112th Congress, 2d Session – – – – – – – – – – – – – House Document 112–142

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY RECONSTRUCTION PROJECT

COMMUNICATION

FROM

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

TRANSMITTING

RECONSTRUCTION PROPOSAL FOR THE OHIO RIVER SHORELINE, PADUCAH, KENTUCKY

PART 1 OF 2

SEPTEMBER 19, 2012.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

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HOUSE DOCUMENT NUMBER 112-142

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

SEP - 7 2012

Mr. John A. Boehner
Speaker of the House
of Representatives
U.S. Capitol Building, Room H-232
Washington, D.C. 20515-0001

Dear Mr. Speaker:

In final response to Section 5077 of the Water Resources Development Act (WRDA) of 2007, the Secretary of the Army recommends authorization of the Ohio River Shoreline, Paducah, Kentucky Reconstruction project. The reconstruction proposal is described in the report of the Chief of Engineers, dated May 16, 2012. The views of the Department of Agriculture, Natural Resources Conservation Service, the Commonwealth of Kentucky and the City of Paducah, Kentucky are set forth in the enclosed communications. Section 5077 authorizes the Secretary to carry out the project, if determined feasible, at a total cost of $3,000,000. However, the proposed reconstruction project exceeds the authorized amount. The Secretary of the Army plans to implement the reconstruction project through the normal budget process at the appropriate time, considering national priorities and the availability of funds.

The Paducah, Kentucky local flood protection project is a 12.2 mile-long levee and floodwall system which was authorized by Section 4 of the Flood Control Act of June 28, 1938. Construction was completed in 1949. The project consists of about 9.2 miles of levees and 3 miles of floodwalls, and includes 12 floodwater pumping stations and other appurtenant facilities. There are 47 openings in the floodwall system that must be manually closed in advance of flooding. The recommended plan would reconstruct obsolete features to restore the performance and improve the reliability of the system. The proposed reconstruction work would replace deteriorated mechanical, electrical and structural components that have exceeded their design service lives and update the project to modern design and safety standards. As part of this work, the construction of one new pumping station and the rehabilitation of the existing drainage structures, including corrugated metal pipes, are included in the estimated project first cost. The recommended plan is the national economic development plan. The report includes an Environmental Assessment and a Finding of No Significant Impact. No compensatory mitigation is required.

The estimated project first cost is $19,500,000 at an October 2011 price level. In accordance with the cost sharing provisions of Section 103(a) of the Water Resources Development Act of 1986, as amended (33 U.S.C. 2213(c)), structural flood risk management features are cost shared at 65 percent Federal and 35 percent non-Federal. Thus, the Federal share of the project first cost is estimated to be $12,675,000 and the non-Federal share is estimated at $6,825,000. The non-Federal cost sharing sponsor, the City of Paducah, Kentucky, would provide all required lands, easements, rights-of-way, relocations, and excavated material disposal areas and be responsible for the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project after reconstruction, a cost currently estimated at $636,000 per year.

Based on a 4.0 percent discount rate and a 50-year period of economic analysis, the total equivalent average annual costs of the project, including OMRR&R, are estimated to be $1,599,000. The equivalent average annual benefits are estimated to be $7,349,000. Net average annual benefits are estimated at $5,750,000. The benefit cost ratio is approximately 4.6 to 1. The project would reduce expected equivalent annual flood damages by about 85 percent. The recommended plan has an estimated 99.9 percent probability of containing a flood that has a 1-percent chance of happening in any year and a 99.6-percent probability of containing a flood that has a 0.2-percent chance of occurring in any year.

In accordance with U.S. Army Corps of Engineers implementation guidance on the in-kind contribution provisions of Section 221 of the Flood Control Act of 1970, as amended by Section 2003 of the WRDA of 2007, the report of the Chief of Engineers recommends that the non-Federal sponsor receive credit, currently estimated to be $2,100,000, for completed reconstruction of drainage structures, including corrugated metal pipes, at the Paducah, Kentucky local flood protection project if such work is determined to be integral to the proposed project. The credit eligibility was approved on November 14, 2008. I concurred with the recommendations of the Chief of Engineers and on June 28, 2012 determined that the completed work was integral to this project, with credit to be afforded once the project is authorized and a Project Partnership Agreement (PPA) is executed. The actual amount of credit is subject to final accounting under the terms of the PPA. Affording this credit would not relieve the non-Federal sponsor of the requirement to pay 5 percent of the total project costs in cash during construction, as required by Section 103(a) of the WRDA of 1986, as amended.

The Office of Management and Budget (OMB) advises that there is no objection to the submission of the report to Congress and concludes that the report recommendation is consistent with the policy and programs of the President. However, OMB also noted that should the Congress authorize this project for construction, it would need to compete with other proposed investments for funding in future budgets. A copy of OMB's letter, dated August 31, 2012, is enclosed. I am providing a copy of this transmittal and the OMB letter to the Subcommittee on Water Resources and Environment of the House Committee on Transportation and Infrastructure, and the Subcommittee on Energy and Water Development of the House Committee on Appropriations. I am also sending an identical letter to the President of the Senate.

Very truly yours,

Jo-Ellen Darcy

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

Enclosures

RECEIVED
2012 SEP 10 PM 4:50
SPEAKER'S ROOM
U.S. HOUSE OF REPS.

