brenna Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2435
Liquid Limit: 71 **Plasticity Index:** 52
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	155.33 g.	Consolidometer # = 2	Wet w+t =
Dry w+t =	119.48 g.		Dry w+t =
Tare Wt. =	30.27 g.	Spec. Gravity = 2.741	Tare Wt. =
Height =	1.01 in.	Height = 1.01 in.	
Diameter =	2.50 in.	Diameter = 2.50 in.	
Weight =	147.91 g.	Defl. Table = Machine2-Air-2011	
Moisture =	40.2 %	Ht. Solids = 0.4797 in.	Moisture = %
Wet Den. =	114.1 pcf	Dry Wt. = 105.51 g.*	Dry Wt. = n/a
Dry Den. =	81.4 pcf	Void Ratio = 1.102	Void Ratio = 0.995
		Saturation = 99.9 %	

* Initial dry weight used in calculations

End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.08210				1.102	
0.83	0.08150	0.00000			1.104	0.1 Swell
1.00	0.08340	0.00155			1.103	0.0 Swell
2.00	0.09305	0.00225	0.06	0.001	1.084	0.9 Comprs.
4.00	0.11155	0.00295	0.03	0.001	1.047	2.6 Comprs.
8.00	0.14020	0.00380	0.04	0.003	0.989	5.4 Comprs.
2.00	0.11745	0.00225			1.033	3.3 Comprs.
0.83	0.09945	0.00000			1.066	1.7 Comprs.
2.00	0.10900	0.00225			1.051	2.4 Comprs.
8.00	0.14685	0.00380			0.975	6.0 Comprs.
16.00	0.20325	0.00495	0.01	0.008	0.860	11.5 Comprs.
4.00	0.17675	0.00295			0.911	9.1 Comprs.
1.00	0.13875	0.00155			0.988	5.5 Comprs.
0.83	0.13345	0.00000			0.995	5.1 Comprs.

C_c = 0.39 P_c = 3.93 tsf C_r = 0.09

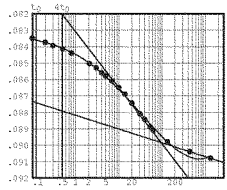
Pressure: 1.00 tsf TEST READINGS **Load No. 2**

No.	Elapsed Time	Dial Reading
1	0.00	0.08250
2	0.20	0.08265
3	10.00	0.08285
4	30.00	0.08305
5	483.00	0.08335
6	1434.00	0.08340

Void Ratio = 1.103 Swell = 0.0 %

Pressure: 2.00 tsf TEST READINGS **Load No. 3**

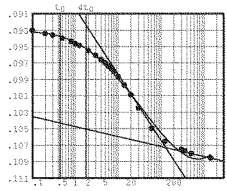
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08340	12	10.00	0.08875
2	0.10	0.08575	13	14.00	0.08915
3	0.20	0.08600	14	20.00	0.08970
4	0.30	0.08620	15	31.00	0.09035
5	0.50	0.08640	16	40.00	0.09070
6	0.80	0.08665	17	53.00	0.09115
7	2.10	0.08730	18	62.30	0.09135
8	3.00	0.08755	19	133.00	0.09205
9	4.00	0.08785	20	442.00	0.09265
10	5.00	0.08805	21	1327.00	0.09305
11	7.00	0.08835			



Void Ratio = 1.084 Compression = 0.9 %
D_0 = 0.08312 D_{50} = 0.08648 D_{100} = 0.08984
C_v at 8.9 min. = 0.06 ft.^{2}/day C_α = 0.001

Pressure: 4.00 tsf TEST READINGS **Load No. 4**

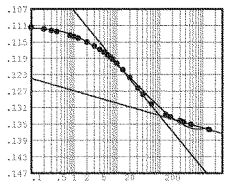
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.09305	14	7.00	0.10065
2	0.10	0.09600	15	8.00	0.10100
3	0.20	0.09640	16	10.00	0.10165
4	0.30	0.09660	17	14.00	0.10265
5	0.50	0.09695	18	20.00	0.10385
6	0.80	0.09735	19	30.00	0.10545
7	1.00	0.09760	20	61.00	0.10795
8	1.25	0.09785	21	124.00	0.10955
9	2.00	0.09845	22	303.00	0.11050
10	3.00	0.09905	23	360.00	0.11065
11	4.00	0.09955	24	511.00	0.11100
12	5.00	0.09995	25	1448.00	0.11155
13	6.00	0.10035			



Void Ratio = 1.047 Compression = 2.6 %
D_0 = 0.09228 D_{50} = 0.09981 D_{100} = 0.10733
C_v at 13.9 min. = 0.03 ft.^{2}/day C_α = 0.001

Pressure: 8.00 tsf | TEST READINGS | Load No. 5

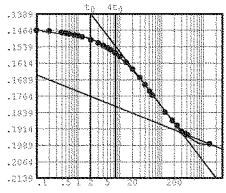
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.11155	15	8.00	0.12305
2	0.10	0.11525	16	10.00	0.12400
3	0.20	0.11565	17	14.00	0.12560
4	0.30	0.11605	18	20.00	0.12750
5	0.40	0.11630	19	31.00	0.13005
6	0.80	0.11720	20	41.00	0.13165
7	1.00	0.11750	21	65.00	0.13395
8	1.25	0.11790	22	140.00	0.13655
9	2.00	0.11885	23	180.00	0.13710
10	3.00	0.11980	24	300.00	0.13800
11	4.00	0.12065	25	360.00	0.13830
12	5.00	0.12135	26	533.00	0.13890
13	6.00	0.12195	27	1440.00	0.14020
14	7.00	0.12250			



Void Ratio = 0.989 Compression = 5.4 %
D_0 = 0.10860 D_{50} = 0.12075 D_{100} = 0.13289
C_v at 10.4 min. = 0.04 ft.^{2}/day C_α = 0.003

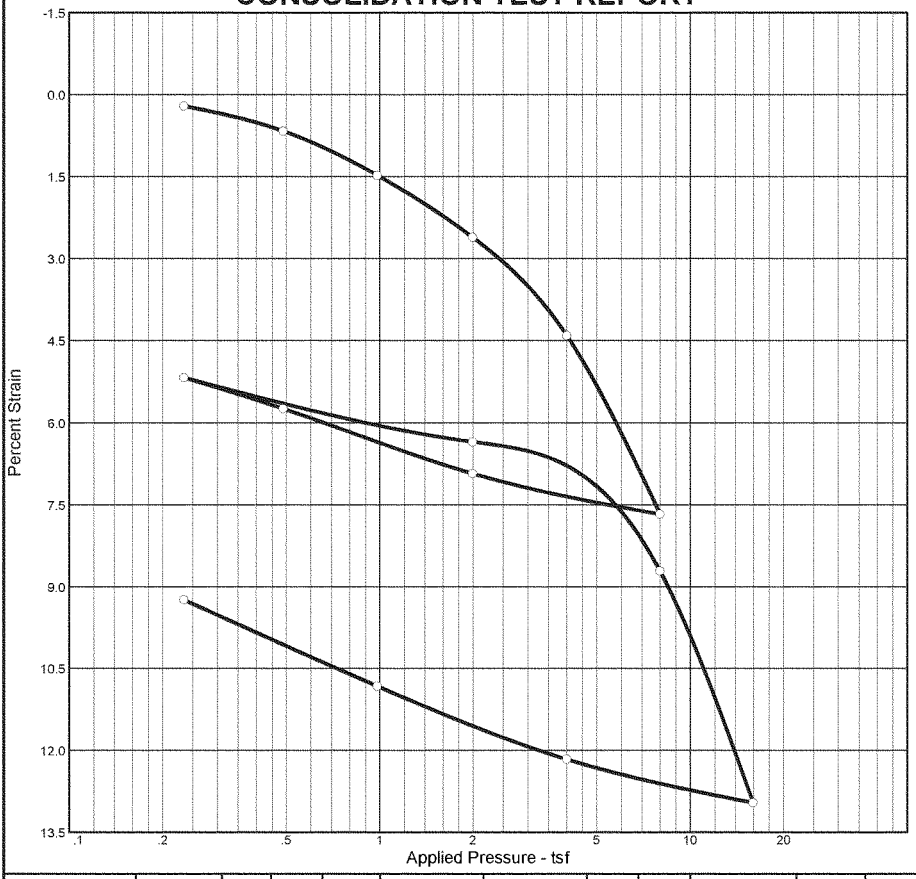
Pressure: 16.00 tsf | TEST READINGS | Load No. 10

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.14685	16	8.00	0.16200
2	0.10	0.15140	17	10.00	0.16345
3	0.20	0.15170	18	14.00	0.16600
4	0.40	0.15240	19	20.00	0.16910
5	0.50	0.15270	20	30.00	0.17310
6	0.60	0.15305	21	40.00	0.17625
7	0.80	0.15355	22	51.00	0.17920
8	1.00	0.15390	23	60.00	0.18105
9	1.25	0.15445	24	120.00	0.18880
10	2.00	0.15580	25	180.00	0.19255
11	3.00	0.15715	26	235.00	0.19485
12	4.00	0.15835	27	300.00	0.19760
13	5.00	0.15940	28	360.00	0.19845
14	6.00	0.16035	29	420.00	0.19925
15	7.50	0.16160	30	1409.00	0.20325



Void Ratio = 0.860 Compression = 11.5 %
D_0 = 0.14355 D_{50} = 0.16835 D_{100} = 0.19316
C_v at 29.4 min. = 0.01 ft.^{2}/day C_α = 0.008

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
99.9 %	39.5 %	82.3	52	31	2.76		3.55	0.30	0.04			1.092

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2435	CH	

Project No. BL-10-10065 **Client:** USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3

Location: Boring11-107MU, #2, 30-32', ND RRCS, MN, Brenna Formation

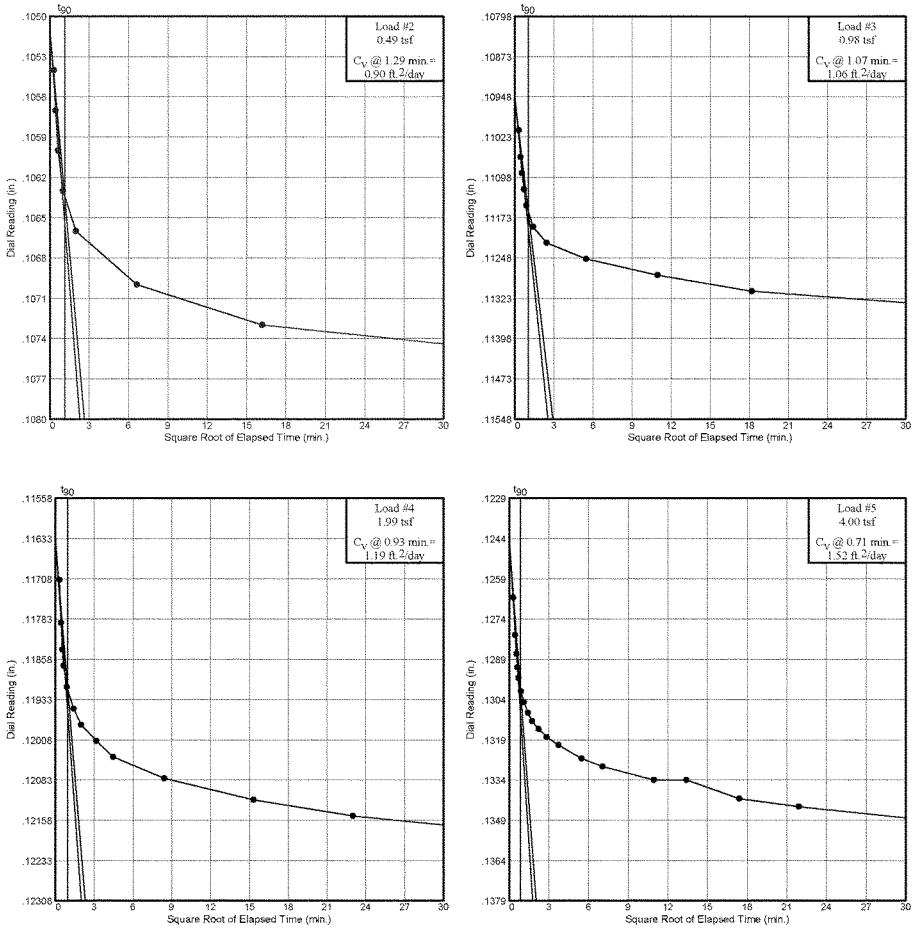
Remarks:

BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: Boring11-107MU, #2, 30-32', ND RRCS, MN, Brenna Formation

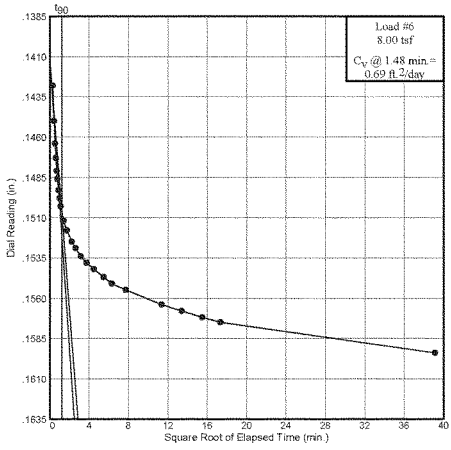


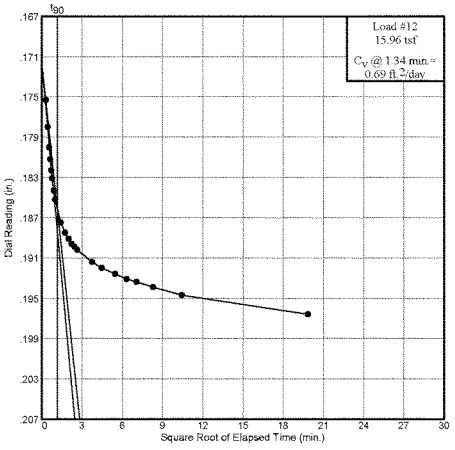
BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: Boring11-107MU, #2, 30-32', ND RRCS, MN, Brenna Formation





BRAUN INTERTEC

Figure

CONSOLIDATION TEST DATA

Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: Boring11-107MU, #2
Elev. or Depth: 30-32' **Sample Length(in./cm.):**
Location: Boring11-107MU, #2, 30-32', ND RRCS, MN, Brenna Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2435
Liquid Limit: 52 **Plasticity Index:** 31
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE	BEFORE TEST	AFTER TEST
Wet w+t = 142.34 g.	Consolidometer # = 4	Wet w+t =
Dry w+t = 110.82 g.		Dry w+t =
Tare Wt. = 31.09 g.	Spec. Gravity = 2.76	Tare Wt. =
Height = .74 in.	Height = .74 in.	
Diameter = 2.49 in.	Diameter = 2.49 in.	
Weight = 109.12 g.	Defl. Table = Machine4-2009	
Moisture = 39.5 %	Ht. Solids = 0.3537 in.	Moisture = %
Wet Den. = 114.9 pcf	Dry Wt. = 78.20 g.*	Dry Wt. = n/a
Dry Den. = 82.3 pcf	Void Ratio = 1.092	Void Ratio = 0.899
	Saturation = 99.9 %	

* Initial dry weight used in calculations

End-of-Load Summary

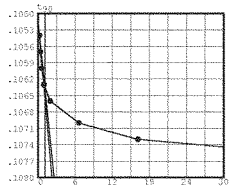
Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.10260				1.092	
0.23	0.10460	0.00050			1.088	0.2 Comprs.
0.49	0.10830	0.00080	0.90		1.079	0.7 Comprs.
0.98	0.11450	0.00100	1.06		1.062	1.5 Comprs.
1.99	0.12340	0.00150	1.19		1.038	2.6 Comprs.
4.00	0.13720	0.00200	1.52		1.000	4.4 Comprs.
8.00	0.16210	0.00270	0.69		0.932	7.7 Comprs.
1.99	0.15540	0.00150			0.947	6.9 Comprs.
0.49	0.14590	0.00080			0.972	5.7 Comprs.
0.23	0.14140	0.00050			0.984	5.2 Comprs.
1.99	0.15110	0.00150			0.960	6.4 Comprs.
8.00	0.16980	0.00270			0.910	8.7 Comprs.
15.96	0.20210	0.00360	0.69		0.821	13.0 Comprs.
4.00	0.19460	0.00200			0.838	12.2 Comprs.

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
0.98	0.18370	0.00100			0.866	10.8 Comprs.
0.23	0.17150	0.00050			0.899	9.2 Comprs.

C_c = 0.30 P_c = 3.55 tsf C_r = 0.04

Pressure: 0.49 tsf TEST READINGS Load No. 2

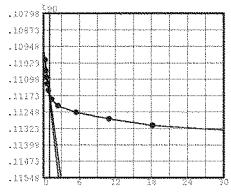
No.	Elapsed Time	Dial Reading
1	0.00	0.10460
2	0.10	0.10620
3	0.20	0.10650
4	0.40	0.10680
5	1.00	0.10710
6	4.00	0.10740
7	44.00	0.10780
8	262.00	0.10810
9	1295.00	0.10830



Void Ratio = 1.079 Compression = 0.7 %
D_0 = 0.10509 D_{90} = 0.10634 D_{100} = 0.10648
C_v at 1.3 min. = 0.90 ft.^{2}/day

Pressure: 0.98 tsf TEST READINGS Load No. 3

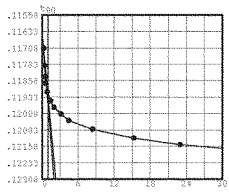
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10830	11	331.00	0.11410
2	0.10	0.11110	12	1628.00	0.11450
3	0.20	0.11160			
4	0.30	0.11190			
5	0.50	0.11220			
6	0.80	0.11250			
7	2.00	0.11290			
8	6.00	0.11320			
9	30.00	0.11350			
10	120.00	0.11380			



Void Ratio = 1.062 Compression = 1.5 %
D_0 = 0.10949 D_{90} = 0.11161 D_{100} = 0.11184
C_v at 1.1 min. = 1.06 ft.^{2}/day

Pressure: 1.99 tsf — TEST READINGS — Load No. 4

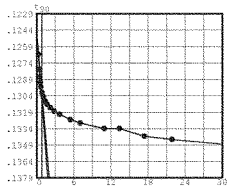
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.11450	11	71.00	0.12230
2	0.10	0.11860	12	235.00	0.12270
3	0.20	0.11940	13	529.30	0.12300
4	0.30	0.11990	14	1568.00	0.12340
5	0.40	0.12020			
6	0.80	0.12060			
7	2.00	0.12100			
8	4.00	0.12130			
9	10.00	0.12160			
10	20.00	0.12190			



Void Ratio = 1.038 Compression = 2.6 %
D_0 = 0.11633 D_{90} = 0.11916 D_{100} = 0.11947
C_v at 0.9 min. = 1.19 ft.^{2}/day

Pressure: 4.00 tsf — TEST READINGS — Load No. 5

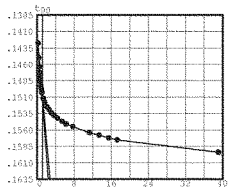
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.12340	11	5.00	0.13350
2	0.10	0.12860	12	8.00	0.13380
3	0.20	0.13000	13	14.00	0.13410
4	0.30	0.13070	14	30.00	0.13460
5	0.40	0.13120	15	50.00	0.13490
6	0.50	0.13160	16	120.00	0.13540
7	0.80	0.13210	17	180.00	0.13540
8	1.25	0.13250	18	303.00	0.13610
9	2.00	0.13290	19	480.00	0.13640
10	3.00	0.13320	20	1420.00	0.13720



Void Ratio = 1.000 Compression = 4.4 %
D_0 = 0.12440 D_{90} = 0.12997 D_{100} = 0.13058
C_v at 0.7 min. = 1.52 ft.^{2}/day

Pressure: 8.00 tsf — TEST READINGS — Load No. 6

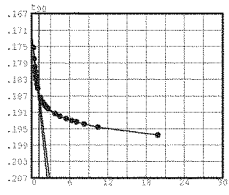
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.13720	14	7.00	0.15560
2	0.10	0.14550	15	10.00	0.15610
3	0.20	0.14770	16	14.00	0.15650
4	0.30	0.14910	17	20.00	0.15690
5	0.40	0.15000	18	30.00	0.15740
6	0.50	0.15080	19	40.00	0.15780
7	0.60	0.15130	20	60.00	0.15820
8	0.80	0.15200	21	129.00	0.15910
9	1.00	0.15250	22	180.00	0.15950
10	1.25	0.15300	23	240.00	0.15990
11	2.00	0.15390	24	301.00	0.16020
12	3.00	0.15450	25	1532.00	0.16210
13	5.00	0.15520			



Void Ratio = 0.932 Compression = 7.7 %
D_0 = 0.14106 D_{90} = 0.15060 D_{100} = 0.15166
C_v at 1.5 min. = 0.69 ft.^{2}/day

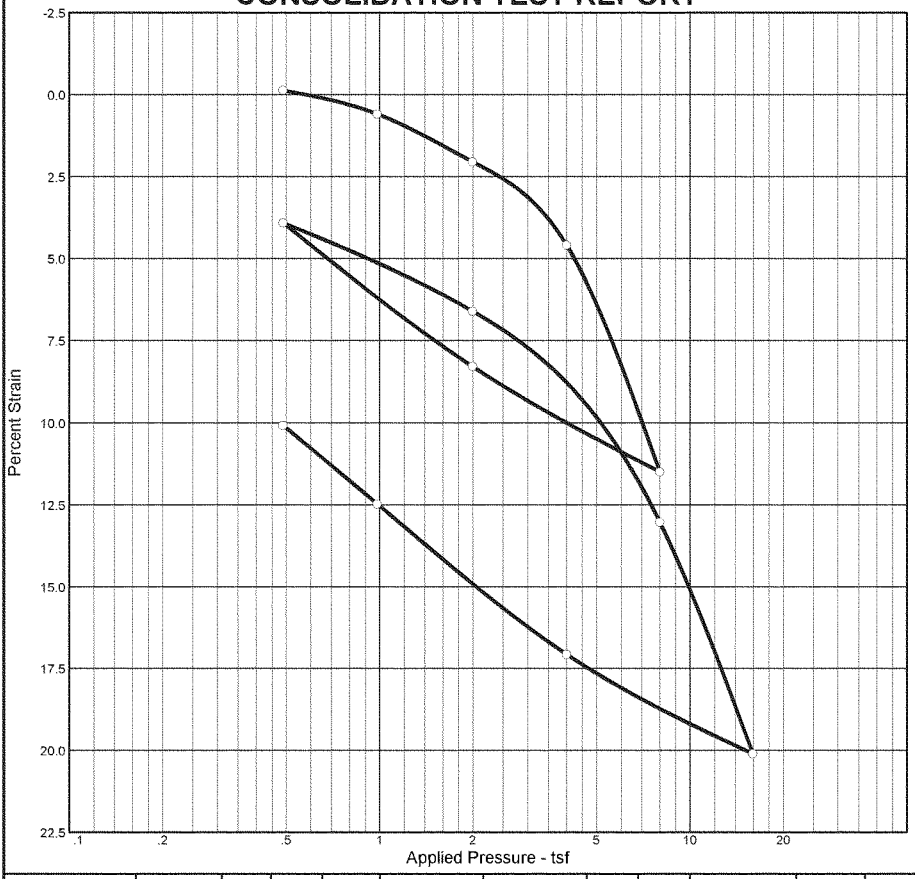
Pressure: 15.96 tsf — TEST READINGS — Load No. 12

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.16980	14	6.00	0.19350
2	0.10	0.17890	15	7.00	0.19380
3	0.20	0.18160	16	14.00	0.19500
4	0.30	0.18360	17	20.00	0.19560
5	0.40	0.18480	18	30.00	0.19620
6	0.50	0.18590	19	40.00	0.19670
7	0.60	0.18670	20	50.00	0.19700
8	0.80	0.18790	21	69.00	0.19750
9	1.00	0.18880	22	109.00	0.19830
10	2.00	0.19110	23	394.00	0.20020
11	3.00	0.19210	24	451.00	0.20050
12	4.00	0.19270	25	1298.00	0.20210
13	5.00	0.19320			



Void Ratio = 0.821 Compression = 13.0 %
D_0 = 0.17163 D_{90} = 0.18607 D_{100} = 0.18768
C_v at 1.3 min. = 0.69 ft.^{2}/day

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
Sat.	Moist.											
103.1 %	50.3 %	73.0	95	67	2.718		4.26	0.67	0.16			1.326

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2435	CH	

Project No. BL-10-10065 **Client:** W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

Location: Boring11-110MU, #2, 35-37', Sheyenne River, Brenna Formation

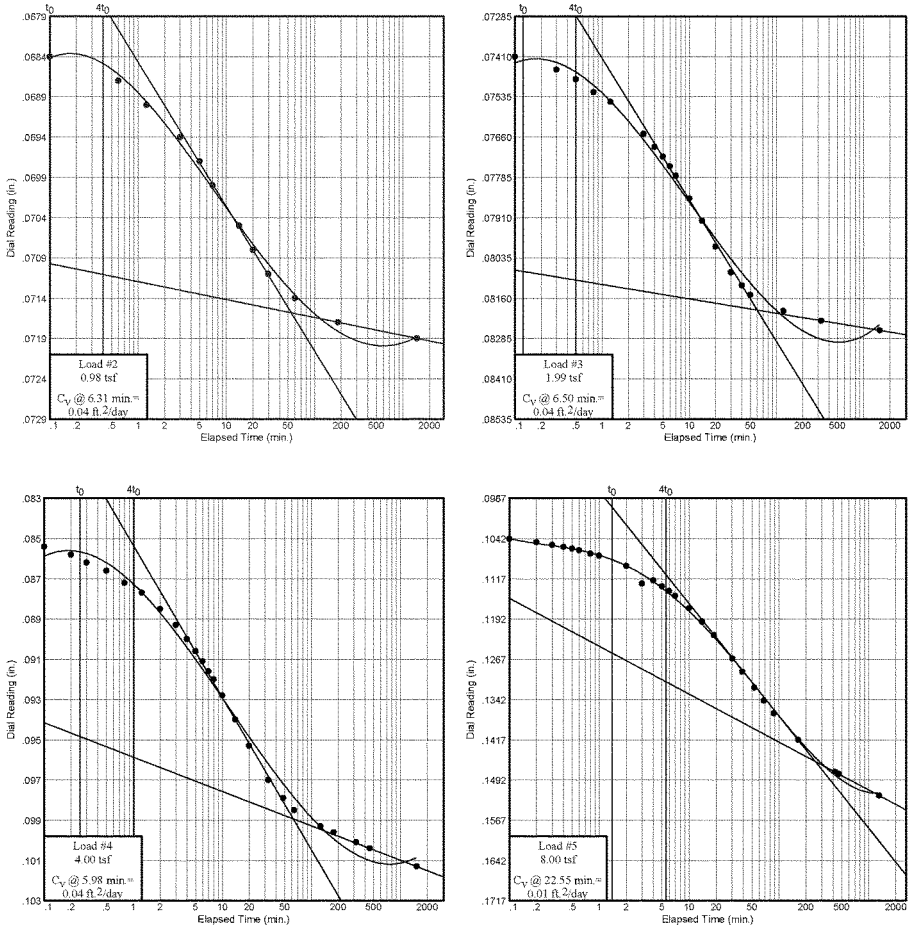
Remarks:

BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Boring11-110MU, #2, 35-37', Sheyenne River, Brenna Formation



BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Boring11-110MU, #2, 35-37', Sheyenne River, Brenna Formation

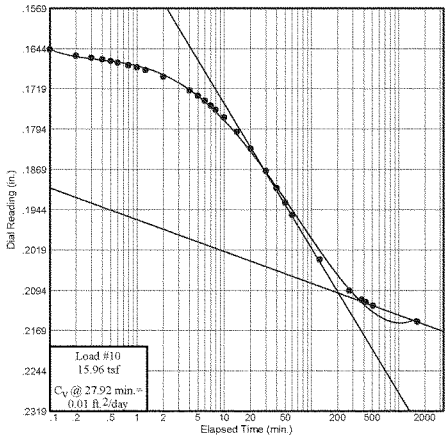


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Figure

SWELL/CONSOLIDATION TEST DATA

Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: 11-110, #2
Elev. or Depth: 35-37' **Sample Length(in./cm.):**
Location: Boring11-110MU, #2, 35-37', Sheyenne River, Brenna Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2435
Liquid Limit: 95 **Plasticity Index:** 67
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	148.41 g.	Consolidometer # = 4	Wet w+t =
Dry w+t =	108.87 g.		Dry w+t =
Tare Wt. =	30.21 g.	Spec. Gravity = 2.718	Tare Wt. =
Height =	.73 in.	Height = .73 in.	
Diameter =	2.49 in.	Diameter = 2.49 in.	
Weight =	103.38 g.	Defl. Table = Machine4-2009	
Moisture =	50.3 %	Ht. Solids = 0.3159 in.	Moisture = %
Wet Den. =	109.6 pcf	Dry Wt. = 68.80 g.*	Dry Wt. = n/a
Dry Den. =	73.0 pcf	Void Ratio = 1.326	Void Ratio = 1.091
		Saturation = 103.1 %	

* Initial dry weight used in calculations

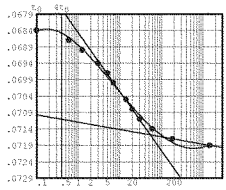
End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.06760				1.326	
0.49	0.06740	0.00080			1.329	0.1 Swell
0.98	0.07290	0.00100	0.04	0.000	1.312	0.6 Comprs.
1.99	0.08410	0.00150	0.04	0.001	1.278	2.0 Comprs.
4.00	0.10330	0.00200	0.04	0.002	1.219	4.6 Comprs.
8.00	0.15480	0.00270	0.01	0.013	1.058	11.5 Comprs.
1.99	0.13000	0.00150			1.133	8.3 Comprs.
0.49	0.09710	0.00080			1.235	3.9 Comprs.
1.99	0.11760	0.00150			1.172	6.6 Comprs.
8.00	0.16610	0.00270			1.022	13.0 Comprs.
15.96	0.21890	0.00360	0.01	0.009	0.858	20.1 Comprs.
4.00	0.19500	0.00200			0.929	17.1 Comprs.
0.98	0.16030	0.00100			1.035	12.5 Comprs.
0.49	0.14250	0.00080			1.091	10.1 Comprs.

C_c = 0.67 P_c = 4.26 tsf C_r = 0.16

Pressure: 0.98 tsf — TEST READINGS — **Load No. 2**

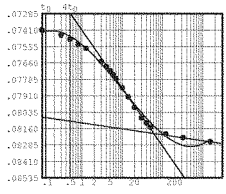
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.06740	11	60.00	0.07240
2	0.10	0.06940	12	183.00	0.07270
3	0.60	0.06970	13	1442.00	0.07290
4	1.25	0.07000			
5	3.00	0.07040			
6	5.00	0.07070			
7	7.00	0.07100			
8	14.00	0.07150			
9	20.00	0.07180			
10	30.00	0.07210			



Void Ratio = 1.312 Compression = 0.6 %
D_0 = 0.06836 D_{50} = 0.06997 D_{100} = 0.07158
C_v at 6.3 min. = 0.04 ft.^{2}/day C_a = 0.000

Pressure: 1.99 tsf — TEST READINGS — **Load No. 3**

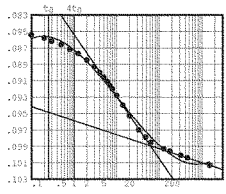
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.07290	11	7.00	0.07930
2	0.10	0.07560	12	10.00	0.08000
3	0.30	0.07600	13	14.00	0.08070
4	0.50	0.07630	14	20.00	0.08150
5	0.80	0.07670	15	30.00	0.08230
6	1.25	0.07700	16	40.00	0.08270
7	3.00	0.07800	17	50.00	0.08300
8	4.00	0.07840	18	120.00	0.08350
9	5.00	0.07870	19	327.00	0.08380
10	6.00	0.07900	20	1531.00	0.08410



Void Ratio = 1.278 Compression = 2.0 %
D_0 = 0.07385 D_{50} = 0.07791 D_{100} = 0.08197
C_v at 6.5 min. = 0.04 ft.^{2}/day C_a = 0.001

Pressure: 4.00 tsf | TEST READINGS | Load No. 4

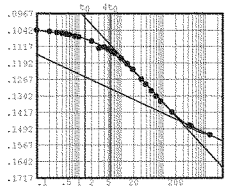
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08410	14	8.00	0.09400
2	0.10	0.08740	15	10.00	0.09480
3	0.20	0.08780	16	14.00	0.09600
4	0.30	0.08820	17	20.00	0.09730
5	0.50	0.08860	18	33.00	0.09900
6	0.80	0.08920	19	48.30	0.09990
7	1.25	0.08970	20	64.00	0.10050
8	2.00	0.09050	21	127.00	0.10130
9	3.00	0.09130	22	178.00	0.10160
10	4.00	0.09200	23	318.00	0.10210
11	5.00	0.09260	24	453.00	0.10240
12	6.00	0.09310	25	1524.00	0.10330
13	7.00	0.09360			



Void Ratio = 1.219 Compression = 4.6 %
D_0 = 0.08404 D_{50} = 0.09149 D_{100} = 0.09893
C_v at 6.0 min. = 0.04 ft.^{2}/day C_α = 0.002

Pressure: 8.00 tsf | TEST READINGS | Load No. 5

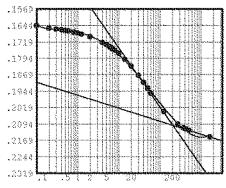
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10330	15	7.00	0.11760
2	0.10	0.10700	16	10.00	0.11990
3	0.20	0.10760	17	14.00	0.12240
4	0.30	0.10810	18	19.00	0.12490
5	0.40	0.10850	19	30.30	0.12930
6	0.50	0.10880	20	39.00	0.13170
7	0.60	0.10910	21	53.00	0.13470
8	0.80	0.10970	22	68.00	0.13710
9	1.00	0.11010	23	88.00	0.13950
10	2.00	0.11200	24	164.00	0.14440
11	3.00	0.11530	25	422.00	0.15040
12	4.00	0.11470	26	463.50	0.15080
13	5.00	0.11580	27	1300.00	0.15480
14	6.00	0.11670			



Void Ratio = 1.058 Compression = 11.5 %
D_0 = 0.10225 D_{50} = 0.12401 D_{100} = 0.14577
C_v at 22.6 min. = 0.01 ft.^{2}/day C_α = 0.013

Pressure: 15.96 tsf | TEST READINGS | Load No. 10

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.16610	16	8.00	0.17940
2	0.10	0.16810	17	10.00	0.18080
3	0.20	0.16930	18	14.00	0.18350
4	0.30	0.16970	19	20.00	0.18660
5	0.40	0.17000	20	30.00	0.19080
6	0.50	0.17030	21	40.00	0.19400
7	0.60	0.17060	22	50.00	0.19670
8	0.80	0.17110	23	60.00	0.19900
9	1.00	0.17150	24	124.00	0.20730
10	1.25	0.17200	25	273.00	0.21310
11	2.00	0.17320	26	379.00	0.21480
12	4.00	0.17580	27	420.00	0.21520
13	5.00	0.17680	28	508.00	0.21590
14	6.00	0.17770	29	1631.00	0.21890
15	7.00	0.17860			

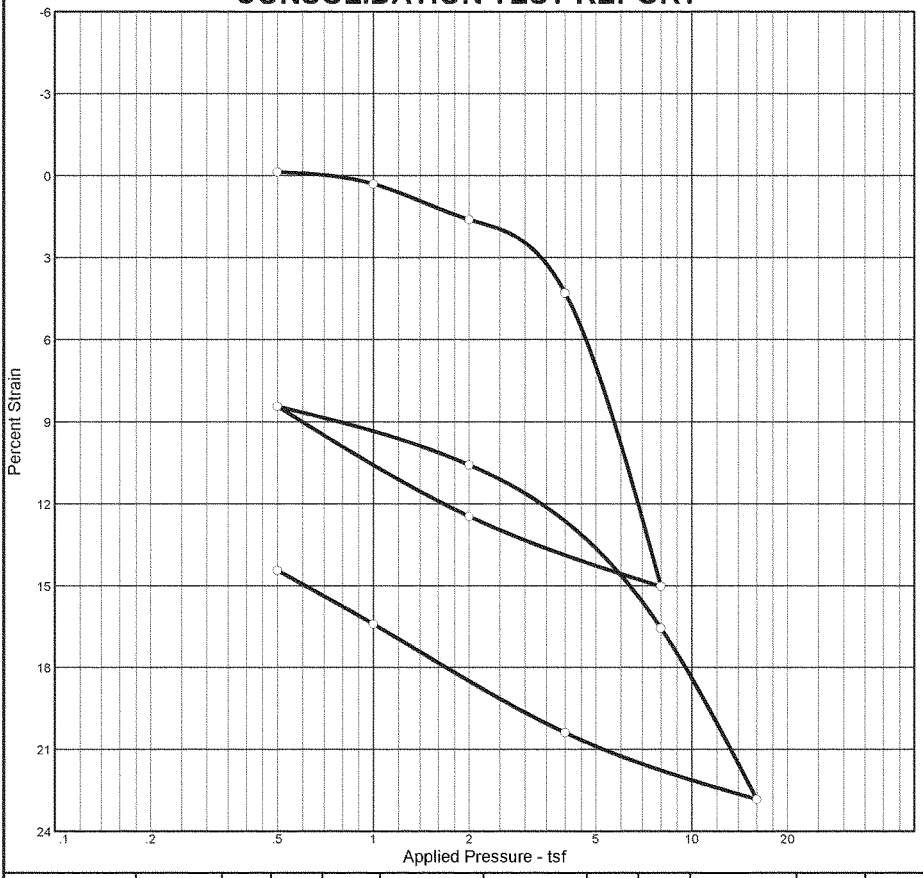


Void Ratio = 0.858 Compression = 20.1 %

D_0 = 0.16340 D_{50} = 0.18668 D_{100} = 0.20997

C_v at 27.9 min. = 0.01 ft.^{2}/day C_α = 0.009

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
100.0 %	53.1 %	69.4	86	64	2.710		4.03	0.94	0.15			1.439

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2435	CH	

Project No. BL-10-10065 **Client:** W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

Location: Boring11-110MU, #3, 48-50', Sheyenne River, Brenna Formation

Remarks:

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Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Boring11-110MU, #3, 48-50', Sheyenne River, Brenna Formation

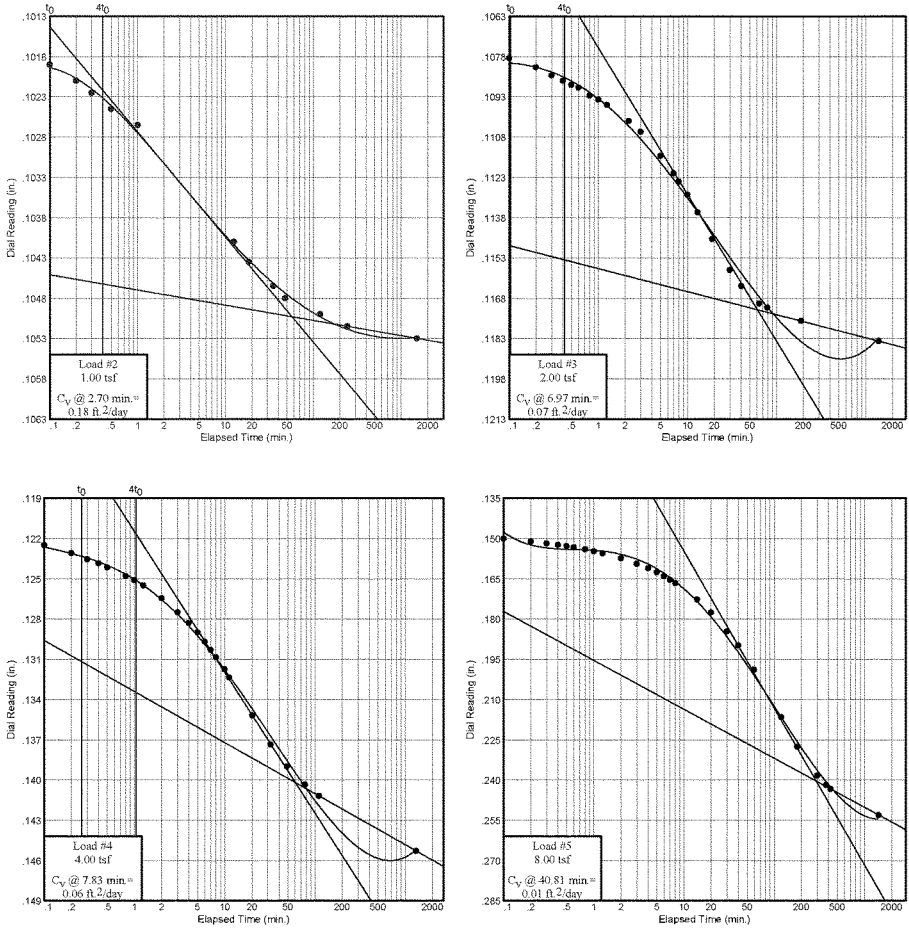

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Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Boring11-110MU, #3, 48-50', Sheyenne River, Brenna Formation

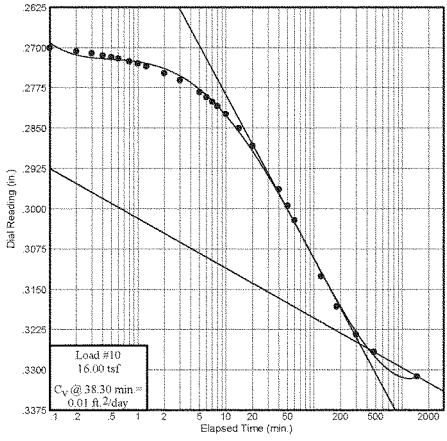

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Figure

SWELL/CONSOLIDATION TEST DATA

Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: 11-110, #3
Elev. or Depth: 48-50' **Sample Length(in./cm.):**
Location: Boring11-110MU, #3, 48-50', Sheyenne River, Brenna Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2435
Liquid Limit: 86 **Plasticity Index:** 64
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE	BEFORE TEST	AFTER TEST
Wet w+t = 132.86 g.	Consolidometer # = 2	Wet w+t =
Dry w+t = 97.60 g.		Dry w+t =
Tare Wt. = 31.18 g.	Spec. Gravity = 2.710	Tare Wt. =
Height = 1.00 in.	Height = 1.00 in.	
Diameter = 2.50 in.	Diameter = 2.50 in.	
Weight = 136.92 g.	Defl. Table = Machine2-Air-2011	
Moisture = 53.1 %	Ht. Solids = 0.4113 in.	Moisture = %
Wet Den. = 106.2 pcf	Dry Wt. = 89.44 g.*	Dry Wt. = n/a
Dry Den. = 69.4 pcf	Void Ratio = 1.439	Void Ratio = 1.086
	Saturation = 100.0 %	

* Initial dry weight used in calculations

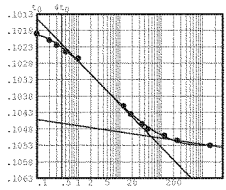
End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.10230				1.439	
0.50	0.10185	0.00095			1.442	0.1 Swell
1.00	0.10685	0.00155	0.18	0.000	1.431	0.3 Comprs.
2.00	0.12065	0.00225	0.07	0.001	1.400	1.6 Comprs.
4.00	0.14825	0.00295	0.06	0.004	1.334	4.3 Comprs.
8.00	0.25690	0.00380	0.01	0.019	1.072	15.0 Comprs.
2.00	0.22960	0.00225			1.135	12.5 Comprs.
0.50	0.18790	0.00095			1.233	8.4 Comprs.
2.00	0.21075	0.00225			1.181	10.6 Comprs.
8.00	0.27220	0.00380			1.035	16.6 Comprs.
16.00	0.33620	0.00495	0.01	0.011	0.882	22.8 Comprs.
4.00	0.30975	0.00295			0.942	20.4 Comprs.
1.00	0.26845	0.00155			1.039	16.4 Comprs.
0.50	0.24815	0.00095			1.086	14.4 Comprs.

C_c = 0.94 P_c = 4.03 tsf C_r = 0.15

Pressure: 1.00 tsf TEST READINGS Load No. 2

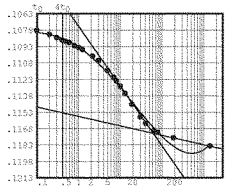
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10185	11	120.00	0.10655
2	0.10	0.10345	12	244.00	0.10670
3	0.20	0.10365	13	1515.00	0.10685
4	0.30	0.10380			
5	0.50	0.10400			
6	1.00	0.10420			
7	12.50	0.10565			
8	18.50	0.10590			
9	35.00	0.10620			
10	48.00	0.10635			



Void Ratio = 1.431 Compression = 0.3 %
D_0 = 0.10156 D_{50} = 0.10330 D_{100} = 0.10503
C_v at 2.7 min. = 0.18 ft.^{2}/day C_α = 0.000

Pressure: 2.00 tsf TEST READINGS Load No. 3

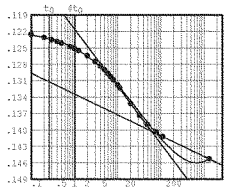
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10685	13	5.00	0.11375
2	0.10	0.11010	14	7.00	0.11440
3	0.20	0.11045	15	8.00	0.11470
4	0.30	0.11075	16	10.00	0.11520
5	0.40	0.11095	17	13.00	0.11585
6	0.50	0.11110	18	19.00	0.11685
7	0.60	0.11120	19	30.00	0.11800
8	0.80	0.11150	20	40.30	0.11860
9	1.00	0.11165	21	64.00	0.11925
10	1.25	0.11185	22	79.00	0.11940
11	2.20	0.11245	23	188.50	0.11990
12	3.00	0.11285	24	1409.00	0.12065



Void Ratio = 1.400 Compression = 1.6 %
D_0 = 0.10750 D_{50} = 0.11236 D_{100} = 0.11723
C_v at 7.0 min. = 0.07 ft.^{2}/day C_α = 0.001

Pressure: 4.00 tsf | TEST READINGS | Load No. 4

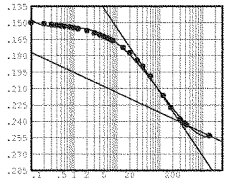
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.12065	13	5.00	0.13195
2	0.10	0.12545	14	6.00	0.13265
3	0.20	0.12605	15	7.00	0.13325
4	0.30	0.12650	16	8.00	0.13380
5	0.40	0.12680	17	10.00	0.13470
6	0.50	0.12710	18	11.20	0.13530
7	0.80	0.12775	19	20.20	0.13815
8	1.00	0.12805	20	32.30	0.14030
9	1.25	0.12845	21	49.20	0.14195
10	2.00	0.12940	22	77.50	0.14330
11	3.00	0.13045	23	111.00	0.14415
12	4.00	0.13125	24	1324.00	0.14825



Void Ratio = 1.334 Compression = 4.3 %
D_0 = 0.12152 D_{50} = 0.13086 D_{100} = 0.14020
C_v at 7.8 min. = 0.06 ft.^{2}/day C_α = 0.004

Pressure: 8.00 tsf | TEST READINGS | Load No. 5

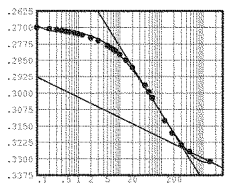
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.14825	15	6.00	0.16785
2	0.10	0.15380	16	7.00	0.16915
3	0.20	0.15490	17	8.00	0.17040
4	0.30	0.15565	18	14.00	0.17655
5	0.40	0.15620	19	20.00	0.18140
6	0.50	0.15670	20	30.00	0.18845
7	0.60	0.15715	21	40.00	0.19365
8	0.80	0.15785	22	60.00	0.20275
9	1.00	0.15855	23	120.00	0.22040
10	1.25	0.15936	24	181.00	0.23140
11	2.00	0.16120	25	300.00	0.24215
12	3.00	0.16325	26	377.00	0.24570
13	4.00	0.16490	27	420.00	0.24715
14	5.00	0.16645	28	1436.00	0.25690



Void Ratio = 1.072 Compression = 15.0 %
D_0 = 0.14530 D_{50} = 0.19290 D_{100} = 0.24049
C_v at 40.8 min. = 0.01 ft.^{2}/day C_α = 0.019

Pressure: 16.00 tsf | TEST READINGS | Load No. 10

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.27220	15	7.00	0.28505
2	0.10	0.27500	16	8.00	0.28585
3	0.20	0.27560	17	10.00	0.28735
4	0.30	0.27600	18	14.00	0.28995
5	0.40	0.27640	19	20.00	0.29325
6	0.50	0.27670	20	40.00	0.30135
7	0.60	0.27700	21	50.00	0.30440
8	0.80	0.27750	22	60.00	0.30710
9	1.00	0.27790	23	120.00	0.31755
10	1.25	0.27845	24	180.00	0.32320
11	2.00	0.27970	25	300.00	0.32840
12	3.00	0.28100	26	478.00	0.33165
13	5.00	0.28325	27	1477.00	0.33620
14	6.00	0.28420			

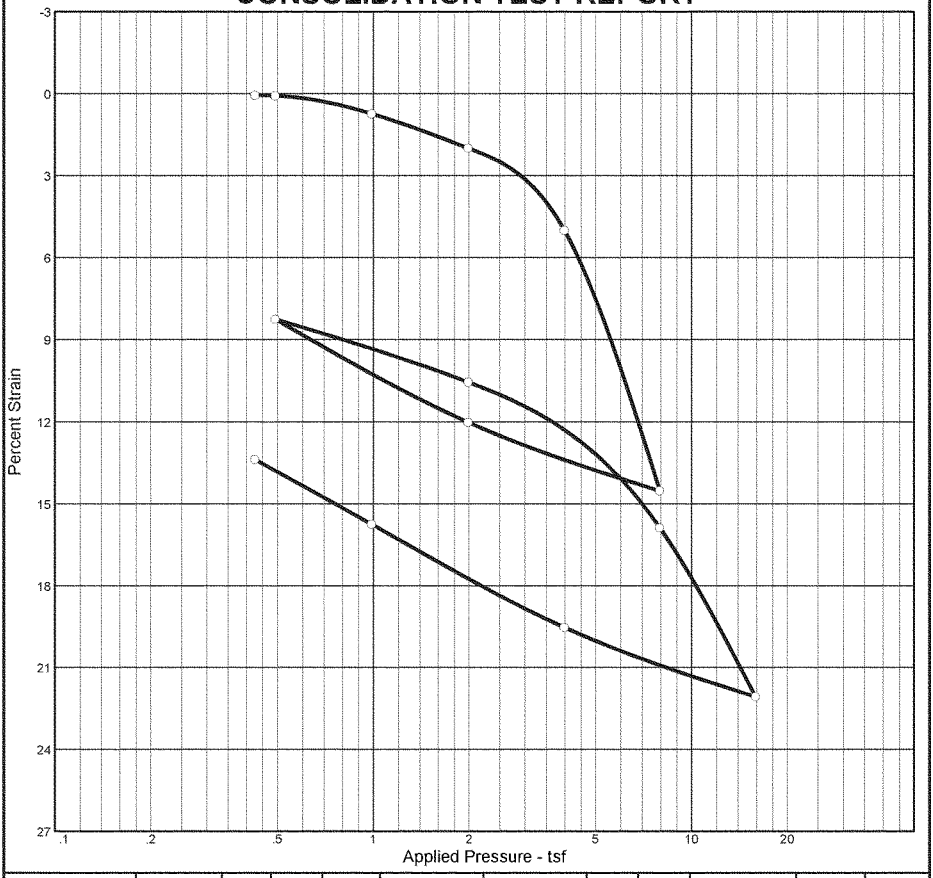


Void Ratio = 0.882 Compression = 22.8 %

D_0 = 0.26840 D_{50} = 0.29682 D_{100} = 0.32523

C_v at 38.3 min. = 0.01 ft.^{2}/day C_α = 0.011

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
97.0 %	43.5 %	76.3	72	53	2.70		3.97	0.72	0.13			1.210

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2435	CH	

Project No. BL-10-10065 **Client:** USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2

Location: Boring11-118MU, #2, 33-35', Wild Rice, Brenna Formation

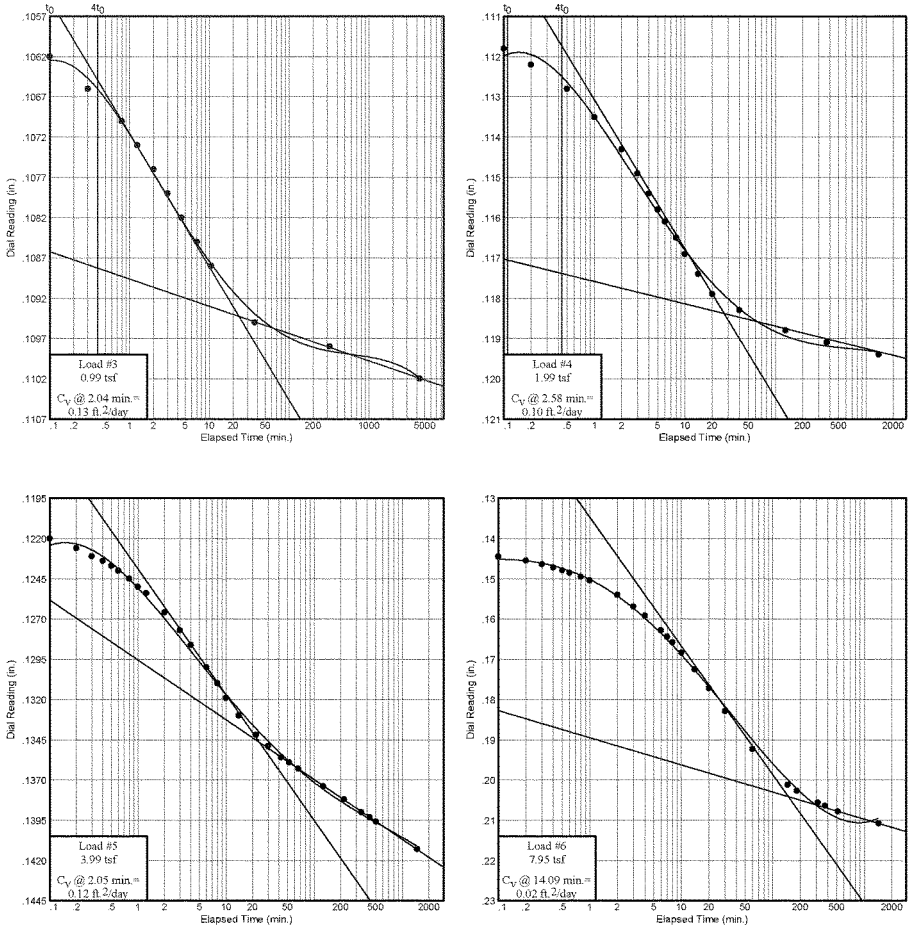
Remarks:

BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Location: Boring11-118MU, #2, 33-35', Wild Rice, Brenna Formation

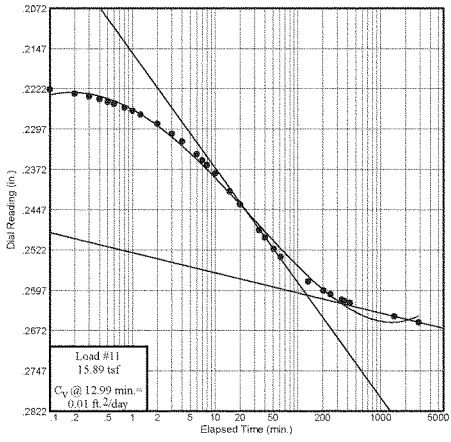


BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Location: Boring11-118MU, #2, 33-35', Wild Rice, Brenna Formation



BRAUN INTERTEC

Figure

CONSOLIDATION TEST DATA

Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: Boring11-118MU, #2
Elev. or Depth: 33-35' **Sample Length(in./cm.):**
Location: Boring11-118MU, #2, 33-35', Wild Rice, Brenna Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2435
Liquid Limit: 72 **Plasticity Index:** 53
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	158.20 g.	Consolidometer # = 3	Wet w+t =
Dry w+t =	119.30 g.		Dry w+t =
Tare Wt. =	29.87 g.	Spec. Gravity = 2.70	Tare Wt. =
Height =	.73 in.	Height = .73 in.	
Diameter =	2.50 in.	Diameter = 2.50 in.	
Weight =	102.56 g.	Defl. Table = Machine3-2009	
Moisture =	43.5 %	Ht. Solids = 0.3296 in.	Moisture = %
Wet Den. =	109.4 pcf	Dry Wt. = 71.47 g.*	Dry Wt. = n/a
Dry Den. =	76.3 pcf	Void Ratio = 1.210	Void Ratio = 0.914
		Saturation = 97.0 %	

* Initial dry weight used in calculations

End-of-Load Summary

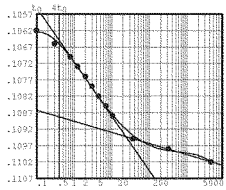
Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.10490				1.210	
0.43	0.10530	0.00000			1.209	0.1 Comprs.
0.49	0.10590	0.00050			1.209	0.1 Comprs.
0.99	0.11090	0.00070	0.13	0.000	1.194	0.7 Comprs.
1.99	0.12040	0.00100	0.10	0.001	1.166	2.0 Comprs.
3.99	0.14280	0.00150	0.12	0.005	1.100	5.0 Comprs.
7.95	0.21280	0.00200	0.02	0.010	0.889	14.5 Comprs.
1.99	0.19350	0.00100			0.944	12.0 Comprs.
0.49	0.16550	0.00050			1.028	8.2 Comprs.
1.99	0.18280	0.00100			0.977	10.6 Comprs.
7.95	0.22260	0.00200			0.859	15.9 Comprs.
15.89	0.26860	0.00290	0.01	0.006	0.722	22.1 Comprs.
3.99	0.24870	0.00150			0.778	19.5 Comprs.
0.99	0.22040	0.00070			0.862	15.8 Comprs.

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
0.43	0.20240	0.00000			0.914	13.4 Comprs.

C_c = 0.72 P_c = 3.97 tsf C_r = 0.13

Pressure: 0.99 tsf — TEST READINGS — Load No. 3

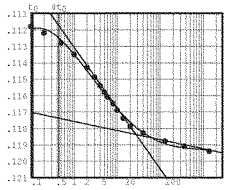
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10590	11	37.00	0.11020
2	0.10	0.10690	12	321.00	0.11050
3	0.30	0.10730	13	4312.00	0.11090
4	0.80	0.10770			
5	1.25	0.10800			
6	2.00	0.10830			
7	3.00	0.10860			
8	4.50	0.10890			
9	7.00	0.10920			
10	10.50	0.10950			



Void Ratio = 1.194 Compression = 0.7 %
D_0 = 0.10590 D_{50} = 0.10766 D_{100} = 0.10943
C_v at 2.0 min. = 0.13 ft.^{2}/day C_α = 0.000

Pressure: 1.99 tsf — TEST READINGS — Load No. 4

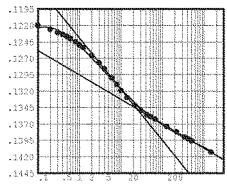
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.11090	11	8.00	0.11750
2	0.10	0.11280	12	10.00	0.11790
3	0.20	0.11320	13	14.00	0.11840
4	0.50	0.11380	14	20.00	0.11890
5	1.00	0.11450	15	40.00	0.11930
6	2.00	0.11530	16	129.00	0.11980
7	3.00	0.11590	17	368.00	0.12010
8	4.00	0.11640	18	1386.00	0.12040
9	5.00	0.11680			
10	6.00	0.11710			



Void Ratio = 1.166 Compression = 2.0 %
D_0 = 0.11139 D_{50} = 0.11488 D_{100} = 0.11838
C_v at 2.6 min. = 0.10 ft.^{2}/day C_α = 0.001

Pressure: 3.99 tsf — TEST READINGS — Load No. 5

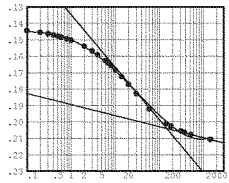
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.12040	15	8.00	0.13250
2	0.10	0.12350	16	10.00	0.13340
3	0.20	0.12410	17	14.00	0.13450
4	0.30	0.12460	18	22.00	0.13570
5	0.40	0.12490	19	30.00	0.13640
6	0.50	0.12520	20	42.00	0.13710
7	0.60	0.12550	21	52.00	0.13740
8	0.80	0.12600	22	66.00	0.13780
9	1.00	0.12650	23	127.00	0.13890
10	1.25	0.12690	24	218.00	0.13970
11	2.00	0.12810	25	343.00	0.14050
12	3.00	0.12920	26	425.00	0.14080
13	4.00	0.13010	27	504.00	0.14110
14	6.00	0.13150	28	1472.00	0.14280



Void Ratio = 1.100 Compression = 5.0 %
D_0 = 0.11940 D_{50} = 0.12704 D_{100} = 0.13468
C_v at 2.1 min. = 0.12 ft.^{2}/day C_α = 0.005

Pressure: 7.95 tsf — TEST READINGS — Load No. 6

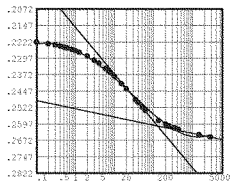
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.14280	14	7.00	0.16640
2	0.10	0.14650	15	8.00	0.16780
3	0.20	0.14750	16	10.00	0.17040
4	0.30	0.14840	17	14.00	0.17450
5	0.40	0.14920	18	20.00	0.17920
6	0.50	0.14990	19	30.00	0.18490
7	0.60	0.15050	20	60.00	0.19430
8	0.80	0.15150	21	145.00	0.20320
9	1.00	0.15240	22	183.00	0.20470
10	2.00	0.15600	23	311.00	0.20760
11	3.00	0.15890	24	373.00	0.20840
12	4.00	0.16120	25	514.30	0.20980
13	6.00	0.16480	26	1431.00	0.21280



Void Ratio = 0.889 Compression = 14.5 %
D_0 = 0.14130 D_{50} = 0.17273 D_{100} = 0.20416
C_v at 14.1 min. = 0.02 ft.^{2}/day C_α = 0.010

Pressure: 15.89 tsf | TEST READINGS | Load No. 11

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.22260	17	10.00	0.24090
2	0.10	0.22520	18	15.00	0.24420
3	0.20	0.22600	19	20.00	0.24660
4	0.30	0.22650	20	34.00	0.25140
5	0.40	0.22700	21	40.00	0.25280
6	0.50	0.22750	22	51.00	0.25490
7	0.60	0.22790	23	62.00	0.25640
8	0.80	0.22860	24	133.00	0.26100
9	1.00	0.22920	25	204.00	0.26270
10	1.25	0.22990	26	247.00	0.26340
11	2.00	0.23160	27	341.00	0.26440
12	3.00	0.23350	28	364.00	0.26460
13	4.00	0.23490	29	427.00	0.26500
14	6.00	0.23730	30	1466.00	0.26750
15	7.00	0.23840	31	2880.00	0.26860
16	8.00	0.23930			



Void Ratio = 0.722 Compression = 22.1 %
D_0 = 0.22060 D_{50} = 0.24062 D_{100} = 0.26064
C_v at 13.0 min. = 0.01 ft.^{2}/day C_α = 0.006

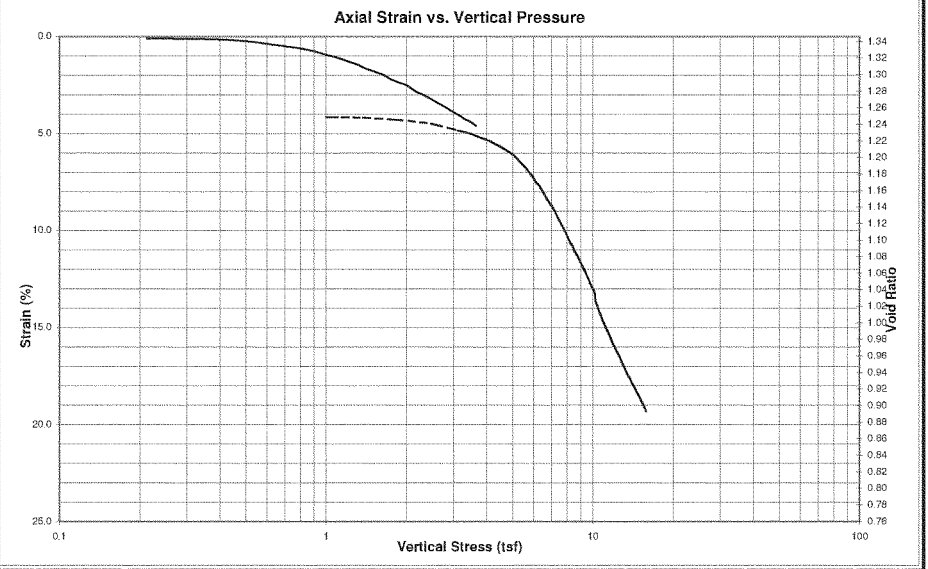
Constant Rate of Strain Consolidation Test

Date: 10/27/10
Job: 7577

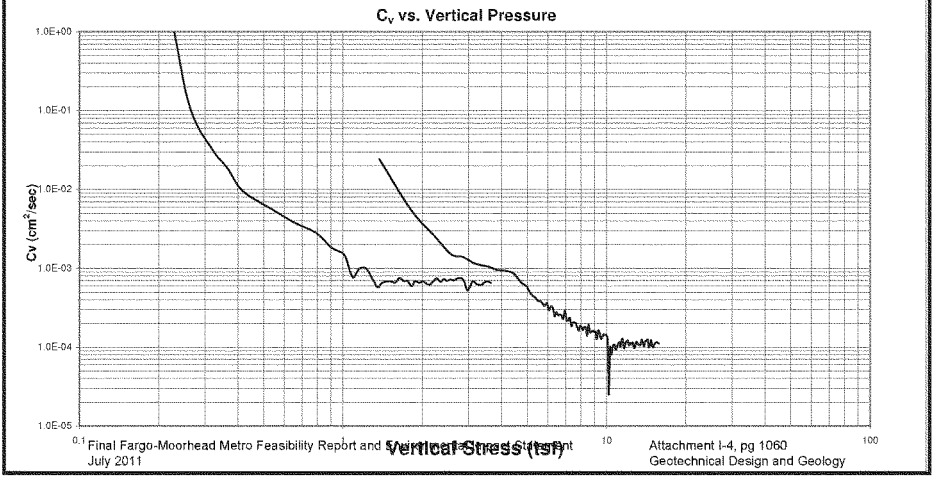
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING

Specimen Information

Boring:	FAR 10-78MU	Sample:	3	Depth: 55-57	Type: 5T
Soil Type:	Fat Clay w/a few pockets of silt (CH)	Argusville			
Initial Conditions:	Dry Density (pcf):	73.8	Moisture Content (%):	47.5%	e_o 1.344



Calculated Consolidation Coefficients	Pc	5.3 tsf	Cc	0.82	Cr	0.05



Constant Rate of Strain Consolidation Test

Date: 10/27/10
Job: 7577

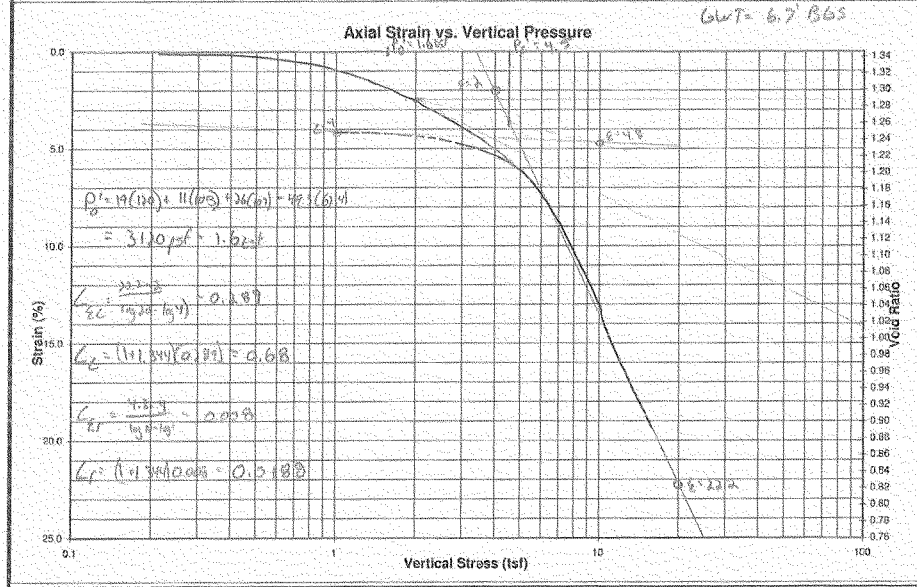
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING

Specimen Information

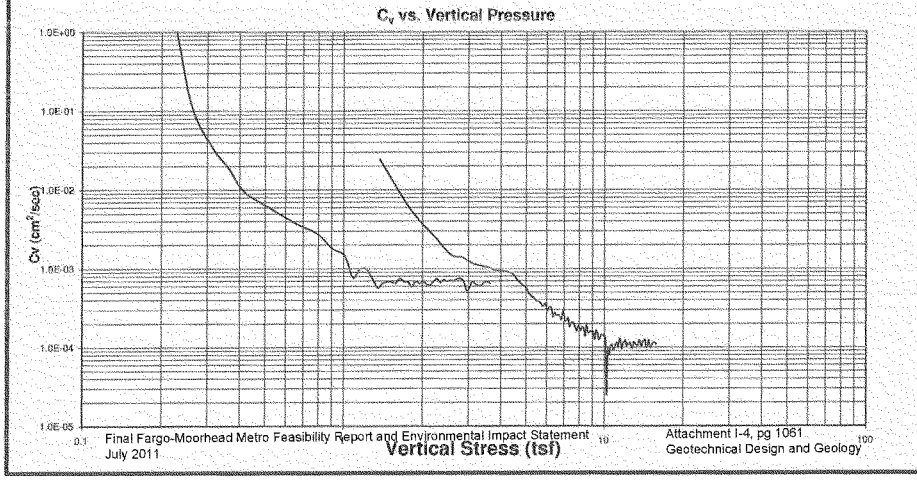
Boring: FAR 10-78MU Sample: 3 Depth: 55-57 Type: ST

Soil Type: Fat Clay w/a few pockets of silt (CH) Argusville

Initial Conditions: Dry Density (pcf): 73.8 Moisture Content (%): 47.5% e_o 1.344



Calculated Consolidation Coefficients	Pc 5.3 tsf	Cc 0.82	Cr 0.05



Constant Rate of Strain Data Table

Project: IOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL Date: 10/27/10

Boring: 10-78MU Sample 3 Depth: 55-57 Job: 7577

Axial Strain	Vert. Stress (tsf)	Excess Pressure (tsf)	Pressure Ratio	Eff. Stress (tsf)	Cv (cm^2/sec)	K (cm/sec)	Void Ratio
0.11%	0.229	0.003	0.011	0.227	9.85E-01	3.43E-06	1.342
0.97%	1.010	0.298	0.295	0.800	1.47E-03	2.34E-08	1.321
1.82%	1.520	0.387	0.255	1.249	6.84E-04	9.69E-09	1.301
2.53%	2.010	0.444	0.221	1.701	6.81E-04	1.36E-08	1.285
3.35%	2.564	0.486	0.189	2.228	7.16E-04	9.96E-09	1.265
3.94%	3.026	0.571	0.189	2.632	5.71E-04	6.63E-09	1.252
4.96%	3.922	0.718	0.183	3.427	5.30E-04	8.43E-09	1.228
4.19%	1.373	0.134	0.097	1.282	2.43E-02	3.84E-08	1.246
4.71%	2.852	0.832	0.292	2.266	1.39E-03	7.84E-09	1.234
5.51%	4.251	0.985	0.232	3.565	9.10E-04	7.78E-09	1.215
6.37%	5.241	1.159	0.221	4.437	4.46E-04	5.97E-09	1.195
7.42%	6.041	1.367	0.226	5.092	2.93E-04	6.48E-09	1.170
8.83%	7.061	1.700	0.241	5.876	2.17E-04	3.77E-09	1.137
10.34%	8.034	2.096	0.261	6.567	1.79E-04	2.10E-09	1.102
11.80%	9.081	2.572	0.283	7.274	1.58E-04	2.54E-09	1.067
13.13%	10.095	3.009	0.298	7.973	1.25E-04	1.52E-09	1.036
14.78%	10.979	3.022	0.275	8.859	1.02E-04	8.91E-10	0.998
16.11%	12.156	3.353	0.276	9.803	1.04E-04	1.16E-09	0.966
17.05%	13.097	3.590	0.274	10.579	1.11E-04	1.17E-09	0.944
17.76%	13.880	3.822	0.275	11.199	1.02E-04	1.30E-09	0.928
18.46%	14.749	4.075	0.276	11.889	1.22E-04	7.43E-10	0.911
19.33%	15.815	4.344	0.275	12.767	1.10E-04	9.65E-10	0.891

Constant Rate of Strain Consolidation Test

Date: 10/8/10
Job: 7577

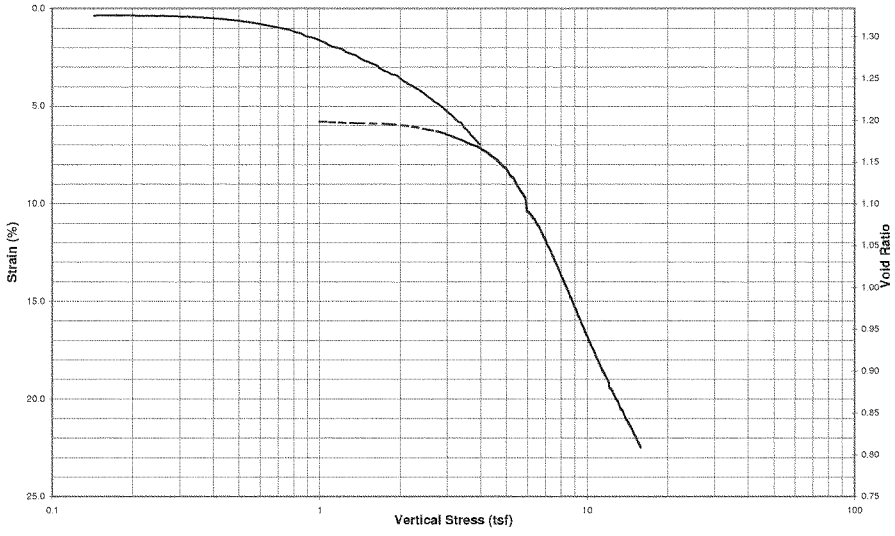
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING

Specimen Information

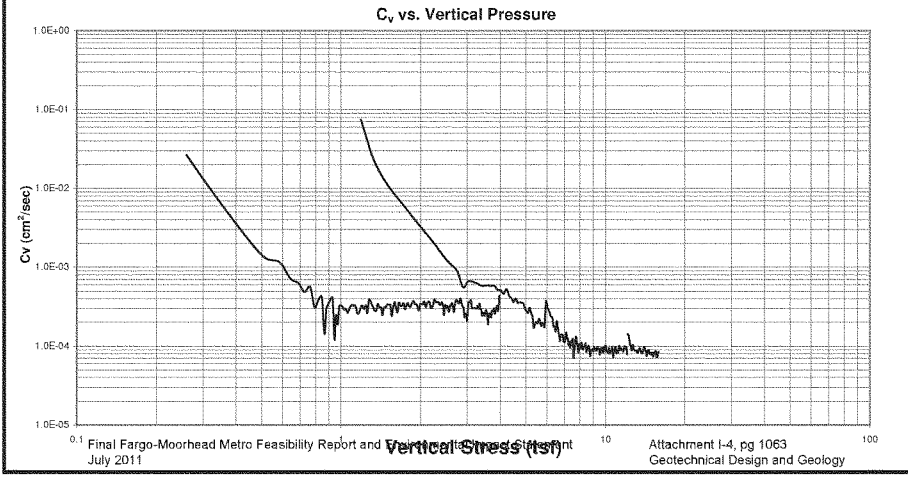
Boring: FAR 10-79MU Sample: 2 Depth: 40-42 (Top) Type: 5T

Soil Type: Fat Clay (CH) Argusville

Initial Conditions: Dry Density (pcf): 72.7 Moisture Content (%): 49.3% e_o 1.336



Calculated Consolidation Coefficients	Pc	3.9 tsf	Cc	0.69	Cr	0.051



Constant Rate of Strain Consolidation Test

Date: 10/8/10
Job: 7577

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING

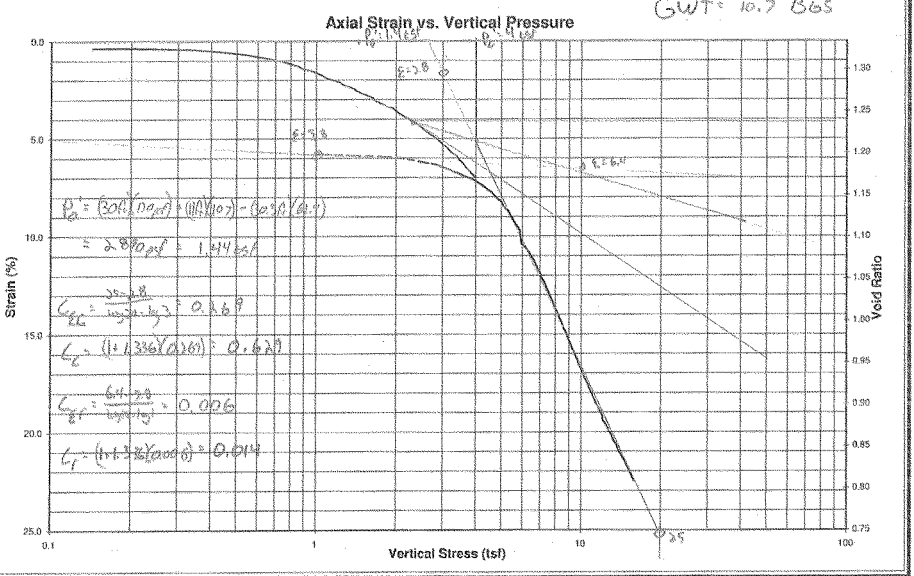
Specimen Information

Boring: FAR 10-79MU Sample: 2 Depth: 40-42 (Top) Type: 5T

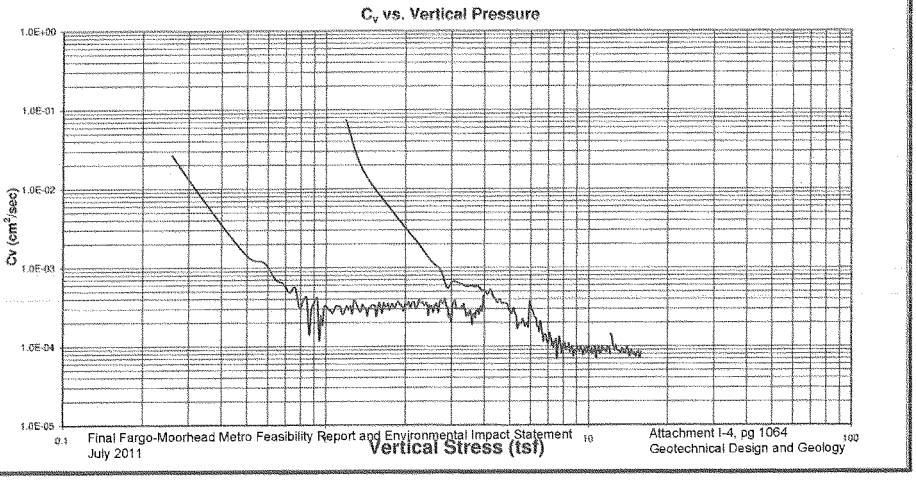
Soil Type: Fat Clay (CH) Argusville

Initial Conditions: Dry Density (pcf): 72.7 Moisture Content (%): 49.3% e_o 1.336

GWT: 10.7' BGS



Calculated Consolidation Coefficients	Pc	3.9 tsf	Cc	0.69	Cr	0.051



Constant Rate of Strain Data Table

Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING Date: 10/8/10

Boring: 10-79MU Sample 2 Depth: 40-42 (Top) Job: 7577

Axial Strain	Vert. Stress (tsf)	Excess Pressure (tsf)	Pressure Ratio	Eff. Stress (tsf)	Cv (cm^2/sec)	K (cm/sec)	Void Ratio
0.39%	0.259	0.042	0.160	0.231	2.66E-02	1.26E-07	1.327
1.53%	0.955	0.282	0.295	0.756	2.45E-04	4.39E-09	1.300
3.62%	2.014	0.320	0.159	1.794	3.38E-04	7.51E-09	1.251
5.32%	3.014	0.348	0.115	2.778	2.82E-04	4.49E-09	1.212
6.94%	3.968	0.376	0.095	3.714	4.41E-04	5.51E-09	1.174
5.84%	1.185	0.047	0.040	1.154	7.42E-02	9.21E-08	1.199
6.29%	2.732	0.848	0.310	2.132	9.16E-04	4.51E-09	1.189
7.08%	3.904	0.876	0.224	3.296	5.16E-04	4.87E-09	1.170
8.13%	4.886	0.932	0.191	4.243	3.45E-04	4.08E-09	1.146
9.29%	5.602	1.100	0.196	4.842	2.20E-04	4.72E-09	1.119
10.64%	6.212	1.252	0.202	5.346	2.36E-04	4.11E-09	1.087
11.96%	7.033	1.596	0.227	5.924	1.18E-04	3.13E-09	1.057
13.18%	7.719	1.858	0.241	6.424	1.31E-04	2.39E-09	1.028
14.66%	8.577	2.169	0.253	7.062	9.56E-05	2.83E-09	0.994
15.74%	9.247	2.394	0.259	7.572	8.67E-05	1.26E-09	0.968
16.69%	9.930	2.598	0.262	8.113	8.53E-05	1.24E-09	0.946
17.76%	10.753	2.844	0.264	8.762	8.88E-05	1.29E-09	0.921
18.57%	11.428	3.034	0.265	9.303	9.36E-05	8.61E-10	0.902
19.76%	12.584	3.326	0.264	10.255	8.82E-05	1.13E-09	0.874
20.70%	13.647	3.686	0.270	11.063	8.21E-05	1.02E-09	0.852
21.53%	14.680	4.012	0.273	11.866	7.93E-05	1.11E-09	0.833
22.50%	15.867	4.340	0.274	12.822	8.40E-05	1.10E-09	0.810

Constant Rate of Strain Consolidation Test

Date: 10/27/10
Job: 7577

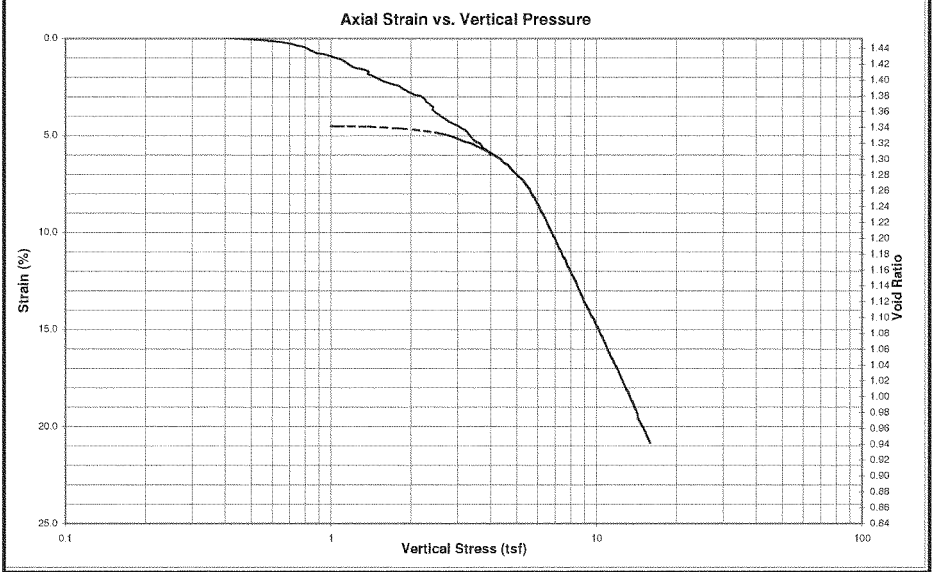
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING

Specimen Information

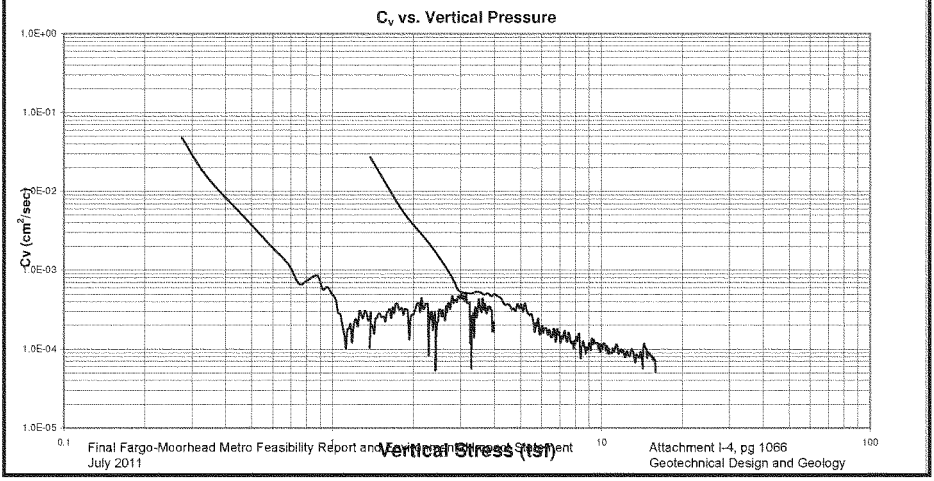
Boring: FAR 10-80MU Sample: 3 Depth: 55-57 Type: 5T

Soil Type: Fat Clay w/a few pockets of silt (CH) Argusville

Initial Conditions: Dry Density (pcf): 70.8 Moisture Content (%): 51.8% e_o 1.450



Calculated Consolidation Coefficients	Pc	4.4 tsf	Cc	0.73	Cr	0.09



Constant Rate of Strain Consolidation Test

Date: 10/27/10
Job: 7577

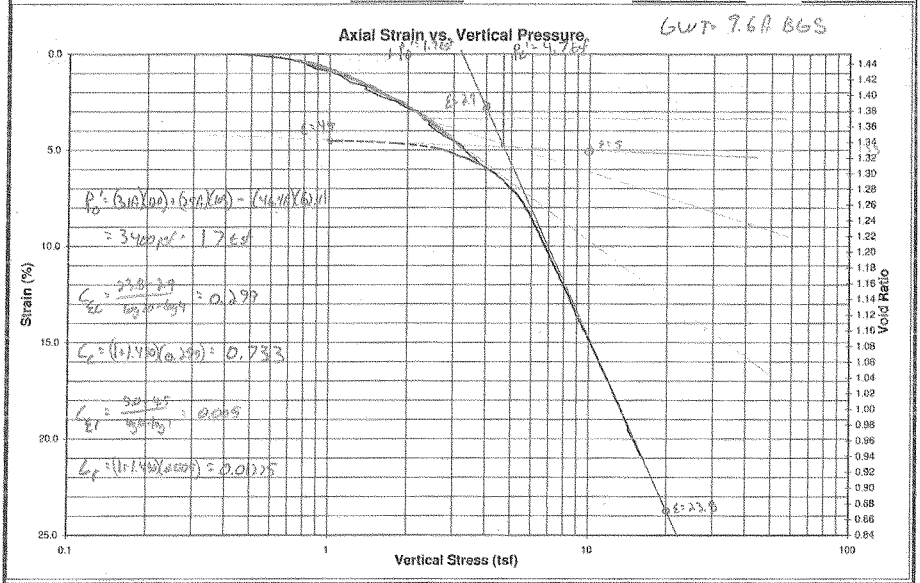
Project: FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING

Specimen Information

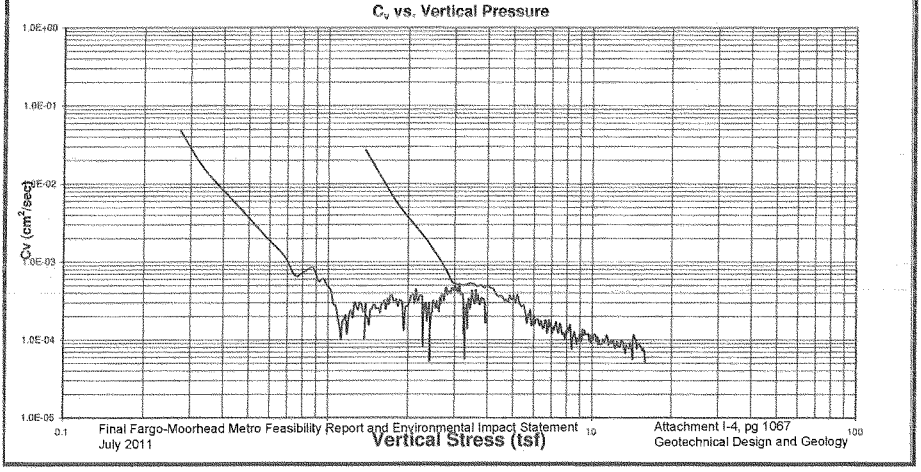
Boring: FAR 10-80MU Sample: 3 Depth: 55-57 Type: ST

Soil Type: Fat Clay w/a few pockets of silt (CH) Argusville

Initial Conditions: Dry Density (pcf): 70.8 Moisture Content (%): 51.8% e_o 1.450



Calculated Consolidation Coefficients	Pc	4.4 tsf	Cc	0.73	Cr	0.09



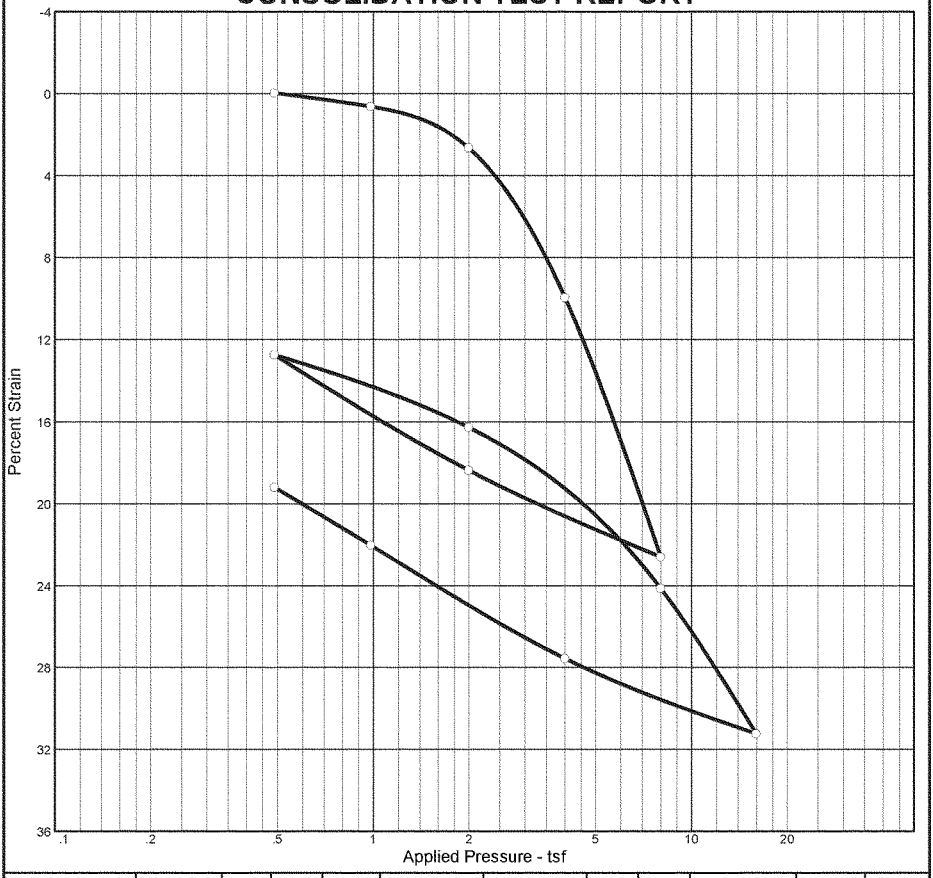
Constant Rate of Strain Data Table

Project: IOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL Date: 10/27/10

Boring: 10-80MU Sample 3 Depth: 55-57 Job: 7577

Axial Strain	Vert. Stress (tsf)	Excess Pressure (tsf)	Pressure Ratio	Eff. Stress (tsf)	Cv (cm^2/sec)	K (cm/sec)	Void Ratio
0.02%	0.467	0.143	0.305	0.366	4.76E-03	4.11E-08	1.449
0.74%	0.875	0.259	0.296	0.693	8.48E-04	1.21E-08	1.431
1.54%	1.257	0.321	0.256	1.032	3.03E-04	2.82E-09	1.412
2.42%	1.765	0.316	0.179	1.547	3.18E-04	9.56E-10	1.390
3.40%	2.356	0.315	0.134	2.141	1.75E-04	5.24E-09	1.366
5.40%	3.612	0.308	0.085	3.404	4.41E-04	5.72E-09	1.317
6.03%	3.975	0.325	0.082	3.756	2.21E-04	3.63E-09	1.302
4.55%	1.378	0.119	0.086	1.298	2.72E-02	3.63E-08	1.338
5.22%	3.053	0.936	0.306	2.392	5.19E-04	4.85E-09	1.322
5.92%	4.001	0.957	0.239	3.335	4.97E-04	4.91E-09	1.305
7.06%	5.030	0.983	0.195	4.351	3.68E-04	4.11E-09	1.277
8.59%	6.019	1.172	0.195	5.210	1.97E-04	2.80E-09	1.239
10.44%	7.024	1.458	0.208	6.015	1.19E-04	3.96E-09	1.194
12.16%	8.056	1.809	0.224	6.800	1.44E-04	2.63E-09	1.152
13.66%	9.058	2.200	0.243	7.524	1.19E-04	1.23E-09	1.115
14.96%	10.148	2.566	0.253	8.355	1.14E-04	1.48E-09	1.083
15.98%	10.942	2.824	0.258	8.967	8.91E-05	1.37E-09	1.058
16.98%	11.924	3.111	0.261	9.748	8.90E-05	1.02E-09	1.034
17.99%	12.816	3.380	0.264	10.449	8.71E-05	1.08E-09	1.009
18.89%	13.774	3.683	0.267	11.194	7.79E-05	1.04E-09	0.987
20.11%	15.045	4.037	0.268	12.217	8.91E-05	9.07E-10	0.957
20.85%	15.924	4.336	0.272	12.883	5.11E-05	3.32E-10	0.939

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
93.2 %	56.0 %	64.4	90	63	2.709		2.68	1.03	0.22			1.627

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2850		

Project No. BL-10-10065 **Client:** W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

Location: Boring 10-105MU, #4, 45-47', Maple River, Argusville Formation

BRAUN INTERTEC

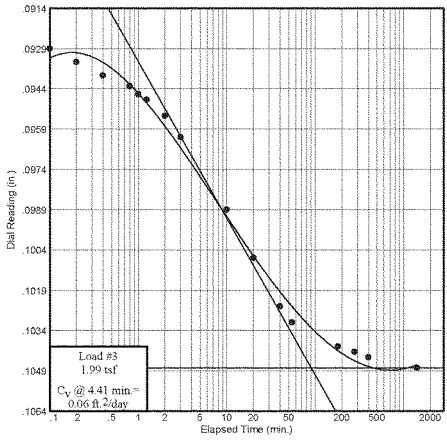
Remarks:

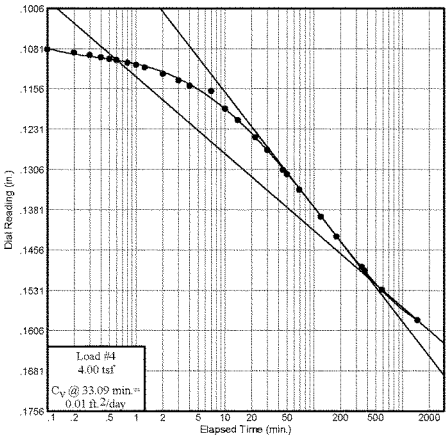
Load #3 Cv = 0.057 ft2/day
Load #4 Cv = 0.0065 ft2/day
Load #5 Cv = 0.0034 ft2/day
Load #10 Cv = 0.0030 ft2/day

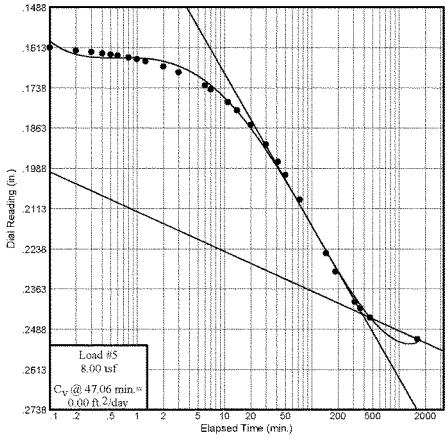
Figure

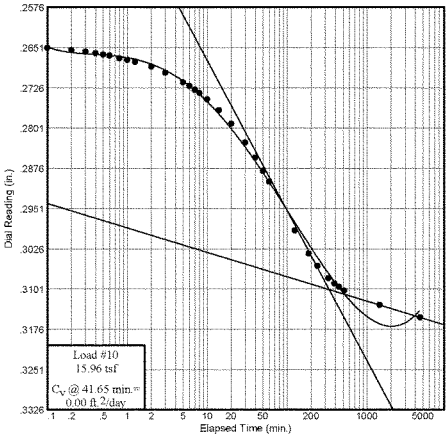
Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Boring 10-105MU, #4, 45-47', Maple River, Argusville Formation









BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: Boring 10-105MU, #4
Elev. or Depth: 45-47' **Sample Length(in./cm.):**
Location: Boring 10-105MU, #4, 45-47', Maple River, Argusville Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2850
Liquid Limit: 90 **Plasticity Index:** 63
USCS: **AASHTO:** **Figure No.:**
Testing Remarks: Load #3 Cv = 0.057 ft2/day
Load #4 Cv = 0.0065 ft2/day
Load #5 Cv = 0.0034 ft2/day
Load #10 Cv = 0.0030 ft2/day

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	158.11 g.	Consolidometer # = 4	Wet w+t =
Dry w+t =	112.29 g.		Dry w+t =
Tare Wt. =	30.44 g.	Spec. Gravity = 2.709	Tare Wt. =
Height =	.74 in.	Height = .74 in.	
Diameter =	2.49 in.	Diameter = 2.49 in.	
Weight =	94.92 g.	Defl. Table = Machine4-2009	
Moisture =	56.0 %	Ht. Solids = 0.2804 in.	Moisture = %
Wet Den. =	100.4 pcf	Dry Wt. = 60.85 g.*	Dry Wt. = n/a
Dry Den. =	64.4 pcf	Void Ratio = 1.627	Void Ratio = 1.122
		Saturation = 93.2 %	

* Initial dry weight used in calculations

End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.08540				1.627	
0.49	0.08590	0.00080			1.628	0.0 Swell
0.98	0.09100	0.00100			1.610	0.6 Comprs.
1.99	0.10630	0.00150	0.06	0.000	1.558	2.6 Comprs.
4.00	0.16070	0.00200	0.01	0.020	1.365	10.0 Comprs.
8.00	0.25460	0.00270	0.00	0.019	1.033	22.6 Comprs.
1.99	0.22220	0.00150			1.144	18.4 Comprs.
0.49	0.18000	0.00080			1.292	12.7 Comprs.
1.99	0.20680	0.00150			1.199	16.3 Comprs.
8.00	0.26590	0.00270			0.993	24.1 Comprs.
15.96	0.31900	0.00360	0.00	0.008	0.806	31.2 Comprs.

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
4.00	0.29040	0.00200			0.903	27.6 Comprs.
0.98	0.24870	0.00100			1.048	22.0 Comprs.
0.49	0.22760	0.00080			1.122	19.2 Comprs.

C_c = 1.03 P_c = 2.68 tsf C_r = 0.22

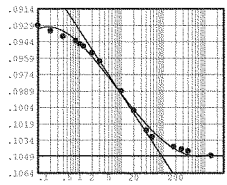
Pressure: 0.98 tsf TEST READINGS **Load No. 2**

No.	Elapsed Time	Dial Reading
1	0.00	0.08590
2	0.10	0.08630
3	0.20	0.08670
4	0.80	0.08730
5	1.25	0.08750
6	5.00	0.08840
7	8.30	0.08880
8	1194.00	0.09100

Void Ratio = 1.610 Compression = 0.6 %

Pressure: 1.99 tsf TEST READINGS **Load No. 3**

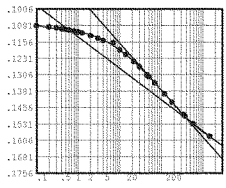
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.09100	11	20.00	0.10220
2	0.10	0.09440	12	40.00	0.10400
3	0.20	0.09490	13	55.00	.1046.
4	0.40	0.09540	14	180.00	0.10550
5	0.80	0.09580	15	278.00	0.10570
6	1.00	0.09610	16	398.00	0.10590
7	1.25	0.09630	17	1411.00	0.10630
8	2.00	0.09690	18	1412.00	0.10630
9	3.00	0.09770			
10	10.00	0.10040			



Void Ratio = 1.558 Compression = 2.6 %
D_0 = 0.09000 D_{50} = 0.09740 D_{100} = 0.10480
C_v at 4.4 min. = 0.06 ft.^{2}/day C_α = 0.000

Pressure: 4.00 tsf | TEST READINGS | Load No. 4

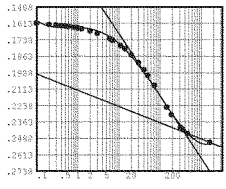
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10630	15	10.00	0.12130
2	0.10	0.11020	16	14.00	0.12340
3	0.20	0.11080	17	22.00	0.12660
4	0.30	0.11130	18	30.00	0.12900
5	0.40	0.11170	19	45.00	0.13270
6	0.50	0.11200	20	50.00	0.13350
7	0.60	0.11220	21	69.00	0.13640
8	0.80	0.11270	22	120.00	0.14140
9	1.00	0.11310	23	180.00	0.14510
10	1.25	0.11360	24	347.00	0.15080
11	2.00	0.11480	25	375.00	0.15150
12	3.00	0.11600	26	586.00	0.15500
13	4.00	0.11700	27	1464.00	0.16070
14	7.00	0.11800			



Void Ratio = 1.365 Compression = 10.0 %
D_0 = 0.10480 D_{50} = 0.12785 D_{100} = 0.15089
C_v at 33.1 min. = 0.01 ft.^{2}/day C_α = 0.020

Pressure: 8.00 tsf | TEST READINGS | Load No. 5

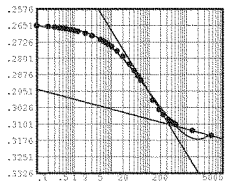
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.16070	15	11.00	0.18100
2	0.10	0.16400	16	14.00	0.18350
3	0.20	0.16500	17	20.00	0.18810
4	0.30	0.16540	18	30.00	0.19410
5	0.40	0.16590	19	41.00	0.19950
6	0.50	0.16620	20	50.00	0.20360
7	0.60	0.16650	21	73.00	0.21130
8	0.80	0.16710	22	146.00	0.22790
9	1.00	0.16760	23	188.00	0.23360
10	1.25	0.16830	24	313.00	0.24300
11	2.00	0.16990	25	360.00	0.24500
12	3.00	0.17170	26	464.00	0.24790
13	6.00	0.17580	27	1618.00	0.25460
14	7.00	0.17700			



Void Ratio = 1.033 Compression = 22.6 %
D_0 = 0.15870 D_{50} = 0.20143 D_{100} = 0.24415
C_v at 47.1 min. = 0.00 ft.^{2}/day C_α = 0.019

Pressure: 15.96 tsf | TEST READINGS | Load No. 10

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.26590	17	10.00	0.27840
2	0.10	0.26880	18	14.00	0.28040
3	0.20	0.26920	19	20.00	0.28290
4	0.30	0.26950	20	30.00	0.28640
5	0.40	0.26980	21	40.00	0.28920
6	0.50	0.27000	22	50.00	0.29170
7	0.60	0.27020	23	60.00	0.29370
8	0.80	0.27070	24	125.00	0.30280
9	1.00	0.27100	25	186.00	0.30710
10	1.25	0.27140	26	240.00	0.30940
11	2.00	0.27230	27	330.00	0.31170
12	3.00	0.27340	28	391.00	0.31270
13	5.00	0.27520	29	446.00	0.31330
14	6.00	0.27590	30	521.00	0.31400
15	7.00	0.27660	31	1437.00	0.31670
16	8.00	0.27720	32	4602.00	0.31900



Void Ratio = 0.806 Compression = 31.2 %
D_0 = 0.26320 D_{50} = 0.28672 D_{100} = 0.31023
C_v at 41.7 min. = 0.00 ft.^{2}/day C_α = 0.008

Constant Rate of Strain Consolidation Test

Date: 5/11/11
Job: 7922

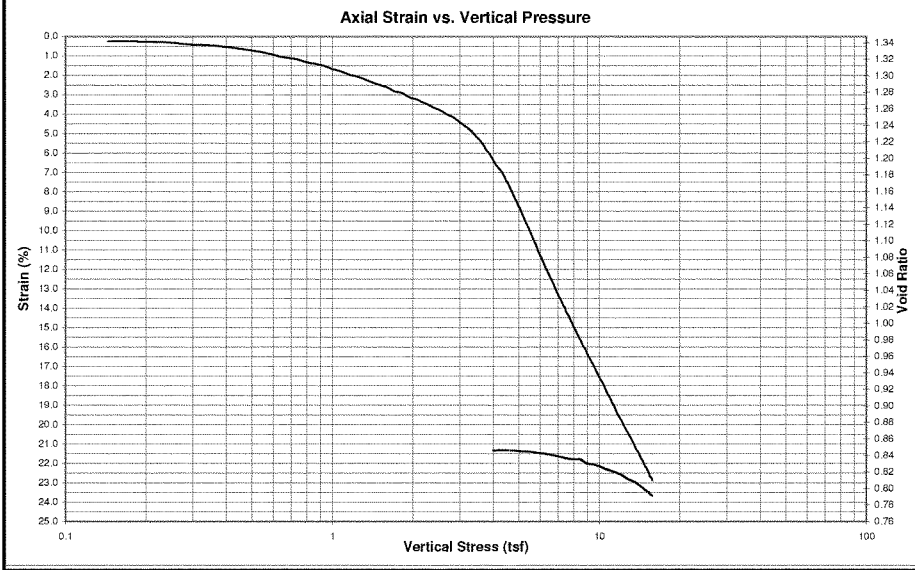
Project: Fargo Moorhead Metro Feasibility Project

Specimen Information

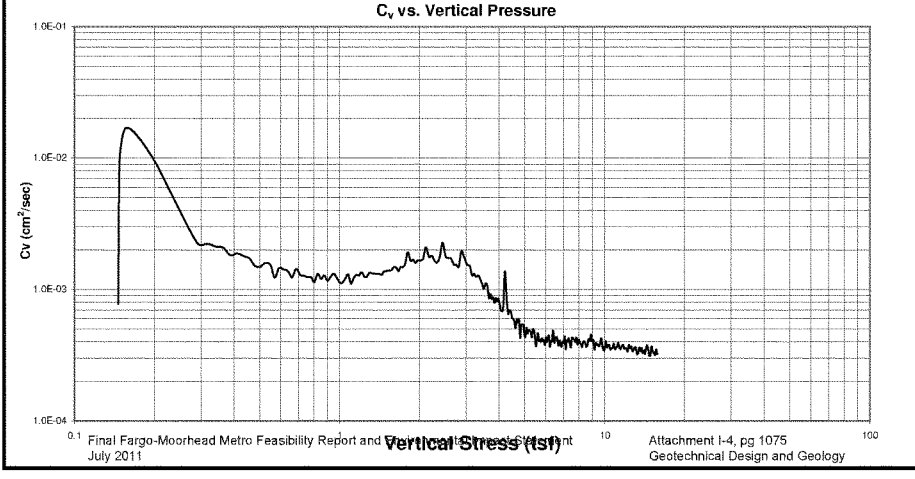
Boring: 10-105MU Sample: 5 Depth: 55-57 Type: 5T

Soil Type: Fat Clay (CH)

Initial Conditions: Dry Density (pcf): 73.1 Moisture Content (%): 48.0% e_o 1.350



Calculated Consolidation Coefficients	Pc	3.8 tsf	Cc	0.65	Cr	0.09



Constant Rate of Strain Data Table

Project: Fargo Moorhead Metro Feasibility Project Date: 5/11/11
Boring: 10-105MU Sample 5 Depth: 55-57 Job: 7922

Axial Strain	Vert. Stress (tsf)	Excess Pressure (tsf)	Pressure Ratio	Eff. Stress (tsf)	Cv (cm^2/sec)	K (cm/sec)	Void Ratio
0.25%	0.159	0.009	0.057	0.153	1.70E-02	5.29E-08	1.344
0.43%	0.317	0.044	0.137	0.288	2.22E-03	1.32E-08	1.340
1.29%	0.780	0.078	0.101	0.727	1.24E-03	2.56E-08	1.320
1.69%	1.002	0.087	0.086	0.944	1.12E-03	1.22E-08	1.310
2.50%	1.504	0.093	0.062	1.441	1.38E-03	1.57E-08	1.291
3.24%	2.064	0.107	0.052	1.992	1.72E-03	1.54E-08	1.274
3.87%	2.576	0.145	0.056	2.479	1.74E-03	3.00E-08	1.259
4.46%	3.026	0.176	0.058	2.908	1.54E-03	2.43E-08	1.245
5.25%	3.504	0.190	0.054	3.376	1.01E-03	2.05E-08	1.227
6.41%	4.015	0.214	0.053	3.870	7.65E-04	2.31E-08	1.199
8.83%	5.025	0.339	0.067	4.797	4.34E-04	1.27E-08	1.142
11.41%	6.051	0.433	0.072	5.759	3.98E-04	8.92E-09	1.082
13.45%	7.062	0.519	0.073	6.712	4.38E-04	3.90E-09	1.034
15.06%	8.059	0.611	0.076	7.647	3.88E-04	4.92E-09	0.996
16.45%	9.064	0.685	0.076	8.601	4.12E-04	1.47E-09	0.963
17.48%	9.904	0.767	0.077	9.386	3.44E-04	3.37E-09	0.939
18.61%	10.928	0.842	0.077	10.359	3.51E-04	4.29E-09	0.913
19.79%	12.088	0.940	0.078	11.453	3.57E-04	3.41E-09	0.885
20.71%	13.103	1.012	0.077	12.420	3.56E-04	2.95E-09	0.863
21.47%	14.029	1.070	0.076	13.306	3.45E-04	3.58E-09	0.845
22.30%	15.031	1.133	0.075	14.266	3.68E-04	3.17E-09	0.826
22.87%	15.787	1.178	0.075	14.991	3.24E-04	2.70E-09	0.813

CONSOLIDATION TEST REPORT

Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
98.1 %	35.1 %	85.8	63	44	2.705		4.53	0.37	0.08			0.969

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2435	CH	

Project No. BL-10-10065 **Client:** USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3

Location: Boring11-107MU, #4, 50-52', ND RRCS, MN, Argusville Formation

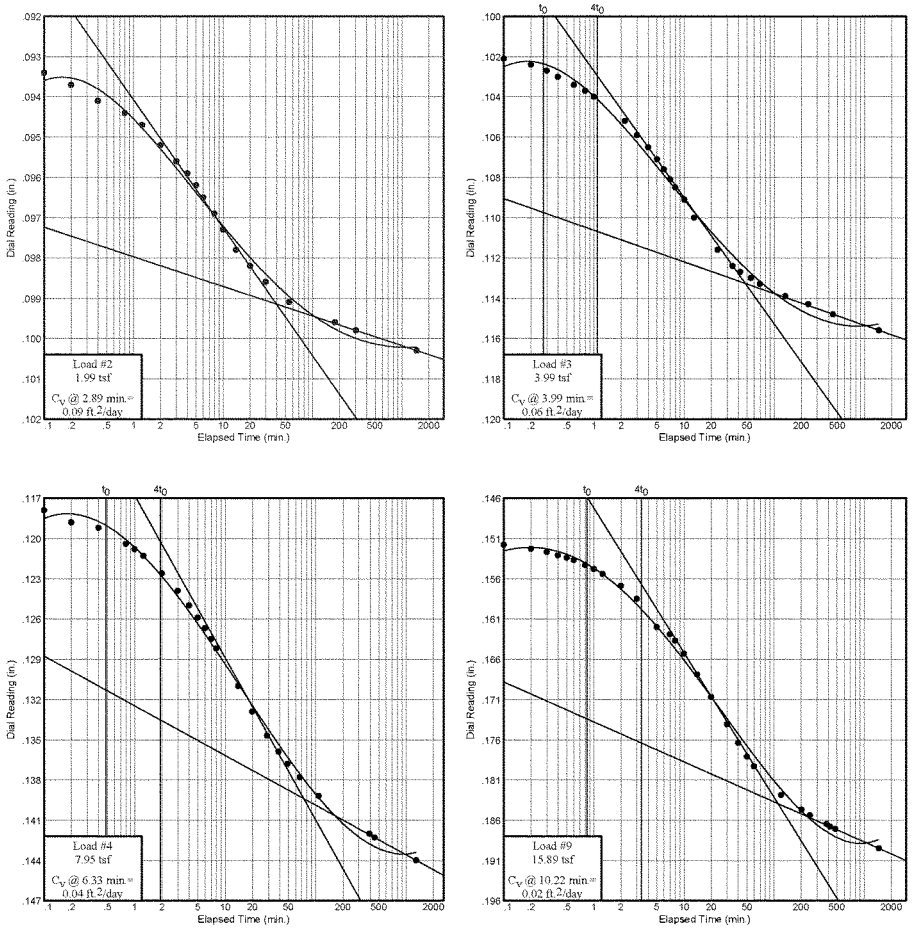
Remarks:

BRAUN™ INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: Boring11-107MU, #4, 50-52', ND RRCS, MN, Argusville Formation



BRAUN INTERTEC

Figure

CONSOLIDATION TEST DATA

Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: Boring11-107MU, #4
Elev. or Depth: 50-52' **Sample Length(in./cm.):**
Location: Boring11-107MU, #4, 50-52', ND RRCS, MN, Argusville Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2435
Liquid Limit: 63 **Plasticity Index:** 44
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	74.80 g.	Consolidometer # = 3	Wet w+t =
Dry w+t =	63.16 g.		Dry w+t =
Tare Wt. =	30.01 g.	Spec. Gravity = 2.705	Tare Wt. =
Height =	.73 in.	Height = .73 in.	
Diameter =	2.50 in.	Diameter = 2.50 in.	
Weight =	109.49 g.	Defl. Table = Machine3-2009	
Moisture =	35.1 %	Ht. Solids = 0.3730 in.	Moisture = %
Wet Den. =	115.9 pcf	Dry Wt. = 81.04 g.*	Dry Wt. = n/a
Dry Den. =	85.8 pcf	Void Ratio = 0.969	Void Ratio = 0.798
		Saturation = 98.1 %	

* Initial dry weight used in calculations

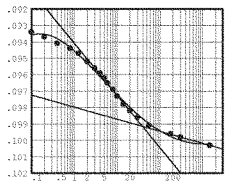
End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.08980				0.969	
0.99	0.09300	0.00070			0.962	0.3 Comprs.
1.99	0.10130	0.00100	0.09	0.001	0.940	1.4 Comprs.
3.99	0.11710	0.00150	0.06	0.002	0.899	3.5 Comprs.
7.95	0.14600	0.00200	0.04	0.005	0.823	7.4 Comprs.
1.99	0.13120	0.00100			0.860	5.5 Comprs.
0.99	0.12180	0.00070			0.885	4.3 Comprs.
1.99	0.12660	0.00100			0.873	4.9 Comprs.
7.95	0.15190	0.00200			0.807	8.2 Comprs.
15.89	0.19240	0.00290	0.02	0.007	0.701	13.6 Comprs.
3.99	0.17760	0.00150			0.737	11.8 Comprs.
0.99	0.15410	0.00070			0.798	8.7 Comprs.

C_c = 0.37 P_c = 4.53 tsf C_r = 0.08

Pressure: 1.99 tsf — TEST READINGS — Load No. 2

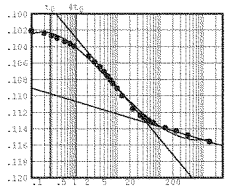
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.09300	11	6.00	0.09750
2	0.10	0.09440	12	8.00	0.09790
3	0.20	0.09470	13	10.00	0.09830
4	0.40	0.09510	14	14.00	0.09880
5	0.80	0.09540	15	20.00	0.09920
6	1.25	0.09570	16	30.00	0.09960
7	2.00	0.09620	17	55.00	0.10010
8	3.00	0.09660	18	178.00	0.10060
9	4.00	0.09690	19	305.00	0.10080
10	5.00	0.09720	20	1457.00	0.10130



Void Ratio = 0.940 Compression = 1.4 %
D_0 = 0.09230 D_{50} = 0.09572 D_{100} = 0.09915
C_v at 2.9 min. = 0.09 ft.^{2}/day C_α = 0.001

Pressure: 3.99 tsf — TEST READINGS — Load No. 3

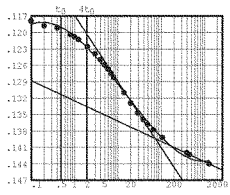
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10130	14	7.00	0.10960
2	0.10	0.10360	15	8.00	0.11000
3	0.20	0.10390	16	10.00	0.11060
4	0.30	0.10420	17	13.00	0.11150
5	0.40	0.10450	18	23.50	0.11310
6	0.60	0.10490	19	34.50	0.11390
7	0.80	0.10520	20	42.00	0.11420
8	1.00	0.10550	21	55.00	0.11450
9	2.20	0.10670	22	69.30	0.11480
10	3.00	0.10740	23	133.50	0.11540
11	4.00	0.10800	24	238.30	0.11580
12	5.00	0.10860	25	449.00	0.11630
13	6.00	0.10910	26	1448.00	0.11710



Void Ratio = 0.899 Compression = 3.5 %
D_0 = 0.10058 D_{50} = 0.10692 D_{100} = 0.11327
C_v at 4.0 min. = 0.06 ft.^{2}/day C_α = 0.002

Pressure: 7.95 tsf — TEST READINGS — Load No. 4

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.11710	13	7.00	0.12950
2	0.10	0.11990	14	8.00	0.13020
3	0.20	0.12080	15	14.00	0.13300
4	0.40	0.12120	16	20.00	0.13490
5	0.80	0.12240	17	29.00	0.13670
6	1.00	0.12280	18	39.00	0.13790
7	1.25	0.12330	19	49.00	0.13880
8	2.00	0.12460	20	67.00	0.13980
9	3.00	0.12590	21	108.00	0.14120
10	4.00	0.12700	22	393.00	0.14400
11	5.00	0.12790	23	450.00	0.14430
12	6.00	0.12870	24	1295.00	0.14600



Void Ratio = 0.823 Compression = 7.4 %
D_0 = 0.11534 D_{50} = 0.12737 D_{100} = 0.13940
C_v at 6.3 min. = 0.04 ft.^{2}/day C_α = 0.005

Pressure: 1.99 tsf — TEST READINGS — Load No. 7

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.12180	11	20.00	0.12550
2	0.10	0.12230	12	40.00	0.12600
3	0.40	0.12260	13	125.00	0.12630
4	1.00	0.12290	14	1459.00	0.12660
5	2.00	0.12330			
6	3.00	0.12360			
7	5.00	0.12400			
8	8.00	0.12450			
9	10.00	0.12480			
10	14.00	0.12520			

Void Ratio = 0.873 Compression = 4.9 %

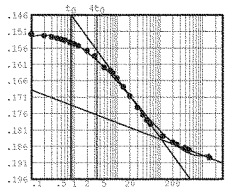
Pressure: 7.95 tsf — TEST READINGS — Load No. 8

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.12660	11	2.00	0.13490
2	0.10	0.12980	12	2880.00	0.15190
3	0.20	0.13030			
4	0.30	0.13080			
5	0.40	0.13120			
6	0.50	0.13160			
7	0.60	0.13190			
8	0.80	0.13240			
9	1.00	0.13290			
10	1.25	0.13350			

Void Ratio = 0.807 Compression = 8.2 %

Pressure: 15.89 tsf | TEST READINGS | Load No. 9

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.15190	16	10.00	0.16820
2	0.10	0.15470	17	14.00	0.17080
3	0.20	0.15520	18	20.00	0.17360
4	0.30	0.15560	19	30.00	0.17700
5	0.40	0.15600	20	40.00	0.17930
6	0.50	0.15630	21	50.00	0.18100
7	0.60	0.15660	22	60.00	0.18220
8	0.80	0.15720	23	120.00	0.18580
9	1.00	0.15770	24	202.00	0.18760
10	1.25	0.15830	25	250.00	0.18830
11	2.00	0.15980	26	383.00	0.18940
12	3.00	0.16140	27	420.00	0.18970
13	5.00	0.16490	28	480.00	0.19000
14	7.00	0.16580	29	1460.00	0.19240
15	8.00	0.16660			

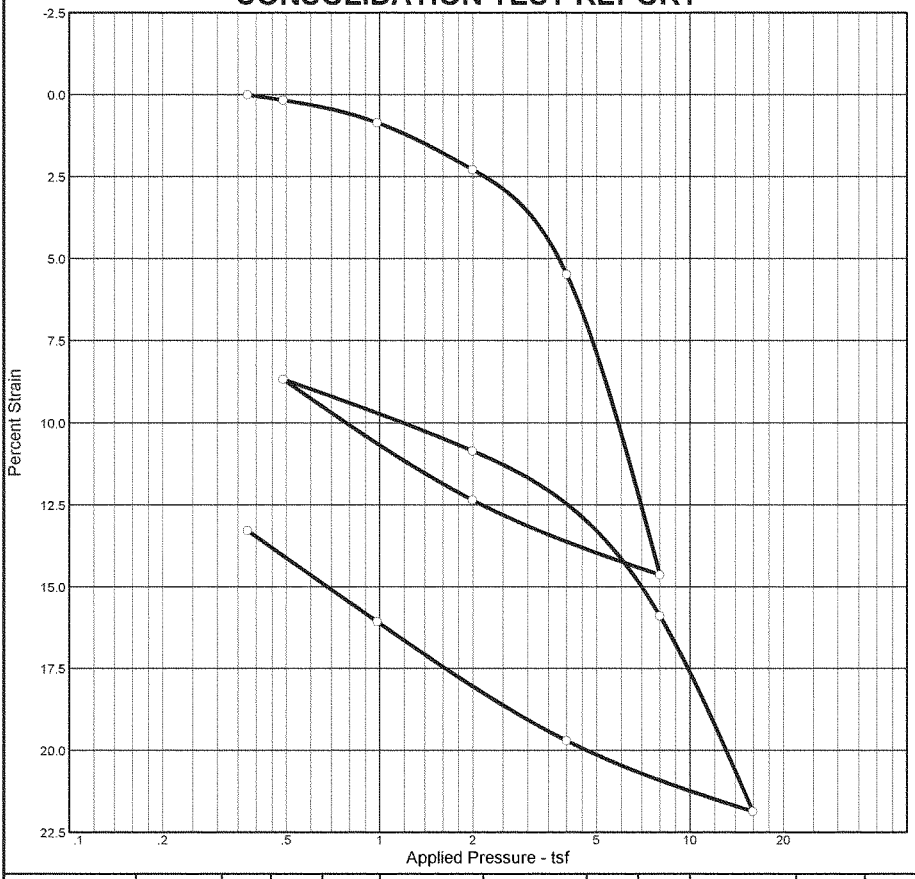


Void Ratio = 0.701 Compression = 13.6 %

D_0 = 0.14857 D_{50} = 0.16625 D_{100} = 0.18393

C_v at 10.2 min. = 0.02 ft.^{2}/day C_α = 0.007

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
99.1 %	49.2 %	71.9	85	64	2.693		4.15	0.72	0.13			1.338

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2435	CH	

Project No. BL-10-10065 **Client:** W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

Location: Boring11-110MU, #4, 55-57', Sheyenne River, Argusville Formation

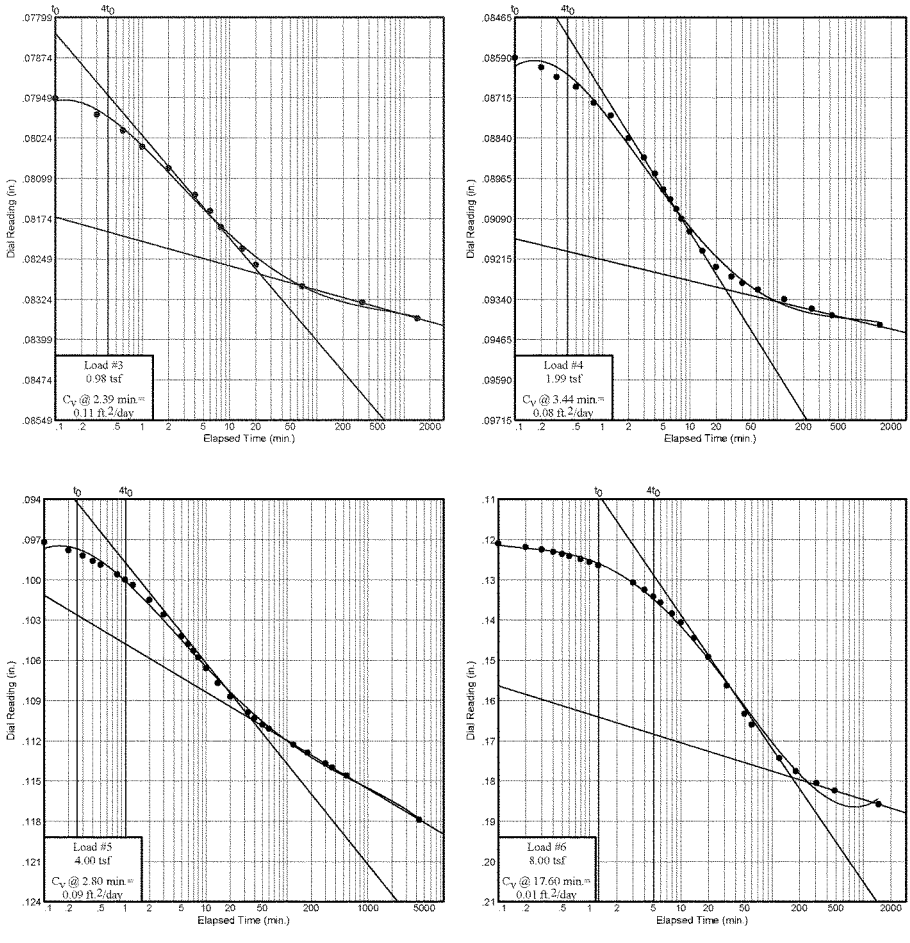
Remarks:

BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Boring11-110MU, #4, 55-57', Sheyenne River, Argusville Formation

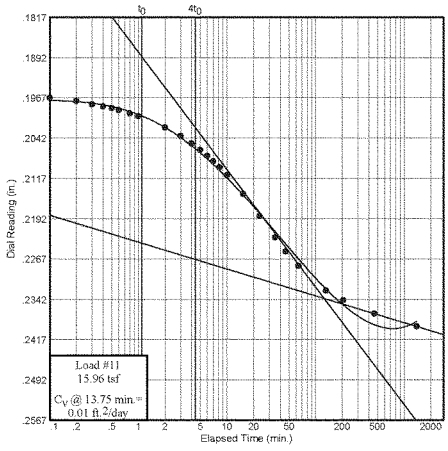


BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Boring11-110MU, #4, 55-57', Sheyenne River, Argusville Formation



BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: 11-110, #4
Elev. or Depth: 55-57' **Sample Length(in./cm.):**
Location: Boring11-110MU, #4, 55-57', Sheyenne River, Argusville Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2435
Liquid Limit: 85 **Plasticity Index:** 64
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	150.83 g.	Consolidometer # = 4	Wet w+t =
Dry w+t =	111.11 g.		Dry w+t =
Tare Wt. =	30.46 g.	Spec. Gravity = 2.693	Tare Wt. =
Height =	.74 in.	Height = .74 in.	
Diameter =	2.49 in.	Diameter = 2.49 in.	
Weight =	102.05 g.	Defl. Table = Machine4-2009	
Moisture =	49.2 %	Ht. Solids = 0.3169 in.	Moisture = %
Wet Den. =	107.3 pcf	Dry Wt. = 68.38 g.*	Dry Wt. = n/a
Dry Den. =	71.9 pcf	Void Ratio = 1.338	Void Ratio = 1.027
		Saturation = 99.1 %	

* Initial dry weight used in calculations

End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.07730				1.338	
0.38	0.07730	0.00000			1.338	0.0 Swell
0.49	0.07850	0.00080			1.334	0.2 Comprs.
0.98	0.08460	0.00100	0.11	0.001	1.318	0.9 Comprs.
1.99	0.09570	0.00150	0.08	0.001	1.285	2.3 Comprs.
4.00	0.11990	0.00200	0.09	0.005	1.210	5.5 Comprs.
8.00	0.16850	0.00270	0.01	0.010	0.996	14.6 Comprs.
1.99	0.17040	0.00150			1.049	12.4 Comprs.
0.49	0.14240	0.00080			1.135	8.7 Comprs.
1.99	0.15930	0.00150			1.084	10.9 Comprs.
8.00	0.19780	0.00270			0.967	15.9 Comprs.
15.96	0.24290	0.00360	0.01	0.008	0.827	21.9 Comprs.
4.00	0.22530	0.00200			0.878	19.7 Comprs.
0.98	0.19740	0.00100			0.962	16.1 Comprs.

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
0.38	0.17580	0.00000			1.027	13.3 Comprs.

C_c = 0.72 P_c = 4.15 tsf C_r = 0.13

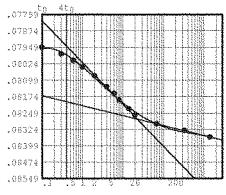
Pressure: 0.49 tsf — **TEST READINGS** — **Load No. 2**

No.	Elapsed Time	Dial Reading
1	0.00	0.07730
2	0.10	0.07760
3	0.50	0.07780
4	2.00	0.07800
5	1440.00	0.07850

Void Ratio = 1.334 Compression = 0.2 %

Pressure: 0.98 tsf — **TEST READINGS** — **Load No. 3**

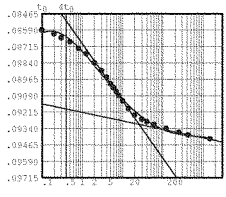
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.07850	11	20.00	0.08360
2	0.10	0.08050	12	68.00	0.08400
3	0.30	0.08080	13	333.00	0.08430
4	0.60	0.08110	14	1426.00	0.08460
5	1.00	0.08140			
6	2.00	0.08180			
7	4.00	0.08230			
8	6.00	0.08260			
9	8.00	0.08290			
10	14.00	0.08330			



Void Ratio = 1.318 Compression = 0.9 %
D_0 = 0.07925 D_{50} = 0.08102 D_{100} = 0.08278
C_v at 2.4 min. = 0.11 ft.^{2}/day C_α = 0.001

Pressure: 1.99 tsf — **TEST READINGS** — **Load No. 4**

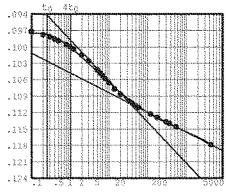
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08460	13	7.00	0.09210
2	0.10	0.08740	14	8.00	0.09240
3	0.20	0.08770	15	10.00	0.09280
4	0.30	0.08800	16	14.00	0.09340
5	0.50	0.08830	17	20.00	0.09390
6	0.80	0.08880	18	30.00	0.09420
7	1.25	0.08920	19	40.00	0.09440
8	2.00	0.08990	20	60.00	0.09460
9	3.00	0.09050	21	120.00	0.09490
10	4.00	0.09100	22	249.00	0.09520
11	5.00	0.09150	23	423.00	0.09540
12	6.00	0.09180	24	1485.00	0.09570



Void Ratio = 1.285 Compression = 2.3 %
D_0 = 0.08591 D_{50} = 0.08950 D_{100} = 0.09309
C_v at 3.4 min. = 0.08 ft.^{2}/day C_α = 0.001

Pressure: 4.00 tsf — TEST READINGS — Load No. 5

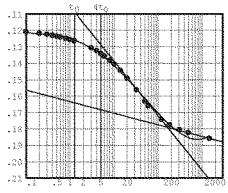
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.09570	15	8.00	0.10780
2	0.10	0.09920	16	10.00	0.10860
3	0.20	0.09980	17	14.00	0.10970
4	0.30	0.10020	18	20.00	0.11070
5	0.40	0.10060	19	33.00	0.11190
6	0.50	0.10090	20	40.00	0.11230
7	0.80	0.10160	21	50.00	0.11280
8	1.00	0.10200	22	60.00	0.11310
9	1.25	0.10240	23	120.00	0.11430
10	2.00	0.10350	24	180.00	0.11490
11	3.00	0.10460	25	300.00	0.11570
12	5.00	0.10620	26	364.00	0.11600
13	6.00	0.10680	27	544.00	0.11660
14	7.00	0.10730	28	4317.00	0.11990



Void Ratio = 1.210 Compression = 5.5 %
D_0 = 0.09527 D_{50} = 0.10282 D_{100} = 0.11038
C_v at 2.8 min. = 0.09 ft.^{2}/day C_α = 0.005

Pressure: 8.00 tsf — TEST READINGS — Load No. 6

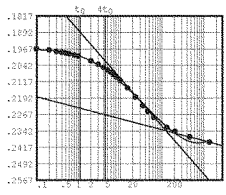
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.11990	14	6.00	0.13840
2	0.10	0.12370	15	8.00	0.14110
3	0.20	0.12460	16	10.00	0.14330
4	0.30	0.12520	17	14.00	0.14720
5	0.40	0.12580	18	20.00	0.15190
6	0.50	0.12630	19	32.00	0.15900
7	0.60	0.12680	20	50.00	0.16600
8	0.80	0.12760	21	60.00	0.16870
9	1.00	0.12830	22	120.00	0.17700
10	1.25	0.12910	23	182.00	0.18030
11	3.00	0.13340	24	305.00	0.18320
12	4.00	0.13520	25	485.00	0.18510
13	5.00	0.13690	26	1468.00	0.18850



Void Ratio = 0.996 Compression = 14.6 %
D_0 = 0.11710 D_{50} = 0.14808 D_{100} = 0.17907
C_v at 17.6 min. = 0.01 ft.^{2}/day C_α = 0.010

Pressure: 15.96 tsf | TEST READINGS | Load No. 11

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.19780	14	6.00	0.21110
2	0.10	0.20030	15	7.00	0.21210
3	0.20	0.20090	16	8.25	0.21320
4	0.30	0.20150	17	10.00	0.21470
5	0.40	0.20190	18	15.20	0.21820
6	0.50	0.20220	19	23.30	0.22230
7	0.60	0.20260	20	35.00	0.22630
8	0.80	0.20320	21	46.00	0.22890
9	1.00	0.20370	22	64.00	0.23160
10	2.00	0.20580	23	131.50	0.23620
11	3.00	0.20740	24	205.00	0.23800
12	4.00	0.20880	25	460.00	0.24050
13	5.00	0.21000	26	1387.00	0.24290

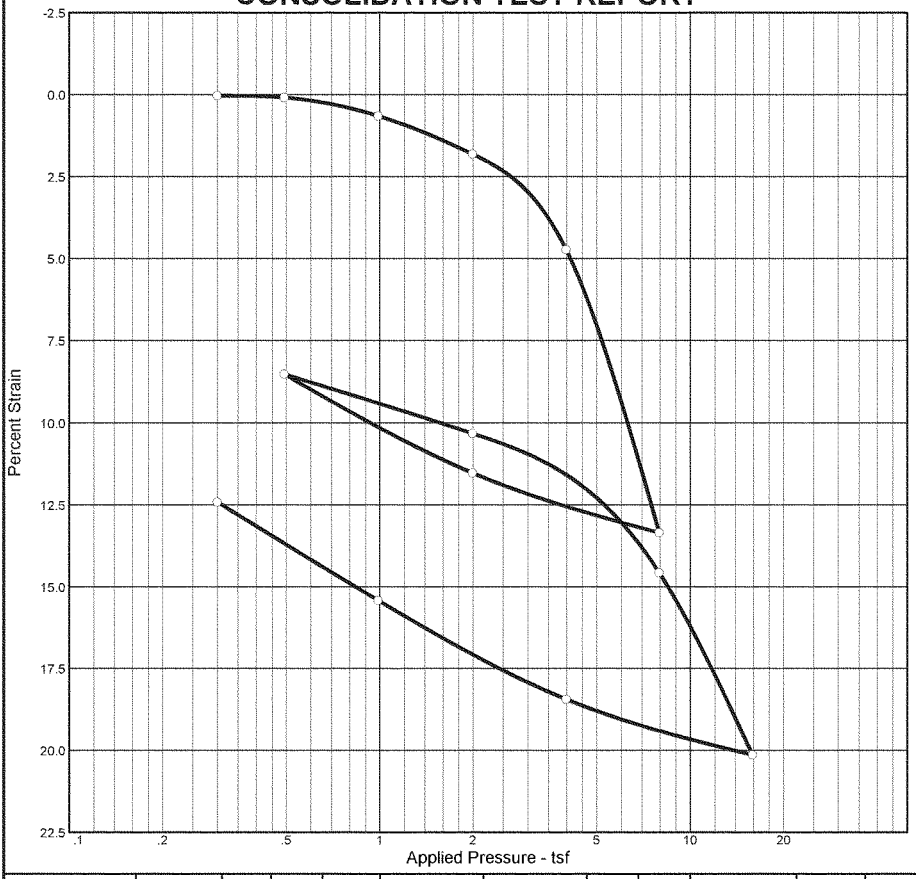


Void Ratio = 0.827 Compression = 21.9 %

D_0 = 0.19395 D_{50} = 0.21401 D_{100} = 0.23407

C_v at 13.7 min. = 0.01 ft.^{2}/day C_α = 0.008

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
100.0 %	45.5 %	75.4	70	48	2.679		4.29	0.83	0.10			1.218

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2435	CH	

Project No. BL-10-10065 **Client:** W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

Location: Boring11-110MU, #5, 60-62', Sheyenne River, Argusville Formation

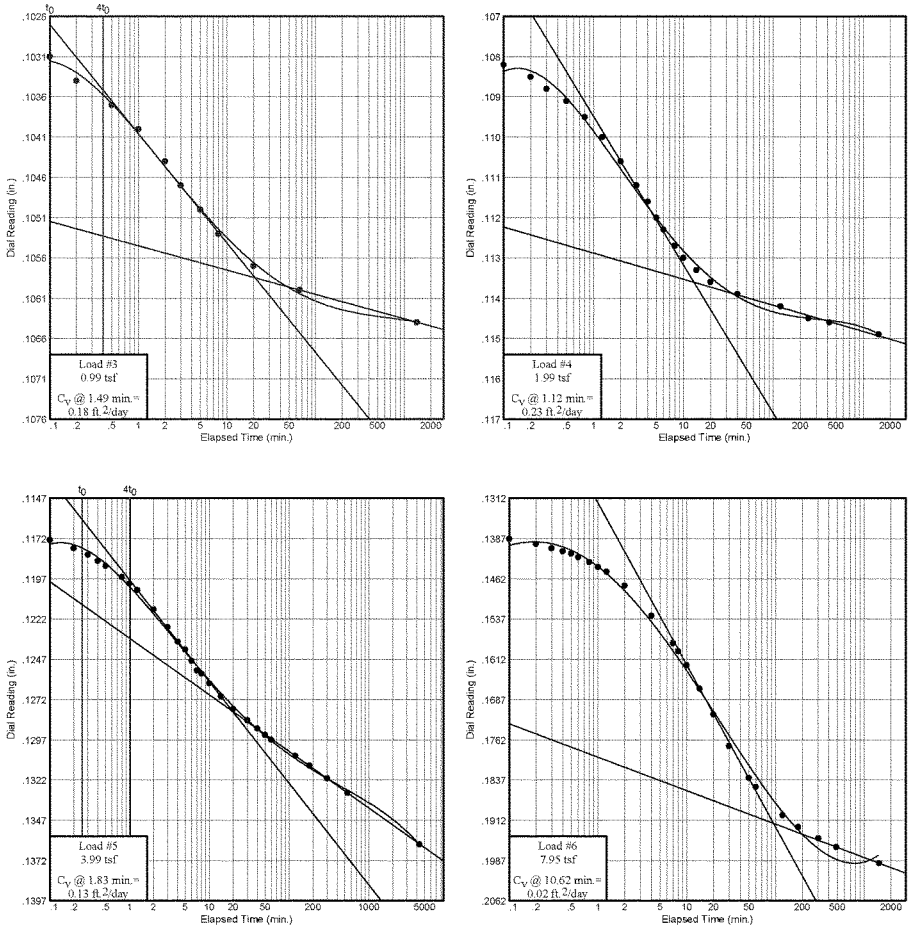
Remarks:

BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Boring11-110MU, #5, 60-62', Sheyenne River, Argusville Formation

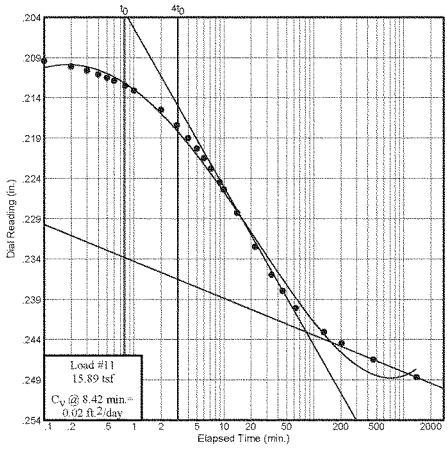


BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Boring11-110MU, #5, 60-62', Sheyenne River, Argusville Formation



BRAUN INTERTEC

Figure

CONSOLIDATION TEST DATA

Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: 11-110, #5
Elev. or Depth: 60-62' **Sample Length(in./cm.):**
Location: Boring11-110MU, #5, 60-62', Sheyenne River, Argusville Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2435
Liquid Limit: 70 **Plasticity Index:** 48
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	153.85 g.	Consolidometer # = 3	Wet w+t =
Dry w+t =	115.25 g.		Dry w+t =
Tare Wt. =	30.35 g.	Spec. Gravity = 2.679	Tare Wt. =
Height =	.73 in.	Height = .73 in.	
Diameter =	2.50 in.	Diameter = 2.50 in.	
Weight =	103.03 g.	Defl. Table = Machine3-2009	
Moisture =	45.5 %	Ht. Solids = 0.3292 in.	Moisture = %
Wet Den. =	109.7 pcf	Dry Wt. = 70.83 g.*	Dry Wt. = n/a
Dry Den. =	75.4 pcf	Void Ratio = 1.218	Void Ratio = 0.942
		Saturation = 100.0 %	

* Initial dry weight used in calculations

End-of-Load Summary

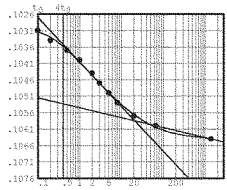
Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.10170				1.218	
0.30	0.10190	0.00000			1.217	0.0 Comprs.
0.49	0.10280	0.00050			1.216	0.1 Comprs.
0.99	0.10710	0.00070	0.18	0.000	1.203	0.6 Comprs.
1.99	0.11590	0.00100	0.23	0.001	1.177	1.8 Comprs.
3.99	0.13770	0.00150	0.13	0.005	1.113	4.7 Comprs.
7.95	0.20120	0.00200	0.02	0.009	0.921	13.4 Comprs.
1.99	0.18690	0.00100			0.962	11.5 Comprs.
0.49	0.16440	0.00050			1.029	8.5 Comprs.
1.99	0.17810	0.00100			0.988	10.3 Comprs.
7.95	0.21010	0.00200			0.894	14.6 Comprs.
15.89	0.25160	0.00290	0.02	0.007	0.771	20.1 Comprs.
3.99	0.23780	0.00150			0.809	18.4 Comprs.
0.99	0.21500	0.00070			0.875	15.4 Comprs.

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
0.30	0.19240	0.00000			0.942	12.4 Comprs.

C_c = 0.83 P_c = 4.29 tsf C_r = 0.10

Pressure: 0.99 tsf — TEST READINGS — Load No. 3

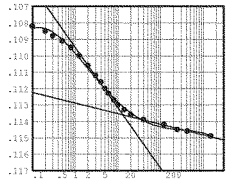
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10280	11	66.00	0.10670
2	0.10	0.10380	12	1387.00	0.10710
3	0.20	0.10410			
4	0.50	0.10440			
5	1.00	0.10470			
6	2.00	0.10510			
7	3.00	0.10540			
8	5.00	0.10570			
9	8.00	0.10600			
10	20.00	0.10640			



Void Ratio = 1.203 Compression = 0.6 %
D_0 = 0.10273 D_{50} = 0.10429 D_{100} = 0.10585
C_v at 1.5 min. = 0.18 ft.^{2}/day C_α = 0.000

Pressure: 1.99 tsf — TEST READINGS — Load No. 4

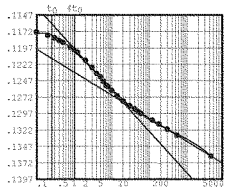
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10710	12	6.00	0.11330
2	0.10	0.10920	13	8.00	0.11370
3	0.20	0.10950	14	10.00	0.11400
4	0.30	0.10980	15	14.00	0.11430
5	0.50	0.11010	16	20.00	0.11460
6	0.80	0.11050	17	40.00	0.11490
7	1.25	0.11100	18	120.00	0.11520
8	2.00	0.11160	19	246.00	0.11550
9	3.00	0.11220	20	420.00	0.11560
10	4.00	0.11260	21	1486.00	0.11590
11	5.00	0.11300			



Void Ratio = 1.177 Compression = 1.8 %
D_0 = 0.10640 D_{50} = 0.11000 D_{100} = 0.11361
C_v at 1.1 min. = 0.23 ft.^{2}/day C_α = 0.001

Pressure: 3.99 tsf — TEST READINGS — Load No. 5

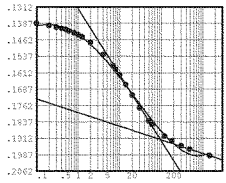
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.11590	15	7.00	0.12690
2	0.10	0.11880	16	8.00	0.12710
3	0.20	0.11930	17	10.00	0.12770
4	0.30	0.11970	18	14.00	0.12850
5	0.40	0.12010	19	20.00	0.12930
6	0.50	0.12040	20	30.00	0.13000
7	0.80	0.12110	21	40.00	0.13050
8	1.00	0.12150	22	50.00	0.13090
9	1.25	0.12190	23	60.00	0.13120
10	2.00	0.12310	24	120.00	0.13220
11	3.00	0.12420	25	180.00	0.13280
12	4.00	0.12510	26	300.00	0.13360
13	5.00	0.12560	27	541.00	0.13450
14	6.00	0.12630	28	4315.00	0.13770



Void Ratio = 1.113 Compression = 4.7 %
D_0 = 0.11535 D_{50} = 0.12165 D_{100} = 0.12796
C_v at 1.8 min. = 0.13 ft.^{2}/day C_α = 0.005

Pressure: 7.95 tsf — TEST READINGS — Load No. 6

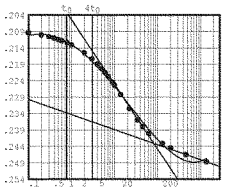
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.13770	14	8.00	0.16170
2	0.10	0.14080	15	10.00	0.16430
3	0.20	0.14170	16	14.00	0.16870
4	0.30	0.14250	17	20.00	0.17350
5	0.40	0.14310	18	30.00	0.17940
6	0.50	0.14350	19	50.00	0.18530
7	0.60	0.14420	20	60.00	0.18700
8	0.80	0.14510	21	120.00	0.19230
9	1.00	0.14600	22	180.00	0.19450
10	1.25	0.14690	23	304.00	0.19660
11	2.00	0.14950	24	484.00	0.19820
12	4.00	0.15510	25	1466.00	0.20120
13	7.00	0.16020			



Void Ratio = 0.921 Compression = 13.4 %
D_0 = 0.13620 D_{50} = 0.16400 D_{100} = 0.19180
C_v at 10.6 min. = 0.02 ft.^{2}/day C_α = 0.009

Pressure: 15.89 tsf | TEST READINGS | Load No. 11

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.21010	14	6.00	0.22440
2	0.10	0.21230	15	7.20	0.22570
3	0.20	0.21300	16	9.00	0.22740
4	0.30	0.21350	17	10.00	0.22830
5	0.40	0.21400	18	14.00	0.23120
6	0.50	0.21440	19	22.30	0.23540
7	0.60	0.21480	20	34.00	0.23890
8	0.80	0.21540	21	45.00	0.24090
9	1.00	0.21600	22	63.00	0.24300
10	2.00	0.21840	23	130.00	0.24600
11	3.00	0.22030	24	204.10	0.24740
12	4.00	0.22190	25	459.00	0.24940
13	5.00	0.22320	26	1386.00	0.25160

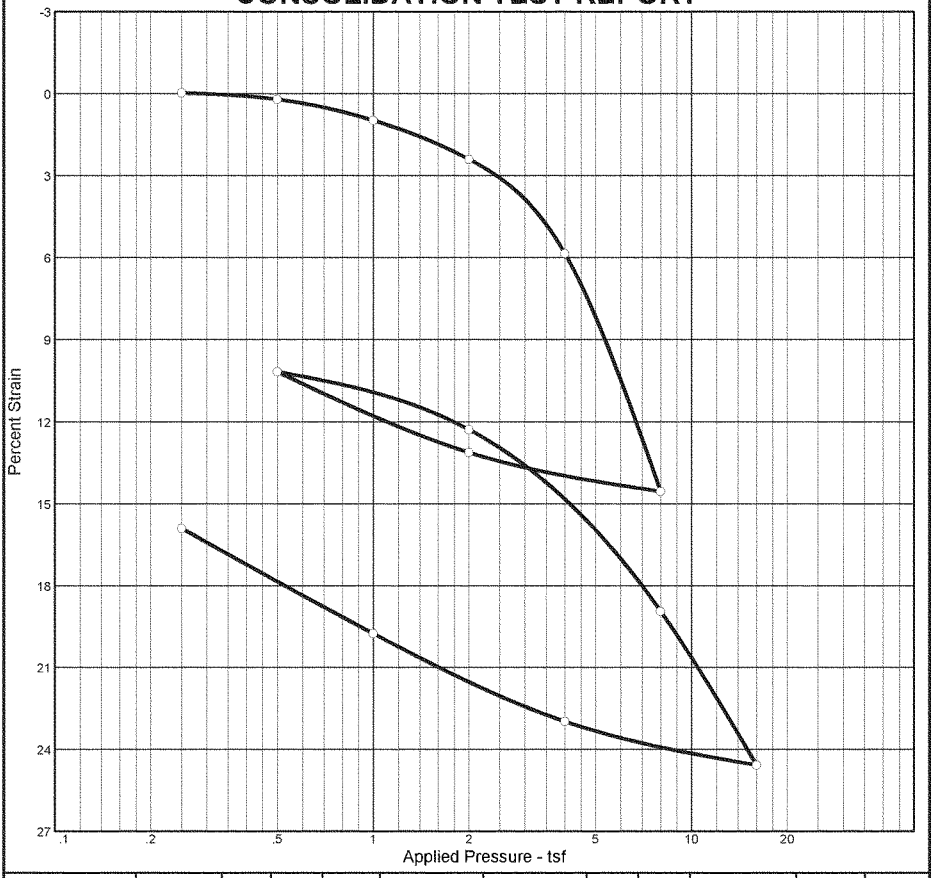


Void Ratio = 0.771 Compression = 20.1 %

D_0 = 0.20600 D_{50} = 0.22454 D_{100} = 0.24308

C_v at 8.4 min. = 0.02 ft.^{2}/day C_α = 0.007

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
99.9 %	47.6 %	73.7	60	43	2.693		4.02	0.76	0.12			1.282

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2435	CH	

Project No. BL-10-10065 **Client:** USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2

Location: Boring11-118MU, #3, 45-47', Wild Rice, Argusville Formation

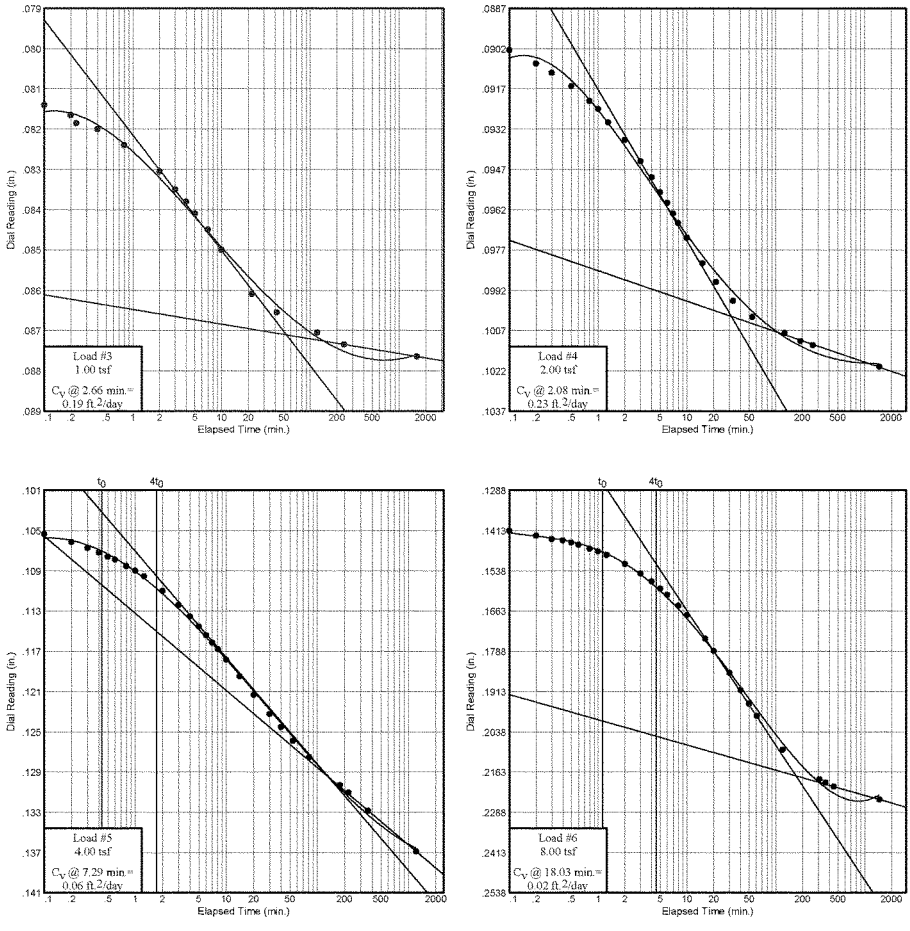
Remarks:

BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Location: Boring11-118MU, #3, 45-47', Wild Rice, Argusville Formation

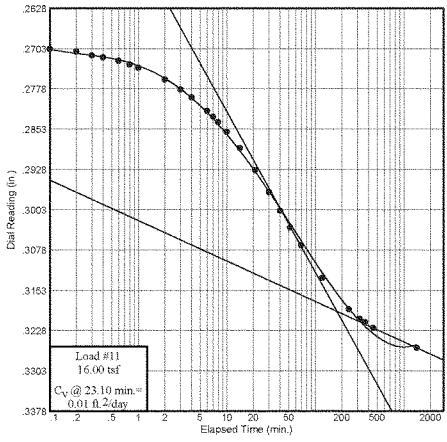


BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Location: Boring11-118MU, #3, 45-47', Wild Rice, Argusville Formation



BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: Boring11-118MU, #3
Elev. or Depth: 45-47' **Sample Length(in./cm.):**
Location: Boring11-118MU, #3, 45-47', Wild Rice, Argusville Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2435
Liquid Limit: 60 **Plasticity Index:** 43
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE	BEFORE TEST	AFTER TEST
Wet w+t = 158.48 g.	Consolidometer # = 2	Wet w+t =
Dry w+t = 117.09 g.		Dry w+t =
Tare Wt. = 30.09 g.	Spec. Gravity = 2.693	Tare Wt. =
Height = 1.01 in.	Height = 1.01 in.	
Diameter = 2.50 in.	Diameter = 2.50 in.	
Weight = 141.13 g.	Defl. Table = Machine2-Air-2011	
Moisture = 47.6 %	Ht. Solids = 0.4425 in.	Moisture = %
Wet Den. = 108.7 pcf	Dry Wt. = 95.63 g.*	Dry Wt. = n/a
Dry Den. = 73.7 pcf	Void Ratio = 1.282	Void Ratio = 0.919
	Saturation = 99.9 %	

* Initial dry weight used in calculations

End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.07785				1.282	
0.25	0.07795	0.00050			1.283	0.0 Swell
0.50	0.08085	0.00095			1.278	0.2 Comprs.
1.00	0.08920	0.00155	0.19	0.000	1.260	1.0 Comprs.
2.00	0.10430	0.00225	0.23	0.001	1.228	2.4 Comprs.
4.00	0.13985	0.00295	0.06	0.008	1.149	5.8 Comprs.
8.00	0.22865	0.00380	0.02	0.008	0.950	14.6 Comprs.
2.00	0.21270	0.00225			0.983	13.1 Comprs.
0.50	0.18155	0.00095			1.050	10.2 Comprs.
2.00	0.20425	0.00225			1.002	12.3 Comprs.
8.00	0.27300	0.00380			0.850	18.9 Comprs.
16.00	0.33100	0.00495	0.01	0.009	0.721	24.6 Comprs.
4.00	0.31285	0.00295			0.758	23.0 Comprs.
1.00	0.27895	0.00155			0.831	19.8 Comprs.

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
0.25	0.23900	0.00050			0.919	15.9 Comprs.

C_c = 0.76 P_c = 4.02 tsf C_r = 0.12

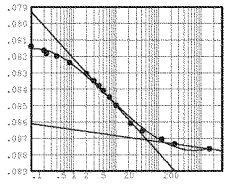
Pressure: 0.50 tsf TEST READINGS Load No. 2

No.	Elapsed Time	Dial Reading
1	0.00	0.07795
2	0.10	0.07885
3	0.50	0.07920
4	8.20	0.08010
5	15.00	0.08025
6	238.00	0.08070
7	1316.00	0.08085

Void Ratio = 1.278 Compression = 0.2 %

Pressure: 1.00 tsf TEST READINGS Load No. 3

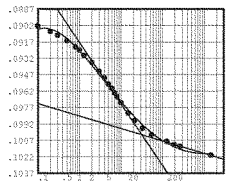
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08085	11	7.00	0.08605
2	0.10	0.08295	12	10.00	0.08655
3	0.20	0.08320	13	22.00	0.08765
4	0.23	0.08340	14	42.00	0.08810
5	0.40	0.08355	15	120.00	0.08860
6	0.80	0.08395	16	240.00	0.08890
7	2.00	0.08460	17	1589.00	0.08920
8	3.00	0.08505			
9	4.00	0.08535			
10	5.00	0.08565			



Void Ratio = 1.260 Compression = 1.0 %
D_0 = 0.07990 D_{50} = 0.08351 D_{100} = 0.08711
C_v at 2.7 min. = 0.19 ft.^{2}/day C_α = 0.000

Pressure: 2.00 tsf | TEST READINGS | Load No. 4

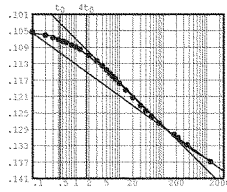
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08920	13	6.00	0.09820
2	0.10	0.09250	14	7.00	0.09860
3	0.20	0.09300	15	8.00	0.09895
4	0.30	0.09335	16	10.00	0.09950
5	0.50	0.09385	17	15.00	0.10045
6	0.80	0.09440	18	21.30	0.10115
7	1.00	0.09470	19	33.00	0.10185
8	1.30	0.09520	20	54.50	0.10245
9	2.00	0.09585	21	126.50	0.10305
10	3.00	0.09665	22	190.50	0.10335
11	4.00	0.09725	23	262.50	0.10350
12	5.00	0.09780	24	1470.00	0.10430



Void Ratio = 1.228 Compression = 2.4 %
D_0 = 0.08765 D_{50} = 0.09391 D_{100} = 0.10018
C_v at 2.1 min. = 0.23 ft.^{2}/day C_α = 0.001

Pressure: 4.00 tsf | TEST READINGS | Load No. 5

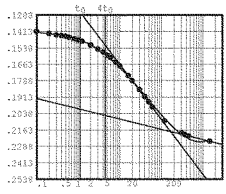
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10430	15	6.00	0.11835
2	0.10	0.10830	16	7.00	0.11910
3	0.20	0.10910	17	8.10	0.11975
4	0.30	0.10970	18	10.00	0.12080
5	0.40	0.11015	19	14.00	0.12245
6	0.50	0.11055	20	20.10	0.12430
7	0.60	0.11085	21	30.00	0.12620
8	0.80	0.11150	22	40.00	0.12750
9	1.00	0.11195	23	54.30	0.12885
10	1.25	0.11250	24	81.30	0.13050
11	2.00	0.11395	25	178.00	0.13325
12	3.00	0.11535	26	220.00	0.13400
13	4.00	0.11650	27	361.00	0.13580
14	5.00	0.11750	28	1218.00	0.13985



Void Ratio = 1.149 Compression = 5.8 %
D_0 = 0.10332 D_{50} = 0.11642 D_{100} = 0.12953
C_v at 7.3 min. = 0.06 ft.^{2}/day C_α = 0.008

Pressure: 8.00 tsf — TEST READINGS — Load No. 6

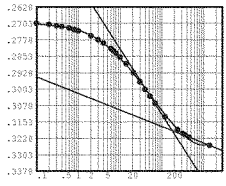
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.13985	15	6.00	0.16505
2	0.10	0.14520	16	8.00	0.16845
3	0.20	0.14670	17	10.00	0.17140
4	0.30	0.14780	18	16.00	0.17870
5	0.40	0.14820	19	20.00	0.18255
6	0.50	0.14885	20	30.00	0.18935
7	0.60	0.14955	21	40.00	0.19470
8	0.80	0.15075	22	50.00	0.19890
9	1.00	0.15160	23	61.00	0.20275
10	1.25	0.15270	24	120.00	0.21320
11	2.00	0.15550	25	310.00	0.22240
12	3.00	0.15850	26	361.00	0.22340
13	4.00	0.16095	27	450.00	0.22465
14	5.00	0.16315	28	1460.00	0.22865



Void Ratio = 0.950 Compression = 14.6 %
D_0 = 0.13697 D_{50} = 0.17723 D_{100} = 0.21750
C_v at 18.0 min. = 0.02 ft.^{2}/day C_α = 0.008

Pressure: 16.00 tsf — TEST READINGS — Load No. 11

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.27300	15	10.00	0.29075
2	0.10	0.27530	16	14.00	0.29380
3	0.20	0.27580	17	21.00	0.29790
4	0.30	0.27650	18	30.00	0.30195
5	0.40	0.27685	19	40.00	0.30545
6	0.60	0.27750	20	52.00	0.30860
7	0.80	0.27820	21	69.00	0.31185
8	1.00	0.27880	22	120.00	0.31795
9	2.00	0.28100	23	240.00	0.32380
10	3.00	0.28285	24	317.00	0.32560
11	4.00	0.28435	25	363.00	0.32620
12	6.00	0.28685	26	453.00	0.32730
13	7.00	0.28795	27	1402.00	0.33100
14	8.00	0.28895			



Void Ratio = 0.721 Compression = 24.6 %
D_0 = 0.26920 D_{50} = 0.29423 D_{100} = 0.31926
C_v at 23.1 min. = 0.01 ft.^{2}/day C_α = 0.009

CONSOLIDATION TEST REPORT

Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
99.6 %	45.7 %	75.1	77	55	2.687		4.41	0.74	0.12			1.233

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2435	CH	

Project No. BL-10-10065 **Client:** USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2

Location: Boring11-118MU, #4, 55-57', Wild Rice, Argusville Formation

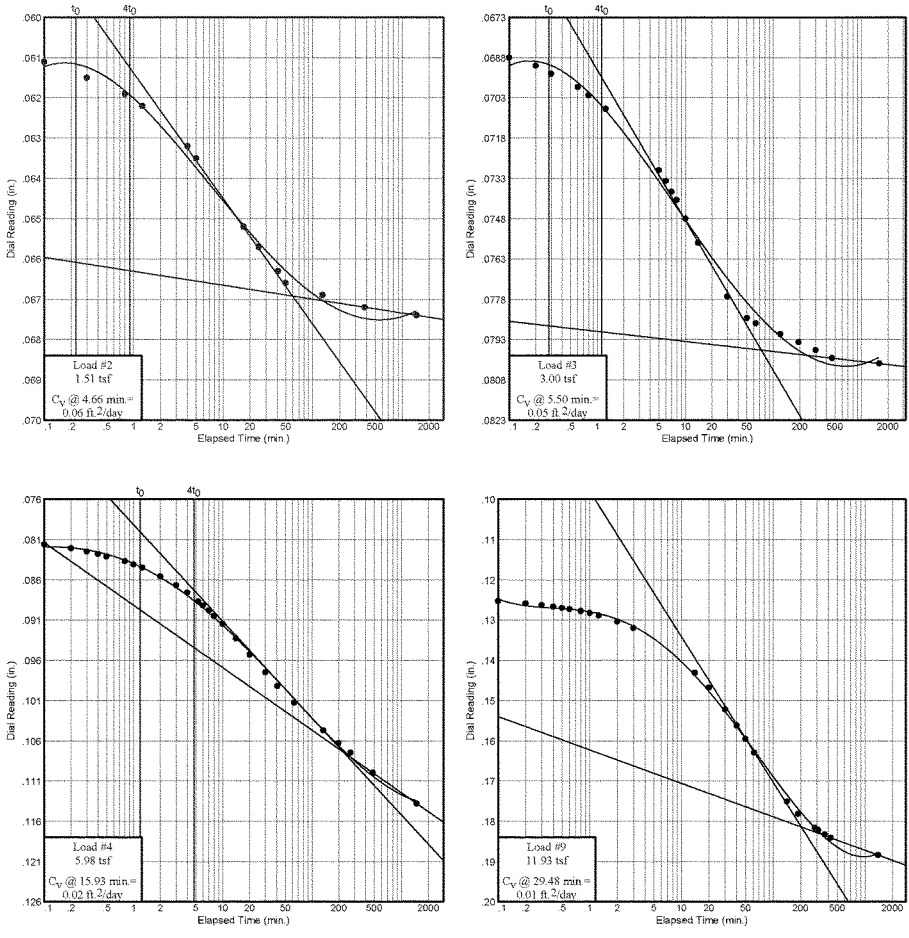
Remarks:

BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Location: Boring11-118MU, #4, 55-57', Wild Rice, Argusville Formation



BRAUN INTERTEC

Figure

CONSOLIDATION TEST DATA

Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: Boring11-118MU, #4
Elev. or Depth: 55-57' **Sample Length(in./cm.):**
Location: Boring11-118MU, #4, 55-57', Wild Rice, Argusville Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2435
Liquid Limit: 77 **Plasticity Index:** 55
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE	BEFORE TEST	AFTER TEST
Wet w+t = 139.43 g.	Consolidometer # = 5	Wet w+t =
Dry w+t = 105.15 g.		Dry w+t =
Tare Wt. = 30.11 g.	Spec. Gravity = 2.687	Tare Wt. =
Height = .77 in.	Height = .77 in.	
Diameter = 2.50 in.	Diameter = 2.50 in.	
Weight = 108.81 g.	Defl. Table = Machine5-2009	
Moisture = 45.7 %	Ht. Solids = 0.3453 in.	Moisture = %
Wet Den. = 109.4 pcf	Dry Wt. = 74.69 g.*	Dry Wt. = n/a
Dry Den. = 75.1 pcf	Void Ratio = 1.233	Void Ratio = 1.006
	Saturation = 99.6 %	

* Initial dry weight used in calculations

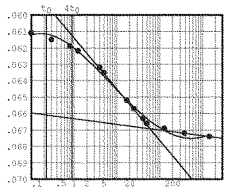
End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.05940				1.233	
0.75	0.06200	0.00190			1.231	0.1 Comprs.
1.51	0.07040	0.00300	0.06	0.000	1.210	1.0 Comprs.
3.00	0.08450	0.00430	0.05	0.000	1.173	2.7 Comprs.
5.98	0.11980	0.00600	0.02	0.010	1.075	7.1 Comprs.
1.51	0.09750	0.00300			1.131	4.6 Comprs.
0.75	0.08470	0.00190			1.165	3.0 Comprs.
1.51	0.09080	0.00300			1.151	3.7 Comprs.
5.98	0.12970	0.00600			1.047	8.3 Comprs.
11.93	0.19670	0.00830	0.01	0.012	0.859	16.7 Comprs.
3.00	0.17200	0.00430			0.919	14.0 Comprs.
1.51	0.15710	0.00300			0.959	12.3 Comprs.
0.75	0.13970	0.00190			1.006	10.2 Comprs.

C_c = 0.74 P_c = 4.41 tsf C_r = 0.12

Pressure: 1.51 tsf — TEST READINGS — Load No. 2

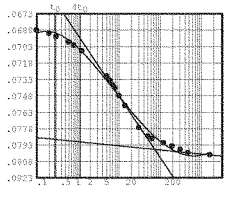
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.06200	11	50.00	0.06960
2	0.10	0.06410	12	129.00	0.06990
3	0.30	0.06450	13	382.00	0.07020
4	0.80	0.06490	14	1449.00	0.07040
5	1.25	0.06520			
6	4.00	0.06620			
7	5.00	0.06650			
8	17.00	0.06820			
9	25.00	0.06870			
10	41.00	0.06930			



Void Ratio = 1.210 Compression = 1.0 %
D_0 = 0.06039 D_{50} = 0.06366 D_{100} = 0.06692
C_v at 4.7 min. = 0.06 ft.^{2}/day C_α = 0.000

Pressure: 3.00 tsf — TEST READINGS — Load No. 3

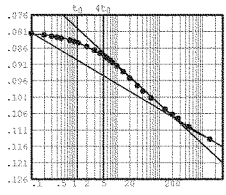
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.07040	12	10.00	0.07910
2	0.10	0.07310	13	14.00	0.08000
3	0.20	0.07340	14	30.00	0.08200
4	0.30	0.07370	15	50.00	0.08280
5	0.60	0.07420	16	63.00	0.08300
6	0.80	0.07450	17	120.00	0.08340
7	1.25	0.07500	18	193.00	0.08370
8	5.00	0.07730	19	302.00	0.08400
9	6.00	0.07770	20	466.00	0.08430
10	7.00	0.07810	21	1592.00	0.08450
11	8.00	0.07840			



Void Ratio = 1.173 Compression = 2.7 %
D_0 = 0.06751 D_{50} = 0.07360 D_{100} = 0.07970
C_v at 5.5 min. = 0.05 ft.^{2}/day C_α = 0.000

Pressure: 5.98 tsf | TEST READINGS | Load No. 4

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08450	15	7.00	0.09580
2	0.10	0.08760	16	8.00	0.09650
3	0.20	0.08810	17	10.00	0.09750
4	0.30	0.08850	18	14.00	0.09930
5	0.40	0.08880	19	20.00	0.10130
6	0.50	0.08910	20	30.10	0.10350
7	0.80	0.08970	21	41.00	0.10520
8	1.00	0.09010	22	63.00	0.10730
9	1.25	0.09050	23	134.00	0.11070
10	2.00	0.09160	24	198.00	0.11230
11	3.00	0.09270	25	270.00	0.11350
12	4.00	0.09360	26	480.00	0.11600
13	5.30	0.09470	27	1480.00	0.11980
14	6.00	0.09520			



Void Ratio = 1.075 Compression = 7.1 %
D_0 = 0.08016 D_{50} = 0.09381 D_{100} = 0.10746
C_v at 15.9 min. = 0.02 ft.^{2}/day C_α = 0.010

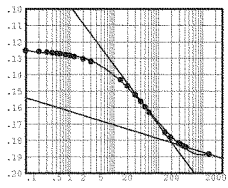
Pressure: 5.98 tsf | TEST READINGS | Load No. 8

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.09080	10	4.00	0.10290	19	50.00	0.12100
2	0.30	0.09550	11	6.00	0.10510	20	60.00	0.12190
3	0.40	0.09590	12	7.00	0.10600	21	124.00	0.12430
4	0.50	0.09630	13	8.00	0.10690	22	266.00	0.12620
5	0.80	0.09730	14	10.00	0.10860	23	345.00	0.12690
6	1.00	0.09780	15	14.00	0.11120	24	420.00	0.12730
7	1.25	0.09840	16	20.00	0.11430	25	1499.00	0.12970
8	2.00	0.09990	17	30.00	0.11770			
9	3.00	0.10150	18	40.00	0.11970			

Void Ratio = 1.047 Compression = 8.3 %

Pressure: 11.93 tsf | TEST READINGS | Load No. 9

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.12970	14	20.00	0.15510
2	0.10	0.13360	15	30.00	0.16050
3	0.20	0.13420	16	40.00	0.16450
4	0.30	0.13460	17	50.00	0.16790
5	0.40	0.13500	18	62.00	0.17130
6	0.50	0.13530	19	141.00	0.18340
7	0.60	0.13560	20	187.00	0.18650
8	0.80	0.13610	21	286.00	0.19000
9	1.00	0.13660	22	309.00	0.19050
10	1.25	0.13720	23	365.00	0.19160
11	2.00	0.13870	24	424.00	0.19240
12	3.00	0.14030	25	1396.00	0.19670
13	14.00	0.15140			

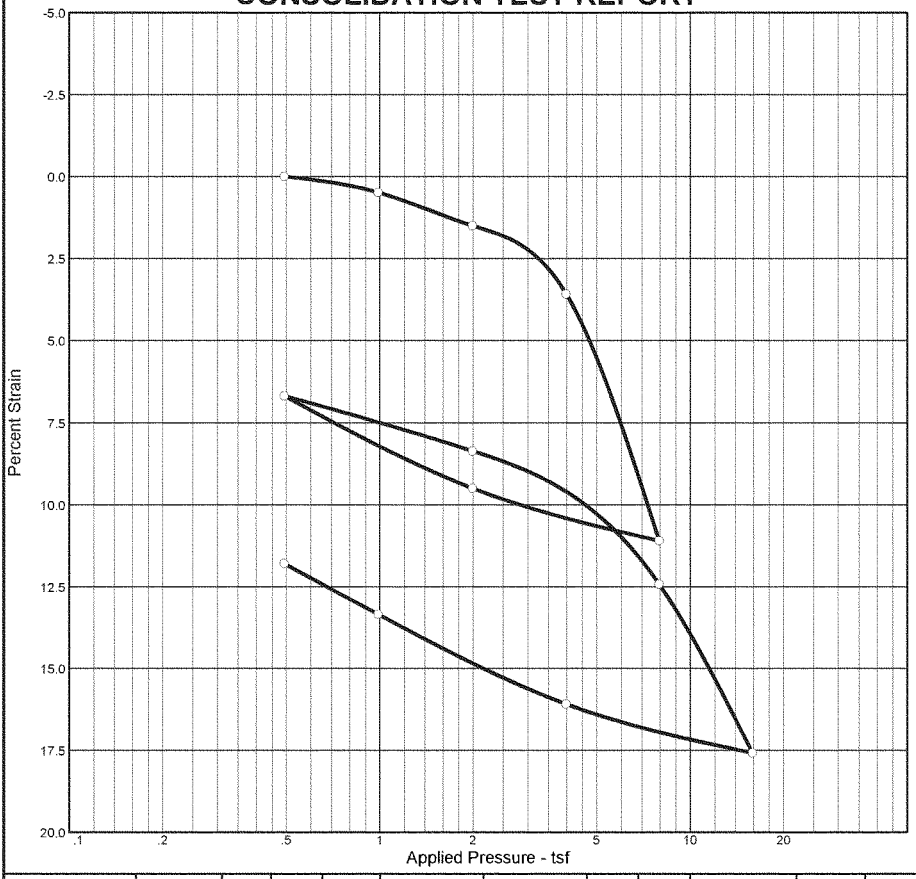


Void Ratio = 0.859 Compression = 16.7 %

D_0 = 0.12370 D_{50} = 0.15257 D_{100} = 0.18144

C_v at 29.5 min. = 0.01 ft.^{2}/day C_α = 0.012

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
100.1 %	39.6 %	81.5	61	41	2.695		4.52	0.59	0.09			1.066

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2435	CH	

Project No. BL-10-10065 **Client:** USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2

Location: Boring11-118MU, #5, 65-67', Wild Rice, Argusville Formation

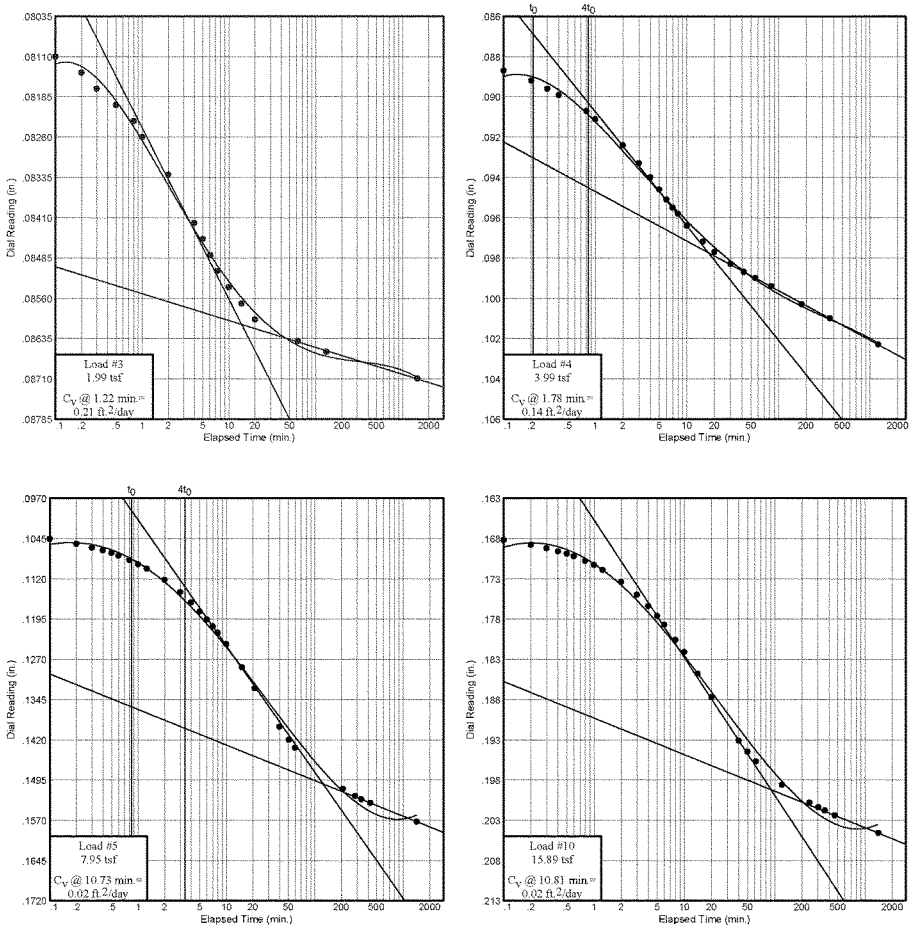
Remarks:

BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Location: Boring11-118MU, #5, 65-67', Wild Rice, Argusville Formation



BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 2
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: Boring11-118MU, #5
Elev. or Depth: 65-67' **Sample Length(in./cm.):**
Location: Boring11-118MU, #5, 65-67', Wild Rice, Argusville Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2435
Liquid Limit: 61 **Plasticity Index:** 41
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE	BEFORE TEST	AFTER TEST
Wet w+t = 166.80 g.	Consolidometer # = 3	Wet w+t =
Dry w+t = 128.34 g.		Dry w+t =
Tare Wt. = 31.13 g.	Spec. Gravity = 2.695	Tare Wt. =
Height = .73 in.	Height = .73 in.	
Diameter = 2.50 in.	Diameter = 2.50 in.	
Weight = 106.83 g.	Defl. Table = Machine3-2009	
Moisture = 39.6 %	Ht. Solids = 0.3537 in.	Moisture = %
Wet Den. = 113.7 pcf	Dry Wt. = 76.55 g.*	Dry Wt. = n/a
Dry Den. = 81.5 pcf	Void Ratio = 1.066	Void Ratio = 0.822
	Saturation = 100.1 %	

* Initial dry weight used in calculations

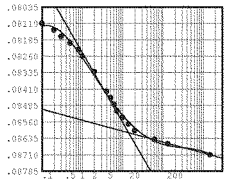
End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.07620				1.066	
0.49	0.07660	0.00050			1.066	0.0 Swell
0.99	0.08040	0.00070			1.056	0.5 Comprs.
1.99	0.08810	0.00100	0.21	0.001	1.035	1.5 Comprs.
3.99	0.10380	0.00150	0.14	0.003	0.992	3.6 Comprs.
7.95	0.15930	0.00200	0.02	0.009	0.836	11.1 Comprs.
1.99	0.14660	0.00100			0.869	9.5 Comprs.
0.49	0.12550	0.00050			0.928	6.7 Comprs.
1.99	0.13830	0.00100			0.893	8.4 Comprs.
7.95	0.16900	0.00200			0.809	12.4 Comprs.
15.89	0.20750	0.00290	0.02	0.007	0.702	17.6 Comprs.
3.99	0.19520	0.00150			0.733	16.1 Comprs.
0.99	0.17440	0.00070			0.790	13.3 Comprs.
0.49	0.16290	0.00050			0.822	11.8 Comprs.

C_c = 0.59 P_c = 4.52 tsf C_r = 0.09

Pressure: 1.99 tsf — TEST READINGS — **Load No. 3**

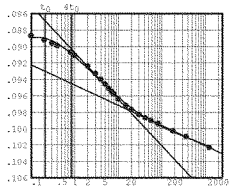
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08040	11	6.10	0.08580
2	0.10	0.08210	12	7.30	0.08610
3	0.20	0.08240	13	10.00	0.08640
4	0.30	0.08270	14	14.00	0.08670
5	0.50	0.08300	15	20.00	0.08700
6	0.80	0.08330	16	62.00	0.08740
7	1.00	0.08360	17	133.00	0.08760
8	2.00	0.08430	18	1479.00	0.08810
9	4.00	0.08520			
10	5.00	0.08550			



Void Ratio = 1.035 Compression = 1.5 %
D_0 = 0.07970 D_{50} = 0.08290 D_{100} = 0.08609
C_v at 1.2 min. = 0.21 ft.^{2}/day C_α = 0.001

Pressure: 3.99 tsf — TEST READINGS — **Load No. 4**

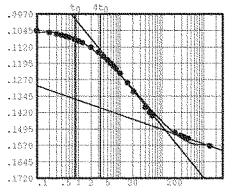
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08810	13	7.00	0.09700
2	0.10	0.09020	14	8.00	0.09730
3	0.20	0.09070	15	10.00	0.09790
4	0.30	0.09110	16	15.00	0.09870
5	0.40	0.09140	17	20.00	0.09920
6	0.80	0.09220	18	30.00	0.09980
7	1.00	0.09260	19	42.00	0.10020
8	2.00	0.09390	20	56.00	0.10050
9	3.00	0.09480	21	83.30	0.10090
10	4.00	0.09550	22	180.00	0.10180
11	5.00	0.09610	23	364.00	0.10250
12	6.00	0.09660	24	1228.00	0.10380



Void Ratio = 0.992 Compression = 3.6 %
D_0 = 0.08713 D_{50} = 0.09243 D_{100} = 0.09774
C_v at 1.8 min. = 0.14 ft.^{2}/day C_α = 0.003

Pressure: 7.95 tsf — TEST READINGS — Load No. 5

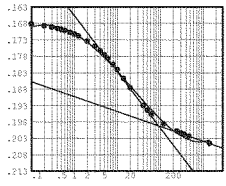
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10380	15	6.00	0.12160
2	0.10	0.10660	16	7.00	0.12290
3	0.20	0.10750	17	8.00	0.12410
4	0.30	0.10820	18	10.00	0.12620
5	0.40	0.10870	19	15.00	0.13050
6	0.50	0.10920	20	21.00	0.13440
7	0.60	0.10970	21	40.00	0.14160
8	0.80	0.11050	22	51.00	0.14400
9	1.00	0.11130	23	60.00	0.14550
10	1.25	0.11210	24	208.00	0.15320
11	2.00	0.11420	25	286.00	0.15450
12	3.00	0.11650	26	338.00	0.15510
13	4.00	0.11840	27	425.00	0.15580
14	5.00	0.12010	28	1432.00	0.15930



Void Ratio = 0.836 Compression = 11.1 %
D_0 = 0.10059 D_{50} = 0.12543 D_{100} = 0.15026
C_v at 10.7 min. = 0.02 ft.^{2}/day C_α = 0.009

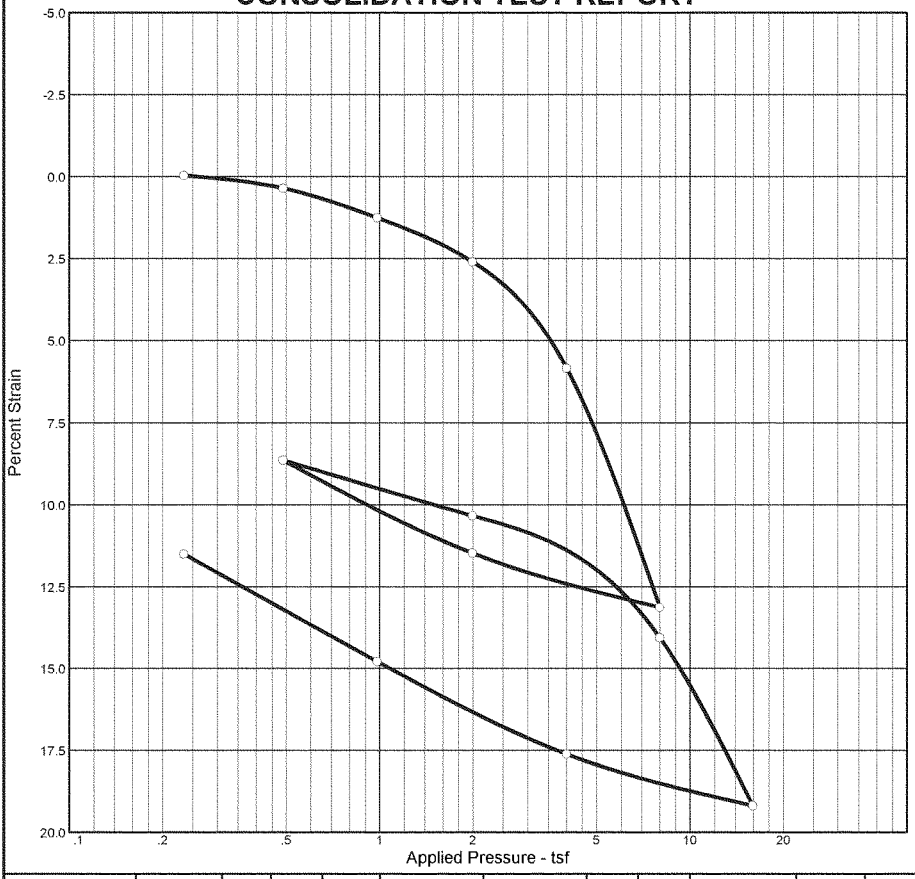
Pressure: 15.89 tsf — TEST READINGS — Load No. 10

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.16900	15	6.00	0.18160
2	0.10	0.17110	16	8.00	0.18350
3	0.20	0.17170	17	10.00	0.18500
4	0.30	0.17210	18	14.00	0.18770
5	0.40	0.17250	19	20.00	0.19060
6	0.50	0.17280	20	40.00	0.19600
7	0.60	0.17310	21	50.00	0.19740
8	0.80	0.17370	22	62.00	0.19860
9	1.00	0.17420	23	120.00	0.20150
10	1.25	0.17480	24	243.00	0.20370
11	2.00	0.17630	25	304.00	0.20430
12	3.00	0.17790	26	360.00	0.20470
13	4.00	0.17930	27	462.00	0.20530
14	5.00	0.18050	28	1410.00	0.20750



Void Ratio = 0.702 Compression = 17.6 %
D_0 = 0.16700 D_{50} = 0.18310 D_{100} = 0.19920
C_v at 10.8 min. = 0.02 ft.^{2}/day C_α = 0.007

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
99.1 %	41.5 %	79.1	56	34	2.698		3.22	0.46	0.09			1.131

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2435	CH	

Project No. BL-10-10065 **Client:** USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3

Location: Boring11-119MU, #2, 40-42', Fargo Pile Load Test, Argusville Formation

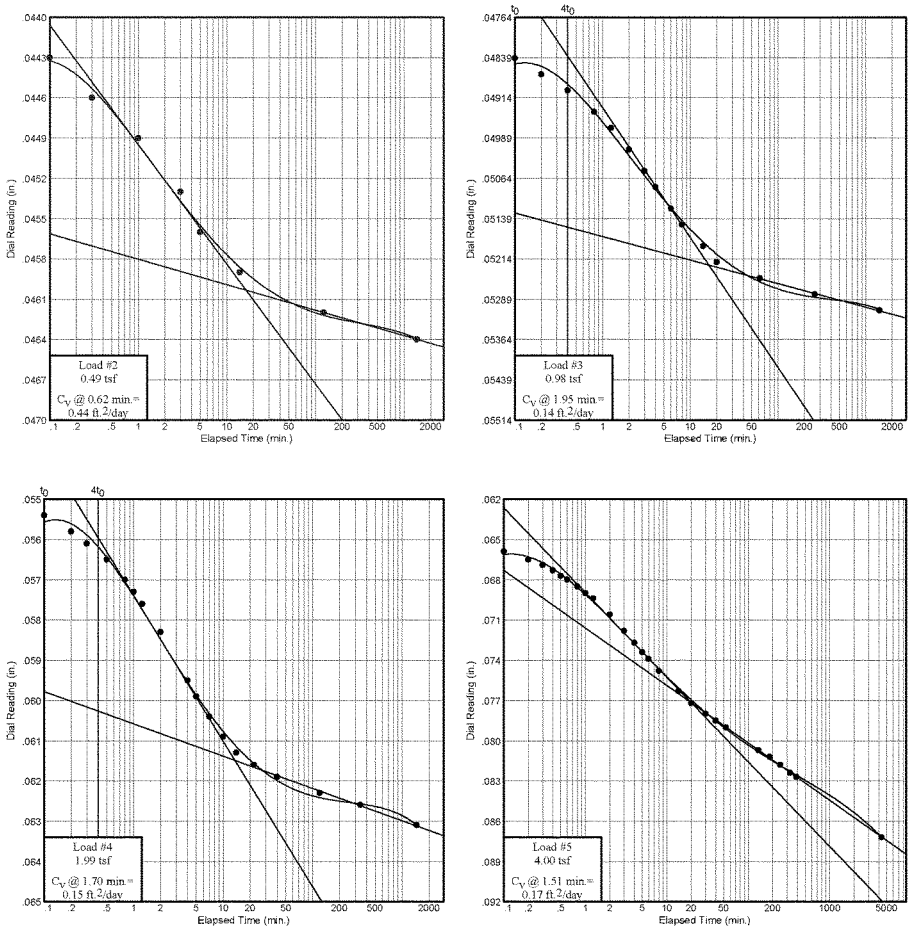
Remarks:

BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: Boring11-119MU, #2, 40-42', Fargo Pile Load Test, Argusville Formation

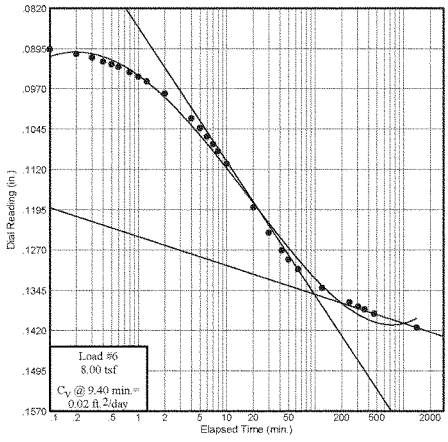


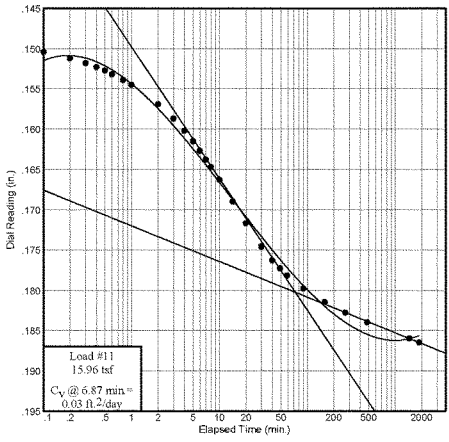
BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: Boring11-119MU, #2, 40-42', Fargo Pile Load Test, Argusville Formation





BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: Boring11-119MU, #2
Elev. or Depth: 40-42' **Sample Length(in./cm.):**
Location: Boring11-119MU, #2, 40-42', Fargo Pile Load Test, Argusville Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2435
Liquid Limit: 56 **Plasticity Index:** 34
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST		AFTER TEST	
Wet w+t	= 161.71 g.	Consolidometer #	= 4	Wet w+t	=
Dry w+t	= 123.10 g.			Dry w+t	=
Tare Wt.	= 30.17 g.	Spec. Gravity	= 2.698	Tare Wt.	=
Height	= .74 in.	Height	= .74 in.		
Diameter	= 2.49 in.	Diameter	= 2.49 in.		
Weight	= 106.82 g.	Defl. Table	= Machine4-2009		
Moisture	= 41.5 %	Ht. Solids	= 0.3491 in.	Moisture	= %
Wet Den.	= 111.9 pcf	Dry Wt.	= 75.47 g.*	Dry Wt.	= n/a
Dry Den.	= 79.1 pcf	Void Ratio	= 1.131	Void Ratio	= 0.885
		Saturation	= 99.1 %		

* Initial dry weight used in calculations

End-of-Load Summary

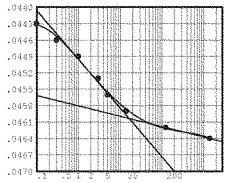
Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.04380				1.131	
0.23	0.04400	0.00050			1.131	0.0 Swell
0.49	0.04720	0.00080	0.44	0.000	1.123	0.3 Comprs.
0.98	0.05410	0.00100	0.14	0.001	1.104	1.3 Comprs.
1.99	0.06460	0.00150	0.15	0.001	1.075	2.6 Comprs.
4.00	0.08920	0.00200	0.17	0.006	1.006	5.8 Comprs.
8.00	0.14420	0.00270	0.02	0.008	0.851	13.1 Comprs.
1.99	0.13070	0.00150			0.886	11.5 Comprs.
0.49	0.10890	0.00080			0.946	8.6 Comprs.
1.99	0.12220	0.00150			0.910	10.3 Comprs.
8.00	0.15110	0.00270			0.831	14.1 Comprs.
15.96	0.19010	0.00360	0.03	0.007	0.722	19.2 Comprs.
4.00	0.17680	0.00200			0.755	17.6 Comprs.
0.98	0.15480	0.00100			0.816	14.8 Comprs.

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
0.23	0.12990	0.00050			0.885	11.5 Comprs.

C_c = 0.46 P_c = 3.22 tsf C_r = 0.09

Pressure: 0.49 tsf — TEST READINGS — Load No. 2

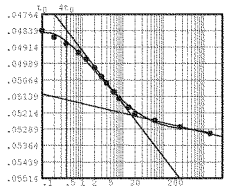
No.	Elapsed Time	Dial Reading
1	0.00	0.04400
2	0.10	0.04510
3	0.30	0.04540
4	1.00	0.04570
5	3.00	0.04610
6	5.00	0.04640
7	14.00	0.04670
8	124.00	0.04700
9	1400.00	0.04720



Void Ratio = 1.123 Compression = 0.3 %
D_0 = 0.04350 D_{50} = 0.04477 D_{100} = 0.04603
C_v at 0.6 min. = 0.44 ft.^{2}/day C_α = 0.000

Pressure: 0.98 tsf — TEST READINGS — Load No. 3

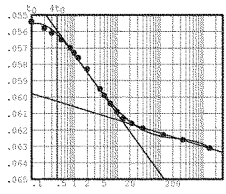
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.04720	11	8.00	0.05250
2	0.10	0.04940	12	14.00	0.05290
3	0.20	0.04970	13	20.00	0.05320
4	0.40	0.05000	14	62.00	0.05350
5	0.80	0.05040	15	262.00	0.05380
6	1.25	0.05070	16	1437.00	0.05410
7	2.00	0.05110			
8	3.00	0.05150			
9	4.00	0.05180			
10	6.00	0.05220			



Void Ratio = 1.104 Compression = 1.3 %
D_0 = 0.04813 D_{50} = 0.05019 D_{100} = 0.05225
C_v at 1.9 min. = 0.14 ft.^{2}/day C_α = 0.001

Pressure: 1.99 tsf — TEST READINGS — Load No. 4

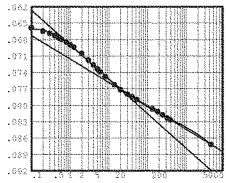
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.05410	11	5.00	0.06140
2	0.10	0.05690	12	7.00	0.06190
3	0.20	0.05730	13	10.00	0.06240
4	0.30	0.05760	14	14.00	0.06280
5	0.50	0.05800	15	22.00	0.06310
6	0.80	0.05850	16	40.00	0.06340
7	1.00	0.05880	17	120.00	0.06380
8	1.25	0.05910	18	343.00	0.06410
9	2.00	0.05980	19	1452.00	0.06460
10	4.00	0.06100			



Void Ratio = 1.075 Compression = 2.6 %
D_0 = 0.05497 D_{50} = 0.05823 D_{100} = 0.06149
C_v at 1.7 min. = 0.15 ft.^{2}/day C_α = 0.001

Pressure: 4.00 tsf — TEST READINGS — Load No. 5

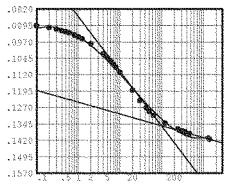
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.06460	15	6.00	0.07590
2	0.10	0.06790	16	8.00	0.07680
3	0.20	0.06850	17	14.00	0.07830
4	0.30	0.06890	18	20.00	0.07920
5	0.40	0.06930	19	30.00	0.08000
6	0.50	0.06970	20	40.00	0.08050
7	0.60	0.07000	21	53.00	0.08100
8	0.80	0.07050	22	134.00	0.08270
9	1.00	0.07100	23	183.00	0.08320
10	1.25	0.07140	24	247.00	0.08380
11	2.00	0.07260	25	326.00	0.08440
12	3.00	0.07380	26	390.00	0.08470
13	4.00	0.07470	27	4333.00	0.08920
14	5.00	0.07540			



Void Ratio = 1.006 Compression = 5.8 %
D_0 = 0.06310 D_{50} = 0.07013 D_{100} = 0.07715
C_v at 1.5 min. = 0.17 ft.^{2}/day C_α = 0.006

Pressure: 8.00 tsf | TEST READINGS | Load No. 6

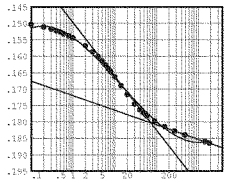
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08920	15	7.00	0.11000
2	0.10	0.09230	16	8.00	0.11130
3	0.20	0.09320	17	10.00	0.11370
4	0.30	0.09390	18	20.00	0.12180
5	0.40	0.09460	19	30.00	0.12650
6	0.50	0.09510	20	42.00	0.12980
7	0.60	0.09560	21	50.00	0.13150
8	0.80	0.09660	22	64.00	0.13330
9	1.00	0.09740	23	120.00	0.13680
10	1.25	0.09830	24	245.00	0.13950
11	2.00	0.10060	25	307.00	0.14030
12	4.00	0.10520	26	362.00	0.14080
13	5.00	0.10700	27	465.00	0.14160
14	6.00	0.10860	28	1411.00	0.14420



Void Ratio = 0.851 Compression = 13.1 %
D_0 = 0.08720 D_{50} = 0.11122 D_{100} = 0.13525
C_v at 9.4 min. = 0.02 ft.^{2}/day C_α = 0.008

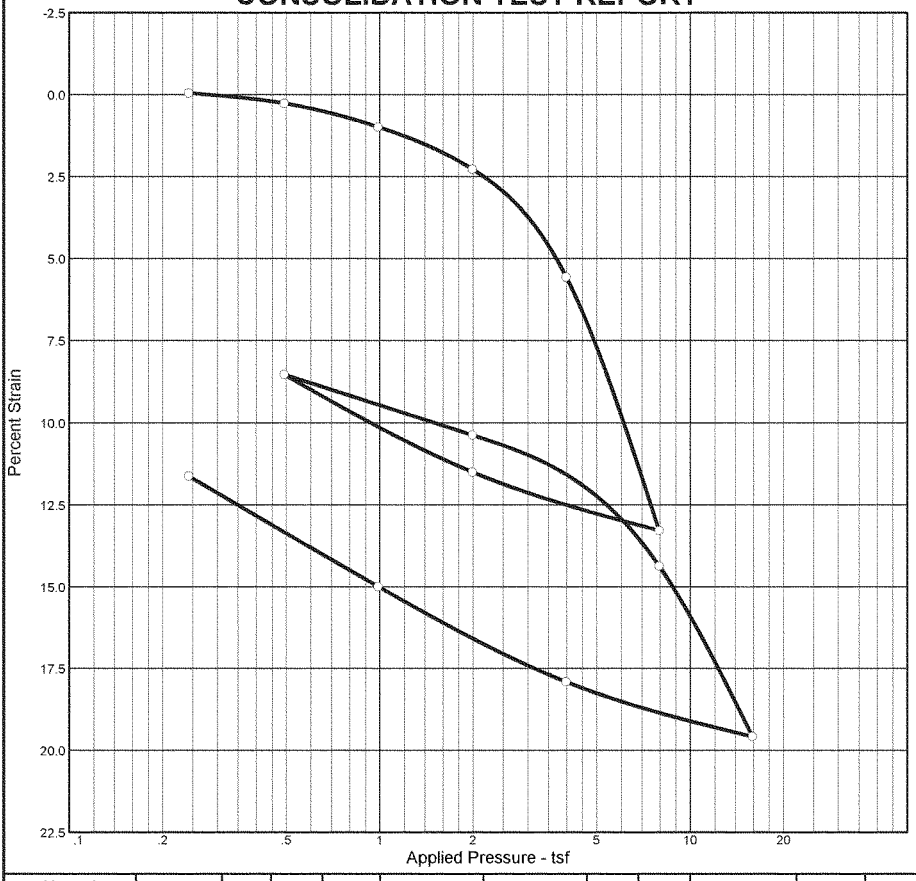
Pressure: 15.96 tsf | TEST READINGS | Load No. 11

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.15110	16	8.00	0.16830
2	0.10	0.15400	17	10.00	0.16990
3	0.20	0.15480	18	14.20	0.17260
4	0.30	0.15540	19	20.00	0.17530
5	0.40	0.15590	20	30.00	0.17820
6	0.50	0.15630	21	40.00	0.17990
7	0.60	0.15680	22	49.00	0.18090
8	0.80	0.15750	23	59.00	0.18180
9	1.00	0.15810	24	90.00	0.18340
10	2.00	0.16050	25	158.00	0.18510
11	3.00	0.16230	26	271.00	0.18640
12	4.00	0.16380	27	479.00	0.18760
13	5.00	0.16510	28	1445.00	0.18960
14	6.00	0.16630	29	1874.00	0.19010
15	7.00	0.16740			



Void Ratio = 0.722 Compression = 19.2 %
D_0 = 0.14840 D_{50} = 0.16433 D_{100} = 0.18026
C_v at 6.9 min. = 0.03 ft.^{2}/day C_α = 0.007

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
98.0 %	41.6 %	78.7	62	43	2.712		3.45	0.48	0.09			1.152

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2435	CH	

Project No. BL-10-10065 **Client:** USACE W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3

Location: Boring11-119MU, #3, 50-52', Fargo Pile Load Test, Argusville Formation

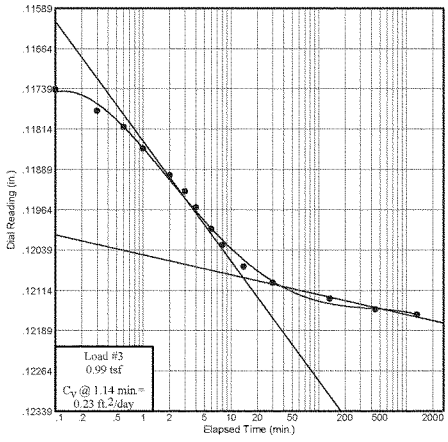
Remarks:

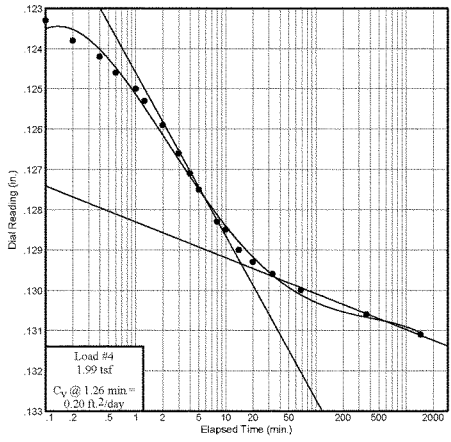
BRAUN INTERTEC

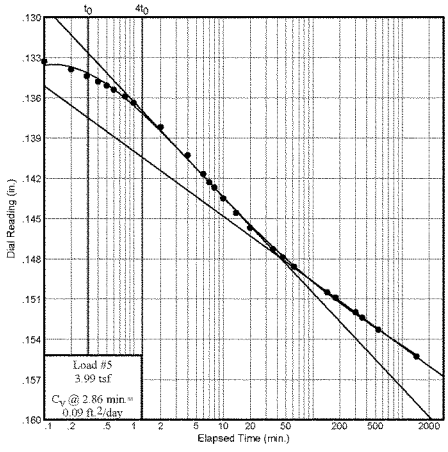
Figure

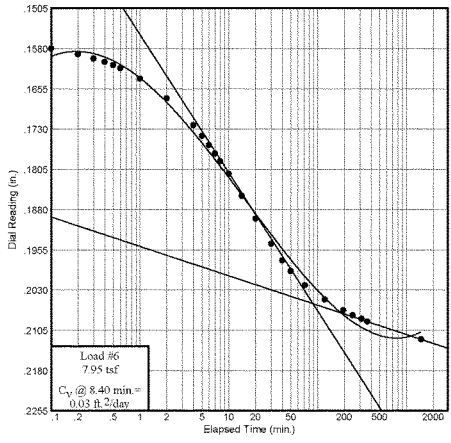
Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: Boring11-119MU, #3, 50-52', Fargo Pile Load Test, Argusville Formation







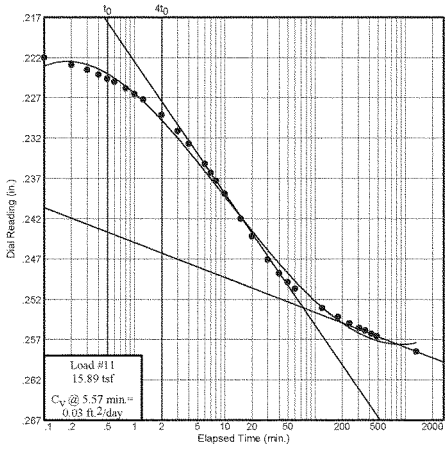


BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Location: Boring11-119MU, #3, 50-52', Fargo Pile Load Test, Argusville Formatiou



BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: USACE W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing Request NO. 3
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: Boring11-119MU, #3
Elev. or Depth: 50-52' **Sample Length(in./cm.):**
Location: Boring11-119MU, #3, 50-52', Fargo Pile Load Test, Argusville Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2435
Liquid Limit: 62 **Plasticity Index:** 43
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST
Wet w+t =	161.98 g.	Consolidometer # = 3	Wet w+t =
Dry w+t =	123.44 g.		Dry w+t =
Tare Wt. =	30.81 g.	Spec. Gravity = 2.712	Tare Wt. =
Height =	.74 in.	Height = .74 in.	
Diameter =	2.50 in.	Diameter = 2.50 in.	
Weight =	105.50 g.	Defl. Table = Machine3-2009	
Moisture =	41.6 %	Ht. Solids = 0.3421 in.	Moisture = %
Wet Den. =	111.4 pcf	Dry Wt. = 74.50 g.*	Dry Wt. = n/a
Dry Den. =	78.7 pcf	Void Ratio = 1.152	Void Ratio = 0.901
		Saturation = 98.0 %	

* Initial dry weight used in calculations

End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.11440				1.152	
0.24	0.11430	0.00030			1.153	0.1 Swell
0.49	0.11680	0.00050			1.146	0.3 Comprs.
0.99	0.12230	0.00070	0.23	0.001	1.131	1.0 Comprs.
1.99	0.13210	0.00100	0.20	0.001	1.103	2.3 Comprs.
3.99	0.15680	0.00150	0.09	0.007	1.032	5.6 Comprs.
7.95	0.21420	0.00200	0.03	0.008	0.866	13.3 Comprs.
1.99	0.20010	0.00100			0.904	11.5 Comprs.
0.49	0.17770	0.00050			0.968	8.5 Comprs.
1.99	0.19180	0.00100			0.928	10.4 Comprs.
7.95	0.22220	0.00200			0.842	14.4 Comprs.
15.89	0.26140	0.00290	0.03	0.007	0.730	19.6 Comprs.
3.99	0.24770	0.00150			0.766	17.9 Comprs.
0.99	0.22550	0.00070			0.829	15.0 Comprs.

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
0.24	0.20030	0.00030			0.901	11.6 Comprs.

C_c = 0.48 P_c = 3.45 tsf C_r = 0.09

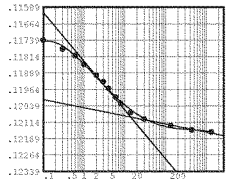
Pressure: 0.49 tsf — TEST READINGS — Load No. 2

No.	Elapsed Time	Dial Reading
1	0.00	0.11430
2	0.10	0.11480
3	0.50	0.11510
4	2.00	0.11560
5	5.00	0.11590
6	10.00	0.11630
7	89.00	0.11660
8	1427.00	0.11680

Void Ratio = 1.146 Compression = 0.3 %

Pressure: 0.99 tsf — TEST READINGS — Load No. 3

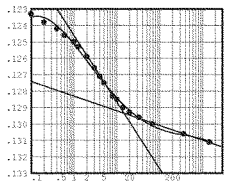
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.11680	11	14.00	0.12140
2	0.10	0.11810	12	30.00	0.12170
3	0.30	0.11850	13	134.00	0.12200
4	0.60	0.11880	14	442.00	0.12220
5	1.00	0.11920	15	1323.00	0.12230
6	2.00	0.11970			
7	3.00	0.12000			
8	4.00	0.12030			
9	6.00	0.12070			
10	8.00	0.12100			



Void Ratio = 1.131 Compression = 1.0 %
D_0 = 0.11630 D_{50} = 0.11860 D_{100} = 0.12090
C_v at 1.1 min. = 0.23 ft.^{2}/day C_α = 0.001

Pressure: 1.99 tsf — TEST READINGS — Load No. 4

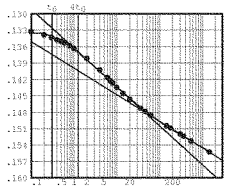
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.12230	11	5.00	0.12850
2	0.10	0.12430	12	8.00	0.12930
3	0.20	0.12480	13	10.00	0.12950
4	0.40	0.12520	14	14.00	0.13000
5	0.60	0.12560	15	20.00	0.13030
6	1.00	0.12600	16	33.00	0.13060
7	1.25	0.12630	17	68.00	0.13100
8	2.00	0.12690	18	364.00	0.13160
9	3.00	0.12760	19	1450.00	0.13210
10	4.00	0.12810			



Void Ratio = 1.103 Compression = 2.3 %
D_0 = 0.12160 D_{50} = 0.12547 D_{100} = 0.12935
C_v at 1.3 min. = 0.20 ft.^{2}/day C_α = 0.001

Pressure: 3.99 tsf — TEST READINGS — Load No. 5

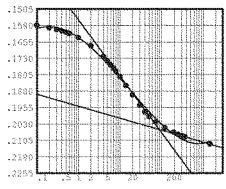
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.13210	14	8.00	0.14420
2	0.10	0.13480	15	10.00	0.14500
3	0.20	0.13540	16	14.00	0.14610
4	0.30	0.13590	17	20.00	0.14720
5	0.40	0.13630	18	36.00	0.14880
6	0.50	0.13660	19	46.00	0.14940
7	0.60	0.13690	20	62.00	0.15010
8	0.80	0.13740	21	145.00	0.15200
9	1.00	0.13790	22	180.00	0.15240
10	2.00	0.13970	23	302.00	0.15350
11	4.00	0.14180	24	360.00	0.15390
12	6.00	0.14320	25	538.50	0.15480
13	7.00	0.14380	26	1442.00	0.15680



Void Ratio = 1.032 Compression = 5.6 %
D_0 = 0.13121 D_{50} = 0.13956 D_{100} = 0.14790
C_v at 2.9 min. = 0.09 ft.^{2}/day C_α = 0.007

Pressure: 7.95 tsf — TEST READINGS — Load No. 6

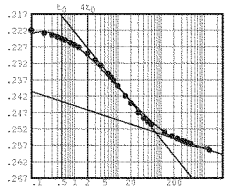
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.15680	15	10.00	0.18340
2	0.10	0.16000	16	14.00	0.18750
3	0.20	0.16110	17	20.00	0.19170
4	0.30	0.16190	18	30.00	0.19640
5	0.40	0.16250	19	40.00	0.19950
6	0.50	0.16310	20	50.00	0.20150
7	0.60	0.16370	21	72.00	0.20410
8	1.00	0.16560	22	120.00	0.20680
9	2.00	0.16930	23	194.00	0.20880
10	4.00	0.17430	24	249.00	0.20970
11	5.00	0.17630	25	312.00	0.21040
12	6.00	0.17800	26	364.00	0.21090
13	7.00	0.17960	27	1459.00	0.21420
14	8.00	0.18100			



Void Ratio = 0.866 Compression = 13.3 %
D_0 = 0.15530 D_{50} = 0.18042 D_{100} = 0.20554
C_v at 8.4 min. = 0.03 ft.^{2}/day C_α = 0.008

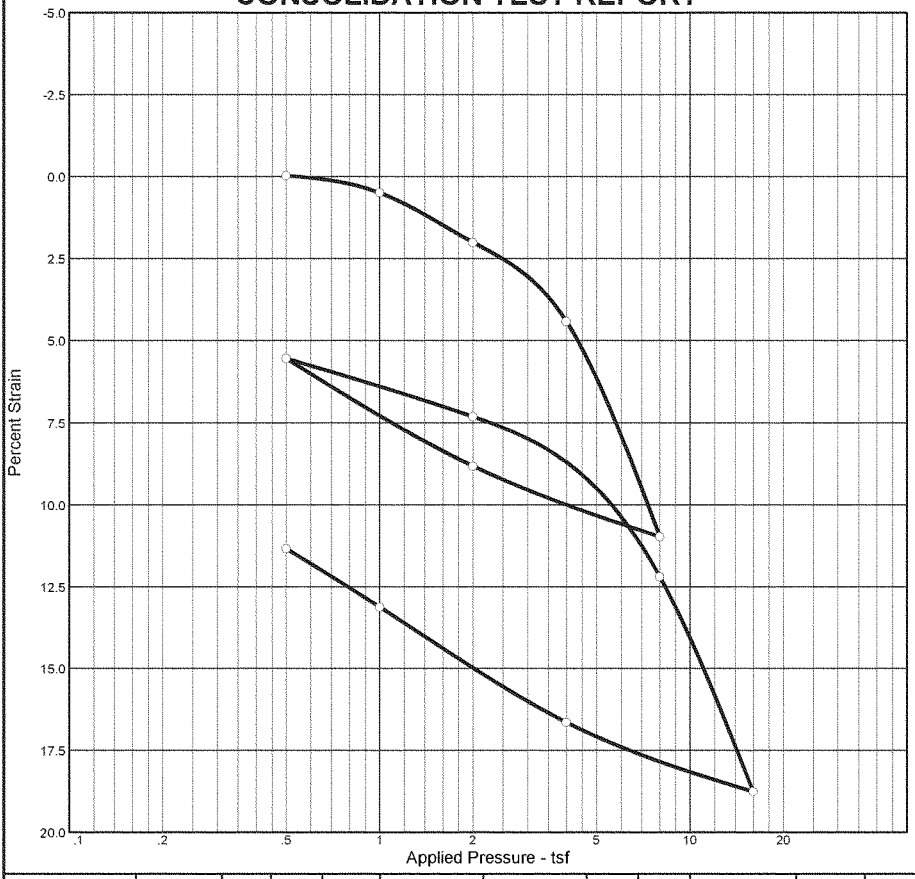
Pressure: 15.89 tsf — TEST READINGS — Load No. 11

No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.22220	17	10.00	0.24180
2	0.10	0.22490	18	15.00	0.24490
3	0.20	0.22580	19	20.00	0.24710
4	0.30	0.22640	20	30.00	0.25000
5	0.40	0.22700	21	40.00	0.25170
6	0.50	0.22750	22	50.00	0.25280
7	0.60	0.22790	23	60.00	0.25360
8	0.80	0.22870	24	120.00	0.25600
9	1.00	0.22940	25	180.00	0.25710
10	1.25	0.23010	26	240.00	0.25790
11	2.00	0.23200	27	308.00	0.25850
12	3.00	0.23400	28	360.00	0.25880
13	4.00	0.23560	29	420.00	0.25920
14	6.00	0.23810	30	483.00	0.25950
15	7.00	0.23920	31	1325.00	0.26140
16	8.00	0.24020			



Void Ratio = 0.730 Compression = 19.6 %
D_0 = 0.21821 D_{50} = 0.23564 D_{100} = 0.25307
C_v at 5.6 min. = 0.03 ft.^{2}/day C_α = 0.007

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
Sat.	Moist.											
98.3 %	42.9 %	77.2	66	46	2.689		4.45	0.56	0.11			1.174

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY, brown (CH), Top of sample, ASTM D 2435	CH	

Project No. BL-10-10065 **Client:** W912ES-11-P-0024

Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

Location: Boring11-110MU, #6, 65-67', Sheyenne River, Till Formation

Remarks:

BRAUN INTERTEC

Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Boring11-110MU, #6, 65-67', Sheyenne River, Till Formation

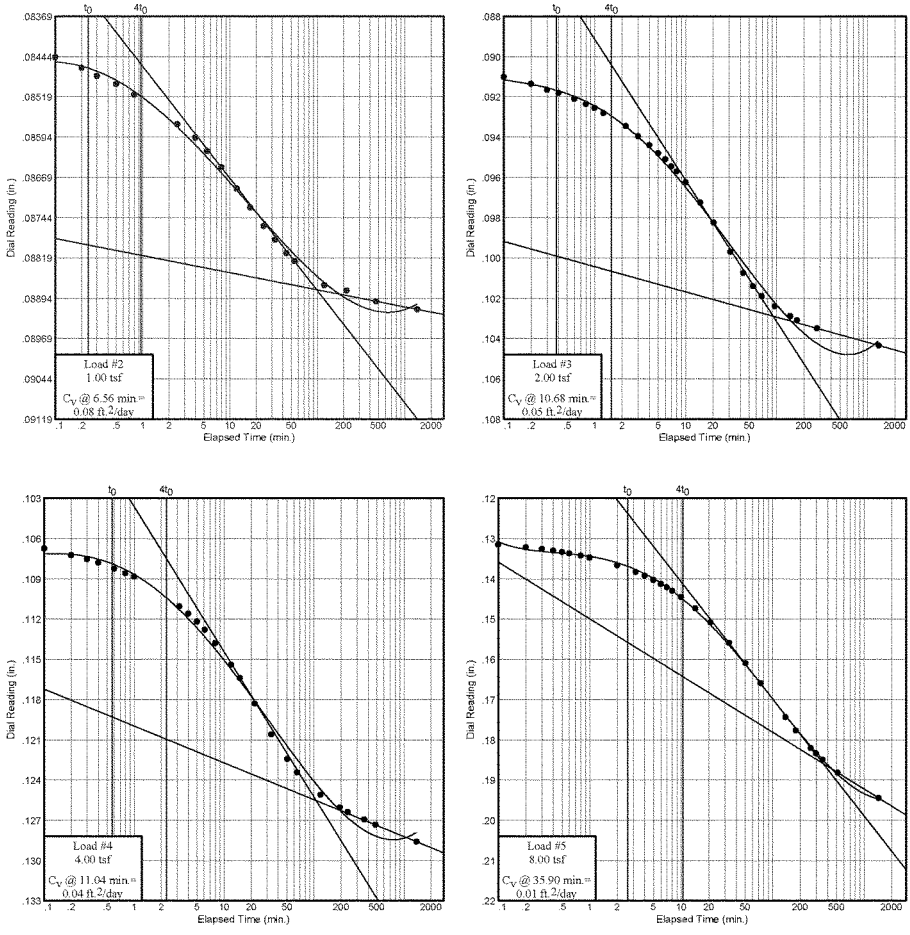


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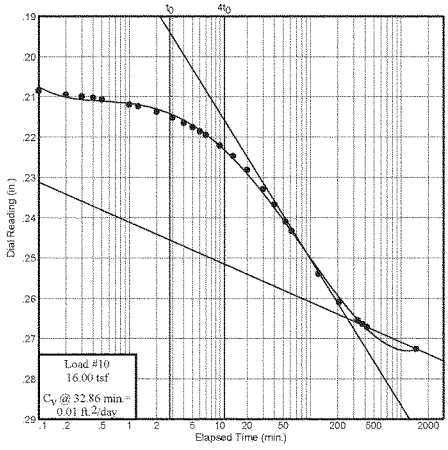
Figure

Dial Reading vs. Time

Project No.: BL-10-10065
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Location: Boring11-110MU, #6, 65-67', Sheyenne River, Till Formation



BRAUN INTERTEC

Figure

SWELL/CONSOLIDATION TEST DATA

Client: W912ES-11-P-0024
Project: Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
Project Number: BL-10-10065

Sample Data

Source:
Sample No.: 11-110, #6
Elev. or Depth: 65-67' **Sample Length(in./cm.):**
Location: Boring11-110MU, #6, 65-67', Sheyenne River, Till Formation
Description: FAT CLAY, brown (CH), Top of sample, ASTM D 2435
Liquid Limit: 66 **Plasticity Index:** 46
USCS: CH **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE	BEFORE TEST	AFTER TEST
Wet w+t = 167.36 g.	Consolidometer # = 2	Wet w+t =
Dry w+t = 126.14 g.		Dry w+t =
Tare Wt. = 30.12 g.	Spec. Gravity = 2.689	Tare Wt. =
Height = 1.00 in.	Height = 1.00 in.	
Diameter = 2.50 in.	Diameter = 2.50 in.	
Weight = 142.45 g.	Defl. Table = Machine2-Air-2011	
Moisture = 42.9 %	Ht. Solids = 0.4619 in.	Moisture = %
Wet Den. = 110.4 pcf	Dry Wt. = 99.67 g.*	Dry Wt. = n/a
Dry Den. = 77.2 pcf	Void Ratio = 1.174	Void Ratio = 0.927
	Saturation = 98.3 %	

* Initial dry weight used in calculations

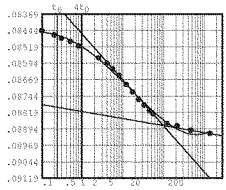
End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.08425				1.174	
0.50	0.08480	0.00095			1.175	0.0 Swell
1.00	0.09070	0.00155	0.08	0.000	1.163	0.5 Comprs.
2.00	0.10660	0.00225	0.05	0.001	1.130	2.0 Comprs.
4.00	0.13155	0.00295	0.04	0.003	1.078	4.4 Comprs.
8.00	0.19830	0.00380	0.01	0.015	0.935	11.0 Comprs.
2.00	0.17510	0.00225			0.982	8.8 Comprs.
0.50	0.14085	0.00095			1.053	5.5 Comprs.
2.00	0.16000	0.00225			1.015	7.3 Comprs.
8.00	0.21055	0.00380			0.909	12.2 Comprs.
16.00	0.27755	0.00495	0.01	0.011	0.766	18.8 Comprs.
4.00	0.25430	0.00295			0.812	16.6 Comprs.
1.00	0.21755	0.00155			0.888	13.1 Comprs.
0.50	0.19905	0.00095			0.927	11.3 Comprs.

C_c = 0.56 P_c = 4.45 tsf C_r = 0.11

Pressure: 1.00 tsf TEST READINGS **Load No. 2**

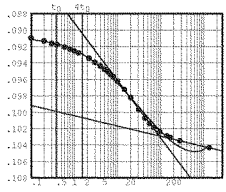
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.08480	11	12.00	0.08845
2	0.10	0.08600	12	17.10	0.08880
3	0.20	0.08620	13	24.30	0.08915
4	0.30	0.08635	14	33.00	0.08940
5	0.50	0.08650	15	44.30	0.08965
6	0.80	0.08670	16	55.00	0.08980
7	2.50	0.08725	17	120.00	0.09025
8	4.00	0.08750	18	215.00	0.09035
9	5.50	0.08775	19	470.00	0.09055
10	8.00	0.08805	20	1390.00	0.09070



Void Ratio = 1.163 Compression = 0.5 %
D_0 = 0.08413 D_{50} = 0.08646 D_{100} = 0.08878
C_v at 6.6 min. = 0.08 ft.^{2}/day C_α = 0.000

Pressure: 2.00 tsf TEST READINGS **Load No. 3**

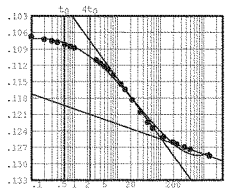
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.09070	15	7.00	0.09770
2	0.10	0.09325	16	8.00	0.09795
3	0.20	0.09360	17	10.00	0.09850
4	0.30	0.09390	18	14.50	0.09950
5	0.40	0.09405	19	20.30	0.10050
6	0.60	0.09435	20	31.00	0.10195
7	0.80	0.09460	21	43.00	0.10300
8	1.00	0.09480	22	55.00	0.10365
9	1.25	0.09505	23	69.00	0.10415
10	2.20	0.09570	24	95.50	0.10465
11	3.00	0.09620	25	141.50	0.10515
12	4.00	0.09665	26	168.00	0.10535
13	5.00	0.09705	27	279.00	0.10575
14	6.00	0.09735	28	1331.00	0.10660



Void Ratio = 1.130 Compression = 2.0 %
D_0 = 0.09040 D_{50} = 0.09665 D_{100} = 0.10290
C_v at 10.7 min. = 0.05 ft.^{2}/day C_α = 0.001

Pressure: 4.00 tsf — TEST READINGS — Load No. 4

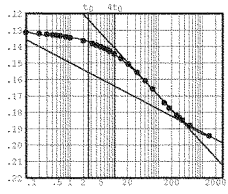
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.10660	14	12.00	0.11835
2	0.10	0.10970	15	15.00	0.11935
3	0.20	0.11020	16	22.00	0.12125
4	0.30	0.11050	17	33.50	0.12355
5	0.40	0.11075	18	50.50	0.12540
6	0.60	0.11120	19	65.00	0.12640
7	0.80	0.11155	20	118.00	0.12805
8	1.00	0.11180	21	194.00	0.12900
9	3.20	0.11400	22	237.00	0.12935
10	4.00	0.11455	23	363.00	0.12990
11	5.00	0.11515	24	484.00	0.13030
12	6.10	0.11575	25	1380.00	0.13155
13	8.00	0.11675			



Void Ratio = 1.078 Compression = 4.4 %
D_0 = 0.10535 D_{50} = 0.11544 D_{100} = 0.12554
C_v at 11.0 min. = 0.04 ft.^{2}/day C_α = 0.003

Pressure: 8.00 tsf — TEST READINGS — Load No. 5

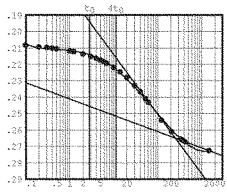
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.13155	16	8.00	0.14680
2	0.10	0.13530	17	10.00	0.14835
3	0.20	0.13600	18	14.30	0.15115
4	0.30	0.13645	19	21.00	0.15465
5	0.40	0.13685	20	33.50	0.15970
6	0.50	0.13720	21	50.50	0.16475
7	0.60	0.13750	22	74.00	0.16975
8	0.80	0.13805	23	138.20	0.17820
9	1.00	0.13855	24	179.30	0.18150
10	2.00	0.14045	25	261.50	0.18585
11	3.20	0.14210	26	298.00	0.18720
12	4.00	0.14305	27	352.30	0.18880
13	5.00	0.14410	28	515.00	0.19200
14	6.00	0.14510	29	1440.00	0.19830
15	7.00	0.14595			



Void Ratio = 0.935 Compression = 11.0 %
D_0 = 0.12871 D_{50} = 0.15735 D_{100} = 0.18599
C_v at 35.9 min. = 0.01 ft.^{2}/day C_α = 0.015

Pressure: 16.00 tsf | TEST READINGS | Load No. 10

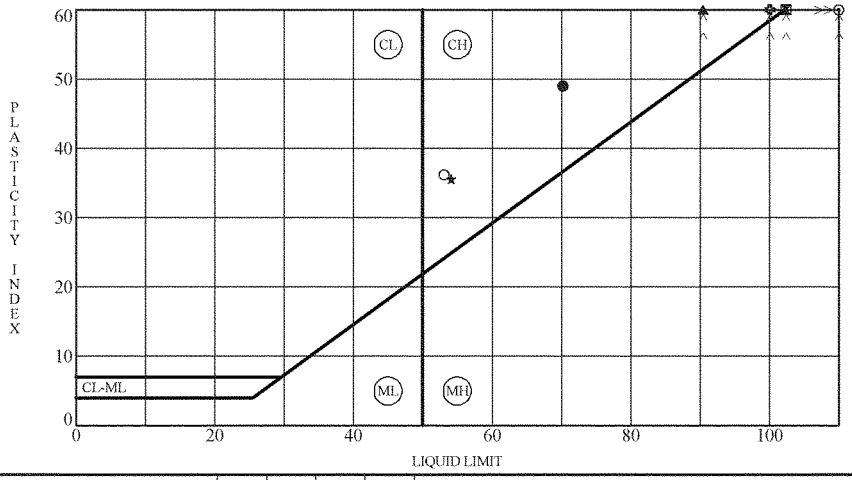
No.	Elapsed Time	Dial Reading	No.	Elapsed Time	Dial Reading
1	0.00	0.21055	15	10.00	0.22705
2	0.10	0.21338	16	14.00	0.22965
3	0.20	0.21440	17	20.00	0.23310
4	0.30	0.21480	18	30.00	0.23790
5	0.40	0.21515	19	40.00	0.24170
6	0.50	0.21560	20	53.00	0.24595
7	1.00	0.21685	21	62.00	0.24825
8	1.25	0.21730	22	122.00	0.25895
9	2.00	0.21865	23	207.00	0.26595
10	3.00	0.22015	24	332.00	0.27045
11	4.00	0.22140	25	374.00	0.27135
12	5.00	0.22250	26	420.00	0.27215
13	6.00	0.22350	27	1466.00	0.27755
14	7.00	0.22440			



Void Ratio = 0.766 Compression = 18.8 %

D_0 = 0.20508 D_{50} = 0.23506 D_{100} = 0.26504

C_v at 32.9 min. = 0.01 ft.^{2}/day C_α = 0.011



Moorhead

	Specimen Identification		LL	PL	PI	Fines	Classification
●	09-11MU	10.0'-12.0'	70	21	49		
⊠	09-11MU	30.0'-32.0'	102	24	78		
▲	09-11MU	40.0'-42.0'	90	24	66		
★	09-14MU	8.0'-10.0'	54	19	35		
⊙	09-14MU	15.0'-17.0'	124	25	99	99	FAT CLAY(CH)
✿	09-14MU	38.0'-40.0'	100	22	78		
○	09-14MU	58.0'-60.0'	53	17	36		

Braun Project BL-09-03127
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, ND

ATTERBERG LIMITS RESULTS

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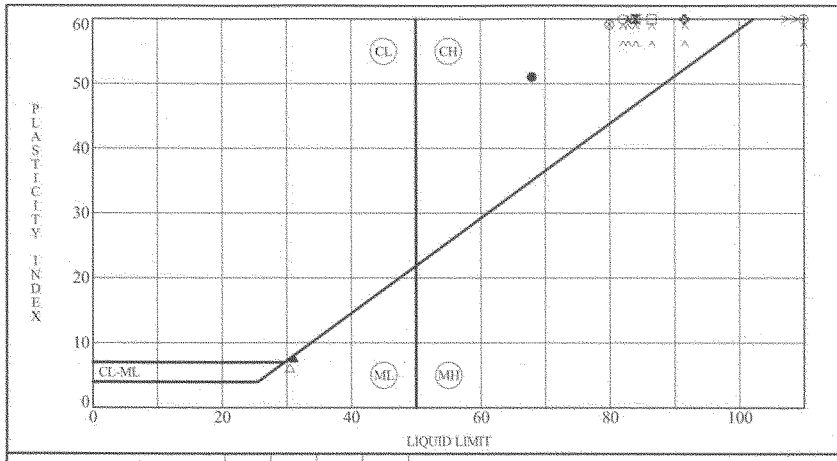
ATTERBERG LIMITS BL-09-03127-2.GPJ BRAUN.GDT 10/13/09 13:41



	Specimen Identification		LL	PL	PI	Fines	Classification
Fargo	09-23MU	2.0'-4.0'	68	17	51		
Fargo	09-23MU	10.0'-12.0'	84	20	64		
Fargo	09-23MU	20.0'-22.0'	31	23	8	100	SILT(ML)
Fargo	09-23MU	28.0'-30.0'	83	20	63	100	FAT CLAY(CH)
Fargo	09-23MU	38.0'-40.0'	111	25	86		
Fargo	09-23MU	80.0'-82.0'	92	22	70		
Moorhead	09-25MU	8.0'-10.0'	82	20	62		
Moorhead	09-25MU	21.0'-23.0'	30	24	6	100	SILT(ML)
Moorhead	09-25MU	25.0'-27.0'	80	21	59	97	FAT CLAY(CH)
Moorhead	09-25MU	38.0'-40.0'	116	25	91		
Moorhead	09-25MU	68.0'-70.0'	87	22	65		

ATTERBERG LIMITS BL-09-03127.GPJ BRAUN.GDT 9/16/09 16:08

Braun Project BL-09-03127
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, ND

ATTERBERG LIMITS RESULTS

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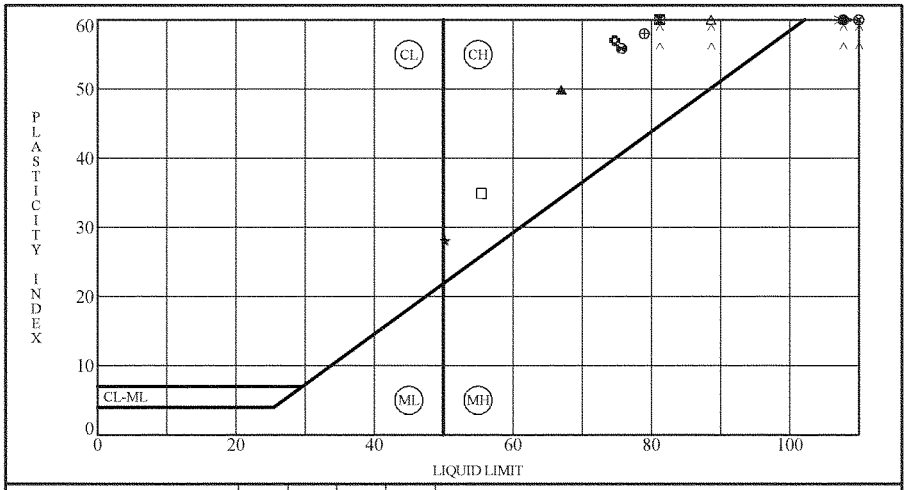


	Specimen Identification		LL	PL	PI	Fines	Classification
●	09-25MU	50.0'-52.0'	108	22	86	100	FAT CLAY(CH)
⊠	09-25MU	66.0'-68.0'	81	20	61	95	FAT CLAY(CH)
▲	09-26MU-F	8.0'-10.0'	67	17	50		
★	09-26MU-F	16.0'-18.0'	50	22	28		
⊙	09-26MU-F	28.0'-30.0'	110	24	86	100	FAT CLAY(CH)
✪	09-27MU	6.0'-8.0'	75	18	57		
○	09-27MU	32.0'-34.0'	117	25	92		
△	09-27MU	64.0'-66.0'	89	20	69	96	FAT CLAY(CH)
⊗	09-34MU	16.0'-18.0'	114	24	90	100	FAT CLAY(CH)
⊕	09-34MU	56.0'-58.0'	79	21	58		
□	09-53MU	18.0'-20.0'	55	21	34		
⊖	09-53MU	68.0'-70.0'	76	20	56		

Fargo

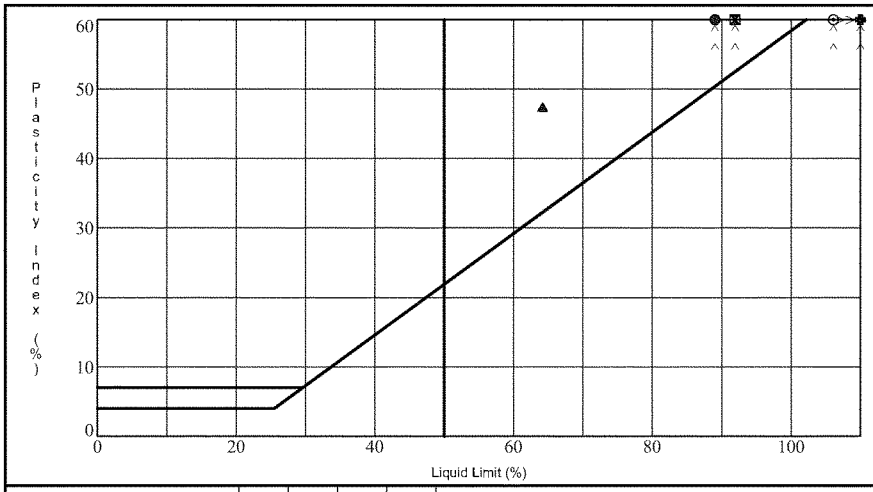
Moorhead

ATTERBERG LIMITS BL-09-03127-3.GPJ BRAUN.GDT 11/16/09 16:43

Braun Project BL-09-03127
W912ES-09-P-0115
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, ND

ATTERBERG LIMITS RESULTS

BRAUN INTERTEC



	Specimen Identification		LL	PL	PI	Fines	Classification
●	09-59MU	10.0'-12.0'	89	21	68		
⊠	09-59MU	20.0'-22.0'	92	19	73	100	FAT CLAY(CH)
▲	09-59MU	35.0'-37.0'	64	17	47	100	FAT CLAY(CH)
★	09-60MU	15.0'-17.0'	113	26	87		
⊙	09-60MU	25.0'-27.0'	106	24	82	100	FAT CLAY(CH)
✪	09-60MU	35.0'-37.0'	111	26	85	100	FAT CLAY(CH)

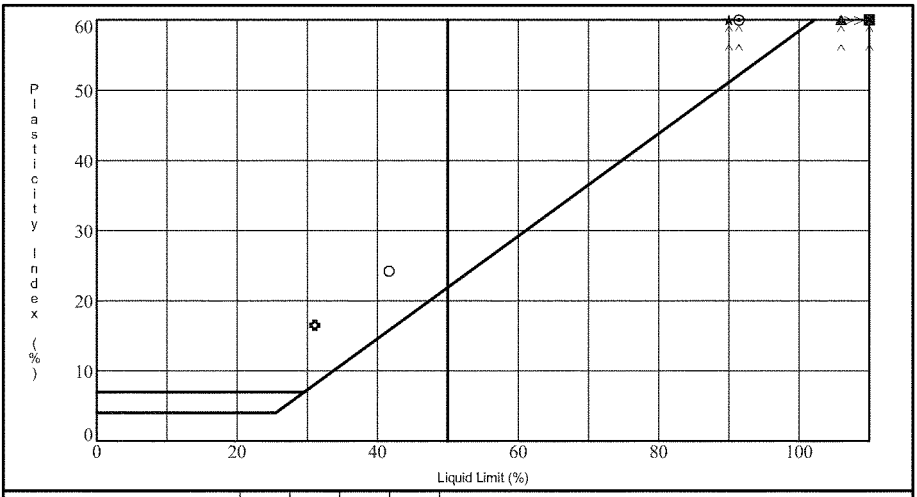
Fargo

Braun Project BL-09-03127A
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, MN

ATTERBERG LIMITS RESULTS

BRAUN INTERTEC

ATTERBERG LIMITS BL-09-03127A.GPJ BRAUN.GDT 2/25/10 08:54



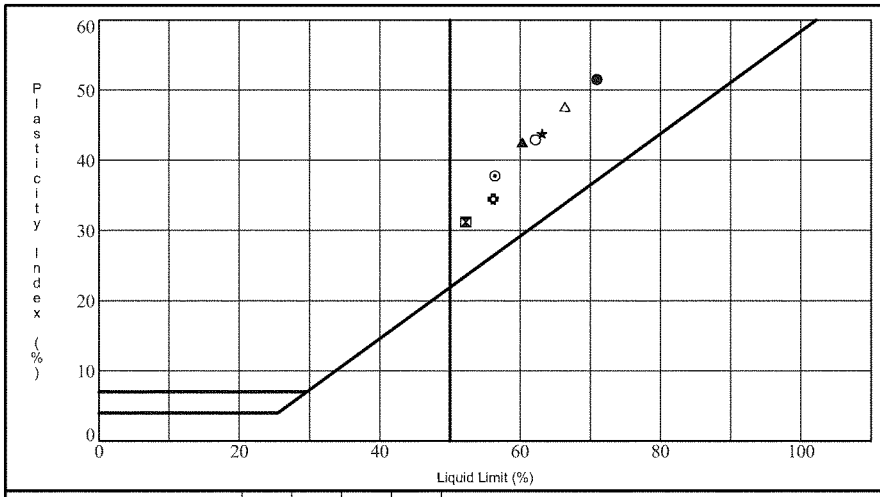
	Specimen Identification		LL	PL	PI	Fines	Classification
●	10-105MU	15.0'-17.0'	113	32	81	100	FAT CLAY, brown (CH)
⊠	10-105MU	25.0'-27.0'	119	32	87	100	FAT CLAY, brown (CH)
▲	10-105MU	35.0'-37.0'	106	29	77	100	FAT CLAY, brown (CH)
★	10-105MU	45.0'-47.0'	90	27	63	94	FAT CLAY, brown (CH)
⊙	10-105MU	55.0'-57.0'	91	25	66	92	FAT CLAY, brown (CH)
✿	10-105MU	67.0'-69.0'	31	15	16	59	SANDY LEAN CLAY, brown (CL)
○	10-105MU	77.0'-79.0'	42	17	25	58	SANDY LEAN CLAY, brown (CL)

Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

ATTERBERG LIMITS RESULTS

BRAUN INTERTEC

ATTERBERG LIMITS BL-10-10065.GPJ BRAUN.GDT 3/4/11 12:55



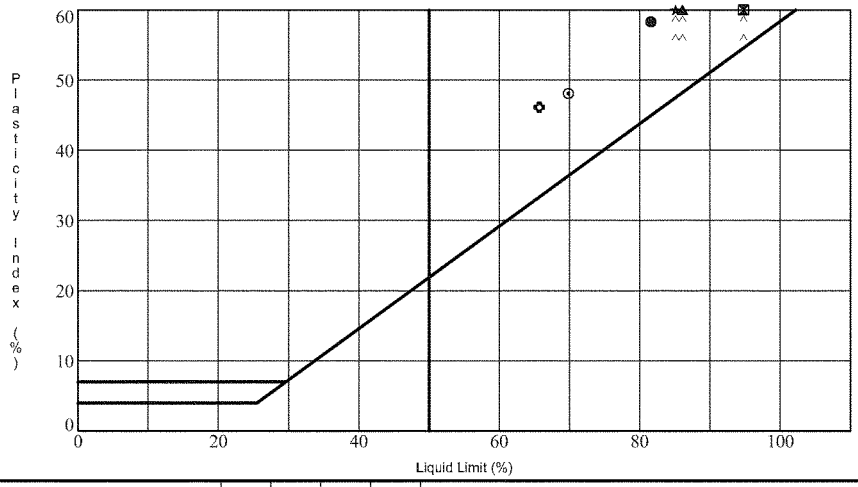
	Specimen Identification		LL	PL	PI	Fines	Classification
●	11-107MU	20.0'-22.0'	71	19	52	100	FAT CLAY, brown (CH)
⊠	11-107MU	30.0'-32.0'	52	21	31	99	FAT CLAY, brown (CH)
▲	11-107MU	40.0'-42.0'	60	18	42	93	FAT CLAY, brown (CH)
★	11-107MU	50.0'-52.0'	63	19	44	98	FAT CLAY, brown (CH)
⊙	11-119MU	30.0'-32.0'	56	19	37	97	FAT CLAY, brown (CH)
✪	11-119MU	40.0'-42.0'	56	22	34	96	FAT CLAY, brown (CH)
○	11-119MU	50.0'-52.0'	62	19	43	96	FAT CLAY, brown (CH)
△	11-119MU	61.0'-64.0'	66	19	47	96	FAT CLAY, brown (CH)

ATTERBERG LIMITS N:\GINT\PROJECTS\X-GEOLAB\1-GINT FILES\MINNEAPOLIS\2010\BL-10-10065.GPJ BRAUN_V8_CURRENT.GDT 6/2/11 13:12

Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

ATTERBERG LIMITS RESULTS

BRAUN INTERTEC



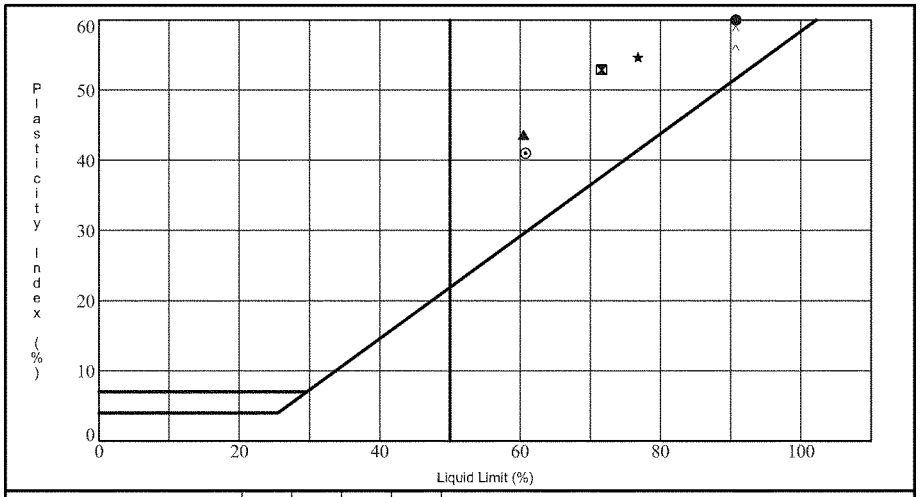
	Specimen Identification		LL	PL	PI	Fines	Classification
●	11-110MU	20.' -24.' -	12	25	09	8' '	FAT CLAY, brown (CH)
⊠	11-110MU	50.' -54.' -	90	21	74	8' '	FAT CLAY, brown (CH)
▲	11-110MU	61.' -0' .' -	17	22	76	94	FAT CLAY, brown (CH)
★	11-110MU	00.' -04.' -	10	28	76	94	FAT CLAY, brown (CH)
⊙	11-110MU	7' .' -72.' -	4'	22	61	97	FAT CLAY, brown (CH)
✪	11-110MU	70.' -74.' -	77	2'	67	92	FAT CLAY, brown (CH)

Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

ATTERBERG LIMITS RESULTS

BRAUN INTERTEC

ATTERBERG LIMITS N:\GINT\PROJECTS\X-GEOLAB\1-GINT FILES\MINNEAPOLIS\2010\BL-10-10065.GPJ BRAUN_V8_CURRENT.GDT 4/26/11 08:02



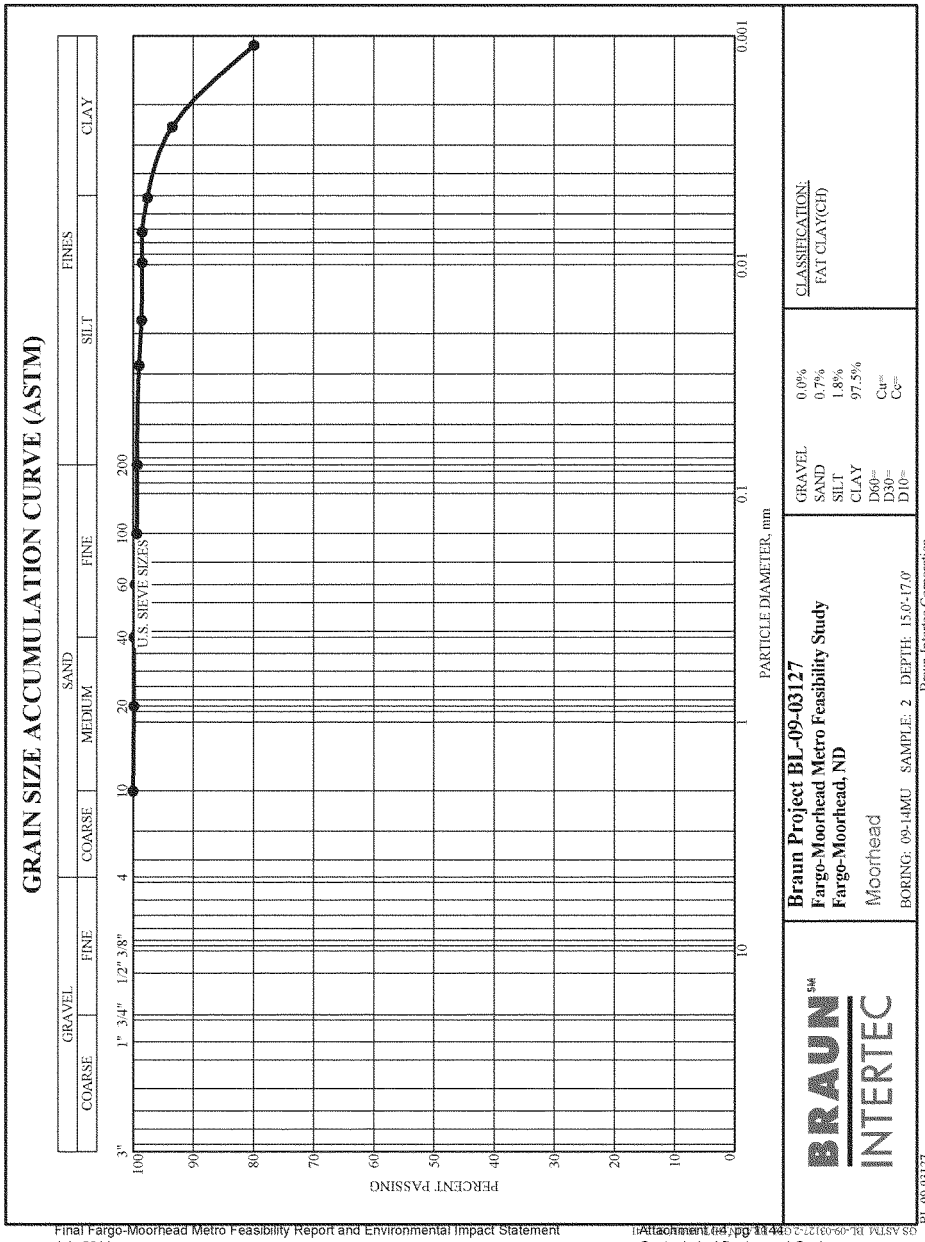
	Specimen Identification		LL	PL	PI	Fines	Classification
●	11-118MU	20.0'-21.0'	91	24	67	100	FAT CLAY, brown (CH)
⊠	11-118MU	33.0'-35.0'	72	19	53	98	FAT CLAY, brown (CH)
▲	11-118MU	45.0'-47.0'	60	17	43	96	FAT CLAY, brown (CH)
★	11-118MU	55.0'-57.0'	77	22	55	95	FAT CLAY, brown (CH)
⊙	11-118MU	65.0'-67.0'	61	20	41	98	FAT CLAY, brown (CH)

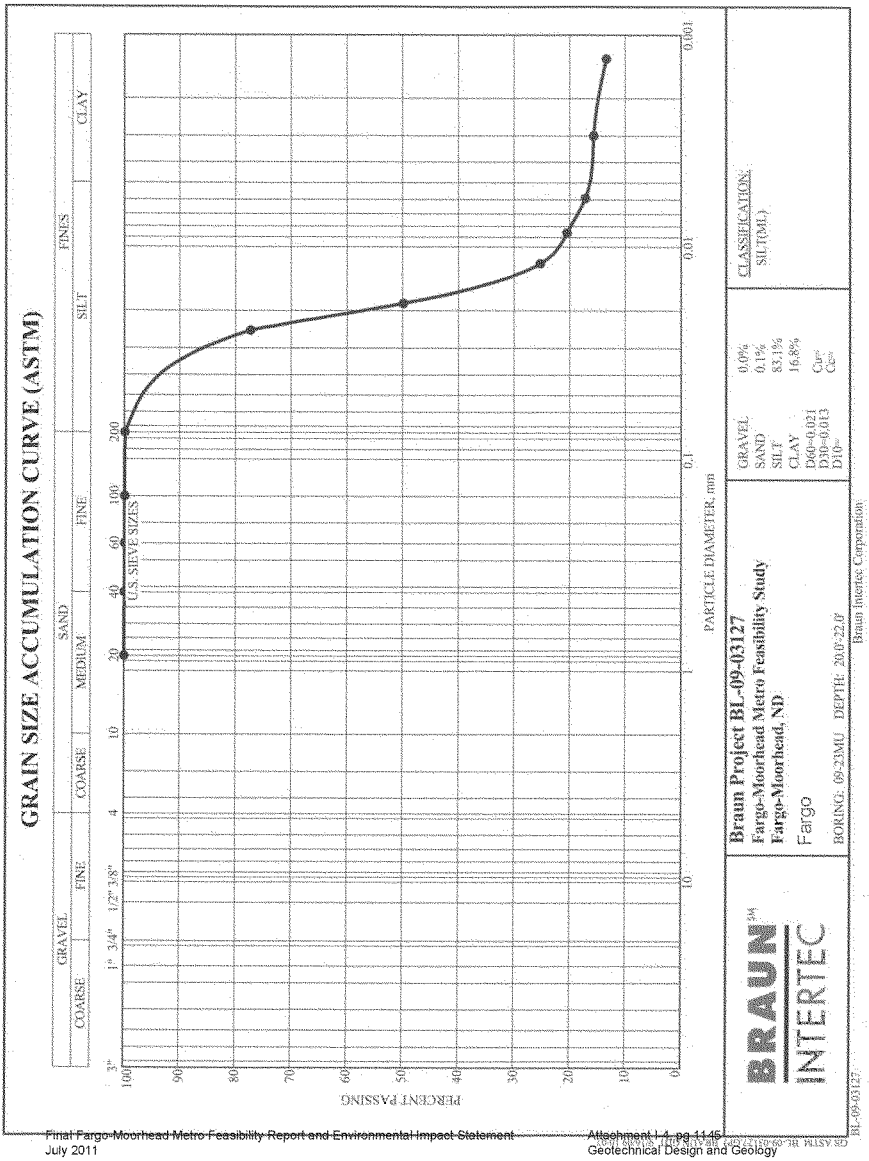
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

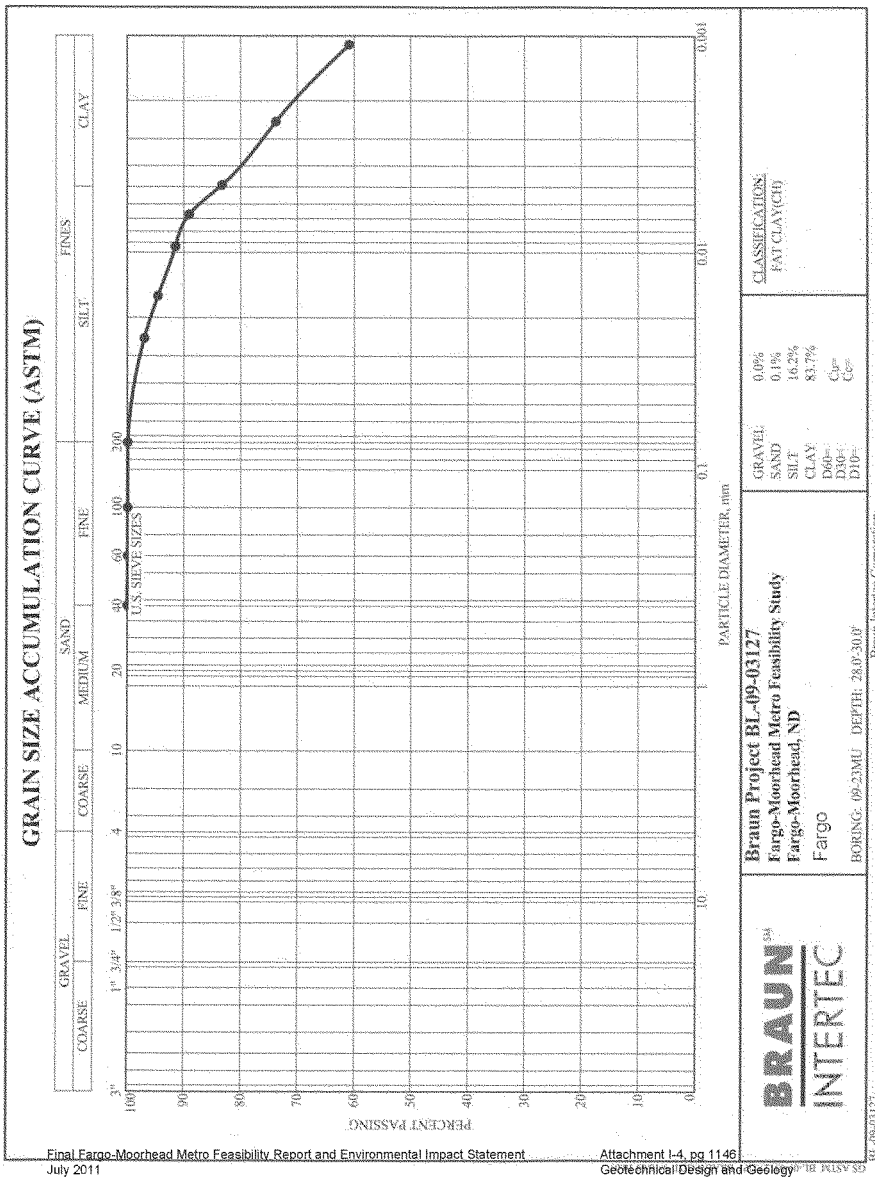
ATTERBERG LIMITS RESULTS

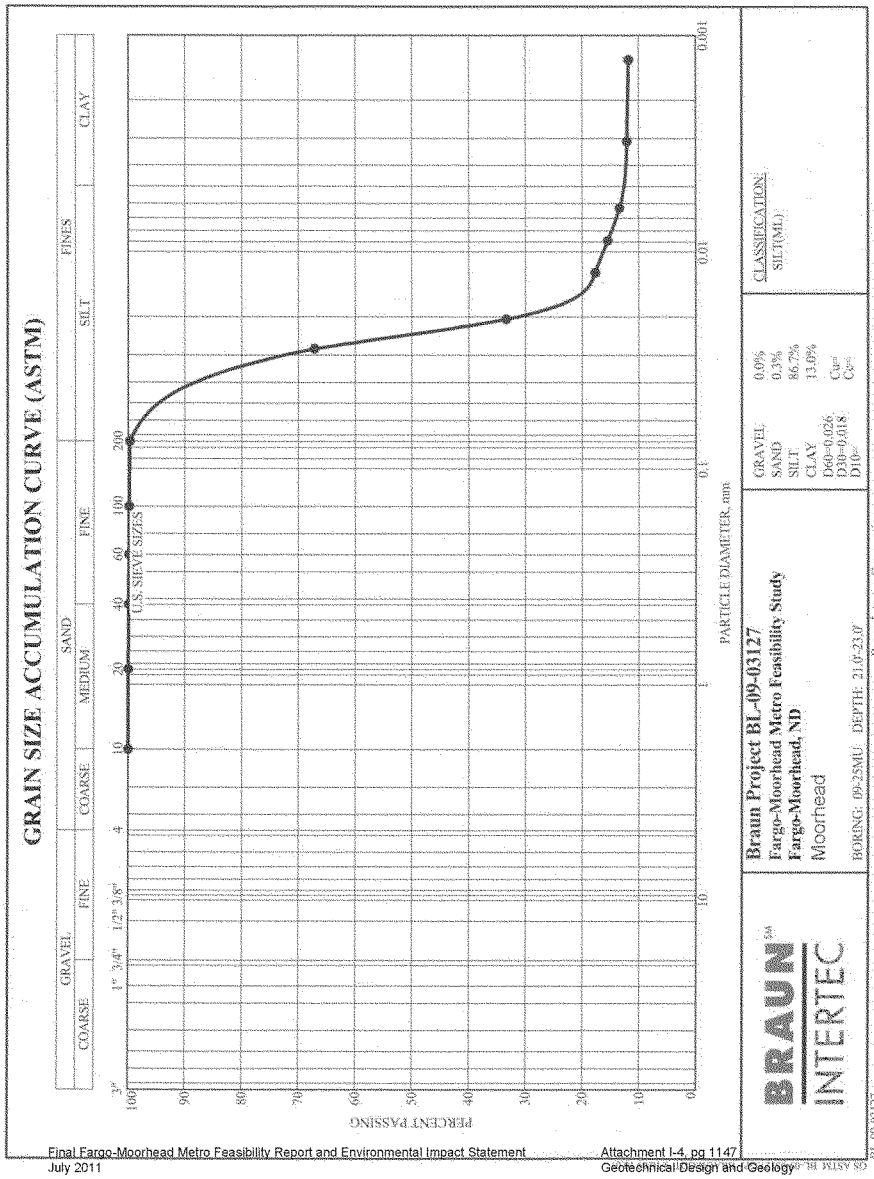
BRAUN INTERTEC

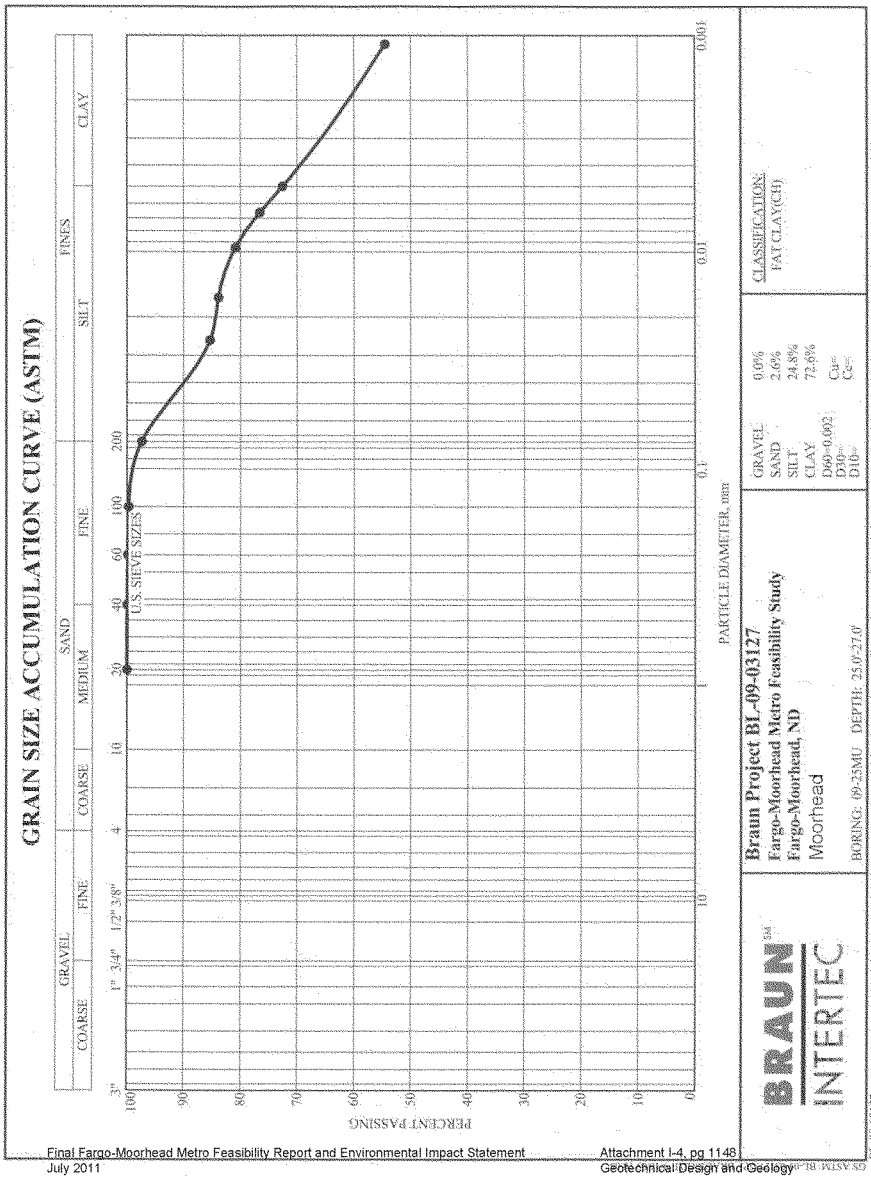
ATTERBERG LIMITS N:\GINT\PROJECTS\X-GEOLAB\1-GINT FILES\MINNEAPOLIS\2010\BL-10-10065-DUMMY.GPJ BRAUN_V8_CURRENT.GDT 5/18/11 16:19


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
BRAUN INTERTEC
Braun Project BL-09-03127
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, ND
Moorhead
BORING: 09-14MU SAMPLE: 2 DEPTH: 15.0-17.0
GRAVEL 0.0%
SAND 0.7%
SILT 1.8%
CLAY 97.5%
D60=
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY(CH)
Braun Intertec Corporation
BL-09-03127

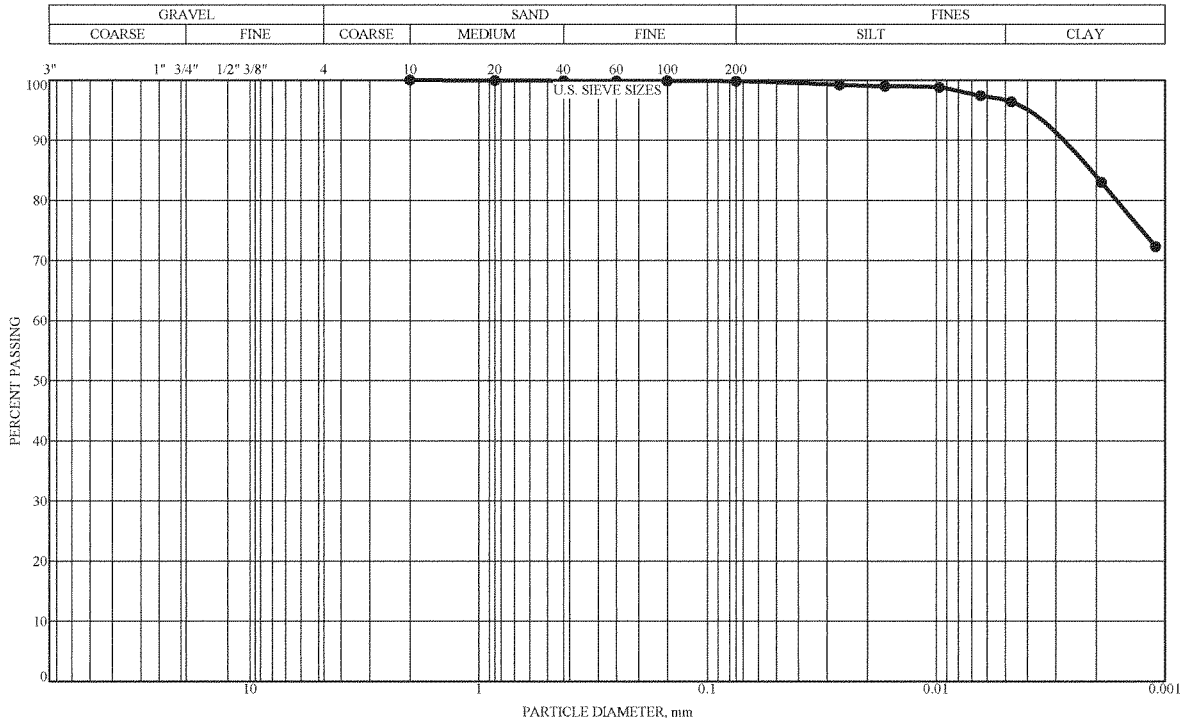

GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
SAND
FINES
COARSE
FINE
COARSE
MEDIUM
FINE
SILT
CLAY
3"
1" 3/4" 1/2" 3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
Braun Project BL-09-03127
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, ND
Fargo
BORING: 09-23MU DEPTH: 20.0'-22.0'
GRAVEL 0.0%
SAND 0.1%
SILT 83.1%
CLAY 16.8%
D60=0.021
D30=0.013
D10=
Cu=
Cc=
CLASSIFICATION:
SILT(ML)
BRAUN INTERTEC
Braun Intertec Corporation
BL-09-03127


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
Braun Project BL-09-03127
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, ND
Fargo
BORING: 09-23MU DEPTH: 28.0'-30.0'
GRAVEL 0.0%
SAND 0.1%
SILT 16.2%
CLAY 83.7%
D60=
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY(CH)
BRAUN
INTERTEC
Braun Intertec Corporation
BL-09-03127


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
SAND
FINES
COARSE
FINE
COARSE
MEDIUM
FINE
SILT
CLAY
3"
1" 3/4" 1/2" 3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
BRAUN INTERTEC
Braun Project BL-09-03127
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, ND
Moorhead
BORING: 09-25ML DEPTH: 21.0'-23.0'
GRAVEL 0.0%
SAND 0.3%
SILT 86.7%
CLAY 13.0%
D60=0.026
D30=0.018
D10=
Cu=
Cc=
CLASSIFICATION:
SILT(ML)
Braun Intertec Corporation
BL-09-03127


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
SAND
FINES
COARSE
FINE
COARSE
MEDIUM
FINE
SILT
CLAY
3"
1" 3/4" 1/2" 3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
BRAUN INTERTEC
Braun Project BL-09-03127
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, ND
Moorhead
BORING: 09-25MU DEPTH: 25.0'-27.0'
GRAVEL 0.0%
SAND 2.6%
SILT 24.8%
CLAY 72.6%
D60=0.002
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY(CH)
Braun Intertec Corporation
BL-09-03127

GRAIN SIZE ACCUMULATION CURVE (ASTM)



BRAUN INTERTEC

Braun Project BL-09-03127
W912ES-09-P-0115
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, ND
Fargo
BORING: 09-25MU SAMPLE: 4 DEPTH: 50.0'-52.0'

GRAVEL	0.0%
SAND	0.2%
SILT	3.2%
CLAY	96.6%
D60=	Cu=
D30=	Cc=
D10=	

CLASSIFICATION:
FAT CLAY(CH)

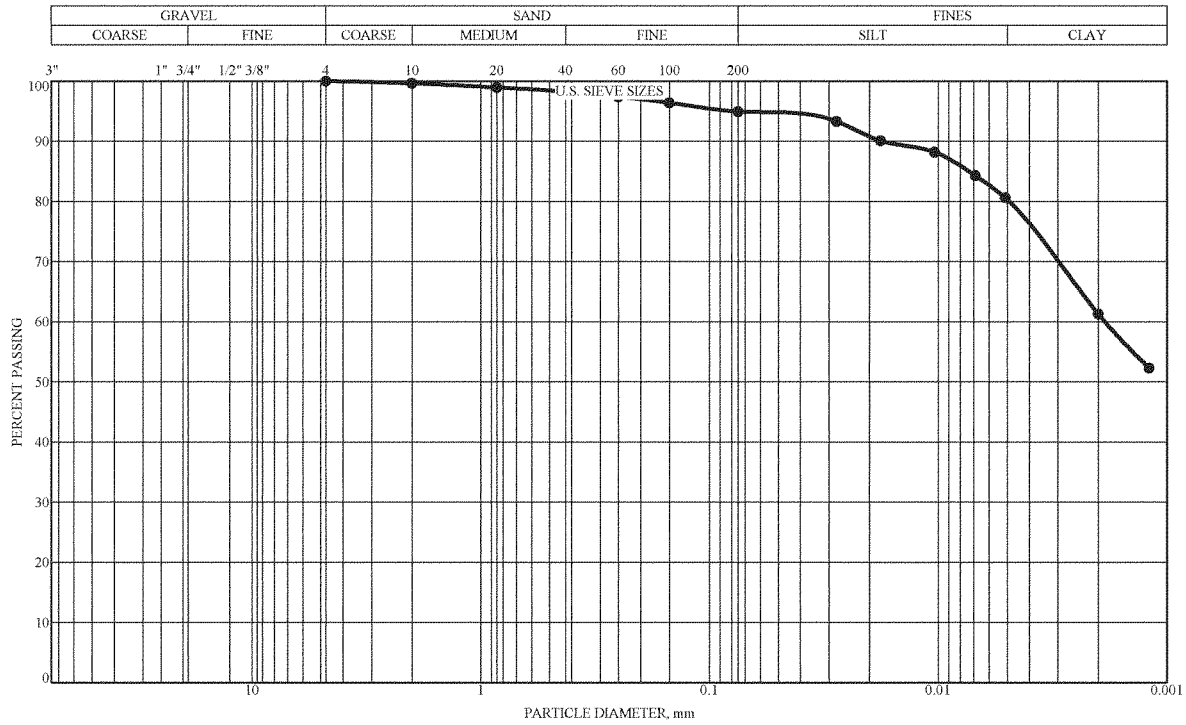
SE-F-13, Fargo, Brenna Formation

OS ASTM BL-09-03127-3 GRAIN 8.4.0 Attachment 1.4.pg 1 of 1

BL-09-03127

Braun Intertec Corporation

GRAIN SIZE ACCUMULATION CURVE (ASTM)



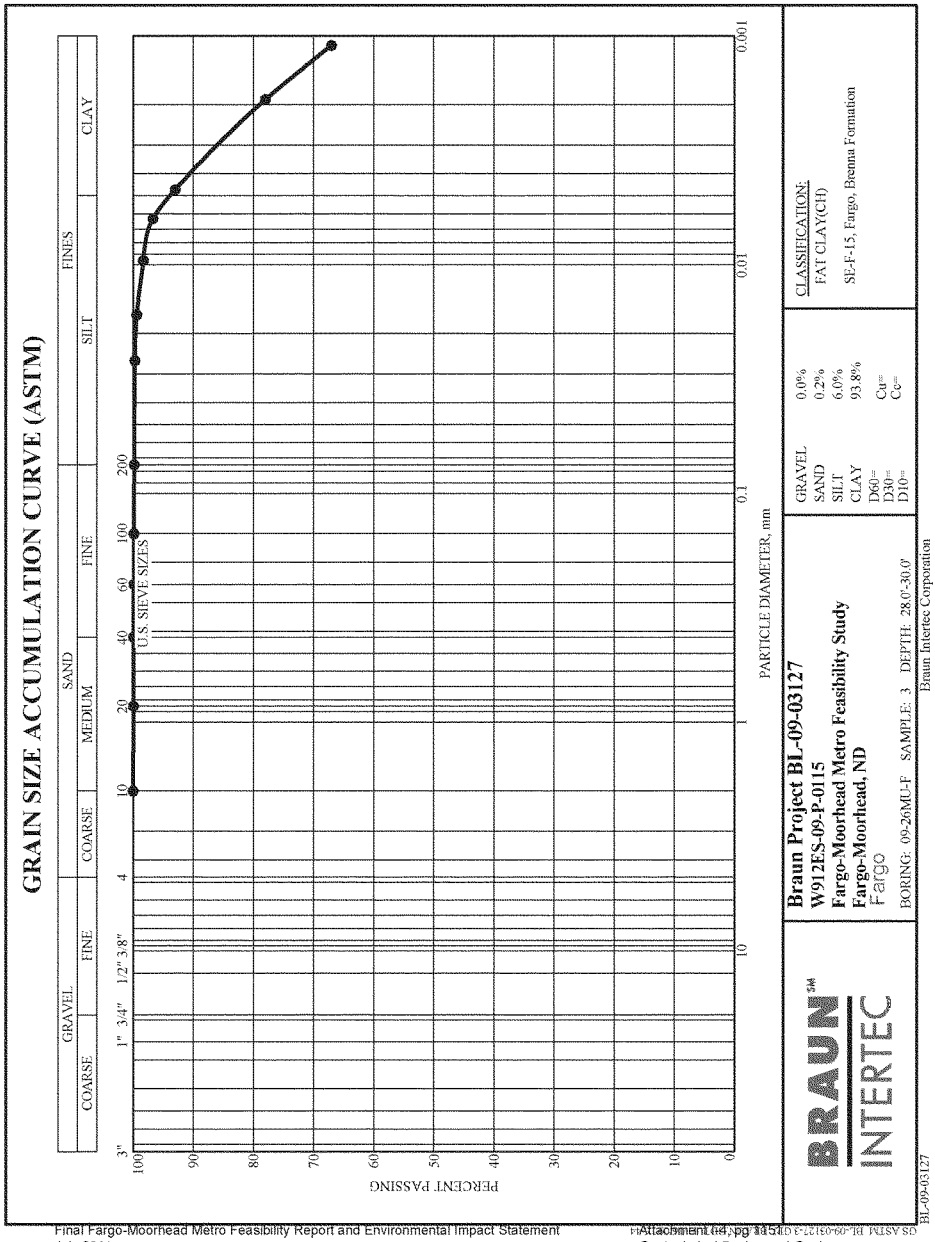
BRAUN INTERTEC

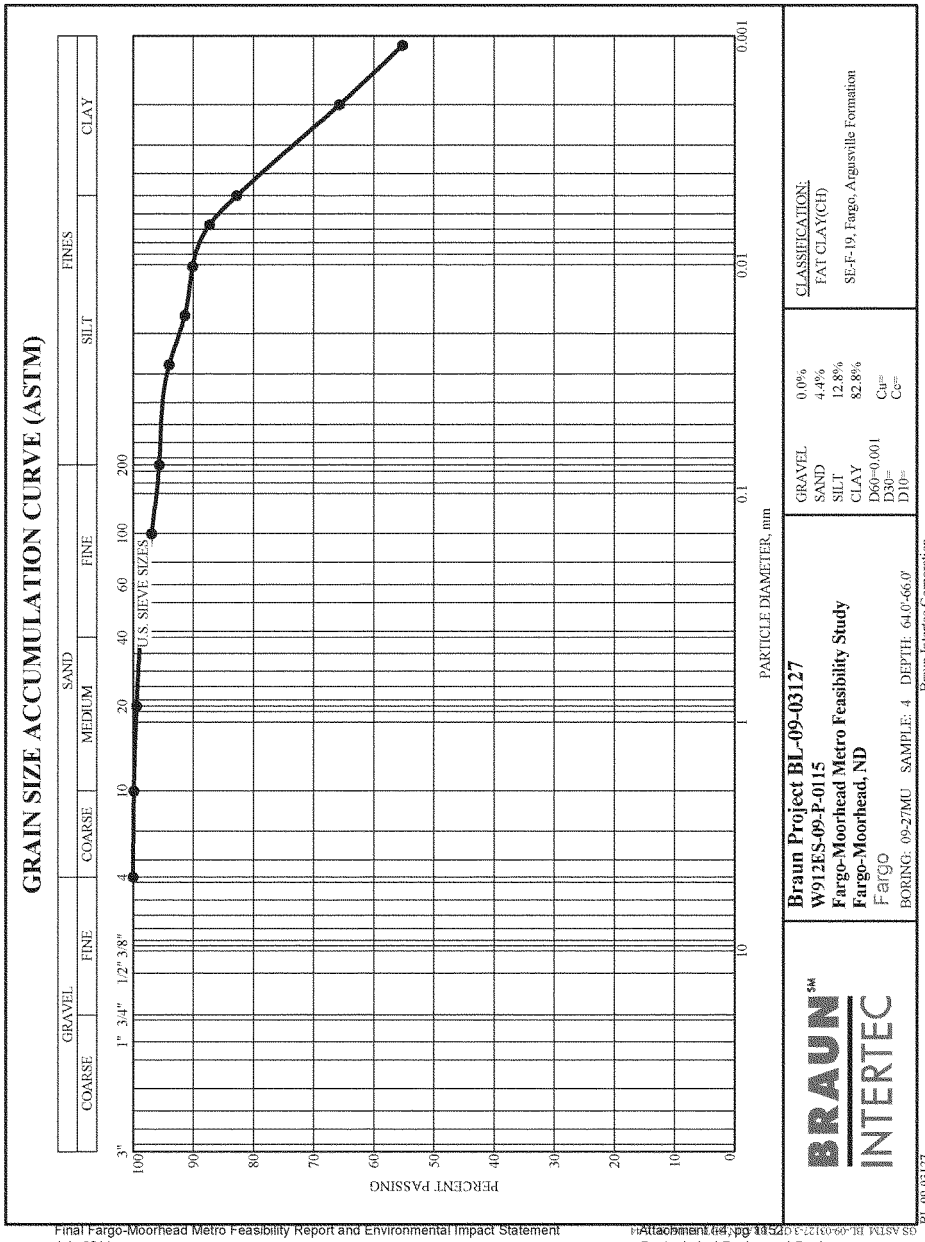
Braun Project BL-09-03127
W912ES-09-P-0115
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, ND
Fargo
BORING: 09-25MU SAMPLE: 5 DEPTH: 66.0'-68.0'

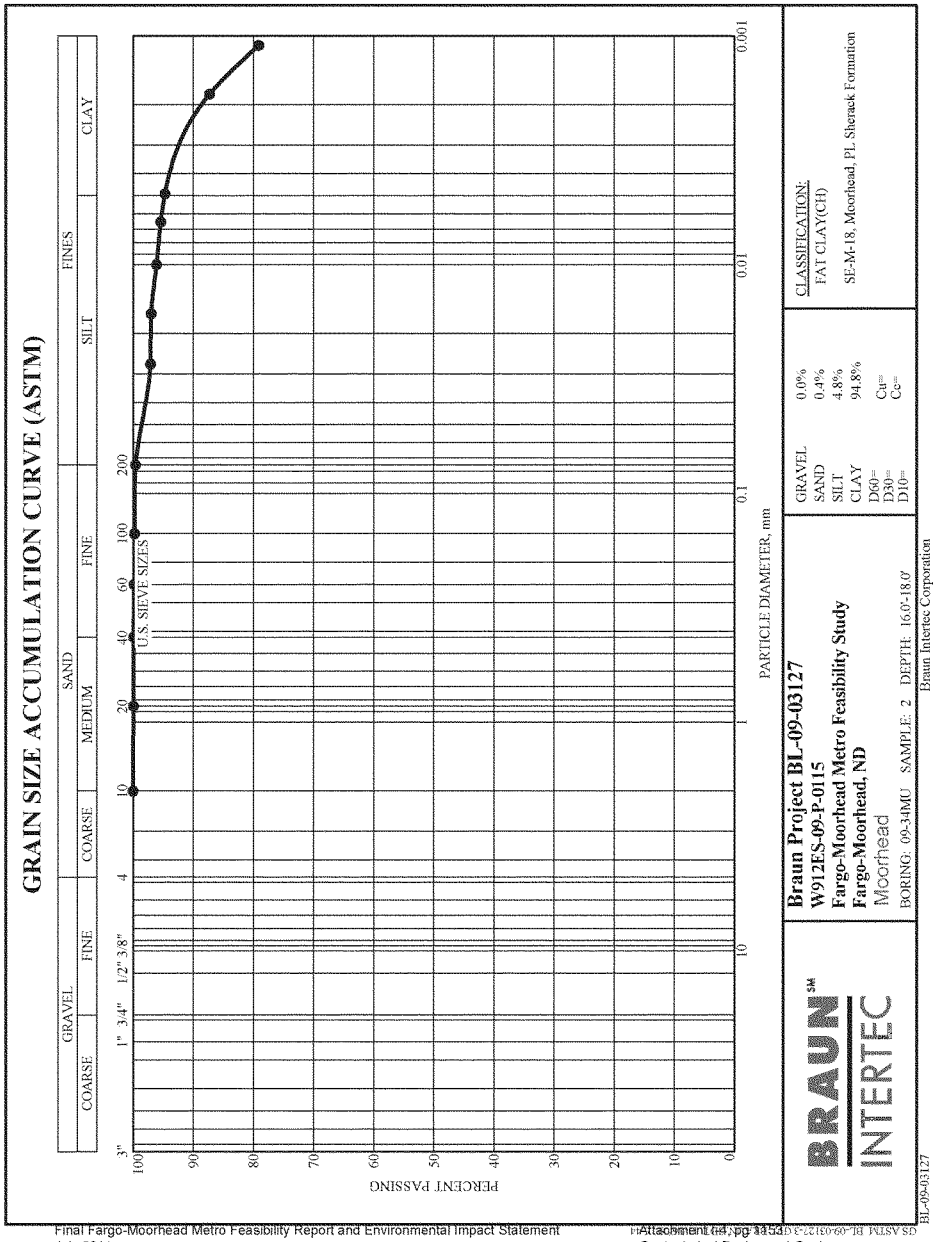
GRAVEL	0.0%
SAND	5.1%
SILT	14.7%
CLAY	80.2%
D60=0.002	Cu=
D30=	Cc=
D10=	

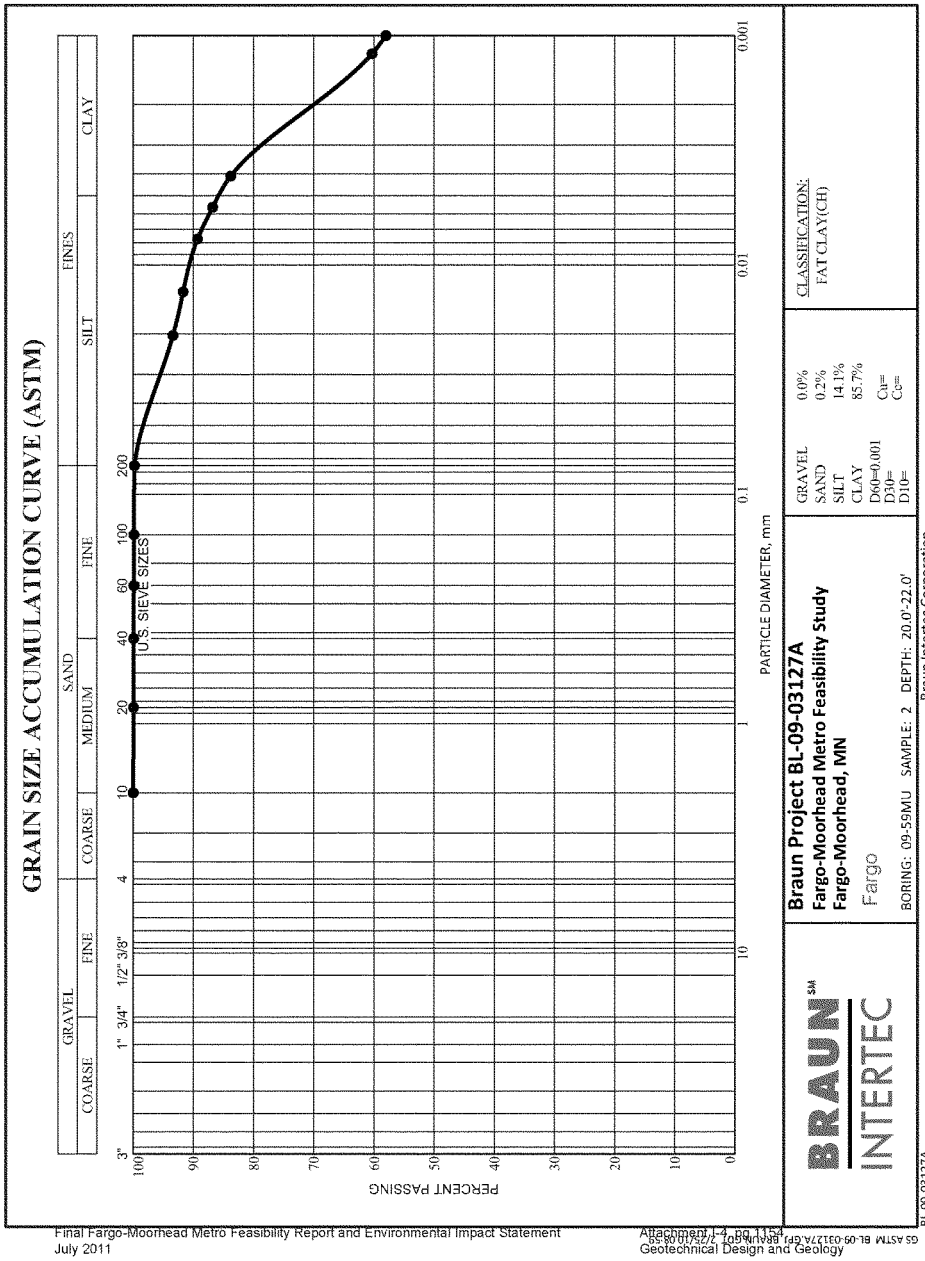
CLASSIFICATION:
FAT CLAY(CH)

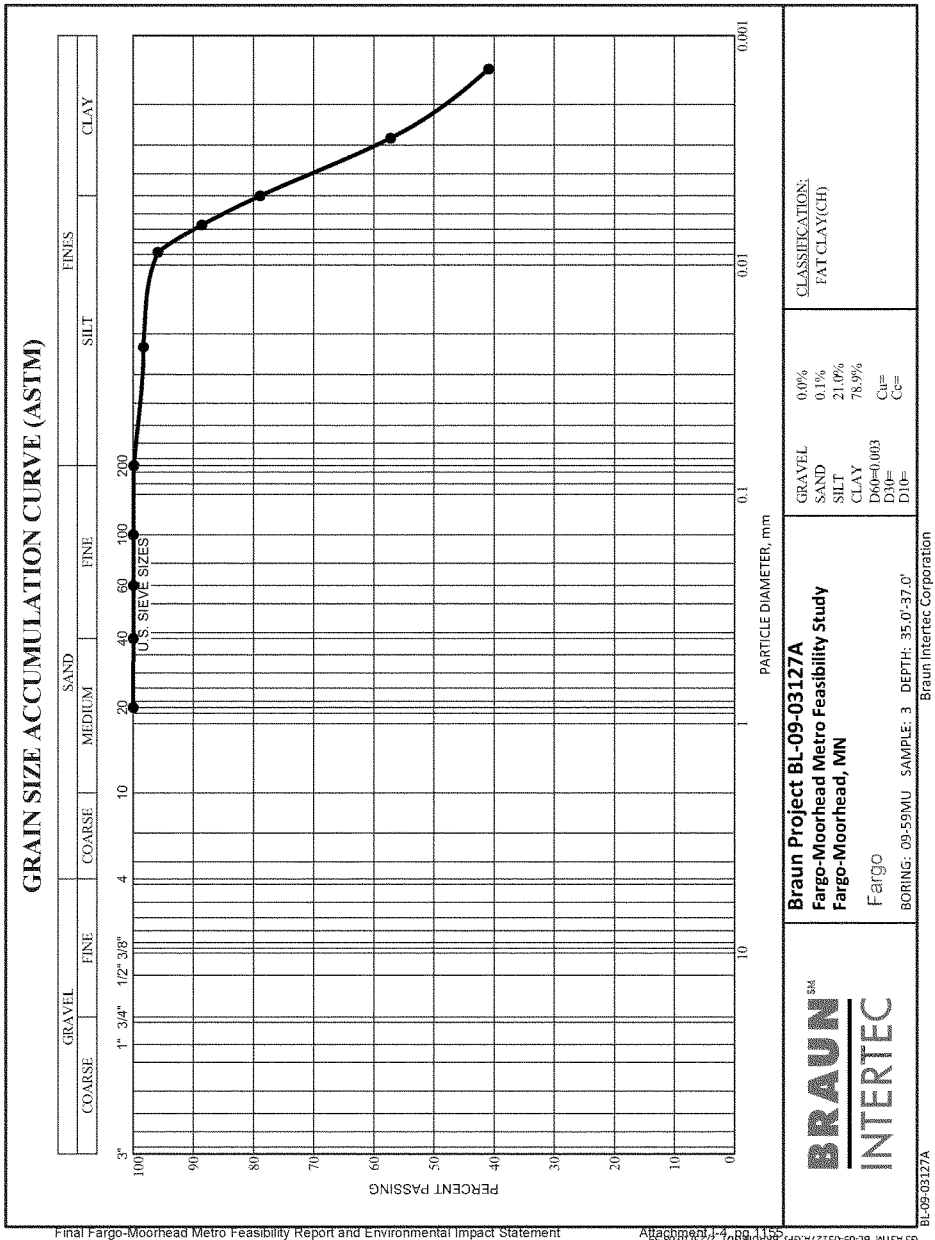
SE-F-13, Fargo, Argusville Formation

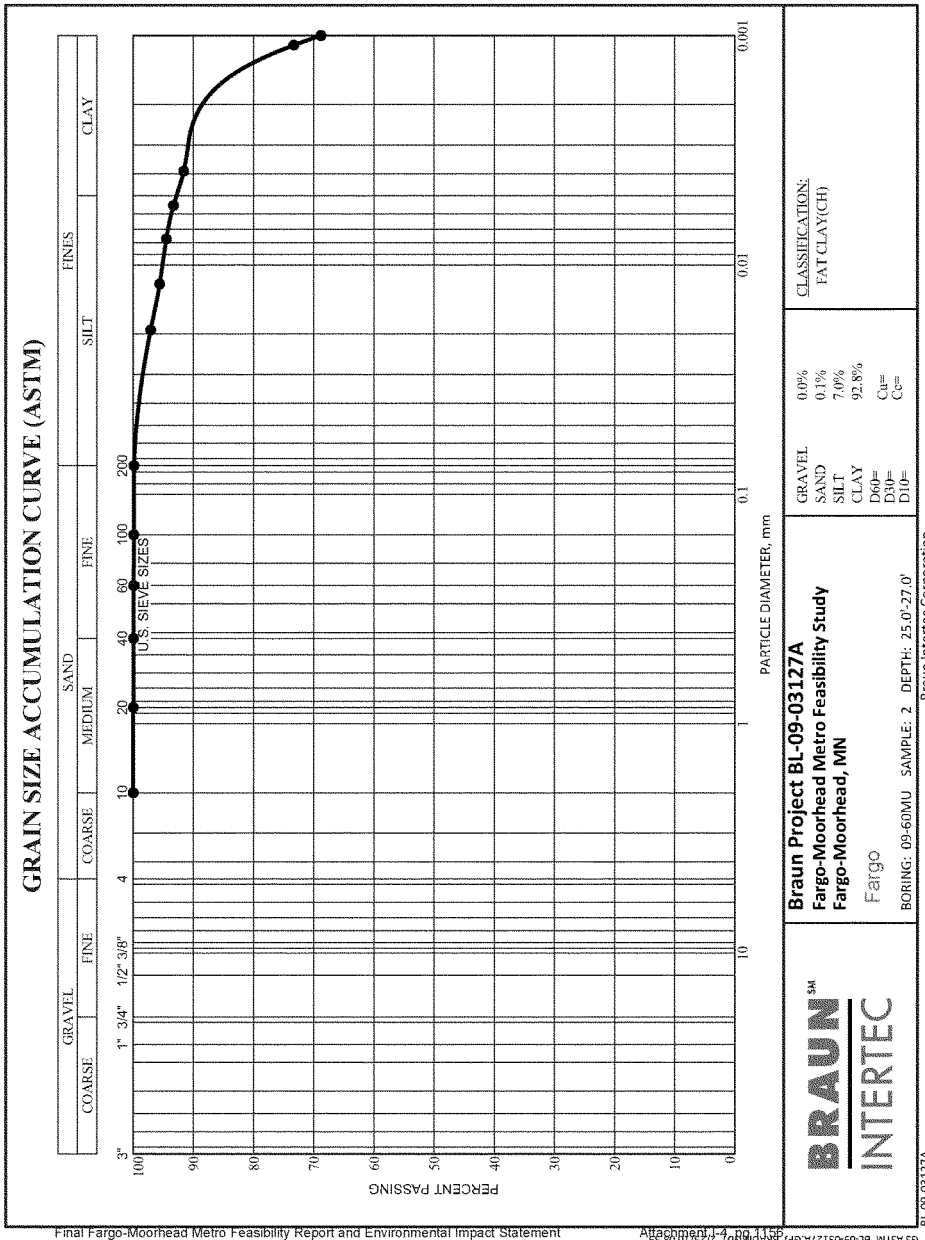

GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
Braun Project BL-09-03127
W912ES-09-P-0115
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, ND
Fargo
BORING: 09-26MU-F SAMPLE: 3 DEPTH: 28.0'-30.0'
GRAVEL 0.0%
SAND 0.2%
SILT 6.0%
CLAY 93.8%
D60=
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY(CH)
SE-F-15, Fargo, Brenna Formation
BRAUN INTERTEC
Braun Intertec Corporation
BL-09-03127

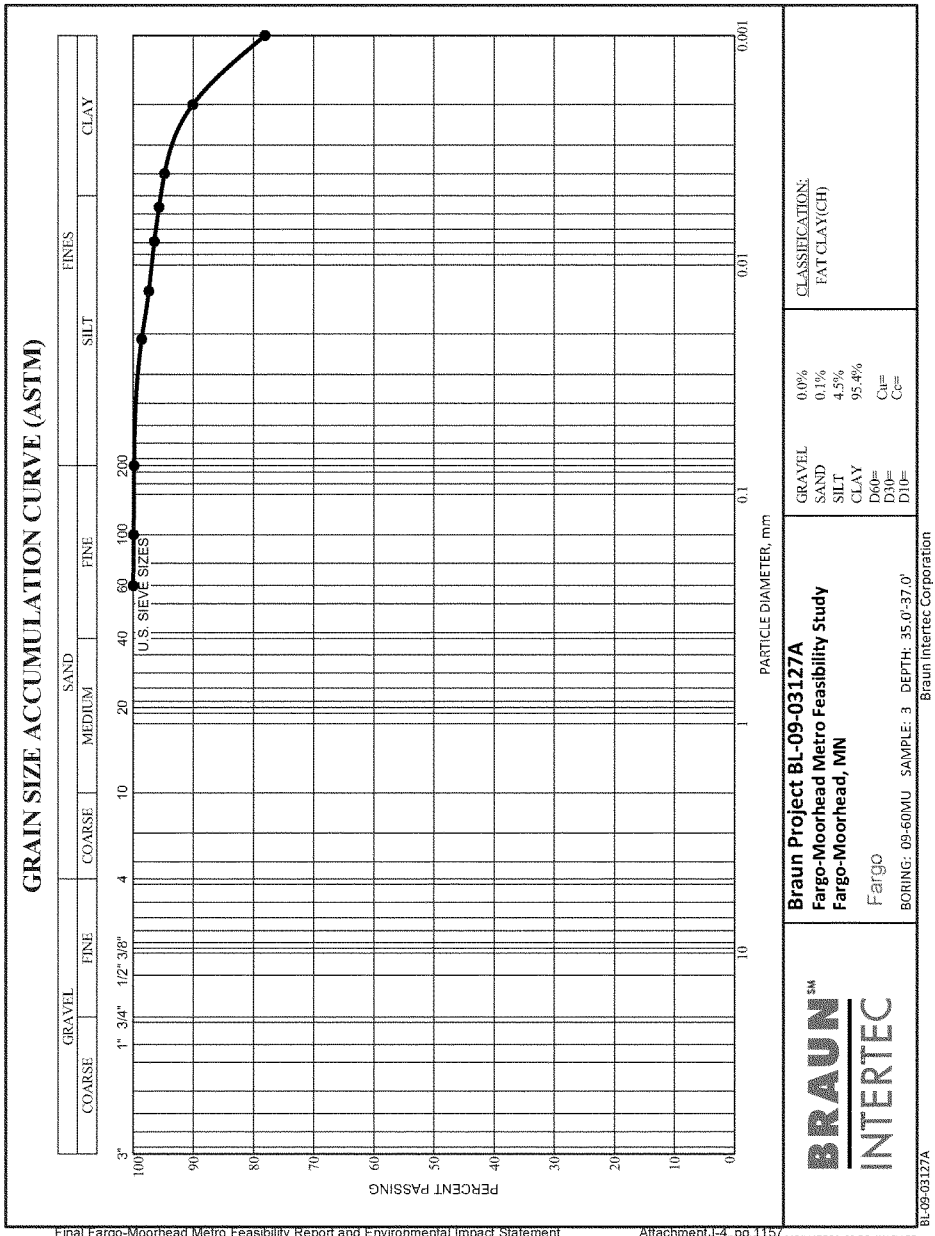

GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1" 3/4" 1/2" 3/8"
4 10 20 40 60 100 200
U.S. SIEVE SIZES
PERCENT PASSING
100 90 80 70 60 50 40 30 20 10 0
10 1 0.1 0.01 0.001
PARTICLE DIAMETER, mm
BRAUN INTERTEC
Braun Project BL-09-03127
W912ES-09-P-0115
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, ND
Fargo
BORING: 09-27MU SAMPLE: 4 DEPTH: 64.0-66.0'
GRAVEL 0.0%
SAND 4.4%
SILT 12.8%
CLAY 82.8%
D60=0.001
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY(CH)
SE-F-19, Fargo Argusville Formation
Braun Intertec Corporation
GS ASTM BL-09-03127-3 02/11/10
BL-09-03127


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
SAND
FINES
COARSE
FINE
COARSE
MEDIUM
FINE
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
0.001
Braun Project BL-09-03127
W912ES-09-P-0115
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, ND
Moorhead
BORING: 09-34MU SAMPLE: 2 DEPTH: 16.0'-18.0'
GRAVEL 0.0%
SAND 0.4%
SILT 4.8%
CLAY 94.8%
D60=
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY(CH)
SE-M-18, Moorhead, Pl, Sheyenne Formation
BRAUN INTERTEC
Braun Intertec Corporation
GS ASTM BL-09-03127.3.GPJ
BL-09-03127


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1" 3/4" 1/2" 3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
BRAUN INTERTEC
Braun Project BL-09-03127A
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, MN
Fargo
BORING: 09-59MU SAMPLE: 2 DEPTH: 20.0'-22.0'
GRAVEL 0.0%
SAND 0.2%
SILT 14.1%
CLAY 85.7%
D60=0.001
D10=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY(CH)
Braun Intertec Corporation
BL-09-03127A


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
SAND
FINES
COARSE
FINE
COARSE
MEDIUM
FINE
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
0.001
Braun Project BL-09-03127A
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, MN
Fargo
BORING: 09-59MU SAMPLE: 3 DEPTH: 35.0'-37.0'
GRAVEL 0.0%
SAND 0.1%
SILT 21.0%
CLAY 78.9%
D60=0.003 Cu=
D30= Cc=
D10=
CLASSIFICATION:
FAT CLAY(CH)
BRAUN INTERTEC
Braun Intertec Corporation
BL-09-03127A


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
100
90
80
70
60
50
40
30
20
10
0
PARTICLE DIAMETER, mm
10
1
0.1
0.01
0.001
Braun Project BL-09-03127A
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, MN
Fargo
BORING: 09-60MU SAMPLE: 2 DEPTH: 25.0'-27.0'
GRAVEL 0.0%
SAND 0.1%
SILT 7.0%
CLAY 92.8%
D60= Cu=
D30= Cc=
D10=
CLASSIFICATION:
FAT CLAY(CH)
BRAUN INTERTEC
Braun Intertec Corporation
BL-09-03127A

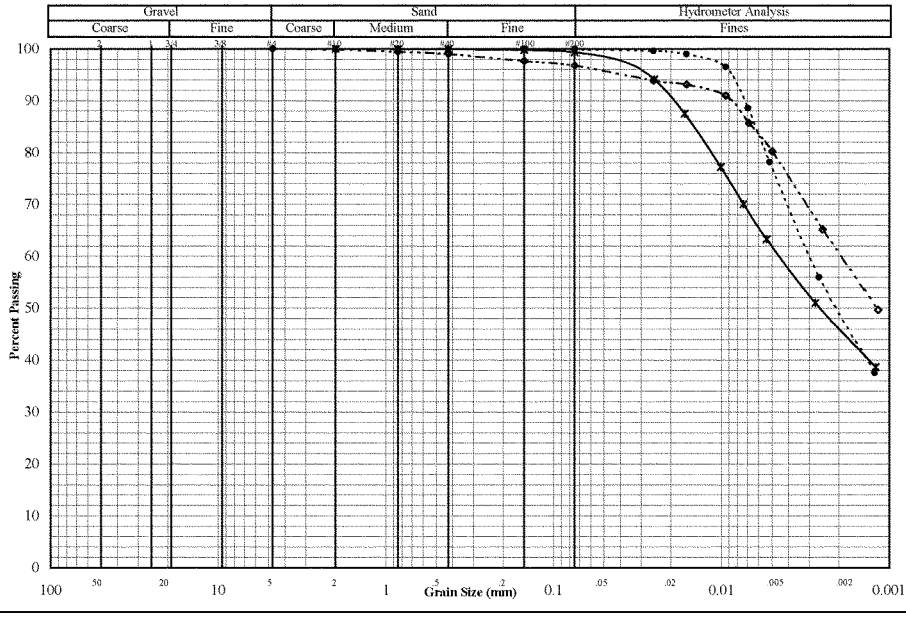

GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
BRAUN INTERTEC
Braun Project BL-09-03127A
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, MN
Fargo
BORING: 09-60MU SAMPLE: 3 DEPTH: 35.0'-37.0'
GRAVEL 0.0%
SAND 0.1%
SILT 4.5%
CLAY 95.4%
D60=
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY(CH)
Braun Intertec Corporation
BL-09-03127A

Grain Size Distribution ASTM D422

Job No. : **7577**

Project:	FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING	Test Date:	8/19/10
Reported To:	USACE -Geotech. & Geology Section	Report Date:	8/20/10

	Location / Boring No.	Sample No.	Depth (ft)	Sample Type	Soil Classification
*	10-78MU / ND Wild Rice	1	13-15	5T	Fat Clay w/a few laminations of silt (CH)
●	10-78MU / ND Wild Rice	2	25-27	5T	Fat Clay (CH)
◇	10-78MU / ND Wild Rice	3	55-57	5T	Fat Clay w/a few pockets of silt (CH)



	*	●	◇
Liquid Limit	55.8	63.8	71.8
Plastic Limit	22.1	23.1	22.4
Plasticity Index	33.7	40.7	49.4
Water Content			
Dry Density (pcf)			
Specific Gravity	2.76	2.76	2.77
Porosity			
Organic Content			
pH			
Shrinkage Limit			
Penetrometer			
Qu (psf)			

(* = assumed)

Other Tests

Percent Passing

	*	●	◇
Mass (g)	232.2	116.9	159.4
2"			
1.5"			
1"			
3/4"			
3/8"			
#4	100.0	100.0	100.0
#10	100.0	100.0	99.8
#20	99.9	100.0	99.4
#40	99.9	99.9	98.9
#100	99.7	99.9	97.6
#200	99.3	99.9	96.8

	*	●	◇
D_{60}			
D_{30}			
D_{10}			
C_U			
C_C			

Remarks:

Fargo
10-78MU

Grain Size Distribution ASTM D422

Job No. : **7577**

Project:	FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING	Test Date:	8/19/10
Reported To:	USACE -Geotech. & Geology Section	Report Date:	8/20/10

	Location / Boring No.	Sample No.	Depth (ft)	Sample Type	Soil Classification
Spec 1	10-78MU / ND Wild Rice	1	13-15	5T	Fat Clay w/a few laminations of silt (CH)
Spec 2	10-78MU / ND Wild Rice	2	25-27	5T	Fat Clay (CH)
Spec 3	10-78MU / ND Wild Rice	3	55-57	5T	Fat Clay w/a few pockets of silt (CH)

Sieve Data

Specimen 1		Specimen 2		Specimen 3	
Sieve	% Passing	Sieve	% Passing	Sieve	% Passing
2"		2"		2"	
1.5"		1.5"		1.5"	
1"		1"		1"	
3/4"		3/4"		3/4"	
3/8"		3/8"		3/8"	
#4	100.0	#4	100.0	#4	100.0
#10	100.0	#10	100.0	#10	99.8
#20	99.9	#20	100.0	#20	99.4
#40	99.9	#40	99.9	#40	98.9
#100	99.7	#100	99.9	#100	97.6
#200	99.3	#200	99.9	#200	96.8

Hydrometer Data

Specimen 1		Specimen 2		Specimen 3	
Diameter (mm)	% Passing	Diameter	% Passing	Diameter	% Passing
0.025	94.1	0.025	99.6	0.025	93.9
0.017	87.5	0.016	99.0	0.016	93.1
0.010	77.2	0.009	96.5	0.009	91.0
0.007	70.0	0.007	88.6	0.007	85.7
0.005	63.3	0.005	78.2	0.005	80.2
0.003	51.0	0.003	56.0	0.002	65.2
0.001	38.6	0.001	37.6	0.001	49.7

Remarks

Specimen 1	Specimen 2	Specimen 3

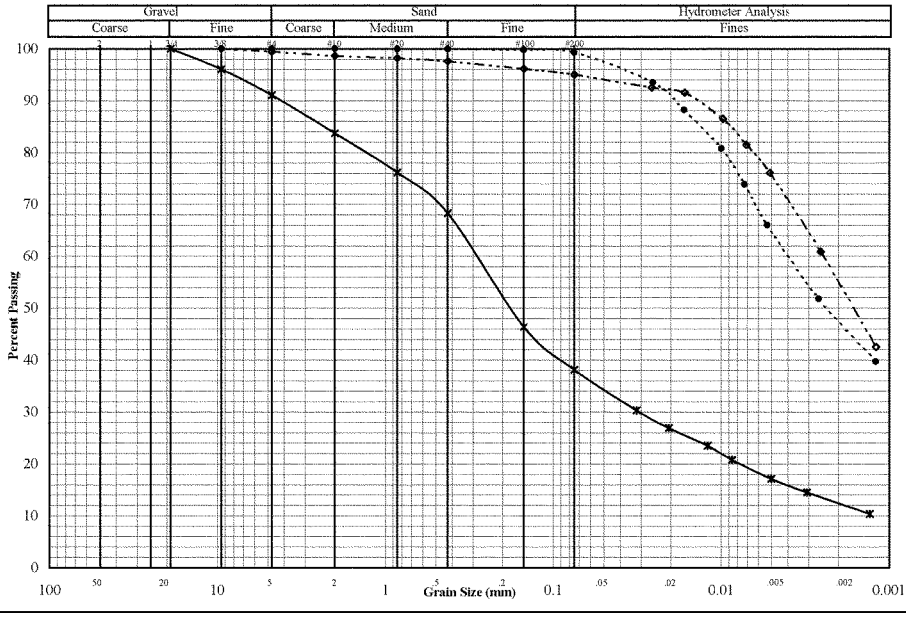
SOIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55420-3436
Geotechnical Design and Geology

Grain Size Distribution ASTM D422

Job No. : **7577**

Project:	FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING	Test Date:	8/19/10
Reported To:	USACE -Geotech. & Geology Section	Report Date:	8/20/10

	Location / Boring No.	Sample No.	Depth (ft)	Sample Type	Soil Classification
*	10-78MU / ND Wild Rice	4	70-71	3T	Clayey Sand w/a little gravel (CL)
●	10-79MU / ND RRCS	1	20-22	5T	Fat Clay w/a few laminations of silt, slightly blocky structured (CH)
◇	10-79MU / ND RRCS	2	40-42	5T	Fat Clay w/a few pockets of silt (CH)



Other Tests	*	●	◇
Liquid Limit	29.5	51.8	83.0
Plastic Limit	16.9	20.5	25.2
Plasticity Index	12.6	31.3	57.8
Water Content			
Dry Density (pcf)			
Specific Gravity	2.69	2.70	2.78
Porosity			
Organic Content			
pH			
Shrinkage Limit			
Penetrometer			
Qu (psf)			

(* = assumed)

Percent Passing	*	●	◇
Mass (g)	284.9	196.3	166.4
2"			
1.5"			
1"			
3/4"	100.0		
3/8"	96.0		100.0
#4	91.1	100.0	99.5
#10	83.7	100.0	98.6
#20	76.1	100.0	98.2
#40	68.3	99.9	97.6
#100	46.4	99.8	96.1
#200	38.1	99.3	95.0

	*	●	◇
D_{60}			
D_{30}			
D_{10}			
C_U			
C_C			

Remarks:

Fargo
10-78MU
10-79MU

Grain Size Distribution ASTM D422

Job No. : **7577**

Project:	FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING	Test Date:	8/19/10
Reported To:	USACE -Geotech. & Geology Section	Report Date:	8/20/10

	Location / Boring No.	Sample No.	Depth (ft)	Sample Type	Soil Classification
Spec 1	10-78MU / ND Wild Rice	4	70-71	3T	Clayey Sand w/a little gravel (CL)
Spec 2	10-79MU / ND RRCS	1	20-22	5T	Fat Clay w/a few laminations of silt, slightly blocky structured (CH)
Spec 3	10-79MU / ND RRCS	2	40-42	5T	Fat Clay w/a few pockets of silt (CH)

Sieve Data

Specimen 1		Specimen 2		Specimen 3	
Sieve	% Passing	Sieve	% Passing	Sieve	% Passing
2"		2"		2"	
1.5"		1.5"		1.5"	
1"		1"		1"	
3/4"	100.0	3/4"		3/4"	
3/8"	96.0	3/8"		3/8"	100.0
#4	91.1	#4	100.0	#4	99.5
#10	83.7	#10	100.0	#10	98.6
#20	76.1	#20	100.0	#20	98.2
#40	68.3	#40	99.9	#40	97.6
#100	46.4	#100	99.8	#100	96.1
#200	38.1	#200	99.3	#200	95.0

Hydrometer Data

Specimen 1		Specimen 2		Specimen 3	
Diameter (mm)	% Passing	Diameter	% Passing	Diameter	% Passing
0.032	30.3	0.026	93.5	0.026	92.5
0.021	26.9	0.017	88.2	0.017	91.5
0.012	23.5	0.010	80.8	0.010	86.5
0.009	20.8	0.007	73.9	0.007	81.5
0.005	17.1	0.005	66.0	0.005	76.1
0.003	14.5	0.003	51.8	0.003	60.9
0.001	10.3	0.001	39.7	0.001	42.5

Remarks

Specimen 1	Specimen 2	Specimen 3

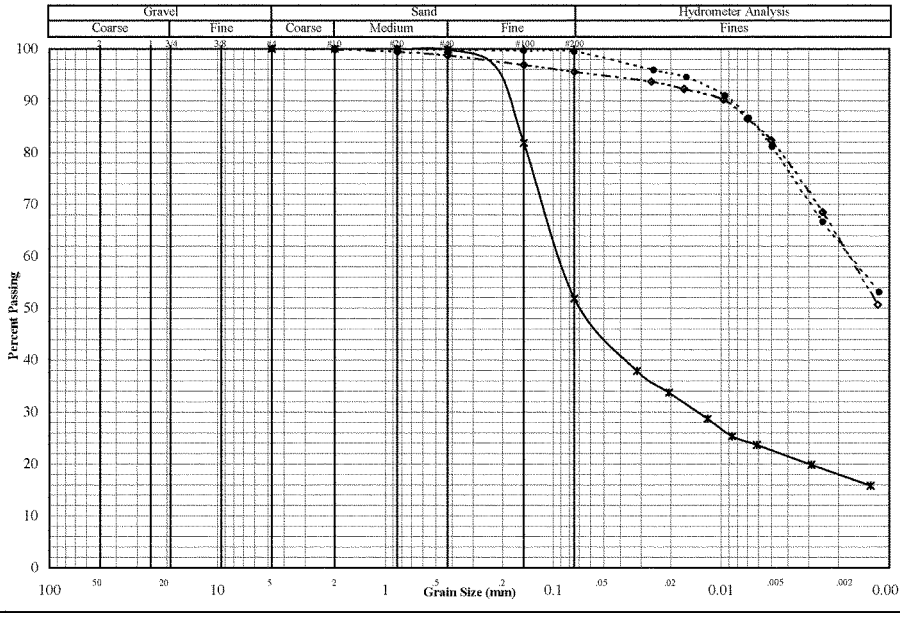
SOIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55420-3436
Geotechnical Design and Geology

Grain Size Distribution ASTM D422

Job No. : **7577**

Project:	FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING	Test Date:	8/19/10
Reported To:	USACE -Geotech. & Geology Section	Report Date:	8/20/10

	Location / Boring No.	Sample No.	Depth (ft)	Sample Type	Soil Classification
*	10-80MU / ND Sheyenne	1	23-25	ST	Sandy Lean Clay w/a few pockets of silty sand (CL)
●	10-80MU / ND Sheyenne	2	35-37	ST	Fat Clay w/laminations of silt (CH)
◇	10-80MU / ND Sheyenne	3	55-57	ST	Fat Clay w/a few pockets of silt (CH)



Other Tests	*	●	◇
Liquid Limit	28.2	90.7	78.1
Plastic Limit	17.1	29.1	26.8
Plasticity Index	11.1	61.6	51.3
Water Content			
Dry Density (pcf)			
Specific Gravity	2.67	2.78	2.78
Porosity			
Organic Content			
pH			
Shrinkage Limit			
Penetrometer			
Qu (psf)			

(* = assumed)

Percent Passing	*	●	◇
Mass (g)	256.6	113.1	164.4
2"			
1.5"			
1"			
3/4"			
3/8"			
#4	100.0	100.0	100.0
#10	100.0	100.0	99.8
#20	100.0	99.9	99.4
#40	99.8	99.8	98.7
#100	81.8	99.6	96.9
#200	51.9	99.4	95.6

	*	●	◇
D_{60}			
D_{30}			
D_{10}			
C_U			
C_C			

Remarks:

Fargo
10-80MU

Grain Size Distribution ASTM D422

Job No. : **7577**

Project:	FARGO-MOORHEAD METRO FEASIBILITY PROJECT - UNDISTURBED LABORATORY SOIL TESTING	Test Date:	8/19/10
Reported To:	USACE -Geotech. & Geology Section	Report Date:	8/20/10

	Location / Boring No.	Sample No.	Depth (ft)	Sample Type	Soil Classification
Spec 1	10-80MU / ND Sheyenne	1	23-25	5T	Sandy Lean Clay w/a few pockets of silty sand (CL)
Spec 2	10-80MU / ND Sheyenne	2	35-37	5T	Fat Clay w/laminations of silt (CH)
Spec 3	10-80MU / ND Sheyenne	3	55-57	5T	Fat Clay w/a few pockets of silt (CH)

Sieve Data

Specimen 1		Specimen 2		Specimen 3	
Sieve	% Passing	Sieve	% Passing	Sieve	% Passing
2"		2"		2"	
1.5"		1.5"		1.5"	
1"		1"		1"	
3/4"		3/4"		3/4"	
3/8"		3/8"		3/8"	
#4	100.0	#4	100.0	#4	100.0
#10	100.0	#10	100.0	#10	99.8
#20	100.0	#20	99.9	#20	99.4
#40	99.8	#40	99.8	#40	98.7
#100	81.8	#100	99.6	#100	96.9
#200	51.9	#200	99.4	#200	95.6

Hydrometer Data

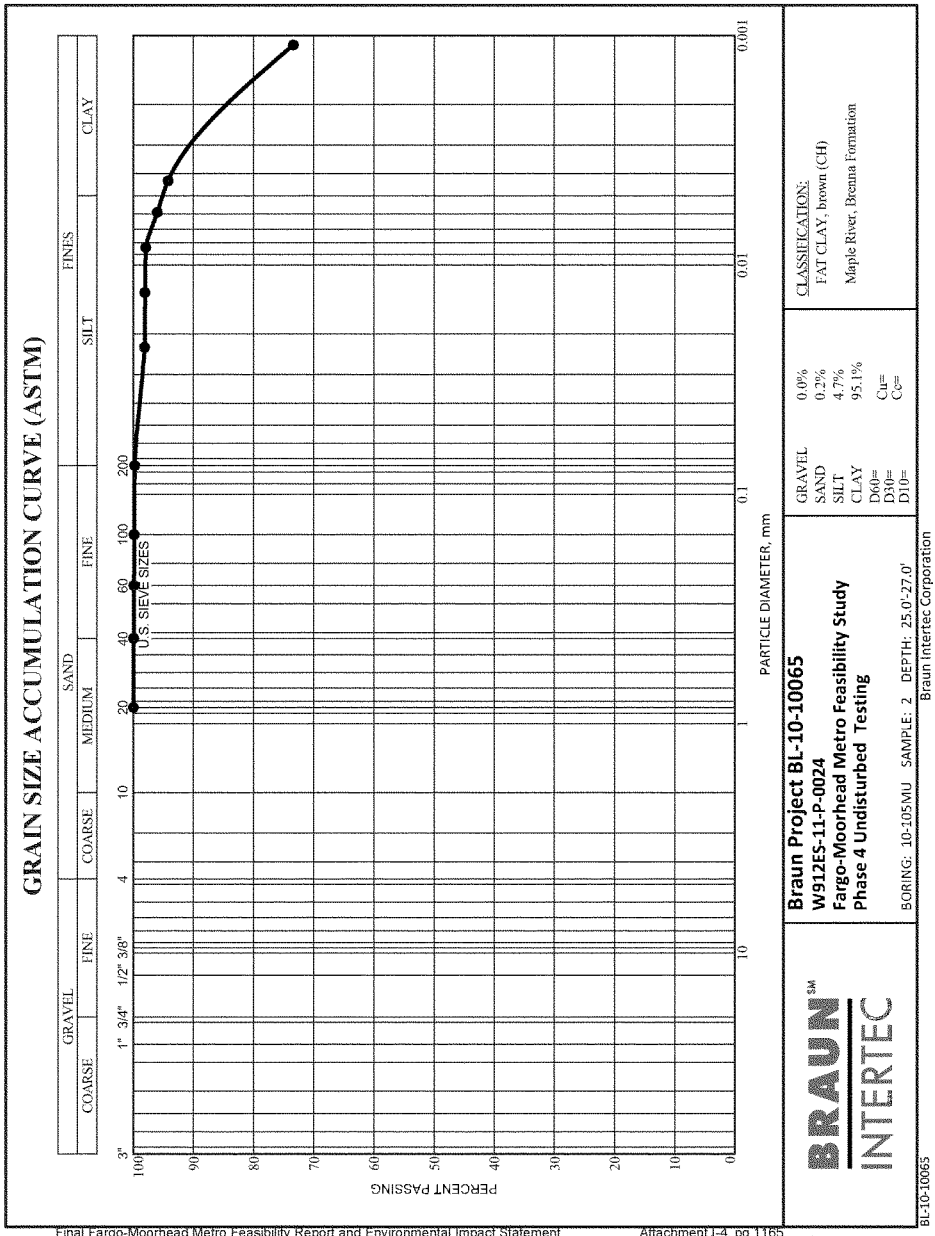
Specimen 1		Specimen 2		Specimen 3	
Diameter (mm)	% Passing	Diameter	% Passing	Diameter	% Passing
0.032	37.9	0.025	95.9	0.026	93.7
0.020	33.7	0.016	94.5	0.017	92.2
0.012	28.7	0.009	91.0	0.010	90.2
0.009	25.3	0.007	86.6	0.007	86.5
0.006	23.7	0.005	81.1	0.005	82.4
0.003	19.8	0.002	66.6	0.002	68.5
0.001	15.8	0.001	53.1	0.001	50.7

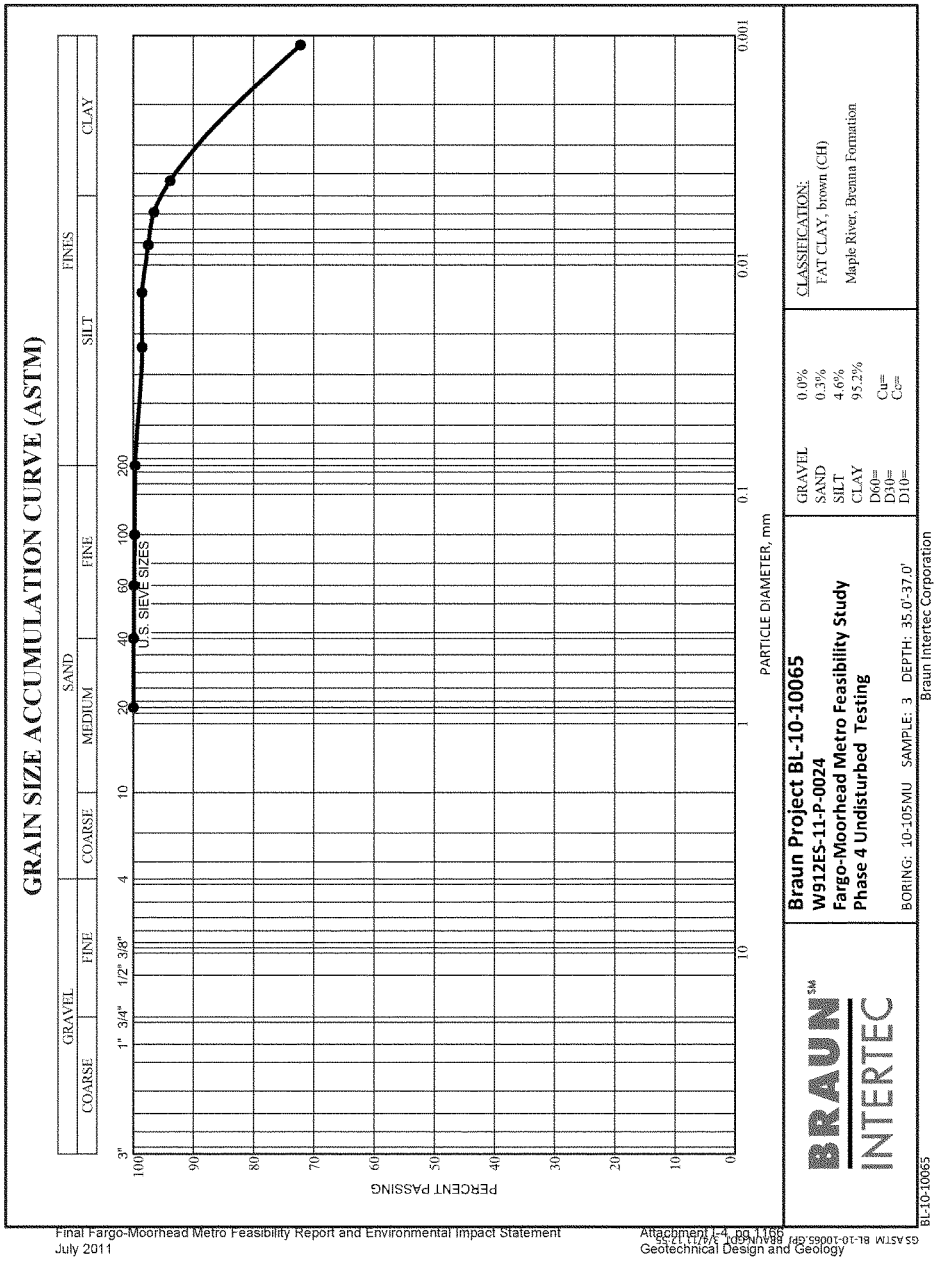
Remarks

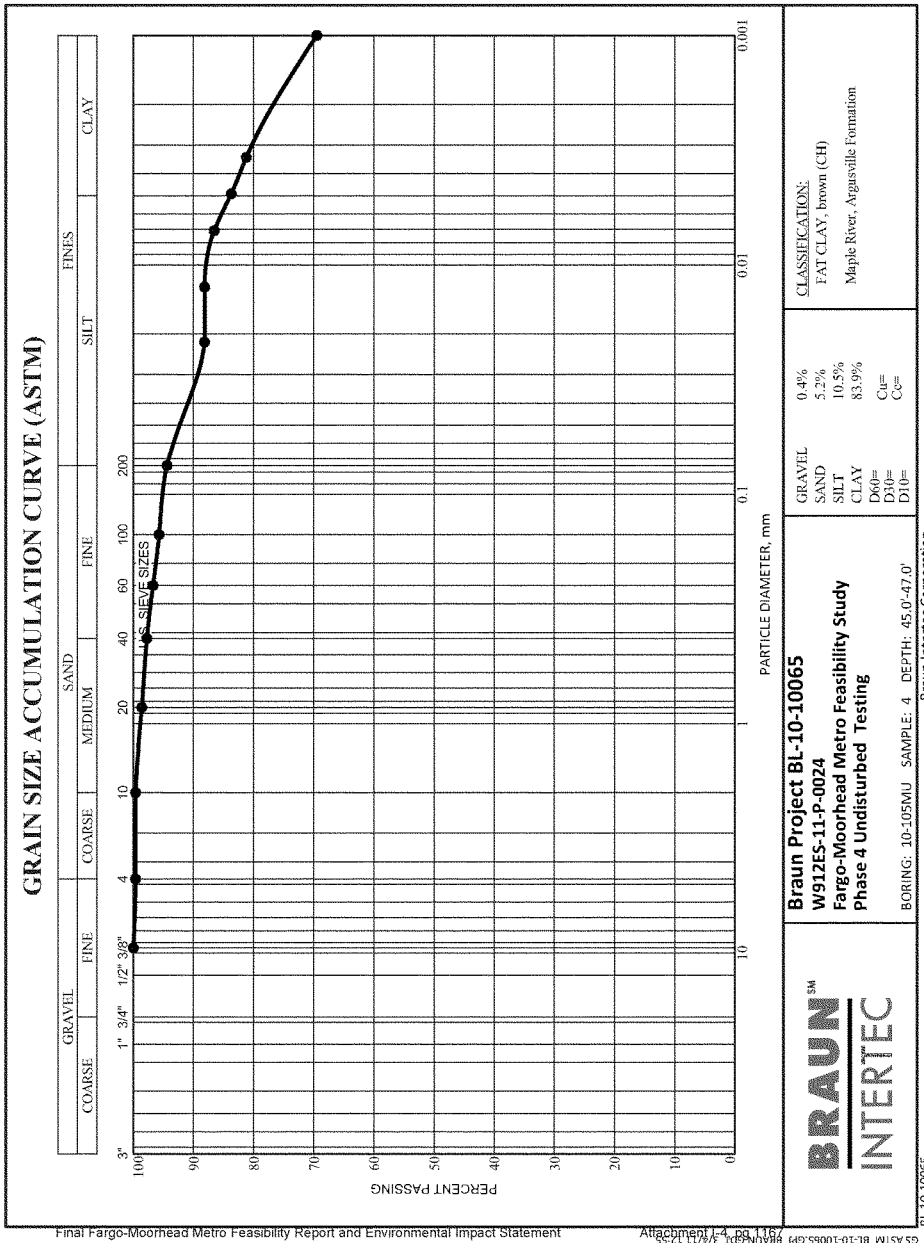
Specimen 1	Specimen 2	Specimen 3

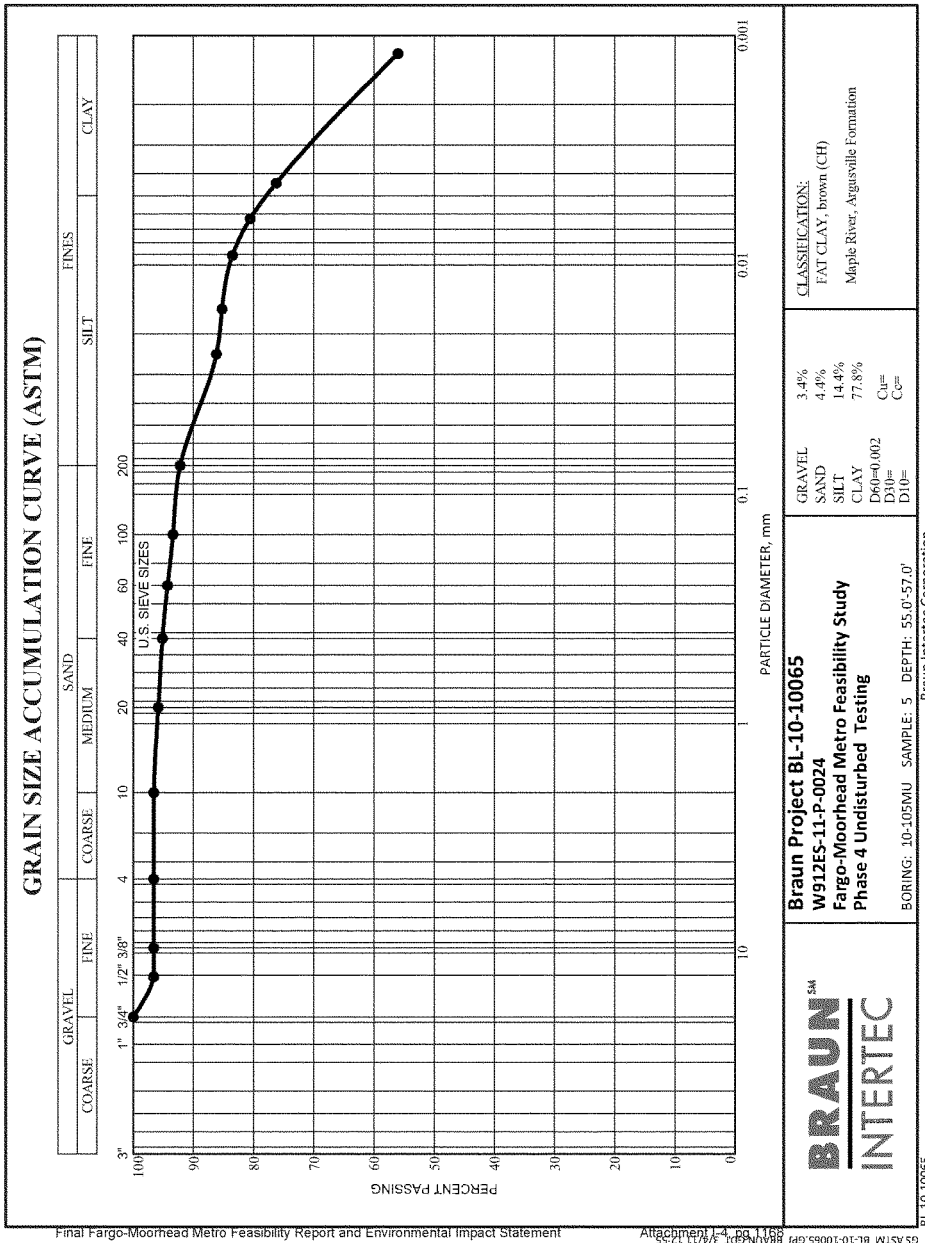
SOIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55420-3436
Geotechnical Design and Geology

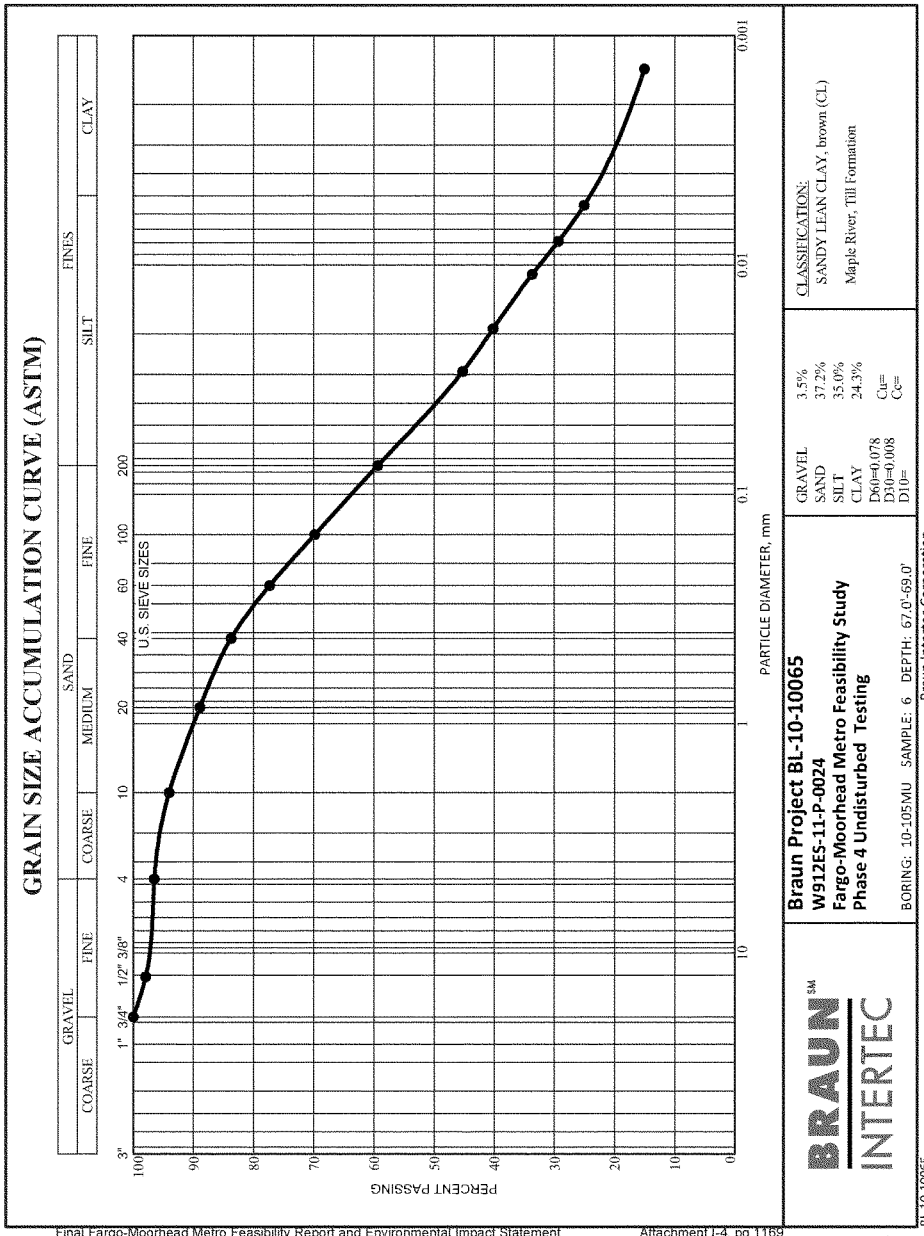
GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
0.001
BRAUN INTERTEC
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 10-105MU SAMPLE: 1 DEPTH: 15.0'-17.0'
GRAVEL 0.0%
SAND 0.2%
SILT 2.9%
CLAY 96.9%
D60=
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY, brown (CH)
Maple River, Dessicated Brenna Formation
Braun Intertec Corporation
BL-10-10065
GS ASTM BL-10-10065.GPJ BRAUN.GDT 3/8/11 12:55


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 10-105/MU SAMPLE: 2 DEPTH: 25.0'-27.0'
GRAVEL 0.0%
SAND 0.2%
SILT 4.7%
CLAY 95.1%
D60=
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY, brown (CH)
Maple River, Brenna Formation
BRAUN INTERTEC
Braun Intertec Corporation
BL-10-10065
GS ASTM BL-10-10065.GPJ BRAUN.GDT 3/4/11 12:53

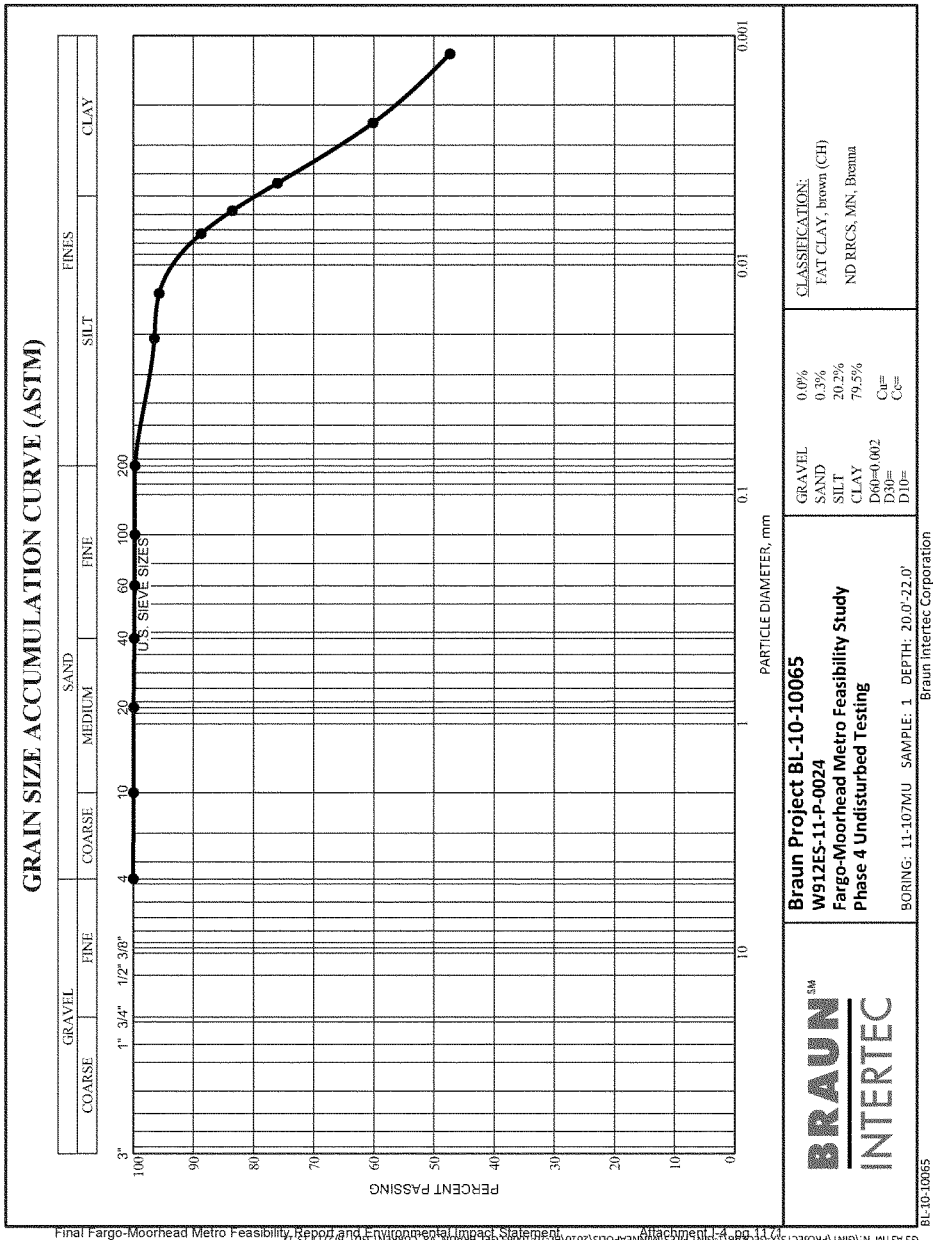

GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
0.001
BRAUN INTERTEC
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 10-105MU SAMPLE: 3 DEPTH: 35.0'-37.0'
GRAVEL 0.0%
SAND 0.3%
SILT 4.6%
CLAY 95.2%
D60= Cu=
D10= Cc=
D10=
CLASSIFICATION:
FAT CLAY, brown (CH)
Maple River, Brenna Formation
Braun Intertec Corporation
BL-10-10065
GS ASTM BL-10-10065.GPJ BRAUN.GDT 8/9/11 12:58


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
10
1
0.1
0.01
0.001
BRAUN INTERTEC
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 10-105MU SAMPLE: 4 DEPTH: 45.0'-47.0'
Braun Intertec Corporation
GRAVEL 0.4%
SAND 5.2%
SILT 10.5%
CLAY 83.9%
D60= Cu=
D10= Cc=
D10=
CLASSIFICATION:
FAT CLAY, brown (CH)
Maple River, Argusville Formation
BL-10-10065
GS ASTM BL-10-10065.GPJ BRAUN.GDT 3/4/11 13:53

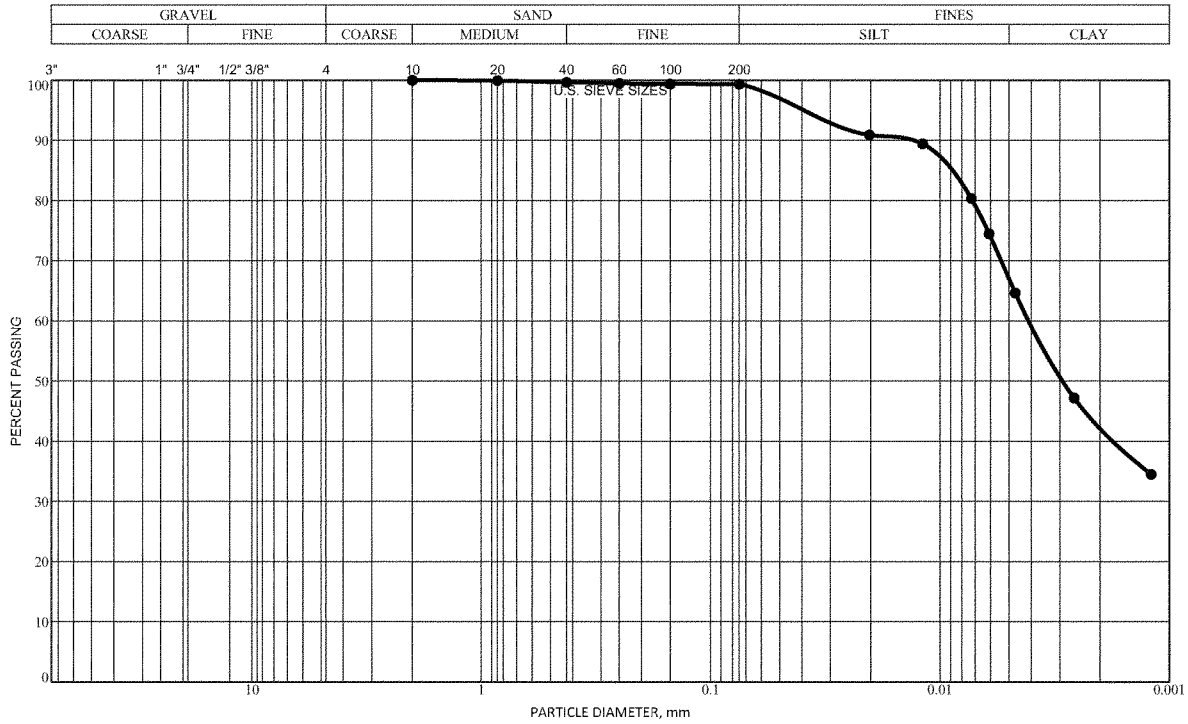

GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
0.001
BRAUN INTERTEC
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 10-105MU SAMPLE: 5 DEPTH: 55.0'-57.0'
GRAVEL 3.4%
SAND 4.4%
SILT 14.4%
CLAY 77.8%
D60=0.002 Cu=
D10= Cc=
D10=
CLASSIFICATION:
FAT CLAY, brown (CH)
Maple River, Argusville Formation
Braun Intertec Corporation
BL-10-10065
GS ASTM BL-10-10065.GPJ BRAUN.GDT 3/8/11 12:55


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
0.001
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 10-105MU SAMPLE: 6 DEPTH: 67.0'-69.0'
GRAVEL 3.5%
SAND 37.2%
SILT 35.0%
CLAY 24.3%
D60=0.078
D30=0.008
D10=
Cu=
Cc=
CLASSIFICATION:
SANDY LEAN CLAY, brown (CL)
Maple River, Till Formation
BRAUN INTERTEC
Braun Intertec Corporation
BL-10-10065
GS ASTM BL-10-10065.GPJ BRAUN.GDT 3/4/11 12:55

GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
BRAUN INTERTEC
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 10-105MU SAMPLE: 7 DEPTH: 77.0'-79.0'
GRAVEL 4.9%
SAND 37.0%
SILT 31.6%
CLAY 26.5%
D60=0.085
D30=0.007
D10=
Cu=
Cc=
CLASSIFICATION:
SANDY LEAN CLAY, brown (CL)
Maple River, Till Formation
Braun Intertec Corporation
BL-10-10065


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
10
1
0.1
0.01
0.001
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-107MU SAMPLE: 1 DEPTH: 20.0'-22.0'
GRAVEL 0.0%
SAND 0.3%
SILT 20.2%
CLAY 79.5%
D60=0.002 Cu=
D30= Cc=
D10=
CLASSIFICATION:
FAT CLAY, brown (CH)
ND RRCS, MN, Brenna
BRAUN INTERTEC
Braun Intertec Corporation
BL-10-10065

GRAIN SIZE ACCUMULATION CURVE (ASTM)



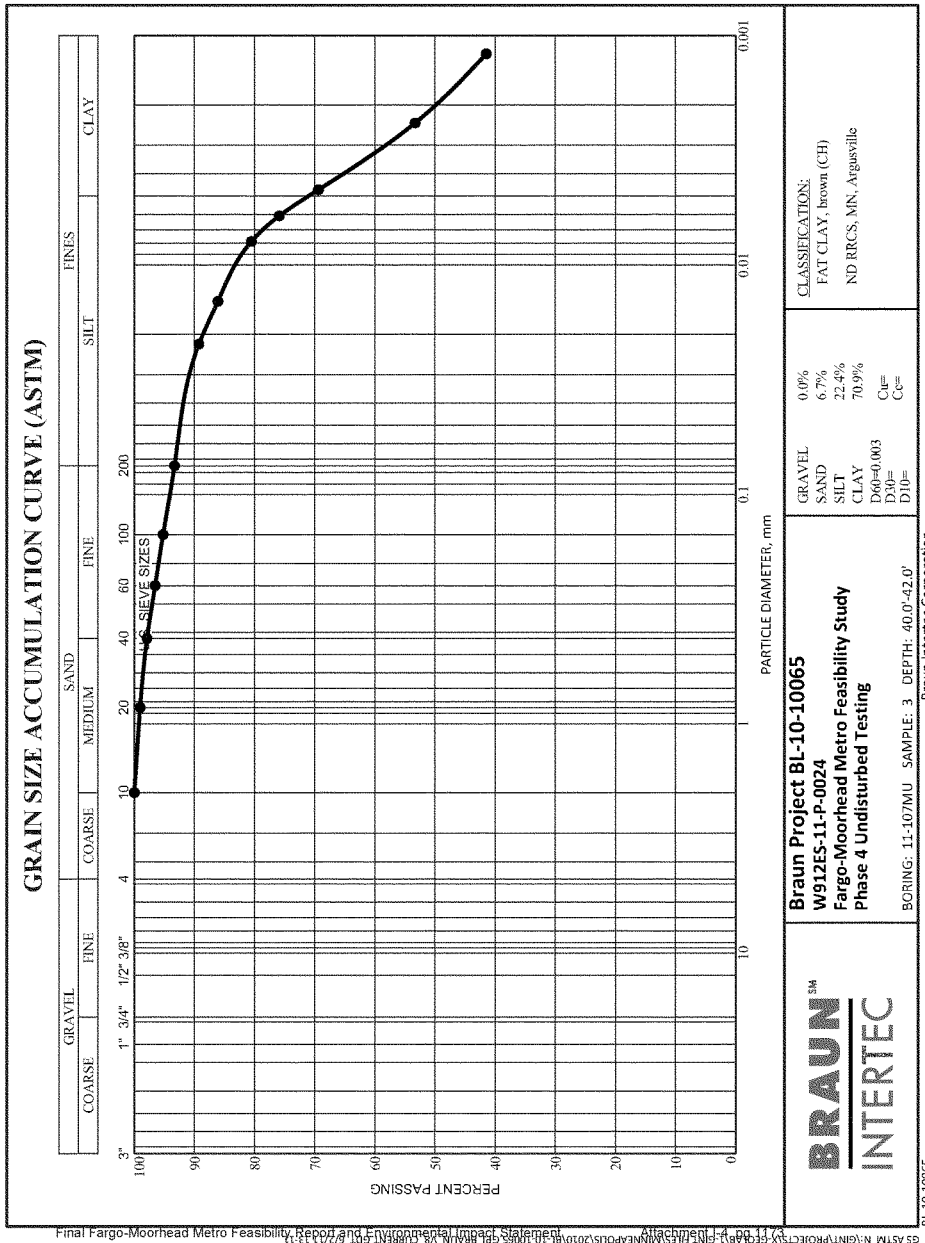
BRAUN INTERTEC

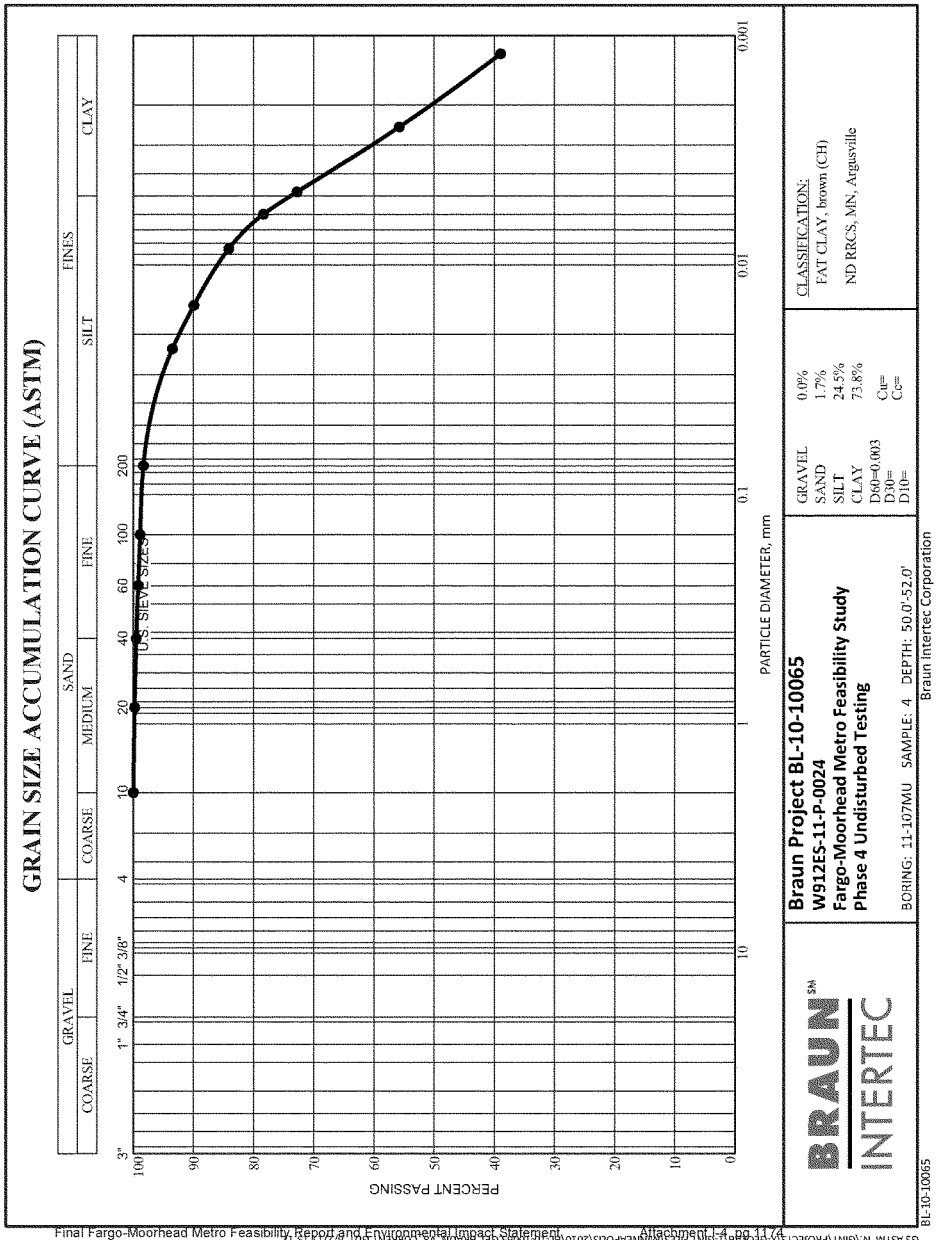
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

BORING: 11-107MU SAMPLE: 2 DEPTH: 30.0'-32.0'

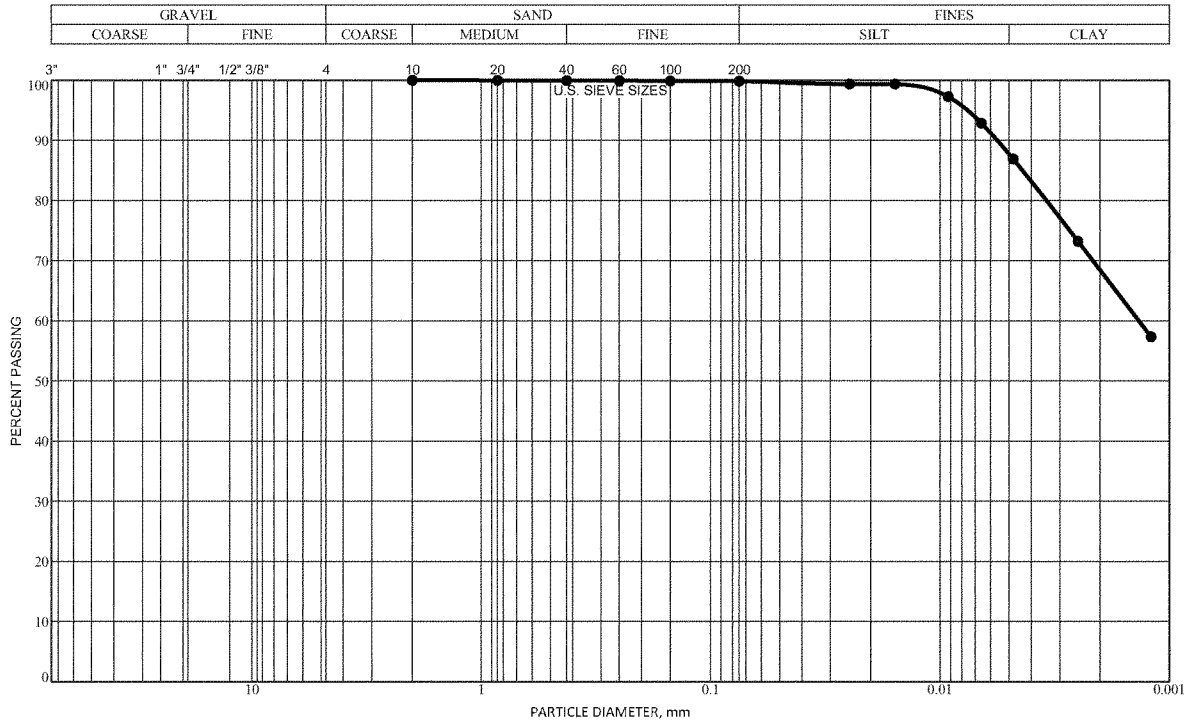
GRAVEL	0.0%
SAND	0.7%
SILT	32.3%
CLAY	67.0%
D60=0.004	Cu=
D30=	Cc=
D10=	

CLASSIFICATION:
FAT CLAY, brown (CH)
ND RRCS, MN, Brenna


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
0.001
BRAUN INTERTEC
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-107MU SAMPLE: 3 DEPTH: 40.0'-42.0'
GRAVEL 0.0%
SAND 6.7%
SILT 22.4%
CLAY 70.9%
D60=0.003
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY, brown (CH)
ND RRCS, MN, Argusville
Braun Intertec Corporation
BL-10-10065


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
US SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
0.001
Braun Project BL-10-10065
W912E5-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-107MU SAMPLE: 4 DEPTH: 50.0'-52.0'
GRAVEL 0.0%
SAND 1.7%
SILT 24.5%
CLAY 73.8%
D60=0.003
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY, brown (CH)
ND RRCS, MN, Argusville
BRAUN INTERTEC
Braun Intertec Corporation
BL-10-10065

GRAIN SIZE ACCUMULATION CURVE (ASTM)



BRAUN INTERTEC

Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

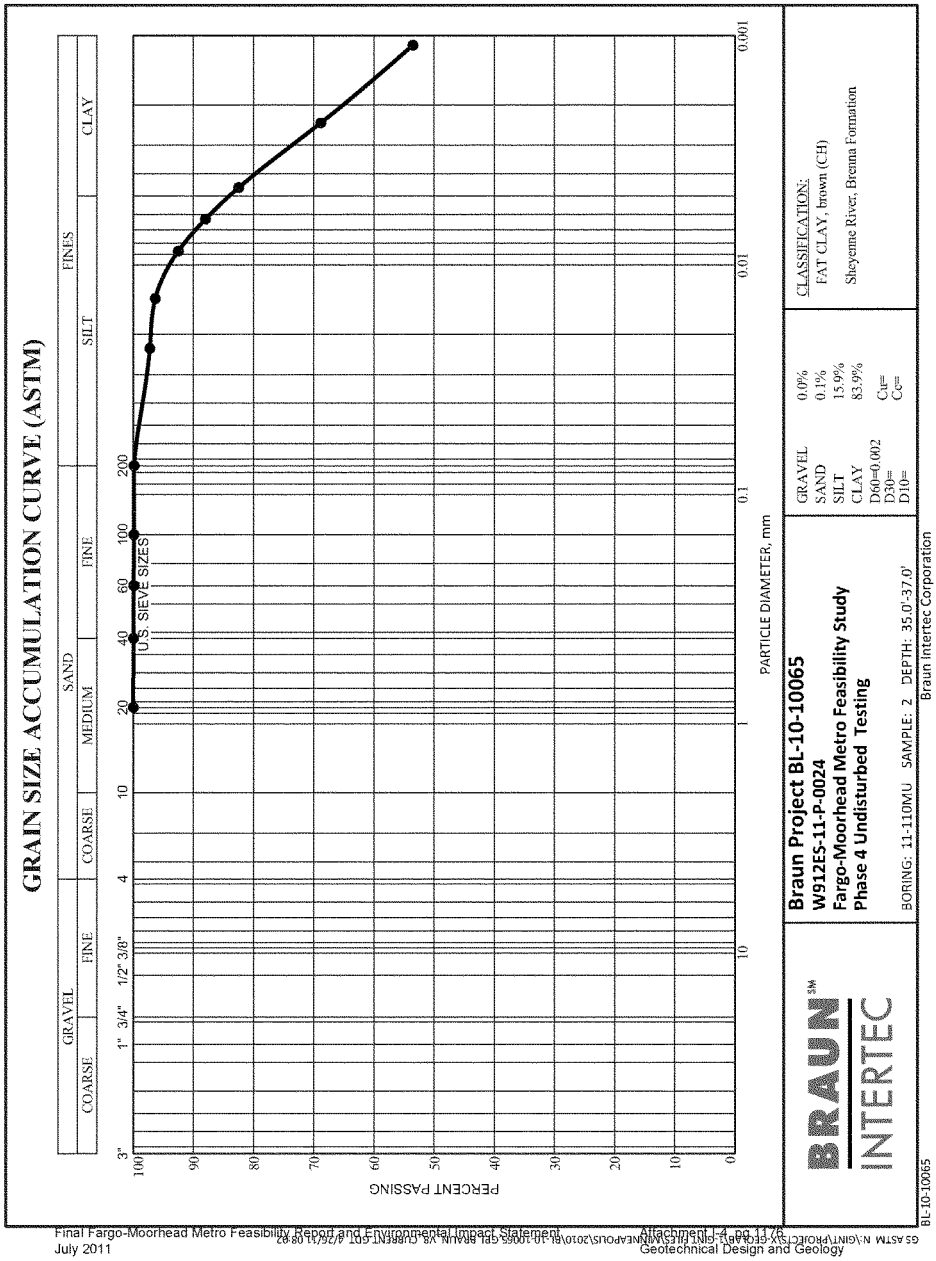
BORING: 11-110MU SAMPLE: 1 DEPTH: 25.0'-27.0'

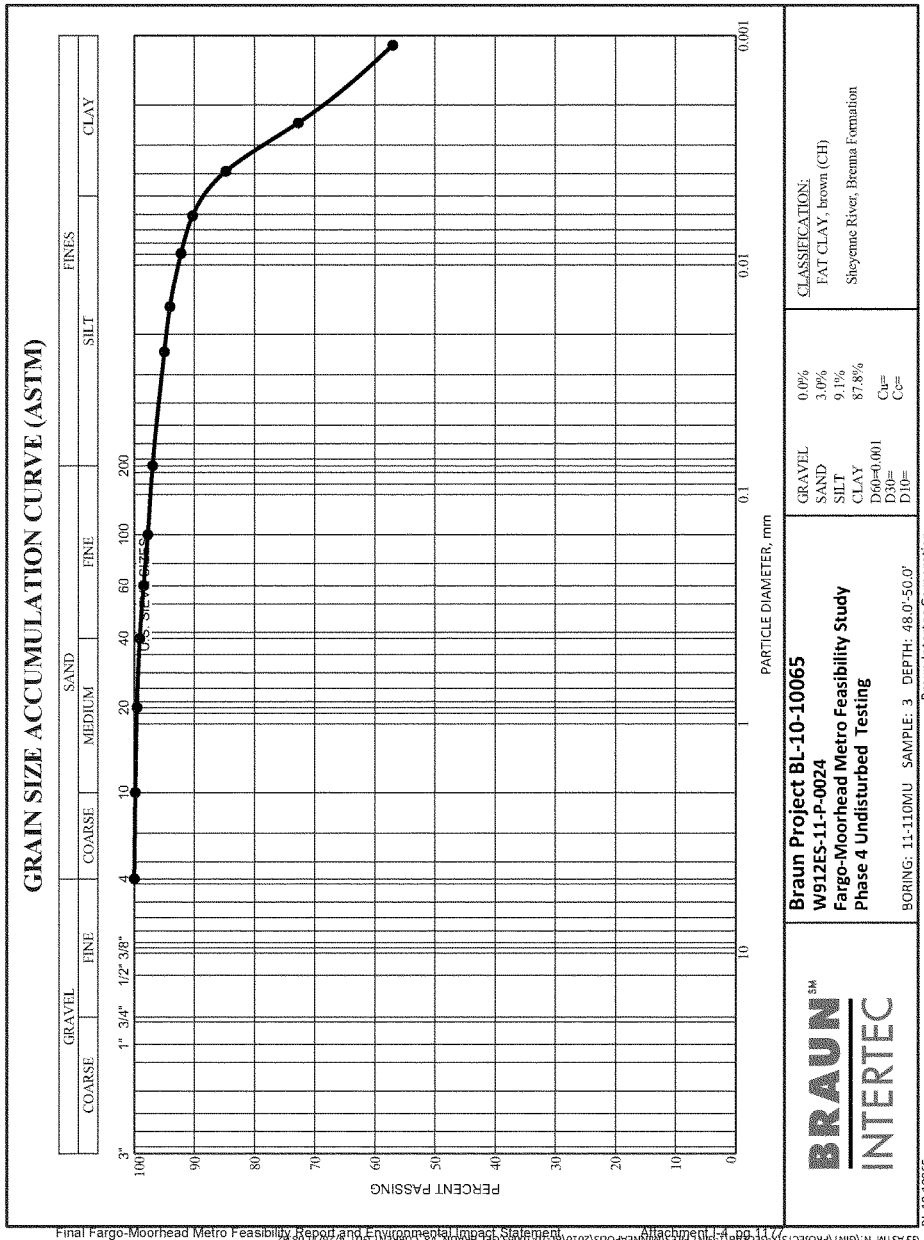
GRAVEL	0.0%
SAND	0.1%
SILT	12.2%
CLAY	87.7%
D60=0.001	Cu=
D30=	Cc=
D10=	

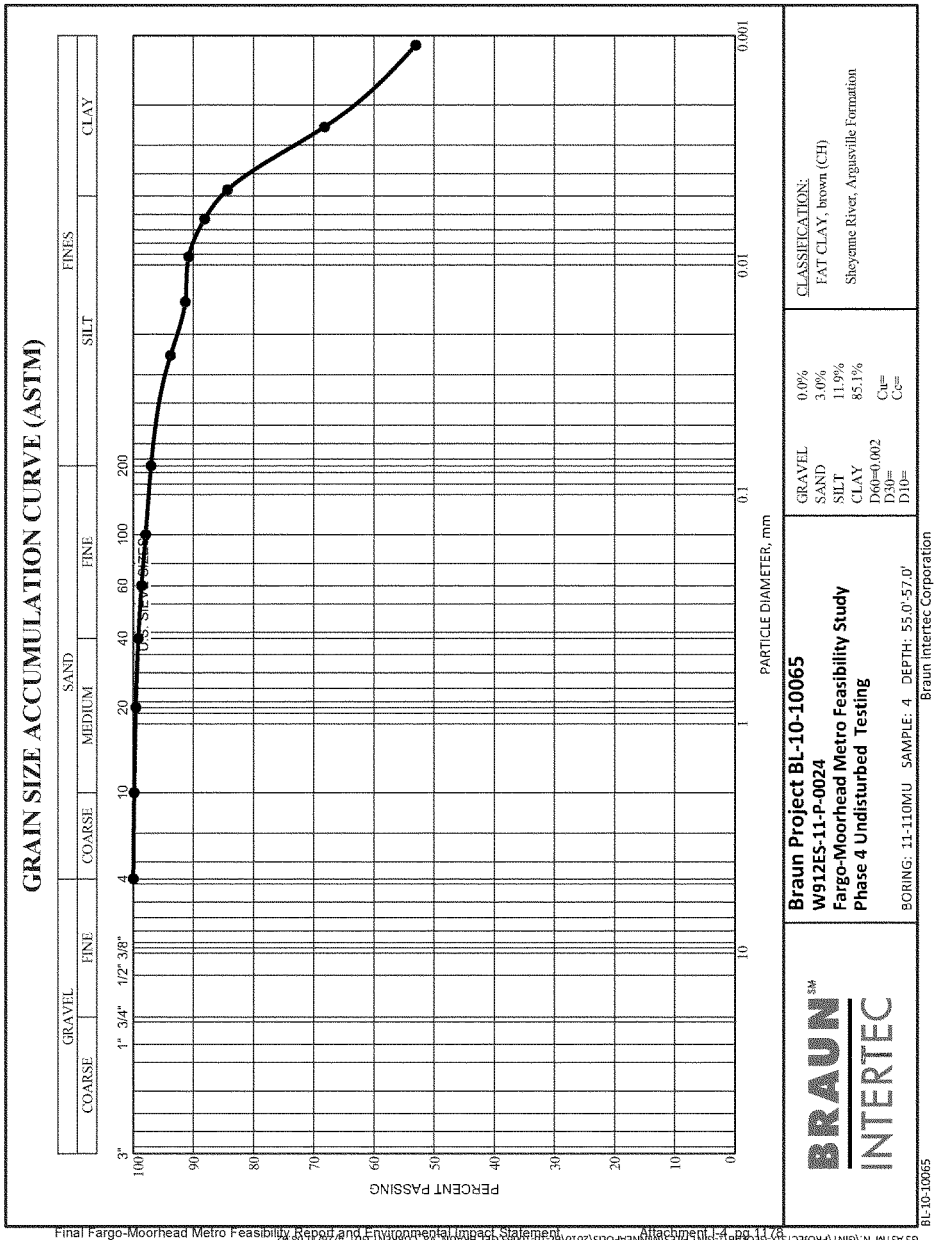
CLASSIFICATION:
FAT CLAY, brown (CH)

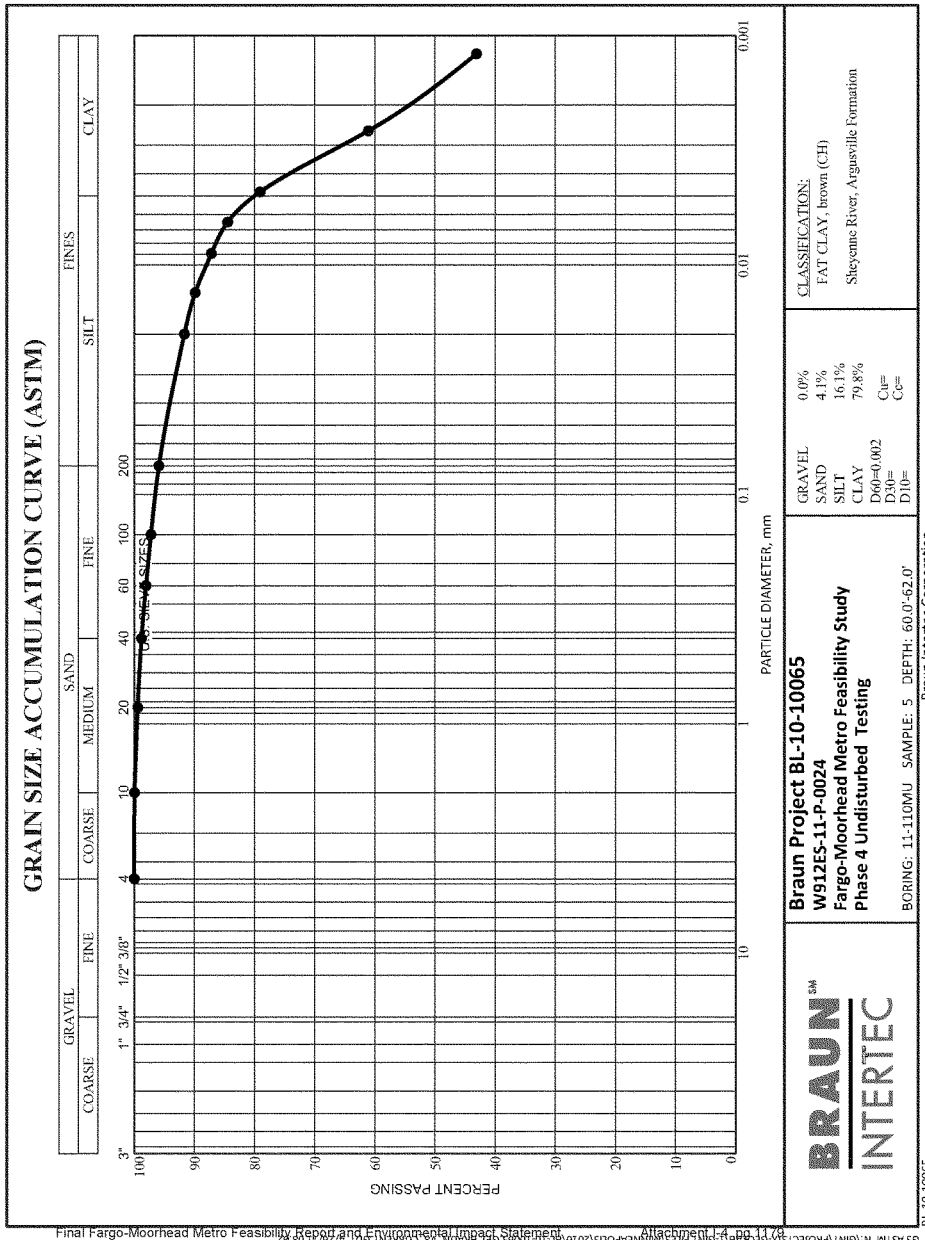
Sheyenne River, OX Brenna Formation

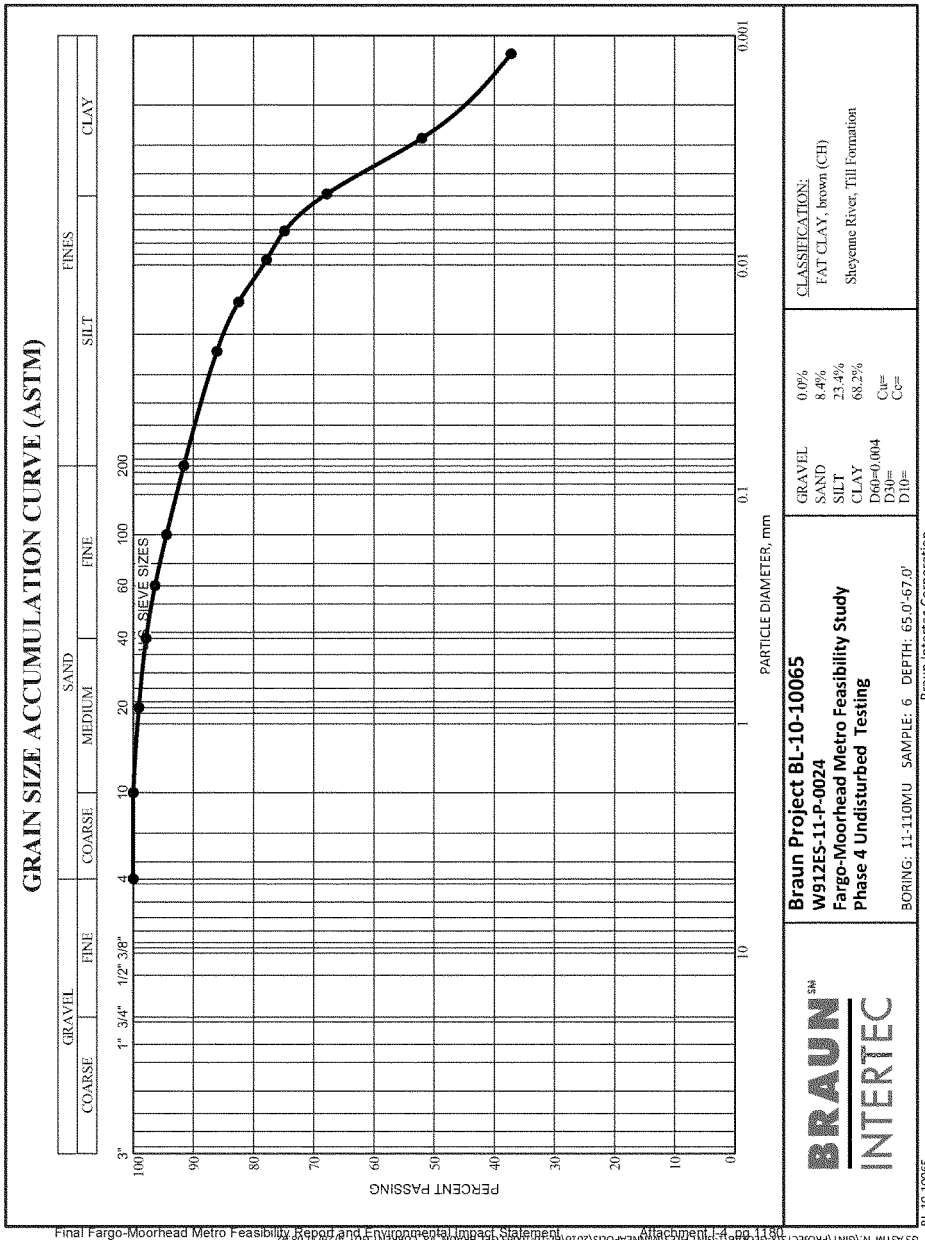
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Attachment H-4 Pg 1175
Geotechnical Design and Geology

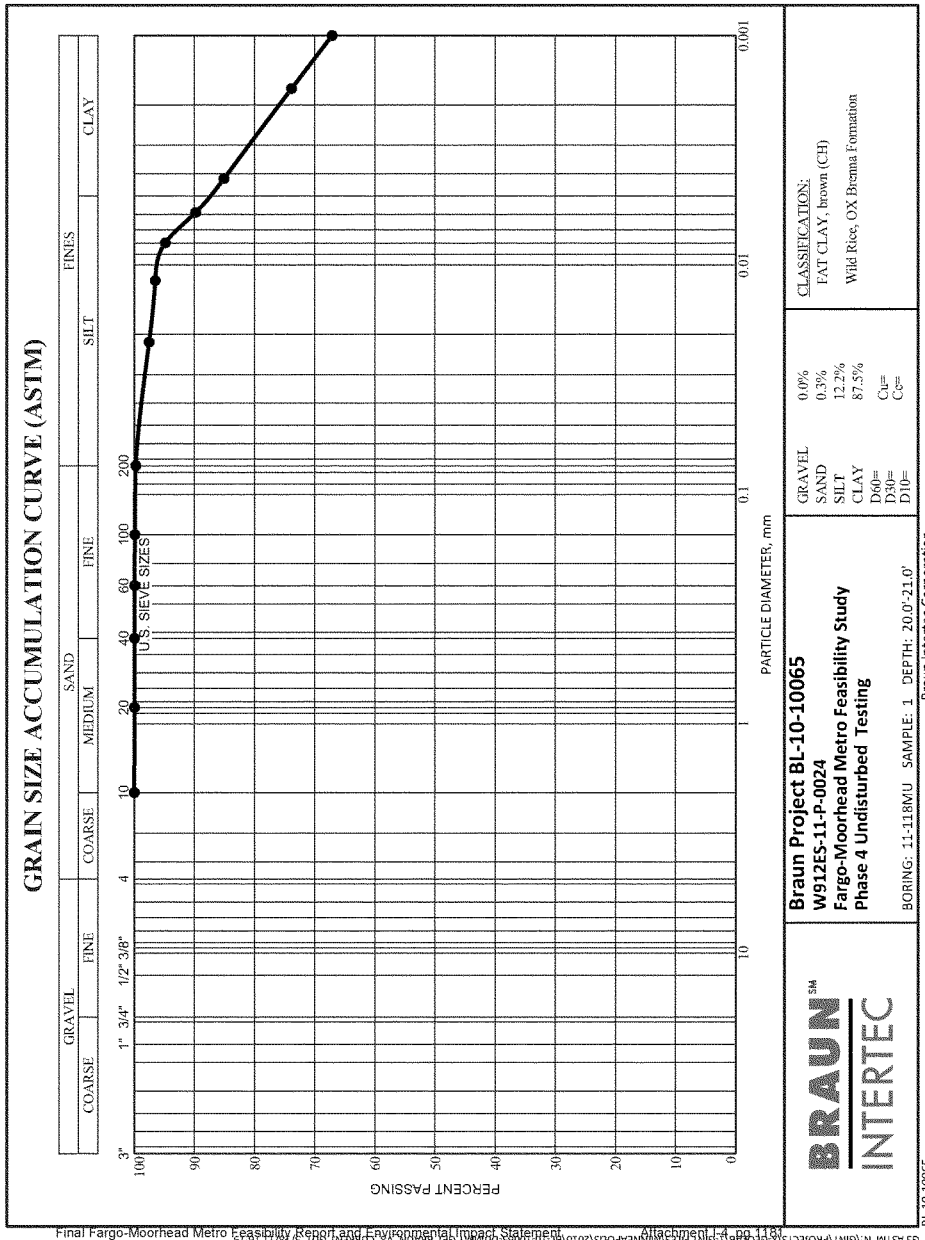

GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
Braun Project BL-10-10065
W912E5-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-110MU SAMPLE: 2 DEPTH: 35.0'-37.0'
GRAVEL 0.0%
SAND 0.1%
SILT 15.9%
CLAY 83.9%
D60=0.002
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY, brown (CH)
Sheyenne River, Brenna Formation
BRAUN INTERTEC
Braun Intertec Corporation
BL-10-10065

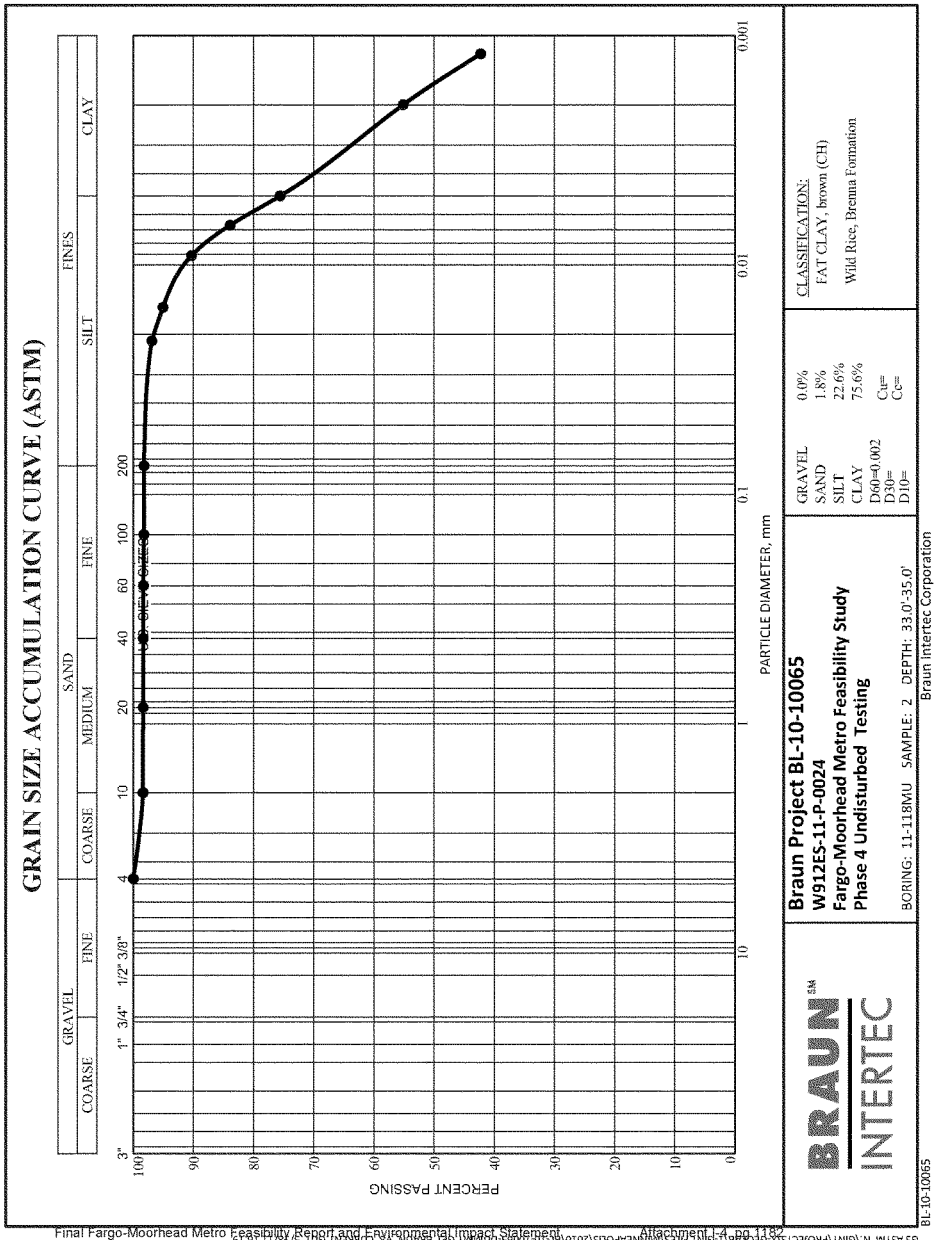

GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
US STD SIEVE SIZE
PERCENT PASSING
PARTICLE DIAMETER, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
0.001
BRAUN INTERTEC
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-110MU SAMPLE: 3 DEPTH: 48.0'-50.0'
Braun Intertec Corporation
GRAVEL 0.0%
SAND 3.0%
SILT 9.1%
CLAY 87.8%
D60=0.001
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY, brown (CH)
Sheyenne River, Brenna Formation
BL-10-10065

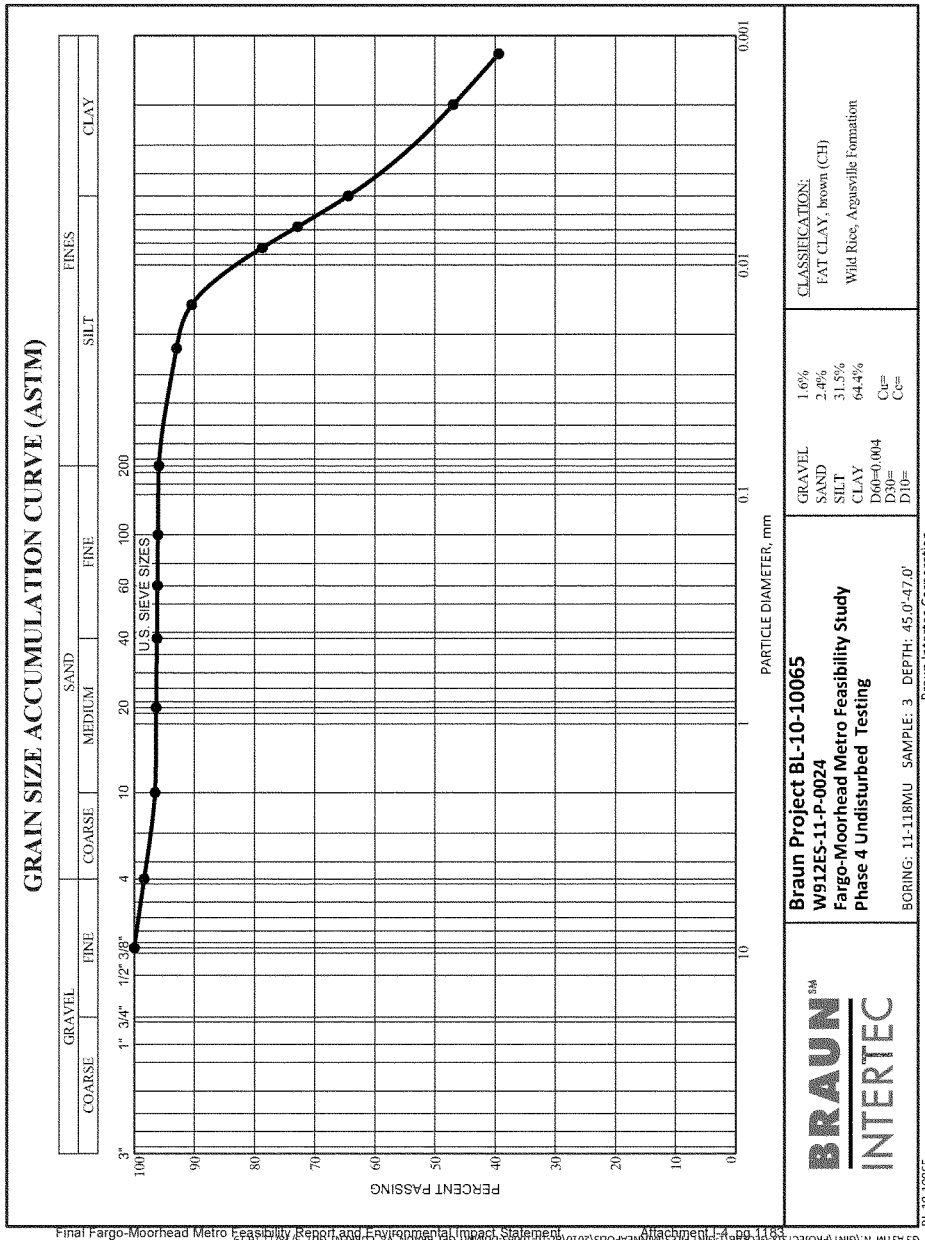

GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
PERCENT PASSING
PARTICLE DIAMETER, mm
0.001
0.01
0.1
1
10
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-110MU SAMPLE: 4 DEPTH: 55.0'-57.0'
GRAVEL 0.0%
SAND 3.0%
SILT 11.9%
CLAY 85.1%
D60=0.002 Cu=
D30= Cc=
D10=
CLASSIFICATION:
FAT CLAY, brown (CH)
Sheyenne River, Argusville Formation
BRAUN INTERTEC
Braun Intertec Corporation
BL-10-10065

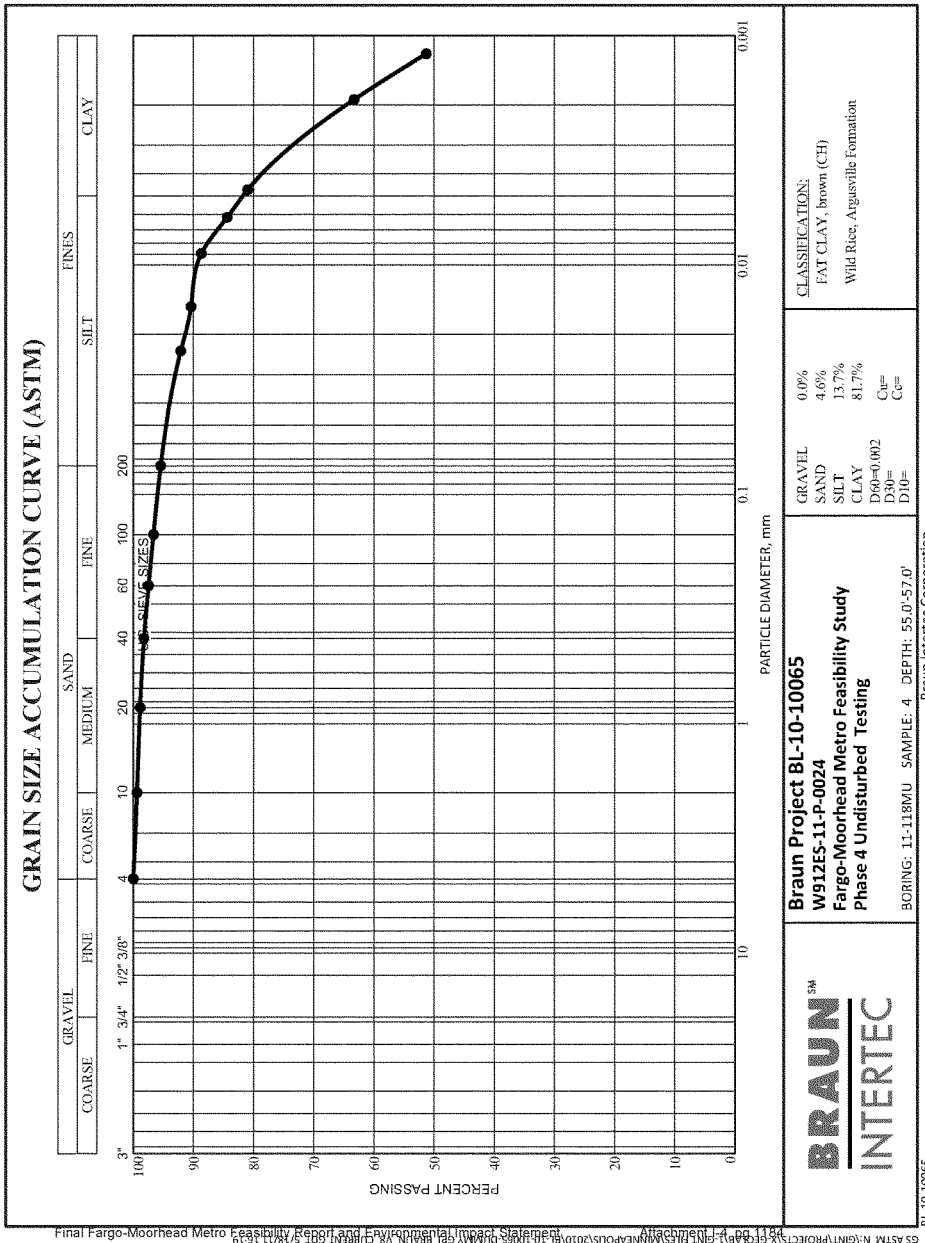

GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
US SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
BRAUN INTERTEC
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-110MU SAMPLE: 5 DEPTH: 60.0'-62.0'
GRAVEL 0.0%
SAND 4.1%
SILT 16.1%
CLAY 79.8%
D60=0.002
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY, brown (CH)
Sheyenne River, Argusville Formation
Braun Intertec Corporation
BL-10-10065

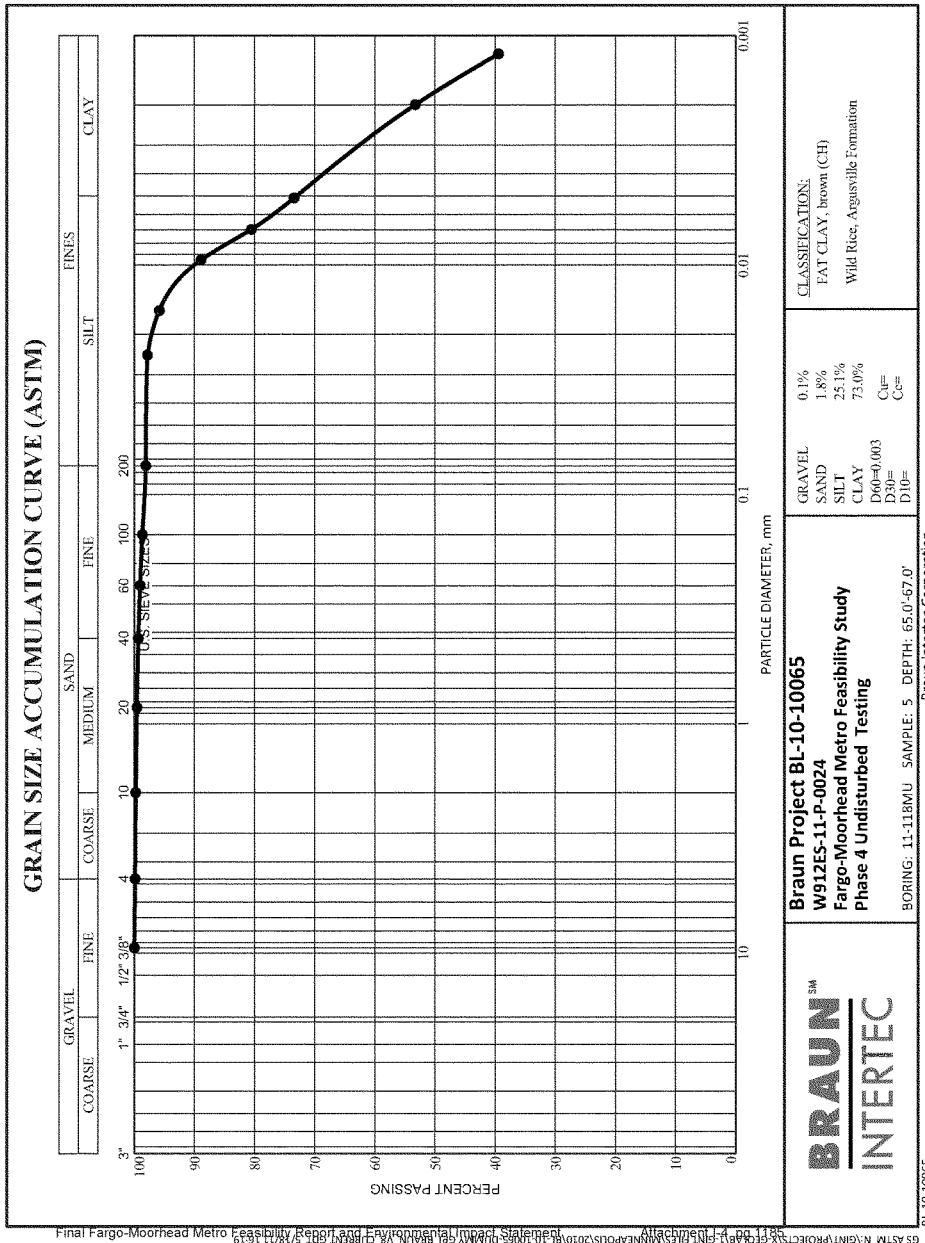

GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
Braun Project BL-10-10065
W912E5-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-110MU SAMPLE: 6 DEPTH: 65.0'-67.0'
GRAVEL 0.0%
SAND 8.4%
SILT 23.4%
CLAY 68.2%
D60=0.004
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY, brown (CH)
Sheyenne River, Till Formation
BRAUN INTERTEC
Braun Intertec Corporation
BL-10-10065

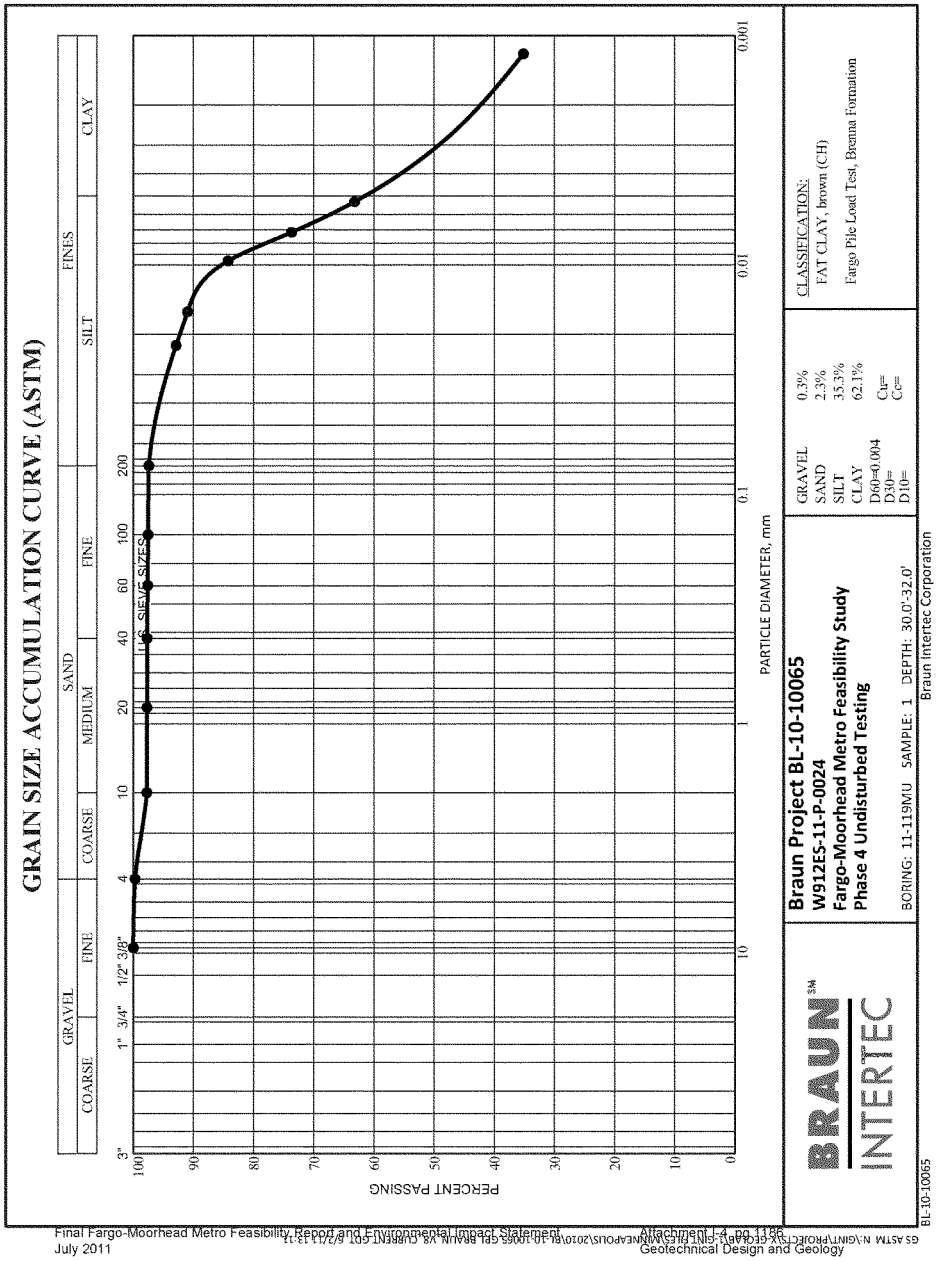

GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
0.001
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-118MU SAMPLE: 1 DEPTH: 20.0'-21.0'
GRAVEL 0.0%
SAND 0.3%
SILT 12.2%
CLAY 87.5%
D60=
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY, brown (CH)
Wild Rice, OX Brenna Formation
BRAUN INTERTEC
Braun Intertec Corporation
BL-10-10065
GS ASTM N:\GINT\PROJECTS\X-GEOLABS-SNT FILES\MINNEAPOLIS\2010\BI-10-10065 BRAUN GPJ BRAUN V8 CURRENT.GDT 5/18/11 16:19

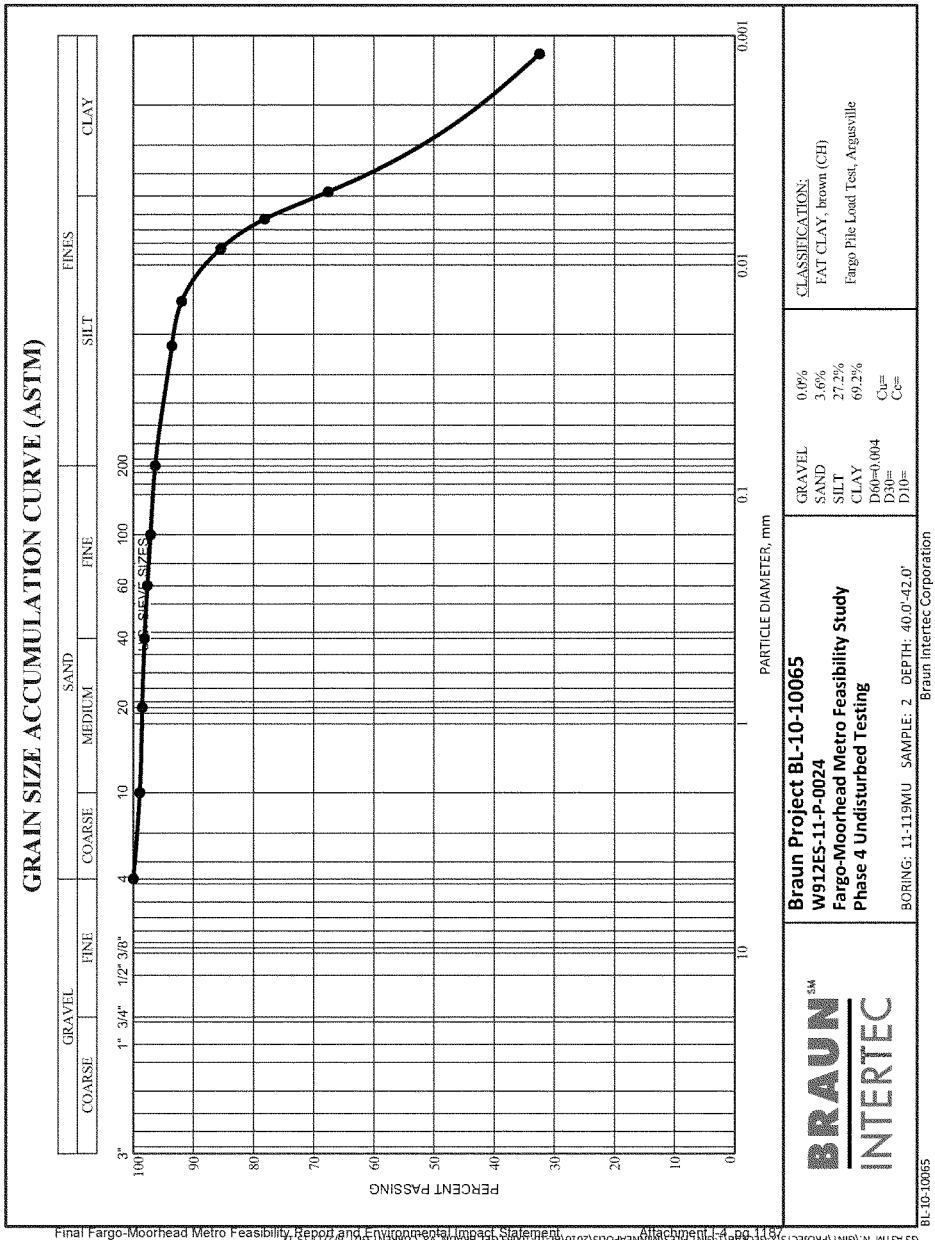

GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
PERCENT PASSING
PARTICLE DIAMETER, mm
0.001
0.01
0.1
1
10
Braun Project BL-10-10065
W912E5-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-118MU SAMPLE: 2 DEPTH: 33.0'-35.0'
GRAVEL 0.0%
SAND 1.8%
SILT 22.6%
CLAY 75.6%
D60=0.002
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY, brown (CH)
Wild Rice, Brenna Formation
BRAUN INTERTEC
Braun Intertec Corporation
BL-10-10065

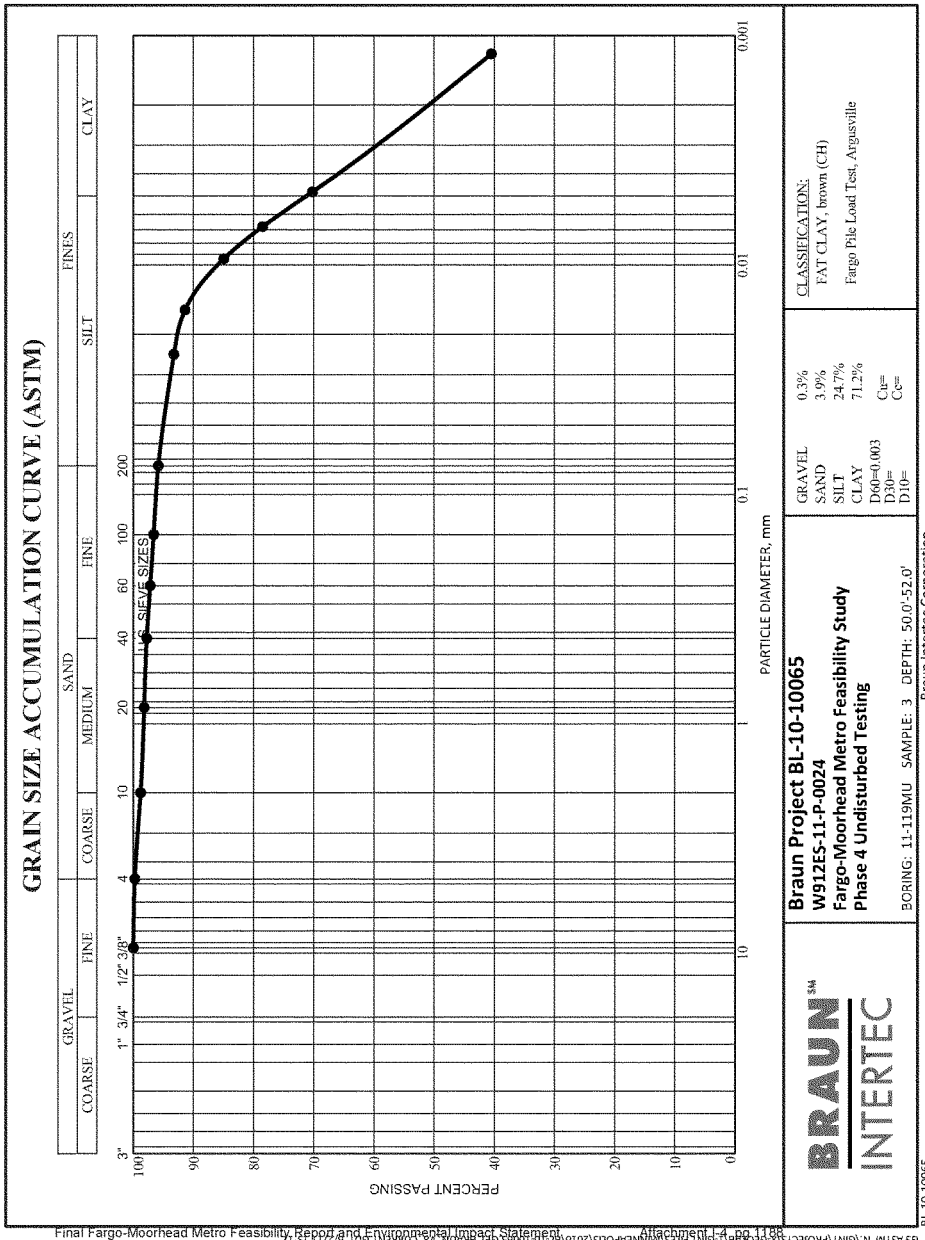

GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
0.001
BRAUN INTERTEC
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-118MU SAMPLE: 3 DEPTH: 45.0'-47.0'
GRAVEL 1.6%
SAND 2.4%
SILT 31.5%
CLAY 64.4%
D60=0.004 Cu=
D30= Cc=
D10=
CLASSIFICATION:
FAT CLAY, brown (CH)
Wild Rice, Argusville Formation
Braun Intertec Corporation
BL-10-10065

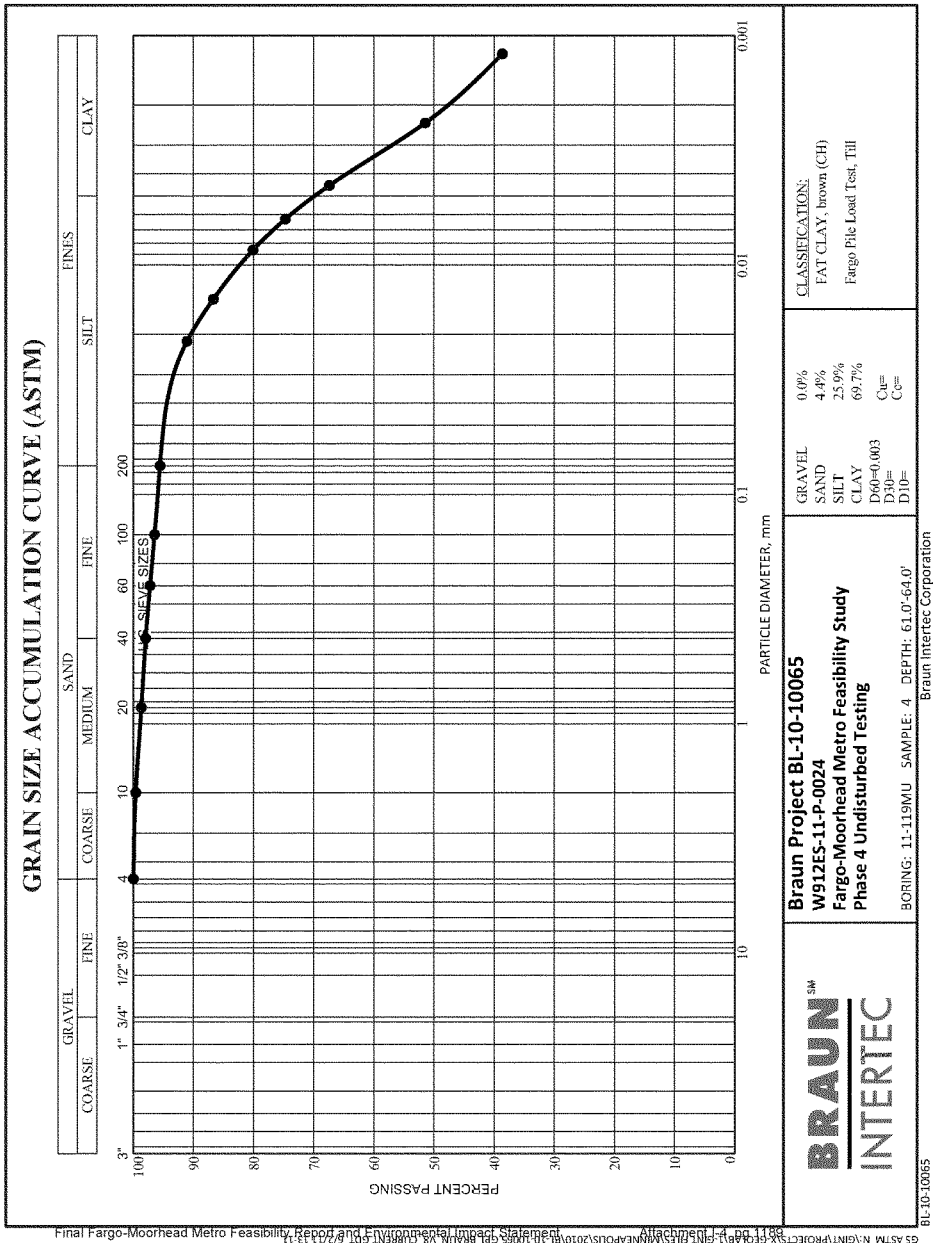

GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
US SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
0.001
Braun Project BL-10-10065
W912E5-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-118MU SAMPLE: 4 DEPTH: 55.0'-57.0'
GRAVEL 0.0%
SAND 4.6%
SILT 13.7%
CLAY 81.7%
D60=0.002
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY, brown (CH)
Wild Rice, Argusville Formation
BRAUN INTERTEC
Braun Intertec Corporation
BL-10-10065


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
US SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
0.001
BRAUN INTERTEC
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-118MU SAMPLE: 5 DEPTH: 65.0'-67.0'
GRAVEL 0.1%
SAND 1.8%
SILT 25.1%
CLAY 73.0%
D60=0.003
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY, brown (CH)
Wild Rice, Argusville Formation
Braun Intertec Corporation
BL-10-10065


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
SAND
FINES
COARSE
FINE
COARSE
MEDIUM
FINE
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
#6 SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
100
90
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
0.001
Braun Project BL-10-10065
W912E5-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-119MU SAMPLE: 1 DEPTH: 30.0'-32.0'
GRAVEL 0.3%
SAND 2.3%
SILT 35.3%
CLAY 62.1%
D60=0.004
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY, brown (CH)
Fargo Pile Load Test, Brenna Formation
BRAUN INTERTEC
Braun Intertec Corporation
BL-10-10065


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
#4
#10
#20
#40
#60
#100
#200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
BRAUN INTERTEC
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-119MU SAMPLE: 2 DEPTH: 40.0'-42.0'
GRAVEL 0.0%
SAND 3.6%
SILT 27.2%
CLAY 69.2%
D60=0.004
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY, brown (CH)
Fargo Pile Load Test, Argusville
Braun Intertec Corporation
BL-10-10065


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
#6 SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
10
1
0.1
0.01
0.001
100
90
80
70
60
50
40
30
20
10
0
Braun Project BL-10-10065
W912E5-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-119MU SAMPLE: 3 DEPTH: 50.0'-52.0'
GRAVEL 0.3%
SAND 3.9%
SILT 24.7%
CLAY 71.2%
D60=0.003
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY, brown (CH)
Fargo Pile Load Test, Argusville
BRAUN
INTERTEC
Braun Intertec Corporation
Geotechnical Design and Geology
BL-10-10065


GRAIN SIZE ACCUMULATION CURVE (ASTM)
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
FINES
SILT
CLAY
3"
1"
3/4"
1/2"
3/8"
4
10
20
40
60
100
200
U.S. SIEVE SIZES
PERCENT PASSING
PARTICLE DIAMETER, mm
10
1
0.1
0.01
0.001
Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing
BORING: 11-119MU SAMPLE: 4 DEPTH: 61.0'-64.0'
GRAVEL 0.0%
SAND 4.4%
SILT 25.9%
CLAY 69.7%
D60=0.003
D30=
D10=
Cu=
Cc=
CLASSIFICATION:
FAT CLAY, brown (CH)
Fargo Pile Load Test, Till
BRAUN INTERTEC
Braun Intertec Corporation
BL-10-10065

Sheet 1 of 1

Borehole	Depth feet	Liquid Limit	Plastic Limit	Plasticity Index	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Organic Content (%)	Specific Gravity	Electrical Resistivity (ohm-cm)
09-25MU	66	81	20	61	94.9	CH				2.714	
09-26MU-F	8	67	17	50						2.738	
09-27MU	6	75	18	57						2.712	
09-27MU	64	89	20	69	95.6	CH				2.704	
09-34MU	16	114	24	90	99.6	CH				2.704	

Fargo

Moorhead

LAB SUMMARY GEO LAB BL-09-03127-3.GPJ BRAUN.GDT 11/16/09 16:30

Braun Project BL-09-03127
W912ES-09-P-0115
Fargo-Moorhead Metro Feasibility Study
Fargo-Moorhead, ND

LABORATORY RESULTS SUMMARY

BRAUN INTERTEC

Sheet 1 of 1

Borehole	Depth feet	Liquid Limit	Plastic Limit	Plasticity Index	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Organic Content (%)	Specific Gravity	Electrical Resistivity (ohm-cm)
10-105MU	15	113	32	81	99.8	CH				2.777	
10-105MU	25	119	32	87	99.8	CH				2.72	
10-105MU	35	106	29	77	99.7	CH				2.764	
10-105MU	45	90	27	63	94.4	CH				2.709	
10-105MU	55	91	25	66	92.2	CH				2.698	
10-105MU	67	31	15	16	59.4	CL				2.676	
10-105MU	77	42	17	25	58.1	CL					

LAB SUMMARY GEO LAB BL-10-10065.GPJ BRAUN.GDT 3/4/11 12:52

Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

LABORATORY RESULTS SUMMARY

BRAUN INTERTEC

Sheet 1 of 1

Borehole	Depth feet	Liquid Limit	Plastic Limit	Plasticity Index	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Organic Content (%)	Specific Gravity	Electrical Resistivity (ohm-cm)
11-107MU	20-22	71	19	52	99.7	CH				2.741	
11-107MU	30-32	52	21	31	99.3	CH				2.76	
11-107MU	40-42	60	18	42	93.3	CH				2.681	
11-107MU	50-52	63	19	44	98.3	CH				2.705	
11-119MU	30-32	56	19	37	97.4	CH				2.704	
11-119MU	40-42	56	22	34	96.4	CH				2.698	
11-119MU	50-52	62	19	43	95.8	CH				2.712	
11-119MU	61-64	66	19	47	95.6	CH				2.702	

LAB SUMMARY GEO LAB N:\GINT\PROJECTS\X-GEOLAB\1-GINT FILES\MINNEAPOLIS\2010\BL-10-10065-DUMMY.GPJ BRAUN_V8_CURRENT.GDT 6/2/11 13:14

Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

LABORATORY RESULTS SUMMARY

BRAUN INTERTEC

Sheet 1 of 1

Borehole	Depth feet	Liquid Limit	Plastic Limit	Plasticity Index	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Organic Content (%)	Specific Gravity	Electrical Resistivity (ohm-cm)
11-110MU	25-27	82	23	59	99.9	CH				2.744	
11-110MU	35-37	95	28	67	99.9	CH				2.718	
11-110MU	48-50	86	22	64	97.0	CH				2.71	
11-110MU	55-57	85	21	64	97.0	CH				2.693	
11-110MU	60-62	70	22	48	95.9	CH				2.679	
11-110MU	65-67	66	20	46	91.6	CH				2.689	

LAB SUMMARY GEO LAB N:\GINT\PROJECTS\X-GEOLAB\1-GINT FILES\MINNEAPOLIS\2010\BL-10-10065-DUMMY.GPJ BRAUN_V8_CURRENT.GDT 4/26/11 08:01

Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

LABORATORY RESULTS SUMMARY

BRAUN INTERTEC

Sheet 1 of 1

Borehole	Depth feet	Liquid Limit	Plastic Limit	Plasticity Index	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Organic Content (%)	Specific Gravity	Electrical Resistivity (ohm-cm)
11-118MU	201	91	24	67	99.7	CH				2.767	
11-118MU	332	72	19	53	98.2	CH				2.7	
11-118MU	453	60	17	43	95.9	CH				2.693	
11-118MU	554	77	22	55	95.4	CH				2.687	
11-118MU	655	61	20	41	98.1	CH				2.695	

Braun Project BL-10-10065
W912ES-11-P-0024
Fargo-Moorhead Metro Feasibility Study
Phase 4 Undisturbed Testing

LABORATORY RESULTS SUMMARY

BRAUN INTERTEC

LAB SUMMARY GEO LAB N:\GINT\PROJECTS\X-GEOLAB\1-GINT FILES\MINNEAPOLIS\2010\BL-10-10065-DUMMY.GPJ BRAUN_V8_CURRENT.GDT 5/18/11 16:20

Attachment I-5: Selected Parameters Summary

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Summary of Selected Parameters
Unit: ALL

Computed By: KAH
Date: 4/21/2010
Revised By: KAH
Date: 9/2/2010

Selected 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	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) Alluvium 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.

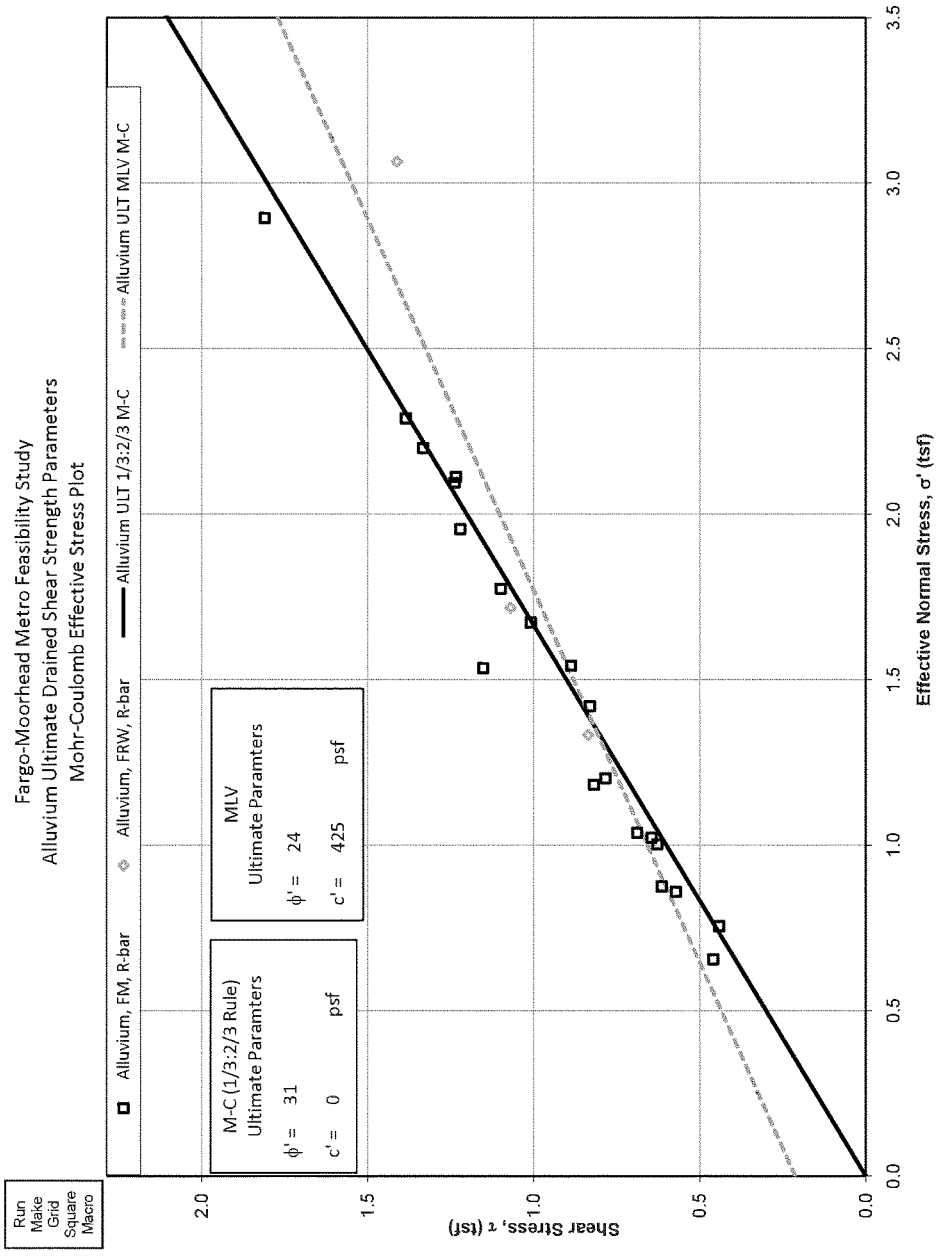
(7) For the Oxidized Brenna, Brenna, and Argusville formations, a curvilinear shear strength envelope was developed for the effective stress analysis of the diversion channel excavated slope. The curvilinear envelop is one standard deviation less than the most likely value.

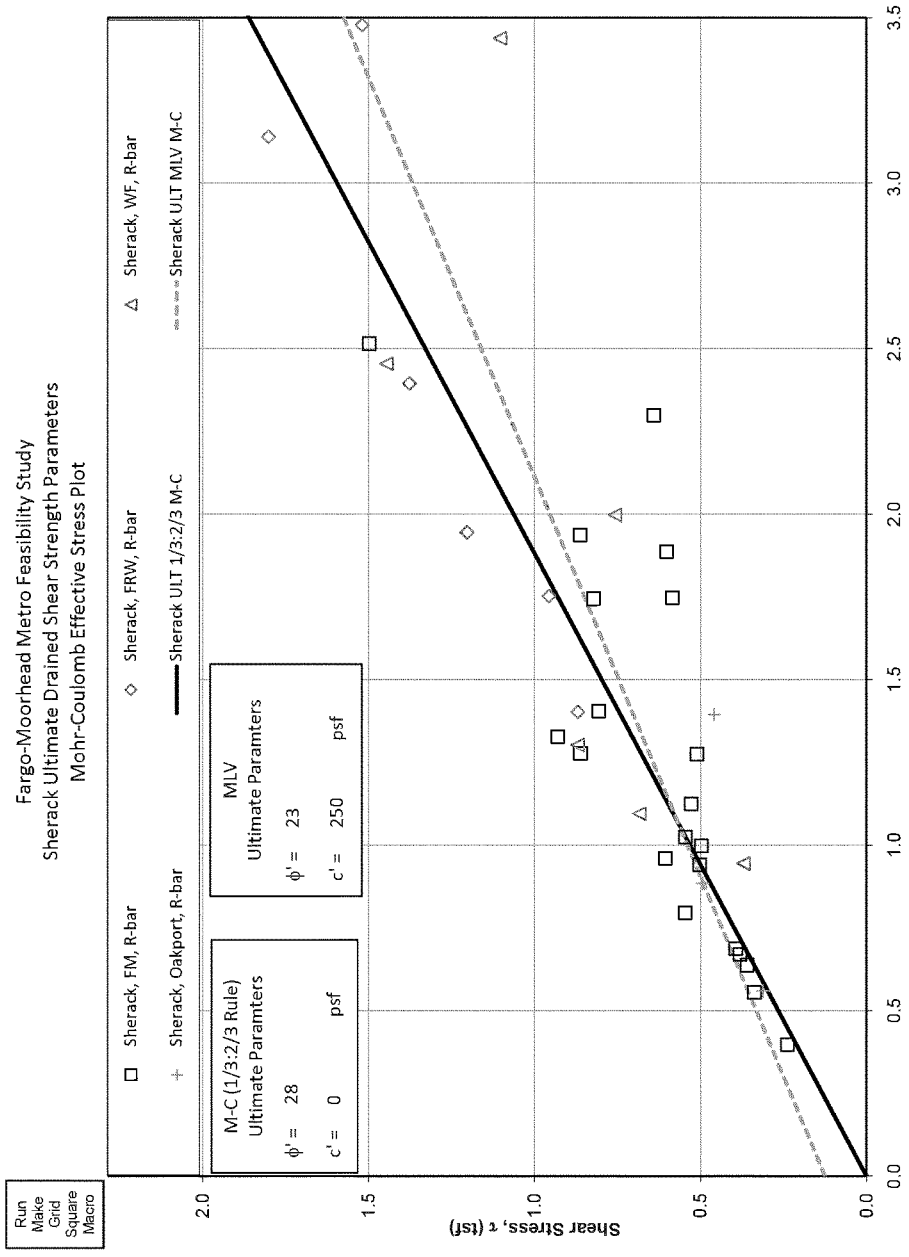
(8) Assumed values based on literature review.

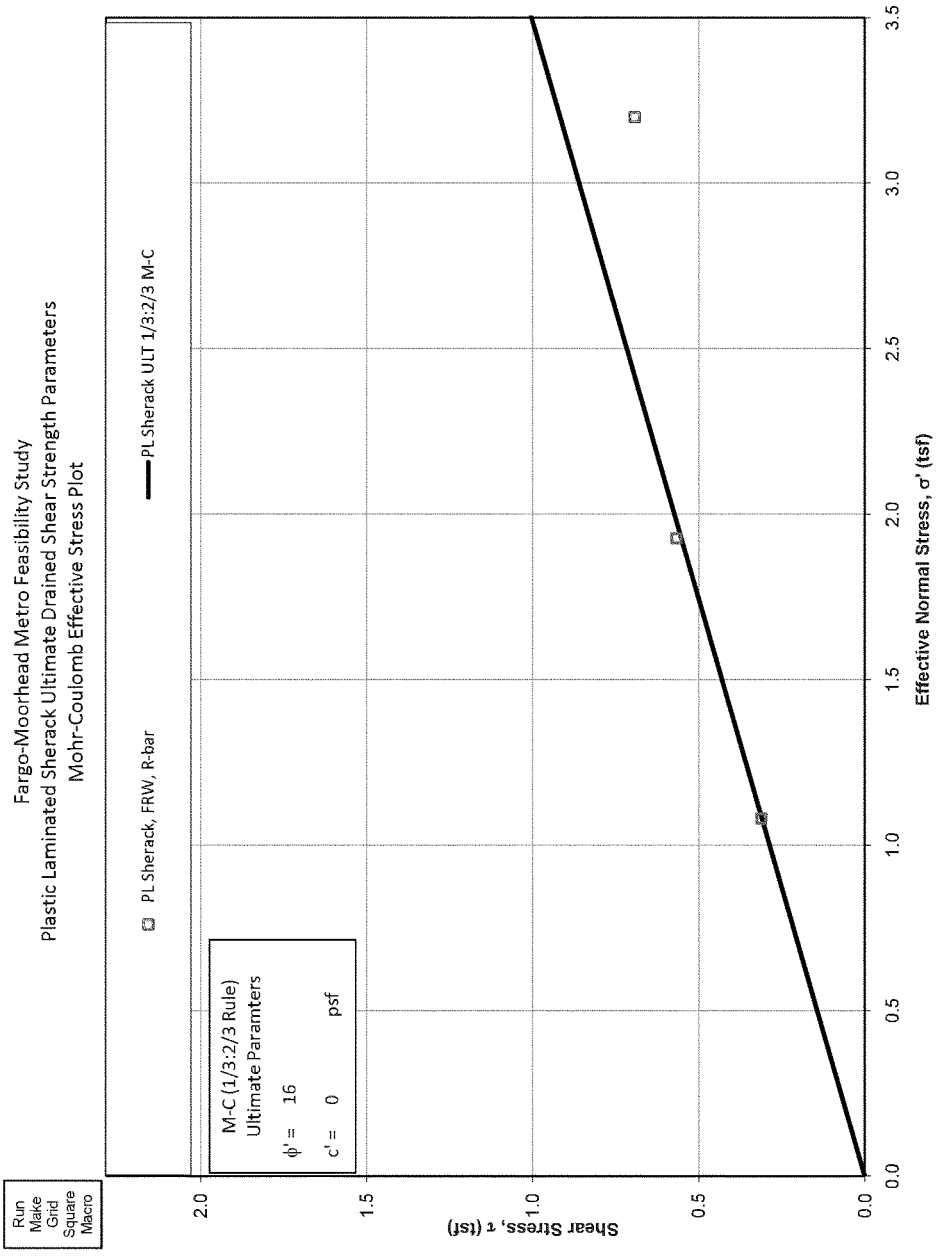
(9) Assumed values based judgment.