6 Enclosures

1. OMB letter, Aug 31, 2012
2. Chief's report, May 16, 2012
3. USDA letter, Dec 21, 2011
4. Commonwealth of Kentucky Clearinghouse letter, Jan 20, 2012
5. City of Paducah, KY, letter, Jul 18, 2012
6. Ohio River Shoreline, Paducah, Kentucky Reconstruction Feasibility Report, April 2011, Revised September 2011

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

August 31, 2012

The Honorable Jo-Ellen Darcy
Assistant Secretary of the Army (Civil Works)
108 Army Pentagon
Washington, DC 20310-0108

Dear Ms. Darcy:

As required by Executive Order 12322, the Office of Management and Budget has reviewed the Army Corps of Engineers (Corps) feasibility study of the Ohio River Shoreline Project, Paducah, Kentucky, with a total project cost of $19.5 million and a Federal cost of $12.7 million (January 2011 prices). Our review concluded that the project is consistent with the policy and programs of the President.

The Office of Management and Budget does not object to your submitting this report to Congress. However, when you do so, please advise the Congress that, should the Congress authorize this project for construction, the project would need to compete with other proposed investments for funding in future budgets.

Sincerely,

Sally Ericsson
Program Associate Director
Natural Resources, Energy and Science

ENCL 1

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF

CECW-LRD (1105-2-10a) MAY 16 2012

SUBJECT: Ohio River Shoreline, Paducah, Kentucky Reconstruction

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on flood risk management along the left bank of the Ohio River at Paducah, Kentucky. It is accompanied by the report of the district and division engineers. This report responds to Section 5077 of the Water Resources Development Act (WRDA) 2007 which directs the Secretary to complete a feasibility report for rehabilitation (reconstruction) of the existing flood damage reduction project at Paducah, Kentucky (Paducah, Kentucky Local Flood Protection Project) authorized by Section 4 of the Flood Control Act of June 28, 1938. Further, Section 5077 authorizes the Secretary to carry out the project, if determined feasible, at a total cost of $3,000,000. The reconstruction project, as currently proposed, exceeds the amount authorized by Section 5077. Preconstruction engineering and design activities for the Ohio River Shoreline, Paducah, Kentucky Reconstruction project will continue under the authority provided by Section 5077 of WRDA 2007.

2. The existing Paducah, Kentucky, Local Flood Protection Project is a 12.2 mile-long levee and floodwall system completed in 1949. The project consists of about 9.2 miles of earthen levee and 3 miles of floodwalls and includes 12 floodwater pumping stations, and other interior drainage facilities. There are 47 movable closure and service openings in the floodwall system that must be manually secured in advance of flooding.

3. The reporting officers recommend authorizing a flood risk management plan to significantly improve reliability and restore system performance of the more than 60 year-old project at Paducah, Kentucky, by reconstructing certain features of the project. The proposed reconstruction work will extend functionality of, and update to modern design and safety standards, deteriorated mechanical, electrical, and structural components that have exceeded their design service lives. Additionally, the proposed plan provides for construction of one new floodwater pumping plant to address changes in interior flooding. The addition of this new pump plant will increase project efficiency and bring the reconstructed project features up to current design standards. Reconstruction items will generally consist of the following:

(a) Recondition pumps, motors and motor control systems, major pump plant components and other miscellaneous items at each of the 12 existing pumping plants;
(b) Construct a new pumping plant at Station 111+67A;
(c) Slip-line 37 existing deteriorated corrugated metal pipes;

ENCL 2

(d) Stabilize diversion channel banks;
(e) Replace floodwall water stop joints;
(f) Plug and / or replace existing deteriorated toe drains;
(g) Replace existing drainage inlet structures (two new gatewell structures) at Bee Branch -at approximate stations 32+12C and 32+38C;
(h) Construct new gate well structures at stations 111+67A (at proposed pump plant #14) and 19+11 section B;
(i) Permanently close 8 existing floodwall closures and raise an existing closure sill;
(j) Install scour erosion control pad at Wall/Levee transitions; and
(k) Provide other miscellaneous items

The proposed project does not require separable mitigation. The report includes an Environmental Assessment and finding of no significant impact-on the quality of the environment. The recommended plan is the national economic development (NED) plan.

4. The estimated total first cost of the recommended plan is $19,500,000 at the October 2011 price level. In accordance with the cost sharing provisions of the Section 103(a) of Public Law 99-662, as amended by Section 202 of WRDA 1996, the Federal share of the total cost of this project is estimated at $12,675,000 (65 percent) and the non-Federal share is estimated at $6,825,000 (35 percent), which includes $436,000 for the estimated value of lands, easements, rights-of-way, relocations, and disposal areas. The city of Paducah, Kentucky is the non-Federal cost sharing sponsor for the recommended plan. The city of Paducah would be responsible for the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project after construction, a cost currently estimated at $636,000 per year.

5. Based on a 4.0-percent discount rate and a 50-year period of economic analysis, the total equivalent average annual costs of the project, including OMRR&R, are estimated to be $1,599,000. The equivalent average annual benefits are estimated to be $7,349,000. Net average annual benefits are estimated as $5,750,000. The benefit-to-cost ratio is approximately 4.6 to 1.