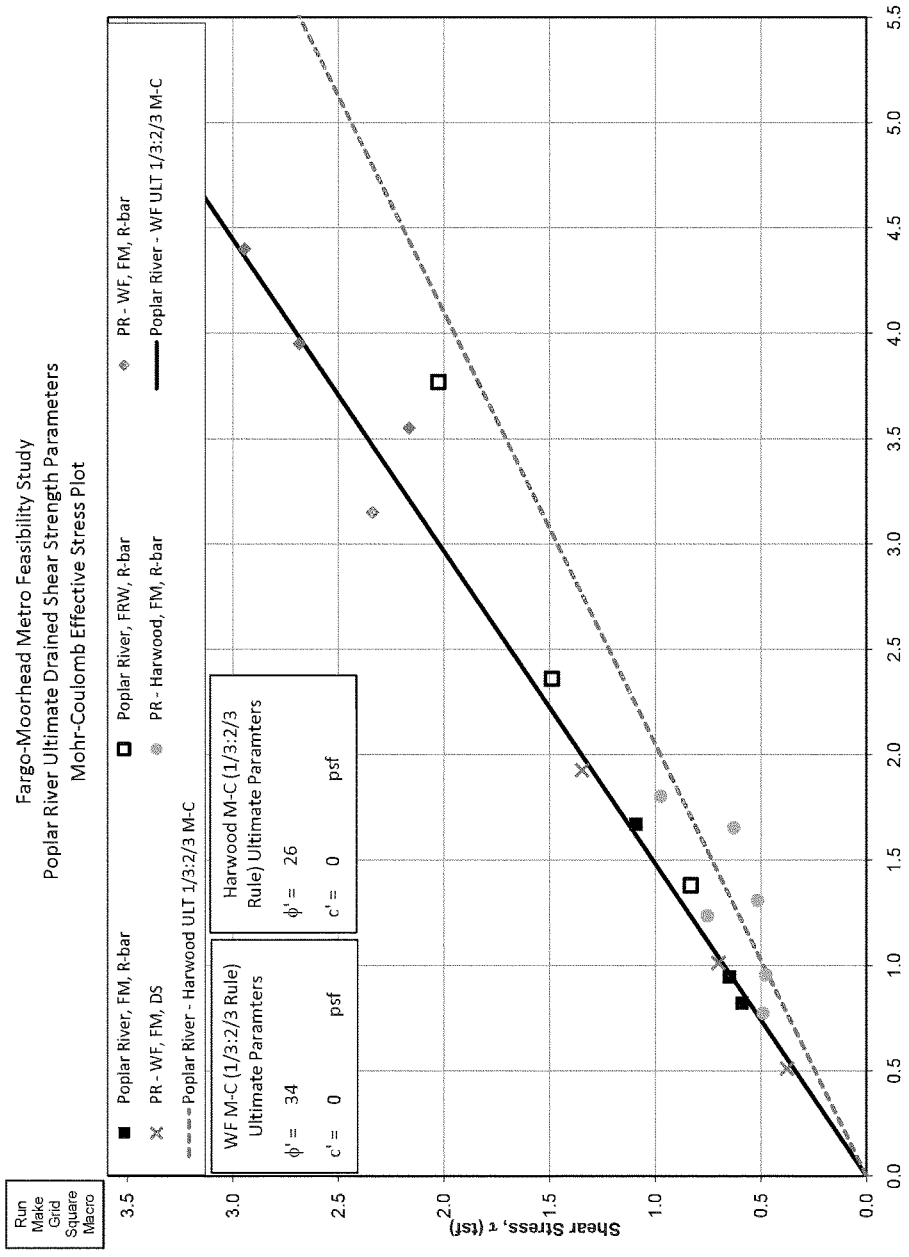
Curve-linear Channel Modeling Parameters

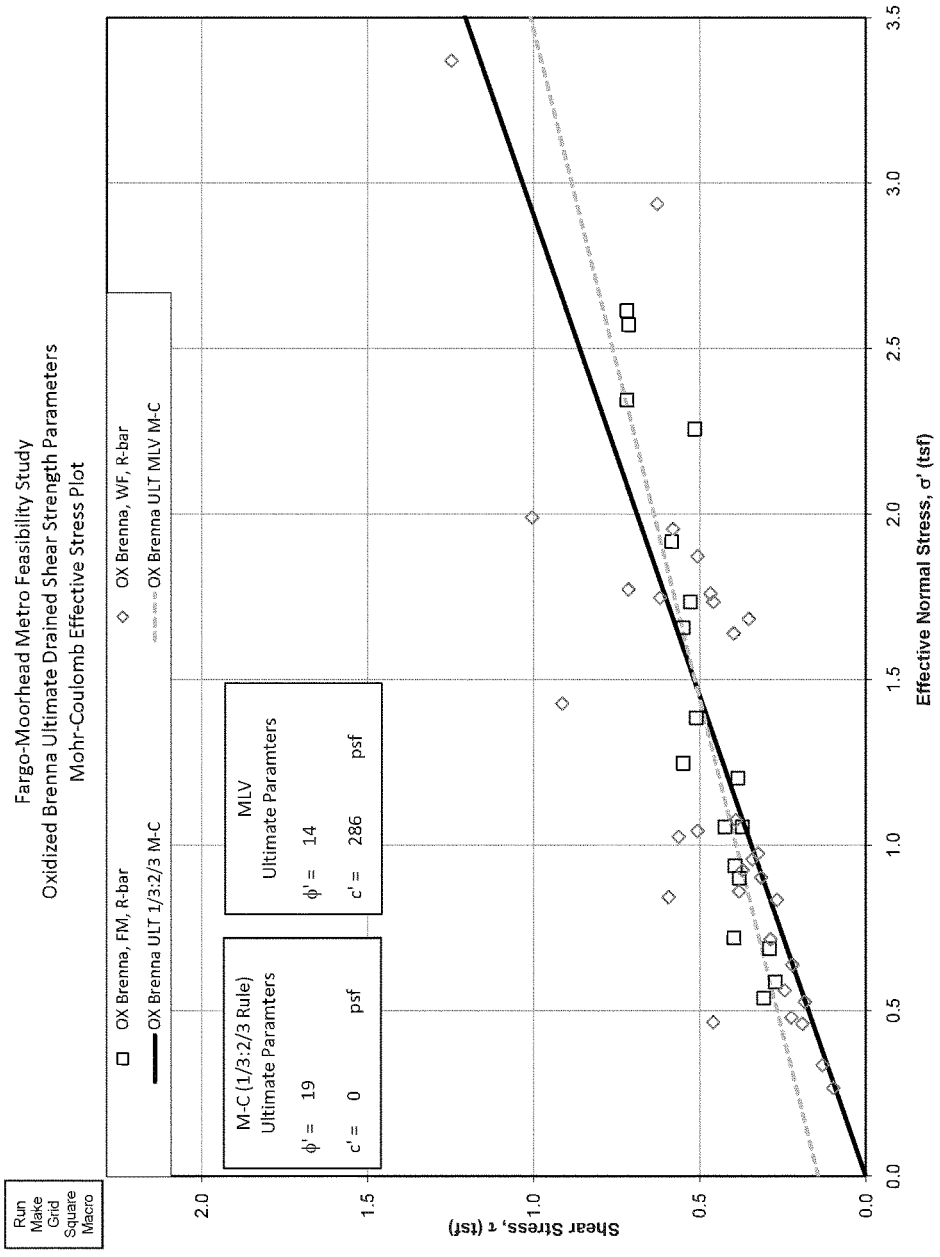
Oxidized Brenna		Brenna		Argusville	
Effective Normal Stress σ' (psf)	Effective Shear Stress τ' (psf)	Effective Normal Stress σ' (psf)	Effective Shear Stress τ' (psf)	Effective Normal Stress σ' (psf)	Effective Shear Stress τ' (psf)
0	25	0	50	0	50
200	113	200	120	200	127
1000	420	1000	333	1000	413
2000	760	2000	540	2000	653
3000	933	3000	673	3000	893
4000	1073	4000	807	4000	1093
7000	1493	6000	1033	6000	1460

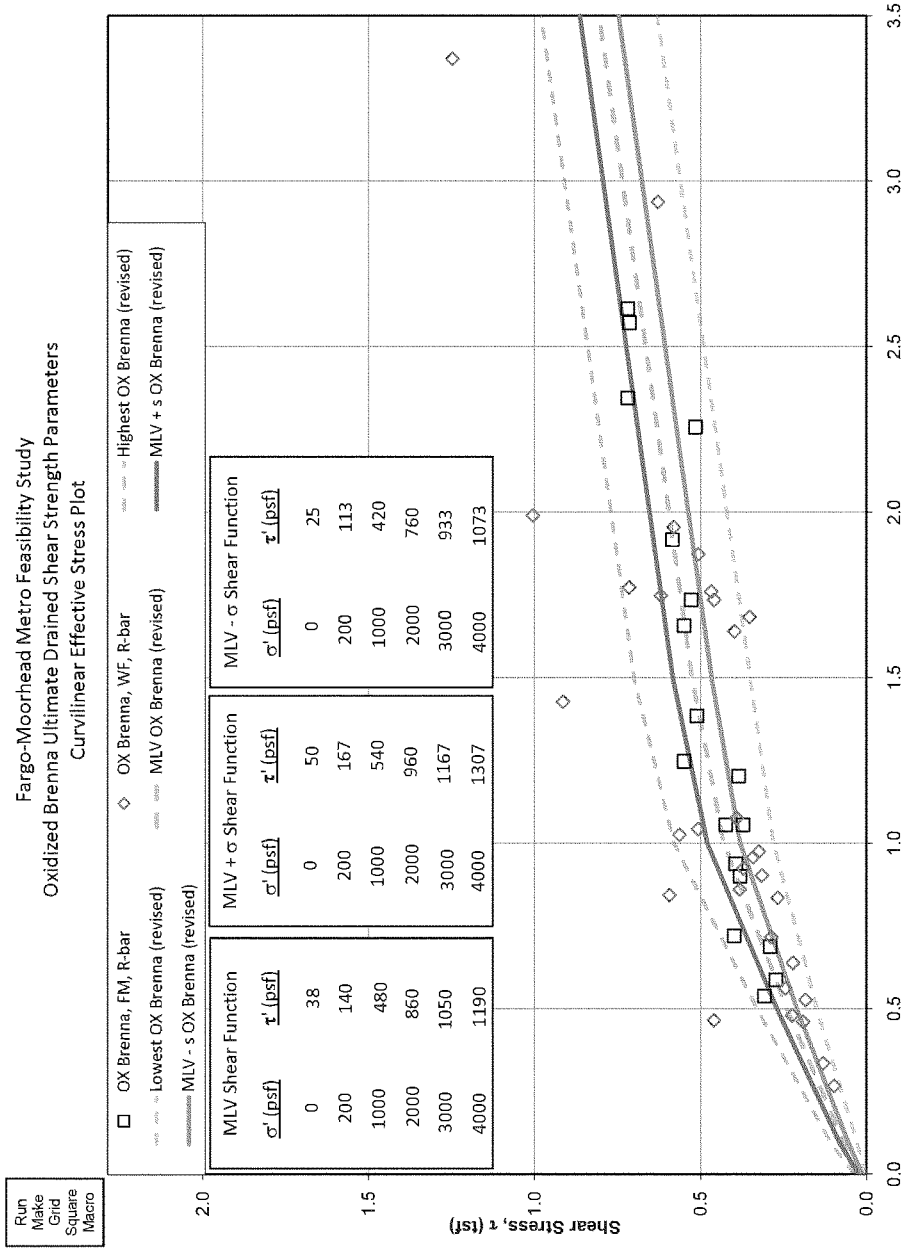

Fargo-Moorhead Metro Feasibility Study
Alluvium Ultimate Drained Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
Run Make Grid Square Macro
Alluvium, FM, R-bar
Alluvium, FRW, R-bar
Alluvium ULT 1/3:2/3 M-C
Alluvium ULT MLV M-C
M-C (1/3:2/3 Rule) Ultimate Paramters
ϕ' = 31
c' = 0 psf
MLV Ultimate Paramters
ϕ' = 24
c' = 425 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

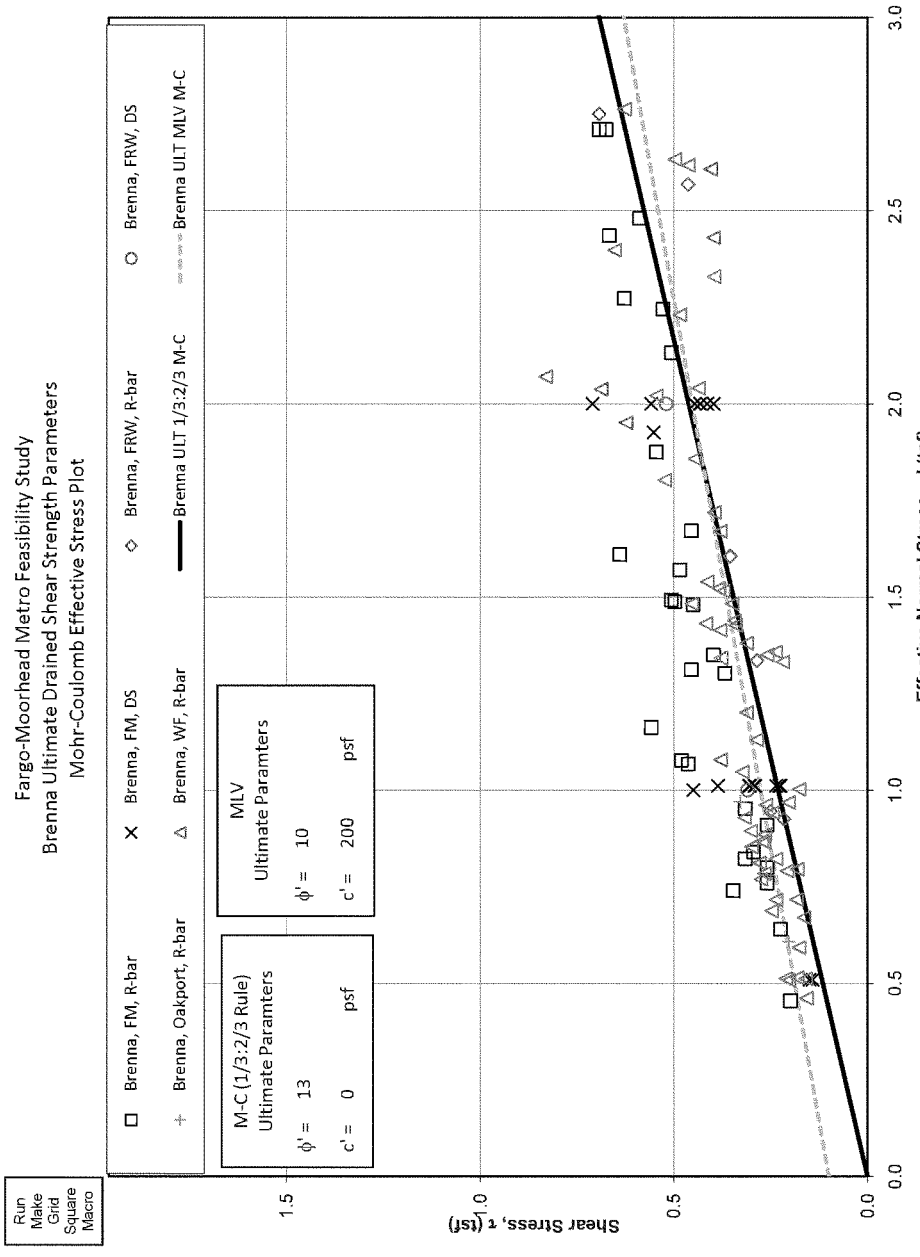

Fargo-Moorhead Metro Feasibility Study
Sherack Ultimate Drained Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
Run Make Grid Square Macro
Sherack, FM, R-bar
Sherack, FRW, R-bar
Sherack, WF, R-bar
Sherack, Oakport, R-bar
Sherack ULT 1/3:2/3 M-C
Sherack ULT MLV M-C
M-C (1/3:2/3 Rule) Ultimate Paramters
ϕ' = 28
c' = 0 psf
MLV Ultimate Paramters
ϕ' = 23
c' = 250 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

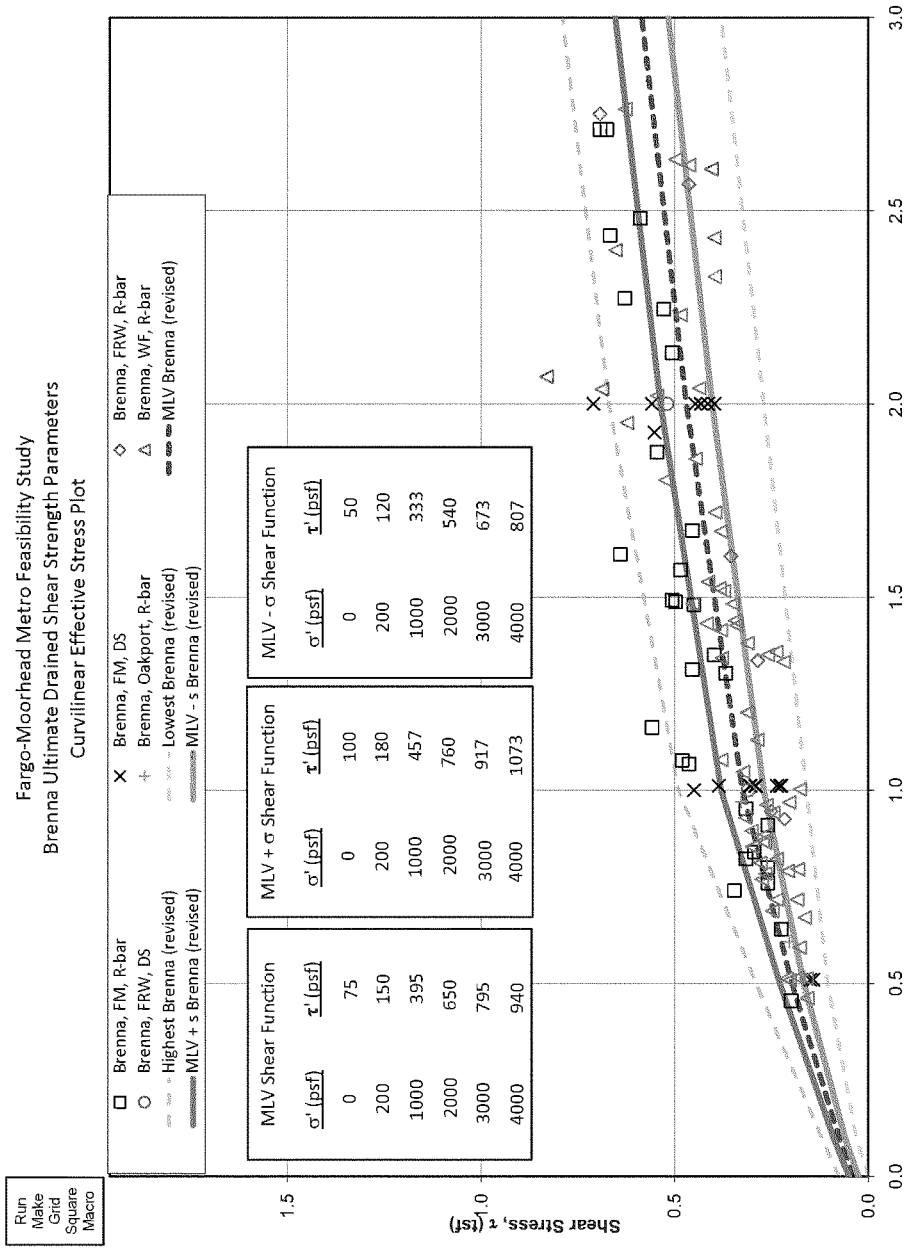

Fargo-Moorhead Metro Feasibility Study
Plastic Laminated Sherack Ultimate Drained Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
Run Make Grid Square Macro
PL Sherack, FRW, R-bar
PL Sherack ULT 1/3:2/3 M-C
M-C (1/3:2/3 Rule)
Ultimate Paramters
ϕ' = 16
c' = 0 psf
Shear Stress, τ (tsf)
Effective Normal Stress, σ' (tsf)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5

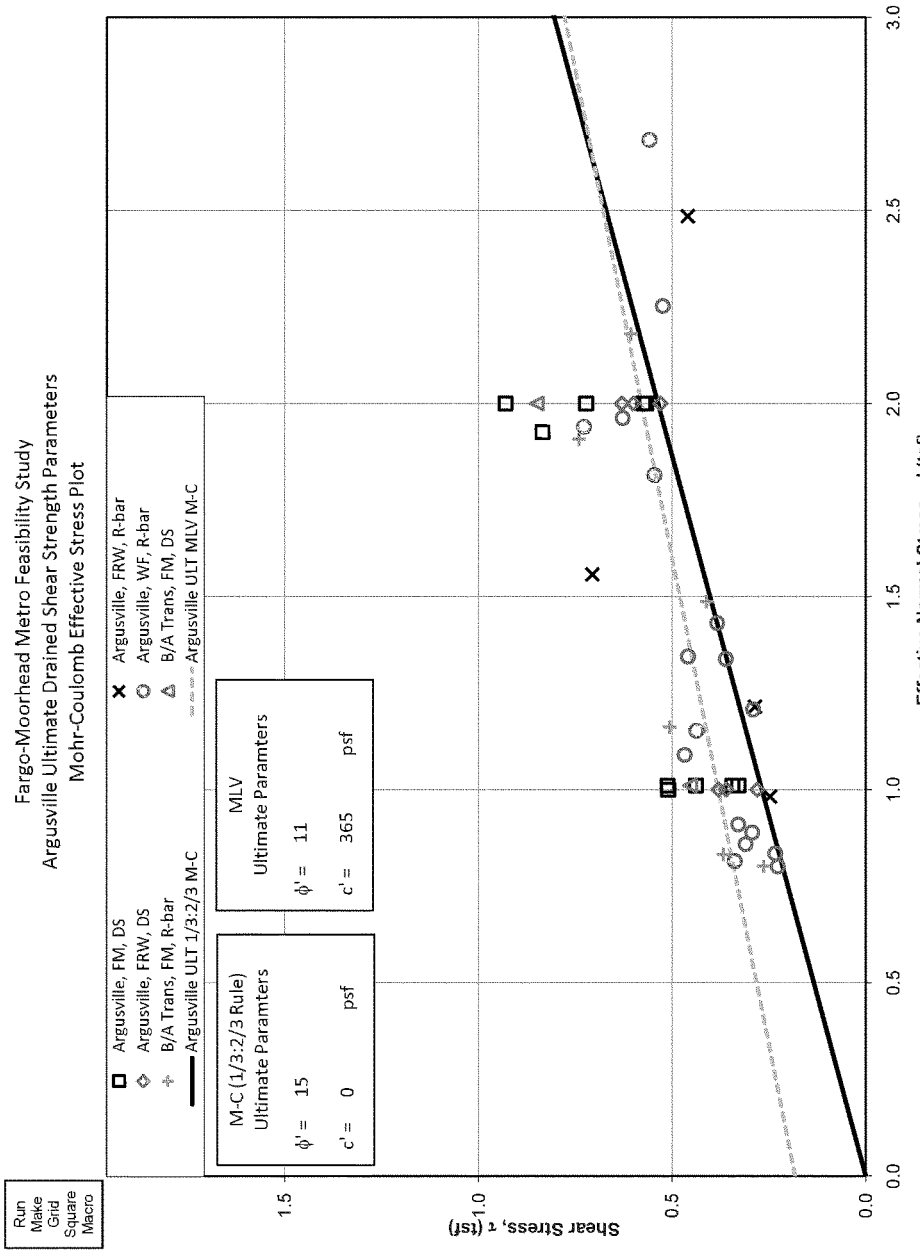

Run Make Grid Square Macro
Fargo-Moorhead Metro Feasibility Study
Poplar River Ultimate Drained Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
Poplar River, FM, R-bar
PR - WF, FM, DS
Poplar River - Harwood ULT 1/3:2/3 M-C
Poplar River, FRW, R-bar
PR - Harwood, FM, R-bar
PR - WF, FM, R-bar
Poplar River - WF ULT 1/3:2/3 M-C
WF M-C (1/3:2/3 Rule) Ultimate Paramters
ϕ' = 34
c' = 0 psf
Harwood M-C (1/3:2/3 Rule) Ultimate Paramters
ϕ' = 26
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
4.5
5.0
5.5

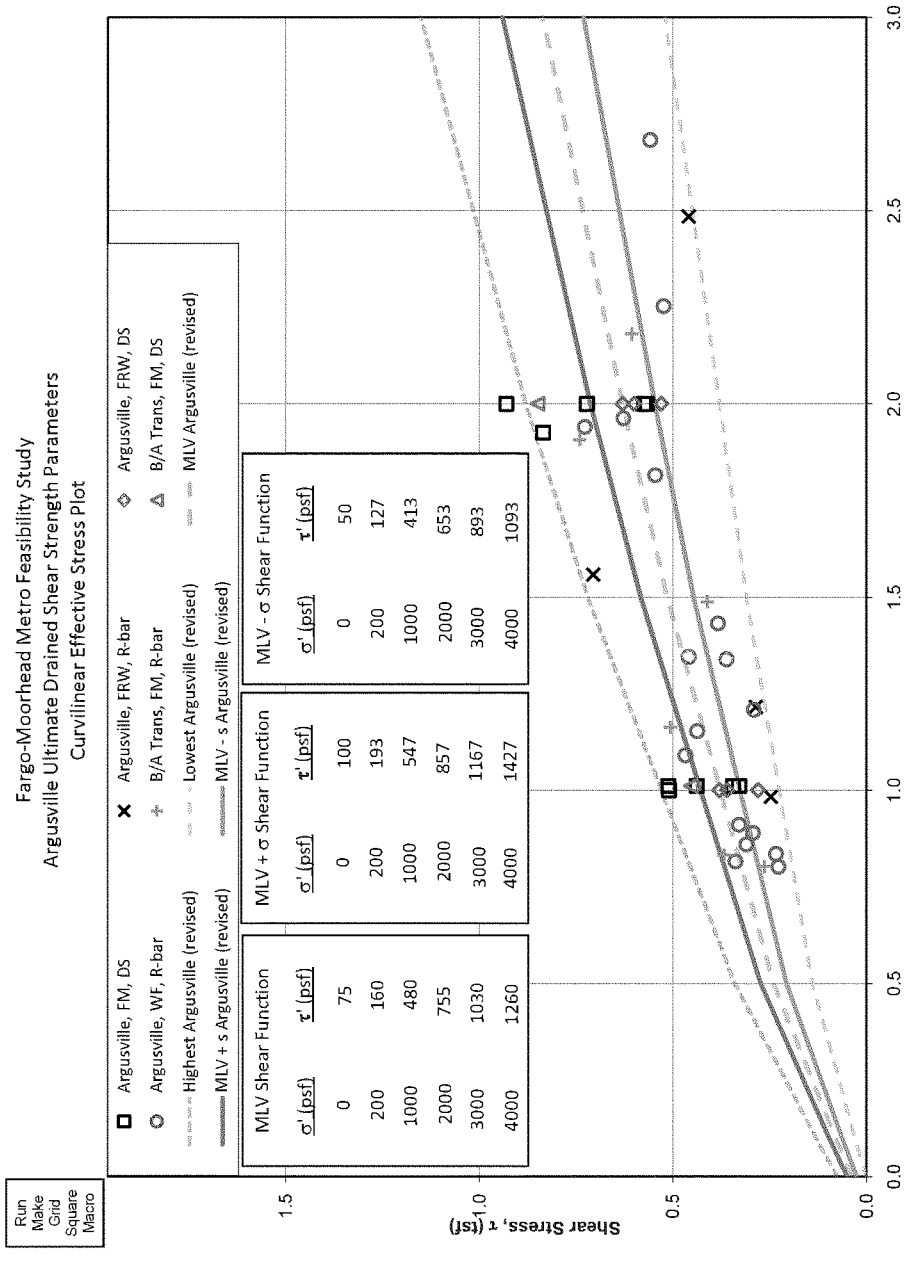

Fargo-Moorhead Metro Feasibility Study
Oxidized Brenna Ultimate Drained Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
Run Make Grid Square Macro
OX Brenna, FM, R-bar
OX Brenna ULT 1/3:2/3 M-C
OX Brenna, WF, R-bar
OX Brenna ULT MLV M-C
M-C (1/3:2/3 Rule) Ultimate Paramters
ϕ' = 19
c' = 0 psf
MLV Ultimate Paramters
ϕ' = 14
c' = 286 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

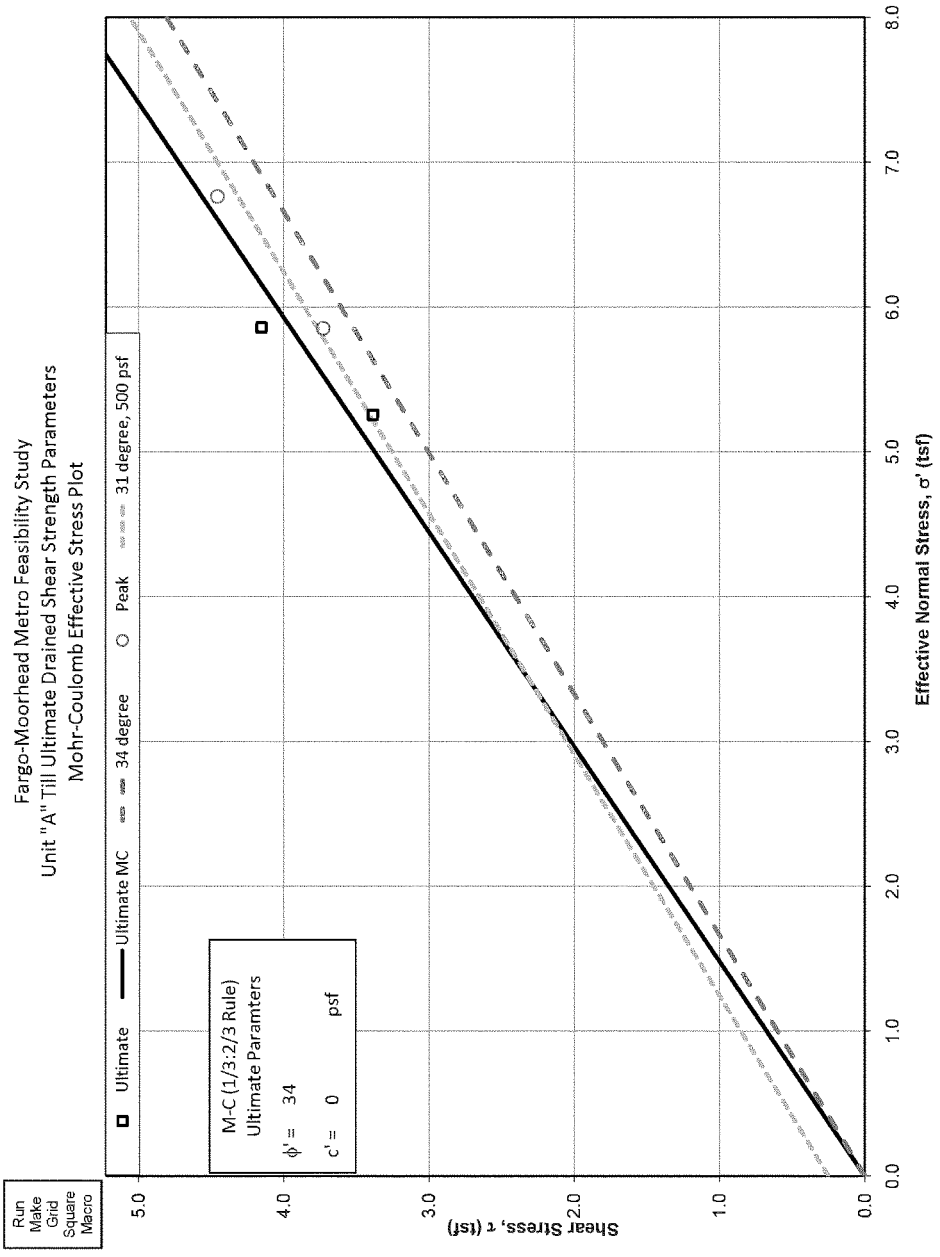

Fargo-Moorhead Metro Feasibility Study
Oxidized Brenna Ultimate Drained Shear Strength Parameters
Curvilinear Effective Stress Plot
Run Make Grid Square Macro
OX Brenna, FM, R-bar
OX Brenna, WF, R-bar
Highest OX Brenna (revised)
Lowest OX Brenna (revised)
MLV OX Brenna (revised)
MLV + s OX Brenna (revised)
MLV - s OX Brenna (revised)
MLV Shear Function
σ' (psf) τ' (psf)
0 38
200 140
1000 480
2000 860
3000 1050
4000 1190
MLV + σ Shear Function
σ' (psf) τ' (psf)
0 50
200 167
1000 540
2000 960
3000 1167
4000 1307
MLV - σ Shear Function
σ' (psf) τ' (psf)
0 25
200 113
1000 420
2000 760
3000 933
4000 1073
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


Fargo-Moorhead Metro Feasibility Study
Brenna Ultimate Drained Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
Run Make Grid Square Macro
Brenna, FM, R-bar
Brenna, FM, DS
Brenna, FRW, R-bar
Brenna, FRW, DS
Brenna, Oakport, R-bar
Brenna, WF, R-bar
Brenna ULT 1/3:2/3 M-C
Brenna ULT MLV M-C
M-C (1/3:2/3 Rule) Ultimate Paramters
ϕ' = 13
c' = 0 psf
MLV Ultimate Paramters
ϕ' = 10
c' = 200 psf
Shear Stress, τ (tsf)
Effective Normal Stress, σ' (tsf)
0.0
0.5
1.0
1.5
2.0
2.5
3.0

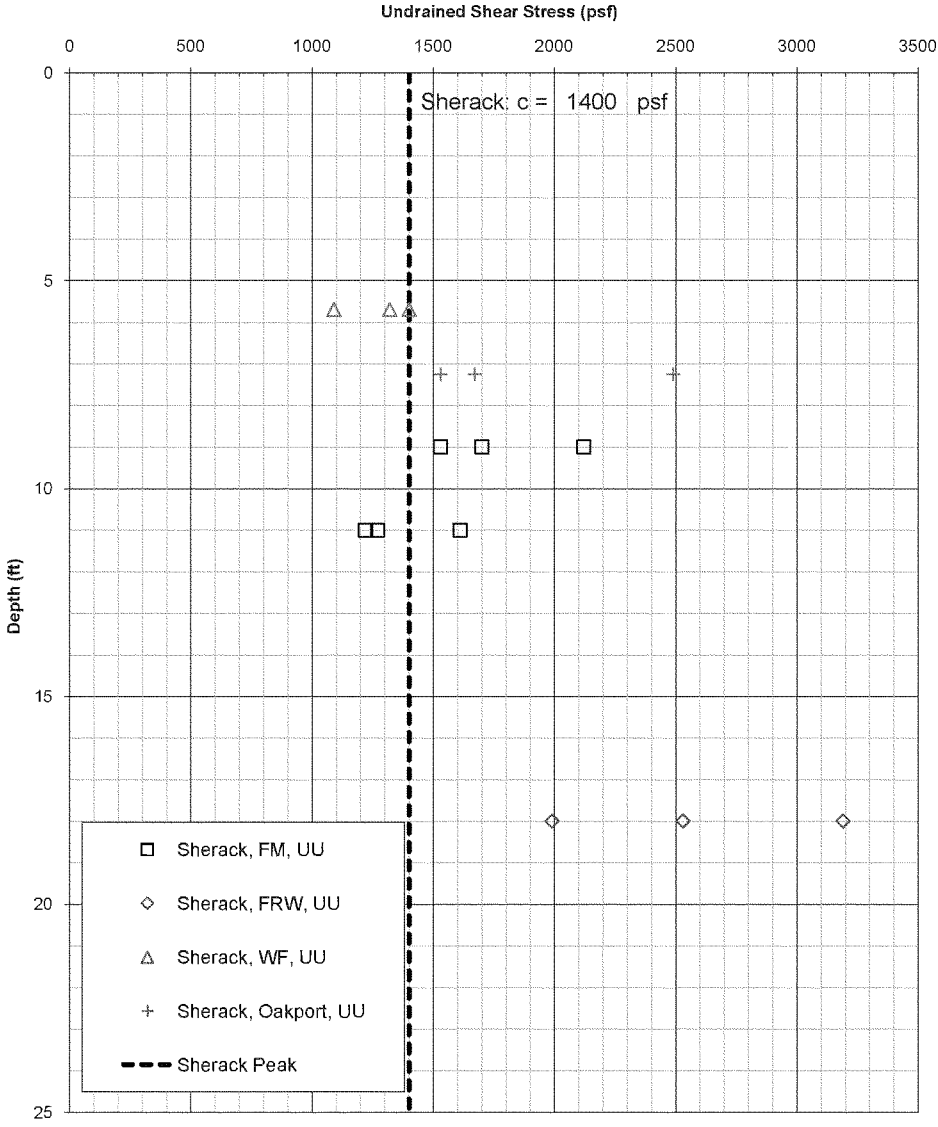

Fargo-Moorhead Metro Feasibility Study
Brenna Ultimate Drained Shear Strength Parameters
Curvilinear Effective Stress Plot
Run Make Grid Square Macro
Brenna, FM, R-bar
Brenna, FRW, DS
Highest Brenna (revised)
MLV + s Brenna (revised)
Brenna, FM, DS
Brenna, Oakport, R-bar
Lowest Brenna (revised)
MLV - s Brenna (revised)
Brenna, FRW, R-bar
Brenna, WF, R-bar
MLV Brenna (revised)
MLV Shear Function
σ' (psf) τ' (psf)
0 75
200 150
1000 395
2000 650
3000 795
4000 940
MLV + σ Shear Function
σ' (psf) τ' (psf)
0 100
200 180
1000 457
2000 760
3000 917
4000 1073
MLV - σ Shear Function
σ' (psf) τ' (psf)
0 50
200 120
1000 333
2000 540
3000 673
4000 807
Shear Stress, τ (tsf)
Effective Normal Stress, σ' (tsf)
0.0
0.5
1.0
1.5
2.0
2.5
3.0


Fargo-Moorhead Metro Feasibility Study
Argusville Ultimate Drained Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
Run Make Grid Square Macro
Argusville, FM, DS
Argusville, FRW, DS
B/A Trans, FM, R-bar
Argusville ULT 1/3:2/3 M-C
Argusville, FRW, R-bar
Argusville, WF, R-bar
B/A Trans, FM, DS
Argusville ULT MLV M-C
M-C (1/3:2/3 Rule)
Ultimate Paramters
ϕ' = 15
c' = 0 psf
MLV
Ultimate Paramters
ϕ' = 11
c' = 365 psf
Shear Stress, τ (tsf)
Effective Normal Stress, σ' (tsf)
0.0
0.5
1.0
1.5
2.0
2.5
3.0

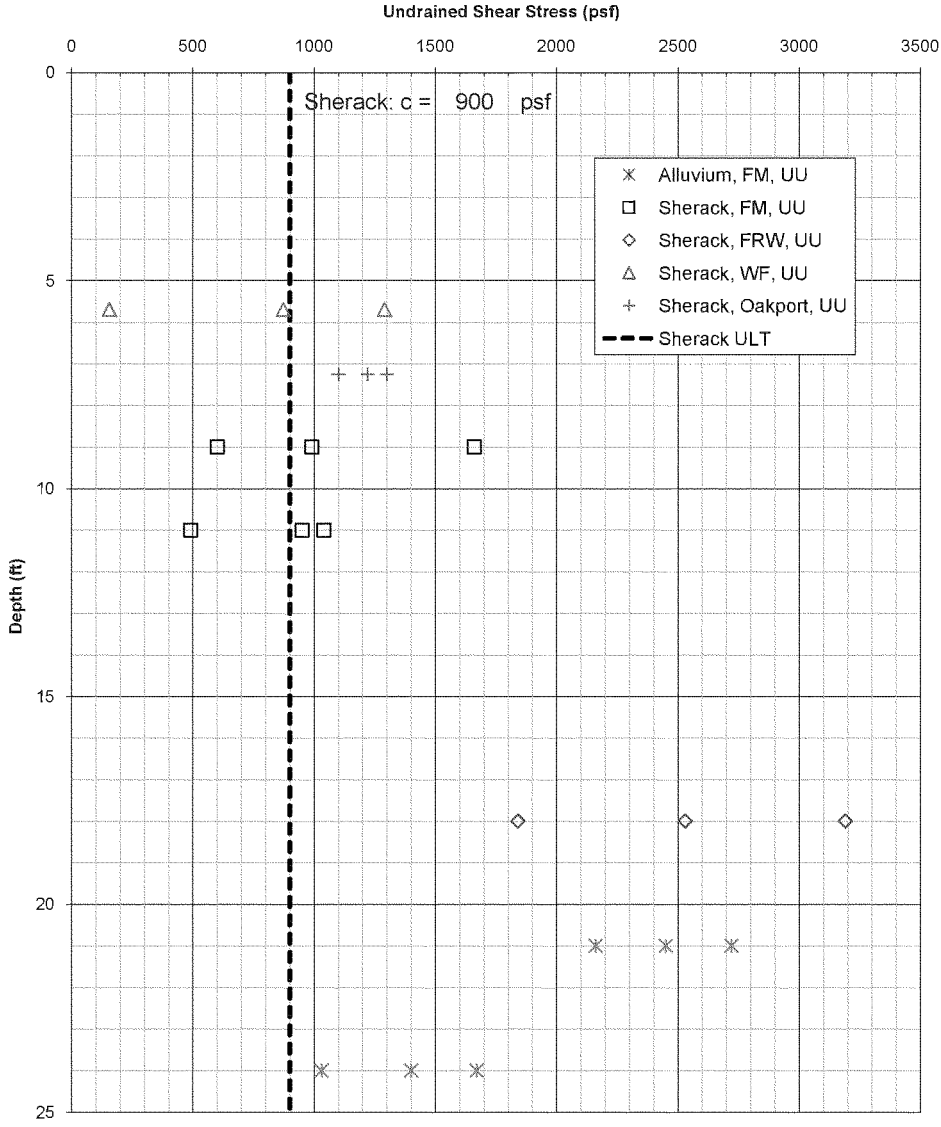

Fargo-Moorhead Metro Feasibility Study
Argusville Ultimate Drained Shear Strength Parameters
Curvilinear Effective Stress Plot
Run Make Grid Square Macro
Argusville, FM, DS
Argusville, WF, R-bar
Highest Argusville (revised)
MLV + s Argusville (revised)
Argusville, FRW, R-bar
B/A Trans, FM, R-bar
Lowest Argusville (revised)
MLV - s Argusville (revised)
Argusville, FRW, DS
B/A Trans, FM, DS
MLV Argusville (revised)
MLV Shear Function
σ' (psf) τ' (psf)
0 75
200 160
1000 480
2000 755
3000 1030
4000 1260
MLV + σ Shear Function
σ' (psf) τ' (psf)
0 100
200 193
1000 547
2000 857
3000 1167
4000 1427
MLV - σ Shear Function
σ' (psf) τ' (psf)
0 50
200 127
1000 413
2000 653
3000 893
4000 1093
Shear Stress, τ (tsf)
Effective Normal Stress, σ' (tsf)
0.0
0.5
1.0
1.5
2.0
2.5
3.0


Fargo-Moorhead Metro Feasibility Study
Unit "A" Till Ultimate Drained Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
Run Make Grid Square Macro
Ultimate
Ultimate MC
34 degree
Peak
31 degree, 500 psf
M-C (1/3:2/3 Rule)
Ultimate Paramters
ϕ' = 34
c' = 0 psf
Shear Stress, τ (tsf)
Effective Normal Stress, σ' (tsf)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0

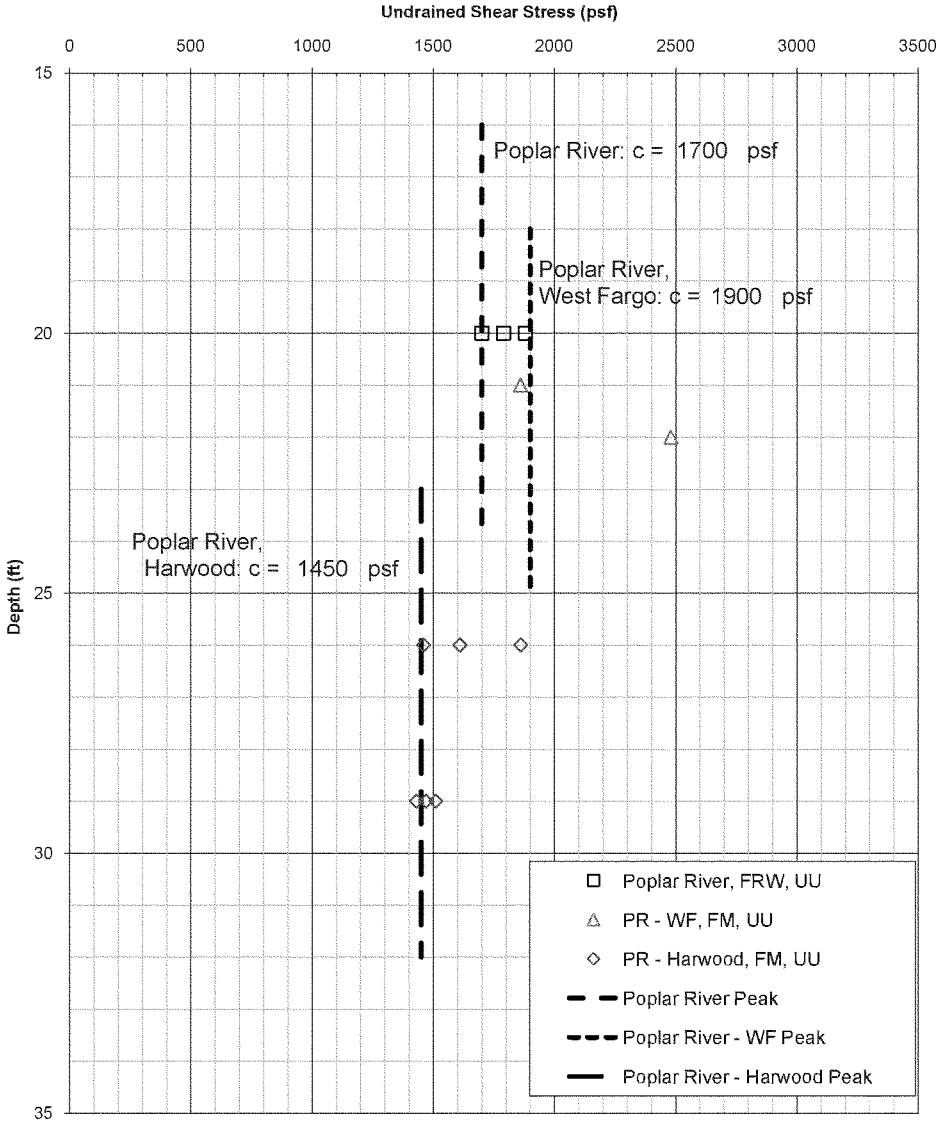
Fargo-Moorhead Metro Feasibility Study
Sherack
Peak Undrained Shear Strength (UU) Data



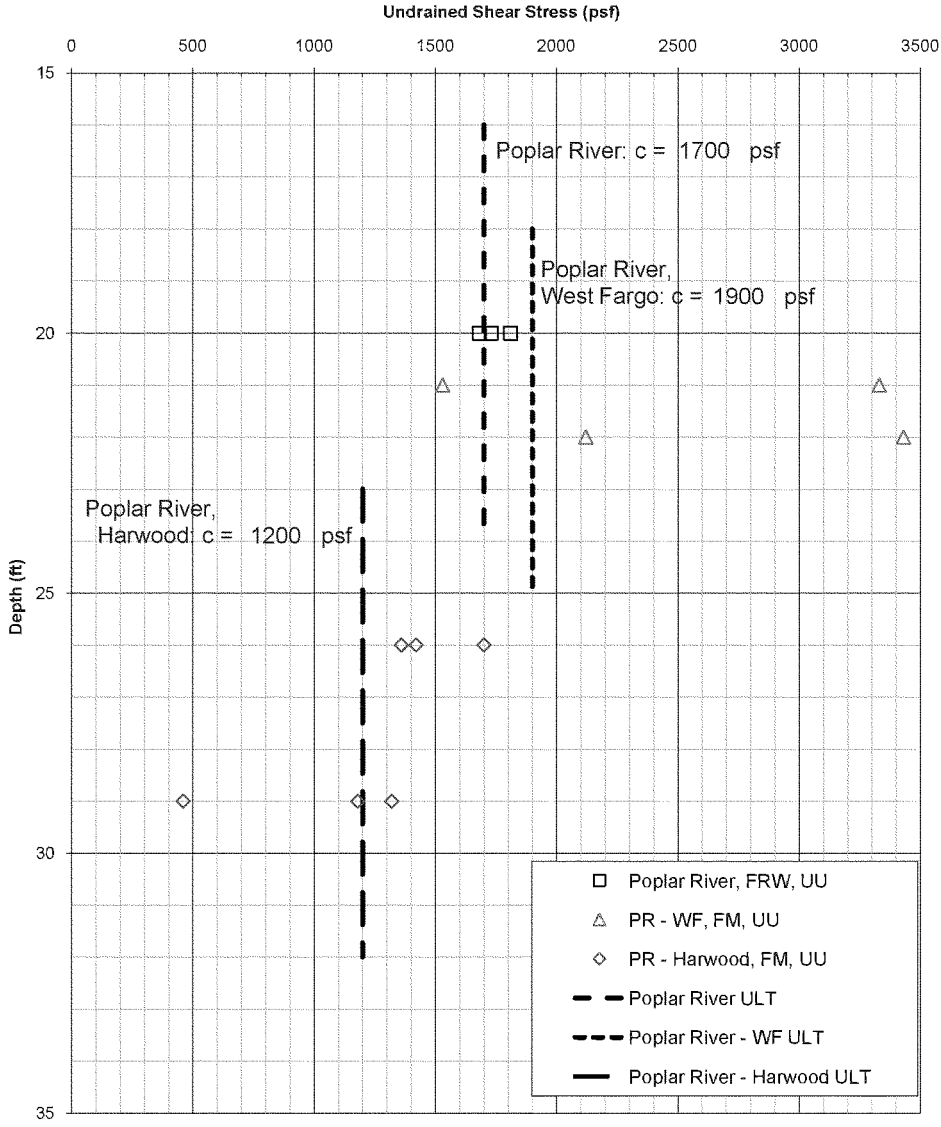
Fargo-Moorhead Metro Feasibility Study
Sherack
Ultimate Undrained Shear Strength (UU) Data



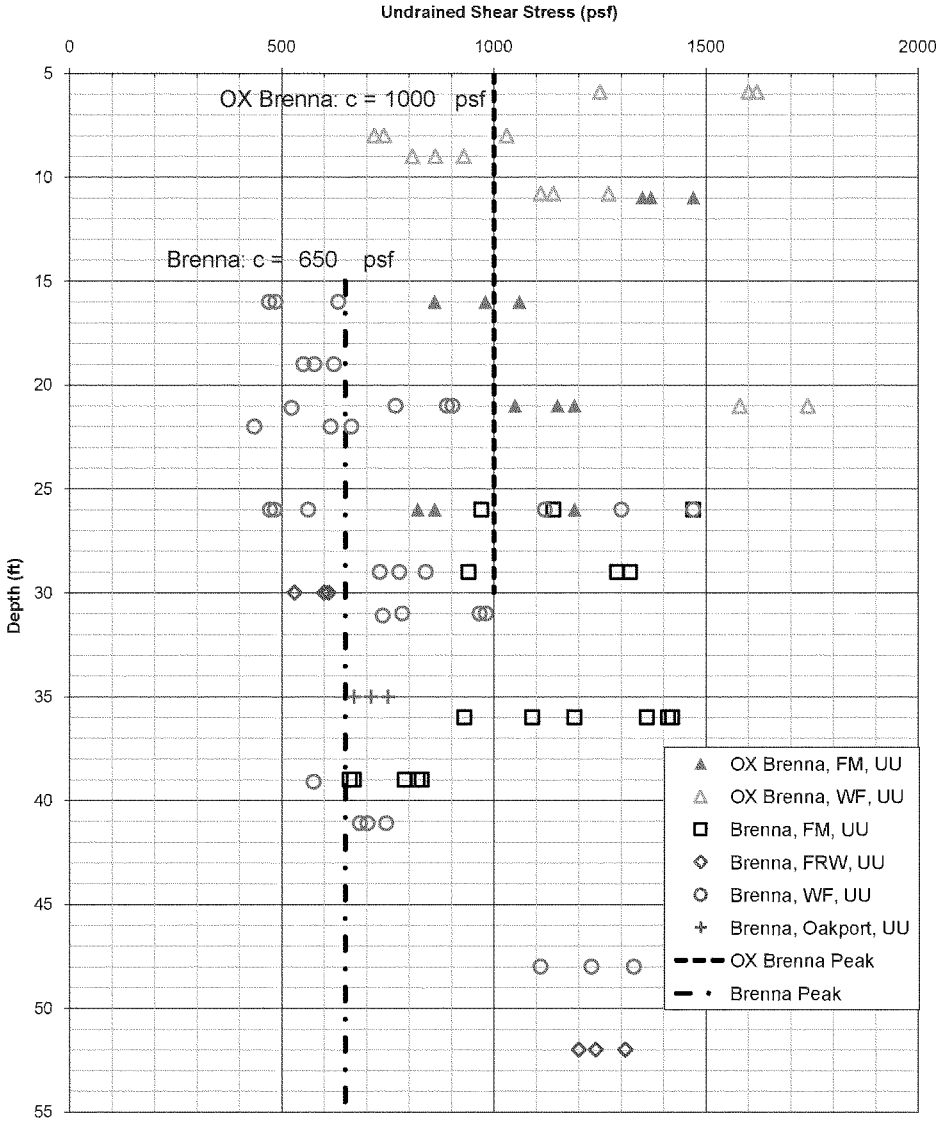
Fargo-Moorhead Metro Feasibility Study
Poplar River
Peak Undrained Shear Strength (UU) Data



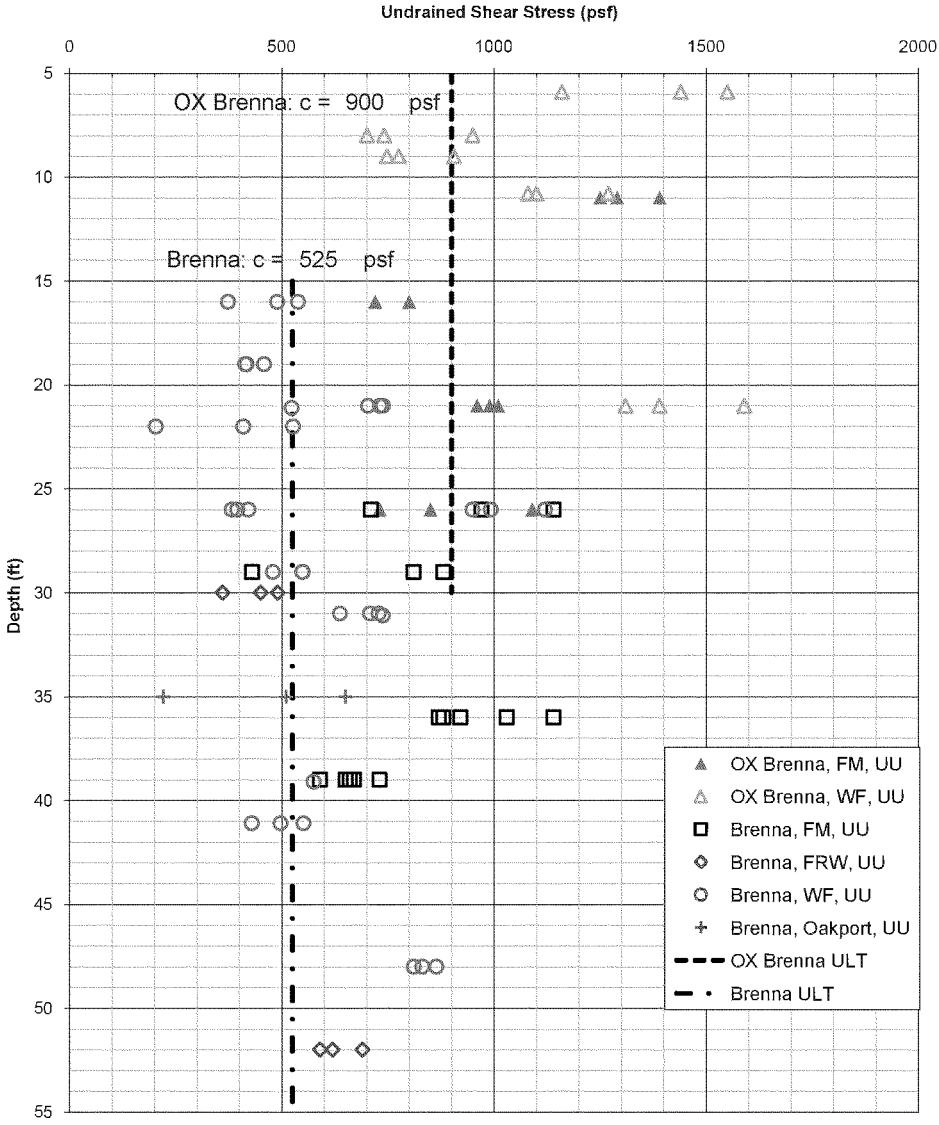
Fargo-Moorhead Metro Feasibility Study
Poplar River
Ultimate Undrained Shear Strength (UU) Data



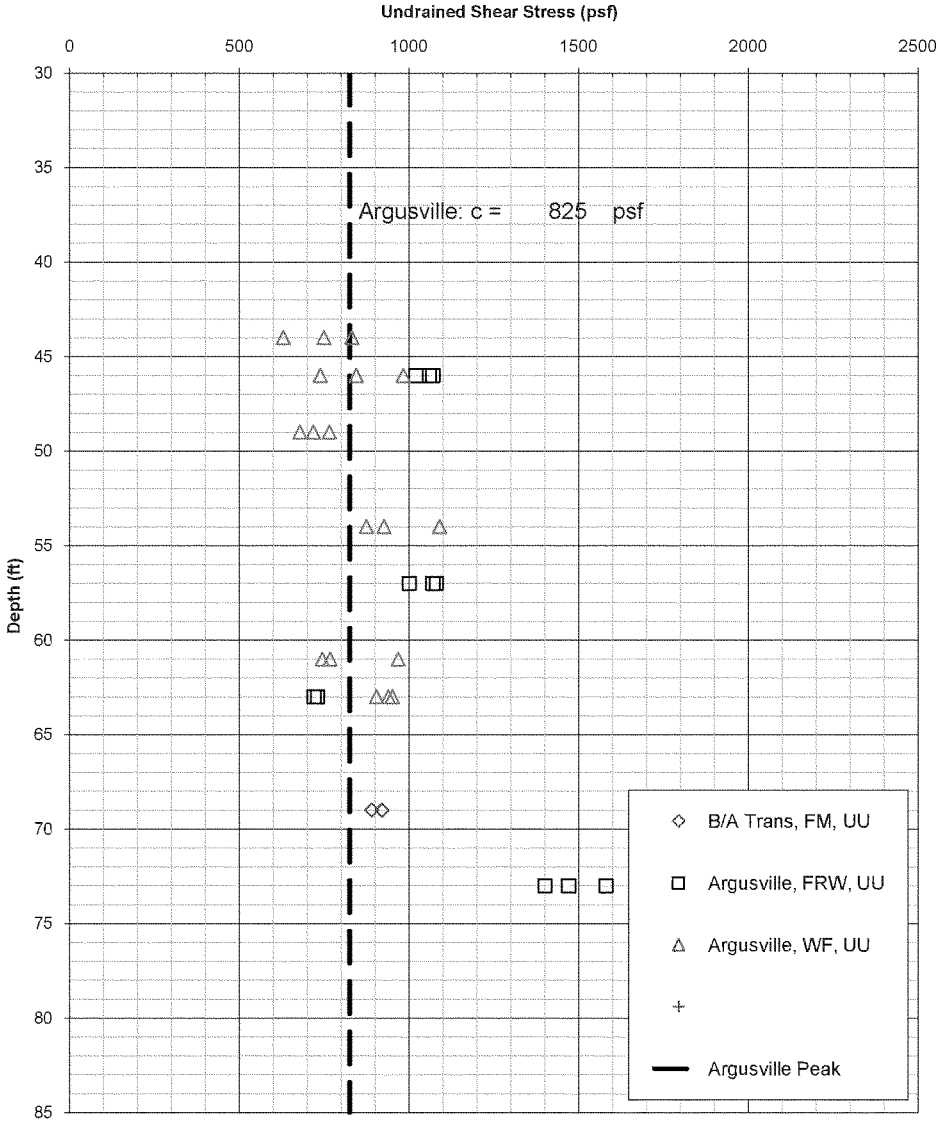
Fargo-Moorhead Metro Feasibility Study
Oxidied Brenna and Brenna
Peak Undrained Shear Strength (UU) Data



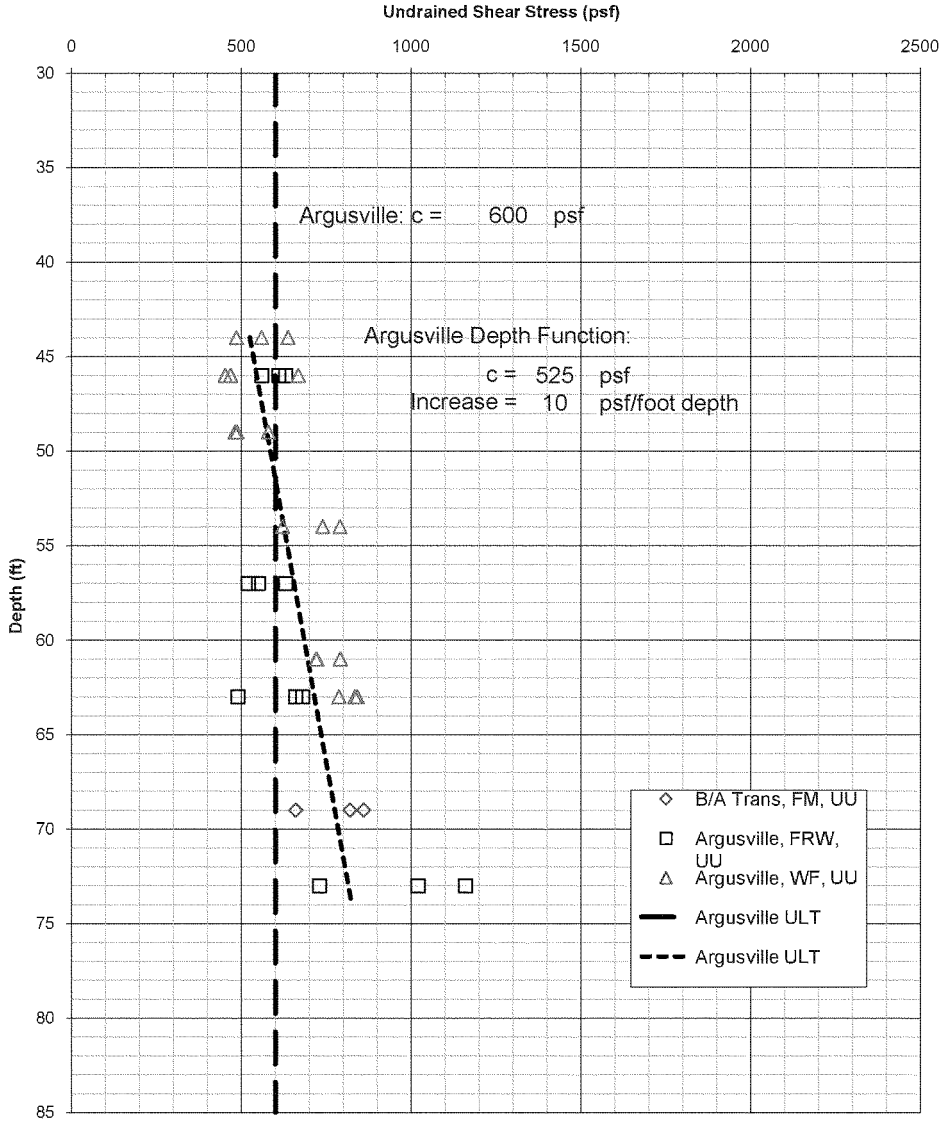
Fargo-Moorhead Metro Feasibility Study
Oxidied Brenna and Brenna
Ultimate Undrained Shear Strength (UU) Data

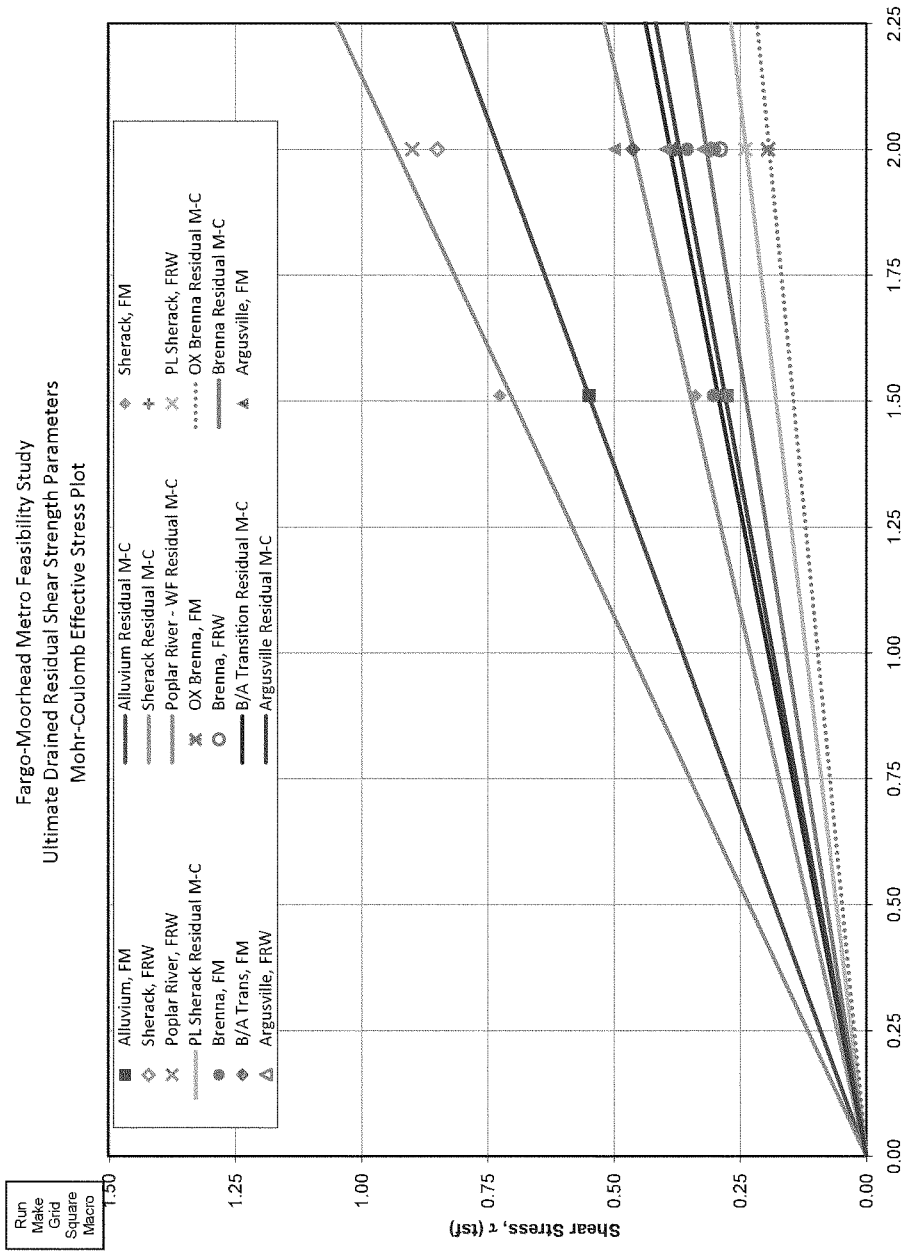


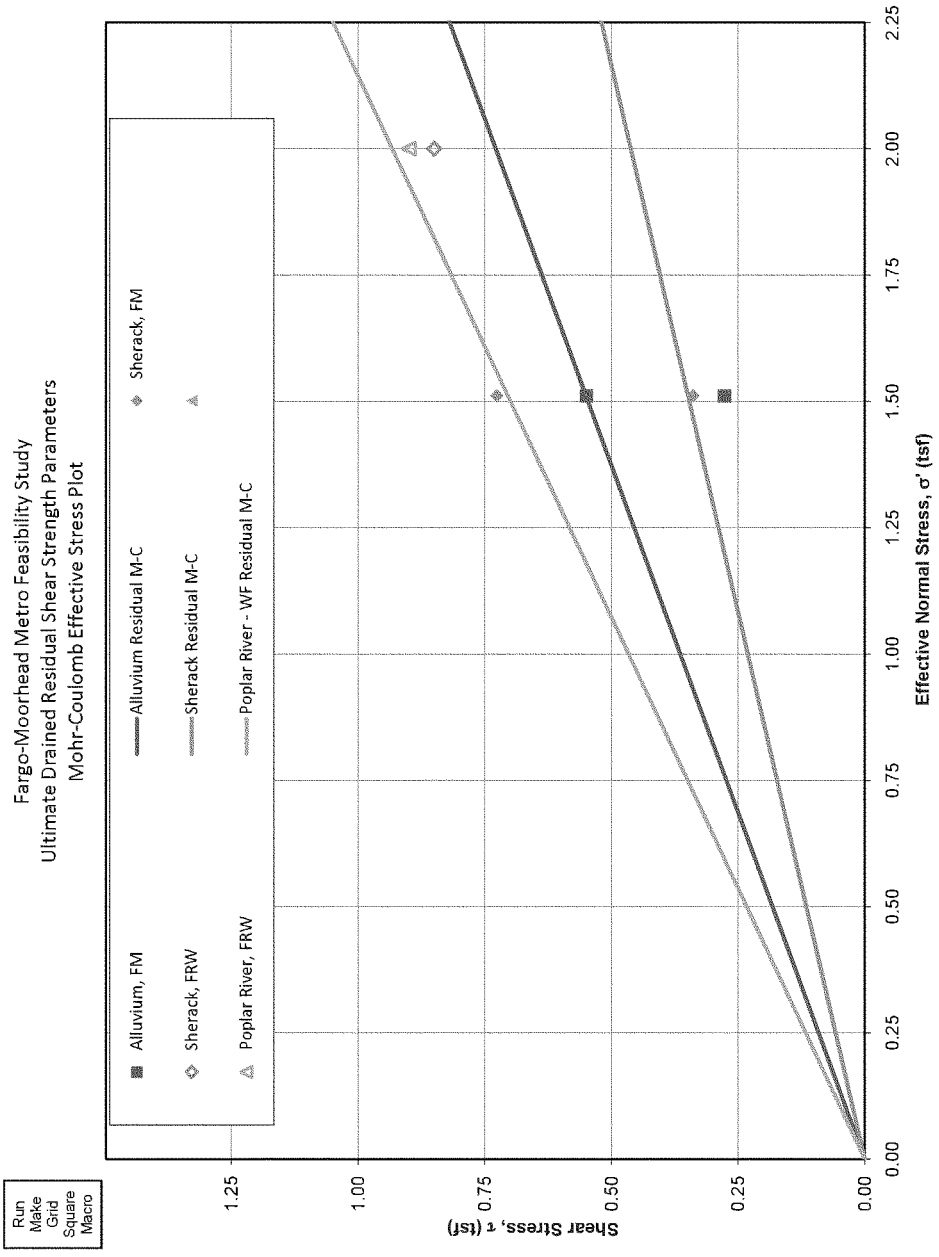
Fargo-Moorhead Metro Feasibility Study
Argusville
Peak Undrained Shear Strength (UU) Data

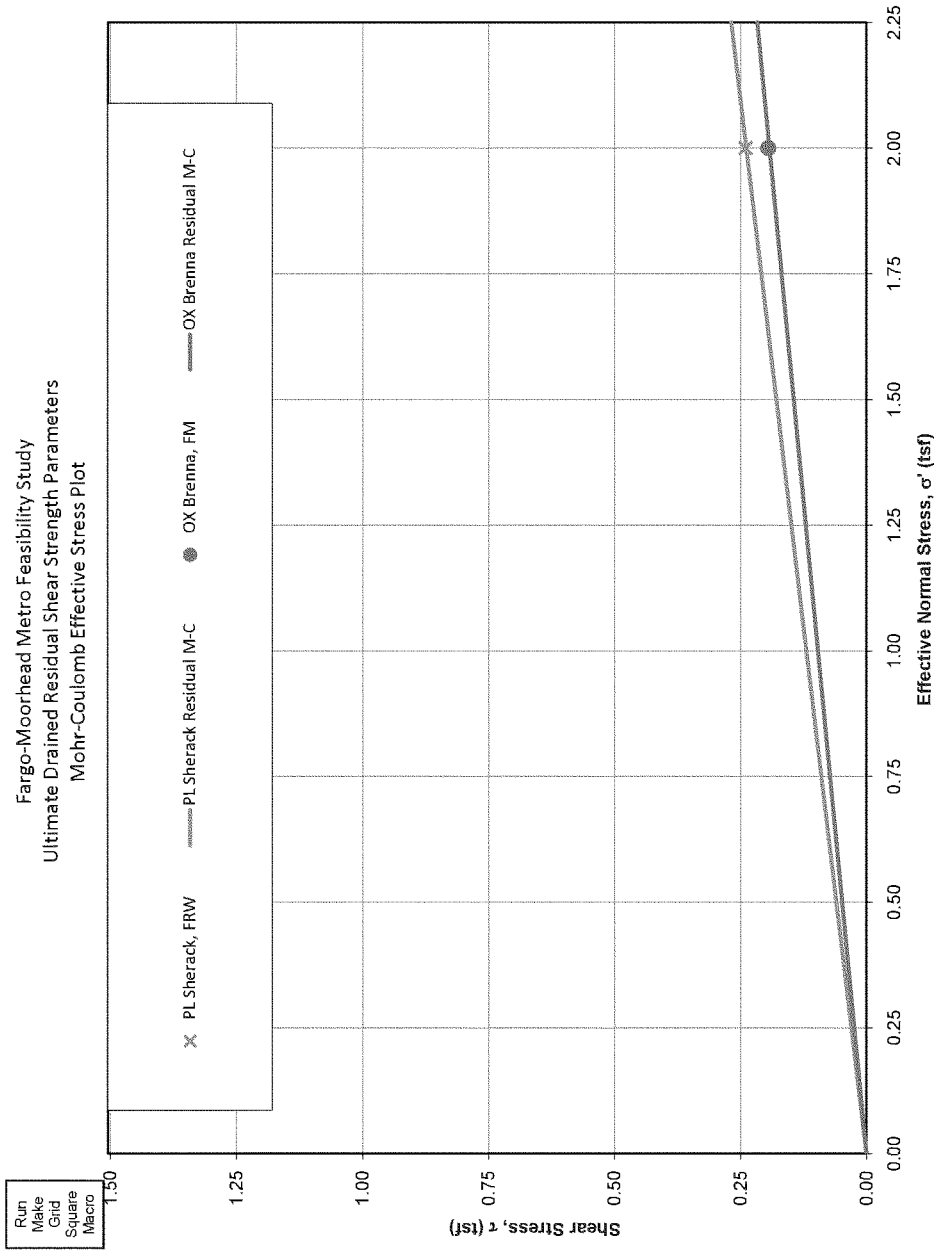


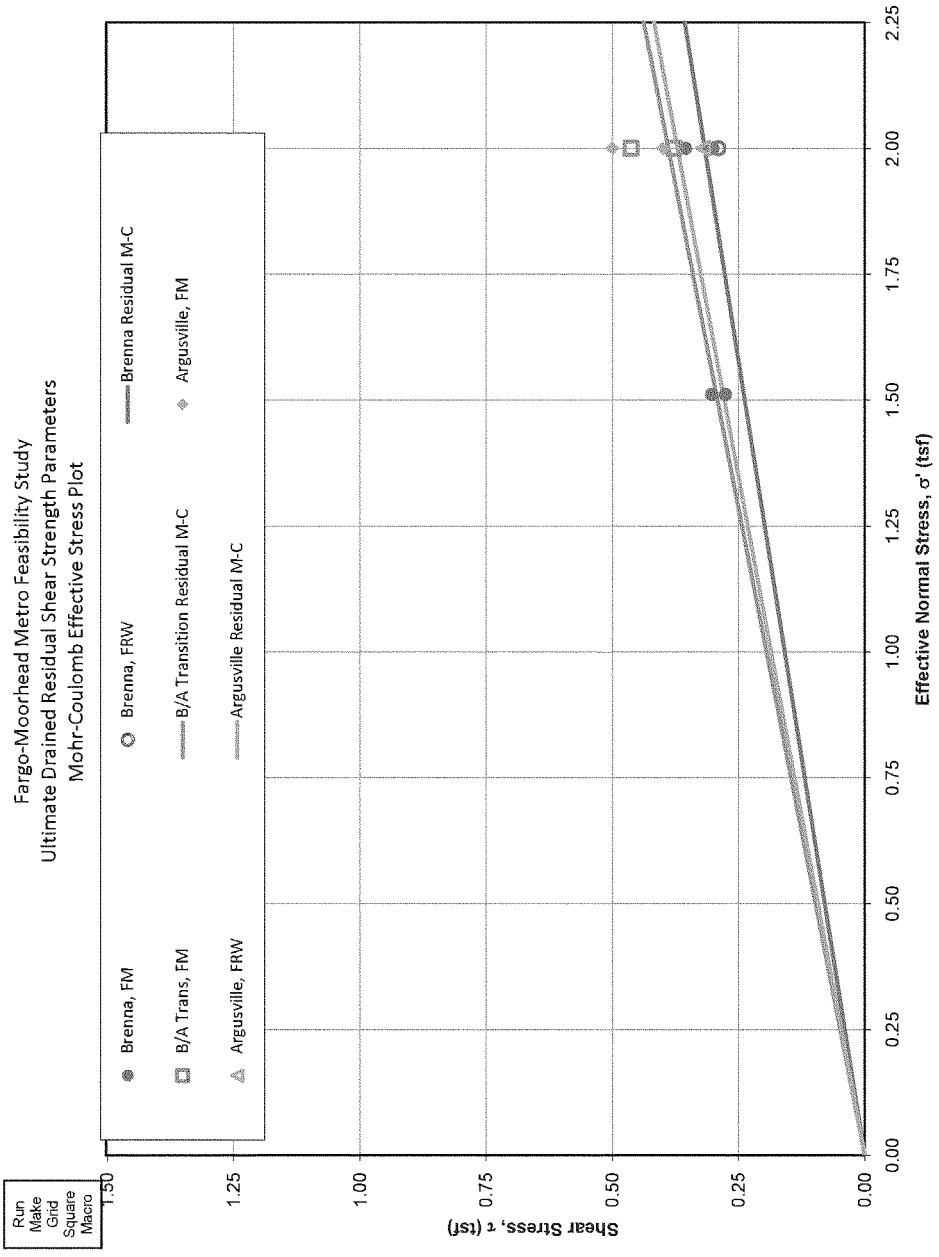
Fargo-Moorhead Metro Feasibility Study
Argusville
Ultimate Undrained Shear Strength (UU) Data




Fargo-Moorhead Metro Feasibility Study
Ultimate Drained Residual Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
Run Make Grid Square Macro
Alluvium, FM
Sherack, FRW
Poplar River, FRW
PL Sherack Residual M-C
Brenna, FM
B/A Trans, FM
Argusville, FRW
Alluvium Residual M-C
Sherack Residual M-C
Poplar River - WF Residual M-C
OX Brenna, FM
Brenna, FRW
B/A Transition Residual M-C
Argusville Residual M-C
Sherack, FM
PL Sherack, FRW
OX Brenna Residual M-C
Brenna Residual M-C
Argusville, FM
Shear Stress, τ (tsf)
Effective Normal Stress, σ' (tsf)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25


Fargo-Moorhead Metro Feasibility Study
Ultimate Drained Residual Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
Run Make Grid Square Macro
Alluvium, FM
Alluvium Residual M-C
Sherack, FM
Sherack, FRW
Sherack Residual M-C
Poplar River, FRW
Poplar River - WF Residual M-C
Shear Stress, τ (tsf)
Effective Normal Stress, σ' (tsf)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25


Fargo-Moorhead Metro Feasibility Study
Ultimate Drained Residual Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
Run
Make
Grid
Square
Macro
PL Sherack, FRW
PL Sherack Residual M-C
OX Brenna, FM
OX Brenna Residual M-C
Shear Stress, τ (tsf)
Effective Normal Stress, σ' (tsf)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25


Fargo-Moorhead Metro Feasibility Study
Ultimate Drained Residual Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
Run
Make
Grid
Square
Macro
Brenna, FM
Brenna, FRW
Brenna Residual M-C
B/A Trans, FM
B/A Transition Residual M-C
Argusville, FM
Argusville, FRW
Argusville Residual M-C
Shear Stress, τ (tsf)
Effective Normal Stress, σ' (tsf)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25

St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Alluvium Formation Effective Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: 4/20/2010 Date: 10/29/2010

Project, Formation, Test, Boring, Sample No, Specimen No	BORING NO	MID-DEPTH (feet)	ELEV (feet)	SAMPLE NO	SPEC NO	FORMATION	TEST	USCS SOIL TYPE	PROJECT	R-bar, Ultimate σ_n (tsf)	R-bar, Ultimate τ_n (tsf)	DS, Ultimate σ_n (tsf)	DS, Ultimate τ_n (tsf)
Alluvium, R-bar, Far 09-23MU, 1, 1, FM	Far 09-23MU	3.0	894.0	1	1	Alluvium	R-bar	CH	FM	0.86	0.57		
Alluvium, R-bar, Far 09-23MU, 1, 2, FM	Far 09-23MU	3.0	894.0	1	2	Alluvium	R-bar	CH	FM	1.02	0.65		
Alluvium, R-bar, Far 09-23MU, 1, 3, FM	Far 09-23MU	3.0	894.0	1	3	Alluvium	R-bar	CH	FM	1.42	0.83		
Alluvium, R-bar, Far 09-25MU, 1, 1, FM	Far 09-25MU	15.0	878.4	1	1	Alluvium	R-bar	CH	FM	0.87	0.61		
Alluvium, R-bar, Far 09-25MU, 1, 2, FM	Far 09-25MU	15.0	878.4	1	2	Alluvium	R-bar	CH	FM	1.20	0.78		
Alluvium, R-bar, Far 09-25MU, 1, 3, FM	Far 09-25MU	15.0	878.4	1	3	Alluvium	R-bar	CH	FM	2.10	1.24		
Alluvium, R-bar, Far 09-25MU, 2, 1, FM	Far 09-25MU	27.0	866.4	2	1	Alluvium	R-bar	CH	FM	0.66	0.46		
Alluvium, R-bar, Far 09-25MU, 2, 2, FM	Far 09-25MU	27.0	866.4	2	2	Alluvium	R-bar	CH	FM	1.04	0.69		
Alluvium, R-bar, Far 09-25MU, 2, 3, FM	Far 09-25MU	27.0	866.4	2	3	Alluvium	R-bar	CH	FM	2.11	1.23		
Alluvium, R-bar, Far 09-27MU, 1, 1, FM	Far 09-27MU	7.0	896.1	1	1	Alluvium	R-bar	CH	FM	0.76	0.44		
Alluvium, R-bar, Far 09-27MU, 1, 2, FM	Far 09-27MU	7.0	896.1	1	2	Alluvium	R-bar	CH	FM	1.00	0.63		
Alluvium, R-bar, Far 09-27MU, 1, 3, FM	Far 09-27MU	7.0	896.1	1	3	Alluvium	R-bar	CH	FM	1.67	1.01		
Alluvium, R-bar, Far 10-78MU, 1, 1, FM	Far 10-78MU	14.0		1	1	Alluvium	R-bar	CH	FM	1.18	0.82		
Alluvium, R-bar, Far 10-78MU, 1, 2, FM	Far 10-78MU	14.0		1	2	Alluvium	R-bar	CH	FM	1.96	1.22		
Alluvium, R-bar, Far 10-78MU, 1, 3, FM	Far 10-78MU	14.0		1	3	Alluvium	R-bar	CH	FM	2.90	1.81		
Alluvium, R-bar, Far 10-79MU, 1, 1, FM	Far 10-79MU	21.0		1	1	Alluvium	R-bar	CH	FM	1.54	0.89		
Alluvium, R-bar, Far 10-79MU, 1, 2, FM	Far 10-79MU	21.0		1	2	Alluvium	R-bar	CH	FM	2.20	1.33		
Alluvium, R-bar, Far 10-79MU, 1, 3, FM	Far 10-79MU	21.0		1	3	Alluvium	R-bar	CH	FM	3.84	1.95		
Alluvium, R-bar, Far 10-80MU, 1, 1, FM	Far 10-80MU	24.0		1	1	Alluvium	R-bar	CL-ML	FM	1.78	1.10		
Alluvium, R-bar, Far 10-80MU, 1, 2, FM	Far 10-80MU	24.0		1	2	Alluvium	R-bar	CL-ML	FM	1.54	1.15		
Alluvium, R-bar, Far 10-80MU, 1, 3, FM	Far 10-80MU	24.0		1	3	Alluvium	R-bar	CL-ML	FM	2.29	1.39		
Alluvium, R-bar, 06-16MU, 1, 1, FRW	06-16MU	20.8	857.8	1	1	Alluvium	R-bar	CH	FRW	1.33	0.84		
Alluvium, R-bar, 06-16MU, 1, 2, FRW	06-16MU	20.8	857.8	1	2	Alluvium	R-bar	CH	FRW	1.72	1.07		
Alluvium, R-bar, 06-16MU, 1, 3, FRW	06-16MU	20.8	857.8	1	3	Alluvium	R-bar	CH	FRW	3.07	1.41		

St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Sherack Formation Effective Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: 4/20/2010 Date: 10/29/2010

Project, Formation, Test, Boring, Sample No, Specimen No.	BORING NO.	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO.	SPEC. NO.	FORMATION	TEST	USCS SOIL TYPE	PROJECT	R-bar, Ultimate σ_n (tsf)	R-bar, Ultimate τ_f (tsf)	DS, Ultimate σ_n (tsf)	DS, Ultimate τ_f (tsf)
Sherack, R-bar, Moor 09-11MU, 1, 1, FM	Moor 09-11MU	11.0	876.6	1	1	Sherack	R-bar	CH	FM	1.28	0.86		
Sherack, R-bar, Moor 09-11MU, 1, 2, FM	Moor 09-11MU	11.0	876.6	1	2	Sherack	R-bar	CH	FM	1.33	0.93		
Sherack, R-bar, Moor 09-11MU, 1, 3, FM	Moor 09-11MU	11.0	876.6	1	3	Sherack	R-bar	CH	FM	2.52	1.50		
Sherack, R-bar, Moor 09-14MU, 1, 1, FM	Moor 09-14MU	9.0	904.1	1	1	Sherack	R-bar	CH	FM	0.80	0.55		
Sherack, R-bar, Moor 09-14MU, 1, 2, FM	Moor 09-14MU	9.0	904.1	1	2	Sherack	R-bar	CH	FM	0.96	0.61		
Sherack, R-bar, Moor 09-14MU, 1, 3, FM	Moor 09-14MU	9.0	904.1	1	3	Sherack	R-bar	CH	FM	1.41	0.81		
Sherack, R-bar, Far 09-23MU, 2, 1, FM	Far 09-23MU	11.0	886.0	2	1	Sherack	R-bar	CH	FM	0.55	0.34		
Sherack, R-bar, Far 09-23MU, 2, 2, FM	Far 09-23MU	11.0	886.0	2	2	Sherack	R-bar	CH	FM	0.94	0.50		
Sherack, R-bar, Far 09-23MU, 2, 3, FM	Far 09-23MU	11.0	886.0	2	3	Sherack	R-bar	CH	FM	1.75	0.82		
Sherack, R-bar, Moor 09-25MU, 1, 1, FM	Moor 09-25MU	9.0	889.7	1	1	Sherack	R-bar	CH	FM	0.40	0.24		
Sherack, R-bar, Moor 09-25MU, 1, 2, FM	Moor 09-25MU	9.0	889.7	1	2	Sherack	R-bar	CH	FM	0.64	0.36		
Sherack, R-bar, Moor 09-25MU, 1, 3, FM	Moor 09-25MU	9.0	889.7	1	3	Sherack	R-bar	CH	FM	1.89	0.60		
Sherack, R-bar, Far 09-26MU, 1, 1, FM	Far 09-26MU	9.0	894.5	1	1	Sherack	R-bar	CH	FM	0.69	0.39		
Sherack, R-bar, Far 09-26MU, 1, 2, FM	Far 09-26MU	9.0	894.5	1	2	Sherack	R-bar	CH	FM	1.03	0.55		
Sherack, R-bar, Far 09-26MU, 1, 3, FM	Far 09-26MU	9.0	894.5	1	3	Sherack	R-bar	CH	FM	1.94	0.86		
Sherack, R-bar, Moor 09-34MU, 1, 1, FM	Moor 09-34MU	9.0	898.9	1	1	Sherack	R-bar	CH	FM	0.67	0.38		
Sherack, R-bar, Moor 09-34MU, 1, 2, FM	Moor 09-34MU	9.0	898.9	1	2	Sherack	R-bar	CH	FM	1.13	0.53		
Sherack, R-bar, Moor 09-34MU, 1, 3, FM	Moor 09-34MU	9.0	898.9	1	3	Sherack	R-bar	CH	FM	1.75	0.58		
Sherack, R-bar, Moor 09-53MU, 1, 1, FM	Moor 09-53MU	19.0	881.5	1	1	Sherack	R-bar	CH	FM	1.00	0.50		
Sherack, R-bar, Moor 09-53MU, 1, 2, FM	Moor 09-53MU	19.0	881.5	1	2	Sherack	R-bar	CH	FM	1.28	0.51		
Sherack, R-bar, Moor 09-53MU, 1, 3, FM	Moor 09-53MU	19.0	881.5	1	3	Sherack	R-bar	CH	FM	2.30	0.64		
Sherack, R-bar, 01-4MU, 1, 1, FRW	01-4MU	19.0	880.2	1	1	Sherack	R-bar	CH/CL	FRW	1.75	0.96		
Sherack, R-bar, 01-4MU, 1, 2, FRW	01-4MU	19.0	880.2	1	2	Sherack	R-bar	CH/CL	FRW	2.40	1.38		
Sherack, R-bar, 01-4MU, 1, 3, FRW	01-4MU	19.0	880.2	1	3	Sherack	R-bar	CH/CL	FRW	3.48	1.52		
Sherack, R-bar, 06-18MU, 1, 1, FRW	06-18MU	22.0	867.7	1	1	Sherack	R-bar	CH	FRW	1.40	0.87		
Sherack, R-bar, 06-18MU, 1, 2, FRW	06-18MU	22.0	867.7	1	2	Sherack	R-bar	CH	FRW	1.95	1.20		
Sherack, R-bar, 06-18MU, 1, 3, FRW	06-18MU	22.0	867.7	1	3	Sherack	R-bar	CH	FRW	3.14	1.80		
Sherack, R-bar, 84-1M, 1, 1, WF	84-1M	5.9	890.2	1	1	Sherack	R-bar	MH	WF	0.94	0.37		
Sherack, R-bar, 84-1M, 1, 2, WF	84-1M	5.9	890.2	1	2	Sherack	R-bar	MH	WF	2.00	0.76		
Sherack, R-bar, 84-1M, 1, 3, WF	84-1M	5.9	890.2	1	3	Sherack	R-bar	MH	WF	3.44	1.10		
Sherack, R-bar, 85-12M, 1, 1, WF	85-12M	6.0	891.3	1	1	Sherack	R-bar	CH	WF	1.10	0.68		
Sherack, R-bar, 85-12M, 1, 2, WF	85-12M	6.0	891.3	1	2	Sherack	R-bar	CH	WF	1.30	0.87		
Sherack, R-bar, 85-12M, 1, 3, WF	85-12M	6.0	891.3	1	3	Sherack	R-bar	CH	WF	2.46	1.45		

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St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Sherack Formation Effective Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: 4/20/2010 Date: 10/29/2010

Project, Formation, Test, Boring, Sample No, Specimen No.	BORING NO.	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO.	SPEC. NO.	FORMATION	TEST	USCS SOIL TYPE	PROJECT	R-bar, Ultimate		DS, Ultimate	
										σ_n (tsf)	τ_f (tsf)	σ_n (tsf)	τ_f (tsf)
Sherack, R-bar, 99-1M, 1, 1, Oakport	99-1M	7.0		1	1	Sherack	R-bar	CH	Oakport	0.56	0.31		
Sherack, R-bar, 99-1M, 1, 2, Oakport	99-1M	7.0		1	2	Sherack	R-bar	CH	Oakport	0.89	0.49		
Sherack, R-bar, 99-1M, 1, 3, Oakport	99-1M	7.0		1	3	Sherack	R-bar	CH	Oakport	1.40	0.46		
Sherack, R-bar, ST-8, , 1, SS-32ND	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Sherack, R-bar, ST-8, , 2, SS-32ND	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Sherack, R-bar, ST-8, , 3, SS-32ND	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Sherack, R-bar, ST-13, 1, 1, SS-32ND	ST-13	15.5	885.4	1	1	Sherack	R-bar	CH	SS-32ND	-0.15	0.52		
Sherack, R-bar, ST-13, 1, 2, SS-32ND	ST-13	15.5	885.4	1	2	Sherack	R-bar	CH	SS-32ND	1.08	0.61		
Sherack, R-bar, ST-13, 1, 3, SS-32ND	ST-13	15.5	885.4	1	3	Sherack	R-bar	CH	SS-32ND	2.41	0.76		
Sherack, R-bar, SL-3, , 1, SA-52ndAVE	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Sherack, R-bar, SL-3, , 2, SA-52ndAVE	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Sherack, R-bar, SL-3, , 3, SA-52ndAVE	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

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St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: PL Sherack Formation Effective Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: 4/20/2010 Date: 10/29/2010

Project, Formation, Test, Boring, Sample No., Specimen No.	BORING NO.	MID-DEPTH (feet)	ELEV (feet)	SAMPLE NO.	SPEC. NO.	FORMATION	TEST	USCS SOIL TYPE	PROJECT	R-bar, Ultimate σ_n (tsf)	R-bar, Ultimate τ_f (tsf)	DS, Ultimate σ_n (tsf)	DS, Ultimate τ_f (tsf)
PL Sherack, R-bar, 01-5MU, 1, 1, FRW	01-5MU	16.0	885.7	1	1	PL Sherack	R-bar	CH	FRW	1.08	0.31		
PL Sherack, R-bar, 01-5MU, 1, 2, FRW	01-5MU	16.0	885.7	1	2	PL Sherack	R-bar	CH	FRW	1.93	0.57		
PL Sherack, R-bar, 01-5MU, 1, 3, FRW	01-5MU	16.0	885.7	1	3	PL Sherack	R-bar	CH	FRW	3.20	0.69		

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St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Poplar Formation Effective Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: 4/20/2010 Date: 10/29/2010

Project, Formation, Test, Boring, Sample No, Specimen No	BORING NO	MID-DEPTH (feet)	ELEV (feet)	SAMPLE NO	SPEC. NO	FORMATION	TEST	USCS SOIL TYPE	PROJECT	R-bar, Ultimate σ_n (tsf)	R-bar, Ultimate τ_n (tsf)	DS, Ultimate σ_n (tsf)	DS, Ultimate τ_n (tsf)
Poplar River, R-bar, Far 09-26MU, 2, 1, FM	Far 09-26MU	17.0	886.5	2	1	Poplar River	R-bar	CH	FM	0.82	0.59		
Poplar River, R-bar, Far 09-26MU, 2, 2, FM	Far 09-26MU	17.0	886.5	2	2	Poplar River	R-bar	CH	FM	0.95	0.65		
Poplar River, R-bar, Far 09-26MU, 2, 3, FM	Far 09-26MU	17.0	886.5	2	3	Poplar River	R-bar	CH	FM	1.67	1.09		
Poplar River, R-bar, 01-10MU, 1, 1, FRW	01-10MU	21.0	860.0	1	1	Poplar River	R-bar	CH	FRW	1.38	0.83		
Poplar River, R-bar, 01-10MU, 1, 2, FRW	01-10MU	21.0	860.0	1	2	Poplar River	R-bar	CH	FRW	2.36	1.49		
Poplar River, R-bar, 01-10MU, 1, 3, FRW	01-10MU	21.0	860.0	1	3	Poplar River	R-bar	CH	FRW	3.77	2.03		
PR - WF, R-bar, Far 09-23MU, 3, 1, FM	Far 09-23MU	21.0	876.0	3	1	PR - WF	R-bar	ML	FM	3.55	2.17		
PR - WF, R-bar, Far 09-23MU, 3, 2, FM	Far 09-23MU	21.0	876.0	3	2	PR - WF	R-bar	ML	FM	4.40	2.94		
PR - WF, R-bar, Far 09-23MU, 3, 3, FM	Far 09-23MU	21.0	876.0	3	3	PR - WF	R-bar	ML	FM	8.90	4.68		
PR - WF, R-bar, Moor 09-25MU, 2, 1, FM	Moor 09-25MU	22.0	876.7	2	1	PR - WF	R-bar	ML	FM	3.15	2.34		
PR - WF, R-bar, Moor 09-25MU, 2, 2, FM	Moor 09-25MU	22.0	876.7	2	2	PR - WF	R-bar	ML	FM	3.95	2.68		
PR - WF, R-bar, Moor 09-25MU, 2, 3, FM	Moor 09-25MU	22.0	876.7	2	3	PR - WF	R-bar	ML	FM	4.98	3.25		
PR - WF, DS, Far 09-23MU, 3, 1, FM	Far 09-23MU	21.0	876.0	3	1	PR - WF	DS	ML	FM			0.51	0.38
PR - WF, DS, Far 09-23MU, 3, 2, FM	Far 09-23MU	21.0	876.0	3	2	PR - WF	DS	ML	FM			1.01	0.70
PR - WF, DS, Far 09-23MU, 3, 3, FM	Far 09-23MU	21.0	876.0	3	3	PR - WF	DS	ML	FM			1.93	1.35
PR - Harwood, R-bar, Far 09-23MU, 4, 1, FM	Far 09-23MU	29.0	868.0	4	1	PR - Harwood	R-bar	CH	FM	0.77	0.49		
PR - Harwood, R-bar, Far 09-23MU, 4, 2, FM	Far 09-23MU	29.0	868.0	4	2	PR - Harwood	R-bar	CH	FM	1.24	0.75		
PR - Harwood, R-bar, Far 09-23MU, 4, 3, FM	Far 09-23MU	29.0	868.0	4	3	PR - Harwood	R-bar	CH	FM	1.80	0.97		
PR - Harwood, R-bar, Moor 09-25MU, 3, 1, FM	Moor 09-25MU	26.0	872.7	3	1	PR - Harwood	R-bar	CH	FM	0.95	0.48		
PR - Harwood, R-bar, Moor 09-25MU, 3, 2, FM	Moor 09-25MU	26.0	872.7	3	2	PR - Harwood	R-bar	CH	FM	1.31	0.52		
PR - Harwood, R-bar, Moor 09-25MU, 3, 3, FM	Moor 09-25MU	26.0	872.7	3	3	PR - Harwood	R-bar	CH	FM	1.65	0.63		

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St. Paul District GEOLOGY GEOTECHNICAL US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Oxidized Brenna Formation Effective Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: 4/20/2010 Date: 10/29/2010

Project, Formation, Test, Boring, Sample No, Specimen No	BORING NO	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO	SPEC. NO	FORMATION	TEST	USCS SOIL TYPE	PROJECT	R-bar, Ultimate σ_n (tsf)	R-bar, Ultimate τ_n (tsf)	DS, Ultimate σ_n (tsf)	DS, Ultimate τ_n (tsf)
OX Brenna, R-bar, Moor 09-26MU, 2, 1, FM	Moor 09-26MU	21.0	890.5	2	1	OX Brenna	R-bar	CH	FM	0.59	0.27		
OX Brenna, R-bar, Moor 09-26MU, 2, 2, FM	Moor 09-26MU	21.0	890.5	2	2	OX Brenna	R-bar	CH	FM	1.06	0.37		
OX Brenna, R-bar, Moor 09-26MU, 2, 3, FM	Moor 09-26MU	21.0	890.5	2	3	OX Brenna	R-bar	CH	FM	1.74	0.53		
OX Brenna, R-bar, Moor 09-34MU, 2, 1, FM	Moor 09-34MU	17.0	890.9	2	1	OX Brenna	R-bar	CH	FM	0.69	0.29		
OX Brenna, R-bar, Moor 09-34MU, 2, 2, FM	Moor 09-34MU	17.0	890.9	2	2	OX Brenna	R-bar	CH	FM	1.20	0.39		
OX Brenna, R-bar, Moor 09-34MU, 2, 3, FM	Moor 09-34MU	17.0	890.9	2	3	OX Brenna	R-bar	CH	FM	2.26	0.52		
OX Brenna, R-bar, Far 09-59MU, 1, 1, FM	Far 09-59MU	11.0	905.2	1	1	OX Brenna	R-bar	CH	FM	0.72	0.40		
OX Brenna, R-bar, Far 09-59MU, 1, 2, FM	Far 09-59MU	11.0	905.2	1	2	OX Brenna	R-bar	CH	FM	1.25	0.55		
OX Brenna, R-bar, Far 09-59MU, 1, 3, FM	Far 09-59MU	11.0	905.2	1	3	OX Brenna	R-bar	CH	FM	2.35	0.72		
OX Brenna, R-bar, Far 09-59MU, 2, 1, FM	Far 09-59MU	21.0	895.2	2	1	OX Brenna	R-bar	CH	FM	0.90	0.38		
OX Brenna, R-bar, Far 09-59MU, 2, 2, FM	Far 09-59MU	21.0	895.2	2	2	OX Brenna	R-bar	CH	FM	1.66	0.55		
OX Brenna, R-bar, Far 09-59MU, 2, 3, FM	Far 09-59MU	21.0	895.2	2	3	OX Brenna	R-bar	CH	FM	2.62	0.72		
OX Brenna, R-bar, Far 09-60MU, 1, 1, FM	Far 09-60MU	16.0	867.3	1	1	OX Brenna	R-bar	CH	FM	0.54	0.31		
OX Brenna, R-bar, Far 09-60MU, 1, 2, FM	Far 09-60MU	16.0	867.3	1	2	OX Brenna	R-bar	CH	FM	1.06	0.42		
OX Brenna, R-bar, Far 09-60MU, 1, 3, FM	Far 09-60MU	16.0	867.3	1	3	OX Brenna	R-bar	CH	FM	1.92	0.58		
OX Brenna, R-bar, Far 09-60MU, 2, 1, FM	Far 09-60MU	26.0	857.3	2	1	OX Brenna	R-bar	CH	FM	0.94	0.39		
OX Brenna, R-bar, Far 09-60MU, 2, 2, FM	Far 09-60MU	26.0	857.3	2	2	OX Brenna	R-bar	CH	FM	1.39	0.51		
OX Brenna, R-bar, Far 09-60MU, 2, 3, FM	Far 09-60MU	26.0	857.3	2	3	OX Brenna	R-bar	CH	FM	2.57	0.71		
OX Brenna, R-bar, 84-2M, 1, 1, WF	84-2M	10.8	893.8	1	1	OX Brenna	R-bar	CH	WF	0.92	0.37		
OX Brenna, R-bar, 84-2M, 1, 2, WF	84-2M	10.8	893.8	1	2	OX Brenna	R-bar	CH	WF	1.77	0.71		
OX Brenna, R-bar, 84-2M, 1, 3, WF	84-2M	10.8	893.8	1	3	OX Brenna	R-bar	CH	WF	3.37	1.25		
OX Brenna, R-bar, 84-2M, 1, 4, WF	84-2M	10.8	893.8	1	4	OX Brenna	R-bar	CH	WF	0.27	0.10		
OX Brenna, R-bar, 85-4M, 1, 1, WF	85-4M	9.0	904.2	1	1	OX Brenna	R-bar	CH	WF	0.56	0.24		
OX Brenna, R-bar, 85-4M, 1, 2, WF	85-4M	9.0	904.2	1	2	OX Brenna	R-bar	CH	WF	1.04	0.51		
OX Brenna, R-bar, 85-4M, 1, 3, WF	85-4M	9.0	904.2	1	3	OX Brenna	R-bar	CH	WF	1.87	0.51		
OX Brenna, R-bar, 85-4M, 1, 4, WF	85-4M	9.0	904.2	1	4	OX Brenna	R-bar	CH	WF	0.84	0.59		
OX Brenna, R-bar, 85-6M, 1, 1, WF	85-6M	8.0	894.2	1	1	OX Brenna	R-bar	CH	WF	0.53	0.18		
OX Brenna, R-bar, 85-6M, 1, 2, WF	85-6M	8.0	894.2	1	2	OX Brenna	R-bar	CH	WF	0.90	0.32		
OX Brenna, R-bar, 85-6M, 1, 3, WF	85-6M	8.0	894.2	1	3	OX Brenna	R-bar	CH	WF	1.76	0.47		
OX Brenna, R-bar, 85-7M, 1, 1, WF	85-7M	5.9	895.7	1	1	OX Brenna	R-bar	CH	WF	0.72	0.29		
OX Brenna, R-bar, 85-7M, 1, 2, WF	85-7M	5.9	895.7	1	2	OX Brenna	R-bar	CH	WF	0.47	0.46		
OX Brenna, R-bar, 85-7M, 1, 3, WF	85-7M	5.9	895.7	1	3	OX Brenna	R-bar	CH	WF	1.75	0.62		
OX Brenna, R-bar, 85-7M, 1, 4, WF	85-7M	5.9	895.7	1	4	OX Brenna	R-bar	CH	WF	0.34	0.13		
OX Brenna, R-bar, 85-7M, 2, 1, WF	85-7M	15.0	886.6	2	1	OX Brenna	R-bar	CH	WF	0.48	0.22		
OX Brenna, R-bar, 85-7M, 2, 2, WF	85-7M	15.0	886.6	2	2	OX Brenna	R-bar	CH	WF	0.83	0.27		
OX Brenna, R-bar, 85-7M, 2, 3, WF	85-7M	15.0	886.6	2	3	OX Brenna	R-bar	CH	WF	1.64	0.40		
OX Brenna, R-bar, 85-11M, 1, 1, WF	85-11M	16.0	883.5	1	1	OX Brenna	R-bar	CH	WF	0.64	0.22		
OX Brenna, R-bar, 85-11M, 1, 2, WF	85-11M	16.0	883.5	1	2	OX Brenna	R-bar	CH	WF	0.96	0.34		

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St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Oxidized Brenna Formation Effective Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: 4/20/2010 Date: 10/29/2010

Project, Formation, Test, Boring, Sample No., Specimen No.	BORING NO.	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO.	SPEC. NO.	FORMATION	TEST	USCS SOIL TYPE	PROJECT	R-bar, Ultimate σ_n (tsf)	R-bar, Ultimate τ_n (tsf)	DS, Ultimate σ_n (tsf)	DS, Ultimate τ_n (tsf)
OX Brenna, R-bar, 85-11M, 1, 3, WF	85-11M	16.0	883.5	1	3	OX Brenna	R-bar	CH	WF	1.68	0.35		
OX Brenna, R-bar, 85-11M, 1, 4, WF	85-11M	16.0	883.5	1	4	OX Brenna	R-bar	CH	WF	0.46	0.19		
OX Brenna, R-bar, 85-12M, 2, 1, WF	85-12M	16.0	8957.0	2	1	OX Brenna	R-bar	CH	WF	1.03	0.56		
OX Brenna, R-bar, 85-12M, 2, 2, WF	85-12M	16.0	8957.0	2	2	OX Brenna	R-bar	CH	WF	1.43	0.91		
OX Brenna, R-bar, 85-12M, 2, 3, WF	85-12M	16.0	8957.0	2	3	OX Brenna	R-bar	CH	WF	1.99	1.00		
OX Brenna, R-bar, 86-28M, 1, 1, WF	86-28M	11.0	906.6	1	1	OX Brenna	R-bar	CH	WF	0.86	0.38		
OX Brenna, R-bar, 86-28M, 1, 2, WF	86-28M	11.0	906.6	1	2	OX Brenna	R-bar	CH	WF	1.08	0.39		
OX Brenna, R-bar, 86-28M, 1, 3, WF	86-28M	11.0	906.6	1	3	OX Brenna	R-bar	CH	WF	1.96	0.58		
OX Brenna, R-bar, 86-28M, 2, 1, WF	86-28M	21.0	896.6	2	1	OX Brenna	R-bar	CH	WF	0.97	0.32		
OX Brenna, R-bar, 86-28M, 2, 2, WF	86-28M	21.0	896.6	2	2	OX Brenna	R-bar	CH	WF	1.74	0.46		
OX Brenna, R-bar, 86-28M, 2, 3, WF	86-28M	21.0	896.6	2	3	OX Brenna	R-bar	CH	WF	2.94	0.63		

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St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Brenna Formation Effective Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: 4/20/2010 Date: 10/29/2010

Project, Formation, Test, Boring, Sample No, Specimen No	BORING NO.	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO.	SPEC. NO.	FORMATION	TEST	USCS SOIL TYPE	PROJECT	R-bar, Ultimate σ_n (tsf)	R-bar, Ultimate τ_f (tsf)	DS, Ultimate σ_n (tsf)	DS, Ultimate τ_f (tsf)
Brenna, R-bar, Moor 09-11MU, 2, 1, FM	Moor 09-11MU	31.0	856.6	2	1	Brenna	R-bar	CH	FM	0.95	0.32		
Brenna, R-bar, Moor 09-11MU, 2, 2, FM	Moor 09-11MU	31.0	856.6	2	2	Brenna	R-bar	CH	FM	1.67	0.45		
Brenna, R-bar, Moor 09-11MU, 2, 3, FM	Moor 09-11MU	31.0	856.6	2	3	Brenna	R-bar	CH	FM	2.71	0.68		
Brenna, R-bar, Moor 09-11MU, 3, 1, FM	Moor 09-11MU	41.0	846.6	3	1	Brenna	R-bar	CH	FM	1.08	0.48		
Brenna, R-bar, Moor 09-11MU, 3, 2, FM	Moor 09-11MU	41.0	846.6	3	2	Brenna	R-bar	CH	FM	1.49	0.51		
Brenna, R-bar, Moor 09-11MU, 3, 3, FM	Moor 09-11MU	41.0	846.6	3	3	Brenna	R-bar	CH	FM	2.27	0.63		
Brenna, R-bar, Moor 09-14MU, 2, 1, FM	Moor 09-14MU	16.0	897.1	2	1	Brenna	R-bar	CH	FM	0.46	0.20		
Brenna, R-bar, Moor 09-14MU, 2, 2, FM	Moor 09-14MU	16.0	897.1	2	2	Brenna	R-bar	CH	FM	0.76	0.26		
Brenna, R-bar, Moor 09-14MU, 2, 3, FM	Moor 09-14MU	16.0	897.1	2	3	Brenna	R-bar	CH	FM	1.30	0.37		
Brenna, R-bar, Far 09-25MU, 4, 1, FM	Far 09-25MU	51.0	842.4	4	1	Brenna	R-bar	CH	FM	0.60	0.26		
Brenna, R-bar, Far 09-25MU, 4, 2, FM	Far 09-25MU	51.0	842.4	4	2	Brenna	R-bar	CH	FM	1.31	0.45		
Brenna, R-bar, Far 09-25MU, 4, 3, FM	Far 09-25MU	51.0	842.4	4	3	Brenna	R-bar	CH	FM	2.13	0.51		
Brenna, R-bar, Moor 09-25MU, 4, 1, FM	Moor 09-25MU	39.0	859.7	4	1	Brenna	R-bar	CH	FM	0.64	0.23		
Brenna, R-bar, Moor 09-25MU, 4, 2, FM	Moor 09-25MU	39.0	859.7	4	2	Brenna	R-bar	CH	FM	0.74	0.35		
Brenna, R-bar, Moor 09-25MU, 4, 3, FM	Moor 09-25MU	39.0	859.7	4	3	Brenna	R-bar	CH	FM	1.88	0.55		
Brenna, R-bar, Far 09-26MU, 3, 1, FM	Far 09-26MU	29.0	874.5	3	1	Brenna	R-bar	CH	FM	0.82	0.32		
Brenna, R-bar, Far 09-26MU, 3, 2, FM	Far 09-26MU	29.0	874.5	3	2	Brenna	R-bar	CH	FM	1.49	0.50		
Brenna, R-bar, Far 09-26MU, 3, 3, FM	Far 09-26MU	29.0	874.5	3	3	Brenna	R-bar	CH	FM	2.44	0.67		
Brenna, R-bar, Far 09-27MU, 3, 1, FM	Far 09-27MU	33.0	870.1	3	1	Brenna	R-bar	CH	FM	0.91	0.26		
Brenna, R-bar, Far 09-27MU, 3, 2, FM	Far 09-27MU	33.0	870.1	3	2	Brenna	R-bar	CH	FM	1.35	0.40		
Brenna, R-bar, Far 09-27MU, 3, 3, FM	Far 09-27MU	33.0	870.1	3	3	Brenna	R-bar	CH	FM	2.25	0.53		
Brenna, R-bar, Moor 09-53MU, 2, 1, FM	Moor 09-53MU	29.0	871.5	2	1	Brenna	R-bar	CH	FM	0.84	0.29		
Brenna, R-bar, Moor 09-53MU, 2, 2, FM	Moor 09-53MU	29.0	871.5	2	2	Brenna	R-bar	CH	FM	1.48	0.45		
Brenna, R-bar, Moor 09-53MU, 2, 3, FM	Moor 09-53MU	29.0	871.5	2	3	Brenna	R-bar	CH	FM	2.48	0.59		
Brenna, R-bar, Far 10-78MU, 2, 1, FM	Far 10-78MU	26.0		2	1	Brenna	R-bar	CH	FM	1.07	0.46		
Brenna, R-bar, Far 10-78MU, 2, 2, FM	Far 10-78MU	26.0		2	2	Brenna	R-bar	CH	FM	1.61	0.64		
Brenna, R-bar, Far 10-78MU, 2, 3, FM	Far 10-78MU	26.0		2	3	Brenna	R-bar	CH	FM	2.71	0.69		
Brenna, R-bar, Far 10-80MU, 2, 1, FM	Far 10-80MU	36.0		2	1	Brenna	R-bar	CH	FM	1.16	0.56		
Brenna, R-bar, Far 10-80MU, 2, 2, FM	Far 10-80MU	36.0		2	2	Brenna	R-bar	CH	FM	1.57	0.48		
Brenna, R-bar, Far 10-80MU, 2, 3, FM	Far 10-80MU	36.0		2	3	Brenna	R-bar	CH	FM	3.05	0.61		
Brenna, DS, Moor 09-14MU, 3, 1, FM	Moor 09-14MU	39.0	874.1	3	1	Brenna	DS	CH	FM			0.51	0.15
Brenna, DS, Moor 09-14MU, 3, 2, FM	Moor 09-14MU	39.0	874.1	3	2	Brenna	DS	CH	FM			1.01	0.29
Brenna, DS, Moor 09-14MU, 3, 3, FM	Moor 09-14MU	39.0	874.1	3	3	Brenna	DS	CH	FM			3.18	0.92
Brenna, DS, Far 09-23MU, 5, 1, FM	Far 09-23MU	39.0	858.0	5	1	Brenna	DS	CH	FM			0.51	0.14
Brenna, DS, Far 09-23MU, 5, 2, FM	Far 09-23MU	39.0	858.0	5	2	Brenna	DS	CH	FM			1.01	0.24
Brenna, DS, Far 09-23MU, 5, 3, FM	Far 09-23MU	39.0	858.0	5	3	Brenna	DS	CH	FM			3.18	0.65
Brenna, DS, Far 09-23MU, 6, 1, FM	Far 09-23MU	81.0	816.0	6	1	Brenna	DS	CH	FM			1.01	0.39
Brenna, DS, Far 09-23MU, 6, 2, FM	Far 09-23MU	81.0	816.0	6	2	Brenna	DS	CH	FM			1.93	0.55

St. Paul District GEOLOGY GEOTECHNICAL
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Project: Fargo-Moorhead Metro Feasibility Study
Subject: Brenna Formation Effective Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: 4/20/2010 Date: 10/29/2010

Project, Formation, Test, Boring, Sample No., Specimen No.	BORING NO.	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO.	SPEC. NO.	FORMATION	TEST	USCS SOIL TYPE	PROJECT	R-bar, Ultimate		DS, Ultimate	
										$\sigma_{n'}$ (tsf)	τ_{ff} (tsf)	$\sigma_{n'}$ (tsf)	τ_{ff} (tsf)
Brenna, DS, Far 09-23MU, 6, 3, FM	Far 09-23MU	81.0	816.0	6	3	Brenna	DS	CH	FM			4.08	1.02
Brenna, DS, Far 09-25MU, 4, 1, FM	Far 09-25MU	51.0	842.4	4	1	Brenna	DS	CH	FM			1.01	0.23
Brenna, DS, Far 09-25MU, 4, 2, FM	Far 09-25MU	51.0	842.4	4	2	Brenna	DS	CH	FM			2.00	0.43
Brenna, DS, Far 09-25MU, 4, 3, FM	Far 09-25MU	51.0	842.4	4	3	Brenna	DS	CH	FM			4.08	0.83
Brenna, DS, Moor 09-26MU, 3, 1, FM	Moor 09-26MU	29.0	882.5	3	1	Brenna	DS	CH	FM			1.01	0.24
Brenna, DS, Moor 09-26MU, 3, 2, FM	Moor 09-26MU	29.0	882.5	3	2	Brenna	DS	CH	FM			2.00	0.43
Brenna, DS, Moor 09-26MU, 3, 3, FM	Moor 09-26MU	29.0	882.5	3	3	Brenna	DS	CH	FM			4.08	0.88
Brenna, DS, Far 09-27MU, 3, 1, FM	Far 09-27MU	33.0	870.1	3	1	Brenna	DS	CH	FM			1.01	0.23
Brenna, DS, Far 09-27MU, 3, 2, FM	Far 09-27MU	33.0	870.1	3	2	Brenna	DS	CH	FM			2.00	0.45
Brenna, DS, Far 09-27MU, 3, 3, FM	Far 09-27MU	33.0	870.1	3	3	Brenna	DS	CH	FM			4.08	0.85
Brenna, DS, Far 09-27MU, 4, 1, FM	Far 09-27MU	65.0	838.1	4	1	Brenna	DS	CH	FM			1.01	0.30
Brenna, DS, Far 09-27MU, 4, 2, FM	Far 09-27MU	65.0	838.1	4	2	Brenna	DS	CH	FM			2.00	0.56
Brenna, DS, Far 09-27MU, 4, 3, FM	Far 09-27MU	65.0	838.1	4	3	Brenna	DS	CH	FM			4.08	1.11
Brenna, DS, Moor 09-34MU, 3, 1, FM	Moor 09-34MU	29.0	878.9	3	1	Brenna	DS	CH	FM			1.01	0.31
Brenna, DS, Moor 09-34MU, 3, 2, FM	Moor 09-34MU	29.0	878.9	3	2	Brenna	DS	CH	FM			2.00	0.41
Brenna, DS, Moor 09-34MU, 3, 3, FM	Moor 09-34MU	29.0	878.9	3	3	Brenna	DS	CH	FM			4.08	0.85
Brenna, DS, Far 09-60MU, 3, 1, FM	Far 09-60MU	36.0	847.3	3	1	Brenna	DS	CH	FM			1.01	0.29
Brenna, DS, Far 09-60MU, 3, 2, FM	Far 09-60MU	36.0	847.3	3	2	Brenna	DS	CH	FM			2.00	0.40
Brenna, DS, Far 09-60MU, 3, 3, FM	Far 09-60MU	36.0	847.3	3	3	Brenna	DS	CH	FM			4.08	0.82
Brenna, DS, Far 10-80MU, 2, 1, FM	Far 10-80MU	36.0		2	1	Brenna	DS	CH	FM			1.00	0.45
Brenna, DS, Far 10-80MU, 2, 2, FM	Far 10-80MU	36.0		2	2	Brenna	DS	CH	FM			2.00	0.71
Brenna, DS, Far 10-80MU, 2, 3, FM	Far 10-80MU	36.0		2	3	Brenna	DS	CH	FM			4.00	1.48
Brenna, R-bar, 01-5MU, 2, 1, FRW	01-5MU	49.0	852.7	2	1	Brenna	R-bar	CH	FRW	0.95	0.25		
Brenna, R-bar, 01-5MU, 2, 2, FRW	01-5MU	49.0	852.7	2	2	Brenna	R-bar	CH	FRW	1.34	0.29		
Brenna, R-bar, 01-5MU, 2, 3, FRW	01-5MU	49.0	852.7	2	3	Brenna	R-bar	CH	FRW	2.57	0.46		
Brenna, R-bar, 01-12MU, 2, 1, FRW	01-12MU	31.0	853.0	2	1	Brenna	R-bar	CH	FRW	0.93	0.22		
Brenna, R-bar, 01-12MU, 2, 2, FRW	01-12MU	31.0	853.0	2	2	Brenna	R-bar	CH	FRW	1.61	0.36		
Brenna, R-bar, 01-12MU, 2, 3, FRW	01-12MU	31.0	853.0	2	3	Brenna	R-bar	CH	FRW	2.75	0.69		
Brenna, DS, 06-18MU, 2, 1, FRW	06-18MU	52.0	837.7	2	1	Brenna	DS	CH	FRW			1.00	0.31
Brenna, DS, 06-18MU, 2, 2, FRW	06-18MU	52.0	837.7	2	2	Brenna	DS	CH	FRW			2.00	0.52
Brenna, DS, 06-18MU, 2, 3, FRW	06-18MU	52.0	837.7	2	3	Brenna	DS	CH	FRW			4.00	0.61
Brenna, R-bar, 99-1M, 5, 2, Oakport	99-1M	35.0		5	2	Brenna	R-bar	CH	Oakport	0.61	0.20		
Brenna, R-bar, 99-1M, 5, 3, Oakport	99-1M	35.0		5	3	Brenna	R-bar	CH	Oakport	0.97	0.33		
Oakport, Brenna, R-bar, 99-1M, 5, 3	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Brenna, R-bar, 84-1M, 3, 1, WF	84-1M	19.0	877.1	3	1	Brenna	R-bar	MH	WF	0.80	0.18		
Brenna, R-bar, 84-1M, 3, 2, WF	84-1M	19.0	877.1	3	2	Brenna	R-bar	MH	WF	1.35	0.26		

St. Paul District GEOLOGY GEOTECHNICAL US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Brenna Formation Effective Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: 4/20/2010 Date: 10/29/2010

Project, Formation, Test, Boring, Sample No., Specimen No.	BORING NO.	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO.	SPEC. NO.	FORMATION	TEST	USCS SOIL TYPE	PROJECT	R-bar, Ultimate		DS, Ultimate	
										σ_n (tsf)	τ_n (tsf)	σ_n (tsf)	τ_n (tsf)
Brenna, R-bar, 84-1M, 3, 3, WF	84-1M	19.0	877.1	3	3	Brenna	R-bar	MH	WF	2.43	0.40		
Brenna, R-bar, 84-1M, 4, 1, WF	84-1M	29.0	867.1	4	1	Brenna	R-bar	CH	WF	0.94	0.25		
Brenna, R-bar, 84-1M, 4, 2, WF	84-1M	29.0	867.1	4	2	Brenna	R-bar	CH	WF	1.36	0.24		
Brenna, R-bar, 84-1M, 4, 3, WF	84-1M	29.0	867.1	4	3	Brenna	R-bar	CH	WF	2.23	0.48		
Brenna, R-bar, 84-2M, 3, 1, WF	84-2M	21.0	883.6	3	1	Brenna	R-bar	CH	WF	0.78	0.27		
Brenna, R-bar, 84-2M, 3, 2, WF	84-2M	21.0	883.6	3	2	Brenna	R-bar	CH	WF	1.52	0.37		
Brenna, R-bar, 84-2M, 3, 3, WF	84-2M	21.0	883.6	3	3	Brenna	R-bar	CH	WF	2.76	0.63		
Brenna, R-bar, 85-4M, 3, 1, WF	85-4M	25.0	888.2	3	1	Brenna	R-bar	CH	WF	0.51	0.21		
Brenna, R-bar, 85-4M, 3, 2, WF	85-4M	25.0	888.2	3	2	Brenna	R-bar	CH	WF	0.77	0.28		
Brenna, R-bar, 85-4M, 3, 3, WF	85-4M	25.0	888.2	3	3	Brenna	R-bar	CH	WF	1.54	0.41		
Brenna, R-bar, 85-4M, 4, 1, WF	85-4M	30.8	882.4	4	1	Brenna	R-bar	CH	WF	0.81	0.28		
Brenna, R-bar, 85-4M, 4, 2, WF	85-4M	30.8	882.4	4	2	Brenna	R-bar	CH	WF	1.43	0.34		
Brenna, R-bar, 85-4M, 4, 3, WF	85-4M	30.8	882.4	4	3	Brenna	R-bar	CH	WF	2.04	0.69		
Brenna, R-bar, 85-4M, 6, 1, WF	85-4M	48.0	865.2	6	1	Brenna	R-bar	CH	WF	0.89	0.30		
Brenna, R-bar, 85-4M, 6, 2, WF	85-4M	48.0	865.2	6	2	Brenna	R-bar	CH	WF	1.43	0.42		
Brenna, R-bar, 85-4M, 6, 3, WF	85-4M	48.0	865.2	6	3	Brenna	R-bar	CH	WF	2.07	0.83		
Brenna, R-bar, 85-4M, 6, 4, WF	85-4M	48.0	865.2	6	4	Brenna	R-bar	CH	WF	0.52	0.18		
Brenna, R-bar, 85-6M, 2, 1, WF	85-6M	18.0	884.2	2	1	Brenna	R-bar	CH	WF	1.00	0.18		
Brenna, R-bar, 85-6M, 2, 2, WF	85-6M	18.0	884.2	2	2	Brenna	R-bar	CH	WF	1.05	0.32		
Brenna, R-bar, 85-6M, 2, 3, WF	85-6M	18.0	884.2	2	3	Brenna	R-bar	CH	WF	1.72	0.40		
Brenna, R-bar, 85-6M, 3, 1, WF	85-6M	31.0	871.2	3	1	Brenna	R-bar	CH	WF	0.96	0.26		
Brenna, R-bar, 85-6M, 3, 2, WF	85-6M	31.0	871.2	3	2	Brenna	R-bar	CH	WF	1.52	0.38		
Brenna, R-bar, 85-6M, 3, 3, WF	85-6M	31.0	871.2	3	3	Brenna	R-bar	CH	WF	2.33	0.40		
Brenna, R-bar, 85-7M, 3, 1, WF	85-7M	22.0	879.6	3	1	Brenna	R-bar	CH	WF	0.51	0.20		
Brenna, R-bar, 85-7M, 3, 2, WF	85-7M	22.0	879.6	3	2	Brenna	R-bar	CH	WF	0.85	0.30		
Brenna, R-bar, 85-7M, 3, 3, WF	85-7M	22.0	879.6	3	3	Brenna	R-bar	CH	WF	1.20	0.31		
Brenna, R-bar, 85-10M, 1, 1, WF	85-10M	16.0	880.1	1	1	Brenna	R-bar	CH	WF	0.51	0.16		
Brenna, R-bar, 85-10M, 1, 2, WF	85-10M	16.0	880.1	1	2	Brenna	R-bar	CH	WF	0.79	0.21		
Brenna, R-bar, 85-10M, 1, 3, WF	85-10M	16.0	880.1	1	3	Brenna	R-bar	CH	WF	1.48	0.35		
Brenna, R-bar, 85-10M, 3, 1, WF	85-10M	26.0	870.1	3	1	Brenna	R-bar	CH	WF	0.46	0.16		
Brenna, R-bar, 85-10M, 3, 2, WF	85-10M	26.0	870.1	3	2	Brenna	R-bar	CH	WF	0.72	0.18		
Brenna, R-bar, 85-10M, 3, 3, WF	85-10M	26.0	870.1	3	3	Brenna	R-bar	CH	WF	1.20	0.31		
Brenna, R-bar, 85-10M, 4, 1, WF	85-10M	37.0	859.1	4	1	Brenna	R-bar	CH	WF	0.87	0.27		
Brenna, R-bar, 85-10M, 4, 2, WF	85-10M	37.0	859.1	4	2	Brenna	R-bar	CH	WF	1.38	0.31		
Brenna, R-bar, 85-10M, 4, 3, WF	85-10M	37.0	859.1	4	3	Brenna	R-bar	CH	WF	2.40	0.65		
Brenna, R-bar, 85-11M, 4, 1, WF	85-11M	31.0	868.5	4	1	Brenna	R-bar	CH	WF	0.97	0.20		
Brenna, R-bar, 85-11M, 4, 2, WF	85-11M	31.0	868.5	4	2	Brenna	R-bar	CH	WF	1.67	0.38		
Brenna, R-bar, 85-11M, 4, 3, WF	85-11M	31.0	868.5	4	3	Brenna	R-bar	CH	WF	2.62	0.46		
Brenna, R-bar, 85-12M, 4, 1, WF	85-12M	26.0	871.3	4	1	Brenna	R-bar	CH	WF	0.59	0.18		
Brenna, R-bar, 85-12M, 4, 2, WF	85-12M	26.0	871.3	4	2	Brenna	R-bar	CH	WF	0.86	0.27		

St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Brenna Formation Effective Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: 4/20/2010 Date: 10/29/2010

Project, Formation, Test, Boring, Sample No., Specimen No.	BORING NO.	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO.	SPEC. NO.	FORMATION	TEST	USCS SOIL TYPE	PROJECT	R-bar, Ultimate		DS, Ultimate	
										σ_n (tsf)	τ_n (tsf)	σ_n (tsf)	τ_n (tsf)
Brenna, R-bar, 85-12M, 4, 3, WF	85-12M	26.0	871.3	4	3	Brenna	R-bar	CH	WF	1.48	0.45		
Brenna, R-bar, 86-6M, 6, 1, WF	86-6M	14.1	888.1	6	1	Brenna	R-bar	CH	WF	1.13	0.29		
Brenna, R-bar, 86-6M, 6, 2, WF	86-6M	14.1	888.1	6	2	Brenna	R-bar	CH	WF	1.86	0.45		
Brenna, R-bar, 86-6M, 6, 3, WF	86-6M	14.1	888.1	6	3	Brenna	R-bar	CH	WF	3.45	0.75		
Brenna, R-bar, 86-6M, 7, 1, WF	86-6M	26.1	876.1	7	1	Brenna	R-bar	CH	WF	1.08	0.38		
Brenna, R-bar, 86-6M, 7, 2, WF	86-6M	26.1	876.1	7	2	Brenna	R-bar	CH	WF	1.80	0.52		
Brenna, R-bar, 86-6M, 7, 3, WF	86-6M	26.1	876.1	7	3	Brenna	R-bar	CH	WF	3.21	0.50		
Brenna, R-bar, 86-9M, 2, 1, WF	86-9M	30.1	866.0	2	1	Brenna	R-bar	CH	WF	0.69	0.25		
Brenna, R-bar, 86-9M, 2, 2, WF	86-9M	30.1	866.0	2	2	Brenna	R-bar	CH	WF	1.41	0.38		
Brenna, R-bar, 86-9M, 2, 3, WF	86-9M	30.1	866.0	2	3	Brenna	R-bar	CH	WF	2.61	0.41		
Brenna, R-bar, 86-29M, 5, 1, WF	86-29M	39.1	864.9	5	1	Brenna	R-bar	CH	WF	0.89	0.27		
Brenna, R-bar, 86-29M, 5, 2, WF	86-29M	39.1	864.9	5	2	Brenna	R-bar	CH	WF	1.34	0.38		
Brenna, R-bar, 86-29M, 5, 3, WF	86-29M	39.1	864.9	5	3	Brenna	R-bar	CH	WF	2.63	0.50		
Brenna, R-bar, 86-31M, 3, 1, WF	86-31M	31.1	862.2	3	1	Brenna	R-bar	CH	WF	0.72	0.24		
Brenna, R-bar, 86-31M, 3, 2, WF	86-31M	31.1	862.2	3	2	Brenna	R-bar	CH	WF	1.44	0.34		
Brenna, R-bar, 86-31M, 3, 3, WF	86-31M	31.1	862.2	3	3	Brenna	R-bar	CH	WF	1.95	0.62		
Brenna, R-bar, 86-31M, 4, 1, WF	86-31M	41.1	852.2	4	1	Brenna	R-bar	CH	WF	0.82	0.24		
Brenna, R-bar, 86-31M, 4, 2, WF	86-31M	41.1	852.2	4	2	Brenna	R-bar	CH	WF	1.33	0.22		
Brenna, R-bar, 86-31M, 4, 3, WF	86-31M	41.1	852.2	4	3	Brenna	R-bar	CH	WF	2.04	0.44		
Brenna, R-bar, 86-32M, 2, 1, WF	86-32M	21.1	866.7	2	1	Brenna	R-bar	CH	WF	0.67	0.16		
Brenna, R-bar, 86-32M, 2, 2, WF	86-32M	21.1	866.7	2	2	Brenna	R-bar	CH	WF	0.93	0.32		
Brenna, R-bar, 86-32M, 2, 3, WF	86-32M	21.1	866.7	2	3	Brenna	R-bar	CH	WF	2.02	0.55		

St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Argusville Formation Effective Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: 4/20/2010 Date: 10/29/2010

Project, Formation, Test, Boring, Sample No, Specimen No	BORING NO	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO	SPEC. NO	FORMATION	TEST	USCS SOIL TYPE	PROJECT	R-bar, Ultimate σ_n (tsf)	R-bar, Ultimate τ_n (tsf)	DS, Ultimate σ_n (tsf)	DS, Ultimate τ_n (tsf)
Argusville, R-bar, Far 10-79MU, 2, 1, FM	Far 10-79MU	41.0		2	1	Argusville	R-bar	CH	FM	0.81	0.43		
Argusville, R-bar, Far 10-79MU, 2, 2, FM	Far 10-79MU	41.0		2	2	Argusville	R-bar	CH	FM	1.26	0.54		
Argusville, R-bar, Far 10-79MU, 2, 3, FM	Far 10-79MU	41.0		2	3	Argusville	R-bar	CH	FM	1.70	0.69		
Argusville, R-bar, Far 10-80MU, 3, 1, FM	Far 10-80MU	56.0		3	1	Argusville	R-bar	CH	FM	0.94	0.30		
Argusville, R-bar, Far 10-80MU, 3, 2, FM	Far 10-80MU	56.0		3	2	Argusville	R-bar	CH	FM	1.48	0.34		
Argusville, R-bar, Far 10-80MU, 3, 3, FM	Far 10-80MU	56.0		3	3	Argusville	R-bar	CH	FM	2.70	0.48		
Argusville, DS, Moor 09-14MU, 4, 1, FM	Moor 09-14MU	59.0	854.1	4	1	Argusville	DS	CH	FM			1.01	0.51
Argusville, DS, Moor 09-14MU, 4, 2, FM	Moor 09-14MU	59.0	854.1	4	2	Argusville	DS	CH	FM			1.93	0.84
Argusville, DS, Moor 09-14MU, 4, 3, FM	Moor 09-14MU	59.0	854.1	4	3	Argusville	DS	CH	FM			4.08	1.29
Argusville, DS, Far 09-25MU, 5, 1, FM	Far 09-25MU	67.0	826.4	5	1	Argusville	DS	CH	FM			1.01	0.33
Argusville, DS, Far 09-25MU, 5, 2, FM	Far 09-25MU	67.0	826.4	5	2	Argusville	DS	CH	FM			2.00	0.57
Argusville, DS, Far 09-25MU, 5, 3, FM	Far 09-25MU	67.0	826.4	5	3	Argusville	DS	CH	FM			4.08	0.88
Argusville, DS, Moor 09-34MU, 4, 1, FM	Moor 09-34MU	57.0	850.9	4	1	Argusville	DS	CH	FM			1.01	0.44
Argusville, DS, Moor 09-34MU, 4, 2, FM	Moor 09-34MU	57.0	850.9	4	2	Argusville	DS	CH	FM			2.00	0.72
Argusville, DS, Moor 09-34MU, 4, 3, FM	Moor 09-34MU	57.0	850.9	4	3	Argusville	DS	CH	FM			4.08	1.04
Argusville, DS, Moor 09-53MU, 3, 1, FM	Moor 09-53MU	69.0	831.5	3	1	Argusville	DS	CH	FM			1.01	0.35
Argusville, DS, Moor 09-53MU, 3, 2, FM	Moor 09-53MU	69.0	831.5	3	2	Argusville	DS	CH	FM			2.00	0.58
Argusville, DS, Moor 09-53MU, 3, 3, FM	Moor 09-53MU	69.0	831.5	3	3	Argusville	DS	CH	FM			4.08	1.15
Argusville, DS, Far 10-78MU, 3, 1, FM	Far 10-78MU	56.0		3	1	Argusville	DS	CH	FM			1.00	0.51
Argusville, DS, Far 10-78MU, 3, 2, FM	Far 10-78MU	56.0		3	2	Argusville	DS	CH	FM			2.00	0.93
Argusville, DS, Far 10-78MU, 3, 3, FM	Far 10-78MU	56.0		3	3	Argusville	DS	CH	FM			4.00	1.60
Argusville, R-bar, 01-5MU, 4, 1, FRW	01-5MU	78.0	823.7	4	1	Argusville	R-bar	CH	FRW	1.22	0.29		
Argusville, R-bar, 01-5MU, 4, 2, FRW	01-5MU	78.0	823.7	4	2	Argusville	R-bar	CH	FRW	2.49	0.46		
Argusville, R-bar, 01-5MU, 4, 3, FRW	01-5MU	78.0	823.7	4	3	Argusville	R-bar	CH	FRW	4.80	0.69		
Argusville, R-bar, 01-12MU, 3, 1, FRW	01-12MU	64.0	820.0	3	1	Argusville	R-bar	CH	FRW	0.98	0.25		
Argusville, R-bar, 01-12MU, 3, 2, FRW	01-12MU	64.0	820.0	3	2	Argusville	R-bar	CH	FRW	1.56	0.71		
Argusville, R-bar, 01-12MU, 3, 3, FRW	01-12MU	64.0	820.0	3	3	Argusville	R-bar	CH	FRW	3.59	0.84		
Argusville, DS, 06-16MU, 2, 1, FRW	06-16MU	46.0	832.6	2	1	Argusville	DS	CH	FRW			1.00	0.28
Argusville, DS, 06-16MU, 2, 2, FRW	06-16MU	46.0	832.6	2	2	Argusville	DS	CH	FRW			2.00	0.53
Argusville, DS, 06-16MU, 2, 3, FRW	06-16MU	46.0	832.6	2	3	Argusville	DS	CH	FRW			4.00	0.64
Argusville, DS, 06-16MU, 3, 1, FRW	06-16MU	57.0	821.6	3	1	Argusville	DS	CH	FRW			1.00	0.38
Argusville, DS, 06-16MU, 3, 2, FRW	06-16MU	57.0	821.6	3	2	Argusville	DS	CH	FRW			2.00	0.60
Argusville, DS, 06-16MU, 3, 3, FRW	06-16MU	57.0	821.6	3	3	Argusville	DS	CH	FRW			4.00	0.97
Argusville, DS, 06-18MU, 3, 1, FRW	06-18MU	73.0	816.7	3	1	Argusville	DS	CH	FRW			1.00	0.36
Argusville, DS, 06-18MU, 3, 2, FRW	06-18MU	73.0	816.7	3	2	Argusville	DS	CH	FRW			2.00	0.63
Argusville, DS, 06-18MU, 3, 3, FRW	06-18MU	73.0	816.7	3	3	Argusville	DS	CH	FRW			4.00	1.11

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St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Argusville Formation Effective Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: 4/20/2010 Date: 10/29/2010

Project, Formation, Test, Boring, Sample No., Specimen No	BORING NO.	MID-DEPTH (feet)	ELEV (feet)	SAMPLE NO.	SPEC. NO	FORMATION	TEST	USCS SOIL TYPE	PROJECT	R-bar, Ultimate σ_n (tsf)	R-bar, Ultimate τ_n (tsf)	DS, Ultimate σ_n (tsf)	DS, Ultimate τ_n (tsf)
Argusville, R-bar, 84-2M, 6, 1, WF	84-2M	61.0	843.6	6	1	Argusville	R-bar	CH	WF	0.86	0.31		
Argusville, R-bar, 84-2M, 6, 2, WF	84-2M	61.0	843.6	6	2	Argusville	R-bar	CH	WF	1.15	0.44		
Argusville, R-bar, 84-2M, 6, 3, WF	84-2M	61.0	843.6	6	3	Argusville	R-bar	CH	WF	1.96	0.63		
Argusville, R-bar, 85-6M, 4, 1, WF	85-6M	44.0	858.2	4	1	Argusville	R-bar	CH	WF	0.84	0.23		
Argusville, R-bar, 85-6M, 4, 2, WF	85-6M	44.0	858.2	4	2	Argusville	R-bar	CH	WF	1.43	0.38		
Argusville, R-bar, 85-6M, 4, 3, WF	85-6M	44.0	858.2	4	3	Argusville	R-bar	CH	WF	2.25	0.52		
Argusville, R-bar, 85-6M, 5, 1, WF	85-6M	54.0	848.2	5	1	Argusville	R-bar	CH	WF	0.91	0.33		
Argusville, R-bar, 85-6M, 5, 2, WF	85-6M	54.0	848.2	5	2	Argusville	R-bar	CH	WF	1.35	0.46		
Argusville, R-bar, 85-6M, 5, 3, WF	85-6M	54.0	848.2	5	3	Argusville	R-bar	CH	WF	4.11	0.58		
Argusville, R-bar, 85-7M, 5, 1, WF	85-7M	46.0	855.6	5	1	Argusville	R-bar	CH	WF	0.82	0.34		
Argusville, R-bar, 85-7M, 5, 2, WF	85-7M	46.0	855.6	5	2	Argusville	R-bar	CH	WF	1.09	0.47		
Argusville, R-bar, 85-7M, 5, 3, WF	85-7M	46.0	855.6	5	3	Argusville	R-bar	CH	WF	1.94	0.73		
Argusville, R-bar, 85-12M, 7, 1, WF	85-12M	49.0	848.3	7	1	Argusville	R-bar	CH	WF	0.80	0.23		
Argusville, R-bar, 85-12M, 7, 2, WF	85-12M	49.0	848.3	7	2	Argusville	R-bar	CH	WF	1.21	0.29		
Argusville, R-bar, 85-12M, 7, 3, WF	85-12M	49.0	848.3	7	3	Argusville	R-bar	CH	WF	2.68	0.56		
Argusville, R-bar, 84-3M, 6, 1, WF	84-3M	63.0	839.2	6	1	Argusville	R-bar	CH	WF	0.89	0.29		
Argusville, R-bar, 84-3M, 6, 2, WF	84-3M	63.0	839.2	6	2	Argusville	R-bar	CH	WF	1.34	0.36		
Argusville, R-bar, 84-3M, 6, 3, WF	84-3M	63.0	839.2	6	3	Argusville	R-bar	CH	WF	1.82	0.55		
B/A Trans, R-bar, Moor 09-25MU, 5, 1, FM	Moor 09-25MU	69.0	829.7	5	1	B/A Trans	R-bar	CH	FM	0.80	0.26		
B/A Trans, R-bar, Moor 09-25MU, 5, 2, FM	Moor 09-25MU	69.0	829.7	5	2	B/A Trans	R-bar	CH	FM	1.49	0.41		
B/A Trans, R-bar, Moor 09-25MU, 5, 3, FM	Moor 09-25MU	69.0	829.7	5	3	B/A Trans	R-bar	CH	FM	2.18	0.61		
B/A Trans, R-bar, Far 09-27MU, 4, 1, FM	Far 09-27MU	65.0	838.1	4	1	B/A Trans	R-bar	CH	FM	0.83	0.37		
B/A Trans, R-bar, Far 09-27MU, 4, 2, FM	Far 09-27MU	65.0	838.1	4	2	B/A Trans	R-bar	CH	FM	1.16	0.51		
B/A Trans, R-bar, Far 09-27MU, 4, 3, FM	Far 09-27MU	65.0	838.1	4	3	B/A Trans	R-bar	CH	FM	1.91	0.74		
B/A Trans, DS, Far 09-59MU, 3, 1, FM	Far 09-59MU	36.0	880.2	3	1	B/A Trans	DS	CH	FM			1.01	0.45
B/A Trans, DS, Far 09-59MU, 3, 2, FM	Far 09-59MU	36.0	880.2	3	2	B/A Trans	DS	CH	FM			2.00	0.85
B/A Trans, DS, Far 09-59MU, 3, 3, FM	Far 09-59MU	36.0	880.2	3	3	B/A Trans	DS	CH	FM			4.08	1.63

St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Unit "A" Till Formation Effective Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: 4/20/2010 Date: 10/29/2010

Project, Formation, Test, Boring, Sample No., Specimen No.	BORING NO.	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO.	SPEC. NO.	FORMATION	TEST	USCS SOIL TYPE	PROJECT	R-bar, Ultimate		DS, Ultimate	
										σ_n (tsf)	τ_n (tsf)	σ_n (tsf)	τ_n (tsf)
Unit "A" Till, R-bar, Far 10-78MU, 4, 1, FM	Far 10-78MU	70.6		4	1	Unit "A" Till	R-bar	SC	FM	5.86	4.15		
Unit "A" Till, R-bar, Far 10-78MU, 4, 2, FM	Far 10-78MU	70.6		4	2	Unit "A" Till	R-bar	SC	FM	5.26	3.39		

St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study

Subject: Residual Direct Shear Strength Data from Borings

Compiled By: KAH Revised By: KAH

Date: 2 DEC 09 Date: 10/29/2010

Project, Formation, Test, Boring, Sample No., Specimen No.	BORING NO.	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO.	SPEC. NO.	LL (%)	MC (%)	PL (%)	PI (%)	LI	G_s	e	γ_d (pcf)	γ_m (pcf)	γ_{sat} (pcf)	Residual Stress Values σ_n (tsf)	Residual Stress Values τ_R (tsf)	USCS SOIL TYPE	TEST	FORMATION	PROJECT
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	45	44	46	47	48	49
Alluvium, Res DS, Far 09-25MU, 1, 1, FM	Far 09-25MU	15.0	878.4	1	1		31.6				2.75	0.95	88.2	116.1	118.5	1.511	0.550	CH	Res DS	Alluvium	FM
Alluvium, Res DS, Far 09-27MU, 1, 1, FM	Far 09-27MU	7.0	886.1	1	1	75	29.7	18	57	0.21	2.71	0.85	91.6	118.8	120.2	1.511	0.277	CH	Res DS	Alluvium	FM
Sherack, Res DS, Far 09-26MU, 1, 1, FM	Far 09-26MU	9.0	894.5	1	1		34.8				2.74	0.98	86.3	116.3	117.2	1.511	0.339	CH	Res DS	Sherack	FM
Sherack, Res DS, Moor 09-34MU, 1, 1, FM	Moor 09-34MU	9.0	898.9	1	1		40.5				2.75	1.17	79.2	111.3	112.8	1.511	0.339	CH	Res DS	Sherack	FM
Sherack, Res DS, Moor 09-53MU, 1, 1, FM	Moor 09-53MU	19.0	881.5	1	1	55	40.3	21	34	0.57	2.75	1.13	80.4	112.8	113.8	1.511	0.726	CH	Res DS	Sherack	FM
Sherack, Res DS, 01-12MU, 1, 1, FRW	01-12MU	19.0	865.0	1	1	53	97.2	21	32	2.38	2.68	0.72	97.2	191.7	123.3	2.000	0.850	CH	Res DS	Sherack	FRW
PL Sherack, Res DS, 01-05MU, 1, 1, FRW	01-05MU	16.0	885.7	1	1	78	35.5	28	50	0.15	2.71	1.04	82.9	112.3	114.7	2.000	0.240	CH	Res DS	PL Sherack	FRW
OX Brenna, Res DS, Moor 09-34MU, 2, 1, FM	Moor 09-34MU	16.0	883.0	2	1	114	62.5	24	90	0.43	2.70	1.69	62.7	101.9	101.9	2.000	0.195	CH	Res DS	OX Brenna	FM
	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Poplar River, Res DS, 01-10MU, 1, 1, FRW	01-10MU	21.0	860.0	1	1	61	30.3	24	37	0.17	2.73	0.85	92.3	120.3	120.8	2.000	0.900	CH	Res DS	Poplar River	FRW
Brenna, Res DS, Far 09-25MU, 4, 1, FM	Far 09-25MU	51.0	842.4	4	1	108	57.7	22	86	0.42	2.75	1.60	66.0	104.1	104.4	2.000	0.355	CH	Res DS	Brenna	FM
Brenna, Res DS, Far 09-26MU, 3, 1, FM	Far 09-26MU	29.0	874.5	3	1	110	52.1	24	86	0.33	2.75	1.45	70.0	106.5	106.9	1.511	0.303	CH	Res DS	Brenna	FM
Brenna, Res DS, Far 09-26MU, 3, 2, FM	Far 09-26MU	29.0	874.5	3	2	110	52.2	24	86	0.33	2.75	1.44	70.3	107.0	107.1	1.511	0.276	CH	Res DS	Brenna	FM
Brenna, Res DS, Far 09-27MU, 3, 1, FM	Far 09-27MU	33.0	870.1	3	1	117	65.0	25	92	0.43	2.75	1.83	60.7	100.2	101.0	2.000	0.301	CH	Res DS	Brenna	FM
Brenna, Res DS, 01-12MU, 2, 1, FRW	01-12MU	31.0	853.0	2	1	118	67.7	33	86	0.41	2.74	1.92	58.5	98.1	99.6	2.000	0.290	CH	Res DS	Brenna	FRW
B/A Trans, Res DS, Far 09-27MU, 4, 1, FM	Far 09-27MU	65.0	838.1	4	1	111	52.2	25	86	0.32	2.70	1.43	69.5	105.8	106.2	2.000	0.378	CH	Res DS	B/A Trans	FM
B/A Trans, Res DS, Far 09-27MU, 4, 2, FM	Far 09-27MU	66.0	837.1	4	2	111	49.8	25	86	0.29	2.70	1.35	71.9	107.7	107.7	2.000	0.463	CH	Res DS	B/A Trans	FM
Argusville, Res DS, Far 09-25MU, 5, 1, FM	Far 09-25MU	67.0	826.4	5	1	81	52.1	20	61	0.53	2.71	1.41	70.2	106.8	106.7	2.000	0.400	CH	Res DS	Argusville	FM
Argusville, Res DS, Moor 09-34MU, 4, 1, FM	Moor 09-34MU	57.0	841.0	4	1	79	48.5	21	58	0.47	2.75	1.37	72.6	107.8	108.8	2.000	0.500	CH	Res DS	Argusville	FM
Argusville, Res DS, 01-05MU, 4, 1, FRW	01-05MU	78.0	823.7	4	1	99	58.1	28	71	0.42	2.77	1.66	64.9	102.6	103.9	2.000	0.320	CH	Res DS	Argusville	FRW

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St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Undrained Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: OCT 09 Date: 10/29/2010

							Q Strengths								
							Ultimate Stress Values				Peak Stress Values				
TEST NO.	BORING NO.	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO.	SPEC. NO.	σ_c' (tsf)	σ_d (tsf)	q (tsf)	q (psf)	p (tsf)	σ_d (tsf)	q (tsf)	q (psf)	p (tsf)	FORMATION
1	2	3	4	5	6	17	38	39		40	41	42		43	46
Alluvium, UU, Far 10-79MU, 1, 1, FM	Far 10-79MU	21.0		1	1	1.0	2.16	1.08	2160	2.08	2.21	1.11	2210	2.11	Alluvium
Alluvium, UU, Far 10-79MU, 1, 2, FM	Far 10-79MU	21.0		1	2	2.0	2.45	1.23	2450	3.23	2.45	1.23	2450	3.23	Alluvium
Alluvium, UU, Far 10-79MU, 1, 3, FM	Far 10-79MU	21.0		1	3	4.0	2.72	1.36	2720	5.36	2.73	1.37	2730	5.37	Alluvium
Alluvium, UU, Far 10-80MU, 1, 1, FM	Far 10-80MU	24.0		1	1	1.0	1.03	0.52	1030	1.52	1.09	0.55	1090	1.55	Alluvium
Alluvium, UU, Far 10-80MU, 1, 2, FM	Far 10-80MU	24.0		1	2	2.0	1.40	0.70	1400	2.70	1.47	0.74	1470	2.74	Alluvium
Alluvium, UU, Far 10-80MU, 1, 3, FM	Far 10-80MU	24.0		1	3	4.0	1.67	0.84	1670	4.84	1.85	0.93	1850	4.93	Alluvium
Sherack, UU, Far 09-23MU, 2, 1, FM	Far 09-23MU	11.0	886.0	2	1	0.5	0.95	0.48	950	0.98	1.22	0.61	1220	1.11	Sherack
Sherack, UU, Far 09-23MU, 2, 2, FM	Far 09-23MU	11.0	886.0	2	2	1.0	1.04	0.52	1040	1.52	1.27	0.64	1270	1.64	Sherack
Sherack, UU, Far 09-23MU, 2, 3, FM	Far 09-23MU	11.0	886.0	2	3	2.0	0.49	0.25	490	2.25	1.61	0.81	1610	2.81	Sherack
Sherack, UU, Moor 09-25MU, 1, 1, FM	Moor 09-25MU	9.0	889.7	1	1	0.5	0.99	0.50	990	1.00	1.53	0.77	1530	1.27	Sherack
Sherack, UU, Moor 09-25MU, 1, 2, FM	Moor 09-25MU	9.0	889.7	1	2	1.0	0.60	0.30	600	1.30	1.70	0.85	1700	1.85	Sherack
Sherack, UU, Moor 09-25MU, 1, 3, FM	Moor 09-25MU	9.0	889.7	1	3	2.0	1.66	0.83	1660	2.83	2.12	1.06	2120	3.06	Sherack
Sherack, UU, 01-4MU, 1, 1, FRW	01-4MU	18.0	881.2	1	1	1.0	1.84	0.92	1840	1.92	1.99	1.00	1990	2.00	Sherack
Sherack, UU, 01-4MU, 2, 2, FRW	01-4MU	18.0	881.2	2	2	2.0	2.53	1.27	2530	3.27	2.53	1.27	2530	3.27	Sherack
Sherack, UU, 01-4MU, 3, 3, FRW	01-4MU	18.0	881.2	3	3	4.0	3.19	1.60	3190	5.60	3.19	1.60	3190	5.60	Sherack
Sherack, UU, 84-1M, 1, 1, WF	84-1M	5.7	890.4	1	1	1.0	0.87	0.44	873	1.44	1.09	0.55	1090	1.55	Sherack
Sherack, UU, 84-1M, 1, 2, WF	84-1M	5.7	890.4	1	2	2.0	1.29	0.65	1290	2.65	1.32	0.66	1320	2.66	Sherack
Sherack, UU, 84-1M, 1, 3, WF	84-1M	5.7	890.4	1	3	4.0	0.16	0.08	156	4.08	1.40	0.70	1400	4.70	Sherack
Sherack, UU, 85-12M, 1, 1, WF	85-12M	6.0	891.3	1	1	0.5	4.01	2.01	4010	2.51	7.05	3.53	7050	4.03	Sherack
Sherack, UU, 85-12M, 1, 2, WF	85-12M	6.0	891.3	1	2	1.0	5.36	2.68	5360	3.68	7.29	3.65	7290	4.65	Sherack
Sherack, UU, 85-12M, 1, 3, WF	85-12M	6.0	891.3	1	3	2.0	8.55	4.28	8550	6.28	8.69	4.35	8690	6.35	Sherack
Sherack, UU, 99-1M, 1, 1, Oakport	99-1M	7.3		1	1	0.3	1.10	0.55	1100	0.80	1.53	0.77	1530	1.02	Sherack
Sherack, UU, 99-1M, 1, 2, Oakport	99-1M	7.3		1	2	0.5	1.30	0.65	1300	1.15	1.67	0.84	1670	1.34	Sherack
Sherack, UU, 99-1M, 1, 3, Oakport	99-1M	7.3		1	3	1.0	1.22	0.61	1220	1.61	2.49	1.25	2490	2.25	Sherack
????, UU, SB-1, , 1, SS-40	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
????, UU, SB-1, , 2, SS-40	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
????, UU, SB-1, , 3, SS-40	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
????, UU, SB-11, , 1, SS-40	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
????, UU, SB-11, , 2, SS-40	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
????, UU, SB-11, , 3, SS-40	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Undrained Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: OCT 09 Date: 10/29/2010

							Q Strengths								
							Ultimate Stress Values				Peak Stress Values				
TEST NO.	BORING NO.	MID-DEPTH (feet)	ELEV (feet)	SAMPLE NO.	SPEC NO.	σ_c (tsf)	σ_d (tsf)	q (tsf)	q (psf)	p (tsf)	σ_d (tsf)	q (tsf)	q (psf)	p (tsf)	FORMATION
????, UU, SB-17, , 1, SS-40	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
????, UU, SB-17, , 2, SS-40	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
????, UU, SB-17, , 3, SS-40	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
????, UU, SB-2, , 1, SS-40	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
????, UU, SB-2, , 2, SS-40	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
????, UU, SB-2, , 3, SS-40	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
????, UU, ST-2, 2A, 1, SS-MP	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
????, UU, ST-7, 7A, 1, SS-MP	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
????, UU, ST-7, 7C, 1, SS-MP	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Poplar River, UU, 01-10MU, 1, 1, FRW	01-10MU	20.0	861.0	1	1	1.0	1.68	0.84	1680	1.84	1.70	0.85	1700	1.85	Poplar River
Poplar River, UU, 01-10MU, 1, 2, FRW	01-10MU	20.0	861.0	1	2	2.0	1.73	0.87	1730	2.87	1.79	0.90	1790	2.90	Poplar River
Poplar River, UU, 01-10MU, 1, 3, FRW	01-10MU	20.0	861.0	1	3	4.0	1.81	0.91	1810	4.91	1.88	0.94	1880	4.94	Poplar River
PR - WF, UU, Far 09-23MU, 3, 1, FM	Far 09-23MU	21.0	876.0	3	1	0.5	1.53	0.77	1530	1.26	1.86	0.93	1860	1.42	PR - WF
PR - WF, UU, Far 09-23MU, 3, 2, FM	Far 09-23MU	21.0	876.0	3	2	1.0	3.33	1.67	3330	2.70	3.52	1.76	3520	2.79	PR - WF
PR - WF, UU, Far 09-23MU, 3, 3, FM	Far 09-23MU	21.0	876.0	3	3	2.0	5.08	2.54	5080	4.53	5.14	2.57	5140	4.56	PR - WF
PR - WF, UU, Moor 09-25MU, 2, 1, FM	Moor 09-25MU	22.0	876.7	2	1	5.0	2.12	1.06	2120	6.06	2.48	1.24	2480	6.24	PR - WF
PR - WF, UU, Moor 09-25MU, 2, 2, FM	Moor 09-25MU	22.0	876.7	2	2	1.0	3.43	1.72	3430	2.72	3.98	1.99	3980	2.99	PR - WF
PR - WF, UU, Moor 09-25MU, 2, 3, FM	Moor 09-25MU	22.0	876.7	2	3	2.0	5.78	2.89	5780	4.89	6.30	3.15	6300	5.15	PR - WF
PR - Harwood, UU, Far 09-23MU, 4, 1, FM	Far 09-23MU	29.0	868.0	4	1	0.5	1.32	0.66	1320	1.16	1.47	0.74	1470	1.24	PR - Harwood
PR - Harwood, UU, Far 09-23MU, 4, 2, FM	Far 09-23MU	29.0	868.0	4	2	1.0	1.18	0.59	1180	1.59	1.43	0.72	1430	1.72	PR - Harwood
PR - Harwood, UU, Far 09-23MU, 4, 3, FM	Far 09-23MU	29.0	868.0	4	3	2.0	0.46	0.23	460	2.23	1.51	0.76	1510	2.76	PR - Harwood
PR - Harwood, UU, Moor 09-25MU, 3, 1, FM	Moor 09-25MU	26.0	872.7	3	1	0.5	1.36	0.68	1360	1.18	1.46	0.73	1460	1.23	PR - Harwood
PR - Harwood, UU, Moor 09-25MU, 3, 2, FM	Moor 09-25MU	26.0	872.7	3	2	1.0	1.42	0.71	1420	1.71	1.61	0.81	1610	1.81	PR - Harwood
PR - Harwood, UU, Moor 09-25MU, 3, 3, FM	Moor 09-25MU	26.0	872.7	3	3	2.0	1.70	0.85	1700	2.85	1.86	0.93	1860	2.93	PR - Harwood
OX Brenna, UU, Far 09-59MU, 1, 1, FM	Far 09-59MU	11.0	905.2	1	1	0.8	1.29	0.65	1290	1.40	1.35	0.68	1350	1.43	OX Brenna
OX Brenna, UU, Far 09-59MU, 1, 2, FM	Far 09-59MU	11.0	905.2	1	2	1.5	1.25	0.63	1250	2.13	1.37	0.69	1370	2.19	OX Brenna
OX Brenna, UU, Far 09-59MU, 1, 3, FM	Far 09-59MU	11.0	905.2	1	3	3.0	1.39	0.70	1390	3.70	1.47	0.74	1470	3.74	OX Brenna
OX Brenna, UU, Far 09-59MU, 2, 1, FM	Far 09-59MU	21.0	895.2	2	1	1.0	0.96	0.48	960	1.48	1.15	0.58	1150	1.58	OX Brenna
OX Brenna, UU, Far 09-59MU, 2, 2, FM	Far 09-59MU	21.0	895.2	2	2	2.0	0.99	0.50	990	2.50	1.19	0.60	1190	2.60	OX Brenna
OX Brenna, UU, Far 09-59MU, 2, 3, FM	Far 09-59MU	21.0	895.2	2	3	4.0	1.01	0.51	1010	4.51	1.05	0.53	1050	4.53	OX Brenna

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St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Undrained Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: OCT 09 Date: 10/29/2010

							Q Strengths								
							Ultimate Stress Values				Peak Stress Values				
TEST NO.	BORING NO.	MID-DEPTH (feet)	ELEV (feet)	SAMPLE NO.	SPEC. NO.	σ_c (tsf)	σ_d (tsf)	q (tsf)	q (psf)	p (tsf)	σ_d (tsf)	q (tsf)	q (psf)	p (tsf)	FORMATION
OX Brenna, UU, Far 09-60MU, 1, 1, FM	Far 09-60MU	16.0	867.3	1	1	0.8	0.72	0.36	720	1.11	0.86	0.43	860	1.18	OX Brenna
OX Brenna, UU, Far 09-60MU, 1, 2, FM	Far 09-60MU	16.0	867.3	1	2	1.5	0.80	0.40	800	1.90	0.98	0.49	980	1.99	OX Brenna
OX Brenna, UU, Far 09-60MU, 1, 3, FM	Far 09-60MU	16.0	867.3	1	3	3.0	0.80	0.40	800	3.40	1.06	0.53	1060	3.53	OX Brenna
OX Brenna, UU, Far 09-60MU, 2, 1, FM	Far 09-60MU	26.0	857.3	2	1	1.0	1.09	0.55	1090	1.55	1.19	0.60	1190	1.60	OX Brenna
OX Brenna, UU, Far 09-60MU, 2, 2, FM	Far 09-60MU	26.0	857.3	2	2	2.0	0.73	0.37	730	2.37	0.82	0.41	820	2.41	OX Brenna
OX Brenna, UU, Far 09-60MU, 2, 3, FM	Far 09-60MU	26.0	857.3	2	3	4.0	0.85	0.43	850	4.43	0.86	0.43	860	4.43	OX Brenna
OX Brenna, UU, 84-2M, 1, 1, WF	84-2M	10.8	893.8	1	1	1.0	1.08	0.54	1080	1.54	1.11	0.56	1110	1.56	OX Brenna
OX Brenna, UU, 84-2M, 1, 2, WF	84-2M	10.8	893.8	1	2	2.0	1.27	0.64	1270	2.64	1.27	0.64	1270	2.64	OX Brenna
OX Brenna, UU, 84-2M, 1, 3, WF	84-2M	10.8	893.8	1	3	4.0	1.10	0.55	1100	4.55	1.14	0.57	1140	4.57	OX Brenna
OX Brenna, UU, 85-4M, 1, 1, WF	85-4M	9.0	904.2	1	1	0.5	0.78	0.39	776	0.89	0.81	0.40	808	0.90	OX Brenna
OX Brenna, UU, 85-4M, 1, 2, WF	85-4M	9.0	904.2	1	2	1.0	0.91	0.45	906	1.45	0.93	0.46	929	1.46	OX Brenna
OX Brenna, UU, 85-4M, 1, 3, WF	85-4M	9.0	904.2	1	3	2.0	0.75	0.37	748	2.37	0.86	0.43	862	2.43	OX Brenna
OX Brenna, UU, 85-6M, 1, 1, WF	85-6M	8.0	894.2	1	1	0.5	0.70	0.35	701	0.85	0.72	0.36	718	0.86	OX Brenna
OX Brenna, UU, 85-6M, 1, 2, WF	85-6M	8.0	894.2	1	2	1.0	0.95	0.48	950	1.48	1.03	0.52	1030	1.52	OX Brenna
OX Brenna, UU, 85-6M, 1, 3, WF	85-6M	8.0	894.2	1	3	2.0	0.74	0.37	741	2.37	0.74	0.37	741	2.37	OX Brenna
OX Brenna, UU, 85-7M, 1, 1, WF	85-7M	5.9	895.7	1	1	0.5	1.16	0.58	1160	1.08	1.25	0.63	1250	1.13	OX Brenna
OX Brenna, UU, 85-7M, 1, 2, WF	85-7M	5.9	895.7	1	2	1.0	1.55	0.78	1550	1.78	1.60	0.80	1600	1.80	OX Brenna
OX Brenna, UU, 85-7M, 1, 3, WF	85-7M	5.9	895.7	1	3	2.0	1.44	0.72	1440	2.72	1.62	0.81	1620	2.81	OX Brenna
OX Brenna, UU, 85-12M, 2, 1, WF	85-12M	16.0	881.3	2	1	0.5	2.02	1.01	2020	1.51	2.04	1.02	2040	1.52	OX Brenna
OX Brenna, UU, 85-12M, 2, 2, WF	85-12M	16.0	881.3	2	2	1.0	2.40	1.20	2400	2.20	2.40	1.20	2400	2.20	OX Brenna
OX Brenna, UU, 85-12M, 2, 3, WF	85-12M	16.0	881.3	2	3	2.0	2.28	1.14	2280	3.14	2.28	1.14	2280	3.14	OX Brenna
OX Brenna, UU, 86-28M, 2, 1, WF	86-28M	21.0	896.6	2	1	1.0	1.31	0.66	1310	1.66	1.74	0.87	1740	1.87	OX Brenna
OX Brenna, UU, 86-28M, 2, 2, WF	86-28M	21.0	896.6	2	2	2.0	1.39	0.70	1390	2.70	1.58	0.79	1580	2.79	OX Brenna
OX Brenna, UU, 86-28M, 2, 3, WF	86-28M	21.0	896.6	2	3	4.0	1.59	0.80	1590	4.80	2.36	1.18	2360	5.18	OX Brenna
Brenna, UU, Far 09-23MU, 5, 1, FM	Far 09-23MU	39.0	858.0	5	1	0.8	0.65	0.33	650	1.08	0.79	0.40	790	1.15	Brenna
Brenna, UU, Far 09-23MU, 5, 2, FM	Far 09-23MU	39.0	858.0	5	2	1.5	0.59	0.30	590	1.80	0.82	0.41	820	1.91	Brenna
Brenna, UU, Far 09-23MU, 5, 3, FM	Far 09-23MU	39.0	858.0	5	3	3.0	0.73	0.37	730	3.37	0.83	0.42	830	3.42	Brenna
Brenna, UU, Far 09-23MU, 6, 1, FM	Far 09-23MU	81.0	816.0	6	1	1.0	0.76	0.38	760	1.38	0.86	0.43	860	1.43	Brenna
Brenna, UU, Far 09-23MU, 6, 2, FM	Far 09-23MU	81.0	816.0	6	2	2.0	0.63	0.32	630	2.32	0.76	0.38	760	2.38	Brenna
Brenna, UU, Far 09-23MU, 6, 3, FM	Far 09-23MU	81.0	816.0	6	3	4.0	0.71	0.36	710	4.36	0.71	0.36	710	4.36	Brenna
Brenna, UU, Moor 09-25MU, 4, 1, FM	Moor 09-25MU	39.0	859.7	4	1	0.8	0.66	0.33	660	1.08	0.66	0.33	660	1.08	Brenna
Brenna, UU, Moor 09-25MU, 4, 2, FM	Moor 09-25MU	39.0	859.7	4	2	1.5	0.67	0.34	670	1.84	0.67	0.34	670	1.84	Brenna
Brenna, UU, Moor 09-25MU, 4, 3, FM	Moor 09-25MU	39.0	859.7	4	3	3.0	0.67	0.34	670	3.34	0.79	0.40	790	3.40	Brenna
Brenna, UU, Far 09-26MU, 3, 1, FM	Far 09-26MU	29.0	874.5	3	1	1.0	0.43	0.22	430	1.22	1.29	0.65	1290	1.65	Brenna
Brenna, UU, Far 09-26MU, 3, 2, FM	Far 09-26MU	29.0	874.5	3	2	2.0	0.88	0.44	880	2.44	1.32	0.66	1320	2.66	Brenna
Brenna, UU, Far 09-26MU, 3, 3, FM	Far 09-26MU	29.0	874.5	3	3	4.0	0.81	0.41	810	4.41	0.94	0.47	940	4.47	Brenna
Brenna, UU, Far 09-27MU, 4, 1, FM	Far 09-27MU	65.0	838.1	4	1	1.0	0.68	0.34	680	1.34	0.79	0.40	790	1.40	Brenna
Brenna, UU, Far 09-27MU, 4, 2, FM	Far 09-27MU	65.0	838.1	4	2	2.0	0.75	0.38	750	2.38	0.66	0.43	860	2.43	Brenna
Brenna, UU, Far 09-27MU, 4, 3, FM	Far 09-27MU	65.0	838.1	4	3	4.0	0.82	0.41	820	4.41	0.84	0.42	840	4.42	Brenna

St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Undrained Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: OCT 09 Date: 10/29/2010

							Q Strengths								
							Ultimate Stress Values				Peak Stress Values				
TEST NO.	BORING NO.	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO.	SPEC. NO.	σ_3' (tsf)	σ_d (tsf)	q (tsf)	q (psf)	p (tsf)	σ_d (tsf)	q (tsf)	q (psf)	p (tsf)	FORMATION
Brenna, UU, Far 09-60MU, 3, 1, FM	Far 09-60MU	36.0	847.3	3	1	1.0	0.87	0.44	870	1.44	1.19	0.60	1190	1.60	Brenna
Brenna, UU, Far 09-60MU, 3, 2, FM	Far 09-60MU	36.0	847.3	3	2	2.0	1.03	0.52	1030	2.52	1.42	0.71	1420	2.71	Brenna
Brenna, UU, Far 09-60MU, 3, 3, FM	Far 09-60MU	36.0	847.3	3	3	4.0	1.03	0.52	1030	4.52	1.36	0.68	1360	4.68	Brenna
Brenna, UU, Far 10-78MU, 2, 1, FM	Far 10-78MU	26.0		2	1	1.0	0.71	0.36	710	1.36	0.97	0.49	970	1.49	Brenna
Brenna, UU, Far 10-78MU, 2, 2, FM	Far 10-78MU	26.0		2	2	2.0	0.97	0.49	970	2.49	1.14	0.57	1140	2.57	Brenna
Brenna, UU, Far 10-78MU, 2, 3, FM	Far 10-78MU	26.0		2	3	4.0	1.14	0.57	1140	4.57	1.47	0.74	1470	4.74	Brenna
Brenna, UU, Far 10-80MU, 2, 1, FM	Far 10-80MU	36.0		2	1	1.0	0.88	0.44	880	1.44	0.93	0.47	930	1.47	Brenna
Brenna, UU, Far 10-80MU, 2, 2, FM	Far 10-80MU	36.0		2	2	2.0	0.92	0.46	920	2.46	1.09	0.55	1090	2.55	Brenna
Brenna, UU, Far 10-80MU, 2, 3, FM	Far 10-80MU	36.0		2	3	4.0	1.14	0.57	1140	4.57	1.41	0.71	1410	4.71	Brenna
Brenna, UU, 01-12MU, 2, 1, FRW	01-12MU	30.0	854.0	2	1	1.0	0.36	0.18	360	1.18	0.53	0.27	530	1.27	Brenna
Brenna, UU, 01-12MU, 2, 2, FRW	01-12MU	30.0	854.0	2	2	2.0	0.45	0.23	450	2.23	0.60	0.30	600	2.30	Brenna
Brenna, UU, 01-12MU, 2, 3, FRW	01-12MU	30.0	854.0	2	3	4.0	0.49	0.25	490	4.25	0.61	0.31	610	4.31	Brenna
Brenna, UU, 06-18MU, 2, 1, FRW	06-18MU	52.0	837.7	2	1	1.0	0.69	0.35	690	1.35	1.24	0.62	1240	1.62	Brenna
Brenna, UU, 06-18MU, 2, 2, FRW	06-18MU	52.0	837.7	2	2	2.0	0.62	0.31	620	2.31	1.20	0.60	1200	2.60	Brenna
Brenna, UU, 06-18MU, 2, 3, FRW	06-18MU	52.0	837.7	2	3	4.0	0.59	0.30	590	4.30	1.31	0.66	1310	4.66	Brenna
Brenna, UU, 84-1M, 3, 1, WF	84-1M	19.0	877.1	3	1	1.0	0.42	0.21	417	1.21	0.55	0.28	551	1.28	Brenna
Brenna, UU, 84-1M, 3, 2, WF	84-1M	19.0	877.1	3	2	2.0	0.41	0.21	414	2.21	0.62	0.31	623	2.31	Brenna
Brenna, UU, 84-1M, 3, 3, WF	84-1M	19.0	877.1	3	3	4.0	0.46	0.23	458	4.23	0.58	0.29	577	4.29	Brenna
Brenna, UU, 84-1M, 4, 1, WF	84-1M	29.0	867.4	4	1	1.0	0.55	0.27	549	1.27	0.84	0.42	839	1.42	Brenna
Brenna, UU, 84-1M, 4, 2, WF	84-1M	29.0	867.4	4	2	2.0	0.55	0.27	548	2.27	0.73	0.37	731	2.37	Brenna
Brenna, UU, 84-1M, 4, 3, WF	84-1M	29.0	867.4	4	3	4.0	0.48	0.24	479	4.24	0.78	0.39	777	4.39	Brenna
Brenna, UU, 84-2M, 3, 1, WF	84-2M	21.0	883.6	3	1	1.0	0.70	0.35	703	1.35	0.77	0.38	768	1.38	Brenna
Brenna, UU, 84-2M, 3, 2, WF	84-2M	21.0	883.6	3	2	2.0	0.74	0.37	738	2.37	0.89	0.44	889	2.44	Brenna
Brenna, UU, 84-2M, 3, 3, WF	84-2M	21.0	883.6	3	3	4.0	0.73	0.37	731	4.37	0.90	0.45	902	4.45	Brenna
Brenna, UU, 85-4M, 6, 1, WF	85-4M	48.0	865.2	6	1	1.0	0.83	0.42	831	1.42	1.33	0.67	1330	1.67	Brenna
Brenna, UU, 85-4M, 6, 2, WF	85-4M	48.0	865.2	6	2	2.0	0.81	0.41	811	2.41	1.11	0.56	1110	2.56	Brenna
Brenna, UU, 85-4M, 6, 3, WF	85-4M	48.0	865.2	6	3	4.0	0.86	0.43	864	4.43	1.23	0.62	1230	4.62	Brenna
Brenna, UU, 85-6M, 3, 1, WF	85-6M	31.0	871.2	3	1	1.0	0.64	0.32	637	1.32	0.78	0.39	784	1.39	Brenna
Brenna, UU, 85-6M, 3, 2, WF	85-6M	31.0	871.2	3	2	2.0	0.71	0.35	708	2.35	0.98	0.49	981	2.49	Brenna
Brenna, UU, 85-6M, 3, 3, WF	85-6M	31.0	871.2	3	3	4.0	0.73	0.36	728	4.36	0.97	0.48	966	4.48	Brenna
Brenna, UU, 85-7M, 3, 1, WF	85-7M	22.0	879.6	3	1	0.5	0.20	0.10	203	0.60	0.44	0.22	435	0.72	Brenna
Brenna, UU, 85-7M, 3, 2, WF	85-7M	22.0	879.6	3	2	1.0	0.53	0.26	526	1.26	0.62	0.31	615	1.31	Brenna
Brenna, UU, 85-7M, 3, 3, WF	85-7M	22.0	879.6	3	3	2.0	0.41	0.20	409	2.20	0.66	0.33	664	2.33	Brenna
Brenna, UU, 85-10M, 1, 1, WF	85-10M	16.0	880.1	1	1	0.5	0.37	0.19	373	0.69	0.49	0.24	485	0.74	Brenna
Brenna, UU, 85-10M, 1, 2, WF	85-10M	16.0	880.1	1	2	1.0	0.54	0.27	538	1.27	0.63	0.32	633	1.32	Brenna
Brenna, UU, 85-10M, 1, 3, WF	85-10M	16.0	880.1	1	3	2.0	0.49	0.24	489	2.24	0.47	0.24	470	2.24	Brenna
Brenna, UU, 85-10M, 3, 1, WF	85-10M	26.0	870.1	3	1	0.5	0.40	0.20	395	0.70	0.48	0.24	484	0.74	Brenna
Brenna, UU, 85-10M, 3, 2, WF	85-10M	26.0	870.1	3	2	1.0	0.38	0.19	382	1.19	0.47	0.24	472	1.24	Brenna
Brenna, UU, 85-10M, 3, 3, WF	85-10M	26.0	870.1	3	3	2.0	0.42	0.21	421	2.21	0.56	0.28	562	2.28	Brenna

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St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Undrained Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: OCT 09 Date: 10/29/2010

							Q Strengths								
							Ultimate Stress Values				Peak Stress Values				
TEST NO	BORING NO	MID-DEPTH (feet)	ELEV (feet)	SAMPLE NO	SPEC NO	σ_c (tsf)	σ_d (tsf)	q (tsf)	q (psf)	p (tsf)	σ_d (tsf)	q (tsf)	q (psf)	p (tsf)	FORMATION
Brenna, UU, 85-12M, 4, 1, WF	85-12M	26.0	871.3	4	1	0.5	0.95	0.47	949	0.97	1.12	0.56	1120	1.06	Brenna
Brenna, UU, 85-12M, 4, 2, WF	85-12M	26.0	871.3	4	2	1.0	1.12	0.56	1120	1.56	1.30	0.65	1300	1.65	Brenna
Brenna, UU, 85-12M, 4, 3, WF	85-12M	26.0	871.3	4	3	2.0	0.99	0.50	992	2.50	1.47	0.74	1470	2.74	Brenna
Brenna, UU, 86-29M, 5, 1, WF	86-29M	39.1	864.9	5	1		0.58	0.29	575	0.29	0.58	0.29	575	0.29	Brenna
Brenna, UU, 86-31M, 3, 1, WF	86-31M	31.1	862.2	3	1		0.74	0.37	738	0.37	0.74	0.37	738	0.37	Brenna
Brenna, UU, 86-31M, 4, 1, WF	86-31M	41.1	852.2	4	1	1.0	0.50	0.25	497	1.25	0.75	0.37	746	1.37	Brenna
Brenna, UU, 86-31M, 4, 2, WF	86-31M	41.1	852.2	4	2	2.0	0.43	0.21	429	2.21	0.68	0.34	684	2.34	Brenna
Brenna, UU, 86-31M, 4, 3, WF	86-31M	41.1	852.2	4	3	4.0	0.55	0.28	551	4.28	0.70	0.35	702	4.35	Brenna
Brenna, UU, 86-32M, 2, 1, WF	86-32M	21.1	866.6	2	1		0.52	0.26	523	0.26	0.52	0.26	523	0.26	Brenna
Brenna, UU, 99-1M, 5, 1, Oakport	99-1M	35.0		5	1	0.3	0.22	0.11	220	0.36	0.67	0.34	670	0.59	Brenna
Brenna, UU, 99-1M, 5, 2, Oakport	99-1M	35.0		5	2	0.5	0.51	0.26	510	0.76	0.71	0.36	710	0.86	Brenna
Brenna, UU, 99-1M, 5, 3, Oakport	99-1M	35.0		5	3	1.0	0.65	0.33	650	1.33	0.75	0.38	750	1.38	Brenna
B/A Trans, UU, Moor 09-25MU, 5, 1, FM	Moor 09-25MU	69.0	829.7	5	1	1.0	0.66	0.33	660	1.33	0.92	0.46	920	1.46	B/A Trans
B/A Trans, UU, Moor 09-25MU, 5, 2, FM	Moor 09-25MU	69.0	829.7	5	2	2.0	0.86	0.43	860	2.43	0.89	0.45	890	2.45	B/A Trans
B/A Trans, UU, Moor 09-25MU, 5, 3, FM	Moor 09-25MU	69.0	829.7	5	3	4.0	0.82	0.41	820	4.41	0.89	0.45	890	4.45	B/A Trans
Argusville, UU, Far 10-78MU, 3, 1, FM	Far 10-78MU	56.0		3	1	1.0	0.83	0.42	830	1.42	1.10	0.55	1098	1.55	Argusville
Argusville, UU, Far 10-78MU, 3, 2, FM	Far 10-78MU	56.0		3	2	2.0	0.96	0.48	960	2.48	1.16	0.58	1160	2.58	Argusville
Argusville, UU, Far 10-78MU, 3, 3, FM	Far 10-78MU	56.0		3	3	4.0	1.12	0.56	1120	4.56	1.21	0.61	1210	4.61	Argusville
Argusville, UU, Far 10-79MU, 2, 1, FM	Far 10-79MU	41.0		2	1	0.8	0.80	0.40	800	1.15	0.97	0.49	970	1.24	Argusville
Argusville, UU, Far 10-79MU, 2, 2, FM	Far 10-79MU	41.0		2	2	1.5	0.82	0.41	820	1.91	1.10	0.55	1100	2.05	Argusville
Argusville, UU, Far 10-79MU, 2, 3, FM	Far 10-79MU	41.0		2	3	3.0	0.91	0.46	910	3.46	1.19	0.60	1190	3.60	Argusville
Argusville, UU, Far 10-80MU, 3, 1, FM	Far 10-80MU	56.0		3	1	1.0	0.86	0.43	860	1.43	1.00	0.50	1000	1.50	Argusville
Argusville, UU, Far 10-80MU, 3, 2, FM	Far 10-80MU	56.0		3	2	2.0	0.92	0.46	920	2.46	1.04	0.52	1040	2.52	Argusville
Argusville, UU, Far 10-80MU, 3, 3, FM	Far 10-80MU	56.0		3	3	4.0	0.77	0.39	770	4.39	1.07	0.54	1070	4.54	Argusville
Argusville, UU, 01-12MU, 3, 1, FRW	01-12MU	63.0	821.0	3	1	1.0	0.49	0.25	490	1.25	0.72	0.36	720	1.36	Argusville
Argusville, UU, 01-12MU, 3, 2, FRW	01-12MU	63.0	821.0	3	2	2.0	0.66	0.33	660	2.33	0.72	0.36	720	2.36	Argusville
Argusville, UU, 01-12MU, 3, 3, FRW	01-12MU	63.0	821.0	3	3	4.0	0.68	0.34	680	4.34	0.73	0.37	730	4.37	Argusville
Argusville, UU, 06-18MU, 3, 1, FRW	06-18MU	73.0	816.7	3	1	1.0	1.02	0.51	1020	1.51	1.40	0.70	1400	1.70	Argusville
Argusville, UU, 06-18MU, 3, 2, FRW	06-18MU	73.0	816.7	3	2	2.0	0.73	0.37	730	2.37	1.47	0.74	1470	2.74	Argusville
Argusville, UU, 06-18MU, 3, 3, FRW	06-18MU	73.0	816.7	3	3	4.0	1.16	0.58	1160	4.58	1.58	0.79	1580	4.79	Argusville
Argusville, UU, 06-16MU, 2, 1, FRW	06-16MU	46.0	832.6	2	1	1.0	0.56	0.28	560	1.28	1.02	0.51	1020	1.51	Argusville
Argusville, UU, 06-16MU, 2, 2, FRW	06-16MU	46.0	832.6	2	2	2.0	0.61	0.31	610	2.31	1.06	0.53	1060	2.53	Argusville
Argusville, UU, 06-16MU, 2, 3, FRW	06-16MU	46.0	832.6	2	3	4.0	0.63	0.32	630	4.32	1.07	0.54	1070	4.54	Argusville

St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers®

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Undrained Shear Strength Data from Borings
Compiled By: KAH Revised By: KAH
Date: OCT 09 Date: 10/29/2010

							Q Strengths								
							Ultimate Stress Values				Peak Stress Values				
TEST NO	BORING NO	MID-DEPTH (feet)	ELEV (feet)	SAMPLE NO	SPEC NO	σ_c (tsf)	σ_d (tsf)	q (tsf)	q (psf)	p (tsf)	σ_d (tsf)	q (tsf)	q (psf)	p (tsf)	FORMATION
Argusville, UU, 06-16MU, 3, 1, FRW	06-16MU	57.0	821.6	3	1	1.0	0.52	0.26	520	1.26	1.00	0.50	1000	1.50	Argusville
Argusville, UU, 06-16MU, 3, 2, FRW	06-16MU	57.0	821.6	3	2	2.0	0.55	0.28	550	2.28	1.07	0.54	1070	2.54	Argusville
Argusville, UU, 06-16MU, 3, 3, FRW	06-16MU	57.0	821.6	3	3	4.0	0.63	0.32	630	4.32	1.08	0.54	1080	4.54	Argusville
Argusville, UU, 84-2M, 6, 1, WF	84-2M	61.0	843.6	6	1	1.0	0.79	0.40	791	1.40	0.97	0.48	968	1.48	Argusville
Argusville, UU, 84-2M, 6, 2, WF	84-2M	61.0	843.6	6	2	2.0	0.72	0.36	720	2.36	0.74	0.37	744	2.37	Argusville
Argusville, UU, 84-2M, 6, 3, WF	84-2M	61.0	843.6	6	3	4.0	0.72	0.36	722	4.36	0.77	0.38	767	4.38	Argusville
Argusville, UU, 84-3M, 6, 1, WF	84-3M	63.0	839.2	6	1	1.0	0.79	0.39	787	1.39	0.90	0.45	904	1.45	Argusville
Argusville, UU, 84-3M, 6, 2, WF	84-3M	63.0	839.2	6	2	2.0	0.84	0.42	841	2.42	0.94	0.47	939	2.47	Argusville
Argusville, UU, 84-3M, 6, 3, WF	84-3M	63.0	839.2	6	3	4.0	0.83	0.42	834	4.42	0.95	0.48	951	4.48	Argusville
Argusville, UU, 85-6M, 4, 1, WF	85-6M	44.0	858.2	4	1	1.0	0.56	0.28	559	1.28	0.63	0.31	629	1.31	Argusville
Argusville, UU, 85-6M, 4, 2, WF	85-6M	44.0	858.2	4	2	2.0	0.49	0.24	485	2.24	0.83	0.42	831	2.42	Argusville
Argusville, UU, 85-6M, 4, 3, WF	85-6M	44.0	858.2	4	3	4.0	0.64	0.32	637	4.32	0.75	0.37	749	4.37	Argusville
Argusville, UU, 85-6M, 5, 1, WF	85-6M	54.0	848.2	5	1	1.0	0.74	0.37	739	1.37	0.93	0.46	926	1.46	Argusville
Argusville, UU, 85-6M, 5, 2, WF	85-6M	54.0	848.2	5	2	2.0	0.62	0.31	621	2.31	0.87	0.44	874	2.44	Argusville
Argusville, UU, 85-6M, 5, 3, WF	85-6M	54.0	848.2	5	3	4.0	0.79	0.40	790	4.40	1.09	0.55	1090	4.55	Argusville
Argusville, UU, 85-7M, 5, 1, WF	85-7M	46.0	855.6	5	1	1.0	0.47	0.23	468	1.23	0.74	0.37	738	1.37	Argusville
Argusville, UU, 85-7M, 5, 2, WF	85-7M	46.0	855.6	5	2	2.0	0.45	0.23	452	2.23	0.84	0.42	844	2.42	Argusville
Argusville, UU, 85-7M, 5, 3, WF	85-7M	46.0	855.6	5	3	4.0	0.67	0.33	667	4.33	0.98	0.49	983	4.49	Argusville
Argusville, UU, 85-12M, 7, 1, WF	85-12M	49.0	848.3	7	1	1.0	0.58	0.29	579	1.29	0.77	0.38	765	1.38	Argusville
Argusville, UU, 85-12M, 7, 2, WF	85-12M	49.0	848.3	7	2	2.0	0.48	0.24	481	2.24	0.72	0.36	718	2.36	Argusville
Argusville, UU, 85-12M, 7, 3, WF	85-12M	49.0	848.3	7	3	4.0	0.49	0.24	487	4.24	0.68	0.34	678	4.34	Argusville
Argusville, UU, SB-3, , 1, SS-40	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Argusville, UU, SB-3, , 2, SS-40	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Argusville, UU, SB-3, , 3, SS-40	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Argusville, UU, ST-1, 1B, 1, SS-MP	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Argusville, UU, ST-8, 8A, 1, SS-MP	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

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St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasibility Study
Subject: Consolidated Test Results
Compiled By:
Date: 2008

Revised By: KAH
Date: 2/15/2011

Project, Formation, Boring, Sample No., Specimen No.	BORING NO.	TOP BORING ELEV. (feet)		Water Table Elevation (feet)	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO.	SPEC	LL (%)	MC (%)	PL (%)	PI (%)	LI	G_s	e	γ_d (pcf)	γ_m (pcf)	γ_{sat} (pcf)	COE p_c (tsf)	Lab p_c	p_o (tsf)	OCR	USCS SOIL TYPE	FORMATION	PROJECT
SS_ST-10_	ST-10	908		895	10.0	898.0				39.6				2.70	1.13	79.2	110.7	112.2	2.52		0.57	4.45	CH		SS
SS_ST-10_	ST-10	908		895	20.0	888.0				80.2				2.70	1.63	64.1	102.7	102.7	4.38		0.72	6.12	CH		SS
SS_ST-10_	ST-10	908		895	30.0	878.0				84.5				2.70	1.74	61.8	101.3	101.1	2.48		0.89	2.78	CH		SS
SS_SB-11_	SB-11	905		895	33.3	870.0				48.9				2.75	1.35	73.1	108.8	108.9	4.30		1.15	3.82	CH		SS
SS_SB-17_	SB-17	905		895	28.3	874.0				45.2				2.75	1.26	75.9	110.2	110.7	3.70		1.06	3.49	CH		SS
SS-WRL_ST-7_	ST-7	908		895	15.0	892.9								2.70	1.03	83.1		114.7	1.04		0.70	1.48	CH		SS-WRL
SS-WRL_ST-7_	ST-7	908		895	25.0	883.0								2.70	1.40	70.1		106.5	3.1		0.86	3.60	CH		SS-WRL
SS-WRL_ST-9_	ST-9	914		904	10.0	903.8								2.70	1.06	81.8		113.9	2.3		0.57	4.04	CH		SS-WRL
SA-52ndAVE_ST-1_	ST-1	905		895	20.0	885.2				60.9				2.71	1.65	63.8	102.7	102.6	4.0		0.71	5.60	CH		SA-52ndAVE
SA-52ndAVE_ST-2_	ST-2	891		879	15.0	875.7								2.67	1.18	76.4		110.2	4.5		0.72	6.22	of lean Clay (CH) and Silt (M		SA-52ndAVE
SA-52ndAVE_SL-3_	SL-3	888		859	15.5	872.3			62	32.8	23	40	0.26	2.73	0.90	89.6	119.0	119.1	1.8		1.44	1.25	CH		SA-52ndAVE
SS-32ND_ST-13_	ST-13	901		891	15.0	886.4			58	31.0	25	34	0.19	2.72	0.85	91.9	120.4	120.4	2.0		0.75	2.68	CH		SS-32ND
SS-32ND_ST-13_	ST-13	901		891	30.0	871.0			115	64.0	31	84	0.39	2.71	1.71	62.5	102.5	101.8	2.7		0.90	2.99	CH		SS-32ND
FRW PL Sherack 01-5MU_1	01-5MU				16.0	885.7	1		78	35.7	28	50	0.15	2.71	0.97	85.6	116.2	116.5	1.95		0.56	3.48		PL Sherack	FRW
FRW PL Sherack 01-5MU_1	01-5MU				16.0	885.7	1		78	35.7	28	50	0.15	2.71	0.97	85.6	116.2	116.5	1.95		0.84	2.32		PL Sherack	FRW
FRW Sherack 01-12MU_1	01-12MU				19.0	865.0	1		53	25.8	21	31	0.14	2.68	0.87	100.2	125.9	125.2	3.20		0.72	4.44		Sherack	FRW
FRW Brenna 01-5MU_2	01-5MU				49.0	852.7	2		108	71.2	35	73	0.49	2.73	1.95	57.7	98.8	99.0	2.95		1.60	1.84		Brenna	FRW
FRW Brenna 01-5MU_2	01-5MU				49.0	852.7	2		108	71.2	35	73	0.49	2.73	1.95	57.7	98.8	99.0	2.95		1.60	1.84		Brenna	FRW
FRW Argusville 01-5MU_4	01-5MU				78.0	823.7	4		99	63.9	28	70	0.51	2.77	1.80	61.8	101.3	101.9	2.60		2.20	1.18		Argusville	FRW
FRW Argusville 01-5MU_4	01-5MU				78.0	823.7	4		99	63.9	28	70	0.51	2.77	1.80	61.8	101.3	101.9	2.60		2.30	1.13		Argusville	FRW
FM Brenna Far 09-25MU_4	Far 09-25MU	893.4	9.0	884.4	51.0	842.4	4		108	82.6	22	86	0.47	2.75	1.77	62.0	100.9	101.9	2.6		1.70	1.62	CH	Brenna	FM
FM Sherack Far 09-26MU_1	Far 09-26MU	903.5	7.9	895.6	9.0	894.5	1		67	32.4	17	50	0.31	2.74	0.91	89.5	118.5	119.2	1.4		0.51	2.80	CH	Sherack	FM
FM Brenna Far 09-26MU_3	Far 09-26MU	903.5	7.9	895.6	29.0	874.5	3		110	54.2	24	86	0.35	2.75	1.51	65.5	101.0	106.0	3.7		1.04	3.56	CH	Brenna	FM
FM Alluvium Far 09-27MU_1	Far 09-27MU	903.1	7.9	895.2	7.0	896.1	1		75	29.7	18	57	0.21	2.71	0.84	92.1	119.5	120.5	1.6		0.42	3.81	CH	Alluvium	FM
FM Brenna Far 09-27MU_4	Far 09-27MU	903.1	7.9	895.2	65.0	838.1	4		89	55.4	20	69	0.51	2.70	1.52	67.0	104.1	104.8	2.8		1.82	1.51	CH	Brenna	FM
FM OX Brenna Far 09-59MU_2	Far 09-59MU	916.2	14.4	901.8	21.0	895.2	2		92	53.3	19	73	0.47	2.75	1.50	68.6	105.2	106.1	3.5	3.0	0.95	3.68	CH	OX Brenna	FM
FM B-A Trans Far 09-59MU_3	Far 09-59MU	916.2	14.4	901.8	36.0	880.2	3		64	38.3	17	47	0.45	2.75	1.08	82.6	114.2	114.9	2.7		1.30	2.08	CH	B-A Trans	FM
FM OX Brenna Far 09-60MU_2	Far 09-60MU	887.3	8.0	879.3	26.0	861.3	2		106	49.1	24	82	0.31	2.70	1.42	69.8	104.1	106.3	4.9	5.6	0.90	5.44	CH	OX Brenna	FM
FM Brenna Far 09-60MU_3	Far 09-60MU	887.3	8.0	879.3	38.0	851.3	3		111	57.5	26	85	0.37	2.70	1.55	66.0	104.0	103.9	5.2	4.7	1.10	4.73	CH	Brenna	FM
FM Alluvium Far 10-78MU_1	Far 10-78MU	905.7	8.7	899.0	14.0	891.7	1			29.6					0.93	89.5	116.2		2.9	3.0	0.61	4.75	CH	Alluvium	FM
FM Brenna Far 10-78MU_2	Far 10-78MU	905.7	8.7	899.0	25.0	879.7	2			42.2					1.17	79.6	113.2		3.6	4.0	0.90	4.00	CH	Brenna	FM
FM Argusville Far 10-78MU_3	Far 10-78MU	905.7	8.7	899.0	56.0	849.7	3			47.5					1.34	73.6	108.9		4.5	5.3	1.60	2.81	CH	Argusville	FM
FM Alluvium Far 10-79MU_1	Far 10-79MU	905.7	10.7	895.0	21.0	884.7	1			30.3					0.84	91.7	119.5		4.0	4.0	0.93	4.30	CH	Alluvium	FM
FM Argusville Far 10-79MU_2	Far 10-79MU	905.7	10.7	895.0	41.0	864.7	2			49.3					1.34	72.7	108.5		4.0	3.9	1.40	2.86	CH	Argusville	FM
FM Alluvium Far 10-80MU_1	Far 10-80MU	921.1	9.6	911.5	24.0	897.1	1		28	28.7	17	11	1.06	2.67	0.75	95.3	122.7	122.0	2.2	2.0	1.00	2.20	CL & SM	Alluvium	FM
FM Brenna Far 10-80MU_2	Far 10-80MU	921.1	9.6	911.5	36.0	885.1	2			46.1					1.31	75.3	110.0		5.1	5.0	1.30	3.88	CH	Brenna	FM
FM Argusville Far 10-80MU_3	Far 10-80MU	921.1	9.6	911.5	56.0	865.1	3			51.8					1.45	70.8	107.5		4.7	4.4	1.70	2.76	CH	Argusville	FM
FM PR - WF Moor 09-25MU_2	Moor 09-25MU	898.7	8.8	889.9	22.0	876.7	2		30	26.3	24	6	0.72	2.75	0.78	96.6	123.9	123.8	1.6		0.93	1.72	ML	PR - WF	FM
FM PR - Harwood Moor 09-25MU_3	Moor 09-25MU	898.7	8.8	889.9	26.0	872.7	3		80	36.3	21	59	0.26	2.75	1.03	84.7	115.4	116.3	3.4		1.04	3.27	CH	PR - Harwood	FM
FM Brenna Moor 09-25MU_4	Moor 09-25MU	898.7	8.8	889.9	39.0	859.7	4		116	70.5	25	91	0.50	2.75	1.99	57.3	97.7	98.9	2.9		1.34	2.15	CH	Brenna	FM
FM B-A Trans Moor 09-25MU_5	Moor 09-25MU	898.7	8.8	889.9	69.0	829.7	5		87	55.0	22	65	0.51	2.75	1.49	59.0	107.0	106.3	2.8		1.95	1.44	CH	B-A Trans	FM
FM OX Brenna Moor 09-34MU_2	Moor 09-34MU	907.9	9.8	898.1	17.0	890.9	2		114	60.7	24	90	0.41	2.70	1.66	63.5	102.0	102.4	3.8		0.80	4.75	CH	OX Brenna	FM

* Water Table Assumed to be 10' below ground surface (No observed water table data in boring)

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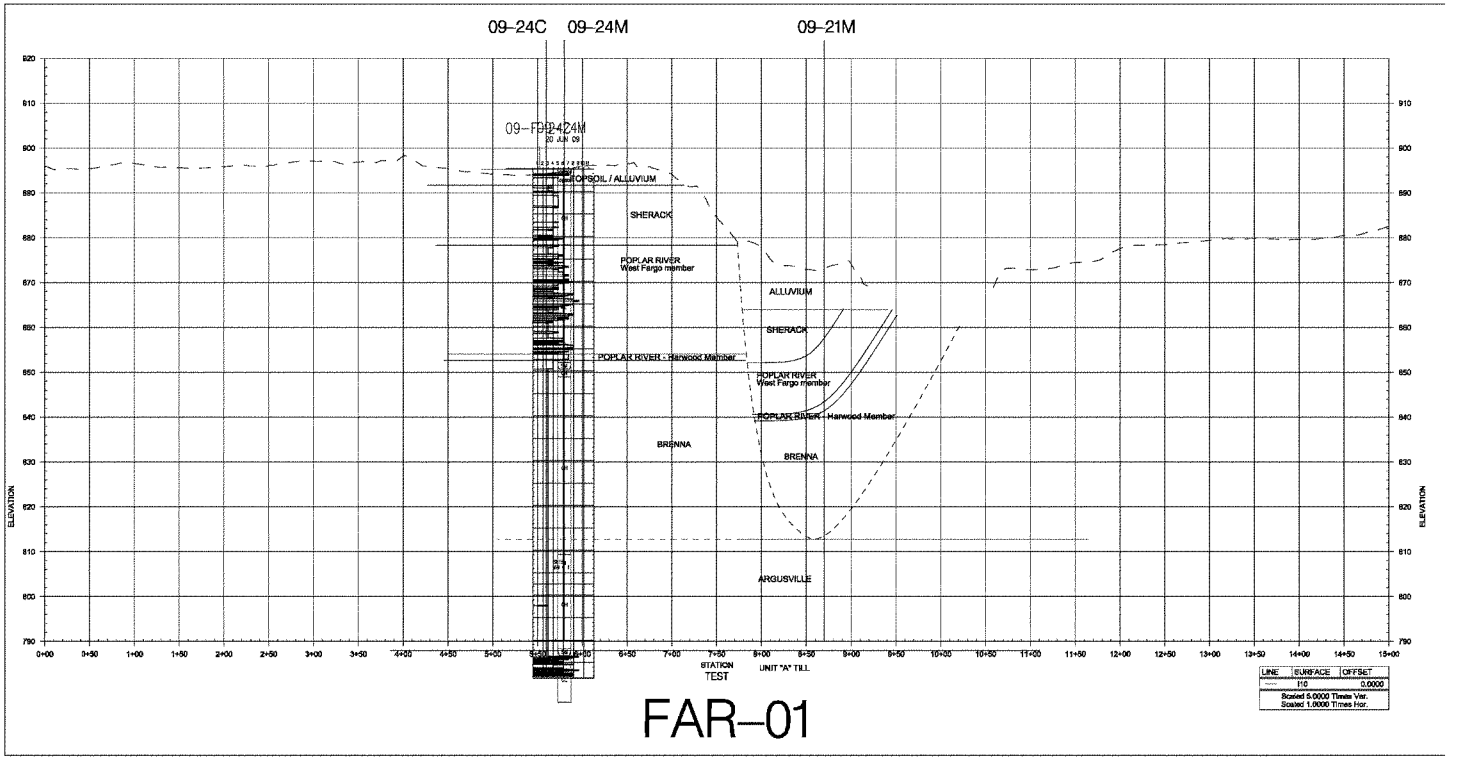
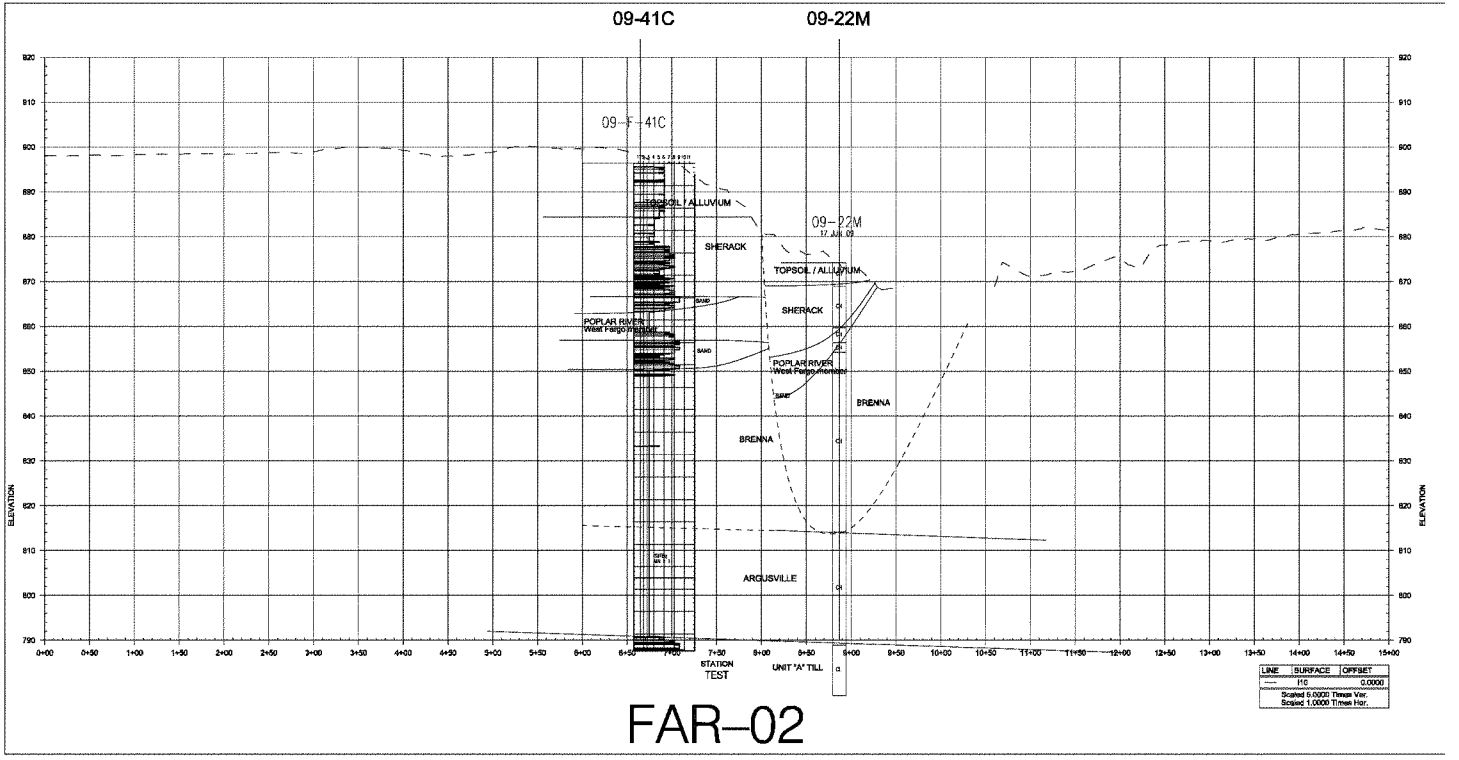
Attachment I-6: In-Town Levee Alternative Stratigraphy


09-24C
09-24M
09-21M
09-F09-24M
20 JUN 09
TOPSOIL / ALLUVIUM
SHERACK
POPLAR RIVER
West Fargo member
ALLUVIUM
SHERACK
POPLAR RIVER - Harwood Member
POPLAR RIVER
West Fargo member
POPLAR RIVER - Harwood Member
BRENNA
BRENNA
ARGUSVILLE
ELEVATION
STATION
TEST
UNIT "A" TILL
LINE
SURFACE
OFFSET
I10
0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.
FAR-01


09-41C
09-22M
09-F-41C
09-22M
17 JUN 09
TOPSOIL / ALLUVIUM
SHERACK
TOPSOIL / ALLUVIUM
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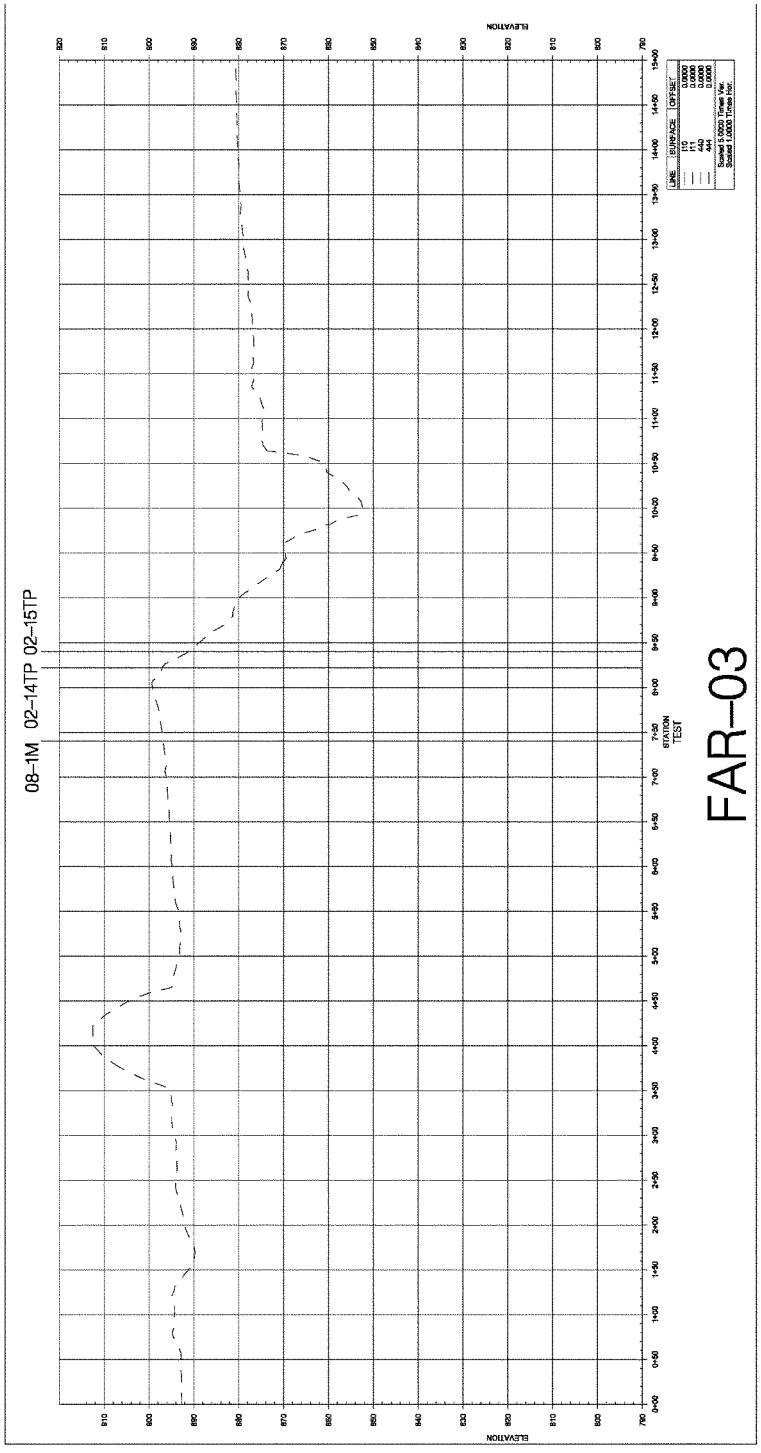
POPLAR RIVER
West Fargo moment
POPLAR RIVER
West Fargo moment
BRENNA
BRENNA
ARGUSVILLE
ELEVATION
STATION
TEST
UNIT "A" TILL
LINE
SURFACE
OFFSET
I10
0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.
FAR–02

1198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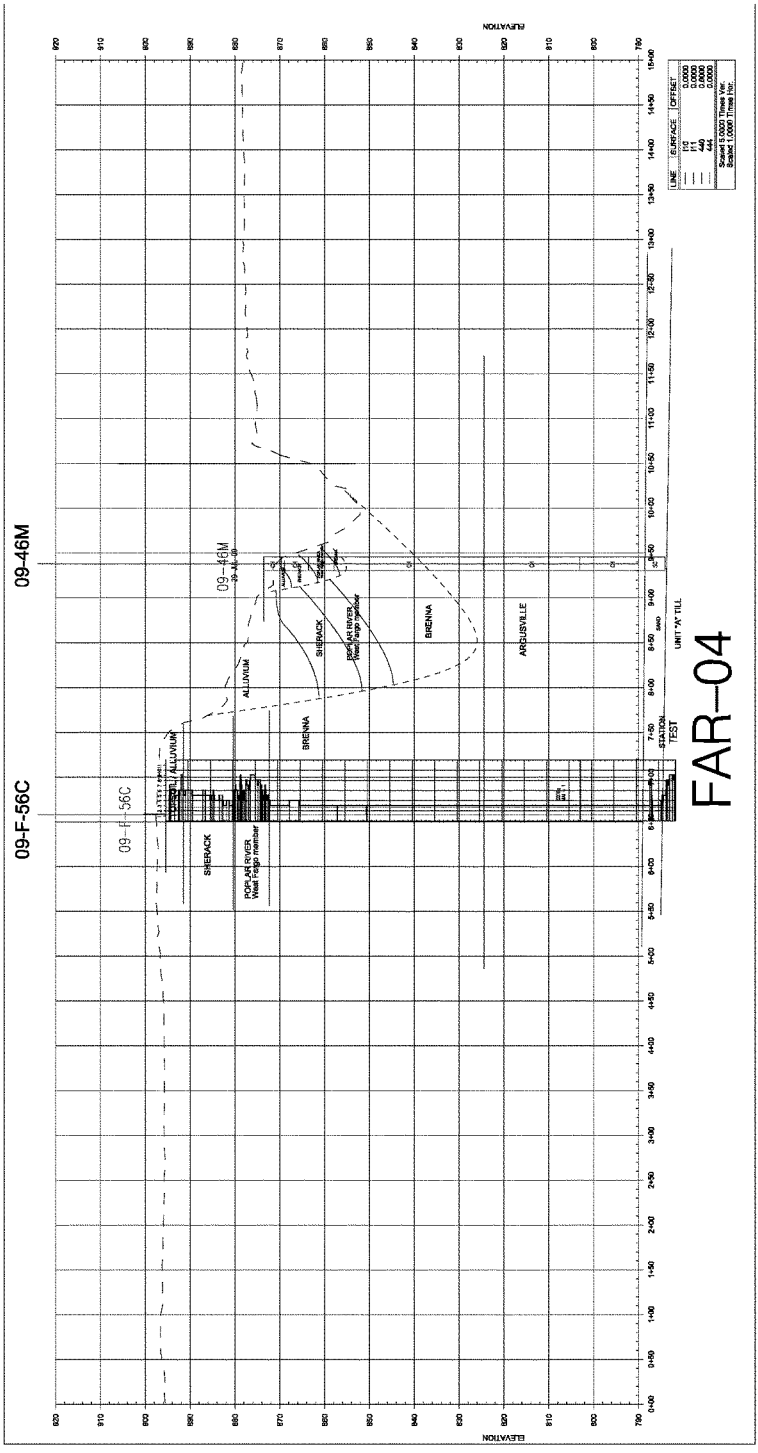
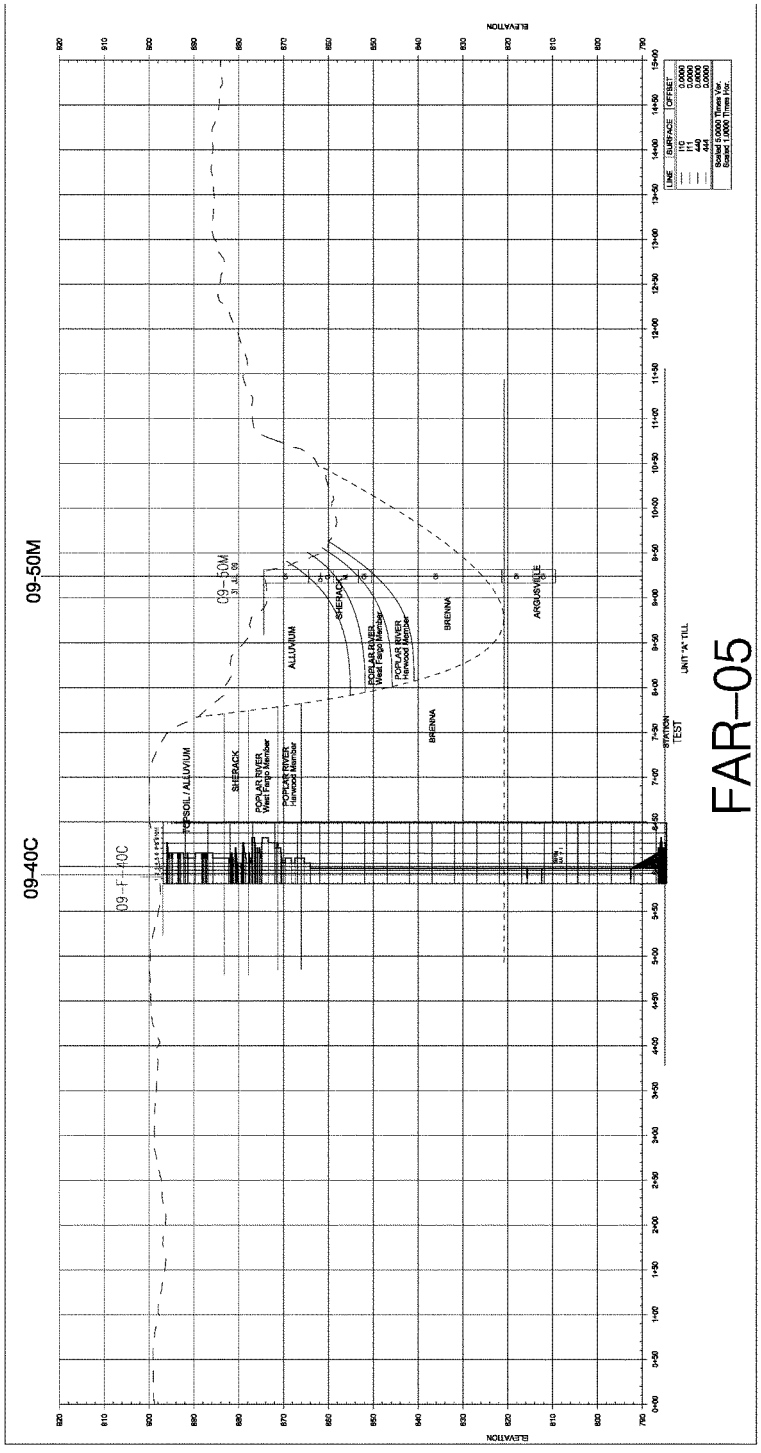
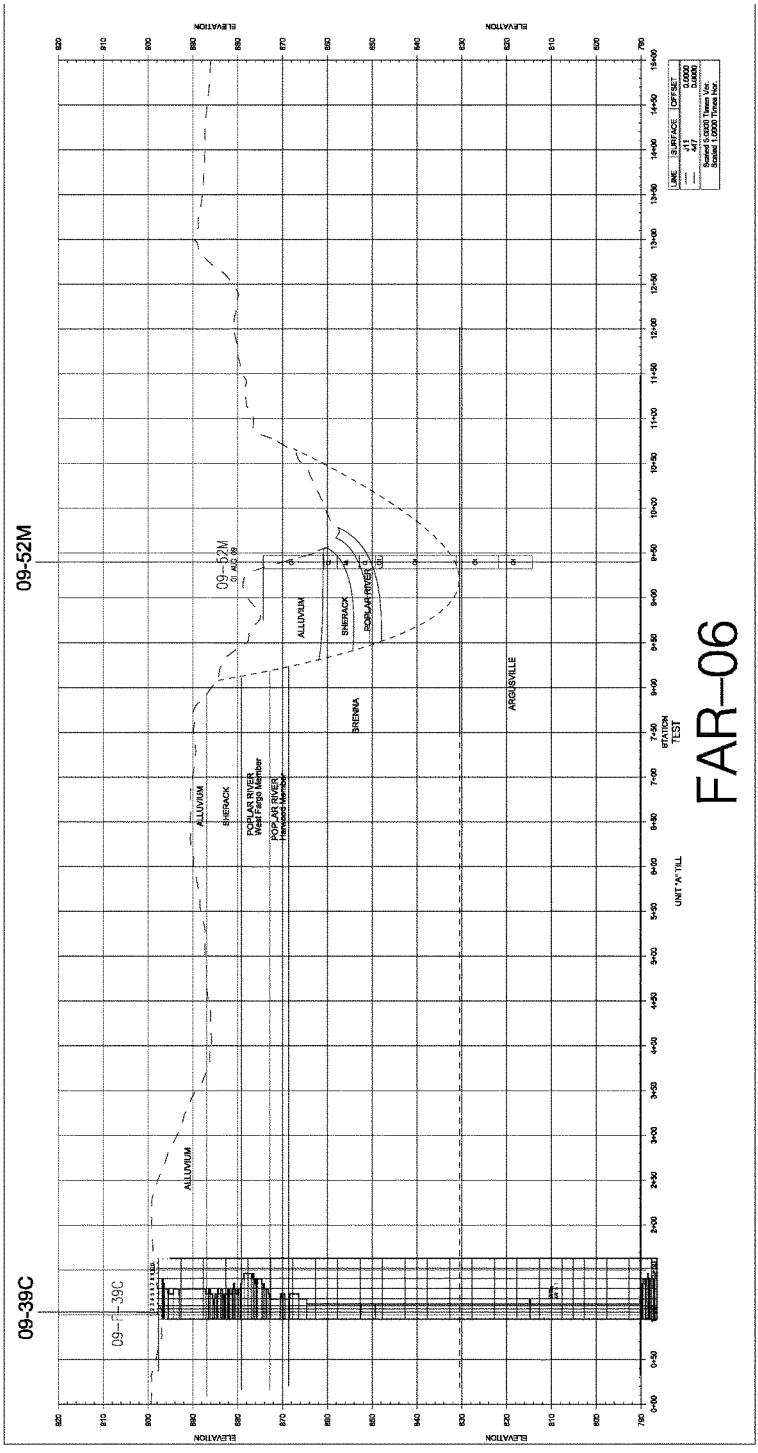
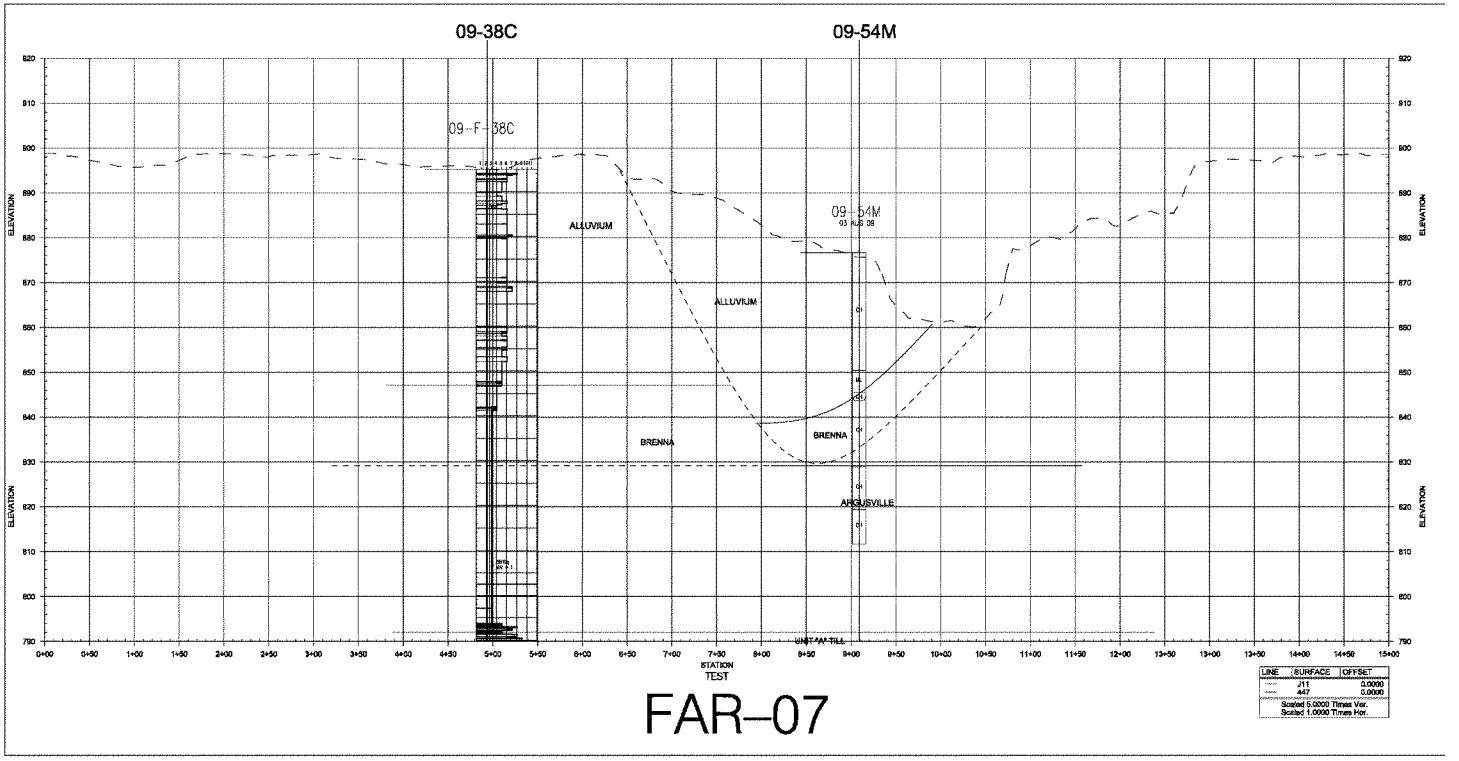
FAR-03
ELEVATION
STATION
TEST
LINE SURFACE OFFSET
110 0.0000
111 0.0000
440 0.0000
444 0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

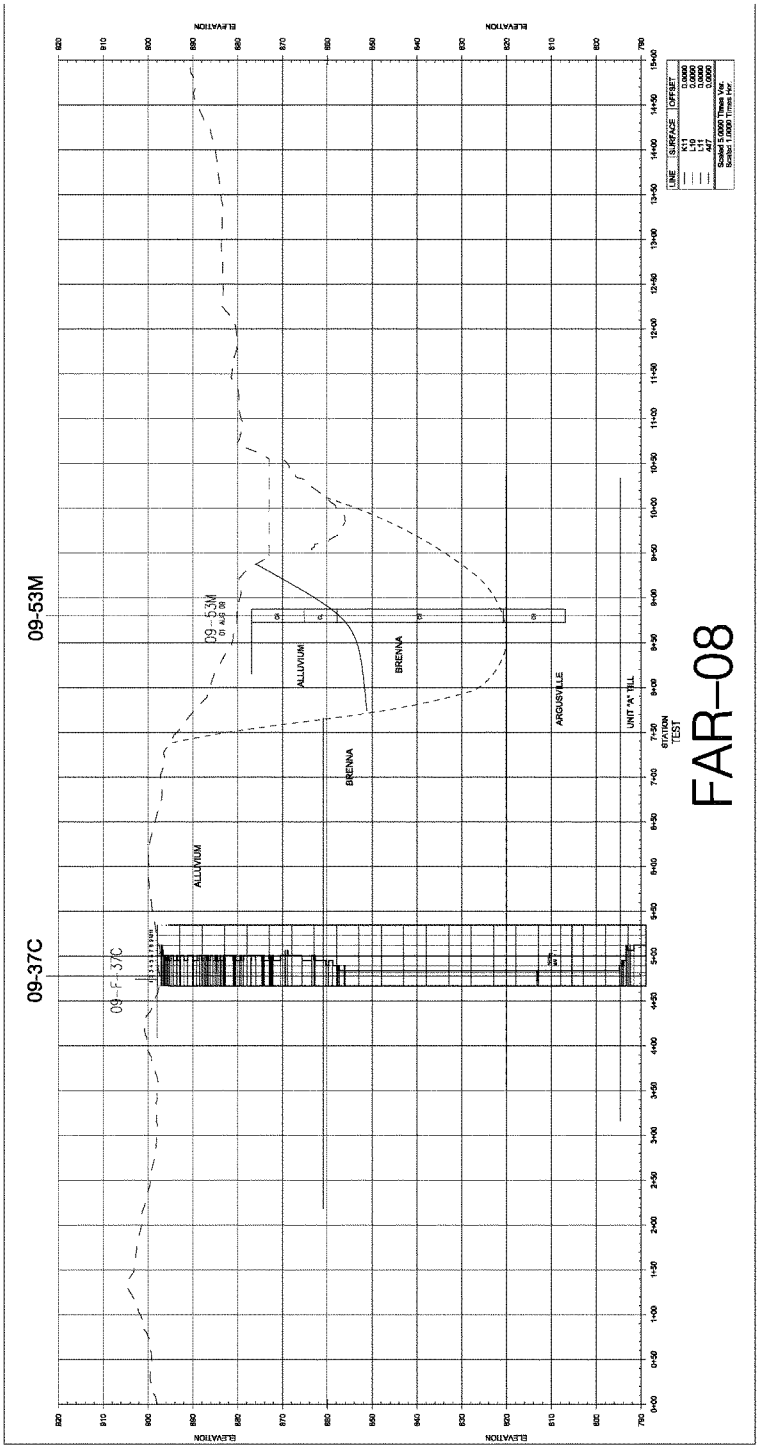

09-F-56C
09-46M
09-F-56C
09-46M
FAR-04
ELEVATION
STATION
TEST
ALLUVIUM
SHERACK
POPLAR RIVER
West Fargo member
BRENNA
ARGUSVILLE
UNIT "A" TILL
LINE
SURFACE
OFFSET
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

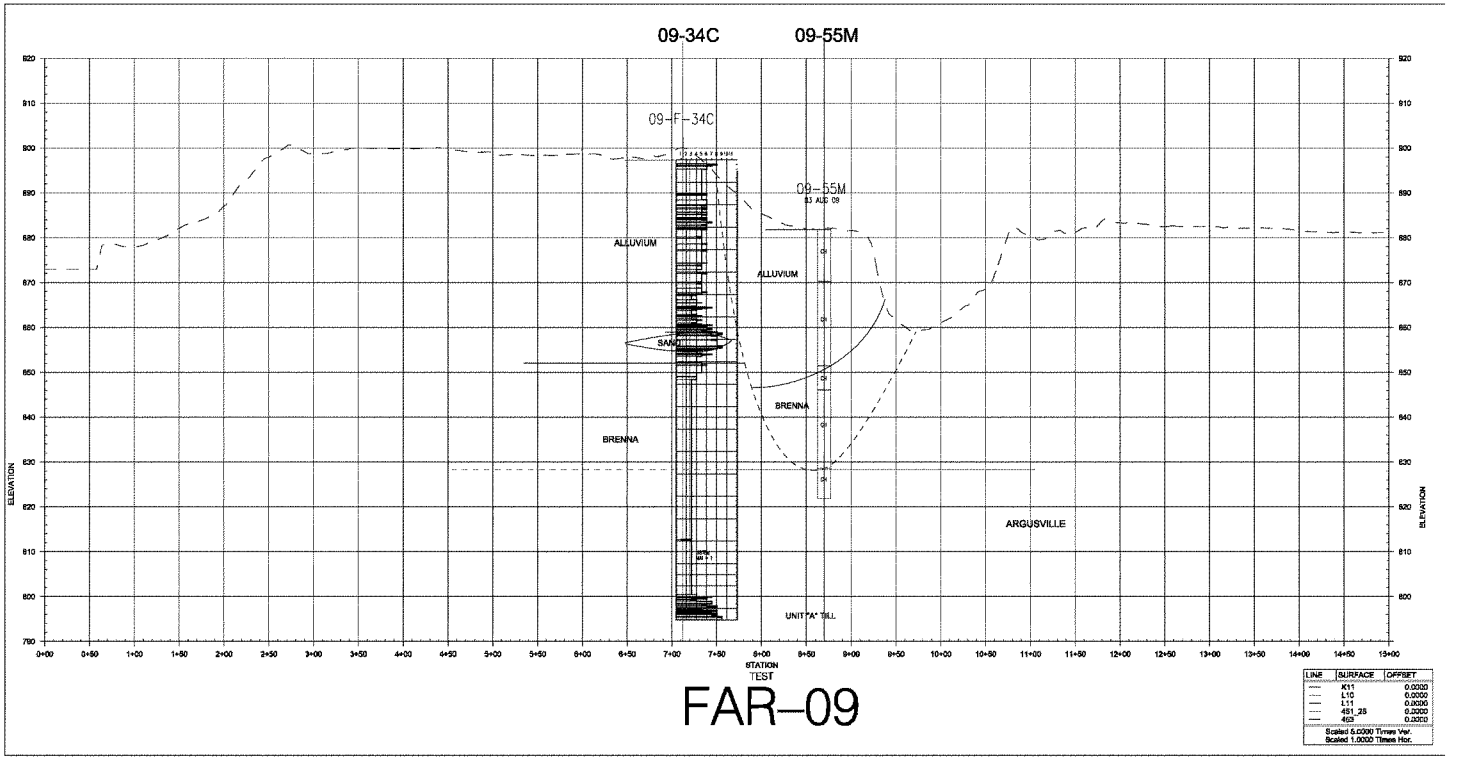

09-40C
09-50M
09-F-40C
09-50M
FAR-05
TOPSOIL / ALLUVIUM
SHERACK
POPLAR RIVER
West Fargo Member
POPLAR RIVER
Harwood Member
ALLUVIUM
SHERACK
POPLAR RIVER
West Fargo Member
POPLAR RIVER
Harwood Member
BRENNA
BRENNA
ARGUSVILLE
UNIT "A" TILL
ELEVATION
TEST
LINE SURFACE OFFSET
I15 0.0000
I11 0.0000
444 0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

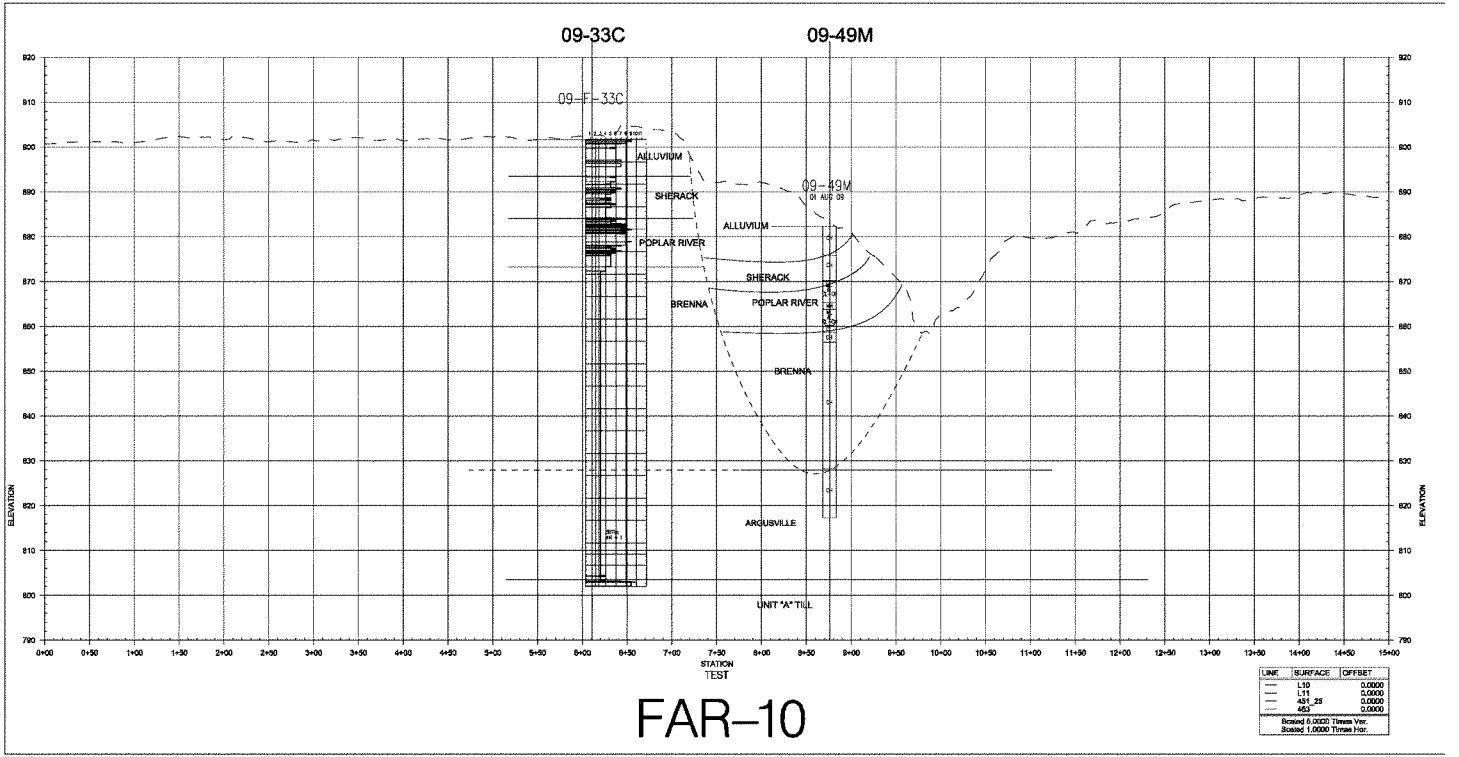

09-52M
09-39C
09-52M
09-39C
ALLUVIUM
SHERACK
POPLAR RIVER
West Fargo Member
POPLAR RIVER
Horwood Member
BRENNA
ALLUVIUM
SHERACK
POPLAR RIVER
ARGUSVILLE
UNIT "A" TILL
STATION
TEST
ELEVATION
FAR-06


09-38C
09-54M
09-F-38C
09-54M
03 AUG 09
ALLUVIUM
ALLUVIUM
BRENNA
BRENNA
ARGUSVILLE
UNIT "A" TILL
ELEVATION
STATION
TEST
LINE SURFACE OFFSET
J11 0.0000
447 0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

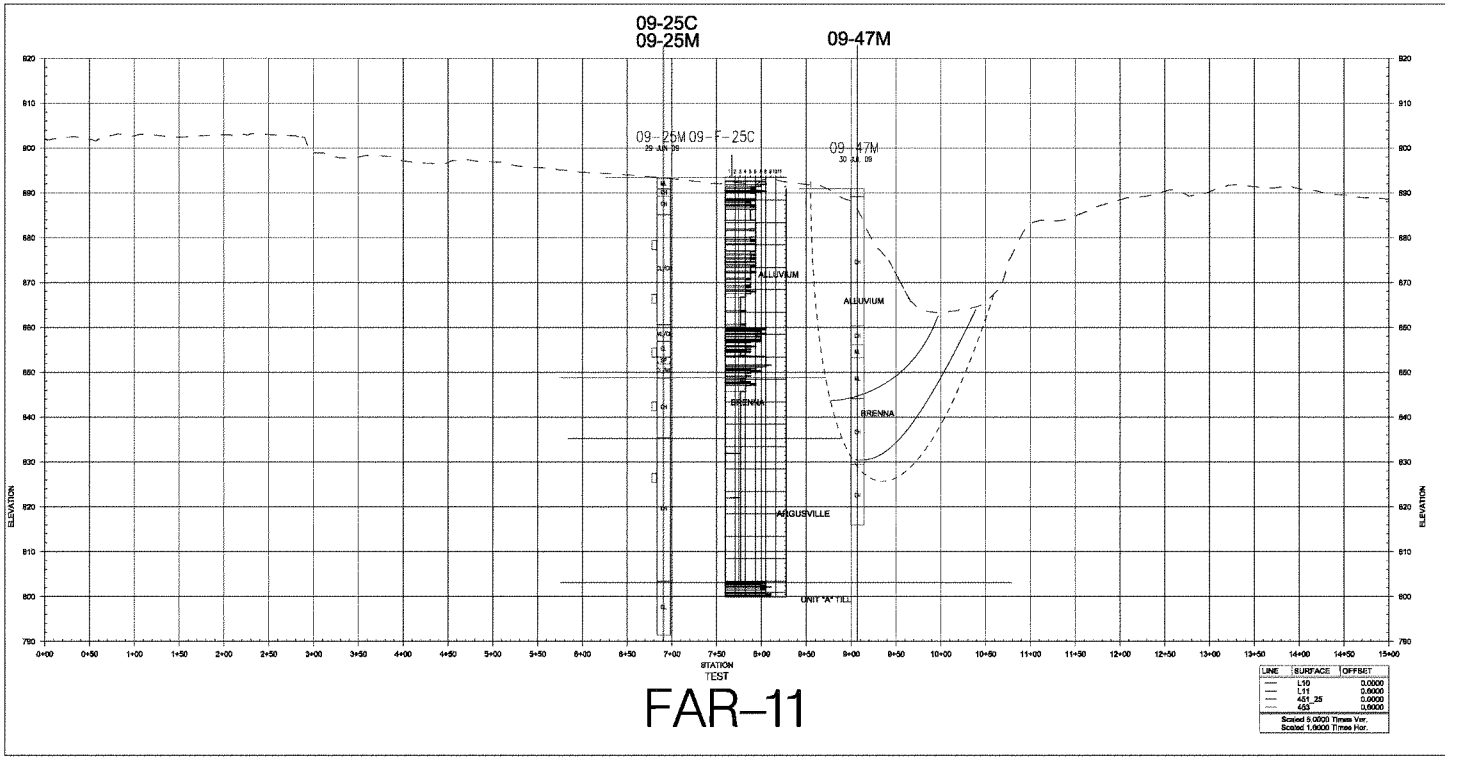
FAR–07

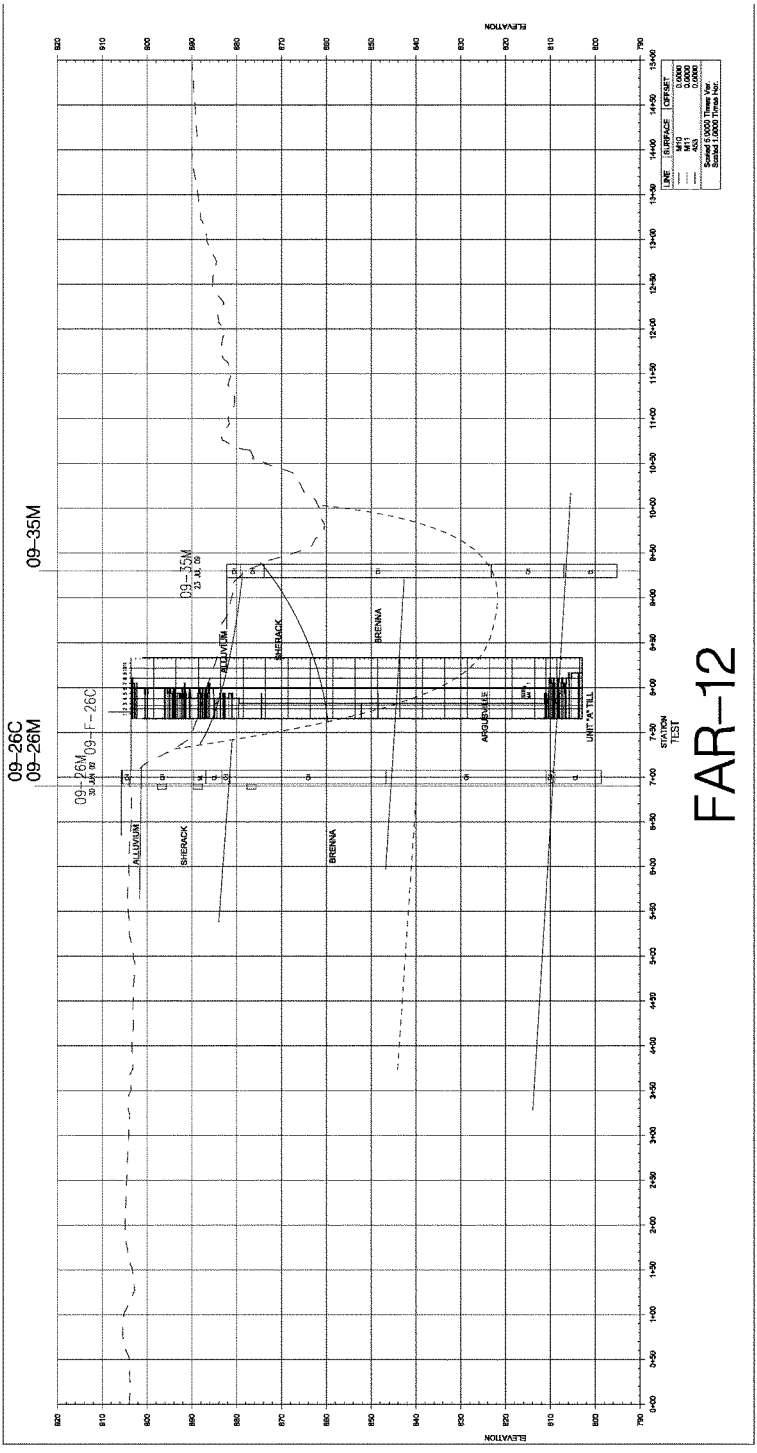

09-37C
09-53M
09-F-37C
09-F-53M
ALLUVIUM
BRENNA
ARGUSVILLE
UNIT "A" TILL
ELEVATION
STATION
TEST
FAR-08

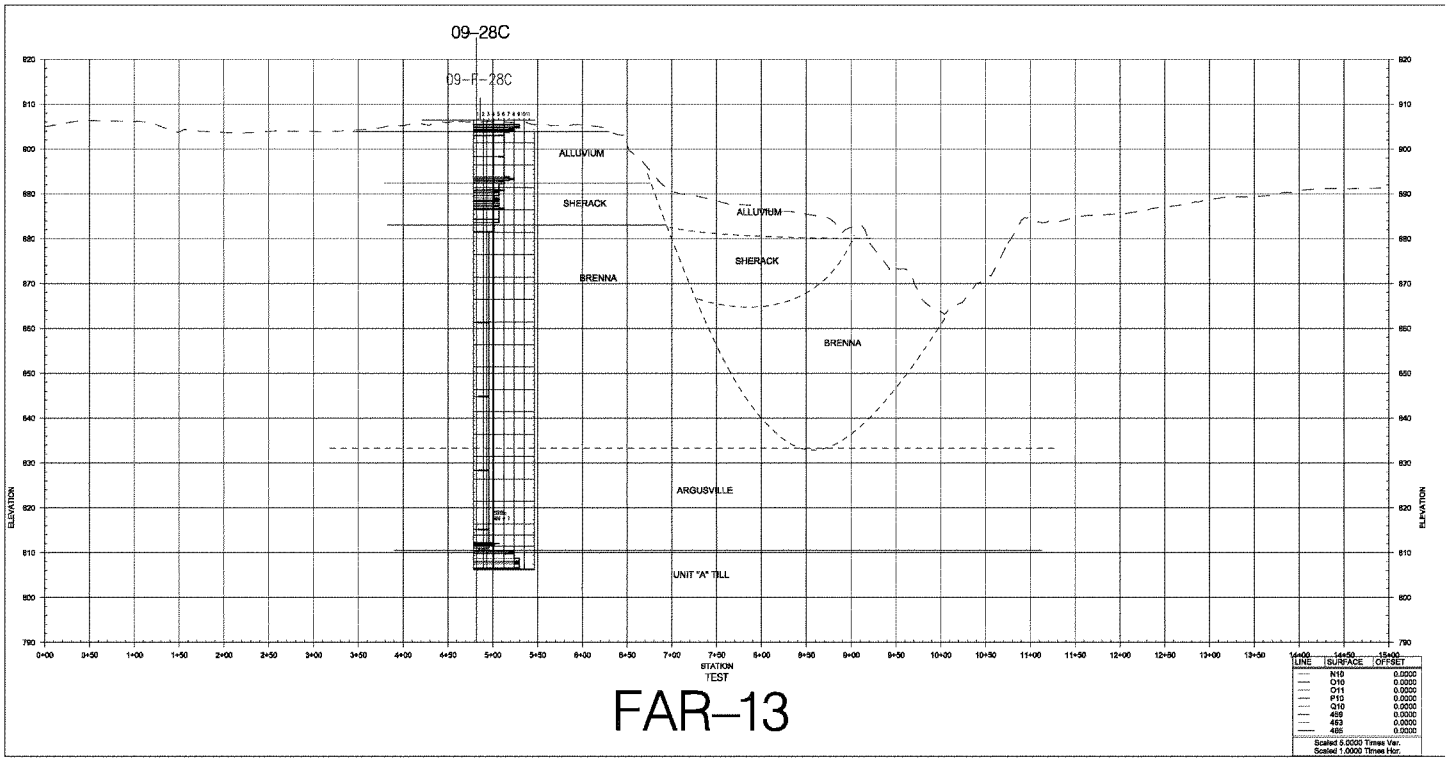

09-34C
09-55M
09-F-34C
09-55M
ALLUVIUM
ALLUVIUM
SAND
BRENNA
BRENNA
ARGUSVILLE
UNIT "A" TILL
ELEVATION
STATION
TEST
FAR-09
LINE SURFACE OFFSET
K11 0.0000
L10 0.0000
L11 0.0000
451_25 0.0000
463 0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.


09-33C
09-49M
09-F-33C
09-49M
01 AUG 09
ALLUVIUM
SHERACK
POPLAR RIVER
BRENNA
ARGUSVILLE
UNIT "A" TILL
ELEVATION
STATION
TEST
LINE
SURFACE
OFFSET
L10
L11
451_25
453
0.0000
Scaled 6.0000 Times Ver.
Scaled 1.0000 Times Hor.

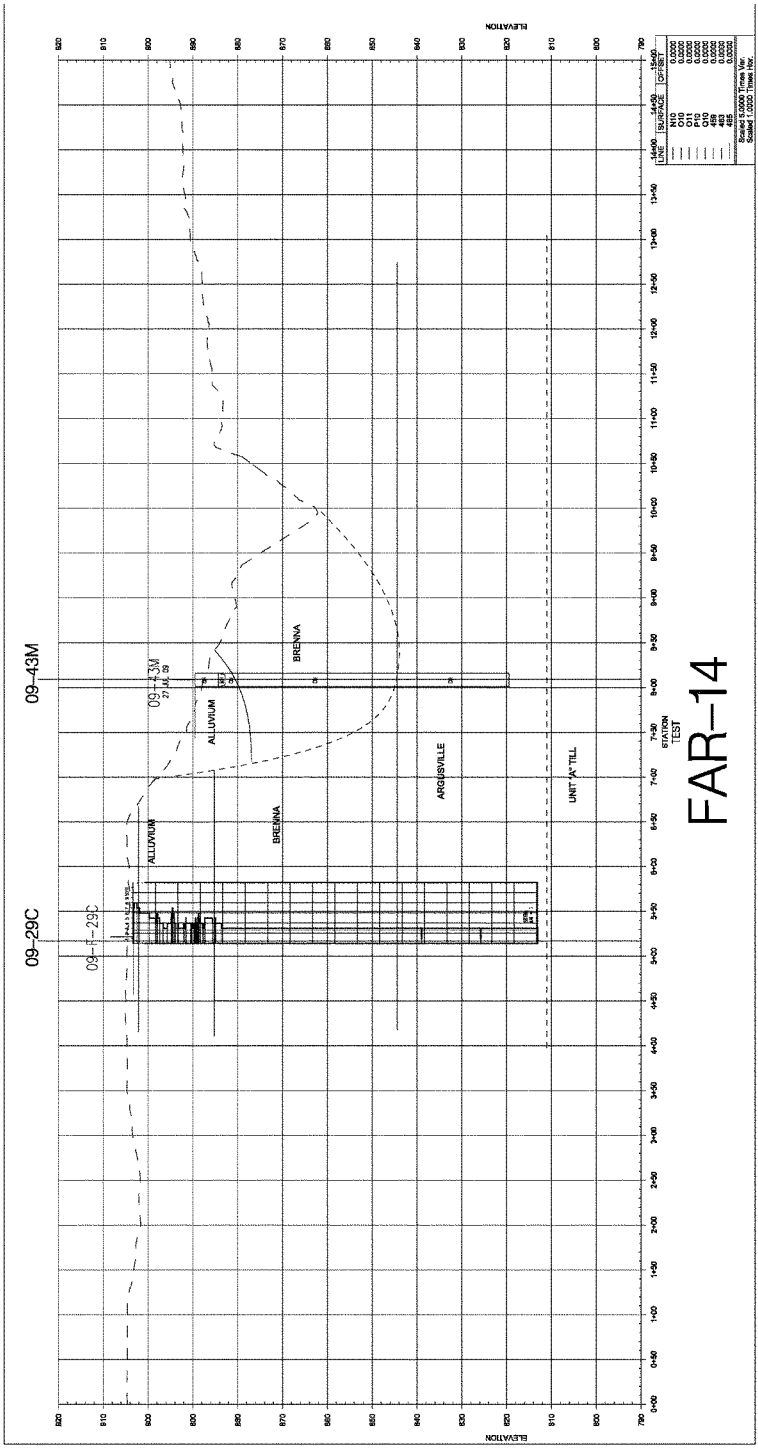
FAR–10

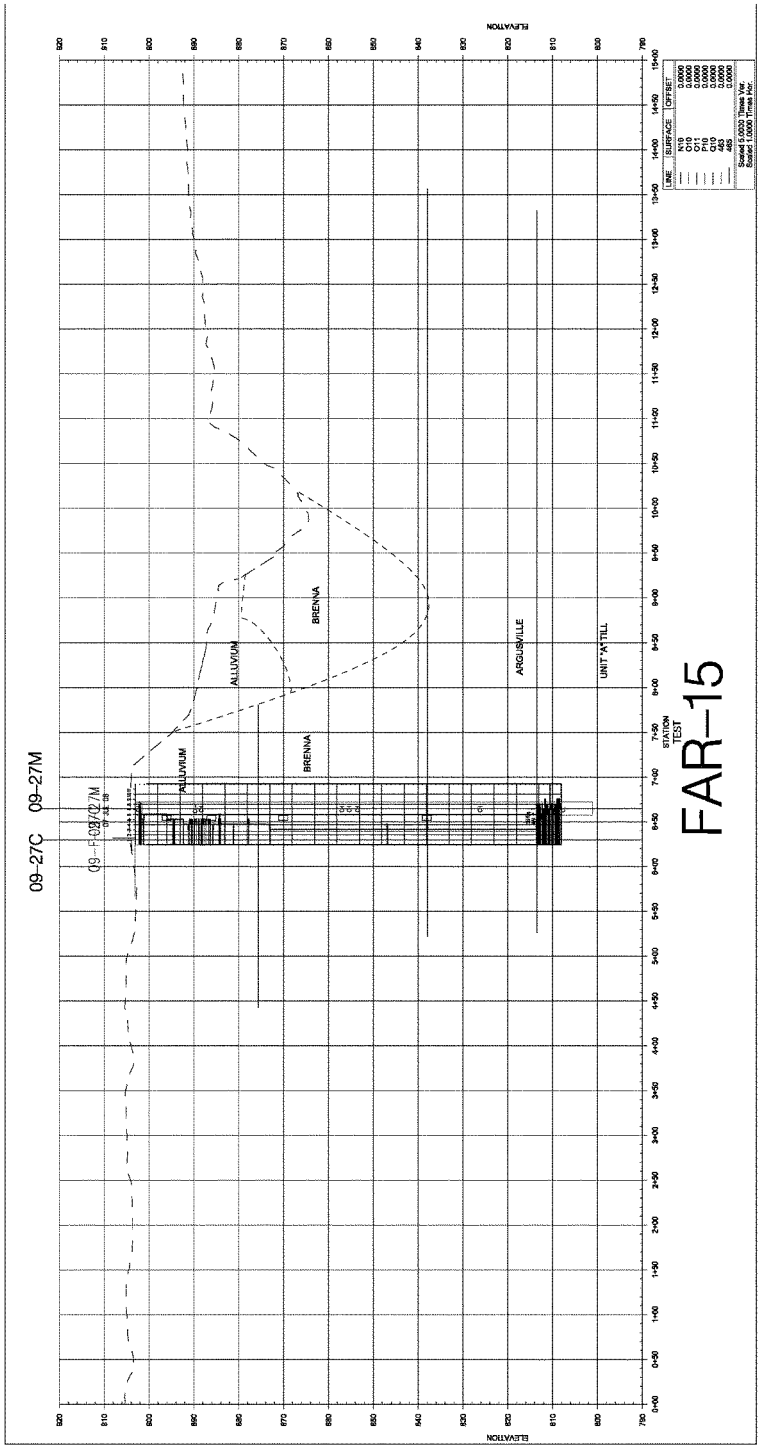

09-25C
09-25M
09-47M
09-25M 09-F-25C
29 JUN 09
09-47M
30 JUL 09
ALLUVIUM
BRENNA
ARGUSVILLE
UNIT "A" TILL
ELEVATION
STATION
TEST
FAR-11
LINE
SURFACE
OFFSET
L10
0.0000
L11
0.0000
451_25
0.0000
453
0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

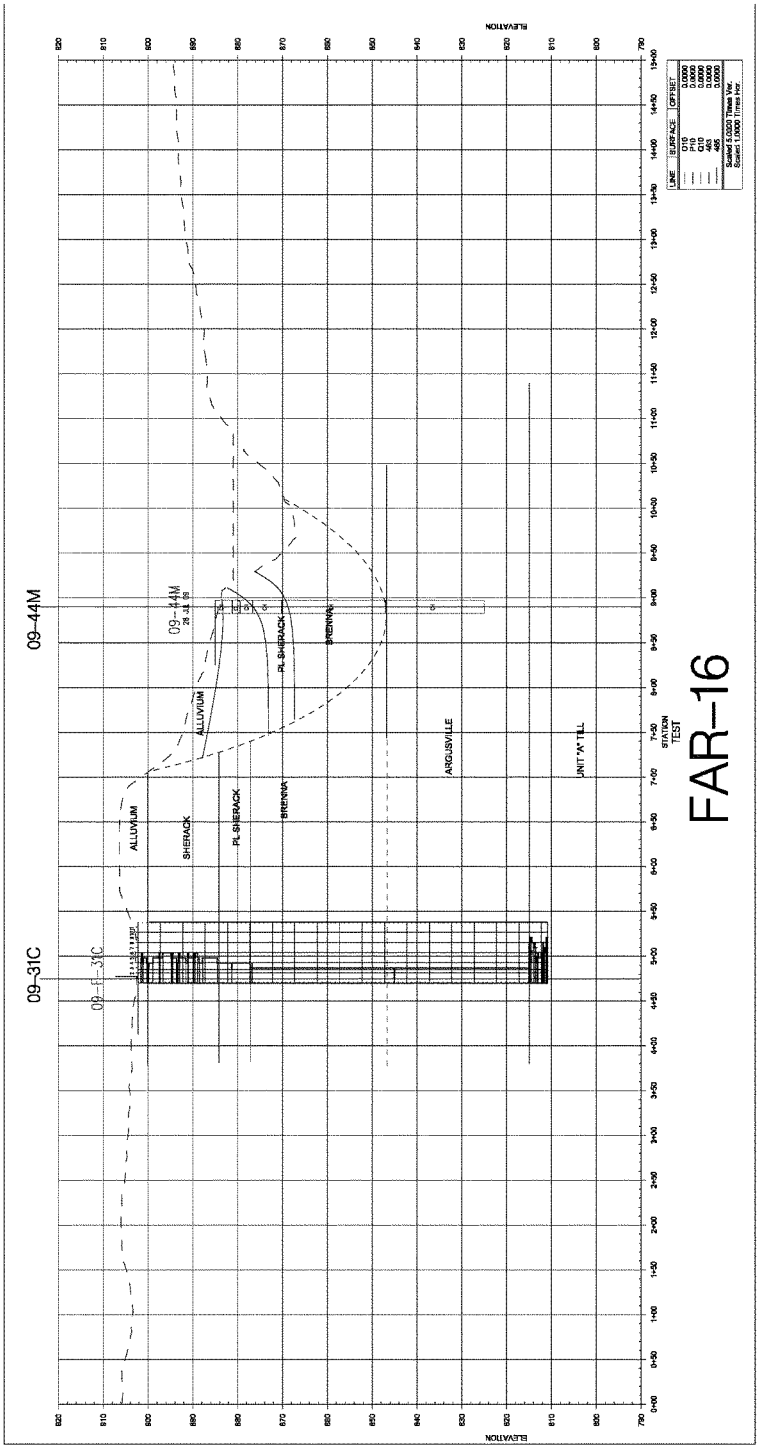

09-26C
09-26M
09-35M
09-26M
09-F-26C
09-35M
ALLUVIUM
SHERACK
BRENNA
ARGUSVILLE
UNIT "A" TILL
ELEVATION
STATION
TEST
FAR-12

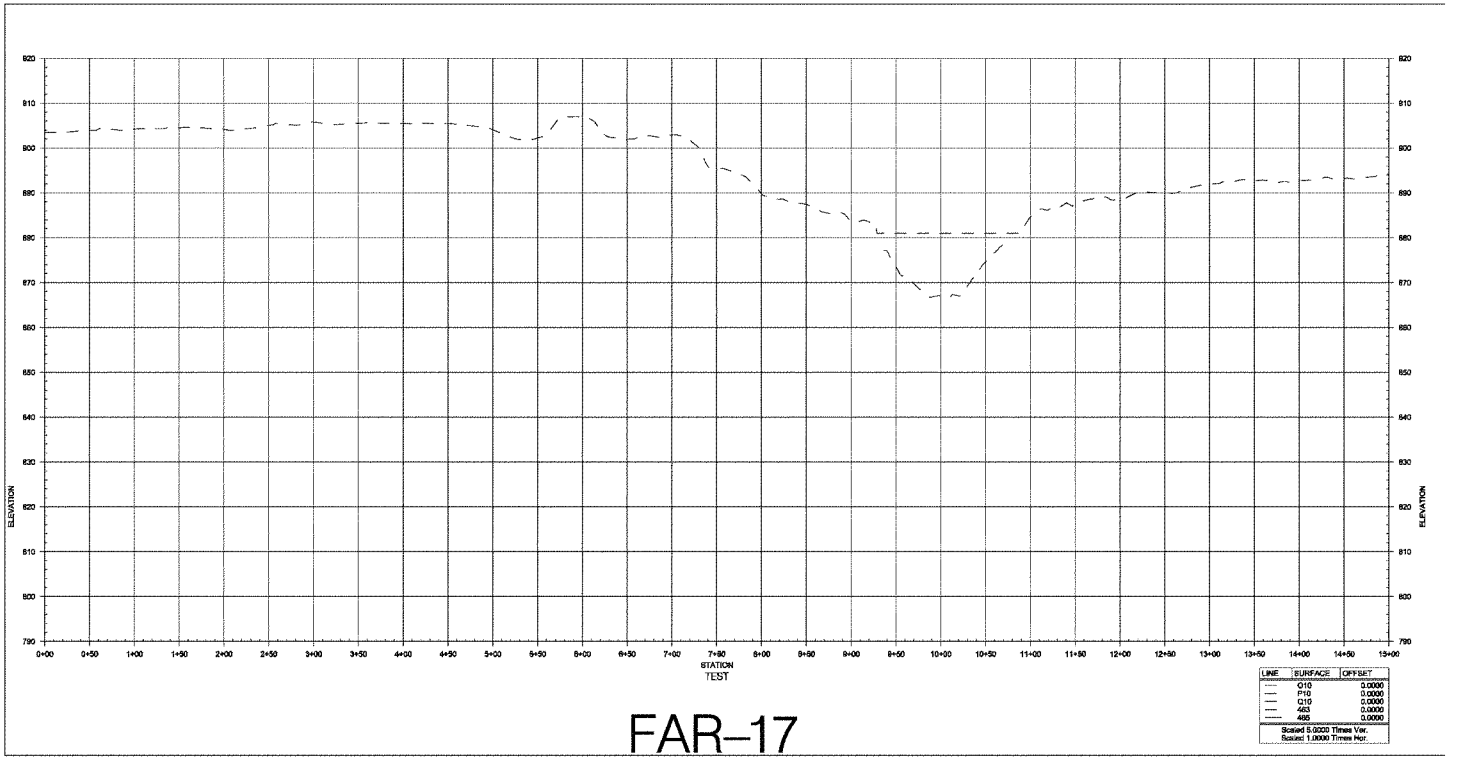

09-28C
09-F-28C
ALLUVIUM
SHERACK
BRENNA
ALLUVIUM
SHERACK
BRENNA
ARGUSVILLE
UNIT "A" TILL
ELEVATION
STATION
TEST
LINE | SURFACE | OFFSET
N10 0.0000
O10 0.0000
O11 0.0000
P10 0.0000
Q10 0.0000
469 0.0000
483 0.0000
485 0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

FAR-13

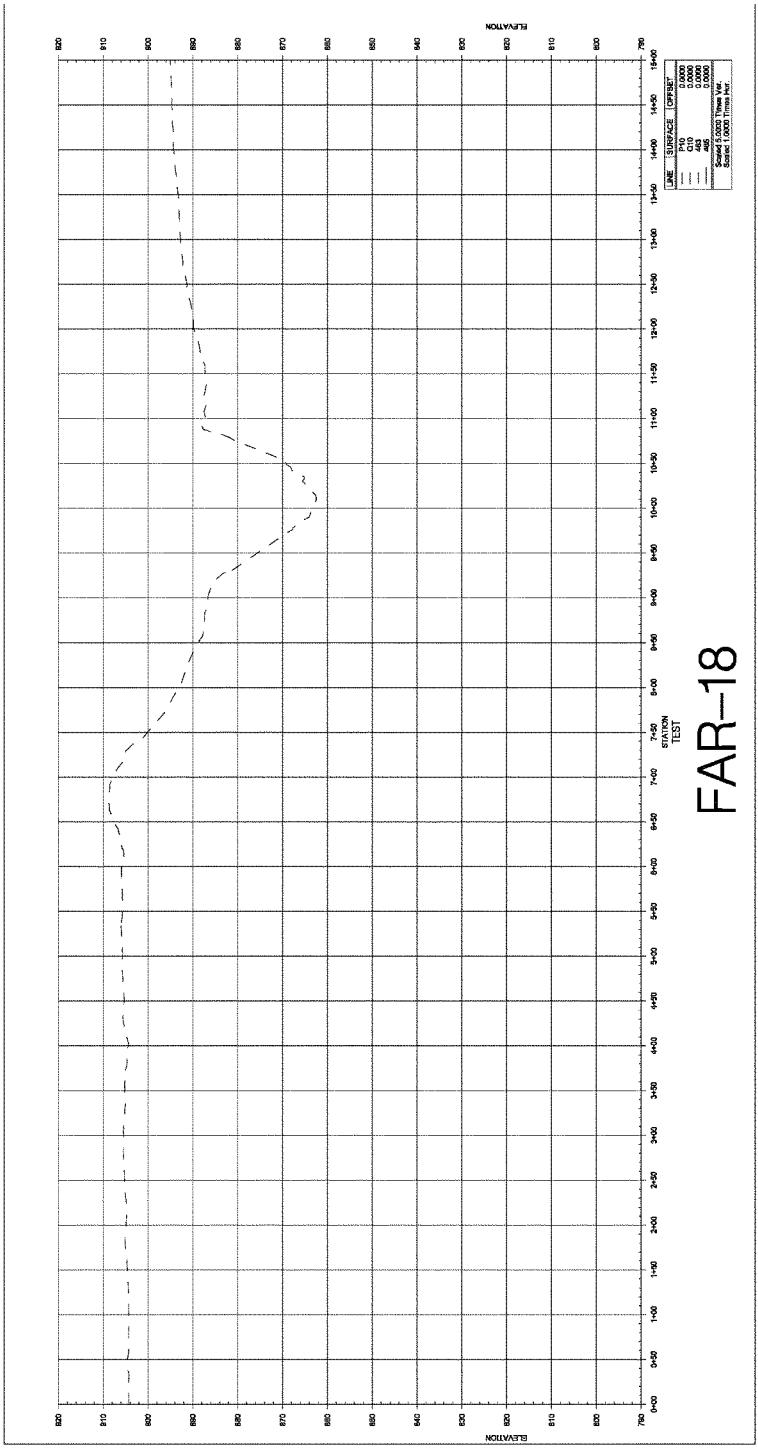

09-43M
09-29C
09-F-29C
09-F-43M
ALLUVIUM
BRENNA
ARGUSVILLE
UNIT "A" TILL
ELEVATION
STATION
FAR-14


09-27C
09-27M
09-27C 09-27M
ALLUVIUM
BRENNA
ALLUVIUM
BRENNA
ARGUSVILLE
UNIT "A" TILL
ELEVATION
STATION
TEST
FAR-15

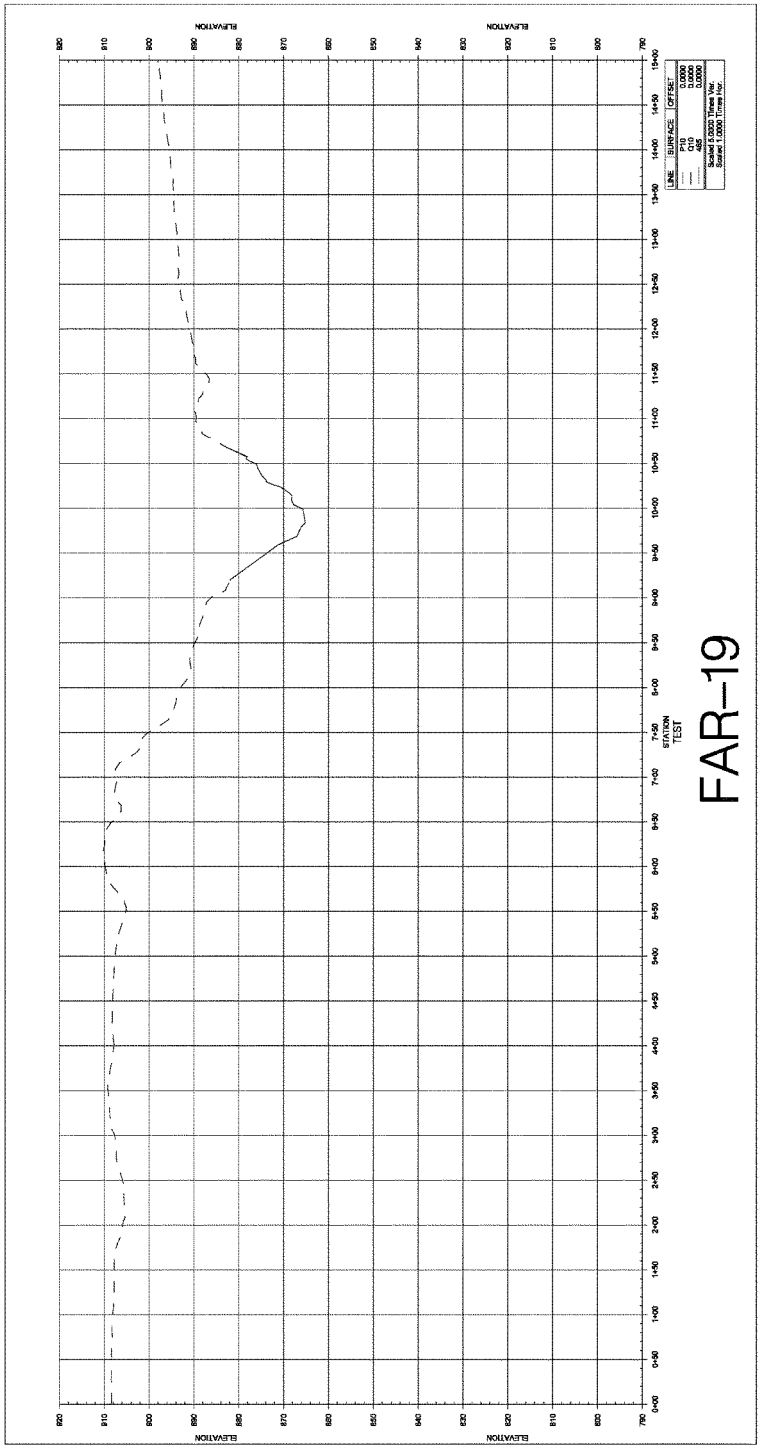

09-31C
09-44M
09-44M
28 JUL 09
ALLUVIUM
SHERACK
PL SHERACK
BRENNA
ARGUSVILLE
UNIT "A" TILL
ELEVATION
STATION
TEST
LINE
SURFACE
OFFSET
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Ver.
FAR-16


ELEVATION
STATION
TEST
LINE SURFACE OFFSET
Q10 0.0000
P10 0.0000
Q10 0.0000
463 0.0000
465 0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

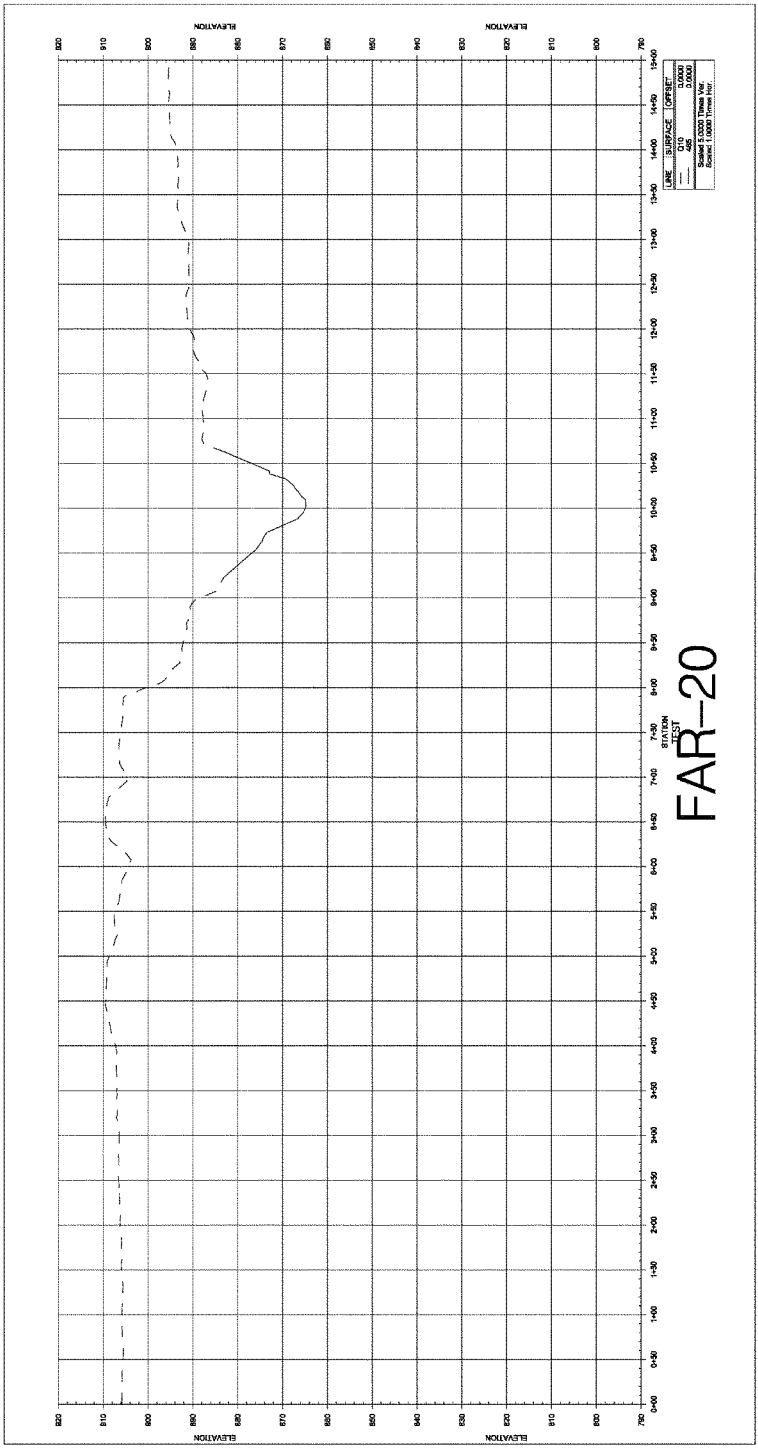
FAR–17

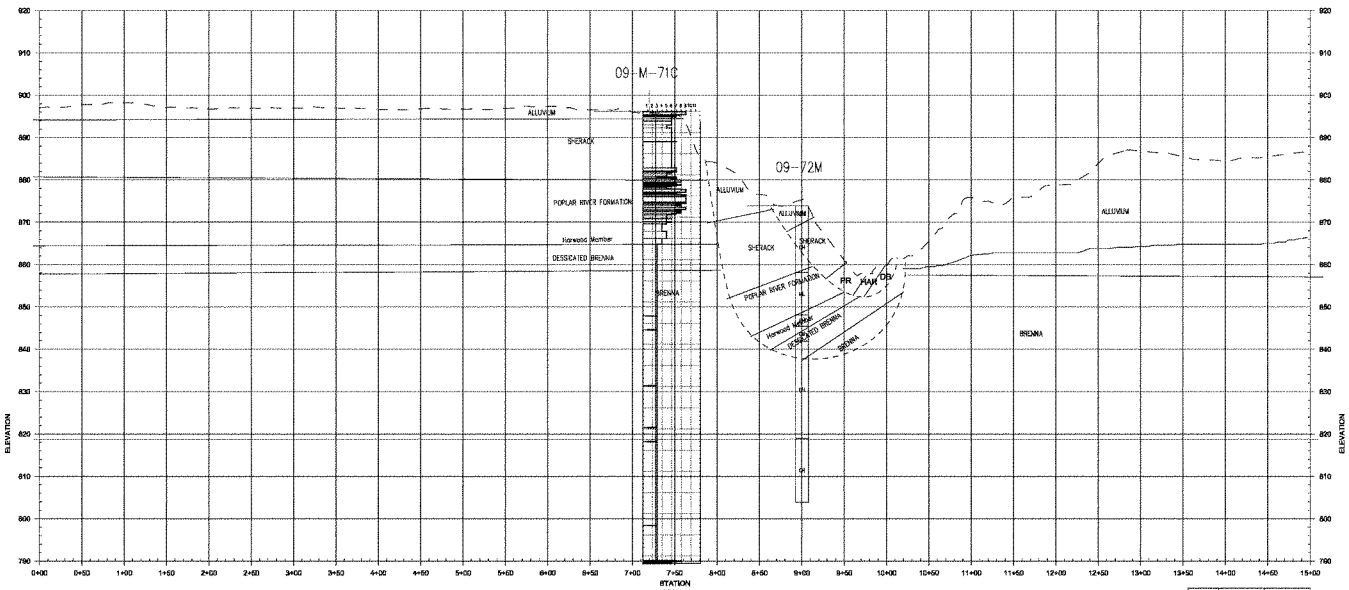

ELEVATION
STATION
TEST
LINE | SURFACE | OFFSET
P10 0.0000
G10 0.0000
A6 0.0000
A66 0.0000
Scaled 5.0000 Times Ver.
Scale: 1.0000 Times Hor.

FAR–18


ELEVATION
STATION
TEST
LINE SURFACE OFFSET
G10 0.0000
485 0.0000
Scaled 1.0000 Times Ver
Scaled 1.0000 Times Ver

FAR–19


ELEVATION
STATION
FEET
LINE | SURFACE | OFFSET
D10 | 0.0000
495 | 0.0000
Scaled 1.0000 Times Ver
Scaled 1.0000 Times Ver
FAR–20



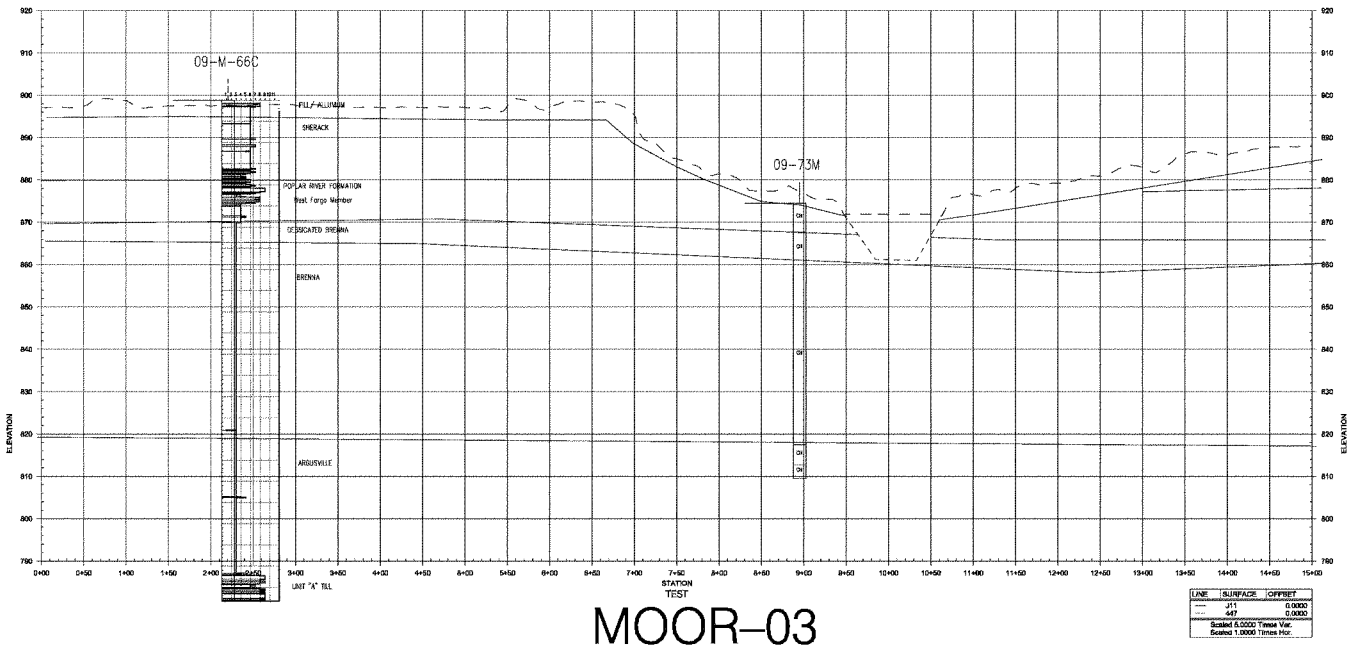
LINE	SURFACE	OFFSET
	I10	0.0000
	I11	0.0000
	440	0.0000
	444	0.0000

Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

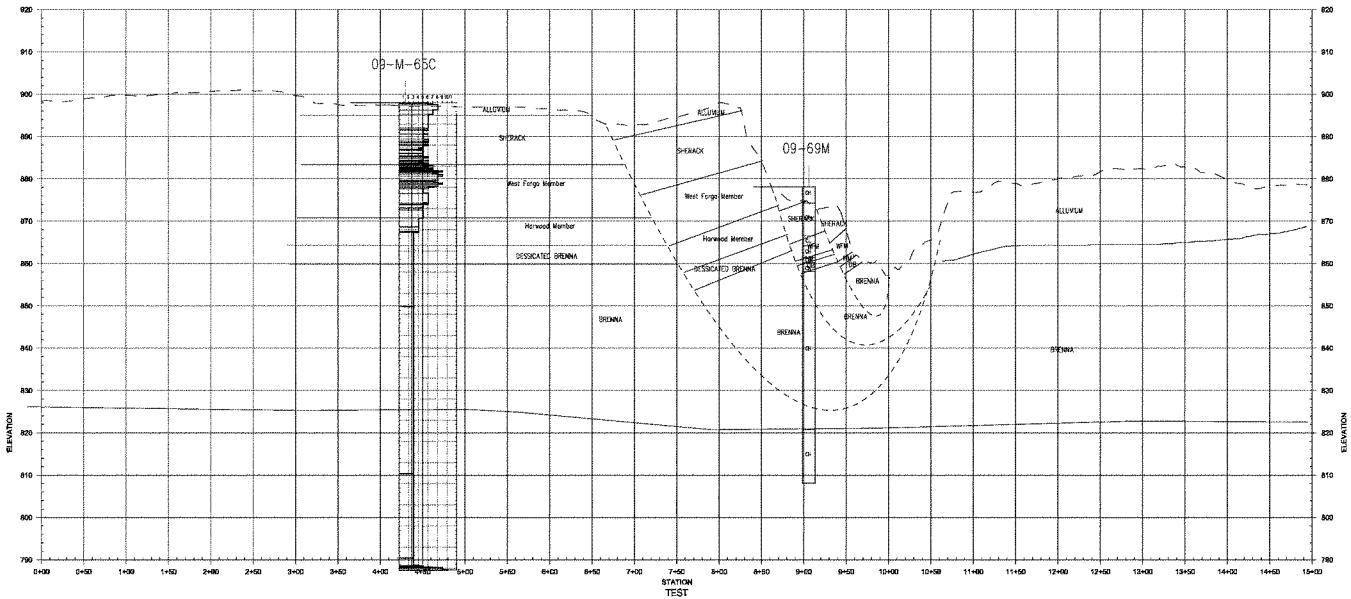
MOOR–01

ELEVATION
920
910
900
890
880
870
860
850
840
830
820
810
800
790
0+00
0+50
1+00
1+50
2+00
2+50
3+00
3+50
4+00
4+50
5+00
5+50
6+00
6+50
7+00
7+50
8+00
8+50
9+00
9+50
10+00
10+50
11+00
11+50
12+00
12+50
13+00
13+50
14+00
14+50
15+00
STATION
TEST
FILL/ ALLUVIUM
SHERACK
POPLAR RIVER FORMATION
ALLUVIUM
SHERACK
DESSICATED BRENNA
POPLAR RIVER FORMATION
DESSICATED BRENNA
BRENNA
BRENNA
BRENNA
ALLUVIUM
LINE
SURFACE
OFFSET
I10
0.0000
I11
0.0000
440
0.0000
444
0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

MOOR–02


09-M-66C
09-73M
FILL/ALLUVIUM
SHERACK
POPLAR RIVER FORMATION
West Fargo Member
DESSICATED BRENNA
BRENNA
ARGUSVILLE
UNIT "A" TILL
ELEVATION
STATION
TEST
LINE SURFACE OFFSET
J11 0.0000
447 0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

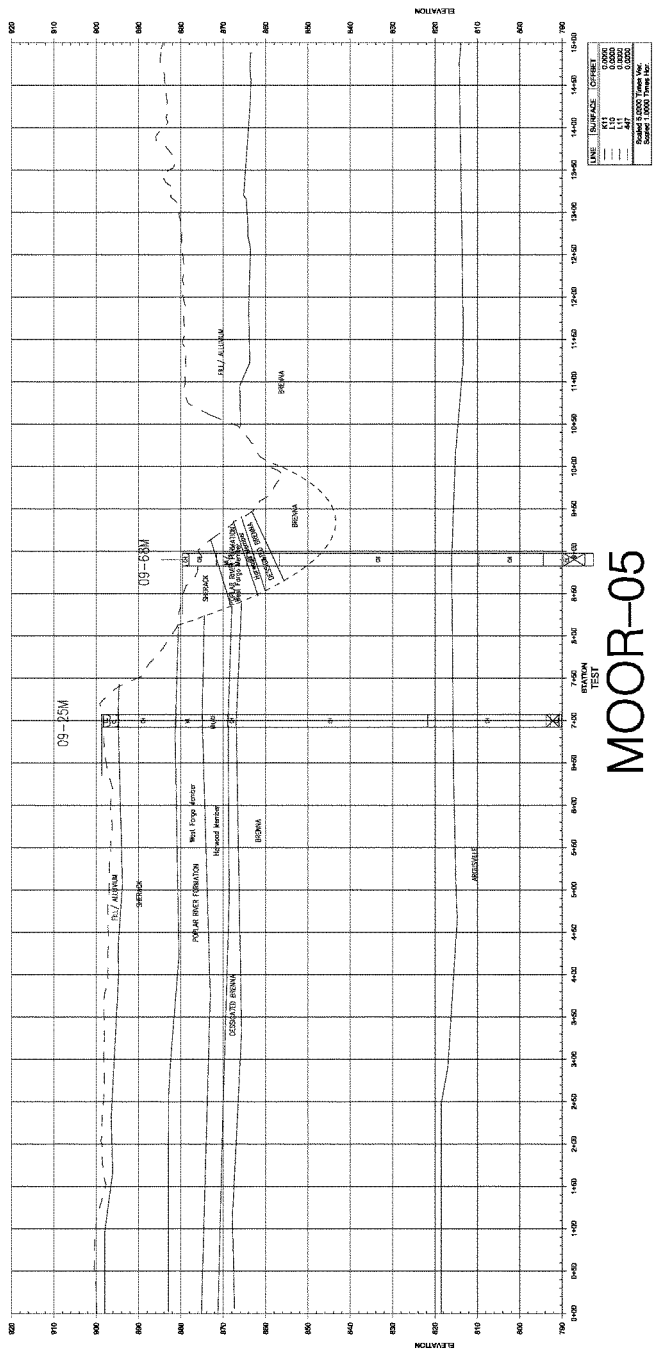
MOOR–03

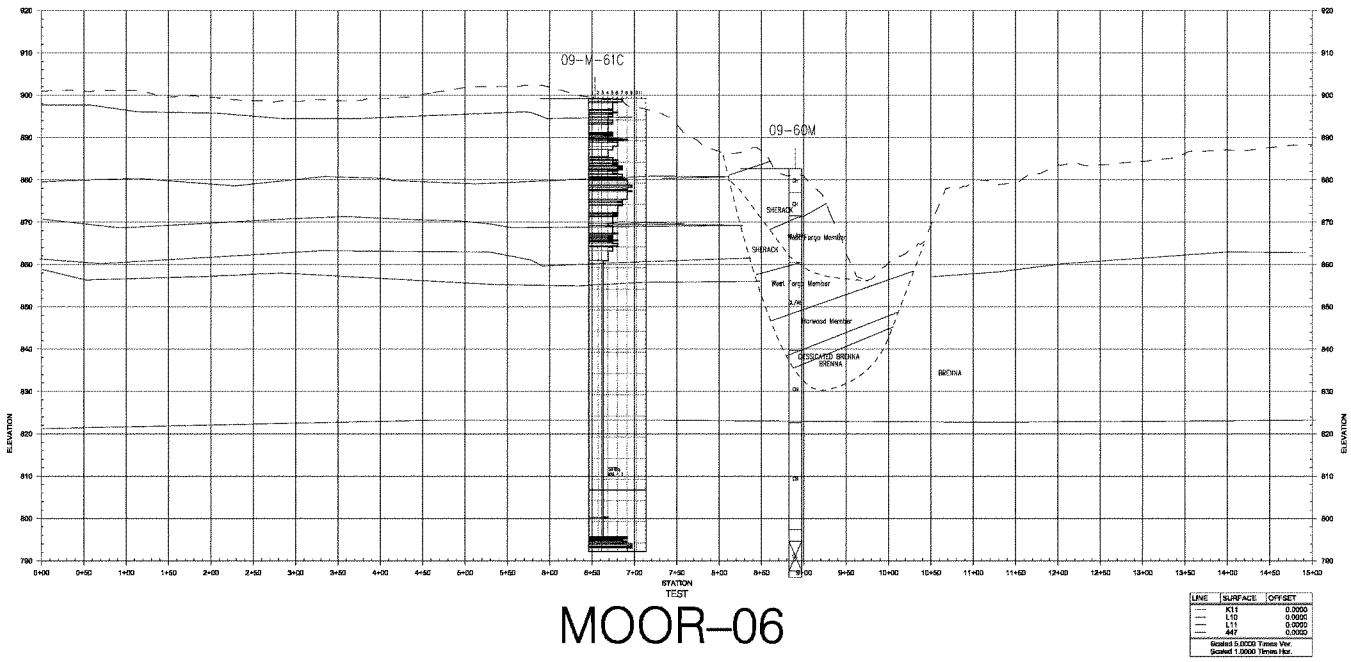


LINE	SURFACE	OFFSET
----	J11	0.0000
----	447	0.0000

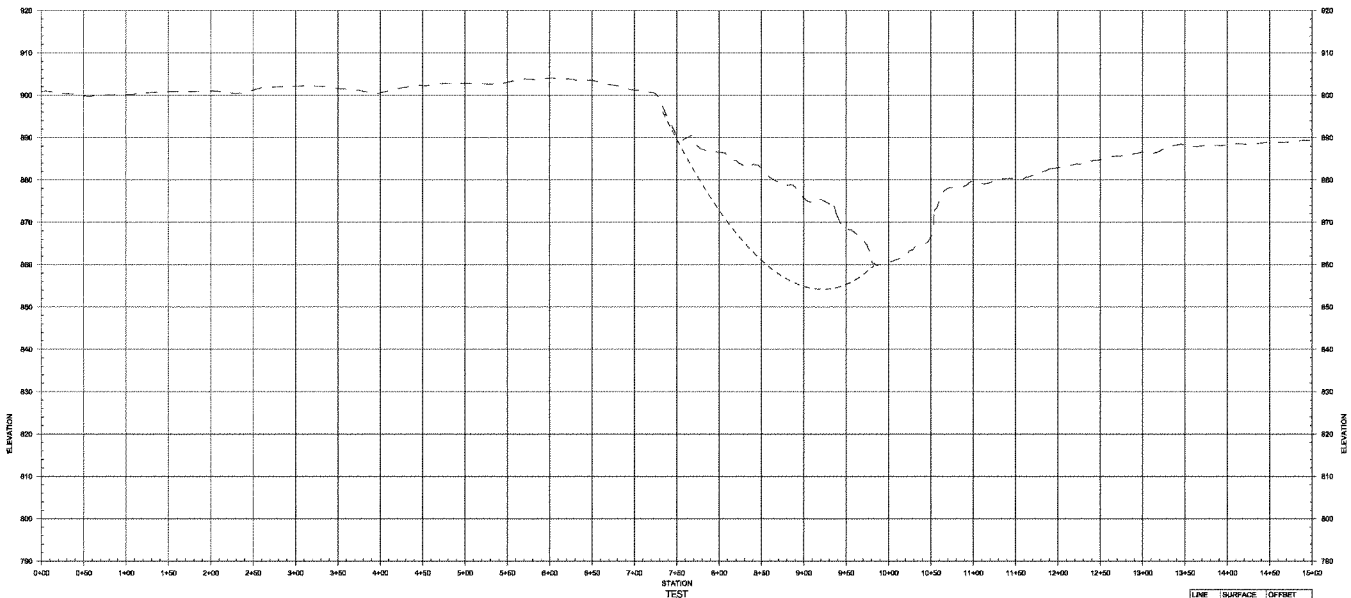
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

MOOR–04

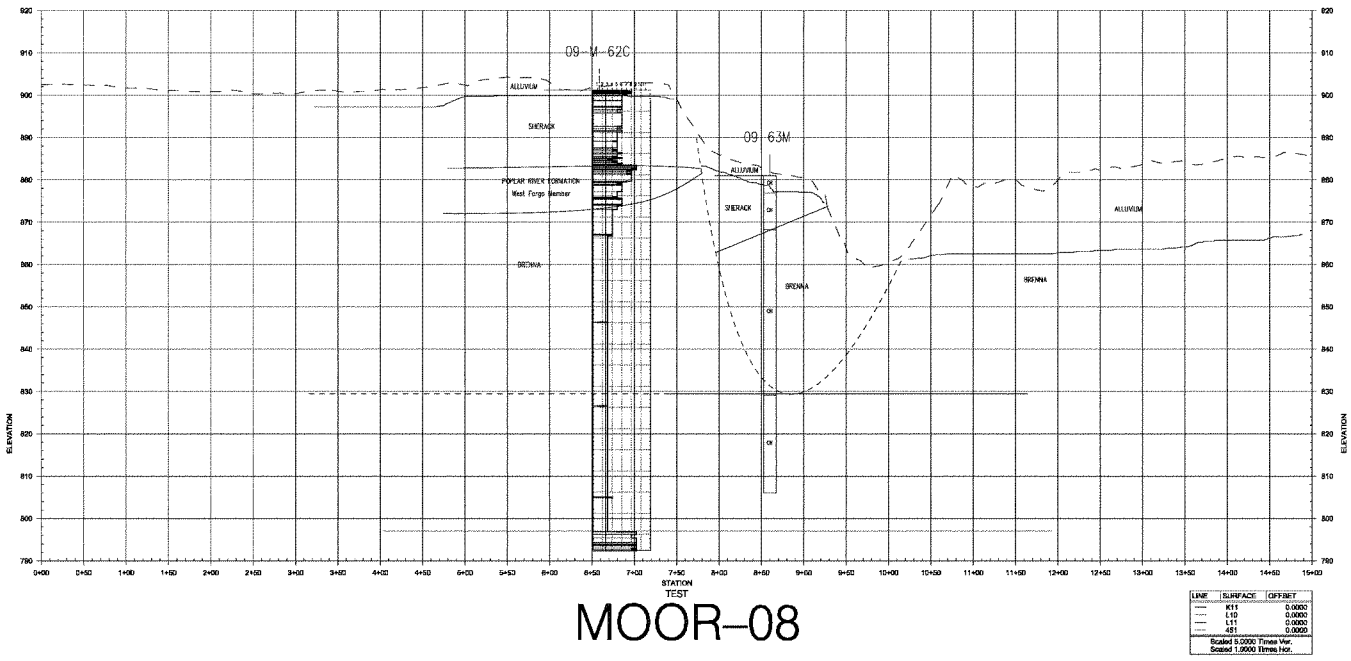

MOOR-05
TEST
STATION
ELEVATION
09-68M
09-25M
FILL/ ALLUVIUM
SHERACK
POPLAR RIVER FORMATION
West Fargo Member
Horwood Member
BRENNA
DESIGNATED BRENNA
ARGUSVILLE
LINE
SURFACE
OFFSET
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Ver.


09-M-61C
09-60M
SHERACK
West Fargo Member
Norwood Member
DISSICATED BRENNA
BRENNA
ELEVATION
STATION
TEST
LINE | SURFACE | OFFSET
K11 | 0.0000
L10 | 0.0000
L11 | 0.0000
447 | 0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

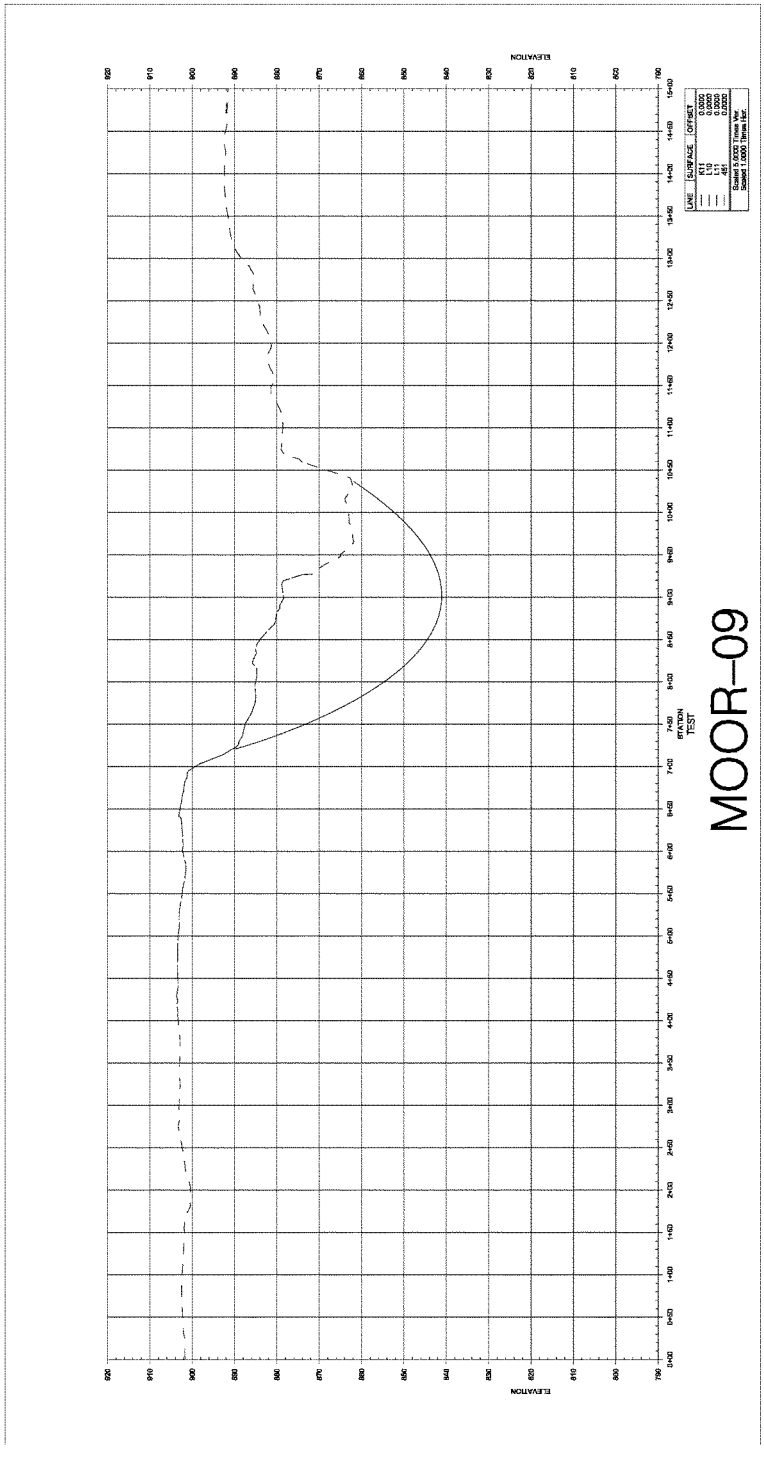
MOOR–06

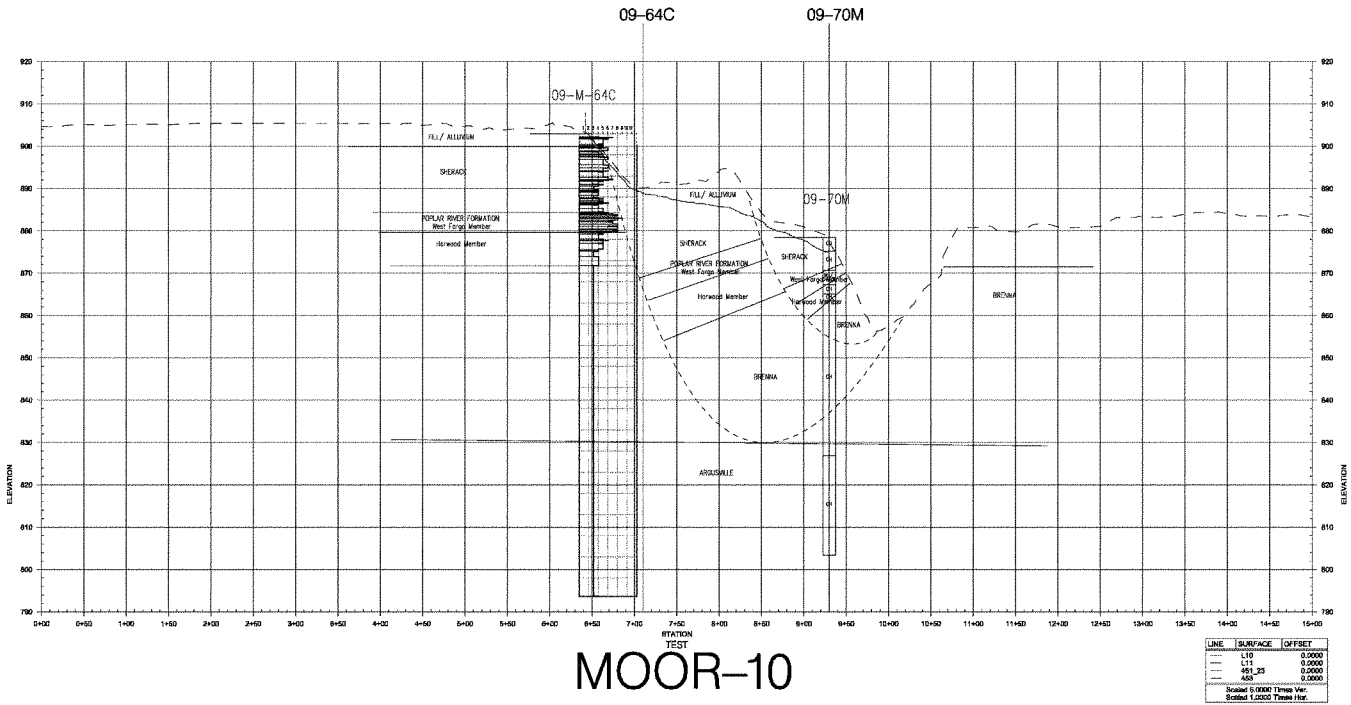

ELEVATION
STATION
TEST
LINE | SURFACE | OFFSET
K11 0.0000
L10 0.0000
L11 0.0000
447 0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

MOOR–07

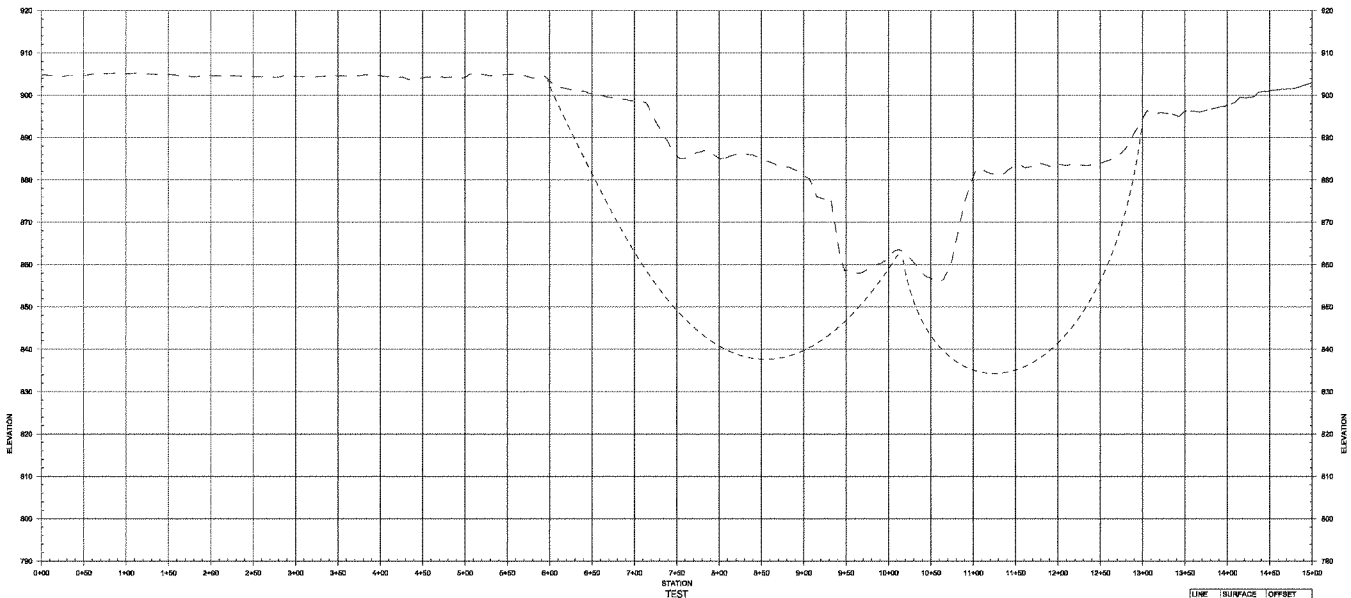

09-M-62C
09-63M
ALLUVIUM
SHERACK
POPLAR RIVER FORMATION
West Fargo Member
BRENNA
ELEVATION
STATION
TEST
LINE
SURFACE
OFFSET
K11 0.0000
L10 0.0000
L11 0.0000
481 0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

MOOR–08

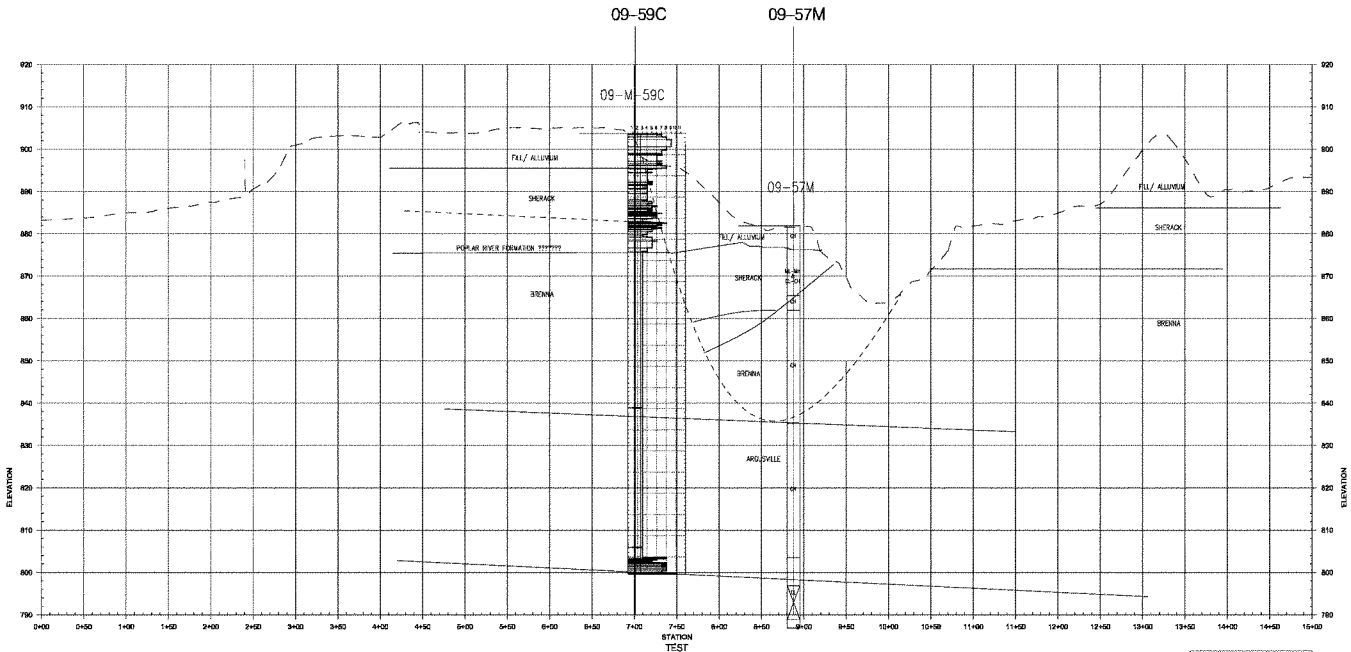

MOOR–09
ELEVATION
STATION
TEST
LINE
SURFACE
OFFSET
K11
L11
M11
Scaled 5.0000 Times Ver
Scaled 1.0000 Times Hor


09-64C
09-70M
09-M-64C
09-70M
FILL/ ALLUVIUM
SHERACK
POPLAR RIVER FORMATION
West Fargo Member
Horwood Member
BRENNA
ARGUSVILLE
ELEVATION
STATION
TEST
LINE
SURFACE
OFFSET
L10
L11
451_25
453
0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

MOOR-10


ELEVATION
STATION
TEST
LINE SURFACE OFFSET
L10 0.0000
L11 0.0000
451_75 0.0000
453 0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

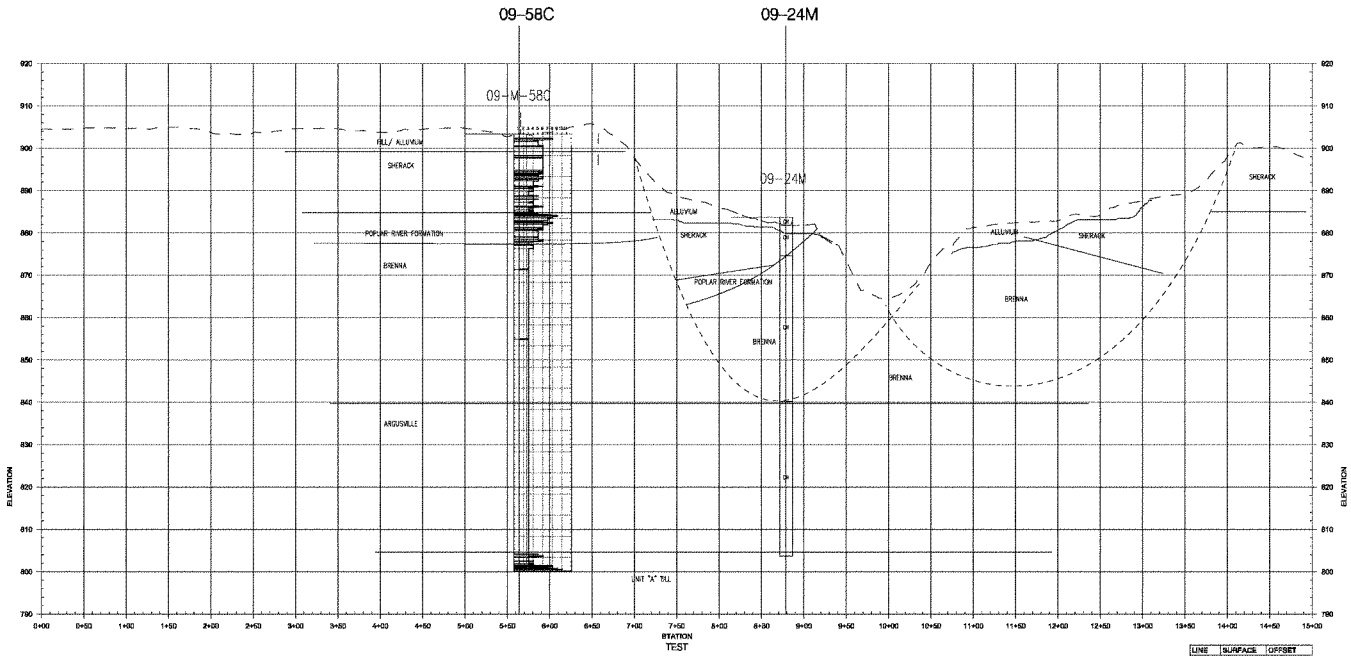
MOOR–11



MOOR-12

LINE	SURFACE	OFFSET
	L10	0.0000
	L11	0.0000
	459	0.0000

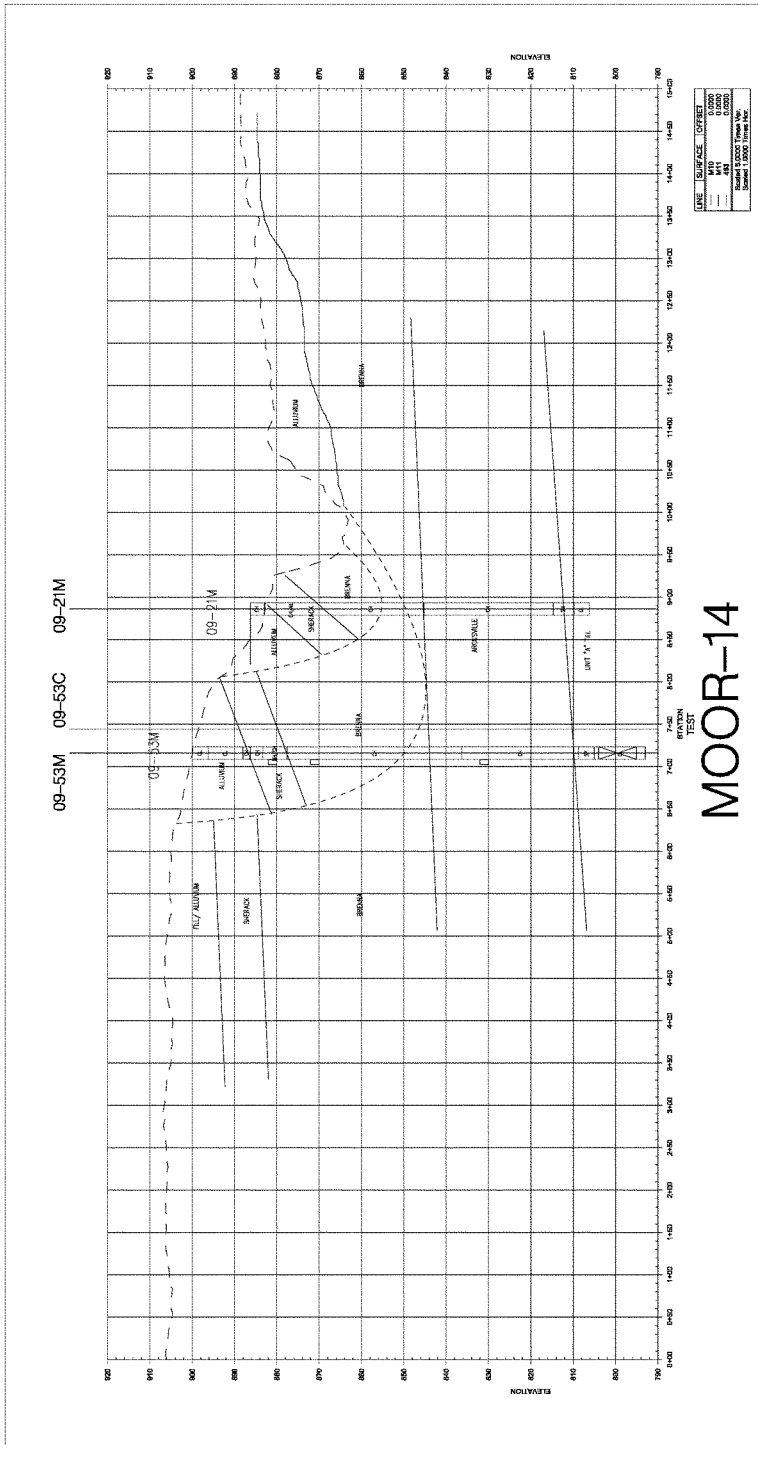
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

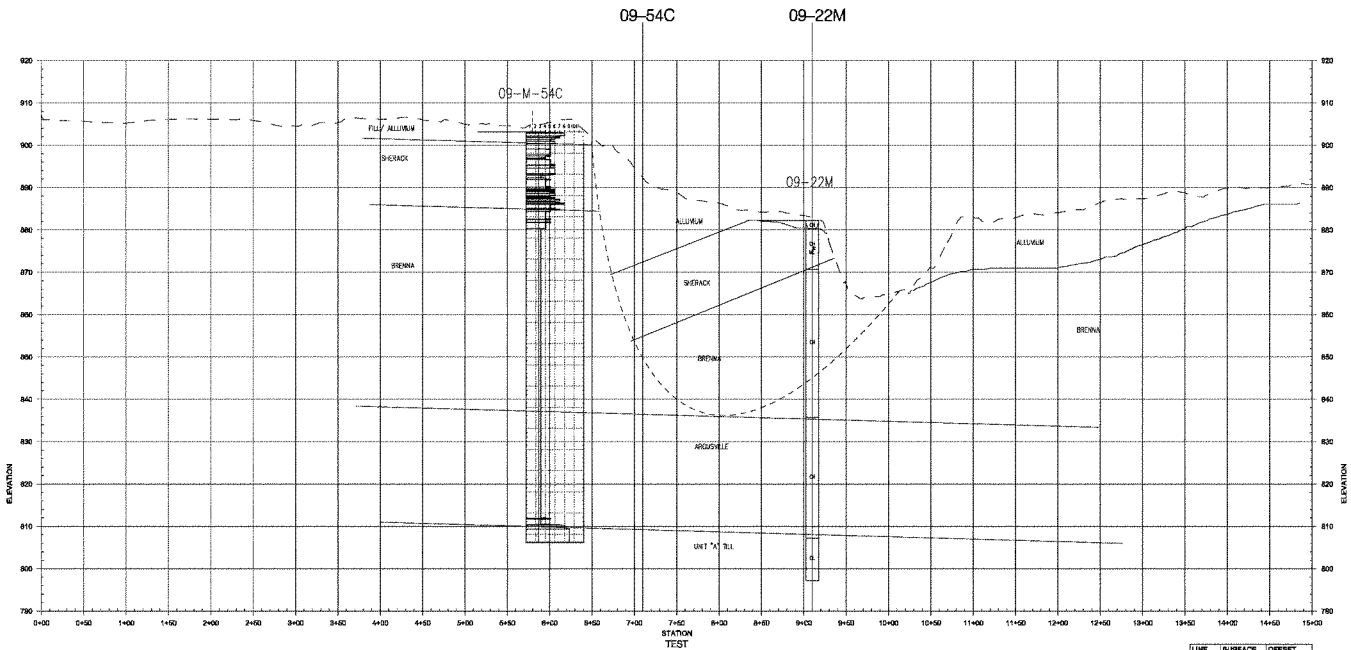


MOOR–13

LINE	SURFACE	OFFSET
	M10	0.0000
	M11	0.0000
	453	0.0000

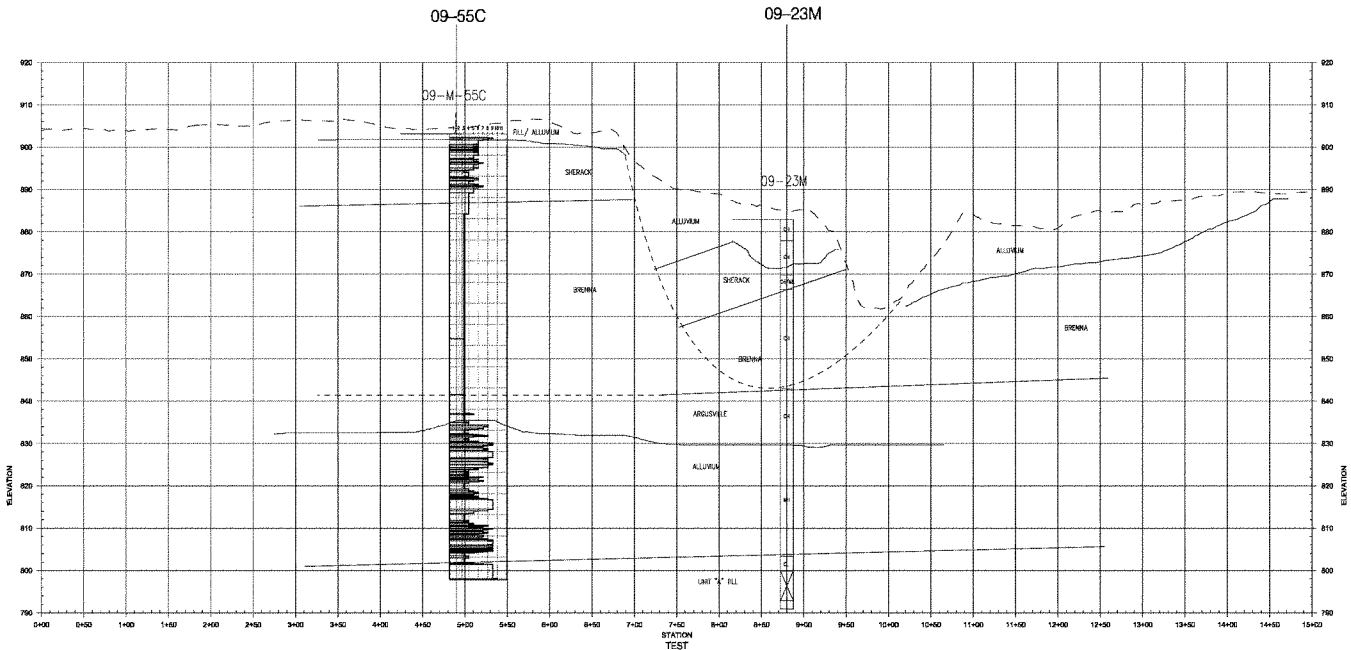
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.


09–53M
09–53C
09–21M
MOOR–14
STATION
TEST
ELEVATION
ELEVATION
09–53M
09–21M
ALLUVIUM
SHERACK
BRENNA
ARKOSEALLE
UNIT "A" TAL
LINE
SURFACE
OFFSET
M10
M11
M12
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.



MOOR–15

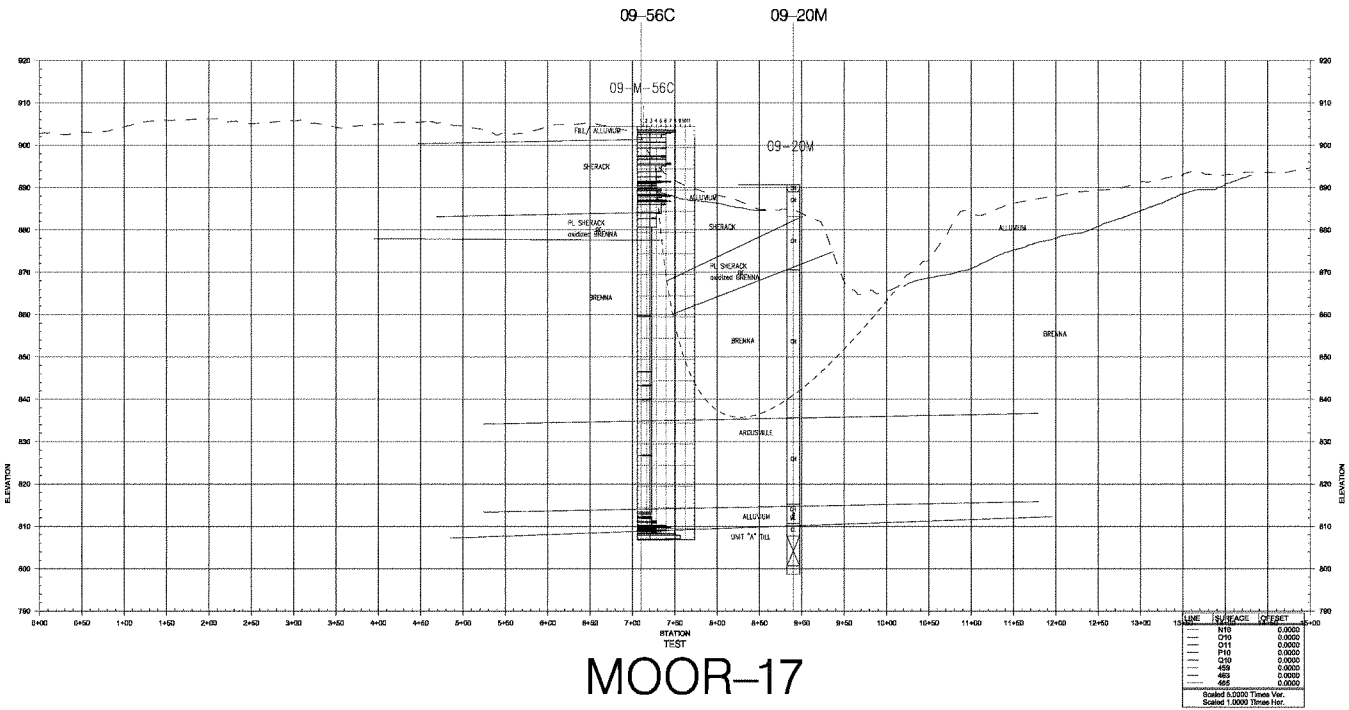
LINE	SURFACE	OFFSET
—	M11	0.0000
—	456	0.0000
Scaled 5.0000 Times Ver. Scaled 1.0000 Times Hor.		



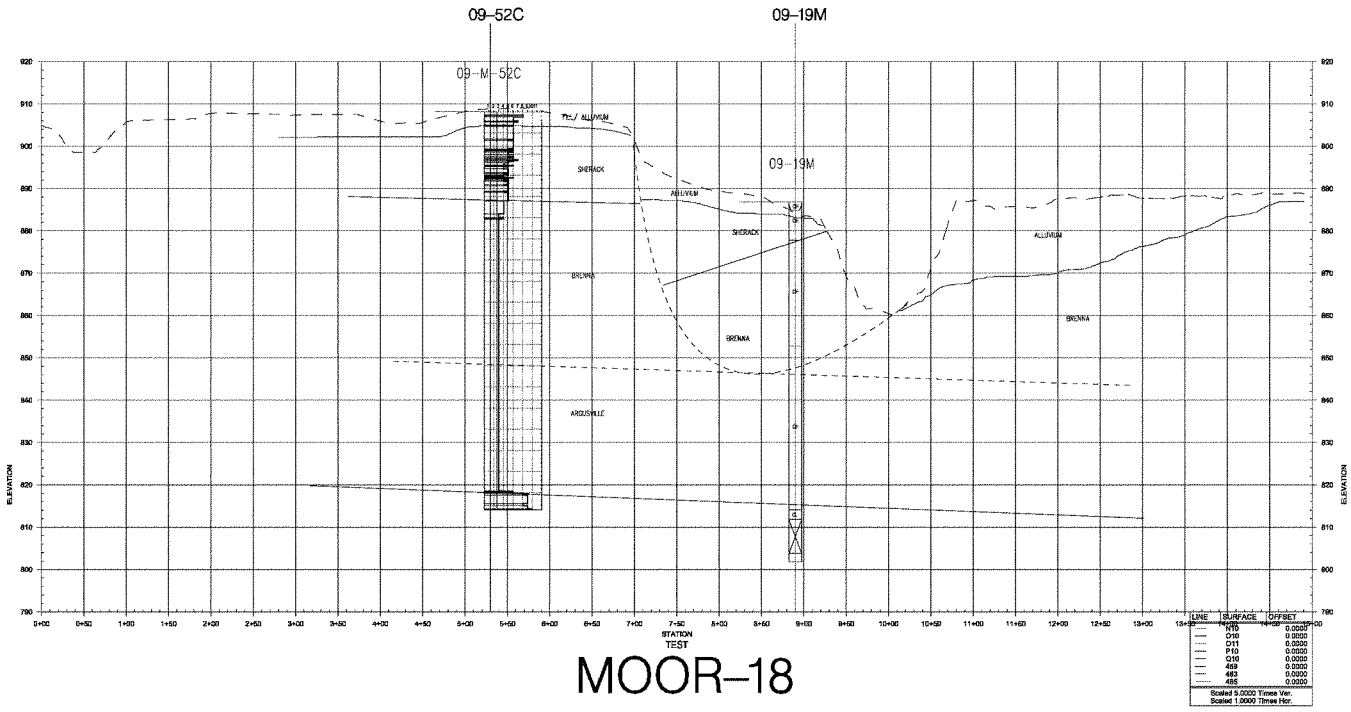
MOOR–16

LINE	SURFACE	OFFSET
----	N11	0.0000
----	459	0.0000

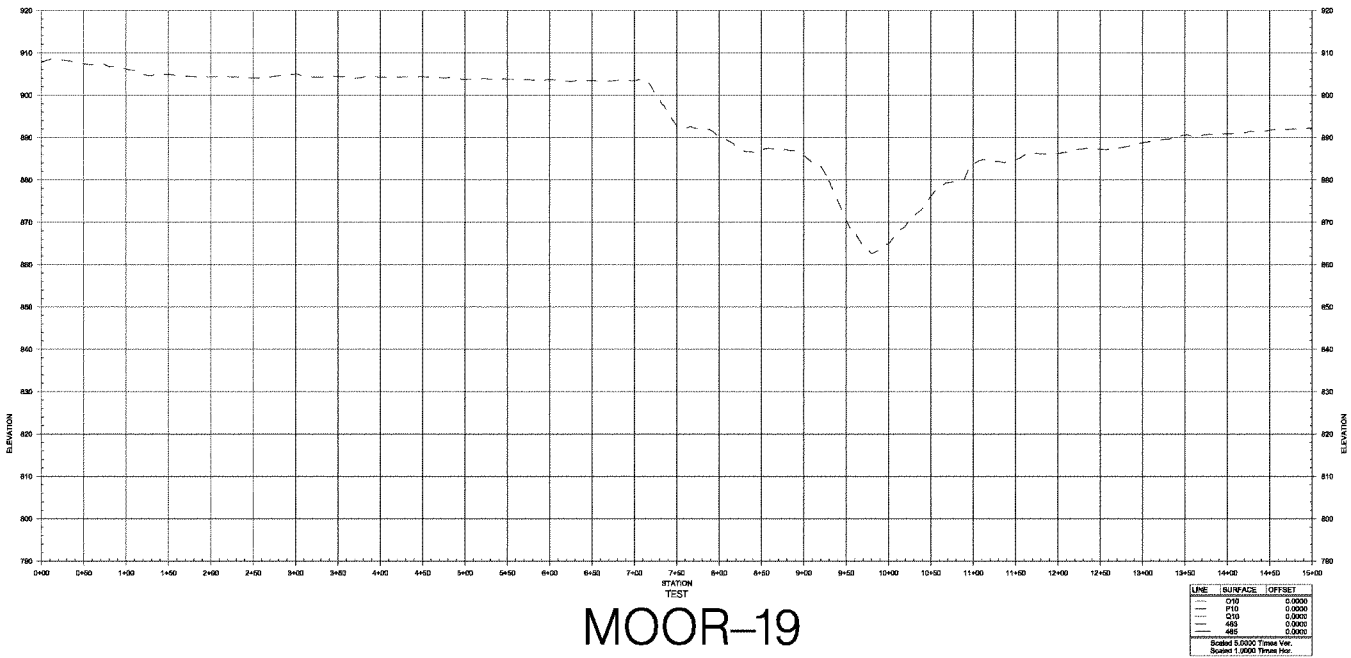
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.


09-56C
09-20M
09-M-56C
09-20M
FILL/ ALLUVIUM
SHERACK
ALLUVIUM
PL SHERACK
oxidized BRENNA
BRENNA
ARDUSVILLE
UNIT "A" TILL
ELEVATION
STATION
TEST
LINE SURFACE OFFSET
N10 0.0000
O10 0.0000
O11 0.0000
P10 0.0000
Q10 0.0000
459 0.0000
463 0.0000
465 0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

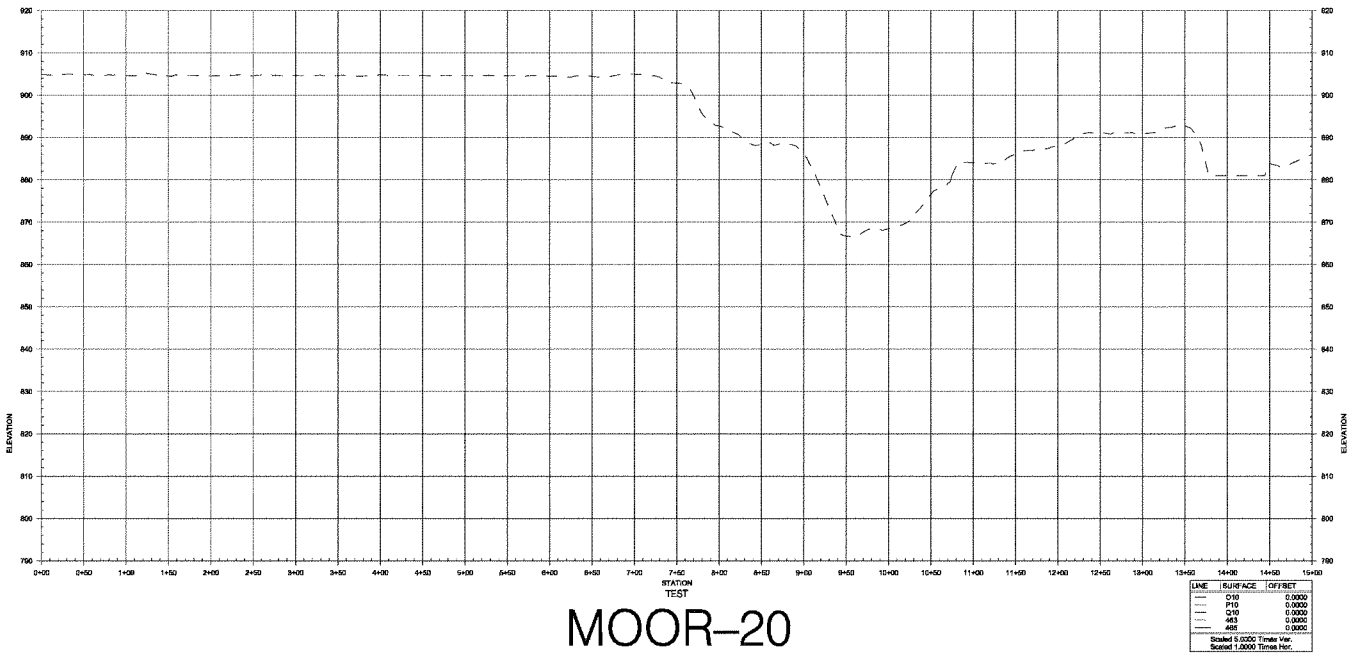
MOOR–17


09–52C
09–19M
09–M–52C
09–19M
ALLUVIUM
SHERACK
ALLUVIUM
SHERACK
ALLUVIUM
BRENNA
BRENNA
BRENNA
ARGUSVILLE
ELEVATION
STATION
TEST
LINE
SURFACE
OFFSET
N10 0.0000
O10 0.0000
O11 0.0000
P10 0.0000
Q10 0.0000
459 0.0000
463 0.0000
465 0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

MOOR–18


ELEVATION
STATION
TEST
LINE | SURFACE | OFFSET
O10 | 0.0000
P10 | 0.0000
Q10 | 0.0000
463 | 0.0000
465 | 0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

MOOR–19


ELEVATION
STATION
TEST
LINE | SURFACE | OFFSET
O10 0.0000
P10 0.0000
Q10 0.0000
463 0.0000
465 0.0000
Scaled 5.0000 Times Ver.
Scaled 1.0000 Times Hor.

MOOR–20

Attachment I-7: Preliminary In-Town Levee Analyses

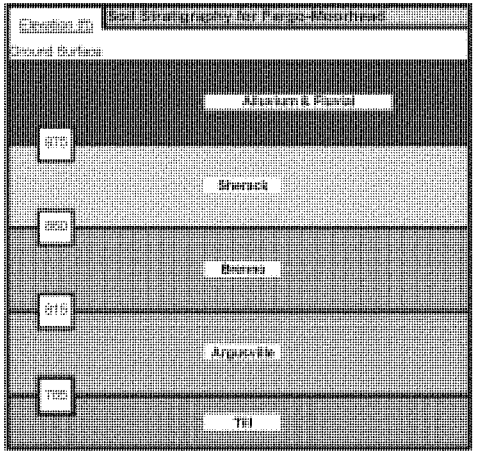
St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

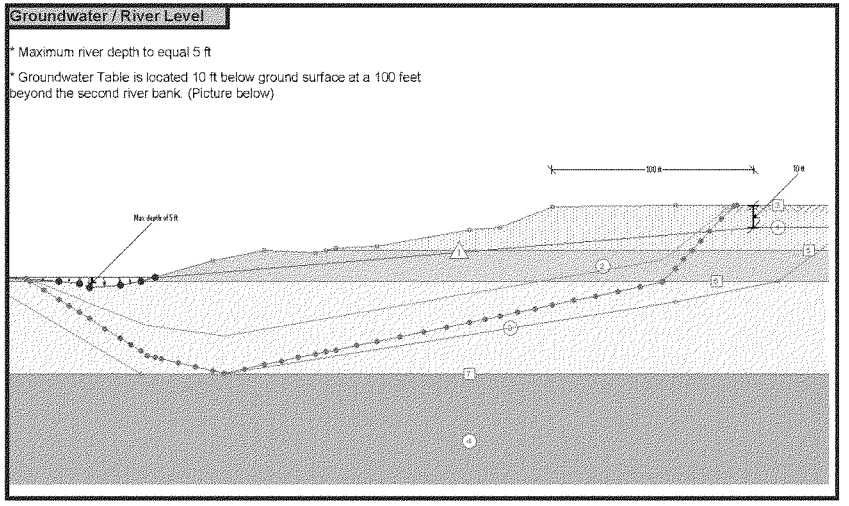
Fargo-Moorhead Metro Feasibility Study

Assumptions used in GeoStudio Cross-sections for Preliminary Analysis

Low Head Dam Crest Elevations and Location

1) North Dam	871.38 ft	12th Avenue N, Fargo OR 15th Avenue, Moorhead
2) Midtown D	876.2 ft	Dike East
3) South Dam	878.4 ft	32nd Avenue S, Fargo OR River Oaks Park, Moorhead





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St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Fargo-Moorhead Metro Feasibility Study

Assumptions used in GeoStudio Cross-sections for Preliminary Analysis

		Drained Ultimate Strengths		Undrained Total Stress	
Material	Unit Weight [pcf]	Friction Angle [Deg] ϕ'	Cohesion [psf] c'	Friction Angle [Deg] ϕ	Cohesion [Psf] c
Alluvium / Fluvial	121	26	0	0	1150
Sherack	121	26	0	0	1150
PL Sherack	113	19	0	0	1150
Poplar River	121	29	0	0	1700
Brenna	103	13	0	0	650
Argusville	105	16	0	0	850
Sand	128	30	0	30	0
Sand Delta	128	25	0	25	0
Till	122	31	0	0	1900
Levee Fill	121	26	0	0	1150
Sand Drain	128	30	0	30	0
Fill (Spoil Area)	121	26	0	0	1150
Riprap	120	32	0	32	0

St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Fargo-Moorhead Metro Feasibility Study

Assumptions used in GeoStudio Cross-sections for Preliminary Analysis

Settlement Paramenters, Taken from Fundamentals of Geotechnical Engineering (Second Edition), Braja M. Das						
	Modulus of Elasticity, E_s [MN/m^2]		Modulus of Elasticity, E_s [lb/ft^2]		Poisson's Ratio, μ_s	
Type of Soil	High	Low	High	Low	High	Low
Loose Sand	10	25	2.09E+05	5.22E+05	0.2	0.4
Medium Dense Sand	15	30	3.13E+05	6.27E+05	0.25	0.4
Dense Sand	35	55	7.31E+05	1.15E+06	0.3	0.45
Silty Sand	10	20	2.09E+05	4.18E+05	0.2	0.4
Sand and Gravel	70	170	1.46E+06	3.55E+06	0.15	0.35
Soft Clay	4	20	8.35E+04	4.18E+05		
Medium Clay	20	40	4.18E+05	8.35E+05	0.2	0.5
Stiff Clay	40	100	8.35E+05	2.09E+06		

Typical Elastic Moduli taken from EM-1110-1-1904, Appendix D

	Modulus of Elasticity, Es [tsf]		Modulus of Elasticity, Es [psf]	
Soil	Low	High	Low	High
Very Soft Clay	5	50	1.00E+04	1.00E+05
Soft Clay	50	200	1.00E+05	4.00E+05
Medium Clay	200	500	4.00E+05	1.00E+06
Stiff Clay, Silty Clay	500	1000	1.00E+06	2.00E+06
Sandy Clay	250	2000	5.00E+05	4.00E+06
Clay Shale	1000	2000	2.00E+06	4.00E+06
Loose Sand	100	250	2.00E+05	5.00E+05
Dense Sand	250	1000	5.00E+05	2.00E+06
Dense Sand and Gravel	1000	2000	2.00E+06	4.00E+06
Silty Sand	250	2000	5.00E+05	4.00E+06

Fargo-Moorhead Metro Feasibility Study

Preliminary Setback Distances for Earthen Levees: Houston's 0.1-percent annual chance event (100-year) level plus 4 feet

Computed By: Luke Schmidt Revised By:
Date: Date:

Preliminary Setback Distances for Earthen Levees: Houston's 0.1-percent annual chance event (100-year) level plus 4 feet

- Measured from center of river channel to center of the levee
- Required Factor of Safety of 1.4 (EM 1110-2-1913)

Top Elevations for Earthen Leeves

- The elevations were taken from the City of Fargo Flood Insurance Study
  (North Side Flood Control Evaluation Fargo, ND and Moorhead, MN) [Project No. 5031-2]
- Levee elevations based off the 100 yr flood plus 4 feet protection.
- Prepared by: Houston Engineering, Inc.
- Prepared on: April 30, 2008

Levee Embankment Geometry

- Earthen leeve section assumed to have a top width of 10 feet and a side slope of 1:3 (Vert:Horz).

Stratigraphy

- Stratigraphy was assumed and generalized based on the findings of the Fargo Ridgewood/VA Hospital S205 Feasibility Report

Slope Stability Analysis

- Analyzed using GeoStudio (Slope/W)
- Entry/Exit Slip Surface with Optimization
- Two slip surfaces were analyzed:
  (1) Front toe of the leeve
  (2) At or beyond the back toe of the leeve

St. Paul District GEOLOGY GEOTECHNICAL US Army Corps of Engineers

Fargo-Moorhead Metro Feasibility Study

Preliminary Setback Distances for Earthen Levees: Houston's 0.1-percent annual chance event (100-year) level plus 4 feet

Fargo, North Dakota

Cross-Section	HEC Ras	Level of Protection [ft]	Levee Height [ft]	Setback Distance [ft]	Fully-Specified FS	Front Toe FS	Back Toe FS	Notes
FAR-01	(1/3) from 316 to 315	899	3	520	1.401	1.43	1.45	-
FAR-02	(1/2) from 321 to 320	899	0	555	1.417	1.402	-	Top of secondary bank exceeds leeve height
FAR-03	326/325/324/322	900	9	480		1.403	1.575	-
FAR-04	327	900	3	495		1.393	1.455	-
FAR-05	(2/3) from 334 to 333	901	1	510	1.406	1.418	1.457	-
FAR-06	(2/3) from 339 to 338	901	11	380		1.417	1.588	-
FAR-07	339	901	11	345	1.403	1.458	1.401	Levee constructed on secondary bank side slope
FAR-08	351	903	3	410		1.405	1.458	-
FAR-09	355	904	5	435		1.395	1.521	-
FAR-10	359	904	1	460		1.391	1.437	Top of secondary bank exceeds leeve height
FAR-11	(1/3) from 361 to 360	905	11	370		1.402	1.586	-
FAR-12	391	907	3	475		1.403	1.451	-
FAR-13	(7/8) from 406 to 405	908	11	340		1.547	1.393	Levee constructed on secondary bank side slope
FAR-14	(1/2) 408 to 407	909	4	365		1.51	1.393	Levee constructed on secondary bank side slope
FAR-15	414	909	5	410		1.399	1.435	-
FAR-16	(1/3) from 415 to 414	910	5	360		1.415	1.398	-
FAR-17	(2/3) from 461.3 to 460.72	N/D	N/D	N/D	N/D	N/D	N/D	-
FAR-18	(1/3) from 462.03 to 461.3	N/D	N/D	N/D	N/D	N/D	N/D	-
FAR-19	462.7	N/D	N/D	N/D	N/D	N/D	N/D	-
FAR-20	(1/5) from 465.1 to 464.6	N/D	N/D	N/D	N/D	N/D	N/D	-

Moorhead, Minnesota

Cross-Section	HEC Ras	Level of Protection [ft]	Levee Height [ft]	Setback Distance [ft]	Fully-Specified FS	Front Toe FS	Back Toe FS	Notes
MOOR-01	(1/3) from 330 to 329	900	4	470		1.406	1.5	-
MOOR-02	332	901	11	435	1.41	1.426	1.695	No River Profile
MOOR-03	(3/5) from 337 to 336	901	3	435	1.394	1.426	1.46	No River Profile
MOOR-04	(1/4) from 340 to 339	902	6	445		1.403	1.546	-
MOOR-05	(1/2) from 343 to 342	902	4	495		1.403	1.482	-
MOOR-06	(2/5) from 345 to 344	903	1	400		1.498	1.407	Levee constructed on secondary bank side slope
MOOR-07	(1/5) from 345 to 344	903	0	480		1.399	-	Top of secondary bank exceeds leeve height
MOOR-08	(2/3) from 354 to 353	903	0	455		1.393	-	Top of secondary bank exceeds leeve height
MOOR-09	(1/6) from 354 to 353	904	3	435		1.399	1.464	-
MOOR-10	356	904	0	460		1.403	-	Top of secondary bank exceeds leeve height
MOOR-11	(1/2) from 371 to 370	905	0	470		1.4	-	Top of secondary bank equals leeve height
MOOR-12	(1/4) from 387 to 386	906	1	415		1.389	1.441	-
MOOR-13	(1/3) from 391 to 390	906	1	380		1.408	1.394	-
MOOR-14	(1/2) from 393/394 to 392	907	2	405		1.412	1.452	-
MOOR-15	395	907	8	320		1.411	1.437	Levee constructed on secondary bank side slope
MOOR-16	(1/2) from 405 to 404	908	4	385		1.393	1.416	-
MOOR-17	(1/3) from 407 to 406	908	3	430		1.408	1.422	-
MOOR-18	414	909	0	500		1.395	-	Top of secondary bank equals leeve height
MOOR-19	(1/2) from 415 to 414/413	910	6	385		1.404	1.415	-
MOOR-20	(1/2) from 460.72 to 460.28	910	6	425		1.4	1.5	-

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Fargo-Moorhead Metro Feasibility Study

Preliminary Setback Distances for Earthen Levees: MVP's 0.5-percent annual chance event (200-year) level plus superiority

Computed By: Luke Schmidt Revised By:
Date: Date:

Preliminary Setback Distances for Earthen Levees: MVP's 0.5-percent annual chance event (200-year) level plus superiority

- Measured from center of river channel to center of the levee
- Required Factor of Safety of 1.4 (EM 1110-2-1913)

*** Only the Fargo Sections were analyzed with the MVP's 0.5-percent annual chance event profile as the required levee heights were similar to the Houston 0.1-percent annual chance event plus 4 feet profile.

Top Elevations for Earthen Leeves

- The elevations were determined by USACE based on a risk and uncertainty analysis
- Level of Protection provided to be determined based on R&U analysis
- Elevations in NAVD 1988

Levee Embankment Geometry

- Earthen leeve section assumed to have a top width of 10 feet and a side slope of 1:3 (Vert:Horz).

Stratigraphy

- Stratigraphy was assumed and generalized based on the findings of the Fargo Ridgewood/VA Hospital S205 Feasibility Report

Slope Stability Analysis

- Analyzed using GeoStudio (Slope/W)
- Entry/Exit Slip Surface with Optimization
- Two slip surfaces were analyzed:
  (1) Front toe of the leeve
  (2) At or beyond the back toe of the leeve

Fargo-Moorhead Metro Feasibility Study

Preliminary Setback Distances for Earthen Levees: MVP's 0.5-percent annual chance event (200-year) level plus superiority

Fargo, North Dakota

						Drained Strength			Undrained Stregths				
Cross-Section	HEC Ras Section	HEC Ras TOL	Level of Protection [ft]	Levee Height [ft]	Setback Distance [ft]	Fully-Specified FS	Front Toe FS	Back Toe FS	Front Toe FS	Back Toe FS	Notes	Δ Levee Setback from Houston 0.1% annual chance [ft]	Δ Levee Elevation from Houston 0.1% annual chance [ft]
FAR-01	(1/3) from 316 to 315	895.5	897	1	520	1.409	1.4	1.46	N/D	N/D	-	0	1.5
FAR-02	(1/2) from 321 to 320	897.1	897	0	555	1.417	1.402	-	N/D	N/D	Top of Secondary Bank exceeds top of leeve elevation	0	-0.1
FAR-03	326/325/324/322	897.4	897	-	545	N/D	N/D	N/D	N/D	N/D	Top of Secondary Bank exceeds top of leeve elevation	65	-0.4
FAR-04	327	897.7	898	1	495	N/D	1.406	1.442	N/D	N/D	-	0	0.3
FAR-05	(2/3) from 334 to 333	899	899	-	290	N/D	N/D	N/D	N/D	N/D	Top of Secondary Bank exceeds top of leeve elevation	-220	0
FAR-06	(2/3) from 339 to 338	899.8	900	10	380	N/D	1.41	1.598	N/D	N/D	-	0	0.2
FAR-07	339	899.9	900	8	335	1.403	1.438	1.401	N/D	N/D	Levee on hill side of secondary bank	-10	0.1
FAR-08	351	901.8	902	2	405	N/D	1.403	1.444	N/D	N/D	-	-5	0.2
FAR-09	355	902.9	903	4	435	N/D	1.4	1.445	N/D	N/D	-	0	0.1
FAR-10	359	903.5	904	1	460	N/D	1.391	1.437	N/D	N/D	-	0	0.5
FAR-11	(1/3) from 361 to 360	903.6	904		370	N/D	N/D	N/D	N/D	N/D		0	0.4
FAR-12	391	906.6	907		475	N/D	N/D	N/D	N/D	N/D		0	0.4
FAR-13	(7/8) from 406 to 405	908.2	908		340	N/D	N/D	N/D	N/D	N/D		0	-0.2
FAR-14	(1/2) 408 to 407	908.6	909		365	N/D	N/D	N/D	N/D	N/D		0	0.4
FAR-15	414	909.2	909		410	N/D	N/D	N/D	N/D	N/D		0	-0.2
FAR-16	(1/3) from 415 to 414	909.5	909		360	N/D	N/D	N/D	N/D	N/D		0	-0.5
FAR-17	(2/3) from 461.3 to 460.72	910.8	911	8	365	N/D	1.407	1.427	1.398	1.289	Slide along Brenna and Argusville Contact	#VALUE!	0.2
FAR-18	(1/3) from 462.03 to 461.3	911.5	912	6	435	N/D	1.401	1.561	1.209	1.21	Slide along Brenna and Argusville Contact	#VALUE!	0.5
FAR-19	462.7	912.1	912	6	485	N/D	1.404	1.543	1.198	1.209	Slide along Brenna and Argusville Contact	#VALUE!	-0.1
FAR-20	(1/5) from 465.1 to 464.6	913.1	913	8	435	N/D	1.393	1.528	1.159	1.195	Slide along Brenna and Argusville Contact	#VALUE!	-0.1

St. Paul District GEOLOGY GEOTECHNICAL US Army Corps of Engineers

Fargo-Moorhead Metro Feasibility Study

Preliminary Setback Distances for Earthen Levees: MVP's 0.5-percent annual chance event (200-year) level plus superiority

Moorhead, Minnesota

						Drained Strength			Undrained Stregths			
Cross-Section	HEC Ras	HEC Ras TOL	Level of Protection [ft]	Levee Height [ft]	Setback Distance [ft]	Fully-Specified FS	Front Toe FS	Back Toe FS	Front Toe FS	Back Toe FS	Notes	Δ Levee Elevation from Houston 0.1% annual chance [ft]
MOOR-01	(1/3) from 330 to 329	898.4	898	N/D	N/D	N/D	N/D	N/D	N/D	N/D		-0.4
MOOR-02	332	898.8	899	N/D	N/D	N/D	N/D	N/D	N/D	N/D		0.2
MOOR-03	(3/5) from 337 to 336	899.5	899	N/D	N/D	N/D	N/D	N/D	N/D	N/D		-0.5
MOOR-04	(1/4) from 340 to 339	900.1	900	N/D	N/D	N/D	N/D	N/D	N/D	N/D		-0.1
MOOR-05	(1/2) from 343 to 342	900.9	901	N/D	N/D	N/D	N/D	N/D	N/D	N/D		0.1
MOOR-06	(2/5) from 345 to 344	901.5	902	N/D	N/D	N/D	N/D	N/D	N/D	N/D		0.5
MOOR-07	(1/5) from 345 to 344	901.6	902	N/D	N/D	N/D	N/D	N/D	N/D	N/D		0.4
MOOR-08	(2/3) from 354 to 353	902.5	903	N/D	N/D	N/D	N/D	N/D	N/D	N/D		0.5
MOOR-09	(1/6) from 354 to 353	902.7	903	N/D	N/D	N/D	N/D	N/D	N/D	N/D		0.3
MOOR-10	356	903.3	904	N/D	N/D	N/D	N/D	N/D	N/D	N/D		0.7
MOOR-11	(1/2) from 371 to 370	904.8	905	N/D	N/D	N/D	N/D	N/D	N/D	N/D		0.2
MOOR-12	(1/4) from 387 to 386	905.6	906	N/D	N/D	N/D	N/D	N/D	N/D	N/D		0.4
MOOR-13	(1/3) from 391 to 390	906.5	907	N/D	N/D	N/D	N/D	N/D	N/D	N/D		0.5
MOOR-14	(1/2) from 393/394 to 392	906.9	907	N/D	N/D	N/D	N/D	N/D	N/D	N/D		0.1
MOOR-15	395	907.3	907	N/D	N/D	N/D	N/D	N/D	N/D	N/D		-0.3
MOOR-16	(1/2) from 405 to 404	908.1	908	N/D	N/D	N/D	N/D	N/D	N/D	N/D		-0.1
MOOR-17	(1/3) from 407 to 406	908.4	908	N/D	N/D	N/D	N/D	N/D	N/D	N/D		-0.4
MOOR-18	414	909.2	909	N/D	N/D	N/D	N/D	N/D	N/D	N/D		-0.2
MOOR-19	(1/2) from 415 to 414/413	909.4	909	N/D	N/D	N/D	N/D	N/D	N/D	N/D		-0.4
MOOR-20	(1/2) from 460.72 to 460.28		910	N/D	N/D	N/D	N/D	N/D	N/D	N/D		

Fargo-Moorhead Metro Feasibility Study

Preliminary Setback Distances for Earthen Levees: MVP's 0.2-percent annual chance event (500-year) level plus superiority

Computed By: Luke Schmidt
Date:

Revised By:
Date:

Preliminary Setback Distances for Earthen Levees: MVP's 0.2-percent annual chance event (500-year) level plus superiority

- Measured from center of river channel to center of the levee
- Required Factor of Safety of 1.4 (EM 1110-2-1913)

Top Elevations for Earthen Leeves

- The elevations were determined by USACE based on a risk and uncertainty analysis
- Level of Protection proveded to be determined based on R&U analysis
- Elevations in NAVD 1988

Levee Embankment Geometry

- Earthen leeve section assumed to have a top width of 10 feet and a side slope of 1:3 (Vert:Horz).

Stratigraphy

- Stratigraphy was assumed and generalized based on the findings of the Fargo Ridgewood/VA Hospital S205 Feasibility Report

Slope Stability Analysis

- Analyzed using GeoStudio (Slope/W)
- Entry/Exit Slip Surface with Optimization
- Two slip surfaces were analyzed:
  (1) Front toe of the leeve
  (2) At or beyond the back toe of the leeve

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St. Paul District GEOLOGY GEOTECHNICAL US Army Corps of Engineers

Fargo-Moorhead Metro Feasibility Study

Preliminary Setback Distances for Earthen Levees: MVP's 0.2-percent annual chance event (500-year) level plus superiority

Fargo, North Dakota

Cross-Section	HEC Ras Section	HEC Ras TOL	Height of Leeve [ft]	Setback Distance [ft]	Setback Dist. W/ Low Flow	Drained Strengths			Undrained Strengths		Notes	Δ Levee Setbacks from 0.5% Annual Chance [ft]	Δ Levee Elevation from 0.5% Annual Chance [ft]
						Fully-Specified FS	Front Toe FS	Back Toe FS	Front Toe FS	Back Toe FS			
FAR-01	(1/3) from 316 to 315	898	2	520	N/D	1.399	1.399	1.484	1.211	1.261	Slide along Brenna and Argusville contact	0	2.6
FAR-02	(1/2) from 321 to 320	899	-	555	N/D	1.417	1.402	1.402	1.195	-	Top of secondary bank exceeds levee elevation	0	1.8
FAR-03	326/325/324/322	899	5	480	460	N/D	1.408	1.566	1.167	1.245	Levee is 45 feet from secondary bank (at elevation 912 ft)	-65	1.9
FAR-04	327	900	3	490	N/D	N/D	1.388	1.454	1.263	1.258	Slide along Brenna and Argusville contact	-5	1.9
FAR-05	(2/3) from 334 to 333	901	1	510	N/D	1.406	1.42	1.488	1.240	1.254	Levee is 1 foot high, slide along Brenna and Argusville contact	220	2
FAR-06	(2/3) from 339 to 338	902	12	385	N/D	N/D	1.413	1.410	1.464	1.443	Slide goes down to Brenna-Argusville contact	5	2.3
FAR-07	339	902	9	355	N/D	1.4	1.403	1.396	1.436	1.403	Levee built on slope of secondary bank	20	2.3
FAR-08	351	905	5	410	360	N/D	1.393	1.419	1.212	1.208	Levee built on top of secondary slope	5	3
FAR-09	355	906	7	450	N/D	N/D	1.397	1.493	1.245	1.223	Slide along Brenna and Argusville contact	15	2.9
FAR-10	359	907	4	470	N/D	N/D	1.391	1.477	1.189	1.199	Slide along Brenna and Argusville contact	10	3
FAR-11	(1/3) from 361 to 360	907	12	365	350	N/D	1.447	1.417	1.391	1.350	Slide goes thru middle of levee	-5	3.1
FAR-12	391	911	7	485	430	N/D	1.399	1.418	1.192	1.216	Slide along Brenna and Argusville contact	10	3.9
FAR-13	(7/8) from 406 to 405	912	7	380	N/D	N/D	1.437	1.394	1.322	1.322	Levee built on top of secondary bank	40	3.9
FAR-14	(1/2) 408 to 407	913	8	410	N/D	N/D	1.418	1.391	1.274	1.240	Levee built on top of secondary bank	45	3.9
FAR-15	414	913	9	425	370	N/D	1.4	1.422	1.284	1.205	Levee built on top of secondary bank	15	4
FAR-16	(1/3) from 415 to 414	913	8	400	N/D	N/D	1.41	1.414	1.240	1.262	Levee built on top of secondary bank	40	3.9
FAR-17	(2/3) from 461.3 to 460.72	915	12	385	355	N/D	1.392	1.403	1.241	1.230	Levee built on top of secondary bank	20	4.2
FAR-18	(1/3) from 462.03 to 461.3	916	10	445	N/D	N/D	1.401	1.466	1.213	1.194	Levee built on top of secondary bank	10	4.5
FAR-19	462.7	916	10	500	435	N/D	1.408	1.544	1.198	1.223	Slide along Brenna and Argusville contact	15	3.9
FAR-20	(1/5) from 465.1 to 464.6	917	11	450	N/D	N/D	1.421	1.617	1.173	1.195	Slide along Brenna and Argusville contact	15	3.9

St. Paul District GEOLOGY GEOTECHNICAL US Army Corps of Engineers

Fargo-Moorhead Metro Feasibility Study

Preliminary Setback Distances for Earthen Levees: MVP's 0.2-percent annual chance event (500-year) level plus superiority

Moorhead, Minnesota

						Drained Strengths			Undrained Strengths				
Cross-Section	HEC Ras	HEC Ras TOL	Levee Height [ft]	Setback Distance [ft]	Setback Dist. W/ Low Flow Elev. [ft]	Fully-Specified FS	Front Toe FS	Back Toe FS	Front Toe FS	Back Toe FS	Notes	Δ Levee Setbacks from 0.5% Annual Chance [ft]	Δ Levee Elevation from 0.5% Annual Chance [ft]
MOOR-01	(1/3) from 330 to 329	900	4	470	N/D	N/D	1.403	1.482	1.28	1.335	Slide along Brenna and Argusville contact	0	1.9
MOOR-02	332	901	11	435	N/D	1.41	1.381	1.437	1.158	1.214	Slide along Brenna and Argusville contact	0	2.0
MOOR-03	(3/5) from 337 to 336	902	4	435	N/D	1.383	1.42	1.448	1.364	1.315	Slide along Brenna and Argusville contact	0	2.2
MOOR-04	(1/4) from 340 to 339	903	7	445	425	N/D	1.395	1.438	1.291	1.295	Slide along Brenna and Argusville contact	0	2.4
MOOR-05	(1/2) from 343 to 342	904	6	495	N/D	N/D	1.387	1.43	1.208	1.257	Slide along Brenna and Argusville contact	0	2.9
MOOR-06	(2/5) from 345 to 344	904	2	415	N/D	N/D	1.401	1.421	1.187	1.236	Slide along Brenna and Argusville contact	15	2.8
MOOR-07	(1/5) from 345 to 344	904	1	485	N/D	N/D	1.409	1.443	1.339	1.292	Levee only 1 foot high	5	2.7
MOOR-08	(2/3) from 354 to 353	905	1	465	N/D	N/D	1.394	1.393	1.181	1.199	Levee only 1 foot high	10	2.8
MOOR-09	(1/6) from 354 to 353	906	5	435	400	N/D	1.39	1.417	1.268	1.283	Slide along Brenna and Argusville contact	0	2.8
MOOR-10	356	908	1	470	N/D	N/D	1.412	1.413	1.232	1.211	Slide along Brenna and Argusville contact	10	3.0
MOOR-11	(1/2) from 371 to 370	908	3	485	N/D	N/D	1.4	1.444	1.125	1.147	Slide along Brenna and Argusville contact	15	3.5
MOOR-12	(1/4) from 387 to 386	909	4	440	N/D	N/D	1.405	1.42	1.255	1.241	Slide along Brenna and Argusville contact	25	3.8
MOOR-13	(1/3) from 391 to 390	910	5	395	355	N/D	1.409	1.406	1.320	1.286	Slide along Brenna and Argusville contact	15	3.9
MOOR-14	(1/2) from 393/394 to 392	911	6	420	N/D	N/D	1.413	1.435	1.196	1.191	Slide along Brenna and Argusville contact	15	4.0
MOOR-15	395	911	5	370	N/D	N/D	1.410	1.392	1.355	1.304	Levee built on secondary bank	50	3.9
MOOR-16	(1/2) from 405 to 404	912	7	410	N/D	N/D	1.408	1.426	1.213	1.212	Slide along Brenna and Argusville contact	25	3.9
MOOR-17	(1/3) from 407 to 406	912	7	440	N/D	N/D	1.410	1.419	1.247	1.202	Slide along Brenna and Argusville contact	10	3.9
MOOR-18	414	913	4	515	N/D	N/D	1.394	1.423	1.130	1.129	Slide along Brenna and Argusville contact	15	4.0
MOOR-19	(1/2) from 415 to 414/413	913	9	405	360	N/D	1.420	1.398	1.202	1.239	Slide along Brenna and Argusville contact	20	4.0
MOOR-20	(1/2) from 460.72 to 460.28	915	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D			

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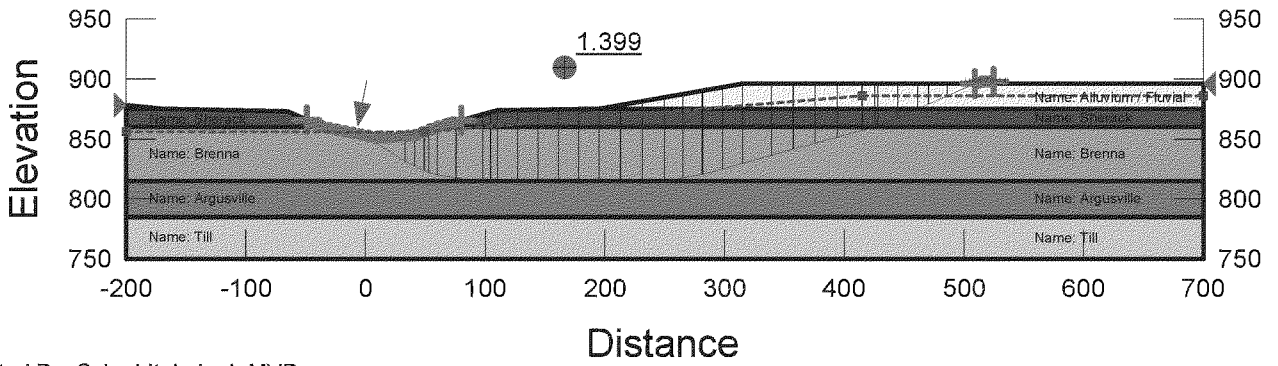
File Name: FAR_01_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 1

Level of Protection: 898 ft

Soil Properties

Name: Leave Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Date: 9/21/2009

1249

File Name: FAR_02_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 2

Level of Protection: 899 ft

Soil Properties

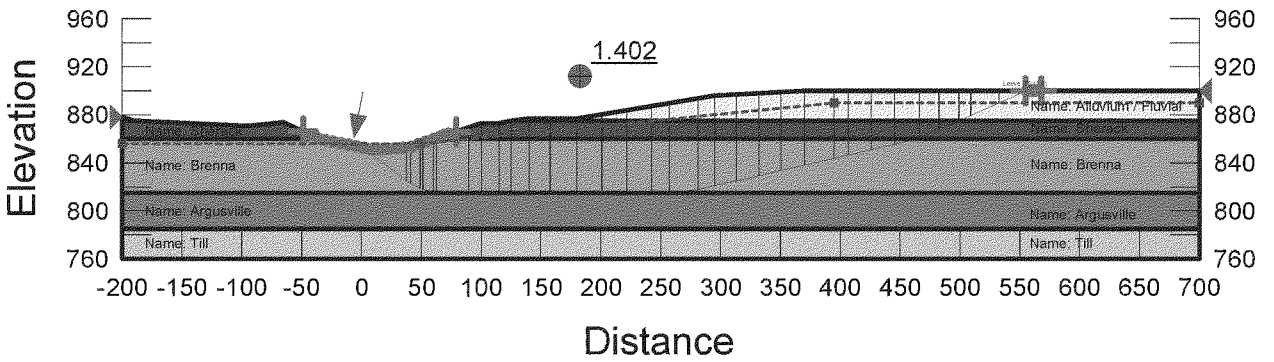
Name: Alluvium / Fluvial
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Brenna
Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 13 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 31 °

Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Argusville
Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 16 °



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1250

File Name: FAR_03_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 3

Level of Protection: 899 ft

Soil Properties

Name: Leeve Fill
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

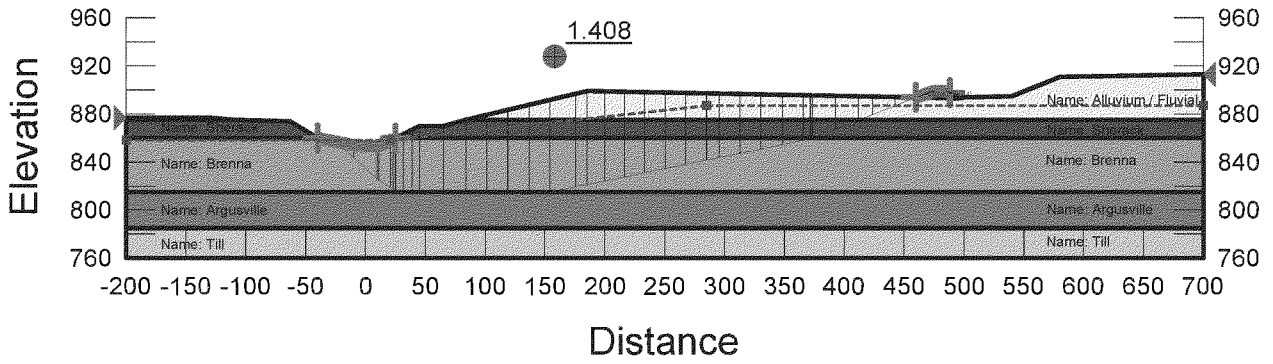
Name: Alluvium / Fluvial
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Brenna
Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 13 °

Name: Argusville
Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 16 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 31 °



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1251

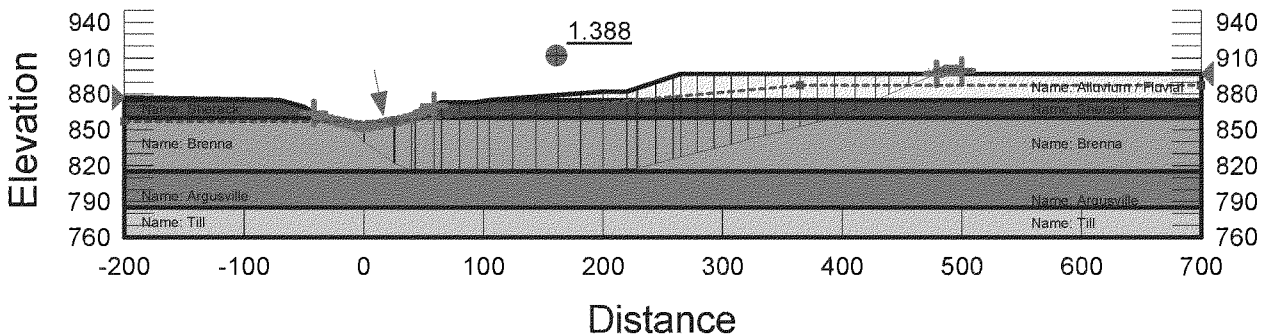
File Name: FAR_04_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 4

Level of Protection: 900 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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1252

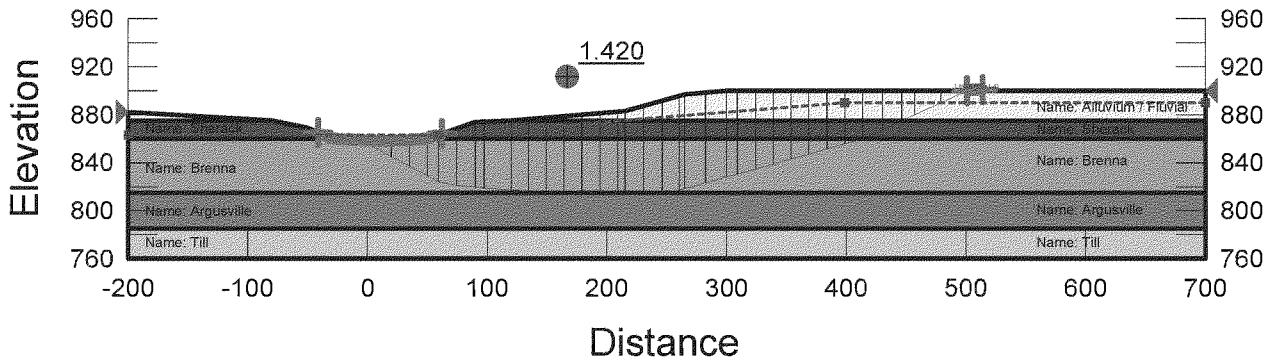
File Name: FAR_05_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 5

Level of Protection: 901 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Date: 9/22/2009

1253

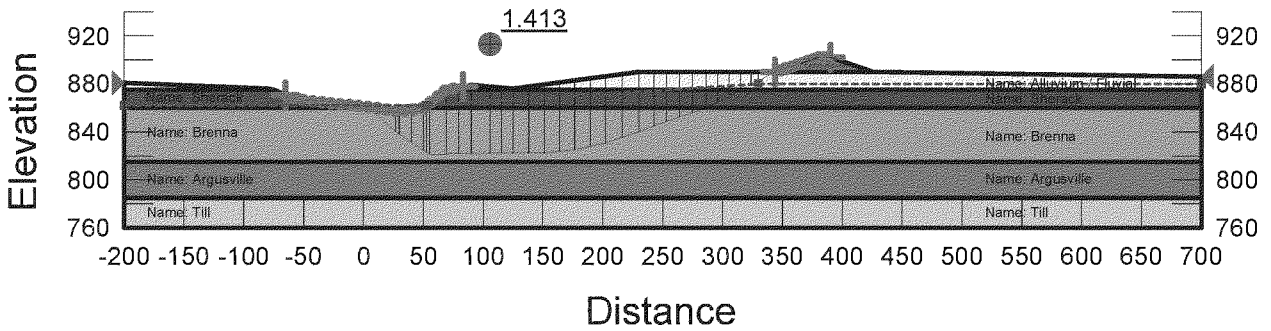
File Name: FAR_06_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 6

Level of Protection: 902 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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File Name: FAR_07_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 7

Level of Protection: 902 ft

Soil Properties

Name: Leeve Fill
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

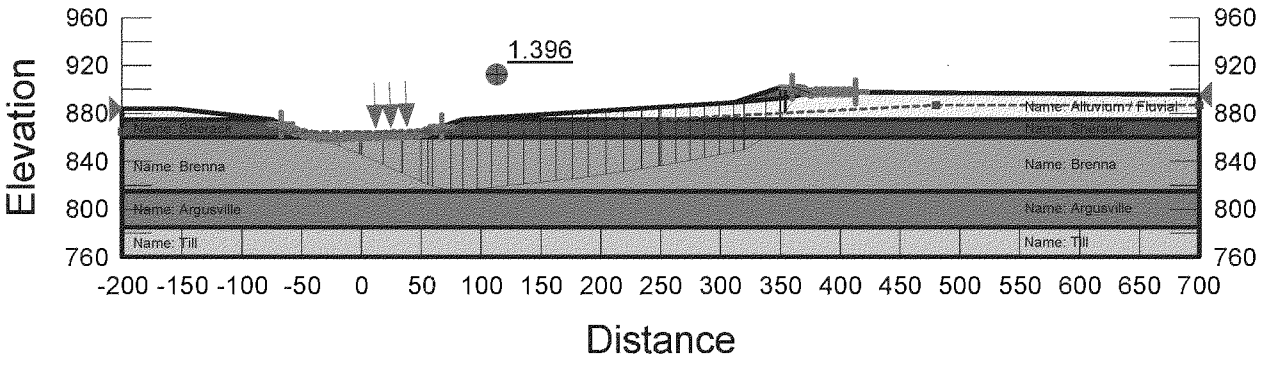
Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Argusville
Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 16 °

Name: Alluvium / Fluvial
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Brenna
Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 13 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 31 °



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Date: 9/22/2009

1255

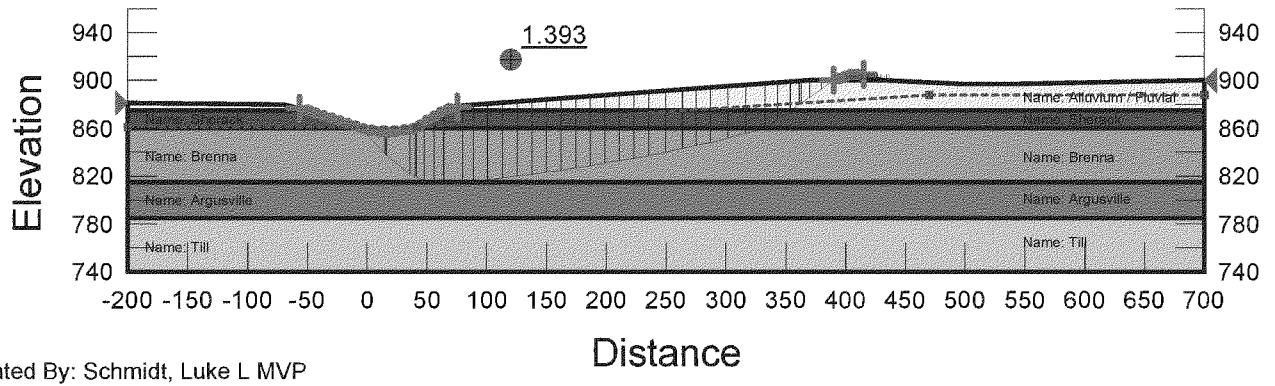
File Name: FAR_08_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 8

Level of Protection: 905 ft

Soil Properties

Name: Leave Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 18 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Date: 9/22/2009

1256

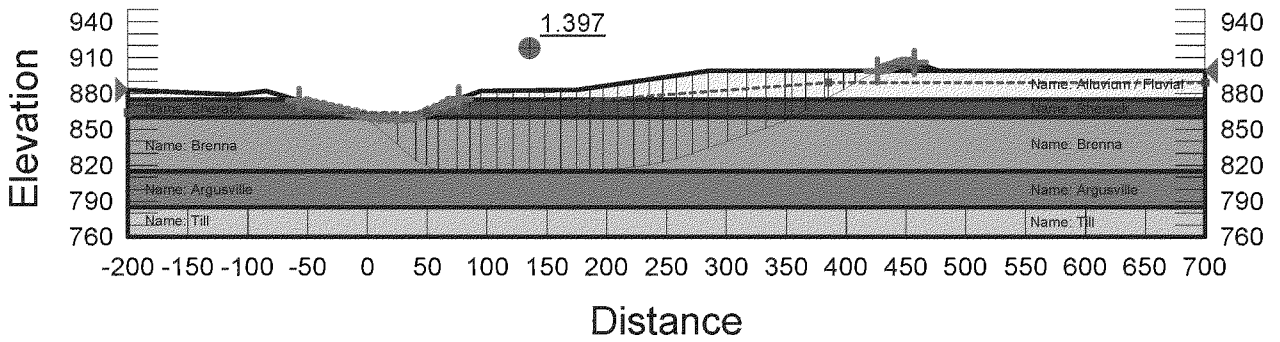
File Name: FAR_09_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 9

Level of Protection: 906 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Date: 9/22/2009

1257

File Name: FAR_10_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 10

Level of Protection: 907 ft

Soil Properties

Name: Leeve Fill
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

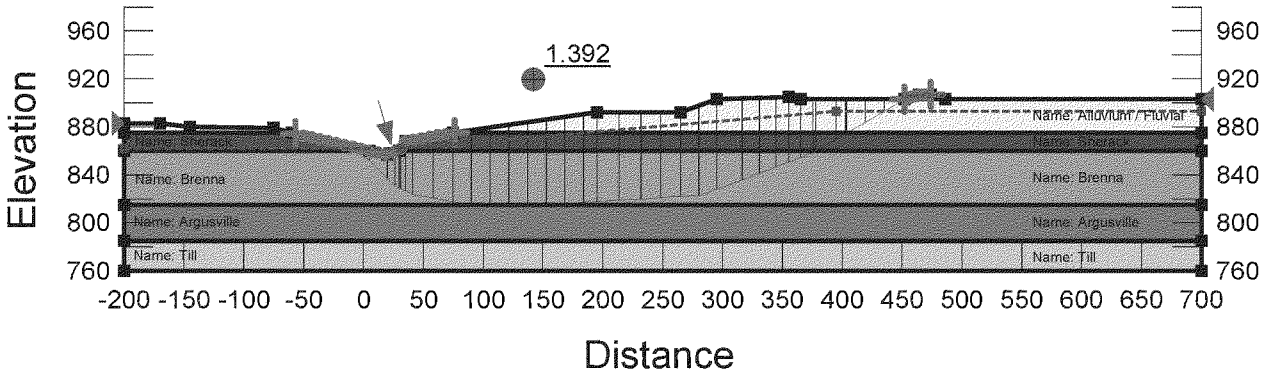
Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Argusville
Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 16 °

Name: Alluvium / Fluvial
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Brenna
Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 13 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf



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Date: 9/28/2009

1258

File Name: FAR_11_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 11

Level of Protection: 907 ft

Soil Properties

Name: Till
Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 31 °

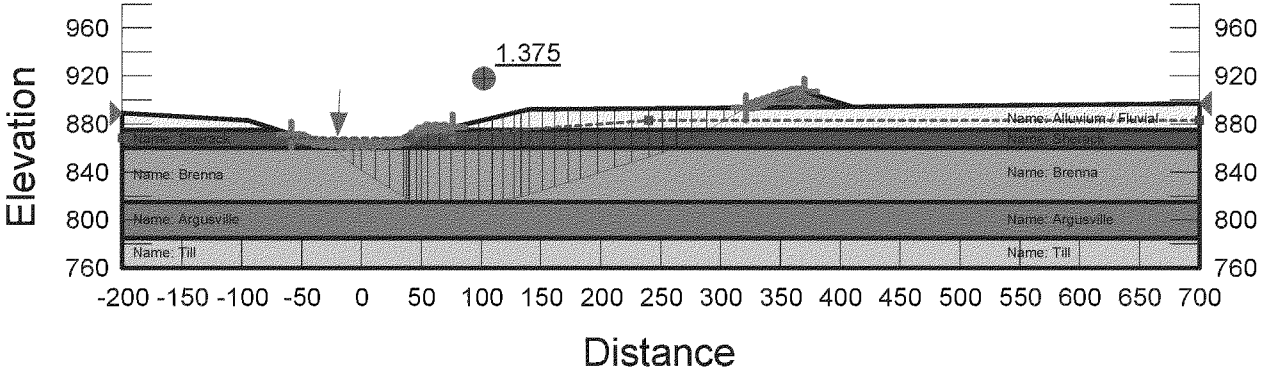
Name: Alluvium / Fluvial
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Brenna
Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 13 °

Name: Argusville
Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 16 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf



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Last Edited By: Schmidt, Luke L MVP
Date: 9/28/2009

File Name: FAR_12_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 12

Level of Protection: 911 ft

Soil Properties

Name: Leeve Fill
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

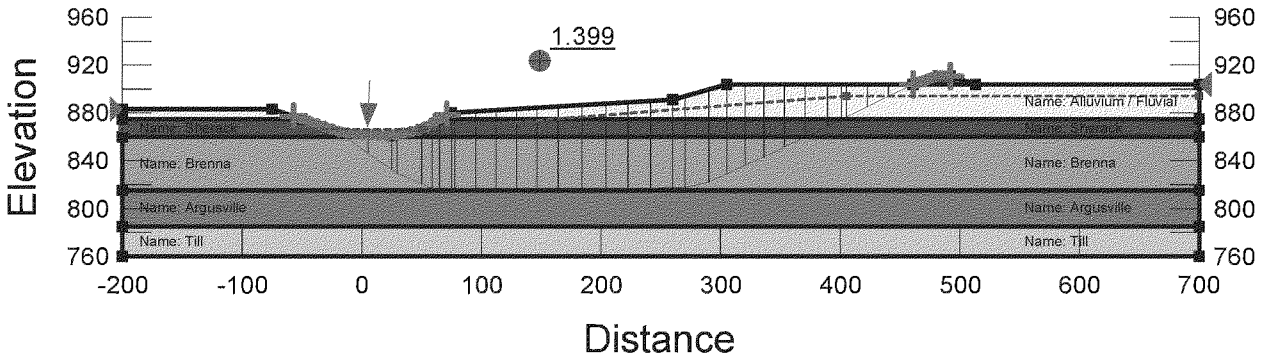
Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Argusville
Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 16 °

Name: Alluvium / Fluvial
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Brenna
Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 13 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 31 °



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Date: 9/22/2009

1260

File Name: FAR_13_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 13

Level of Protection: 912 ft

Soil Properties

Name: Leeve Fill
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

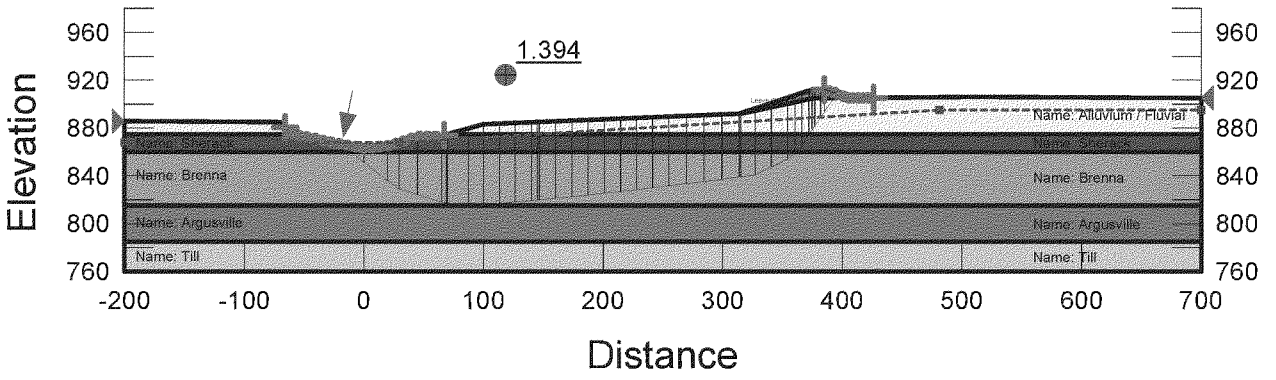
Name: Alluvium / Fluvial
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Argusville
Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 16 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 31 °



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Date: 9/22/2009

1261

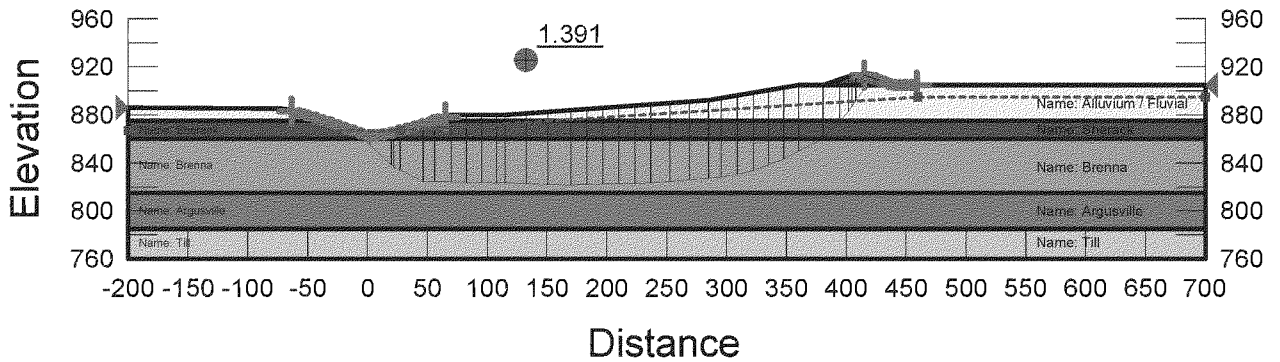
File Name: FAR_14_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 14

Level of Protection: 913 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Last Edited By: Schmidt, Luke L MVP
Date: 9/22/2009

1262

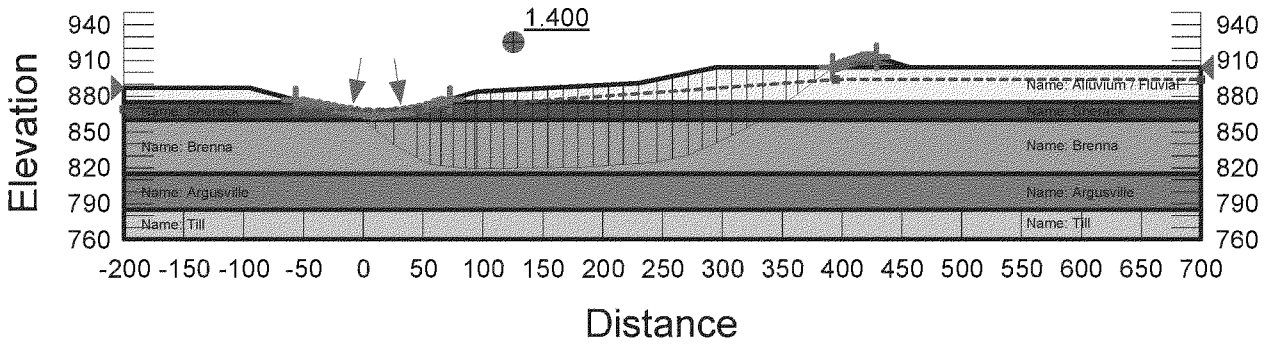
File Name: FAR_15_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 15

Level of Protection: 913 ft

Soil Properties

Name: Leave Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Date: 9/22/2009

1263

File Name: FAR_16_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 16

Level of Protection: 913 ft

Soil Properties

Name: Leeve Fill
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

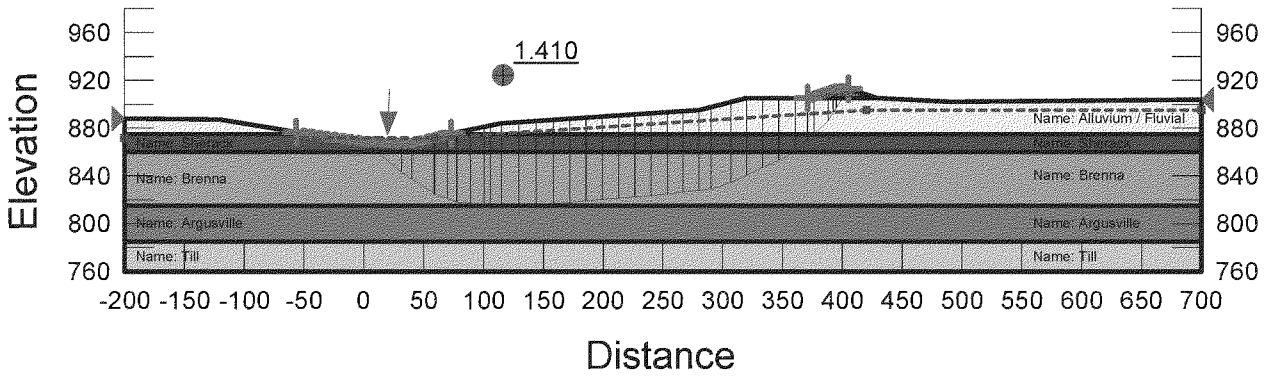
Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Argusville
Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 16 °

Name: Alluvium / Fluvial
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Brenna
Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 13 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 31 °



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Date: 9/22/2009

1264

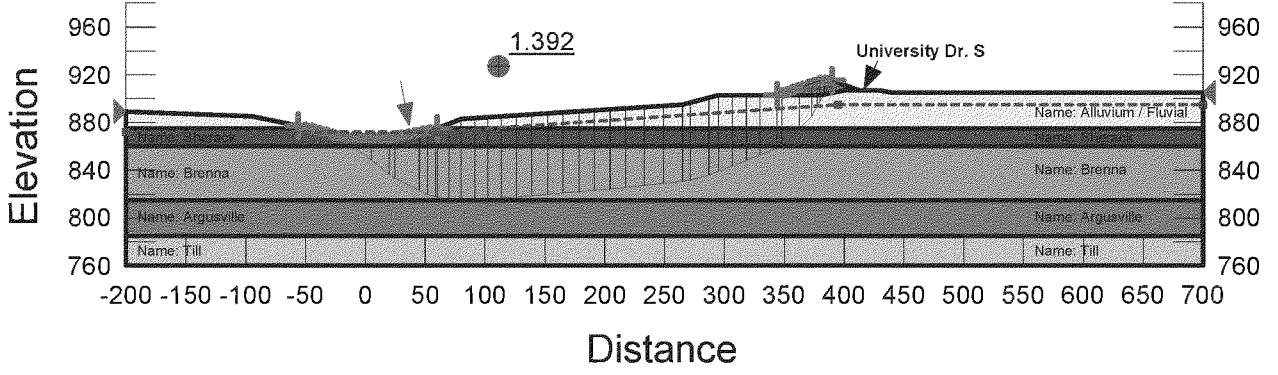
File Name: FAR_17_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 17

Level of Protection: 915 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Last Edited By: Schmidt, Luke L MVP
Date: 9/24/2009

1265

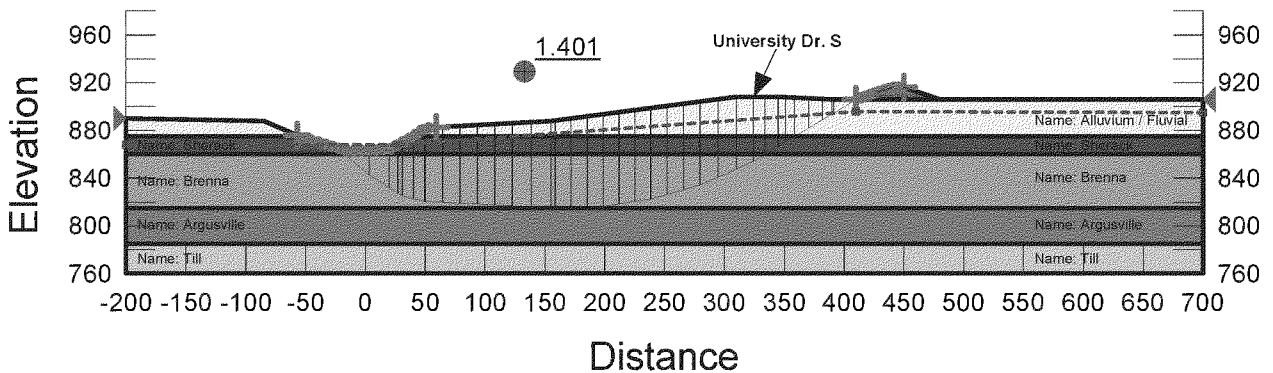
File Name: FAR_18_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 18

Level of Protection: 916 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 28 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 28 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



Created By: Schmidt, Luke L MVP
Last Edited By: Schmidt, Luke L MVP
Date: 9/24/2009

1266

File Name: FAR_19_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 19

Level of Protection: 916 ft

Soil Properties

Name: Leeve Fill
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

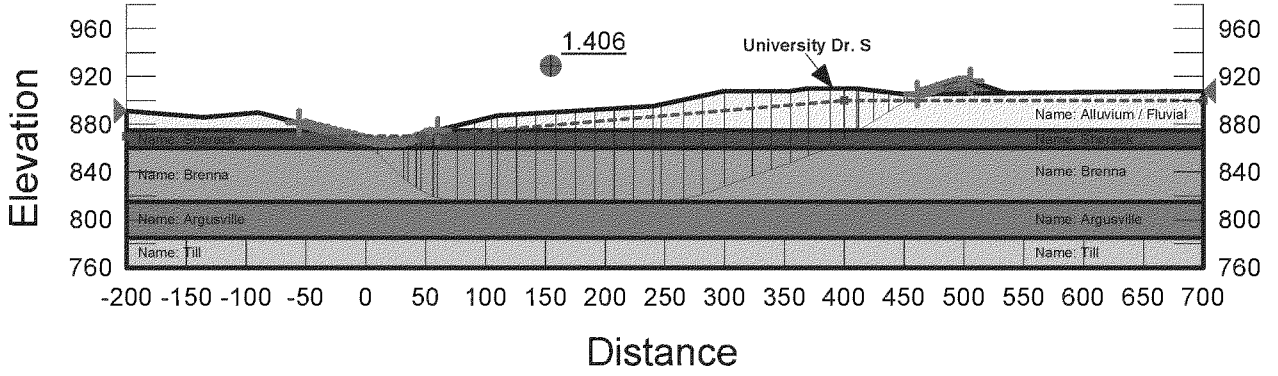
Name: Alluvium / Fluvial
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Brenna
Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 13 °

Name: Argusville
Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 16 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 31 °



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Date: 9/24/2009

1267

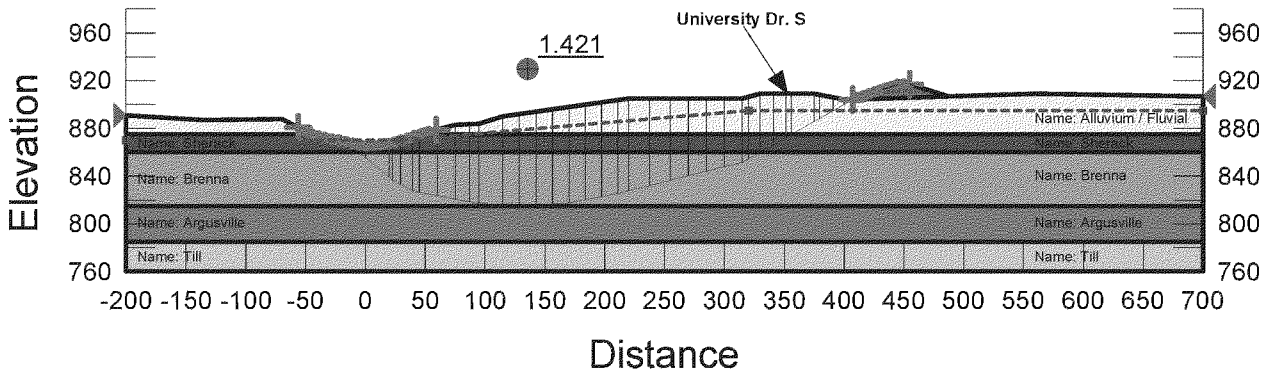
File Name: FAR_20_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 20

Level of Protection: 917 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Date: 9/24/2009

1268

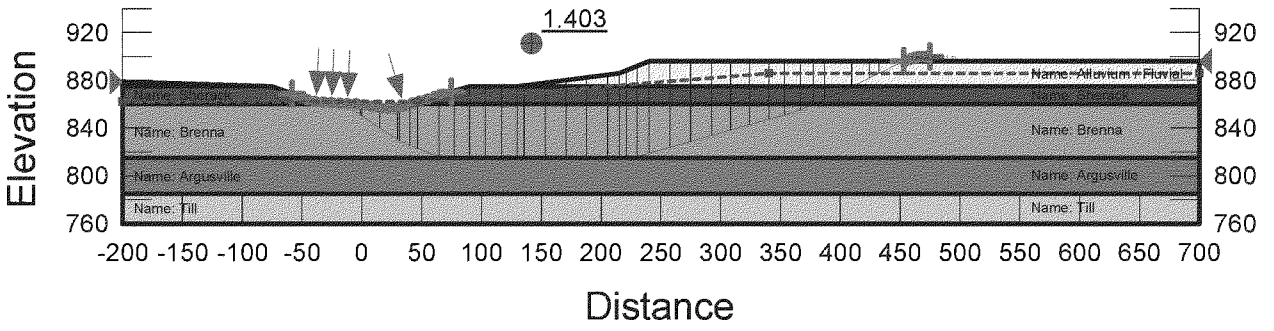
File Name: MOOR_01_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 1

Level of Protection: 900 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Date: 9/23/2009

1269

File Name: MOOR_02_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 2

Level of Protection: 901 ft

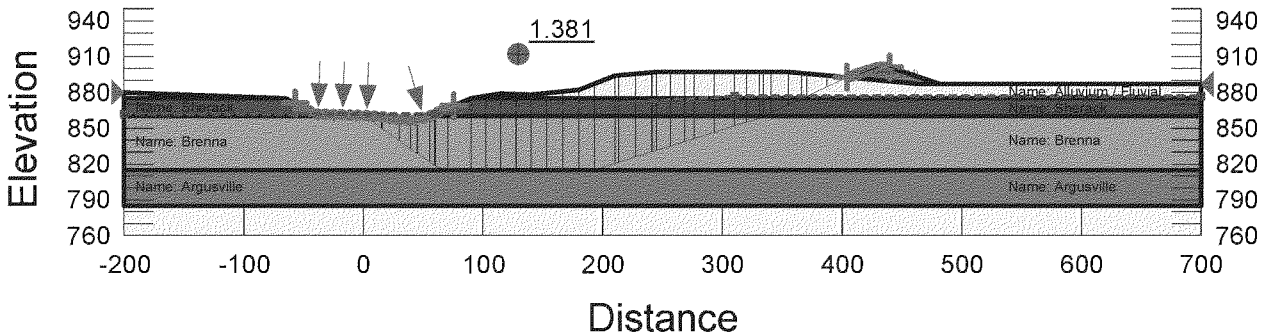
Soil Properties

Name: Leeve Fill
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Alluvium / Fluvial
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Brenna
Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 13 °



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Date: 9/23/2009

1270

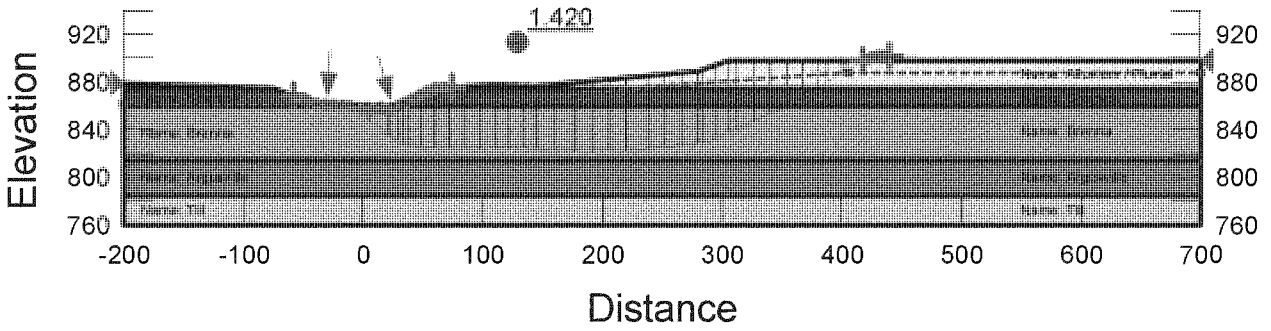
File Name: MOOR_03_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 3

Level of Protection: 902 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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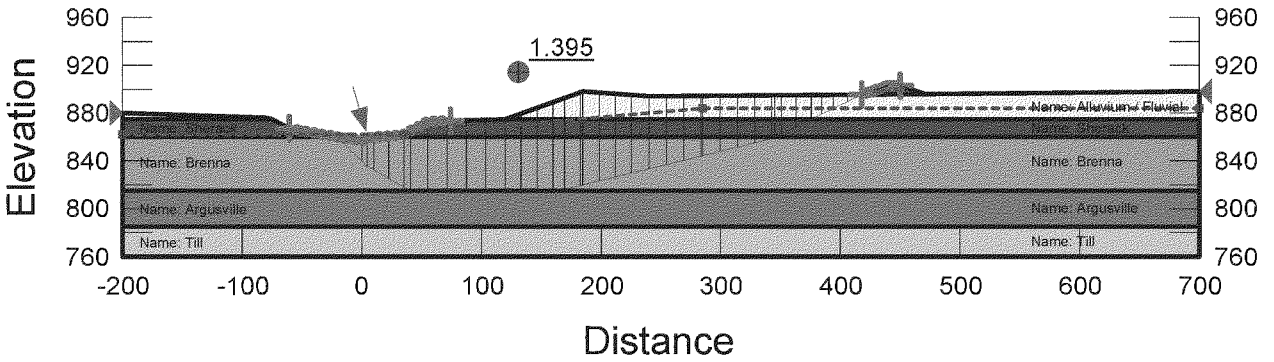
File Name: MOOR_04_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 4

Level of Protection: 903 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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1272

File Name: MOOR_05_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 5

Level of Protection: 904 ft

Soil Properties

Name: Leeve Fill
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

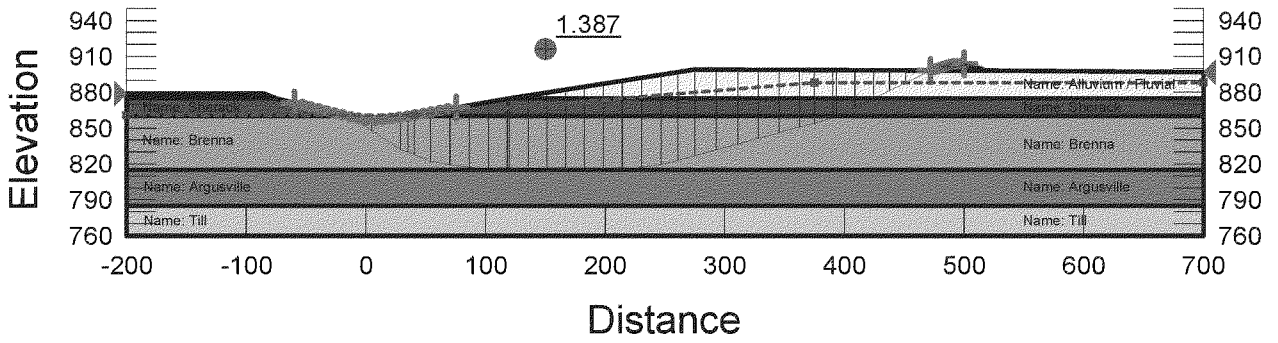
Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Argusville
Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 16 °

Name: Alluvium / Fluvial
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Brenna
Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 13 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 31 °



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Last Edited By: Schmidt, Luke L MVP
Date: 9/23/2009

1273

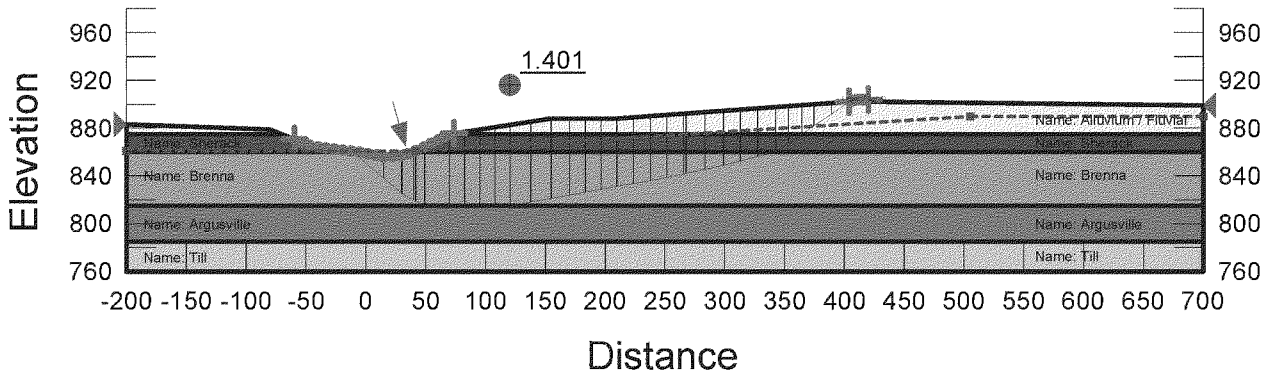
File Name: MOOR_06_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 6

Level of Protection: 904 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Last Edited By: Schmidt, Luke L MVP
Date: 9/23/2009

1274

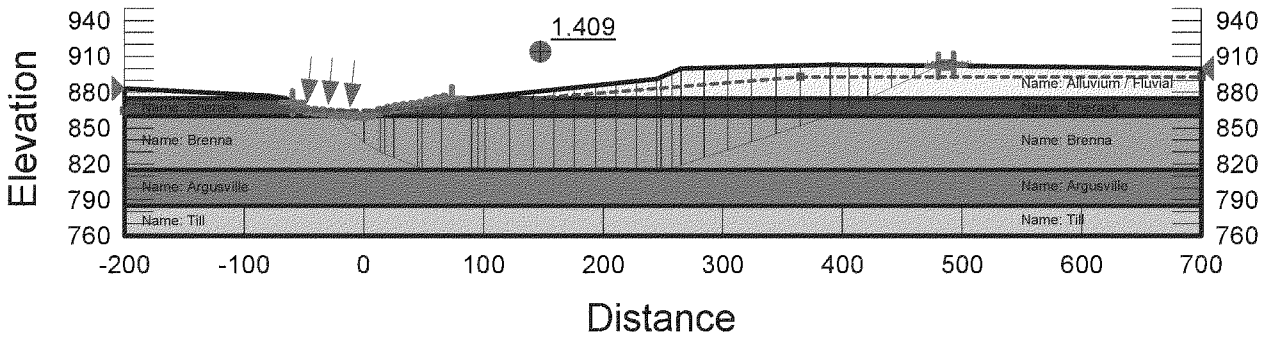
File Name: MOOR_07_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 7

Level of Protection: 904 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Last Edited By: Schmidt, Luke L MVP
Date: 9/23/2009

1275

File Name: MOOR_08_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 8

Level of Protection: 905 ft

Soil Properties

Name: Leeve Fill
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

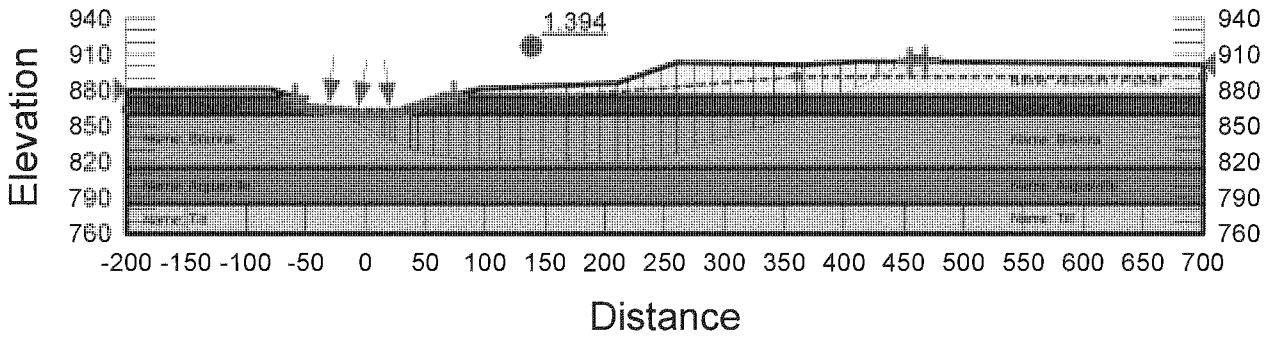
Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Argusville
Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 16 °

Name: Alluvium / Fluvial
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Brenna
Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 13 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 31 °



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Date: 9/23/2009

1276

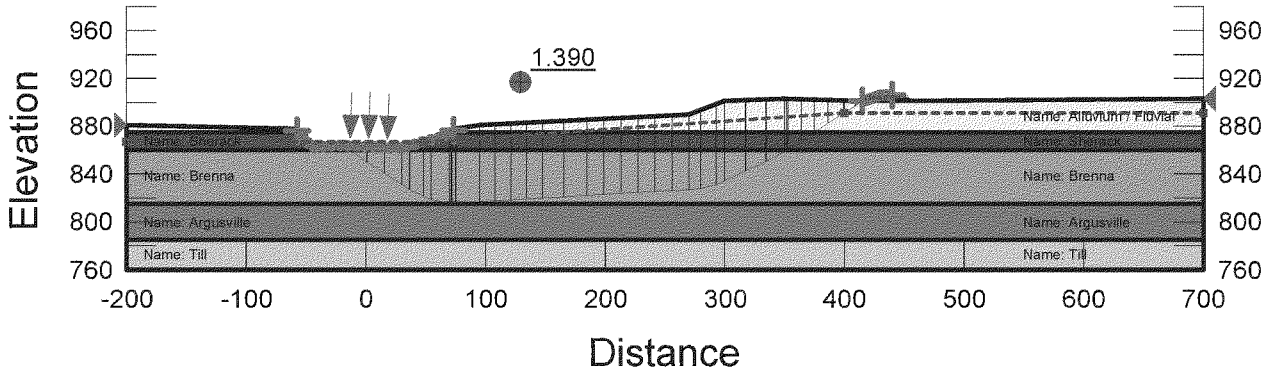
File Name: MOOR_09_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 9

Level of Protection: 906 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Date: 9/23/2009

1277

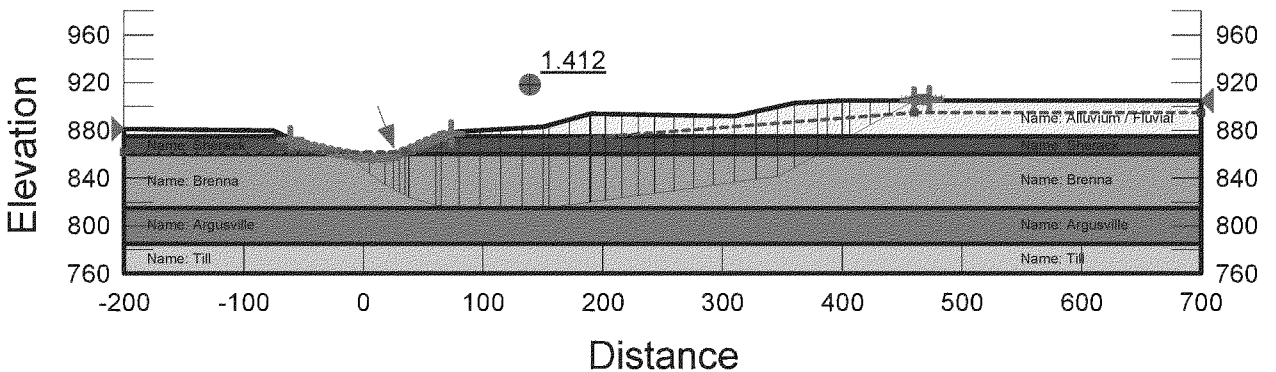
File Name: MOOR_10_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 10

Level of Protection: 906 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Date: 9/23/2009

1278

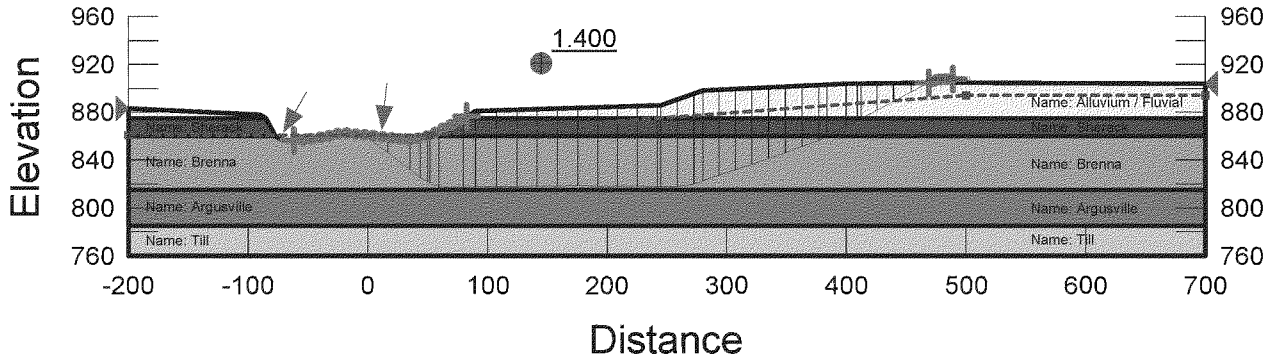
File Name: MOOR_11_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 11

Level of Protection: 908 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Last Edited By: Schmidt, Luke L MVP
Date: 9/23/2009

1279

File Name: MOOR_12_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 12

Level of Protection: 909 ft

Soil Properties

Name: Leeve Fill
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

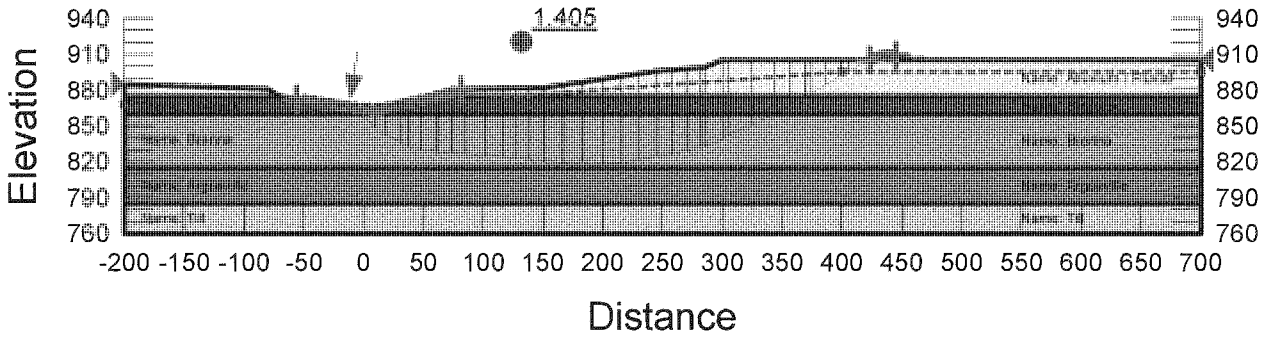
Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Argusville
Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 16 °

Name: Alluvium / Fluvial
Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion: 0 psf
Phi: 26 °

Name: Brenna
Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 13 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 31 °



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Date: 9/23/2009

1280

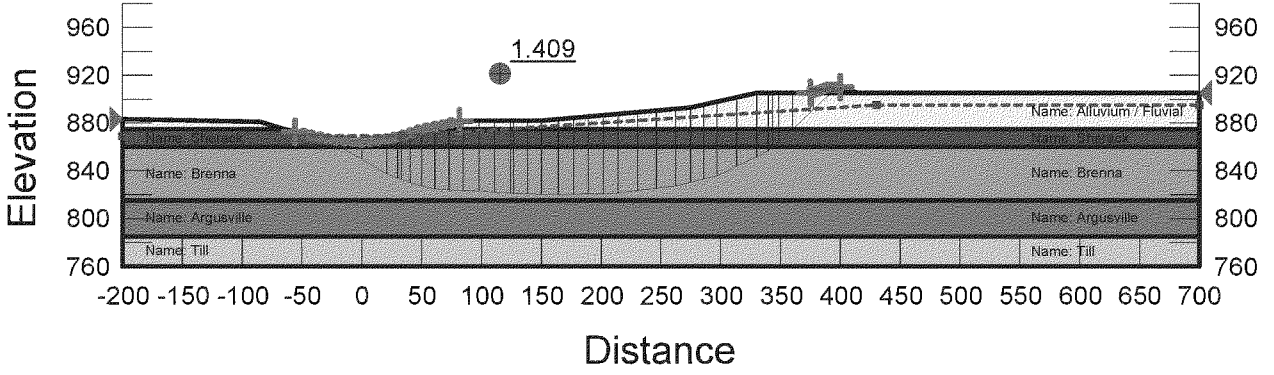
File Name: MOOR_13_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 13

Level of Protection: 910 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 28 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 28 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Date: 9/23/2009

1281

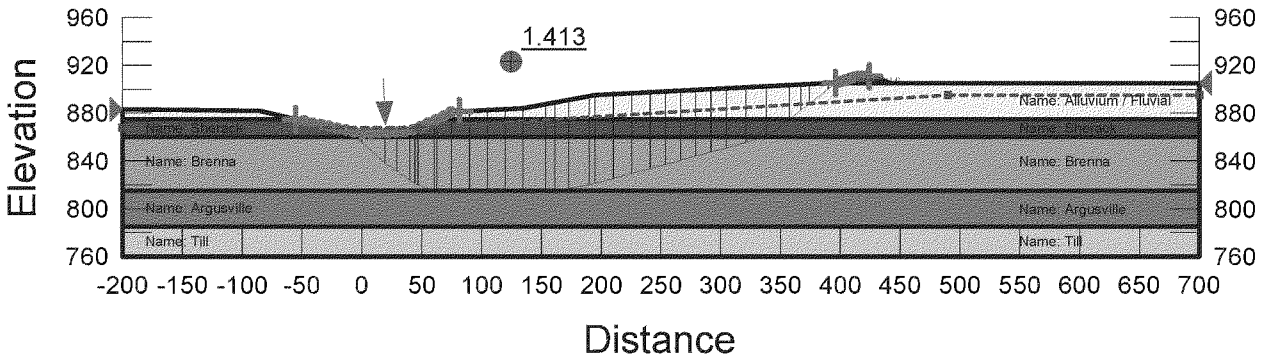
File Name: MOOR_14_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 14

Level of Protection: 911 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Date: 9/23/2009

1282

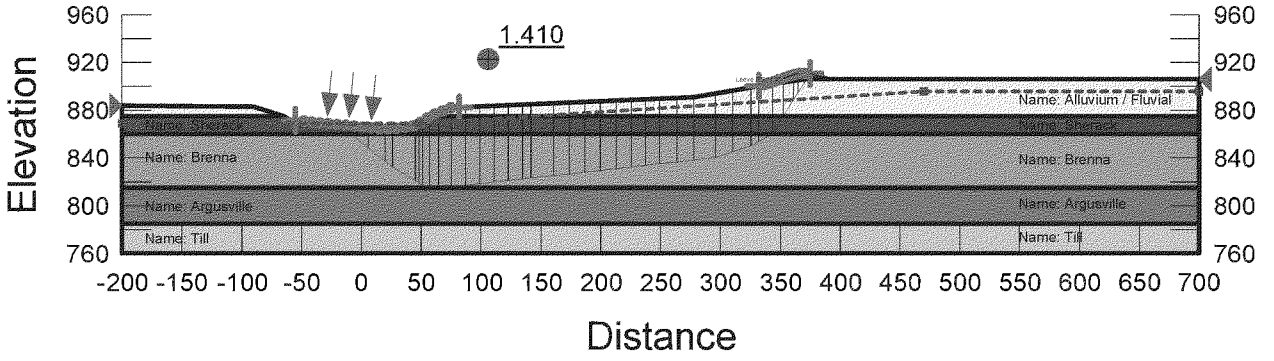
File Name: MOOR_15_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 15

Level of Protection: 911 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



Created By: Schmidt, Luke L MVP
Last Edited By: Schmidt, Luke L MVP
Date: 9/23/2009

1283

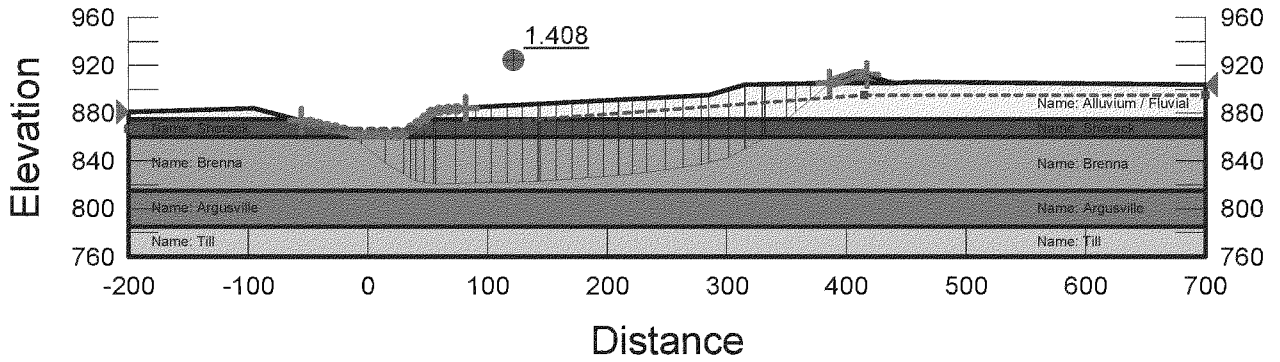
File Name: MOOR_16_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 16

Level of Protection: 912 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 15 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



Created By: Schmidt, Luke L MVP
Last Edited By: Schmidt, Luke L MVP
Date: 9/24/2009

1284

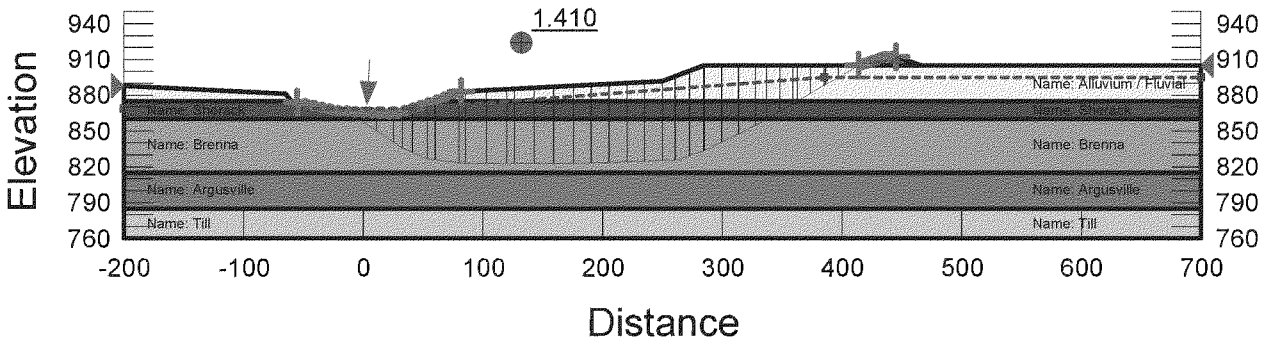
File Name: MOOR_17_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 17

Level of Protection: 912 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Last Edited By: Schmidt, Luke L MVP
Date: 9/24/2009

1285

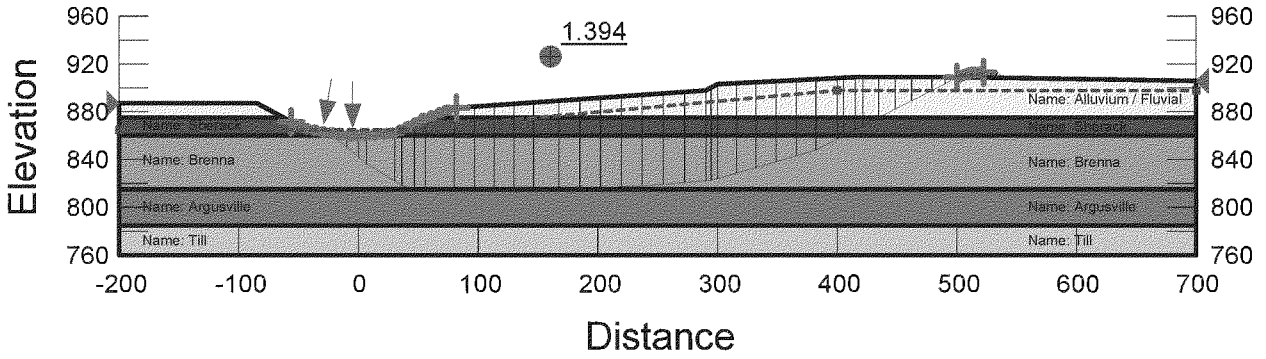
File Name: MOOR_18_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 18

Level of Protection: 913 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Date: 9/24/2009

1286

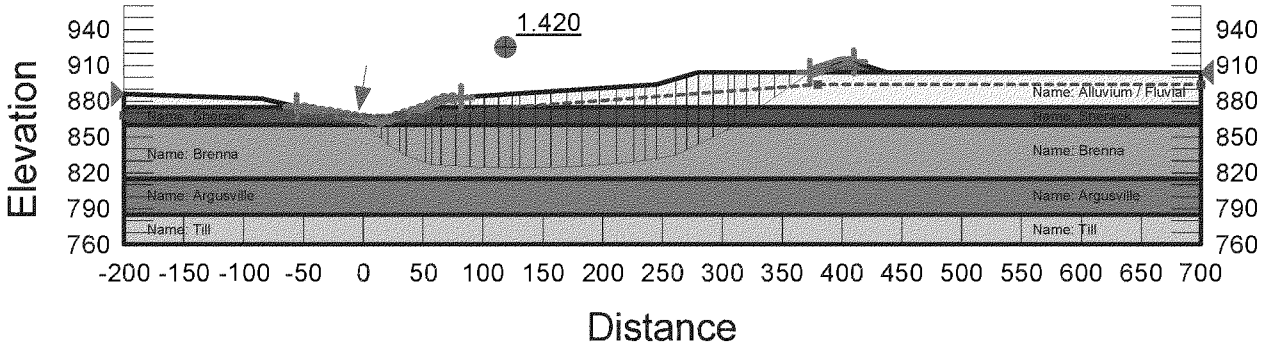
File Name: MOOR_19_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 19

Level of Protection: 913 ft

Soil Properties

Name: Leeve Fill Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 16 °
Name: Alluvium / Fluvial Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 26 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 °



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Last Edited By: Schmidt, Luke L MVP
Date: 9/24/2009

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Attachment I-8: Revised In-Town Levee Analyses

St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers®

Fargo-Moorhead Metro Feasibility Study

Assumptions used in GeoStudio Cross-sections for Revised Analysis

Low Head Dam Crest Elevations and Location

1) North Dam	871.38 ft	12th Avenue N, Fargo OR 15th Avenue, Moorhead
2) Midtown D	876.2 ft	Dike East
3) South Dar	878.4 ft	32nd Avenue S, Fargo OR River Oaks Park, Moorhead

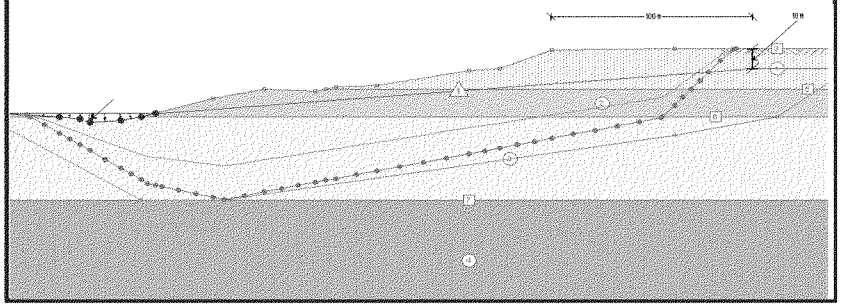
		Drained			Undrained	
		Ultimate Strengths		Residual	Total Stress	
Material	Unit Weight [pcf]	Friction Angle [Deg] ϕ'	Cohesion [psf] c'		Friction Angle [Deg] ϕ	Cohesion [Psf] c
Alluvium / Fluvial	119	31	0	20		1400
Sherack	118	28	0	13	0	1400
PL Sherack	112	19	0	6	0	1150
Poplar River West Fargo	123	34	0	20	0	1900
Poplar River Harwood	116	26	0	20	0	1450
Brenna	103	13	0	9*	0	650
Argusville	106	15	0	11	0	825
Sand	128	30	0		30	0
Sand Delta	128	25	0		25	0
Till	122	31	0		0	1900
Levee Fill	118	28	250		0	1400
Sand Drain	128	30	0		30	0
Fill (Spoil Area)	118	28	0		0	1400
Riprap	120	32	0		32	0

* Actual value used to compute levee setback was backcalculated from assumed failures.

Groundwater / River Level

*River depth was based on low water level elevations.

* Groundwater Table is located 10 ft below ground surface at a 100 feet beyond the second river bank. (Picture below)



1289

Fargo-Moorhead Metro Feasibility Study

Revised Setback Distances for Earthen Levees: MVP's 0.2-percent annual chance event (500-year) level plus superiority

Computed By: RWP, JF
Date: Dec-09

Revised By:
Date:

Setback Distances for Earthen Levees MVP's 0.2-percent annual chance event (500-year) level plus superiority
- Measured from center of river channel to center of the levee
- Required Factor of Safety of 1.4 (EM 1110-2-1913)

Top Elevations for Earthen Leeves
- The elevations were determined by USACE based on a risk and uncertainty analysis
- Level of Protection proveded to be determined based on R&U analysis
- Elevations in NAVD 1988

Levee Embankment Geometry
- Earthen leeve section assumed to have a top width of 10 feet and a side slope of 1:3 (Vert:Horz).