6. Implementation of the proposed reconstruction project would reduce expected equivalent annual flood damages in the project area by about 85 percent, from $8,174,000 to $1,257,000. The reporting officers estimate that the recommended plan has a 99.9 percent probability of containing a flood that has a 1-percent chance of happening in any year and a 99.6-percent probability of containing a flood that has a 0.2-percent chance of occurring in any year.

7. In accordance with implementation guidance on the in-kind contribution provisions of Section 221 of the Flood Control Act of 1970, as amended by Section 2003 of WRDA 2007, the reporting officers recommend that the non-Federal sponsor receive credit, currently estimated to be $2,100,000, for completed reconstruction of drainage structures, including corrugated metal pipes, at the Paducah, Kentucky Local Flood Protection Project. Crediting is subject to the Secretary's determination that such work is integral to the proposed project. This credit

eligibility was approved in concept by the Assistant Secretary of the Army for Civil Works on November 14, 2008. Affording this credit would not relieve the non-Federal sponsor of the requirement to pay 5 percent of the total project costs in cash during construction of the remainder of the proposed project.

8. All technical, engineering and scientific work underwent an open, dynamic and vigorous review process to ensure technical quality. This included an independent Agency Technical Review (ATR) and a Headquarters, USACE policy and legal review. All concerns of the ATR and policy and legal reviews have been addressed and incorporated into the final report. Given the nature of reconstructing an existing project in the original project footprint, I have granted an exclusion from the requirement to conduct a Type I Independent External Peer Review.

9. I concur with the findings, conclusions, and recommendations of the reporting officers. Accordingly, I recommend that the Ohio River Shoreline, Paducah, Kentucky Reconstruction project be authorized in accordance with the reporting officer's recommended plan with such modifications as may be advisable in the discretion of the Chief of Engineers. My recommendation is subject to cost sharing, financing, and other applicable requirements of Federal and State laws and policies, including Section 103 of WRDA 1986, as amended by Section 202 of WRDA 1996. Accordingly, the non-Federal sponsor must agree with the following requirements prior to project implementation:

a. Provide a minimum of 35 percent, but not to exceed 50 percent of total first costs further specified as follows:

(1) Provide 35 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for project;

(2) Provide, during construction, a contribution of funds equal to 5 percent of total project costs;

(3) Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Federal Government to be required or to be necessary for the construction, operation, and maintenance of the project;

(4) Provide, during construction, any additional funds necessary to make its total contribution equal to at least 35 percent of total project costs;

b. Not use funds from other Federal programs, including any non-Federal contribution required as a matching share for that other program, to meet any of its obligations for the project

unless the Federal agency providing the Federal portion of such funds verifies in writing that such funds are authorized to be used to carry out the project;

c. Not less than once each year, inform affected interests of the extent of flood damage reduction afforded by the flood risk management features;

d. Agree to participate in and comply with applicable Federal floodplain management and flood insurance programs;

e. Comply with Section 402 of WRDA 1986, as amended (33 U.S.C. 701b-12), which requires a non-Federal interest to prepare a floodplain management plan within one year after the date of signing a project cooperation agreement, and to implement such plan not later than one year after completion of construction of the flood risk management features;

f. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with degrees of flood risk management provided by the flood risk management features;

g. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the level of protection the flood risk management features afford, hinder operation and maintenance of the project, or interfere with the project's proper function;

h. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

i. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and state laws and regulations and any specific directions prescribed by the Federal Government;

j. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the City owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

k. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project, except for damages due to the fault or negligence of the United States or its contractors;

l. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of three years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations Section 33.20;

m. Comply with all applicable Federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.),* the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.),* and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c *et seq.);*

n. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under CERCLA, Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the City with prior specific written direction, in which case the City shall perform such investigations in accordance with such written direction;

o. Assume, as between the Federal Government and the City, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project;

p. Agree, as between the Federal Government and the City, that the City shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent

practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

q. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 1030) of WRDA 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the City has entered into a written agreement to furnish its required cooperation for the project or separable element.

r. Provide the non-Federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of one percent of the total amount authorized to be appropriated for the project.

10. The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program or the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to the Congress as a proposal for authorization and implementation funding. However, prior to transmittal to Congress, the sponsor, the State, interested Federal agencies, and other parties will be advised of any significant modifications and will be afforded an opportunity to comment further.

MERDITH W. B. TEMPLE
Major General, U.S. Army
Acting Commander

United States Department of Agriculture

NRCS

Natural Resources Conservation Service
771 Corporate Drive, Suite 210
Lexington, KY 40503

December 21, 2011

Theodore A. Brown, P.E.
Headquarters
U.S. Army Corps of Engineers
CECW-P (SA)
7701 Telegraph Road
Alexandria, VA 22315-3860

RE: Ohio River Shoreline, Paducah, Kentucky Project

Dear Ms. Brown:

In regards to the Ohio River Shoreline, Paducah, Kentucky reconstruction feasibility report with environmental assessment, the USDA-Natural Resources Conservation Service (NRCS) is concerned with potential impacts that any water resource project might have upon prime farmland soils, farmlands of statewide importance, PL-566 watershed structures, wetlands, Wetland Reserve Program (WRP) easements, and Grassland Reserve Program (GRP) easements. Based upon the information provided, Kentucky NRCS does not anticipate the proposed actions will negatively impact farmland, wetlands, WRP, GRP or PL-566 watershed structures. If federal dollars are to be used to convert wetlands or convert important prime farmlands from agricultural uses to non-agricultural uses a Form AD-1006 (or Form NRCS-CPA-106 if the project is a corridor type project) must be submitted to the local NRCS office. These forms may be obtained from the local NRCS office and are also available as electronic forms on the web at http://forms.sc.egov.usda.gov/eForms/welcomeAction.do?Home.