Stratigraphy
- Stratigraphy is based on the soil exploration completed and developed stratigraphy'
- A residual zone was assumed to occur from the secondary bank to the river

Slope Stability Analysis
- Analyzed using GeoStudio (Slope/W)
- Entry/Exit Slip Surface with Optimization
- Two slip surfaces were analyzed:
  (1) Front toe of the leeve
  (2) At or beyond the back toe of the leeve

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St. Paul District GEOTECHNICAL US Army Corps of Engineers

Fargo-Moorhead Metro Feasibility Study

Revised Setback Distances for Earthen Levees: MVP's 0.2-percent annual chance event (500-year) level plus superiority

Fargo, North Dakota

										Drained Strengths		Undrained Strengths			
Cross-Section	HEC Ras Section	HEC Ras TOL	Low Water Profile	Height of Leeve [ft]	Preliminary Setback Distance [ft]	Revised Setback Dist. W/ Low Flow Elev. [ft]	Setback Difference	Setback Used	Description	Front Toe FS	Back Toe FS	Front Toe FS	Back Toe FS	Brenna Residual Friction Angle (Backcalculated)	Notes
FAR-01	(1/3) from 316 to 315	898	861	2	520	415	-105	520	10th St N, north end	1.219	1.319	1.409	1.404		
FAR-02	(1/2) from 321 to 320	899	862	0	555	545	-10	555	10th St N, south end	1.529		1.304			Undrained Analysis Controls
FAR-03	326/325/324/322	899	862	5	480	443	-37	480	Fargo WWTP	1.326	1.321	1.321	1.363		Undrained Analysis Controls
FAR-04	327	900	863	3	490	487	-3	495	Golf course north	1.207	1.278	1.360	1.417	12.25	1 foot tension crack in drained analysis
FAR-05	(2/3) from 334 to 333	901	865	1	510	454	-56	500	South of Seminary	1.201	1.260	1.346	1.363	10.3	
FAR-06	(2/3) from 339 to 338	902	865	12	385	362	-23	660	Lilac Lane	1.201	1.379	1.628	1.680		
FAR-07	339	902	865	9	355	345	-10	380	Woodcrest Drive	1.209	1.295	1.673	1.655		tension in drained analysis - increased FS when a tension crack was added.
FAR-08	351	905	872	5	410	415	5	420	The Shrine	1.206	1.283	1.439	1.448	11.6	
FAR-09	355	906	872	7	450	360	-90	Oakgrove	Oakgrove School	1.219	1.350	1.475	1.506		
FAR-10	359	907	872	4	470	453	-17	450	Downtown, north	1.216	1.298	1.498	1.521		
FAR-11	(1/3) from 361 to 360	907	872	13	365	263	-102	520	Downtown, City Hall	1.204	1.663	1.443	1.513	10.7	
FAR-12	391	911	877	7	485	489	4	465	Elmwood Ave S (Lindenwood Area)	1.209	1.430	1.631	1.646	10.4	3' tension crack in drained analysis
FAR-13	(7/8) from 406 to 405	912	877	6	380	516	136	340	Fargo Country Club	1.203	1.325	1.747	1.769		2.5' tension crack in drained analysis
FAR-14	(1/2) 408 to 407	913	877	8	410	483	73	365	Southwood Drive	1.204	1.358	1.690	1.725		
FAR-15	414	913	879	9	425	448	23	420	River Drive, north end	1.212	1.442	1.609	1.692		
FAR-16	(1/3) from 415 to 414	914	879	9	400	440	40	430	River Drive, south end	1.2	1.397	1.665	1.736	9.6	1' tension crack in drained analysis
FAR-17	(2/3) from 451.3 to 460.72	915	880	12	385	405	20	505	University Dr, golf course	1.199	1.507	1.757	1.779		3' tension crack in drained analysis
FAR-18	(1/3) from 462.03 to 461.3	916	880	10	445	453	8	410	University Dr, cemetery	1.201	1.541	1.614	1.702		7' tension crack in drained analysis - couldn't get rid of tension, Checked w/ LT4
FAR-19	462.7	916	880	10	500	458	-42	470	University Dr, south end	1.204	1.562	1.598	1.644		5' tension crack in drained analysis - couldn't get rid of tension. Checked w/ LT4.
FAR-20	(1/5) from 485.1 to 464.6	917	880	14	450	406	-44	415	University Dr, south end tie-back	1.209	1.518	1.635	1.713		5' tension crack in drained analysis

Pink indicates location that setback could potentially seen bigger difference

Setback distances decreased less than 50 ft	8
Setback distances decreased between 50 - 100 ft	2
Setback distances decreased more than 100 ft	2
Setback distances increased less than 50 ft	6
Setback distances increased between 50 - 100 ft	1
Setback distances increased more than 100 ft	1
	20

1291

Fargo-Moorhead Metro Feasibility Study

Revised Setback Distances for Earthen Levees: MVP's 0.2-percent annual chance event (500-year) level plus superiority

Moorhead, Minnesota											Drained Strengths		Undrained Strengths		
Cross-Section	HEC Ras	HEC Ras TOL	Low Water Profile	Levee Height [ft]	Preliminary Setback Distance [ft]	Revised Setback Dist. W/ Low Flow Elev. [ft]	Setback Difference	Setback Used	Description	Front Toe FS	Back Toe FS	Front Toe FS	Back Toe FS	Notes
MOOR-01	(1/3) from 330 to 329	901	884	5	470	431	-39	415	North Moorhead	1.2	1.313	1.517	1.541	--
MOOR-02	332	901	884	13	435	442	7	430	North Moorhead	1.209	1.578	1.307	1.434	Small Tension (<10lbs) Ignored
MOOR-03	(3/5) from 337 to 336	902	885	4	435	476	41	425	North Moorhead	1.227	1.288	1.514	1.511	--
MOOR-04	(1/4) from 340 to 339	903	885	6	445	458	13	450	Crystal Sugar	1.205	1.321	1.407	1.471	Small Tension (<10lbs) Ignored
MOOR-05	(1/2) from 343 to 342	904	886	8	495	442	-53	485	North of golf course	1.203	1.32	1.383	1.421	--
MOOR-06	(2/5) from 345 to 344	905	887	7	415	336	-79	400	south of golf course	1.283	1.303	1.522	1.536	--
MOOR-07	(1/5) from 345 to 344	905	887	3	485	483	-2	660	Municiple building	1.205	1.285	1.408	1.423	2' Tension Crack in Drained Front of Toe
MOOR-08	(2/3) from 354 to 353	906	872	3	465	462	-3	455	S Homestead park	1.206	1.286	1.412	1.43	Small Tension (<10lbs) Ignored
MOOR-09	(1/6) from 354 to 353	906	872	3	435	488	53	430	Moorhead Jail	1.229	1.303	1.487	1.508	Small Tension (<10lbs) Ignored
MOOR-10	356	907	872	2	470	498	28	470	Moorhead City Hall	1.224	1.285	1.455	1.453	2' Tension Crack in Drained Front of Toe
MOOR-11	(1/2) from 371 to 370	909	872	5	485	540	55	475	S City Hall	1.203	1.318	1.515	1.538	4' Tension Crack in Drained Front of Toe
MOOR-12	(1/4) from 387 to 386	910	877	6	440	472	32	570	Old Plant	1.212	1.384	1.58	1.618	3' Tension Crack in Drained Front of Toe
MOOR-13	(1/3) from 391 to 390	911	877	6	395	475	80	395	N Gooseberry Park	1.204	1.355	1.628	1.679	2' Tension Crack in Drained Front of Toe
MOOR-14	(1/2) from 393/394 to 392	911	877	6	420	466	46	415	Gooseberry Park	1.207	1.355	1.658	1.691	4' Tension Crack in Drained Front of Toe
MOOR-15	395	911	877	5	370	470	100	380	Rivershore Dr. north	1.209	1.342	1.671	1.682	--
MOOR-16	(1/2) from 405 to 404	912	877	6	410	471	61	405	Rivershore Dr. south	1.201	1.374	1.909	1.987	5' Tension Crack in Drained Front of Toe
MOOR-17	(1/3) from 407 to 406	913	877	8	440	492	52	435	River Oak Circle	1.205	1.342	1.624	1.694	1' Tension Crack in Drained Front of Toe
MOOR-18	414	913	879	6	515	502	-13	530	south subdivision	1.201	1.367	1.679	1.727	4' Tension Crack in Drained Front of Toe
MOOR-19	415	914	879	10	405	446	41	435	south subdivision	1.203	1.474	1.672	1.754	5' Tension Crack in Drained Front of Toe (Some Difficulties)
MOOR-20	(1/2) from 460.72 to 460.28	915	880				0	495	Art center					

Pink indicates location that setback could potentially seen bigger difference

Setback distances decreased less than 50 ft	4
Setback distances decreased between 50 - 100 ft	2
Setback distances decreased more than 100 ft	0
Setback distances increased less than 50 ft	8
Setback distances increased between 50 - 100 ft	6
Setback distances increased more than 100 ft	
	20

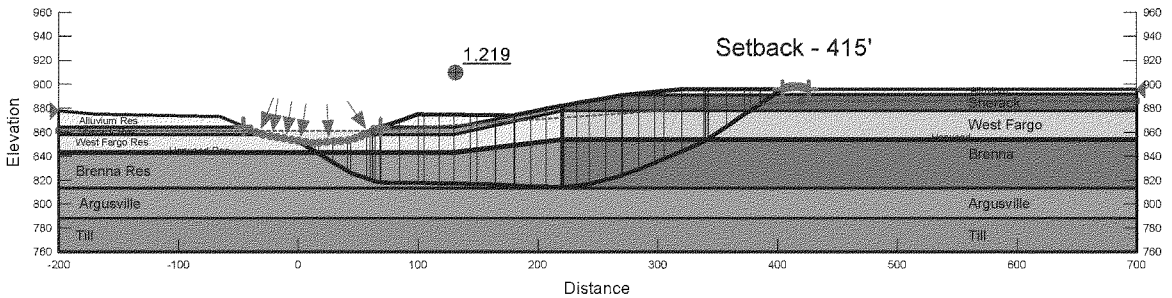
File Name: revFAR_01_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 1

Level of Protection: 898 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °	
Sherack Res 118 pcf 0 psf 13 °	Levee Fill 118 pcf 250 psf 28 °	Harwood 116 pcf 0 psf 28 °	
West Fargo Res 123 pcf 0 psf 25 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °	
Harwood Res 116 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °	Argusville 106 pcf 0 psf 15 °	Till 122 pcf 0 psf 31 °



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Last Edited By: Price, Ryan W MVP
Date: 12/8/2009

File Name: revFAR_02_500yr_USACE.gsz

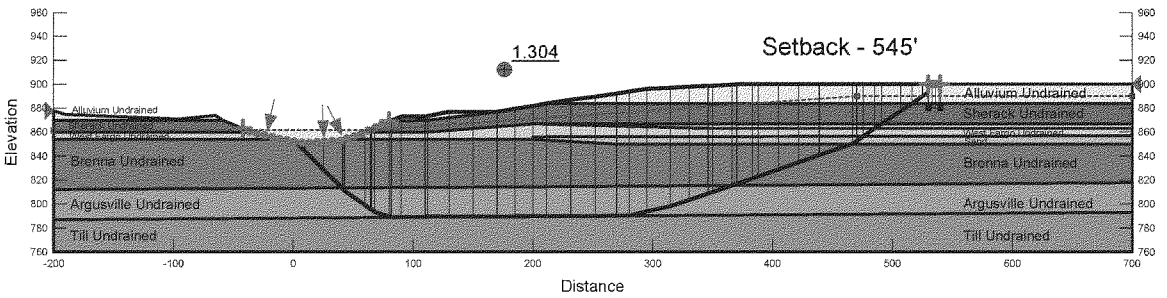
Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 2

Level of Protection: 899 ft

Undrained Strengths

Soil Properties

Alluvium Undrained 119 pcf 1400 psf Sherack Undrained 116 pcf 1400 psf West Fargo Undrained 123 pcf 1900 psf Brenna Undrained 103 pcf 650 psf	Alluvium Undrained 119 pcf 1400 psf Sherack Undrained 116 pcf 1400 psf Sand 125 pcf 0 psf 28 ° West Fargo Undrained 123 pcf 1900 psf	Brenna Undrained 103 pcf 650 psf Argusville Undrained 106 pcf 825 psf Till Undrained 122 pcf 1900 psf



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File Name: revFAR_03_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 3

Level of Protection: 899 ft

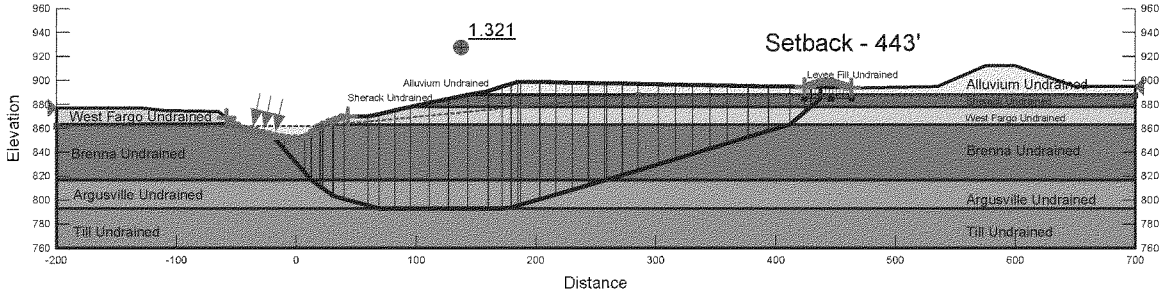
Undrained Strengths

Soil Properties

Alluvium Undrained
119 pcf
1400 psf
Sherack Undrained
118 pcf
1400 psf
West Fargo Undrained
123 pcf
1900 psf
Brenna Undrained
103 pcf
650 psf

Levee Fill Undrained
118 pcf
1400 psf
Alluvium Undrained
119 pcf
1400 psf
Sherack Undrained
118 pcf
1400 psf
West Fargo Undrained
123 pcf
1900 psf

Brenna Undrained
103 pcf
650 psf
Argusville Undrained
106 pcf
825 psf
Till Undrained
122 pcf
1900 psf



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Date: 12/8/2009

1295

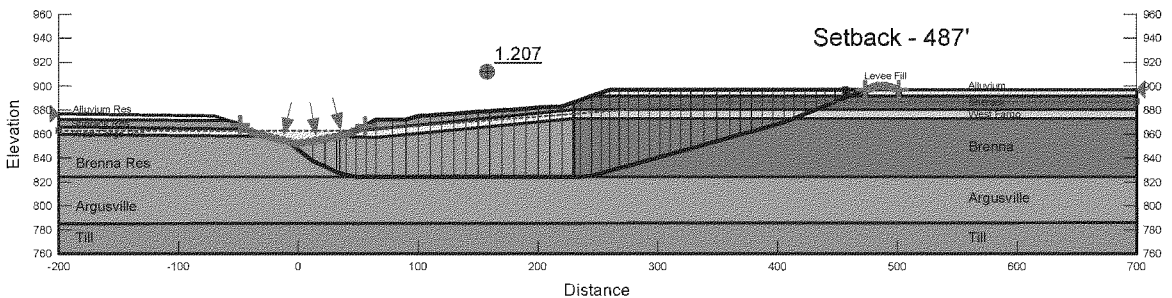
File Name: revFAR_04_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 4

Level of Protection: 900 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 29 °	Levee Fill 118 pcf 250 psf 28 °	
Sherack Res 118 pcf 0 psf 13 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °
West Fargo Res 123 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °	Argusville 105 pcf 0 psf 15 °
Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °	Till 122 pcf 0 psf 31 °



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Last Edited By: Price, Ryan W MVP
Date: 12/17/2009

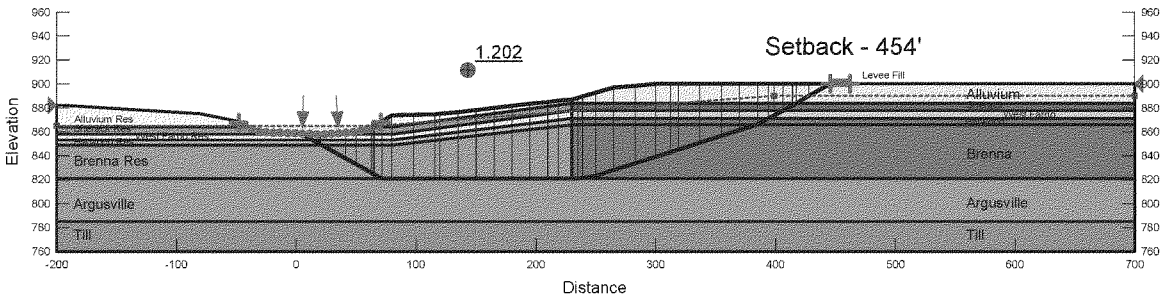
File Name: revFAR_05_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 5

Level of Protection: 901 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °	
Sherack Res 119 pcf 0 psf 13 °	Levee Fill 118 pcf 250 psf 28 °	Harwood 116 pcf 0 psf 26 °	
West Fargo Res 123 pcf 0 psf 25 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °	
Harwood Res 116 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °	Argusville 108 pcf 0 psf 15 °	Till 122 pcf 0 psf 31 °



Created By: Schmidt, Luke L MVP
Last Edited By: Foss, Jason MVP
Date: 12/17/2009

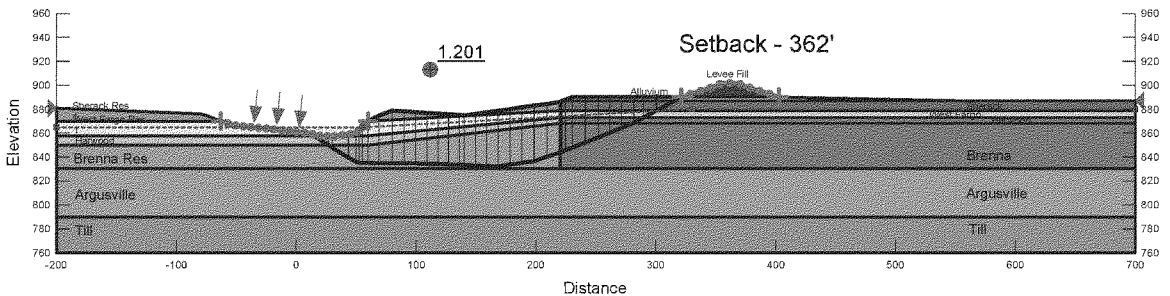
File Name: revFAR_06_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 6

Level of Protection: 902 ft

Soil Properties

Sherack Res 118 pcf 0 psf 13 ° West Fargo Res 123 pcf 0 psf 25 ° Harwood Res 116 pcf 0 psf 25 ° Brenna Res 103 pcf 0 psf 9 °	Levee Fill 118 pcf 250 psf 28 ° Alluvium 119 pcf 0 psf 31 ° Sherack 118 pcf 0 psf 28 ° West Fargo 123 pcf 0 psf 34 °	Harwood 116 pcf 0 psf 26 ° Brenna 103 pcf 0 psf 13 ° Argusville 106 pcf 0 psf 15 ° Till 122 pcf 0 psf 31 °



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Last Edited By: Price, Ryan W MVP
Date: 12/16/2009

1298

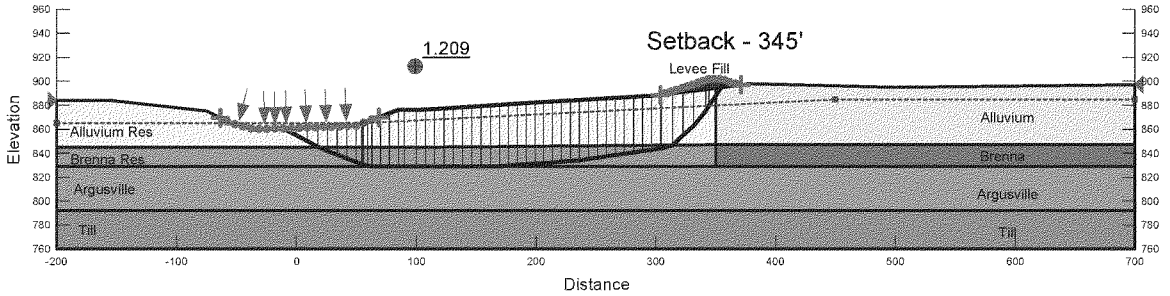
File Name: revFAR_07_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 7

Level of Protection: 902 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Brenna 103 pcf 0 psf 13 °
Brenna Res 103 pcf 0 psf 9 °	Argusville 106 pcf 0 psf 15 °
Levee Fill 118 pcf 250 psf 28 °	Till 122 pcf 0 psf 31 °
Alluvium 119 pcf 0 psf 31 °	



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Last Edited By: Price, Ryan W MVP
Date: 12/16/2009

1299

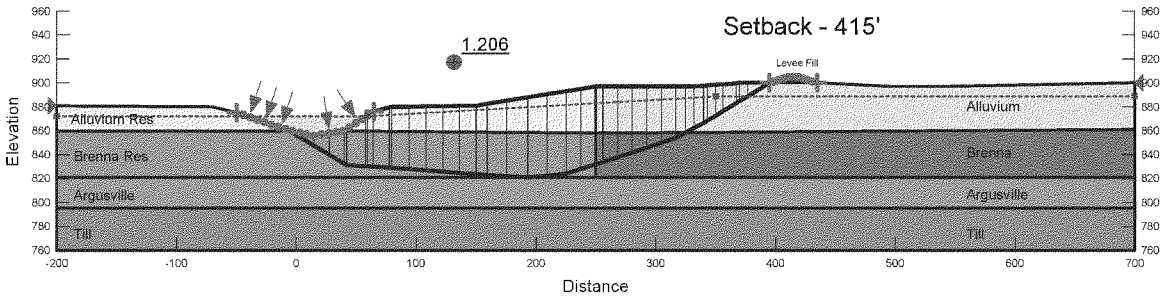
File Name: revFAR_08_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 8

Level of Protection: 905 ft

Soil Properties

Alluvium Res	Alluvium	
119 pcf	119 pcf	
0 psf	0 psf	
20 °	31 °	
Brenna Res	Brenna	
103 pcf	103 pcf	
0 psf	0 psf	
9 °	13 °	
Levee Fill	Argusville	Till
118 pcf	106 pcf	122 pcf
250 psf	0 psf	0 psf
28 °	15 °	31 °



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Date: 12/17/2009

1300

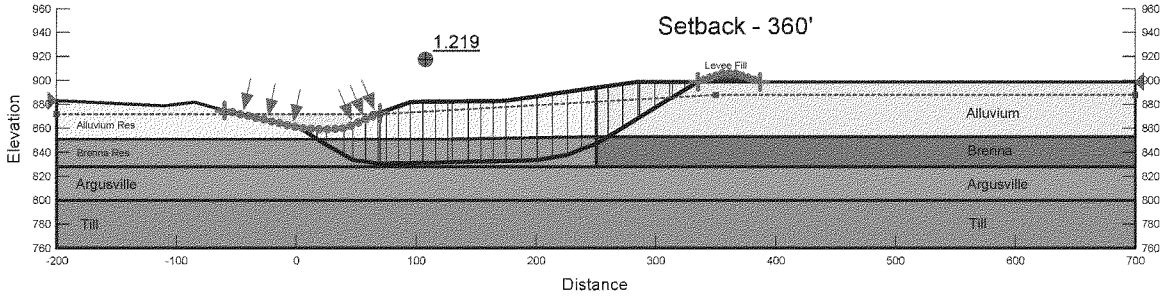
File Name: revFAR_09_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 9

Level of Protection: 906 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	
Brenna Res 103 pcf 0 psf 9 °	Brenna 103 pcf 0 psf 13 °
Alluvium 119 pcf 0 psf 31 °	Argusville 106 pcf 0 psf 15 °
Levee Fill 118 pcf 250 psf 28 °	Till 122 pcf 0 psf 31 °



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Date: 12/14/2009

1301

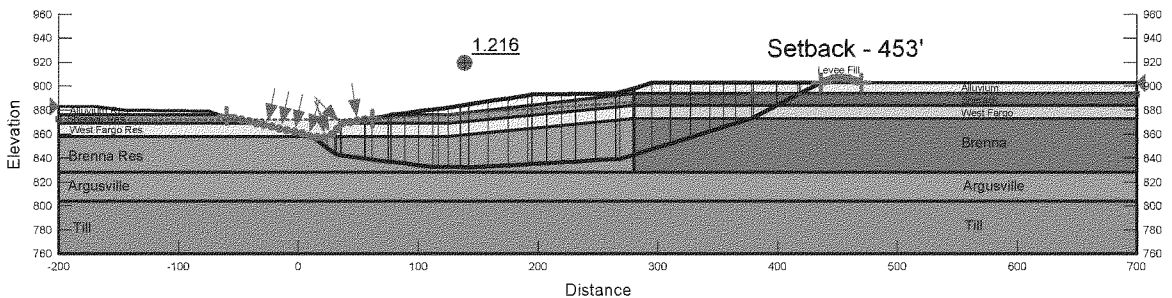
File Name: revFAR_10_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 10

Level of Protection: 907 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Levee Fill 118 pcf 250 psf 28 °	
Sherack Res 118 pcf 0 psf 13 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °
West Fargo Res 123 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °	Argusville 105 pcf 0 psf 15 °
Brenna Res 103 pcf 0 psf 9 °	West Fargo Res 123 pcf 0 psf 25 °	Till 122 pcf 0 psf 31 °



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Date: 12/14/2009

1302

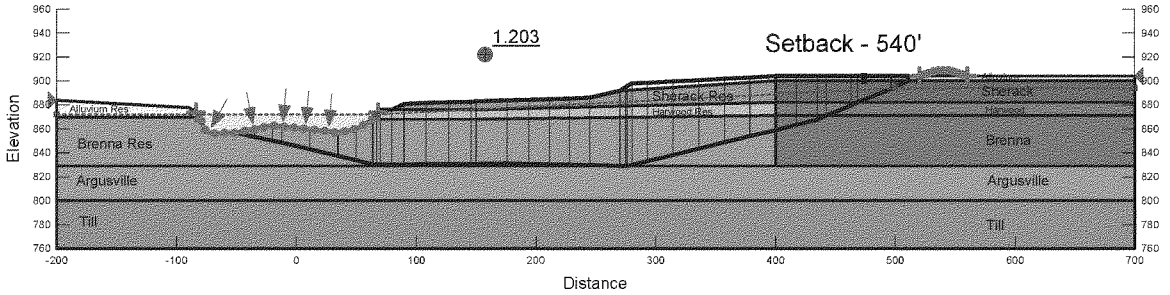
File Name: revMOOR_11_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 11

Level of Protection: 909 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Levee Fill 118 pcf 250 psf 28 °		
Brenna Res 103 pcf 0 psf 9 °	Alluvium 119 pcf 0 psf 31 °		Brenna 103 pcf 0 psf 13 °
Sherack Res 118 pcf 0 psf 13 °	Sherack 118 pcf 0 psf 26 °		Argusville 105 pcf 0 psf 15 °
Harwood Res 116 pcf 0 psf 25 °	Harwood 116 pcf 0 psf 26 °		Till 122 pcf 0 psf 31 °



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Last Edited By: Foss, Jason MVP
Date: 12/16/2009

1303

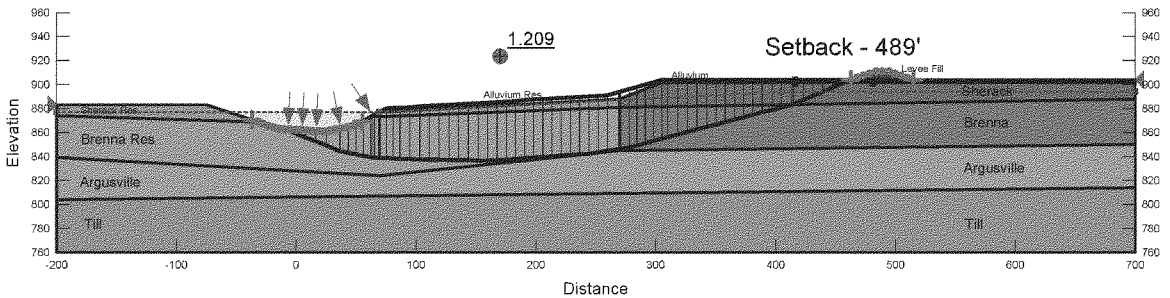
File Name: revFAR_12_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 12

Level of Protection: 911 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Levee Fill 118 pcf 250 psf 28 °	Brenna 103 pcf 0 psf 13 °
Sherack Res 118 pcf 0 psf 13 °	Alluvium 119 pcf 0 psf 31 °	Argusville 106 pcf 0 psf 15 °
Brenna Res 103 pcf 0 psf 9 °	Sherack 118 pcf 0 psf 28 °	Till 122 pcf 0 psf 31 °



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Last Edited By: Price, Ryan W MVP
Date: 12/18/2009

1304

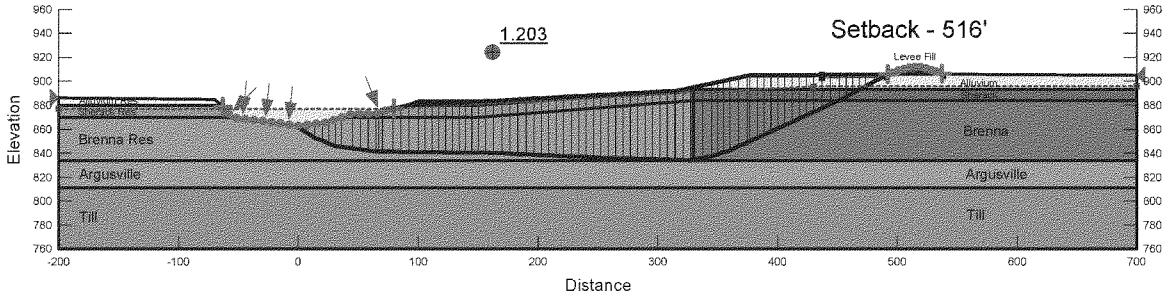
File Name: revFAR_13_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 13

Level of Protection: 912 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Alluvium 119 pcf 0 psf 31 °	
Sherack Res 119 pcf 0 psf 13 °	Sherack 119 pcf 0 psf 26 °	
Brenna Res 103 pcf 0 psf 9 °	Brenna 103 pcf 0 psf 13 °	
Levee Fill 116 pcf 250 psf 28 °	Argusville 106 pcf 0 psf 15 °	Till 122 pcf 0 psf 31 °



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Last Edited By: Price, Ryan W MVP
Date: 12/16/2009

1305

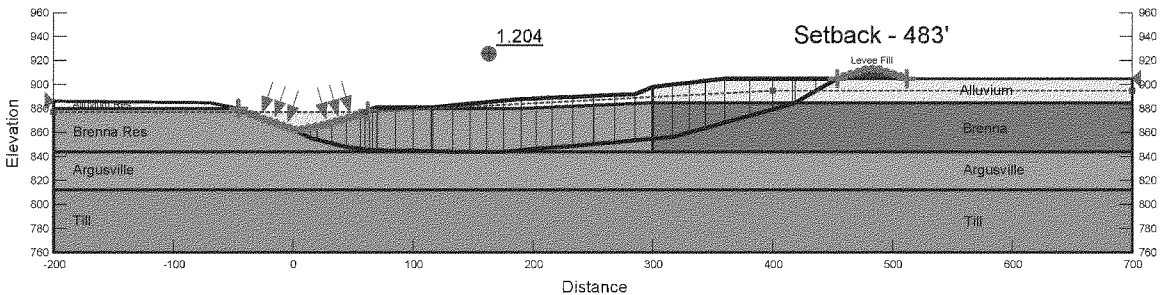
File Name: revFAR_14_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 14

Level of Protection: 913 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	
Brenna Res 103 pcf 0 psf 9 °	Brenna 103 pcf 0 psf 13 °
Levee Fill 118 pcf 250 psf 28 °	Argusville 106 pcf 0 psf 15 °
Alluvium 119 pcf 0 psf 31 °	Till 122 pcf 0 psf 31 °



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Date: 12/14/2009

1306

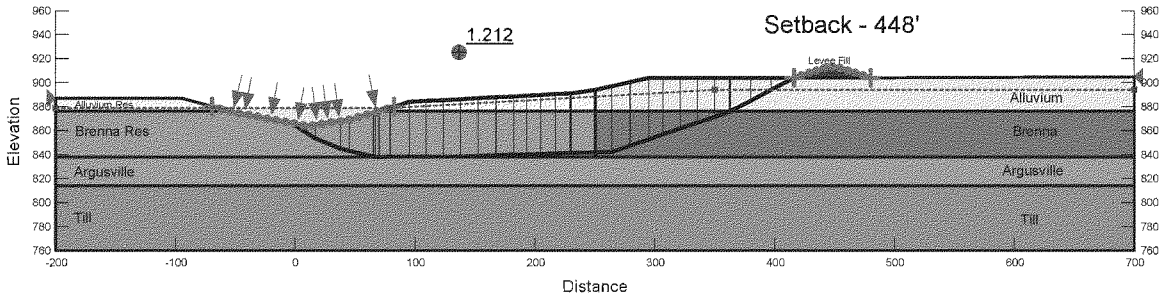
File Name: revFAR_15_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 15

Level of Protection: 913 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	
Brenna Res 103 pcf 0 psf 9 °	Brenna 103 pcf 0 psf 13 °
Levee Fill 118 pcf 250 psf 28 °	Argusville 105 pcf 0 psf 15 °
Alluvium 119 pcf 0 psf 31 °	Till 122 pcf 0 psf 31 °



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Last Edited By: Price, Ryan W MVP
Date: 12/14/2009

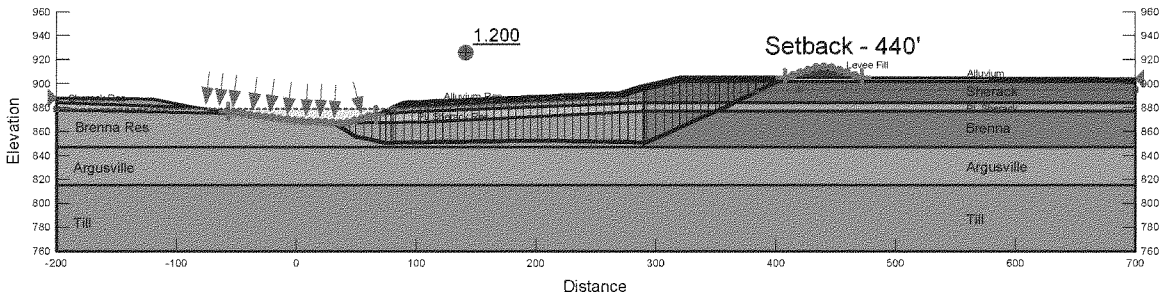
File Name: revFAR_16_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 16

Level of Protection: 914 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Levee Fill 118 pcf 250 psf 28 °		
Sherack Res 118 pcf 0 psf 13 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °	
PL Sherack Res 112 pcf 0 psf 7 °	Sherack 118 pcf 0 psf 28 °	Argusville 106 pcf 0 psf 15 °	
Brenna Res 103 pcf 0 psf 9 °	PL Sherack 112 pcf 0 psf 19 °	Till 122 pcf 0 psf 31 °	



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Last Edited By: Foss, Jason MVP
Date: 12/18/2009

1308

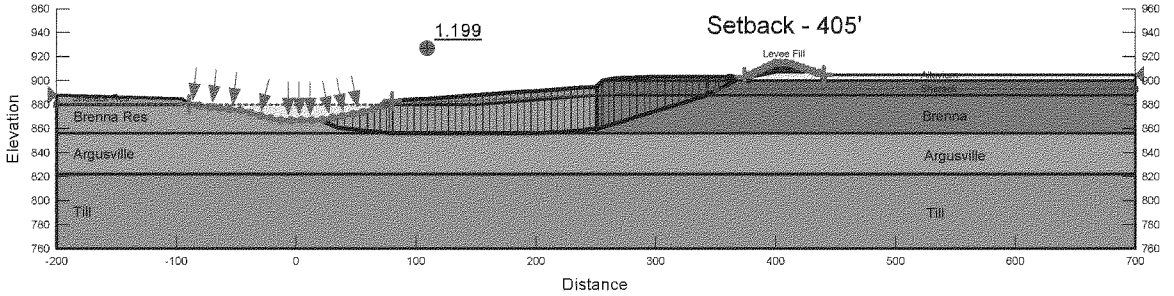
File Name: revFAR_17_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 17

Level of Protection: 915 ft

Soil Properties

Sherack Res 118 pcf 0 psf 13 °	Sherack 118 pcf 0 psf 28 °
Brenna Res 103 pcf 0 psf 9 °	Brenna 103 pcf 0 psf 13 °
Levee Fill 118 pcf 250 psf 28 °	Argusville 109 pcf 0 psf 15 °
Alluvium 119 pcf 0 psf 31 °	Till 122 pcf 0 psf 31 °



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Last Edited By: Price, Ryan W MVP
Date: 12/18/2009

1309

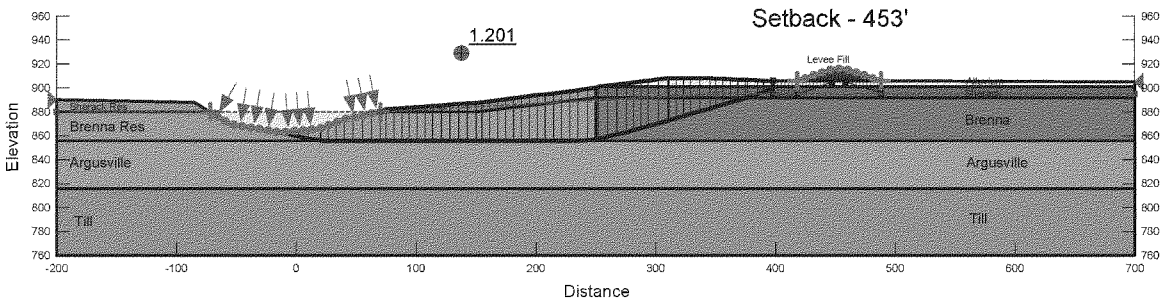
File Name: revFAR_18_500yr_USACE.gst

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 18

Level of Protection: 916 ft

Soil Properties

Sherack Res 118 pcf 0 psf 13 °	Sherack 118 pcf 0 psf 28 °
Brenna Res 103 pcf 0 psf 9 °	Brenna 103 pcf 0 psf 13 °
Levee Fill 118 pcf 250 psf 28 °	Argusville 106 pcf 0 psf 15 °
Alluvium 119 pcf 0 psf 31 °	Till 122 pcf 0 psf 31 °



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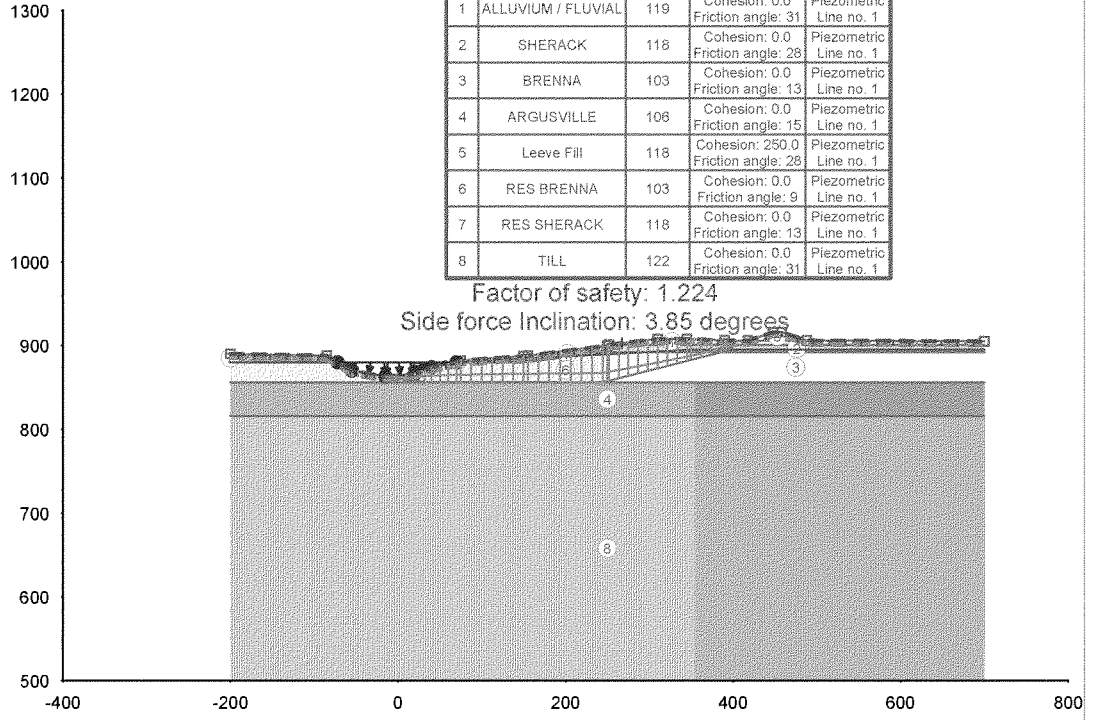
Last Edited By: Price, Ryan W MVP
Date: 12/16/2009

1310

FARGO-MOORHEAD METRO FEASIBILITY STUDY, PHASE 2

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	ALLUVIUM / FLUVIAL	119	Cohesion: 0.0 Friction angle: 31	Piezometric Line no. 1
2	SHERACK	118	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
3	BRENNA	103	Cohesion: 0.0 Friction angle: 13	Piezometric Line no. 1
4	ARGUSVILLE	106	Cohesion: 0.0 Friction angle: 15	Piezometric Line no. 1
5	Leeve Fill	118	Cohesion: 250.0 Friction angle: 28	Piezometric Line no. 1
6	RES BRENNA	103	Cohesion: 0.0 Friction angle: 9	Piezometric Line no. 1
7	RES SHERACK	118	Cohesion: 0.0 Friction angle: 13	Piezometric Line no. 1
8	TILL	122	Cohesion: 0.0 Friction angle: 31	Piezometric Line no. 1



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1311

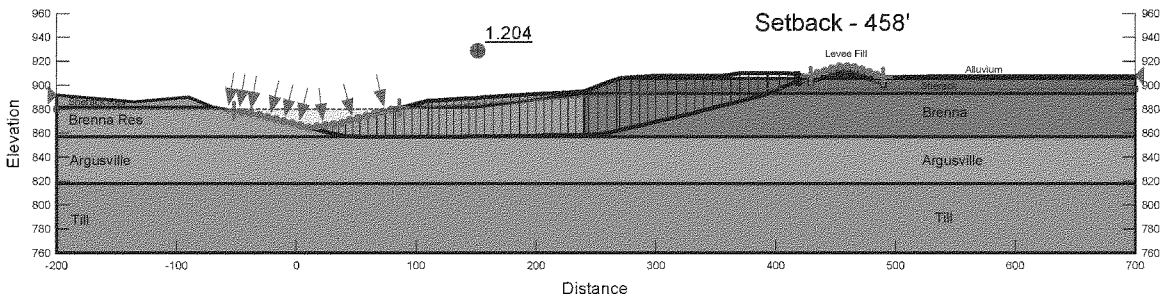
File Name: revFAR_19_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 19

Level of Protection: 916 ft

Soil Properties

Sherack Res 116 pcf 0 psf 13 °	Sherack 118 pcf 0 psf 28 °
Brenna Res 103 pcf 0 psf 9 °	Brenna 103 pcf 0 psf 13 °
Levee Fill 116 pcf 250 psf 28 °	Argusville 106 pcf 0 psf 15 °
Alluvium 119 pcf 0 psf 31 °	Till 122 pcf 0 psf 31 °



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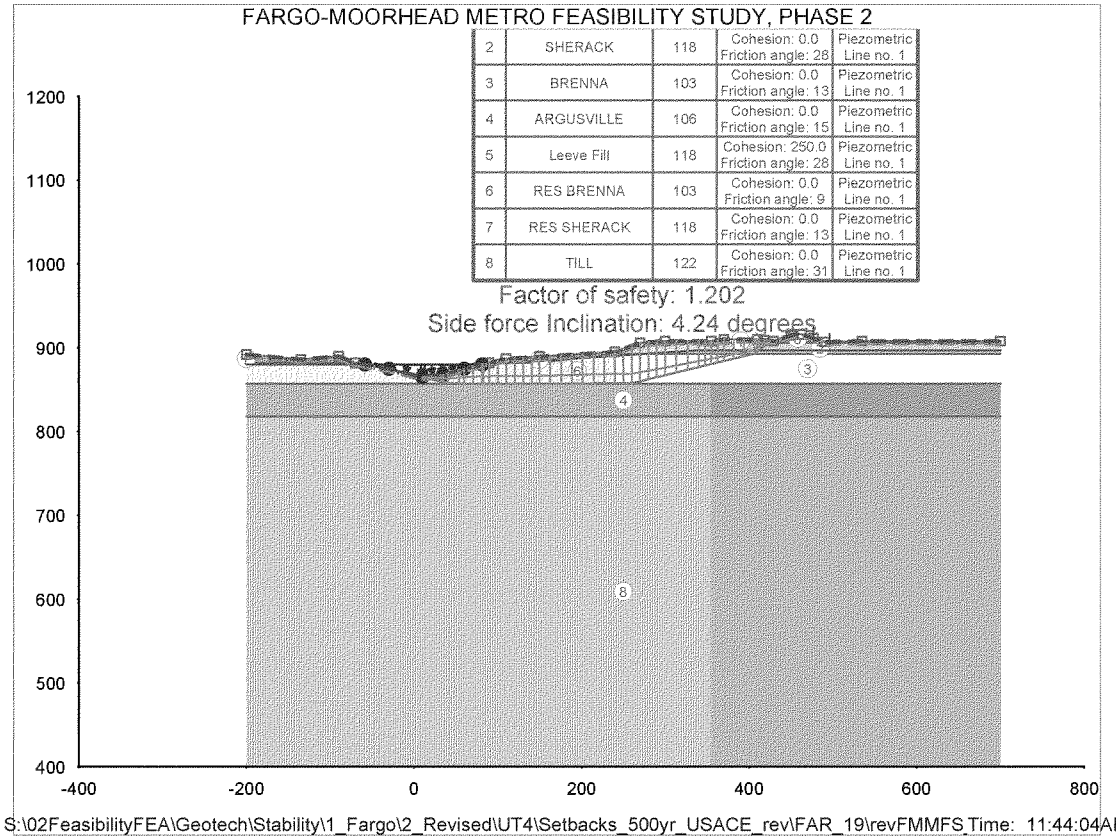
Last Edited By: Price, Ryan W MVP
Date: 12/16/2009

1312


FARGO-MOORHEAD METRO FEASIBILITY STUDY, PHASE 2
2 SHERACK 118 Cohesion: 0.0 Friction angle: 28 Piezometric Line no. 1
3 BRENNA 103 Cohesion: 0.0 Friction angle: 13 Piezometric Line no. 1
4 ARGUSVILLE 106 Cohesion: 0.0 Friction angle: 15 Piezometric Line no. 1
5 Leeve Fill 118 Cohesion: 250.0 Friction angle: 28 Piezometric Line no. 1
6 RES BRENNA 103 Cohesion: 0.0 Friction angle: 9 Piezometric Line no. 1
7 RES SHERACK 118 Cohesion: 0.0 Friction angle: 13 Piezometric Line no. 1
8 TILL 122 Cohesion: 0.0 Friction angle: 31 Piezometric Line no. 1
Factor of safety: 1.202
Side force Inclination: 4.24 degrees
1200
1100
1000
900
800
700
600
500
400
-400
-200
0
200
400
600
800
Filename: S:\02FeasibilityFEA\Geotech\Stability\1_Fargo\2_Revised\UT4\Setbacks_500yr_USACE_rev\FAR_19\revFMMFS.Time: 11:44:04AR_19.UT4

1313

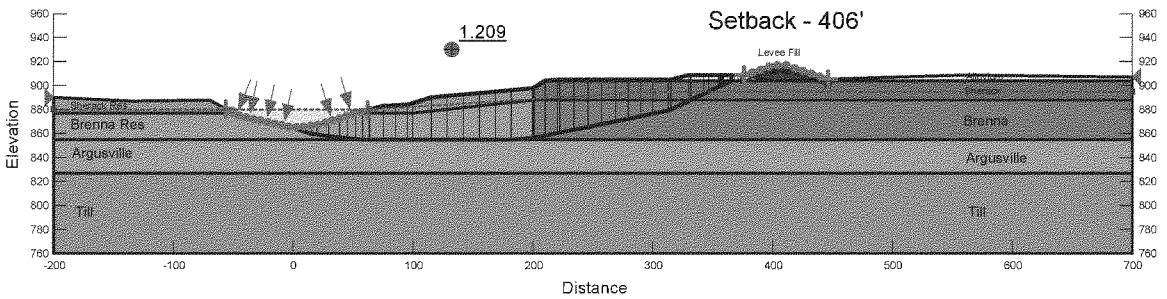
File Name: revFAR_20_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Fargo Section 20

Level of Protection: 917 ft

Soil Properties

Sherack Res 118 pcf 0 psf 13 °	Sherack 118 pcf 0 psf 28 °
Brenna Res 103 pcf 0 psf 9 °	Brenna 103 pcf 0 psf 13 °
Levee Fill 118 pcf 250 psf 28 °	Argusville 106 pcf 0 psf 15 °
Alluvium 119 pcf 0 psf 31 °	Till 122 pcf 0 psf 31 °



Created By: Schmidt, Luke L MVP
Last Edited By: Price, Ryan W MVP
Date: 12/16/2009

1314

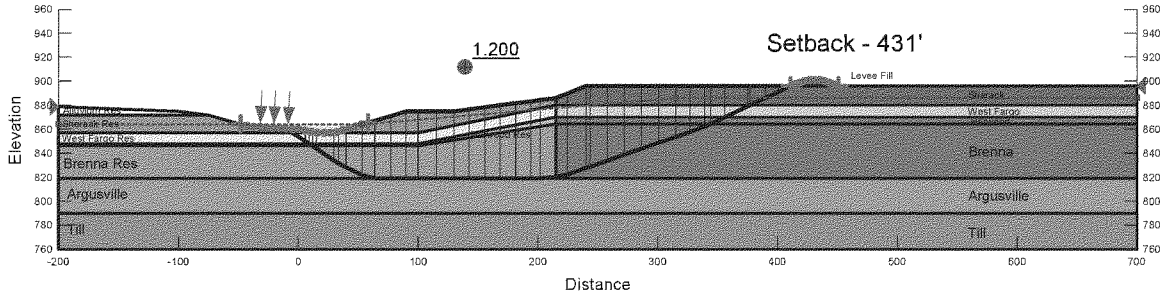
File Name: revMOOR_01_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 1

Level of Protection: 901 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Brenna Res 103 pcf 0 psf 9 °	Harwood 116 pcf 0 psf 26 °
Sherack Res 118 pcf 0 psf 13 °	Levee Fill 118 pcf 250 psf 28 °	Brenna 103 pcf 0 psf 13 °
West Fargo Res 123 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °	Argusville 106 pcf 0 psf 15 °
Harwood Res 116 pcf 0 psf 25 °	West Fargo 123 pcf 0 psf 34 °	Till 122 pcf 0 psf 31 °



Created By: Schmidt, Luke L MVP
Last Edited By: Foss, Jason MVP
Date: 12/15/2009

1315

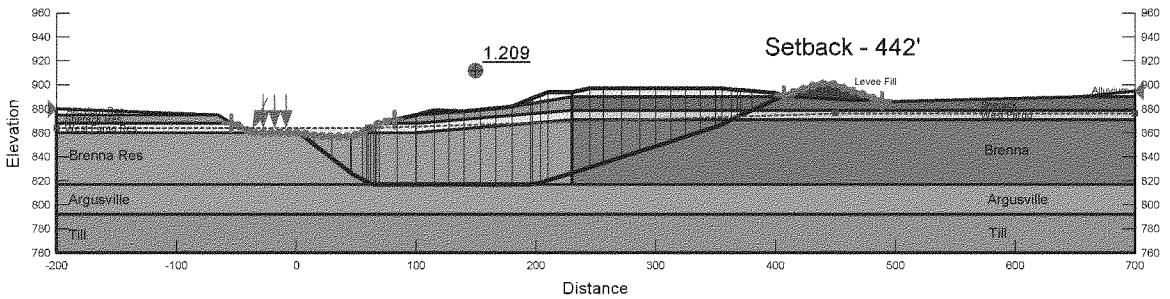
File Name: revMOOR_02_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 2

Level of Protection: 901 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Levee Fill 118 pcf 250 psf 28 °				
Sherack Res 118 pcf 0 psf 13 °	Alluvium 119 pcf 0 psf 31 °		Brenna 103 pcf 0 psf 13 °		
West Fargo Res 123 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °		Argusville 106 pcf 0 psf 15 °		
Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °		Till 122 pcf 0 psf 31 °		



Created By: Schmidt, Luke L MVP
Last Edited By: Foss, Jason MVP
Date: 12/16/2009

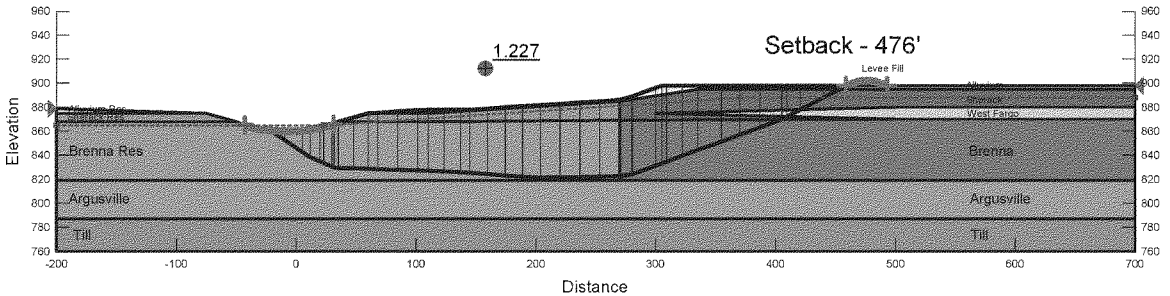
File Name: revMOOR_03_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 3

Level of Protection: 902 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °
Sherack Res 118 pcf 0 psf 13 °	Sherack 118 pcf 0 psf 28 °	Argusville 108 pcf 0 psf 15 °
Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °	Till 122 pcf 0 psf 31 °
Levee Fill 118 pcf 250 psf 28 °		



Created By: Schmidt, Luke L MVP
Last Edited By: Foss, Jason MVP
Date: 12/16/2009

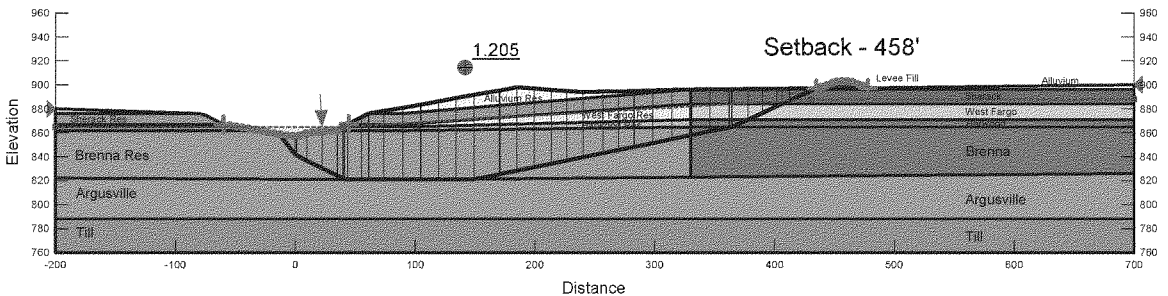
File Name: revMOOR_04_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 4

Level of Protection: 903 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °	
Sherack Res 118 pcf 0 psf 13 °	Levee Fill 118 pcf 250 psf 28 °	Harwood 116 pcf 0 psf 26 °	
West Fargo Res 123 pcf 0 psf 25 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °	
Harwood Res 116 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °	Argusville 108 pcf 0 psf 15 °	Till 122 pcf 0 psf 31 °



Created By: Schmidt, Luke L MVP
Last Edited By: Foss, Jason MVP
Date: 12/14/2009

1318

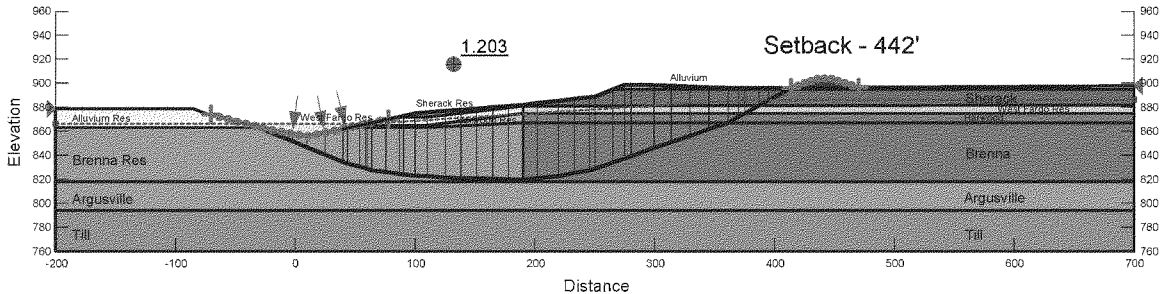
File Name: revMOOR_05_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 5

Level of Protection: 901 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Brenna Res 103 pcf 0 psf 9 °	Harwood 116 pcf 0 psf 26 °
Sherack Res 118 pcf 0 psf 13 °	Levee Fill 118 pcf 250 psf 28 °	Brenna 103 pcf 0 psf 13 °
West Fargo Res 123 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 26 °	Argusville 106 pcf 0 psf 15 °
Harwood Res 116 pcf 0 psf 25 °	West Fargo 123 pcf 0 psf 34 °	Till 122 pcf 0 psf 31 °



Created By: Schmidt, Luke L MVP
Last Edited By: Price, Ryan W MVP
Date: 12/9/2009

1319

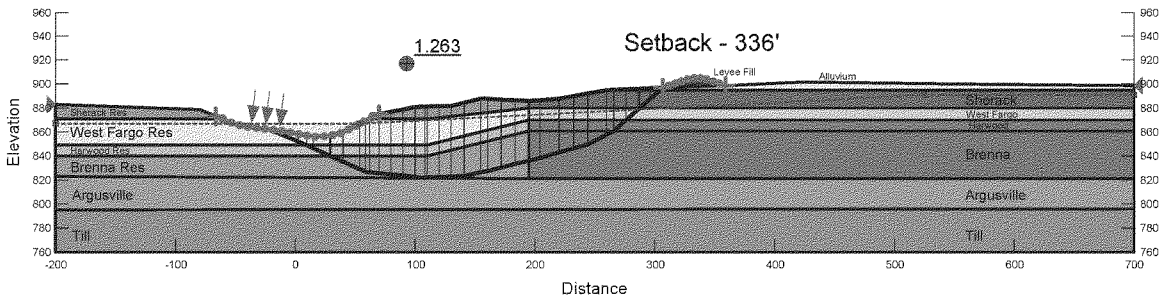
File Name: revMOOR_08_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 6

Level of Protection: 905 ft

Soil Properties

Sherack Res 118 pcf 0 psf 13 °	Levee Fill 118 pcf 250 psf 28 °	Harwood 116 pcf 0 psf 26 °
West Fargo Res 123 pcf 0 psf 25 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °
Harwood Res 116 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °	Argusville 108 pcf 0 psf 15 °
Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °	Till 122 pcf 0 psf 31 °



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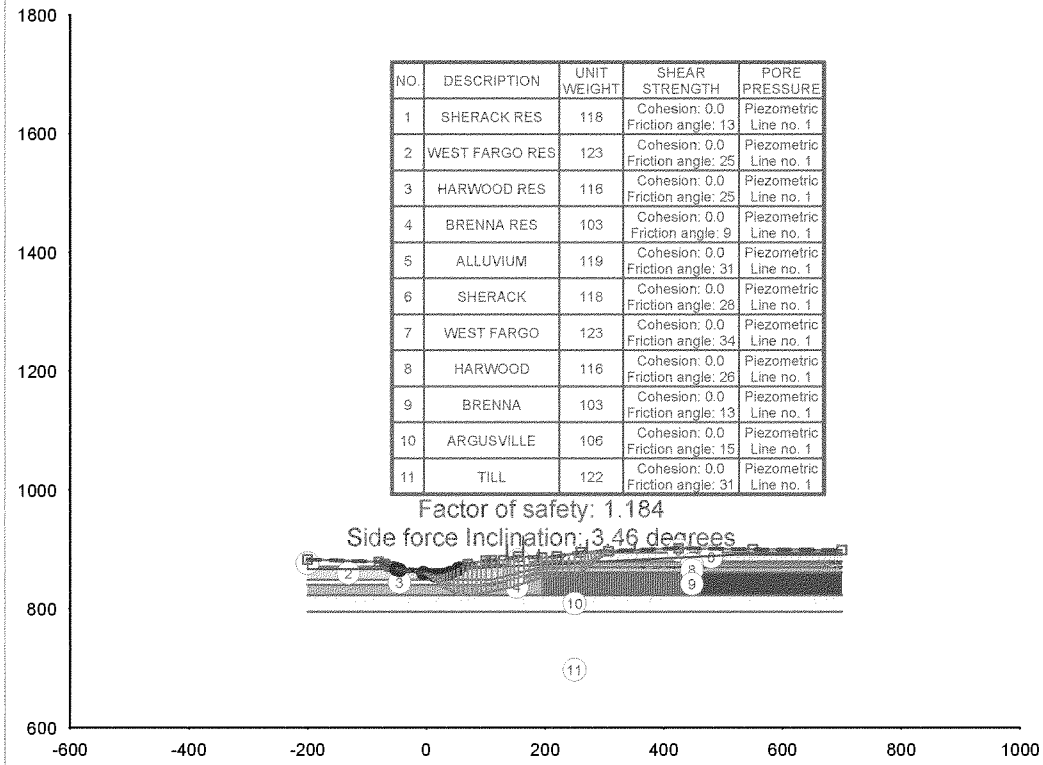
Last Edited By: Foss, Jason MVP
Date: 12/16/2009

1320

FARGO-MOORHEAD METRO FEASIBILITY STUDY, PHASE 2



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	SHERACK RES	118	Cohesion: 0.0 Friction angle: 13	Piezometric Line no. 1
2	WEST FARGO RES	123	Cohesion: 0.0 Friction angle: 25	Piezometric Line no. 1
3	HARWOOD RES	116	Cohesion: 0.0 Friction angle: 25	Piezometric Line no. 1
4	BRENNA RES	103	Cohesion: 0.0 Friction angle: 9	Piezometric Line no. 1
5	ALLUVIUM	119	Cohesion: 0.0 Friction angle: 31	Piezometric Line no. 1
6	SHERACK	118	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
7	WEST FARGO	123	Cohesion: 0.0 Friction angle: 34	Piezometric Line no. 1
8	HARWOOD	116	Cohesion: 0.0 Friction angle: 26	Piezometric Line no. 1
9	BRENNA	103	Cohesion: 0.0 Friction angle: 13	Piezometric Line no. 1
10	ARGUSVILLE	106	Cohesion: 0.0 Friction angle: 15	Piezometric Line no. 1
11	TILL	122	Cohesion: 0.0 Friction angle: 31	Piezometric Line no. 1

ıame: S:\02FeasibilityFEA\Geotech\Stability\2_Moorhead_Cross-sections\2_Revised\UT4\Setback_500yr_USACE_rev\MOOR_06\rTime: 14:08:20Setback_Moor_06.

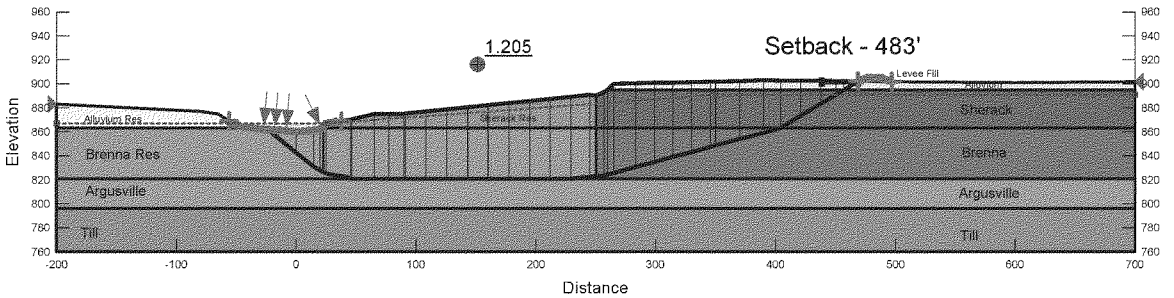
File Name: revMOOR_07_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 7

Level of Protection: 905 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Levee Fill 118 pcf 250 psf 28 °	Brenna 103 pcf 0 psf 13 °
Sherack Res 118 pcf 0 psf 15 °	Alluvium 119 pcf 0 psf 31 °	Argusville 106 pcf 0 psf 15 °
Brenna Res 103 pcf 0 psf 9 °	Sherack 118 pcf 0 psf 28 °	Till 122 pcf 0 psf 31 °



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Last Edited By: Foss, Jason MVP
Date: 12/16/2009

1322

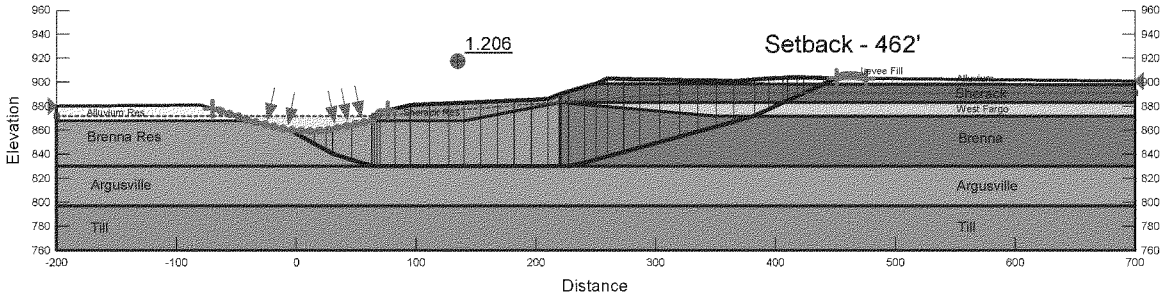
File Name: revMOOR_08_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 8

Level of Protection: 906 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °		
Sherack Res 118 pcf 0 psf 13 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °
Brenna Res 103 pcf 0 psf 9 °	Sherack 118 pcf 0 psf 28 °	Argusville 106 pcf 0 psf 15 °
Levee Fill 118 pcf 250 psf 28 °	West Fargo 123 pcf 0 psf 34 °	Till 122 pcf 0 psf 31 °



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Last Edited By: Foss, Jason MVP
Date: 12/16/2009

1323

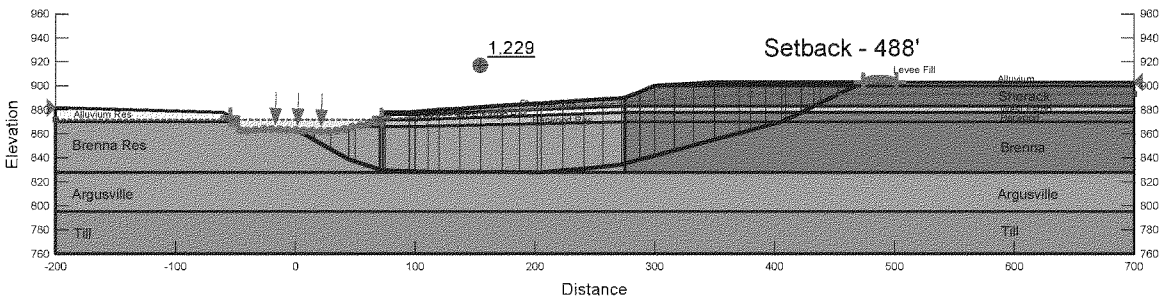
File Name: revMOOR_09_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 9

Level of Protection: 906 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °	
Sherack Res 118 pcf 0 psf 13 °	Levee Fill 118 pcf 250 psf 28 °	Harwood 116 pcf 0 psf 26 °	
West Fargo Res 123 pcf 0 psf 25 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °	
Harwood Res 116 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °	Argusville 108 pcf 0 psf 15 °	Till 122 pcf 0 psf 31 °



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Last Edited By: Foss, Jason MVP
Date: 12/15/2009

1324

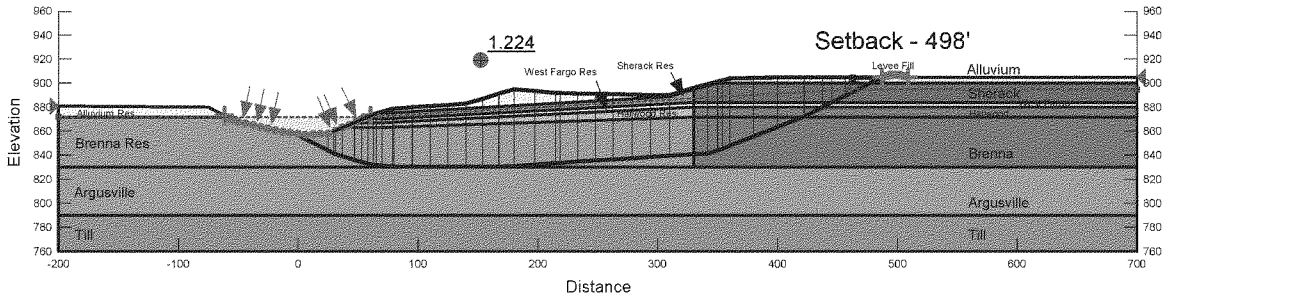
File Name: revMOOR_10_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 10

Level of Protection: 907 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °	
Sherack Res 118 pcf 0 psf 13 °	Levee Fill 118 pcf 250 psf 28 °	Harwood 116 pcf 0 psf 26 °	
West Fargo Res 123 pcf 0 psf 25 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 15 °	
Harwood Res 116 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °	Argusville 106 pcf 0 psf 15 °	Till 122 pcf 0 psf 31 °



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Date: 12/16/2009

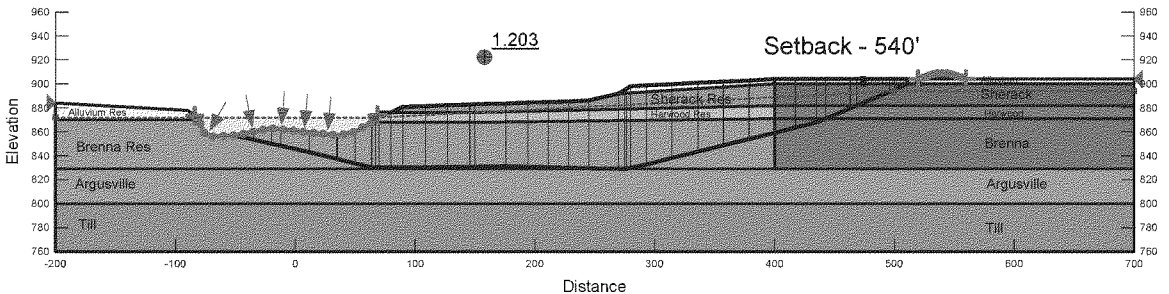
File Name: revMOOR_11_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 11

Level of Protection: 909 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °
Brenna Res 103 pcf 0 psf 8 °	Sherack 118 pcf 0 psf 28 °	Argusville 106 pcf 0 psf 15 °
Sherack Res 118 pcf 0 psf 13 °	Harwood 116 pcf 0 psf 26 °	Till 122 pcf 0 psf 31 °
Harwood Res 116 pcf 0 psf 25 °		



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Date: 12/16/2009

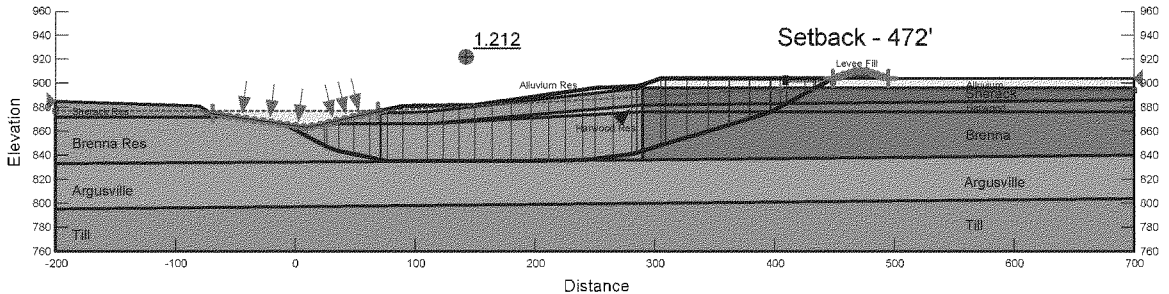
File Name: revMOOR_12_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 12

Level of Protection: 910 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Levee Fill 118 pcf 250 psf 28 °		
Sherack Res 118 pcf 0 psf 13 °	Alluvium 119 pcf 0 psf 31 °		Brenna 103 pcf 0 psf 13 °
Harwood Res 116 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °		Argusville 106 pcf 0 psf 15 °
Brenna Res 103 pcf 0 psf 9 °	Harwood 116 pcf 0 psf 26 °		Till 122 pcf 0 psf 31 °



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Date: 12/16/2009

1327

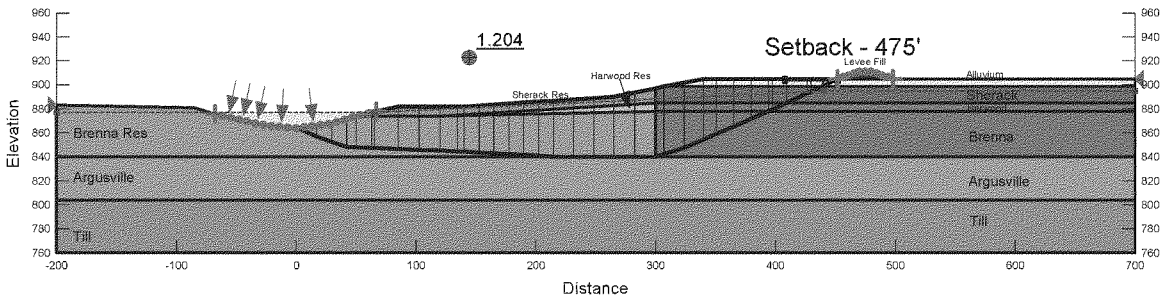
File Name: revMOOR_13_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 13

Level of Protection: 911 ft

Soil Properties

Sherack Res 118 pcf 0 psf 13 °	Alluvium 119 pcf 0 psf 31 °		
Harwood Res 116 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °		
Brenna Res 103 pcf 0 psf 9 °	Harwood 116 pcf 0 psf 26 °	Argusville 106 pcf 0 psf 15 °	
Levee Fill 118 pcf 250 psf 28 °	Brenna 103 pcf 0 psf 13 °	Till 122 pcf 0 psf 31 °	



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Date: 12/16/2009

1328

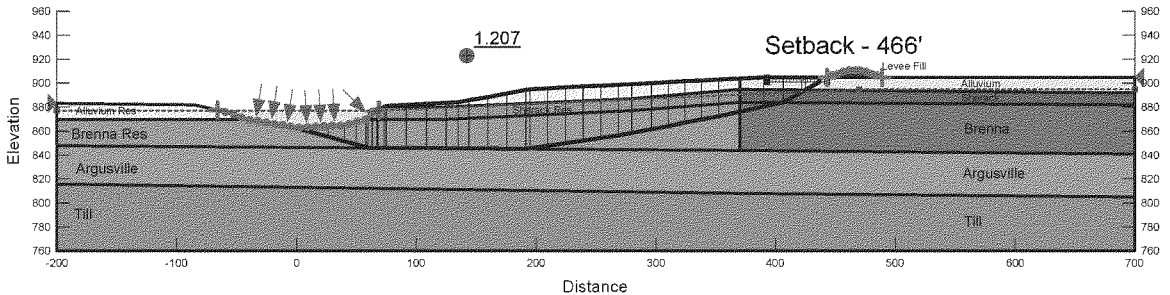
File Name: revMOOR_14_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 14

Level of Protection: 911 ft

Soil Properties

Alluvium Res	Levee Fill	Brenna
119 pcf	118 pcf	103 pcf
0 psf	250 psf	0 psf
20 °	28 °	13 °
Sherack Res	Alluvium	Argusville
118 pcf	119 pcf	106 pcf
0 psf	0 psf	0 psf
13 °	31 °	15 °
Brenna Res	Sherack	Till
103 pcf	118 pcf	122 pcf
0 psf	0 psf	0 psf
9 °	28 °	31 °



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Last Edited By: Foss, Jason MVP
Date: 12/16/2009

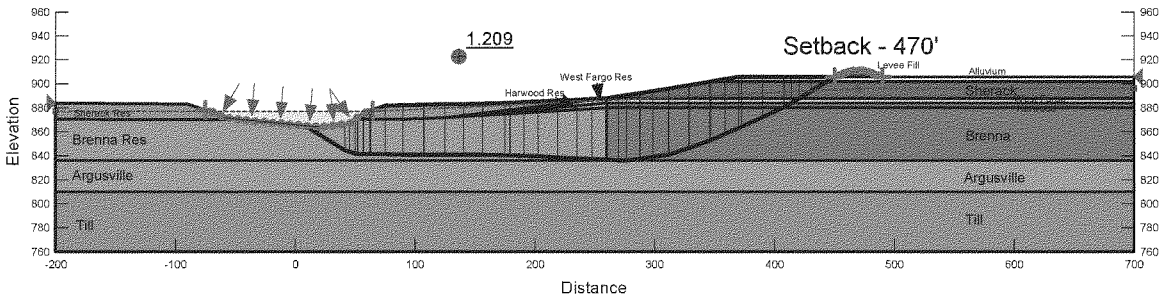
File Name: revMOOR_15_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 15

Level of Protection: 911 ft

Soil Properties

Sherack Res 118 pcf 0 psf 13 °	Levee Fill 118 pcf 250 psf 28 °	Harwood 118 pcf 0 psf 28 °
West Fargo Res 123 pcf 0 psf 25 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °
Harwood Res 116 pcf 0 psf 25 °	Sherack 116 pcf 0 psf 28 °	Argusville 106 pcf 0 psf 15 °
Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °	Till 122 pcf 0 psf 31 °



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Date: 12/16/2009

1330

File Name: revMOOR_16_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 16

Level of Protection: 912 ft

Soil Properties

Sherack Res
118 pcf
0 psf
13 °

Brenna Res
103 pcf
0 psf
9 °

Levee Fill
118 pcf
250 psf
28 °

Alluvium
119 pcf
0 psf
31 °

Sherack
118 pcf
0 psf
28 °

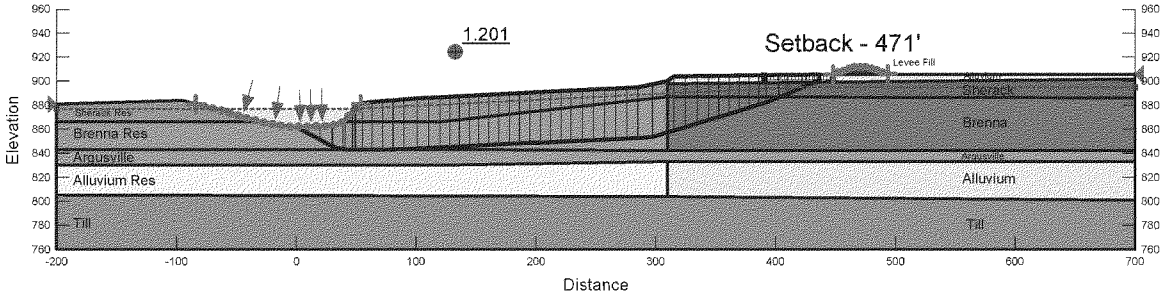
Brenna
103 pcf
0 psf
13 °

Argusville
105 pcf
0 psf
15 °

Alluvium
119 pcf
0 psf
31 °

Alluvium Res
119 pcf
0 psf
20 °

Till
122 pcf
0 psf
31 °



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Last Edited By: Foss, Jason MVP
Date: 12/16/2009

1331

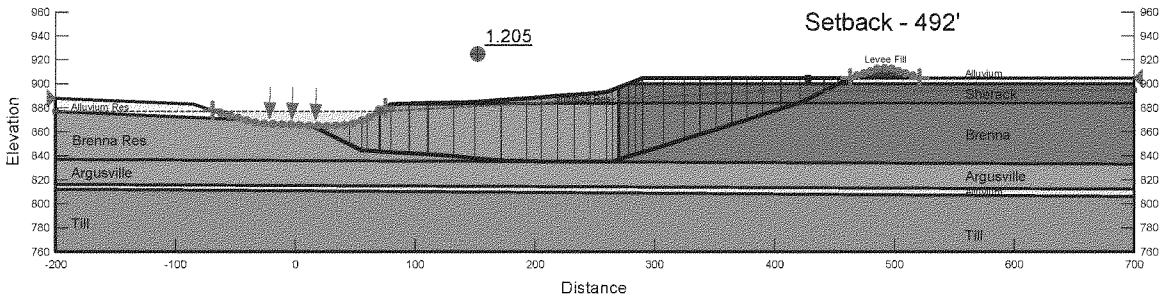
File Name: revMOOR_17_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 17

Level of Protection: 913 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Alluvium 119 pcf 0 psf 31 °		
Sherack Res 118 pcf 0 psf 19 °	Sherack 118 pcf 0 psf 28 °		
Brenna Res 103 pcf 0 psf 9 °	Brenna 103 pcf 0 psf 13 °		
Levee Fill 116 pcf 250 psf 28 °	Argusville 108 pcf 0 psf 15 °	Till 122 pcf 0 psf 31 °	



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Last Edited By: Foss, Jason MVP
Date: 12/16/2009

1332

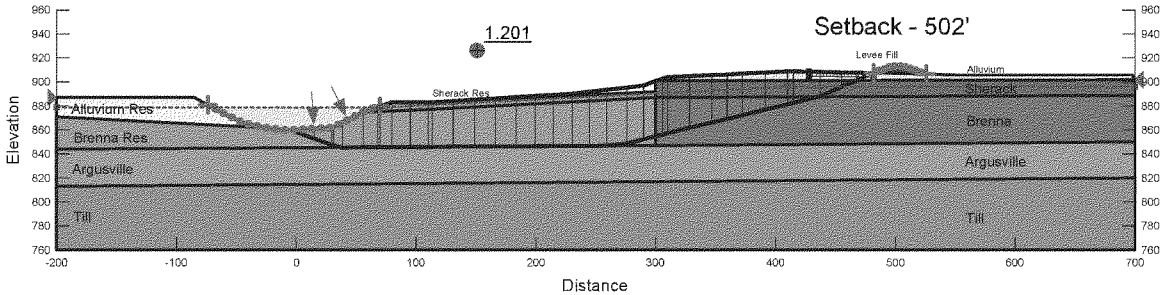
File Name: revMOOR_18_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 18

Level of Protection: 913 ft

Soil Properties

Alluvium Res	Levee Fill	Brenna
119 pcf	118 pcf	103 pcf
0 psf	250 psf	0 psf
20 °	28 °	13 °
Sherack Res	Alluvium	Argusville
118 pcf	119 pcf	106 pcf
0 psf	0 psf	0 psf
13 °	31 °	15 °
Brenna Res	Sherack	Till
103 pcf	118 pcf	122 pcf
0 psf	0 psf	0 psf
9 °	28 °	31 °



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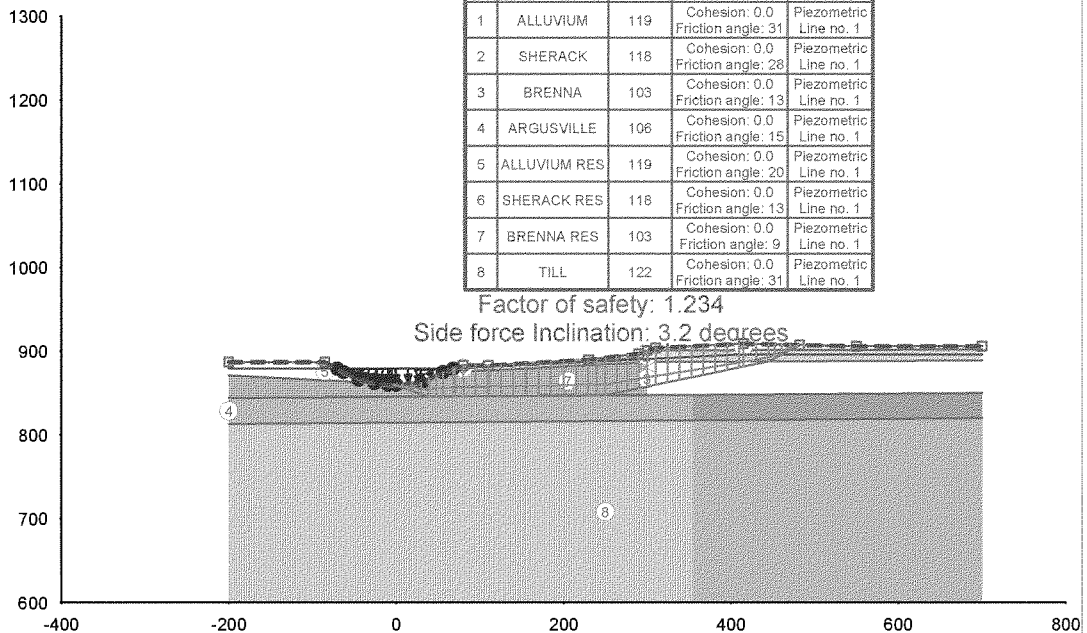
Last Edited By: Foss, Jason MVP
Date: 12/16/2009

FARGO-MOORHEAD METRO FEASIBILITY STUDY, PHASE 2

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	ALLUVIUM	119	Cohesion: 0.0 Friction angle: 31	Piezometric Line no. 1
2	SHERACK	118	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
3	BRENNA	103	Cohesion: 0.0 Friction angle: 13	Piezometric Line no. 1
4	ARGUSVILLE	106	Cohesion: 0.0 Friction angle: 15	Piezometric Line no. 1
5	ALLUVIUM RES	119	Cohesion: 0.0 Friction angle: 20	Piezometric Line no. 1
6	SHERACK RES	118	Cohesion: 0.0 Friction angle: 13	Piezometric Line no. 1
7	BRENNA RES	103	Cohesion: 0.0 Friction angle: 9	Piezometric Line no. 1
8	TILL	122	Cohesion: 0.0 Friction angle: 31	Piezometric Line no. 1



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1334

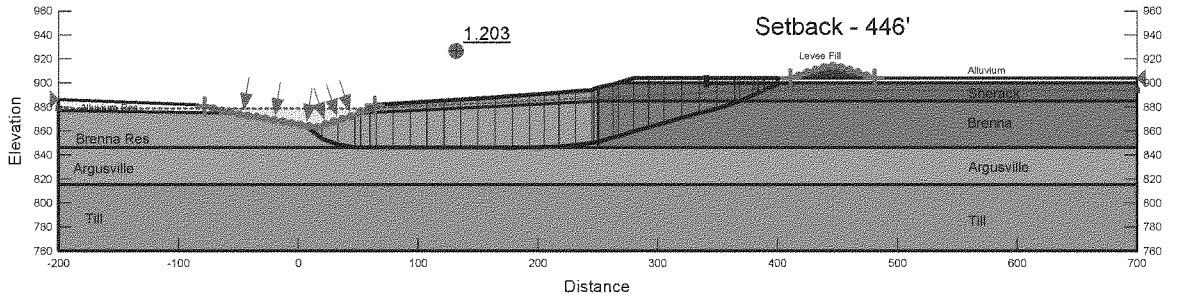
File Name: revMOOR_19_500yr_USACE.gsz

Fargo-Moorhead Metro Feasibilty Study
Setback Distance for Levee (500 yr)
Moorhead Section 19

Level of Protection: 914 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Alluvium 119 pcf 0 psf 31 °		
Sherack Res 118 pcf 0 psf 19 °	Sherack 118 pcf 0 psf 28 °		
Brenna Res 103 pcf 0 psf 9 °	Brenna 103 pcf 0 psf 13 °		
Levee Fill 118 pcf 250 psf 28 °	Argusville 108 pcf 0 psf 15 °	Till 122 pcf 0 psf 31 °	



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Last Edited By: Foss, Jason MVP
Date: 12/16/2009

1335

Attachment I-9: Diversion Channel Analysis – Phase 2

Fargo-Moorhead Metro Feasibility Study

Minnesota Diversion Modeling Results

Computed By: KAH
Date: 4-Sep-08

Revised By: KAH
Date: 28-Dec-09

Diversion Channel

- Analyzed using GeoStudio (SEEP/W & SLOPE/W)
- Cross Sections revised based on Moore's revision on 7/20/09
- 500 ft Bottom Width Analyzed
- Stratigraphy Based on Boring Logs taken by USACE

Elevations

- Ground Surface and Bottom of Channel Elevations Based on Moore Engineering Report, revision 7/20/09
  - The 3 different capacities (45k, 35k, and 25k CFS) all have same bottom channel elevation, but the channel has different widths.

Spoil Area

- Spoil Embankment Top Width Varies with Depth & Width of Diversion Channel
- Spoil Embankment Height of 10' 10
- Landside Slope 1':10' (Vert/Horz) 0.10
- Diversion Channel Slope 1':7' (Vert/Horz) 0.14

Seepage Analysis

- Only one half of the diversion channel was modeled (1/2 space)
- Model extended to 1750' (~1/3 mile) beyond toe of ditch slope
- Total Head boundary conditions used at the extent of model.
  - Total Head equals ground water elevation observed during drilling
  - Total Head in sand formation equals observed piezometric level (or if not observed, ground surface elevation)

Diversion Channel Stability

- Slope Stability computed using Spencer's Method with the Optimization function
- Two Factors of Safety's were analyzed for slope stability using entry/exit slip surface
  - Global Failure is indicated by slip surface initiating above 3/4 of the slope
  - Localized Failure is indicated by slip surfaces initiating in below 3/4 of the slope and 5' above bottom of channel
- Undrained global failure is indicated by a slip surface initiating above 1/2 of the slope
- Factor of Safety against uplift/heave was calculated for Sections containing a sand seam. Both short and long term Factor of Safety's were computed.

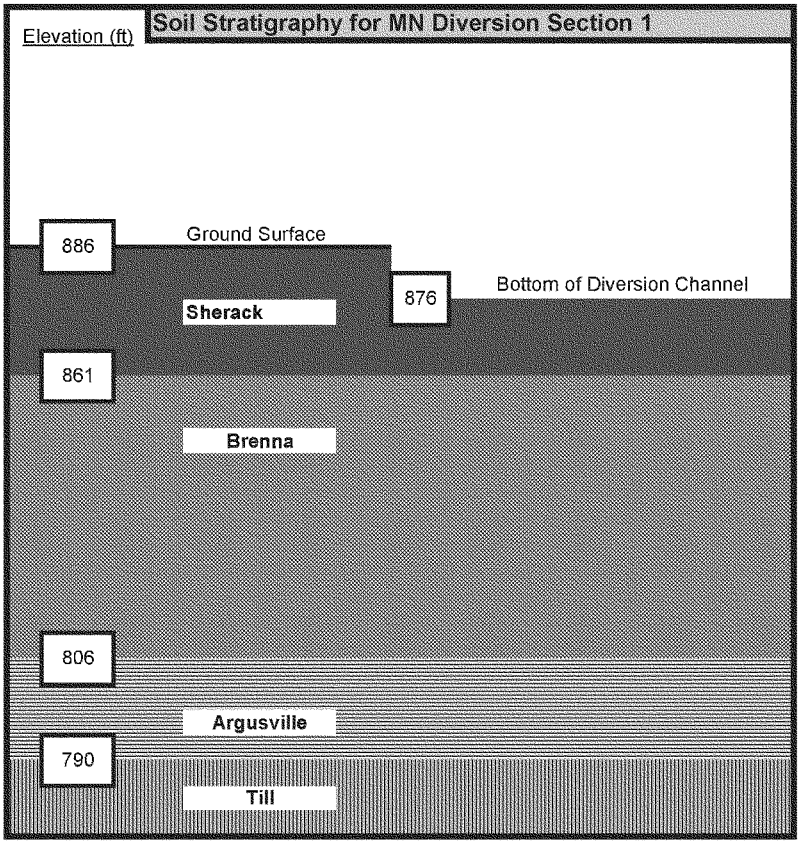
MN Diversion Channel Model Results

Cross-Section	Channel Bottom Width [ft]	Ground Surface Elevation [ft]	Water Table Depth [ft]	Channel Elevation [ft]	Elevation of Sand Formation [ft]	Channel Depth [ft]	Total Seepage into Channel [ft²/sec]	Total Seepage into Channel [gal/day/LF]	Y-Gradient	Total Head in Sand at Bottom of Channel [ft]	Factor of Safety: Piping	Factor of Safety: Uplift/Heave Short Term	Factor of Safety: Uplift/Heave Long Term	Factor of Safety: Long Term / Drained Slope Stability: Global - Circular Opt	Global - Circular	Global Wedge Opt	Global Wedge	Localized Circular Opt	Localized Circular	Factor of Safety: Short Term / Undrained Slope Stability: Global Circular Opt	Global Circular	Extents for Failure Surface: Global	Local	Undrained
1	500	886	881.5	876		10	9.8473E-09	0.013	0.012		55.56			1.722	1.746			1.897		1.935	1.967	891	891	899
2	500	911	906.1	882	849	29	3.4786E-06	4.497	0.51	864.676	1.30	1.21	1.79	0.986	0.928			0.366	0.408	1.607	1.693	911	892	902
3	500	913	906.9	886		27	4.5601E-09	0.059	0.09		7.56			1.201	1.206	1.204	1.321	1.083	1.098	1.325	1.350	914	895	905
4	500	910	906.6	892	864	18	1.6371E-06	2.116	0.10	893.061	6.80	1.61	17.59	2.699	2.705			2.484	2.536	2.874	3.142	913	899	905

F_{tot} = 104

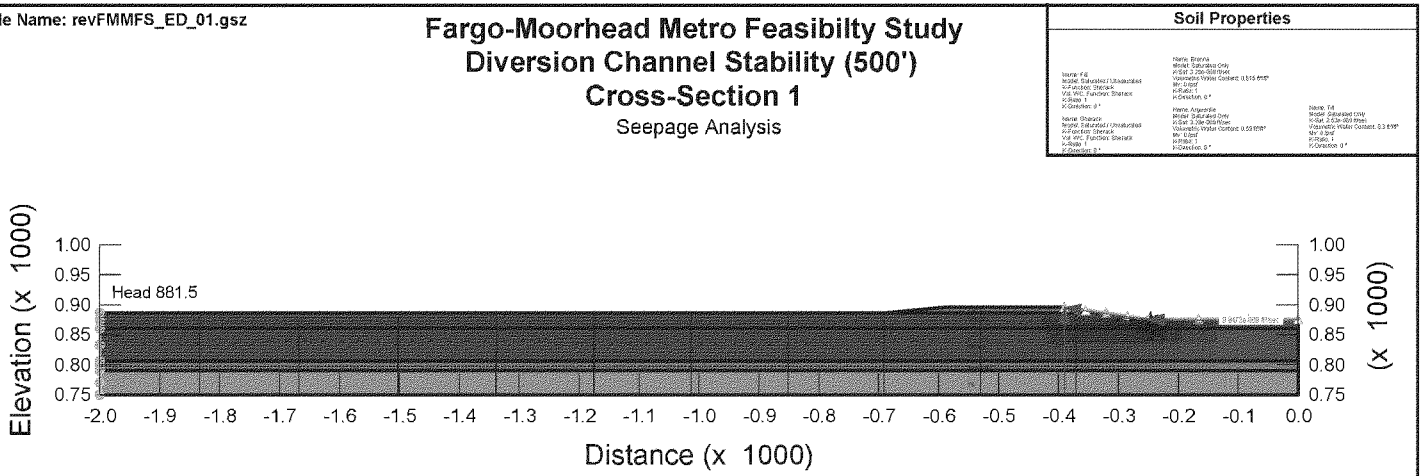
* Note: No Uplift/Heave was calculated for sections 1 and 3 due to the fact that there was no sand seam or permeable layer.

Cross-Section	Channel Bottom Width [ft]	Ground Surface Elevation [ft]	Water Table Depth [ft]	Channel Elevation [ft]	Elevation of Sand Formation [ft]	Channel Depth [ft]	Total Seepage into Channel [ft²/sec]	Total Seepage into Channel [gal/day/LF]	Y-Gradient	Total Head in Sand at Bottom of Channel [ft]	Factor of Safety: Piping	Factor of Safety: Uplift/Heave Short Term	Factor of Safety: Uplift/Heave Long Term	Factor of Safety: Long Term / Drained Slope Stability: Global - Circular Opt	Global - Circular	Global Wedge Opt	Global Wedge	Localized Circular Opt	Localized Circular	Factor of Safety: Short Term / Undrained Slope Stability: Global Circular Opt	Global Circular	Extents for Failure Surface: Global	Local	Undrained
2	500	911	906.1	882	849	29	3.7446E-06	4.840	0.44	863.501	1.52	1.26	1.97	1.390	1.577			1.041	1.138	2.189	2.662	911	892	902
3	500	913	906.9	886		27	4.4353E-08	0.057	0.08		8.70			1.370	1.463	1.434	1.581	1.462	1.503	1.467	1.511	914	895	905

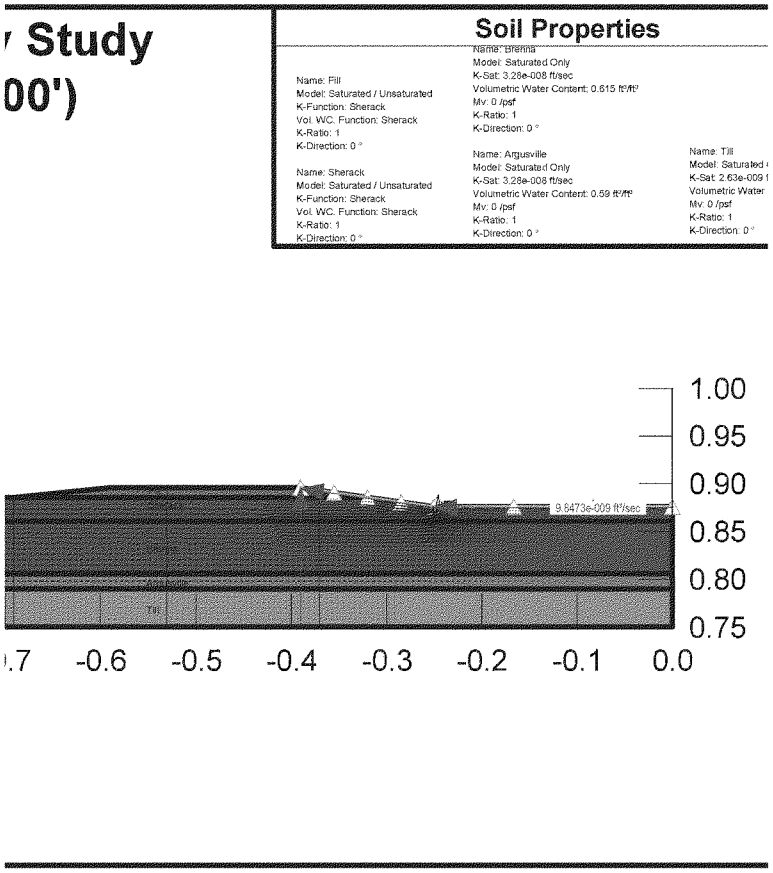

Soil Stratigraphy for MN Diversion Section 1
Elevation (ft)
886
Ground Surface
876
Bottom of Diversion Channel
Sherack
861
Brenna
806
Argusville
790
Till

File Name: revFMMFS_ED_01.gsz

Fargo-Moorhead Metro Feasibilty Study
Diversion Channel Stability (500')
Cross-Section 1
Seepage Analysis



Created By: Heckendorf, Kurt A MVP
Last Edited By: Heckendorf, Kurt A MVP
Date: 12/28/2009



Study
00')
Soil Properties
Name: Fill
Model: Saturated / Unsaturated
K-Function: Sherack
Vol. WC. Function: Sherack
K-Ratio: 1
K-Direction: 0 °
Name: Sherack
Model: Saturated / Unsaturated
K-Function: Sherack
Vol. WC. Function: Sherack
K-Ratio: 1
K-Direction: 0 °
Name: Brenna
Model: Saturated Only
K-Sat: 3.28e-008 ft/sec
Volumetric Water Content: 0.615 ft³/ft³
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °
Name: Argusville
Model: Saturated Only
K-Sat: 3.28e-008 ft/sec
Volumetric Water Content: 0.59 ft³/ft³
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °
Name: Till
Model: Saturated
K-Sat: 2.63e-009
Volumetric Water
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °
9.8473e-009 ft³/sec
1.00
0.95
0.90
0.85
0.80
0.75
.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

' Study
00')

Soil Properties

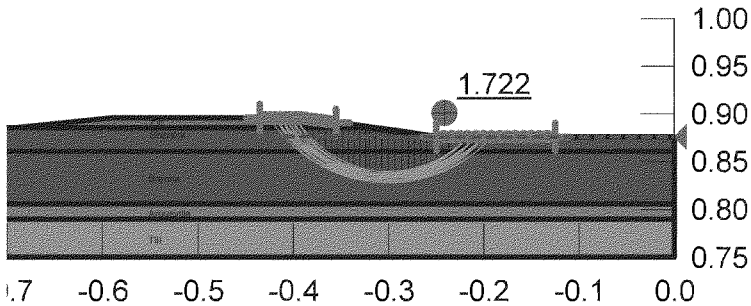
Name: Fill
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 28 °

Name: Brenna
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 13 °

Name: Sherack
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 28 °

Name: Argusville
Unit Weight: 106 pcf
Cohesion: 0 psf
Phi: 15 °

Name: Till
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 31 °



' Study
00')

Soil Properties

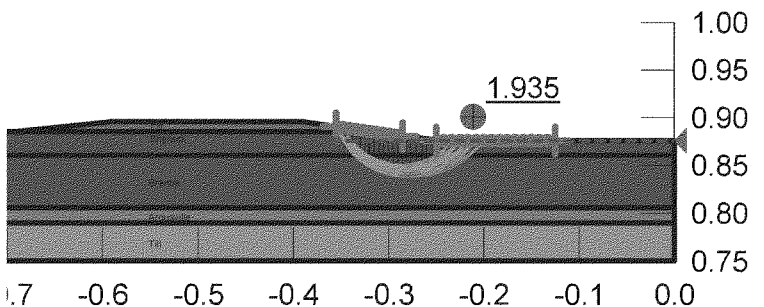
Name: Fill
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 28 °

Name: Sherack
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 28 °

Name: Brenna
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 13 °

Name: Argusville
Unit Weight: 106 pcf
Cohesion: 0 psf
Phi: 15 °

Name: Till
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 31 °



1342

' Study
00')

Soil Properties

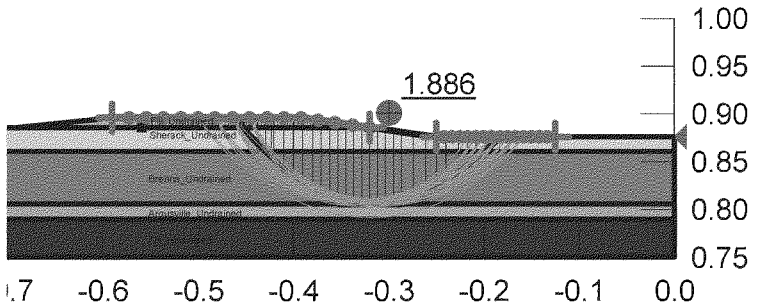
Name: Fill_Undrained
Unit Weight: 118 pcf
Cohesion: 1400 psf

Name: Brenna_Undrained
Unit Weight: 103 pcf
Cohesion: 650 psf

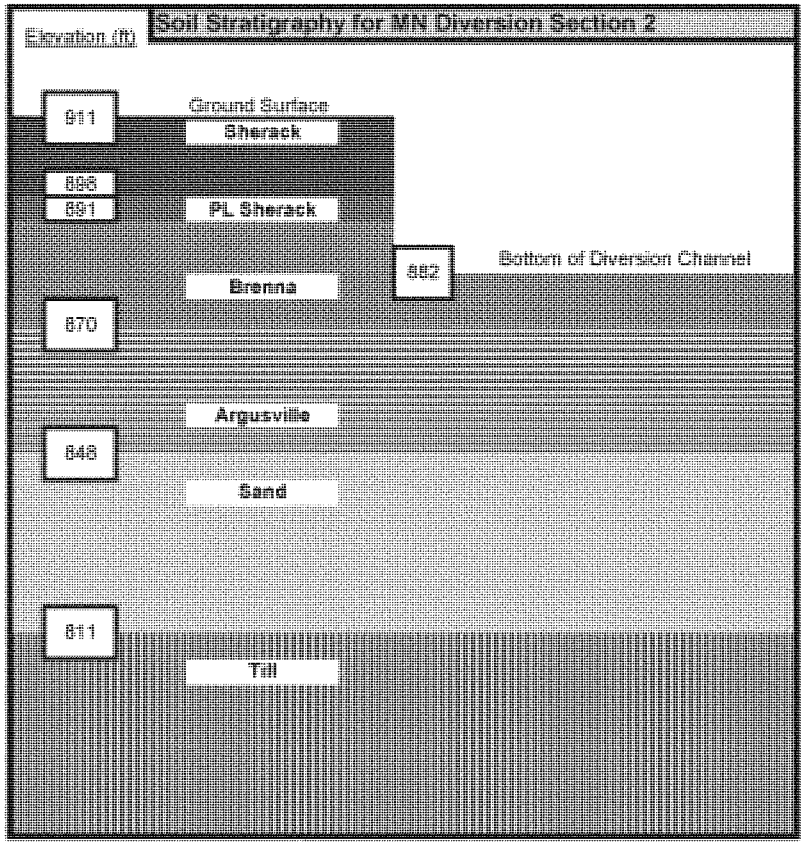
Name: Sherack_Undrained
Unit Weight: 118 pcf
Cohesion: 1400 psf

Name: Argusville_Undrained
Unit Weight: 106 pcf
Cohesion: 825 psf

Name: Till_
Unit Weight
Cohesion: 1

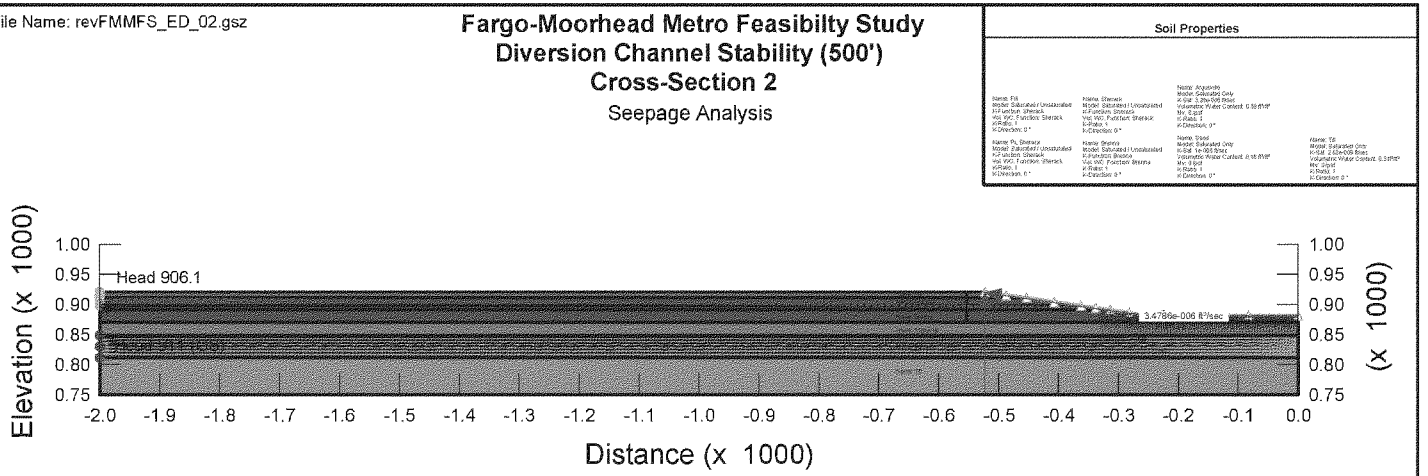


1343


Soil Stratigraphy for MN Diversion Section 2
Elevation (ft)
911
Ground Surface
Sherack
896
891
PL Sherack
882
Bottom of Diversion Channel
Brenna
870
Argusville
848
Sand
811
Till

File Name: revFMMFS_ED_02.gsz

Fargo-Moorhead Metro Feasibilty Study
Diversion Channel Stability (500')
Cross-Section 2
Seepage Analysis



Created By: Heckendorf, Kurt A MVP
Last Edited By: Heckendorf, Kurt A MVP
Date: 12/28/2009

1345

tudy
)

Soil Properties

Name: Fill
Model: Saturated / Unsaturated
K-Function: Sherack
Vol. WC. Function: Sherack
K-Ratio: 1
K-Direction: 0 °

Name: Sherack
Model: Saturated / Unsaturated
K-Function: Sherack
Vol. WC. Function: Sherack
K-Ratio: 1
K-Direction: 0 °

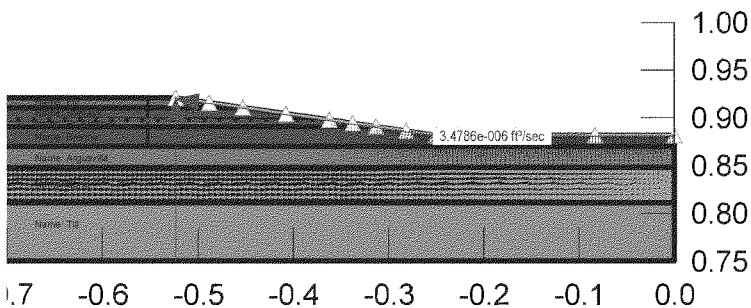
Name: Argusville
Model: Saturated Only
K-Sat: 3.28e-008 ft/sec
Volumetric Water Content: 0.59 ft³/ft³
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

Name: PL Sherack
Model: Saturated / Unsaturated
K-Function: Sherack
Vol. WC. Function: Sherack
K-Ratio: 1
K-Direction: 0 °

Name: Brenna
Model: Saturated / Unsaturated
K-Function: Brenna
Vol. WC. Function: Brenna
K-Ratio: 1
K-Direction: 0 °

Name: Sand
Model: Saturated Only
K-Sat: 1e-005 ft/sec
Volumetric Water Content: 0.16 ft³/ft³
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

Name: Till
Model: Saturated
K-Sat: 2.63e-009
Volumetric Water
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °



1346

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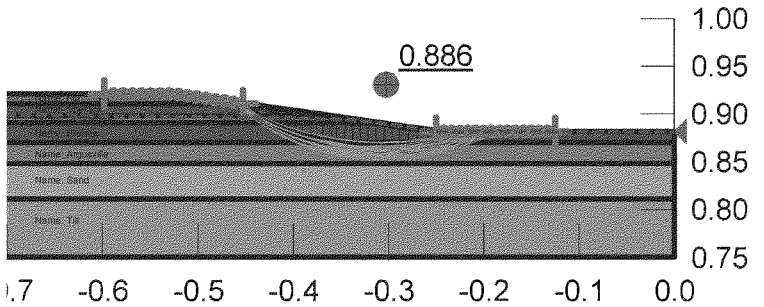
)

Soil Properties

Name: Fill Model: Mohr-Coulomb Unit Weight: 118 pcf Cohesion: 0 psf Phi: 28 ° Phi-B: 0 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 118 pcf Cohesion: 0 psf Phi: 28 ° Phi-B: 0 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 106 pcf Cohesion: 0 psf Phi: 15 ° Phi-B: 0 °	
Name: PL Sherack Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion: 0 psf Phi: 19 ° Phi-B: 0 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 ° Phi-B: 0 °	Name: Sand Model: Mohr-Coulomb Unit Weight: 128 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 °	Name: Till Model: Mohr-Coul Unit Weight: 122 Cohesion: 0 psf Phi: 31 ° Phi-B: 0 °



1347

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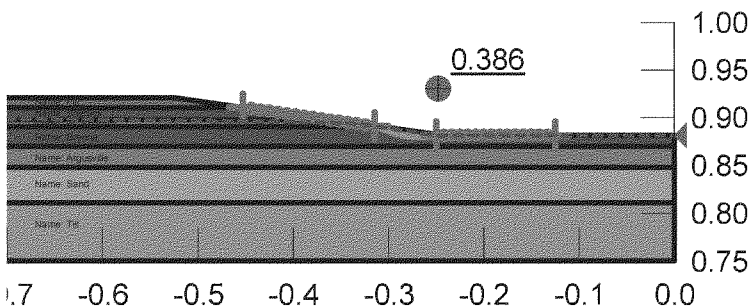
)

Soil Properties

Name: Fill Model: Mohr-Coulomb Unit Weight: 118 pcf Cohesion: 0 psf Phi: 28 ° Phi-B: 0 °	Name: Sherack Model: Mohr-Coulomb Unit Weight: 118 pcf Cohesion: 0 psf Phi: 28 ° Phi-B: 0 °	Name: Argusville Model: Mohr-Coulomb Unit Weight: 106 pcf Cohesion: 0 psf Phi: 15 ° Phi-B: 0 °	
Name: PL Sherack Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion: 0 psf Phi: 19 ° Phi-B: 0 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 ° Phi-B: 0 °	Name: Sand Model: Mohr-Coulomb Unit Weight: 128 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 °	Name: Till Model: Mohr-Coul Unit Weight: 122 Cohesion: 0 psf Phi: 31 ° Phi-B: 0 °



1348

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)

Soil Properties

Name: Fill_Undrained
Model: Undrained (Phi=0)
Unit Weight: 118 pcf
Cohesion: 1400 psf

Name: Sherack_Undrained
Model: Undrained (Phi=0)
Unit Weight: 118 pcf
Cohesion: 1400 psf

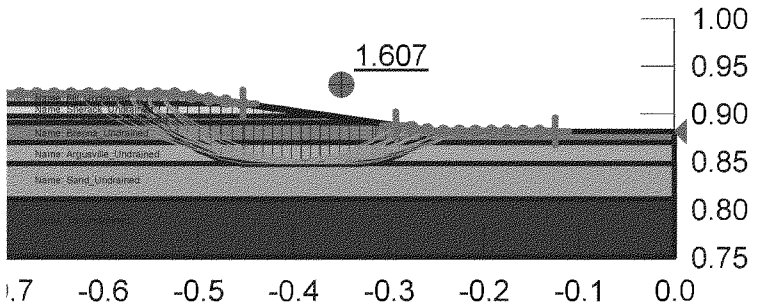
Name: Argusville_Undrained
Model: Undrained (Phi=0)
Unit Weight: 106 pcf
Cohesion: 825 psf

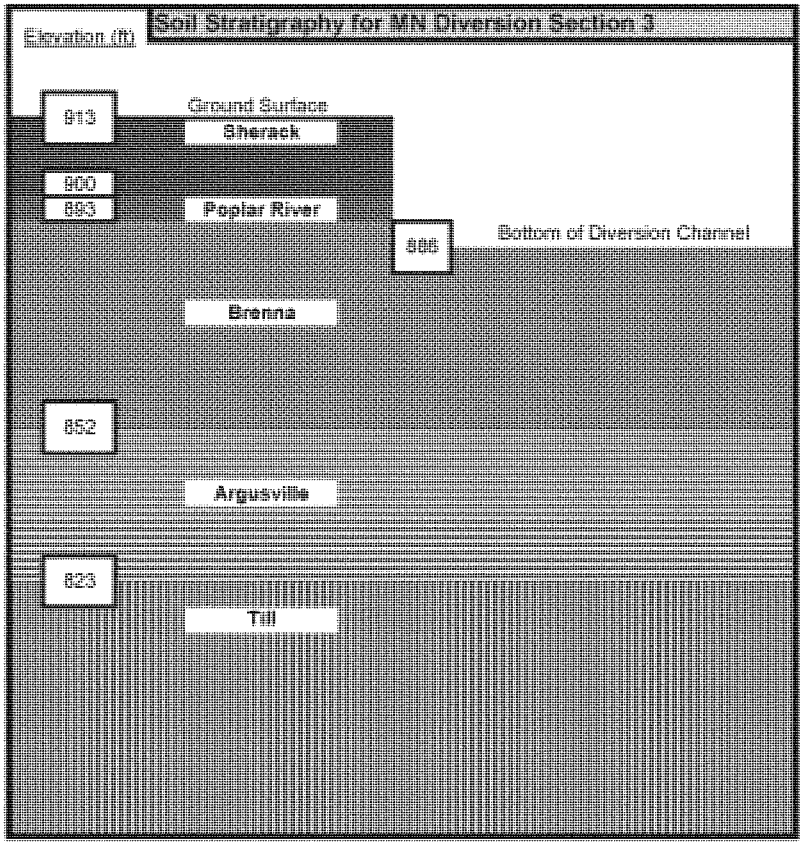
Name: PL Sherack_Undrained
Model: Undrained (Phi=0)
Unit Weight: 112 pcf
Cohesion: 1150 psf

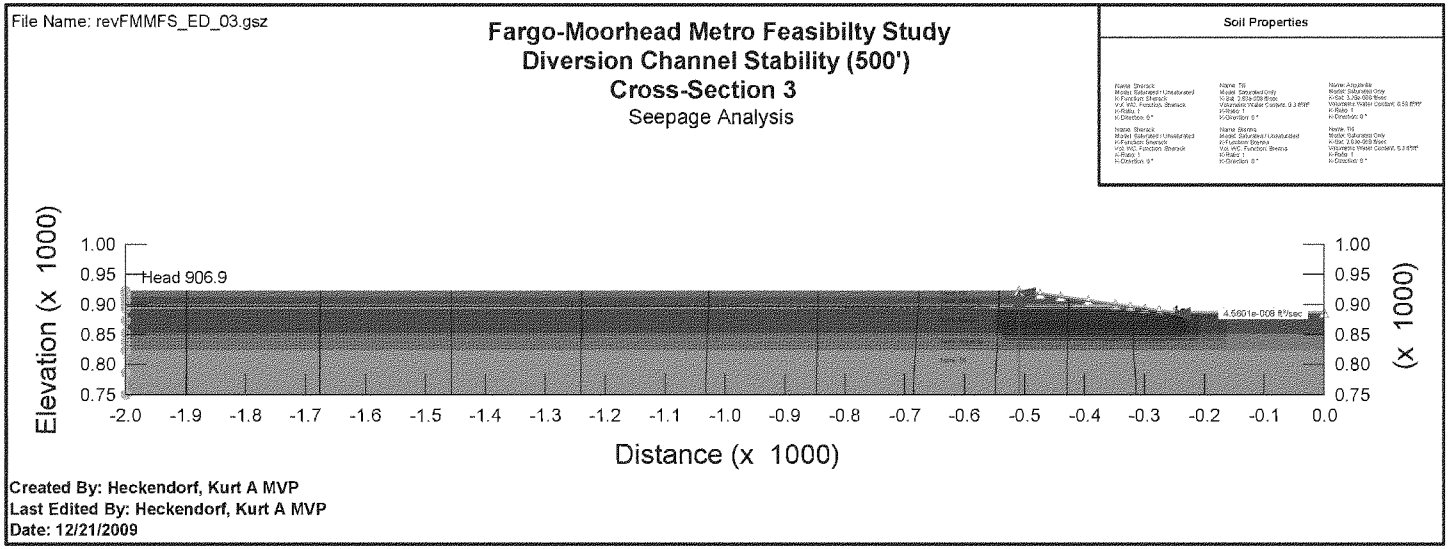
Name: Brenna_Undrained
Model: Undrained (Phi=0)
Unit Weight: 103 pcf
Cohesion: 650 psf

Name: Sand_Undrained
Model: Mohr-Coulomb
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °

Name: Till_Undra
Model: Undrained
Unit Weight: 122
Cohesion: 1900 p



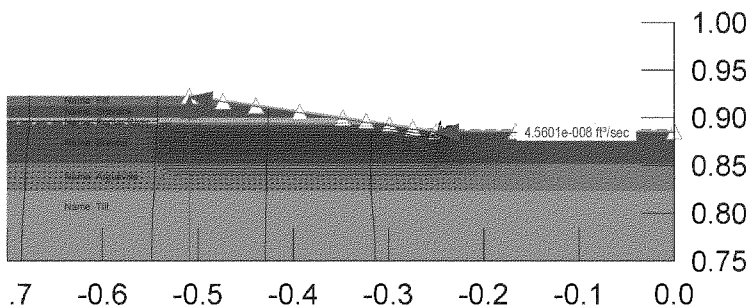

Soil Stratigraphy for MN Diversion Section 3
Elevation (ft)
913
Ground Surface
Sherack
900
893
Poplar River
886
Bottom of Diversion Channel
Brenna
852
Argusville
823
Till


File Name: revFMMFS_ED_03.gsz
Fargo-Moorhead Metro Feasibilty Study
Diversion Channel Stability (500')
Cross-Section 3
Seepage Analysis
Soil Properties
Elevation (x 1000)
1.00
0.95
0.90
0.85
0.80
0.75
Head 906.9
4.5601e-006 ft/sec
-2.0 -1.9 -1.8 -1.7 -1.6 -1.5 -1.4 -1.3 -1.2 -1.1 -1.0 -0.9 -0.8 -0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0.0
Distance (x 1000)
(x 1000)
Created By: Heckendorf, Kurt A MVP
Last Edited By: Heckendorf, Kurt A MVP
Date: 12/21/2009

tudy
)

Soil Properties

Name: Sherack Model: Saturated / Unsaturated K-Function: Sherack Vol. WC. Function: Sherack K-Ratio: 1 K-Direction: 0 °	Name: Till Model: Saturated Only K-Sat: 2.63e-009 ft/sec Volumetric Water Content: 0.3 ft³/ft³ K-Ratio: 1 K-Direction: 0 °	Name: Argusville Model: Saturated Or K-Sat: 3.28e-008 ft/s Volumetric Water Co K-Ratio: 1 K-Direction: 0 °
Name: Sherack Model: Saturated / Unsaturated K-Function: Sherack Vol. WC. Function: Sherack K-Ratio: 1 K-Direction: 0 °	Name: Brenna Model: Saturated / Unsaturated K-Function: Brenna Vol. WC. Function: Brenna K-Ratio: 1 K-Direction: 0 °	Name: Till Model: Saturated Or K-Sat: 2.63e-009 ft/s Volumetric Water Co K-Ratio: 1 K-Direction: 0 °



1352

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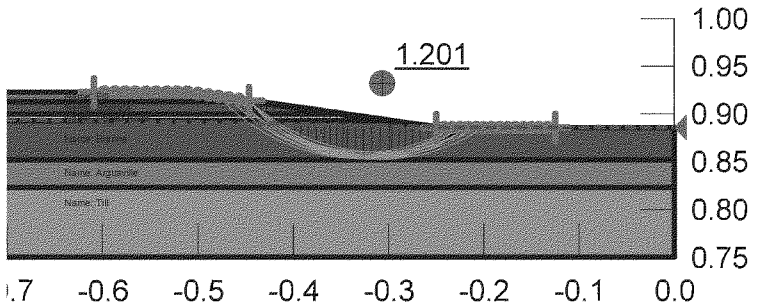
)

Soil Properties

Name: Sherack Model: Mohr-Coulomb Unit Weight: 118 pcf Cohesion: 0 psf Phi: 28 ° Phi-B: 0 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 ° Phi-B: 0 °	Name: Argusville Model: Mohr-Coulon Unit Weight: 106 pcf Cohesion: 0 psf Phi: 15 °
Name: Sherack Model: Mohr-Coulomb Unit Weight: 118 pcf Cohesion: 0 psf Phi: 28 ° Phi-B: 0 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 ° Phi-B: 0 °	Name: Till Model: Mohr-Coulon Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 ° Phi-B: 0 °

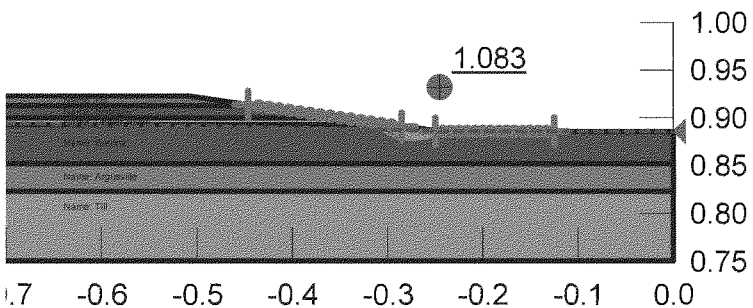


1353

tudy
)

Soil Properties

Name: Sherack Model: Mohr-Coulomb Unit Weight: 118 pcf Cohesion: 0 psf Phi: 28 ° Phi-B: 0 °	Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 ° Phi-B: 0 °	Name: Argusville Model: Mohr-Coulon Unit Weight: 106 pcf Cohesion: 0 psf Phi: 15 °
Name: Sherack Model: Mohr-Coulomb Unit Weight: 118 pcf Cohesion: 0 psf Phi: 28 ° Phi-B: 0 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 ° Phi-B: 0 °	Name: Till Model: Mohr-Coulon Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 ° Phi-B: 0 °



1354

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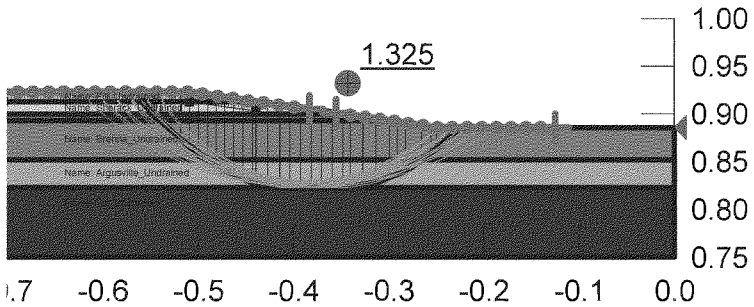
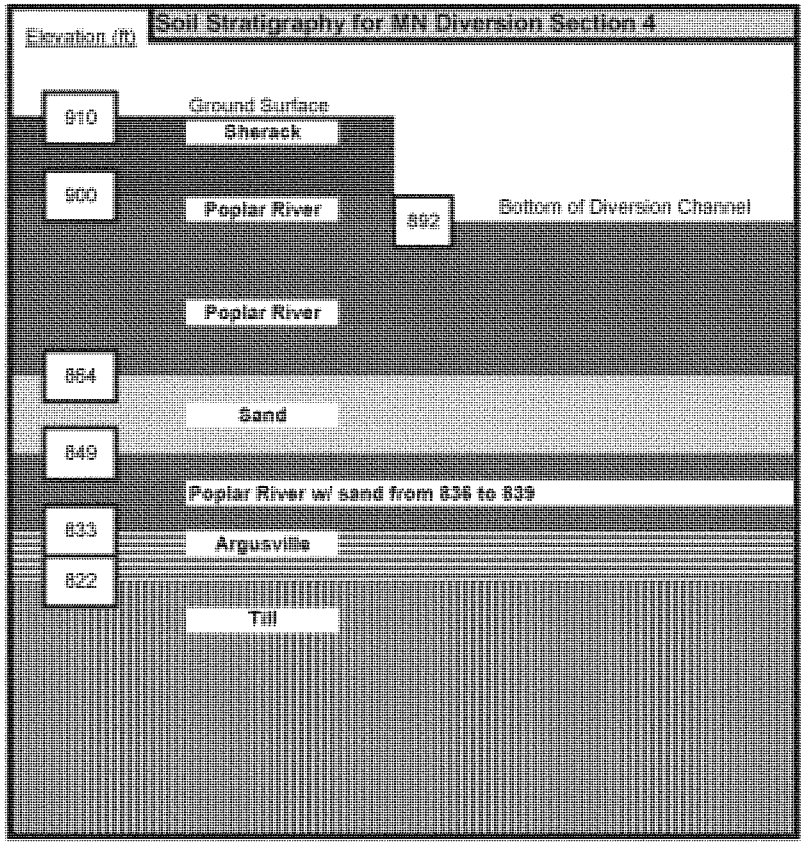
)

Soil Properties

Name: Sherack_Undrained Model: Undrained (Phi=0) Unit Weight: 118 pcf Cohesion: 1400 psf	Name: Till_Undrained Model: Undrained (Phi=0) Unit Weight: 122 pcf Cohesion: 1900 psf	Name: Argusville_U Model: Undrained (F Unit Weight: 106 pcf Cohesion: 825 psf
Name: Sherack_Undrained Model: Undrained (Phi=0) Unit Weight: 118 pcf Cohesion: 1400 psf	Name: Brenna_Undrained Model: Undrained (Phi=0) Unit Weight: 103 pcf Cohesion: 650 psf	Name: Till_Undraine Model: Undrained (F Unit Weight: 122 pcf Cohesion: 1900 psf

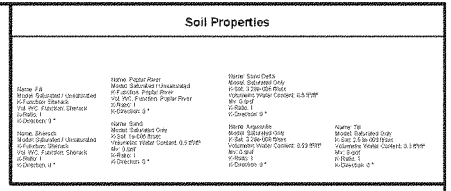


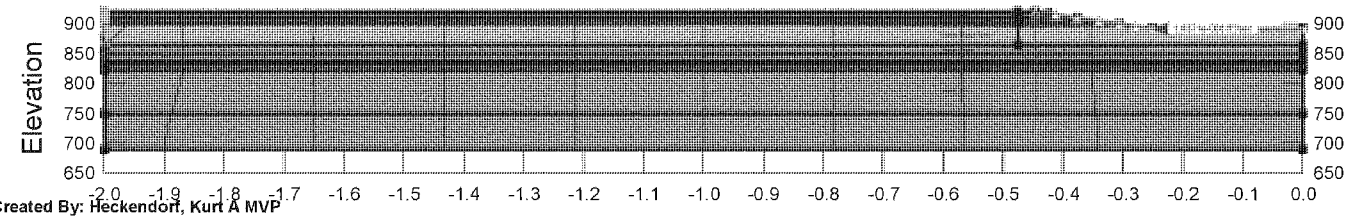
1355


Elevation (ft)
Soil Stratigraphy for MN Diversion Section 4
910
Ground Surface
Sherack
900
Poplar River
892
Bottom of Diversion Channel
Poplar River
864
Sand
849
Poplar River w/ sand from 836 to 839
833
Argusville
822
Till

File Name: revFMMFS_ED_04.gsz

Fargo-Moorhead Metro Feasibilty Study
Diversion Channel Stability (500')
Cross-Section 4
Seepage Analysis





Created By: Heckendorf, Kurt A MVP
Last Edited By: Heckendorf, Kurt A MVP
Date: 12/21/2009

1357

udy

)

Soil Properties

Name: Fill
Model: Saturated / Unsaturated
K-Function: Sherack
Vol. WC. Function: Sherack
K-Ratio: 1
K-Direction: 0 °

Name: Sherack
Model: Saturated / Unsaturated
K-Function: Sherack
Vol. WC. Function: Sherack
K-Ratio: 1
K-Direction: 0 °

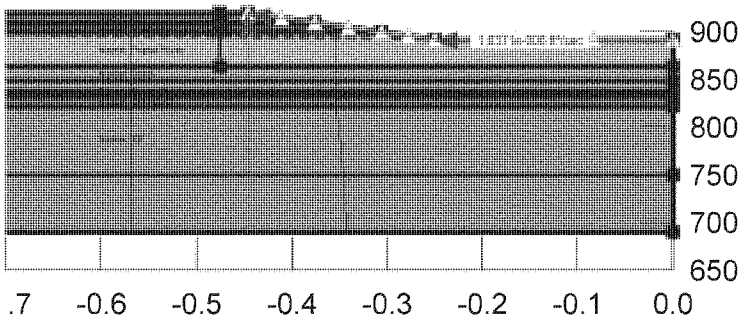
Name: Poplar River
Model: Saturated / Unsaturated
K-Function: Poplar River
Vol. WC. Function: Poplar River
K-Ratio: 1
K-Direction: 0 °

Name: Sand
Model: Saturated Only
K-Sat: 1e-005 ft/sec
Volumetric Water Content: 0.5 ft³/ft³
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

Name: Sand Delta
Model: Saturated Only
K-Sat: 3.28e-006 ft/sec
Volumetric Water Content: 0.5 ft³/ft³
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

Name: Argusville
Model: Saturated Only
K-Sat: 3.28e-008 ft/sec
Volumetric Water Content: 0.59 ft³/ft³
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

Name: Till
Model: Saturated
K-Sat: 2.63e-009 f
Volumetric Water
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °



1358

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Soil Properties

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °

Name: Poplar River
Model: Mohr-Coulomb
Unit Weight: 116 pcf
Cohesion: 0 psf
Phi: 26 °
Phi-B: 0 °

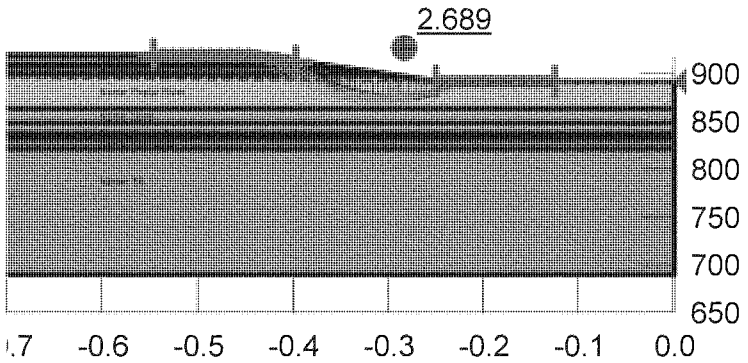
Name: Sand Delta
Model: Mohr-Coulomb
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °

Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °

Name: Sand
Model: Mohr-Coulomb
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °

Name: Argusville
Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion: 0 psf
Phi: 15 °
Phi-B: 0 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 31 °
Phi-B: 0 °



1359

udy

Soil Properties

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °

Name: Poplar River
Model: Mohr-Coulomb
Unit Weight: 116 pcf
Cohesion: 0 psf
Phi: 26 °
Phi-B: 0 °

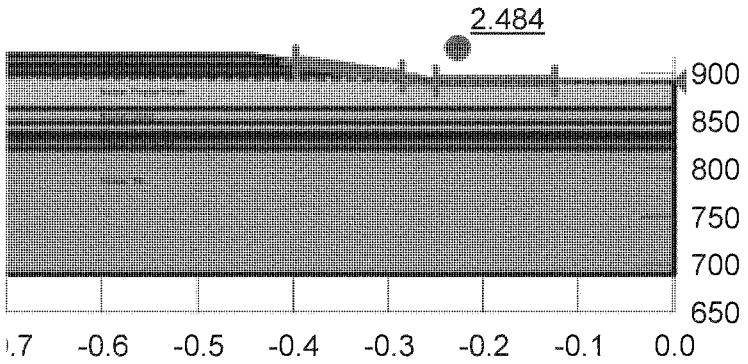
Name: Sand Delta
Model: Mohr-Coulomb
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 26 °
Phi-B: 0 °

Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °

Name: Sand
Model: Mohr-Coulomb
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °

Name: Argusville
Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion: 0 psf
Phi: 15 °
Phi-B: 0 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 31 °
Phi-B: 0 °



1360

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)

Soil Properties

Name: Fill_Undrained
Model: Undrained (Phi=0)
Unit Weight: 118 pcf
Cohesion: 1400 psf

Name: Sherack_Undrained
Model: Undrained (Phi=0)
Unit Weight: 118 pcf
Cohesion: 1400 psf

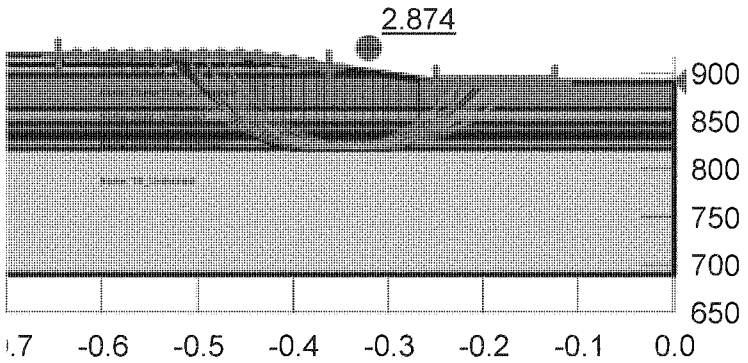
Name: Poplar River_Undrained
Model: Undrained (Phi=0)
Unit Weight: 116 pcf
Cohesion: 1450 psf

Name: Sand_Undrained
Model: Mohr-Coulomb
Unit Weight: 126 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °

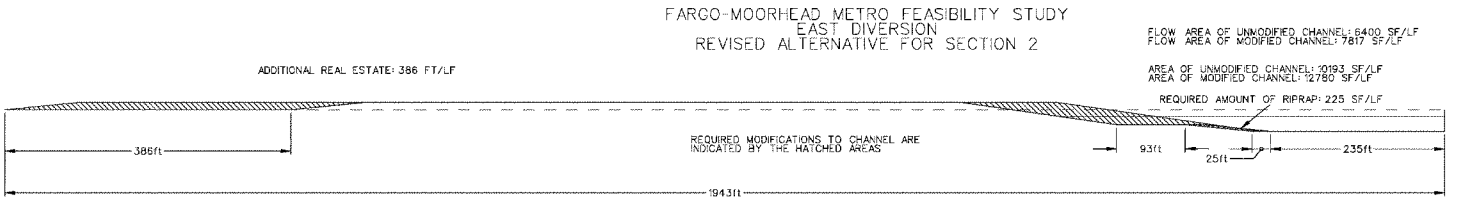
Name: Sand Delta
Model: Mohr-Coulomb
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 26 °
Phi-B: 0 °

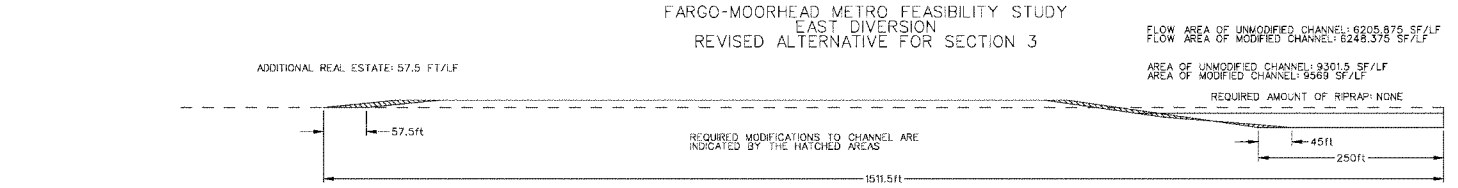
Name: Argusville_Undrained
Model: Undrained (Phi=0)
Unit Weight: 106 pcf
Cohesion: 825 psf

Name: Till_Undrained
Model: Undrained (Phi=0)
Unit Weight: 122 pcf
Cohesion: 1900 psf



1361


FARGO-MOORHEAD METRO FEASIBILITY STUDY
EAST DIVERSION
REVISED ALTERNATIVE FOR SECTION 2
FLOW AREA OF UNMODIFIED CHANNEL: 6400 SF/LF
FLOW AREA OF MODIFIED CHANNEL: 7817 SF/LF
ADDITIONAL REAL ESTATE: 386 FT/LF
AREA OF UNMODIFIED CHANNEL: 10193 SF/LF
AREA OF MODIFIED CHANNEL: 12780 SF/LF
REQUIRED AMOUNT OF RIPRAP: 225 SF/LF
386ft
REQUIRED MODIFICATIONS TO CHANNEL ARE
INDICATED BY THE HATCHED AREAS
93ft
25ft
235ft
1943ft


FARGO-MOORHEAD METRO FEASIBILITY STUDY
EAST DIVERSION
REVISED ALTERNATIVE FOR SECTION 3
FLOW AREA OF UNMODIFIED CHANNEL: 6205.875 SF/LF
FLOW AREA OF MODIFIED CHANNEL: 6248.375 SF/LF
ADDITIONAL REAL ESTATE: 57.5 FT/LF
AREA OF UNMODIFIED CHANNEL: 9301.5 SF/LF
AREA OF MODIFIED CHANNEL: 9569 SF/LF
REQUIRED AMOUNT OF RIPRAP: NONE
57.5ft
REQUIRED MODIFICATIONS TO CHANNEL ARE
INDICATED BY THE HATCHED AREAS
45ft
250ft
1511.5ft

Fargo-Moorhead Metro Feasibility Study

Minnesota Diversion Alternative Configurations

Computed By: KAH
Date: 4-Sep-08

Revised By: KAH
Date: 19-Mar-10

Due to seepage & slope stability concerns, the configuration of the diversion channel had to be modified
Based on discussion with Mike Lesher (3 SEP 09), the configuration of the channel could be modifed but the flow area should be kept the same
Elevations for the ground surfce, channel bottom, and water surface profile along the diversion were obtained from Moore Enginnering's MN Short Diversion calculation:

Summary of Required Modifications

	MN Short Diversion					Quantities Based on 1/2 of the Diversion Channel											
Section	Location (FT)	Ground Elevation (FT)	Bottom of Channel (FT)	Water Profile (FT)	Required Modification	Original Channel Width (FT)	Modified Channel Width (FT)	% Decrease	Original Flow Area (SF/LF)	Modified Flow Area (SF/LF)	% Increase	Original Excavation (SF/LF)	Modified Excavation (SF/LF)	% Increase	Original Real Estate (FT)	Modified Real Estate (FT)	% Increase	Required Riprap (SF/LF)
2	69000	911	882	902	Slope in Brenna flatten to 1V:10H, 9 FT up; 25 FT wide riprap berm added to slope cut in Brenna; 118 FT bench	250	235	6.0%	6,400	**7,817**	22.13%	10,193	**12,780**	25.38%	1,557	**1,943**	24.79%	**225**
3	96000	913	886	905.5	Slope in Brenna flatten to 1V:12H, 14 FT up	250	205	18.0%	6,206	**6,248**	0.68%	9,302	**9,569**	2.88%	1,454	**1,512**	3.95%	**0**

	MN Short Diversion					Quantities Based on the FULL Diversion Channel											
Section	Location (FT)	Ground Elevation (FT)	Bottom of Channel (FT)	Water Profile (FT)	Required Length of Modification (FT)	Original Channel Width (FT)	Modified Channel Width (FT)	% Decrease	Original Flow Area (SF/LF)	Modified Flow Area (SF/LF)	% Increase	Original Excavation (CY)	Modified Excavation (CY)	% Increase	Original Real Estate (ACRE)	Modified Real Estate (SF)	% Increase	Required Riprap (CY)
2	69000	911	882	902	16,000	500	470	6.0%	12,800	**15,633**	22.13%	12,080,593	**15,146,667**	25.38%	1,144	**1,427**	24.79%	**266,667**
3	96000	913	886	905.5	73,500	500	410	18.0%	12,412	**12,497**	0.68%	50,641,500	**52,097,889**	2.88%	4,907	**5,101**	3.95%	**0**

Mod Type	Start	End	Length	
3	35,500	65,000	29,500	22%
2	65,000	81,000	16,000	12%
3	81,000	125,000	44,000	33%
			89,500	66.9%

Total Diversion Channel Length 133,745
44,245

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

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Fargo-Moorhead Metro Feasibility Study

Minnesota Diversion Alternative Lengths

Computed By: KAH Revised By:
Date: 4-Sep-09 Date:

Sounding	Location	Elevation	Bottom Elevation	Top of Sherack		Top of Brenna		Notes	
09-11C	0	888.2	875	-6	882.2	-25	863.2		
09-27C	3400	886.2	875	-5	881.2	-29	857.2		
09-28C	9000	888.4	876	-8	880.4	-30	858.4		
09-30C	15000	892.4	877	-6	886.4	-33	859.4		
09-29C	20100	891	877	-6	885	-38	853		
09-12C	24500	894	878	-2	892	-29.5	864.5		
09-31C	30100	895.8	878	-3	892.8	-26	869.8		
09-35C	35500	902.4	878	-4	898.4	-28	874.4	Questionable	Start Mod #3 at 35500
09-33C	50000	907.3	880	-2	905.3	-32	875.3	Questionable	
09-37C	57100	909.7	880	-2	907.7	-17	892.7	Brenna exposed	
09-38C	62500	907.8	881		907.8	-23	884.8	Brenna exposed	Continue with Mod #3 to 65000
09-14C	67600	913.1	882	-3	910.1	-28	885.1	Sand below	Start Mod #2 at 65000
09-39C	73000	910.5	883		910.5	-17	893.5	Brenna exposed	
09-40C	78700	912.8	883	-3	909.8	-20	892.8	Sand below	Continue with Mod #2 to 81000
09-42C	84100	912.2	884		912.2	-15	897.2	Brenna exposed	Start Mod #3 at 81000
09-43C	90000	912.7	885		912.7	-17	895.7	Brenna exposed	
09-15C	95000	914.9	886	-3.5	911.4	-14.5	900.4	Brenna exposed	
09-44C	100000	915.8	887		915.8	-15	900.8	Brenna exposed	
09-45C	108000	920.4	888		920.4	-19	901.4	Brenna exposed	
09-46C	114000	916.5	890		916.5	-18	898.5	Brenna exposed	
09-48C	120000	912.7	891		912.7	-20	892.7	Brenna exposed	Continue with Mod #3 to 125000
09-50C	130250	913.4	893		913.4	-26	887.4		
09-51C	133000	911.8	893		911.8	-25	886.8		

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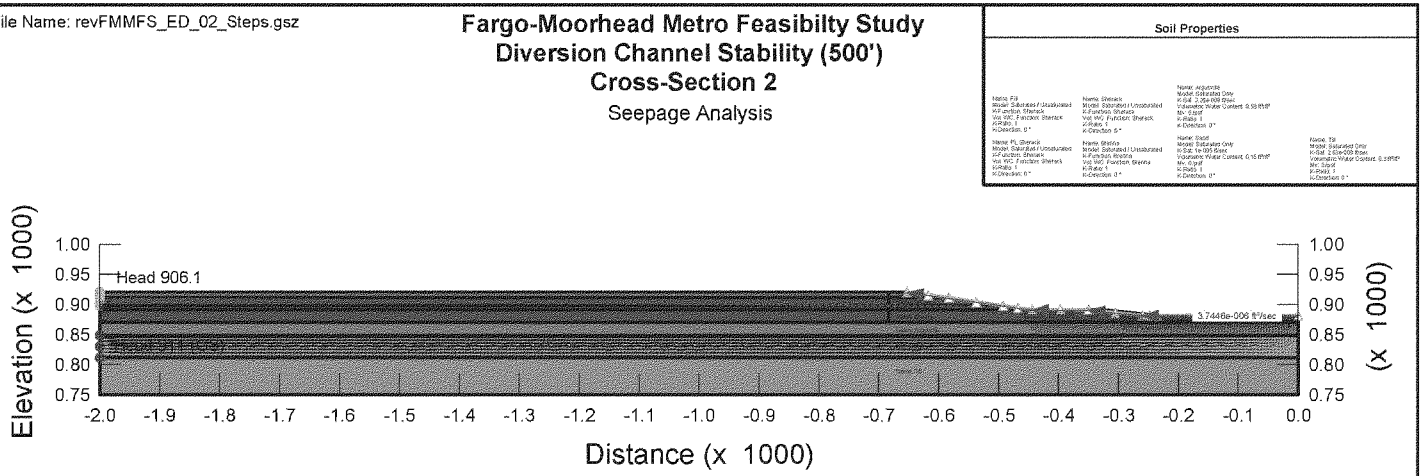
Fargo-Moorhead Metro Feasibilty Study
Diversion Channel Stability (500')
Cross-Section 2
Seepage Analysis



Created By: Heckendorf, Kurt A MVP
Last Edited By: Heckendorf, Kurt A MVP
Date: 12/28/2009

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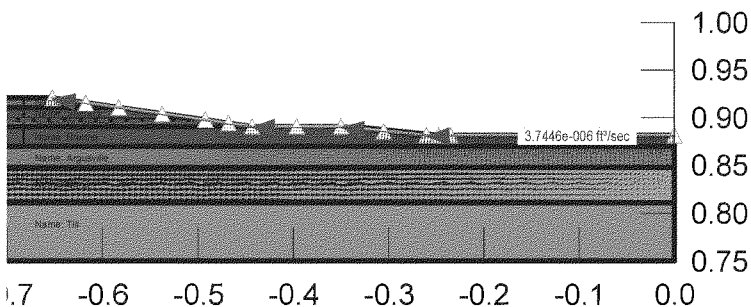
Soil Properties

Name: Fill Model: Saturated / Unsaturated K-Function: Sherack Vol. WC. Function: Sherack K-Ratio: 1 K-Direction: 0 °	Name: Sherack Model: Saturated / Unsaturated K-Function: Sherack Vol. WC. Function: Sherack K-Ratio: 1 K-Direction: 0 °	Name: Argusville Model: Saturated Only K-Sat: 3.28e-008 ft/sec Volumetric Water Content: 0.59 ft³/ft³ Mv: 0 /psf K-Ratio: 1 K-Direction: 0 °	
Name: PL Sherack Model: Saturated / Unsaturated K-Function: Sherack Vol. WC. Function: Sherack K-Ratio: 1 K-Direction: 0 °	Name: Brenna Model: Saturated / Unsaturated K-Function: Brenna Vol. WC. Function: Brenna K-Ratio: 1 K-Direction: 0 °	Name: Sand Model: Saturated Only K-Sat: 1e-005 ft/sec Volumetric Water Content: 0.16 ft³/ft³ Mv: 0 /psf K-Ratio: 1 K-Direction: 0 °	Name: Till Model: Saturated K-Sat: 2.63e-009 Volumetric Water Mv: 0 /psf K-Ratio: 1 K-Direction: 0 °



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Soil Properties

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °

Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °

Name: Argusville
Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion: 0 psf
Phi: 15 °
Phi-B: 0 °

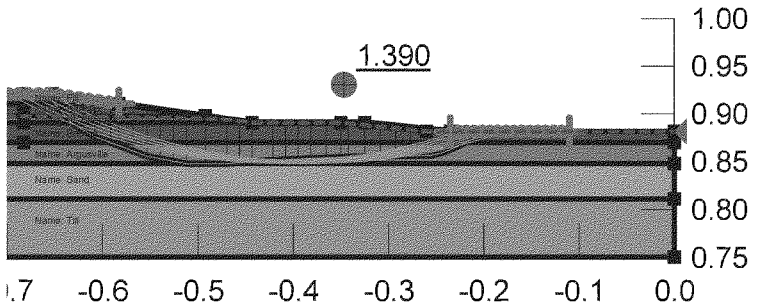
Name: Riprap
Model: Mohr-Coul
Unit Weight: 125 p
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °

Name: PL Sherack
Model: Mohr-Coulomb
Unit Weight: 112 pcf
Cohesion: 0 psf
Phi: 19 °
Phi-B: 0 °

Name: Brenna
Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 13 °
Phi-B: 0 °

Name: Sand
Model: Mohr-Coulomb
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °

Name: Till
Model: Mohr-Coul
Unit Weight: 122 p
Cohesion: 0 psf
Phi: 31 °
Phi-B: 0 °



1367

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Soil Properties

Name: Fill
Model: Mohr-Coulomb
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °

Name: Sherack
Model: Mohr-Coulomb
Unit Weight: 118 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °

Name: Argusville
Model: Mohr-Coulomb
Unit Weight: 106 pcf
Cohesion: 0 psf
Phi: 15 °
Phi-B: 0 °

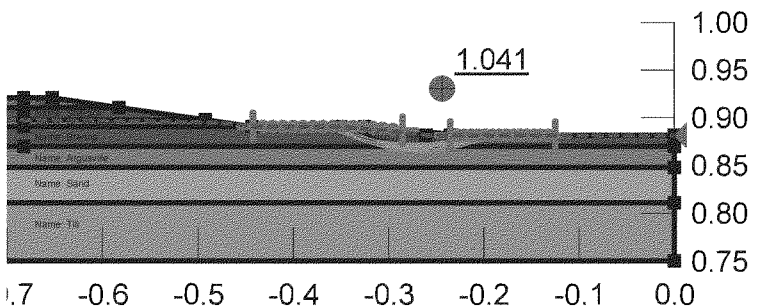
Name: Riprap
Model: Mohr-Coul
Unit Weight: 125
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °

Name: PL Sherack
Model: Mohr-Coulomb
Unit Weight: 112 pcf
Cohesion: 0 psf
Phi: 19 °
Phi-B: 0 °

Name: Brenna
Model: Mohr-Coulomb
Unit Weight: 103 pcf
Cohesion: 0 psf
Phi: 13 °
Phi-B: 0 °

Name: Sand
Model: Mohr-Coulomb
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °

Name: Till
Model: Mohr-Coul
Unit Weight: 122
Cohesion: 0 psf
Phi: 31 °
Phi-B: 0 °



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Soil Properties

Name: Riprap
Model: Mohr-Coul
Unit Weight: 125 p
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °

Name: Fill_Undrained
Model: Undrained (Phi=0)
Unit Weight: 118 pcf
Cohesion: 1400 psf

Name: Sherack_Undrained
Model: Undrained (Phi=0)
Unit Weight: 118 pcf
Cohesion: 1400 psf

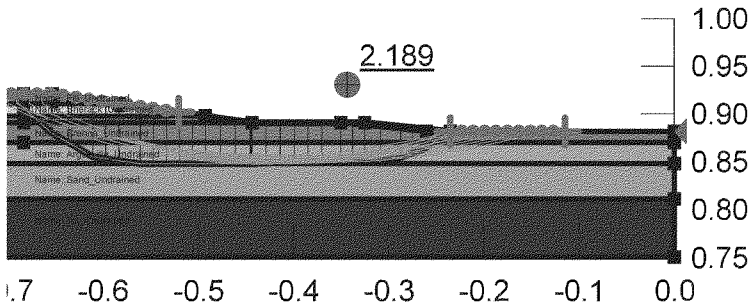
Name: Argusville_Undrained
Model: Undrained (Phi=0)
Unit Weight: 106 pcf
Cohesion: 825 psf

Name: Sand_Undrained
Model: Mohr-Coulomb
Unit Weight: 128 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °

Name: PL Sherack_Undrained
Model: Undrained (Phi=0)
Unit Weight: 112 pcf
Cohesion: 1150 psf

Name: Brenna_Undrained
Model: Undrained (Phi=0)
Unit Weight: 103 pcf
Cohesion: 650 psf

Name: Till_Undra
Model: Undrained
Unit Weight: 122 p
Cohesion: 1900 p



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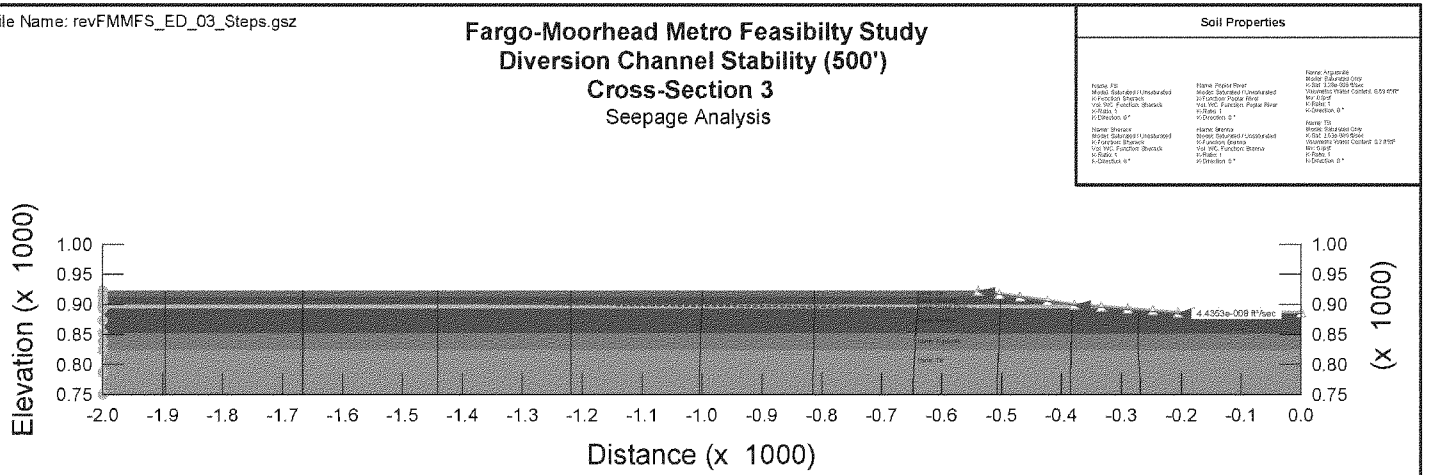
Fargo-Moorhead Metro Feasibilty Study
Diversion Channel Stability (500')
Cross-Section 3
Seepage Analysis



Created By: Heckendorf, Kurt A MVP
Last Edited By: Heckendorf, Kurt A MVP
Date: 12/28/2009

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Soil Properties

Name: Fill
Model: Saturated / Unsaturated
K-Function: Sherack
Vol. WC. Function. Sherack
K-Ratio: 1
K-Direction: 0 °

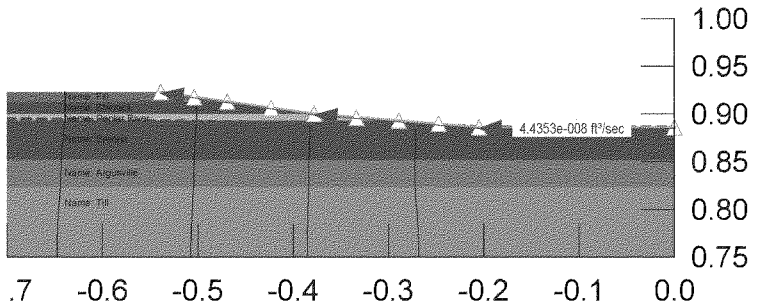
Name: Poplar River
Model: Saturated / Unsaturated
K-Function: Poplar River
Vol. WC. Function: Poplar River
K-Ratio: 1
K-Direction: 0 °

Name: Argusville
Model: Saturated Or
K-Sat: 3.28e-008 ft/s
Volumetric Water Cc
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °

Name: Sherack
Model: Saturated / Unsaturated
K-Function: Sherack
Vol. WC. Function: Sherack
K-Ratio: 1
K-Direction: 0 °

Name: Brenna
Model: Saturated / Unsaturated
K-Function: Brenna
Vol. WC. Function: Brenna
K-Ratio: 1
K-Direction: 0 °

Name: Till
Model: Saturated Or
K-Sat: 2.63e-009 ft/s
Volumetric Water Cc
Mv: 0 /psf
K-Ratio: 1
K-Direction: 0 °



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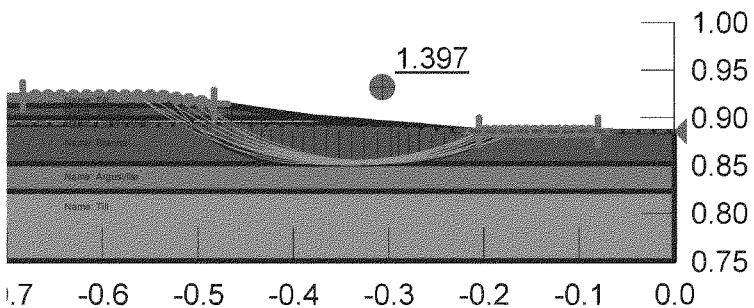
Soil Properties

Name: Fill Model: Mohr-Coulomb Unit Weight: 118 pcf Cohesion: 0 psf Phi: 28 ° Phi-B: 0 °	Name: Poplar River Model: Mohr-Coulomb Unit Weight: 116 pcf Cohesion: 0 psf Phi: 26 ° Phi-B: 0 °	Name: Argusville Model: Mohr-Coulon Unit Weight: 106 pcf Cohesion: 0 psf Phi: 15 ° Phi-B: 0 °
Name: Sherack Model: Mohr-Coulomb Unit Weight: 118 pcf Cohesion: 0 psf Phi: 28 ° Phi-B: 0 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 ° Phi-B: 0 °	Name: Till Model: Mohr-Coulon Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 ° Phi-B: 0 °



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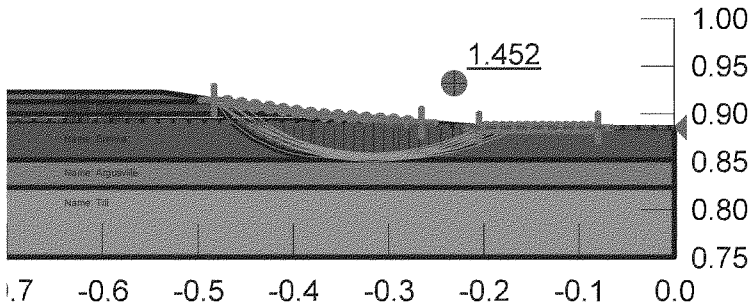
Soil Properties

Name: Fill Model: Mohr-Coulomb Unit Weight: 118 pcf Cohesion: 0 psf Phi: 28 ° Phi-B: 0 °	Name: Poplar River Model: Mohr-Coulomb Unit Weight: 116 pcf Cohesion: 0 psf Phi: 26 ° Phi-B: 0 °	Name: Argusville Model: Mohr-Coulon Unit Weight: 106 pcf Cohesion: 0 psf Phi: 15 ° Phi-B: 0 °
Name: Sherack Model: Mohr-Coulomb Unit Weight: 118 pcf Cohesion: 0 psf Phi: 28 ° Phi-B: 0 °	Name: Brenna Model: Mohr-Coulomb Unit Weight: 103 pcf Cohesion: 0 psf Phi: 13 ° Phi-B: 0 °	Name: Till Model: Mohr-Coulon Unit Weight: 122 pcf Cohesion: 0 psf Phi: 31 ° Phi-B: 0 °



1373

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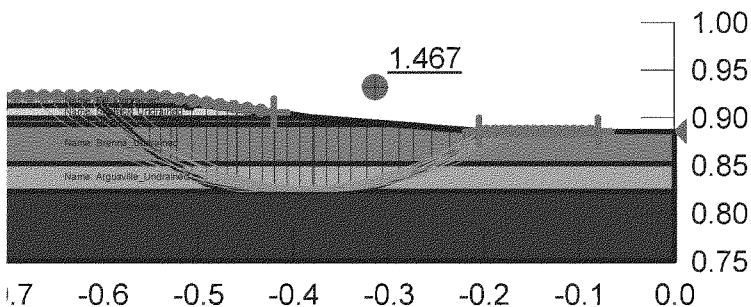
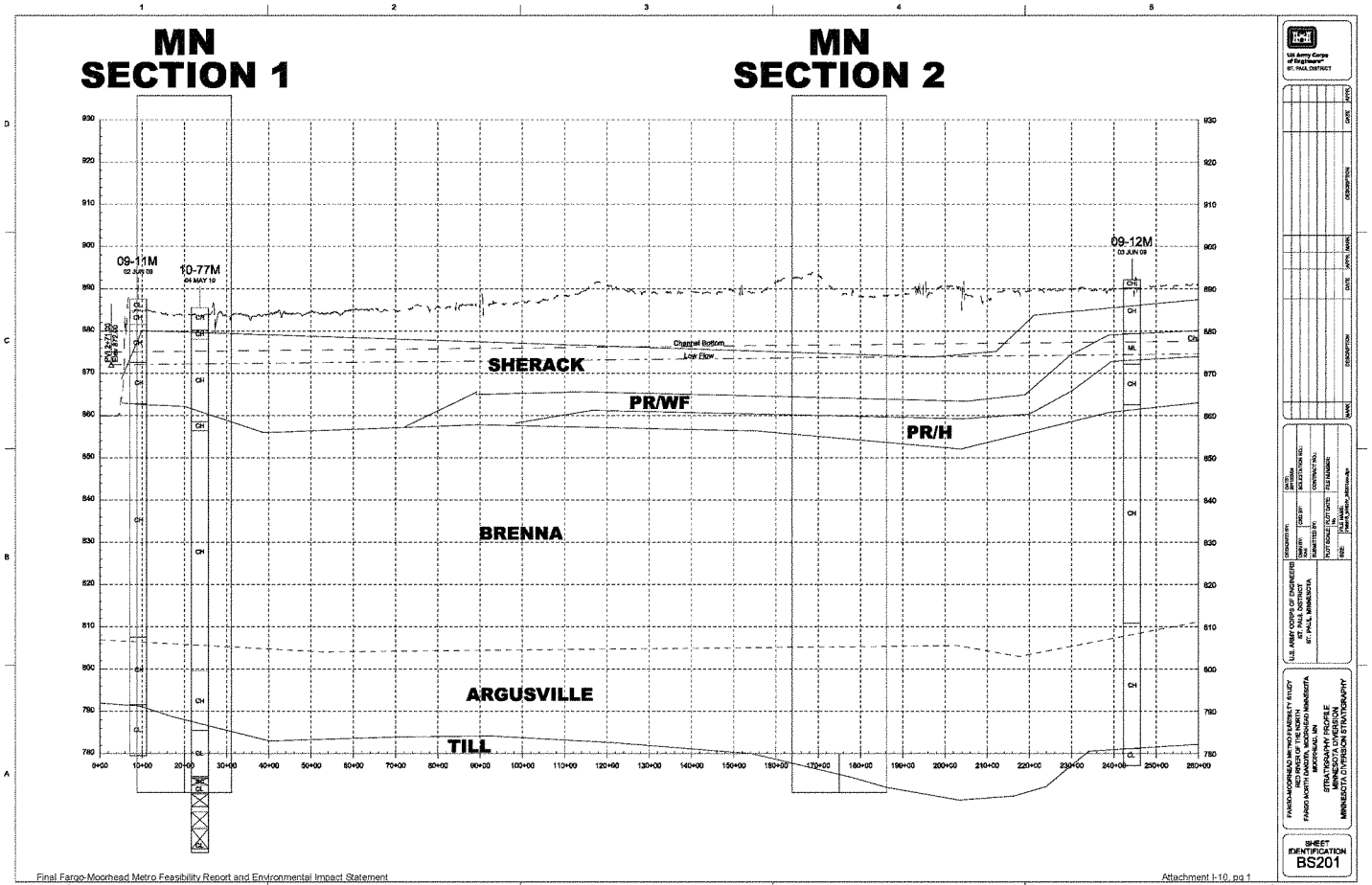
Soil Properties

Name: Fill_Undrained Model: Undrained (Phi=0) Unit Weight: 118 pcf Cohesion: 1400 psf	Name: Poplar River_Undrained Model: Undrained (Phi=0) Unit Weight: 116 pcf Cohesion: 1450 psf	Name: Argusville_U Model: Undrained (F Unit Weight: 106 pcf Cohesion: 825 psf
Name: Sherack_Undrained Model: Undrained (Phi=0) Unit Weight: 118 pcf Cohesion: 1400 psf	Name: Brenna_Undrained Model: Undrained (Phi=0) Unit Weight: 103 pcf Cohesion: 650 psf	Name: Till_Undraine Model: Undrained (F Unit Weight: 122 pcf Cohesion: 1900 psf



1374

Attachment I-10: Diversion Channel Stratigraphy – Phase 3 & Phase 4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SECTION 1
MN
SECTION 2
09-11M
02 JUN 09
10-77M
04 MAY 10
09-12M
03 JUN 09
Channel Bottom
Low Flow
SHERACK
PR/WF
PR/H
BRENNA
ARGUSVILLE
TILL
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, MOORHEAD MINNESOTA
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MINNESOTA DIVERSION STRATIGRAPHY
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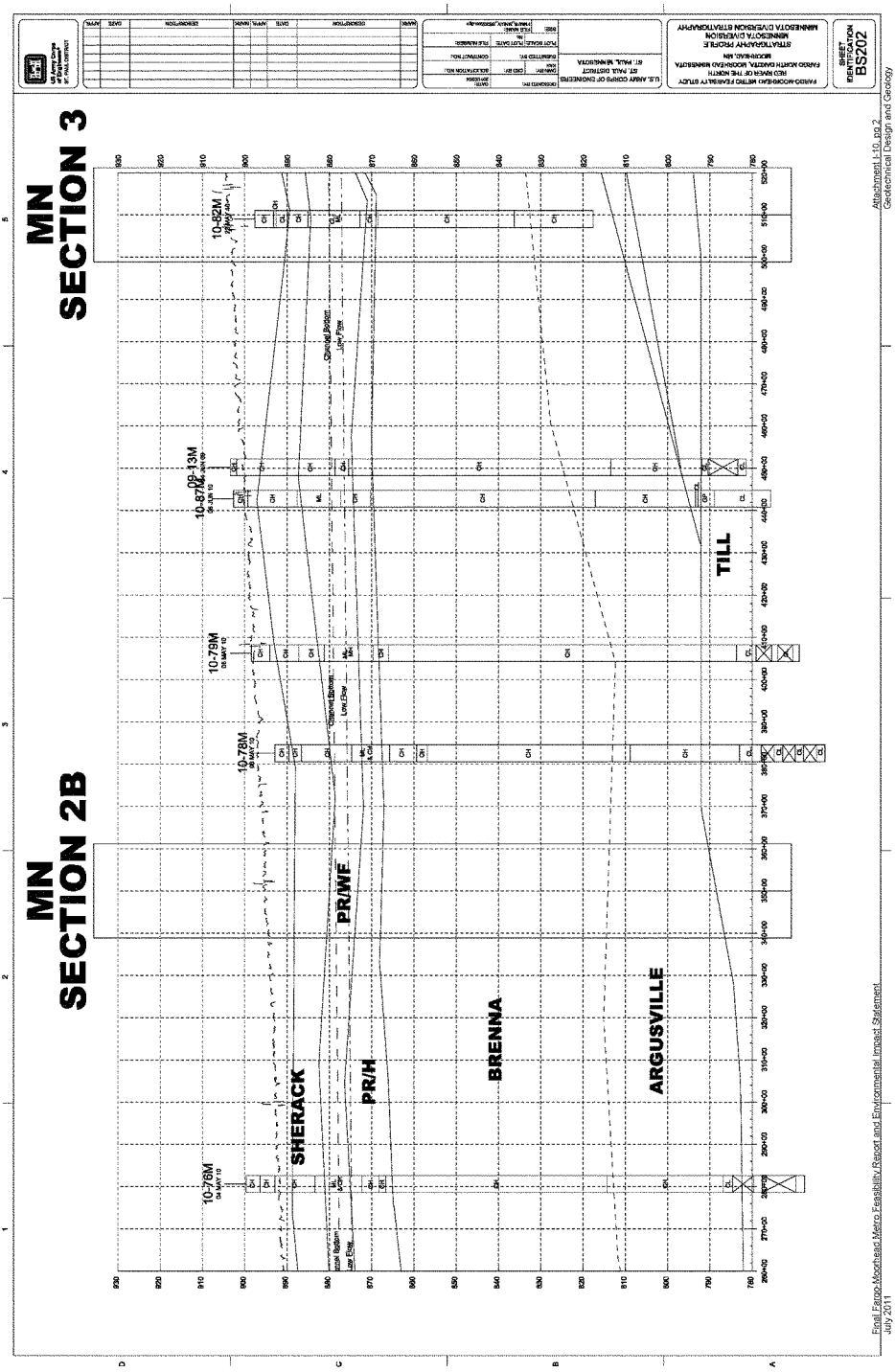
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SECTION 3
MN
SECTION 2B
SHERACK
PR/WF
PR/H
BRENNA
ARGUSVILLE
TILL
10-78M
10-79M
10-87M
09-13M
10-82M
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO, NORTH DAKOTA, MOORHEAD, MINNESOTA
STRATIGRAPHY PROFILE
MINNESOTA DIVERSION
MINNESOTA DIVERSION STRATIGRAPHY
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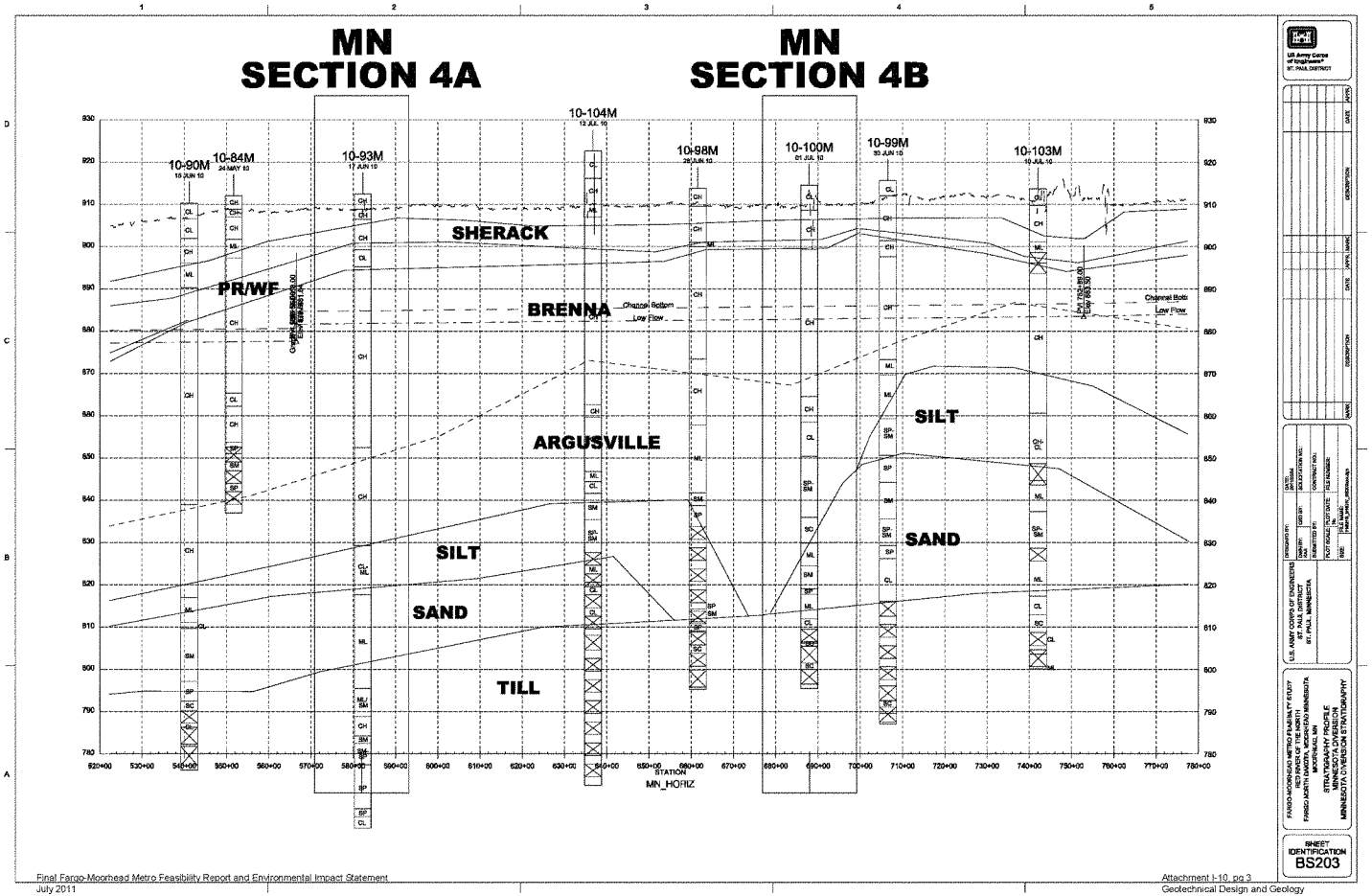
US ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
US Army Corps of Engineers
ST. PAUL DISTRICT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SECTION 4A
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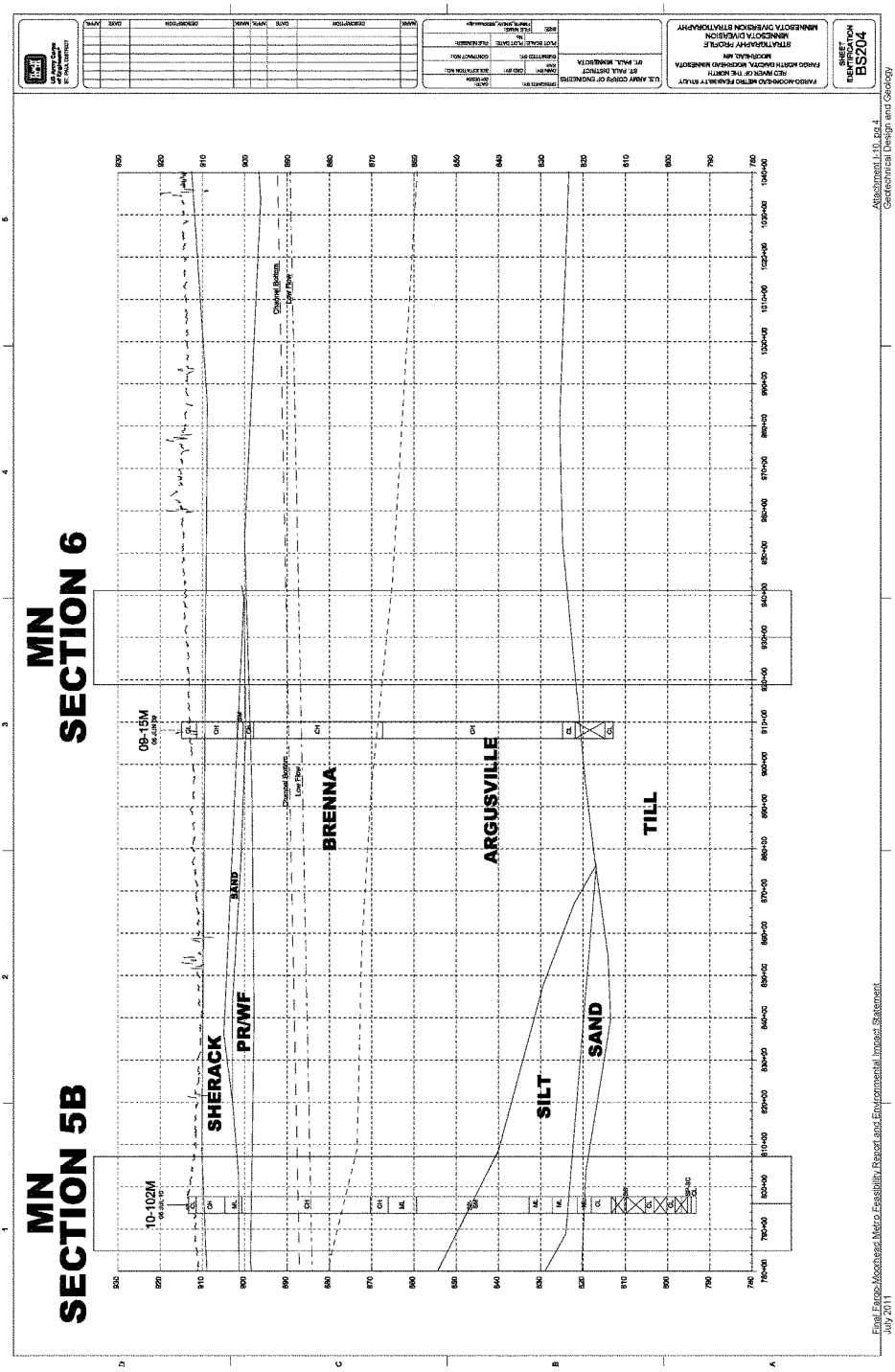
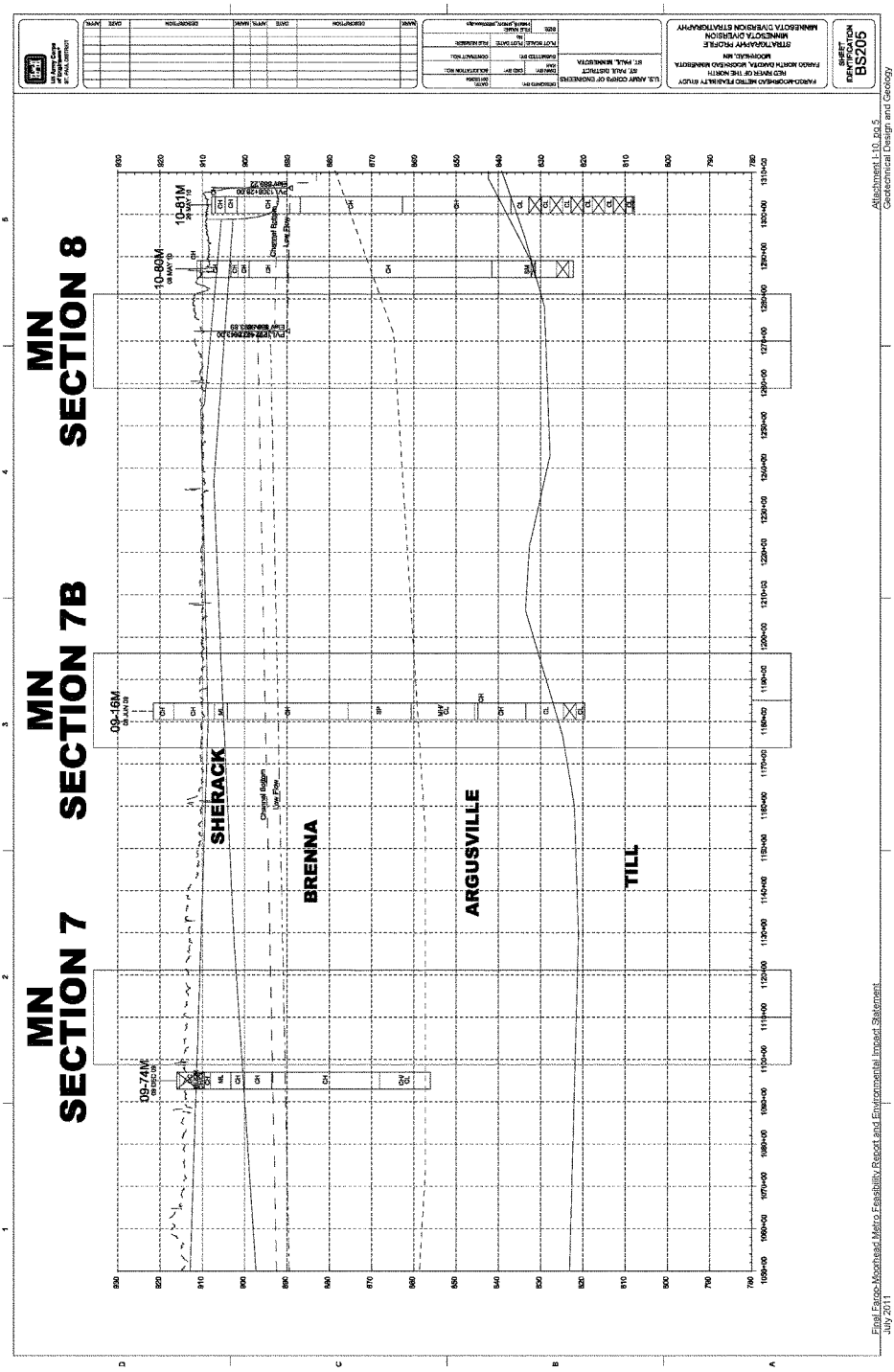
SECTION 4B
10-90M
10-84M
10-93M
10-104M
10-98M
10-100M
10-99M
10-103M
SHERACK
PR/WF
BRENNA
ARGUSVILLE
SILT
SAND
TILL
Channel Bottom
Low Flow
STATION
MN_HORIZ
US Army Corps of Engineers
ST. PAUL DISTRICT
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO NORTH DAKOTA, MOORHEAD MINNESOTA
MOORHEAD, MN
STRATIGRAPHY PROFILE
MINNESOTA DIVERSION
MINNESOTA DIVERSION STRATIGRAPHY
SHEET IDENTIFICATION
BS203


MN
SECTION 5B
MN
SECTION 6
10-102M
08-15M
SHERACK
PR/WF
SAND
BRENNA
ARGUSVILLE
TILL
SILT
SAND
Channel Bottom
Low Flow
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO, NORTH DAKOTA, MOORHEAD, MINNESOTA
MOORHEAD, MN
STRATIGRAPHY PROFILE
MINNESOTA DIVERSION
MINNESOTA DIVERSION STRATIGRAPHY
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
SHEET
BS204
Final Fargo Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Attachment 1-10_pg 4
Geotechnical Design and Geology


MN
SECTION 7
MN
SECTION 7B
MN
SECTION 8
SHERACK
BRENNA
ARGUSVILLE
TILL
09-74M
09-16M
10-81M
10-80M
FARGO-MOORHEAD METRO FLASHILITY STUDY
RED RIVER OF THE NORTH
FARGO NORTH DAKOTA, MOORHEAD MINNESOTA
MINNESOTA DIVERSION
STRATIGRAPHY PROFILE
MOORHEAD, MN
MINNESOTA DIVERSION STRATTGRAPHY
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
SHEET IDENTIFICATION
BS205
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011
Attachment 1-10, pg 5
Geotechnical Design and Geology

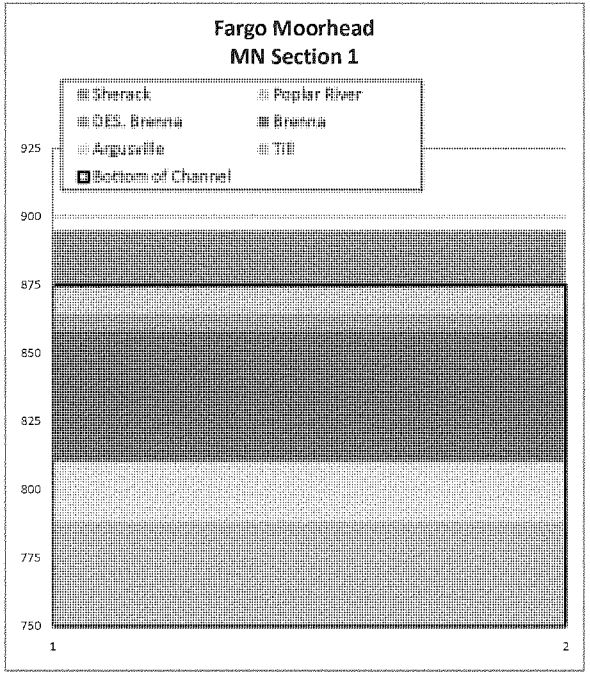
Fargo-Moorhead Metro Feasibility Study

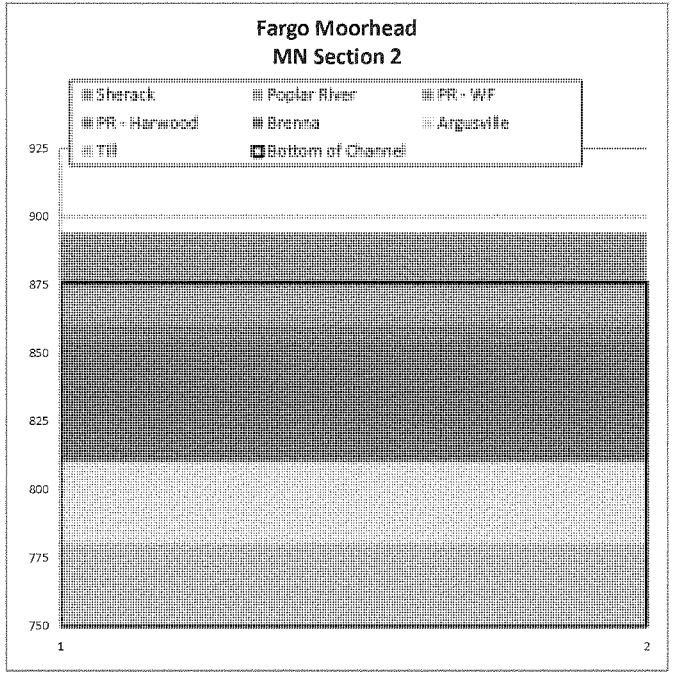
Phase 3 Diversion Modeling Configuration

Compiled By: KAH Revised By: KAH
Date: 30-Apr-10 Date: 12-Jul-10

Sherack	Poplar River	DES. Brenna	Brenna	Argusville	Till	Bottom of Channel
895	875	864	858	810	788	875
895	875	864	858	810	788	875

Sherack	Poplar River	PR - WF	PR - Harwood	Brenna	Argusville	Till	Bottom of Channel
894	874	864	860	854	810	780	876
894	874	864	860	854	810	780	876





Fargo-Moorhead Metro Feasibility Study

Phase 3 Diversion Modeling Configuration

Compiled By: KAH Revised By: KAH

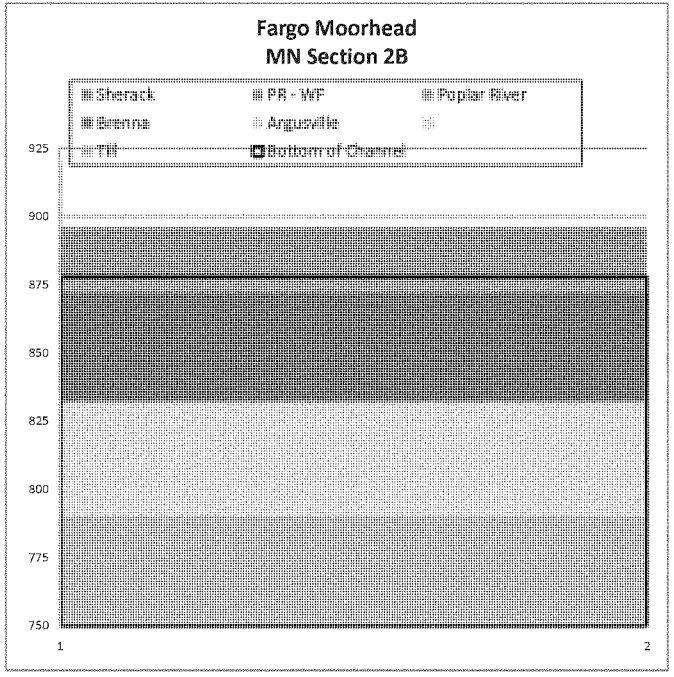
Date: 30-Apr-10 Date: 12-Jul-10

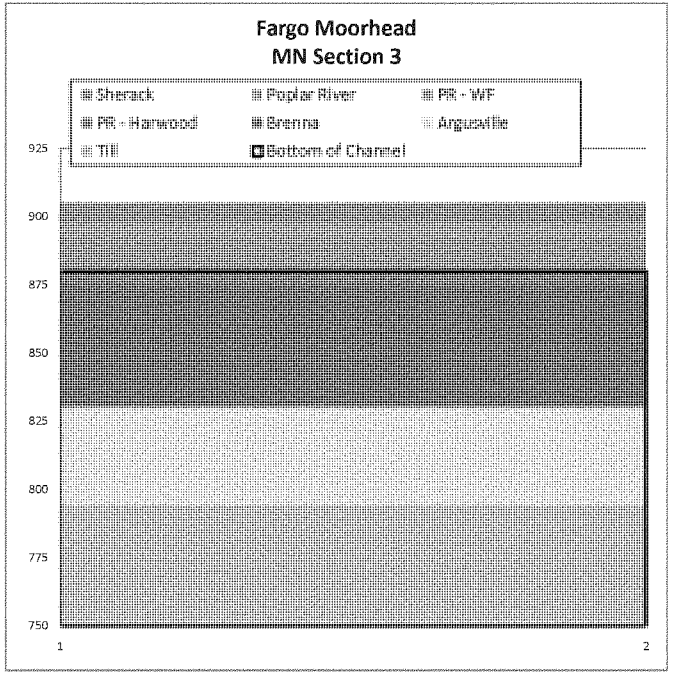
MN Section 2B

Sherack	PR - WF	Poplar River	Brenna	Argusville		Till	Bottom of Channel
896	887	876	872	832		790	878
896	887	876	872	832	0	790	878

MN Section 3

Sherack	Poplar River	PR - WF	PR - Harwood	Brenna	Argusville	Till	Bottom of Channel
905	898	892	880	875	830	794	880
905	898	892	880	875	830	794	880





1382

Fargo-Moorhead Metro Feasibility Study

Phase 3 Diversion Modeling Configuration

Compiled By: KAH Revised By: KAH

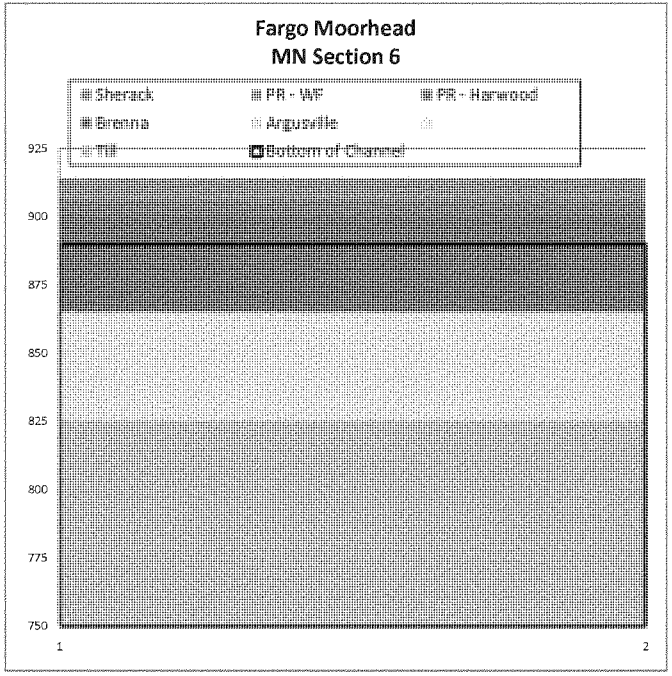
Date: 30-Apr-10 Date: 12-Jul-10

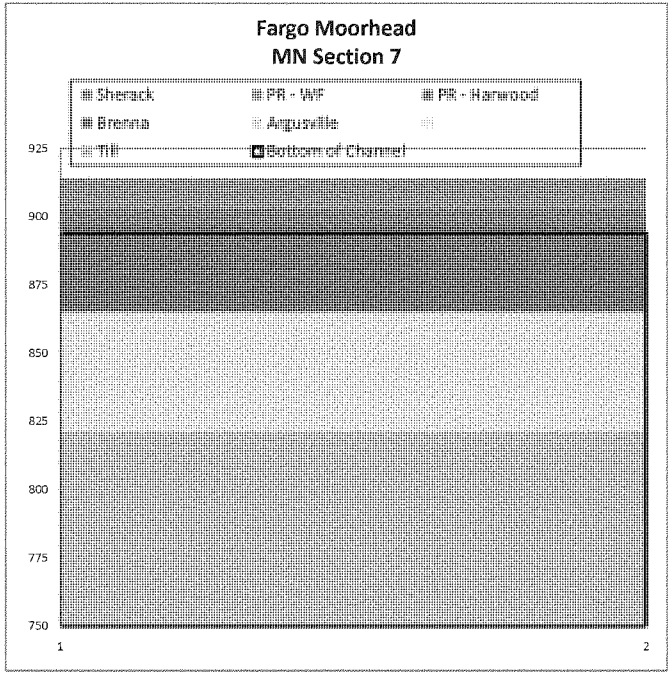
MN Section 6

Sherack	PR - WF	PR - Harwood	Brenna	Argusville		Till	Bottom of Channel
914	908	906	900	865		825	890
914	908	906	900	865		825	890

MN Section 7

Sherack	PR - WF	PR - Harwood	Brenna	Argusville		Till	Bottom of Channel
914	905	903	897	865		821	894
914	905	903	897	865		821	894





1383

Fargo-Moorhead Metro Feasibility Study

Phase 3 Diversion Modeling Configuration

Compiled By: KAH Revised By: KAH

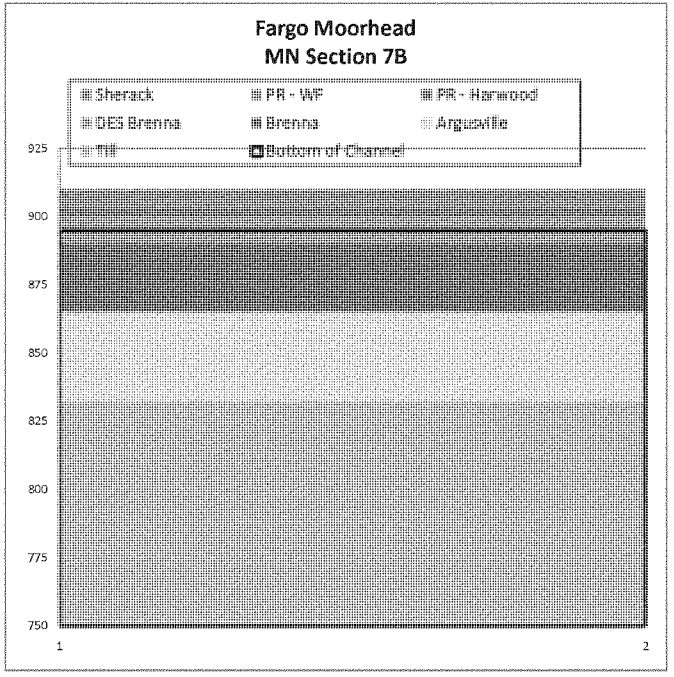
Date: 30-Apr-10 Date: 12-Jul-10

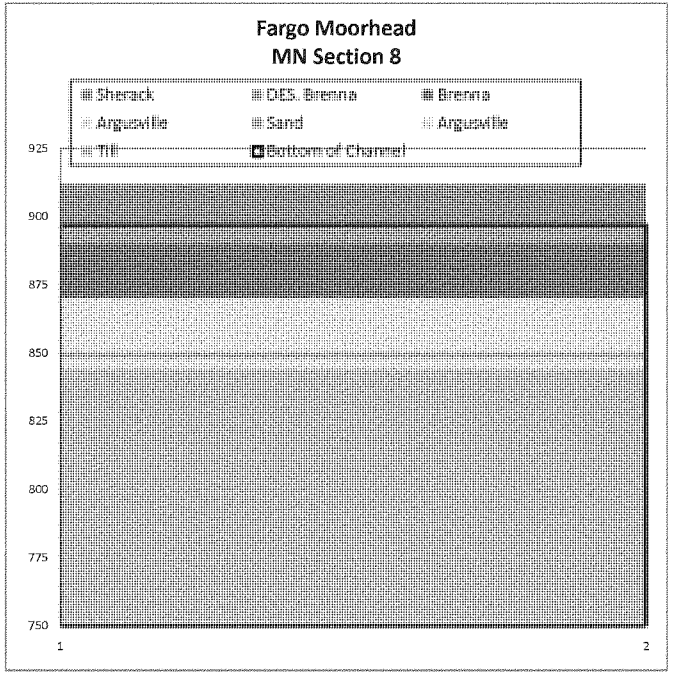
MN Section 7B

Sherack	PR - WF	PR - Harwood	DES Brenna	Brenna	Argusville	Till	Bottom of Channel
910	906	903	900	890	865	832	895
910	906	903	900	890	865	832	895

MN Section 8

Sherack	DES. Brenna	Brenna	Argusville	Sand	Argusville	Till	Bottom of Channel
912	898	890	870	850	848	844	897
912	898	890	870	850	848	844	897





1384

Fargo-Moorhead Metro Feasibility Study

Phase 3 Diversion Modeling Configuration

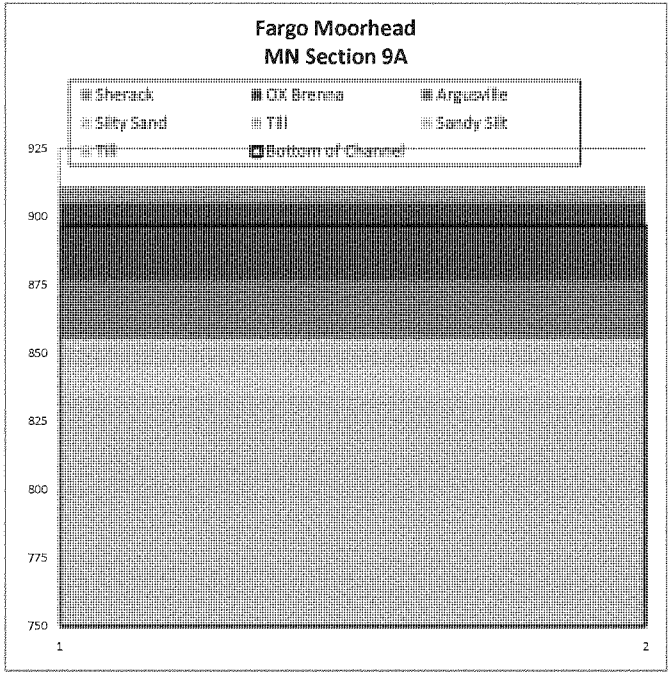
Compiled By: KAH Revised By: KAH
Date: 30-Apr-10 Date: 12-Jul-10

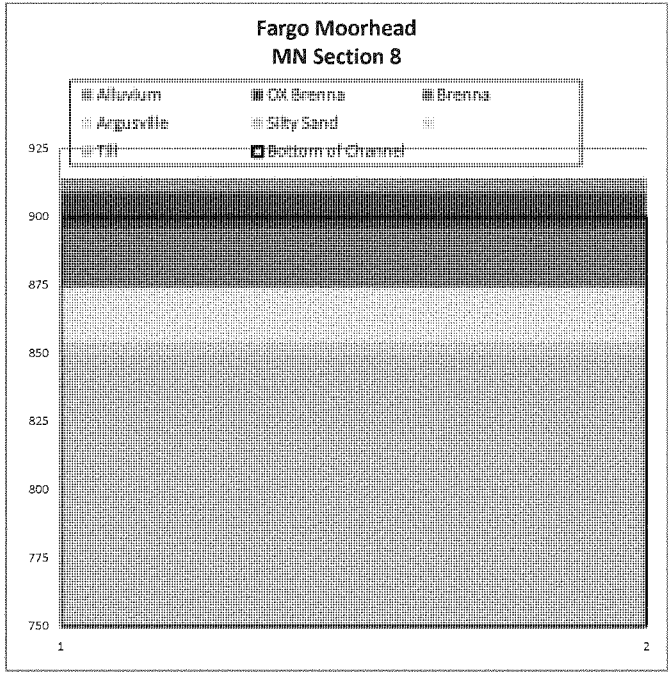
MN Section 9A

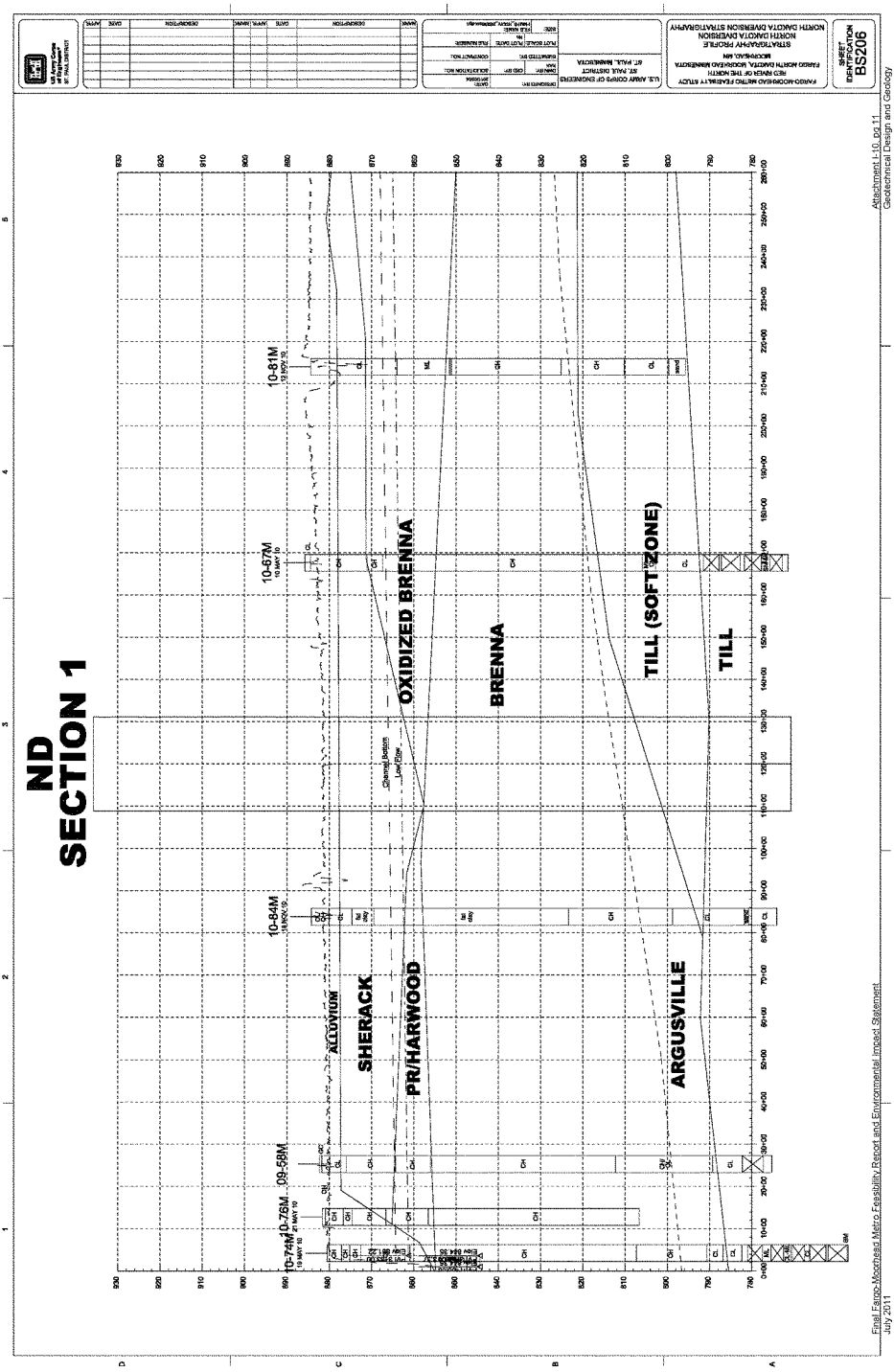
Sherack	OX Brenna	Argusville	Silty Sand	Till	Sandy Silt	Till	Bottom of Channel
911	905	877	855	853	845	834	897
911	905	877	855	853	845	834	897

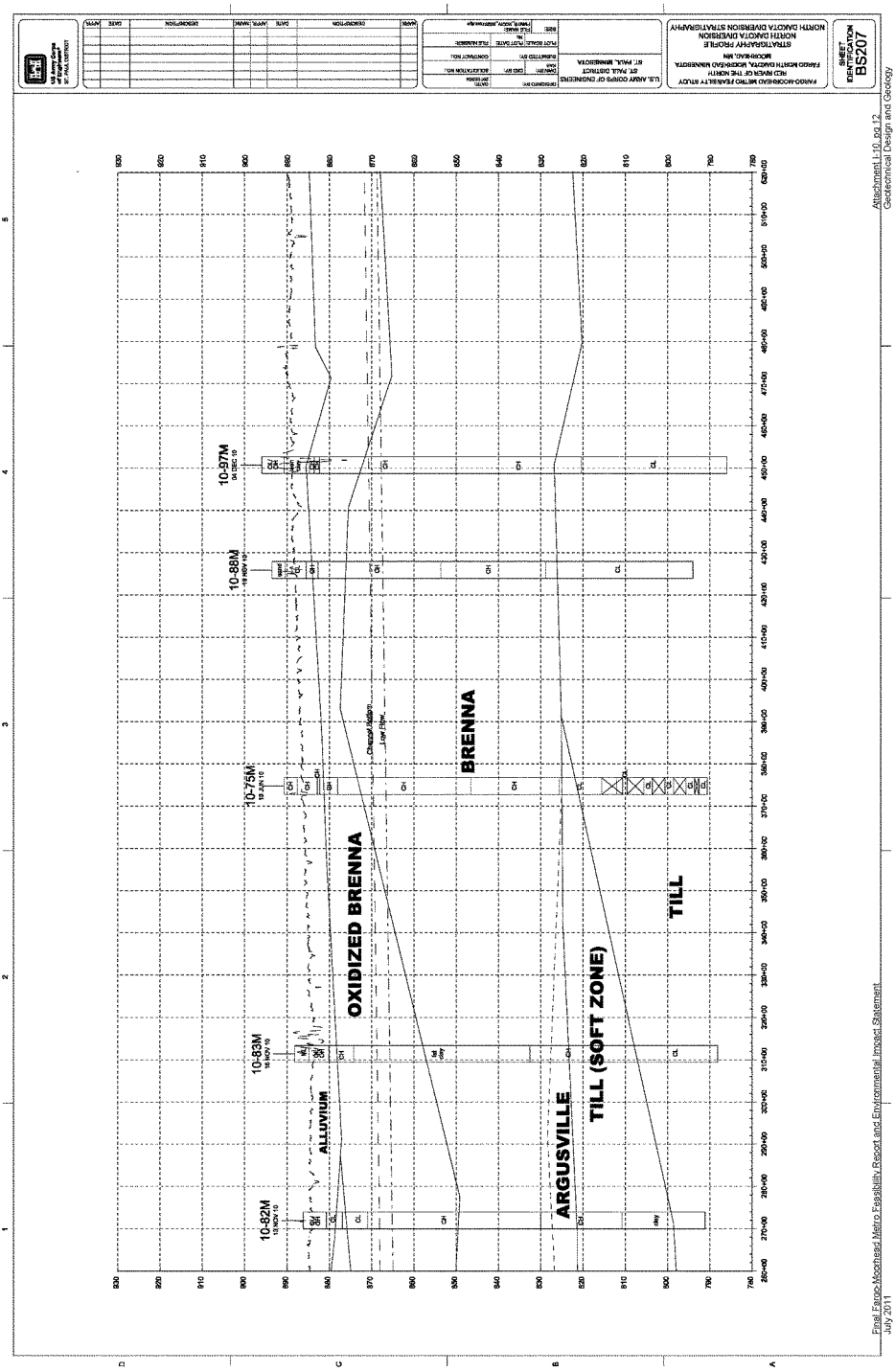
MN Section 9B

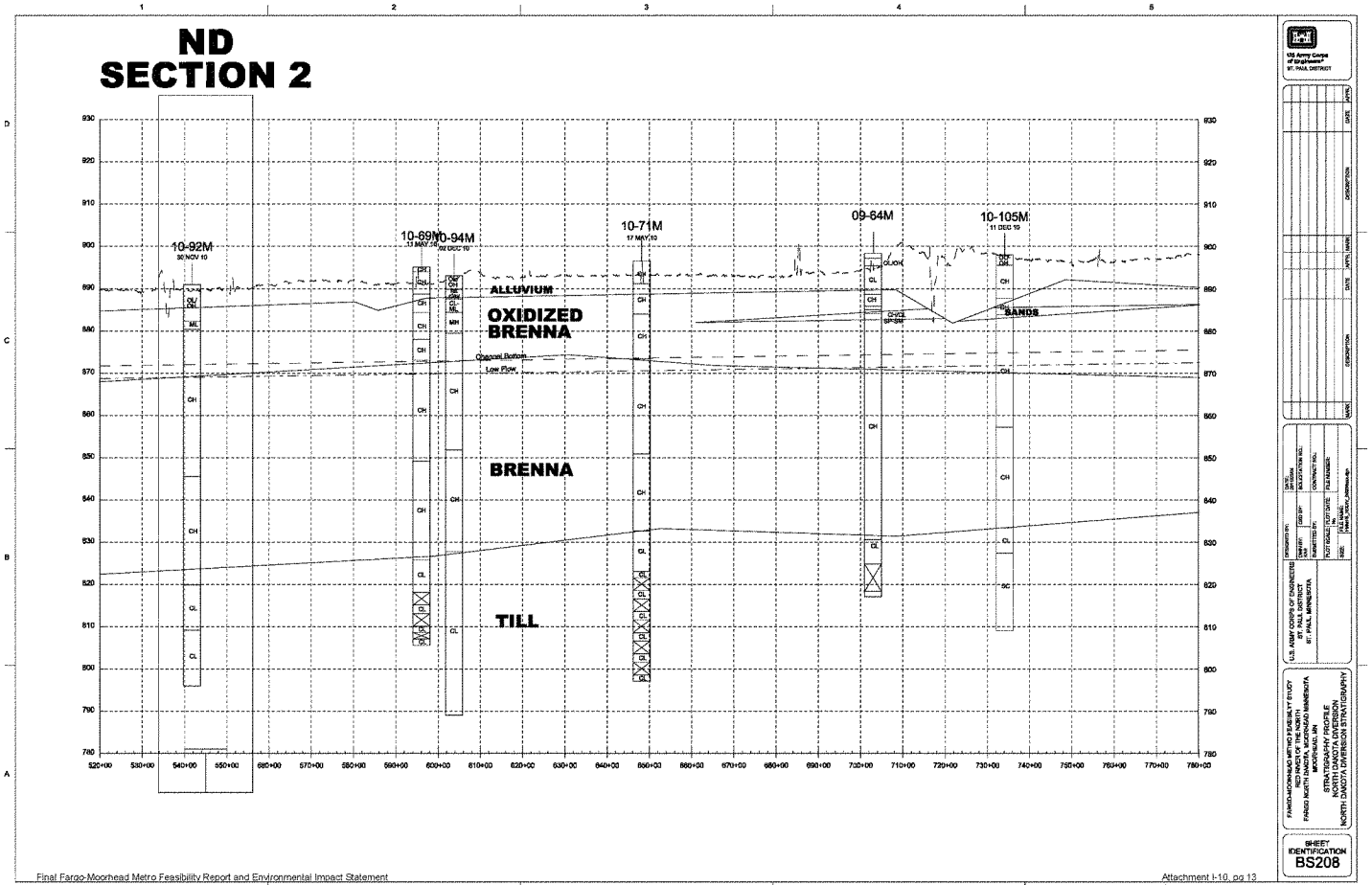
Alluvium	OX Brenna	Brenna	Argusville	Silty Sand		Till	Bottom of Channel
914	909	896	874	854		849	900
914	909	896	874	854		849	900

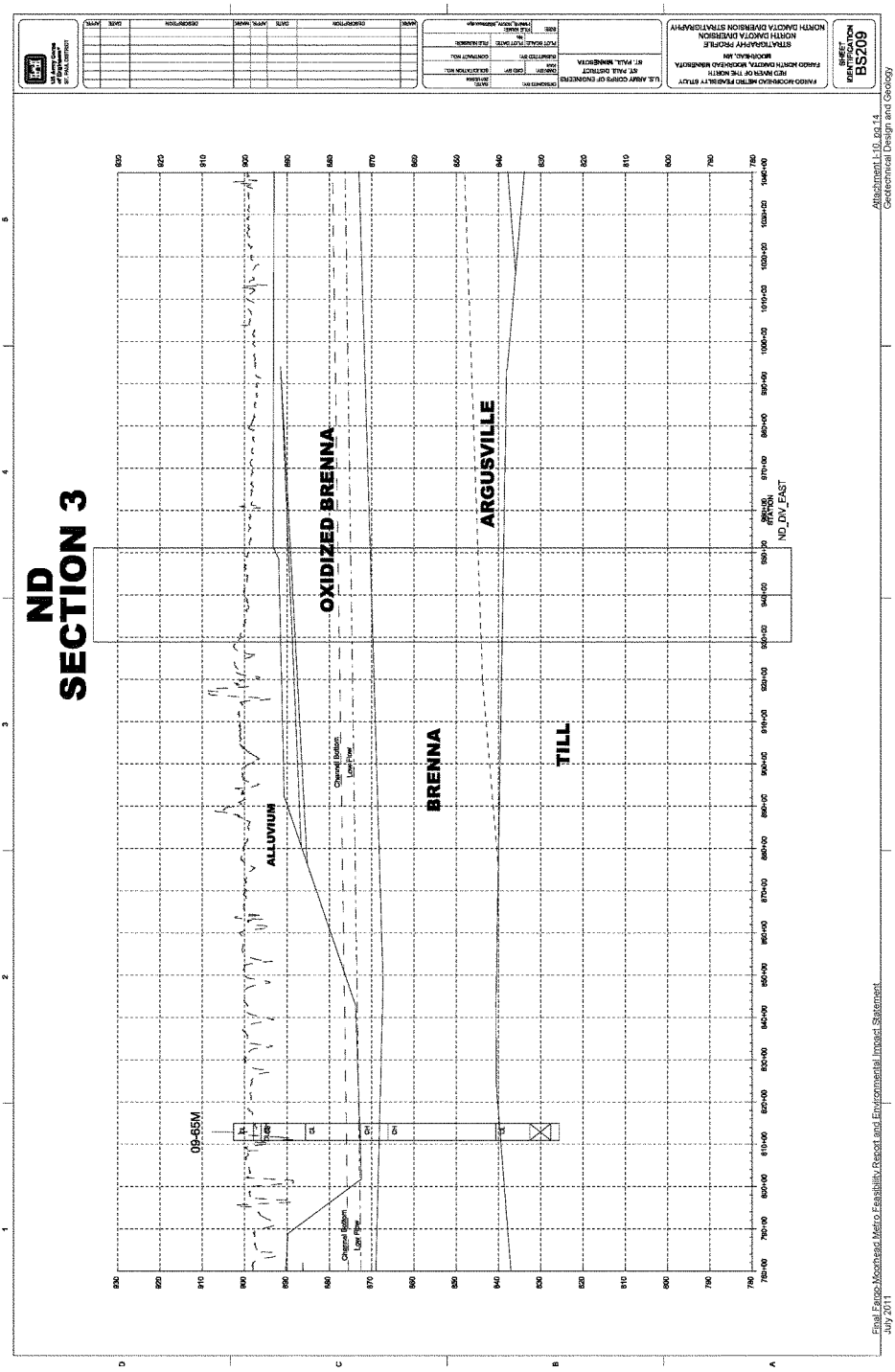


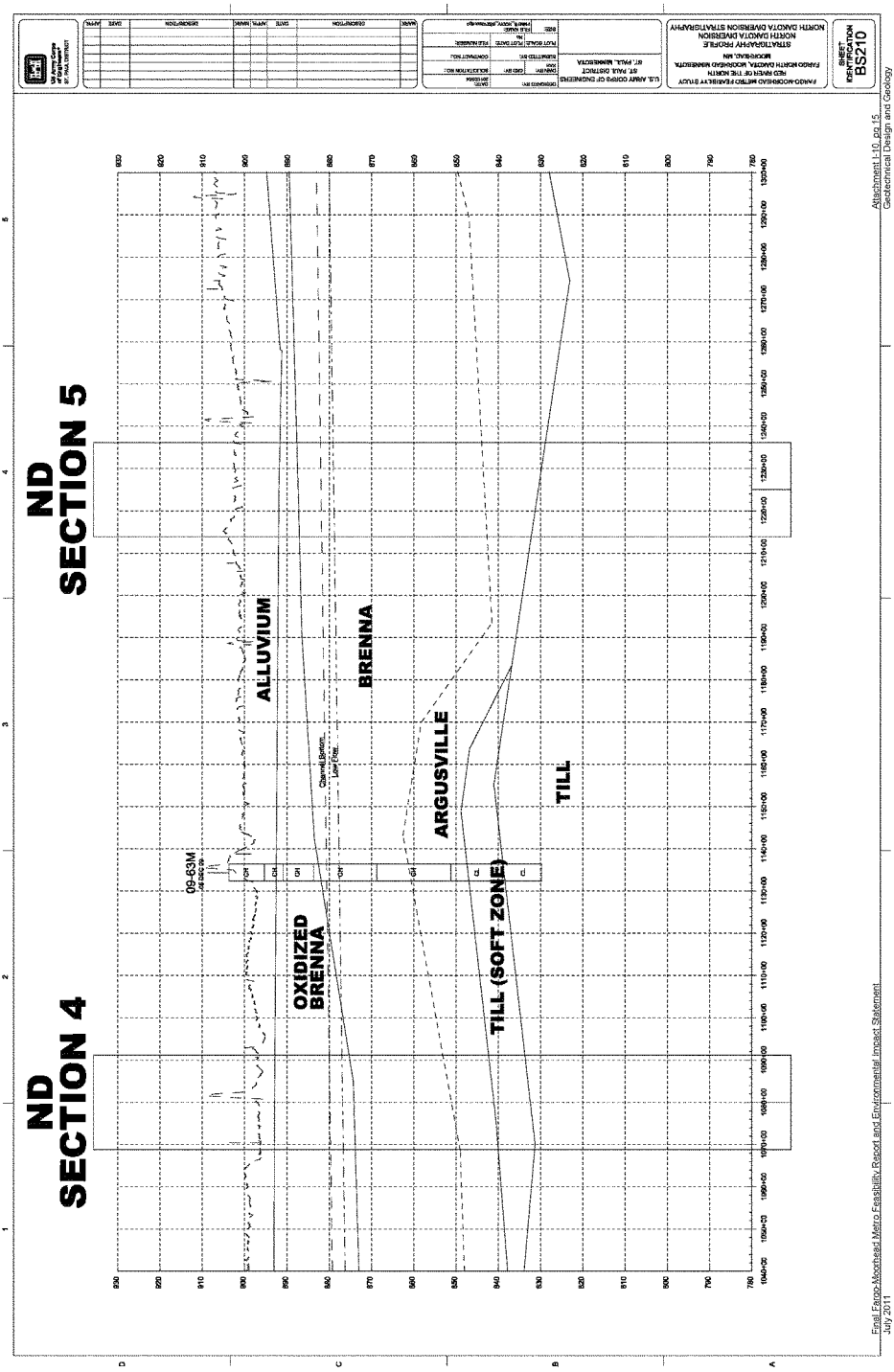


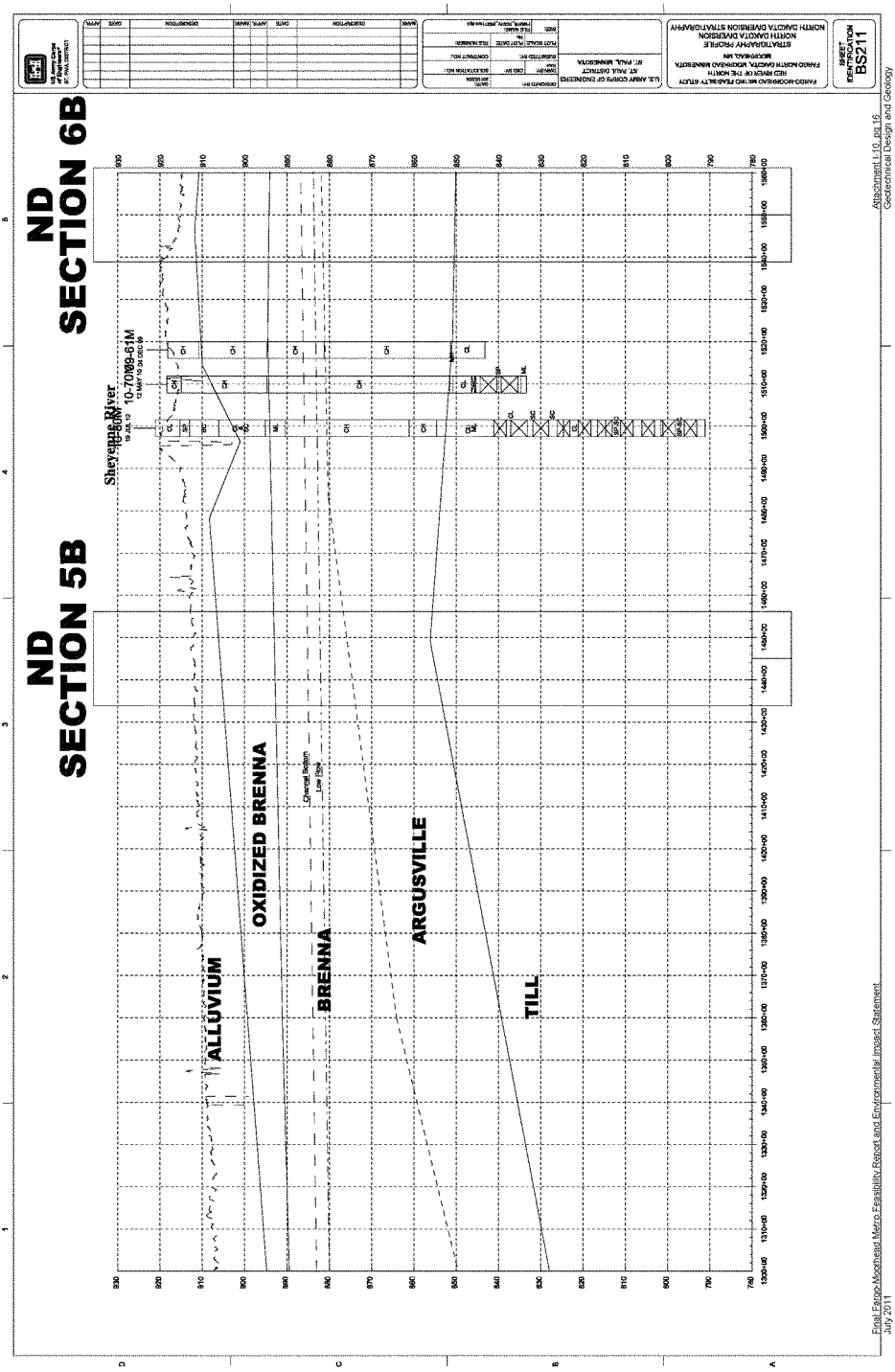

ND
SECTION 1
OXIDIZED BRENNA
BRENNA
TILL (SOFT ZONE)
TILL
ALLUVIUM
SHERACK
PR/HARWOOD
ARGUSVILLE
10-81M
10-67M
10-84M
09-58M
10-76M
10-74M
Attachment I-10, pg 11
Geotechnical Design and Geology
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011

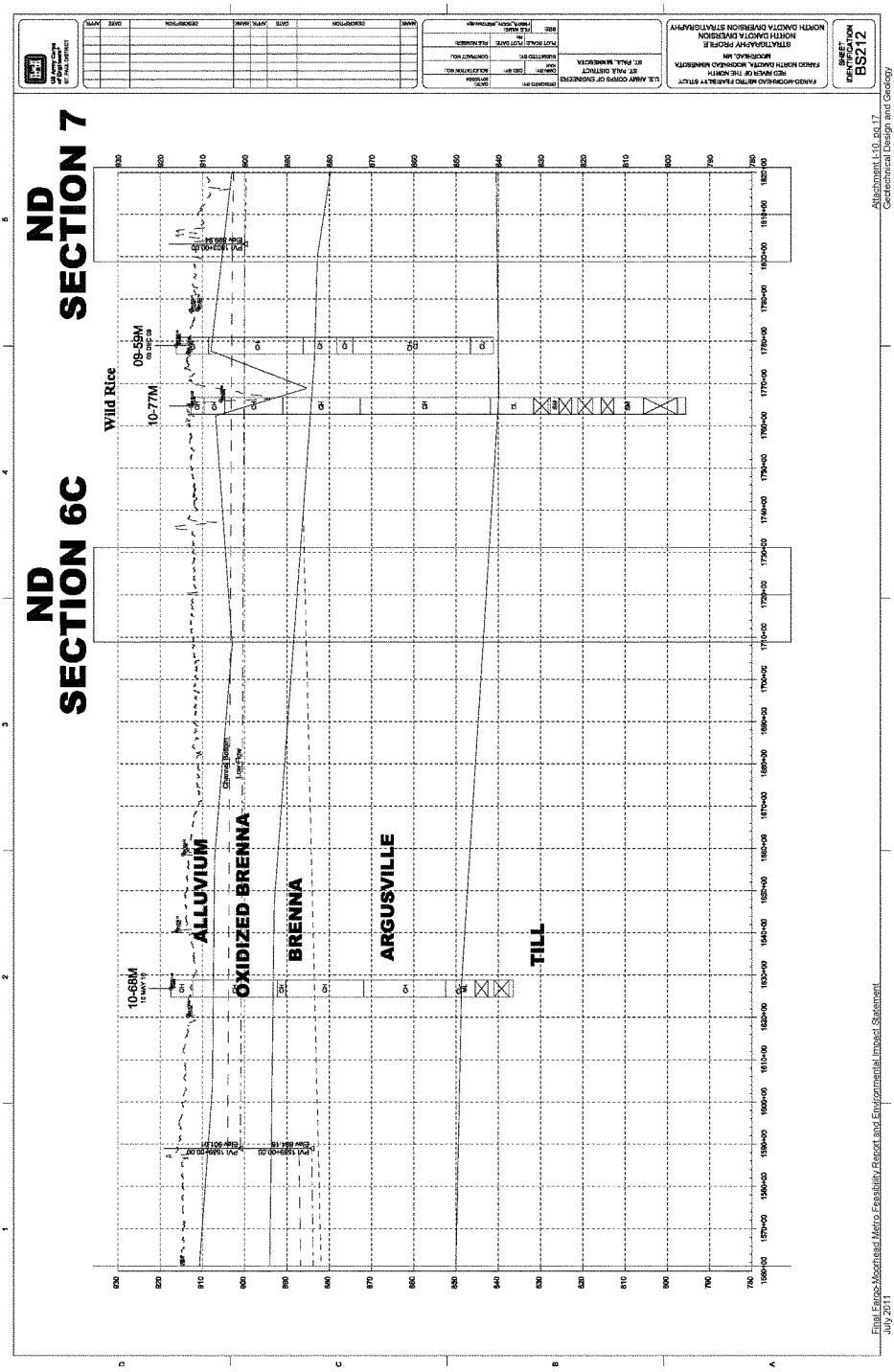

10-97M
10-88M
10-75M
10-83M
10-82M
OXIDIZED BRENNA
BRENNA
ALLUVIUM
ARGUSVILLE
TILL (SOFT ZONE)
TILL

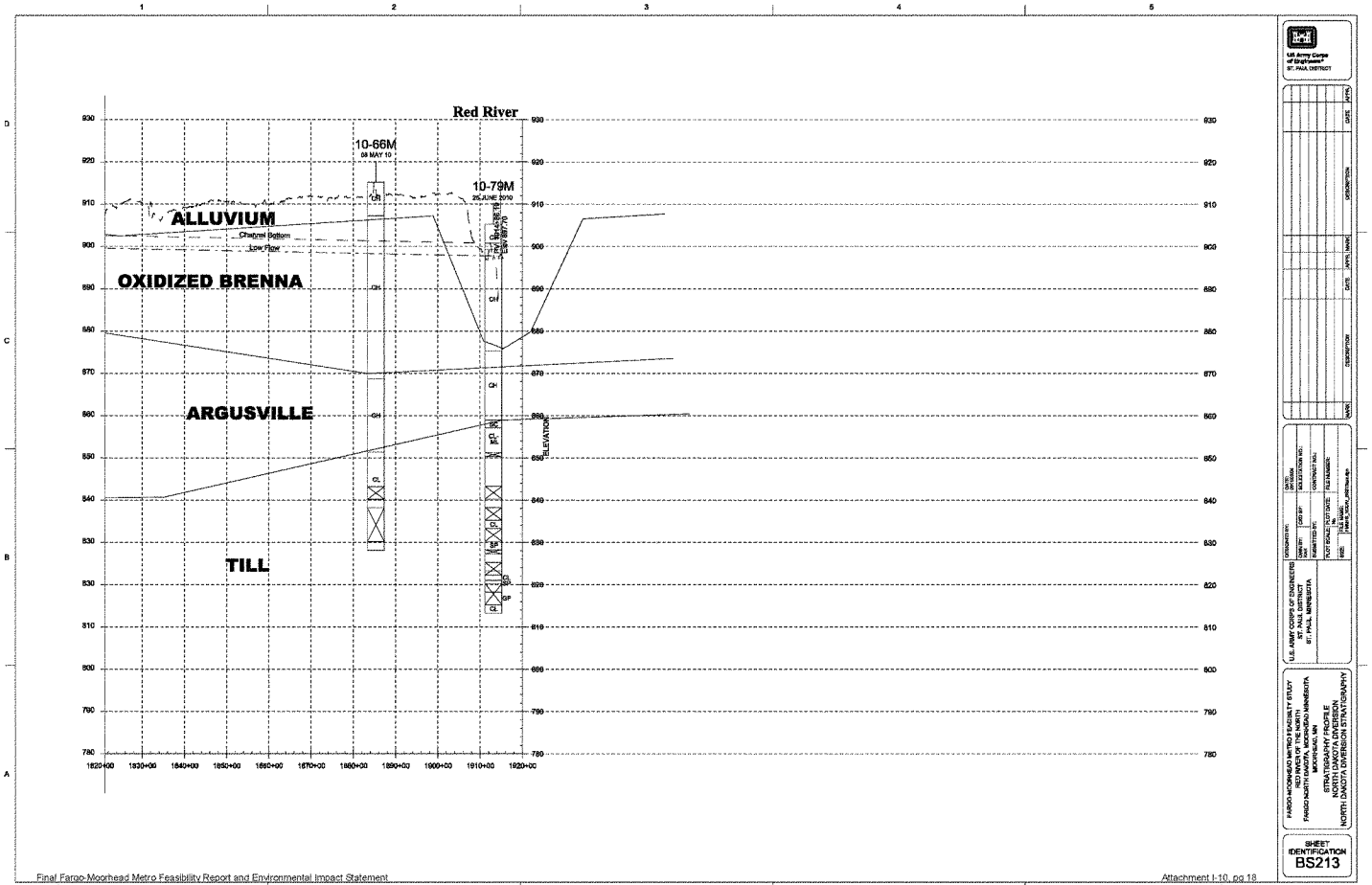

ND
SECTION 2
10-92M
30 NOV 10
10-69M
10-94M
02 DEC 10
10-71M
17 MAY 10
09-64M
10-105M
11 DEC 10
ALLUVIUM
OXIDIZED
BRENNA
Channel Bottom
Low Flow
BRENNA
TILL
SANDS
US Army Corps of Engineers
ST. PAUL DISTRICT
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO NORTH DAKOTA, MOORHEAD MINNESOTA
MOORHEAD, MN
STRATIGRAPHY PROFILE
NORTH DAKOTA DIVERSION
NORTH DAKOTA DIVERSION STRATIGRAPHY
SHEET IDENTIFICATION
BS208


ND
SECTION 3
OXIDIZED BRENNA
ARGUSVILLE
BRENNA
TILL
ALLUVIUM
Channel Bottom
Low Flow
09-65M
ND_DIV_EAST
BS209
Attachment 1-10_pg 14
Geotechnical Design and Geology
Final Fargo Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011


ND SECTION 4
ND SECTION 5
ALLUVIUM
OXIDIZED BRENNA
BRENNA
ARGUSVILLE
TILL (SOFT ZONE)
TILL
09-63M
Channel Bottom Low Flow
FARGO-MOORHEAD METRO FEASIBILITY STUDY
RED RIVER OF THE NORTH
FARGO, NORTH DAKOTA, MOORHEAD, MINNESOTA
MOORHEAD, MN
STRATIGRAPHY PROFILE
NORTH DAKOTA DIVERSION
NORTH DAKOTA DIVERSION STRATIGRAPHY
PROJECT IDENTIFICATION
BS210
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA


ND
SECTION 6B
ND
SECTION 5B
Sheyenne River
10-70065-61M
ALLUVIUM
OXIDIZED BRENNA
BRENNA
ARGUSVILLE
TILL
Channel Bottom
Low Flow
STRATIGRAPHY PROFILE
RED RIVER OF THE NORTH
MOORHEAD, MN
FARGO-MOORHEAD METRO FEASIBILITY STUDY
FARGO, NORTH DAKOTA, MOORHEAD, MINNESOTA
NORTH DAKOTA DIVERSION STRATIGRAPHY
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA
SHEET
DESIGNATION
BS211


ND
SECTION 7
ND
SECTION 6C
Wild Rice
09-59M
10-77M
10-68M
ALLUVIUM
OXIDIZED BRENNA
BRENNA
ARGUSVILLE
TILL
Attachment I-10, pg 17
Geotechnical Design and Geology
Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011


Red River
10-66M
08 MAY 10
10-79M
25 JUNE 2010
ALLUVIUM
Channel Bottom
Low Flow
OXIDIZED BRENNA
ARGUSVILLE
TILL
ELEVATION
CH
CL
SP
GP
930
920
910
900
890
880
870
860
850
840
830
820
810
800
790
780
1820+00
1830+00
1840+00
1850+00
1860+00
1870+00
1880+00
1890+00
1900+00
1910+00
1920+00
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, MOORHEAD MINNESOTA
MOORHEAD, MN
STRATIGRAPHY PROFILE
NORTH DAKOTA DIVERSION
NORTH DAKOTA DIVERSION STRATIGRAPHY
SHEET IDENTIFICATION
BS213

Fargo-Moorhead Metro Feasibility Study

Phase 4 ND Diversion Modeling Configuration

Compiled By: KAH Revised By: KAH

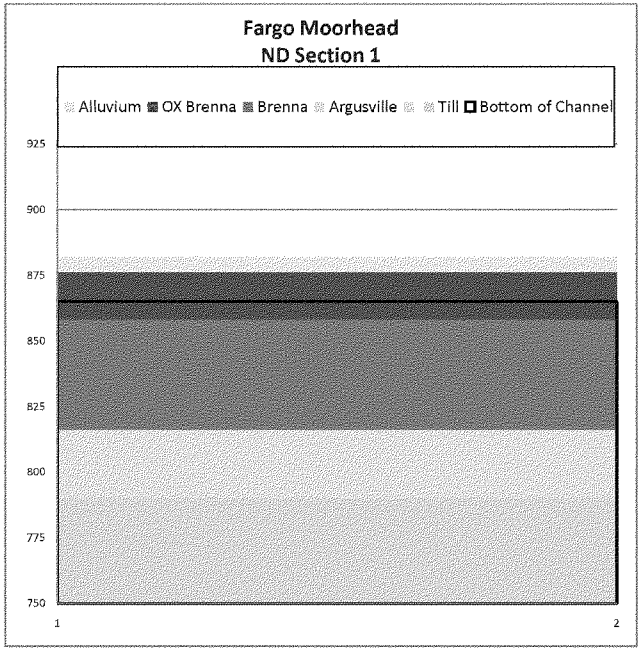
Date: 30-Nov-10 Date: 11-Feb-11

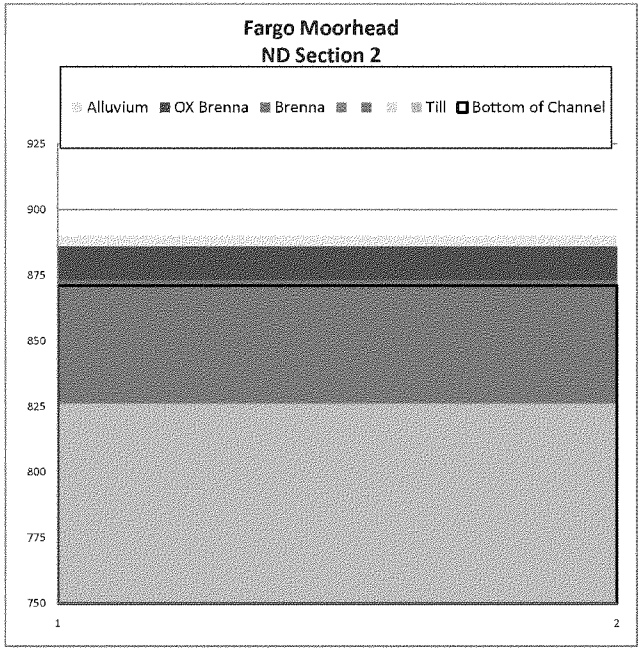
ND Section 1

Alluvium	OX Brenna	Brenna	Argusville			Till	Bottom of Channel
882	876	858	816			790	865
882	876	858	816			790	865

ND Section 2

Alluvium	OX Brenna	Brenna				Till	Bottom of Channel
890	886	873				826	871
890	886	873				826	871





Fargo-Moorhead Metro Feasibility Study

Phase 4 ND Diversion Modeling Configuration

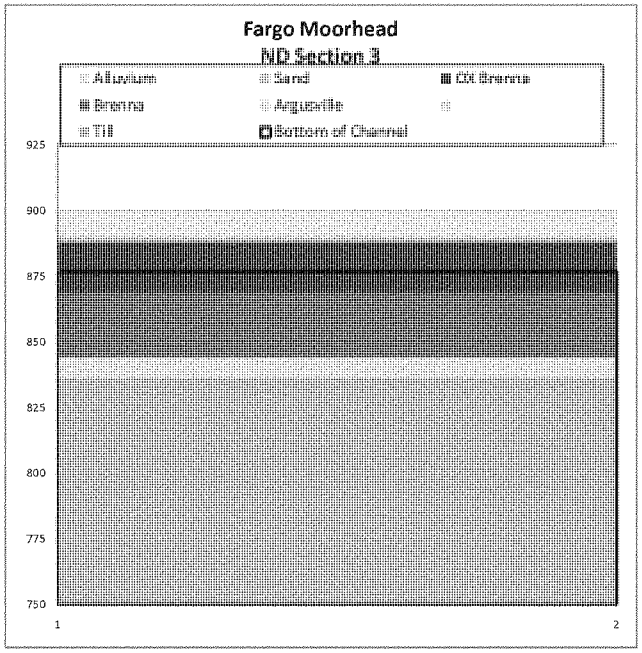
Compiled By: KAH Revised By: KAH
Date: 30-Nov-10 Date: 11-Feb-11

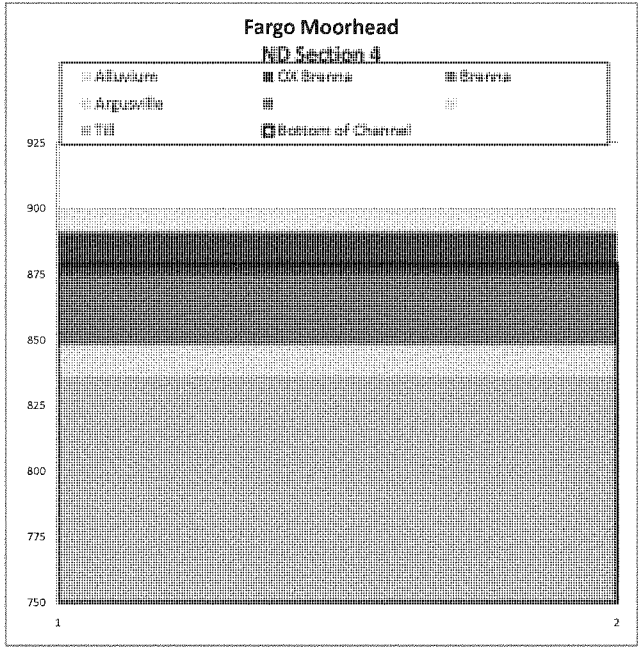
ND Section 3

Alluvium	Sand	OX Brenna	Brenna	Argusville		Till	Bottom of Channel
900	890	888	869	844		836	877
900	890	888	869	844		836	877

ND Section 4

Alluvium	OX Brenna	Brenna	Argusville			Till	Bottom of Channel
900	891	875	848			836	879
900	891	875	848			836	879





Fargo-Moorhead Metro Feasibility Study

Phase 4 ND Diversion Modeling Configuration

Compiled By: KAH Revised By: KAH

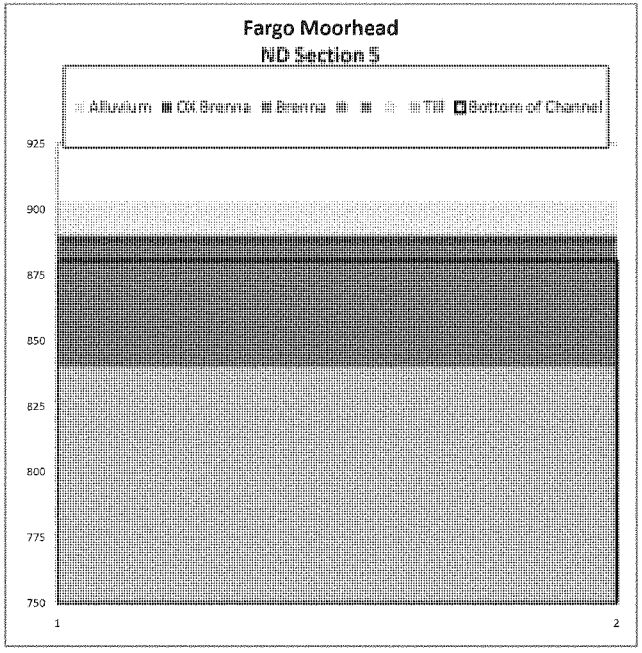
Date: 30-Nov-10 Date: 11-Feb-11

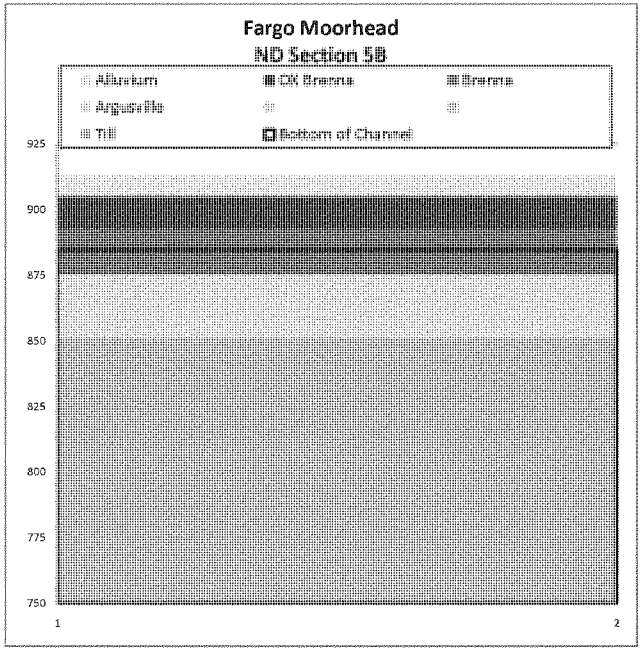
ND Section 5

Alluvium	OX Brenna	Brenna				Till	Bottom of Channel
903	890	887				840	881
903	890	887				840	881

ND Section 5B

Alluvium	OX Brenna	Brenna	Argusville			Till	Bottom of Channel
913	905	893	875			851	885
913	905	893	875			851	885





1396

Fargo-Moorhead Metro Feasibility Study

Phase 4 ND Diversion Modeling Configuration

Compiled By: KAH Revised By: KAH

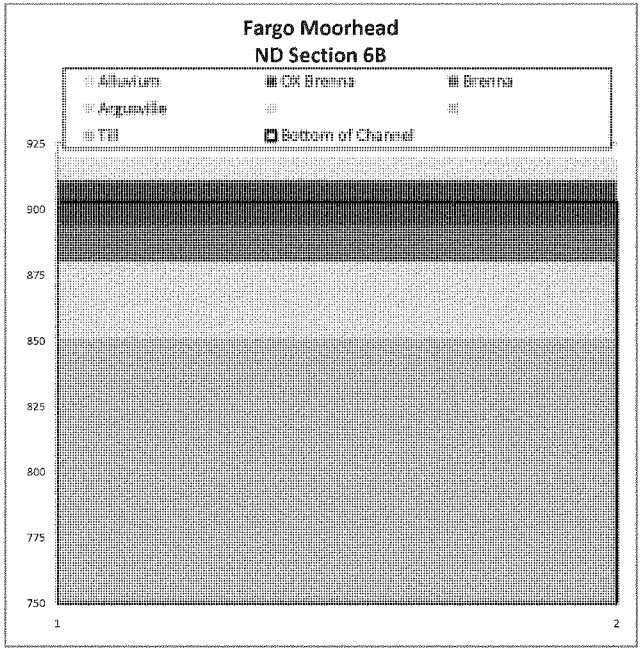
Date: 30-Nov-10 Date: 11-Feb-11

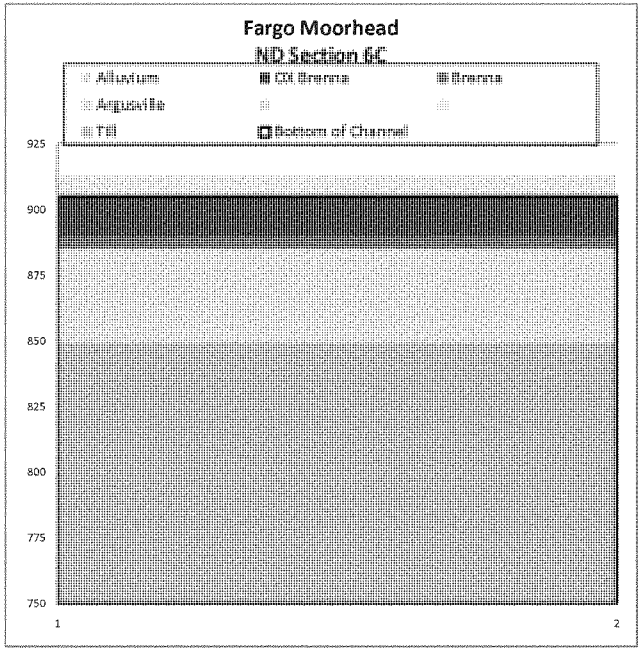
ND Section 6B

Alluvium	OX Brenna	Brenna	Argusville			Till	Bottom of Channel
920	911	894	880			851	903
920	911	894	880		0	851	903

ND Section 6C

Alluvium	OX Brenna	Brenna	Argusville			Till	Bottom of Channel
913	905	890	885			849	905
913	905	890	885			849	905





Fargo-Moorhead Metro Feasibility Study

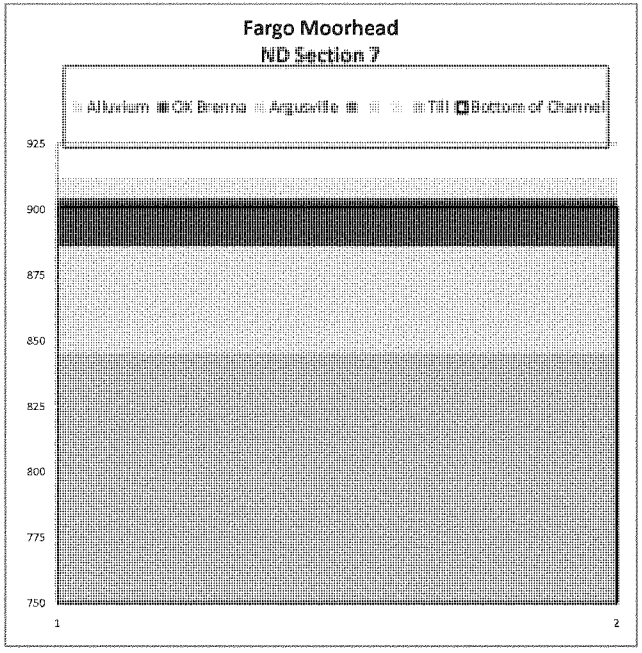
Phase 4 ND Diversion Modeling Configuration

Compiled By: KAH Revised By: KAH

Date: 30-Nov-10 Date: 11-Feb-11

ND Section 7

Alluvium	OX Brenna	Argusville				Till	Bottom of Channel
912	904	886				845	901
912	904	886				845	901



Attachment I-11: MN Diversion Channel Phase 3 Results

Fargo-Moorhead Metro Feasibility Study
Phase 3 Geotechnical Design/Analyses of MN Diversion Alternatives

Compiled By: KAH Revised By: KAH Target Factor of Safety 1.400 1.400 1.200 1.200 1.300
Date: 7/23/2010 Date: 8/3/2010 variation 0.050 0.050 0.050 0.050 0.050
1.350 1.350 1.150 1.150 1.250

Minnesota Diversion Channel, Section 1 STA 20+00 0+00 70+00 7,000 1.3

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS					Water Exits	Below Ground	Height above				
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(E) Undrained Global	Slope	Surface	Bottom	Top of slope	% Increase	X-Sectional Area	% Increase
Original MN Sect-01	360	875				895	7	20												320		10066	
FM_P3_MN_Div_Sect-01_DSGN	225	875	70	7	10	895	7	20	50	11		1.70	1.828	2.604	2.230	1.33	882	13	7	344	7%	9879	-2%

Minnesota Diversion Channel, Section 2 STA 175+00 70+00 220+00 15,000 2.8

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS					Water Exits	Below Ground	Height above				
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(E) Undrained Global	Slope	Surface	Bottom	Top of slope	% Increase	X-Sectional Area	% Increase
Original MN Sect-02	360	876				894	7	18												306		8814	
FM_P3_MN_Div_Sect-02_DSGN	225	876	70	7	10	894	7	18	50			1.91	1.899	3.647	3.245	1.38	876	18	7	330	8%	8533	-3%

Minnesota Diversion Channel, Section 2B STA 350+00 220+00 420+00 20,000 3.8

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS					Water Exits	Below Ground	Height above				
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(E) Undrained Global	Slope	Surface	Bottom	Top of slope	% Increase	X-Sectional Area	% Increase
Original MN Sect-02B	360	878				896	7	18												306		8814	
FM_P3_MN_Div_Sect-02B_DSGN	225	878	70	7	10	896	7	18	50			1.84	1.834	3.647	2.880	1.475	878	18	0	330	8%	8533	-3%

Minnesota Diversion Channel, Section 3 STA 510+00 420+00 570+00 15,000 2.8

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS					Water Exits	Below Ground	Height above				
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(E) Undrained Global	Slope	Surface	Bottom	Top of slope	% Increase	X-Sectional Area	% Increase
Original MN Sect-03	360	880				906	7	26												362		14158	
FM_P3_MN_Div_Sect-03_DSGN	225	880	70	7	10	906	7	26	50	11		1.657	1.634	3.029	3.703	1.442	881	25	1	386	6%	14253	1%
FM_P3_MN_Div_Sect-03_kratio_1-5	225	880	70	7	10	906	7	26	50			1.669	1.664	3.029	3.743	1.442							
FM_P3_MN_Div_Sect-03_kratio_1-10	225	880	70	7	10	906	7	26	50			1.67	1.670	3.100	3.751	1.442							

Minnesota Diversion Channel, Section 4A STA 582+00 570+00 640+00 7,000 1.3 43rd Ave N

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS					Water Exits	Below Ground	Height above				
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(E) Undrained Global	Slope	Surface	Bottom	Top of slope	% Increase	X-Sectional Area	% Increase
Original MN Sect-04A	360	881				910	7	29												383		16393	
FM_P3_MN_Div_Sect-04A_Raise4FT_70	400	884	70	7	10	910	10	26	50	13	Left Side	1.474	1.479	1.652	1.597	1.306						19886	21%
											Right Side	1.475				1.306							
FM_P3_MN_Div_Sect-04A_Raise4FT_70_kratio_1-5	400	884	70	7	10	910	10	26	50	13	Left Side	1.504	1.517	1.652	1.546	1.252							
											Right Side	1.506				1.306							
FM_P3_MN_Div_Sect-04A_Raise4FT_70_kratio_1-10	400	884	70	7	10	910	10	26	50	13	Left Side	1.519	1.532	1.653	1.566	1.252							
											Right Side	1.516				1.306							

Minnesota Diversion Channel, Section 4B STA 688+00 640+00 730+00 9,000 1.7 13th Ave N

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS					Water Exits	Below Ground	Height above				
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(E) Undrained Global	Slope	Surface	Bottom	Top of slope	% Increase	X-Sectional Area	% Increase
Original MN Sect-04B	360	881				912	7	31												397		17953	
FM_P3_MN_Div_Sect-04B_35k_Raise4FT_70	400	885	70	7	10	912	10	31			Left Side	1.457	1.456	1.571	1.447	1.357	901	11	16			20956	17%
											Right Side	1.447	1.419	1.404	1.420	1.335							

Minnesota Diversion Channel, Section 5B STA 796+00 730+00 850+00 12,000 2.3 12th Ave S

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS					Water Exits	Below Ground	Height above				
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(E) Undrained Global	Slope	Surface	Bottom	Top of slope	% Increase	X-Sectional Area	% Increase
Original MN Sect-05B	360	884				912	7	28												376		15634	
FM_P3_MN_Div_Sect-05B_Raise4FT_70	400	888	70	7	10	912	7	24			Left Side	1.498	1.483	1.722	1.488	1.436	896	16	8	459	22%	16939	8%
								0			Right Side	1.568				1.442							
FM_P3_MN_Div_Sect-05B_Raise4FT_70_kratio_1-5	400	888	70	7	10	912	7	24			Left Side	1.489	1.473	1.717	1.490	1.436							
								0			Right Side	1.556				1.442							
FM_P3_MN_Div_Sect-05B_Raise4FT_70_kratio_1-10	400	888	70	7	10	912	7	24			Left Side	1.512	1.497	1.763	1.514	1.436							
								0			Right Side	1.573				1.442							

1400

Fargo-Moorhead Metro Feasibility Study
Phase 3 Geotechnical Design/Analyses of MN Diversion Alternatives

Compiled By: KAH Revised By: KAH Target Factor of Safety 1.400 1.400 1.200 1.200 1.300
Date: 7/23/2010 Date: 8/3/2010 variation 0.050 0.050 0.050 0.050 0.050
1.350 1.350 1.150 1.150 1.250

Minnesota Diversion Channel, Section 6 STA 930+00 850+00 1055+00 20,500 3.9

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS					Water Exits	Below Ground	Height above				
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(E) Undrained Global	Slope	Surface	Bottom	Top of slope	% Increase	X-Sectional Area	% Increase
Original MN Sect-06	360	886				914	7	28												376		15634	
FM_P3_MN_Div_Sect-06_Raise4FT_70	400	890	70	7	10	914	7	24	50			1.611	1.592	1.952	1.476	1.393	901	13	11	459	22%	18936	8%

Minnesota Diversion Channel, Section 7 STA 1100+00 1055+00 1155+00 10,000 1.9

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS					Water Exits	Below Ground	Height above				
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(E) Undrained Global	Slope	Surface	Bottom	Top of slope	% Increase	X-Sectional Area	% Increase
Original MN Sect-07	360	890				914	7	24												348		12738	
FM_P3_MN_Div_Sect-07_Raise4FT_70	400	894	70	7	10	914	7	20	50			1.839	1.839	2.048	1.819	1.533	899	15	5	431	24%	13379	5%

Minnesota Diversion Channel, Section 7B STA 1185+00 1155+00 1235+00 8,000 1.5

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS					Water Exits	Below Ground	Height above				
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(E) Undrained Global	Slope	Surface	Bottom	Top of slope	% Increase	X-Sectional Area	% Increase
Original MN Sect-07B	360	891				910	7	19												313		9433	
FM_P3_MN_Div_Sect-07B_Raise4FT_70	400	895	70	7	10	910	7	15	50			2.198	2.195	2.127	2.114	1.849	905	10	5	396	27%	9244	-2%

Minnesota Diversion Channel, Section 8 STA 1270+00 1235+00 1309+80 7,400 1.4

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS					Water Exits	Below Ground	Height above				
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(E) Undrained Global	Slope	Surface	Bottom	Top of slope	% Increase	X-Sectional Area	% Increase
Original MN Sect-08	360	893				912	7	19												313		9433	
FM_P3_MN_Div_Sect-08_Raise4FT_70	400	897	70	7	10	912	7	15	50			2.080	2.080	1.875	2.189	1.774	902	10	5	396	27%	9244	-2%

Minnesota Diversion Channel, Section 9A EXT CH STA 80+00 0+00 105+00 10,500 2.0

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS					Water Exits	Below Ground	Height above				
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(E) Undrained Global	Slope	Surface	Bottom	Top of slope	% Increase	X-Sectional Area	% Increase
Original MN Sect-09A	50	887				911	7	24												193		5298	
FM_P3_MN_Div_Sect-09A_DSGN	215	897				911	7	14				2.026	2.029	2.156	2.025	1.873	898	13	1	206	6%	4448	-16%

Minnesota Diversion Channel, Section 9B EXT CH STA 130+00 105+00 164+84 5,900 1.1

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS					Water Exits	Below Ground	Height above				
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(E) Undrained Global	Slope	Surface	Bottom	Top of slope	% Increase	X-Sectional Area	% Increase
Original MN Sect-09B	50	890				914	7	24												193		5298	
FM_P3_MN_Div_Sect-09B_DSGN	215	900				914	7	14				1.618	1.620	1.998	1.615	1.500	901	13	1	206	6%	4448	-16%

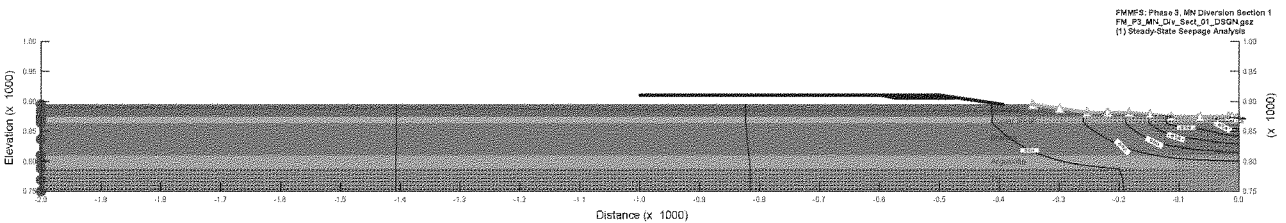
1401

File Name: FM_P3_MN_Div_Sect_01_DSGN.gsz

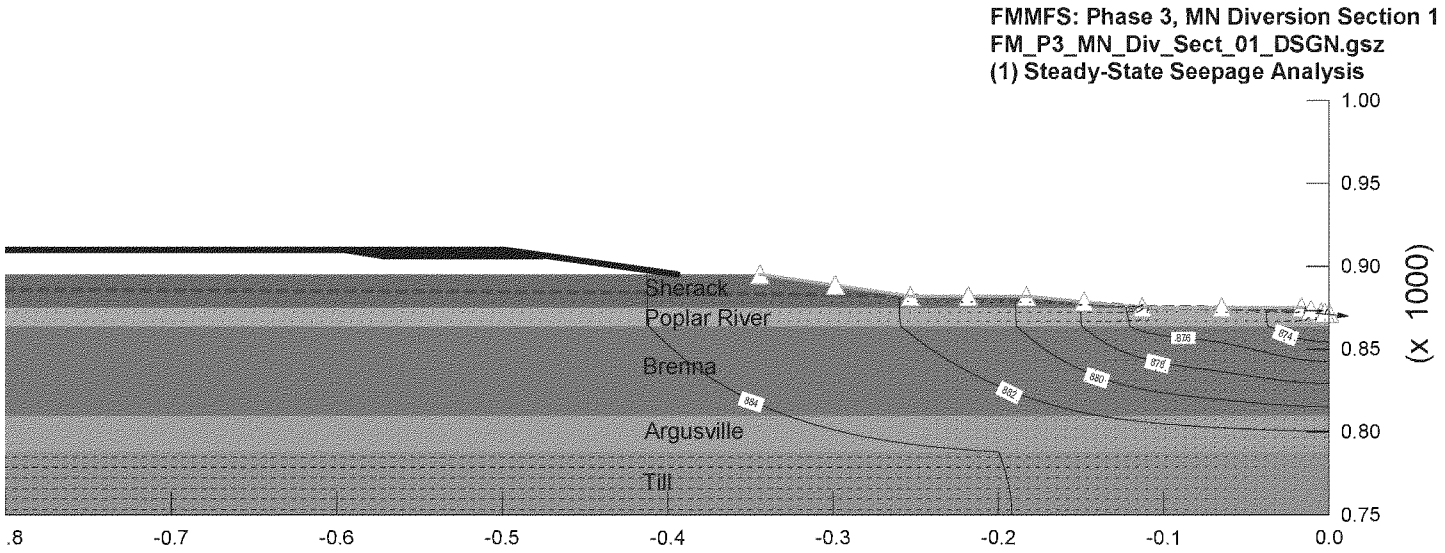
Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 1

(1) Steady-State Seepage Analysis

Soil Properties



Created By: Heckendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/11/2010

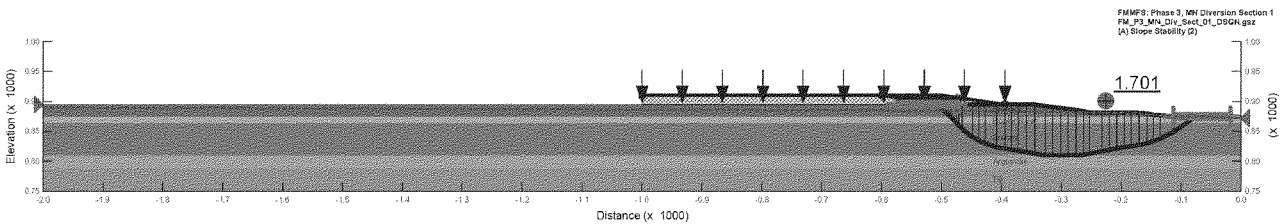

FMMFS: Phase 3, MN Diversion Section 1
FM_P3_MN_Div_Sect_01_DSGN.gsz
(1) Steady-State Seepage Analysis
Sherack
Poplar River
Brenna
Argusville
Till
884
882
880
878
876
874
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P3_MN_Div_Sect_01_DSGN.gsz

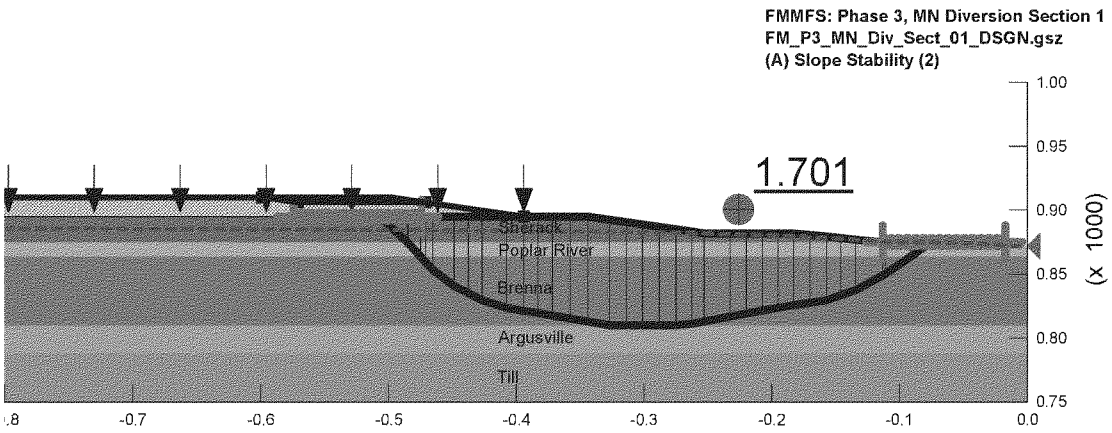
Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 1

(A) Slope Stability (2)

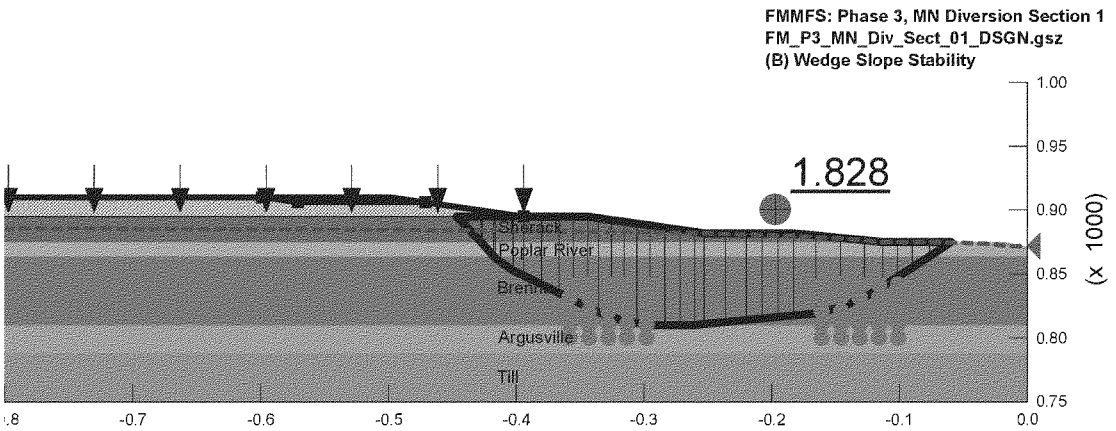
Soil Properties



Created By: Heckendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/11/2010


FMMFS: Phase 3, MN Diversion Section 1
FM_P3_MN_Div_Sect_01_DSGN.gsz
(A) Slope Stability (2)
1.701
Sherack
Poplar River
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1405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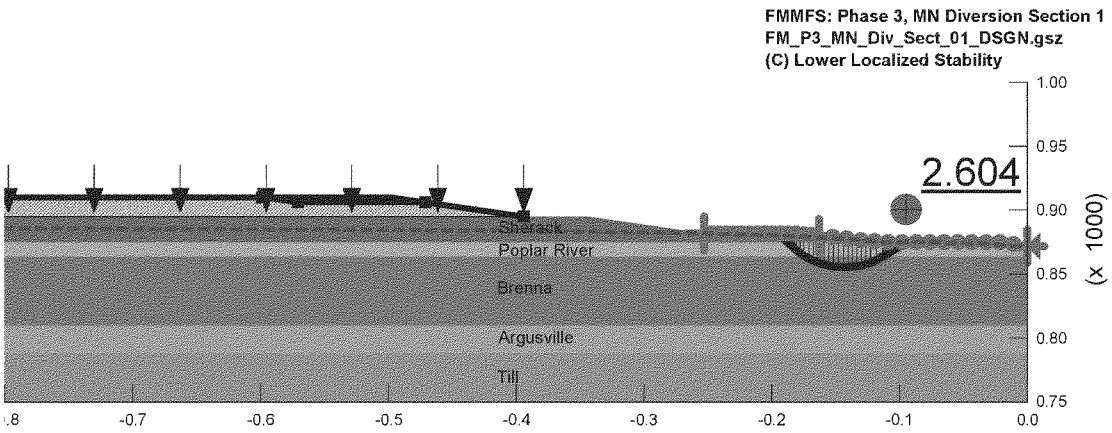
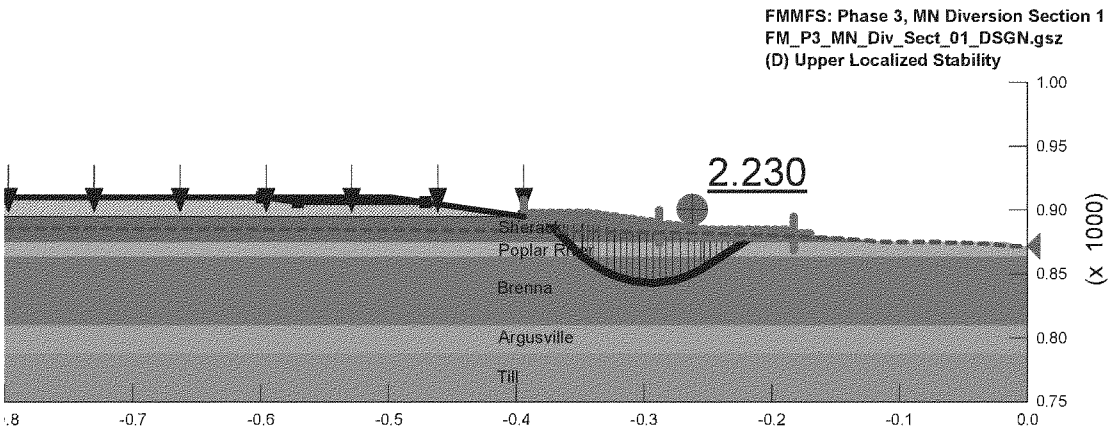
FM_P3_MN_Div_Sect_01_DSGN.gsz
(B) Wedge Slope Stability
1.828
Sherack
Poplar River
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1406


FMMFS: Phase 3, MN Diversion Section 1
FM_P3_MN_Div_Sect_01_DSGN.gsz
(C) Lower Localized Stability
2.604
Sherack
Poplar River
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1407


FMMFS: Phase 3, MN Diversion Section 1
FM_P3_MN_Div_Sect_01_DSGN.gsz
(D) Upper Localized Stability
2.230
Sherack
Poplar River
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

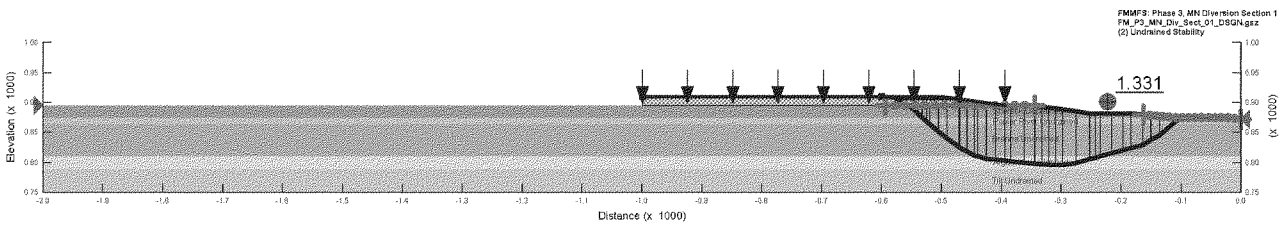
1408

File Name: FM_P3_MN_Div_Sect_01_DSGN.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 1

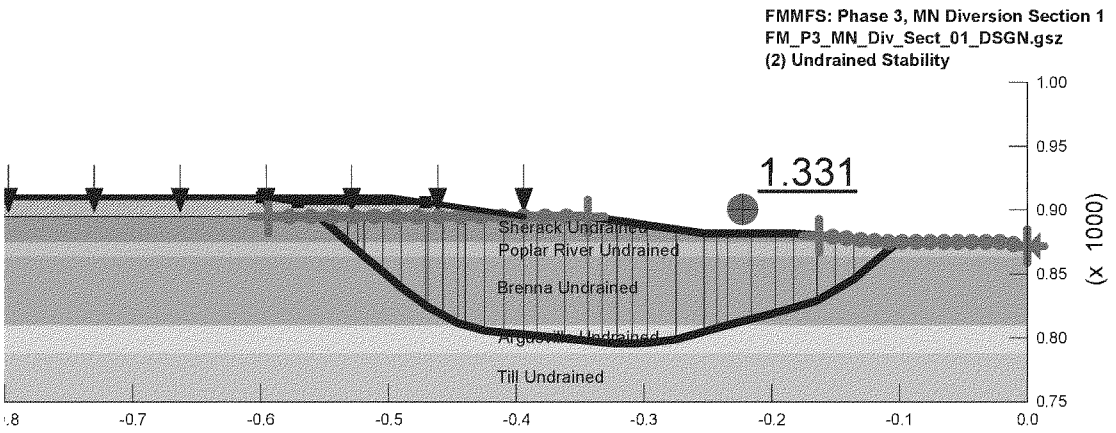
(2) Undrained Stability

Soil Properties



Created By: Heckendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/11/2010

1409


FMMFS: Phase 3, MN Diversion Section 1
FM_P3_MN_Div_Sect_01_DSGN.gsz
(2) Undrained Stability
1.331
Sherack Undrained
Poplar River Undrained
Brenna Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

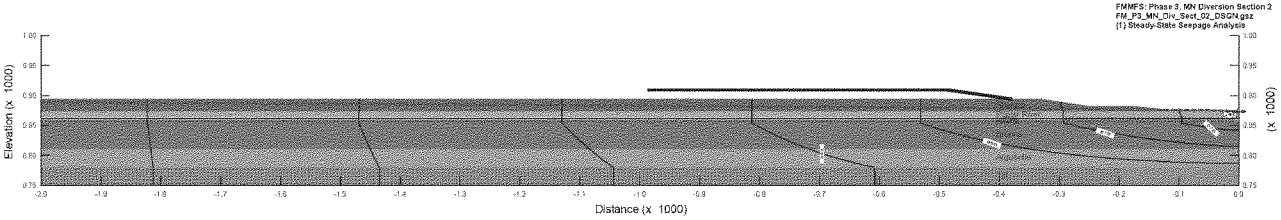
1410

File Name: FM_P3_MN_Div_Sect_02_DSGN.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 2

(1) Steady-State Seepage Analysis

Soil Properties



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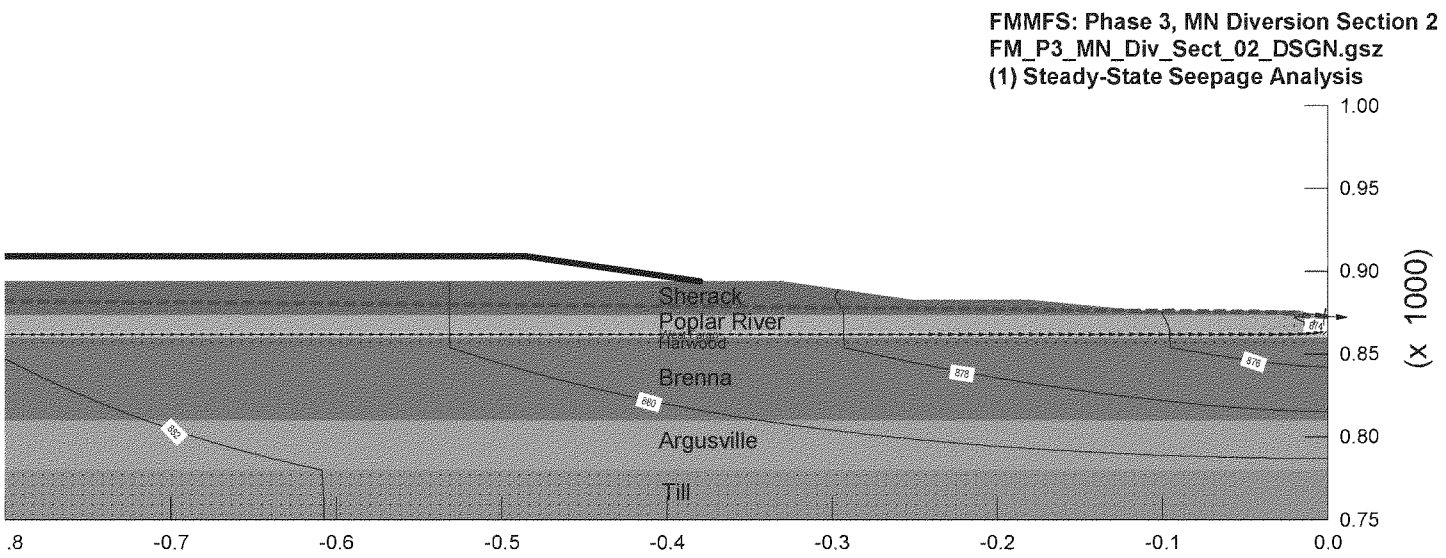
Last Edited By: Killian, Elizabeth A MVP
Date: 8/11/2010

1411


FMMFS: Phase 3, MN Diversion Section 2
FM_P3_MN_Div_Sect_02_DSGN.gsz
(1) Steady-State Seepage Analysis
Sherack
Poplar River
Harwood
Brenna
Argusville
Till
874
878
880
882
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

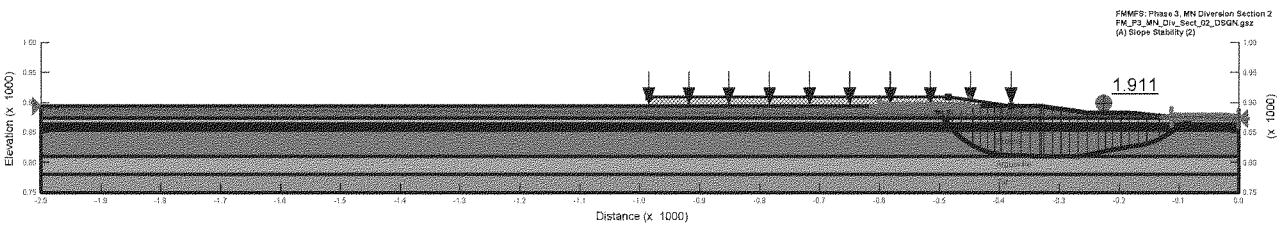
1412

File Name: FM_P3_MN_Div_Sect_02_DSGN.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 2

(A) Slope Stability (2)

Soil Properties



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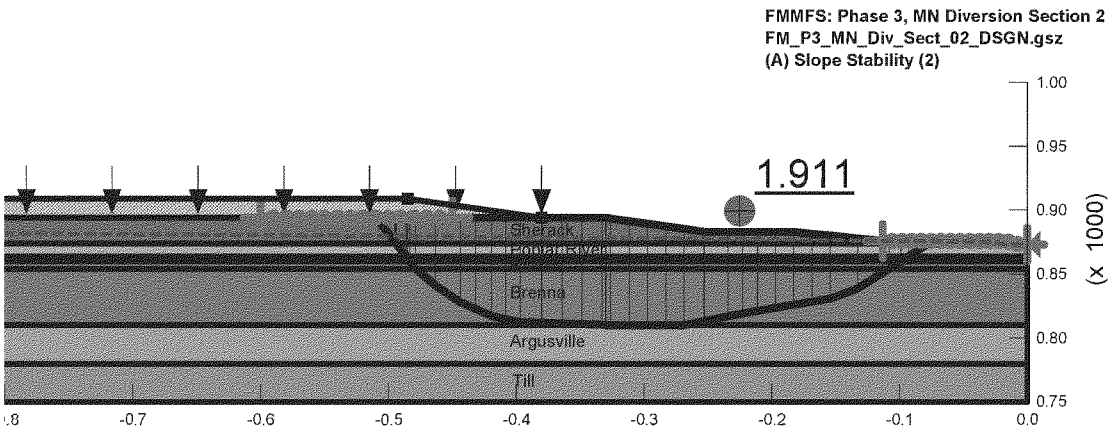
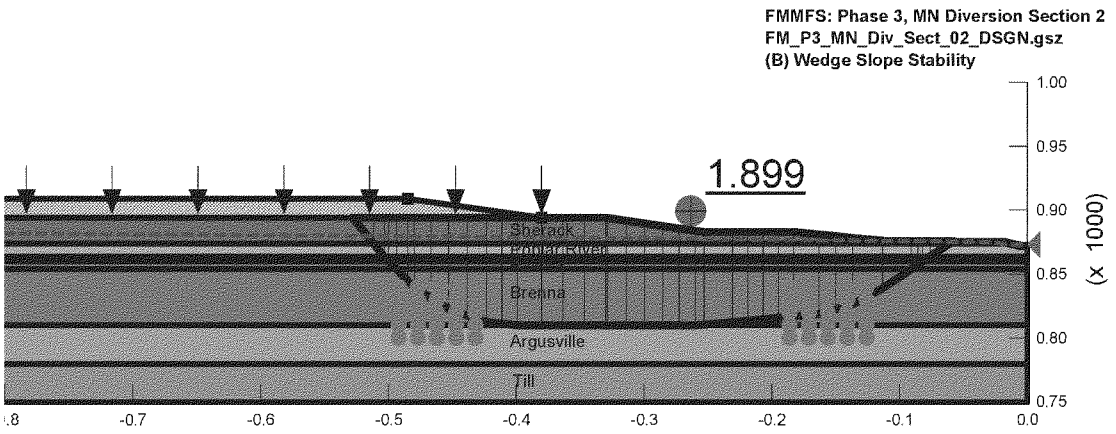
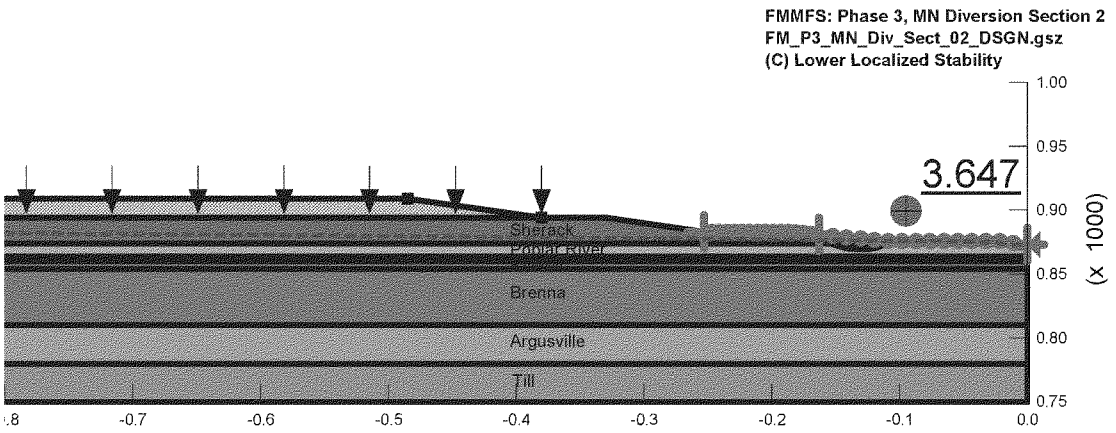
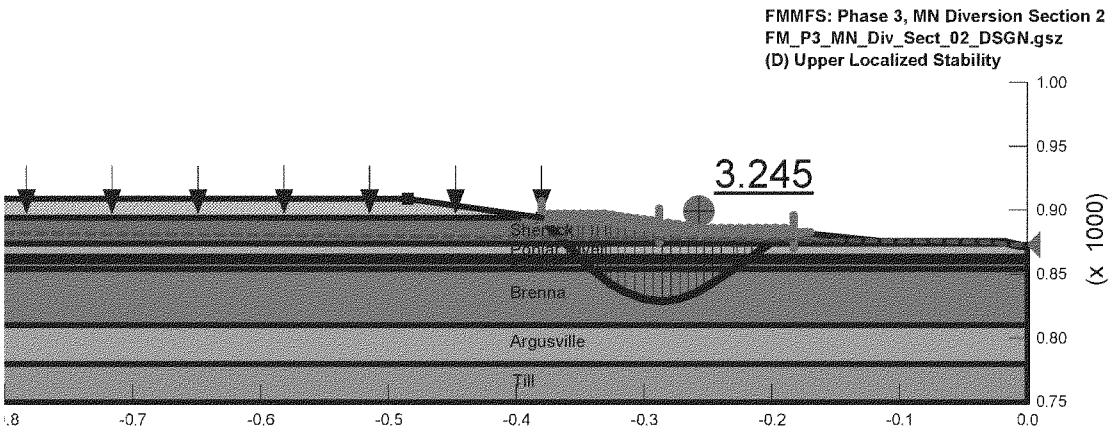
Date: 8/11/2010

1413


FMMFS: Phase 3, MN Diversion Section 2
FM_P3_MN_Div_Sect_02_DSGN.gsz
(A) Slope Stability (2)
1.911
Sherack
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 3, MN Diversion Section 2
FM_P3_MN_Div_Sect_02_DSGN.gsz
(B) Wedge Slope Stability
1.899
Sherack
Poplar River
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 3, MN Diversion Section 2
FM_P3_MN_Div_Sect_02_DSGN.gsz
(C) Lower Localized Stability
3.647
Sherack
Poplar River
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

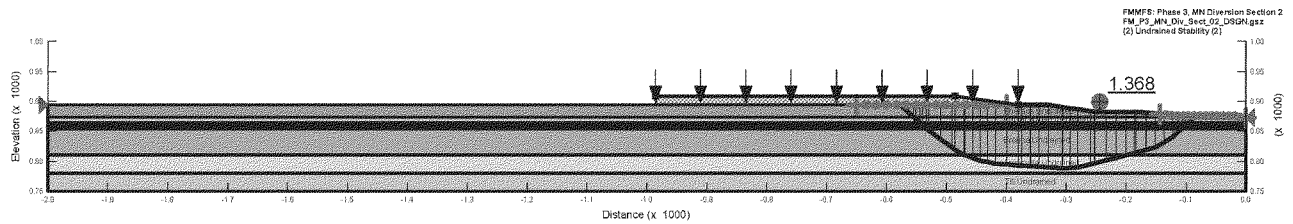

FMMFS: Phase 3, MN Diversion Section 2
FM_P3_MN_Div_Sect_02_DSGN.gsz
(D) Upper Localized Stability
3.245
Sherack
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P3_MN_Div_Sect_02_DSGN.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 2

(2) Undrained Stability (2)

Soil Properties



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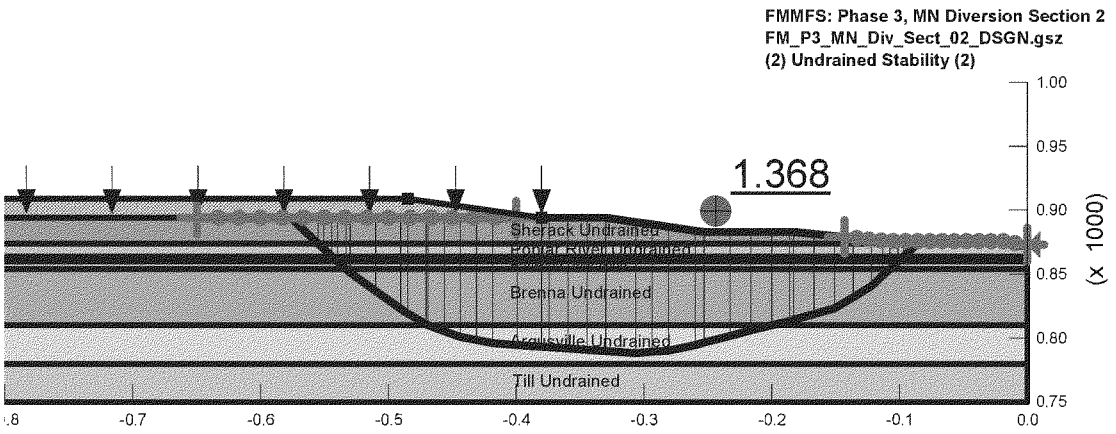
Last Edited By: Killian, Elizabeth A MVP
Date: 8/11/2010

1418


FMMFS: Phase 3, MN Diversion Section 2
FM_P3_MN_Div_Sect_02_DSGN.gsz
(2) Undrained Stability (2)
1.368
Sherack Undrained
Brenna Undrained
Argusville Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

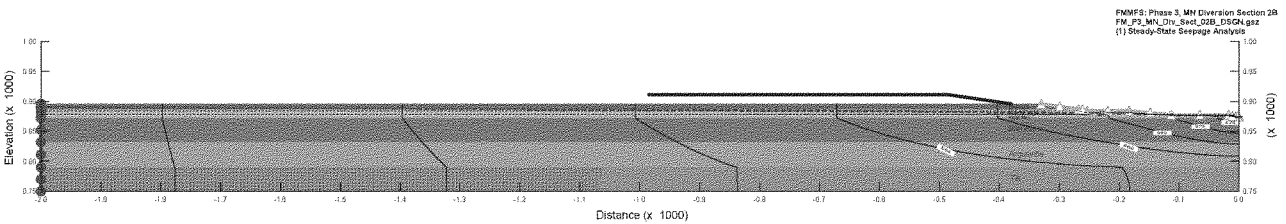
1419

File Name: FM_P3_MN_Div_Sect_02B_DSGN.gsz

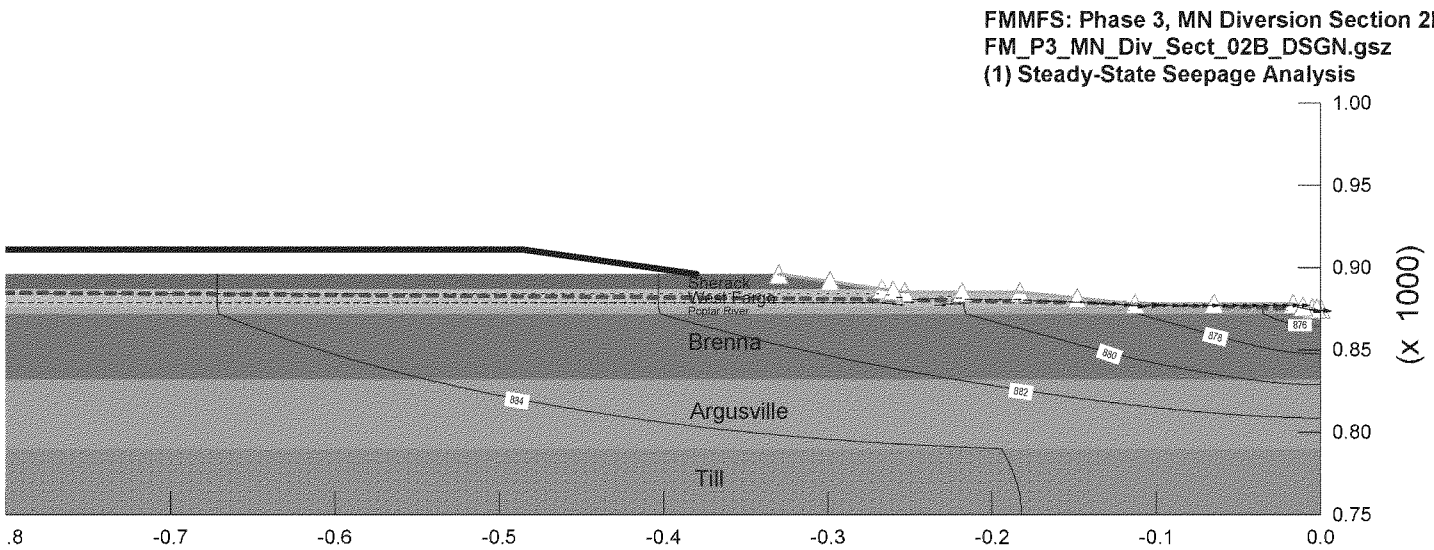
Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 2B

(1) Steady-State Seepage Analysis

Soil Properties



Created By: Heckendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/11/2010


FMMFS: Phase 3, MN Diversion Section 2B
FM_P3_MN_Div_Sect_02B_DSGN.gsz
(1) Steady-State Seepage Analysis
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
Sherack
West Fargo
Poplar River
Brenna
Argusville
Till
884
882
880
878
876
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

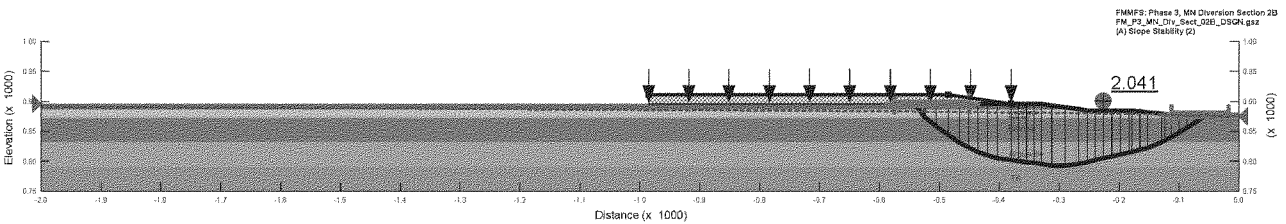
1421

File Name: FM_P3_MN_Div_Sect_02B_DSGN.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 2B

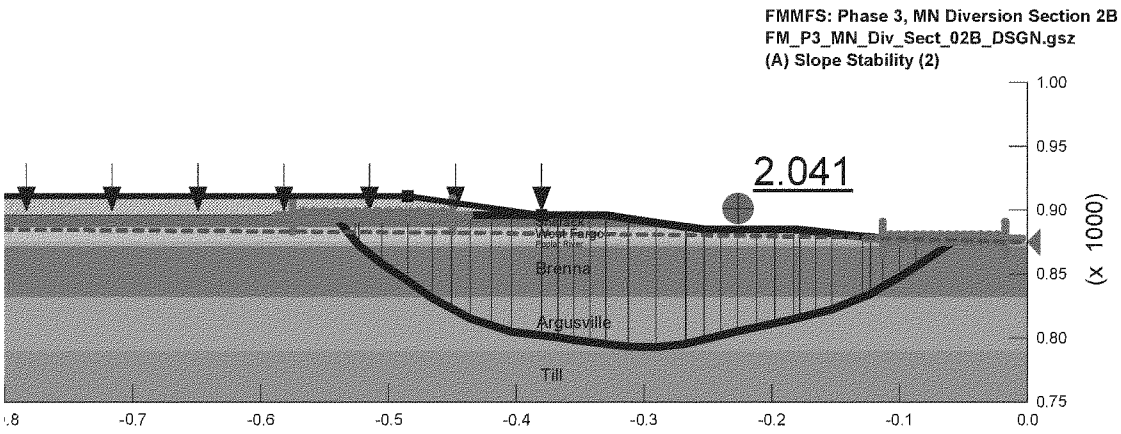
(A) Slope Stability (2)

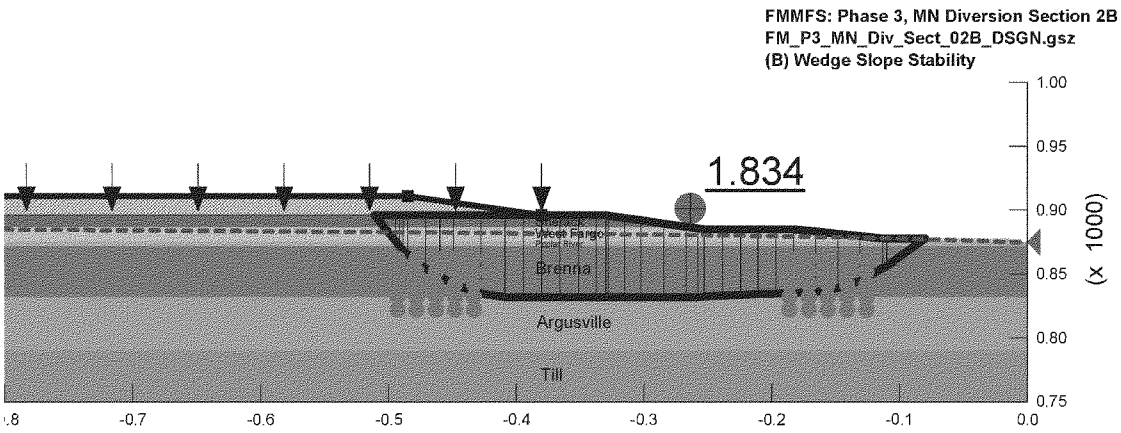
Soil Properties

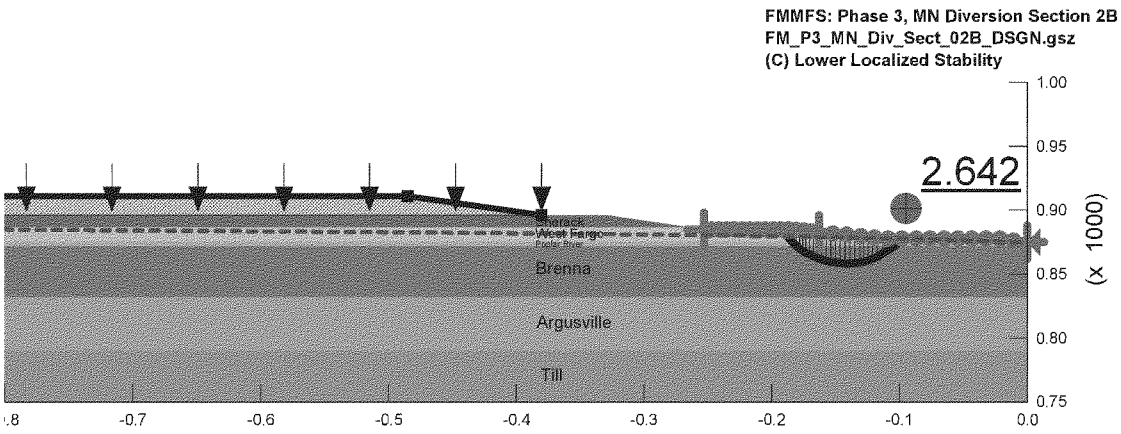


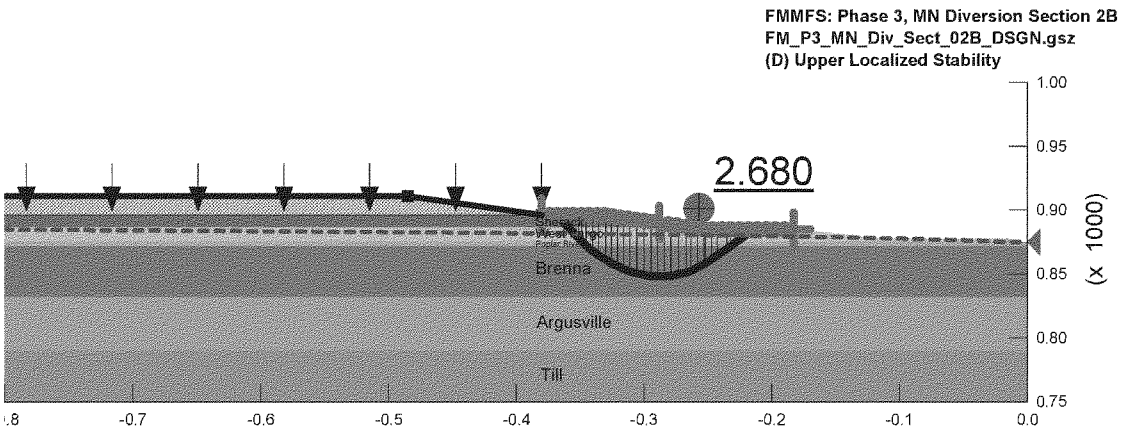
Created By: Heckendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/11/2010

1422


FMMFS: Phase 3, MN Diversion Section 2B
FM_P3_MN_Div_Sect_02B_DSGN.gsz
(A) Slope Stability (2)
2.041
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 3, MN Diversion Section 2B
FM_P3_MN_Div_Sect_02B_DSGN.gsz
(B) Wedge Slope Stability
1.834
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 3, MN Diversion Section 2B
FM_P3_MN_Div_Sect_02B_DSGN.gsz
(C) Lower Localized Stability
2.642
Sherack
Fargo
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

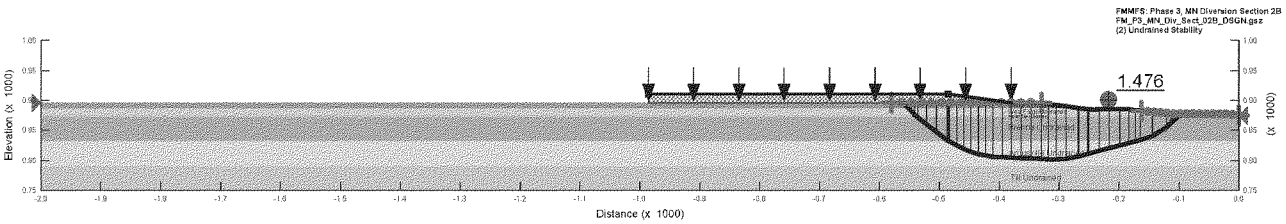

FMMFS: Phase 3, MN Diversion Section 2B
FM_P3_MN_Div_Sect_02B_DSGN.gsz
(D) Upper Localized Stability
2.680
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P3_MN_Div_Sect_02B_DSGN.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 2B

(2) Undrained Stability

Soil Properties



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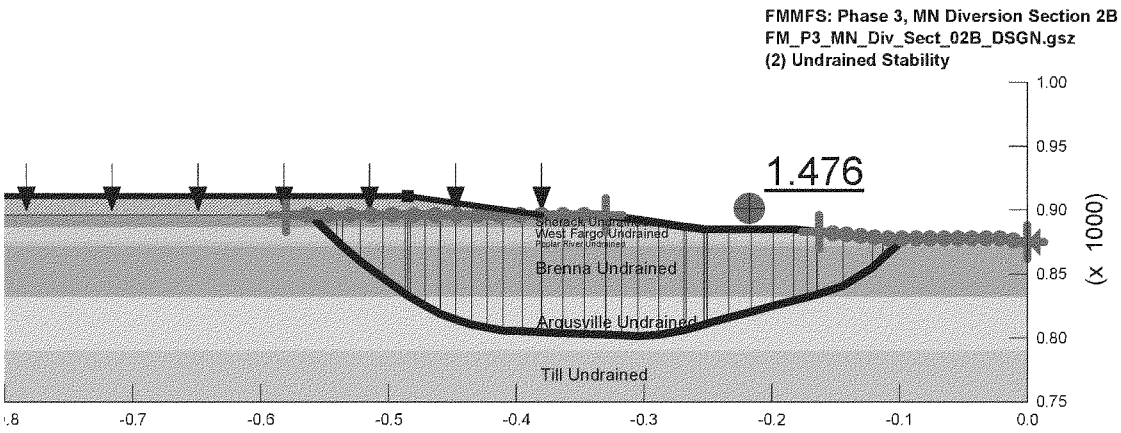
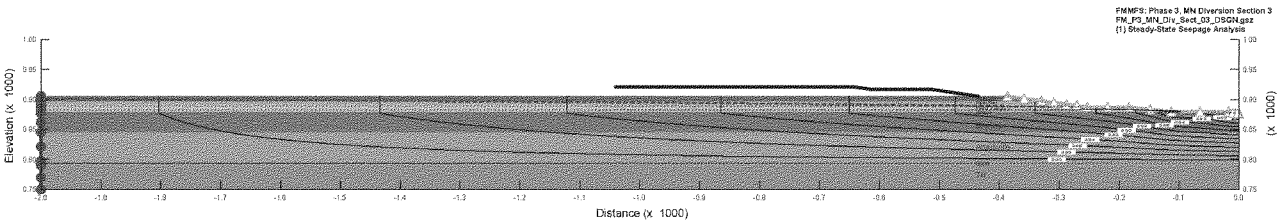

FMMFS: Phase 3, MN Diversion Section 2B
FM_P3_MN_Div_Sect_02B_DSGN.gsz
(2) Undrained Stability
1.476
Sherack Undrained
West Fargo Undrained
Brenna Undrained
Argusville Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P3_MN_Div_Sect_03_DSGN.gsz

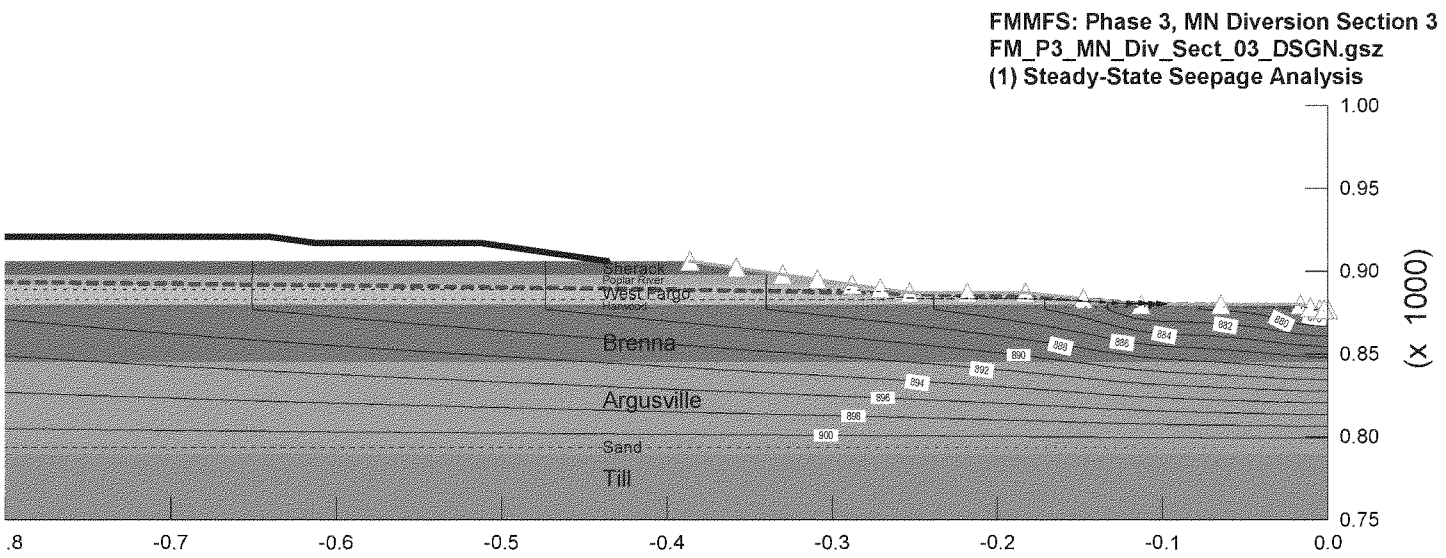
Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 3

(1) Steady-State Seepage Analysis

Soil Properties



Created By: Heckendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/11/2010

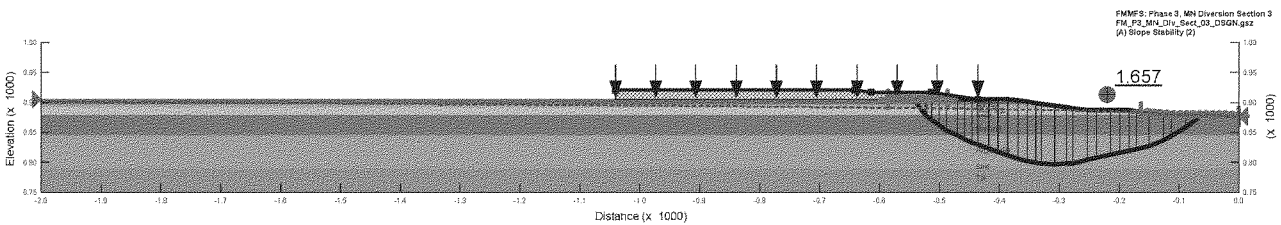

FMMFS: Phase 3, MN Diversion Section 3
FM_P3_MN_Div_Sect_03_DSGN.gsz
(1) Steady-State Seepage Analysis
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
Sherack
Poplar River
West Fargo
Harwood
Brenna
Argusville
Sand
Till
880
882
884
886
888
890
892
894
896
898
900
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P3_MN_Div_Sect_03_DSGN.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 3

(A) Slope Stability (2)

Soil Properties



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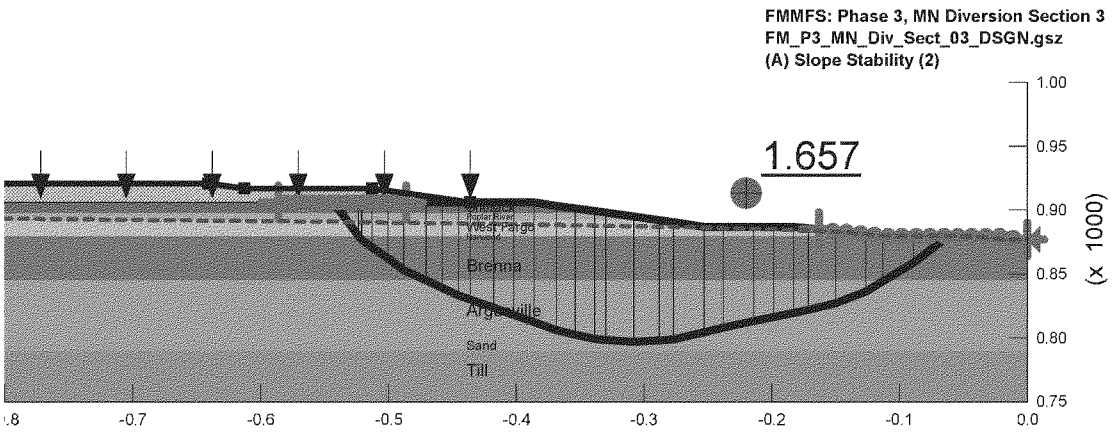
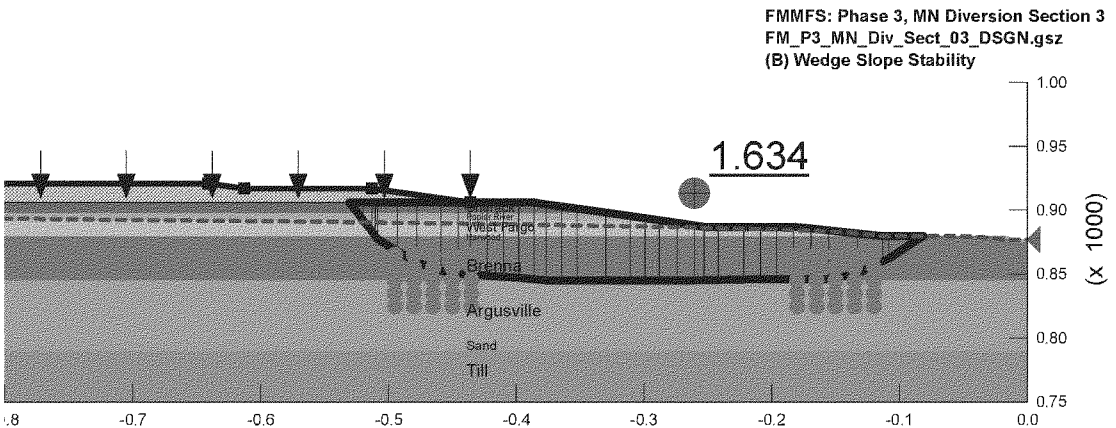
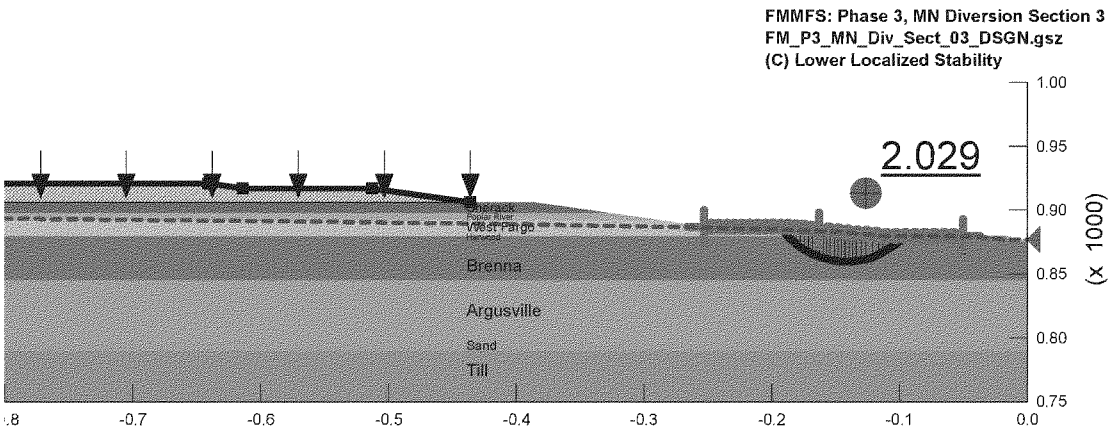
Date: 8/11/2010

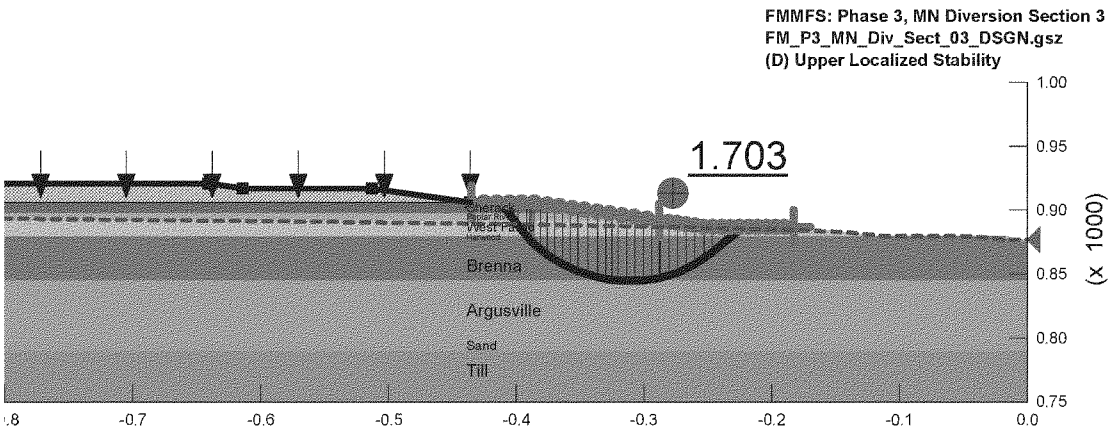
1431


FMMFS: Phase 3, MN Diversion Section 3
FM_P3_MN_Div_Sect_03_DSGN.gsz
(A) Slope Stability (2)
1.657
Brenna
Sand
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 3, MN Diversion Section 3
FM_P3_MN_Div_Sect_03_DSGN.gsz
(B) Wedge Slope Stability
1.634
Brenna
Argusville
Sand
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1433


FMMFS: Phase 3, MN Diversion Section 3
FM_P3_MN_Div_Sect_03_DSGN.gsz
(C) Lower Localized Stability
2.029
Brenna
Argusville
Sand
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

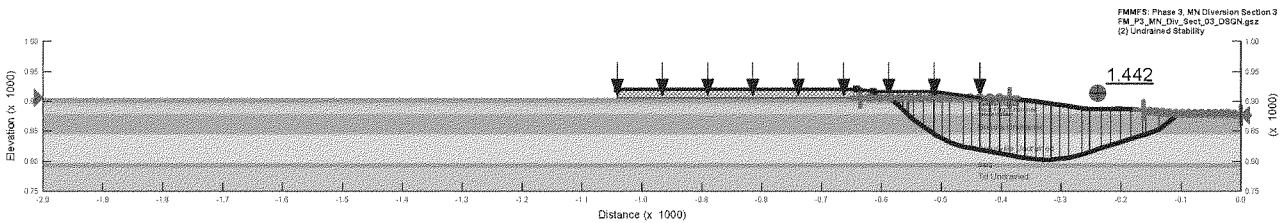

FMMFS: Phase 3, MN Diversion Section 3
FM_P3_MN_Div_Sect_03_DSGN.gsz
(D) Upper Localized Stability
1.703
Brenna
Argusville
Sand
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P3_MN_Div_Sect_03_DSGN.gsz

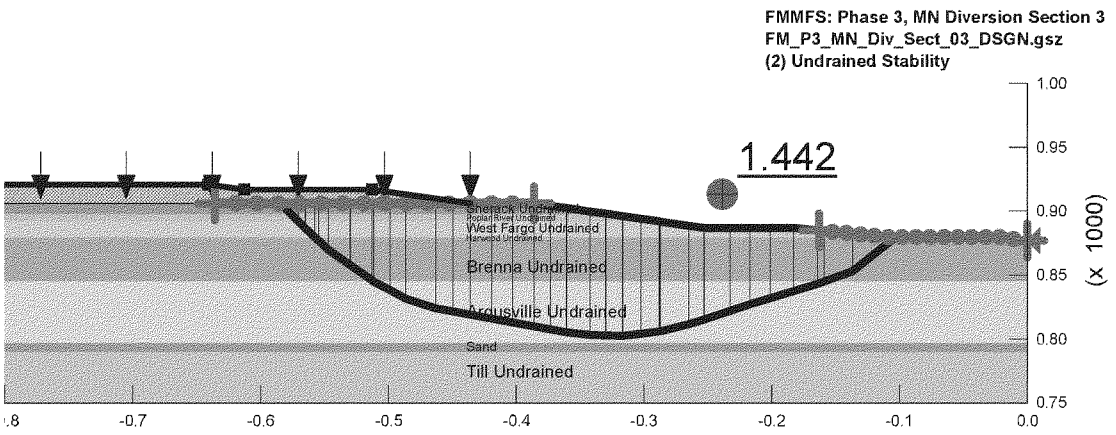
Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 3

(2) Undrained Stability

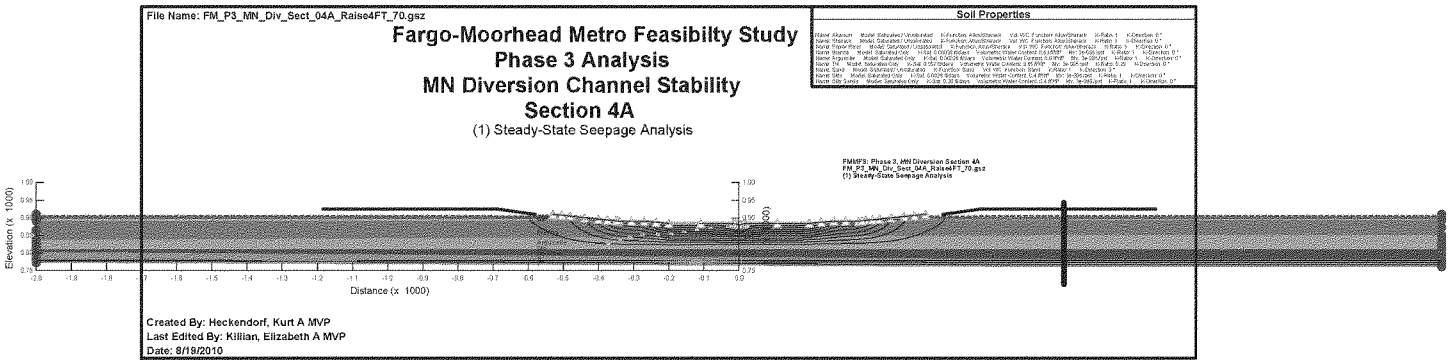
Soil Properties

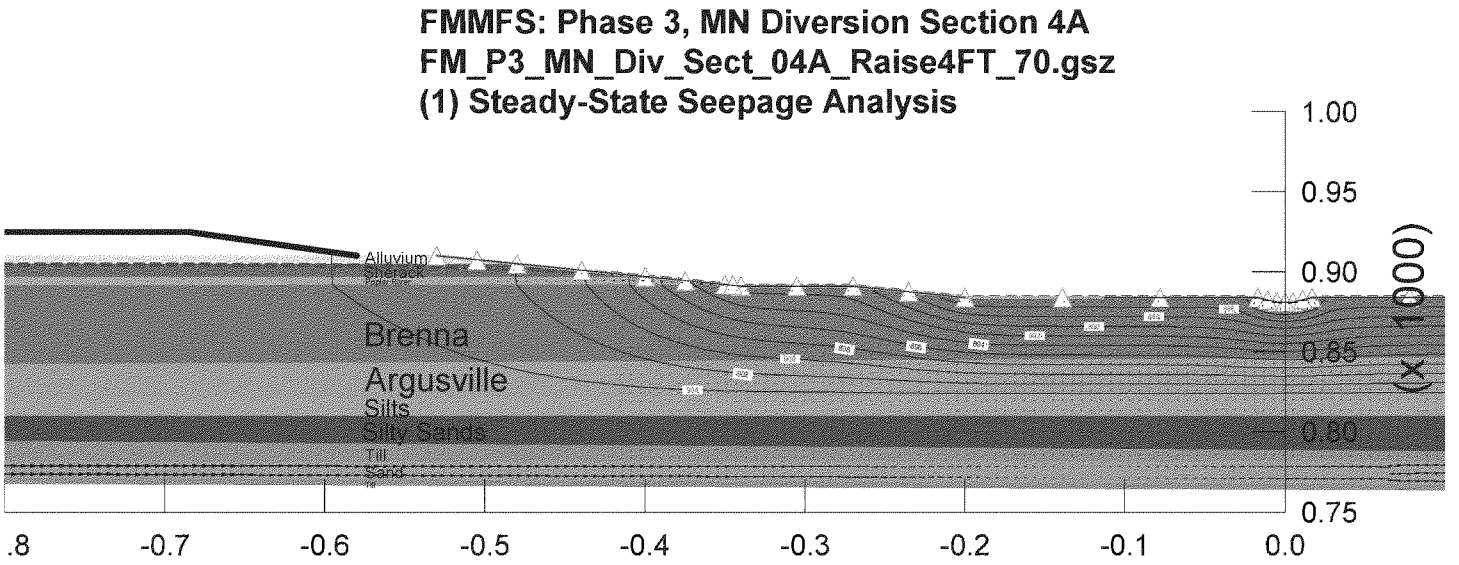


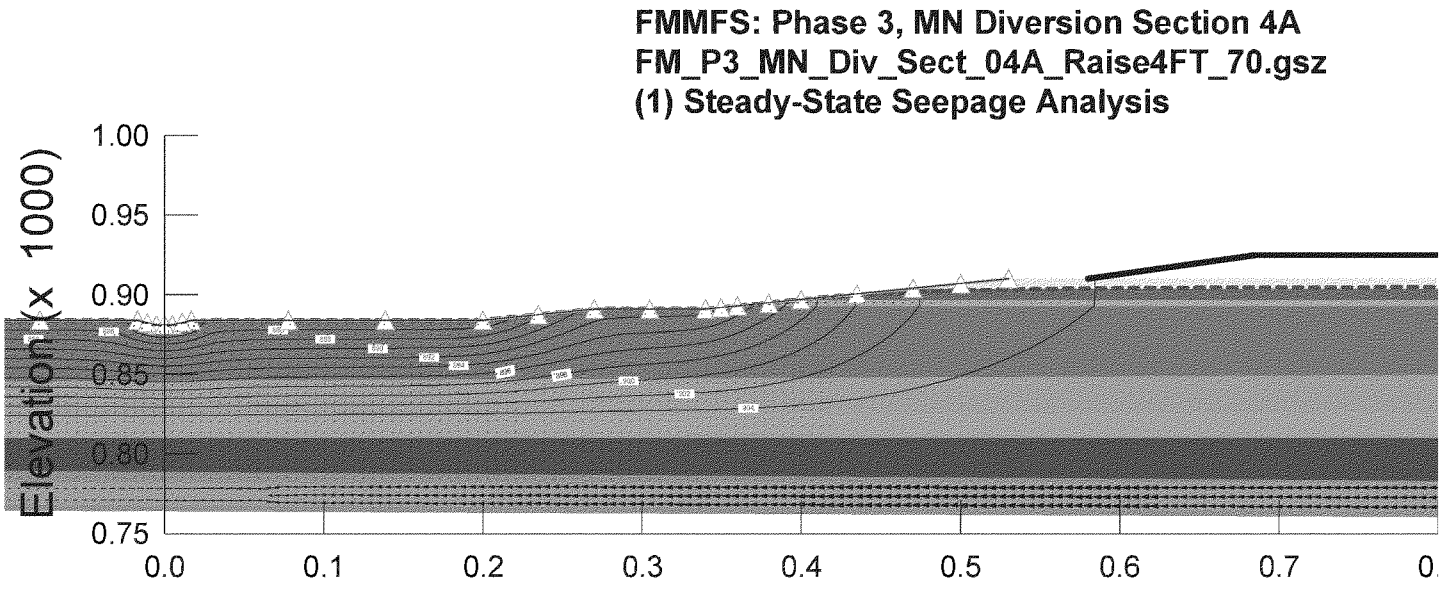
Created By: Heckendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/11/2010

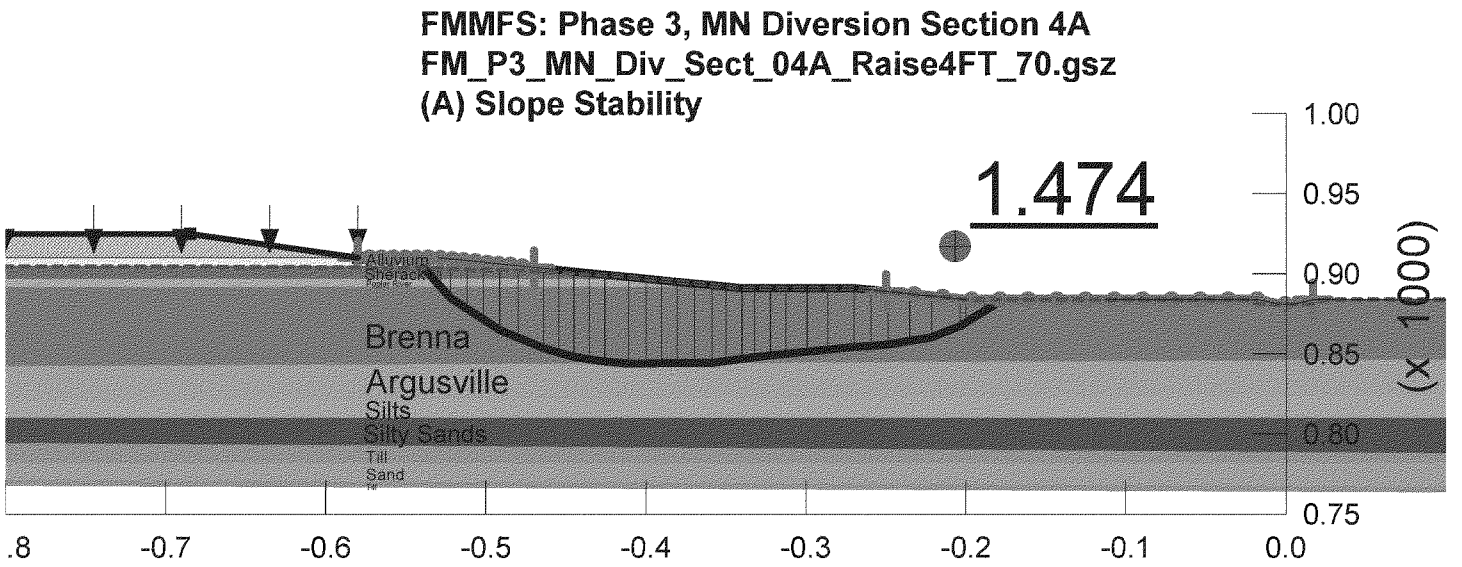

FMMFS: Phase 3, MN Diversion Section 3
FM_P3_MN_Div_Sect_03_DSGN.gsz
(2) Undrained Stability
1.442
Sherack Undrained
Poplar River Undrained
West Fargo Undrained
Harwood Undrained
Brenna Undrained
Arrowville Undrained
Sand
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

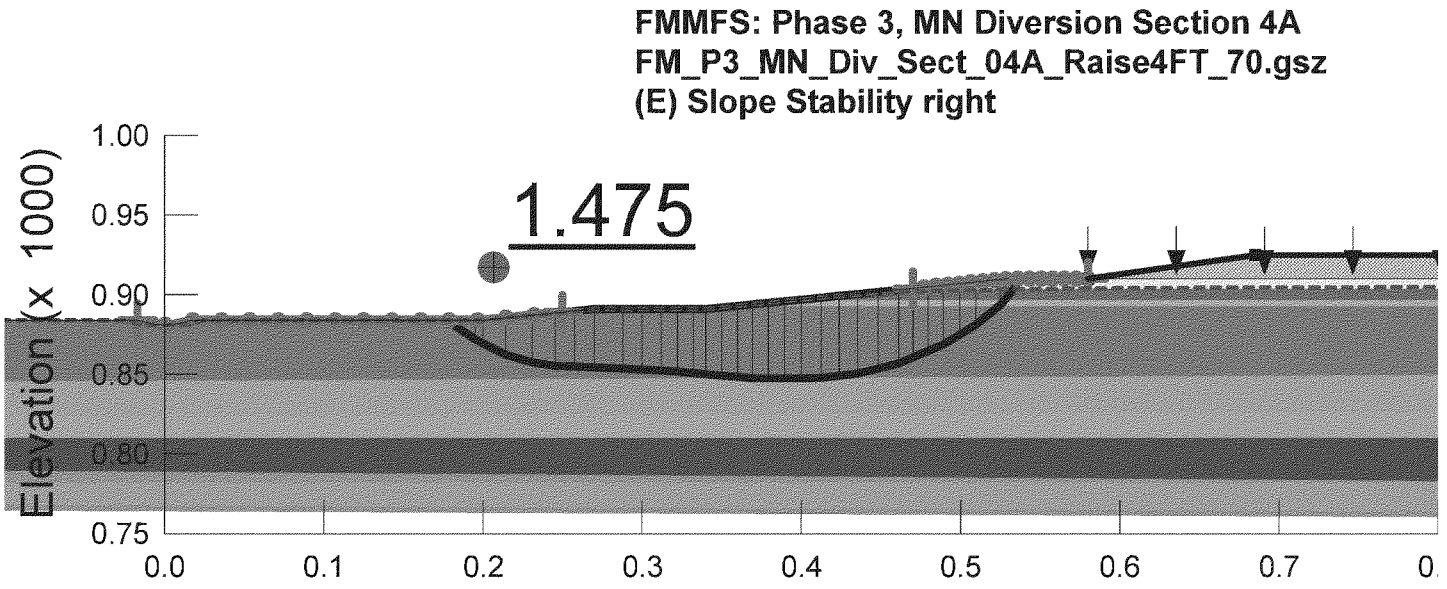
1437


File Name: FM_P3_MN_Div_Sect_04A_Raise4FT_70.gsz
Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 4A
(1) Steady-State Seepage Analysis
Soil Properties
FMMP3: Phase 3, MN Diversion Section 4A
FM_P3_MN_Div_Sect_04A_Raise4FT_70.gsz
(1) Steady-State Seepage Analysis
Elevation (x 1000)
Distance (x 1000)
Created By: Heckendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/18/2010

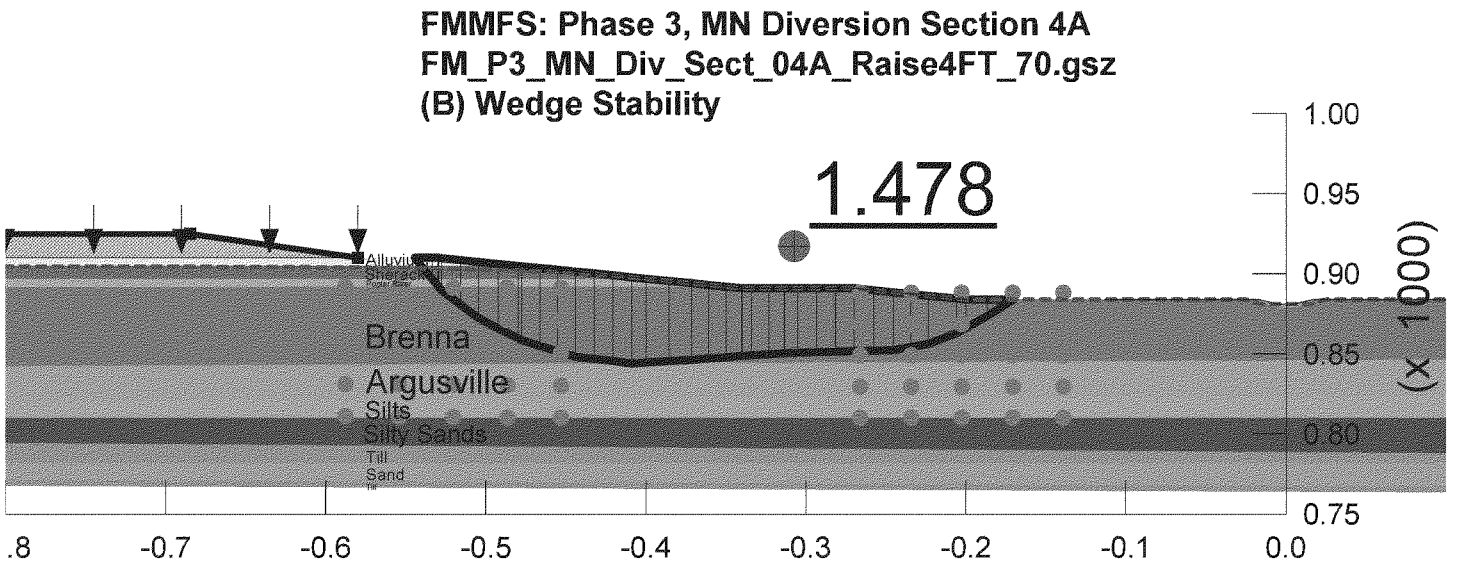

FMMFS: Phase 3, MN Diversion Section 4A
FM_P3_MN_Div_Sect_04A_Raise4FT_70.gsz
(1) Steady-State Seepage Analysis
Alluvium
Sherack
Brenna
Argusville
Silts
Silty Sands
Till
Sand
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

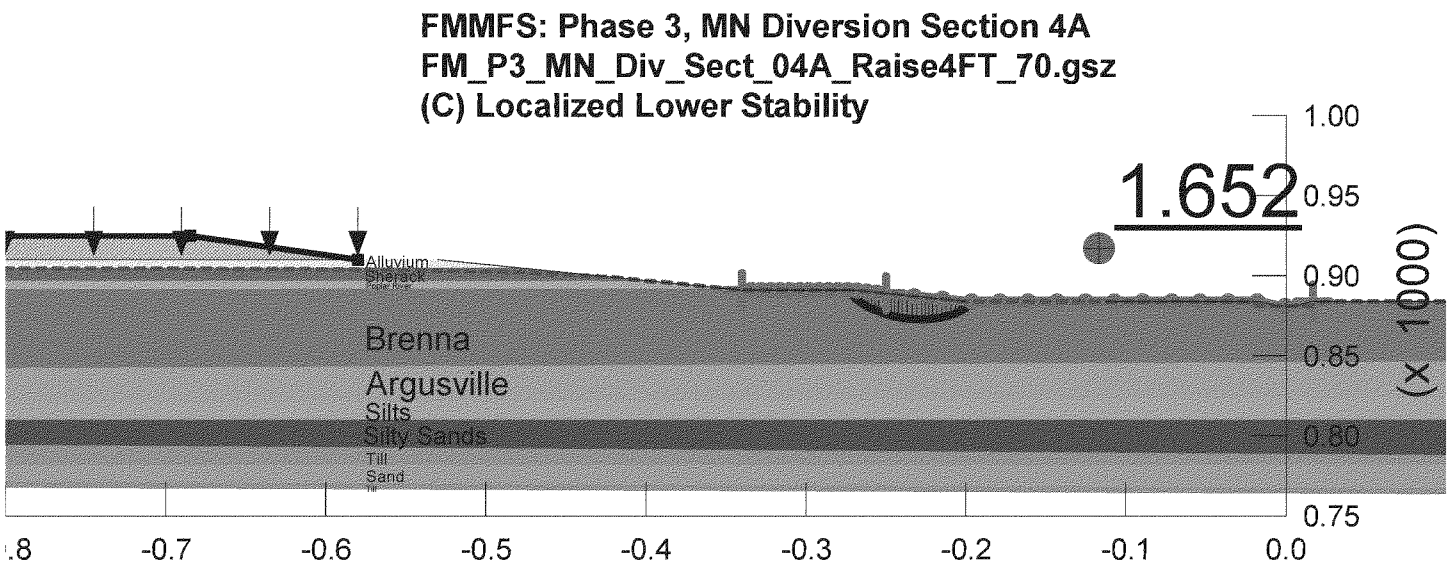

FMMFS: Phase 3, MN Diversion Section 4A
FM_P3_MN_Div_Sect_04A_Raise4FT_70.gsz
(1) Steady-State Seepage Analysis
Elevation (x 1000)
1.00
0.95
0.90
0.85
0.80
0.75
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7


FMMFS: Phase 3, MN Diversion Section 4A
FM_P3_MN_Div_Sect_04A_Raise4FT_70.gsz
(A) Slope Stability
1.474
Alluvium
Sherack
Brenna
Argusville
Silts
Silty Sands
Till
Sand
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

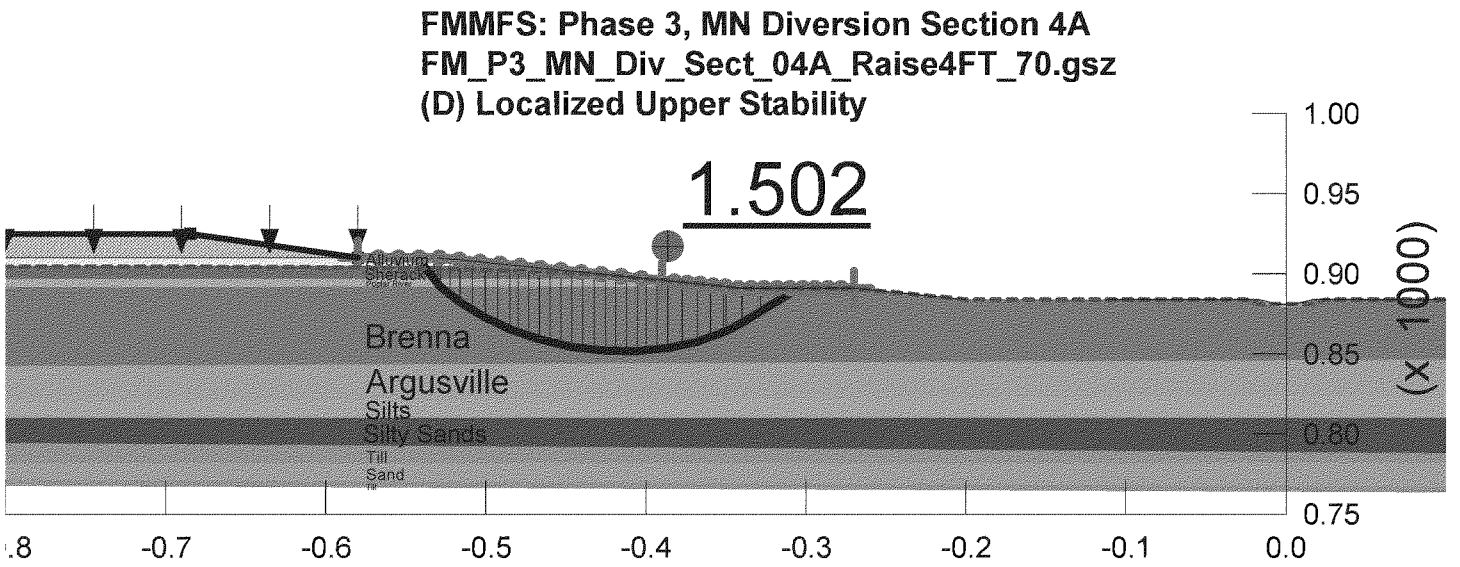

FMMFS: Phase 3, MN Diversion Section 4A
FM_P3_MN_Div_Sect_04A_Raise4FT_70.gsz
(E) Slope Stability right
1.475
Elevation (x 1000)
1.00
0.95
0.90
0.85
0.80
0.75
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

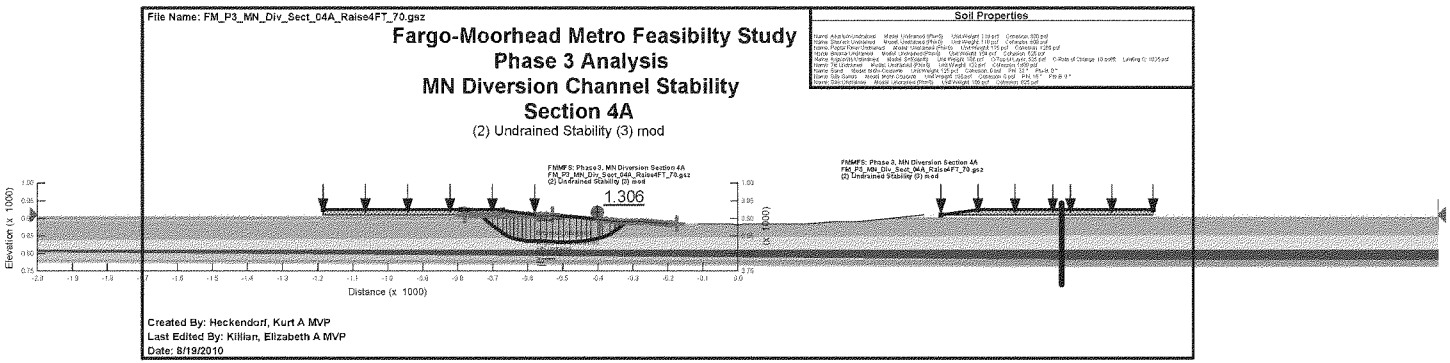
1442

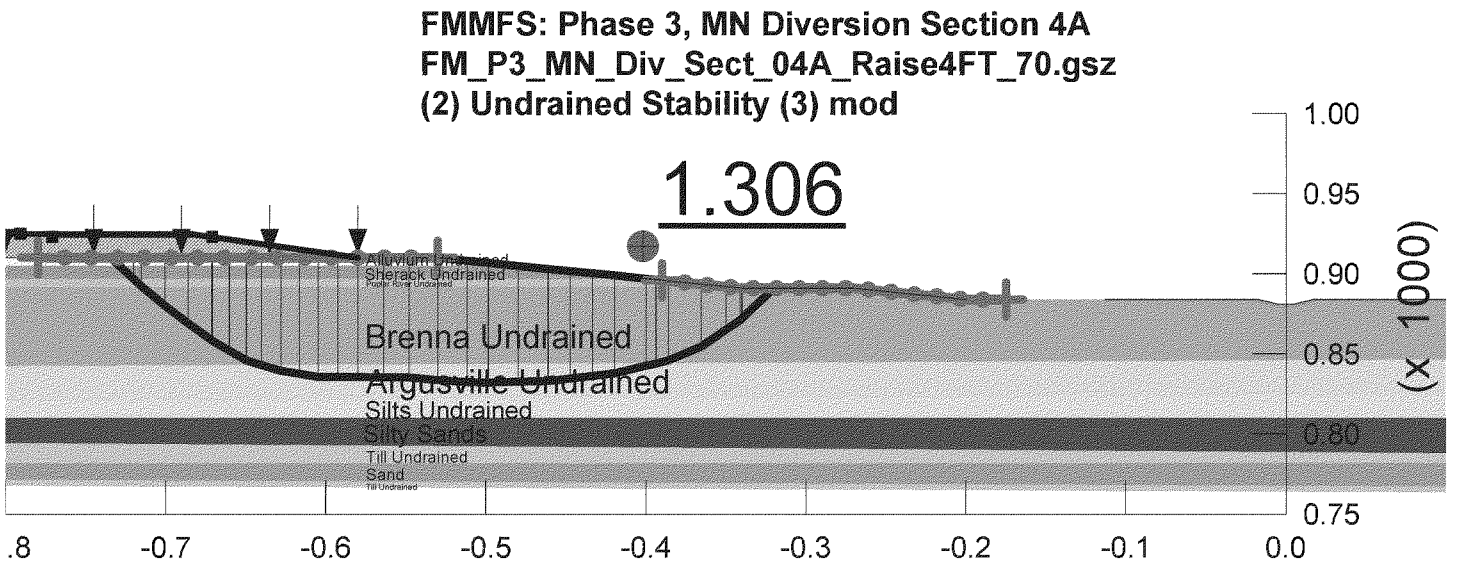

FMMFS: Phase 3, MN Diversion Section 4A
FM_P3_MN_Div_Sect_04A_Raise4FT_70.gsz
(B) Wedge Stability
1.478
Brenna
Argusville
Silts
Silty Sands
Till
Sand
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

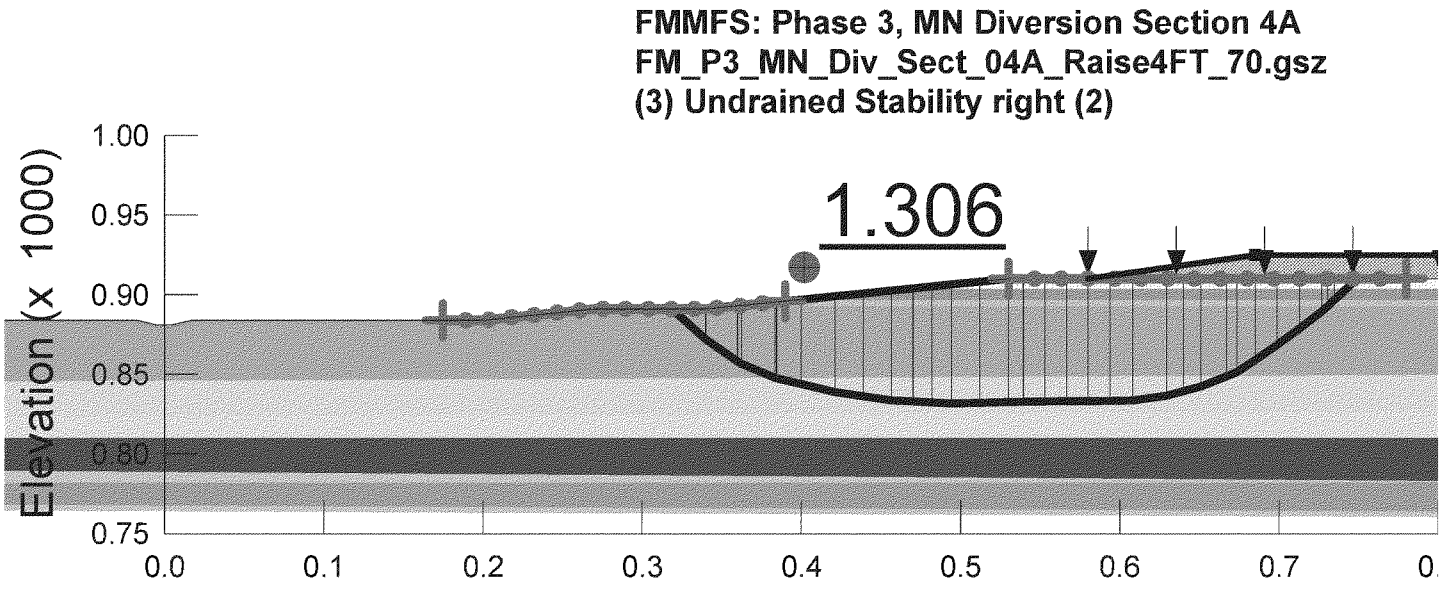

FMMFS: Phase 3, MN Diversion Section 4A
FM_P3_MN_Div_Sect_04A_Raise4FT_70.gsz
(C) Localized Lower Stability
1.652
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
Alluvium
Sherack
Brenna
Argusville
Silts
Silty Sands
Till
Sand
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

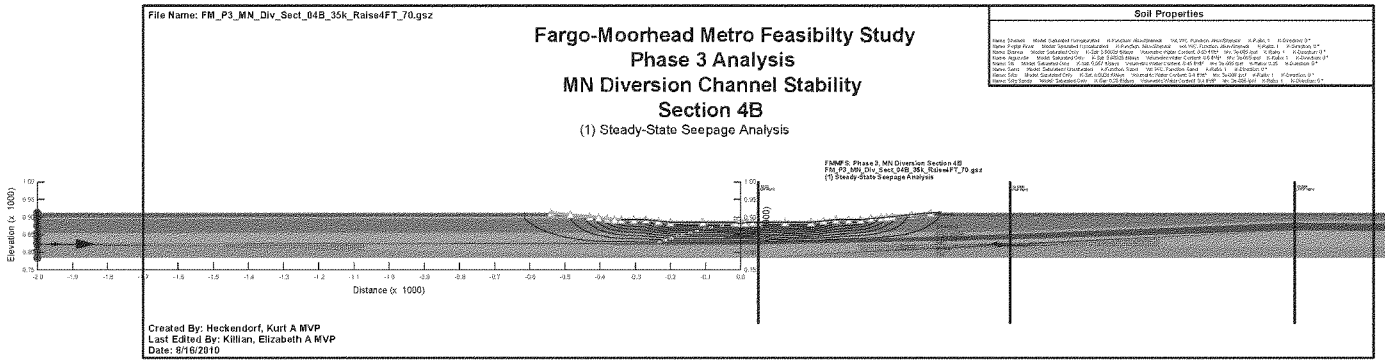
1444

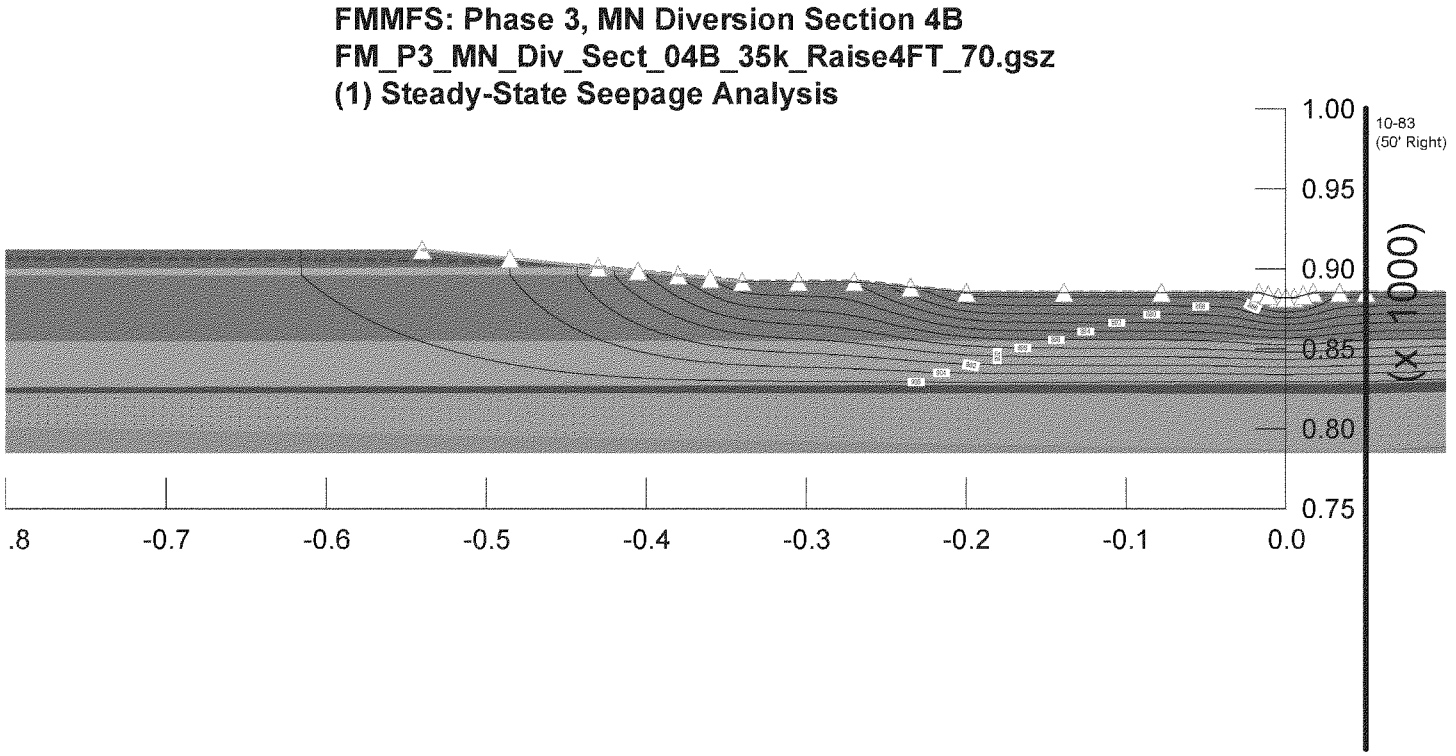

FMMFS: Phase 3, MN Diversion Section 4A
FM_P3_MN_Div_Sect_04A_Raise4FT_70.gsz
(D) Localized Upper Stability
1.502
Alluvium
Sherack
Brenna
Argusville
Silts
Silty Sands
Till
Sand
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

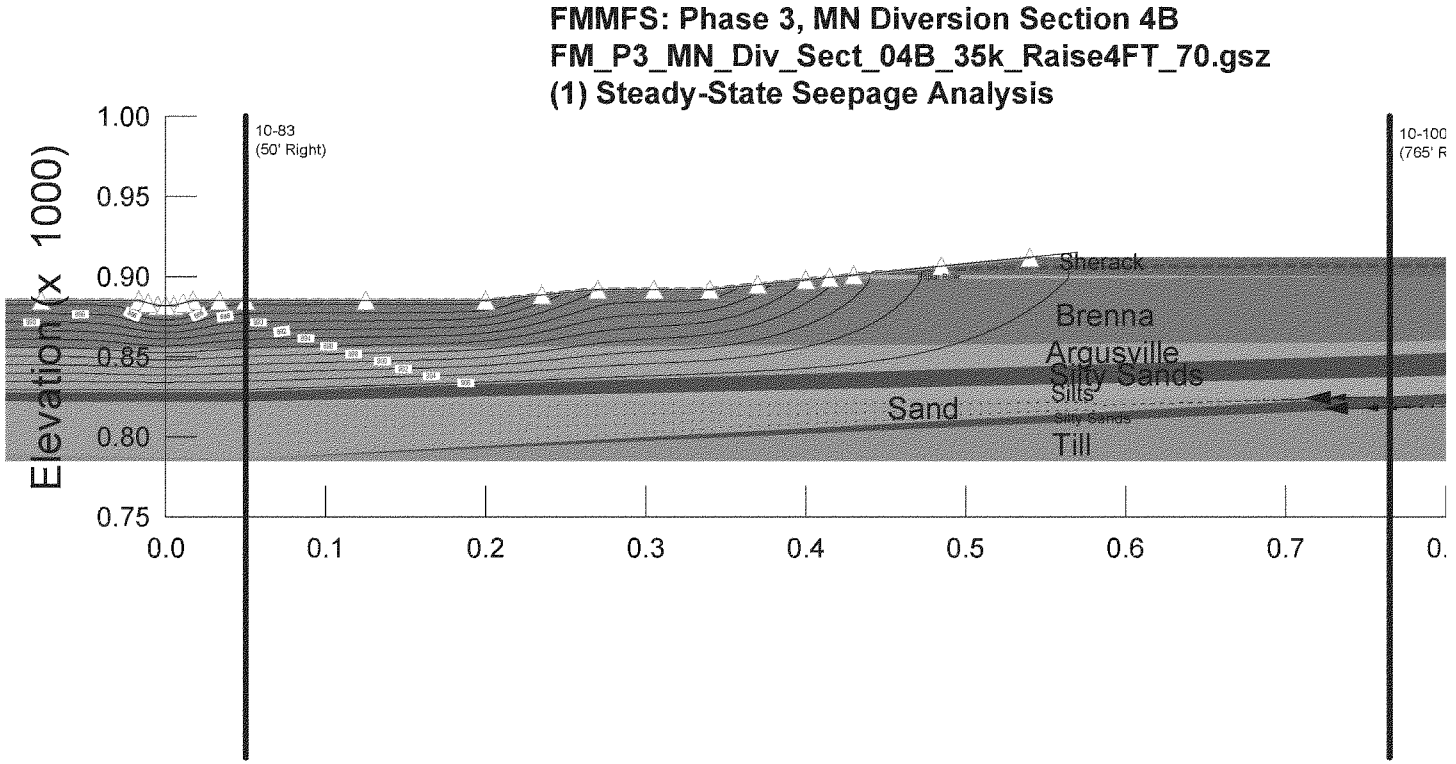

File Name: FM_P3_MN_Div_Sect_04A_Raise4FT_70.gsz
Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 4A
(2) Undrained Stability (3) rnod
Soil Properties
FMMFS: Phase 3, MN Diversion Section 4A
FM_P3_MN_Div_Sect_04A_Raise4FT_70.gsz
(2) Undrained Stability (3) rnod
1.306
Elevation (x 1000)
Distance (x 1000)
Created By: Heckendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/19/2010

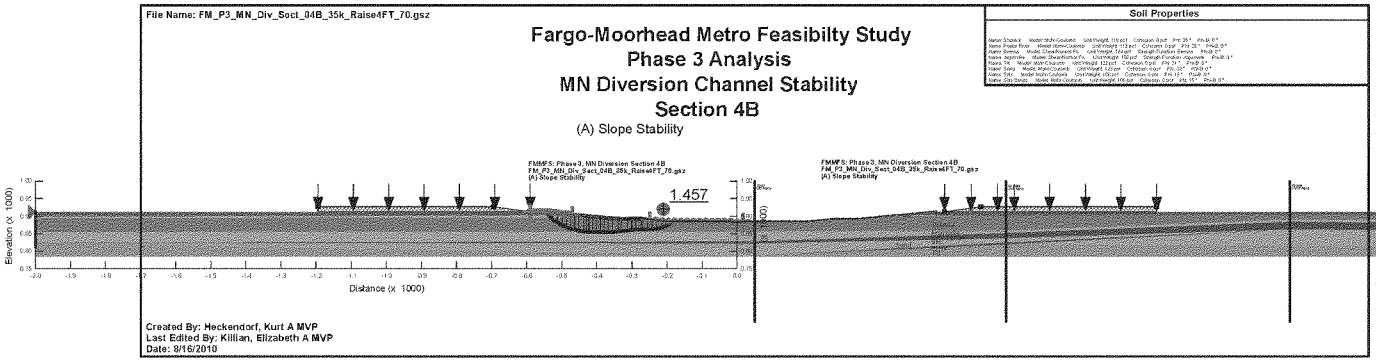

FMMFS: Phase 3, MN Diversion Section 4A
FM_P3_MN_Div_Sect_04A_Raise4FT_70.gsz
(2) Undrained Stability (3) mod
1.306
Alluvium Undrained
Sherack Undrained
Poster Fluvial Undrained
Brenna Undrained
Argusville Undrained
Silts Undrained
Silty Sands
Till Undrained
Sand
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

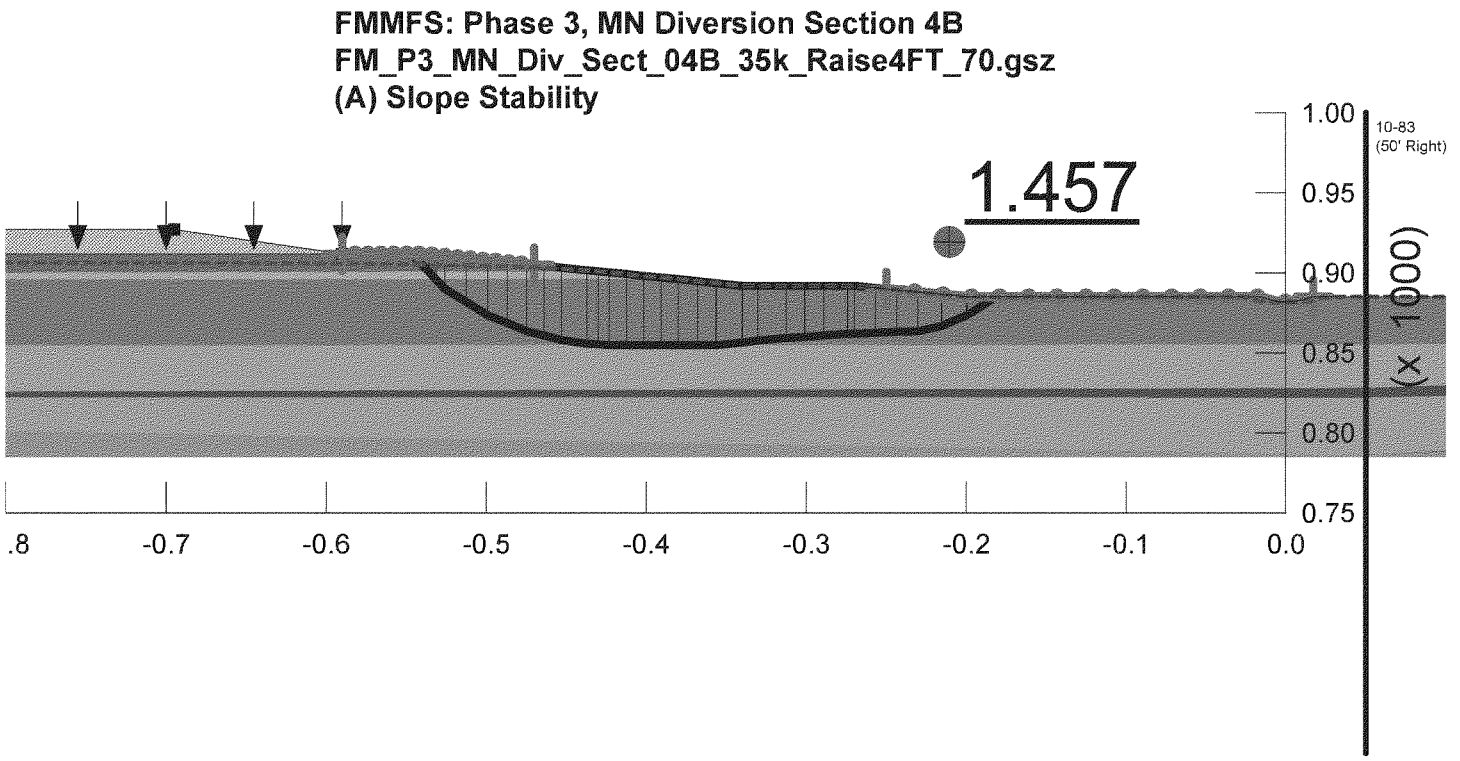

FMMFS: Phase 3, MN Diversion Section 4A
FM_P3_MN_Div_Sect_04A_Raise4FT_70.gsz
(3) Undrained Stability right (2)
1.306
Elevation (x 1000)
1.00
0.95
0.90
0.85
0.80
0.75
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

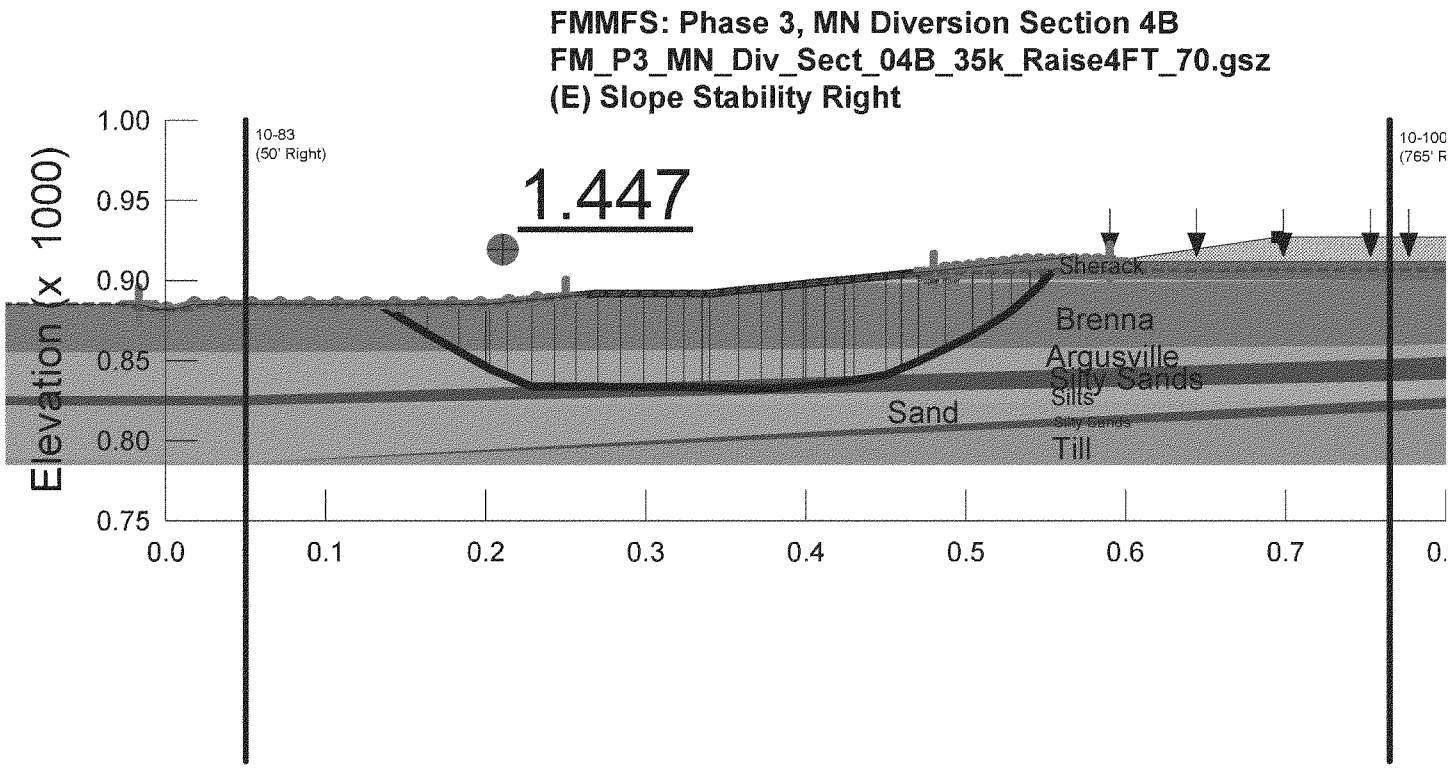

File Name: FM_P3_MN_Div_Sect_04B_35k_Raise4FT_70.gsz
Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 4B
(1) Steady-State Seepage Analysis
Soil Properties
Elevation (x 1000)
Distance (x 1000)
Created By: Heckendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/16/2010


FMMFS: Phase 3, MN Diversion Section 4B
FM_P3_MN_Div_Sect_04B_35k_Raise4FT_70.gsz
(1) Steady-State Seepage Analysis
1.00
0.95
0.90
0.85
0.80
0.75
10-83
(50' Right)
(X 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

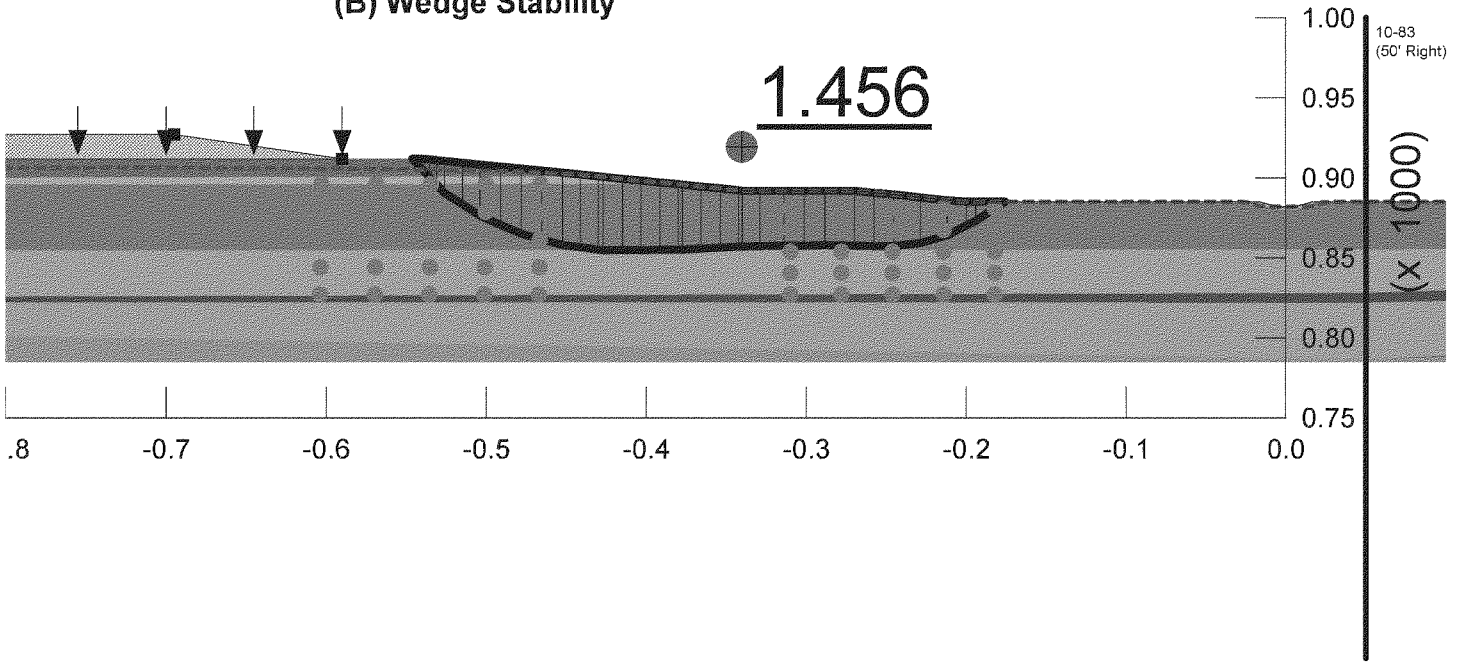

FMMFS: Phase 3, MN Diversion Section 4B
FM_P3_MN_Div_Sect_04B_35k_Raise4FT_70.gsz
(1) Steady-State Seepage Analysis
Elevation (x 1000)
1.00
0.95
0.90
0.85
0.80
0.75
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
10-83
(50' Right)
10-100
(765' R
Sherack
Brenna
Argusville
Silty Sands
Silts
Silty Sands
Sand
Till


File Name: FM_P3_MN_Div_Sect_04B_35k_Raise4FT_70.gsz
Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 4B
(A) Slope Stability
Soil Properties
1.457
Elevation (x 1000)
Distance (x 1000)
Created By: Hockendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/16/2010


FMMFS: Phase 3, MN Diversion Section 4B
FM_P3_MN_Div_Sect_04B_35k_Raise4FT_70.gsz
(A) Slope Stability
1.457
1.00
0.95
0.90
0.85
0.80
0.75
10-83
(50' Right)
(x 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 3, MN Diversion Section 4B
FM_P3_MN_Div_Sect_04B_35k_Raise4FT_70.gsz
(E) Slope Stability Right
1.447
10-83
(50' Right)
10-100
(765' R
Elevation (x 1000)
1.00
0.95
0.90
0.85
0.80
0.75
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Sherack
Brenna
Argusville
Silty Sands
Silts
Silty Sands
Sand
Till

FMMFS: Phase 3, MN Diversion Section 4B
FM_P3_MN_Div_Sect_04B_35k_Raise4FT_70.gsz
(B) Wedge Stability



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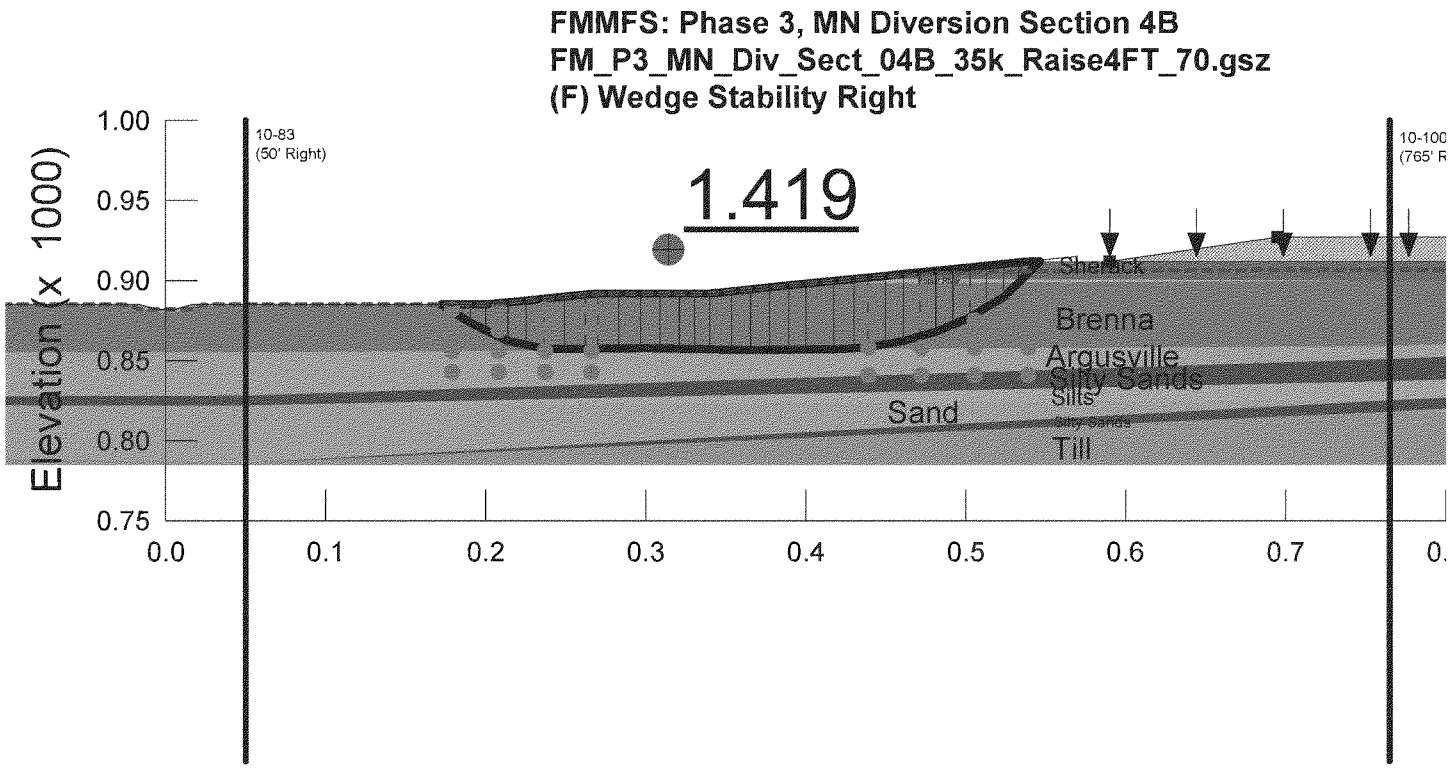
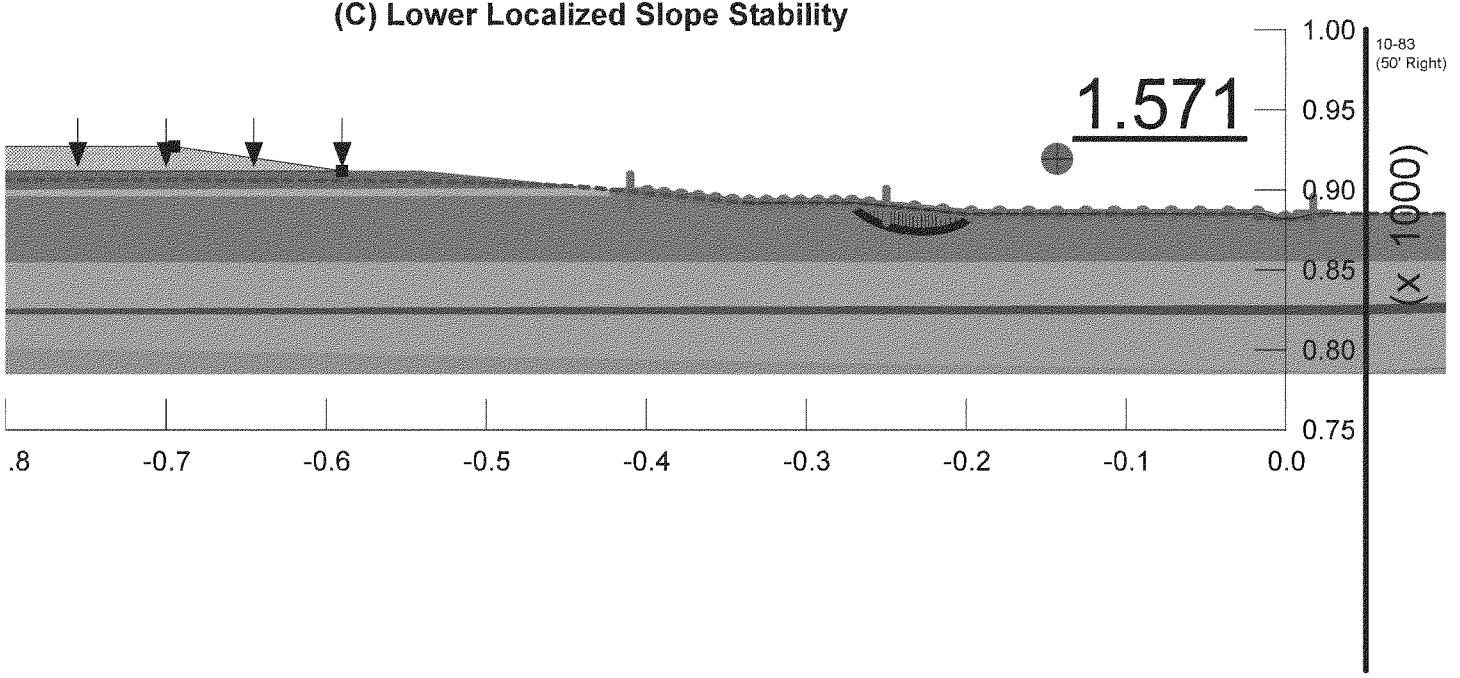

FMMFS: Phase 3, MN Diversion Section 4B
FM_P3_MN_Div_Sect_04B_35k_Raise4FT_70.gsz
(F) Wedge Stability Right
1.419
10-83
(50' Right)
10-100
(765' R
Elevation (x 1000)
1.00
0.95
0.90
0.85
0.80
0.75
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Sherack
Brenna
Argusville
Silty Sands
Silts
Silty Sands
Sand
Till

FMMFS: Phase 3, MN Diversion Section 4B
FM_P3_MN_Div_Sect_04B_35k_Raise4FT_70.gsz
(C) Lower Localized Slope Stability



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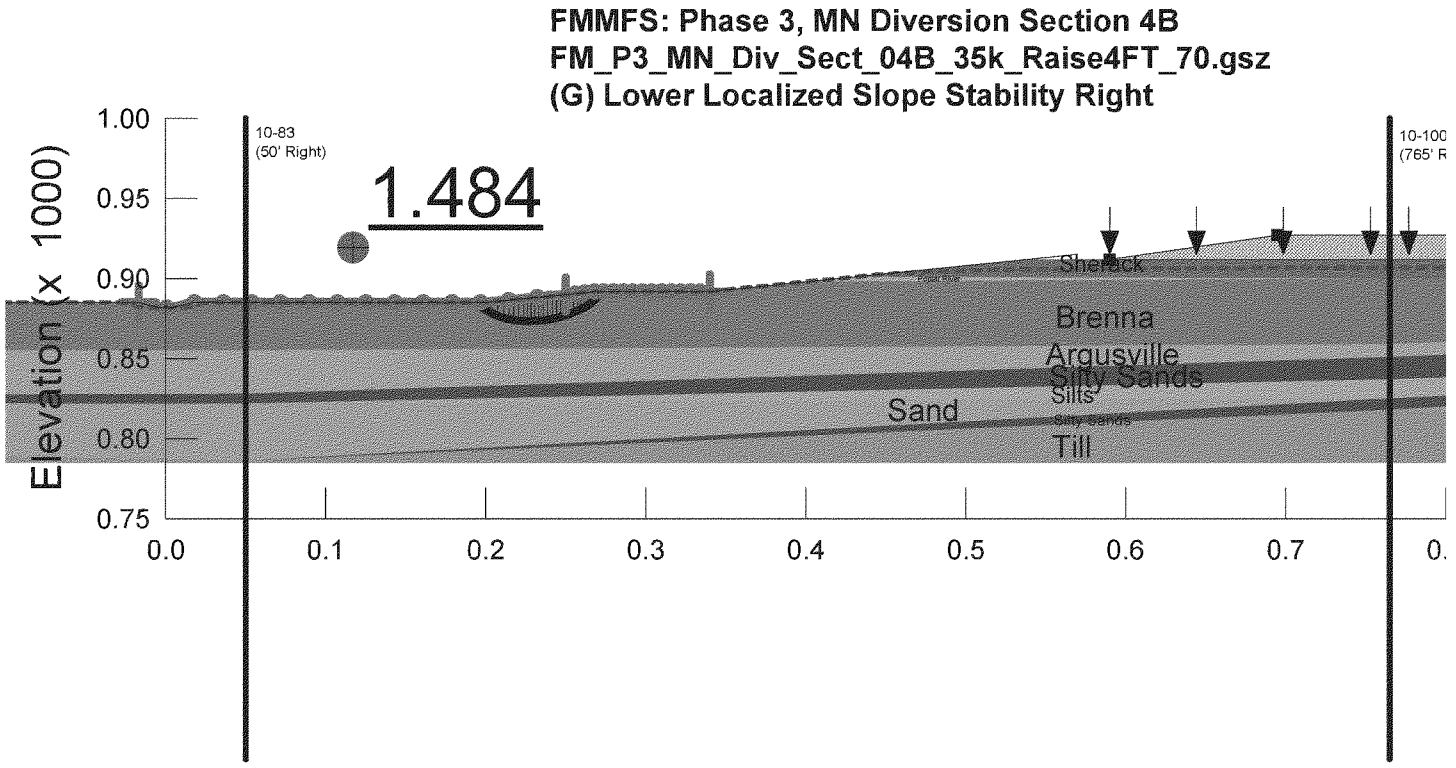
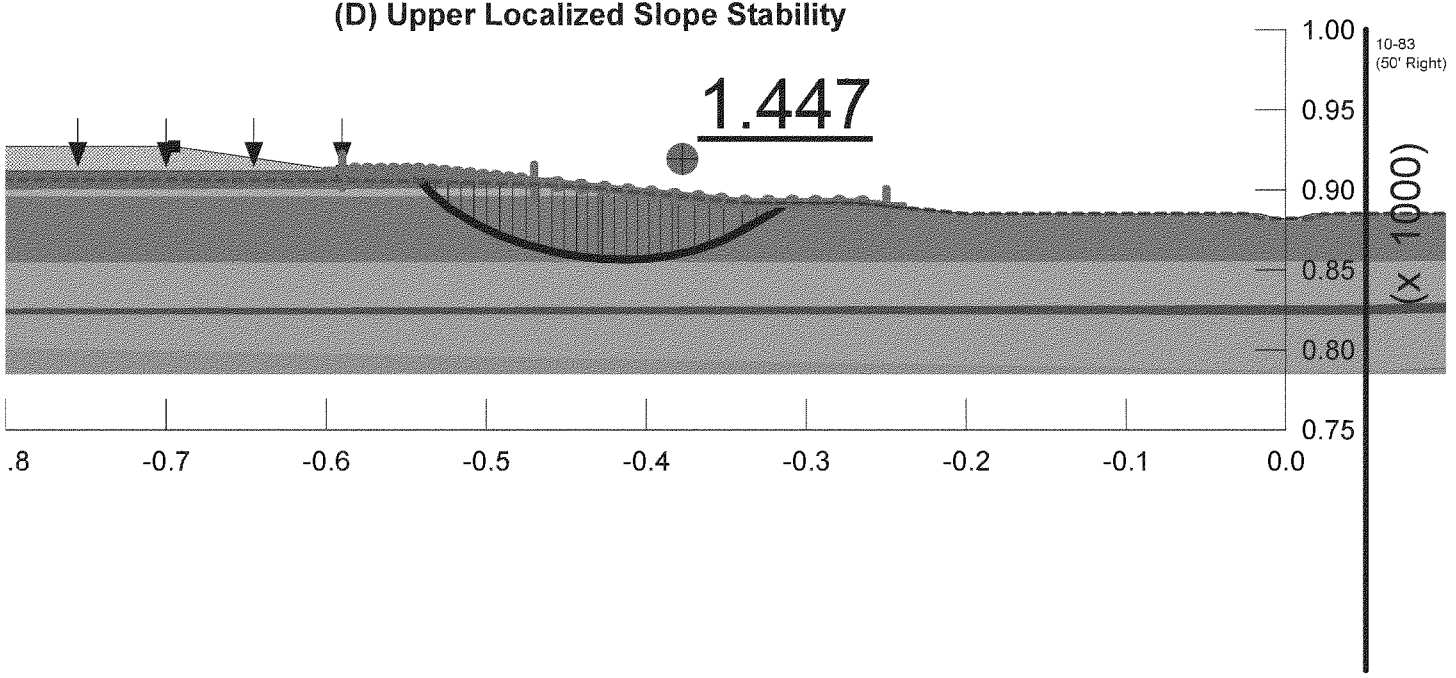

FMMFS: Phase 3, MN Diversion Section 4B
FM_P3_MN_Div_Sect_04B_35k_Raise4FT_70.gsz
(G) Lower Localized Slope Stability Right
1.484
10-83
(50' Right)
10-100
(765' R
Elevation (x 1000)
1.00
0.95
0.90
0.85
0.80
0.75
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Sherack
Brenna
Argusville
Silty Sands
Silts
Silty Sands
Sand
Till

FMMFS: Phase 3, MN Diversion Section 4B
FM_P3_MN_Div_Sect_04B_35k_Raise4FT_70.gsz
(D) Upper Localized Slope Stability



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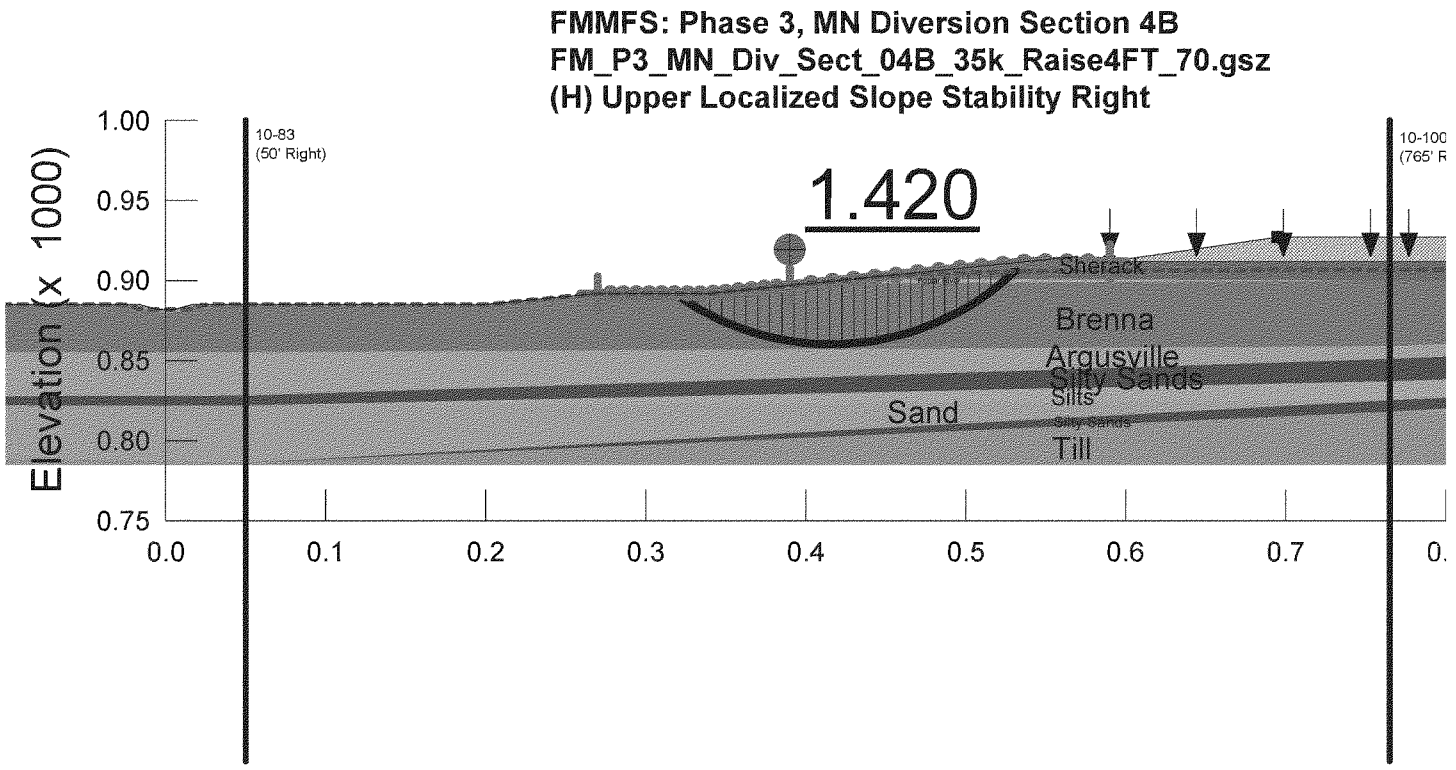
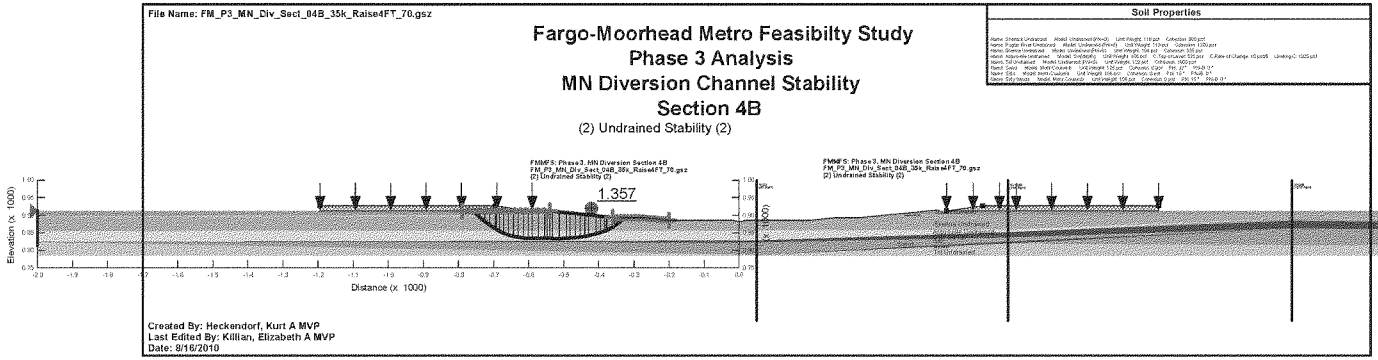
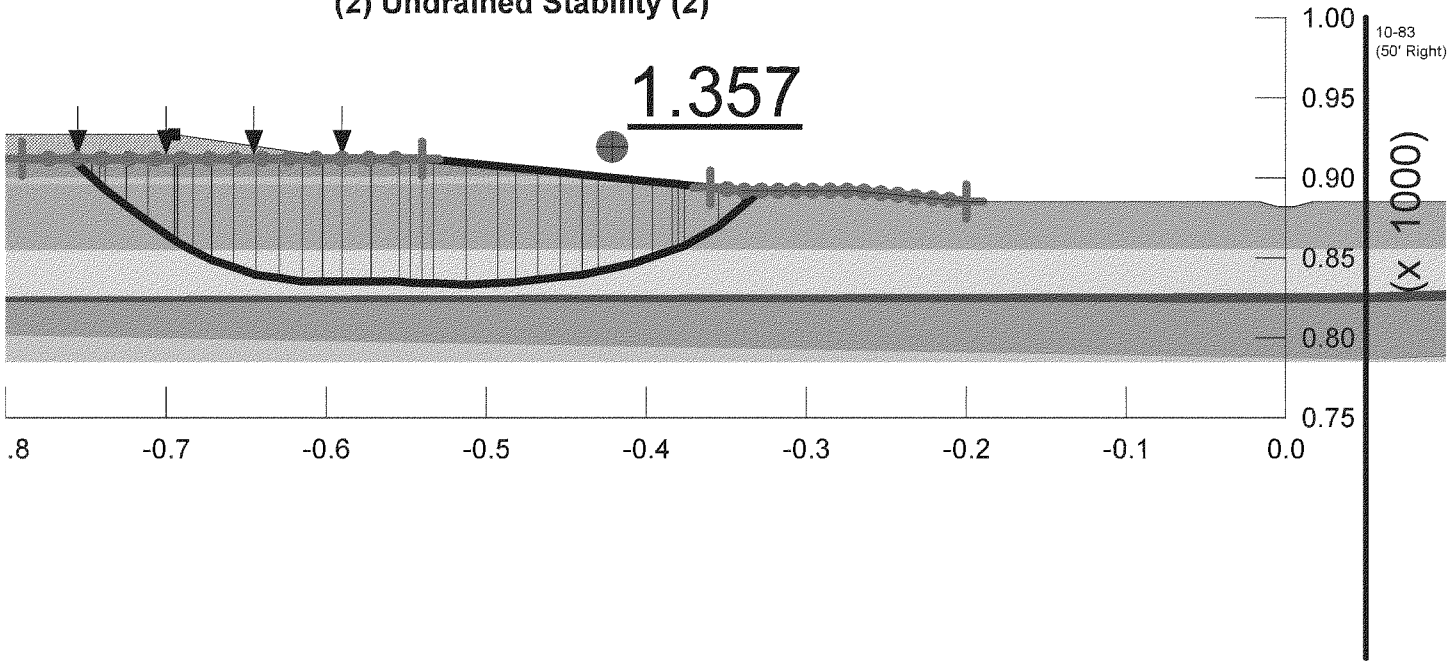

FMMFS: Phase 3, MN Diversion Section 4B
FM_P3_MN_Div_Sect_04B_35k_Raise4FT_70.gsz
(H) Upper Localized Slope Stability Right
1.420
10-83
(50' Right)
10-100
(765' R
Elevation (x 1000)
1.00
0.95
0.90
0.85
0.80
0.75
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Sherack
Brenna
Argusville
Silty Sands
Silts
Silty Sands
Sand
Till

1460


File Name: FM_P3_MN_Div_Sect_04B_35k_Raise4FT_70.gsz
Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 4B
(2) Undrained Stability (2)
Soil Properties
FMMFS: Phase3_MN Diversion Section 4B
FM_P3_MN_Div_Sect_04B_35k_Raise4FT_70.gsz
(2) Undrained Stability (2)
1.357
Elevation (x 1000)
Distance (x 1000)
Created By: Heckendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/16/2010

FMMFS: Phase 3, MN Diversion Section 4B
FM_P3_MN_Div_Sect_04B_35k_Raise4FT_70.gsz
(2) Undrained Stability (2)



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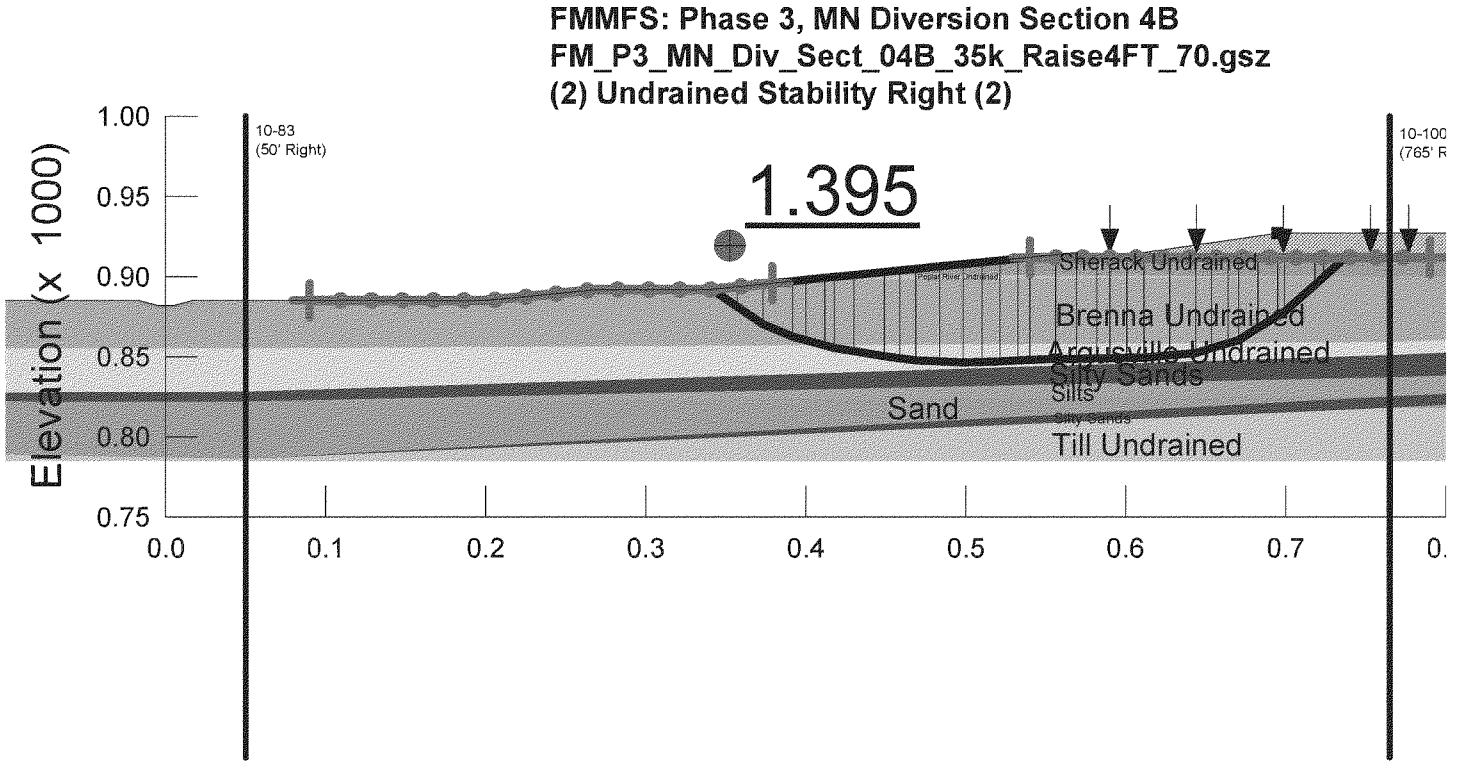
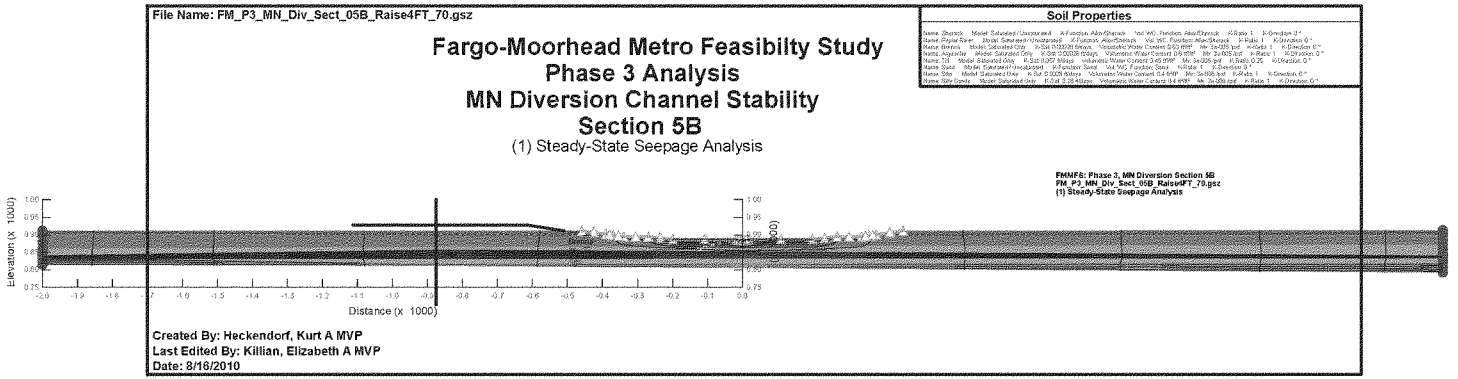

FMMFS: Phase 3, MN Diversion Section 4B
FM_P3_MN_Div_Sect_04B_35k_Raise4FT_70.gsz
(2) Undrained Stability Right (2)
1.395
10-83
(50' Right)
10-100
(765' R
Elevation (x 1000)
1.00
0.95
0.90
0.85
0.80
0.75
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Sherack Undrained
Brenna Undrained
Argusville Undrained
Silty Sands
Silts
Silty Sands
Sand
Till Undrained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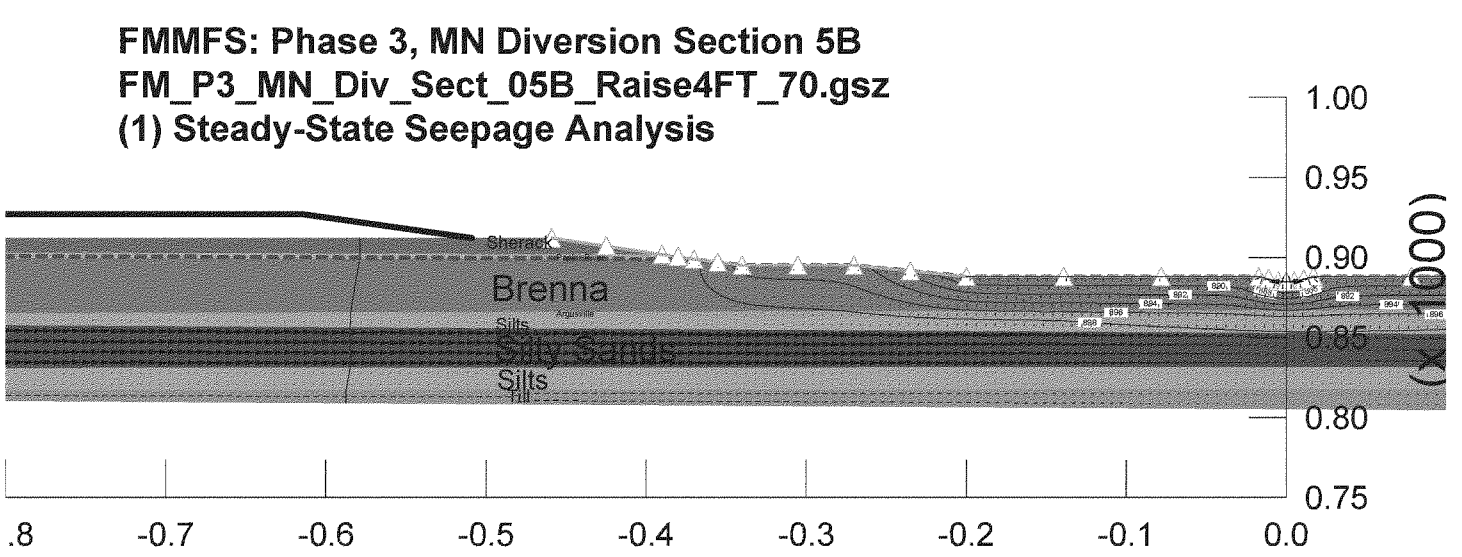
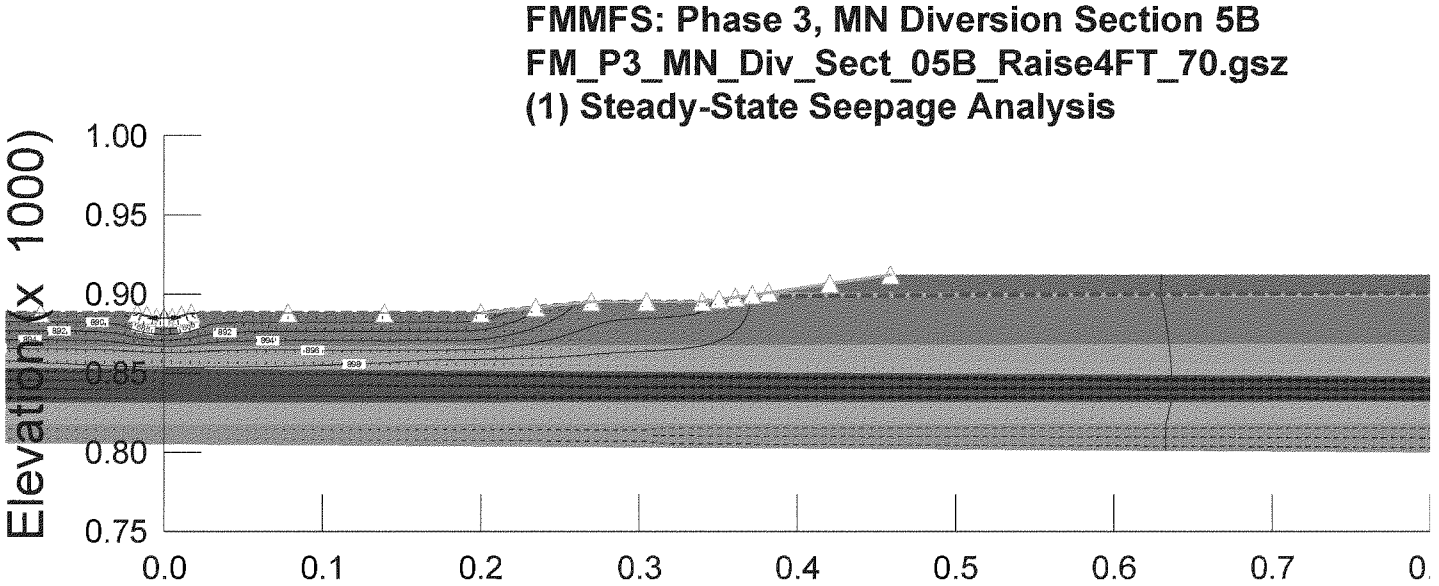
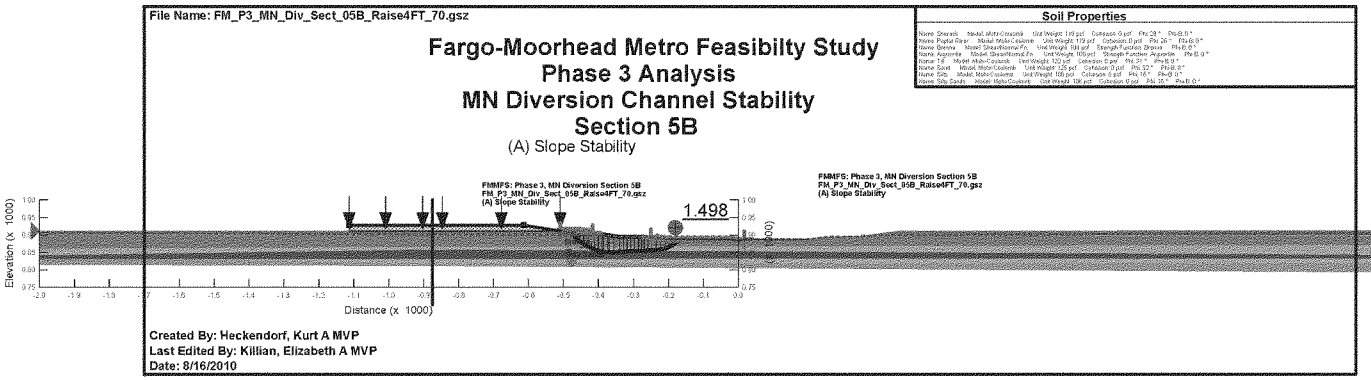
Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 5B
(1) Steady-State Seepage Analysis
Soil Properties
FMMFS: Phase 3, MN Diversion Section 5B
FM_P3_MN_Div_Sect_05B_Raise4FT_70.gsz
(1) Steady-State Seepage Analysis
Elevation (x 1000)
Distance (x 1000)
Created By: Heckendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/16/2010


FMMFS: Phase 3, MN Diversion Section 5B
FM_P3_MN_Div_Sect_05B_Raise4FT_70.gsz
(1) Steady-State Seepage Analysis
Sherack
Brenna
Argusville
Silts
Silty Sands
Silts
Till
1.00
0.95
0.90
0.85
0.80
0.75
(1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1465


FMMFS: Phase 3, MN Diversion Section 5B
FM_P3_MN_Div_Sect_05B_Raise4FT_70.gsz
(1) Steady-State Seepage Analysis
Elevation (x 1000)
1.00
0.95
0.90
0.85
0.80
0.75
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7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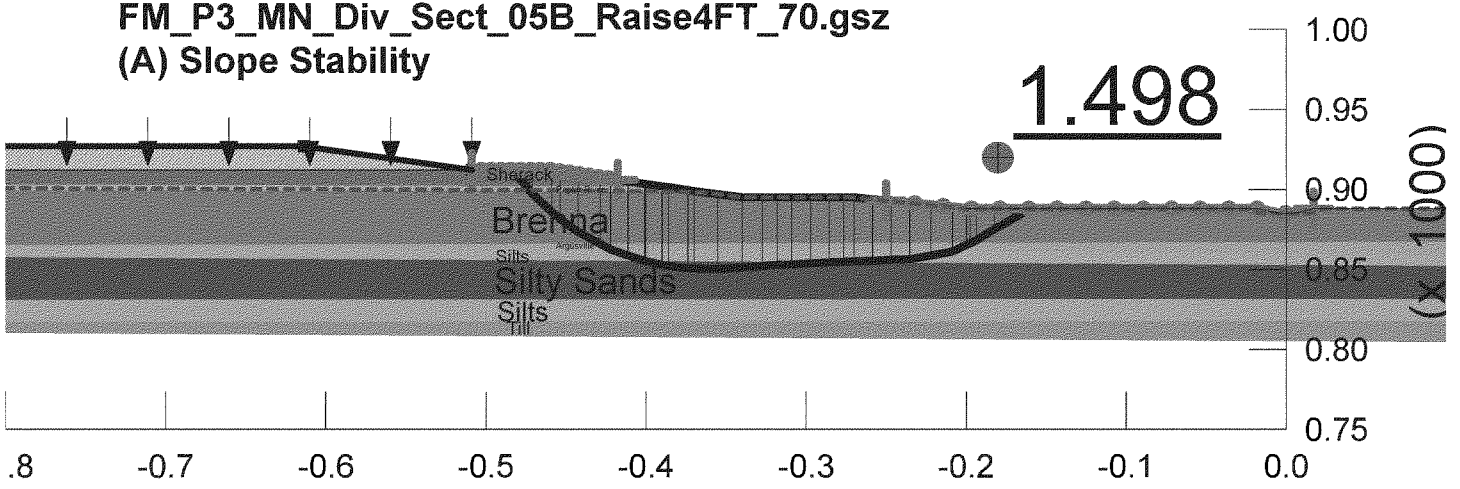
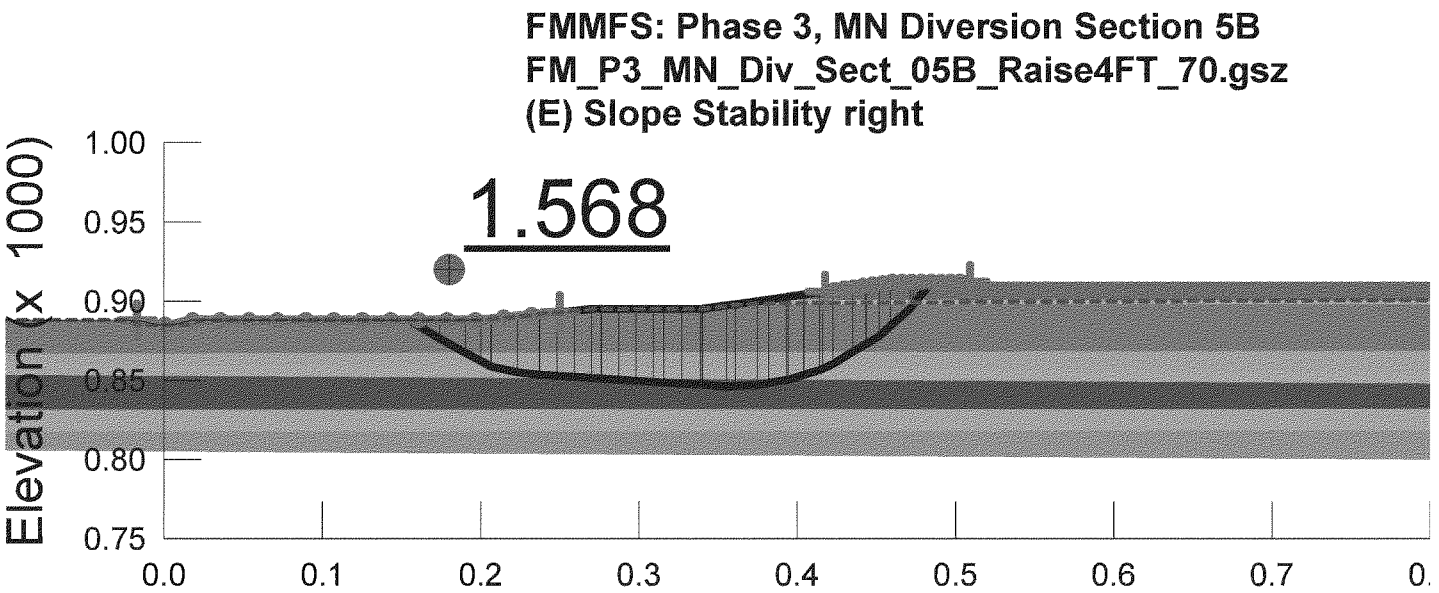
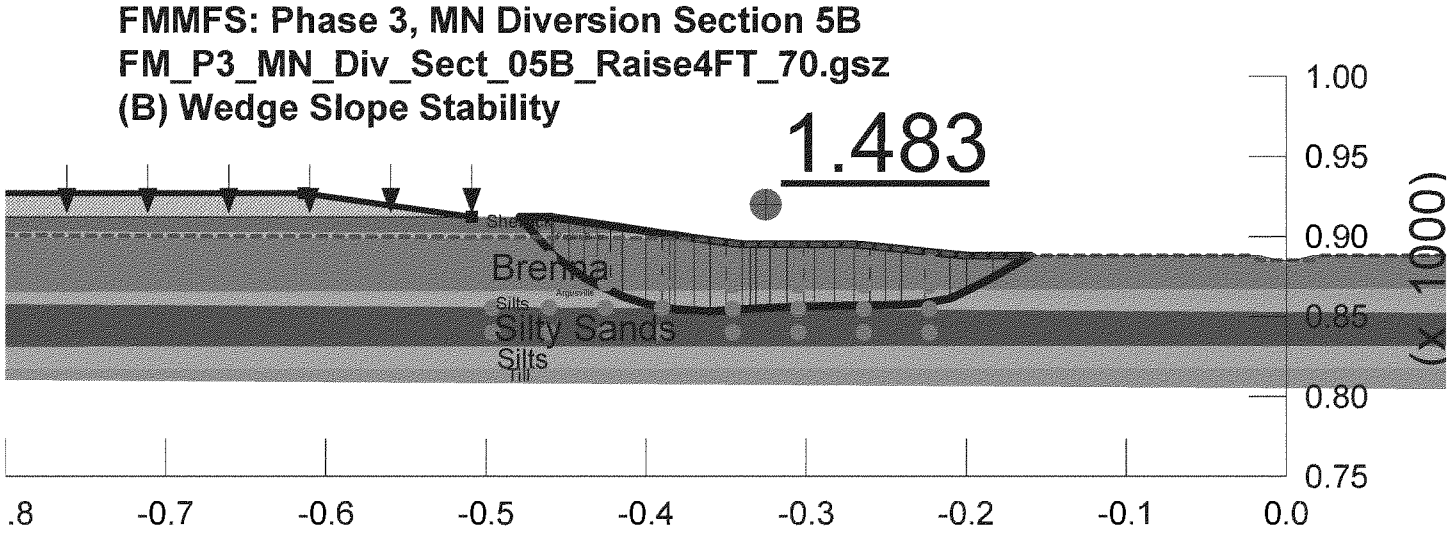
Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 5B
(A) Slope Stability
Soil Properties
FMMFS: Phase 3, MN Diversion Section 5B
FM_P3_MN_Div_Sect_05B_Raise4FT_70.gsz
(A) Slope Stability
1.498
Elevation (x 1000)
Distance (x 1000)
Created By: Heckendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/16/2010


FMMFS: Phase 3, MN Diversion Section 5B
FM_P3_MN_Div_Sect_05B_Raise4FT_70.gsz
(A) Slope Stability
1.498
Sherack
Brenna
Silts
Silty Sands
Silts
till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

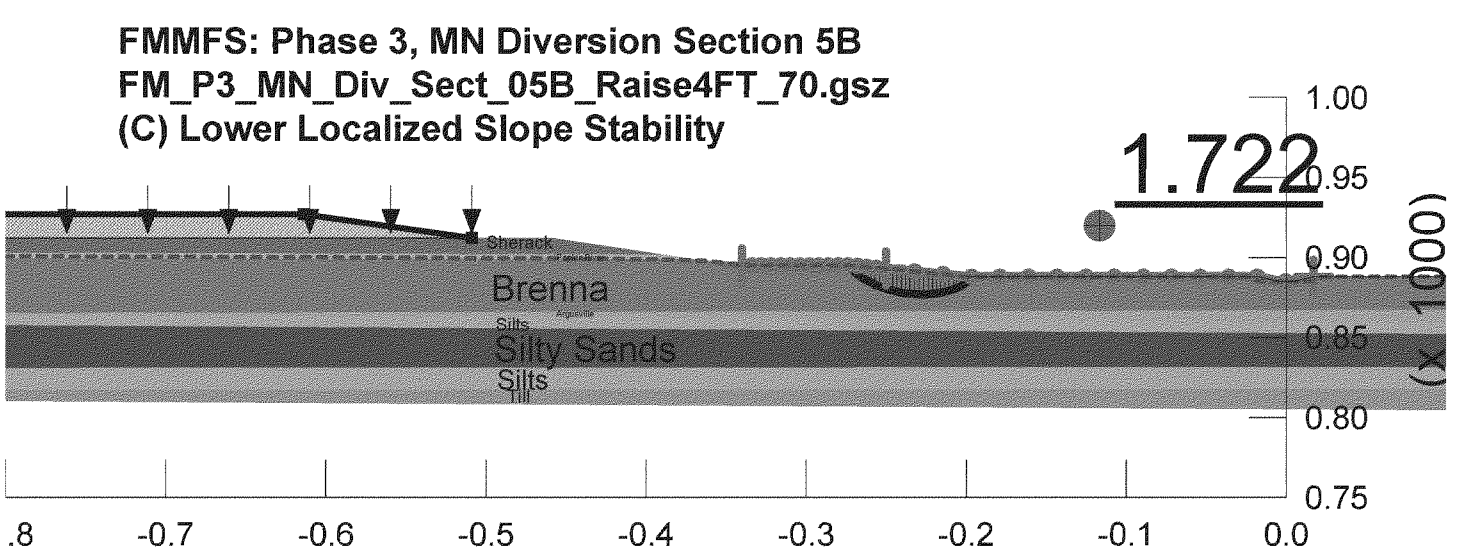
1468


FMMFS: Phase 3, MN Diversion Section 5B
FM_P3_MN_Div_Sect_05B_Raise4FT_70.gsz
(E) Slope Stability right
1.568
Elevation (x 1000)
1.00
0.95
0.90
0.85
0.80
0.75
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

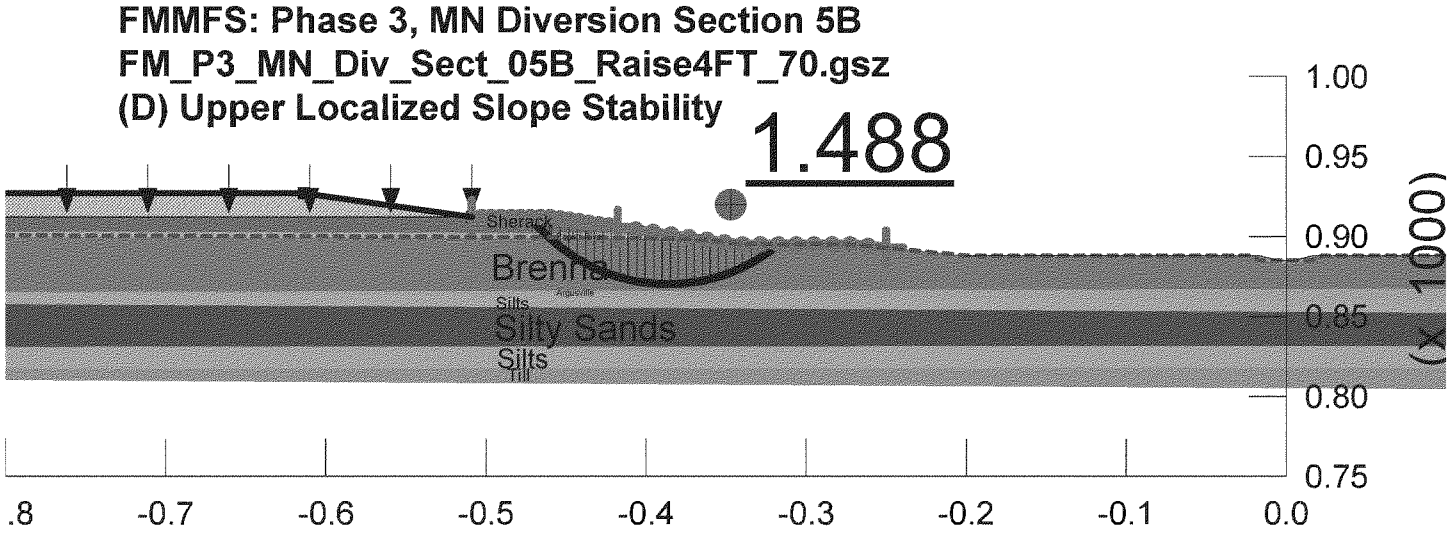
1469


FMMFS: Phase 3, MN Diversion Section 5B
FM_P3_MN_Div_Sect_05B_Raise4FT_70.gsz
(B) Wedge Slope Stability
1.483
Brenna
Silts
Silty Sands
Silts
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1470


FMMFS: Phase 3, MN Diversion Section 5B
FM_P3_MN_Div_Sect_05B_Raise4FT_70.gsz
(C) Lower Localized Slope Stability
1.722
Sherack
Brenna
Aggville
Silts
Silty Sands
Silts
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1471

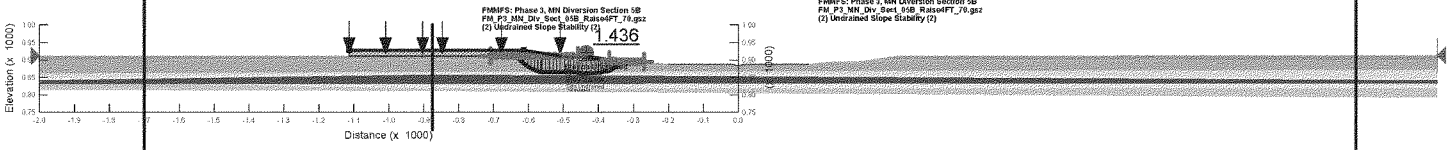

FMMFS: Phase 3, MN Diversion Section 5B
FM_P3_MN_Div_Sect_05B_Raise4FT_70.gsz
(D) Upper Localized Slope Stability
1.488
Sherack
Brenna
Silts
Silty Sands
Silts
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1472

File Name: FM_P3_MN_Div_Sect_05B_Raise4FT_70.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 5B
(2) Undrained Slope Stability (2)

Soil Properties



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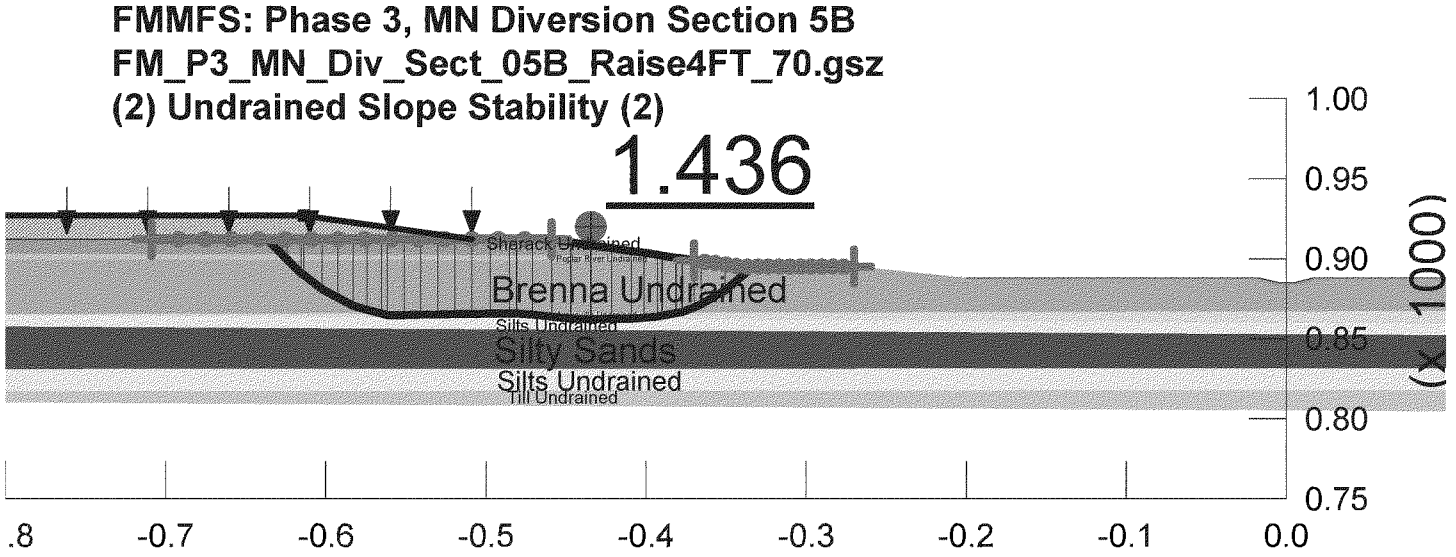
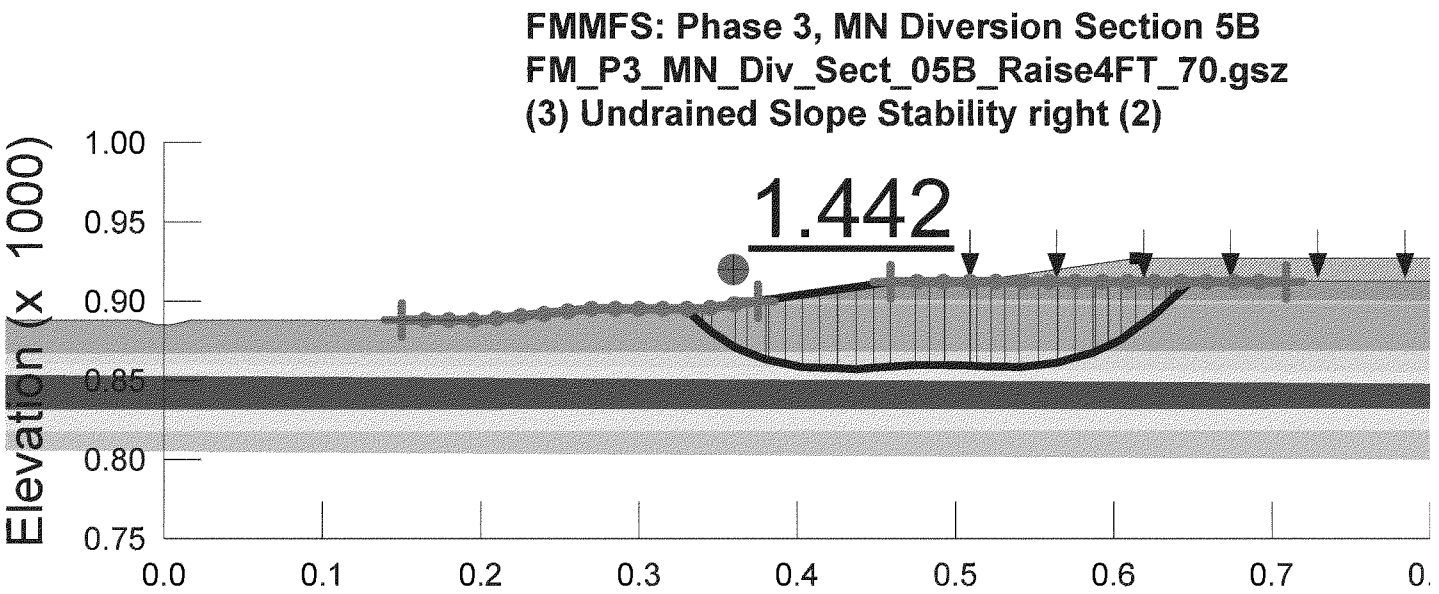
Date: 8/16/2010

1473


FMMFS: Phase 3, MN Diversion Section 5B
FM_P3_MN_Div_Sect_05B_Raise4FT_70.gsz
(2) Undrained Slope Stability (2)
1.436
Sherack Undrained
Fargo River Undrained
Brenna Undrained
Silts Undrained
Silty Sands
Silts Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1474


FMMFS: Phase 3, MN Diversion Section 5B
FM_P3_MN_Div_Sect_05B_Raise4FT_70.gsz
(3) Undrained Slope Stability right (2)
1.442
Elevation (x 1000)
1.00
0.95
0.90
0.85
0.80
0.75
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

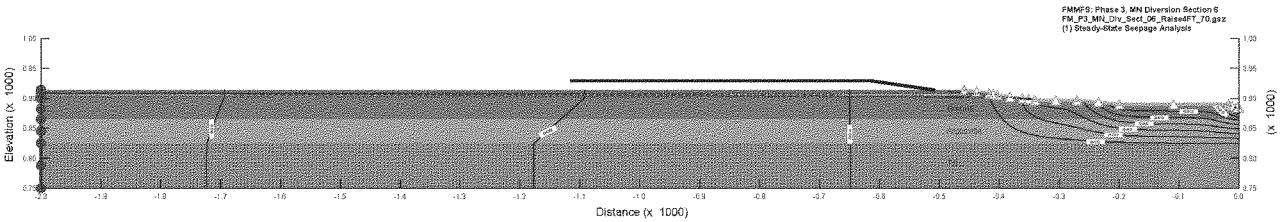
1475

File Name: FM_P3_MN_Div_Sect_06_Raise4FT_70.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 6

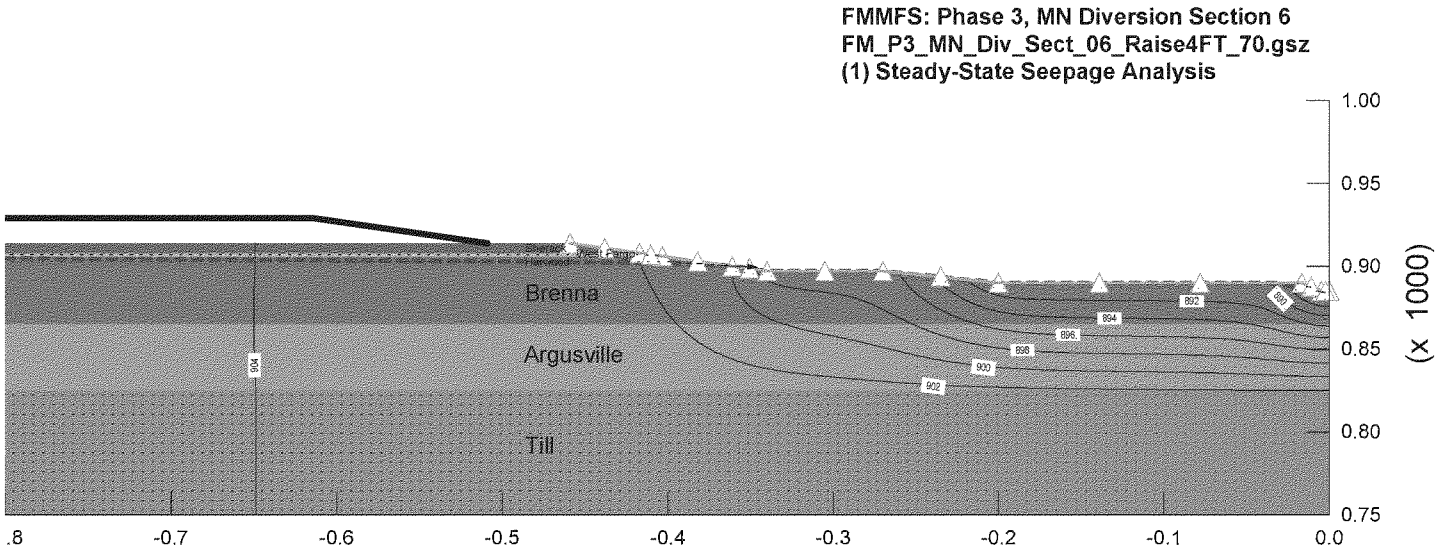
(1) Steady-State Seepage Analysis

Soil Properties



Created By: Heckendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/16/2010

1476


FMMFS: Phase 3, MN Diversion Section 6
FM_P3_MN_Div_Sect_06_Raise4FT_70.gsz
(1) Steady-State Seepage Analysis
Brenna
Argusville
Till
894
892
894
896
898
900
902
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

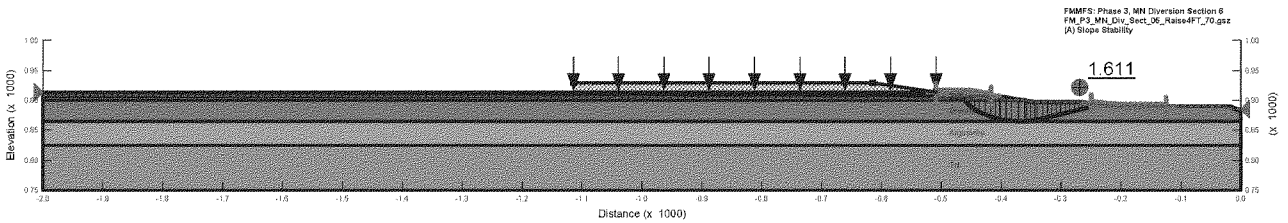
File Name: FM_P3_MN_Div_Sect_06_Raise4FT_70.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 6

(A) Slope Stability

Soil Properties

Name: Shlanck Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 28 ° Phi-B: 0 °
Name: Wind Fargo Model: Mohr-Coulomb Unit Weight: 123 pcf Cohesion: 0 psf Phi: 34 ° Phi-B: 0 °
Name: Harwood Model: Mohr-Coulomb Unit Weight: 118 pcf Cohesion: 0 psf Phi: 35 ° Phi-B: 0 °
Name: Brenna Model: Shear/Normal Fn Unit Weight: 134 pcf Strength Function: Brenna Phi-B: 0 °
Name: Arquadia Model: Shear/Normal Fn Unit Weight: 146 pcf Strength Function: Arquadia Phi-B: 0 °
Name: Till Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 5 psf Phi: 21 ° Phi-B: 0 °
Name: Sand Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 32 ° Phi-B: 0 °



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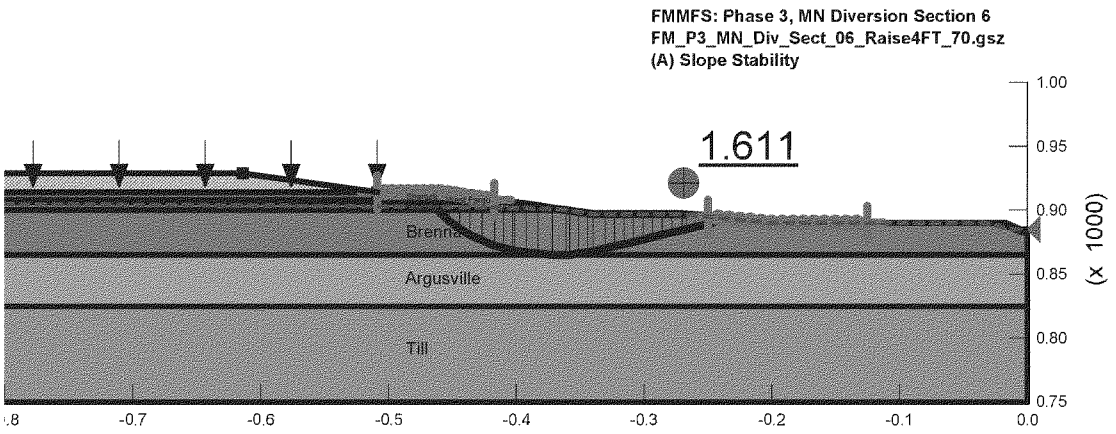
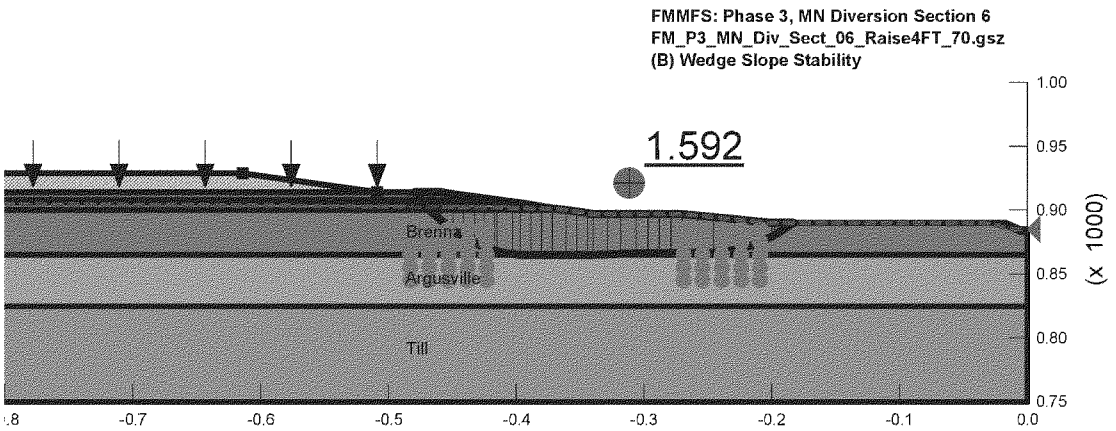
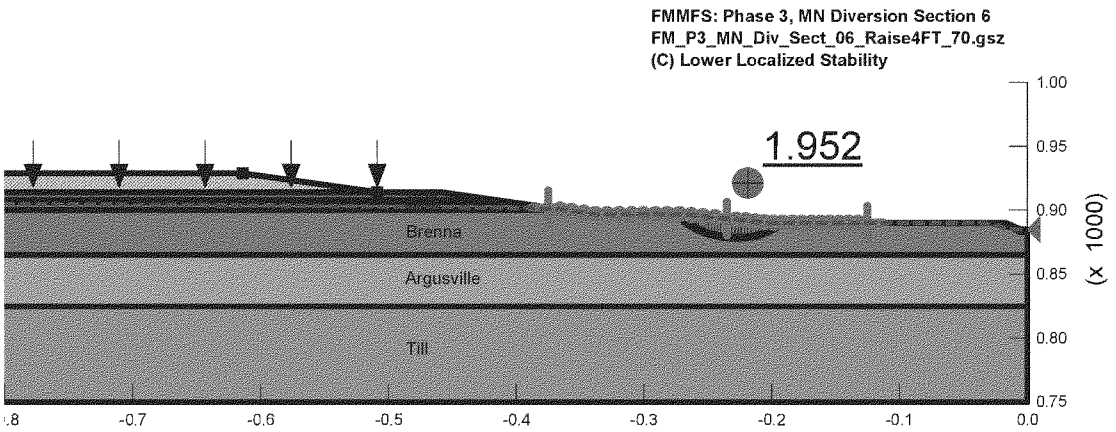
Date: 8/16/2010

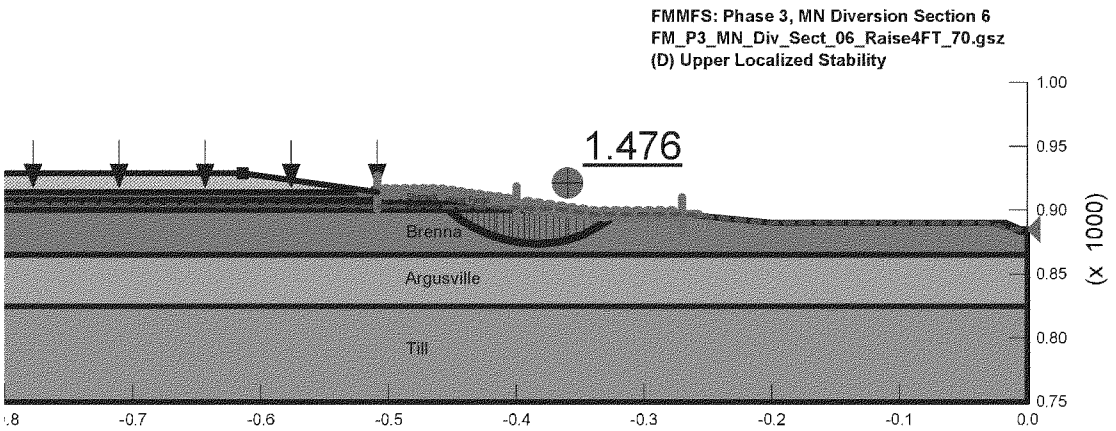

FMMFS: Phase 3, MN Diversion Section 6
FM_P3_MN_Div_Sect_06_Raise4FT_70.gsz
(A) Slope Stability
1.611
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1479


FMMFS: Phase 3, MN Diversion Section 6
FM_P3_MN_Div_Sect_06_Raise4FT_70.gsz
(B) Wedge Slope Stability
1.592
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1480


FMMFS: Phase 3, MN Diversion Section 6
FM_P3_MN_Div_Sect_06_Raise4FT_70.gsz
(C) Lower Localized Stability
1.952
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0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FM_P3_MN_Div_Sect_06_Raise4FT_70.gsz
(D) Upper Localized Stability
1.476
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

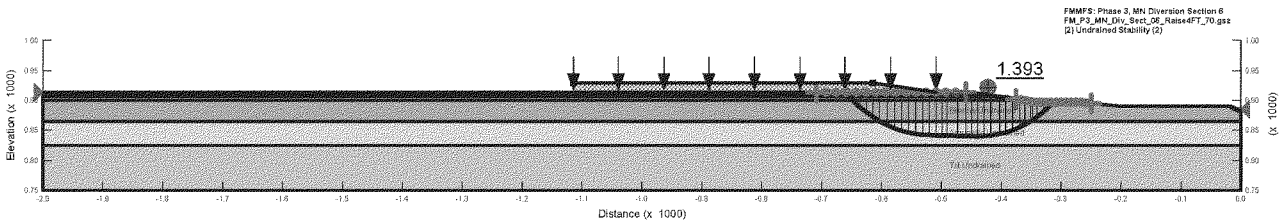
1482

File Name: FM_P3_MN_Div_Sect_06_Raise4FT_70.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 6

(2) Undrained Stability (2)

Soil Properties



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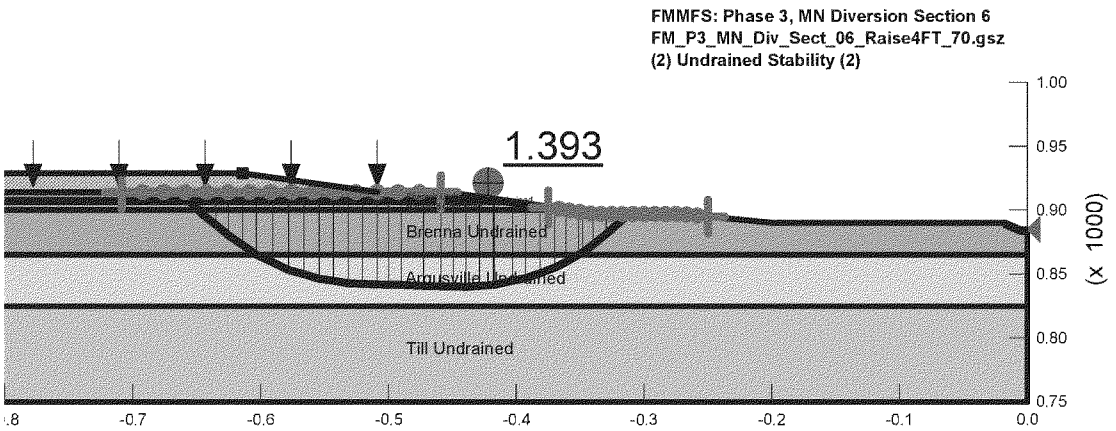
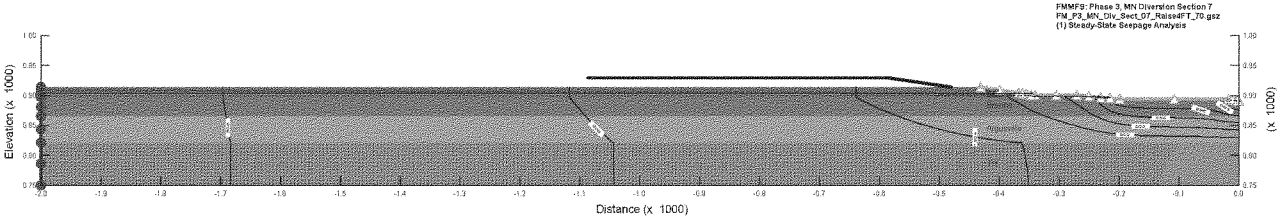

FMMFS: Phase 3, MN Diversion Section 6
FM_P3_MN_Div_Sect_06_Raise4FT_70.gsz
(2) Undrained Stability (2)
1.393
Brenna Undrained
Argusville Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P3_MN_Div_Sect_07_Raise4FT_70.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 7

(1) Steady-State Seepage Analysis

Soil Properties



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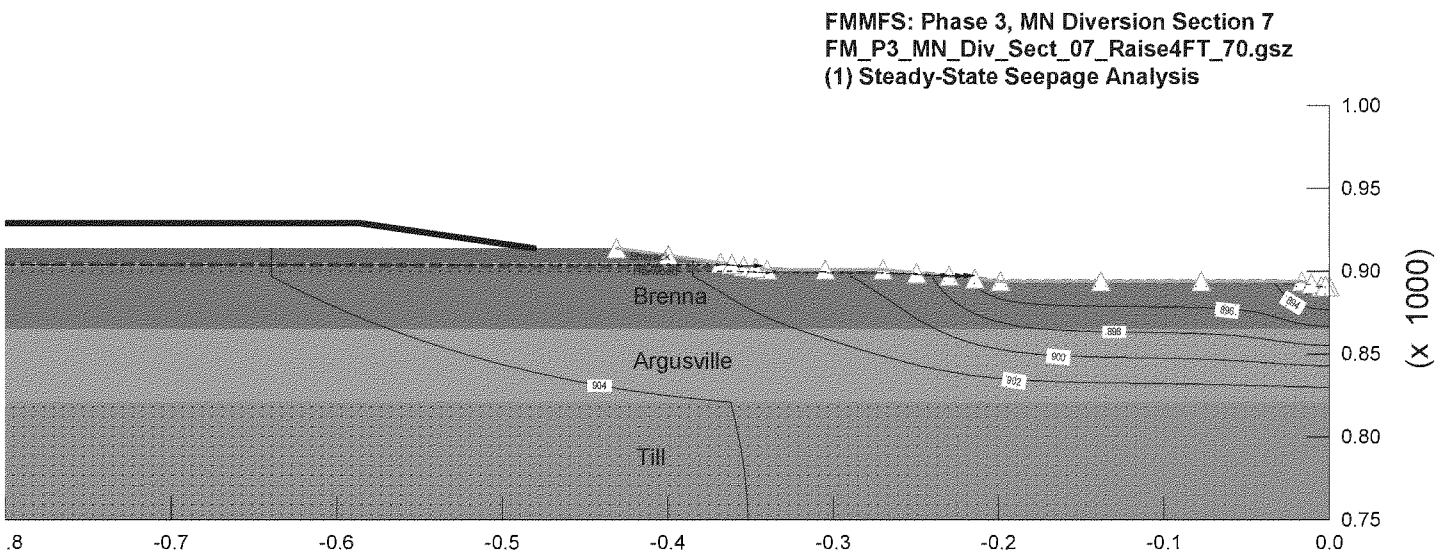

FMMFS: Phase 3, MN Diversion Section 7
FM_P3_MN_Div_Sect_07_Raise4FT_70.gsz
(1) Steady-State Seepage Analysis
Brenna
Argusville
Till
894
896
898
900
902
904
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

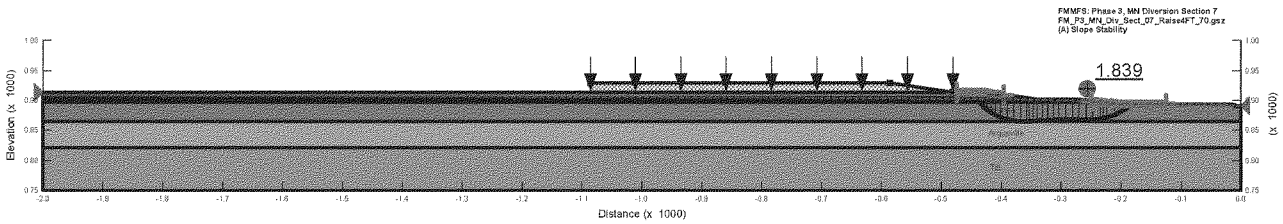
1486

File Name: FM_P3_MN_Div_Sect_07_Raise4FT_70.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 7

(A) Slope Stability

Soil Properties



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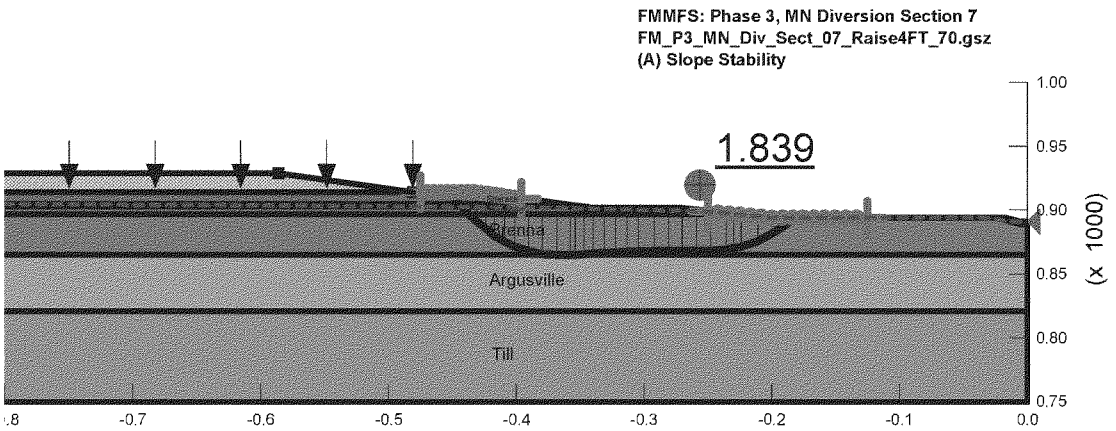
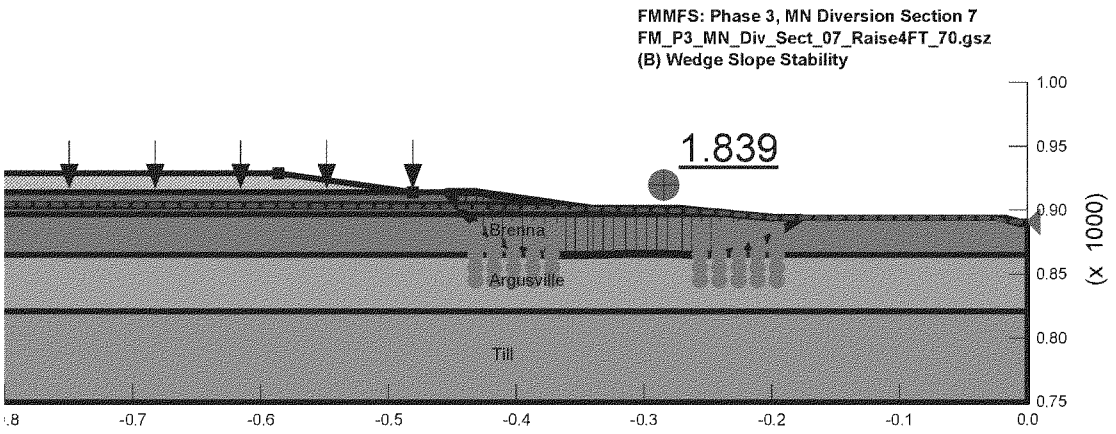
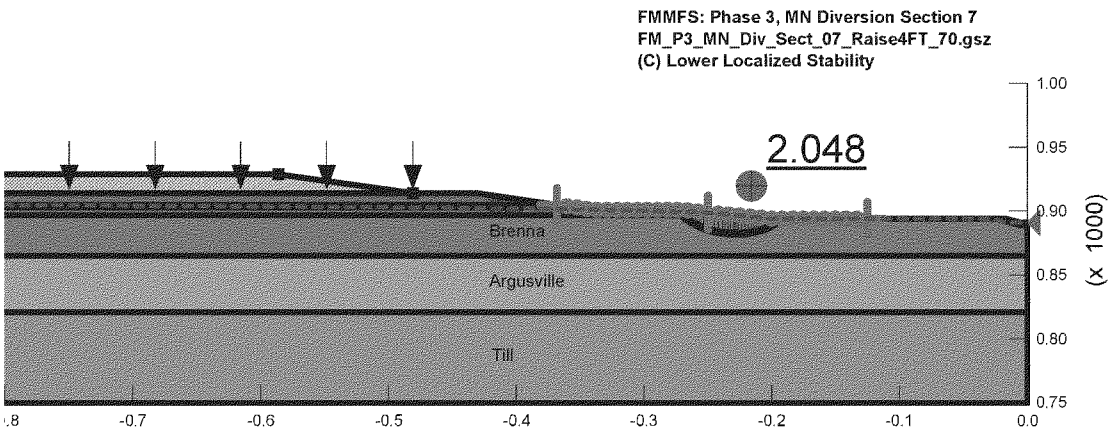
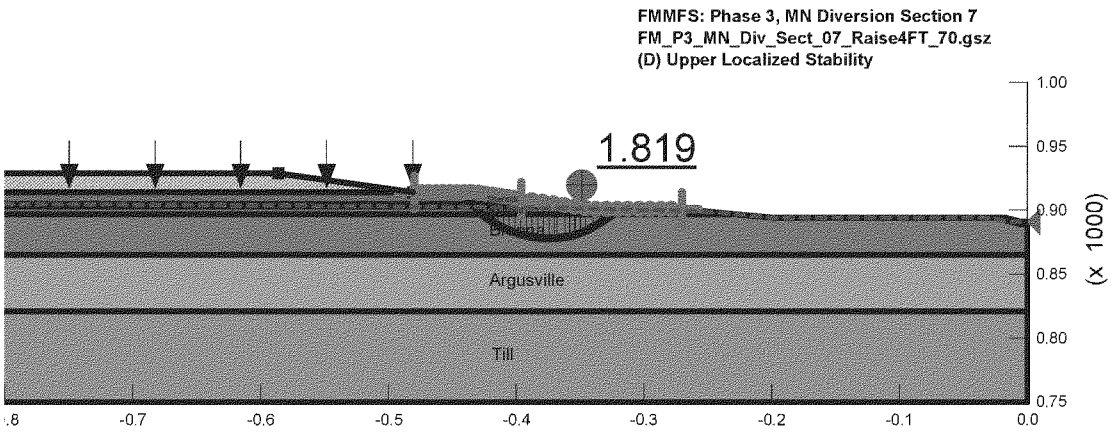
Date: 8/16/2010


FMMFS: Phase 3, MN Diversion Section 7
FM_P3_MN_Div_Sect_07_Raise4FT_70.gsz
(A) Slope Stability
1.839
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 3, MN Diversion Section 7
FM_P3_MN_Div_Sect_07_Raise4FT_70.gsz
(B) Wedge Slope Stability
1.839
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 3, MN Diversion Section 7
FM_P3_MN_Div_Sect_07_Raise4FT_70.gsz
(C) Lower Localized Stability
2.048
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1490


FMMFS: Phase 3, MN Diversion Section 7
FM_P3_MN_Div_Sect_07_Raise4FT_70.gsz
(D) Upper Localized Stability
1.819
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1491

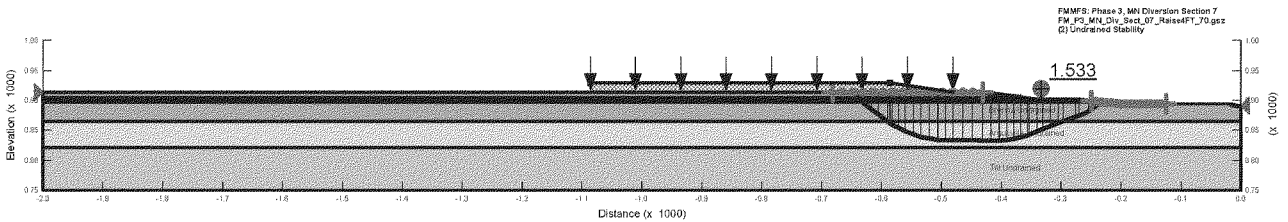
File Name: FM_P3_MN_Div_Sect_07_Raise4FT_70.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 7

(2) Undrained Stability

Soil Properties

Name: Silt/clay Undrained Model: Undrained (Phi=0) Unit Weight: 110 pcf Cohesion: 550 psf
Name: Weak Fargo Undrained Model: Undrained (Phi=0) Unit Weight: 122 pcf Cohesion: 1,000 psf
Name: Harwood Undrained Model: Undrained (Phi=0) Unit Weight: 118 pcf Cohesion: 1,000 psf
Name: Brenna Undrained Model: Undrained (Phi=0) Unit Weight: 104 pcf Cohesion: 525 psf
Name: Argusville Undrained Model: Bilinear Unit Weight: 106 pcf C-Top of Layer: 525 psf C-Rate of Change: 16 psf/ft Limiting C: 1025 psf
Name: Till Undrained Model: Undrained (Phi=0) Unit Weight: 122 psf Cohesion: 1500 psf
Name: Sand Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 32 ° Psi: 0 °



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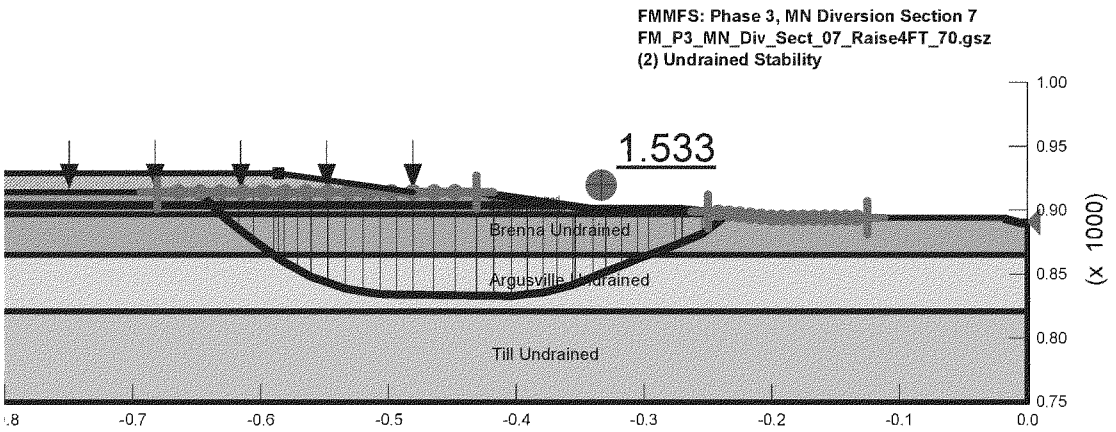
1492


FMMFS: Phase 3, MN Diversion Section 7
FM_P3_MN_Div_Sect_07_Raise4FT_70.gsz
(2) Undrained Stability
1.533
Brenna Undrained
Argusville Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

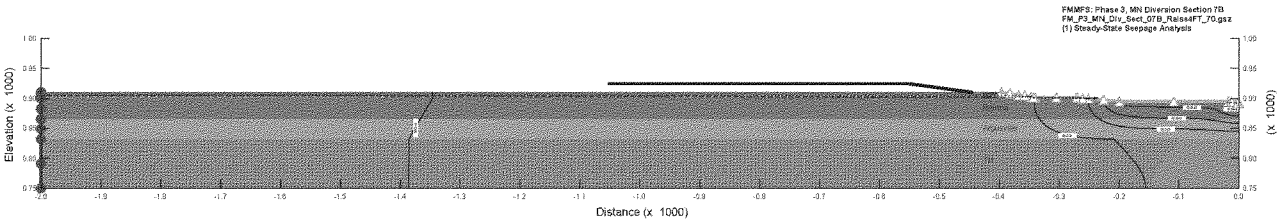
1493

File Name: FM_P3_MN_Div_Sect_07B_Raise4FT_70.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 7B

(1) Steady-State Seepage Analysis

Soil Properties



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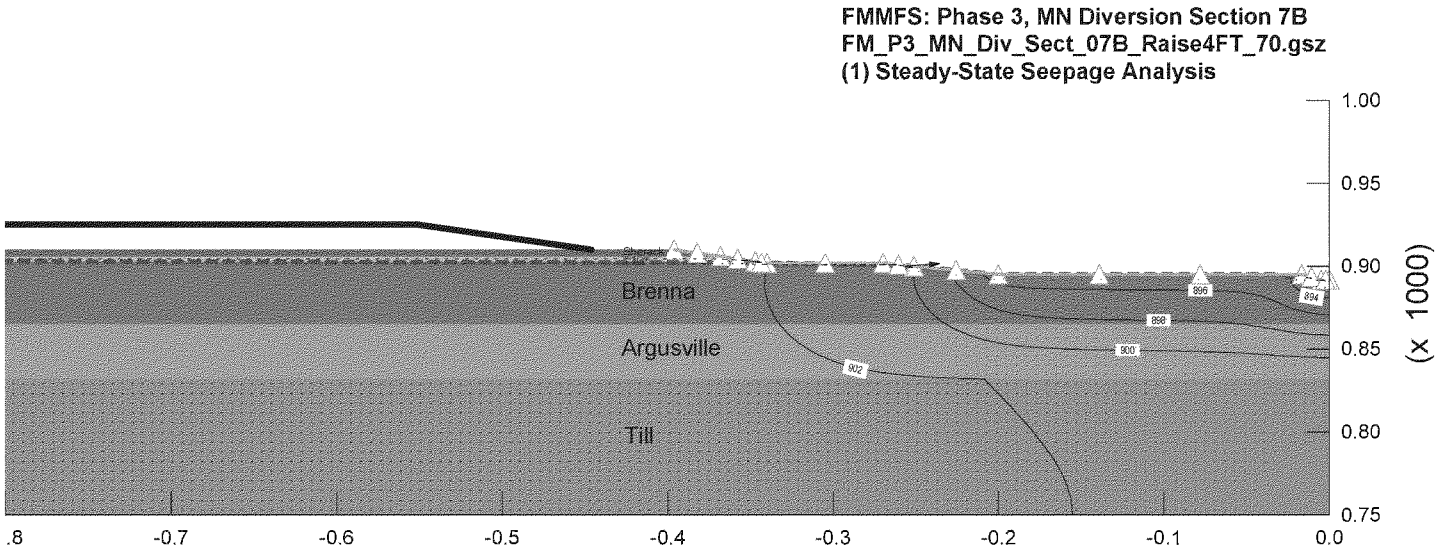
Date: 8/16/2010

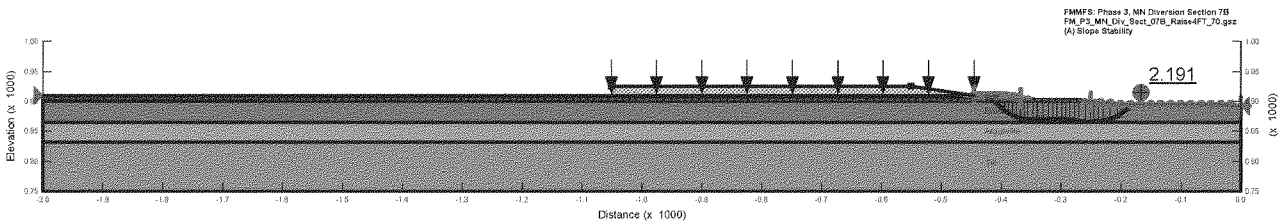

FMMFS: Phase 3, MN Diversion Section 7B
FM_P3_MN_Div_Sect_07B_Raise4FT_70.gsz
(1) Steady-State Seepage Analysis
Brenna
Argusville
Till
894
896
898
900
902
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P3_MN_Div_Sect_07B_Raise4FT_70.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 7B

(A) Slope Stability

Soil Properties



Created By: Heckendorf, Kurt A MVP
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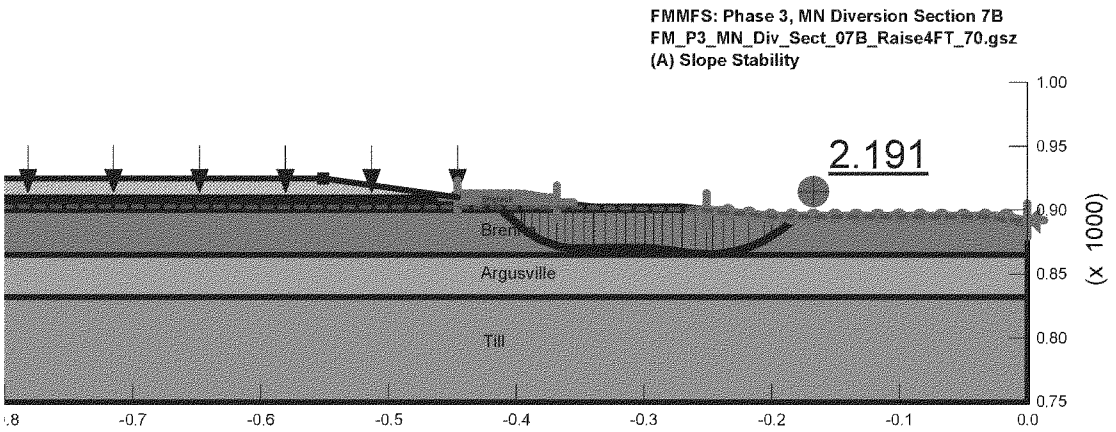
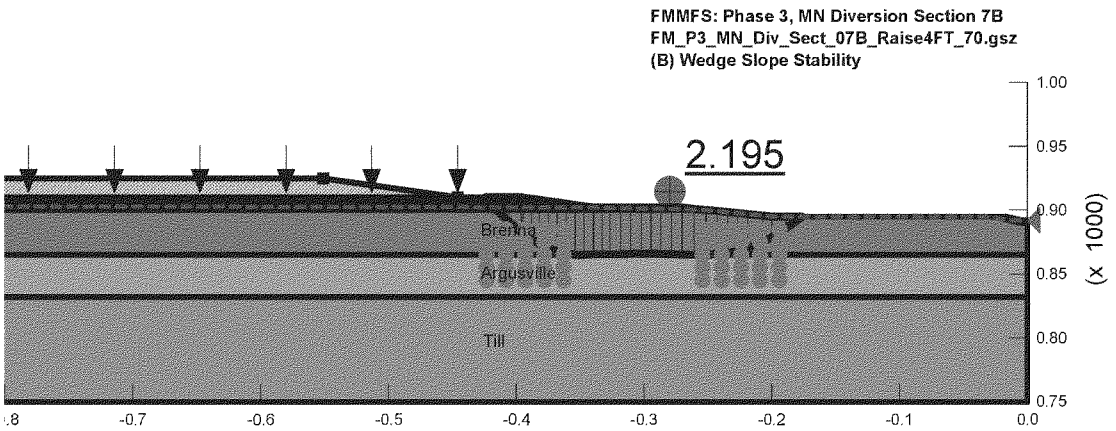
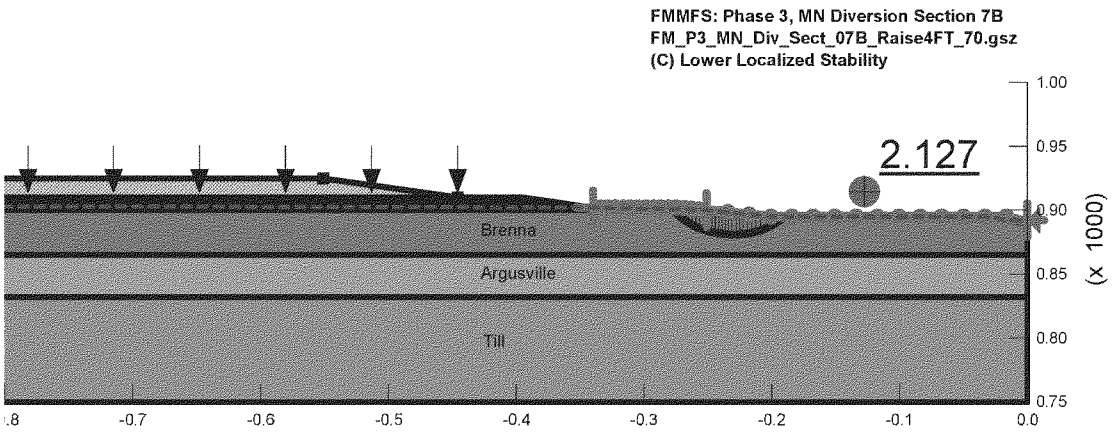
Date: 8/16/2010

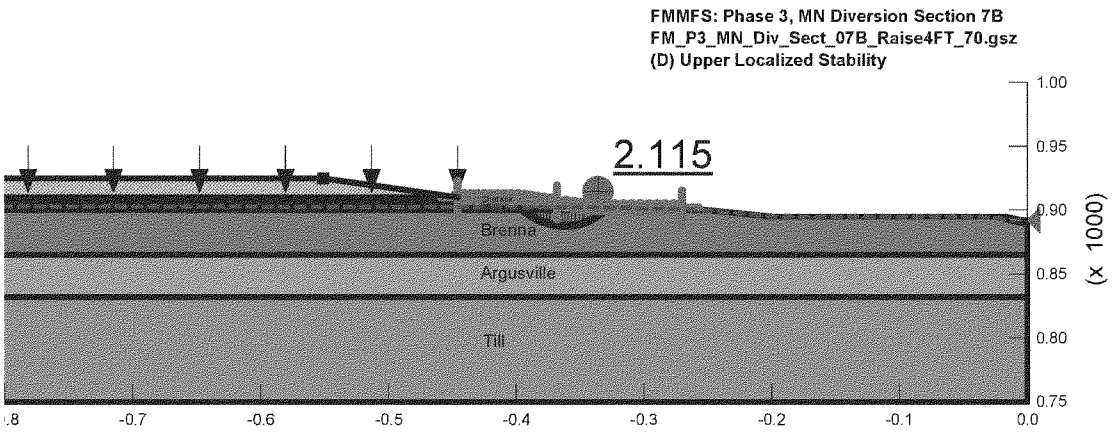

FMMFS: Phase 3, MN Diversion Section 7B
FM_P3_MN_Div_Sect_07B_Raise4FT_70.gsz
(A) Slope Stability
2.191
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1497


FMMFS: Phase 3, MN Diversion Section 7B
FM_P3_MN_Div_Sect_07B_Raise4FT_70.gsz
(B) Wedge Slope Stability
2.195
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 3, MN Diversion Section 7B
FM_P3_MN_Div_Sect_07B_Raise4FT_70.gsz
(C) Lower Localized Stability
2.127
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1499


FMMFS: Phase 3, MN Diversion Section 7B
FM_P3_MN_Div_Sect_07B_Raise4FT_70.gsz
(D) Upper Localized Stability
2.115
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

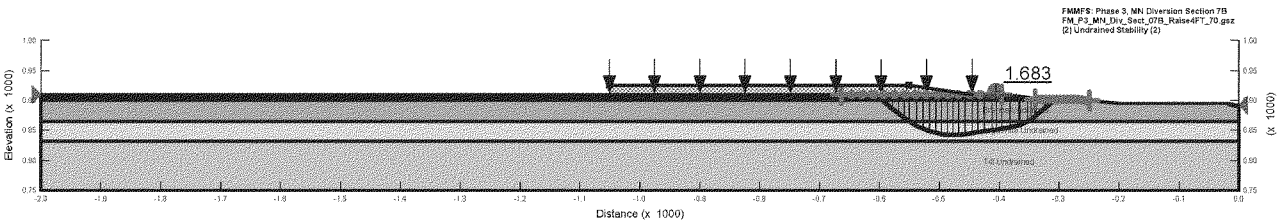
1500

File Name: FM_P3_MN_Div_Sect_07B_Raise4FT_70.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 7B

(2) Undrained Stability (2)

Soil Properties



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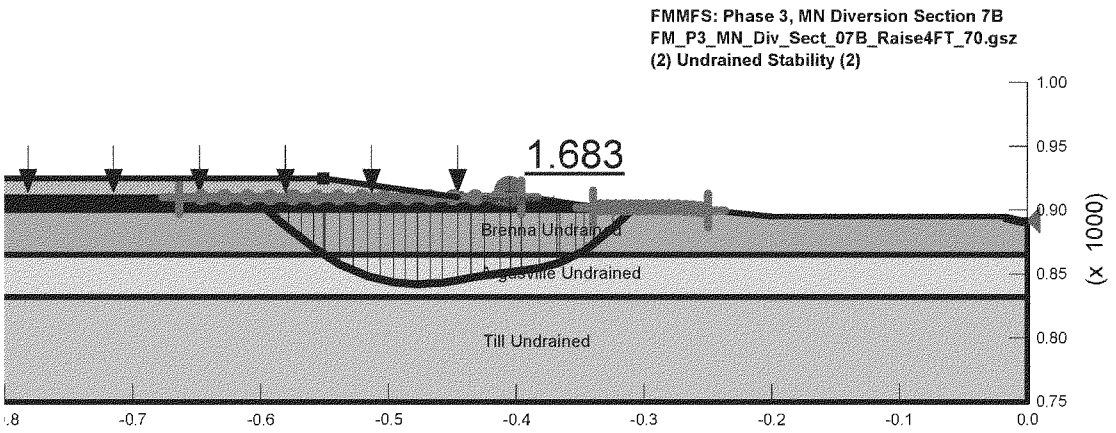
1501


FMMFS: Phase 3, MN Diversion Section 7B
FM_P3_MN_Div_Sect_07B_Raise4FT_70.gsz
(2) Undrained Stability (2)
1.683
Brenna Undrained
Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

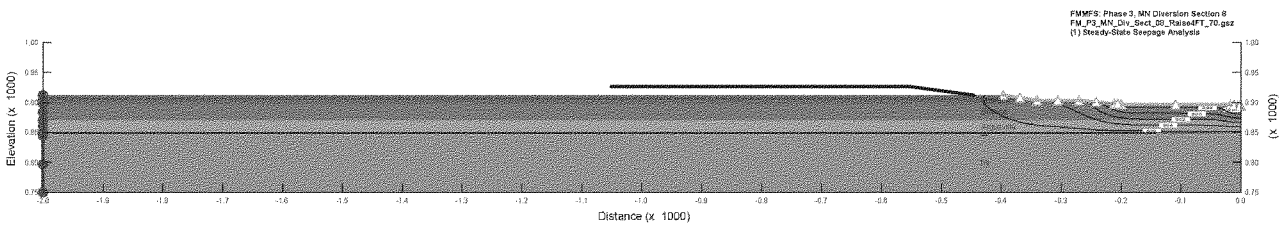
1502

File Name: FM_P3_MN_Div_Sect_08_Raise4FT_70.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 8

(1) Steady-State Seepage Analysis

Soil Properties



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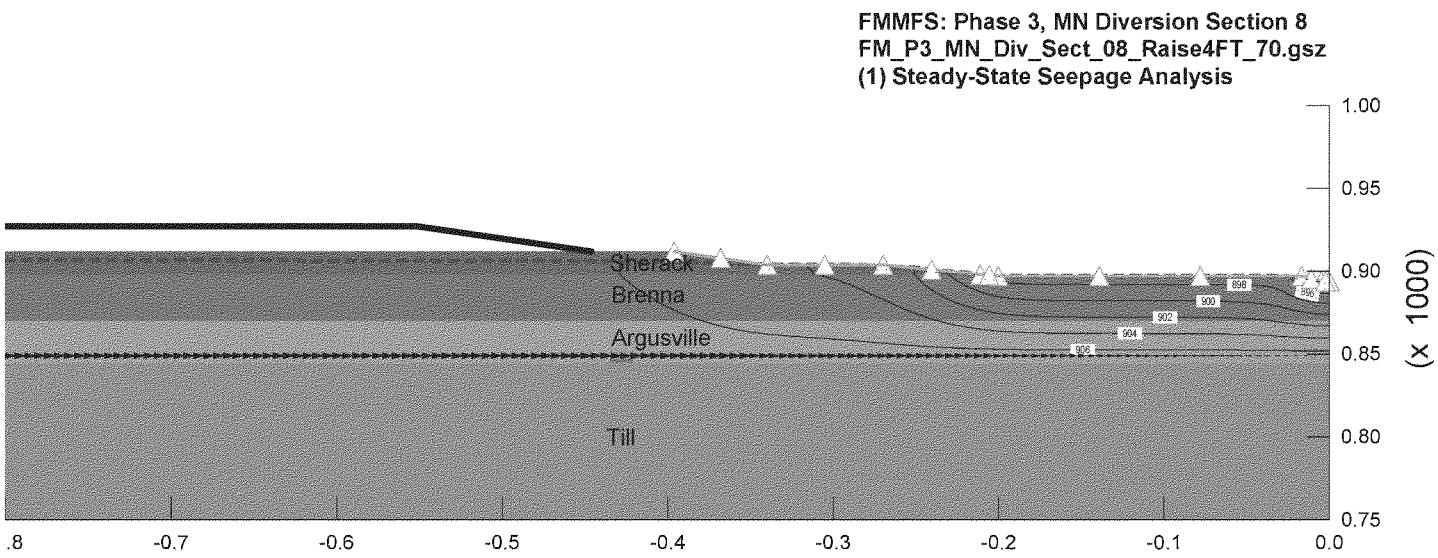
Last Edited By: Killian, Elizabeth A MVP
Date: 8/16/2010

1503

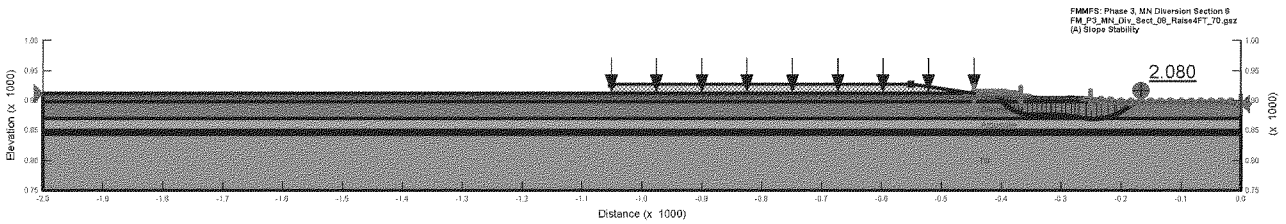

FMMFS: Phase 3, MN Diversion Section 8
FM_P3_MN_Div_Sect_08_Raise4FT_70.gsz
(1) Steady-State Seepage Analysis
Sherack
Brenna
Argusville
Till
898
900
902
904
906
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P3_MN_Div_Sect_08_Raise4FT_70.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 8