The NRCS contact person for McCracken County is
John Shely
5470 US HWY 60 W
Suite B
Paducah, KY 42001
Phone: 270-554-5242 Email: john.shely@ky.usda.gov

Sincerely,

Sonya Keith

for JACOB KUHN
Assistant State Conservationist

ENCL 3

STEVEN L. BESHEAR
GOVERNOR

DEPARTMENT FOR LOCAL GOVERNMENT
OFFICE OF THE GOVERNOR
1024 CAPITAL CENTER DRIVE, SUITE 340
FRANKFORT, KENTUCKY 40601-8204
PHONE (502) 573-2382 FAX (502) 573-2939
TOLL FREE (800) 346-5606
WWW.DLG.KY.GOV

TONY WILDER
COMMISSIONER

January 20, 2012

Ms. Theresa Beckham
DOD - US Army Corps of Engineers
600 Dr. MArtin Luther King Jr. Place Room 708
Louisville, KY 40202

RE: Ohio River Shoreline Paducah, KY (Paducah KY LFPP) Reconstruction Feasibility Report
SAI# KY20111206-1381

Dear Ms. Beckham:

The Kentucky State Clearinghouse, which has been officially designated as the Commonwealth's Single Point of Contact (SPOC) pursuant to Presidential Executive Order 12372, has completed its evaluation of your proposal. The clearinghouse review of this proposal indicates there are no identifiable conflicts with any state or local plan, goal, or objective. Therefore, the State Clearinghouse recommends this project be approved for assistance by the cognizant federal agency.

Although the primary function of the State Single Point of Contact is to coordinate the state and local evaluation of your proposal, the Kentucky State Clearinghouse also utilizes this process to apprise the applicant of statutory and regulatory requirements or other types of information which could prove to be useful in the event the project is approved for assistance. Information of this nature, if any, concerning this particular proposal will be attached to this correspondence.

You should now continue with the application process prescribed by the appropriate funding agency. This process may include a detailed review by state agencies that have authority over specific types of projects.

This letter signifies only that the project has been processed through the State Single Point of Contact. It is neither a commitment of funds from this agency or any other state of federal agency.

ENCL 4

The results of this review are valid for one year from the date of this letter. Continuation or renewal applications must be submitted to the State Clearinghouse annually. An application not submitted to the funding agency, or not approved within one year after completion of this review, must be re-submitted to receive a valid intergovernmental review.

If you have any questions regarding this letter, please feel free to contact my office at 502-573-2382.

Sincerely,

Lee Nalley

Lee Nalley
Kentucky State Clearinghouse

Attachments

The Heritage Council has made the following advisory comment pertaining to State Application Identifier Number KY201112061381

The applicant must ensure compliance with relevant state and federal regulations regarding cultural resources. These may include any or all of the following: the Advisory Council on Historic Preservation's Rules and Regulations for the Protection of Historic and Cultural Properties (36CFR, Part 800) pursuant to the National Historic Preservation Act of 1966; the National Environmental Policy Act of 1969; Executive Order 11593; Kentucky Antiquities Act (KRS 164.705-164.735, KRS 164.990); Kentucky Cave Protection Act (KRS 433.871-433.885); and graves protection legislation (KRS 525.105, KRS 525.110, KRS 525.115, KRS 525.120, KRS 72.020, and 901 KAR 5:090).

Our review indicates that though there are previously recorded archaeological sites in the APE the proposed project will not have an adverse effect to any National Register properties or sites. In accordance with 36 CFR Part 800.4(d) of the Advisory Council's revised regulations our finding is that there will be no Historic Properties Affected within the undertaking's area of potential impact. Therefore, we have no further comment, and the Agency Official's responsibility to consult with the State Historic Preservation Officer under the Section 106 review process is fulfilled.

However, should the project plans change, or should additional information become available regarding cultural resources or citizens' concerns regarding impacts to cultural resources, please submit that information to our office as additional consultation may be warranted. In the event that human remains are encountered during project activities, all work should be immediately stopped in the area and the area cordoned off, and in accordance with KRS 72.020 the county coroner and local law enforcement must be contacted immediately. Upon confirmation that the human remains are not of forensic interest, the unanticipated discovery must be reported to the Kentucky Heritage Council and the Kentucky Office of State Archaeology in the Anthropology Department at the University of Kentucky.

If you have any questions, please contact Philip Mink at the Kentucky Heritage Council (State Historic Preservation Office) at (502)564.7005, ext. 140, or at Philip.Mink@ky.gov.

The Purchase ADD has made the following advisory comment pertaining to State Application Identifier Number KY201112061381
no comments

The Transportation has made the following advisory comment pertaining to State Application Identifier Number KY201112061381

Herring (D-1), Jessica: The Kentucky Transportation Cabinet is responsible for controlling both public and private usage of right-of-way of the State road system. Any firm, individual, or government agency desiring access to a State road or desiring to perform any type of work (including signage, boring, etc.) on or adjacent to State right-of-way must obtain a permit from the Department

Any proposed access or encroachment of a State maintained road right-of- way should be coordinated at the earliest stage with:

Chris Kuntz, P.E., Permits Engineer
Kentucky Department of Highways, District 1
5501 Kentucky Dam Road, Paducah, Kentucky 42003
Telephone: (270) 898-2431 or 1 (800) 338-4283, Fax: (270) 898-7457

Endorsed by:
Jessica Herring, EIT, Planning Section Supervisor
Kentucky Department of Highways, District 1
5501 Kentucky Dam Road, Paducah, Kentucky 42003
Telephone: (270) 898-2431 or 1 (800) 338-4283, Fax: (270) 898-7457

The Kentucky Housing Corporation has made the following advisory comment pertaining to State Application Identifier Number KY201112061381
No comments.

The Labor Cabinet has made the following advisory comment pertaining to State Application Identifier Number KY201112061381

PW RATES MAY APPLY IF CONSTRUCTION IS OVER 250,000.00. CONTACT KY LABOR CABINET AT 502-564-3534

The Kentucky State Fish & Wildlife has made the following advisory comment pertaining to State Application Identifier Number KY201112061381

Based on the information provided, the Kentucky Department of Fish & Wildlife Resources has no comments concerning the proposed project. Please contact Dan Stoelb @ 502-564-7109 ex. 4453 or Daniel.stoelb@ky.gov if you have further questions or require additional information.

The Housing, Building, Construction has made the following advisory comment pertaining to State Application Identifier Number KY201112061381
no comment

The Natural Resources has made the following advisory comment pertaining to State Application Identifier Number KY201112061381

This review was based upon the information that was provided by the applicant through the Clearinghouse for this project. An endorsement of this project does not satisfy, or imply, the acceptance or issuance of any permits, certifications or approvals that may be required from this agency under Kentucky Revised Statutes or Kentucky Administrative Regulations. Such endorsement means this agency has found no major concerns from the review of the proposed project as presented other than those stated as conditions or comments.

The proposed project is subject to Division of Water (DOW) jurisdiction because the following are or appear to be involved: levee reconstruction project, consisting primarily of replacing worn components which have passed their service life. Prior approval must be obtained from the DOW before construction can begin. When submitting plans and specifications to the DOW, the applicant must cite the State Application Identifier # KY201112061381

This is a US Army Corps of Engineers and city of Paducah, KY levee reconstruction project, consisting primarily of replacing worn components which have passed their service life.

The State and Agency Review Period for the Reconstruction Feasibility Report will end on 23 January 2012. Please provide comments prior to that date.

All files can be found at the following location for review :

www.lrl.usace.army.mil Then choose "Projects of Interest" then choose "Ohio River Shoreline, Paducah, KY (Paducah KY LFPP)..."

There are four volumes - Volumes 1 and 2 are the Main Report and Appendices; Volume 3 is made up of the Engineering Drawings; and Volume 4 contains the Engineering Calculations, References, and As-Builts (Volume 4 is a huge file and will be provided on a CD upon request).

From the application data, the DOW ascertains that the site of the proposed project is located in a floodplain area; therefore, a floodplain construction permit is required. Construction in this area will require a 'stream construction permit' from the Division of Water. Julia Harrod 502 564 3410

If the construction area disturbed is equal to or greater than 1 acre, the applicant will need to apply for a Kentucky Pollutant Discharge Elimination System (KPDES) storm water discharge permit.

Utility line projects that cross a stream will require a Section 404 permit from the US Army Corps of Engineers and a 401 Water Quality Certification from DOW.

The Kentucky Division of Water supports the goals of EPA's Sustainable Infrastructure Initiative. This Initiative seeks to promote sustainable practices that will help to reduce the potential gap between funding needs and spending at the local and national level. The Sustainable Infrastructure Initiative will guide our efforts in changing how Kentucky views, values, manages, and invests in its water infrastructure. This website, www.epa.gov/waterinfrastructure/, contains information that will help you ensure your facility and operations are consistent with and can benefit from the aims of the Sustainable Infrastructure Initiative

CITY OF PADUCAH
300 South 5th Street
P. O. Box 2267
Paducah, KY 42002-2267
Phone: (270) 444-8530
Fax: (270) 443-5058

William F. Paxton III
Mayor

July 18, 2012

Ms. Sharon Bond
Chief, Planning Branch and
Acting Deputy Planning, Programs,
and Project Management Division
P.O. Box 59
Louisville, Kentucky 40201-0059

RE: City of Paducah, Kentucky
Letter of Intent (LOI) for Ohio River Shoreline, Kentucky Reconstruction

Dear Ms. Bond:

The City of Paducah, Kentucky, designated hereafter as the "Sponsor," is interested in partnering with the Department of the Army, Corps of Engineers to implement the Reconstruction Plan for the Ohio Shoreline in Paducah, Kentucky.