(A) Slope Stability

Soil Properties



Created By: Heckendorf, Kurt A MVP
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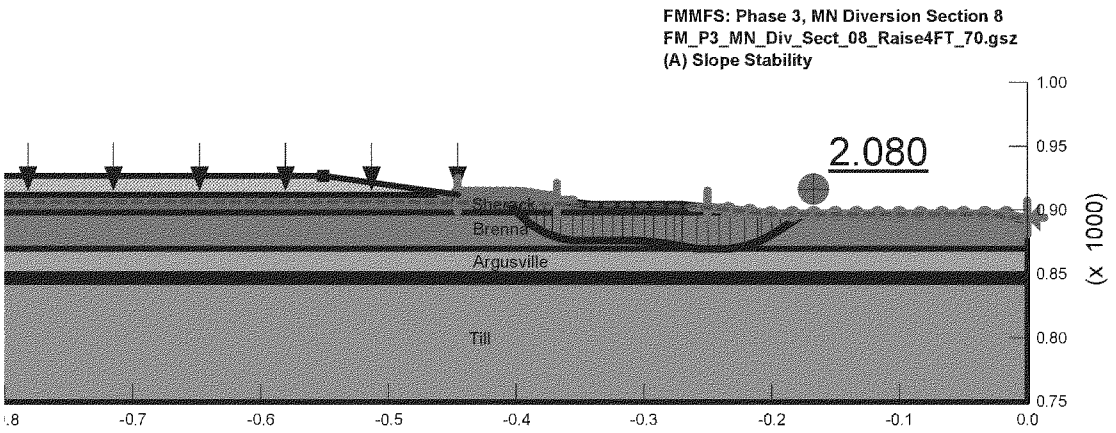
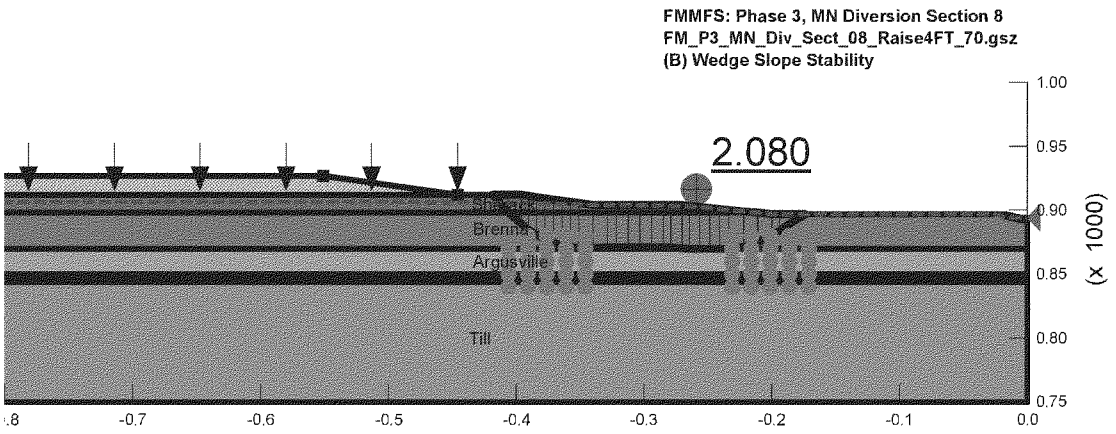
Date: 8/16/2010

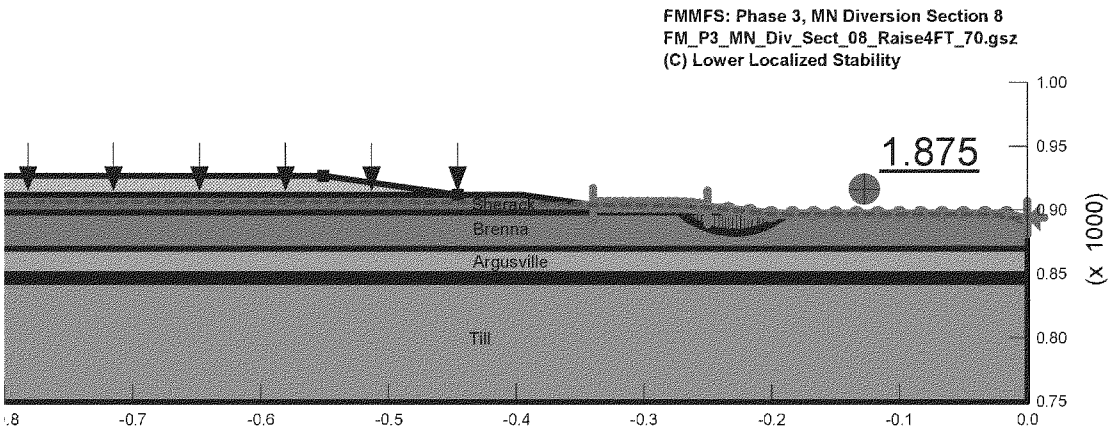
1505


FMMFS: Phase 3, MN Diversion Section 8
FM_P3_MN_Div_Sect_08_Raise4FT_70.gsz
(A) Slope Stability
2.080
Sherack
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

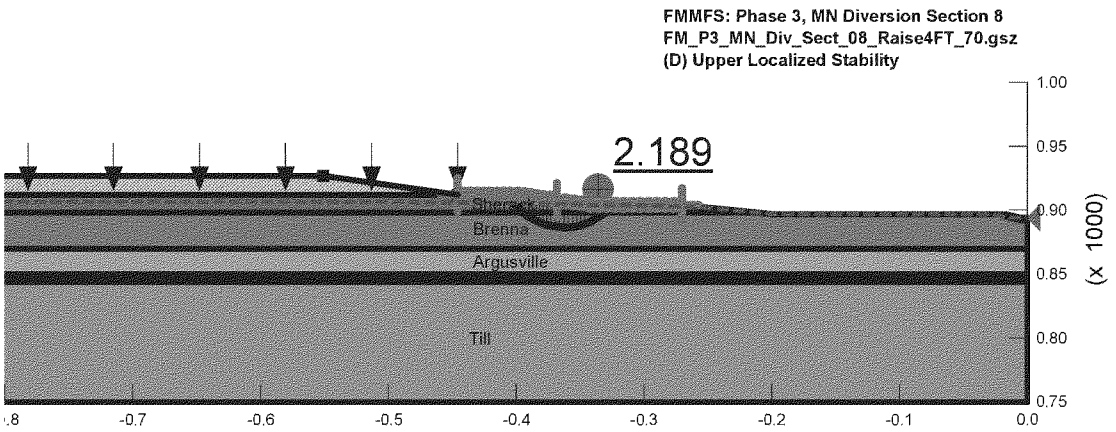
1506


FMMFS: Phase 3, MN Diversion Section 8
FM_P3_MN_Div_Sect_08_Raise4FT_70.gsz
(B) Wedge Slope Stability
2.080
Sherack
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1507


FMMFS: Phase 3, MN Diversion Section 8
FM_P3_MN_Div_Sect_08_Raise4FT_70.gsz
(C) Lower Localized Stability
1.875
Sherack
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1508


FMMFS: Phase 3, MN Diversion Section 8
FM_P3_MN_Div_Sect_08_Raise4FT_70.gsz
(D) Upper Localized Stability
2.189
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1509

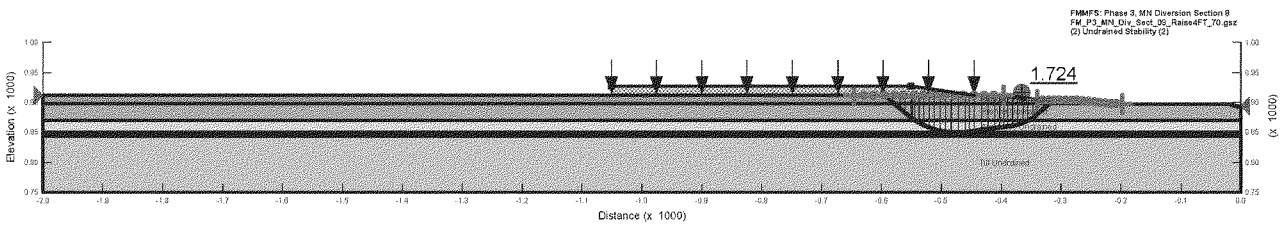
File Name: FM_P3_MN_Div_Sect_08_Raise4FT_70.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 8

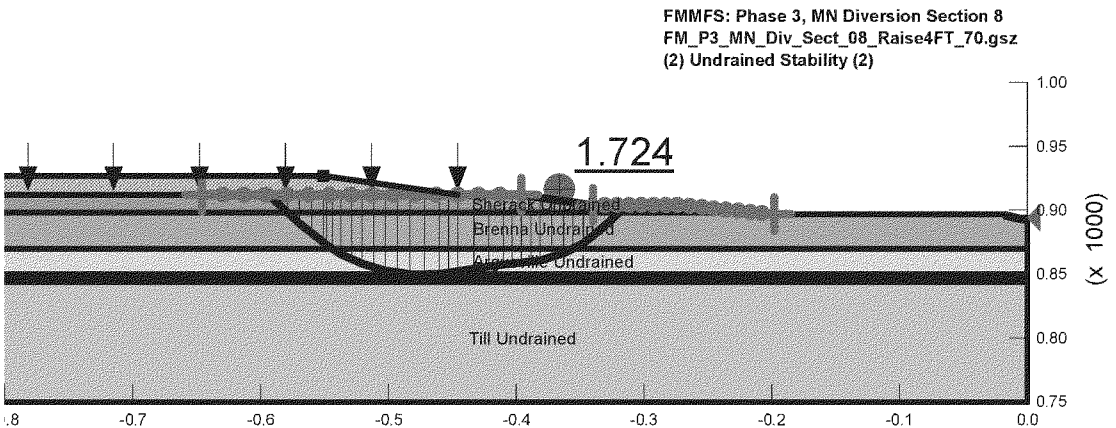
(2) Undrained Stability (2)

Soil Properties

Name: Stratum Undrained Model: Undrained (Phi=0) Unit Weight: 110 pcf Cohesion: 500 psf
Name: Stratum Undrained Model: Undrained (Phi=0) Unit Weight: 104 pcf Cohesion: 525 psf
Name: Aquaveta Undrained Model: Stratum(s) Unit Weight: 100 pcf C-Top of Layer: 625 psf C-Rate of Change: 10 psf/ft Limiting C: 1025 psf
Name: TA Undrained Model: Undrained (Phi=0) Unit Weight: 122 pcf Cohesion: 1000 psf
Name: Sand Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 32 ° Phi-B: 0 °



Created By: Heckendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/16/2010


FMMFS: Phase 3, MN Diversion Section 8
FM_P3_MN_Div_Sect_08_Raise4FT_70.gsz
(2) Undrained Stability (2)
1.724
Sherack Undrained
Brenna Undrained
Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

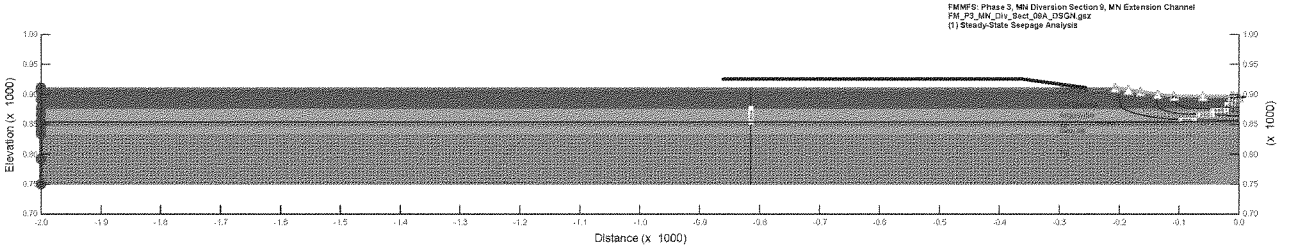
1511

File Name: FM_P3_MN_Div_Sect_09A_DSGN.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 9A

(1) Steady-State Seepage Analysis

Soil Properties



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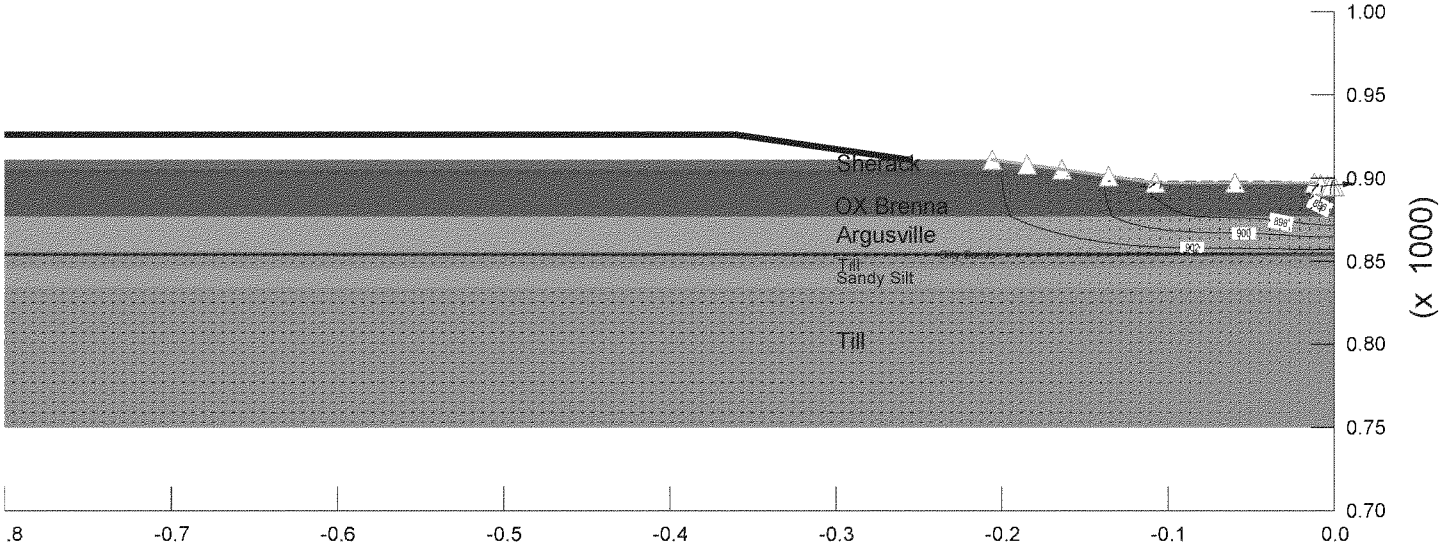
Last Edited By: Killian, Elizabeth A MVP
Date: 8/16/2010

FMMFS: Phase 3, MN Diversion Section 9, MN Extension Channel
FM_P3_MN_Div_Sect_09A_DSGN.gsz
(1) Steady-State Seepage Analysis



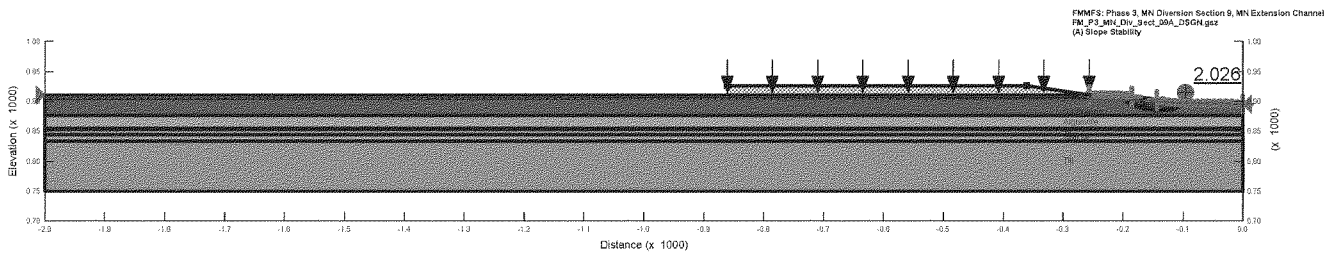
1513

File Name: FM_P3_MN_Div_Sect_09A_DSGN.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 9A

(A) Slope Stability

Soil Properties



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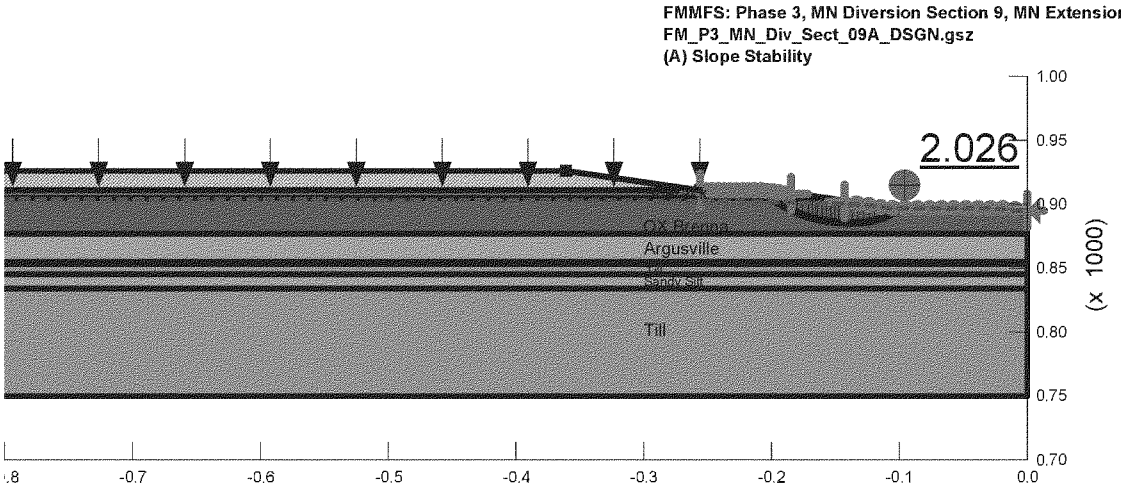
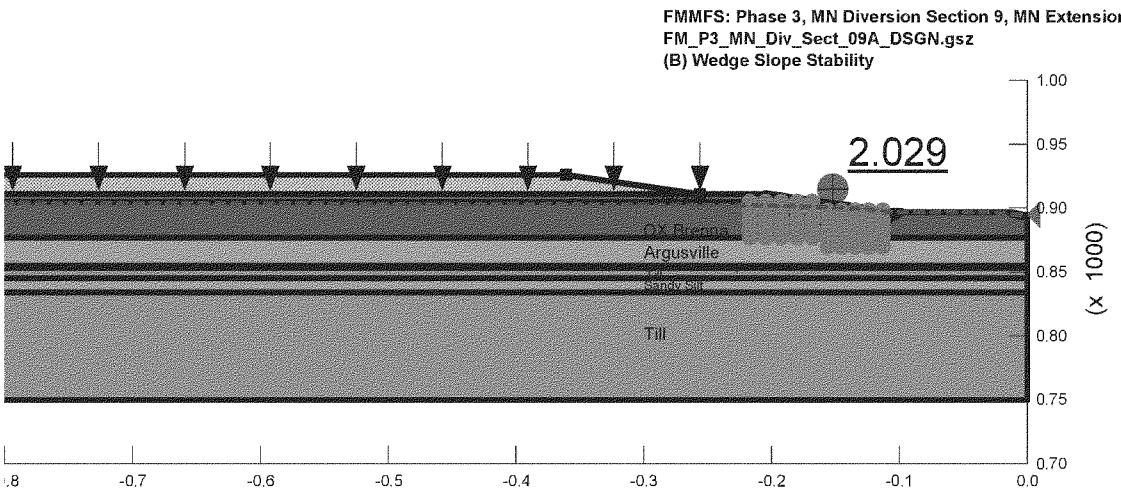
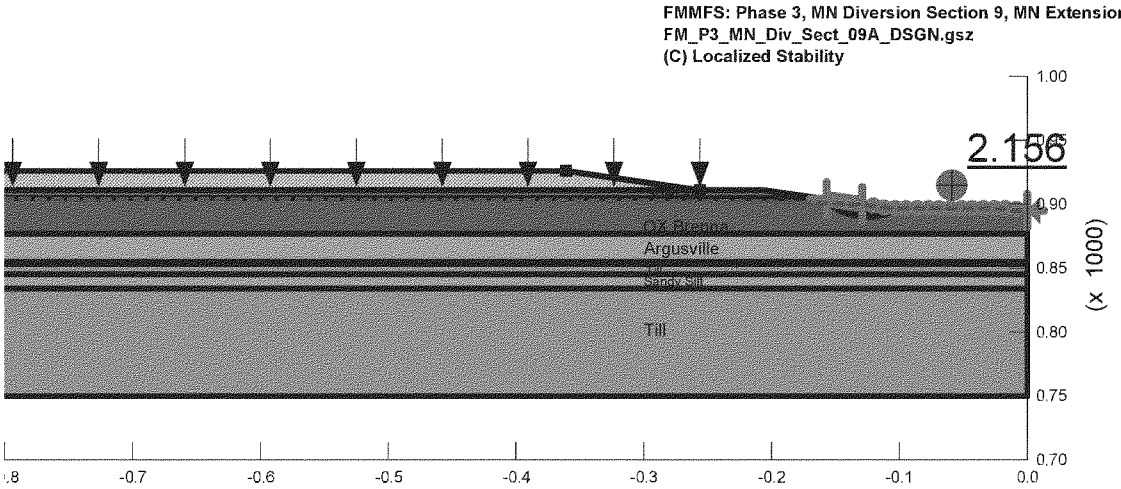
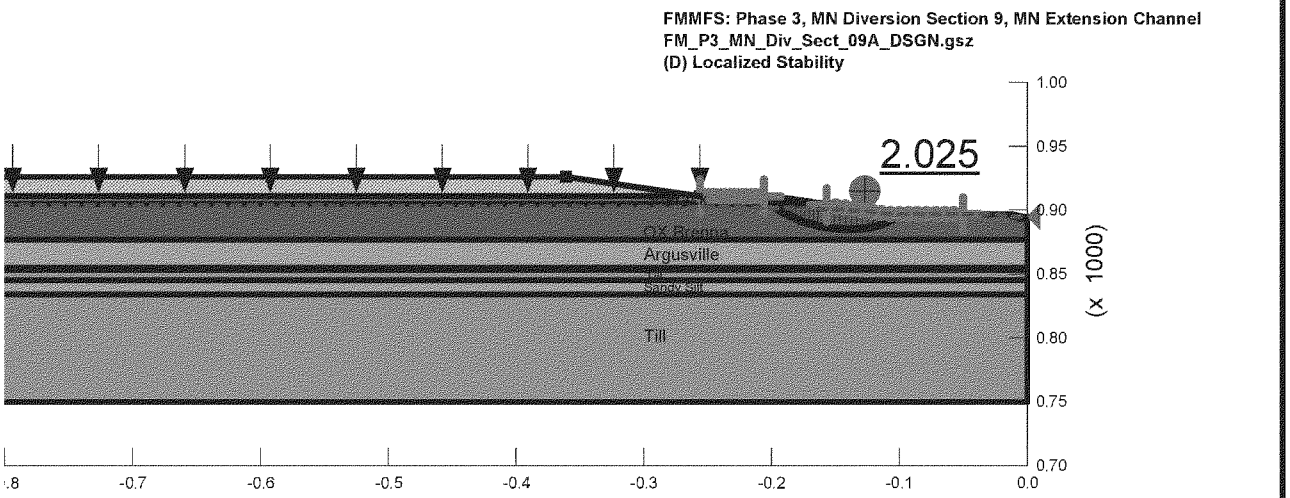
Last Edited By: Killian, Elizabeth A MVP
Date: 8/15/2010


FMMFS: Phase 3, MN Diversion Section 9, MN Extension Channel
FM_P3_MN_Div_Sect_09A_DSGN.gsz
(A) Slope Stability
2.026
OX Brenton
Argusville
Sandy silt
Till
1.00
0.95
0.90
0.85
0.80
0.75
0.70
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1515


FMMFS: Phase 3, MN Diversion Section 9, MN Extension Channel
FM_P3_MN_Div_Sect_09A_DSGN.gsz
(B) Wedge Slope Stability
2.029
OX Brenna
Argusville
Sandy Silt
Till
1.00
0.95
0.90
0.85
0.80
0.75
0.70
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 3, MN Diversion Section 9, MN Extension Channel
FM_P3_MN_Div_Sect_09A_DSGN.gsz
(C) Localized Stability
2.156
QX Brenna
Argusville
Sandy Silt
Till
1.00
0.95
0.90
0.85
0.80
0.75
0.70
(x 1000)
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 3, MN Diversion Section 9, MN Extension Channel
FM_P3_MN_Div_Sect_09A_DSGN.gsz
(D) Localized Stability
2.025
OX Brenna
Argusville
Sandy silt
Till
1.00
0.95
0.90
0.85
0.80
0.75
0.70
(x 1000)
-.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

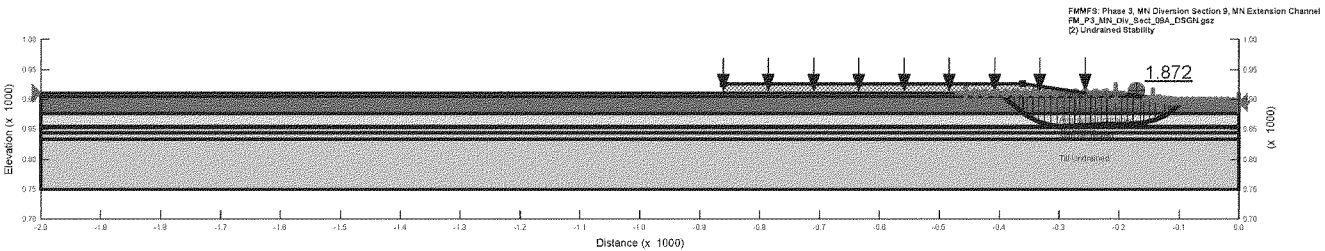
File Name: FM_P3_MN_Div_Sect_09A_DSGN.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 9A

(2) Undrained Stability

Soil Properties

Name: Sherrick Undrained Model: Undrained (Phi=0) Unit Weight: 118 pcf Cohesion: 720 pcf
Name: Argiaquite Undrained Model: S=(depth) Unit Weight: 105 pcf C-Top of Layer: 525 pcf C-Rate of Change: 10 psf/ft Limiting C: 1025 psf
Name: Till Undrained Model: Undrained (Phi=0) Unit Weight: 132 pcf Cohesion: 1650 psf
Name: Sand Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 33 ° Phi-B: 0 °
Name: Silty Sands Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 °
Name: Silt Sands Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 900 psf
Name: Sandy Silt Undrained Model: Undrained (Phi=0) Unit Weight: 119 pcf Cohesion: 1200 psf



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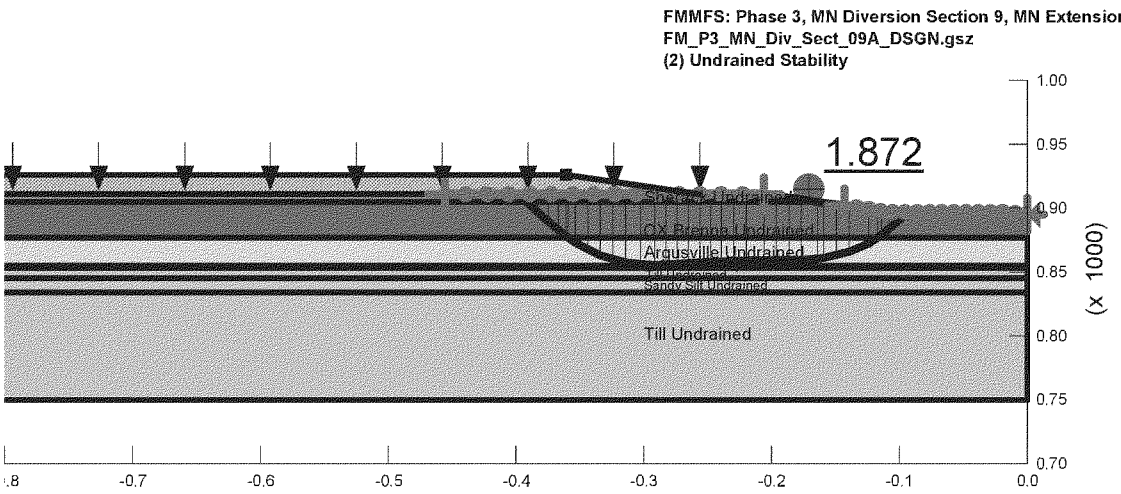
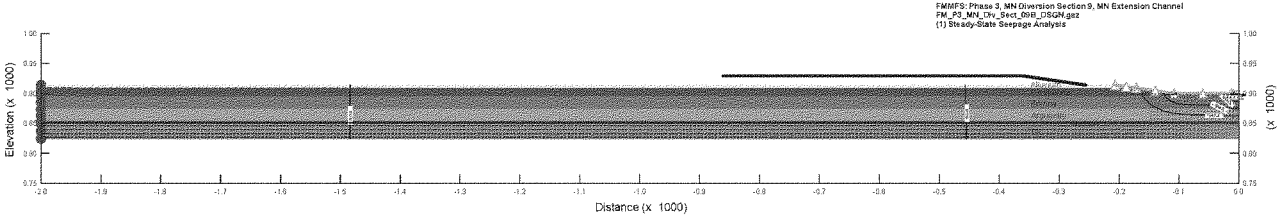

FMMFS: Phase 3, MN Diversion Section 9, MN Extension Channel
FM_P3_MN_Div_Sect_09A_DSGN.gsz
(2) Undrained Stability
1.872
Sherack Undrained
CX Brenna Undrained
Argusville Undrained
Sandy Silt Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
0.70
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P3_MN_Div_Sect_09B_DSGN.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 9B

(1) Steady-State Seepage Analysis

Soil Properties



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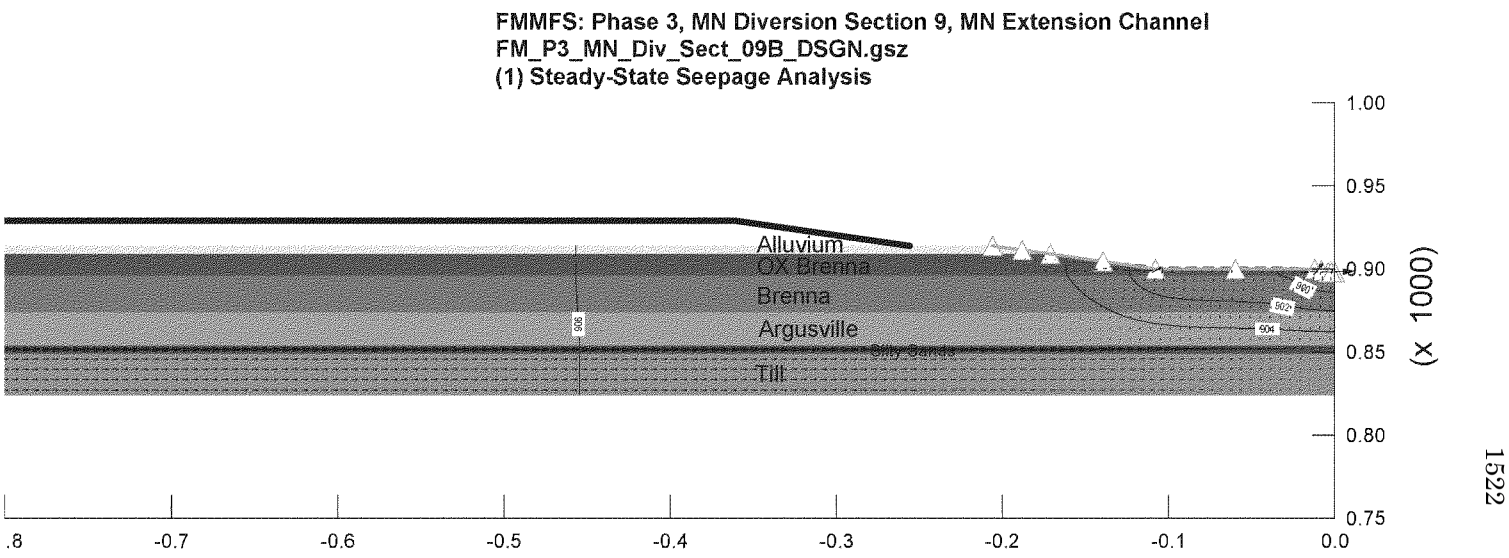
Date: 8/16/2010

1521


FMMFS: Phase 3, MN Diversion Section 9, MN Extension Channel
FM_P3_MN_Div_Sect_09B_DSGN.gsz
(1) Steady-State Seepage Analysis
Alluvium
OX Brenna
Brenna
Argusville
Silty Sands
Till
905
901
502
504
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

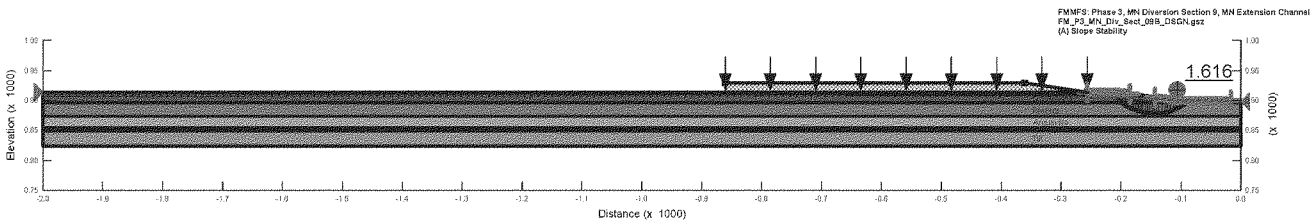
1522

File Name: FM_P3_MN_Div_Sect_09B_DSGN.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 9B

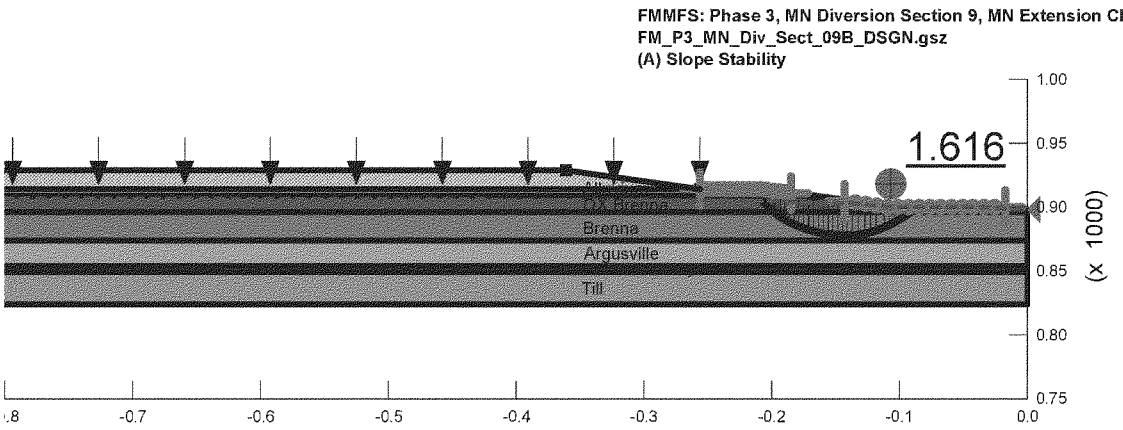
(A) Slope Stability

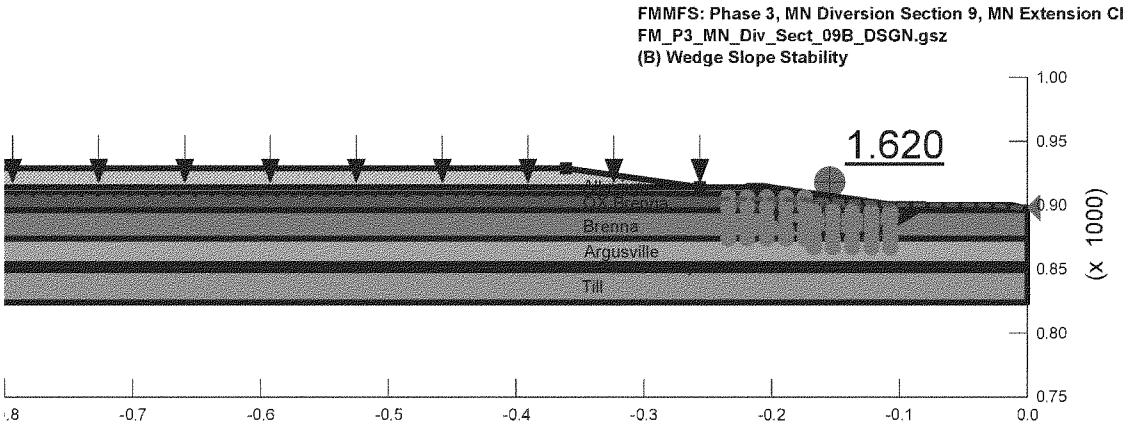
Soil Properties



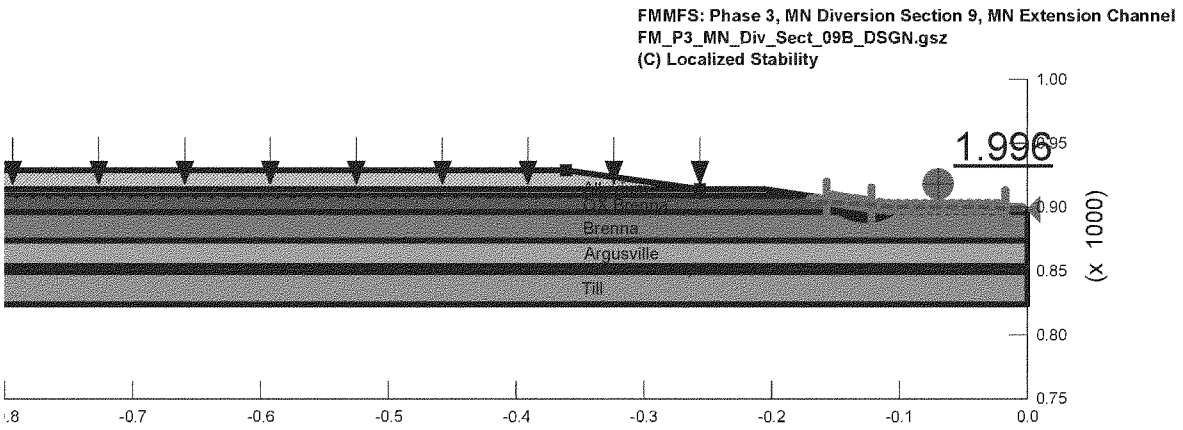
Created By: Heckendorf, Kurt A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 8/16/2010

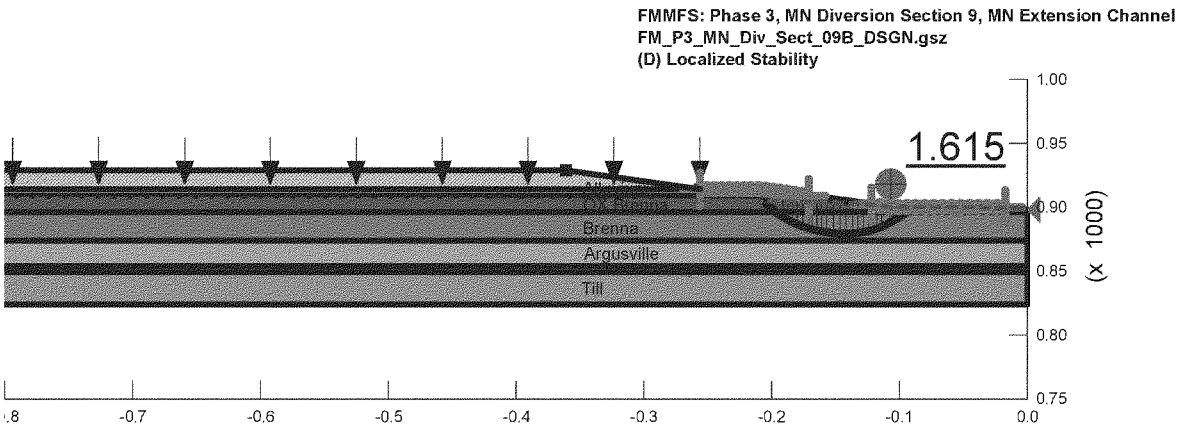
1523


FMMFS: Phase 3, MN Diversion Section 9, MN Extension Channel
FM_P3_MN_Div_Sect_09B_DSGN.gsz
(A) Slope Stability
1.616
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 3, MN Diversion Section 9, MN Extension Channel
FM_P3_MN_Div_Sect_09B_DSGN.gsz
(B) Wedge Slope Stability
1.620
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1525


FMMFS: Phase 3, MN Diversion Section 9, MN Extension Channel
FM_P3_MN_Div_Sect_09B_DSGN.gsz
(C) Localized Stability
1.996
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 3, MN Diversion Section 9, MN Extension Channel
FM_P3_MN_Div_Sect_09B_DSGN.gsz
(D) Localized Stability
1.615
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1527

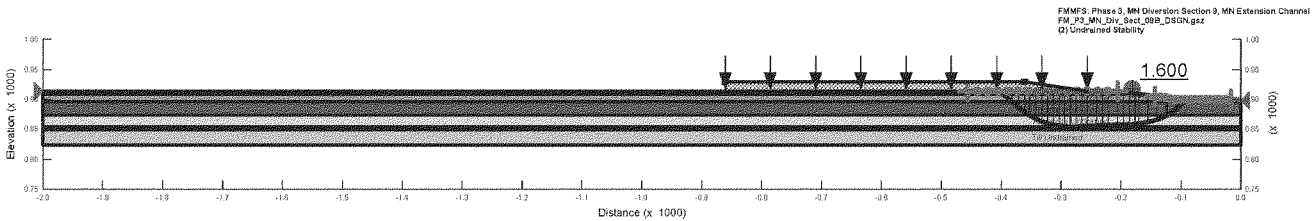
File Name: FM_P3_MN_Div_Sect_09B_DSGN.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 9B

(2) Undrained Stability

Soil Properties

Name: Bedrock Undrained Model: Undrained (Phi=0) Unit Weight: 104 pcf Cohesion: 525 psf
Name: Argusville Undrained Model: Undrained Unit Weight: 105 pcf Cr Top of Layer: 525 psf Cr-Rate of Change: 0 psf/ft Limiting C: 1025 psf
Name: TB Undrained Model: Undrained (Phi=0) Unit Weight: 122 pcf Cohesion: 1900 psf
Name: Sand Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion: 0 psf Phi: 32 ° Phi-B: 0 °
Name: Silty Clay(3) Model: Mohr-Coulomb Unit Weight: 121 pcf Cohesion: 0 psf Phi: 30 ° Phi-B: 0 °
Name: Alluvium Undrained Model: Undrained (Phi=0) Unit Weight: 119 pcf Cohesion: 900 psf
Name: Cl/ Brenda Undrained Model: Undrained (Phi=0) Unit Weight: 111 pcf Cohesion: 858 psf



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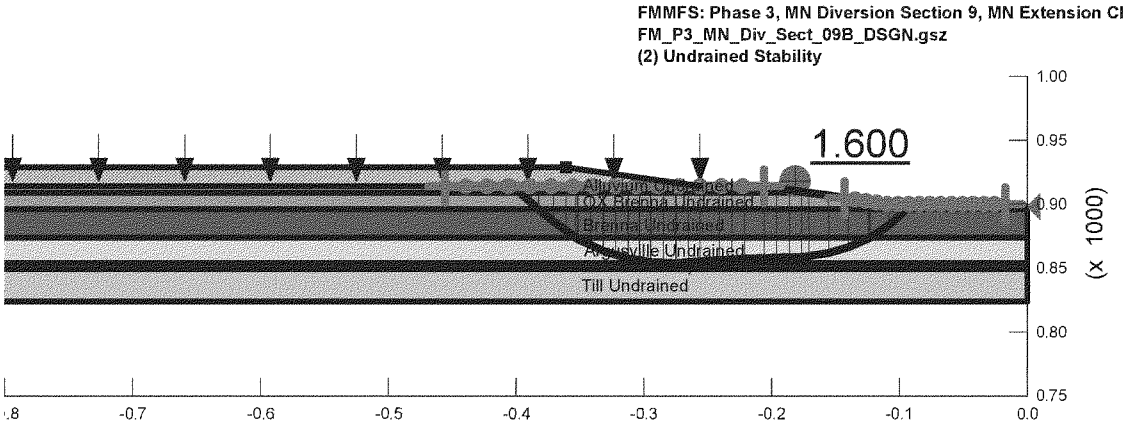
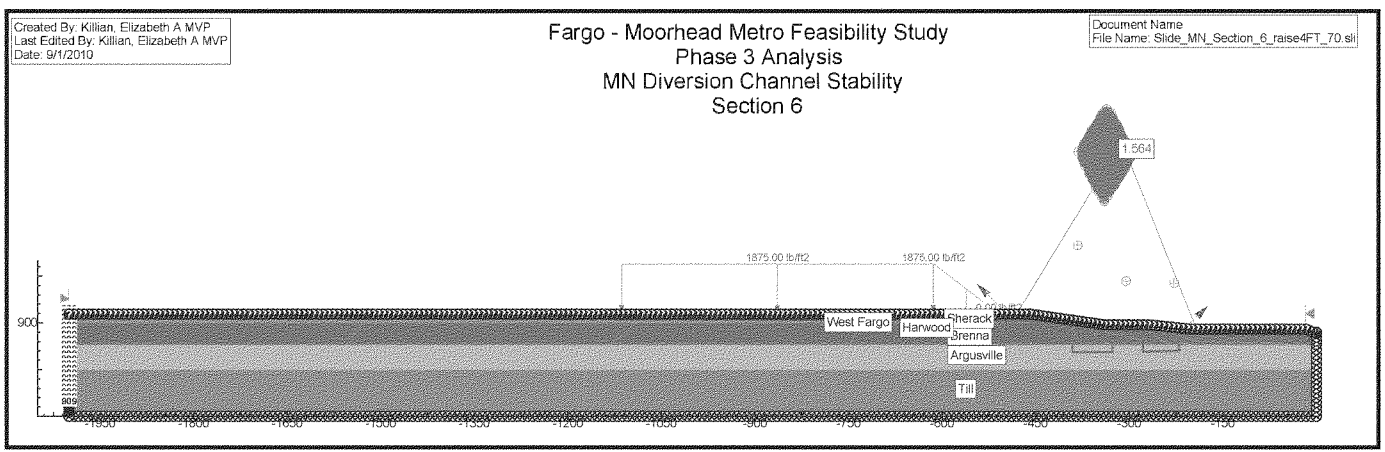
Date: 8/16/2010

1528


FMMFS: Phase 3, MN Diversion Section 9, MN Extension Channel
FM_P3_MN_Div_Sect_09B_DSGN.gsz
(2) Undrained Stability
1.600
Alluvium Undrained
OX Brenna Undrained
Brenna Undrained
Argusville Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1529


Created By: Killian, Elizabeth A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 9/1/2010
Fargo - Moorhead Metro Feasibility Study
Phase 3 Analysis
MN Diversion Channel Stability
Section 6
Document Name
File Name: Slide_MN_Section_6_raise4FT_70.sli
1.564
1875.00 lb/ft2
1875.00 lb/ft2
West Fargo
Harwood
Sherack
Brenna
Argusville
Till
900
909
1600
1400
1200
1000
800
600
400
-2000
-1800
-1600
-1400
-1200
-1000
-800
-600
-400
-200
0

Slide Analysis Information

Document Name

File Name: Slide_MN_Section_6_raise4FT_70.sli

Project Settings

Project Title: SLIDE - MN Section 6 raise 4FT 70
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Finite Element Analysis
Tolerance (groundwater): 1e-006
Maximum number of iterations (groundwater): 500
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:
Spencer

Number of slices: 30
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Non-Circular Block Search
Number of Surfaces: 15000
Pseudo-Random Surfaces: Enabled
Convex Surfaces Only: Disabled
Left Projection Angle (Start Angle): 135
Left Projection Angle (End Angle): 135
Right Projection Angle (Start Angle): 45
Right Projection Angle (End Angle): 45
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Loading

2 Distributed Loads present:
Distributed Load Triangular Distribution, Orientation: Vertical, Magnitudes 1,2: 0 and 1875 lb/ft2
Distributed Load Constant Distribution, Orientation: Vertical, Magnitude: 1875 lb/ft2

Groundwater Analysis

Maximum Number of Iterations: 500

Iteration Tolerance: 1e-006
Mesh Element Type: 4 noded quadrilaterals
Number of Elements: 9552
Number of Nodes: 9619

Material Properties

Material: Sherack
Ks: 3.24074e-008
K2/K1: 1
K Angle: 0

Model: User Defined - Alluv/Sherack

Material: West Fargo
Ks: 3.24074e-006
K2/K1: 1
K Angle: 0

Model: User Defined - West Fargo

Material: Harwood
Ks: 3.24074e-007
K2/K1: 1
K Angle: 0

Model: User Defined - Harwood

Material: Brenna
Ks: 3.24e-009
K2/K1: 1
K Angle: 0

Model: Simple

Material: Argusville
Ks: 3.24e-009
K2/K1: 1
K Angle: 0

Model: Simple

Material: Till
Ks: 6.59e-007
K2/K1: 0.25
K Angle: 0

Model: Simple

Material: Sand
Ks: 0.000324074
K2/K1: 1
K Angle: 0

Model: User Defined - Sand

List of All Coordinates

Material Boundary
-2000.000 908.000
-417.000 908.000

Material Boundary
-2000.000 906.000
-403.000 906.000

Material Boundary
-17.000 890.000
-17.000 888.000
-5.000 883.000
0.000 883.000

Material Boundary
-2000.000 900.000
-361.000 900.000

Material Boundary
-2000.000 865.000
0.000 865.000

Material Boundary
-2000.000 825.000
0.000 825.000

External Boundary
0.000 750.000
0.000 825.000
0.000 865.000
0.000 883.000
0.000 885.000
-5.000 885.000
-17.000 890.000
-200.000 890.000
-270.000 897.000
-340.000 897.000
-361.000 900.000
-403.000 906.000
-417.000 908.000
-459.000 914.000
-2000.000 914.000
-2000.000 908.000
-2000.000 906.000
-2000.000 900.000
-2000.000 865.000
-2000.000 825.000
-2000.000 750.000

Attachment I-12: ND Diversion Channel Phase 4 Results

Fargo-Moorhead Metro Feasibility Study
Phase 4.1 Geotechnical Design/Analyses of ND Diversion with LPP Version #4 Invert Raise

Compiled By: KAH Revised By: KAH
Date: 12/9/2010 Date: 7/24/2011

Target Factor of Safety	1.400	1.400	1.200	1.200	1.300
variation	0.050	0.050	0.050	0.050	0.050
	1.350	1.350	1.150	1.150	1.250

North Dakota Diversion Channel, Section 1 STA 120+00 0+00 375+00 37,500 7.1

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS								
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(Z) Unchained Global	P4 vs P3 Invert Elev	Top of slope	% Increase	X-Sectional Area	% Increase
Original ND Sect 1	100	854				882	7	28										246		8354	
FM_P4_ND_Div_Sect-01_P4_v#4	250	865				882	7	17	50	8		1.564	1.558	1.702	2.205	1.345	8	244	-0.8%	6339	-24%

North Dakota Diversion Channel, Section 2 STA 530+00 375+00 656+00 28,100 5.3

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS								
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(Z) Unchained Global	P4 vs P3 Invert Elev	Top of slope	% Increase	X-Sectional Area	% Increase
Original ND Sect 2	100	862				890	7	28										246		8354	
FM_P4_ND_Div_Sect-02_P4_v#4	250	868	15	8	7	890	7	22	50	11		1.431	1.437	1.608	1.957	1.415	3	294	19.5%	9374	12%

North Dakota Diversion Channel, Section 3 STA 940+00 656+00 1000+00 34,400 6.5

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS								
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(Z) Unchained Global	P4 vs P3 Invert Elev	Top of slope	% Increase	X-Sectional Area	% Increase
Original ND Sect 3	100	870				900	7	30										260		9366	
FM_P3_ND_Div_Sect-03_P4_v#4	250	877	25	8	7	900	7	23	50	15		1.421	1.411	1.710	1.791	1.332	4	311	19.6%	10269	10%

North Dakota Diversion Channel, Section 4 STA 1080+00 1000+00 1150+00 15,000 2.8

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS								
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(Z) Unchained Global	P4 vs P3 Invert Elev	Top of slope	% Increase	X-Sectional Area	% Increase
Original ND Sect 4	100	873				900	7	27										239		7869	
FM_P3_ND_Div_Sect-04_P4_v#4	250	879	20	8	7	900	7	21	50	15		1.429	1.423	1.611	1.880	1.464	3	292	22.2%	8923	13%

North Dakota Diversion Channel, Section 5 STA 1225+00 1150+00 1300+00 15,000 2.8

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS								
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(Z) Unchained Global	P4 vs P3 Invert Elev	Top of slope	% Increase	X-Sectional Area	% Increase
Original ND Sect 5	100	876				903	7	27										239		7869	
FM_P3_ND_Div_Sect-05_P4_v#4	250	881	40	8	7	903	7	22	50	12		1.411	1.412	1.418	1.649	1.406	2	319	33.5%	10074	28%

North Dakota Diversion Channel, Section 5B STA 1445+00 1300+00 1490+00 19,000 3.6

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS								
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(Z) Unchained Global	P4 vs P3 Invert Elev	Top of slope	% Increase	X-Sectional Area	% Increase
Original ND Sect 5B	100	880				913	7	33										281		10989	
FM_P3_ND_Div_Sect-05B_P4_v#4	250	885	40	8	7	913	7	28	50			1.416	1.415	1.708	1.409	1.507	2	361	28.5%	14154	29%

North Dakota Diversion Channel, Section 6B STA 1550+00 1490+00 1670+00 18,000 3.4

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS								
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(Z) Unchained Global	P4 vs P3 Invert Elev	Top of slope	% Increase	X-Sectional Area	% Increase
Original ND Sect 6B	100	882				920	7	38										316		13974	
FM_P3_ND_Div_Sect-06B_P4_v#4	250	903				920	7	17	50			1.512	1.513	1.636	2.346	1.363	18	244	-22.8%	6339	-55%

1535

Fargo-Moorhead Metro Feasibility Study
Phase 4.1 Geotechnical Design/Analyses of ND Diversion with LPP Version #4 Invert Raise

Compiled By: KAH Revised By: KAH
Date: 12/9/2010 Date: 2/24/2011

Target Factor of Safety	1.400	1.400	1.200	1.200	1.300
variation	0.050	0.050	0.050	0.050	0.050
	1.350	1.350	1.150	1.150	1.250

North Dakota Diversion Channel, Section 6C

STA 1720+00 1670+00 1770+00 10,000 1.9

	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS								
Filename	Bottom Width	Bottom Elev	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(Z) Unchained Global	P4 vs P3 Invert Elev	Top of slope	% Increase	X-Sectional Area	% Increase
Original ND Sect 6C	100	886				913	7	27										239		7869	
FM_P3_ND_Div_Sect-06C_P4_v4	250	905				913	7	8	50			2.353	2.150	2.564	4.339	2.022	16	181	-24.3%	2514	-68%

North Dakota Diversion Channel, Section 7

STA 1810+00 1770+00 1915+00 14,500 2.7

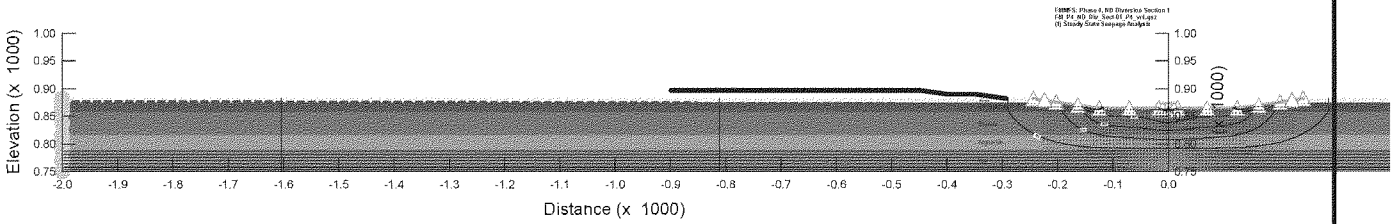
	Channel Configuration								Spoil Pile Surcharge			Stability Analysis: Min FS								
Filename	Bottom Width	Bottom Elev	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Depth	Setback	Height	Other Changes	(A) Global Entry/Exit	(B) Wedge	(C) Lower Localized	(D) Upper Localized	(Z) Unchained Global	P4 vs P3 Invert Elev	Top of slope	% Increase	X-Sectional Area	% Increase
Original ND Sect 7	225	893				912	7	19										245.5		6868	
FM_P3_ND_Div_Sect-07_P4_v4	250	901				912	7	11	50			2.201	2.173	2.274	3.116	2.000	8	202	-17.7%	3663	-47%

1536

File Name: FM_P4_ND_Div_Sect-01_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 1
(1) Steady-State Seepage Analysis

Soil Properties



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Last Edited By: Heckendorf, Kurt A MVP
Date: 1/18/2011

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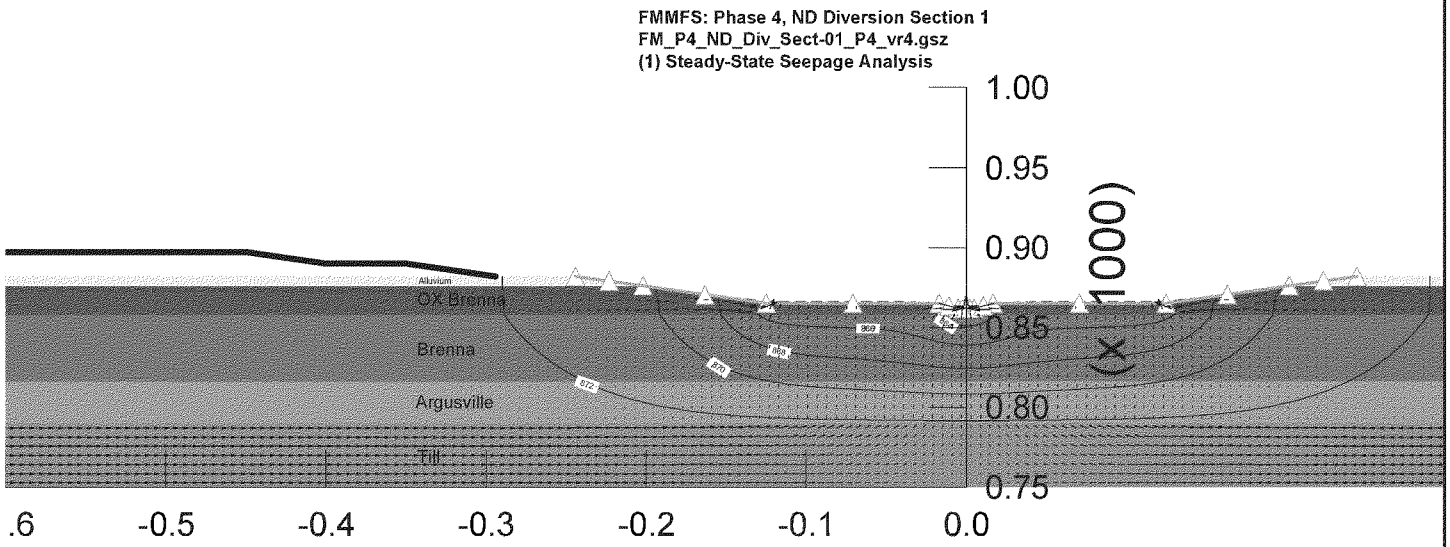
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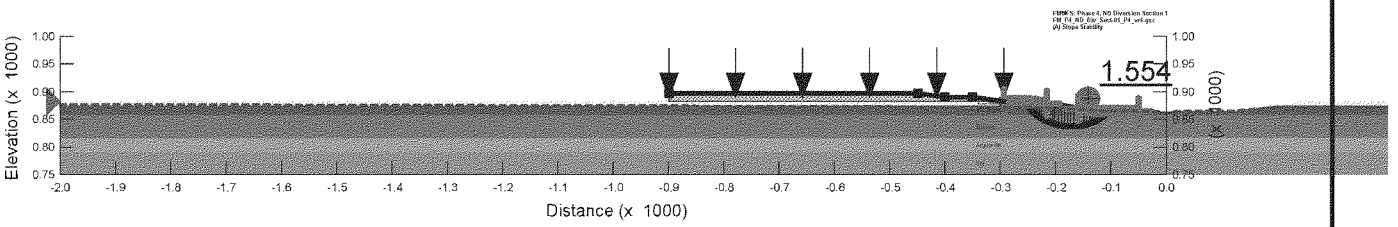
FM_P4_ND_Div_Sect-01_P4_vr4.gsz
(1) Steady-State Seepage Analysis
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
Alluvium
OX Brenna
Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-01_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 1
(A) Slope Stability

Soil Properties



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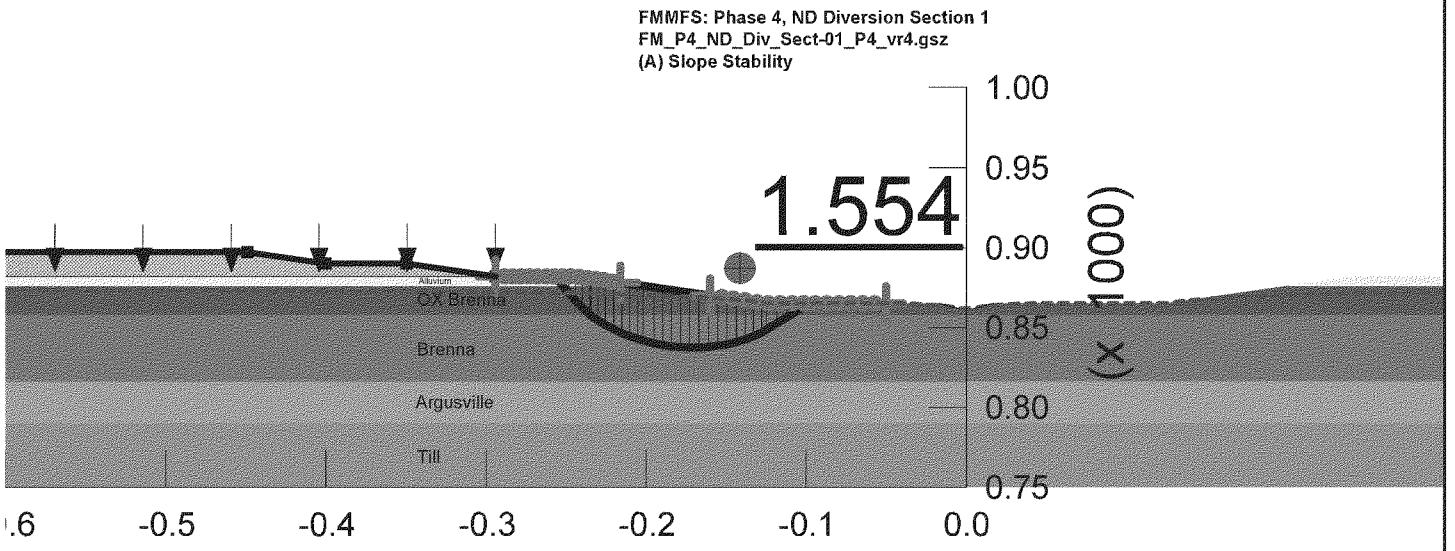
Last Edited By: Heckendorf, Kurt A MVP
Date: 2/11/2011

1539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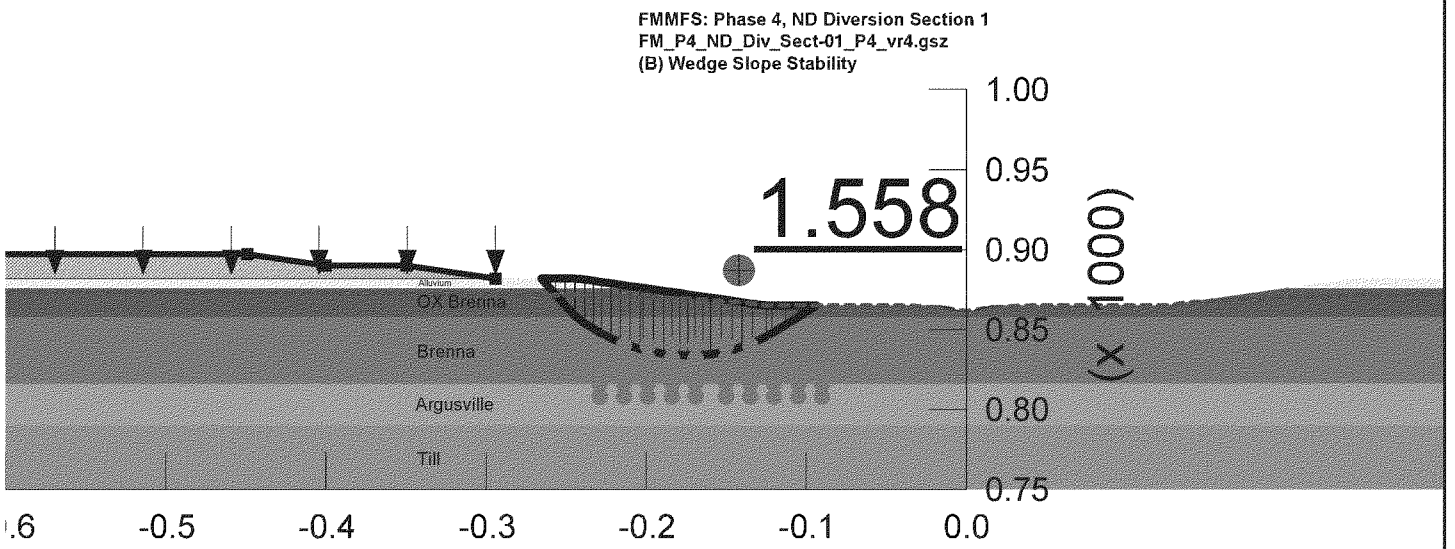
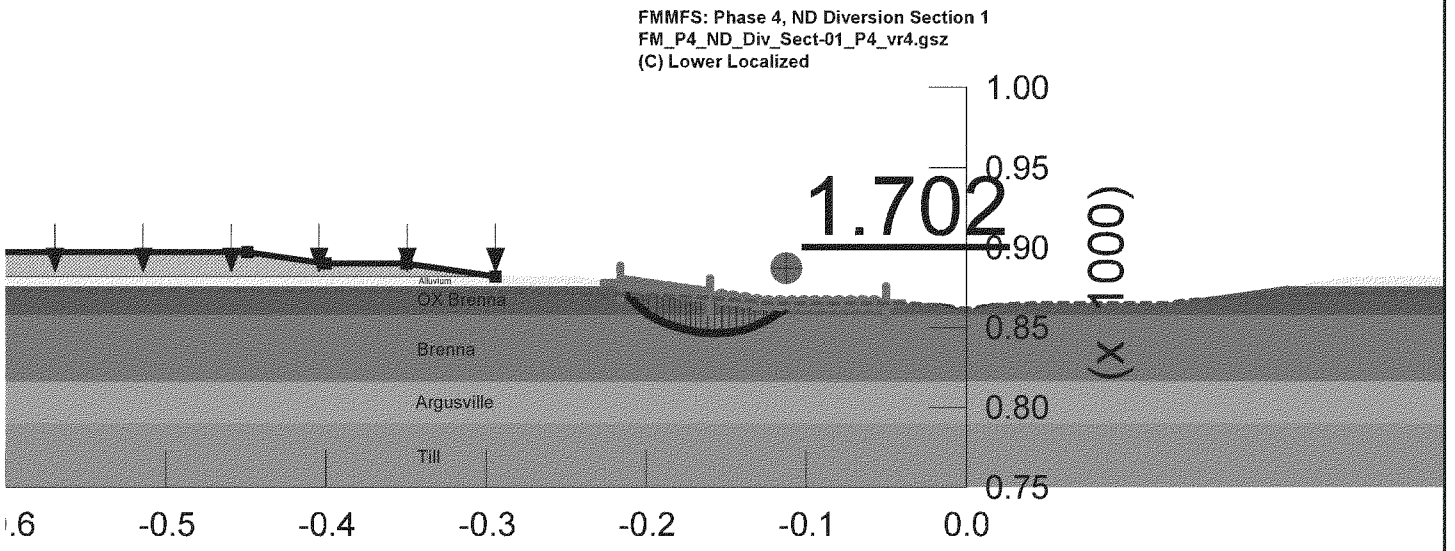
FM_P4_ND_Div_Sect-01_P4_vr4.gsz
(A) Slope Stability
1.554
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
Alluvium
OX Brenna
Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1540


FMMFS: Phase 4, ND Diversion Section 1
FM_P4_ND_Div_Sect-01_P4_vr4.gsz
(B) Wedge Slope Stability
1.558
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
Alluvium
OX Brenna
Brenna
Argusville
Till
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 4, ND Diversion Section 1
FM_P4_ND_Div_Sect-01_P4_vr4.gsz
(C) Lower Localized
1.702
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
Alluvium
OX Brenna
Brenna
Argusville
Till
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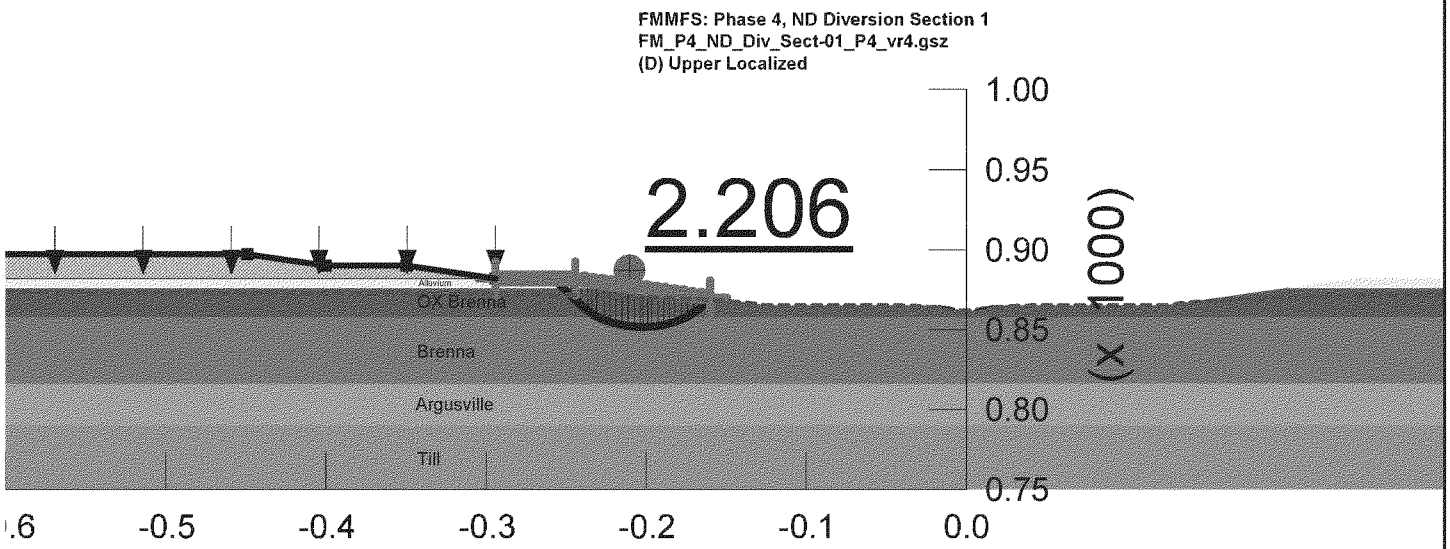
-0.5
-0.4
-0.3
-0.2
-0.1
0.0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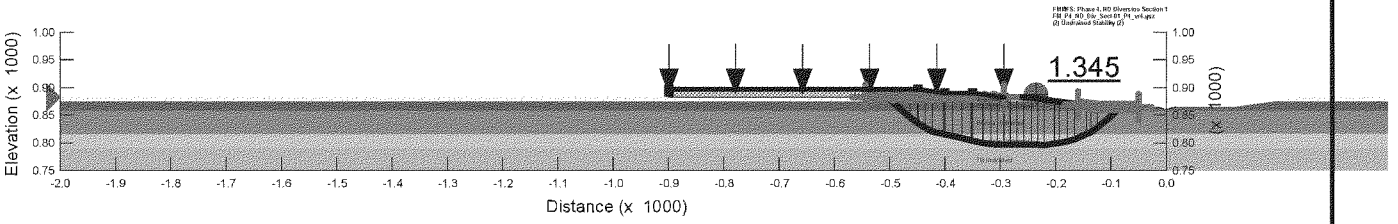
(D) Upper Localized
2.206
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
Alluvium
OX Brenna
Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-01_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 1
(2) Undrained Stability (2)

Soil Properties



Created By: Heckendorf, Kurt A MVP
Last Edited By: Heckendorf, Kurt A MVP
Date: 1/18/2011

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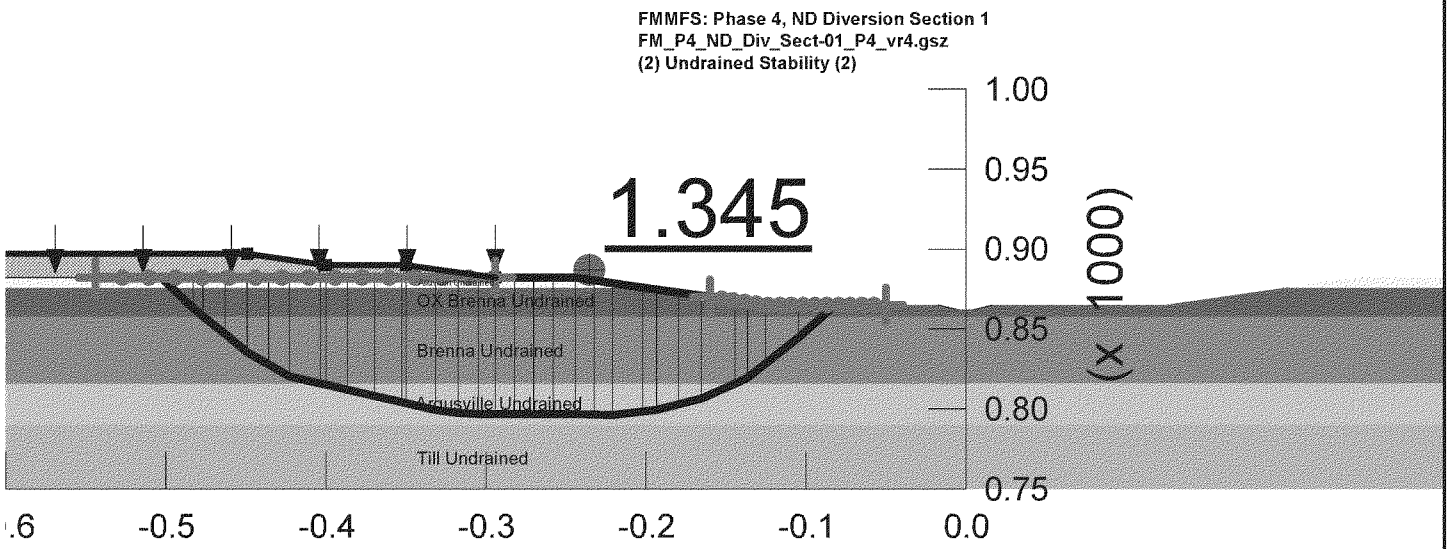
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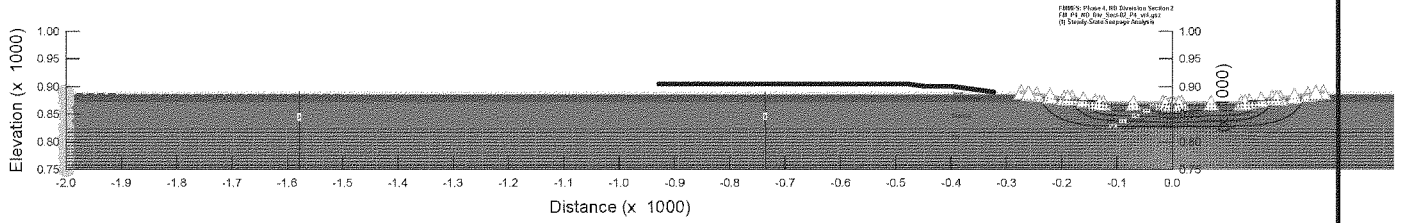
FM_P4_ND_Div_Sect-01_P4_vr4.gsz
(2) Undrained Stability (2)
1.345
OX Brenna Undrained
Brenna Undrained
Argusville Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-02_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 2
(1) Steady-State Seepage Analysis

Soil Properties



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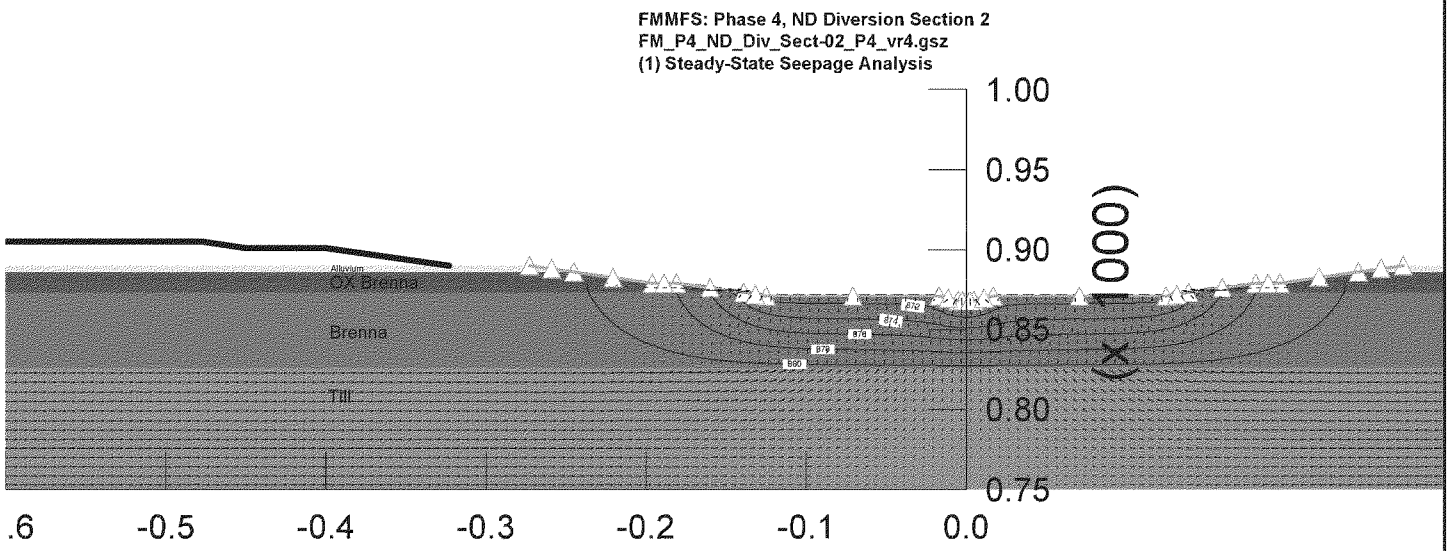
Last Edited By: Heckendorf, Kurt A MVP
Date: 1/18/2011

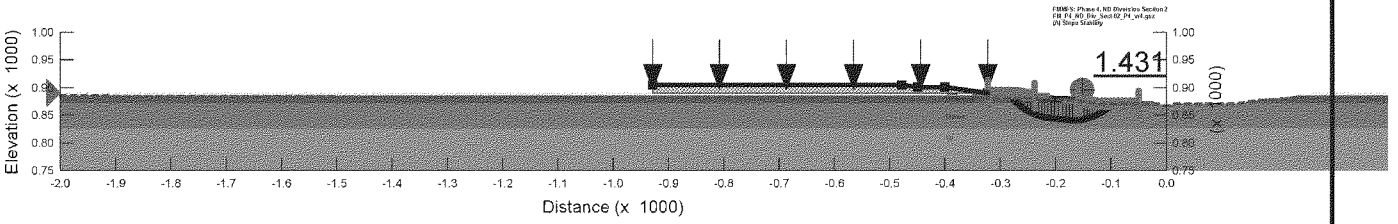
1546


FMMFS: Phase 4, ND Diversion Section 2
FM_P4_ND_Div_Sect-02_P4_vr4.gsz
(1) Steady-State Seepage Analysis
Alluvium
OX Brenna
Brenna
Till
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-02_P4_vr4.gsz

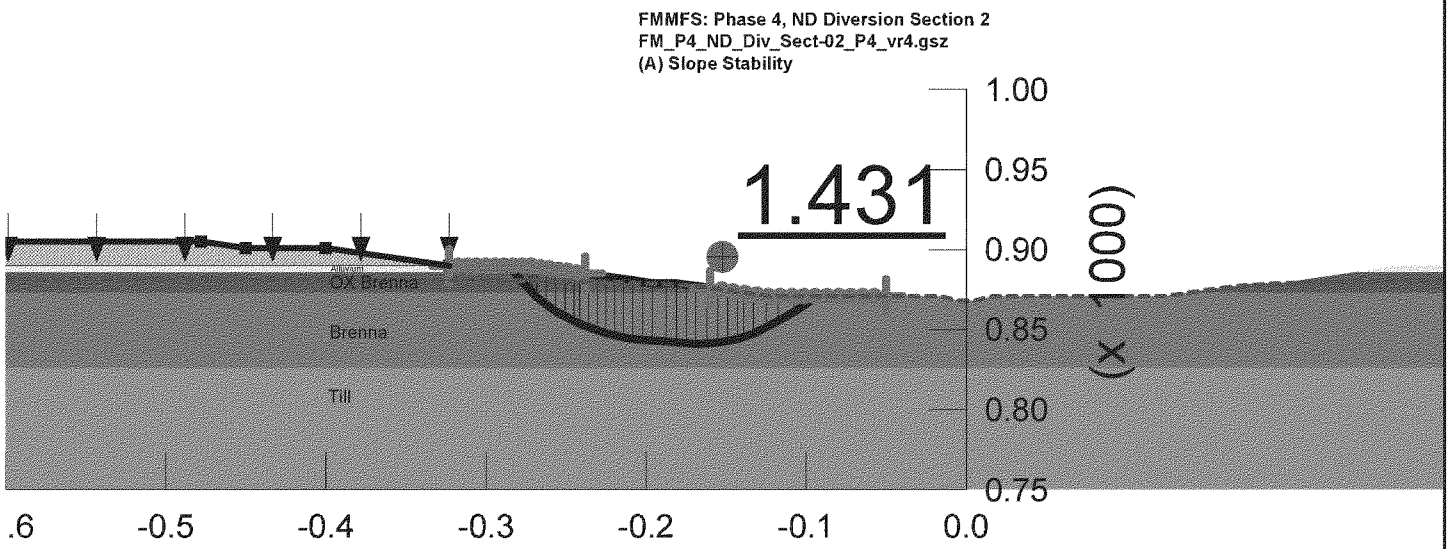
Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 2
(A) Slope Stability

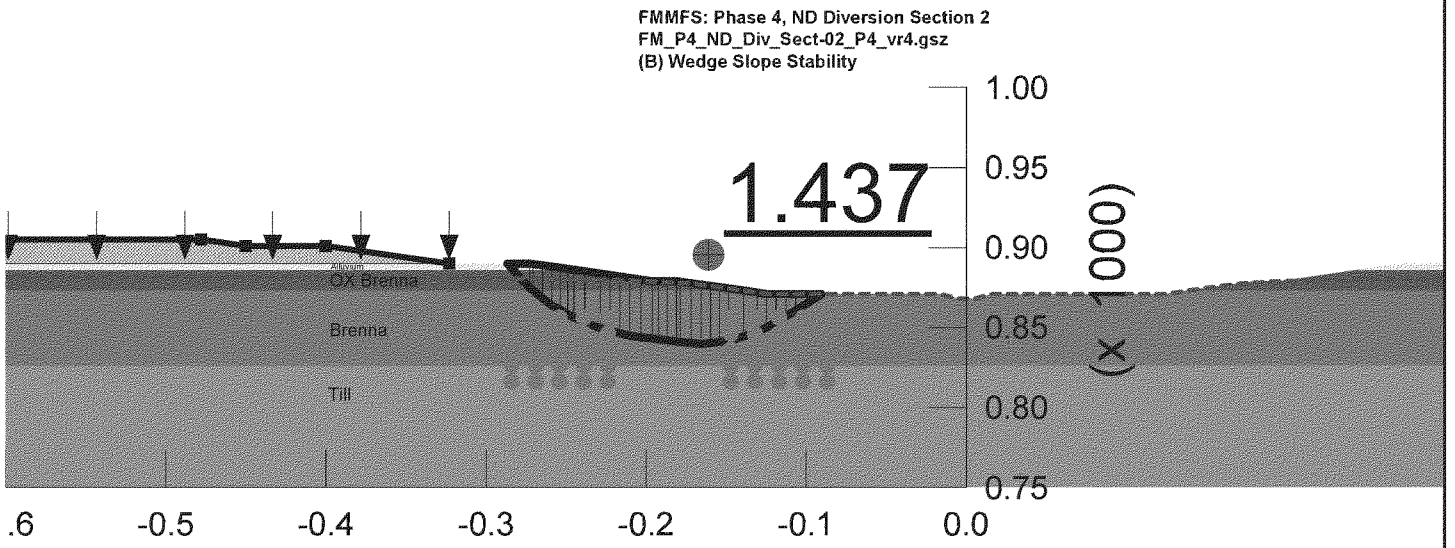
Soil Properties



Created By: Heckendorf, Kurt A MVP
Last Edited By: Heckendorf, Kurt A MVP
Date: 2/11/2011

1548


FMMFS: Phase 4, ND Diversion Section 2
FM_P4_ND_Div_Sect-02_P4_vr4.gsz
(A) Slope Stability
1.431
1.00
0.95
0.90
0.85
0.80
0.75
(000) (X)
Alluvium
OX Brenna
Brenna
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 4, ND Diversion Section 2
FM_P4_ND_Div_Sect-02_P4_vr4.gsz
(B) Wedge Slope Stability
1.437
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
Alluvium
OX Brenna
Brenna
Till
.6
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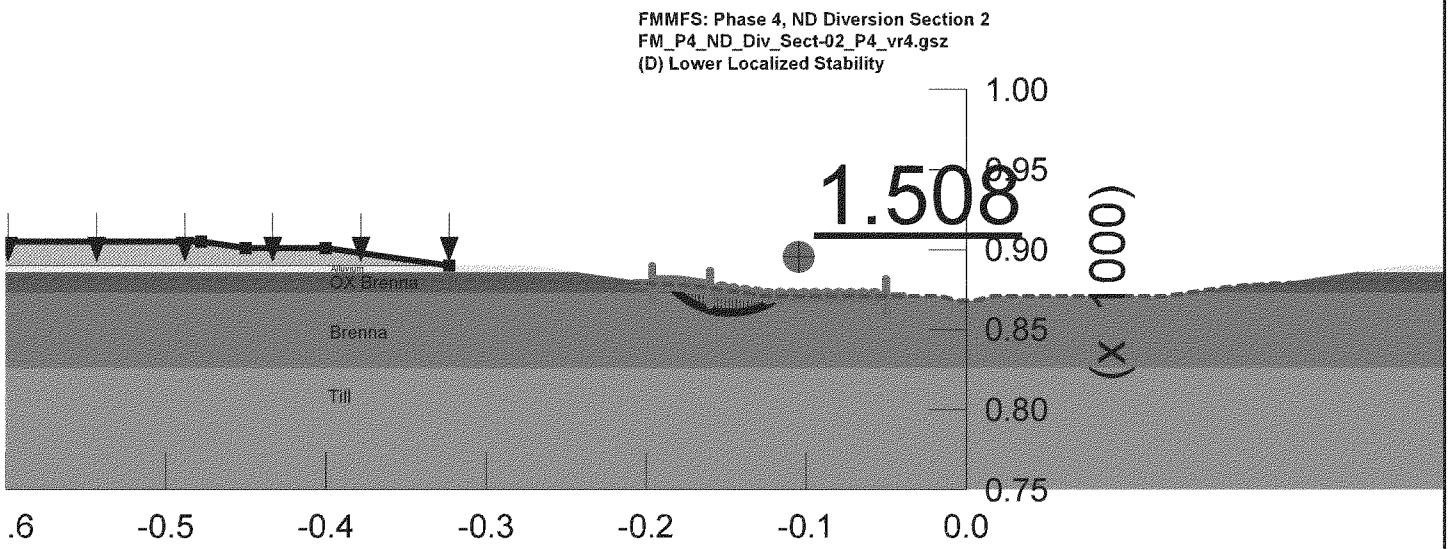
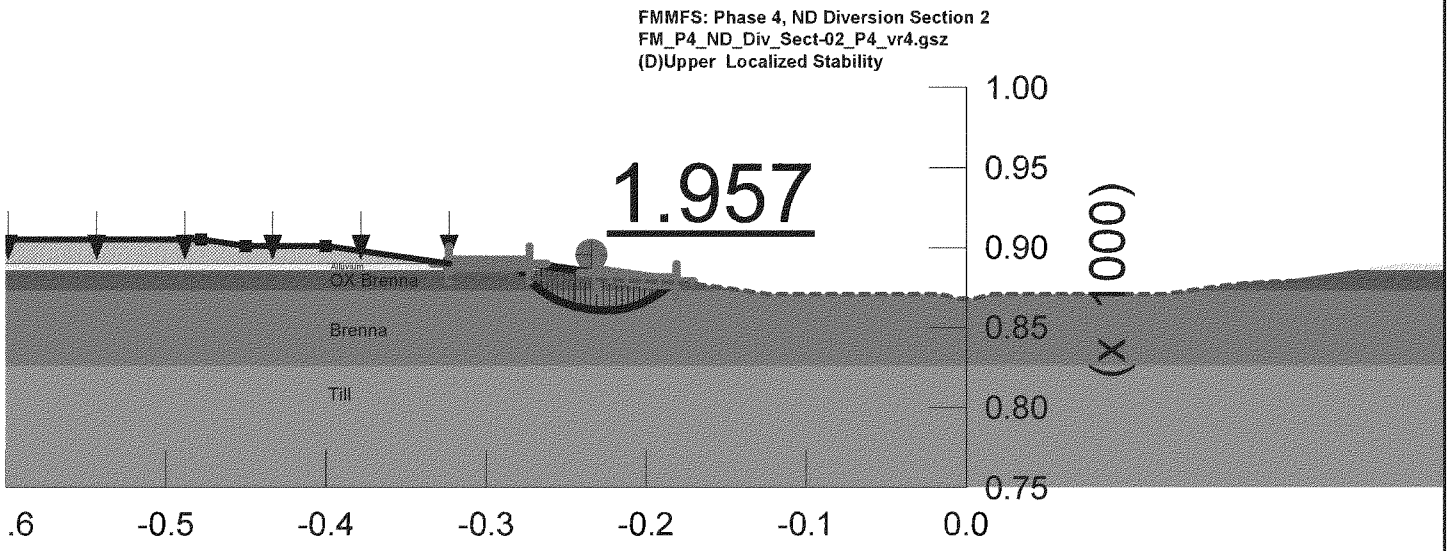
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 4, ND Diversion Section 2
FM_P4_ND_Div_Sect-02_P4_vr4.gsz
(D) Lower Localized Stability
1.508
Alluvium
OX Brenna
Brenna
Till
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

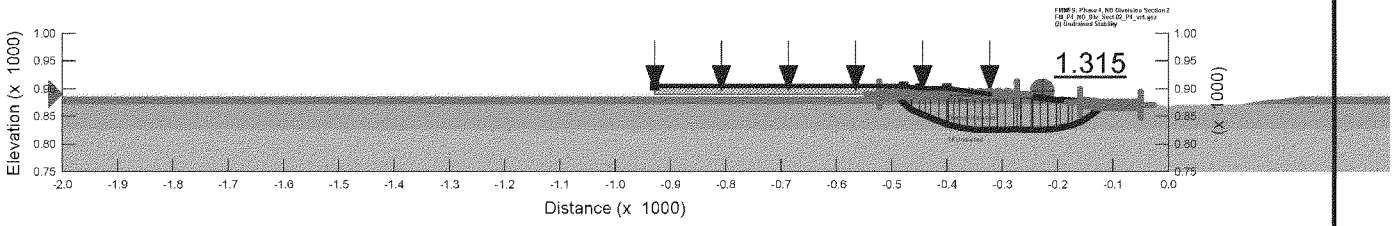

FMMFS: Phase 4, ND Diversion Section 2
FM_P4_ND_Div_Sect-02_P4_vr4.gsz
(D)Upper Localized Stability
1.957
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
Alluvium
OX Brenna
Brenna
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1552

File Name: FM_P4_ND_Div_Sect-02_P4_vr4.gsz

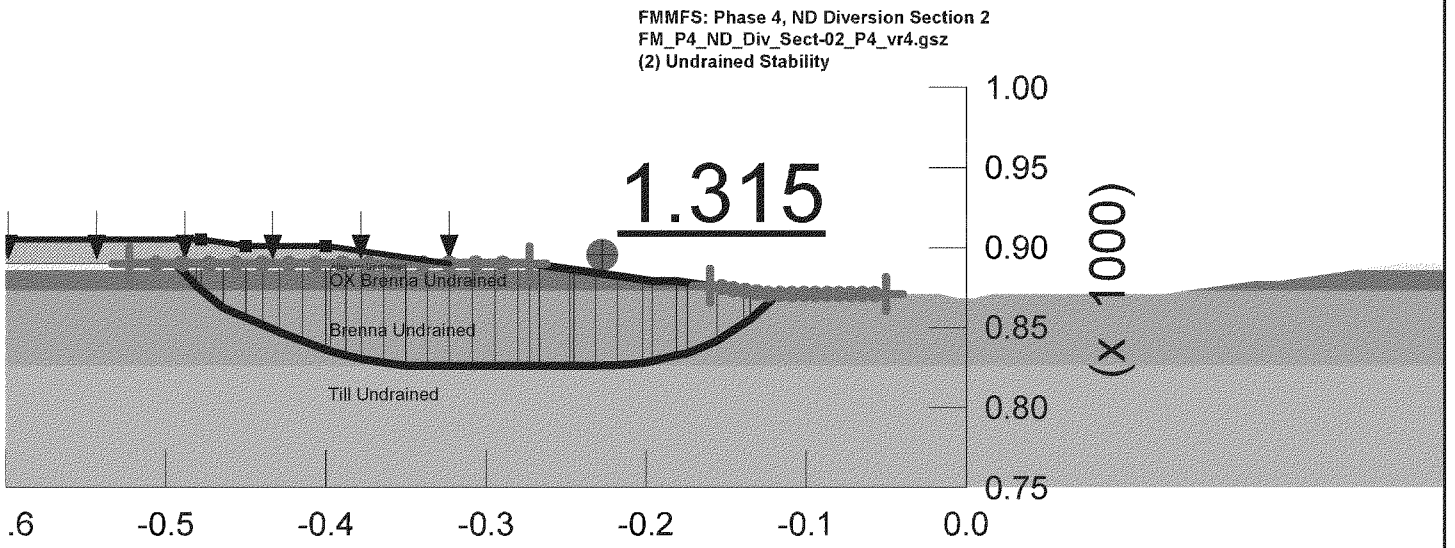
Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 2
(2) Undrained Stability

Soil Properties



Created By: Heckendorf, Kurt A MVP
Last Edited By: Heckendorf, Kurt A MVP
Date: 1/18/2011

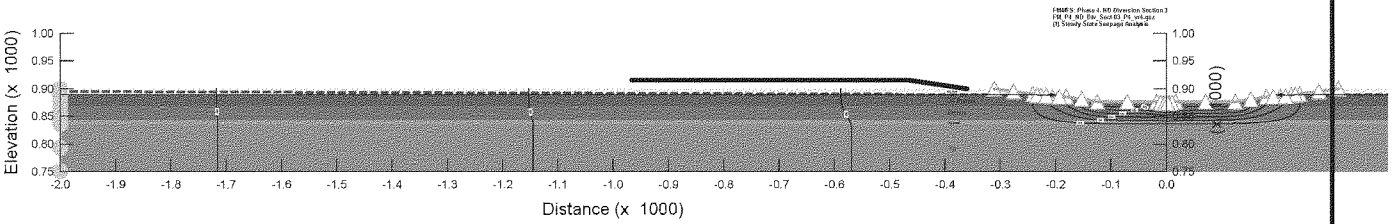
1553


FMMFS: Phase 4, ND Diversion Section 2
FM_P4_ND_Div_Sect-02_P4_vr4.gsz
(2) Undrained Stability
1.315
OX Brenna Undrained
Brenna Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-03_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 3
(1) Steady-State Seepage Analysis

Soil Properties



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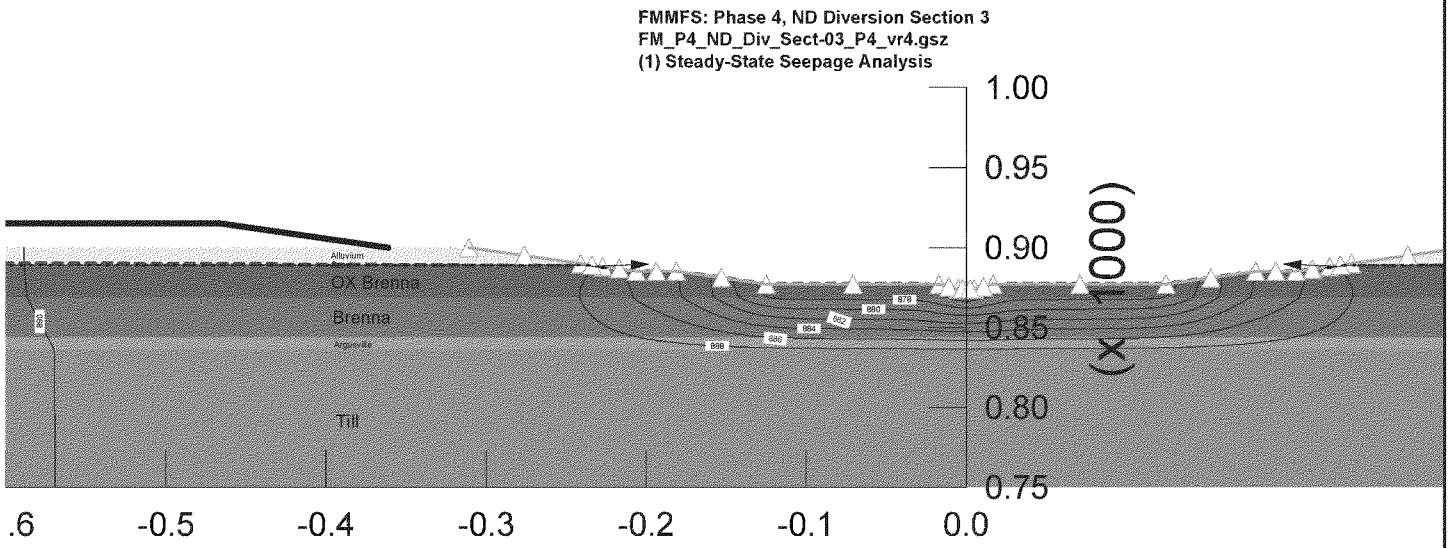
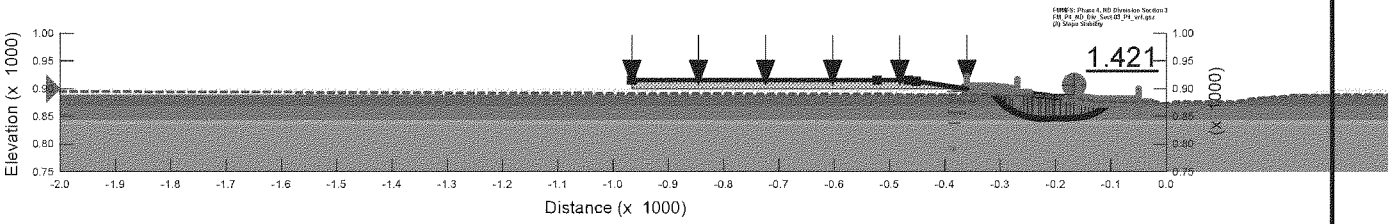

FMMFS: Phase 4, ND Diversion Section 3
FM_P4_ND_Div_Sect-03_P4_vr4.gsz
(1) Steady-State Seepage Analysis
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
Alluvium
OX Brenna
Brenna
Argusville
Till
878
880
882
884
886
888
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1556

File Name: FM_P4_ND_Div_Sect-03_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 3
(A) Slope Stability

Soil Properties



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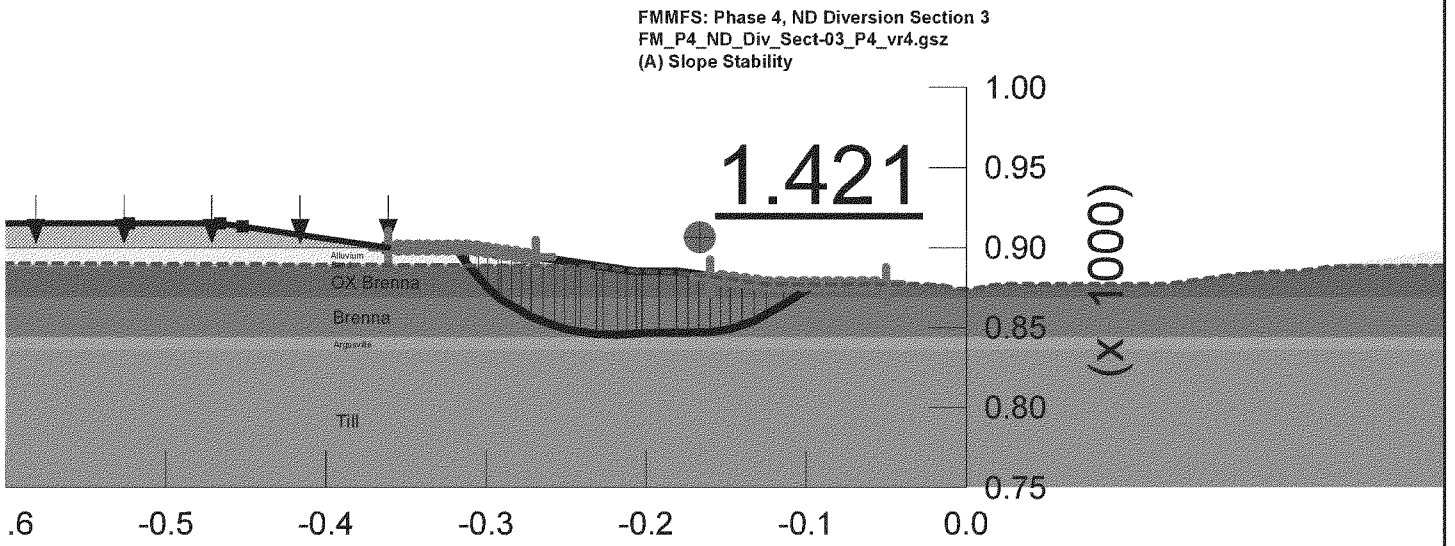
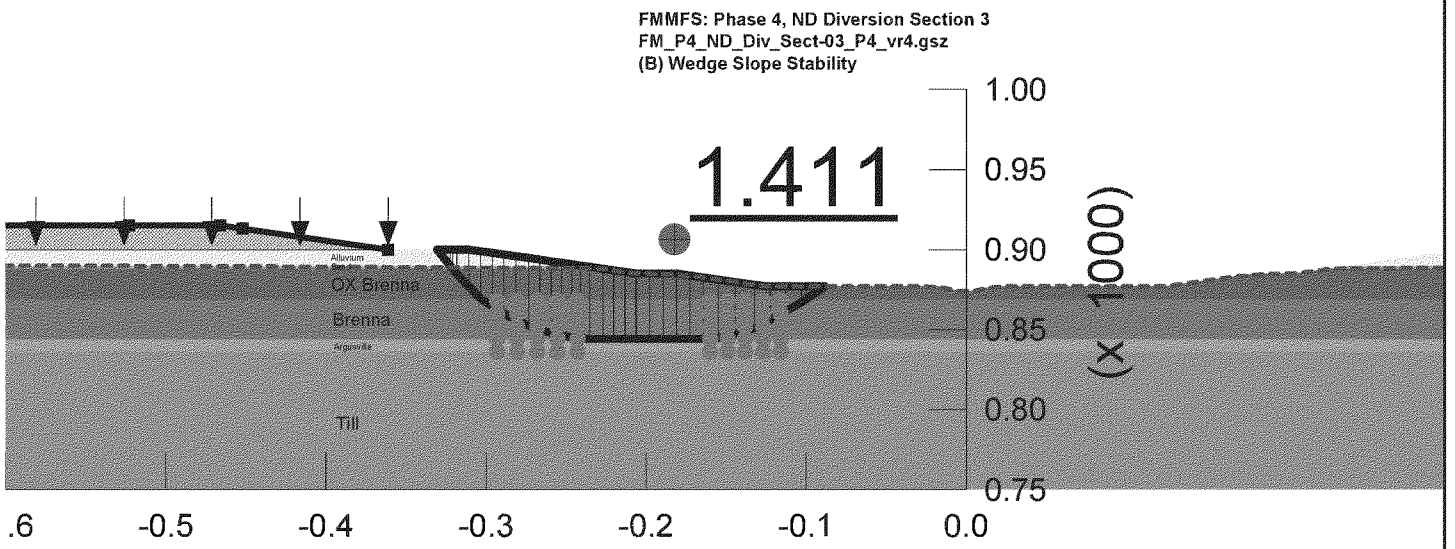
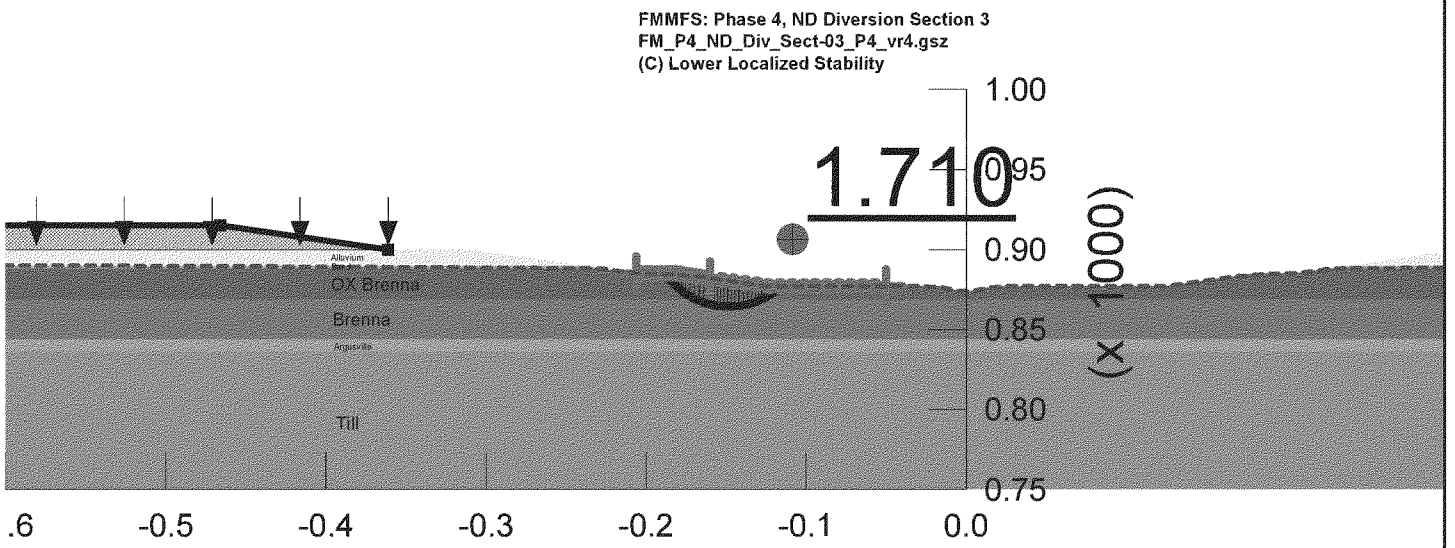
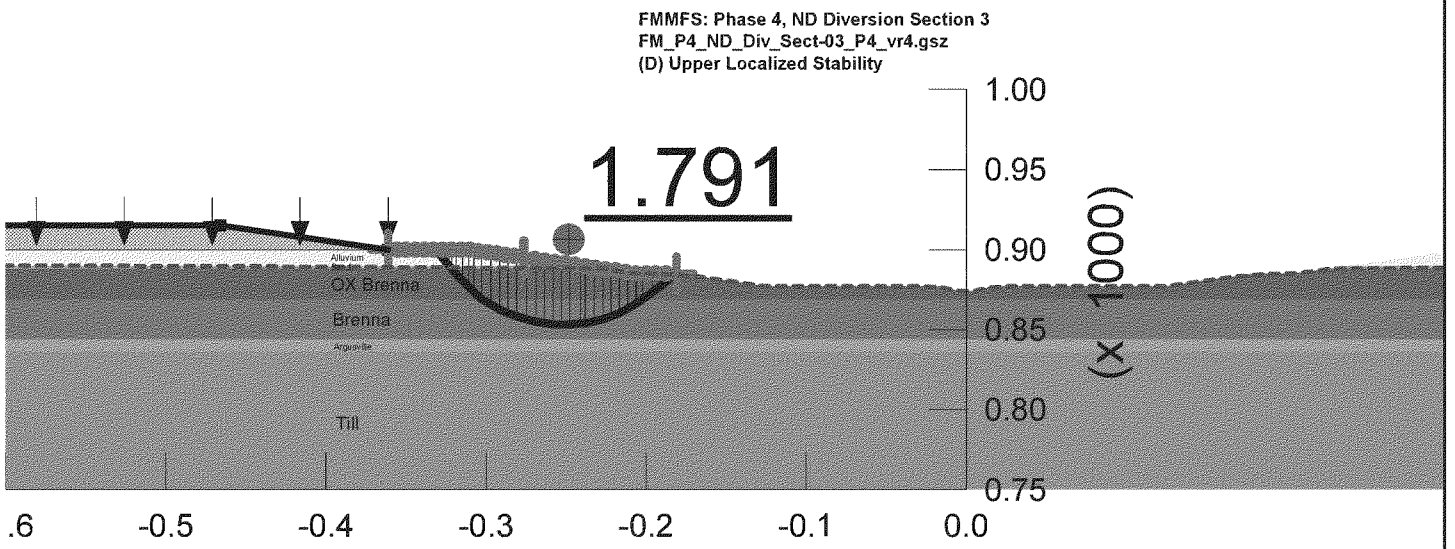
Date: 1/18/2011


FMMFS: Phase 4, ND Diversion Section 3
FM_P4_ND_Div_Sect-03_P4_vr4.gsz
(A) Slope Stability
1.421
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
Alluvium
OX Brenna
Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 4, ND Diversion Section 3
FM_P4_ND_Div_Sect-03_P4_vr4.gsz
(B) Wedge Slope Stability
1.411
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
Alluvium
OX Brenna
Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 4, ND Diversion Section 3
FM_P4_ND_Div_Sect-03_P4_vr4.gsz
(C) Lower Localized Stability
1.710
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
Alluvium
OX Brenna
Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

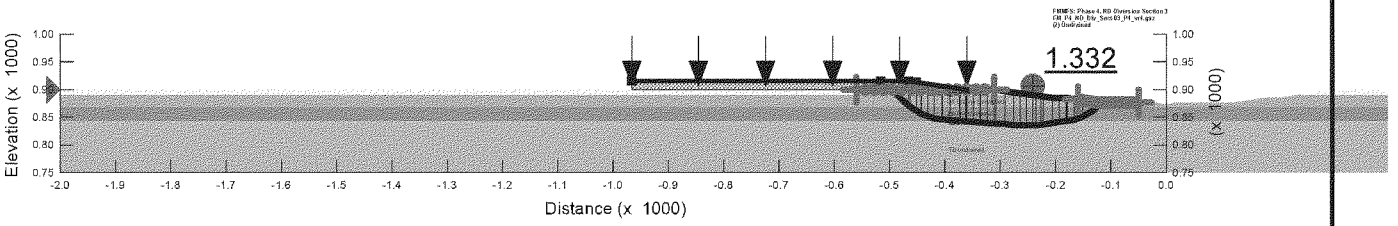

FMMFS: Phase 4, ND Diversion Section 3
FM_P4_ND_Div_Sect-03_P4_vr4.gsz
(D) Upper Localized Stability
1.791
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
Alluvium
OX Brenna
Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-03_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 3

(2) Undrained

Soil Properties



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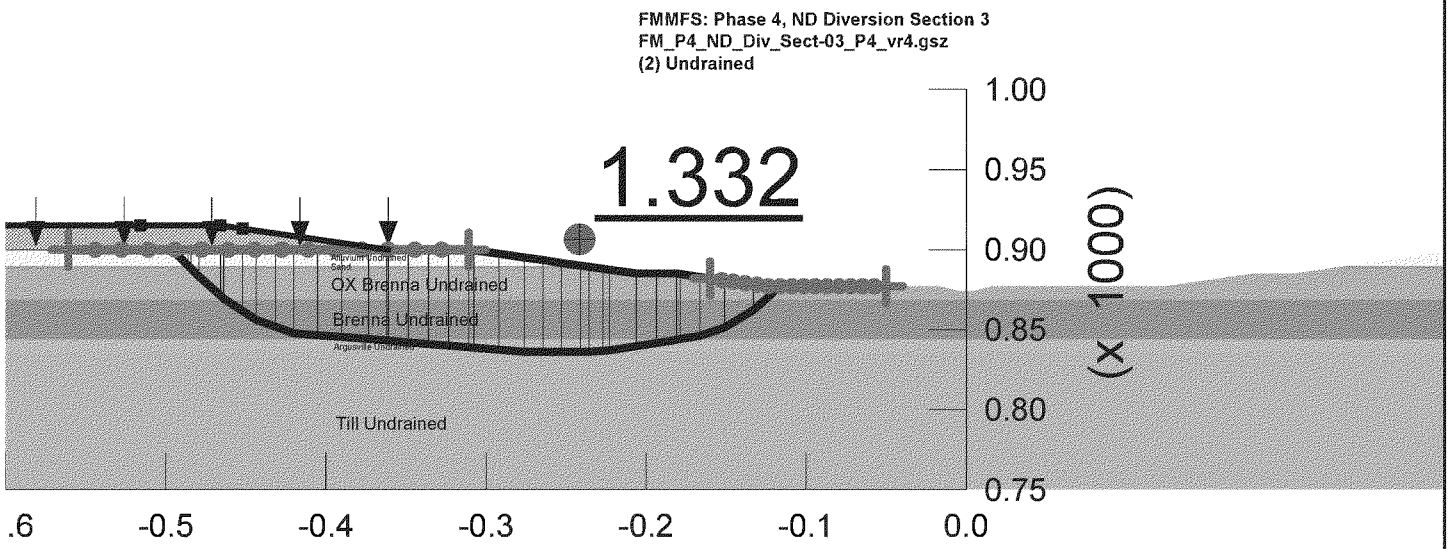
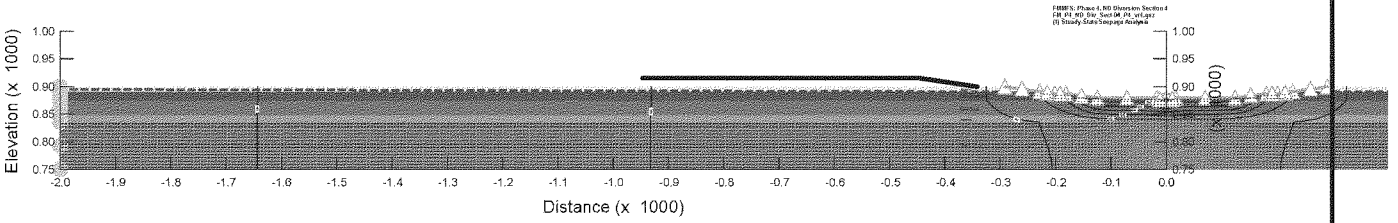

FMMFS: Phase 4, ND Diversion Section 3
FM_P4_ND_Div_Sect-03_P4_vr4.gsz
(2) Undrained
1.332
OX Brenna Undrained
Brenna Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-04_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 4
(1) Steady-State Seepage Analysis

Soil Properties



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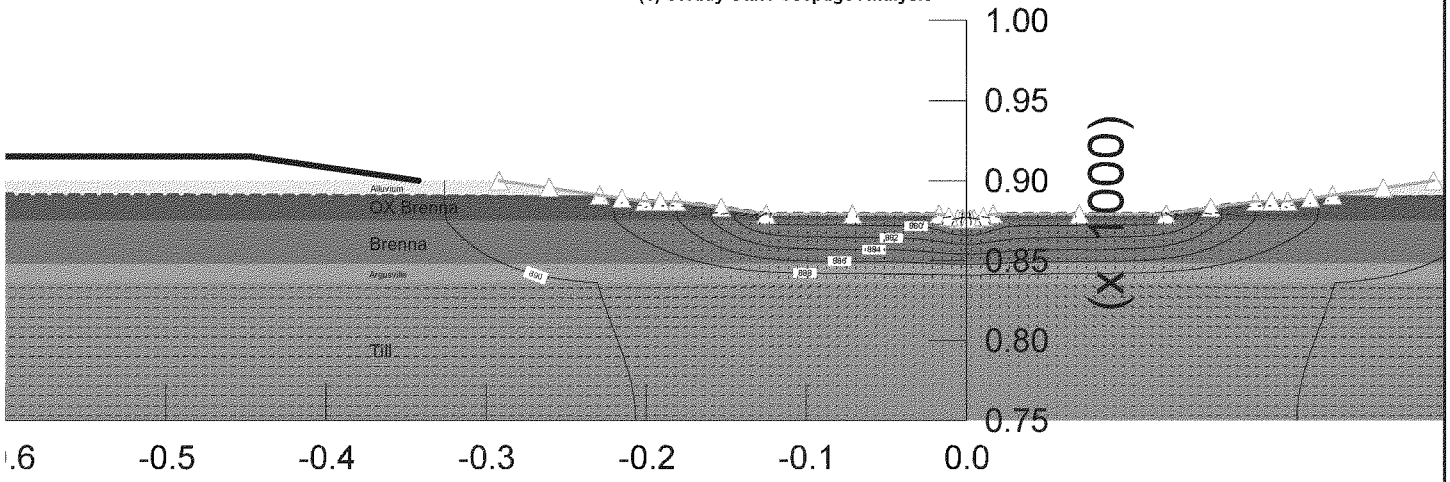
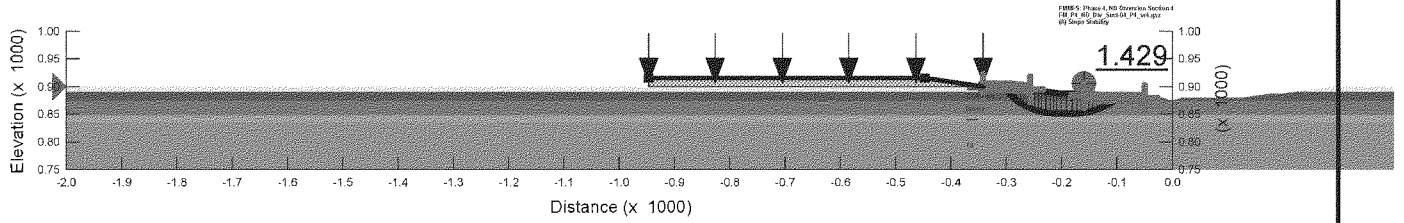

FMMFS: Phase 4, ND Diversion Section 4
FM_P4_ND_Div_Sect-04_P4_vr4.gsz
(1) Steady-State Seepage Analysis
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
Alluvium
OX Brenna
Brenna
Argusville
Till
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-04_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 4
(A) Slope Stability

Soil Properties



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Date: 1/18/2011

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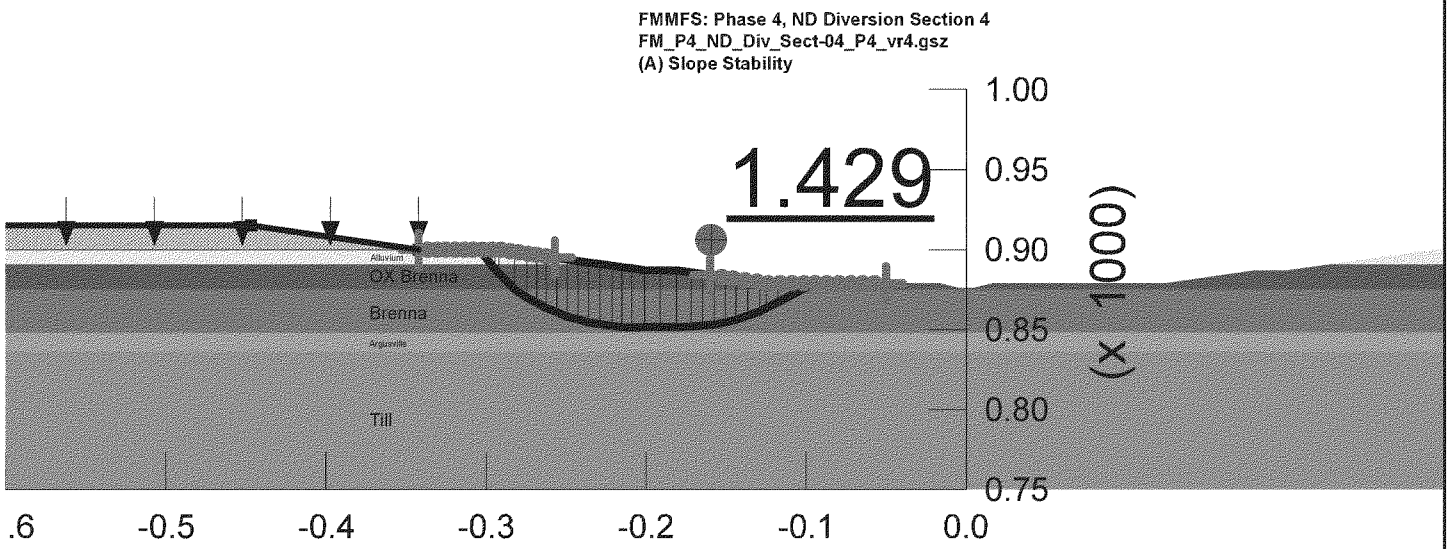
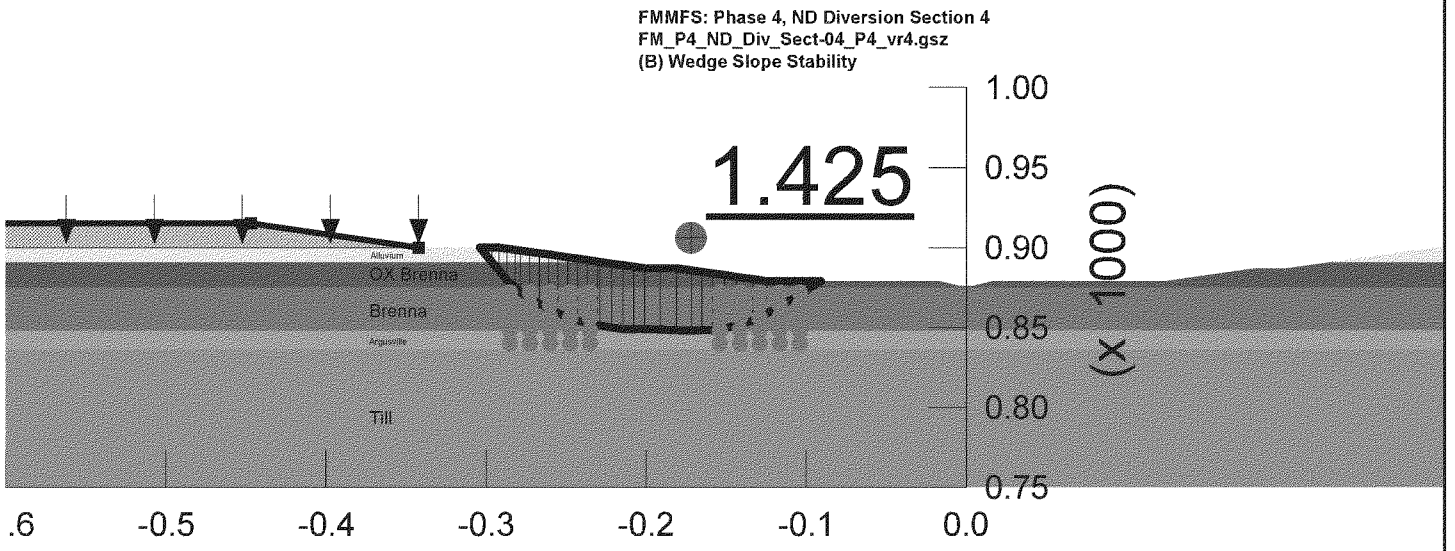
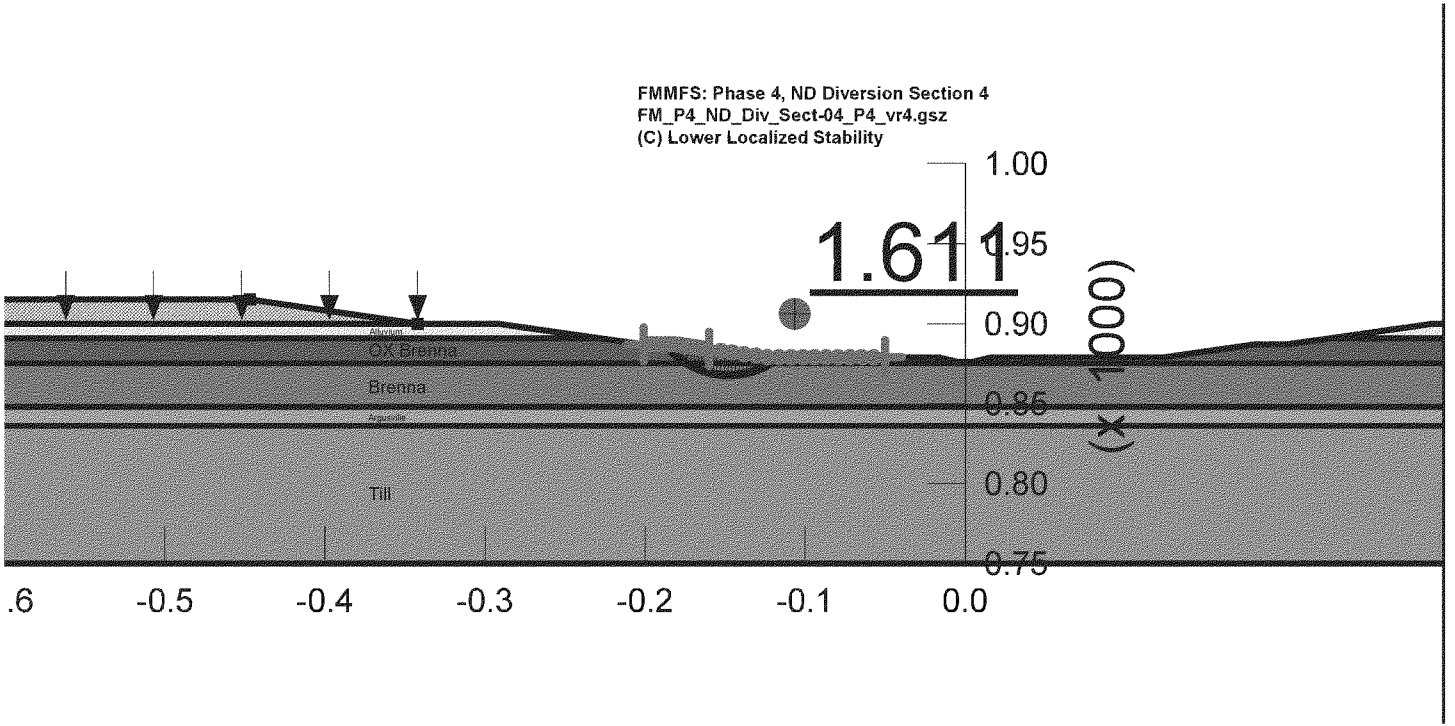
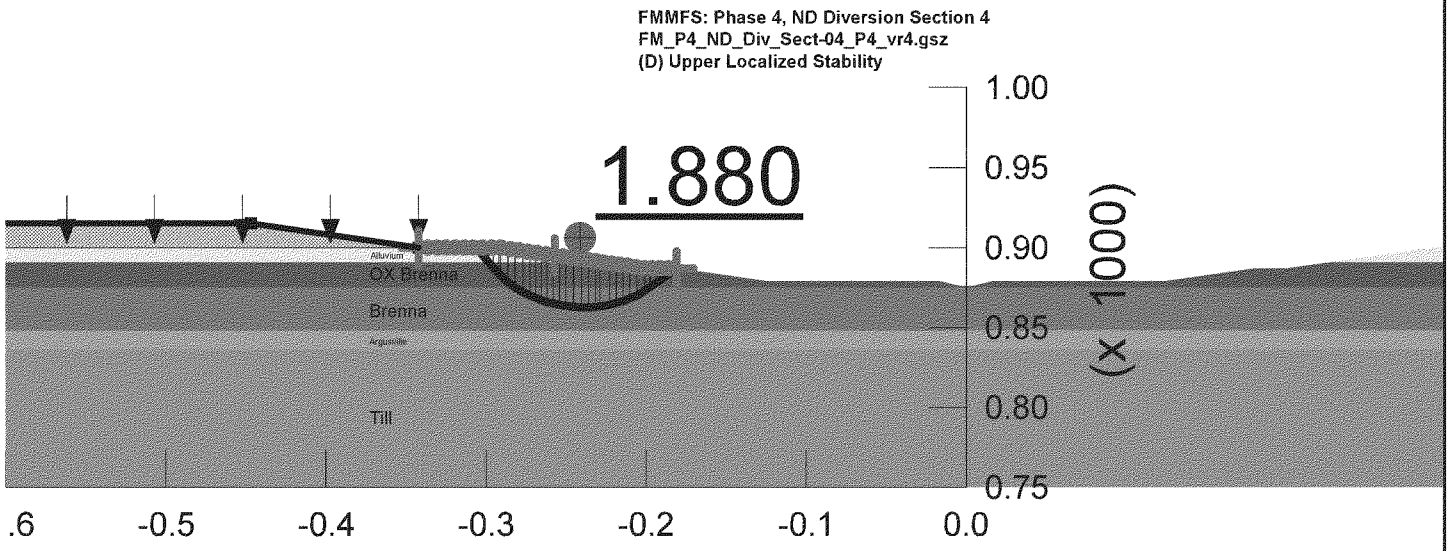

FMMFS: Phase 4, ND Diversion Section 4
FM_P4_ND_Div_Sect-04_P4_vr4.gsz
(A) Slope Stability
1.429
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
Alluvium
OX Brenna
Brenna
Argenite
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 4, ND Diversion Section 4
FM_P4_ND_Div_Sect-04_P4_vr4.gsz
(B) Wedge Slope Stability
1.425
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
Alluvium
OX Brenna
Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

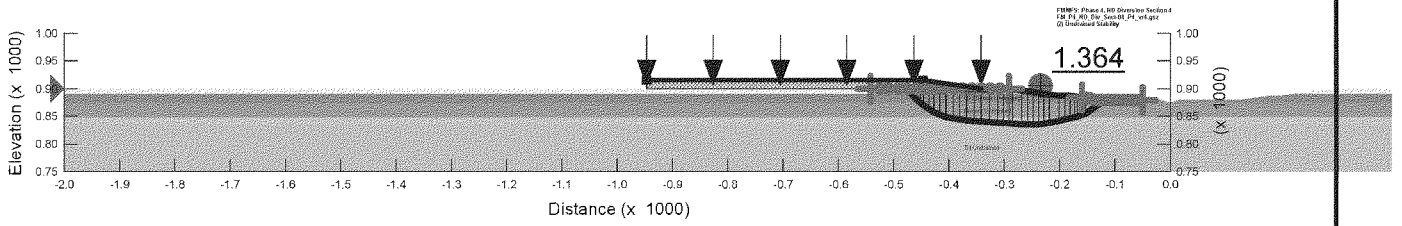

FMMFS: Phase 4, ND Diversion Section 4
FM_P4_ND_Div_Sect-04_P4_vr4.gsz
(C) Lower Localized Stability
1.611
1.00
0.95
0.90
0.85
0.80
0.75
(000)
Alluvium
OX Brenna
Brenna
Argenville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 4, ND Diversion Section 4
FM_P4_ND_Div_Sect-04_P4_vr4.gsz
(D) Upper Localized Stability
1.880
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
Alluvium
OX Brenna
Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-04_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 4
(2) Undrained Stability

Soil Properties



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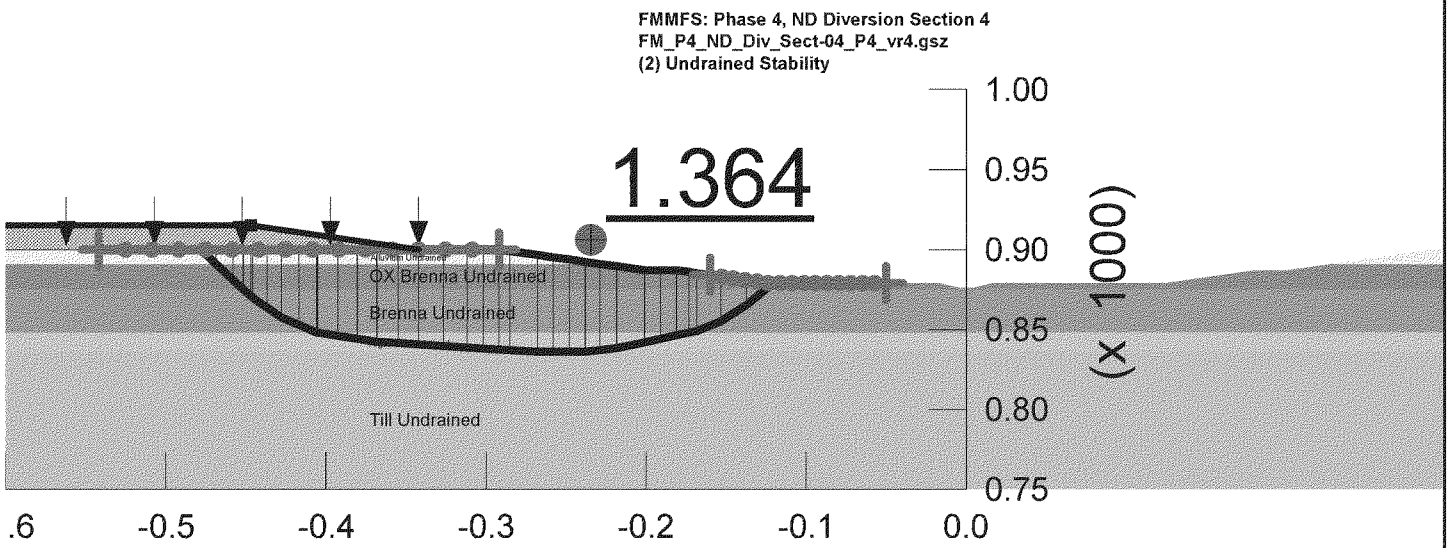
1571

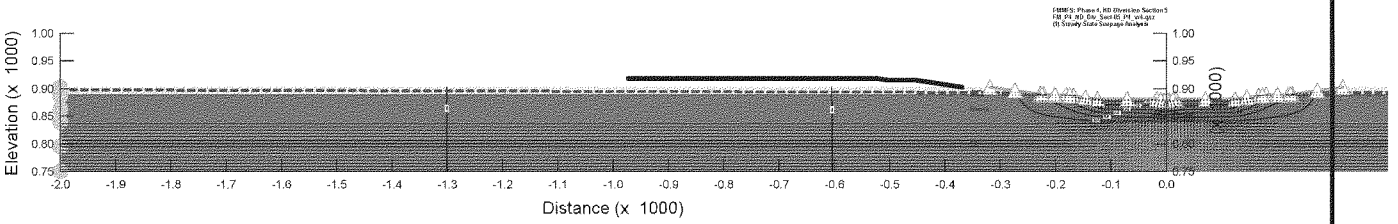

FMMFS: Phase 4, ND Diversion Section 4
FM_P4_ND_Div_Sect-04_P4_vr4.gsz
(2) Undrained Stability
1.364
OX Brenna Undrained
Brenna Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1572

File Name: FM_P4_ND_Div_Sect-05_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 5
(1) Steady-State Seepage Analysis

Soil Properties



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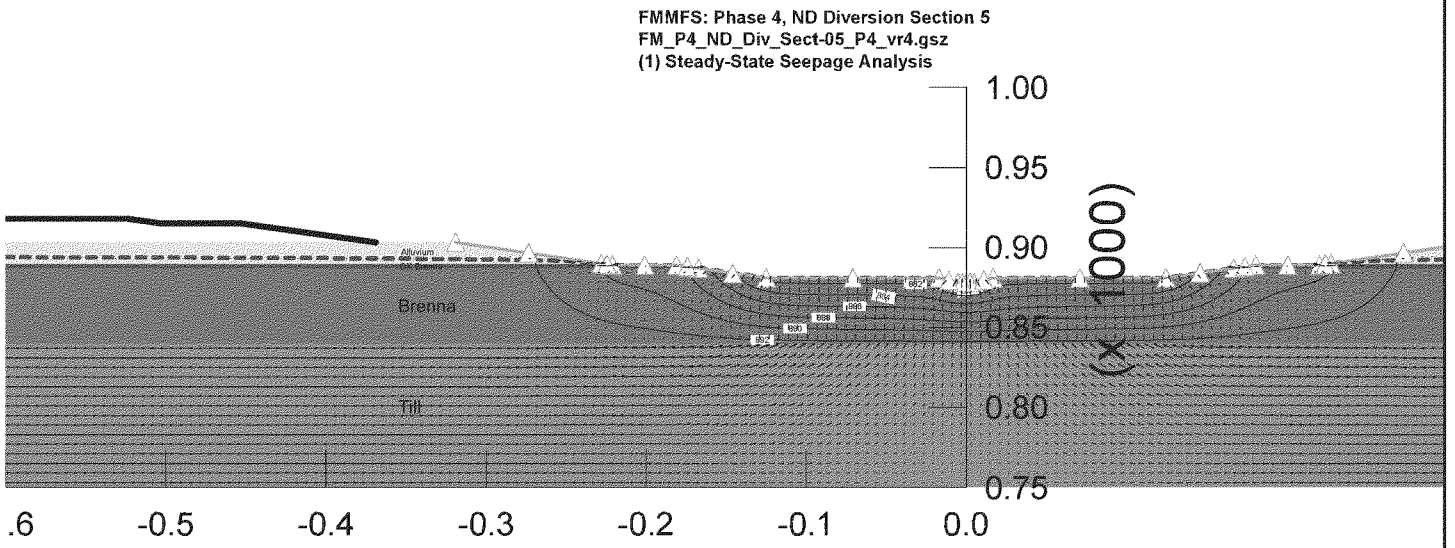
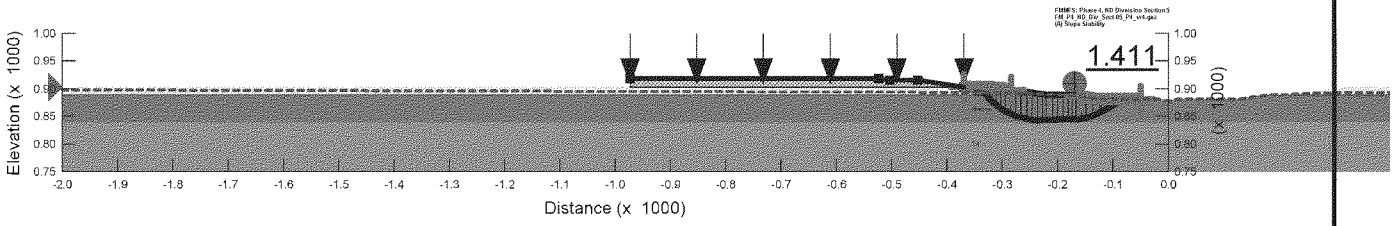
1573


FMMFS: Phase 4, ND Diversion Section 5
FM_P4_ND_Div_Sect-05_P4_vr4.gsz
(1) Steady-State Seepage Analysis
1.00
0.95
0.90
0.85
0.80
0.75
(1000 X)
Alluvium
Brenna
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-05_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 5
(A) Slope Stability

Soil Properties



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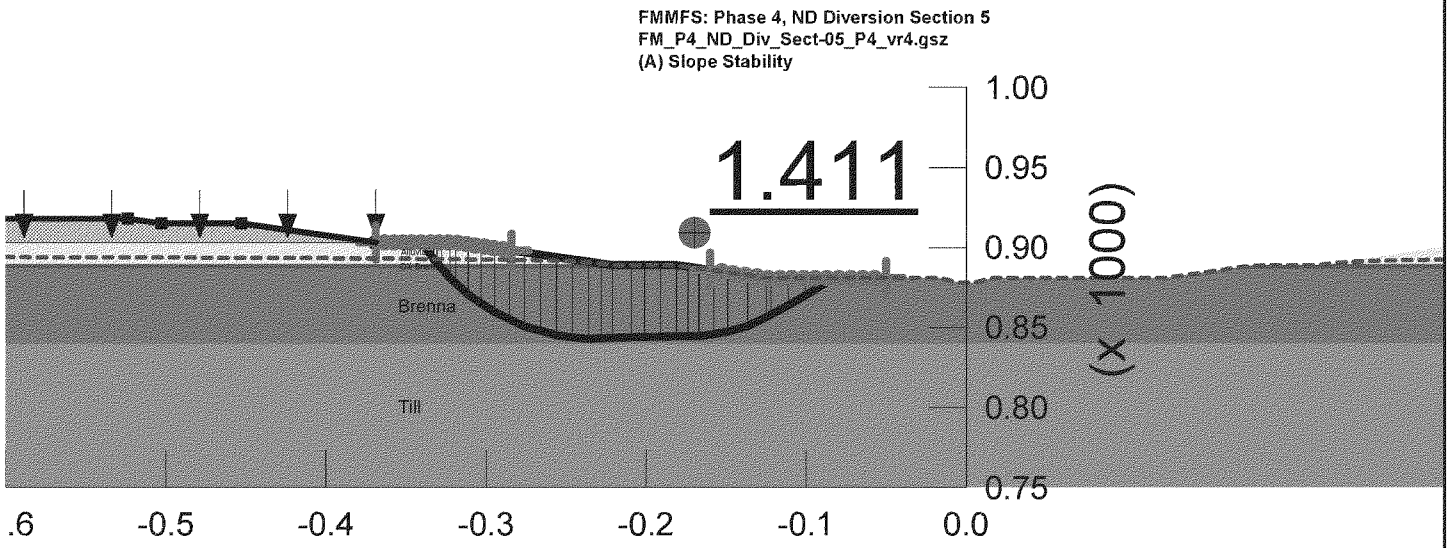
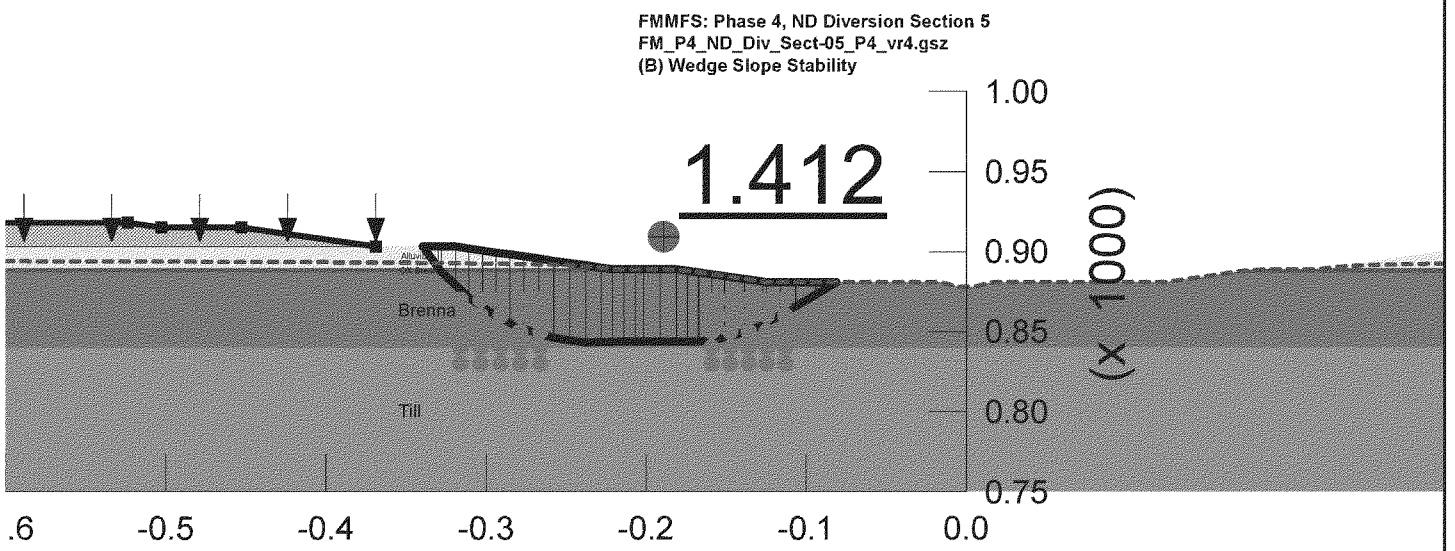
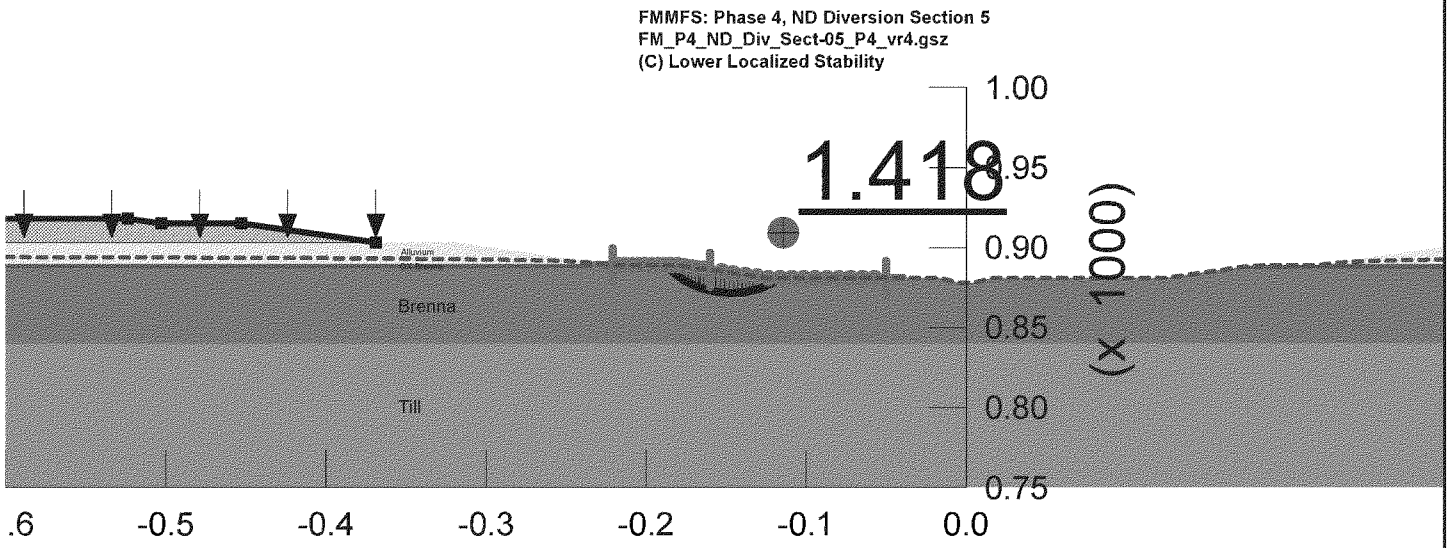
Date: 2/11/2011

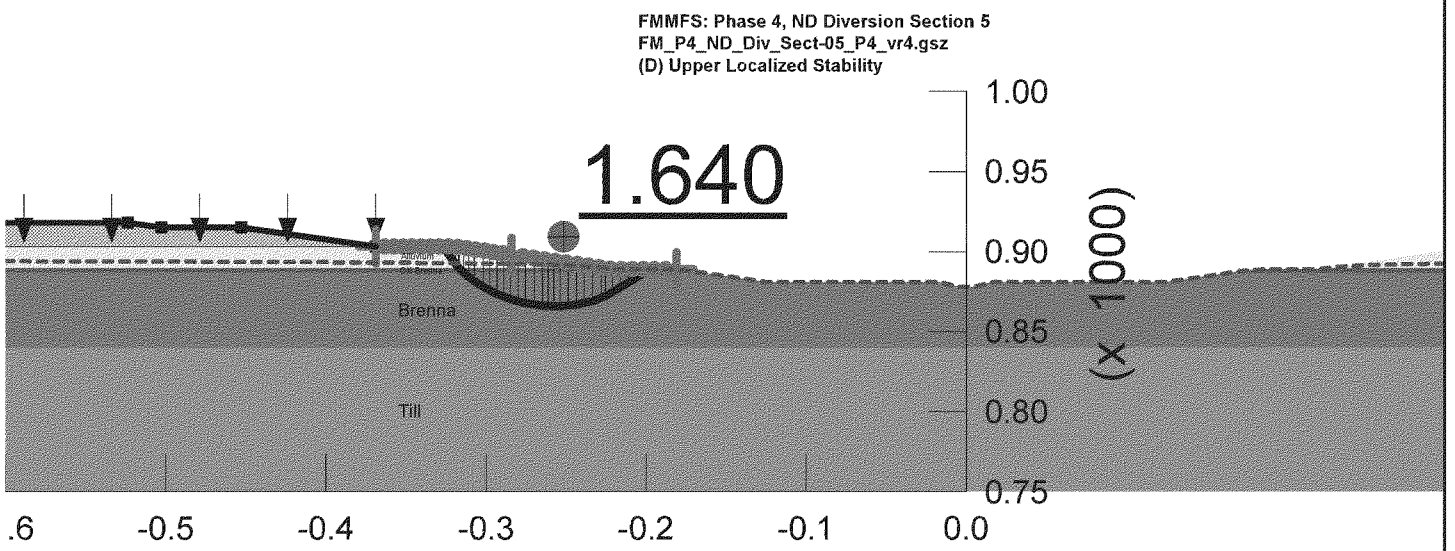
1575


FMMFS: Phase 4, ND Diversion Section 5
FM_P4_ND_Div_Sect-05_P4_vr4.gsz
(A) Slope Stability
1.411
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
Brenna
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 4, ND Diversion Section 5
FM_P4_ND_Div_Sect-05_P4_vr4.gsz
(B) Wedge Slope Stability
1.412
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
Brenna
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 4, ND Diversion Section 5
FM_P4_ND_Div_Sect-05_P4_vr4.gsz
(C) Lower Localized Stability
1.418
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
Alluvium
Brenna
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

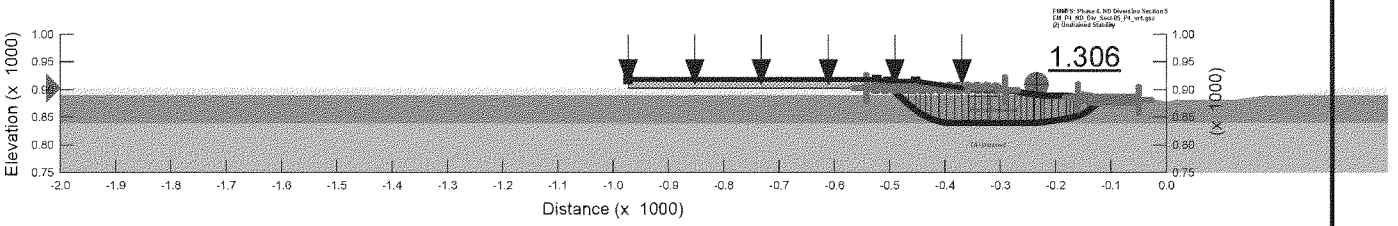
1578


FMMFS: Phase 4, ND Diversion Section 5
FM_P4_ND_Div_Sect-05_P4_vr4.gsz
(D) Upper Localized Stability
1.640
Brenna
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-05_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 5
(2) Undrained Stability

Soil Properties



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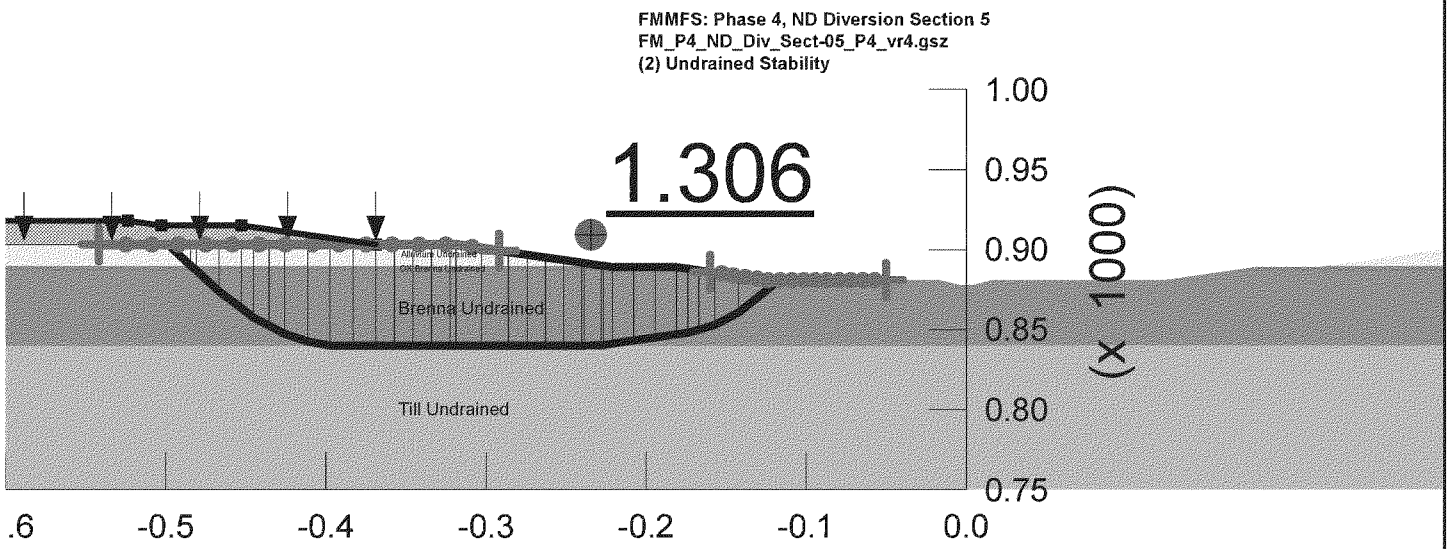
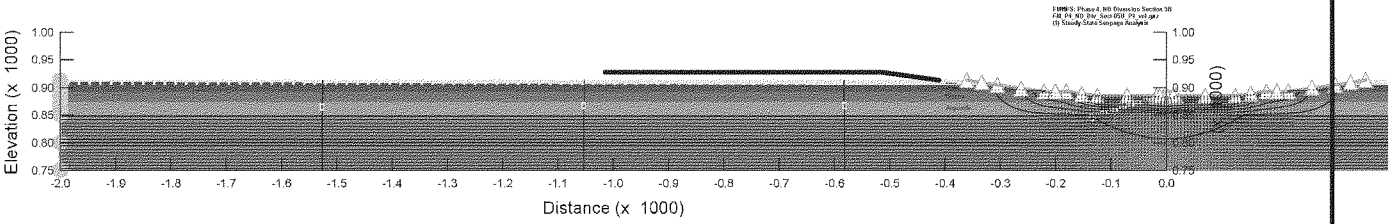
1580


FMMFS: Phase 4, ND Diversion Section 5
FM_P4_ND_Div_Sect-05_P4_vr4.gsz
(2) Undrained Stability
1.306
Brenna Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-05B_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 5B
(1) Steady-State Seepage Analysis

Soil Properties



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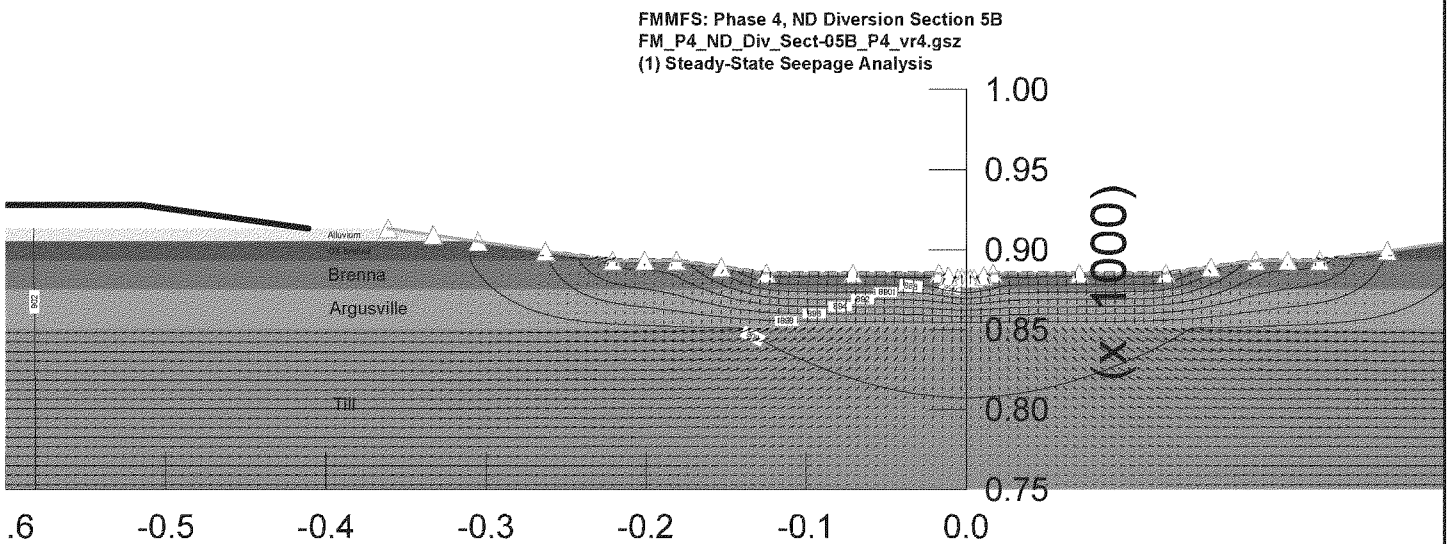
1582

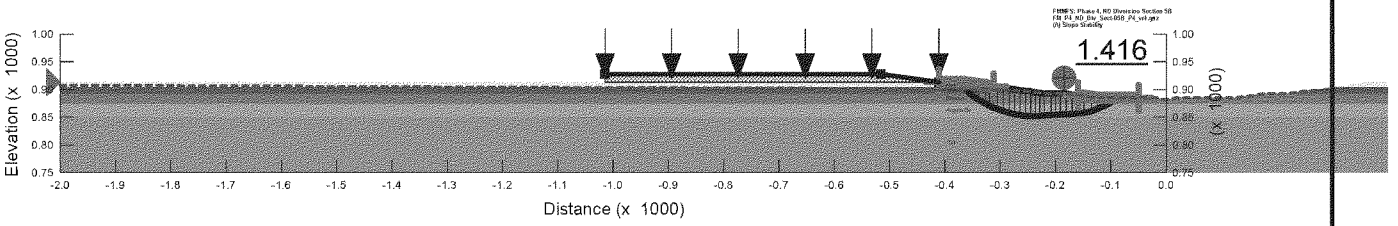

FMMFS: Phase 4, ND Diversion Section 5B
FM_P4_ND_Div_Sect-05B_P4_vr4.gsz
(1) Steady-State Seepage Analysis
Alluvium
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(1X 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1583

File Name: FM_P4_ND_Div_Sect-05B_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 5B
(A) Slope Stability

Soil Properties



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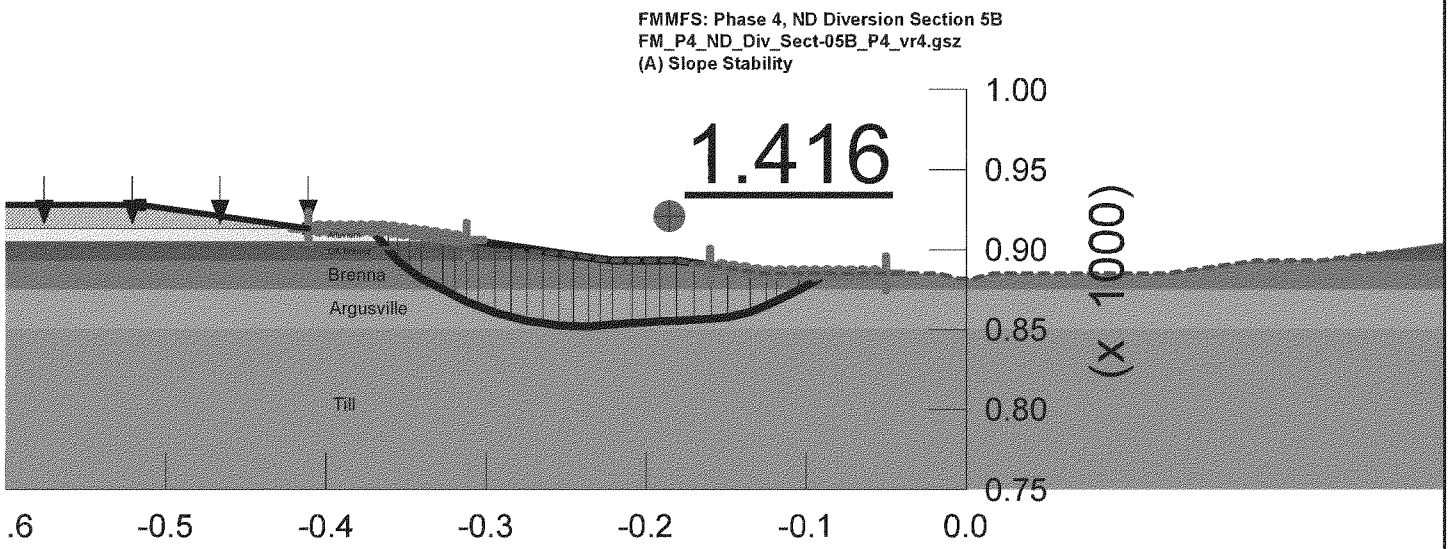
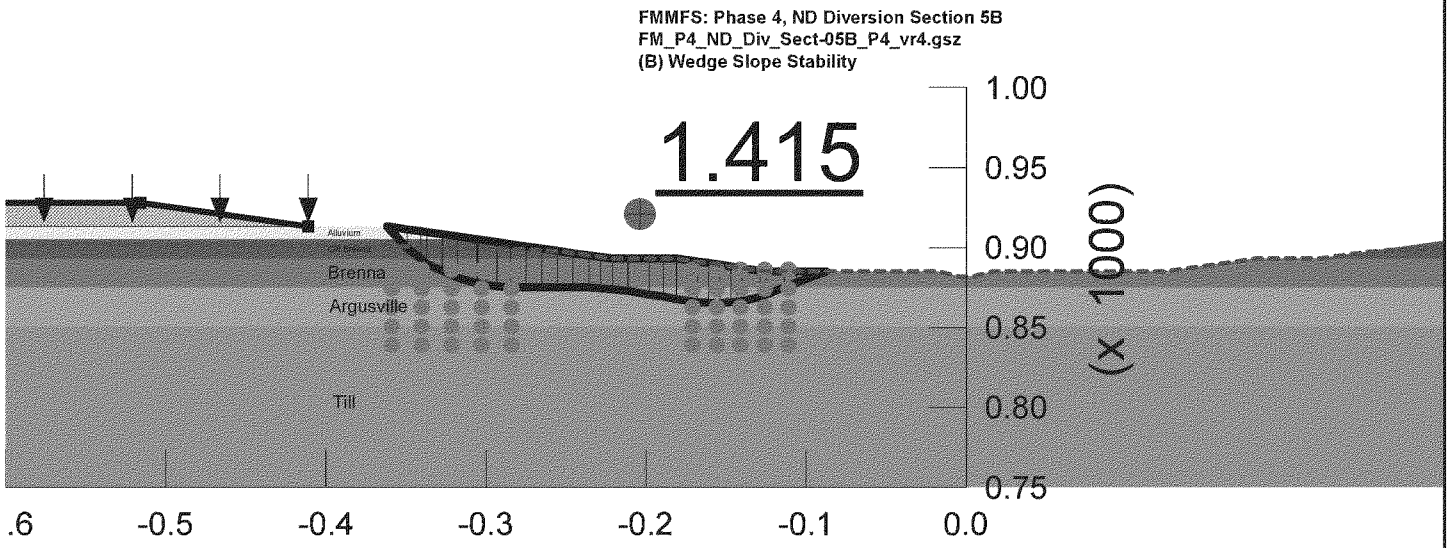
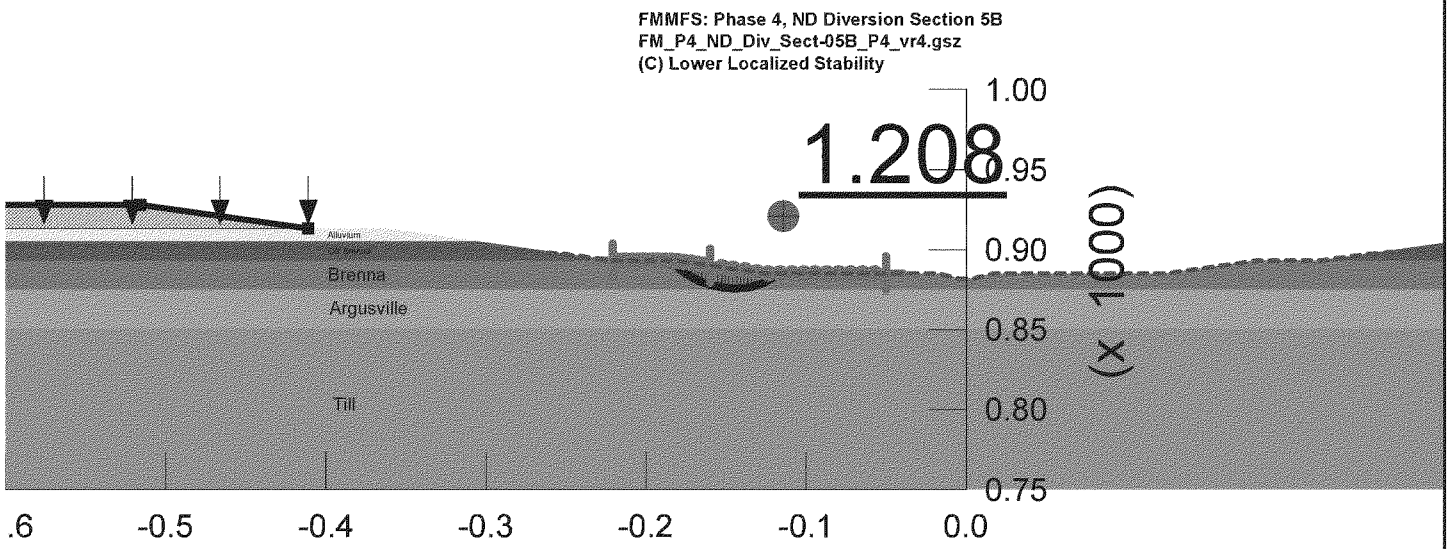
Date: 1/18/2011

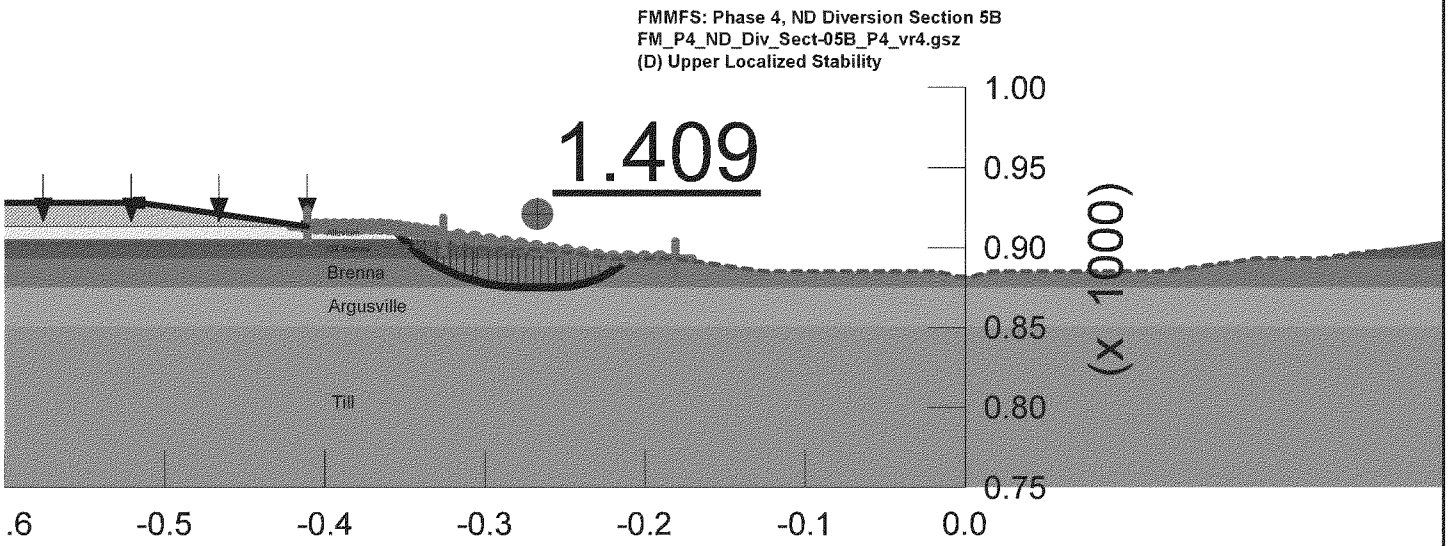
1584


FMMFS: Phase 4, ND Diversion Section 5B
FM_P4_ND_Div_Sect-05B_P4_vr4.gsz
(A) Slope Stability
1.416
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1585


FMMFS: Phase 4, ND Diversion Section 5B
FM_P4_ND_Div_Sect-05B_P4_vr4.gsz
(B) Wedge Slope Stability
1.415
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
Alluvium
Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

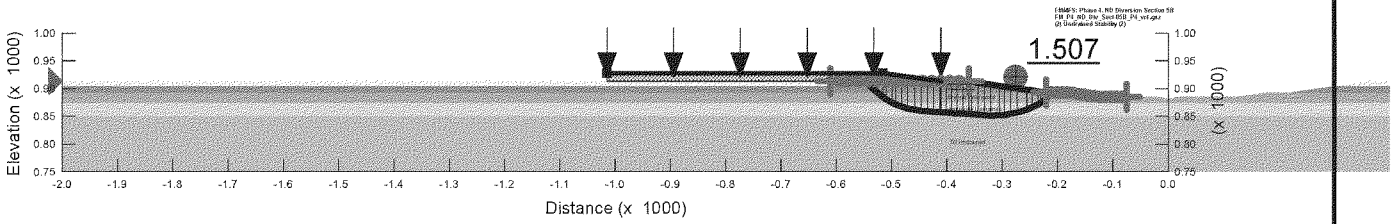

FMMFS: Phase 4, ND Diversion Section 5B
FM_P4_ND_Div_Sect-05B_P4_vr4.gsz
(C) Lower Localized Stability
1.208
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
Alluvium
Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 4, ND Diversion Section 5B
FM_P4_ND_Div_Sect-05B_P4_vr4.gsz
(D) Upper Localized Stability
1.409
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-05B_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 5B
(2) Undrained Stability (2)

Soil Properties



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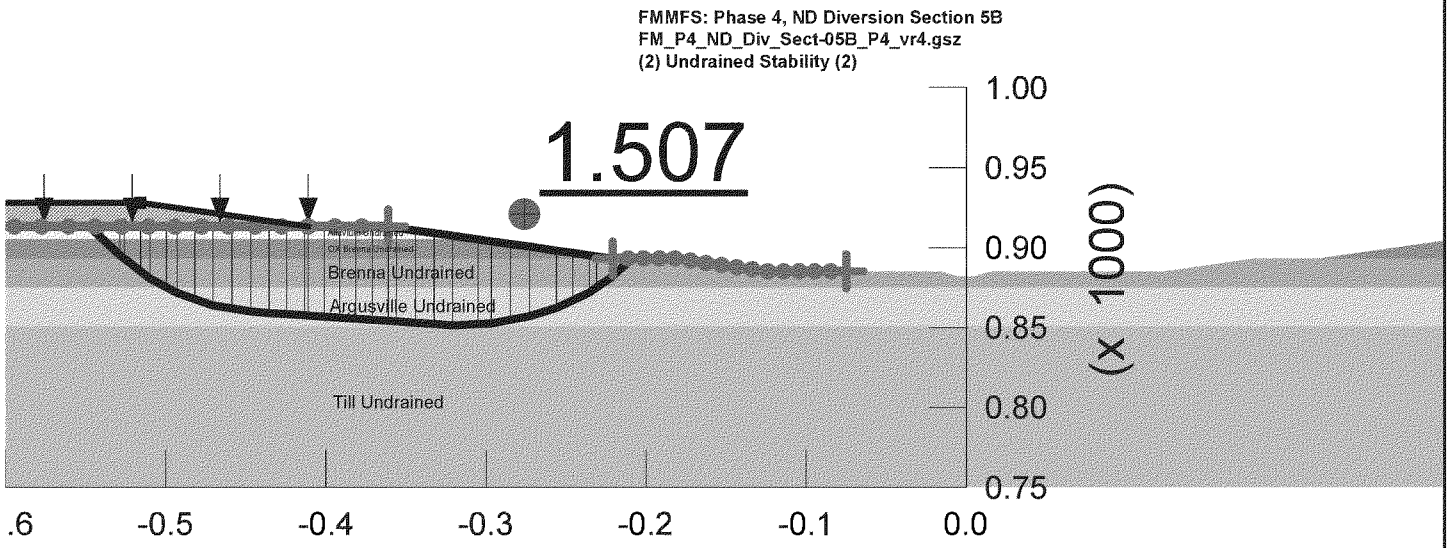
1589

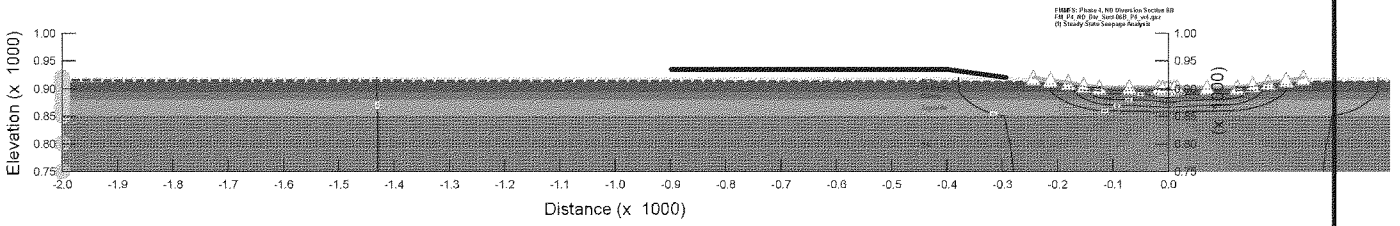

FMMFS: Phase 4, ND Diversion Section 5B
FM_P4_ND_Div_Sect-05B_P4_vr4.gsz
(2) Undrained Stability (2)
1.507
Brenna Undrained
Argusville Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1590

File Name: FM_P4_ND_Div_Sect-06B_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 6B
(1) Steady-State Seepage Analysis

Soil Properties



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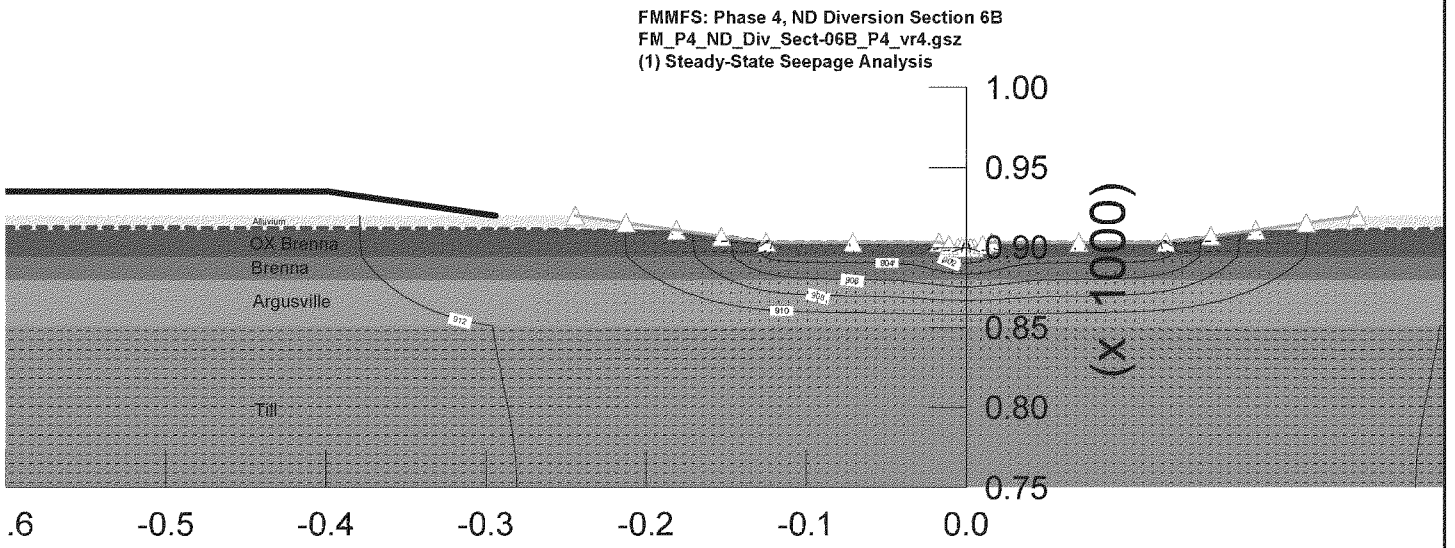
1591

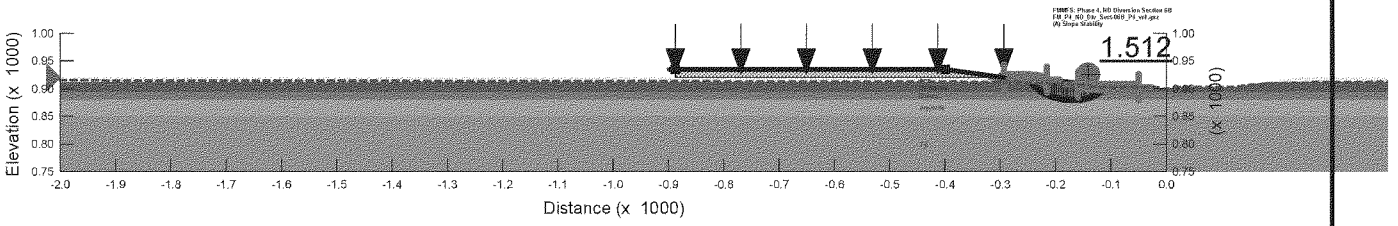

FMMFS: Phase 4, ND Diversion Section 6B
FM_P4_ND_Div_Sect-06B_P4_vr4.gsz
(1) Steady-State Seepage Analysis
Alluvium
OX Brenna
Brenna
Argusville
Till
912
910
908
906
904
902
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1592

File Name: FM_P4_ND_Div_Sect-06B_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 6B
(A) Slope Stability

Soil Properties



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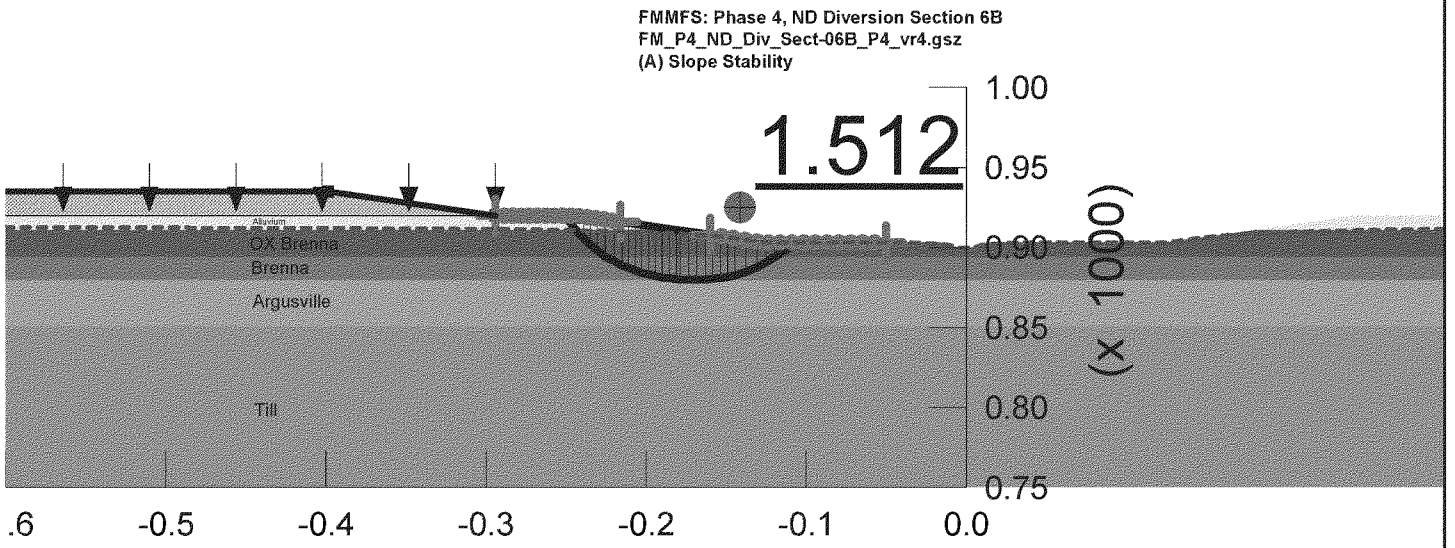
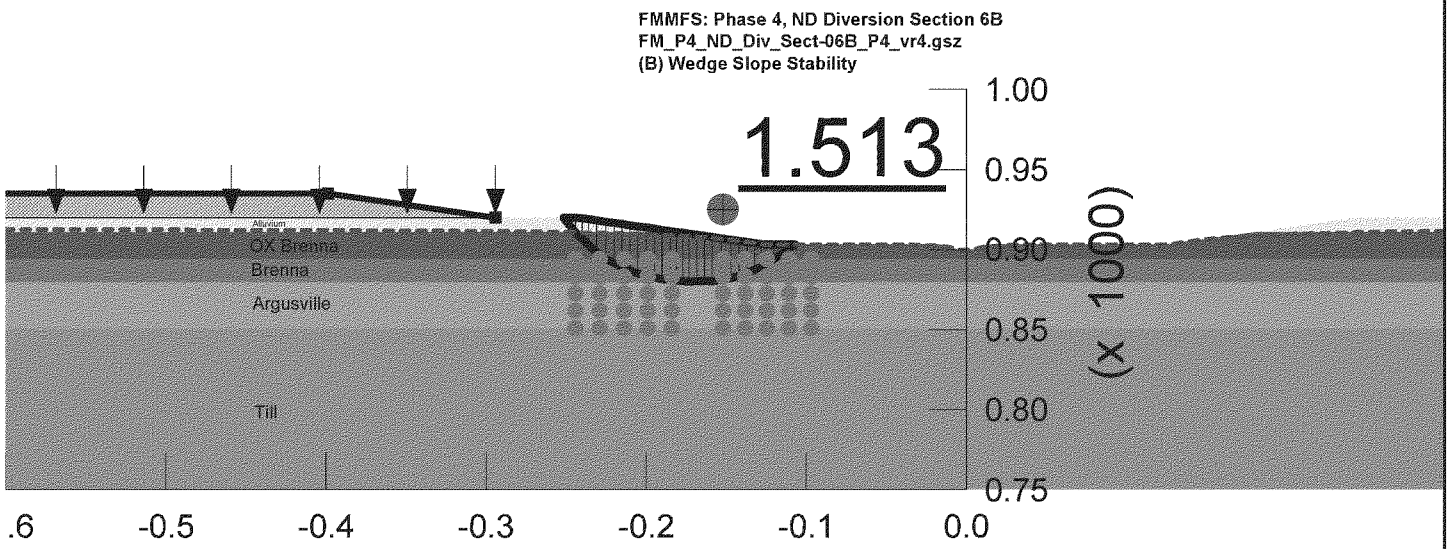
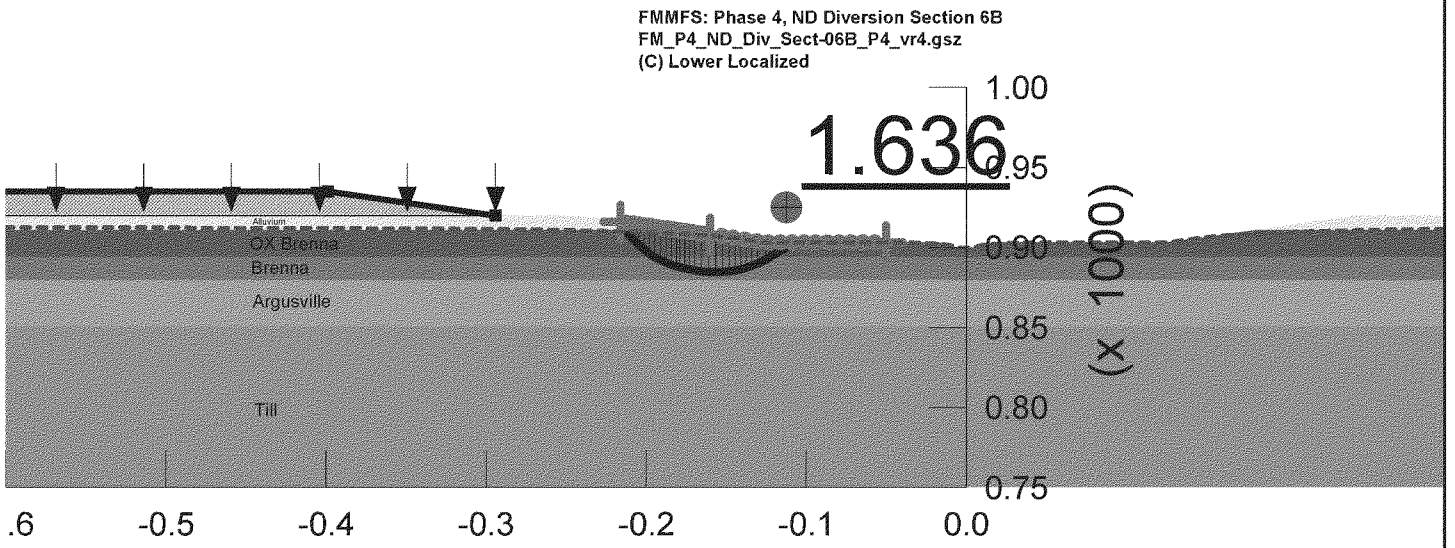
1593

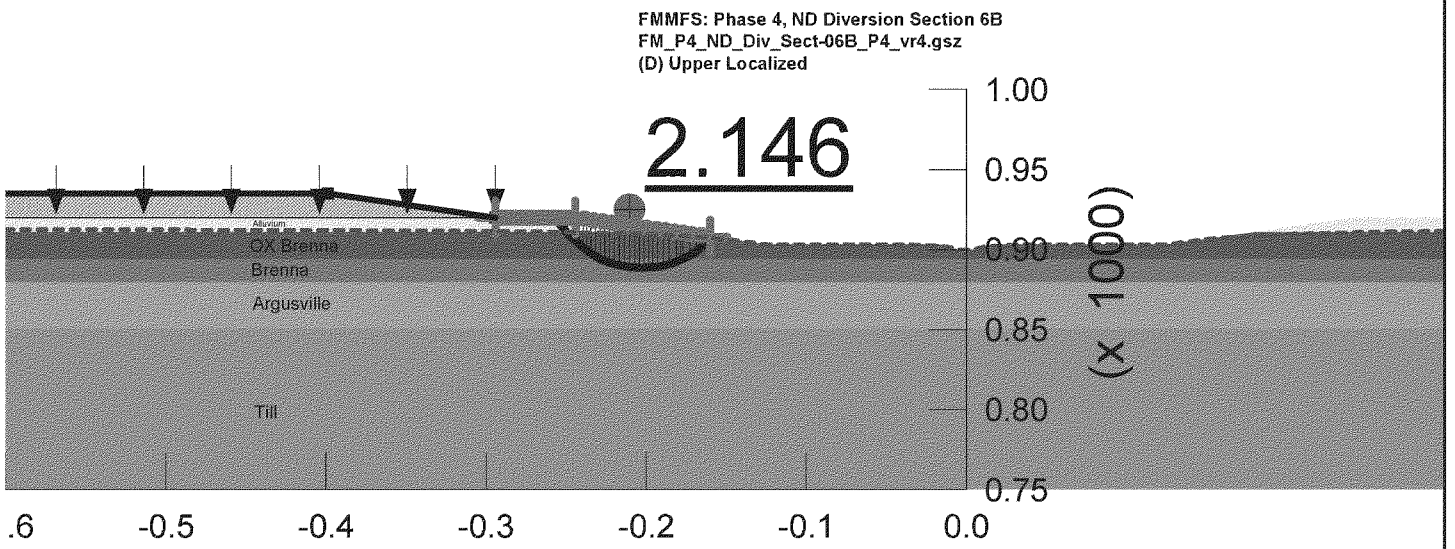

FMMFS: Phase 4, ND Diversion Section 6B
FM_P4_ND_Div_Sect-06B_P4_vr4.gsz
(A) Slope Stability
1.512
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
Alluvium
OX Brenna
Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1594


FMMFS: Phase 4, ND Diversion Section 6B
FM_P4_ND_Div_Sect-06B_P4_vr4.gsz
(B) Wedge Slope Stability
1.513
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
Alluvium
OX Brenna
Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 4, ND Diversion Section 6B
FM_P4_ND_Div_Sect-06B_P4_vr4.gsz
(C) Lower Localized
1.636
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
Alluvium
OX Brenna
Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

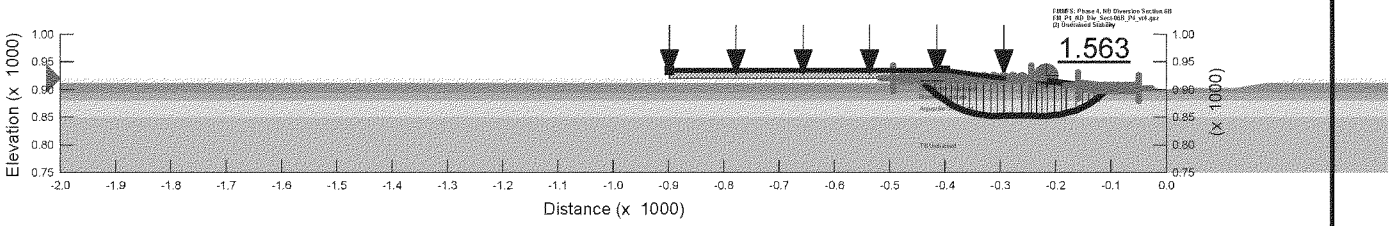
1596


FMMFS: Phase 4, ND Diversion Section 6B
FM_P4_ND_Div_Sect-06B_P4_vr4.gsz
(D) Upper Localized
2.146
Alluvium
CX Brenna
Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-06B_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 6B
(2) Undrained Stability

Soil Properties



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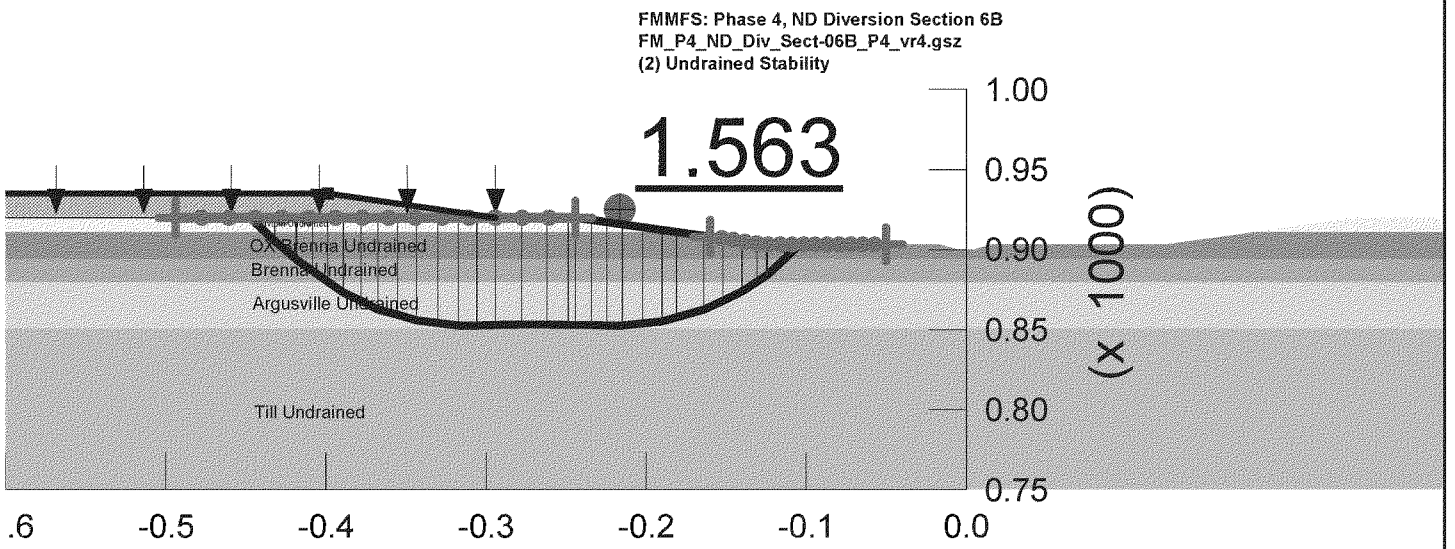
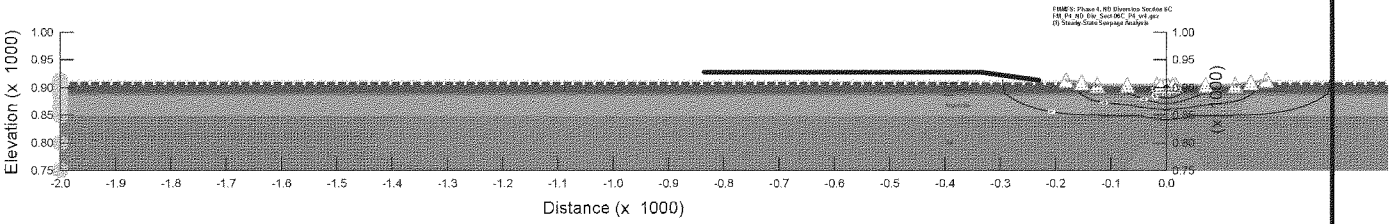
1598


FMMFS: Phase 4, ND Diversion Section 6B
FM_P4_ND_Div_Sect-06B_P4_vr4.gsz
(2) Undrained Stability
1.563
Ox Brenna Undrained
Brenna Undrained
Argusville Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-06C_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 6C
(1) Steady-State Seepage Analysis

Soil Properties



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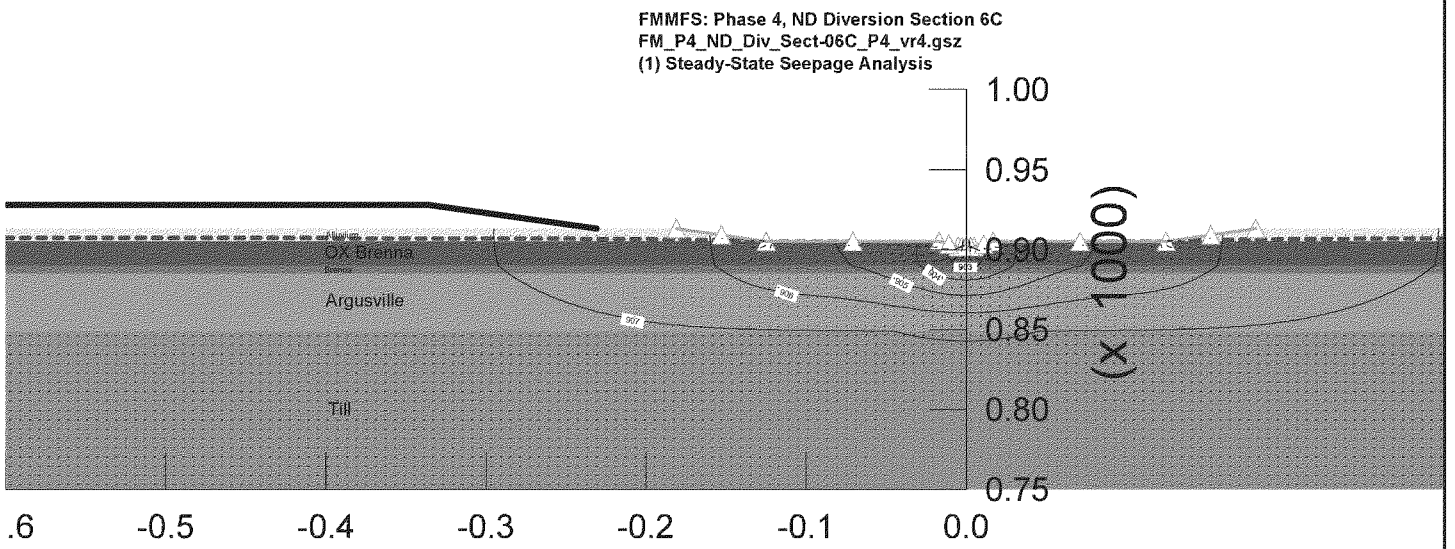
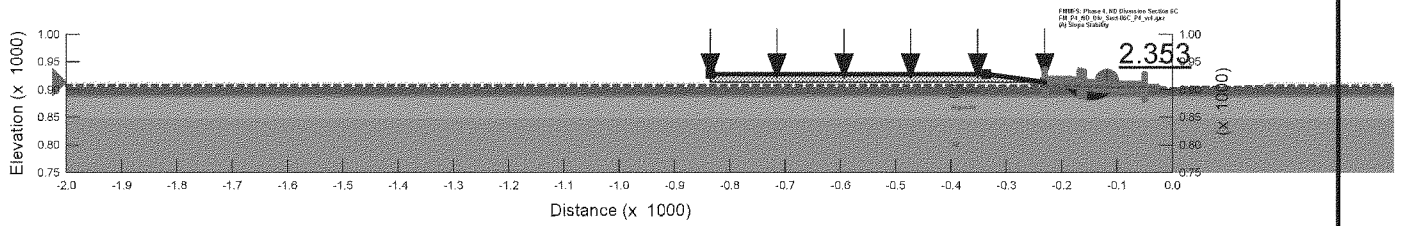
1600


FMMFS: Phase 4, ND Diversion Section 6C
FM_P4_ND_Div_Sect-06C_P4_vr4.gsz
(1) Steady-State Seepage Analysis
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
OX Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-06C_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 6C
(A) Slope Stability

Soil Properties



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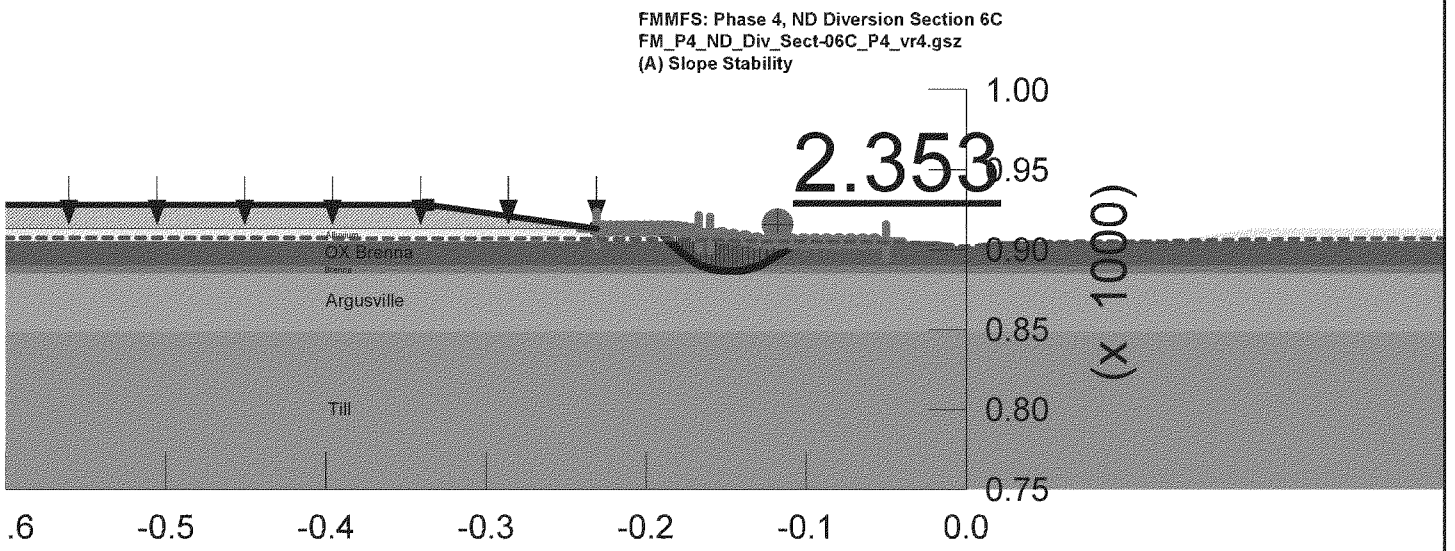
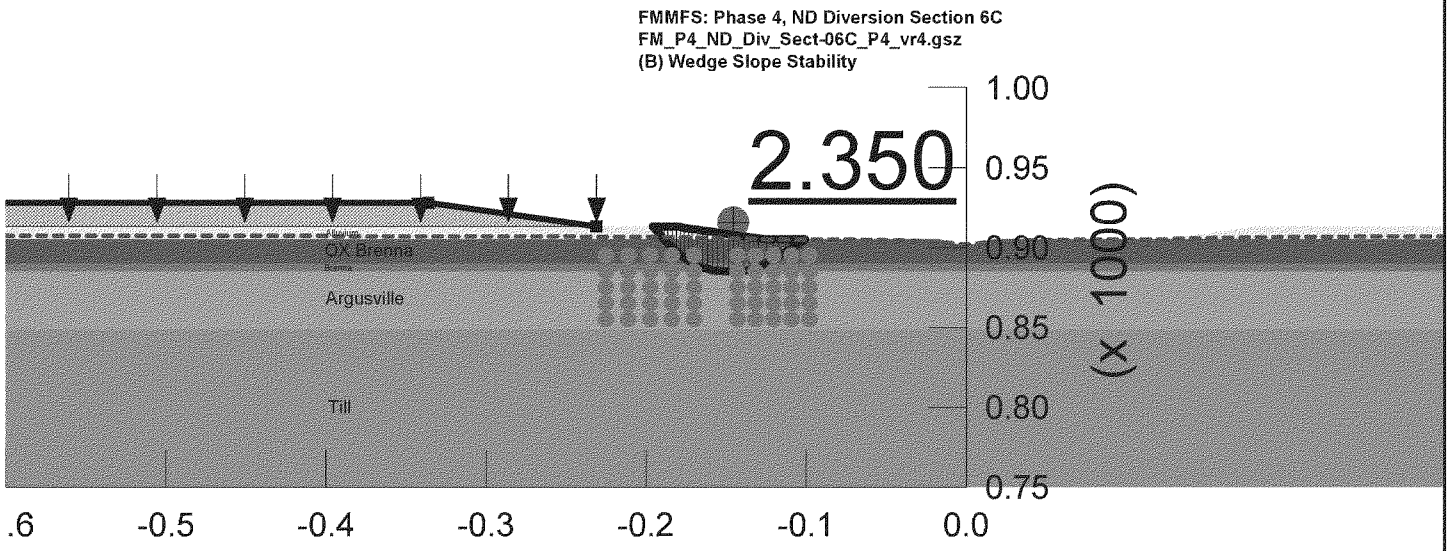
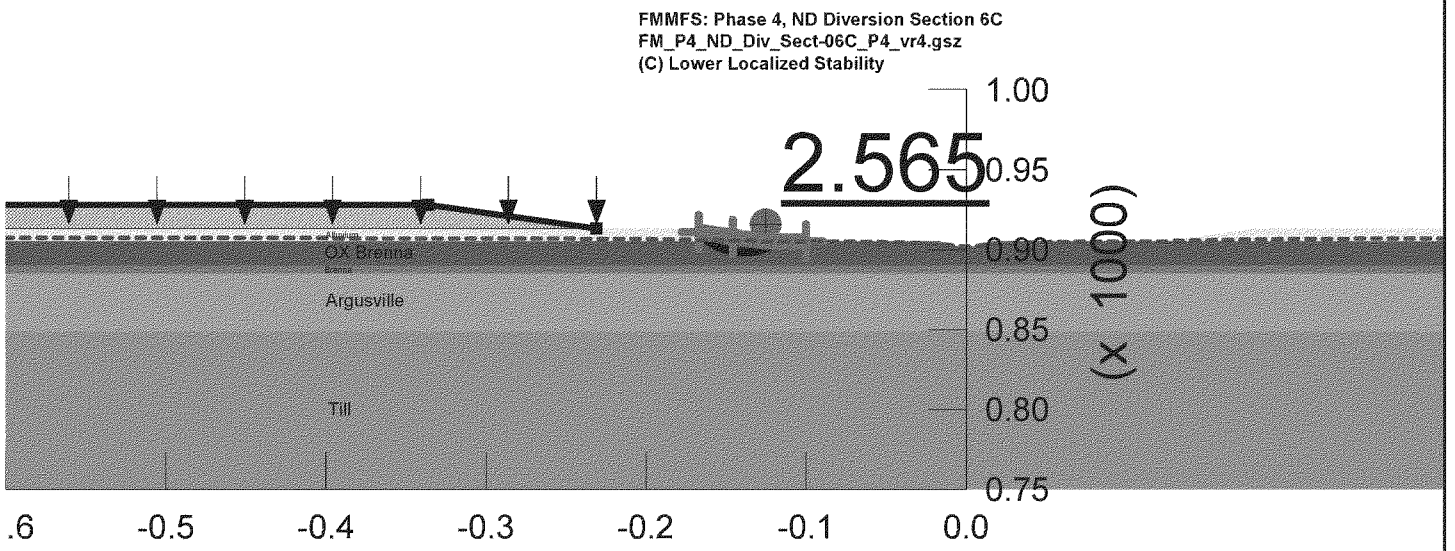
1602

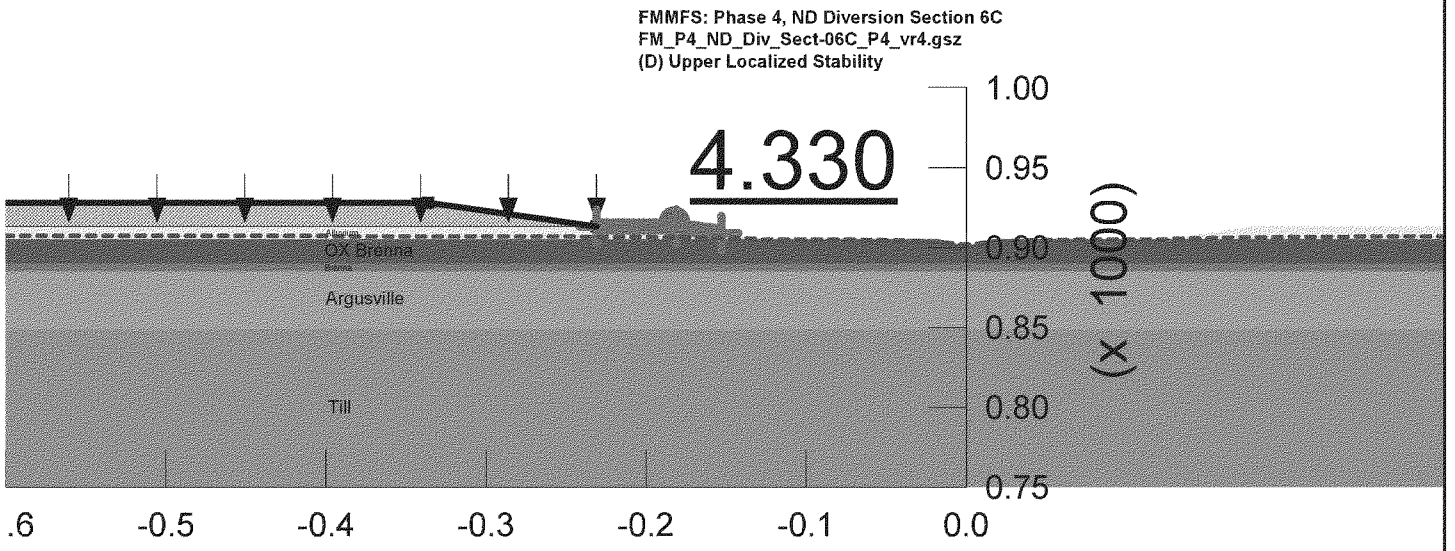

FMMFS: Phase 4, ND Diversion Section 6C
FM_P4_ND_Div_Sect-06C_P4_vr4.gsz
(A) Slope Stability
2.353
OX Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 4, ND Diversion Section 6C
FM_P4_ND_Div_Sect-06C_P4_vr4.gsz
(B) Wedge Slope Stability
2.350
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
OX Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1604


FMMFS: Phase 4, ND Diversion Section 6C
FM_P4_ND_Div_Sect-06C_P4_vr4.gsz
(C) Lower Localized Stability
2.565
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
OX Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1605

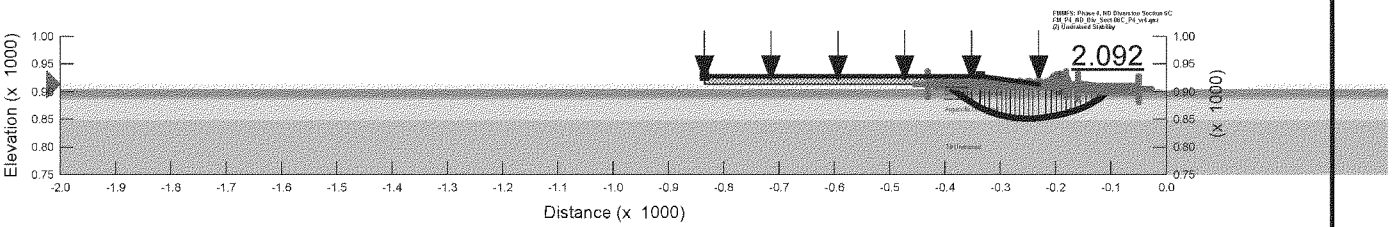

FMMFS: Phase 4, ND Diversion Section 6C
FM_P4_ND_Div_Sect-06C_P4_vr4.gsz
(D) Upper Localized Stability
4.330
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
OX Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1606

File Name: FM_P4_ND_Div_Sect-06C_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 6C
(2) Undrained Stability

Soil Properties



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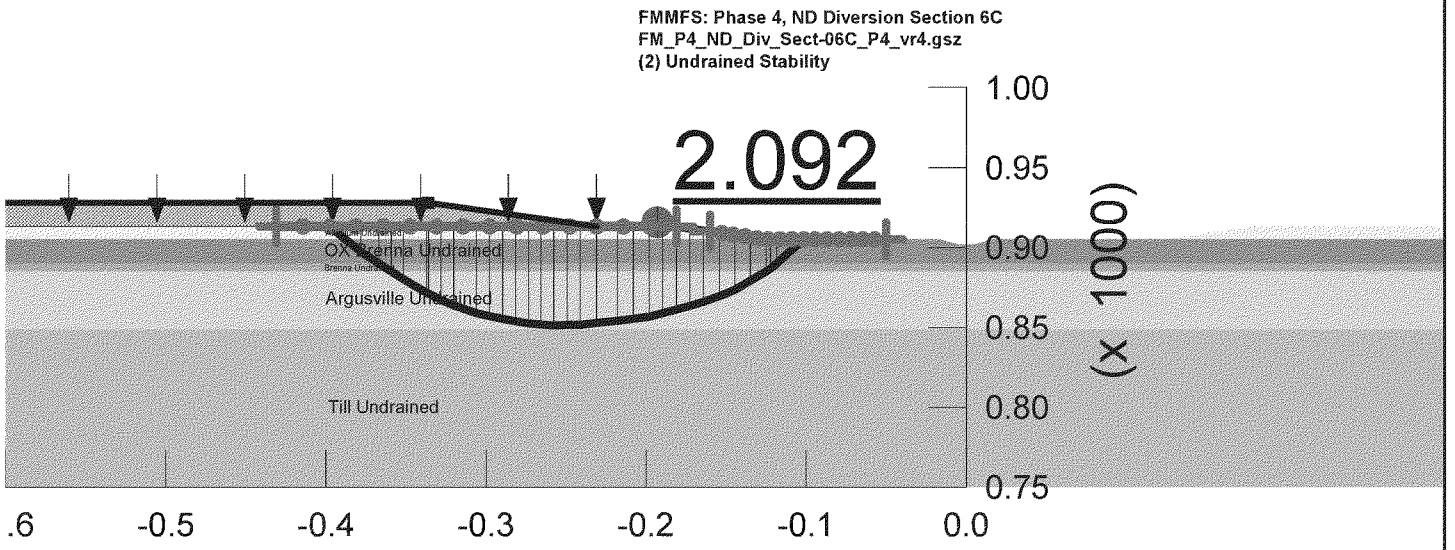
1607

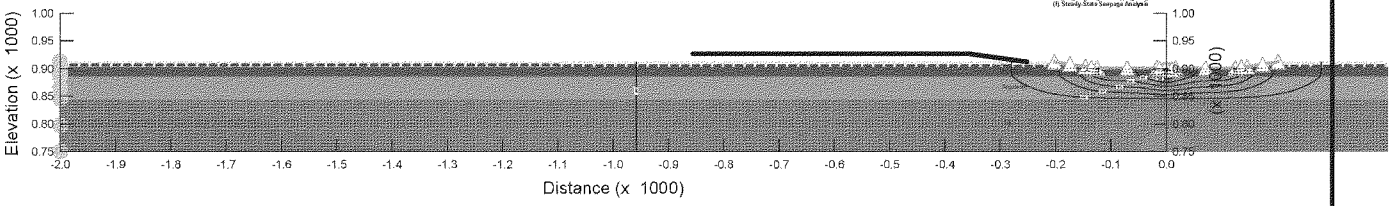

FMMFS: Phase 4, ND Diversion Section 6C
FM_P4_ND_Div_Sect-06C_P4_vr4.gsz
(2) Undrained Stability
2.092
OX Brenna Undrained
Argusville Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1608

File Name: FM_P4_ND_Div_Sect-07_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 7
(1) Steady-State Seepage Analysis

Soil Properties



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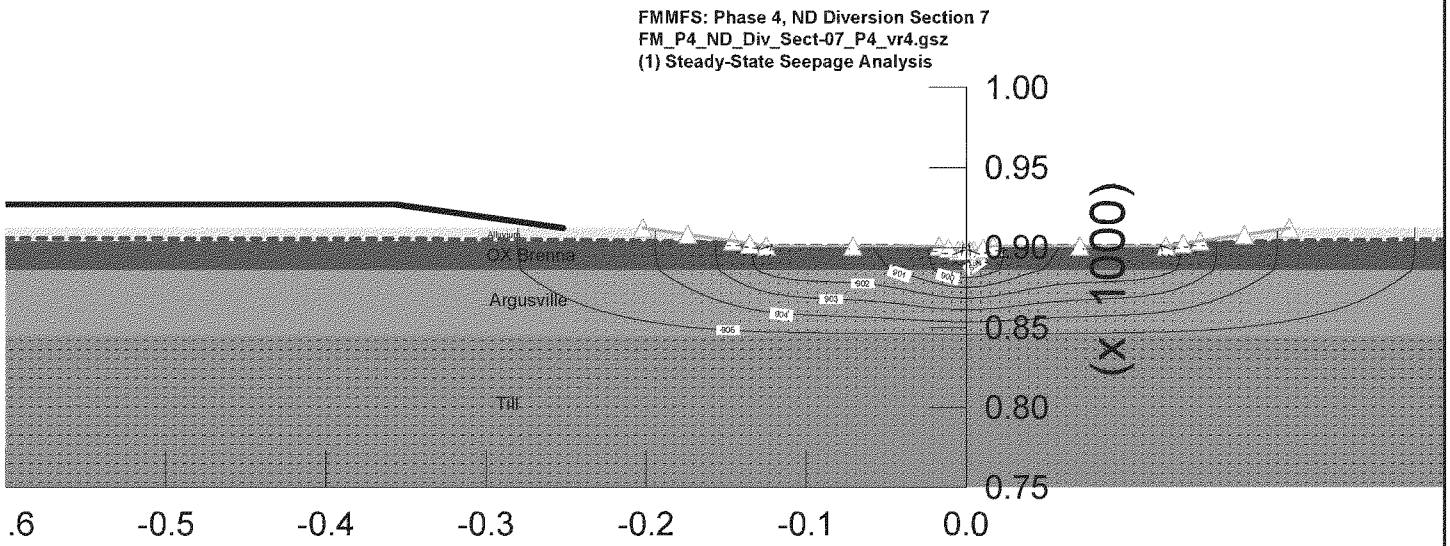
1609

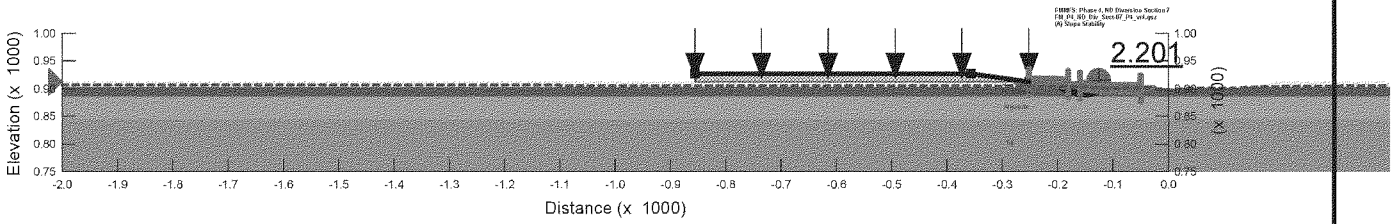

FMMFS: Phase 4, ND Diversion Section 7
FM_P4_ND_Div_Sect-07_P4_vr4.gsz
(1) Steady-State Seepage Analysis
Alluvium
OX Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

1610

File Name: FM_P4_ND_Div_Sect-07_P4_vr4.gsz

Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 7
(A) Slope Stability

Soil Properties



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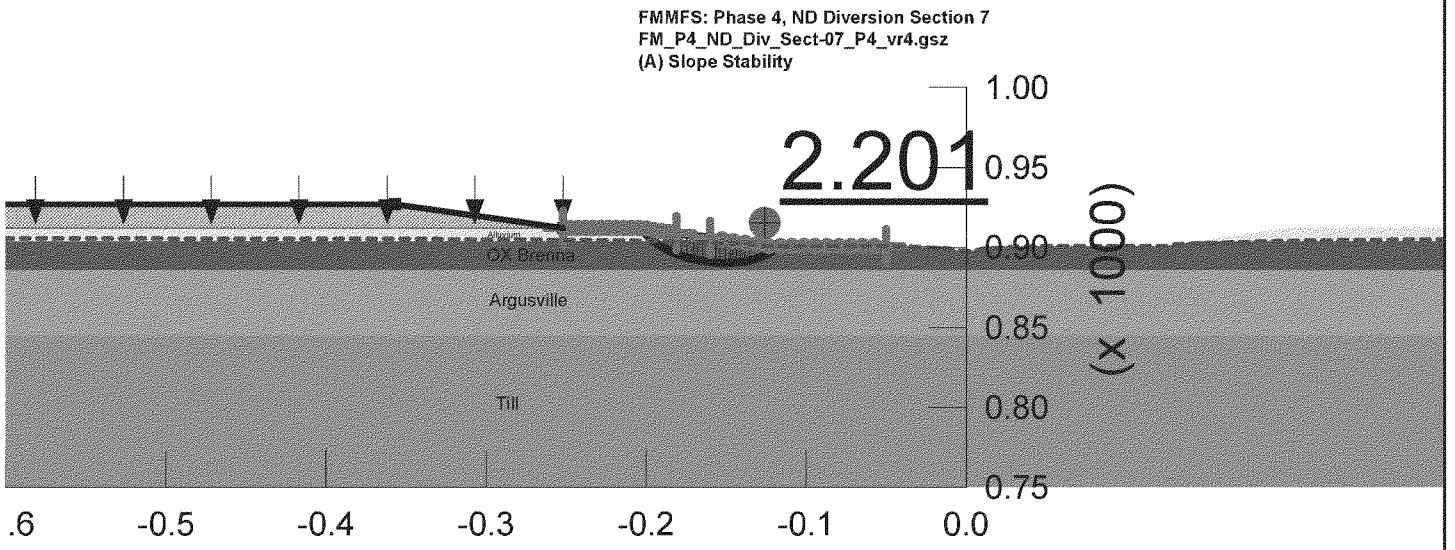
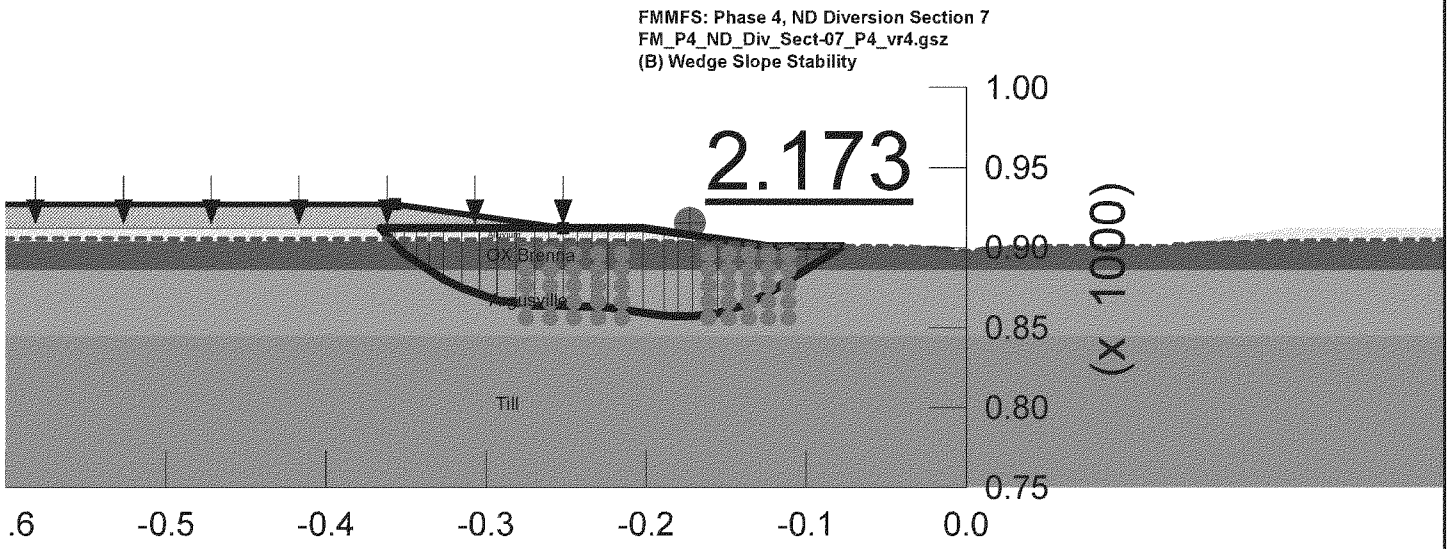
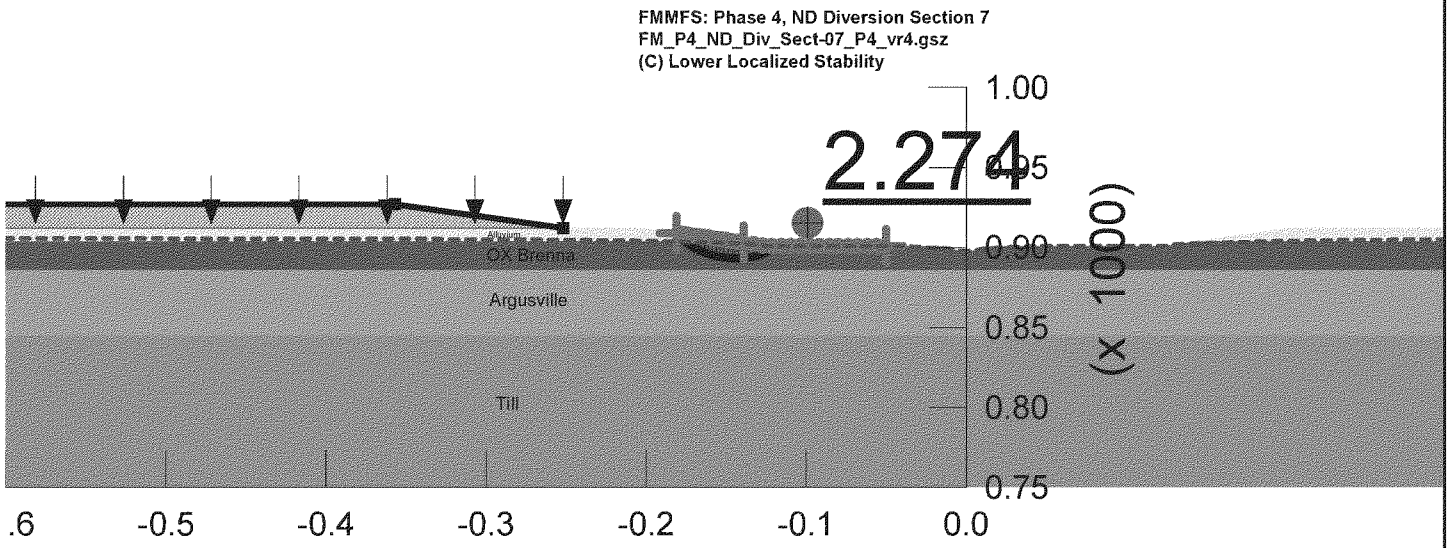
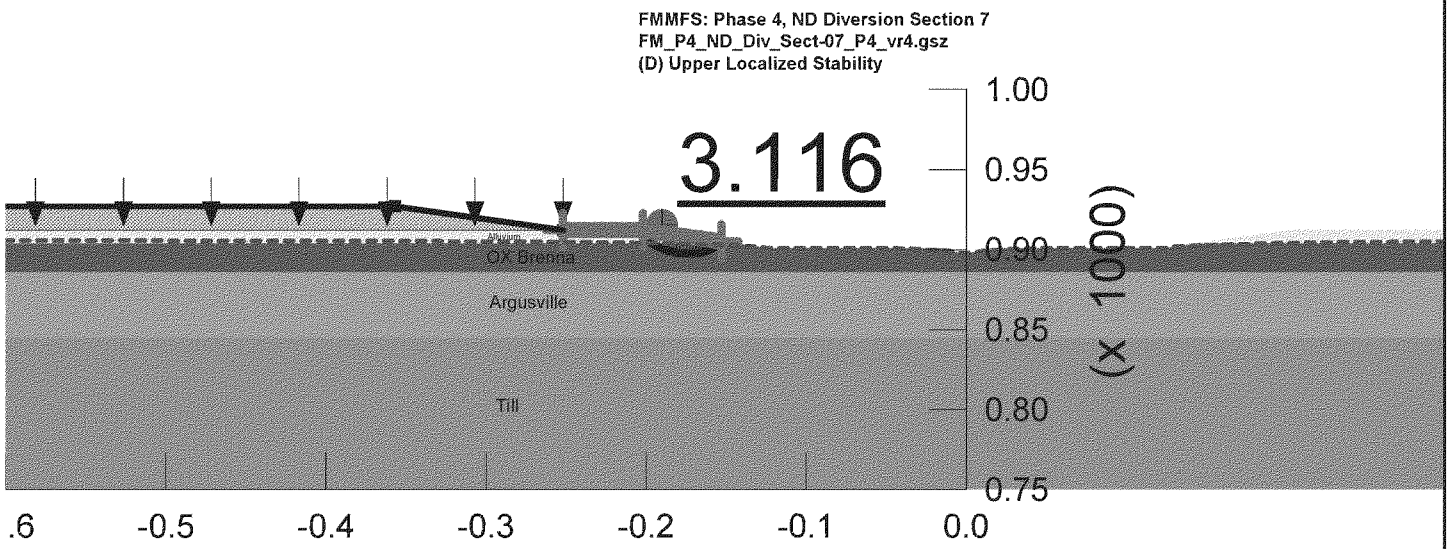
1611


FMMFS: Phase 4, ND Diversion Section 7
FM_P4_ND_Div_Sect-07_P4_vr4.gsz
(A) Slope Stability
2.201
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
OX Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 4, ND Diversion Section 7
FM_P4_ND_Div_Sect-07_P4_vr4.gsz
(B) Wedge Slope Stability
2.173
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
QX Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 4, ND Diversion Section 7
FM_P4_ND_Div_Sect-07_P4_vr4.gsz
(C) Lower Localized Stability
2.274
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
OX Brenna
Argusville
Till
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

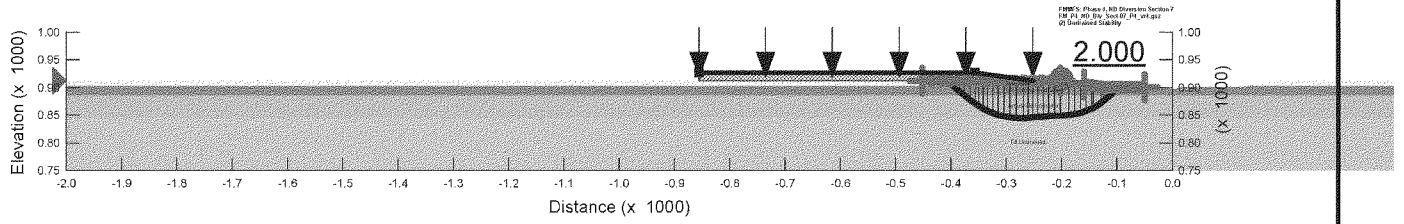
1614


FMMFS: Phase 4, ND Diversion Section 7
FM_P4_ND_Div_Sect-07_P4_vr4.gsz
(D) Upper Localized Stability
3.116
OX Brenna
Argusville
Till
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

File Name: FM_P4_ND_Div_Sect-07_P4_vr4.gsz

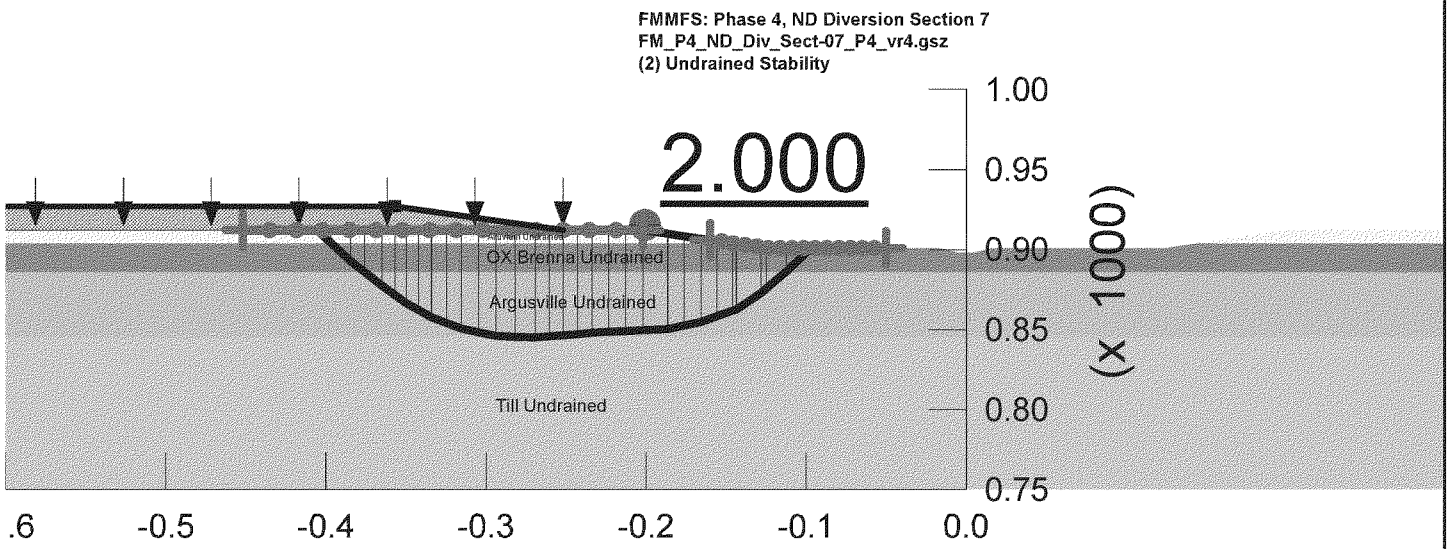
Fargo-Moorhead Metro Feasibilty Study
Phase 4 Analysis
ND Diversion Channel Stability
Section 7
(2) Undrained Stability

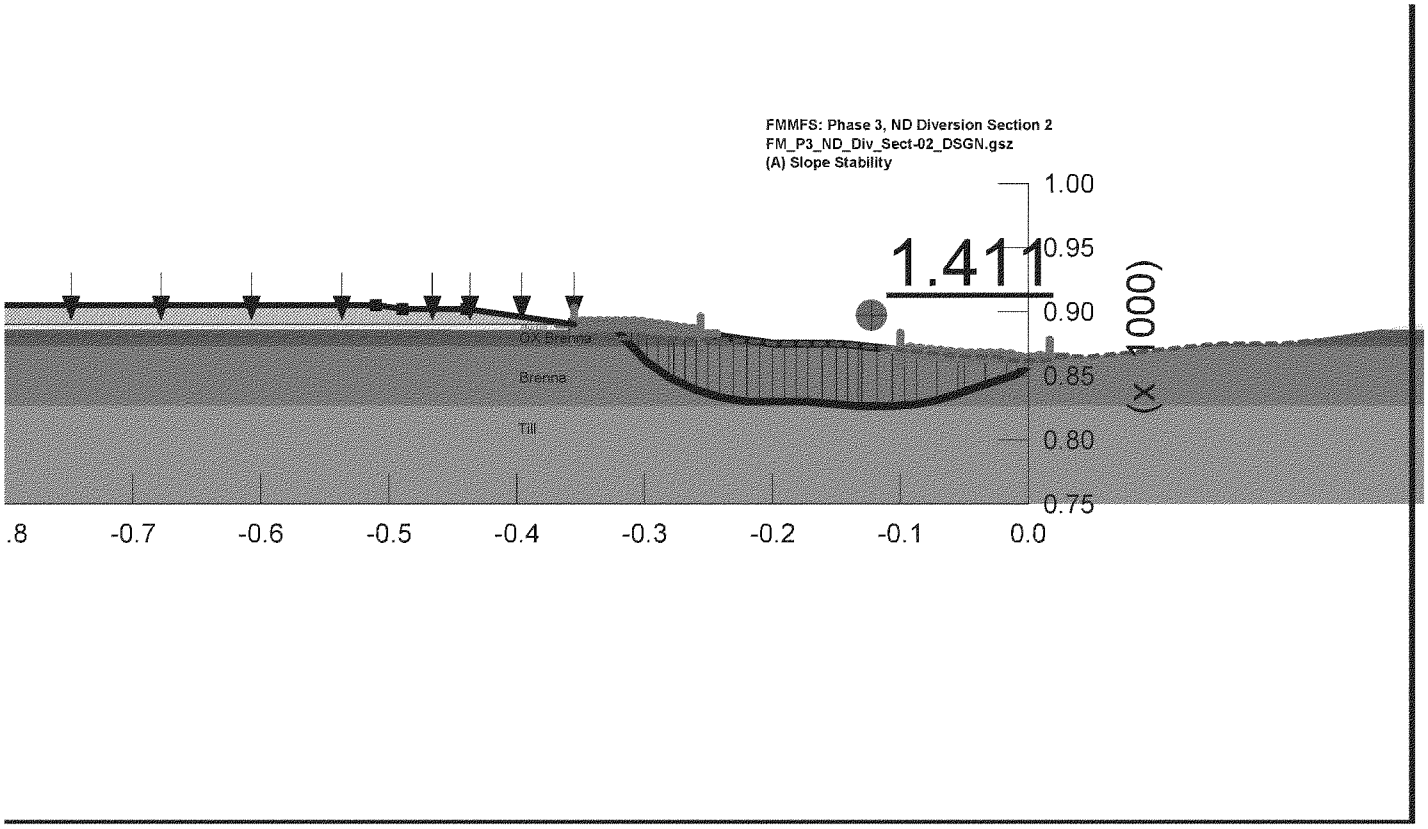
Soil Properties

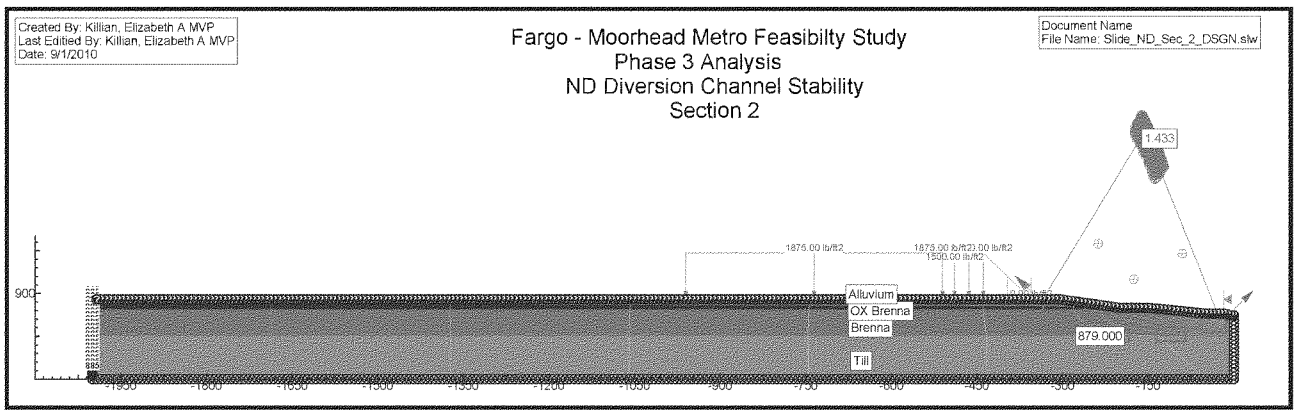


Created By: Heckendorf, Kurt A MVP
Last Edited By: Heckendorf, Kurt A MVP
Date: 1/18/2011

1616


FMMFS: Phase 4, ND Diversion Section 7
FM_P4_ND_Div_Sect-07_P4_vr4.gsz
(2) Undrained Stability
2.000
OX Brenna Undrained
Argusville Undrained
Till Undrained
1.00
0.95
0.90
0.85
0.80
0.75
(x 1000)
.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


FMMFS: Phase 3, ND Diversion Section 2
FM_P3_ND_Div_Sect-02_DSGN.gsz
(A) Slope Stability
1.411
1.00
0.95
0.90
0.85
0.80
0.75
(X 1000)
GX Brenna
Brenna
Till
.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


Created By: Killian, Elizabeth A MVP
Last Edited By: Killian, Elizabeth A MVP
Date: 9/1/2010
Fargo - Moorhead Metro Feasibilty Study
Phase 3 Analysis
ND Diversion Channel Stability
Section 2
Document Name
File Name: Slide_ND_Sec_2_DSGN.slw
1.433
1875.00 lb/ft2
1875.00 lb/ft2
1500.00 lb/ft2
1500.00 lb/ft2
Alluvium
OX Brenna
Brenna
Till
879.000
900
1600
1400
1200
1000
800
600
400
-2200
-2000
-1800
-1600
-1400
-1200
-1000
-800
-600
-400
-200
0
200

Slide Analysis Information

Document Name

File Name: Slide_ND_Sec_2_DSGN.sli

Project Settings

Project Title: SLIDE - ND Section 2
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Finite Element Analysis
Tolerance (groundwater): 1e-006
Maximum number of iterations (groundwater): 500
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:
Spencer

Number of slices: 30
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Non-Circular Block Search
Number of Surfaces: 1500
Pseudo-Random Surfaces: Enabled
Convex Surfaces Only: Disabled
Left Projection Angle (Start Angle): 135
Left Projection Angle (End Angle): 135
Right Projection Angle (Start Angle): 45
Right Projection Angle (End Angle): 45
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Loading

4 Distributed Loads present:
Distributed Load #1 Constant Distribution, Orientation: Normal to boundary, Magnitude: 1500 lb/ft2
Distributed Load #2 Triangular Distribution, Orientation: Vertical, Magnitudes 1,2: 0 and 1500 lb/ft2
Distributed Load #3 Triangular Distribution, Orientation: Vertical, Magnitudes 1,2: 1500 and 1875 lb/ft2
Distributed Load #4 Constant Distribution, Orientation: Vertical, Magnitude: 1875 lb/ft2

Groundwater Analysis

Maximum Number of Iterations: 500
Iteration Tolerance: 1e-006
Mesh Element Type: 4 noded quadrilaterals
Number of Elements: 9904
Number of Nodes: 9952

Material Properties

Material: Alluvium
Strength Type: Mohr-Coulomb
Unit Weight: 119 lb/ft3
Cohesion: 0 psf
Friction Angle: 31 degrees
Unsaturated Shear Strength Angle: 0 degrees
Air Entry Value: 0 psf
Ks: 3.24074e-008
K2/K1: 1
K Angle: 0

Model: User Defined - Alluv/Sherack

Material: OX Brenna
Strength Type: Shear Normal function
Unit Weight: 111 lb/ft3
Unsaturated Shear Strength Angle: 0 degrees
Air Entry Value: 0 psf
Ks: 1.62037e-008
K2/K1: 1
K Angle: 0

Model: User Defined - OX Brenna

Material: Brenna
Strength Type: Shear Normal function
Unit Weight: 104 lb/ft3
Unsaturated Shear Strength Angle: 0 degrees
Air Entry Value: 0 psf
Ks: 3.3e-009
K2/K1: 1
K Angle: 0

Model: Simple

Material: Till
Strength Type: Mohr-Coulomb
Unit Weight: 122 lb/ft3
Cohesion: 0 psf
Friction Angle: 31 degrees
Unsaturated Shear Strength Angle: 0 degrees
Air Entry Value: 0 psf
Ks: 6.6e-007
K2/K1: 0.25
K Angle: 0

Model: Simple

Material: Sand
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 0 psf
Friction Angle: 32 degrees
Unsaturated Shear Strength Angle: 0 degrees
Air Entry Value: 0 psf
Ks: 0.000324074
K2/K1: 1
K Angle: 0

Model: User Defined - Sand

Global Minimums

Method: spencer
FS: 1.433130
Axis Location: -156.180, 1183.327
Left Slip Surface Endpoint: -334.094, 890.000
Right Slip Surface Endpoint: -28.267, 865.000
Resisting Moment=4.878e+007 lb-ft
Driving Moment=3.40375e+007 lb-ft
Resisting Horizontal Force=128787 lb
Driving Horizontal Force=89864.1 lb

Valid / Invalid Surfaces

Method: spencer
Number of Valid Surfaces: 1501
Number of Invalid Surfaces: 3
Error Codes:
Error Code -1000 reported for 3 surfaces

Error Codes

The following errors were encountered during the computation:

-1000 = No valid slip surfaces are generated
at a grid center. Unable to draw a surface.