As the Sponsor, we've not only maintained the Project from 1949 to present, we've also actively maintained our partnership with the USACE Louisville District during the development and review of the Ohio River Shoreline, Paducah, Kentucky (Paducah, Kentucky LFPP) Reconstruction Project Feasibility Report. It is the City's desire to assist in the development of the various construction/reconstruction documents in association with any and all phases of an anticipated reconstruction project. Furthermore, as an active participating partner with the USACE, we are aware of and support the procedures identifying cost-sharing requirements as outlined in the attached Chief's Report dated May 16, 2012.

At this time, it is my understanding that the Corps of Engineers is ready to initiate Preconstruction Engineering and Design (PED) activities and prepare plans and specifications for the reconstruction of the Project. It is also my anticipation and understanding that we, as the Sponsor, will be granted the opportunity to actively participate, assist and/or provide portions of the PED to the USACE for review and implementation into the appropriate reconstruction documents.

Having discussed this project with Rick Murphy P.E., City Engineer & Public Works Director, I understand that detailed design of the project features typically lasts 12-24 months, depending on the complexity of

ENCL 5

the project features; and that there will be some cost-shared up-front expenses at the same percentage as construction. Additionally, it is my understanding that near the end of the PED, the Corps and Sponsor will execute a Project Partnership Agreement that commits both to proceeding with construction. With the expressed understandings outlined herein, this letter constitutes an expression of intent and not a contractual obligation and that the sponsor or the Corps may opt to discontinue the project development process up to and until entering into agreement to construct the project.

To summarize, the City supports the recommended Plan in the feasibility report and pledges its cooperation with the Corps of Engineers, Louisville District during future phases of project implementation.

Sincerely,

William F. Paxton, III
Mayor

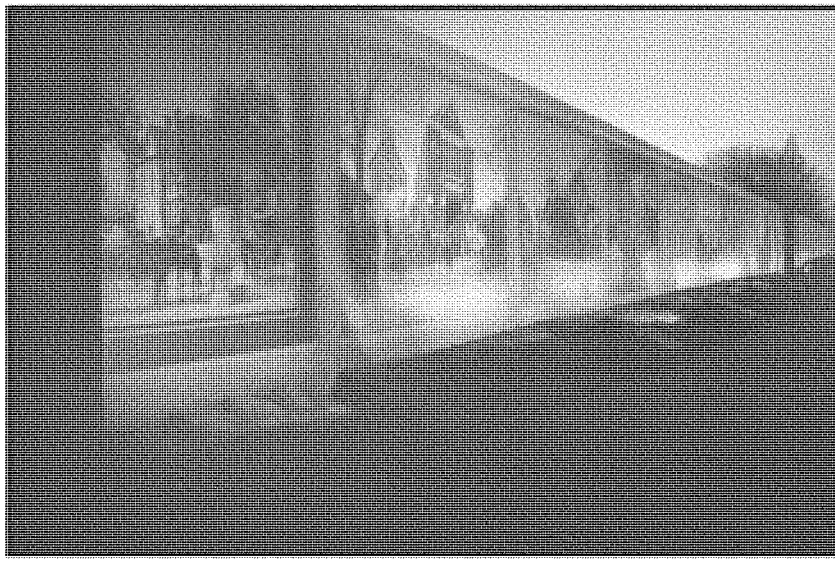
WFP:rbm

C: U.S. Representative Ed Whitfield
U.S. Senator Mitch McConnell
U.S. Senator Rand Paul
Janece Everette, Congressman Whitfield's Local Field Representative
Martie Wiles, Senator McConnell's Local Field Representative
Christina Peterson, Senator Ran Paul's Local Field Representative
Mayor Pro-Tem Gayle Kaler
Commissioner Gerald Watkins
Commissioner Richard Abraham
Commissioner Carol Gault
Jeff Pedersen, City Manager
Rick Murphy, P.E., City Engineer & Public Works Director
Kenny Brannon, Floodwall Superintendent

US Army Corps
of Engineers
Louisville District

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT

VOLUME 1 OF 4
MAIN REPORT



DEPARTMENT OF THE ARMY
U.S. ARMY DISTRICT, LOUISVILLE
LAKES AND RIVERS DIVISION
CORPS OF ENGINEERS
P.O. BOX 59
LOUISVILLE, KENTUCKY 40201-0059

April 2011
Revised September 2011

Proposed Action Categorically Excluded from NEPA Documentation
Report Does Include an Environmental Assessment

Final Submittal

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
P.O. BOX 59
LOUISVILLE KY 40201-0059

http://www.lrl.usace.army.mil/

April 2011
Revised September 2011

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 1 OF 4
MAIN REPORT

Proposed Action Categorically Excluded from NEPA Documentation
Report Does Include an Environmental Assessment

Final Submittal

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 1 OF 4
MAIN REPORT

TABLE OF CONTENTS

Contents

EXECUTIVE SUMMARY ES-1
1. STUDY AUTHORITY 1-1
2. REPORT PURPOSE AND SCOPE 2-1
2.1. Report Content 2-1
2.2. Description of the Study Area 2-1
2.3. Historic Storms and Floods 2-4
3. PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS 3-1
3.1. Prior Studies 3-1
3.1.1. The Ohio River Mainstem System Study (ORMSS) 3-1
3.1.2. Ohio River Ecosystem Restoration Study 3-1
3.1.3. SE Illinois Shoreline 905(b) Analysis (1997) 3-1
3.1.4. Paducah 905(b) Analysis 3-2
3.2. Existing Projects 3-2
3.2.1. Olmsted Locks & Dam 3-2
3.2.2. Lock and Dams 52 & 53 3-2
3.2.3. Kentucky and Lake Barkley Locks and Dams 3-3
3.2.4. Paducah, Kentucky LFPP 3-3
4. Plan Formulation 4-1
4.1. Flood Risk Management Plans 4-1
4.2. Feasibility Study Plan Formulation 4-2
4.3. Existing Conditions 4-3
4.3.1. Flooding and Flood Protection 4-4
4.3.2. Hazardous, Toxic, and Radioactive Waste (HTRW) 4-7
4.3.3. Environmental and Cultural Resources 4-7
4.3.4. Social and Economic Conditions 4-10

4.4. Problems and Opportunities....4-11
4.5. Planning Constraints....4-11
4.6. Future Without Project Condition....4-12
4.7 Alternative Plans (Description of Available Measures and Plan Formulation Screening Criteria)....4-17
4.7.1. Alternative 1: No Action....4-18
4.7.2. Alternative 2: Reconstruction....4-18
4.7.3 Pump Plant at Station 111+67A....4-20
4.7.4. Pump Plant at Station 19+11B....4-23
4.7.5. Non-structural Alternatives....4-23
4.8. Integral Determination....4-24
4.9. Future With Project Condition....4-27
4.10. Other Impacts....4-30
4.11. National Economic Development (NED) Plan....4-30
5. RECOMMENDED PLAN....5-1
5.1. Plan Components....5-1
5.2. Design and Construction Considerations....5-6
5.3. Lands, Easements, Rights-of-Way, Relocations, and Disposals (LERRD) Considerations....5-6
5.4. Economic Summary....5-7
5.5 Operation, Maintenance, Replacement, Repairs, and Rehabilitation (OMRR&R)....5-10
5.6. Plan Accomplishments....5-10
5.6.1. National Economic Development (NED)....5-11
5.6.2. Regional Economic Development (RED)....5-11
5.6.3. Other Social Effects (OSE)....5-11
5.6.4. Summary of Environmental Effects (Environmental Quality)....5-11
5.6.5. Residual Risk....5-14
5.6.6. Flood Warning Emergency Evacuation Plan....5-14
5.6.7 Executive Order 11988....5-18
6. PLAN IMPLEMENTATION....6-1
6.1. Institutional Requirements....6-2
6. 2. Division of Plan Responsibilities Cost Allocation....6-4
6.2.1. Federal Responsibilities....6-4
6.2.2. Anticipated Non-Federal Responsibilities (PPA will govern)....6-4
6.2.3. Non-Federal Sponsor's Financial Self-Certification....6-7
6.2.4. Real Estate Requirements....6-7
6.2.5. Environmental Requirements....6-8

7. SUMMARY OF COORDINATION, PUBLIC VIEW, AND COMMENTS.....7-1
7.1. Public Involvement.....7-1
7.1.1. State Historic Preservation Officer.....7-2
8. CONCLUSIONS AND RECOMMENDATIONS.....8-1

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 1 OF 4
MAIN REPORT

TABLE OF CONTENTS

LIST OF TABLES

Table No.	Title	Page No.
Table 1	Eligibility of Reconstruction – Decision Logic	ES-6
Table 3-1	Paducah Flood Risk Management Project Costs from 1994-2006	3-4
Table 4-1	Peak Historic Floods since Project Completion	4-5
Table 4-2	Affected Structures by Event (Without Project)	4-15
Table 4-3	Estimated Structure Damages by Event	4-16
Table 4-4	Summary of annual Benefits and Costs @ Pump Sta. 111+67 (FY 11 Price Levels)	4-22
Table 5-1	Eligibility for Reconstruction – Decision Process	5-3
Table 5-2	Summary of Reconstruction Items	5-4
Table 5-3	Project Cost Summary Report (FY 11 Price Levels)	5-8
Table 5-4	With Project Condition/Reconstruction Plan Summary of Annual Benefits and Costs (FY 11 Price Levels)	5-9
Table 5-5	Summary of Environmental Effects	5-12
Table 6-1	Summary of Action Items and Schedule to Complete Project	6-1
Table 6-2	Project Cost Distribution, Paducah, Kentucky (January 2011 Price Level)	6-7

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 1 OF 4
MAIN REPORT

LIST OF FIGURES

Figure No.	Title	Page No.
Figure ES-1	Vicinity Map of Project Area	ES-1
Figure 2-1	Watersheds for Paducah, Kentucky LFPP	2-2
Figure 2-2	Project Map Delineating Sections along Line of Protection	2-3
Figure 4-1	Future without Project Condition Floodplain, 0.2% chance (500-year) Event	4-6
Figure 4-2	Future with Project Condition Floodplain, 0.2% chance (500-year) Event	4-29

LIST OF PHOTOS

Figure No.	Title	Page No.
Photo 4.3.1	Murals on Floodwall at Paducah, KY LFPP	4-10