List of All Coordinates

Non-Circ. Failure Surface
-305.000 890.000
-200.000 875.000

Non-Circ. Failure Surface
-200.000 875.000
-150.000 875.000

Non-Circ. Failure Surface
-150.000 875.000
-50.000 865.000

Material Boundary
-2000.000 886.000
-277.000 886.000

Material Boundary
-2000.000 873.000
-130.000 873.000

Material Boundary
-17.000 865.000
-17.000 863.000
-5.000 860.000
0.000 860.000

Material Boundary
-2000.000 826.000
0.000 826.000

External Boundary
0.000 862.000
-5.000 862.000
-17.000 865.000
-50.000 865.000
-130.000 873.000
-150.000 875.000
-200.000 875.000
-277.000 886.000
-305.000 890.000
-2000.000 890.000
-2000.000 886.000
-2000.000 873.000
-2000.000 826.000
-2000.000 750.000
0.000 750.000
0.000 826.000
0.000 860.000

Distributed Load
-439.000 890.000
-489.000 890.000

Distributed Load
-355.000 890.000
-439.000 890.000

Distributed Load
-489.000 890.000
-510.000 890.000

Distributed Load
-510.000 890.000
-960.000 890.000

Focus/Block Search Window
-335.000 883.000
-335.000 848.000

-257.000 848.000
-262.231 883.890

Focus/Block Search Window
-242.000 841.000
-241.000 816.000
-183.000 816.000
-184.000 842.000

Focus/Block Search Window
-136.000 841.000
-136.000 816.000
-85.000 816.000
-86.000 841.000

Focus/Block Search Window
-57.000 858.000
-56.000 831.000
-13.000 832.000
-14.000 857.000

Attachment I-13: Uplift Analysis

Fargo-Moorhead Metro Feasibility Study

Phase 3: Calculations for Uplift Factors of Safety NEAREST CENTERLINE only

Compiled By: KAH Revised By:
Date: 6/20/2010 Date:

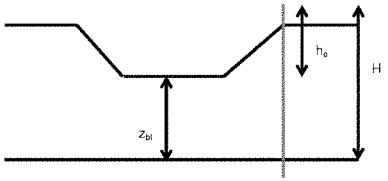
Piezometric Level Below Ground Surface 7.5 FT

	Area	STA	Offset		Boring	Ground Surface	Bottom of Diversion Channel	Depth of Channel	Piezometric Level in Aquifer	Depth to Aquifer	Elevation of Aquifer	Head in Aquifer	Impervious Blanket Thickness	Excess Head above Diversion	**FS (gradient)**	Z_T
3	70th Ave NW	~440+00	400	Right	10-87M	902	883	19	894.5	110	792	102.5	91	11.5	**5.28**	91.0
4	57th Ave N	~510+00	400	Left	10-82M	906	884	22	898.5	100	806	92.5	78	14.5	**3.59**	78.0
9	43rd Ave N	~585+00	900	Right	10-93M	911	884	27	903.5	128	783	120.5	101	19.5	**2.07**	60.5
13	28th Ave N	~636+00	400	Left	10-104M	913	885	28	905.5	87	826	79.5	59	20.5	**1.74**	53.6
16	15th Ave N	~688+00	50	Right	10-83M	913	885	28	905.5	91	822	83.5	63	20.5	**1.87**	57.6
21	HWY 10	~741+00	150	Right	10-103M	913	886	27	905.5	76	837	68.5	49	19.5	**1.46**	42.7
24	12th Ave S	~795+00	805	Left	10-102M	912	887	25	904.5	54	858	46.5	29	17.5	0.86	22.7
25			0												**1.03**	
26		~795+00	2800	Right	10-101M	913	887	26	905.5	77	836	69.5	51	18.5	1.61	44.7
27	I-94	~850+00	4300	Right	09-43C	913	888	25	905.5	94	819	86.5	69	17.5	**2.63**	69.0
28	40th Ave S	~910+00	3100	Right	09-15M	915	889	26	907.5	102	813	94.5	76	18.5	**2.74**	76.0

γ_{sat} = 104 pcf
γ_b = 41.6 pcf
γ_w = 62.4 pcf

$$FS\ (gradient) = \frac{(\gamma_{sat} - \gamma_w) * Z_t}{\gamma_w * h_o}$$

* Ground Surface elevations detemined using LiDAR data; elevations similar to surveyed elevations



EM 1110-2-1914, Relief Wells
Allowable Heads
FS = 1.5, downstream areas
FS = i_g / i_c = $\gamma' Z_t / \gamma_w h_a$

EM 1110-2-1913, Levee Design
Upward Gradient through berm:
if gradient through blanket is greater than 0.8 at gradient at landside toe of levee, berm should be built to reduce to 0.3

berm width based on allowable grdient of 0.8 through top straum landward of berm
i_c based on 115 pcf sat. unit weight

EM 1110-2-1901, Seepage for Dams
FS - 1.5 to 15

1626

St. Paul District GEOTECHNICAL US Army Corps of Engineers

Fargo-Moorhead I

Phase 3: Calculations for Upl

Compiled By: KAH Re
Date: 8/20/2010

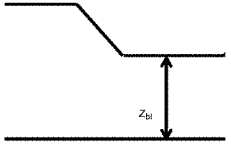
Piezometric Level Below Ground Surface 7.5 FT

						Brenna				Argusville						Silts					
	Area	STA	Offset		Boring	Depth to Top	Depth to Bottom	Thickness	k_v	Depth to Top	Depth to Bottom	Thickness	k_v	F_t	Transformed Thickness	Depth to Top	Depth to Bottom	Thickness	k_v	F_t	Transformed Thickness
3	70th Ave NW	~440+00	400	Right	10-87M	19	85	66	0.00028	85	110	25	0.00028	1	25	110	110	0	0.00283	0.1	0
4	57th Ave N	~510+00	400	Left	10-82M	22	62	40	0.00028	62	100	38	0.00028	1	38	100	100	0	0.00283	0.1	0
9	43rd Ave N	~585+00	900	Right	10-93M	27	60	33	0.00028	60	83	23	0.00028	1	23	83	128	45	0.00283	0.1	4.5
13	28th Ave N	~636+00	400	Left	10-104M	28	60	32	0.00028	60	81	21	0.00028	1	21	81	87	6	0.00283	0.1	0.6
16	15th Ave N	~688+00	50	Right	10-83M	28	58	30	0.00028	58	85	27	0.00028	1	27	85	91	6	0.00283	0.1	0.6
21	HWY 10	~741+00	150	Right	10-103M	27	53	26	0.00028	53	69	16	0.00028	1	16	69	76	7	0.00283	0.1	0.7
24	12th Ave S	~795+00	805	Left	10-102M	25	47	22	0.00028	47	47	0	0.00028	1	0	47	54	7	0.00283	0.1	0.7
25			0																		
26		~795+00	2800	Right	10-101M	26	40	14	0.00028	40	70	30	0.00028	1	30	70	77	7	0.00283	0.1	0.7
27	I-94	~850+00	4300	Right	09-43C	25	50	25	0.00028	50	94	44	0.00028	1	44	94	94	0	0.00283	0.1	0
28	40th Ave S	~910+00	3100	Right	09-15M	26	61	35	0.00028	61	102	41	0.00028	1	41	102	102	0	0.00283	0.1	0

γ_{sat} = 104 pcf
γ_b = 41.6 pcf
γ_w = 62.4 pcf

Transformation: $F_t = k_b / k_n$

* Ground Surface elevations detemined using LiDAR data; elevations sim



1627

Fargo-Moorhead I

Phase 3: Calculations for Upl

Compiled By: KAH Re
Date: 8/20/2010

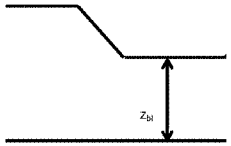
Piezometric Level Below Ground Surface 7.5 FT

Data Entry for calculations

	Area	STA	Offset		Boring	Ground Surface	Depth of Channel	Brenna Depth to Bottom	Argusville Depth to Bottom	Silts Depth to Bottom	Depth to Aquifer	
3	70th Ave NW	~440+00	400	Right	10-87M	1000		85	110	110	110	
4	57th Ave N	~510+00	400	Left	10-82M	1000		62	100	100	100	
9	43rd Ave N	~585+00	900	Right	10-93M	1000		60	83	128	128	
13	28th Ave N	~636+00	400	Left	10-104M			80	87	87	87	
16	15th Ave N	~688+00	50	Right	10-83M	1000		58	85	91	91	
21	HWY 10	~741+00	150	Right	10-103M	1000		53	69	76	76	85
24	12th Ave S	~795+00	805	Left	10-102M	1000		47	47	54	54	80
25			0									
26		~795+00	2600	Right	10-101M	1000		40	70	77	77	????
27	I-94	~850+00	4300	Right	09-43C	1000		50	94	94	94	
28	40th Ave S	~910+00	3100	Right	09-15M	1000		61	102	102	102	

γ_{sat} = 104 pcf
γ_b = 41.6 pcf
γ_w = 62.4 pcf

* Ground Surface elevations determined using LiDAR data; elevations sim



1628

Fargo-Moorhead Metro Feasibility Study

Phase 3: Calculations for ALL Uplift Factors of Safety

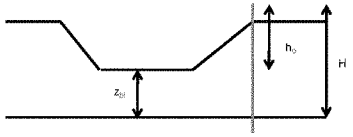
Compiled By: KAH
Date: 8/20/2010

Revised By:
Date:

γ_{sat} = 104 pcf
γ_b = 41.6 pcf
γ_w = 62.4 pcf

	Area	STA	Offset		Boring	Ground Surface	Bottom of Diversion Channel	Depth of Channel	Piezometric Level in Aquifer	Depth to Aquifer	Elevation of Aquifer	Head in Aquifer	Impervious Blanket Thickness	Excess Head above Diversion	Piezometric Level Below Ground Surface: 7.5 FS (gradient)	5 FS (gradient)	7.5 FS (gradient)	10 FS (gradient)	FS (heave)	Z_c
1	70th Ave NW	382+57	7000	Left	10-78M	896	883	13	888.5	110	786	102.5	97	5.5	11.76	8.08	11.76	21.56	1.58	97.0
2		406+30	2200	Left	10-79M	899	883	16	891.5	115	784	107.5	99	8.5	7.76	6.00	7.76	11.00	1.53	99.0
3		~440+00	400	Right	10-87M	902	883	19	894.5	110	792	102.5	91	11.5	**5.28**	4.33	5.28	6.74	1.48	91.0
4	57th Ave N	~510+00	400	Left	10-82M	906	884	22	898.5	100	806	92.5	78	14.5	3.59	3.06	3.59	4.33	1.41	78.0
5			1600	Right	10-90M	908	884	24	900.5	100	808	92.5	76	16.5	2.82	2.45	2.82	3.32	1.37	68.7
6			2400	Right	10-98M	909	884	24	900.5	90	818	82.5	66	16.5	2.67	2.32	2.67	3.14	1.33	66.0
7			4000	Right	10-84M	911	884	27	903.5	68	843	59.5	31	19.5	1.08	0.94	1.08	1.22	1.02	31.0
8	43rd Ave N	~585+00	2500	Left	10-89M	908	884	24	900.5	129	779	121.5	105	16.5	3.30	2.86	3.30	3.89	1.44	81.6
9		~585+00	900	Right	10-93M	911	884	27	903.5	128	783	120.5	101	19.5	2.07	1.83	2.07	2.37	1.40	60.5
10			1500	Right	10-96M	910	884	26	902.5	95	825	77.5	59	18.5	1.96	1.73	1.96	2.27	1.27	54.5
11			4400	Right	10-91M	916	884	32	906.5	35	881	27.5	3	24.5	0.01	0.01	0.01	0.01	0.18	0.3
12	28th Ave N	~636+00	3700	Left	10-92M	909	885	24	901.5	93	816	85.5	69	16.5	2.39	2.07	2.39	2.81	1.35	59.1
13			400	Left	10-104M	913	885	28	905.5	87	826	79.5	59	20.5	1.74	1.55	1.74	1.99	1.24	53.6
14		635+91	1500	Right	09-14M	913	885	28	905.5	70	843	62.5	42	20.5	1.22	1.09	1.22	1.39	1.12	37.5
15	60th St - 28th/15th Ave N		1600	Right	10-98M	913	885	28	905.5	75	838	67.5	47	20.5	0.97	0.87	0.97	1.11	1.18	28.9
16	15th Ave N	~688+00	50	Right	10-83M	913	885	28	905.5	91	822	83.5	63	20.5	1.87	1.67	1.87	2.13	1.26	57.6
17		~688+00	800	Right	10-100M	914	885	29	906.5	64	850	56.5	35	21.5	1.09	0.97	1.09	1.23	1.03	35.0
18			1500	Right	10-88M	916	885	31	908.5	40	876	32.5	0	23.5	0.03	0.02	0.03	0.03	0.46	0.9
19			4100	Right	10-86M	915	885	30	907.5	60	855	52.5	30	22.5	0.46	0.42	0.46	0.52	0.95	15.8
20	60th St - 15th Ave N / HWY 10		1600	Right	10-99M	915	886	29	907.5	56	858	49.5	27	21.5	0.45	0.40	0.45	0.51	0.93	13.4
21	HWY 10	~741+00	150	Right	10-103M	913	886	27	905.5	76	837	68.5	49	19.5	1.46	1.29	1.46	1.67	1.19	42.7
22			1100	Right	10-106M	913	886	27	905.5	70	843	62.5	43	19.5	1.32	1.17	1.32	1.51	1.15	38.5
23			3300	Right	09-46M	913	886	27	905.5	50	863	42.5	23	19.5	0.54	0.48	0.54	0.62	0.90	15.8
24	12th Ave S	~795+00	805	Left	10-102M	912	887	25	904.5	54	858	46.5	29	17.5	0.86	0.76	0.86	1.01	1.04	22.7
25			0												1.03	0.90	1.03	1.20		
26		~795+00	2800	Right	10-101M	913	887	26	905.5	77	836	69.5	51	18.5	1.61	1.42	1.61	1.86	1.22	44.7
27	I-94		4300	Right	09-43C	913	888	25	905.5	94	819	86.5	69	17.5	2.63	2.30	2.63	3.07	1.33	69.0
28	40th Ave S		3100	Right	09-15M	915	889	26	907.5	102	813	94.5	76	18.5	2.74	2.41	2.74	3.17	1.34	76.0

Ground Surface elevations detemined using LiDAR data; elevations similar to surveyed elevations



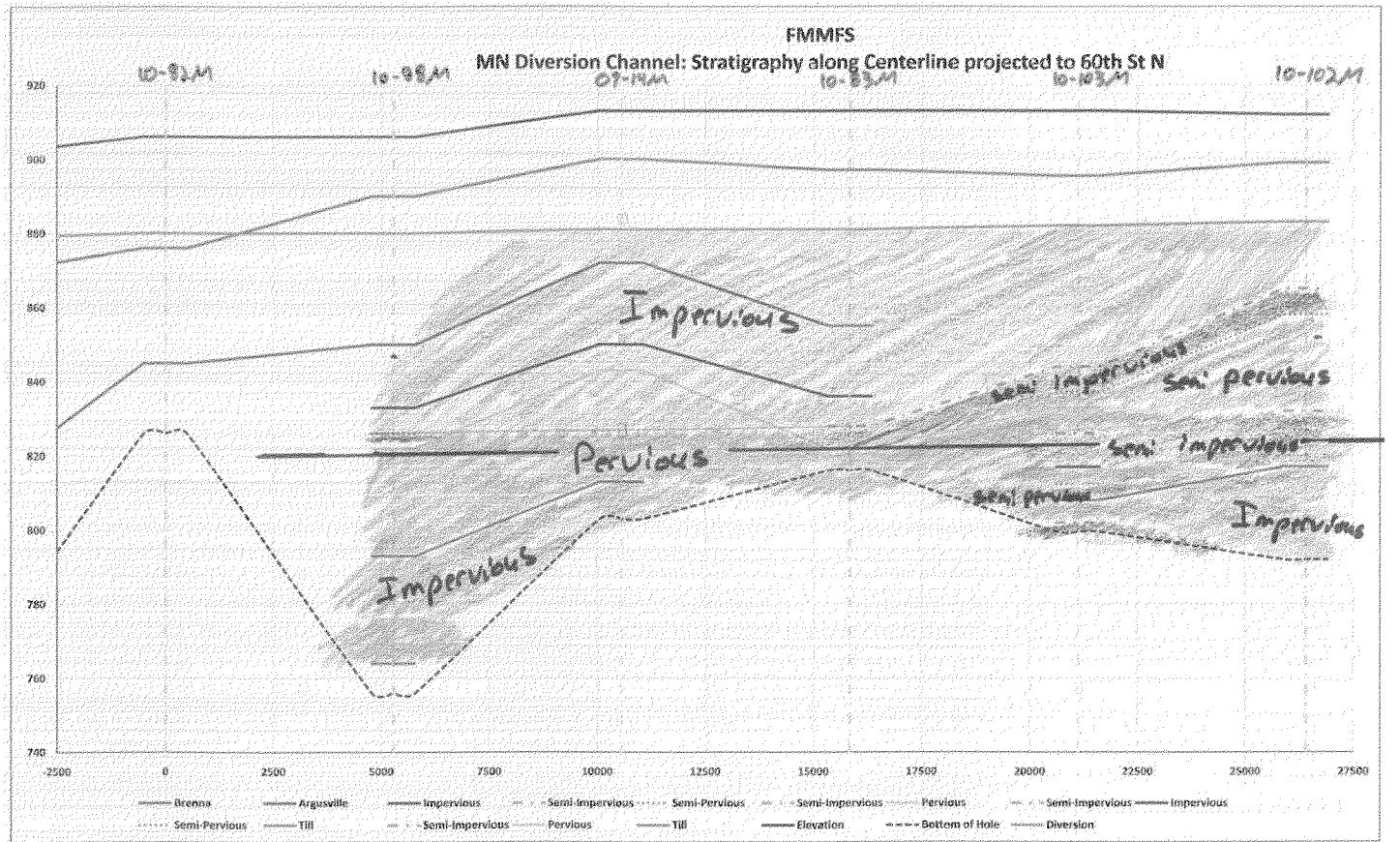
EM 1110-2-1914, Relief Wells
Allowable Heads
FS = 1.5, downstream areas
FS = i_b / i_c = $\gamma' Z_c / \gamma_w h_b$

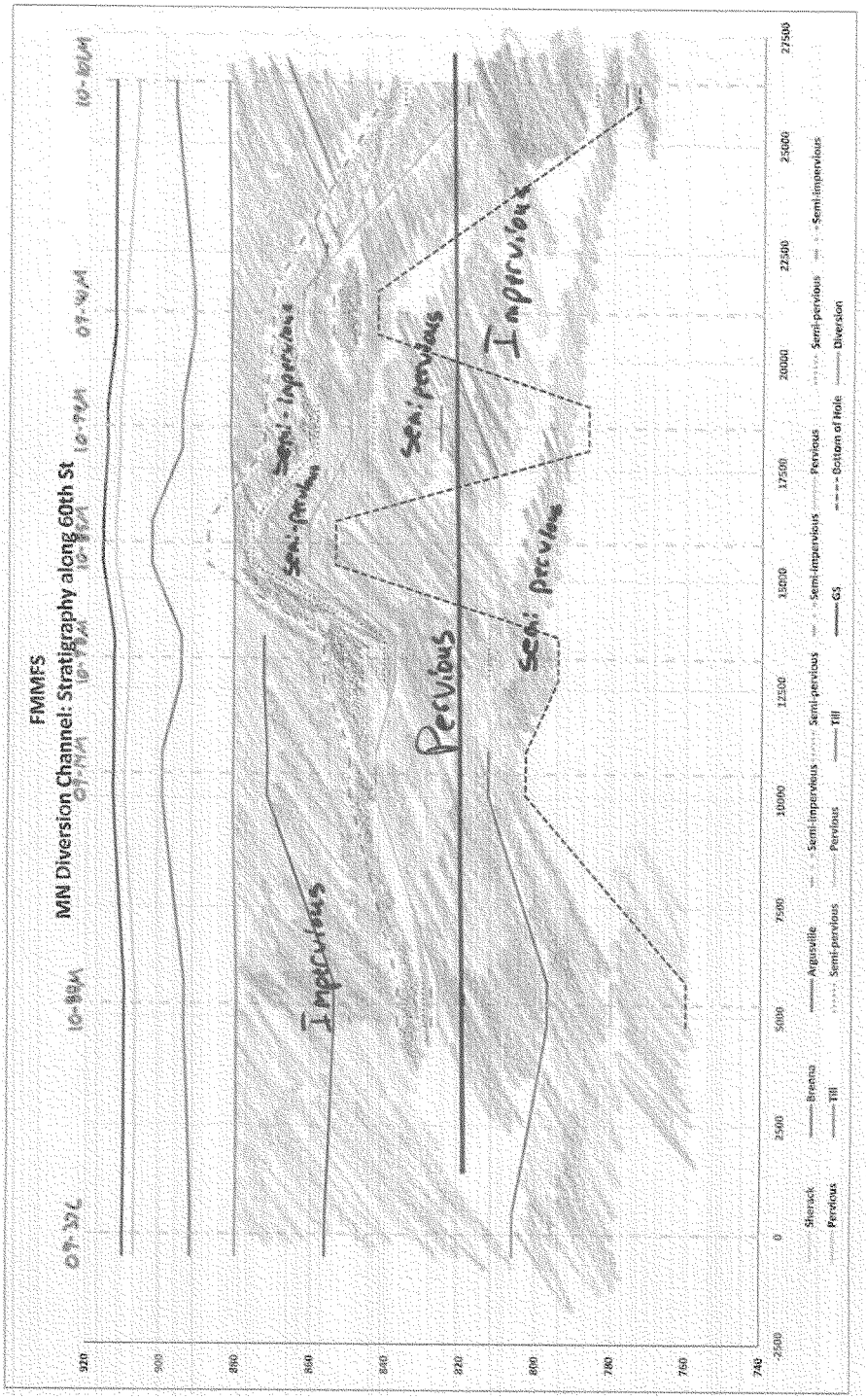
$$FS\ (gradient) = \frac{(\gamma_{sat} - \gamma_w) * Z_c}{\gamma_w * h_b}$$

$$FS\ (heave) = \frac{\gamma_{sat} * Z_{bl}}{\gamma_w * H}$$

EM 1110-2-1913, Levee Design
Upward Gradient through berm:
if gradient through blanket is greater than 0.8 at gradient at landside toe of levee, berm should be built to recude to 0.3
berm width based on allowable grdient of 0.8 through top straum landward of berm
i_c based on 115 pcf sat. unit weight

EM 1110-2-1901, Seepage for Dams
FS - 1.5 to 15

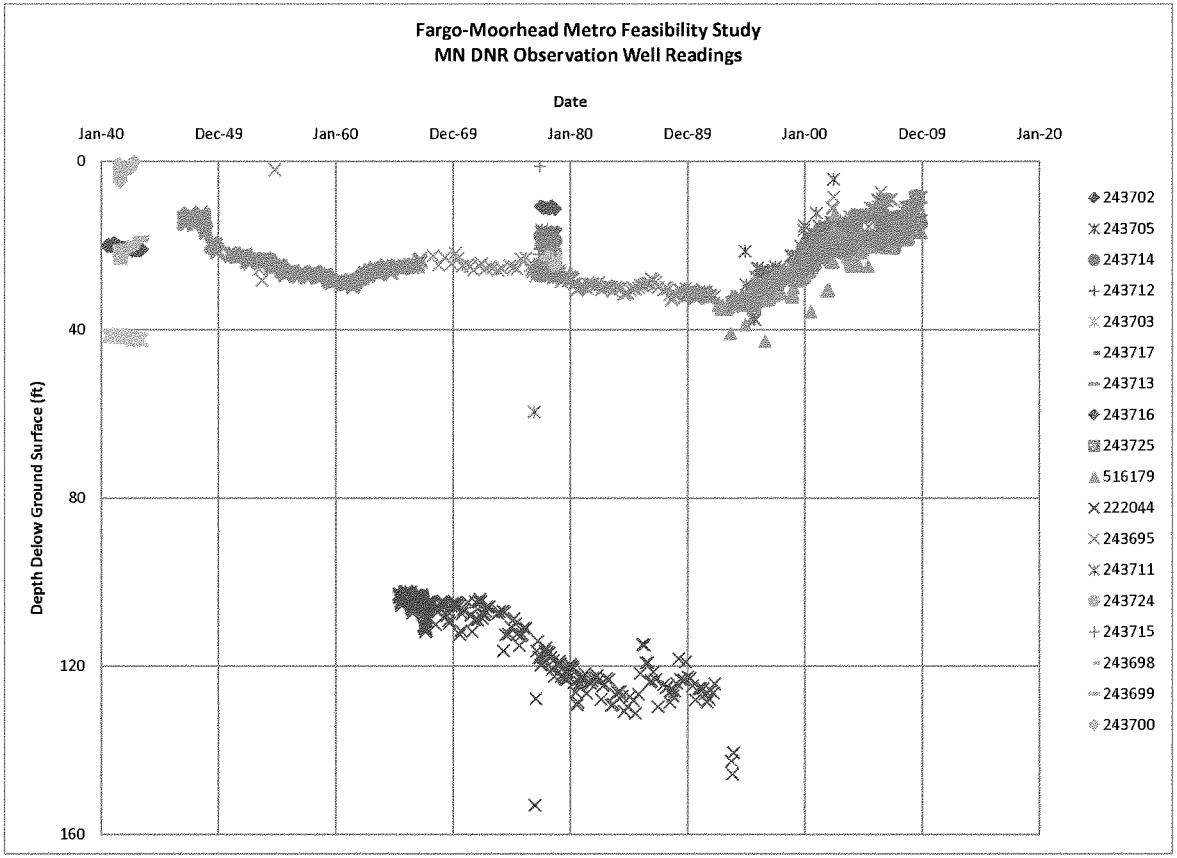

FMMFS
MN Diversion Channel: Stratigraphy along Centerline projected to 60th St N
10-82M
10-98M
09-14M
10-83M
10-103M
10-102M
920
900
880
860
840
820
800
780
760
740
-2500
0
2500
5000
7500
10000
12500
15000
17500
20000
22500
25000
27500
Impervious
Pervious
Impervious
Semi impervious
Semi pervious
Semi impervious
Semi pervious
Impervious
Brenna
Argusville
Impervious
Semi-Impervious
Semi-Pervious
Semi-Impervious
Pervious
Semi-Impervious
Impervious
Semi-Pervious
Till
Semi-Impervious
Pervious
Till
Elevation
Bottom of Hole
Diversion

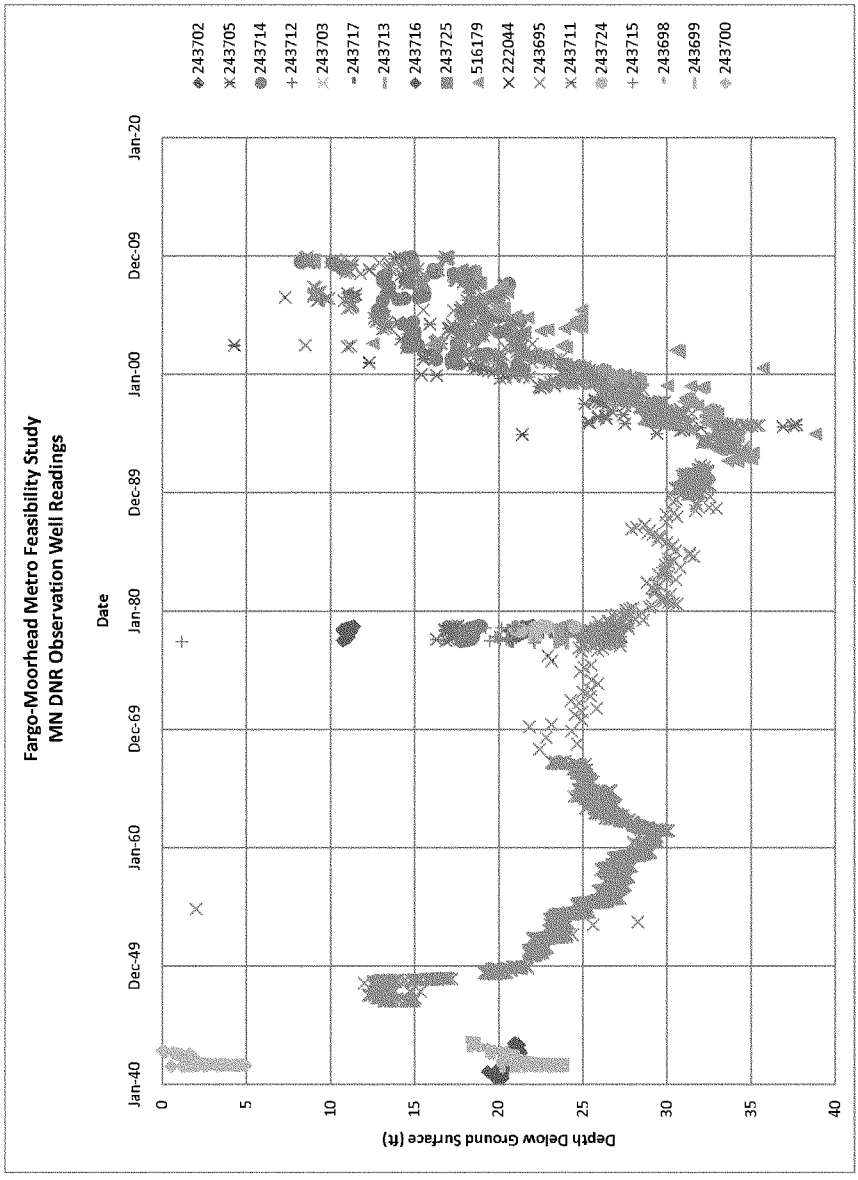


Final Fargo-Moorhead Metro Feasibility Report and Environmental Impact Statement
July 2011

Attachment I-13, pg 6
Geotechnical Design and Geology

St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps
of Engineers®
FMMFS_P3_Geotech_2010-07.mxd
Printed 21 AUG 2010
Fargo - Moorhead Metro Feasibility Study
MN DNR Observation Well Locations
0 2,400 4,800 9,600 14,400 19,200
Feet
1 inch = 4,500 feet


Fargo-Moorhead Metro Feasibility Study
MN DNR Observation Well Readings
Date
Jan-40
Dec-49
Jan-60
Dec-69
Jan-80
Dec-89
Jan-00
Dec-09
Jan-20
Depth Below Ground Surface (ft)
0
40
80
120
160
243702
243705
243714
243712
243703
243717
243713
243716
243725
516179
222044
243695
243711
243724
243715
243698
243699
243700


Fargo-Moorhead Metro Feasibility Study
MN DNR Observation Well Readings
Date
Jan-40
Dec-49
Jan-60
Dec-69
Jan-80
Dec-89
Jan-00
Dec-09
Jan-20
Depth Below Ground Surface (ft)
0
5
10
15
20
25
30
35
40
243702
243705
243714
243712
243703
243717
243713
243716
243725
516179
222044
243695
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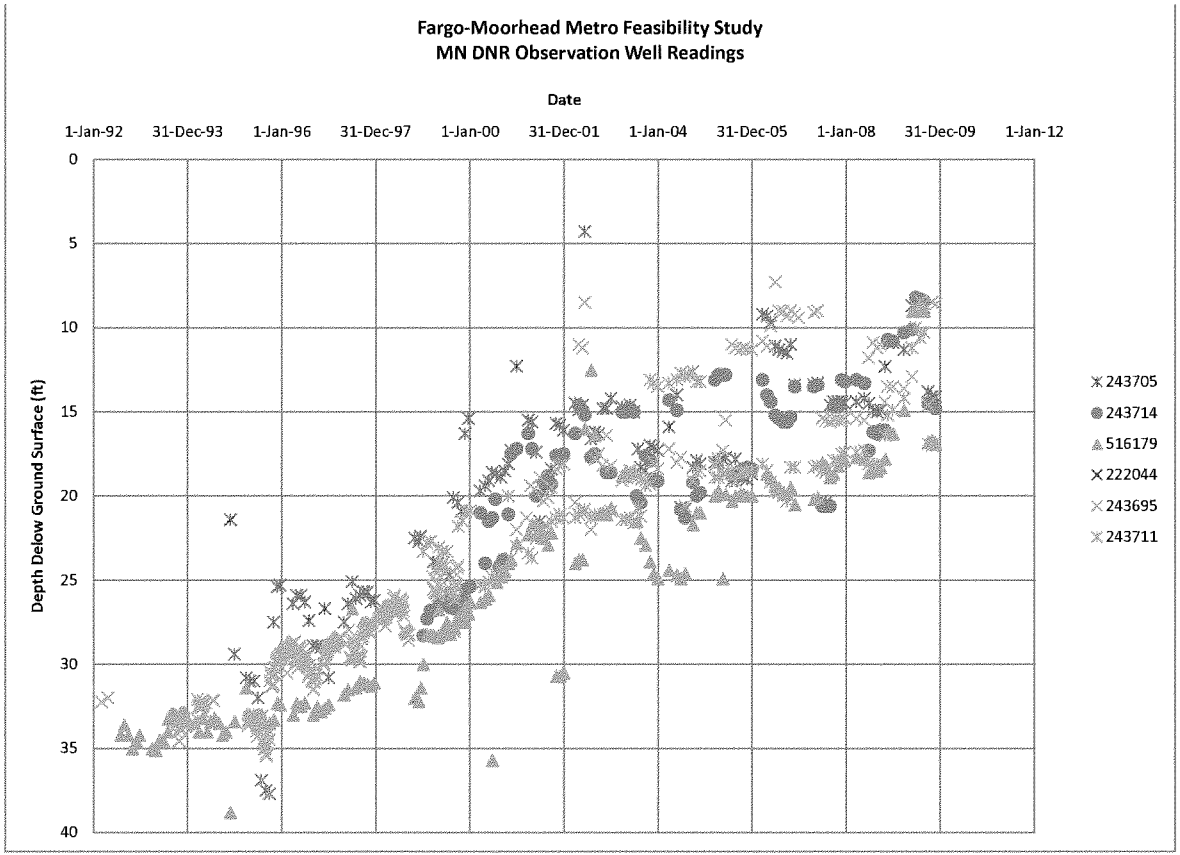
243715
243698
243699
243700


Fargo-Moorhead Metro Feasibility Study
MN DNR Observation Well Readings
Date
1-Jan-92
31-Dec-93
1-Jan-96
31-Dec-97
1-Jan-00
31-Dec-01
1-Jan-04
31-Dec-05
1-Jan-08
31-Dec-09
1-Jan-12
Depth Below Ground Surface (ft)
0
5
10
15
20
25
30
35
40
243705
243714
516179
222044
243695
243711

US Army Corps of Engineers, St. Paul District	PROJECT TITLE: Fargo - Moorhead Metro Feasibility Study	COMPUTED BY: KAH	DATE: 2 SEP 09	SHEET: 1
	SUBJECT TITLE: Seepage: Piping & Uplift	CHECKED BY:	DATE	CONTRACT NO.:

Piping: Factor of Safety for Escape Gradient

EM 1110-2-1901

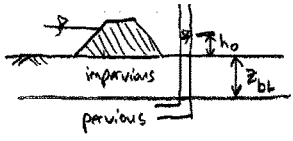
$$i_{cr} = \frac{\gamma_m'}{\gamma_w} = \frac{\gamma_b}{\gamma_w}$$

$$FS_G = \frac{i_{cr}}{i_e} = \frac{\gamma_b}{i_e \times \gamma_w} = \frac{\gamma_{sat} - \gamma_w}{i_e \times \gamma_w}$$

Proof: Look at element at surface

$$FS = \frac{\text{Resistance}}{\text{Applied}} = \frac{\gamma_b \times \text{volume}}{i_o \gamma_w \times \text{volume}} = \frac{\gamma_b}{i_o \gamma_w}$$

Uplift: Factor of Safety Against Uplift or Heaving



EM 1110-2-1901

$$h_c = \frac{z_{bl} \gamma_{sub}}{\gamma_w} \qquad i = \frac{\Delta h}{z}$$

Long Term: (Effective Stress)

$$FS_h = \frac{h_c}{h_o} = \frac{z_{bl} \gamma_{sub}}{\gamma_w h_o} = \frac{\gamma_{sub}}{\gamma_w i}$$

Also look at Short Term, Total Stress

$$FS_h = \frac{\text{Force Down}}{\text{Force Up}} = \frac{\gamma_{sat} z_{bl}}{\gamma_w (z_{bl} + h_o)}$$

(Take from CEE 5554 - Soil & Site Improvement, Martin and Olgun, Spring 2007)

Attachment I-14: Instrumentation

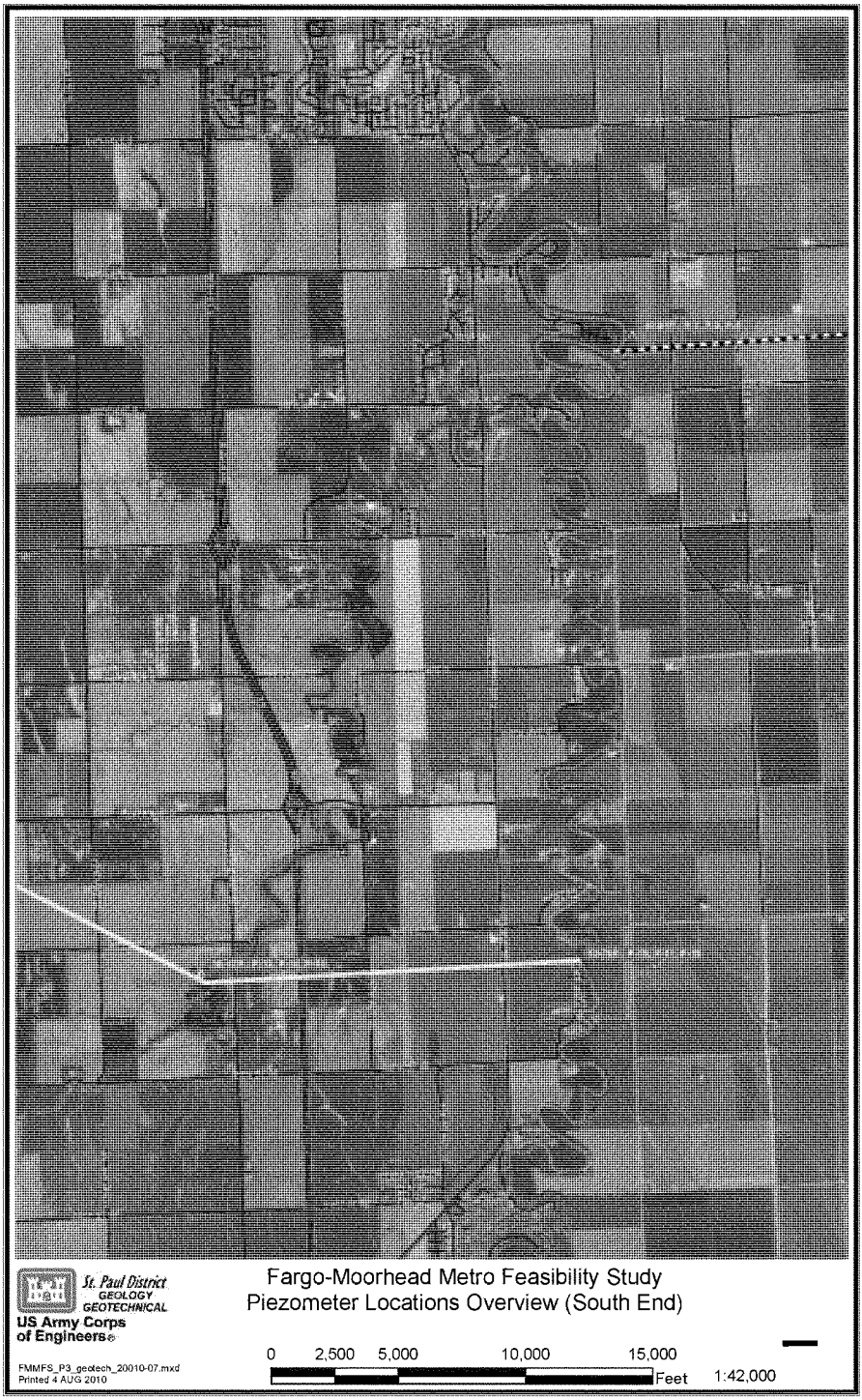
St. Paul District GEOLOGY GEOTECHNICAL
US Army Corps of Engineers

Project: Fargo-Moorhead Metro Feasiblity Study
Subject: Summary of Piezometers

Generated By: KAH
Date: 07/14/10
Last Modified By: KAH
Date of Last Revision: 09/02/10

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

Attachment I-14, pg 2
Geotechnical Design and Geology


St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps
of Engineers
Fargo-Moorhead Metro Feasibility Study
Piezometer Locations Overview (South End)
FMMFS_P3_geotech_20010-07.mxd
Printed 4 AUG 2010
0 2,500 5,000 10,000 15,000
Feet
1:42,000

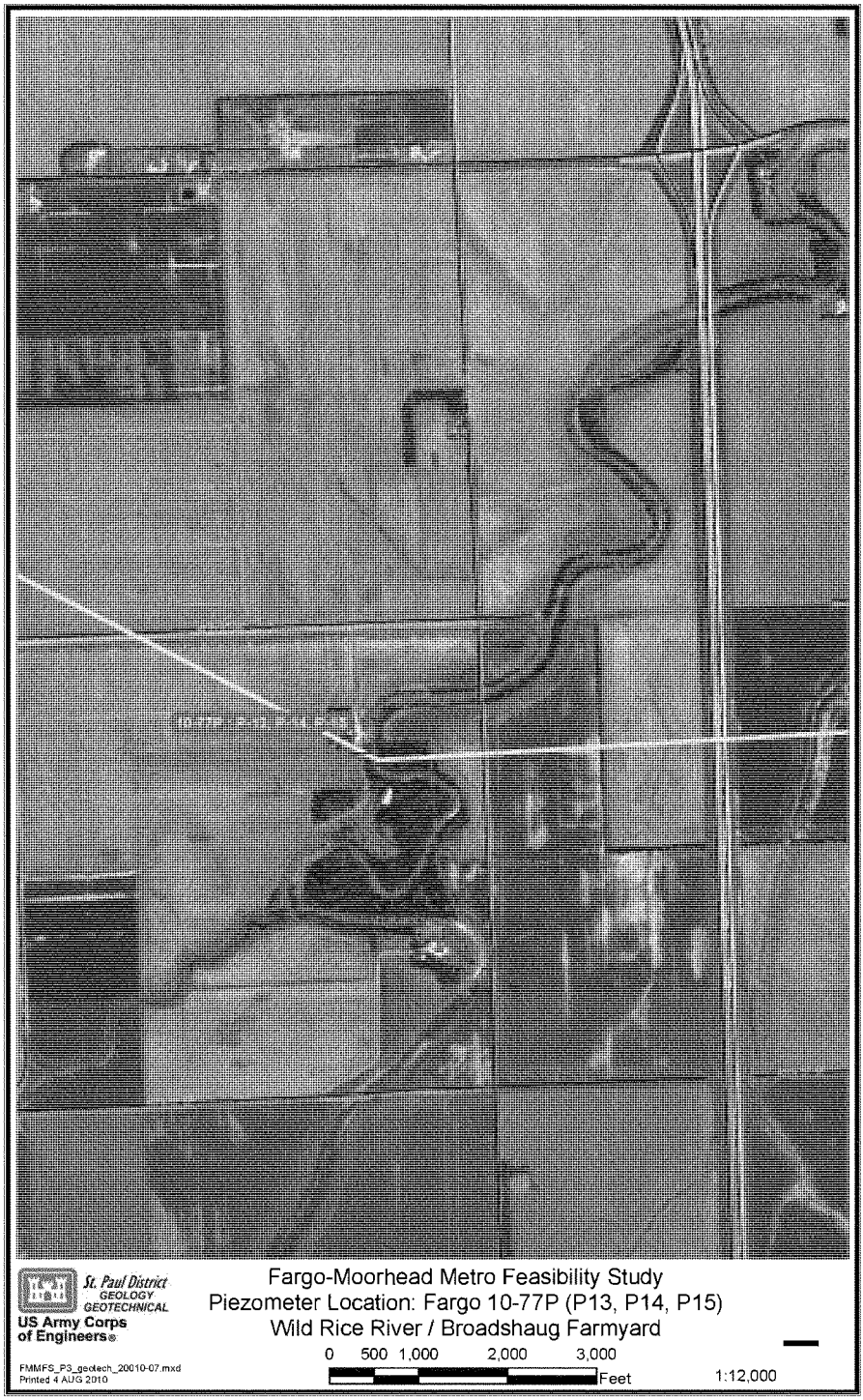
Attachment I-14, pg 4
Geotechnical Design and Geology

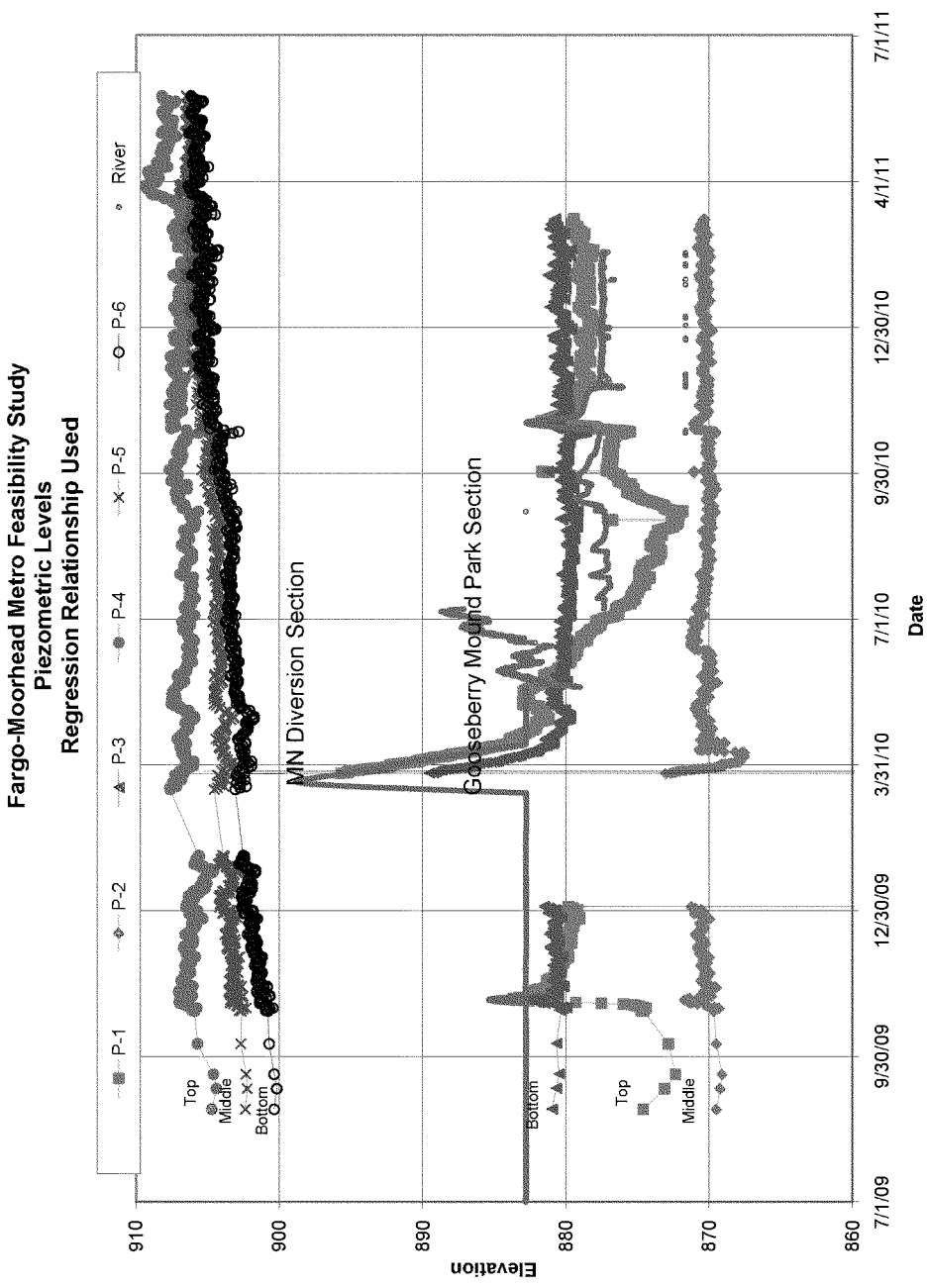
Fargo-Moorhead Metro Feasibility Study
Piezometer Location: MN Diversion
P4 - P6, P10 - P12, & P23
St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps
of Engineers
FMMFS_P3_geotech_20010-07.mxd
Printed 4 AUG 2010
0
1,000
2,000
4,000
6,000
Feet
1:18,000

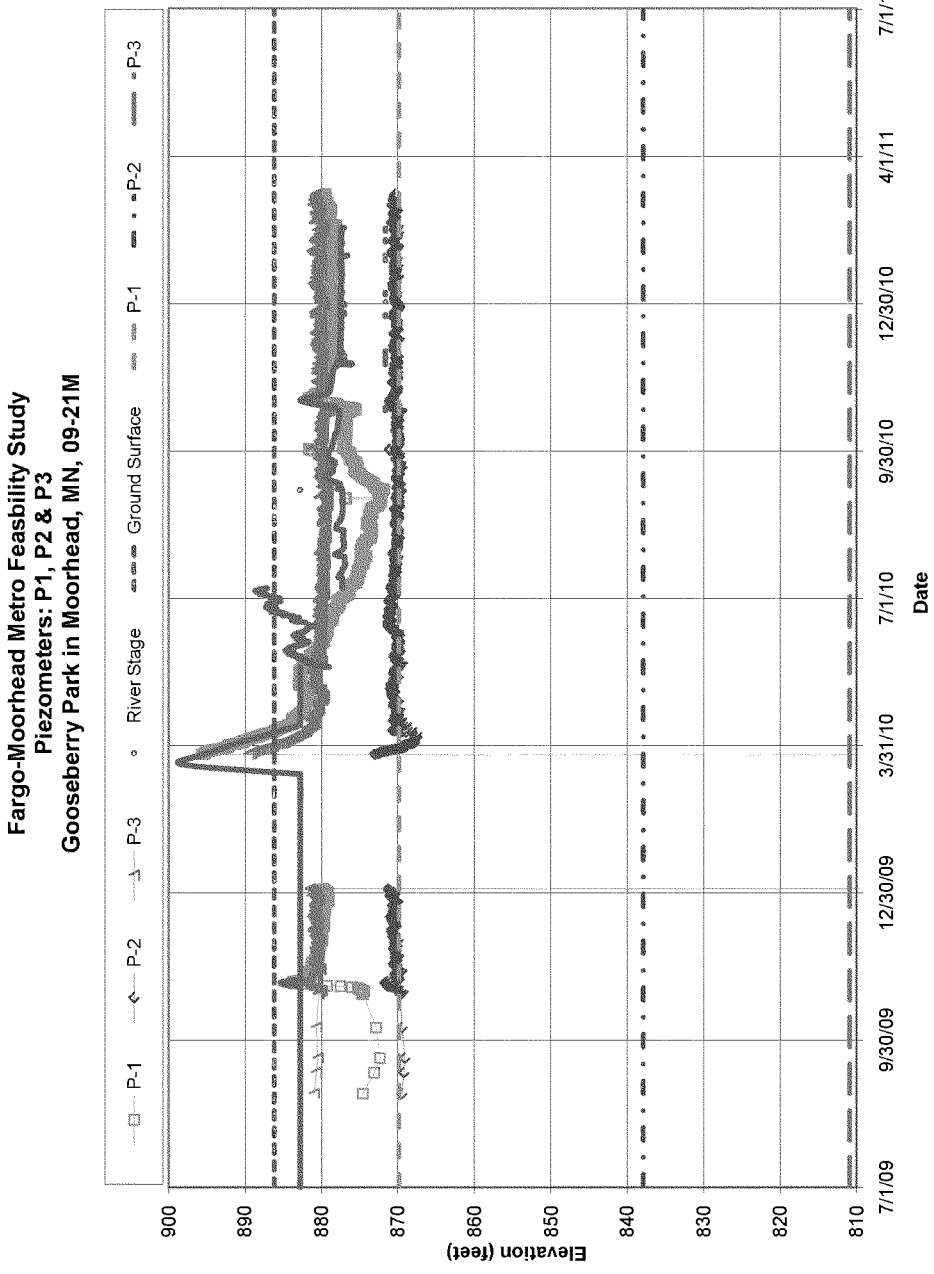
Fargo-Moorhead Metro Feasibility Study
Piezometer Location: MN Diversion
P4 - P6, P19 - P22, & P23
St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps
of Engineers
FMMFS_P3_geotech_20010-07.mxd
Printed 4 AUG 2010
0
1,000
2,000
4,000
6,000
Feet
1:18,000

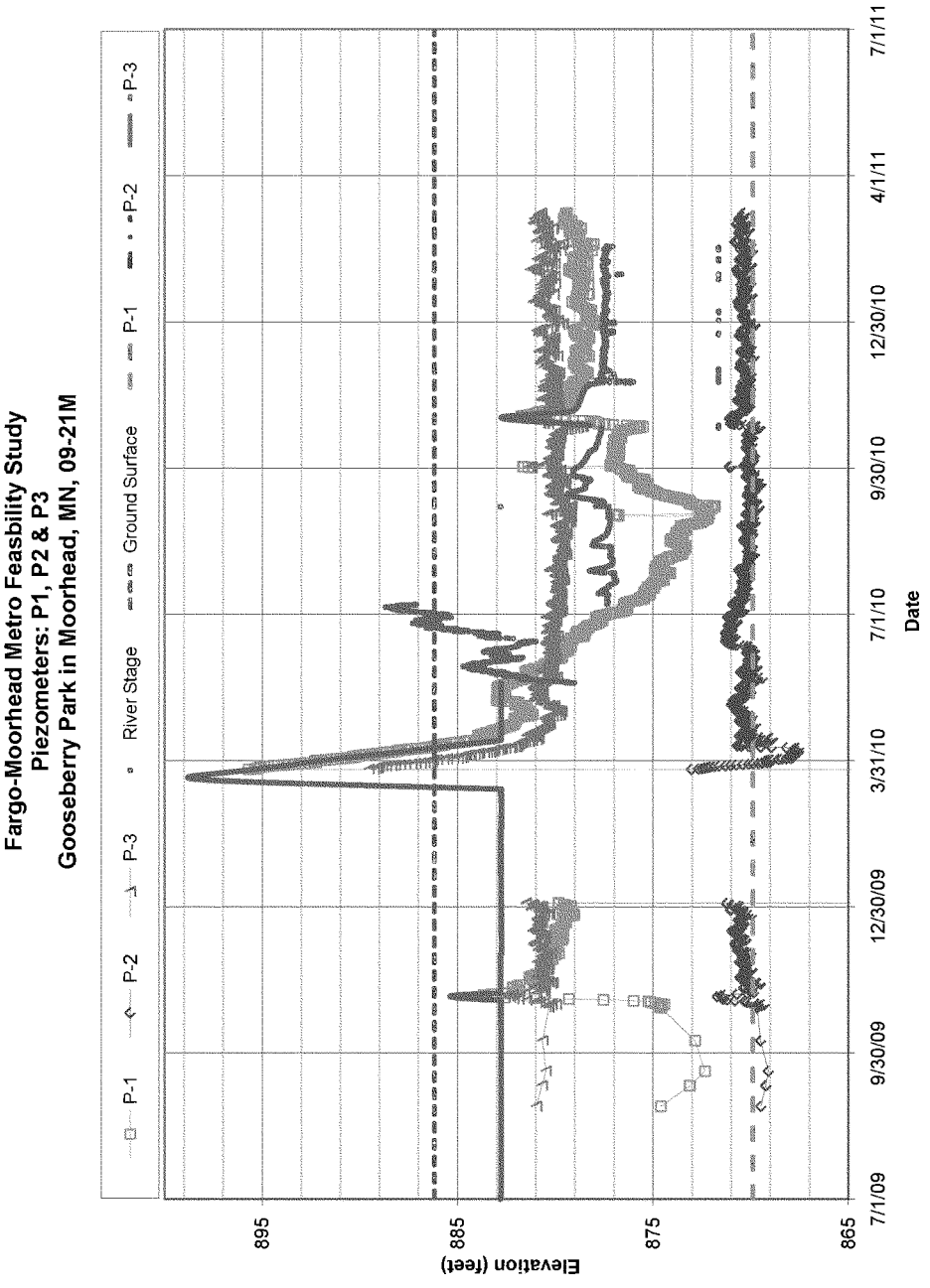
St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps
of Engineers
Fargo-Moorhead Metro Feasibility Study
Piezometer Location: Moorhead 10-81P (P7, P8, P9)
MN Diversion Red River Control Structure
0 500 1,000 2,000 3,000
Feet
1:12,000
FMMFS_P3_geotech_20010-07.mxd
Printed 4 AUG 2010

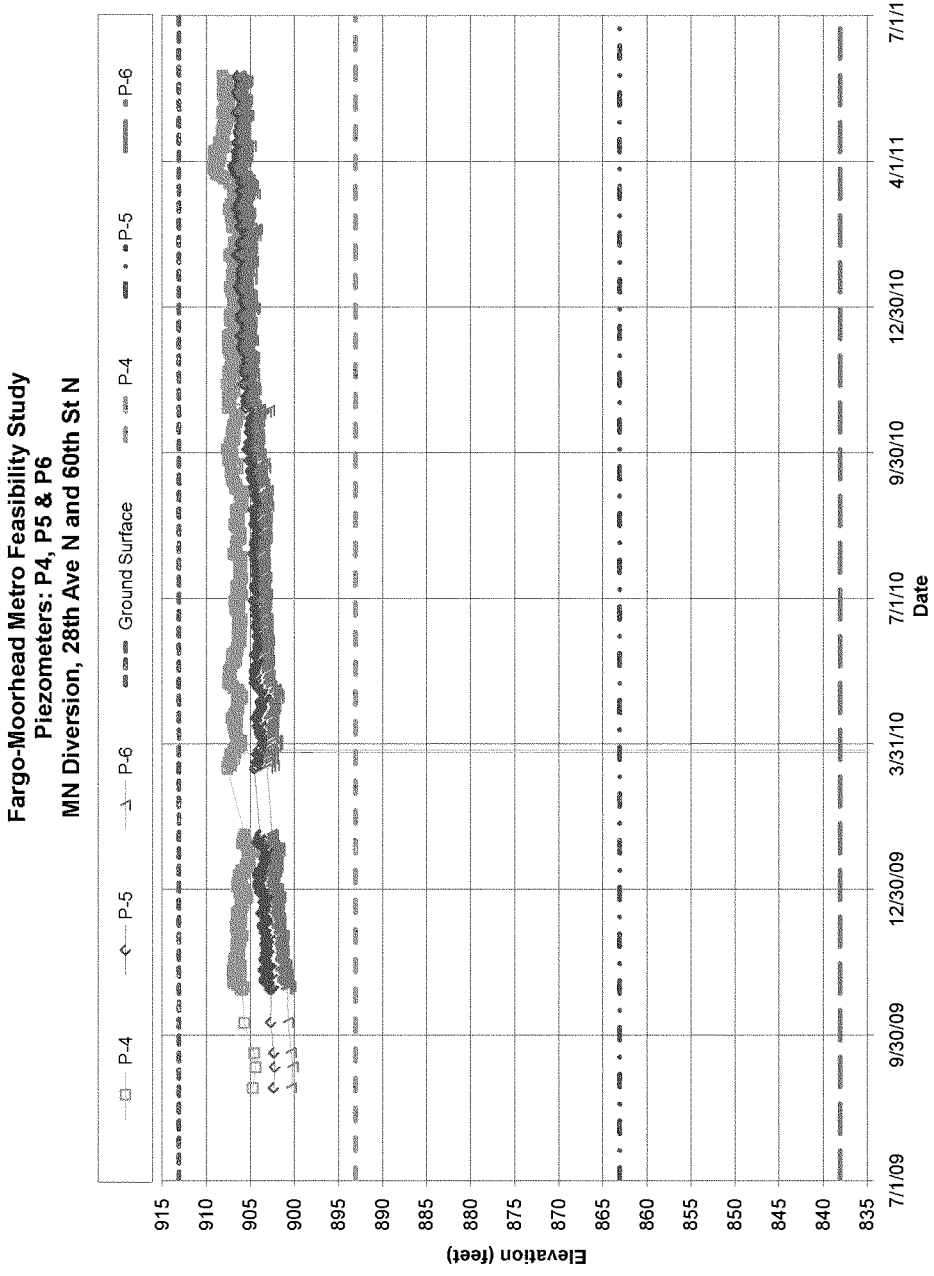
Fargo-Moorhead Metro Feasibility Study
Piezometer Location: Fargo 10-79P (P16, P17, P18)
ND Diversion Red River Control Structure
St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps
of Engineers
FMMPFS_P3_geotech_20010-07.mxd
Printed 4 AUG 2010
0 500 1,000 2,000 3,000
Feet
1:12,000

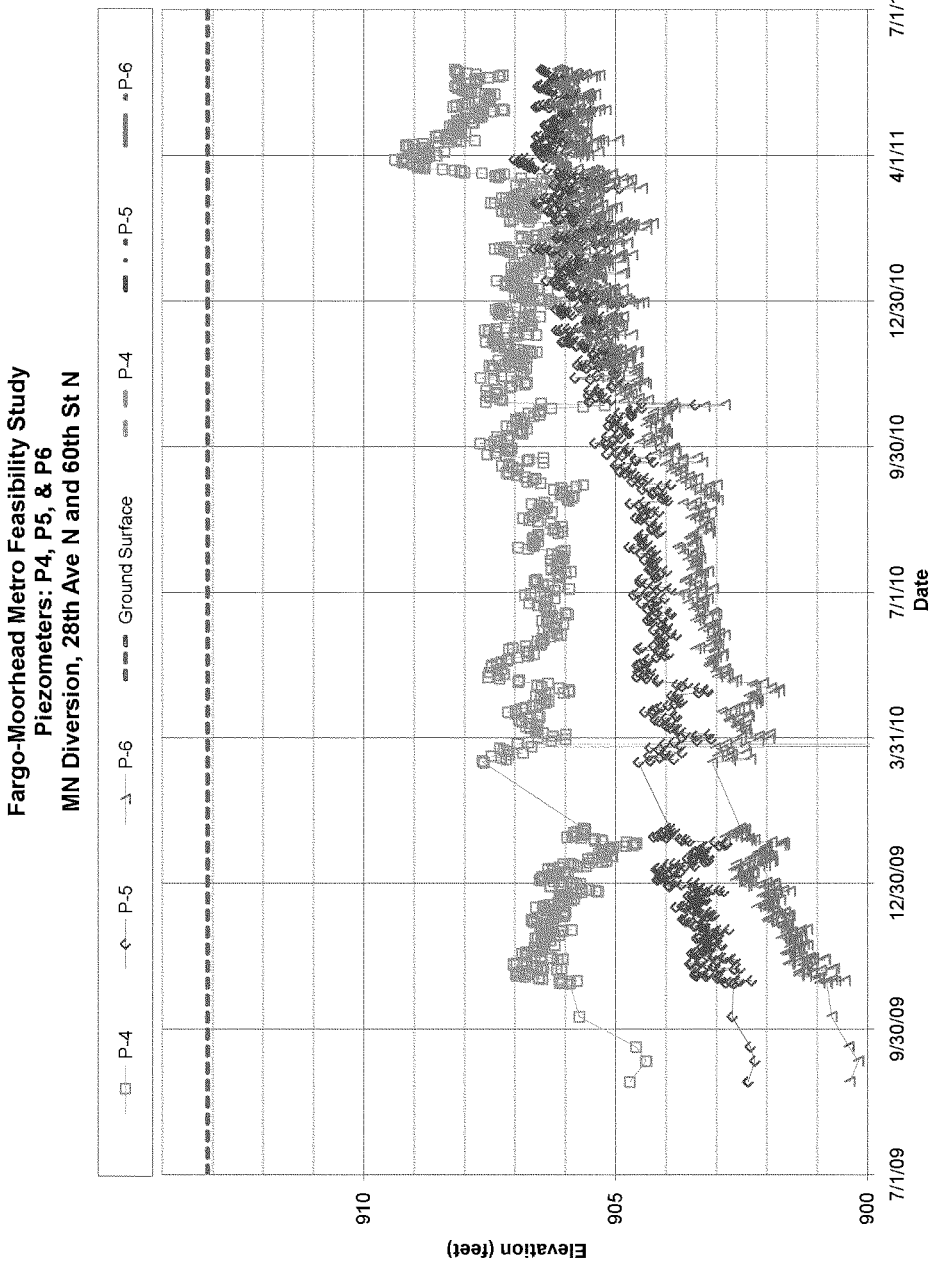

St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps
of Engineers
Fargo-Moorhead Metro Feasibility Study
Piezometer Location: Fargo 10-77P (P13, P14, P15)
Wild Rice River / Broadshaug Farmyard
0 500 1,000 2,000 3,000
Feet
1:12,000
FMMFS_P3_geotech_20010-07.mxd
Printed 4 AUG 2010

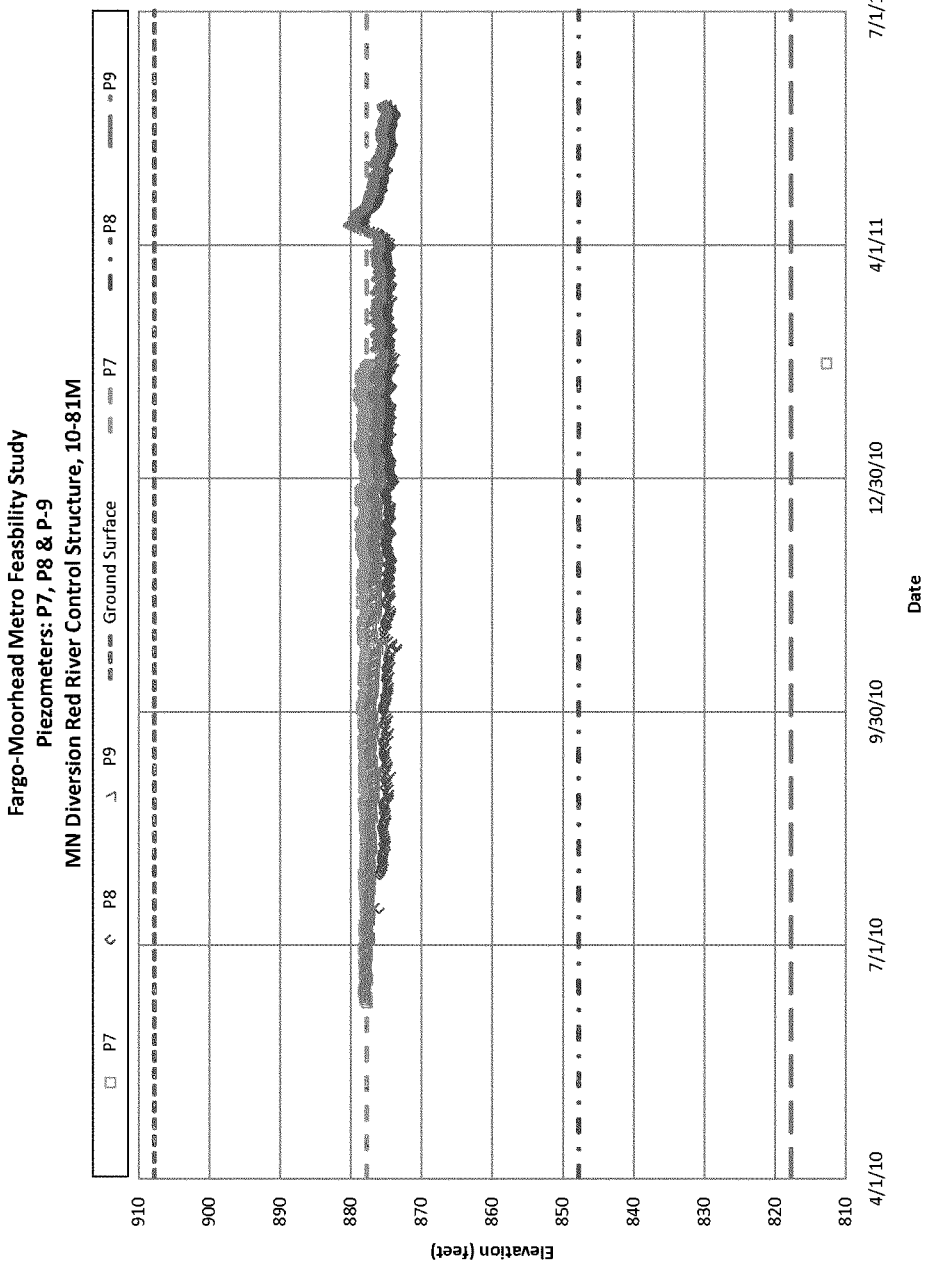

Fargo-Moorhead Metro Feasibility Study
Piezometric Levels
Regression Relationship Used
P-1
P-2
P-3
P-4
P-5
P-6
River
Top
Middle
Bottom
Top
Middle
Bottom
MN Diversion Section
Gooseberry Mound Park Section
Elevation
910
900
890
880
870
860
7/1/09
9/30/09
12/30/09
3/31/10
7/1/10
9/30/10
12/30/10
4/1/11
7/1/11
Date

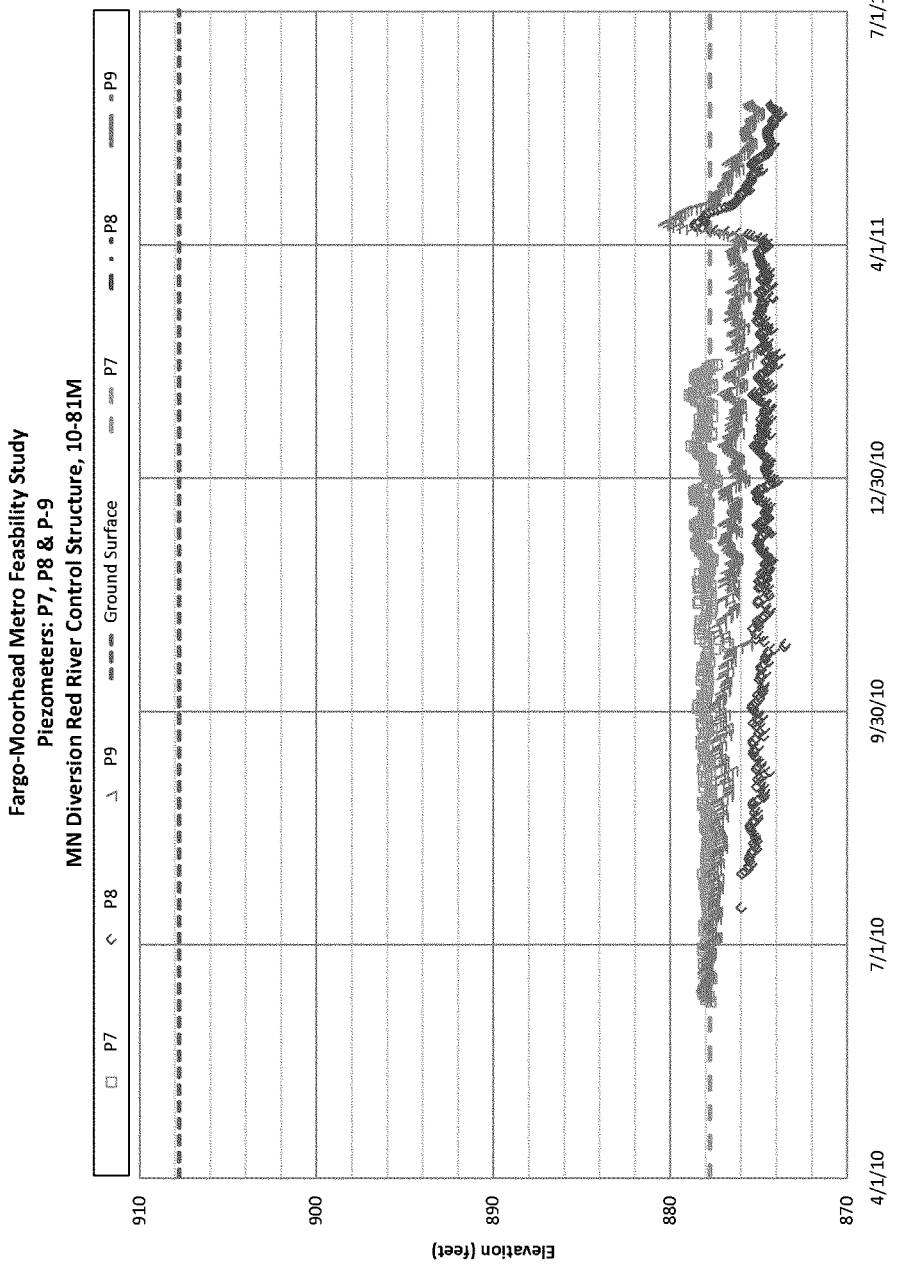

Fargo-Moorhead Metro Feasibility Study
Piezometers: P1, P2 & P3
Gooseberry Park in Moorhead, MN, 09-21M
P-1
P-2
P-3
River Stage
Ground Surface
P-1
P-2
P-3
Elevation (feet)
900
890
880
870
860
850
840
830
820
810
7/1/09
9/30/09
12/30/09
3/31/10
7/1/10
9/30/10
12/30/10
4/1/11
7/1/11
Date

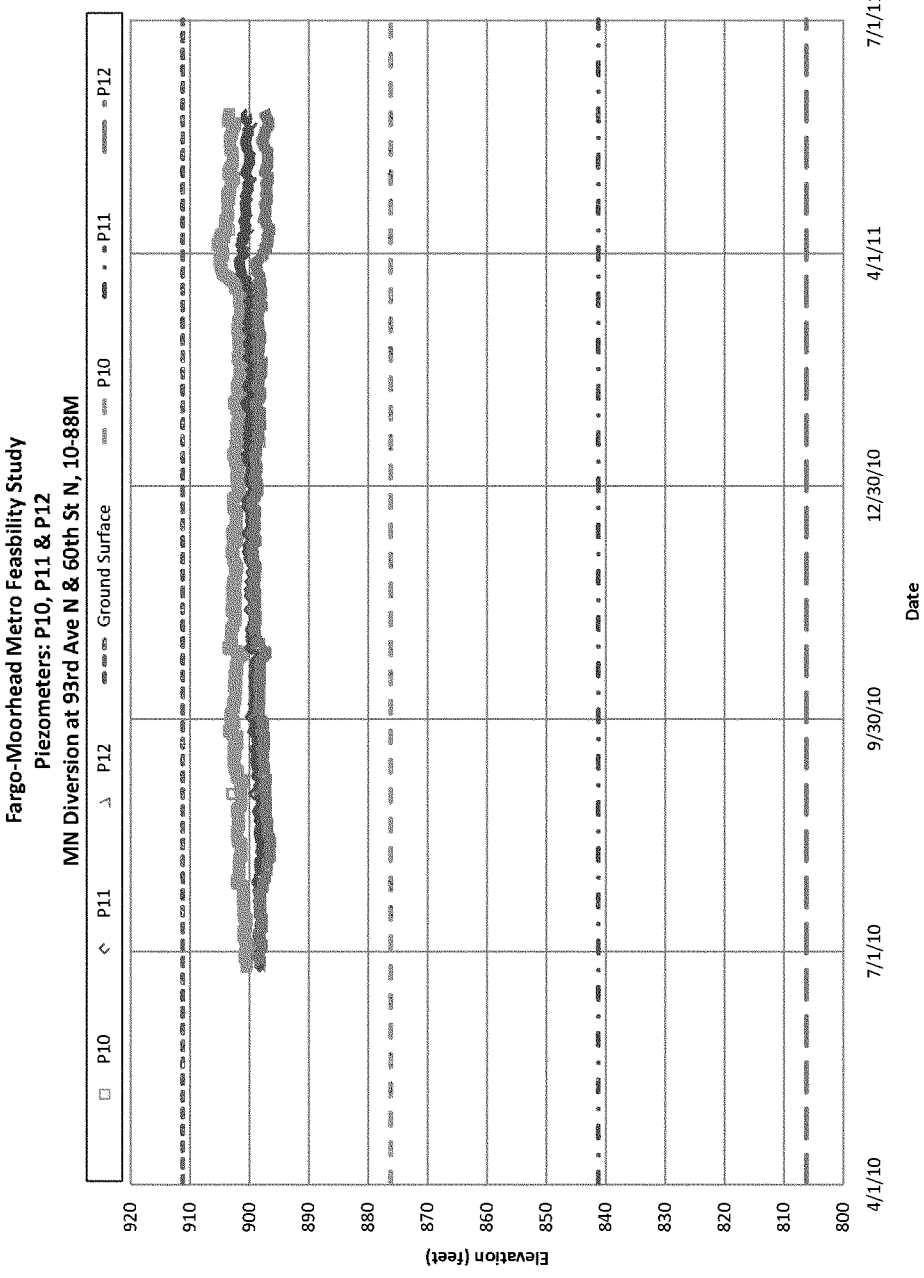

Fargo-Moorhead Metro Feasbility Study
Piezometers: P1, P2 & P3
Gooseberry Park in Moorhead, MN, 09-21M
P-1
P-2
P-3
River Stage
Ground Surface
P-1
P-2
P-3
Elevation (feet)
895
885
875
865
7/1/09
9/30/09
12/30/09
3/31/10
7/1/10
9/30/10
12/30/10
4/1/11
7/1/11
Date

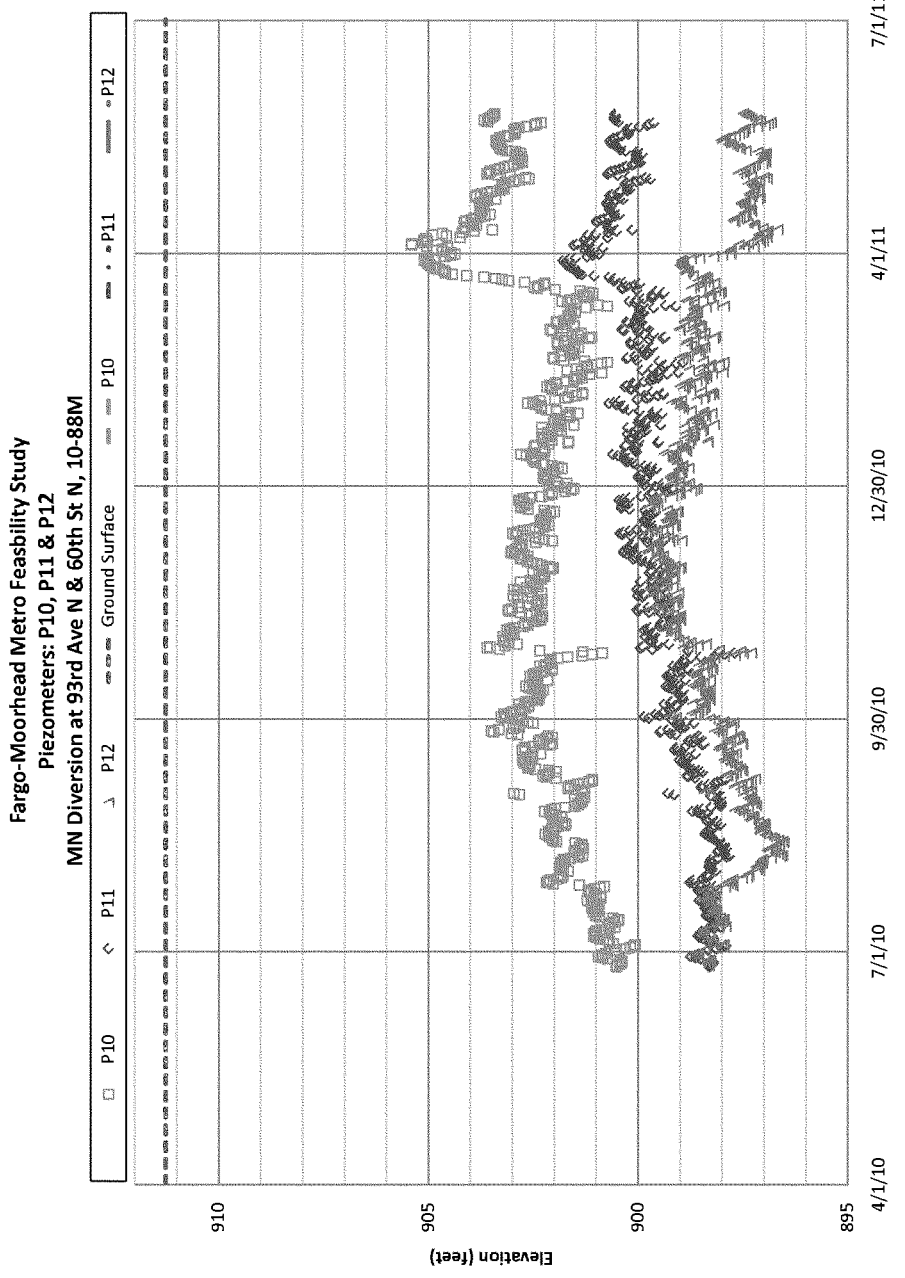

Fargo-Moorhead Metro Feasibility Study
Piezometers: P4, P5 & P6
MN Diversion, 28th Ave N and 60th St N
P-4
P-5
P-6
Ground Surface
P-4
P-5
P-6
Elevation (feet)
915
910
905
900
895
890
885
880
875
870
865
860
855
850
845
840
835
7/1/09
9/30/09
12/30/09
3/31/10
7/1/10
9/30/10
12/30/10
4/1/11
7/1/11
Date

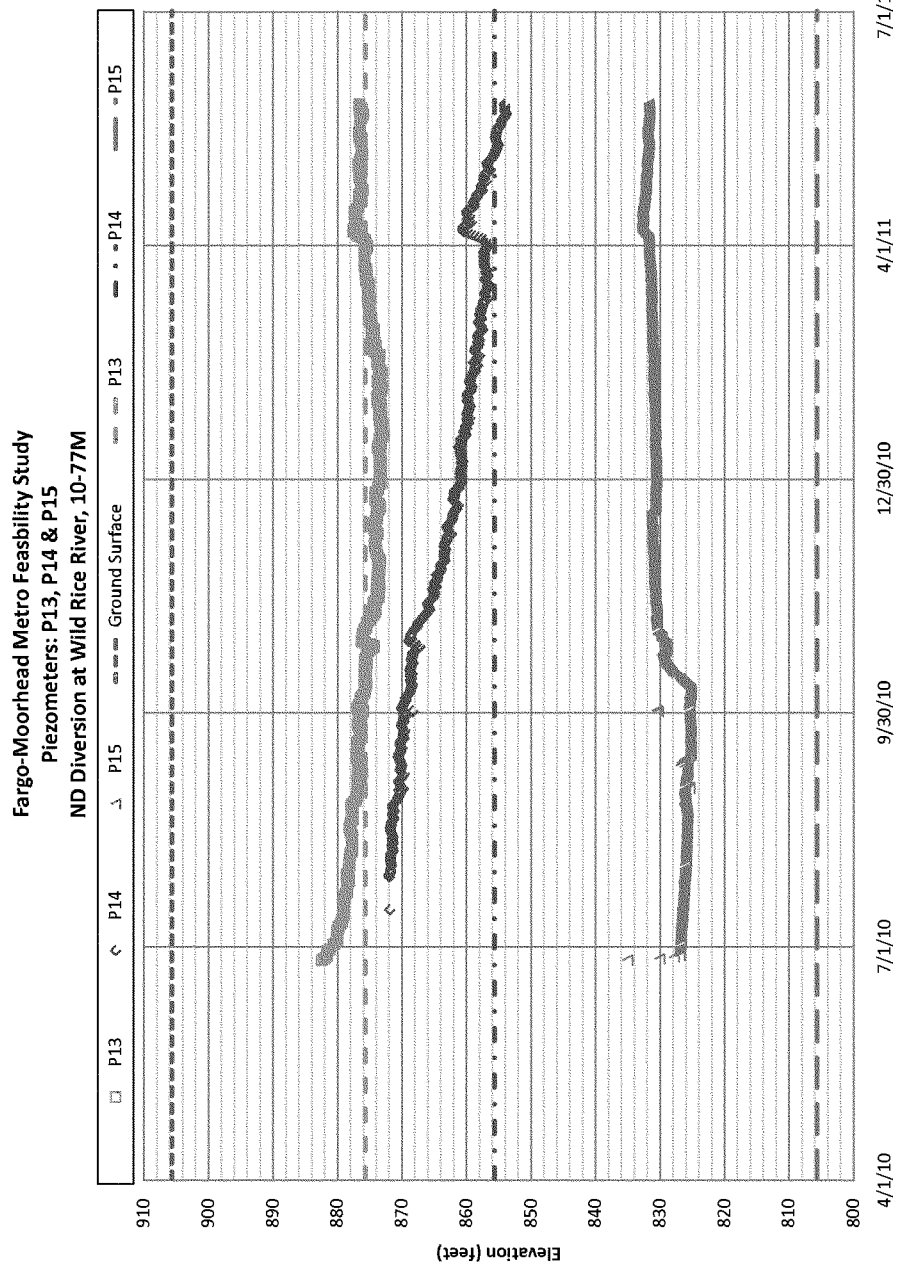

Fargo-Moorhead Metro Feasibility Study
Piezometers: P4, P5, & P6
MN Diversion, 28th Ave N and 60th St N
P-4
P-5
P-6
Ground Surface
P-4
P-5
P-6
Elevation (feet)
910
905
900
7/1/09
9/30/09
12/30/09
3/31/10
7/1/10
9/30/10
12/30/10
4/1/11
7/1/11
Date

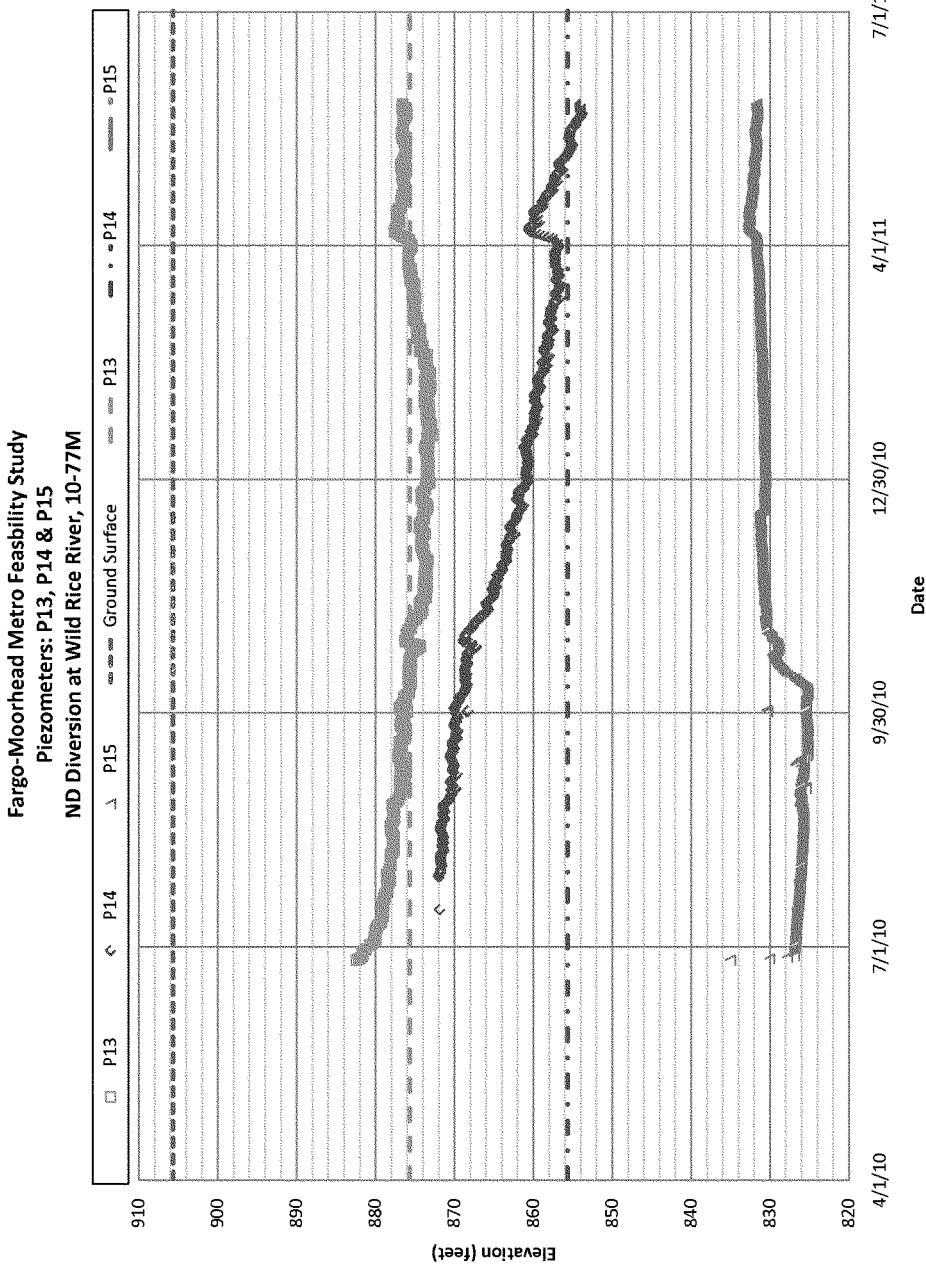

Fargo-Moorhead Metro Feasbility Study
Piezometers: P7, P8 & P-9
MN Diversion Red River Control Structure, 10-81M
P7
P8
P9
Ground Surface
P7
P8
P9
Elevation (feet)
910
900
890
880
870
860
850
840
830
820
810
4/1/10
7/1/10
9/30/10
12/30/10
4/1/11
7/1/11
Date

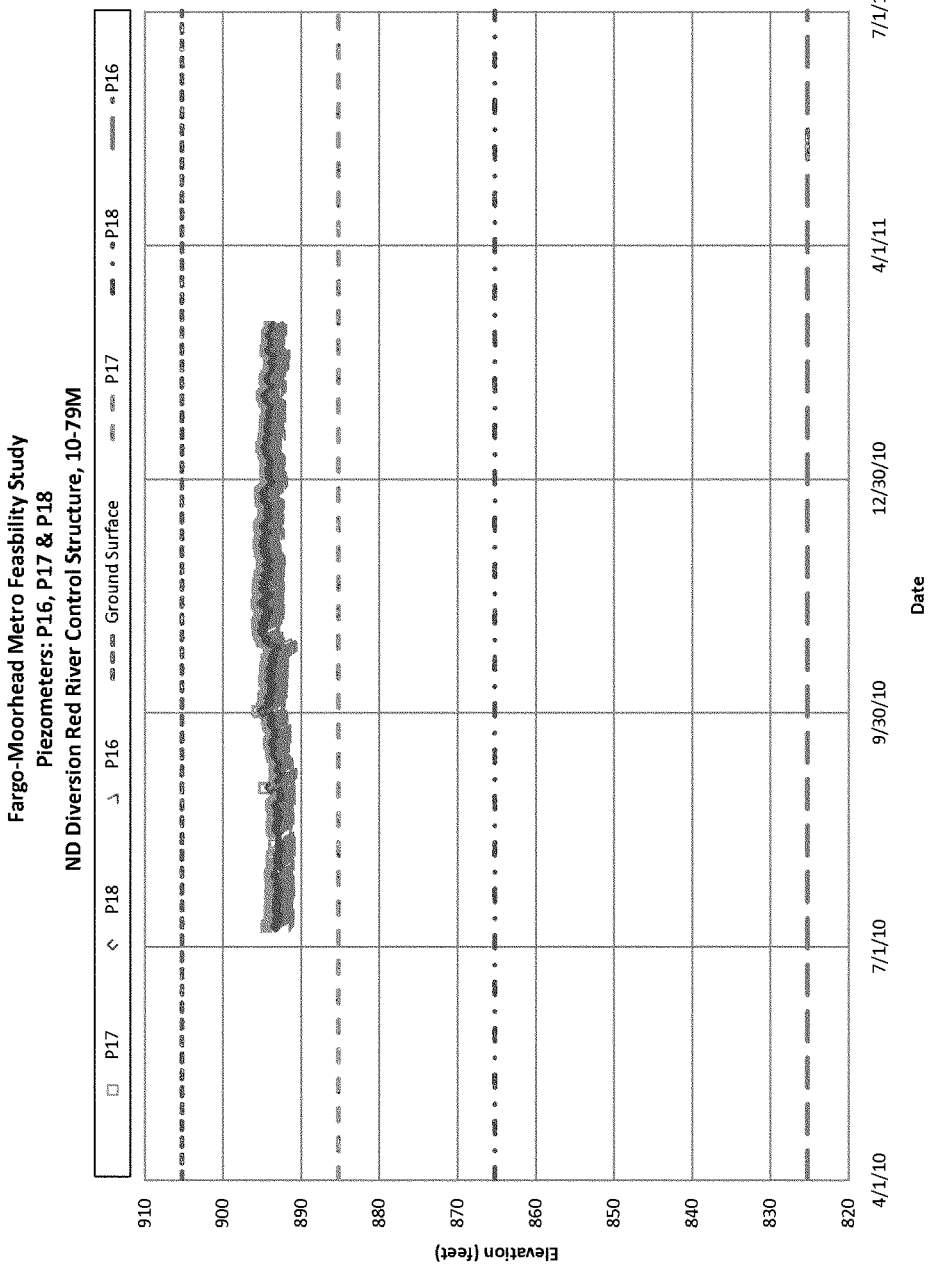

Fargo-Moorhead Metro Feasbility Study
Piezometers: P7, P8 & P-9
MN Diversion Red River Control Structure, 10-81M
P7
P8
P9
Ground Surface
P7
P8
P9
910
900
890
880
870
Elevation (feet)
4/1/10
7/1/10
9/30/10
12/30/10
4/1/11
7/1/11
Date

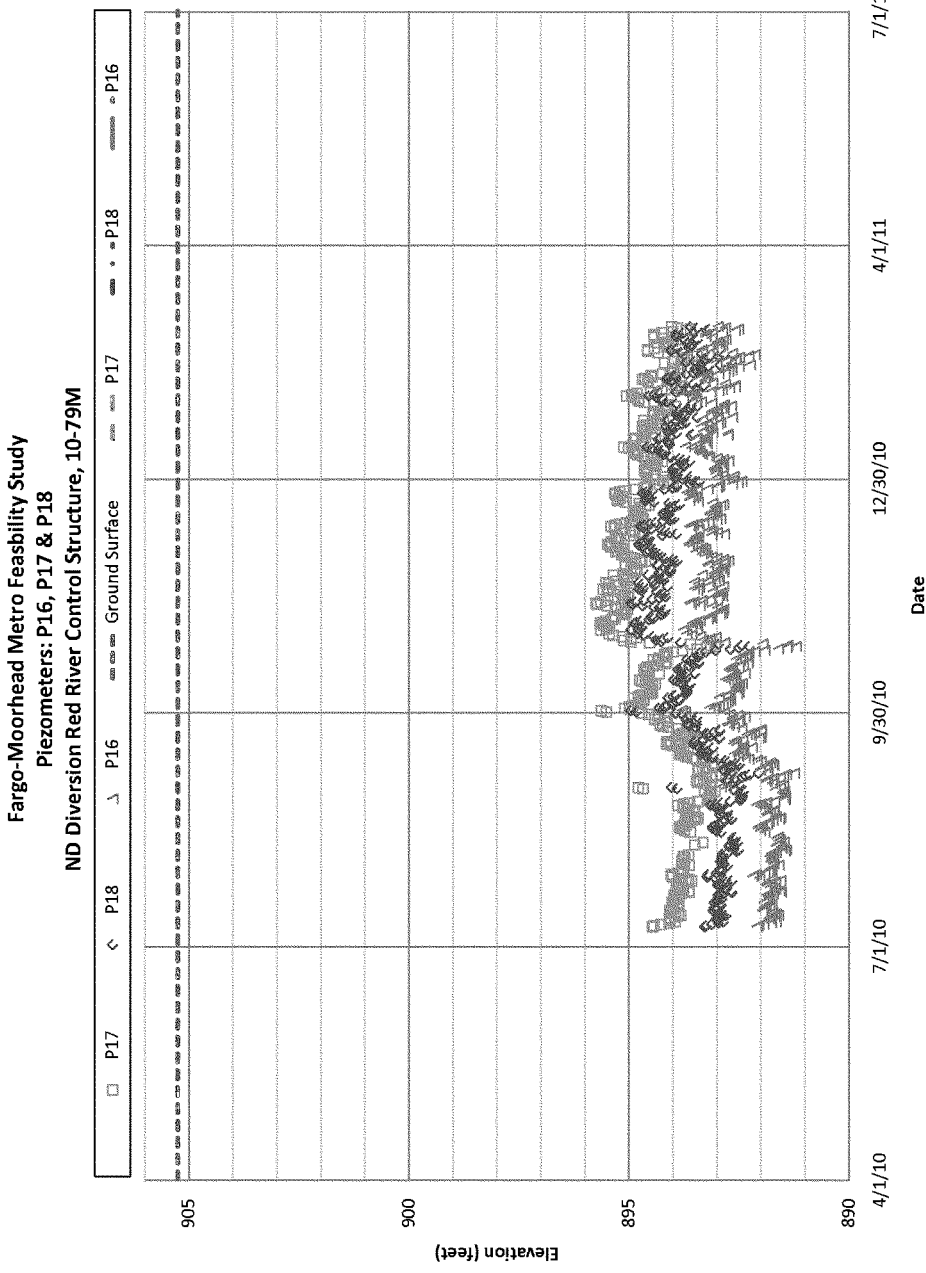

Fargo-Moorhead Metro Feasbility Study
Piezometers: P10, P11 & P12
MN Diversion at 93rd Ave N & 60th St N, 10-88M
P10
P11
P12
Ground Surface
P10
P11
P12
Elevation (feet)
920
910
900
890
880
870
860
850
840
830
820
810
800
4/1/10
7/1/10
9/30/10
12/30/10
4/1/11
7/1/11
Date

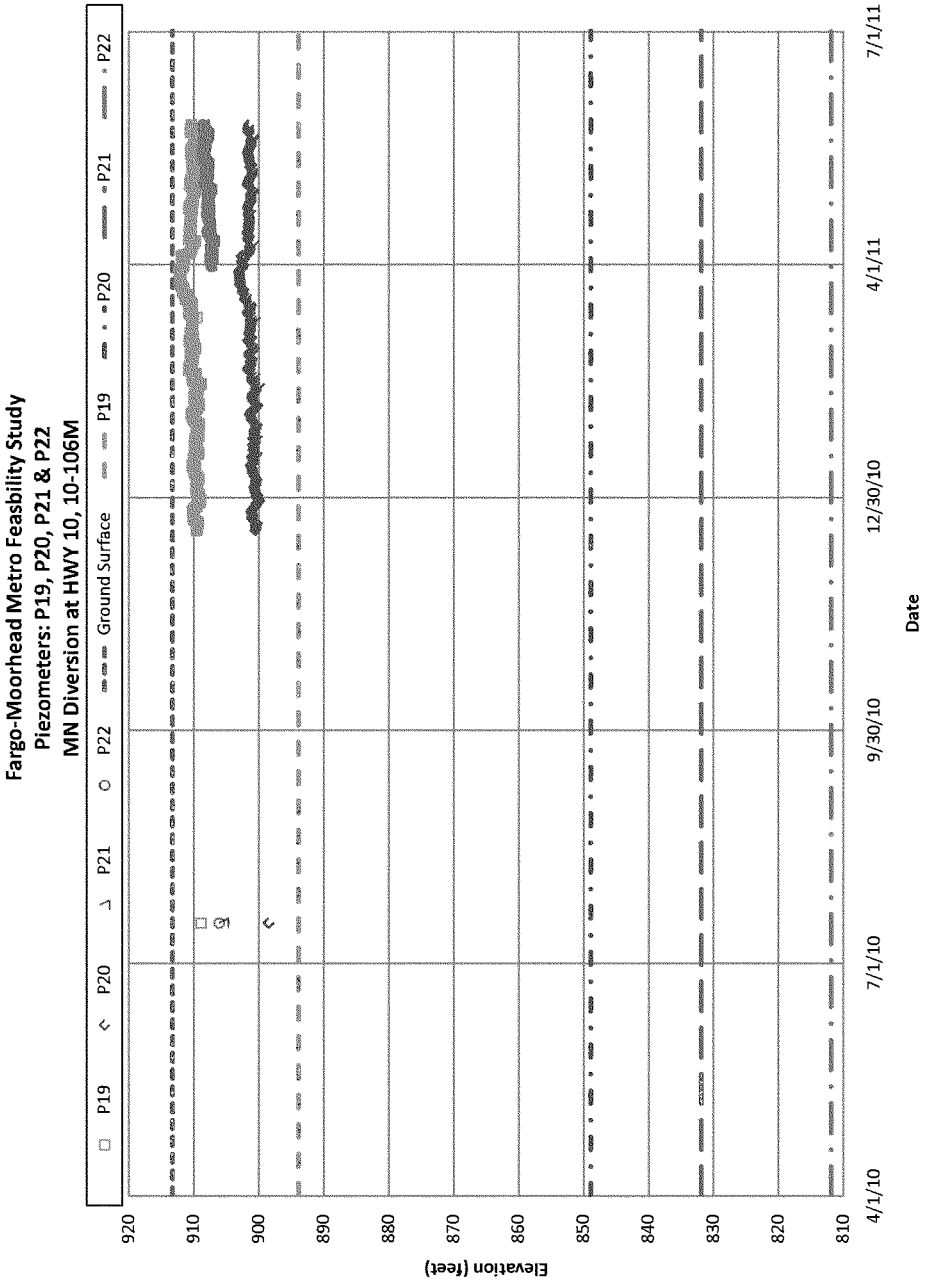

Fargo-Moorhead Metro Feasbility Study
Piezometers: P10, P11 & P12
MN Diversion at 93rd Ave N & 60th St N, 10-88M
P10
P11
P12
Ground Surface
P10
P11
P12
910
905
900
895
Elevation (feet)
4/1/10
7/1/10
9/30/10
12/30/10
4/1/11
7/1/11
Date

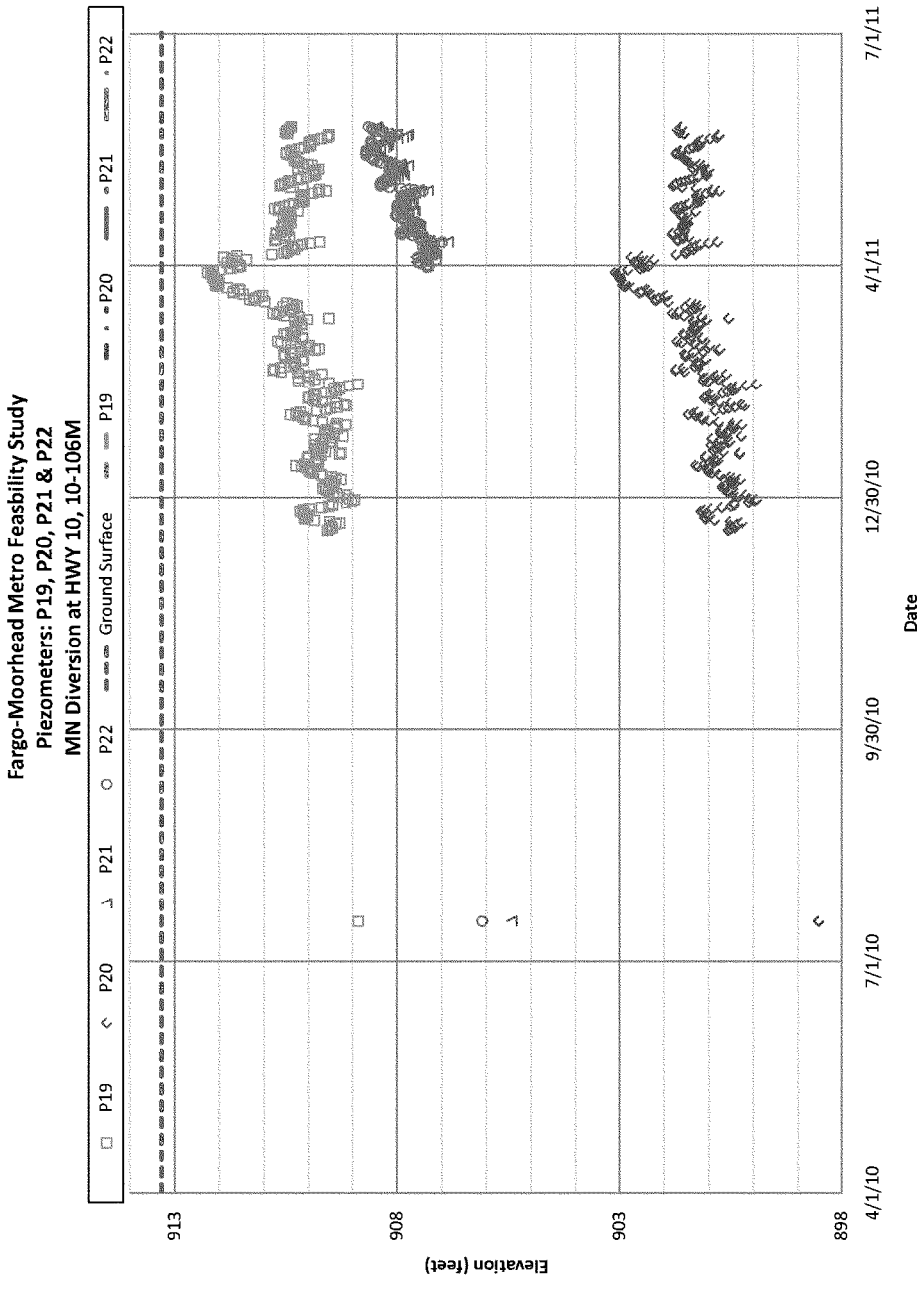

Fargo-Moorhead Metro Feasibility Study
Piezometers: P13, P14 & P15
ND Diversion at Wild Rice River, 10-77M
P13
P14
P15
Ground Surface
P13
P14
P15
Elevation (feet)
910
900
890
880
870
860
850
840
830
820
810
800
4/1/10
7/1/10
9/30/10
12/30/10
4/1/11
7/1/11
Date

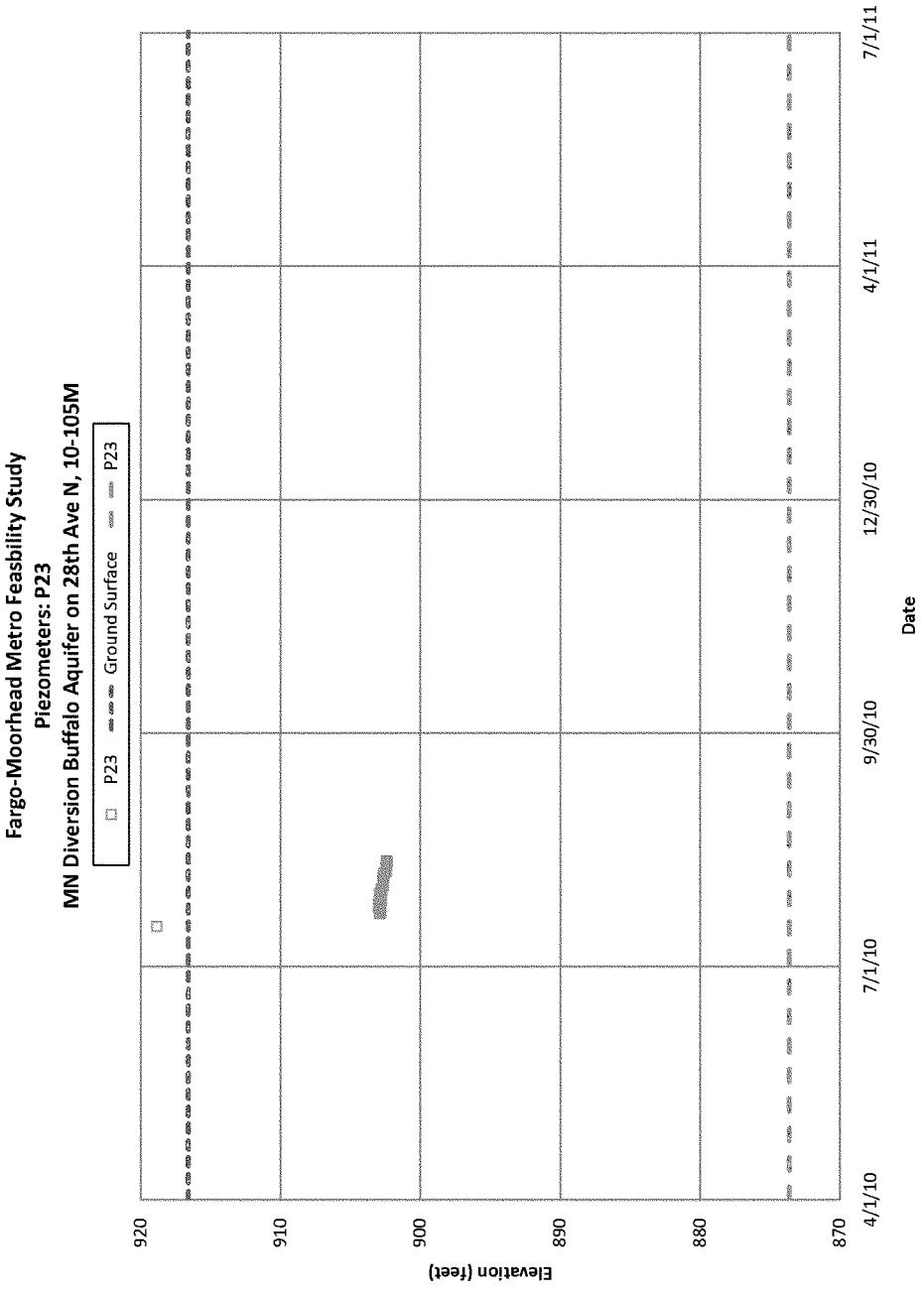

Fargo-Moorhead Metro Feasbility Study
Piezometers: P13, P14 & P15
ND Diversion at Wild Rice River, 10-77M
P13
P14
P15
Ground Surface
P13
P14
P15
Elevation (feet)
910
900
890
880
870
860
850
840
830
820
4/1/10
7/1/10
9/30/10
12/30/10
4/1/11
7/1/11
Date


Fargo-Moorhead Metro Feasbility Study
Piezometers: P16, P17 & P18
ND Diversion Red River Control Structure, 10-79M
P17
P18
P16
Ground Surface
P17
P18
P16
Elevation (feet)
910
900
890
880
870
860
850
840
830
820
4/1/10
7/1/10
9/30/10
12/30/10
4/1/11
7/1/11
Date


Fargo-Moorhead Metro Feasbility Study
Piezometers: P16, P17 & P18
ND Diversion Red River Control Structure, 10-79M
P17
P18
P16
Ground Surface
P17
P18
P16
905
900
895
890
Elevation (feet)
4/1/10
7/1/10
9/30/10
12/30/10
4/1/11
7/1/11
Date


Fargo-Moorhead Metro Feasibility Study
Piezometers: P19, P20, P21 & P22
MN Diversion at HWY 10, 10-106M
P19
P20
P21
P22
Ground Surface
Elevation (feet)
920
910
900
890
880
870
860
850
840
830
820
810
4/1/10
7/1/10
9/30/10
12/30/10
4/1/11
7/1/11
Date


Fargo-Moorhead Metro Feasibility Study
Piezometers: P19, P20, P21 & P22
MN Diversion at HWY 10, 10-106M
P19
P20
P21
P22
Ground Surface
P19
P20
P21
P22
913
908
903
898
Elevation (feet)
4/1/10
7/1/10
9/30/10
12/30/10
4/1/11
7/1/11
Date


Fargo-Moorhead Metro Feasbility Study
Piezometers: P23
MN Diversion Buffalo Aquifer on 28th Ave N, 10-105M
P23
Ground Surface
P23
Elevation (feet)
920
910
900
890
880
870
4/1/10
7/1/10
9/30/10
12/30/10
4/1/11
7/1/11
Date

Attachment I-15: Reviews

Agency Technical Review of Phase 2 and Phase 3 Documents

January 2010 & August 2010

Comment Report: Discipline Specific Comments
Project: **Fargo-Moorhead Metro Feasibility**
Review:**For the ATR - AFB Document**
(sorted by Discipline , ID)
Displaying 29 comments for the criteria specified in this report.

Id	Discipline	Section/Figure	Page Number	Line Number
3094401	Geotechnical	n/a'	I-2	n/a

(Document Reference: Appendix I; Topography)

"The Proposed Project" referred to in paragraph 7 and subsequent discussions in paragraphs 7, 8, and 9 only discuss the in-town levee alternative. Recommend similar overview of topography be included for the diversion alternatives.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 26-Feb-10

1-0	Evaluation **Concurred** The topography discussion (page I-2) was revised to indicate the topography for the In-town levee alignments. Paragraphs were added to discus the topography along the ND and MN diversion channel alternatives (page I-3). As additional borings are obtained, the geology discussion will be revised as needed during Phase 3. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 16-Mar-10
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 17-Mar-10
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3094405	Geotechnical	n/a'	I-7/8	n/a

(Document Reference: Appendix I; Seismic Risk and Earthquake History)

Seismic Risk and Earthquake History - the relevance of low risk for seismic activity should be expanded to demonstrate weather or not seismic loads will control any design. ER 1110-2-1806 and ER 1110-2-1150 require that preliminary design seismic motions and a preliminary evaluation of key features be addressed at the feasibility stage.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 26-Feb-10

1-0	Evaluation **Concurred** A seismic evaluation to determine expected ground motions will be completed and added to the report during Phase 3. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 16-Mar-10
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 17-Mar-10
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3094408	Geotechnical	n/a'	I-9	n/a

(Document Reference: Appendix I; Borings)

Clarify the sampling technique and document relevant factors for interpreting field test results – verify that the blows recorded on the logs are only those produced with the standard split spoon and not the modified spoon used for continuous sampling. Also, include information regarding the type of hammer used and its efficiency so adjustments may be made to the field blow counts if needed for future analyses.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 26-Feb-10

1-0	Evaluation **Concurred** Clarifications have been added to indicate how the sampling was completed using the modified and standard spilt spoons. The blow counts on the drafted logs are from the standard SPT. Autohammers were used during sampling. (pages I-9 & I-10) Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 16-Mar-10
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 17-Mar-10
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3094412	Geotechnical	n/a'	I-10	n/a

(Document Reference: Appendix I; Selection of Design Parameters)

The validity of using the ultimate strength failure criteria as an indication of a materials "post-creep" strength is not understood since changes in the insitu stress state due to creep effects would occur prior to shear. Reduced strengths due to creep effects would best be determined by back-evaluating full scale slope failures known to have been preceeded by soil creep. However, the rationale for using ultimate strength parameters as a conservative shear strength estimate can be justified on the prudent assumption that significant portions of the critical failure surfaces will be indicative of progressive failure through the Brenna soils and it is therefore unlikely that its peak-strength will be mobilized simultaneously along all points throughout the potential failure surface. Recommend that statement be clarified.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 26-Feb-10

1-0	Evaluation **Concurred** The first sentence states that the Lake Agassiz soils tend to creep over time when loaded. "Creep" in this context was in reference to the progressive failure of a slope overtime, in which a small amount of movement occurs suddenly and then the slope continues to move at a slower rate over time. The selection of post-peak strength was based on a number of reasons: 1) previous Corps projects which used the same criteria, 2) Experience in the Red River Valley with expected progressive failure, 3) test data indicating a brittle stress-strain response. The paragraph has been revised to more clearly identify the reasons for selecting drained ultimate strength parameters. The word "creep" has also been removed. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 16-Mar-10
1-1	Backcheck Recommendation **Close Comment**

	Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 17-Mar-10
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3094421	Geotechnical	n/a'	I-12	n/a

(Document Reference: Appendix I; In-Town Levee Alternative, Features)

A short descriptive of the conceptual levee being analyzed (materials cross section, side slopes, crest width, range of heights, etc) and some discussion identifying areas along the alignments where suspected ground modifications (cut or fills) could require extensive evaluations should be included in the final Phase 3 report. Phase 3 refinements should also include short descriptions and relevant information pertaining to conceptual loading and elevations (sizes) for any proposed floodwalls, pump stations, closure structures, or major drainage structures.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 26-Feb-10

1-0	Evaluation **Concurred** A short description of a typical levee will be included (10' top width, 1V on 3H side slopes, 6' deep inspection trench). Discussion on other features will also be included. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 16-Mar-10
1-1	Backcheck Recommendation **Close Comment** Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 17-Mar-10
1-2	Backcheck Recommendation **Close Comment** Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 17-Mar-10
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3094425	Geotechnical	n/a'	I-12/17	n/a

(Document Reference: Appendix I; Geotechnical Design of Feasibility Alternatives; In-Town Levee Alternative)

A brief discussion should be included in Phase 3 to addresses the long-term steady-state seepage and rapid drawdown stability requirements, the necessity (or lack thereof) for seepage cutoff or seepage control, adequacy of proposed embankment materials and their source, settlement considerations, and any assumed constructability issues in order to identify potential unconventional cost issues and demonstrate that these issues have been considered in the study and will not govern levee design.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 26-Feb-10

1-0	Evaluation **Concurred** These issues would not likely be a concern in the consideration of a levee alternative but a brief discussion can be included to address the long-term steady-state seepage & rapid drawdown requirements, seepage control measures, embankment fill, consolidation, and constructability. Verbiage along these lines will be added: Due to the relatively low permeability of the soils in the Red River Valley and duration of the flood events, long-term steady-state seepage is not

	expected to develop. In the same token, stability of levees due to rapid drawdown has not been seen as an issue in the Red Rive after flooding. Based on this, these conditions do not control the levee design. In addition, seepage control/cutoffs are not generally required unless there is some pervious material near the ground surface. The exploration program did not reveal any pervious materials. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 16-Mar-10
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 17-Mar-10
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3094427	Geotechnical	n/a'	I-12/17	n/a

(Document Reference: Appendix I; Geotechnical Design of Feasibility Alternatives; In-Town Levee Alternative)

Commentary should be included to discuss the relevant geotechnical considerations for potential seepage issues around, and the foundations supporting floodwalls, closure structures, pumping plants and major drainage structures. A preliminary structure foundation type and potential need for foundation treatment should be discussed to support the rough cost basis for these structures.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 26-Feb-10

1-0	Evaluation **Concurred** The discussion concerning seepage issues and foundation treatments will be included and discussed in the paragraphs describing these structures. Due to the relative impermeable nature of the materials generally encountered in the Red River Valley, seepage is not a major concern. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 16-Mar-10
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 17-Mar-10
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3094428	Geotechnical	n/a'	I-18	n/a

(Document Reference: Appendix I; Geotechnical Design of Feasibility Alternatives; Minnesota Diversion Channel Alternatives; Design Sections)

Figures detailing the assumed strata thicknesses and excavation depths at each of the four sections would be helpful.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 26-Feb-10

1-0	Evaluation **Concurred** A generalized stratigraphy of the four MN Diversion Channel sections will be included in

	Attachment I-8. It will be similar to the assumed stratigraphy for the preliminary geotech analysis that was shown in the report, Figure I-1. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 16-Mar-10
1-1	Backcheck Recommendation **Close Comment** Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 17-Mar-10
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3094431	Geotechnical	n/a'	I-18	n/a

(Document Reference: Appendix I; Geotechnical Design of Feasibility Alternatives; Minnesota Diversion Channel Alternatives; Design Sections) **[This item is flagged as a critical issue.]**

The discussion on the initial side slope selection should be expanded. What is the depth of the West Fargo Diversion Channel and how long has it been in service? What specific performance observations lead to this conclusion (i.e. was it dictated by performance during construction or long term maintenance needs, etc.). Also, what is the justification for going to steeper slopes at bridge locations.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 26-Feb-10

1-0	Evaluation **Concurred** More details will be included on selection of side slopes: The depth of the WFDC is 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 WFDC indicated that steeper slopes 1V on 5H would be acceptable. 1V on 7H slopes were selected to allow the side slopes to be mowed with standard farm equipment. Erosion of the WFDC at the toe of the slopes have lead to slope instability that had to be fixed. The steepness of the slopes at the bridge locations will be further evaluate during Phase 3. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 16-Mar-10
1-1	Backcheck Recommendation **Close Comment** Potential impacts cannot be identified until further evaluation is done as a part of phase 3. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 17-Mar-10
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3094435	Geotechnical	n/a'	I-18	n/a

(Document Reference: Appendix I; Geotechnical Design of Feasibility Alternatives; Minnesota Diversion Channel Alternatives; Design Sections)

Clarification is needed on the second sentence: "Moore's analyses indicated that the quantity of excavated material decreased with increasing depth, meaning that the deeper excavated channels would likely be more cost effective because there was less materials to excavate"

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 26-Feb-10

1-0	Evaluation **Concurred** The sentence has been clarified to indicate that for a given hydraulic capacity, the amount of excavation required decreases with increasing depth. It reads: "Moore's analyses indicated that for a given channel capacity, the quantity of excavated material decreased with increasing depth. This means that for a given channel capacity, the deeper the excavated channel, the more cost effective it is." Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 16-Mar-10
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 17-Mar-10
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3094436	Geotechnical	n/a'	I-20	n/a

(Document Reference: Appendix I; Geotechnical Design of Feasibility Alternatives; Minnesota Diversion Channel Alternatives; Slope Stability) **[This item is flagged as a critical issue.]**

The slope stability criteria cited in para 81 applies to levees. Since the consequence of failure for a diversion channel is different than a typical levee project, a discussion should be included to define and justify the selected design criteria (i.e. safety factors) and applicable load cases. In areas outside of proposed structures (bridges, diversion structures, major drainage structures), the consequence of failure is minimal and lower FOS targets can easily be justified if it is accepted that the O&M costs over the initial few years will be higher in order to maintain channel conditions until the long term state is reached. However, this is not necessarily the case around proposed structure locations and the potential for instability should be discussed in better detail to identify the need for foundation treatment. Although an effective stress analysis with pore pressures developed through Seep/W would appear to be the most fundamentally correct analysis, there is not enough groundwater information to calibrate the Seep/W model, especially at its most critical state for stability which occurs when pore pressures are at their highest. Additionally, the compacted fills for bridge approaches and spoil piles of excavated materials at the top of the slopes will generate additional pore pressures. It will likely take several years for all pore pressures to stabilize. Due to the uncertainties with the boundary conditions, it is not recommended that the pore pressures from SEEP/W model be used in the stability analyses. Recommend that a staged rapid drawdown stability analysis with a surcharge load be performed to identify the pertinent issues during and in the initial few years after construction. Long-term analyses, with or without a channel flooding, will be less stringent of a load case due to the lower pore pressures and will therefore, not govern design.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 26-Feb-10

1-0	Evaluation **Concurred** During Phase 2, preliminary analyses were completed. The intent is to further evaluate the stability of the selected diversion channels during Phase 3 as indicated in the "Additional Work" Section. The target FOS will be reevaluated during Phase 3. Both global stability and localized stability will be evaluated. The local stability will be used to evaluated the shallow sloughing failures at the toe of the slope that could be a maintenance concern. The rapid drawdown type loading condition will be investigated in addition to the end-of-construction and long-term conditions that have currently be evaluated. The use of a surcharge load for the spoil material will be investigated. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 16-Mar-10
1-1	Backcheck Recommendation **Close Comment** Potential impacts cannot be identified until surcharges are included in the refined analysis identifiied for phase 3. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 17-Mar-10
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3094437	Geotechnical	n/a'	I-21	n/a

(Document Reference: Appendix I; Geotechnical Design of Feasibility Alternatives; Minnesota Diversion Channel Alternatives; Results) [This item is flagged as a critical issue.]

A settlement analysis should be performed around proposed structure locations to identify potential issues requiring special foundation treatments, staged construction, or other special considerations that will affect foundation performance due to the application of a surcharge load, localized groundwater drawdown, and rebounding of the soils below the base of the channel. Recommend that this analysis be used to justify preliminary selection of pile type and anticipated tip elevations to overcome negative skin friction or require foundation treatment.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 26-Feb-10

1-0	Evaluation **Concurred** For the second phase of the feasibility study, no detailed geotechnical analyses were completed for the hydraulic structures or bridges crossing the diversion channel. Information from previous projects and studies in the area were instead used to develop a conceptual foundation design for the hydraulic structures. The details of the conceptual design and the costs used are detailed in Appendix L, section 6.0. In the case of the bridges, a review of the past costs for bridges was completed. A unit price per square foot was developed from historical data. Further details can be found in Appendix L, section 4.2. The methodology used to estimate the costs for the hydraulic structures and bridges is thought to be reasonable for the this stage of the study. This methodology of estimating costs will be reevaluated during Phase 3 and refinement of the assumptions and conceptual designs will be made as necessary. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 16-Mar-10
1-1	Backcheck Recommendation **Close Comment** Impacts cannot be identified until settlement analysis is performed as a part of phase 3. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 17-Mar-10
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3094438	Geotechnical	n/a'	I-23	n/a

(Document Reference: Appendix I; Geotechnical Design of Feasibility Alternatives; Minnesota Diversion Channel Alternatives; Groundwater Considerations) [This item is flagged as a critical issue.]

The Buffalo Aquifer is identified as a planning constraint, but little is presented in the report to demonstrate that the MN Diversion will have no impact on the Aquifer. The Aquifer is said to be recharged by the Buffalo River, which empties into the Red River just a few miles upstream of the diversion's terminus. Additionally, the piezometer in the sand and gravels at boring 09-14M suggests piezometric levels that extend as much as 20 feet above the proposed bottom of excavated elevation. A more detailed study of the groundwater from the Buffalo aquifer should be presented in order to demonstrate that this planning constraint is satisfied. Additional information is needed to demonstrate that a mile will provide a reasonable buffer between the aquifer and excavated diversion channel – ecspecially since it is reported that water levels in the aquifer are stated to have risen 15 feet over a 10 year period. This could potentially require additional piezometers, peophysical methods, or tracer testing to better map seepage from the aquifer.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 26-Feb-10

1-0	Evaluation **Concurred**

	The potential effects that a diversion channel on an aquifer are being evaluated. A document has been prepared to discuss the affects of a diversion channel on ground water, wetlands, and aquifers. Disscussions with other agencies will be done to help determine what is required to further evaluate the aquifer. Additional borings will be taken along the MN Diversion channel and piezometers will be installed in critical locations. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 16-Mar-10
1-1	Backcheck Recommendation **Close Comment** Findings of phase 3 work may have significant impact on study IF piez. levels in granular materials have strong correlation with Buffalo Aquifer water levels and remaining natural blanket thickness after excavation is inadeqaute. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 17-Mar-10
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3094450	Geotechnical	n/a'	I-22	n/a

(Document Reference: Appendix I; Geotechnical Design of Feasibility Alternatives; Minnesota Diversion Channel Alternatives; Uplift) **[This item is flagged as a critical issue.]**

The relevance of a SEEP/W analysis is questionable. Piping should not be a issue in clay soils due to low exit velocities and cohesion, and the pore pressures generated by the model are not reflective of the a conservative case for slope stability. Additional groundwater information would be needed to better define the boundary conditions if pore pressures need to be defined. Reliable uplift calculations could be performed by simplified analyses provided that the minimum blanket thickness and maximum piezometric pressures are characterized. Discussion should also address the effect that bridge foundations may have on the impervious blanket.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 26-Feb-10

1-0	Evaluation **Concurred** The SEEP/W analysis was used to estimate pore pressures in the soil. Assumptions had to be made on the total head boundary conditions and the distance they where located from the diversion channel. The boundary conditions will be reevaluated with respect to observed groundwater and artesian pressures during Phase 3. A simplified analysis to determine the required minimum blanket thickness based on piezometric pressures can be completed during Phase 3. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 16-Mar-10
1-1	Backcheck Recommendation **Close Comment** Impacts cannot be identified until aquifer effects are characterized and uplift analyized in Phase 3. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 17-Mar-10
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3094451	Geotechnical	n/a'	I-24	n/a

(Document Reference: Appendix I; Geotechnical Design of Feasibility Alternatives; Minnesota Diversion Channel Alternatives; Instrumentation)

The statement of a downward gradient of the flow of groundwater into the lower formations is based on the assumption of a continuous vertical flow path through all materials. There is a good potential that portions of the Brenna and

Argusville soils act as aquatards and the PZ observations are not reflective of a single groundwater table. It cannot be concluded that the PZ pressures in the lower granular materials are not hydraulically connected or being driven by the buffalo aquifer with the information presented.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 26-Feb-10

1-0	Evaluation **Concurred** The piezometric data was included in the report to indicate that measurements are being collected to investigate the fluctuation of the ground water table, other subsurface piezometric levels, and if there was excess pressures in a confined sand layer. The piezometric data only covers about 2 months of data collections. Conclusions were not drawn from this data nor was it used in the analyses. Data is being collected through the use of data loggers. Due to the small number of readings, references to trends have be removed from the text. As more data is obtained, it will be evaluated and included in the Phase 3 writeup. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 16-Mar-10
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 17-Mar-10
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3094453	Geotechnical	n/a'	I-12/17	n/a

(Document Reference: Appendix I, Geotechnical Design of Feasibility Alternatives, In-Town Levees Setback Analysis) [This item is flagged as a critical issue.]

The objective of the analysis is essentially to determine the position of the levee so as to not contribute to riverbank instability. However, most of the critical failure surfaces documented do not intersect the proposed levee area, meaning that the analysis is essentially an attempt to model the long-term stability of the existing river banks. The long term stability of the river banks are heavily influenced by the scour and deposition due to river dynamics, groundwater fluctuations and long term creep effects that cannot be accurately anticipated or characterized in the slope stability analyses. The creep, erosion and groundwater effects will take place regardless of the surcharge location and preliminary designs should identify revetments (instead of additional setback) that minimize riverbank erosion. The stability analyses to determine setback distances should tie to the top of the secondary bank. Recommend that a limited number of analyses be presented for composite soil stratigraphies that are considered conservative representations of similar reaches Review of ground surface profiles presented in Attachment I-5 consistently suggest that the average slope between the top of the secondary bank and the toe of the primary bank is about 1V on 7H. These observations suggests that the long-term stability of the riverbank could be modeled as a 1V on 7H slope (which is also significant for the diversion channel alternatives since their maximum depth of excavation is about equal to the height of the secondary bank above the riverbed). Recommend that analysis be replaced with one that determines setback distance by varying the horizontal distance of the surcharge from the top of the secondary bank (projected downward at a 1V on 7H slope) and performing an undrained analysis for the end of construction case. Past experience as well as a cursory analysis on these soils suggest that levees of this height will result in minimal setback distances from the top of the secondary slope and might be dictated more by riverside access for O&M considerations.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 26-Feb-10

1-0	Evaluation **Non-concurred** During Phase 2, the preliminary and revised analyses were completed in order to determine the setback of the levees. These analyses followed the methodology that has been used for other Corps projects within the Red River Valley. These analyses are conservative, but still appropriate to determine the costs associated with the in-town levee alternative which only considered levees. The in-town levees were not recommended for further evaluation during the

	screening process for a number of reasons: 1) top elevation 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, 3) many structures would need to be removed which would have social impacts. If the in-town levees were retained during the screening process, the geotechnical analyses would have further been refined. In addition, an evaluation would have been completed to see if there were locations in which floodwalls could have been a cost effective solution. Better explanation of the analysis methodology and the screening process and its influence of the geotechnical design process will be included in the report. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 16-Mar-10
1-1	Backcheck Recommendation **Close Comment** Additional explanation on the rationale is needed in order to concur on the adequacy or relevance of the model presented for setback requirements. However, this comment is being closed based on the fact that in spite of favorable B/C ratios, the in-town levee alternative is being disconsidered due to limitations on its potential level of protection and the inherent residual risks. If the B/C ratio becomes a relevant factor, additional refinement or alternate analysis would be needed to accurately establish real estate requirements, delineate structure removals, and identify floodwalls and/or revetment needs. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 18-Mar-10
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3689363	Geotechnical	I.3.4.1	I-14	n/a

Paragraph is somewhat confusing. Suggest clarifying the 6th sentence statement "potential shear surfaces are only able to mobilize the ultimate shear strength". I think the key point is that because of the relatively high degree of strain-softening, it is unlikely that the peak shear strength will be mobilized along all points of the postulated shear surface simultaneously. It is therefore necessary to assume effective shear strength parameters that are based on the ultimate (post-peak) strength failure criteria to satisfy critical assumptions for limit equilibrium methods, as recommended in EM 1110-2-1902.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 05-Jan-11

1-0	Evaluation **Concurred** The paragraphs associated with the selection of design parameters have been rewritten to clarify what criteria was used for the different analyses and why. The rewritten paragraphs are as follows: 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 cannot 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 than 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. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 31-Jan-11
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 07-Feb-11
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3689370	Geotechnical	I.3.4.2	I-15	n/a

Not sure of accuracy of the strain estimate or how relevant it is since undrained tests exhibit brittle behavior. Consider deleting last sentence in paragraph to avoid confusion on which strengths were actually adopted for the undrained analysis

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 05-Jan-11

1-0	Evaluation **Concurred** The paragraphs associated with the selection of design parameters have been rewritten to clarify what criteria was used for the different analyses and why. The rewritten paragraphs are as follows: 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 cannot 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 than 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. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 31-Jan-11
1-1	Backcheck Recommendation **Close Comment** Closed without comment.

	Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 07-Feb-11
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3689378	Geotechnical	Appendix I-5	13-20	n/a

UU Strength Data plotted on pages 13-20 in appendix I-5; undrained shear stress is labeled as units of tsf instead of psf.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 05-Jan-11

1-0	Evaluation **Concurred** The indicated units of undrained shear stress have been changed to psf to match the plotted data and will be replotted for the March 2011 submittal. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 31-Jan-11
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 07-Feb-11
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3689382	Geotechnical	I.5.2.1.3	I-20	n/a

The first sentence is not accurate. EM 1110-2-1913 does address foundation stability due to new "flood barrier" loads (Section 6-5; Case I - End of Construction). Suggest editing this paragraph to point out that the design methodology developed by St Paul is based on a conservative pre-construction stability evaluation in order to develop confidence in a minimum setback distance.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 05-Jan-11

1-0	Evaluation **Concurred** The drained loading case addressed by EM 1110-2-1913 is Case 3, Steady seepage from full flood stage, which assesses the stability of the landside slope during a flood. The St. Paul District, through experience, has found that slope stability of the natural slope and determining a stable and reliable zone in which to construction the flood barrier is more critical. Both effective and total stress analyses are completed to determine the stability of the natural slope and flood barrier. In the case of the effective stress analysis, a low river water condition is used as natural slope failures tend to occur during periods of low water when the stabilizing force of the water on the natural bank is at its lowest. Section I.5.2.1 has been revised to better discuss the design philosophy used during the evaluation of the In-Town Levee alternative. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 31-Jan-11
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 07-Feb-11
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3689389	Geotechnical	I.5.2.2.3	I-21	n/a

What was the rationale for not extending the search riverward past the wet-side toe if the minimum factor of safety produced was at the search limits. It would be interesting to see what minimum factor of safety would be produced if the search on entry points extended further riverward of the wet-side toe to the secondary bank. This may help validate the limits assumed for the residual strength zone noted in paragraph I.5.6.2.2 if safety factors remain above 1.0, or it may help illustrate the level of conservatism in the analysis if such a search produces safety factors significantly less than 1.0. In either case, it would help frame the discussion for the adopted minimum target factor of safety (FS=1.2) stated in paragraph I.5.6.4.3.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 05-Jan-11

1-0	Evaluation **Concurred** The In-Town Levee alternative was evaluated during Phase 2 of the project. This evaluation was completed to get an understanding of what the potential setback distances could be for the levee alternative. It is recognized that the stability analysis completed during Phase 2 was the first effort in determining the setback requirements and that additional refinement would be required as this alternative moved forward. The decision was made at the end of Phase 2 that the In-Town Levee alternative would not be pursued any further during Phase 3 and thus no additional refinements were warranted. 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 in respect to sliding down towards the river. The slope stability analysis required that minimum FS be obtained to ensure that the levee could be constructed in a location that remained stable both during construction and also long term. It is recognized that potential shear surfaces riverward of the wet-side toe of the levee would produce lower factors of safety. Shear surfaces riverward of the wet-side toe with lower factors of safety was deemed acceptable. It is recognized that shifting the "entry" search limits riverward would produce lower factors of safety and would provide insight into the conservatism of the stability analysis based on the assumed residual zone. During Phase 3 of the project, the levee alternative would have been refined. The refinements would have included actual slide locations instead of an assumed location. With actual known slide locations, back-analysis would have been completed to estimate the residual shear strength of the soils. The estimated residual shear strength would have then been used in the slope stability analysis used to determine the required setback distances. Paragraph I.5.2.2.3 was rewritten. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 31-Jan-11
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 07-Feb-11
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3689395	Geotechnical	1.5.9.2(3)	I-29	n/a

Suggest eliminating point 3 since the removal of structures could be minimized with a more refined setback analyses or with floodwalls supported by deep foundation systems.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 05-Jan-11

1-0	Evaluation **Non-concurred** A large number of structures would have to be removed to facilitate the construction of the levees. Even with a substantial shift of the levee alignment riverward, the levee would have an impact to the residents as this would reduce the size of their backyards and also obstruct their

	view of the river. This would be considered a social effect. Floodwalls would also have an impact to the residents along the river. Point (3) has been refined as such. (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. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 31-Jan-11
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 07-Feb-11
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3689529	Geotechnical	Section 1.6.3.3; Table I-8;	n/a	n/a

	The assumed ratio of kx to ky equal to 1 may be unrealistic. The horizontal saturated permeabilities listed are typical of approximations found in textbooks, however most natural deposits can be up to ½ to 3 orders of magnitude tighter in the vertical direction. Isotropic permeability may lead to nonconservative results by allowing more pore pressure to dissipate vertically than in reality, and result in lower piezometric heads near the slope face. Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 05-Jan-11
1-0	Evaluation **Concurred** : It is recognized that for the upper foundation materials (i.e. Alluvium, Sherack, Poplar River) that these natural deposits probably have a horizontal permeability greater than the vertical permeability. For the Brenna and Argusville materials are massive and could be considered homogenous. Because of this the horizontal and vertical permeabilities would likely be very similar. Initially when setting up the seepage model, the permeability parameters were varied in order to obtain a piezometric line that seemed reasonable. Varying the horizontal to vertical permeability did not lead to a piezometric line that seemed reasonable. It was found that if the ky to kx ratio was set to 1 in the materials above the till formation and that the till formation permeability was 2 orders of magnitude greater than the Brenna and Argusville formations, that a higher piezometric line was obtained that was judged to be reasonable. This was carried forward through the Phase 3 design. A sensitivity analysis was conducted to determine what affect a ky:kx ratio would have on the stability results. The sections with the lowest FSs were checked; three sections for each diversion alternative. It was found that the slope stability factors of safety obtained when a ky:kx ratio of 1/5 was slightly lower than when using a ky:kx ratio of 1. Generally, the FSs were reduced by less than 1% but remained above the required FS of 1.4. When a ky:kx ratio of 1/10 was used, the FSs increased above those found using a ky:kx ratio of 1. A portion of Section I.6.3 was rewritten to include additional discussion. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 31-Jan-11
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 07-Feb-11
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3689536	Geotechnical	I.6.4.1.3	n/a	n/a

Although this is not the rapid draw-down condition referenced in EM 1110-2-1902, groundwater effects on a slope face are similar during saturated excavation. The highest pore pressures will occur in the soil immediately after excavation

as a result of the localized groundwater drawdown, and from the initial support of the spoil pile load. The report should include some evaluation relating to the constructability of the excavations in order to determine if special phasing or other specialized dewatering methods will be needed to limit pore water pressures near the slope during construction. Finite element procedures in Geostudio might approximate these instantaneous pore pressures for use in an effective stress slope stability analysis at various stages (depths) of excavation. The groundwater lowering process could be modeled through transient seepage analyses, but a sigma analyses may be needed to evaluate the additional pore pressure generated from the weight of the spoil pile. Such a model could also help identify critical areas and pressure thesholds to be monitored with instrumentation during test excavations.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 05-Jan-11

1-0	Evaluation **Concurred** The drained and undrained analyses completed provide for a ranged of expected performance and is deemed adequate for the design of the channel excavation. A staged excavtion type analysis was contemplated but considered more complex than required for the feasibility study for a number of reasons: (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. (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 considerable flat, being 1V on 7H. Section I.6.4.1 was revised to discuss in better details the analyses competed. A recommendation has been included that the staged excavation type analysis be completed during the planning phase. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 31-Jan-11
1-1	Backcheck Recommendation **Open Comment** Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 07-Feb-11
1-2	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 14-Mar-11
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3689548	Geotechnical	Attachment I-13	n/a	n/a

The bottom of channel elevations used in the uplift analysis are several feet higher than provided in Table I-15 and as shown for the low flow channel in Attachment I-10.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 05-Jan-11

1-0	Evaluation **Concurred** The bottom elevations in Table I-15 for the Sections 4A through 8 are incorrect. The elevations reported are based on the original invert elevation and did not consider the 4-foot invert raise that was required based on the uplift calculations. The profiles in Attachment I-13 indicate the original invert elevation and did not include the revised invert due to the 4-foot raise. Table I-15 and Attachment I-13 will be revised indicate the correct invert based on the 4-foot raise. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 31-Jan-11

1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 07-Feb-11
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3689554	Geotechnical	Para I.6.8.3	n/a	n/a

An increasing trend in aquifer water levels is noted in paragraph I.7.0.2 and is apparent on page 9 of Attachment I-13. The uplift analysis should consider long term piezometric projections. It may also be useful to develop piezometric elevation contours from the available data since the confined nature of the aquifer below the diversion channel may not limit projected heads to less than the current ground surface elevation.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 05-Jan-11

1-0	Evaluation **Concurred** Engineering judgment was used in predicting what the future piezometric elevation could be in the aquifer. It is noted that since 1992, the MN DNR observation wells have shown a significant increase in the piezometric level in the aquifer; up to a 20-foot raise. Most of this occurred between 1992 and 2005, with the rate of increase slowing down after 2005. The piezometer clusters installed by the COE in 2009 and 2010 in areas near the proposed diversion alignment are indicating piezometric levels in the aquifer 9 to 14 feet below the ground surface. There is no current modeling being completed to project what piezometric levels may be in the future. Based on the MN DNR observation well levels and the COE piezometer clusters, a piezometric level of 7.5 feet below the ground surface was deemed appropriate. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 31-Jan-11
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 07-Feb-11
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3690096	Geotechnical	I.6.8.5	n/a	n/a

The materials classified in Boring 10-102M are named as a SP-SM, which is a Poorly graded sand with silt. Materials of this classification have very little fines (less than 12%) and should be considered pervious, which does not make the analysis overly conservative.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 05-Jan-11

1-0	Evaluation **Concurred** I agree that the results of the uplift calculation for boring 10-102M is not overly conservative. The explanation was meant to indicate that a minor change to the alignment could be done to eliminate the concern of uplift and to solely base the design of the MN Diversion on boring 10-102M would be over conservative. Will remove the "overly conservative" statement. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 31-Jan-11
1-1	Backcheck Recommendation **Close Comment**

	Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 07-Feb-11
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3690105	Geotechnical	Appendix I	n/a	n/a

There is no geotechnical discussion of the slurry cutoff wall that is called for between stations 700+00 to 815+00 (Civil Sheets CS104, CS303, and CS304). A cutoff wall may pose a issue with the excavations since it may impede drainage of the upper soils during construction. Suggest consideration be given to relief wells to reduce the pressure at the base of the blanket.

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 05-Jan-11

1-0	Evaluation **Concurred** The slurry cutoff wall was one of the alternatives discussed to deal with the uplift problems caused by the aquifer. The slurry cutoff wall was required to isolate a small portion of the aquifer so that relief wells could be installed in the vicinity of the channel bottom to relief the pressure. The aquifer needed to be isolated to allow for the installation of the relief wells, otherwise the relief wells could potentially have a drastic affect on the entire aquifer. The slurry cutoff wall alternative was replaced with the invert raise alternative and will be indicated on the drawings. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 31-Jan-11
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 07-Feb-11
	Current Comment Status: Comment Closed

Id	Discipline	Section/Figure	Page Number	Line Number
3690113	Geotechnical	Appendix I	n/a	n/a

Boring logs 10-97M; 10-99M, 10-100M, 10-101M and 10-104M are not provided

Submitted By: David Sobczyk ((402) 995-2249). Submitted On: 05-Jan-11

1-0	Evaluation **Concurred** Boring logs will be included. Submitted By: Kurt Heckendorf (651-290-5411) Submitted On: 31-Jan-11
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: David Sobczyk ((402) 995-2249) Submitted On: 07-Feb-11
	Current Comment Status: Comment Closed

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Independent External Peer Review Comments

March 26, 2010 to August 31, 2010

Comment Report: Discipline Specific Comments
Project: **Fargo-Moorhead Metro Feasibility**
Review:**For the FMM - IEPR**
(sorted by Discipline , ID)
Displaying 2 comments for the criteria specified in this report.

Id	Discipline	DocType	Spec	Sheet	Detail
3276729	Geotechnical	Other	High	n/a	n/a

(Document Reference: Comment #1)

There are insufficient geotechnical analyses to justify the proposed channel slopes, channel depth, spoil pile configuration, cost estimates, and real estate requirements for the North Dakota Diversion Alternative.

(Attachment: Fargo-Moorhead_IEPR_Comment_1.doc)

Submitted By: Julian Digialleonardo (561-656-6303). Submitted On: 19-May-10

1-0	Evaluation **Concurred** Concur - adopted The USACE recognizes the fact that minimal geotechnical analyses were completed for the MN diversion alternative during Phase 2 and these analyses were presented in the geotechnical appendix. No geotechnical analyses were completed for the ND Diversion alternative during Phase 2. Further, the USACE realized that additional evaluations would be performed during Phase 3 on the NED plan and/or LPP. Following completion of the Phase 2 draft report, additional geotechnical analyses were completed for the ND Diversion channel alignment along with revisions to the MN Diversion channel alternative. These analyses and results have been coordinated with the hydraulics, structural, and cost estimating disciplines. The diversion channels and hydraulic structures are analyzed hydraulically taking into account the geotechnical requirements of the diversion channels. The excavation quantities will be based on the geotechnical/hydraulic analyses and the cost estimate revised. The final report will include the additional geotechnical slope stability analyses. ND Diversion Channel: Nine reaches along the ND Diversion Channel were analyzed. The geotechnical analyses indicated that to obtain adequate factors of safety for slope stability, the invert of the diversion channel needed to be raised 3 feet and a bench included in the channel slope. The bench is required to be 10 feet high above the bottom of the channel with a 1V on 10H side slope to the channel bottom, and a minimum of 50 feet in width. The spoil piles are setback 50 feet from the top of the diversion slope. The results of the ND Diversion Channel analyses are summarized in Attachment 1. MN Diversion Channel: During Phase 2, the MN Diversion Channel was separated into four reaches and geotechnical analyses completed. During Phase 3, the geotechnical analyses were revised. The MN Diversion Channel stratigraphy and ground surface profile were reviewed and eleven separate reaches were determined. The geotechnical analyses indicated that benching of the slope was required to obtain adequate factors of safety along a majority of the diversion channel. The benching requirement for the MN Diversion Channel was set as follows: 7 feet high above the bottom of the channel with a 1V on 10H side slope to the channel bottom, and a minimum of 70 feet in width, the spoil piles setback 50 feet from the top of the diversion slope. The results of the MN Diversion Channel analyses are summarized in Attachment 1. Submitted By: Aaron Snyder (651-290-5489) Submitted On: 21-Jun-10 (Attachment: FMMFS_IEPR_Comment_Responses_Attach_1.pdf)

1-1	Backcheck Recommendation **Close Comment** Concur. In all of the design cross-sections it appears that the spoil piles are located a distance of 50 feet away from the top of the channel excavation. This appears to be an arbitrary assumption that is suitable for feasibility level analysis but could be refined during the final design. It is suggested that during final design a parametric analysis of the setback distance for the spoil piles in combination with the depth of the spoil piles be conducted to optimize the overall configuration. This analysis should include evaluation of stability and unit costs to arrive at the optimal configuration of the spoil pile setbacks and depth of spoil. This analysis should consider the cost impacts of the transportation of the spoil away from the excavation, the additional real estate requirements for spoil pile width and the need to meet required factors of safety. This parametric analysis should be conducted for each design cross-section to ensure that the most economical configuration is obtained based on all relevant costs and stability configuration.

	Submitted By: Julian Digialleonardo (561-656-6303) Submitted On: 06-Jul-10
	Current Comment Status: Comment Closed

Id	Discipline	DocType	Spec	Sheet	Detail
3276734	Geotechnical	Other	High	n/a	n/a

(Document Reference: Comment #2)

The stability of the channel slopes, foundation deposits, and related spoil piles should be evaluated using ultimate or near ultimate soil strength values for the End of Construction (EOC) condition.

(Attachment: Fargo-Moorhead_IEPR_Comment_2.doc)

Submitted By: Julian Digialleonardo (561-656-6303). Submitted On: 19-May-10

1-0	Evaluation **Concurred** Concur - Adopting in part - See attached. Submitted By: Aaron Snyder (651-290-5489) Submitted On: 21-Jun-10 (Attachment: Comment_2_response.docx)
1-1	Backcheck Recommendation **Close Comment** Concur Submitted By: Julian Digialleonardo (561-656-6303) Submitted On: 06-Jul-10
	Current Comment Status: Comment Closed

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Comment 1:

There are insufficient geotechnical analyses to justify the proposed channel slopes, channel depth, spoil pile configuration, cost estimates, and real estate requirements for the North Dakota Diversion Alternative.

Basis for Comment:

The geotechnical design evaluation in Appendix I does not include analyses to support the proposed channel slopes or spoil pile configuration for the North Dakota Alternative. It appears to the Panel that the evaluation of the North Dakota Alternative was not completed. From the information provided in the Fargo-Moorhead DFR/EIS, it also appears that an assumption was made that the typical channel cross-section for the North Dakota Alternative would be similar to that analyzed for the Minnesota Diversion Alternative. However, this may not be the case. A review of the nine borings available for the North Dakota Alternative indicates subsurface profiles that are different in character from the four stability cross-sections evaluated for the Minnesota Diversion Alternatives. The differences in the subsurface profiles may result in potentially different channel configurations and earthwork quantities. The lack of emphasis on the North Dakota Alternative is also illustrated by the fact that 85 borings were taken for the levee alternatives, 40 borings were taken for the Minnesota Diversion Alternative, but only 9 borings were taken for the North Dakota Alternative. The level of geotechnical analysis and evaluation is not sufficient to support an accurate feasibility cost estimate for the North Dakota Alternative.

The lack of geotechnical continuity is further illustrated by the inconsistencies between the Fargo-Moorhead DFR/EIS and the Geotechnical Appendix I.

- The configuration of both the Minnesota Diversion and North Dakota Diversion cross-sections are described in the Fargo-Moorhead DFR/EIS (pages 42 and 48); however, these descriptions do not correspond to the final geotechnical cross-sections found in geotechnical analysis for the Minnesota Diversion Alternative contained in Appendix I (page I-17). Geotechnical analysis for the Minnesota Diversion stated that in order to achieve adequate factors of safety, the channel would require a slope of 1V to 10H. This proposed slope is not consistent with the Fargo-Moorhead DFR/EIS description or as shown on the cross-section (Figure 13) or the cross-sections shown in Appendix K.
- On page 48, paragraph 3.3.4.1 of the Fargo-Moorhead DFR/EIS states that the Minnesota Diversion Alternative channel was limited to a depth of 30 feet based upon the results of a preliminary analysis of slope stability. The Fargo-Moorhead DFR/EIS also states (first paragraph, page 48) that the maximum depth of 32 feet was used for the North Dakota plan; however, there is no geotechnical analysis or stability evaluation to justify the use of a 32-foot channel depth for the North Dakota Alternative

Overall, it appears that the geotechnical analysis for both Diversion Alternatives was not developed completely and/or was not accurately incorporated into the project cost estimates.

Significance – High:

Without a consistent level of geotechnical analysis between alternatives, it is not possible to develop accurate comparative costs for the North Dakota Alternative and the Minnesota Diversion Alternative.

Recommendations for Resolution:

To resolve these concerns the report should be expanded to include:

1. A geotechnical evaluation for the North Dakota Diversion Alternative developed to the same level of detail as that used for the Minnesota Diversion Alternative
2. Revised descriptions to reflect a consistent geotechnical design that provides adequate factors of safety for each alternative (after completing the geotechnical analysis for Diversion Alternatives, Appendix I, the Appendix K cross sections)
3. Recomputed quantity estimates for the channel excavation, and revised cost estimates for all alternatives based on the updated analysis and design
4. A design review of the various hydraulic structures to ensure that the proposed designs are compatible with the final channel configurations based on stability evaluations.

Fargo-Moorhead Metro Feasibility Study
Requirements for the North Dakota Diversion Channel
based on Preliminary Phase 3 Geotechnical analyses

Compiled By: KAH Revised By: KAH
Date: 5/11/2010 Date: 5/12/2010

		Reach		Distance			Modifications			
Section	Location	Start	End	(feet)	(miles)	Percent	Excavation Increase	Sand Trench Drain	Slope Stabilization	Tributary Structures
1	STA 120+00	0+00	390+00	39,000	7.4	20%	15%			
2	STA 545+00	390+00	660+00	27,000	5.1	14%	15%			
3	STA 940+00	660+00	1000+00	34,000	6.4	18%	16%	$45		
4	STA 1080+00	1000+00	1150+00	15,000	2.8	8%	15%			
5	STA 1225+00	1150+00	1300+00	15,000	2.8	8%	15%			
5B	STA 1445+00	1300+00	1500+00	20,000	3.8	10%	17%		$17	
6	STA 1595+00	1500+00	1670+00	17,000	3.2	9%				
6B	STA 1550+00	1500+00	1670+00	17,000	3.2	9%				
6C	STA 1720+00	1670+00	1770+00	10,000	1.9	5%				
7	STA 1810+00	1770+00	1922+00	15,200	2.9	8%				
				192,200	36.4		112%			

Original Cost	346.9		Cost Increase	42.5	45.0	17.0	12.6	464.0	33.8%		
Original Cost w/ Contingency	36%	471.8	Cost Increase w/Contingency	57.9	61.2	23.1	17.1	631.1	33.8%		

REQUIREMENTS

	Configuration																
Filename	Bottom Width	Analyzed Bottom Elev.	Selected Bench Width	Analyzed Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	**Selected X-Sectional Area**	Difference	Analyzed X-Sectional Area	Original X-Sectional Area	Difference	Top of slope, from Centerline	Original Top of Slope	Difference
FM_P3_ND_Div_Sect-01_ALT2	100	857	50	40	10	10	882	7	50	25	**9641**	15%	9341	8354	12%	295	246	20%
FM_P3_ND_Div_Sect-02_ALT2	100	865	50	50	10	10	890	7	50	25	**9641**	15%	9641	8354	15%	305	246	24%
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
FM_P3_ND_Div_Sect-03_ALT2_ModTrench	100	873	50	50	10	10	900	7	50	27	**10889**	16%	10889	9366	3%	319	260	23%
FM_P3_ND_Div_Sect-04_ALT2	100	876	50	30	10	10	900	7	50	24	**9038**	15%	8478	7869	8%	278	239	16%
FM_P3_ND_Div_Sect-05_ALT2	100	879	50	50	10	10	903	7	50	24	**9038**	15%	9038	7869	15%	298	239	25%
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
FM_P3_ND_Div_Sect-05B_ALT2_mod	100	883	50	50	10	10	913	7	50	30	**12866**	17%	12866	10989	17%	340	281	21%
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
FM_P3_ND_Div_Sect-06B_ALT2	100	894	50	50	5	10	920	7	50	26	**10203**	-27%	10203	13974	-27%	297	316	-6%
FM_P3_ND_Div_Sect-06C_ALT2	100	897	0	0	0	0	913	7	50	16	**3458**	-56%	3458	7869	-56%	162	239	-32%
FM_P3_ND_Div_Sect-07_ALT1	125	896	0	0	0	0	912	7	0	16	**3858**	0%	3858	3858	0%	174.5	174.5	0%

NOTES:
1) Original cross sectional area based on constant 1V:7H channel side slope (no benching)
2) All cross sections analyzed with a low flow channel: 3 feet deep, 10 feet wide, 1V:4H side slopes, with riprap

Sand Trench

Depth	40 ft	
Width	6 ft	
X-Sect Area (per side)	240 SF	
Sand Cost	$50 per ton	(cost based on riprap cost)
	1.5 ton/CY	
Sand Cost	$75 per CY	

Slope Stabilization

X-Sect Area (per side)	150 SF	
Riprap Cost	$50.00 per ton	(cost based on bid prices for Fargo-Ridgewood project)
	1.5 ton/CY	
	$75 per CY	

Fargo-Moorhead Metro Feasibility Study
Summary of the Phase 3 Preliminary Geotechnical Analyses of ND Diversion Alternatives

Compiled By: KAH
Date: 5/6/2010

Revised By: KAH
Date: 5/12/2010

Section	Location	Reach Start	Reach End	Distance (feet)	Distance (miles)	Percent
1	STA 120+00	0+00	390+00	39,000	7.4	20%
2	STA 545+00	390+00	880+00	27,000	5.1	14%
3	STA 940+00	660+00	1000+00	34,000	6.4	18%
4	STA 1080+00	1000+00	1150+00	15,000	2.8	8%
5	STA 1225+00	1150+00	1305+00	15,000	2.8	8%
5B	STA 1445+00	1305+00	1500+00	20,000	3.8	10%
6	STA 1550+00	1500+00	1670+00	17,000	3.2	9%
6C	STA 1720+00	1670+00	1770+00	10,000	1.9	5%
7	STA 1810+00	1770+00	1922+00	15,200	2.9	8%
				192,200	36.4	

	Location
Outfall	STA 0+00
I-29	STA 300+00
Rush River	STA 480+00
Lower Rush	STA 600+00
Maple River	STA 750+00
CR 10	STA 900+00
I-94	STA 920+00
Sheyenne R	STA 1500+00
Wild Rice	STA 1780+00
I-29	STA 1820+00
Red River	SRA 1920+00

Alternative 1: Current invert elevation, 10' high bench, 1V:10H slope on bench, 1V:7H channel slope

Minimum FS: 1.4 | 1.4 | 1.2 | 1.2 | 1.3 | 1.3

Filename	Configuration: Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	Top of slope, from Centerline	Original Top of Slope	Difference	X-Sectional Area	Original X-Sectional Area	% Increase	Stability Analysis: Min FS: Global FS	Local FS	Water Exits Slope	Height Below Ground Surface	Height above Bottom	Global	Wedge	Localized	Localized 2	Undrained	Localized
FM_P3_ND_Div_Sect-01_ALT1	100	854	50	10	10	882	7	50	28	326	246	33%	11534	8154	38%	1.433	1.587	864.5	17.5	10.5	1.449	1.433	1.598	1.587	1.431	4.762
FM_P3_ND_Div_Sect-02_ALT1	100	862	80	10	10	860	7	50	28	356	246	45%	12614	8154	51%	1.406	1.408	876	14	14	1.464	1.406	1.408	1.459	1.418	4.226
FM_P3_ND_Div_Sect-03_ALT1	100	870	125	10	10	900	7	50	30	415	260	60%	15886	9366	69%	1.417	1.106	888	12	18	1.446	1.417	1.109	1.106	1.079	4.515
FM_P3_ND_Div_Sect-04_ALT1	100	873	80	10	10	900	7	50	27	329	239	38%	11229	7869	43%	1.416	1.268	884	15	11	1.419	1.416	1.268	1.267	1.263	4.48
FM_P3_ND_Div_Sect-05_ALT1	100	876	80	10	10	903	7	50	27	349	239	46%	11909	7869	51%	1.405	1.402	889	14	13	1.44	1.405	1.402	1.427	1.448	4.805
FM_P3_ND_Div_Sect-06_ALT1	100	882	30	10	10	920	7	50	38	376	316	19%	17634	13674	29%	1.425	0.614	896	24	14	1.425	1.482	0.672	0.614	1.678	6.33
FM_P3_ND_Div_Sect-07_ALT1	125	899	0	0	0	912	7	0	16	174.3	174.5	0%	3858	3858	0%	1.598	1.818	899	13	3	1.598	1.604	1.881	1.616	2.719	2.719

Alternative 2: Invert elevation raised 5 feet, 10' high bench, 1V:10H slope on bench, 1V:7H channel slope

Filename	Configuration: Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	Top of slope, from Centerline	Original Top of Slope	Difference	X-Sectional Area	Original X-Sectional Area	% Increase	Stability Analysis: Min FS: Global FS	Local FS	Water Exits Slope	Height Below Ground Surface	Height above Bottom	Global	Wedge	Localized	Localized 2	Undrained	Localized
FM_P3_ND_Div_Sect-01_ALT2	100	857	40	10	10	882	7	50	23	295	246	20%	9841	8154	21%	1.451	1.659	867	15	10	1.482	1.451	1.659	1.64	1.48	4.888
FM_P3_ND_Div_Sect-02_ALT2	100	865	50	10	10	860	7	50	25	309	246	26%	9841	8154	15%	1.412	1.53	876	14	11	1.412	1.413	1.531	1.53	1.402	4.208
FM_P3_ND_Div_Sect-03_ALT2	100	873	80	10	10	900	7	50	27	349	260	34%	11909	9366	27%	1.413	1.315	888	12	13	1.419	1.413	1.317	1.315	1.694	4.364
FM_P3_ND_Div_Sect-03_ALT2_ModFrench	100	873	50	10	10	900	7	50	27	319	260	23%	10889	9366	16%	1.416	1.448	0	900	873	1.446	1.416	1.447	1.446	1.695	4.364
FM_P3_ND_Div_Sect-04_ALT2	100	876	30	10	10	900	7	50	24	278	239	16%	8478	7869	8%	1.436	1.495	886	14	10	1.45	1.436	1.495	1.496	1.692	4.237
FM_P3_ND_Div_Sect-05_ALT2	100	876	50	10	10	903	7	50	24	298	239	25%	9028	7869	15%	1.415	1.534	890	13	11	1.451	1.415	1.534	1.534	1.42	5.159
FM_P3_ND_Div_Sect-05B_ALT2_mod	100	883	50	10	10	913	7	50	30	340	281	21%	12866	10089	17%	1.551	1.302	895	18	12	1.629	1.551	1.302	1.304	1.764	6.12
FM_P3_ND_Div_Sect-06B_ALT2	100	894	50	5	10	920	7	50	26	297	316	-6%	10203	13974	-27%	1.405	1.425	904	16	10	1.425	1.405	1.425	1.43	1.667	3.628
FM_P3_ND_Div_Sect-06C_ALT2	100	897	0	0	0	913	7	50	16	162	239	-32%	3458	7869	-56%	1.619	1.814	901	12	4	1.619	1.626	1.791	1.814	1.865	4.04

Alternative 3: Invert elevation raised 5 feet, 10' high bench, 1V:10H slope on bench, 1V:7H channel slope

Filename	Configuration: Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	Top of slope, from Centerline	Original Top of Slope	Difference	X-Sectional Area	Original X-Sectional Area	% Increase	Stability Analysis: Min FS: Global FS	Local FS	Water Exits Slope	Height Below Ground Surface	Height above Bottom	Global	Wedge	Localized	Localized 2	Undrained	Localized
FM_P3_ND_Div_Sect-01_ALT3	100	859	20	10	10	882	7	50	23	266	246	8%	7759	8154	-7%	1.453	1.733	869.5	15.5	7.5	1.488	1.453	1.795	1.759	1.442	4.711
FM_P3_ND_Div_Sect-02_ALT3	100	867	30	10	10	860	7	50	23	271	246	10%	7929	8154	-3%	1.401	1.385	877	13	10	1.401	1.417	1.548	1.385	1.386	4.13
FM_P3_ND_Div_Sect-03_ALT3	100	875	50	10	10	900	7	50	25	305	260	17%	9841	9366	5%	1.416	1.427	888	12	13	1.42	1.416	1.437	1.438	1.826	4.39
FM_P3_ND_Div_Sect-04_ALT3	100	878	10	10	10	900	7	50	22	244	239	2%	6814	7869	-13%	1.424	1.6	887	13	9	1.424	1.424	1.601	1.6	1.206	4.145
FM_P3_ND_Div_Sect-05_ALT3	100	881	20	10	10	903	7	50	22	234	239	-6%	7134	7869	-9%	1.412	1.587	891	12	10	1.412	1.412	1.587	1.593	1.587	1.589
FM_P3_ND_Div_Sect-06_ALT3	100	887	50	10	10	920	7	50	33	361	316	14%	14669	13974	5%	1.501	0.538	900	20	13	1.508	1.501	0.537	0.538	1.725	6.105

Other Alternatives:

Filename	Configuration: Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	Top of slope, from Centerline	Original Top of Slope	Difference	X-Sectional Area	Original X-Sectional Area	% Increase	Stability Analysis: Min FS: Global FS	Local FS	Water Exits Slope	Height Below Ground Surface	Height above Bottom	Global	Wedge	Localized	Localized 2	Undrained	Localized
FM_P3_ND_Div_Sect-06B_ALT2	100	894	30	5	10	920	7	50	26	297	316	-6%	10203	13974	-27%	1.405	1.425	904	16	10	1.425	1.405	1.425	1.43	1.667	3.628
FM_P3_ND_Div_Sect-06C_ALT2	100	897	0	0	0	913	7	50	16	162	239	-32%	3458	7869	-56%	1.619	1.814	901	12	4	1.619	1.626	1.791	1.814	1.865	4.04

* Original X-sectional area based on constant 1V:7H channel side slope (no benching)

** All alternatives have a low flow channel: 3 feet deep, 10 feet wide, 1V:4H side slopes, with riprap

Fargo-Moorhead Metro Feasibility Study
Summary of the Phase 3 Preliminary Geotechnical Analyses of MN Diversion Alternatives

Compiled By: KAH Revised By: KAH
Date: 5/17/2010 Date: 5/19/2010

Section	Location	Reach Start	Reach End	Distance (feet)	Distance (miles)	Percent	Requires Modification	
1	STA 20+00	0+00	70+00	7,000	1.3	5%	NO	0
2	STA 175+00	70+00	220+00	15,000	2.8	11%	NO	0
2B	STA 355+00	220+00	440+00	22,000	4.2	16%	NO	0
3	STA 515+00	440+00	540+00	10,000	1.9	7%	YES	10,000
4	STA 635+00	540+00	665+00	12,500	2.4	9%	Probably	12,500
4B	STA 700+00	665+00	750+00	8,500	1.6	6%	Probably	8,500
5	STA 805+00	750+00	900+00	15,000	2.8	11%	Probably	15,000
6	STA 980+00	900+00	1110+00	21,000	4.0	15%	YES	21,000
7	STA 1160+00	1110+00	1190+00	8,000	1.5	6%	YES	8,000
7B	STA 1235+00	1190+00	1280+00	9,000	1.7	7%	YES	9,000
8	STA 1325+00	1280+00	1363+00	8,300	1.6	6%	YES	8,300
				136,300	22.6			92,300

Phase 2 Analysis Modifications						
Modification 2			Modification 3			
Start	End	Length	Start	End	Length	
35500	44000	8,500				0
44000	54000	10,000				0
54000	65000	11,000	65000	66500	1,500	
		0	66500	75000	8,500	
81000	90000	9,000	75000	81000	6,000	
90000	111000	21,000				0
111000	119000	8,000				0
119000	125000	6,000				0
0		0				0
		73,500			16,000	89,500

Requirements:

Filename	Configuration: Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	X-Sectional Area	Original X-Sectional Area	Difference	Top of slope	Original Top of Slope	Difference	Global FS	Local FS
FM_P3_MN_Div_01_20k	175	875	0	0	0	895	7	50	20	6366	6366	0%	227.5	227.5	0%	1.517	1.887
FM_P3_MN_Div_02_20k	175	876	0	0	0	894	7	50	18	5484	5484	0%	213.5	213.5	0%	1.859	2.846
FM_P3_MN_Div_02B_20k	175	878	0	0	0	896	7	50	18	5484	5484	0%	213.5	213.5	0%	1.616	1.928
FM_P3_MN_Div_03_35k_mod	260	880	25	7	10	905	7	50	25	12744	13441	-5%	351	355	-1%	1.488	2.141
FM_P3_MN_Div_06_35k_mod	260	886	70	7	10	914	7	50	28	16803	15634	7%	417	376	11%	1.419	1.585
FM_P3_MN_Div_07_35k_mod	260	890	30	7	10	914	7	0	24	12219	12738	-4%	349	348	0%	1.409	1.786
FM_P3_MN_Div_07B_35k_mod	260	891	10	7	10	910	7	50	19	8424	9433	-11%	294	313	-6%	1.442	1.512
FM_P3_MN_Div_08_35k_mod	260	893	40	7	10	912	7	50	19	9144	9433	-3%	324	313	4%	1.405	1.46

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Fargo-Moorhead Metro Feasibility Study
Phase 3 Preliminary Geotechnical Analyses of MN Diversion Alternatives

Compiled By: KAH Revised By: KAH
Date: 6/3/2010 Date: 5/12/2010

Minnesota Diversion Channel, Section 1 STA 20+00 0+00 70+00 7,000 1.3

	Configuration										Stability Analysis: Min FS									
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	Other Changes	Global	Wedge	Localized	Localized 2	Undrained	Undrained Localized	X-Sectional Area	% Increase	Top of slope	Water Exits Slope	Height Below Ground Surface	Height above Bottom
Original MN 01_20k	175	875	0	0	0	895	7		20								6366		227.5			
FM_P3_MN_Div_01_20k	**175**	**875**	**0**	**0**	**0**	**895**	**7**	**50**	**20**		**1.517**	**1.518**	**2.068**	**1.887**	**1.381**	**4.288**	**6366**	**0%**	**227.5**	**876.5**	**18.5**	**1.5**
FM_P3_MN_Div_01_b_20k										no riprap LF	1.505	1.1	2.065	1.872	1.348	4.268				876.5		

Minnesota Diversion Channel, Section 2 STA 173+00 70+00 220+00 15,000 2.8

	Configuration										Stability Analysis: Min FS									
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	Other Changes	Global	Wedge	Localized	Localized 2	Undrained	Undrained Localized	X-Sectional Area	% Increase	Top of slope	Water Exits Slope	Height Below Ground Surface	Height above Bottom
Original MN 02_20k	175	876	0	0	0	894	7		18								5484		213.5			
FM_P3_MN_Div_02_20k	**175**	**876**	**0**	**0**	**0**	**894**	**7**	**50**	**18**		**1.859**	**1.876**	**2.85**	**2.848**	**1.42**	**6.692**	**5484**	**0%**	**213.5**	**876**	**18**	**0**
FM_P3_MN_Div_02_b_20k											1.833	1.85	2.662	2.667	1.414	6.662	66	-99%	0		0	0
																	66	-99%	0		0	0
																	66	-99%	0		0	0

Minnesota Diversion Channel, Section 2B STA 355+00 220+00 440+00 22,000 4.2

	Configuration										Stability Analysis: Min FS									
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	Other Changes	Global	Wedge	Localized	Localized 2	Undrained	Undrained Localized	X-Sectional Area	% Increase	Top of slope	Water Exits Slope	Height Below Ground Surface	Height above Bottom
Original MN 02B_20k	175	878	0	0	0	896	7		18								5484		213.5			
FM_P3_MN_Div_02B_20k	**175**	**878**	**0**	**0**	**0**	**896**	**7**	**50**	**18**		**1.622**	**1.616**	**1.948**	**1.928**	**1.425**		**5484**	**0%**	**213.5**	**878**	**18**	**0**
																	66	-99%	0		0	0
																	66	-99%	0		0	0
																	66	-99%	0		0	0

Minnesota Diversion Channel, Section 3 STA 515+00 440+00 540+00 10,000 1.9

	Configuration										Stability Analysis: Min FS									
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	Other Changes	Global	Wedge	Localized	Localized 2	Undrained	Undrained Localized	X-Sectional Area	% Increase	Top of slope	Water Exits Slope	Height Below Ground Surface	Height above Bottom
Original MN 03_20k	175	880	0	0	0	905	7		25								8816		262.5			
FM_P3_MN_Div_03_20k	175	880	0	0	0	905	7	50	25		1.347	1.346	1.503	1.689	1.222		8816	0%	262.5	881	24	1
Original MN 03_35k	**360**	**880**	**0**	**0**	**0**	**905**	**7**	**50**	**25**								**13441**		**355**			
FM_P3_MN_Div_03_35k	360	880	0	0	0	905	7	50	25		1.346	1.363	1.709	1.703	1.247		13441	0%	355	881	24	1
FM_P3_MN_Div_03_35k_mod	**260**	**880**	**25**	**7**	**10**	**905**	**7**	**50**	**25**		**1.488**	**1.499**	**2.141**	**2.293**	**1.297**		**12744**	**-5%**	**351**	**882**	**23**	**2**
																	66	-100%	0		0	0

Minnesota Diversion Channel, Section 4 STA 635+00 540+00 665+00 12,500 2.4

	Configuration										Stability Analysis: Min FS									
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	Other Changes	Global	Wedge	Localized	Localized 2	Undrained	Undrained Localized	X-Sectional Area	% Increase	Top of slope	Water Exits Slope	Height Below Ground Surface	Height above Bottom
Original MN 04_20k	175	881	0	0	0	912	7		31								12218		304.5			
FM_P3_MN_Div_04_20k	175	881	0	0	0	912	7	50	31		1.068	1.099	1.1175	1.184	1.175		12218	0%	304.5	890	22	9
Original MN 04_35k	360	881	0	0	0	912	7	50	31								17953		397			
FM_P3_MN_Div_04_35k	360	881	0	0	0	912	7	50	31		1.119				1.179		17953	0%	397	890	22	9
FM_P3_MN_Div_04_35k_mod	260	881	75	7	10	912	7	50	31		1.36				1.756		19608	9%	443	890	22	9
																	66	-100%	0		0	0

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Fargo-Moorhead Metro Feasibility Study
Phase 3 Preliminary Geotechnical Analyses of MN Diversion Alternatives

Compiled By: KAH Revised By: KAH
Date: 5/5/2010 Date: 5/12/2010

Minnesota Diversion Channel, Section 4B STA 700+00 665+00 750+00 8,500 1.6

	Configuration										Stability Analysis: Min FS											
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	Other Changes	Global	Wedge	Localized	Localized 2	Undrained	Localized	X-Sectional Area	% Increase	Top of slope	Water Exits Slope	Height Below Ground Surface	Height above Bottom
Original MN 04B_20k									0								66		0			
FM_P3_MN_Div_04B_20k									0								66	0%	0		0	0
																	66	0%	0		0	0
																	66	0%	0		0	0
																	66	0%	0		0	0

Minnesota Diversion Channel, Section 5 STA 805+00 750+00 900+00 15,000 2.8

	Configuration										Stability Analysis: Min FS											
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	Other Changes	Global	Wedge	Localized	Localized 2	Undrained	Localized	X-Sectional Area	% Increase	Top of slope	Water Exits Slope	Height Below Ground Surface	Height above Bottom
Original MN 05_20k									0								66		0			
FM_P3_MN_Div_05_20k									0								66	0%	0		0	0
																	66	0%	0		0	0
																	66	0%	0		0	0
																	66	0%	0		0	0

Minnesota Diversion Channel, Section 6 STA 980+00 900+00 1110+00 21,000 4.0

	Configuration										Stability Analysis: Min FS											
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	Other Changes	Global	Wedge	Localized	Localized 2	Undrained	Localized	X-Sectional Area	% Increase	Top of slope	Water Exits Slope	Height Below Ground Surface	Height above Bottom
Original MN 06_20k																	66		0			
FM_P3_MN_Div_06_20k																	66	0%	0		0	0
Original MN 06_35k	360	886	0	0	0	914	7	0	28								15634		376			
FM_P3_MN_Div_06_35k	360	886	0	0	0	914	7	50	28		1.107	1.215	1.129	1.171	1.329		15634	0%	376	900	14	14
FM_P3_MN_Div_06_35k_mod	**260**	**886**	**70**	**7**	**10**	**914**	**7**	**50**	**28**		**1.441**	**1.419**	**1.586**	**1.585**	**1.463**		**16803**	**7%**	**417**	**900**	**14**	**14**
																	66	-100%	0		0	0
																	66	-100%	0		0	0

Minnesota Diversion Channel, Section 7 STA 1160+00 1110+00 1190+00 8,000 1.5

	Configuration										Stability Analysis: Min FS											
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	Other Changes	Global	Wedge	Localized	Localized 2	Undrained	Localized	X-Sectional Area	% Increase	Top of slope	Water Exits Slope	Height Below Ground Surface	Height above Bottom
Original MN 07_20k	175	890	0	0	0	914	7	0	24								8298		255.5			
FM_P3_MN_Div_07_20k	175	890	0	0	0	914	7	0	24		1.173	1.33	1.232	1.214	1.337		8298	0%	255.5	899	15	9
Original MN 07_35k	360	890	0	0	0	914	7	0	24								12738		348			
FM_P3_MN_Div_07_35k	360	890	0	0	0	914	7	0	24		1.212	1.277	1.257	1.267	1.358		12738	0%	348	898	16	8
FM_P3_MN_Div_07_35k_mod	**260**	**890**	**30**	**7**	**10**	**914**	**7**	**0**	**24**		**1.411**	**1.409**	**1.787**	**1.796**	**1.427**		**12219**	**-4%**	**349**	**898**	**16**	**8**
	300	890	20	7	10	914	7		24								12839	1%	359		914	-890
																	66	-99%	0		0	0

Minnesota Diversion Channel, Section 7B STA 1235+00 1190+00 1280+00 9,000 1.7

	Configuration										Stability Analysis: Min FS											
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	Other Changes	Global	Wedge	Localized	Localized 2	Undrained	Localized	X-Sectional Area	% Increase	Top of slope	Water Exits Slope	Height Below Ground Surface	Height above Bottom
Original MN 07B_20k	175	891	0	0	0	910	7	0	19								5918		270.5			
FM_P3_MN_Div_07B_20k	175	891	0	0	0	910	7	50	19		1.25	1.293	1.372	1.286	1.367		5918	0%	270.5	900	10	9
Original MN 07B_35k	360	891	0	0	0	910	7	50	19								9433		313		910	-891
FM_P3_MN_Div_07B_35k	360	891	0	0	0	910	7	50	19		1.299	1.337	1.449	1.319	1.562		9433	0%	313	900	10	9
FM_P3_MN_Div_07B_35k_mod	**260**	**891**	**10**	**7**	**10**	**910**	**7**	**50**	**19**		**1.442**	**1.452**	**1.827**	**1.512**	**1.621**		**8424**	**-11%**	**294**		**910**	**-891**
																	66	-99%	0		0	0

Fargo-Moorhead Metro Feasibility Study
Phase 3 Preliminary Geotechnical Analyses of MN Diversion Alternatives

Compiled By: KAH Revised By: KAH
Date: 5/3/2010 Date: 5/12/2010

Minnesota Diversion Channel, Section 8 STA 1325+00 1280+00 1363+00 8,300 1.6

	Configuration										Stability Analysis: MN FS											
Filename	Bottom Width	Bottom Elev.	Bench Width	Bench Height	Bench Slope	Ground Surface	Channel Slope	Surcharge Location	Depth	Other Changes	Global	Wedge	Localized	Localized 2	Undrained	Localized	X-Sectional Area	% Increase	Top of slope	Water Exits Slope	Height Below Ground Surface	Height above Bottom
Original MN 08_20k	175	893	0	0	0	912	7	0	19								5918		220.5			
FM_P3_MN_Div_08_20k	175	893	0	0	0	912	7	50	19		1.057	1.058	1.091	1.069	1.763		5918	0%	220.5	902	10	9
Original MN 08_35k	360	893	0	0	0	912	7	50	19								9433		313			
FM_P3_MN_Div_08_35k	360	893	0	0	0	912	7	50	19		1.072	1.162	1.11	1.083	1.763		9433	0%	313	902	10	9
FM_P3_MN_Div_08_35k_mod	260	893	40	7	10	912	7	50	19		1.407	1.405	1.46	1.46	1.956		9144	-3%	324	902	10	9
									0								66	-99%	0		0	0
									0								66	-99%	0		0	0

Comment 2:

The stability of the channel slopes, foundation deposits, and related spoil piles should be evaluated using ultimate or near ultimate soil strength values for the End of Construction (EOC) condition.

Basis for Comment:

The stability analyses shown in Appendix I (page I-12) indicate that long-term stability will be the controlling load condition in determining the slope configuration of the proposed diversion channel and spoil piles. This is questionable based on the history of many projects in the Red River Valley that have experienced failure or near failure during construction. The failure or near failure during the "End of Construction (EOC) condition" has occurred on many projects within the Red River Valley including the VA Hospital levee failure in Fargo (1948), the Pembina levee project (1978), the Grand Forks levee project (1953), the Fargo Grain Elevator collapse (1955), the Hartsville Pumping Station levee, Grand Forks (2005), and the I-94 Interstate Highway interchange in Fargo (2008). These failures demonstrated that the EOC is a potentially critical failure mode for any excavation or fill slope in the Red River Valley. Furthermore, the use of peak values of Unconsolidated–Undrained (UU) soil strengths to evaluate the EOC conditions appears to be un-conservative.

In Appendix I, the use of peak UU soil strengths in the stability analyses was justified by the following statement (paragraph 46): "During the process of draining, it can be expected that the soils will experience strains less than 5% to 8% which is a strain at which undrained shear strength occurs." Appendix I of the Fargo-Moorhead DFR/EIS does not clarify the basis of this statement and does not contain analysis or justification to identify the level of strains that may occur during the EOC condition.

Experience and laboratory testing indicate that the Brenna formation, which underlies much of the project area and the Red River Valley, is the weakest and most unreliable lacustrine unit. This is composed of highly active clay minerals with high void ratios, water contents, and liquid limits. Laboratory testing of samples obtained throughout the Red River Valley indicates a brittle stress strain curve that achieves high peak strengths at low values of strain and then drops to much lower values of strength at higher strains. The statement described above regarding the 5 to 8% strains at which the peak undrained strength occurs may be untrue in many cases. The tabulation for the Brenna formation (UU) laboratory testing for the recent Hartsville Pumping Station levee failure in Grand Forks indicated that 35 out of 50 shear strength samples failed in the laboratory at peak strengths less than 5%. If the sliding mass reaches strains greater than 5%, it is likely that the mobilized strength will be significantly less than the peak strength values. It should also be noted that the back calculation of strengths for the Hartsville failure indicated values close to the ultimate strengths as determined by UU testing.

Significance – High:

Using un-conservative strength assumptions could affect the channel design, real estate requirements, and estimated project costs.

Recommendations for Resolution:

To resolve these concerns, the report should be expanded to use data from the recent failure of the I-94 Interchange to back calculate the actual UU strengths mobilized at failure. This

information is available from local engineering firms and would provide a realistic basis to assess the methods and test results to evaluate the stability of the proposed channel for the EOC condition.

Concur - Adopting in part:

The USACE recognizes the differences in soil behavior for different material types/formations. The laboratory test data was reviewed and ultimate undrained shear strength parameters were selected based on shear strengths at 15% strain. It was found that there was approximately a 10%, 19%, and 27% reduction in undrained shear strength for the Oxidized Brenna, Brenna, and Argusville formations, respectively. The end-of-construction stability of the diversion channels was checked using the ultimate undrained shear strength parameters and a spoil pile setback distance of 50 feet. It was found that for most cases the minimum factors of safety were still met using the ultimate undrained shear strength parameters. In a few cases, the factors of safety fell below the minimum required. In these instances, the spoil pile height adjacent to the top of the diversion was reduced in order to meet the minimum required factors of safety. This reduced spoil pile height extended out until it could be increase back to 15 feet while maintaining stability.

Not Adopting: The USACE reviewed the I-94 Interchange embankment report completed by Braun Intertec for SRF Consulting Group. The analyses completed for the I-94 Interchange embankment were forensic type analyses completed to evaluate what caused the failure of the embankment during construction. The analyses used lab and field data that was collected during construction and post-failure to calibrate the models to match observed conditions. The reconstruction of the embankment was based on these calibrated models. The I-94 Interchange was a loading only project, whereas the diversion channels will involve loading and unloading along potential slip surfaces due to spoil pile placement as well as channel excavation.

The USACE recreated the undrained model that Braun reported in Figure 1. The USACE results indicated a factor of safety slightly below 1.0 for a wedge type failure search where as Braun reported a factor of safety of 1.168. The USACE also ran the model using the ultimate undrained shear strength parameters selected for the Fargo-Moorhead project along with a 25-foot, water filled crack (the crack depth was selected to eliminate tension in the fill). The results indicated a factor of safety of 1.015. Based on these analyses, the USACE feels that the method being used to model the end-of-construction case for the Fargo-Moorhead diversions is appropriate. The USACE does not feel that including a reference to the I-94 Interchange report would provide any benefit to the review and may even cause confusion.

In addition, the USACE recognizes that a coupled Sigma/W and Slope/W analysis would be another means of evaluating the stability of the excavated channel, like the I-94 failure. The Sigma/W analysis would estimate pore pressures during excavation of the channel and placement of the spoil material and then an effective stress limit equilibrium slope stability analysis could be completed using Slope/W and effective stress parameters. Due to the lack of actual field data the Sigma/W and Slope/W models cannot be calibrated as in the instance of the I-94 Interchange embankment. A number of assumptions would be required for these analyses and could lead to more uncertainty in the results. It is felt that using ultimate undrained shear strength parameters to evaluate the EOC condition is adequate for the feasibility stage of the project. Thought will be given in using a coupled Sigma/W and Slope/W analysis for future refinement of the project. See the embedded PDF attachment below.

Attachment #2.

Formation	Total Stress Shear Strength Parameters		
	Peak Values c (psf)	Ultimate c (psf)	Reduction %
Sherack	1400	900	36%
Poplar River - West Fargo	1900	1900	0%
Poplar River - Harwood	1450	1200	17%
Poplar River, All [5]	1700	1700	0%
Oxidized Brenna [6]	1000	900	10%
Brenna [6]	650	525	19%
Argusville [6]	825	600	27%
Till [7]	1900	1900	0%

St. Paul District Internal Peer Review

August 2010
&
February 2011

CEMVP-EC-D

MEMORANDUM FOR THE RECORD

SUBJECT: Responses to the Peer Review of the Fargo – Moorhead Metro Feasibility Study, Geotechnical Design and Geology Appendix

A peer review of the Geotechnical Design and Geology Appendix for the Fargo-Moorhead Metro Feasibility Study was completed by Chris Behling, St. Paul District EC-D, on August 26, 2010. Mr. Behling provided some minor grammatical edits to the report using the "track changes" feature. In addition to the grammatical edits, Mr. Behling's review prompted 28 comments or questions concerning the report. The undersigned has reviewed and evaluated Mr. Behling's comments/questions and has responded to them. A summary of the evaluation and changes are indicated following the comments.

1. How were the extent of the failed riverbank (areas of residual shear strengths) determined for the slope stability analyses completed for the in-town levees alternative? Was the line simply drawn at the secondary riverbank? Some description of how this was determined would be helpful.

   The extent of the failed riverbank was drawn to coincide with the secondary riverbank as this would provide the most conservative assumption.

2. Were any instrumented cross-sections available to compare to analysis results? Cross-sections where inclinometer data indicated location of the shear zone, perhaps the location of the head or toe of the landslide was known, and water levels from piezometers were available. This would provide some measure of confidence in the limit equilibrium slope stability results for the in-town levees alternative. Since the in-town levee plan is not the design alternative being pursued, this comment is not considered critical.

   Two slope inclinometer installed during the soil exploration program in Spring 2009. Only a few readings have been taken since the installation. The indicated slip plane is near the bottom of the Brenna formation, which coincides with other slides in the Red River Valley.

   The instrumentation data was not used to complete a back calculation stability analysis. The main reason for not completing the back calculation analysis was the level of detail for this analysis was beyond what was needed in the preliminary stages of defining the needs of the in-town levee alternatives. It was decided that some stability analyses be completed based on conservative assumptions to determine preliminary setback distances. As the project evolved, the assumptions would be reevaluated and more detailed analyses completed. It was found during Phase 2 that the in-town levee alternative could only provide a reasonable flood risk reduction level to around a 100-year event due to the

required height of the levees and lack of "high ground" in which to tie the levees into. Due to this, there was no need to evaluate the in-town levee alternative further and complete more detailed analyses.

3. Paragraph I.2.1.3 states, "The slides may extend for several hundred feet along the river bank". The reviewer's experience is that landslides in the F/M area can extend for longer distances along the riverbank, perhaps even a few thousand feet.

   Agree that there could possibly be some areas in which a slide could occur over a longer distance.

4. In Paragraph I.2.1.5, the reviewer wasn't sure what "this relatively steady slope to the north falters very little" meant.

   There is no abrupt changes in elevation.

5. In Paragraph I.2.2.1, the last sentence indicates the riverbank slope is too steep to obtain a mid-slope boring. This seems to contradict para. I.2.1.2 under Topography where the ground slope is described as gentle, flat, or somewhat hummocky.

   The paragraph was rewritten and last sentence was removed.

6. In Paragraph I.2.2.2, under the bulleted NDGS references, should Survey Report of Investigation No. 60 have its own bullet?

   Yes, the NDGS No. 60 report should have its own bullet. This has been changed.

7. Since paragraph I.2.2.3 is one sentence, should it be shown as the last sentence in the previous paragraph?

   To direct the reader to the stratigraphy discussion, this sentence is needed. It does not fit well in the previous paragraph, so it needs to be by itself.

8. Page 11 in Attachment I-1 seems to be repeated and inadvertently included.

   Yes, it was inadvertently included. Page 11 has been removed.

9. In Paragraph I.2.5.2, the second to the last sentence in the paragraph, refers to no known reports of disturbances from either of these events. The reviewer was unsure which events were being referred to.

   The paragraph has been rearranged to clarify what events the statement is referring to. It now states the following:

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 (North Dakota Geological Survey, Geologic Investigations No. 94). 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.12.3).*

10. In Paragraph I.3.0.2, the last two sentences in the paragraph, does this mean 17 CPT total were done next to existing borings? Also, could the CPT determine stratigraphy that correlated with the borings? Some discussion of the success or lack of success of the CPT soundings in determining stratigraphy would be helpful.

    The paragraph was reworded to better indicate the number of borings used for correlation. The sentence reads as follows:

    To better understand the CPT sounding results, 17 soundings were off-set from machine borings. In addition, at 11 of these locations, undisturbed samples were obtained.

    A paragraph was added to the section I.3.2 Cone Pentration Tests to discuss the correlation between the CPT and machine borings

    As mentioned previously, 17 of the CPT soundings were conducted off-set from machine boring locations. 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.

11. In Table I-2, it shows zero water content tests were completed. Assuming wc were determined for all the specimens tested, is there any value to listing the test? Also, does Rbar Disturbed refer to an Rbar conducted on a remolded sample? Suggest a different a name for this test.

    The water content was determined on the specimen as part of the triaxial and DS testing. Therefore water contents were not specifically obtained on the large, tube samples. The WC was removed from the table.

    The "R-bar Disturbed" Test is referring to a remolded sample. This test was intended to test compacted levee fill, but none were completed. This test was removed from the table.

12. It appeared the residual direct shear tests were direct shear tests conducted on pre-cut specimens. It appeared the residual shear stress may not have been reached with this type of testing. Were any of the residual shear strengths compared with values selected from correlations to Atterberg limits, effective normal stress, and clay fraction (Stark and Eid)? Also, why did the shear testing show the Oxidized Brenna and P.L. Sherack have lower residual friction angles than the Brenna?

    The residual direct shear tests were conducted on pre-cut samples and sheared until reaching 15% strain. The laboratory reported these results to the Corps. Upon review of the test results, the Corps asked that the laboratory conduct additional direct shear tests on two samples, Brenna (Fargo 09-26MU Sample #3) and Argusville (Fargo 09-27MU Sample #4), and complete three cycles of shear. The laboratory was able to do this by re-setting the sample and shear box after reaching 15% strain. The test results on these two samples showed that the shear stress at 15% strain was similar for all three cycles, indicating that for pre-cut specimens, the residual shear strength is likely attained at 15% strain.

    The residual shear strength parameters were not compared to correlations during Phase 2.

    The results of the residual shear strength tests for the Oxidized Brenna and PL Sherack were not reviewed in depth to determine why the residual shear strength was lower than the Brenna. This can be investigated if a need arises to reevaluate the In-Town Levee alternative or residual shear strength parameters.

13. For the case of the Oxidized Brenna, Brenna, and Argusville formations non-linear effective shear strengths envelopes were selected and used for design. What was the basis for this? Some discussion on why this was done would be quite helpful.

    The following discussion concerning the curvilinear envelope has been included in Section I.3.4

    The curvilinear shear strength envelope was developed for the Oxidized Brenna, Brenna, and Argusville formations for use in the effective stress analysis of the diversion channel excavated

slope. The excavation of the diversion channel and the steady state seepage into the channel reduced the effective normal stresses in the Oxidized Brenna, Brenna, and Argusville. For example, the effective normal stresses in the Brenna ranged from 0.5 to 1.5 tons per square foot (tsf). The Mohr-Coulomb effective stress envelope used for the In-Town Levee alternative underestimated the available shear strength of the materials in this range of low confining stresses. So to appropriately represent the shear strength of the materials at the lower stresses, curvilinear shear strength envelopes were developed. The fact that the Oxidized Brenna, Brenna, and Argusville can be expected to be slightly overconsolidated, a small cohesion intercept was used.

14. Peak values of Su were used for EOC analysis for the in-town levees, while ultimate values of Su were used for the EOC analyses for the diversion alternatives. I know why this was done; the average reader doesn't. I'm not sure if the reasoning presented supports why one value is used for the levees and a different one for the cut channels. Perhaps a better argument to use ultimate Su values for the cut channels could be a slower loading rate (produced by slower construction) would mobilize a lower value of Su (although I'm not sure about this) or Su Ultimate represents the average Su (based on shear mode) along a shear surface better than Su Peak. I think some additional discussion/reasoning should be included in the write-up.

    A discussion on the reasoning for selecting ultimate undrained shear strength parameters was included in the report and is indicated below:

    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, resulting 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

15. Under paragraph I.5.1.2.1, it states only levees were assumed for Phase 2 design. If one assumed T-walls could be built to save expensive real estate could the in-town levees become a viable alternative?

    Assuming that T-walls could be built and be more cost effectively than levees would not change the fact that the In-Town Levee Alternative is not the best implementable plan. The reasoning for not considering the In-Town levee alternative can be found in Section I.5.9.

16. Under paragraph I.5.1.3.1, one reason why the pump stations and drainage structures are deep in the RRV are because the storm sewer outlets at the river end up being very deep because of the flat topography.

    The reasoning why the pump stations are deep was included in the paragraph.

17. In Table I-7, why do the setback distances used differ from those determined from the stability analyses?

    The speed of the project required that the layout be completed during the same time that the geotechnical analyses were being completed. There was not enough time during Phase 2 to revise the layout for the Phase 2 submittal. This the reason for the discrepancy and would have been resolved during Phase 3 if the In-Town Levee alternative was revised during this stage. The changes to the paragraph to discuss the differences is below.

    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.

18. Under paragraph I.5.8.1, does the generalized riprap cross-section referred to that was 3 feet wide mean the riprap was placed in a 3 foot thickness or layer?

    The riprap cross section was a 3-foot wide top width and 1V:3H slope. A figure was included in the report to depict this.

19. Under paragraph I.6.4.3.1, consider clarifying that non-circular failure surfaces generally produce lower computed FS along the riverbanks where the shear surface passes through a relatively thin weak layer (in effect, these failures can have long neutral blocks). Not sure non-circular shear surfaces would always be critical for the diversion channel. These were critical at

GF/EGF because of the long shear surfaces through a relatively thin, weak soil layer. Along the diversion the full thickness of the lake sediments will generally be present and a circular shear surface might fit that geometry fairly well.

The configuration of the diversion channel is approaching the configuration of the riverbanks along the Red River. The analyses show that a circular failure surface does not represent the critical condition. Slope/W allows one to conduct a "wedge" analysis which is a 3-segment wedge. This 3-segment wedge better represents the failure mechanism. The "optimization" feature in Slope/W was used to fully capture the non-circular type failure surfaces.

The paragraph was revised to clarify that lower FSs are computed for non-circular failures for riverbank stability than circular. The reason being is the long neutral block surface through a weak layer. A similar situation occurs in the diversion channel because the configuration approaches that of the riverbanks.

20. Could a Seep/W model be created to simulate uplift conditions in critical locations, such as the area near Dilworth? This might help refine uplift computations within the various soil layers beneath the diversion channel invert. Also, the heads in the sand were determined from piezometers and available well information. Did any of the CPT soundings penetrate into these sands? This could provide good water level information.

Placing total head boundary conditions on the vertical extent of the seepage models essentially simulates the uplift condition in areas in which there is a clean sand (SP) layer extending across the model. Because the clean sand has such a high permeability when compared to the overlying clay/silt materials, very little head loss occurs through the sand. Placing total head boundary at the interface of the clay and the sand would essentially result in the same results as has been modeled.

The uplift computations takes into consideration the type of soils above the clean sand. If less pervious materials are above the sands and beneath the impervious clay materials of the Brenna and Argusville formations, the thickness of the less pervious materials are transformed into an equivalent thickness of a material with a lower permeability. So in effect, the results from Seep/W will essentially provide similar uplift results as to that which has been presented.

The CPT soundings did penetrate into the sands at a few locations but dissipation tests were not done. So the results from the CPT soundings were not used to get water level information.

21. Sheet 4 of Attachment I-08 shows backcalculated friction angles in the Brenna for six of the design sections. Were these values used in the stability analyses or was a laboratory residual friction angle used?

    The Phase 2 In-Town Levee alternative stability analysis used laboratory residual friction angles. The residual zone was assumed for design purposes and did not represent known and/or existing failures. The residual zone represents a conservative approach. When the back calculations were completed, it was again without the use of a known and existing failure surface. So the back calculated friction angles do not represent what would be calculated using the St. Paul District's methodology and was used as a comparison it to the laboratory residual friction angle.

22. I think something could be learned from a FLAC analysis conducted in stages of excavation and spoil placement (i.e. simulating diversion construction). Neil could do this modeling most efficiently; I wouldn't mind giving it a shot if time permitted.

    I discussed with Neil completing a staged-construction analysis for the diversion channel excavation. He also agreed that something could be learned and could be used to supplement the traditional analyses completed, but not replace them entirely. The intent is to complete this staged-construction in the future and will likely be done using GeoStudio. Additional wording was added to the "Diversion Channel Analysis" under Section I.11.0 Additional Work to indicate that a staged-construction analysis should be completed.

23. In Figure I-6 does the dimension H1 refer to the spoil pile height indicated in Tables I-15 and 16? If so, you might want to add (H1) to the Spoil Pile Height column in the tables.

    The spoil pile height in the tables refers to H1. The tables have been fixed to indicate this.

24. In Tables I-17 and 18 it's not clear which FS values listed are effective stress and which are total stress. It appears they're all effective stress FS except for the last column, undrained global.

    The results of the effective stress analyses are indicated in the first 4 columns and the undrained global is indicated in the last column. The tables have been fixed to indicate the effective stress vs total stress analyses.

25. Were any of the diversion sections checked with another stability program (UT4, Slide, or FLAC/Slope)? If not, consider checking one or two.

    MN Diversion Section 6 and ND Diversion Section 2 were checked using Slide. The drained global stability results indicated similar factors of safety and failure surfaces. These results are included at the end of the respective diversion analysis result attachments.

26. In the future, consider installing a series of VWP near 12th Ave. S. where computed uplift FS values were low.

    It is recognized that additional exploration is needed around the Dilworth area to finalize the design for plans and specifications along with instrumentation. Agree that installing a VWP near 12th Ave S would provide beneficial information. It was not installed in July 2010 due lack of access.

27. Were the artesian conditions assumed for the uplift calculations used in the corresponding seepage and stability calculations? In other words, were head conditions set at the nodes representing the top of the sand in the Seep/W models?

    The artesian conditions assumed for the uplift calculations do not correspond to the seepage and stability calculations. The artesian conditions / piezometric head in the sand was assumed to be 7.5 feet below ground surface and selected base on review of the water levels in the surrounding MN DNR observation wells along with the Corps' instrumentation.

    As previously indicated in the response to Comment 20, the total boundary conditions on the vertical extent(s) of the Seep/W model provided essentially the same results as if the total head boundary conditions were placed on the top of the sand.

28. Some additional discussion of the instrumentation could be helpful, specifically what the piezometers are showing and if anything was or can be learned from them. Some piezometers indicate upward gradient, some a downward gradient or a perched condition, other sets seem to show more or less hydrostatic conditions.

    Some additional discussion on the instrumentation has been included in the report which is indicated below.

    Piezometers P1 through P6 were installed in August 2009 while the reminder of the piezometers, P7 through P23, have recently been installed. P7 though P15 were installed in June 2010 while P16 through P23 were installed in July 2010.

    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. P1 (shallowest) levels have continued to fall and are currently approximately 4 feet above P2 (middle) levels. These trends would indicate that there is a higher pressure at depth.

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 level of P4 (shallowest) is the highest and has been fairly constant, varying at the most, 3 feet. The piezometric levels in P5 (middle) have risen slightly (approximate 2.5 feet) since installation, but began to level off in July 2010. P6 (deepest) is located in a sand formation and is reading the lowest piezometric levels, approximately 10 to 12 feet below ground surface. Again, P6 (deepest) has risen almost 3 feet since the installation, but began to level off in July 2010. The piezometric levels for P4, P5, and P6 can be interpreted either two ways: 1) there is a downward gradient through the clay formations into the sand formation because water is being pumped from the sand formation; 2) there are perched water tables within the different clay formations.

Piezometers P7, P8, and P9 were installed at the proposed location of the Red River Control Structure for the MN Diversion channel alternative. P7 (shallowest) and P9 (deepest) are indicating piezometric levels approximately 10 feet below ground surface, with P9 (deepest) piezometric levels being approximate 0.5 feet lower. The piezometric level for P8 (middle) is the lowest, being approximate 12.5 feet BG5. These trends could indicate that there is perched water table near the ground surface but more readings are needed to verify this.

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. P10 (shallowest) is indicating piezometric levels approximately 10 feet below ground surface. P11 (middle) and P12 (deepest and installed in a sand formation) are indicating piezometric levels approximately 3 feet and 5 feet, lower than P10, respectively. This trend of the shallowest piezometer having the highest piezometric level while the deepest piezometer has the lowest level is similar to that of the instrument cluster of P4, P5, and P6.

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) is indicating a piezometric level 28 feet BGS while P14 (middle) is approximately 34 feet BGS. This is very different from the other instruments, which typically have piezometric levels 10 feet to 15 feet BGS. The piezometric level for P15 (deepest) is approximately 80 feet BGS. Additional readings are needed before a definitive conclusion can be made as to what this trend is indicating as readings have only been collected since the end of June 2010.

Piezometers P17, P18, and P19 were installed at the proposed location of the Red River Control Structure for the ND Diversion channel alternative. P17 (shallowest) is indicating piezometric levels approximately 12 feet below ground surface. P18 (middle) and P19 (deepest) are indicating piezometric levels approximately 1 feet and 2 feet, lower than P17, respectively. This trend of the shallowest piezometer having the highest piezometric level

while the deepest piezometer has the lowest level is similar to that of the instrument cluster of P4 – P6 and P10 – P12.

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 are not available for this cluster.

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.

If any of the responses do not resolve Mr. Behling's questions or comments, please let me know and I'll attempt to clarify them.

Kurt Heckendorf, P.E.
Civil Engineer
Geotechnical and Geology Section

Heckendorf, Kurt A MVP

From: Wachman, Gregory S MVP
Sent: Friday, February 18, 2011 1:23 PM
To: Heckendorf, Kurt A MVP
Subject: RE: FMMFS: Peer Review of Phase 4 (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Kurt,

I saved a version of the writeup with my initials at the end and made some suggested changes and comments. The comments and changes were mostly editorial in nature. The seepage and stability work was good as far as I could tell, but I had some comments on the presentation that you can consider. There is a lot of stability work, so I didn't look at it too closely - if you want me to take a closer look at anything in particular just let me know.

Greg

Comments not made in the writeup:

1) Many of the Phase 2 stability plates are cut off, but not magnified enough to show details well. Also, things like model points are shown unnecessarily.

2) Additional shear surfaces are shown on the Phase 2 models without explanation - is there a reason for them to be shown on the plates? In many cases they cover up the final critical surface.

3) Presentation of the Phase 3 and 4 seepage/stability: There seem to be problems with the axes in relation to the area of interest on a number of sections - the vertical axis could be moved further to the right.

4) The seepage plates might benefit from head contour labels and total head boundary condition descriptions. The flow vectors aren't particularly useful.

5) The grids in the wedge analysis of MN div. sec #9a and 9b are too close to each other - doing this can produce unreliable results. Also, they obscure the critical shear surface.

-----Original Message-----
From: Heckendorf, Kurt A MVP
Sent: Wednesday, February 16, 2011 11:13 AM
To: Wachman, Gregory S MVP
Subject: FMMFS: Peer Review of Phase 4 (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Greg,

Would you have time in the next week or so to complete a peer review of the Phase 4 Fargo-Moorhead geotechnical documents? This would include review of the write-up and the stability models.

Labor Code: 138D83

The documents are located on the server and can be accessed through the following links.

Phase 4 Report Documents: \\mvd\mvp\PROJECTS\SA\SA Fargo-Moorhead Metro FDR-153866\02FeasibilityFEA\Geotech\Phase 4 Report

Phase 4 slope stability models with invert raise: \\mvd\mvp\PROJECTS\SA\SA Fargo-Moorhead Metro FDR-153866\02FeasibilityFEA\Geotech\Stability\Phase 4\ND Invert Raise\03 P4 invert Vr4

Some additional documents that may help in your review:

Phase 3 slope stability models: \\mvd\mvp\PROJECTS\SA\SA Fargo-Moorhead Metro FDR-153866\02FeasibilityFEA\Geotech\Stability\Phase 3

Shear Strength Parameters: \\mvd\mvp\PROJECTS\SA\SA Fargo-Moorhead Metro FDR-153866\02FeasibilityFEA\Geotech\Parameters

Instrumentation: \\mvd\mvp\PROJECTS\SA\SA Fargo-Moorhead Metro FDR-153866\02FeasibilityFEA\Geotech\Instrumentation

Please let me know if you have any questions.

Respectfully,
Kurt
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Classification: UNCLASSIFIED
Caveats: NONE

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FOR CONTINUATION OF HOUSE DOCUMENT 112-130

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

SEE PART 5