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 2 OF 4 APPENDICES

APPENDIX A - PUBLIC AND AGENCY COORDINATION

APPENDIX B - ECONOMIC ANALYSIS

1. ECONOMICS ANALYSIS PROCESS 1
2. PLAN FORMULATION 3
3. STUDY AREA DESCRIPTION 6
4. DAMAGE CATEGORIES 10
5. FUTURE WITHOUT PROJECT CONDITION 11
6. FUTURE WITH PROJECT CONDITION 31
7. INVESTMENT COSTS AND ANNUAL CHARGES 49
8. SUMMARY OF ANNUAL BENEFITS AND COSTS 50
9. ECONOMIC SUMMARY 52
10. PUMP PLANT #14 (at Sta. 111+67A) INCREMENTAL ANALYSIS 52

APPENDIX C - ENGINEERING EVALUATIONS

1. GENERAL 1-1
2. HYDROLOGY AND HYDRAULICS 2-1
3. SURVEYING AND MAPPING REQUIREMENTS 3-1
4. GEOTECHNICAL 4-1
5. ENVIRONMENTAL 5-1
6. CIVIL ENGINEERING 6-1
7. STRUCTURAL 7-1
8. ELECTRICAL AND MECHANICAL 8-1
9. OPERATION AND MAINTENANCE (0&M) 9-1
10. COST ESTIMATE 10-1

APPENDIX D - REAL ESTATE PLAN

1. GENERAL 1
2. PURPOSE OF REAL ESTATE PLAN 1
3. PROPERTY DESCRIPTION/ACREAGES 1
4. ESTATES/VALUATION 2

5. NAVIGATIONAL SERVITUDE..... 2
6. INDUCED FLOODING..... 2
7. MINERAL/TIMBER ACTIVITY.....2
8. LANDOWNERS' CONCERNS..... 3
9. EXISTING GOVERNMENT INTERESTS AND RIGHTS..... 3
10. PUBLIC LAW 91-646..... 3
11. OUTSTANDING CONDITIONS..... 3
12. FACILITY/UTILITY/CEMETERY RELOCATIONS..... 3
13. HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW) IMPACTS..... 4
14. ENVIRONMENTAL AND HISTORICAL PRESERVATION CONSIDERATIONS..... 4
15. ACQUISITION SCHEDULE..... 4
16. NON-FEDERAL SPONSOR..... 4
17. ADMINISTRATION..... 4

APPENDIX E – ENVIRONMENTAL

VOLUME 3 OF 4
11X17 ENGINEERING DRAWINGS

For a complete list of Engineering Drawings, see Volume 3, Sheet GI002.

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 4 OF 4 ENGINEERING CALCULATIONS AND REFERENCES

PLANNING AND GENERAL REFERENCES

1) ER 1105-2-100, Planning Guidance Notebook, 22 April 2000. U.S. Army Corps of Engineers.

2) CE-CWLRD Memorandum for Commander, Great Lakes and Ohio River Division, dated 11 Jun 2009, Subject: Implementation Guidance for Section 5077 of the Water Resources Development Act of 2007 (WRDA 2007) – Paducah, Kentucky.

3) CECW-PB Memorandum, Subject: Reconstruction of U.S. Army Corps of Engineers Structural Flood Damage Reduction Projects for which Non-Federal Interests are Responsible for Operation, Maintenance, Repair, Rehabilitation, and Replacement, Section 3.g. , dated 16 Aug 2005. U. S. Army Corps of Engineers.

4) Ohio River, Paducah, Kentucky Flood Damage Reduction Section 905(b) Report, (WRDA 1996) Analysis, dated May, 2000.

5) Memorandum For The Deputy Commanding General For Civil Works And Emergency Operations dated 14 N ovember, 2008. P aragraph four of this memorandum states:

   "...a one-time exception to the policy on the timing requirements contained in EC 1165-2-208 paragraph 4.a. (1) to allow execution on an In-Kind MOU with the city of Paducah prior to completion of the feasibility study is warranted."

6) Memorandum of Understanding (MOU) Between the Department of the Army and the City of Paducah, Kentucky for Work Provided or Performed Prior to the Execution of a Project Partnership Agreement for Paducah, Kentucky Local Flood Protection Project executed 17 N ovember 2008. This MOU identified the work associated with the slip-lining of the CMP's and other proposed items which are considered to be integral components of the project.

7) ER 1105-2-101, Risk Analysis for Flood Damage Reduction Studies.

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 4 OF 4 ENGINEERING CALCULATIONS AND REFERENCES

(Cont'd.)

8) CECW-PG Memorandum, *Subject: Economic Guidance Memorandum (EGM) 04-01, Generic Depth-Damage Relationships for Residential Structures with Basements,* dated 10 October 2003. U.S. Army Corps of Engineers.

HYDRAULICS REFERENCES

1) Design Memorandum (DM) *"General Information Flood Protection Project: Paducah, Kentucky dated October 1939*

2) Paducah, Kentucky LFPP As-Built drawings

3) Paducah 2-foot contour Mapping, GRW Arial Services & Photo Science (2006)

4) Hydraulic Calculation for Gravity Outlet Pipes by Florence and Hutcheson

5) HEC-HMS Hydrologic Modeling System User's Manual, Hydrologic Engineering Center, Davis, CA

6) EM 1110-2-1413 "*Hydraulic Analysis of Interior Areas*" U.S. Army Corps of Engineers, dated 15 January 1987

7) EM 1110-2-1913 "*Design and Construction of Levees*" U.S. Army Corps of Engineers, dated 30 April 2000

8) NOAA Atlas 14, National Oceanic & Atmospheric Administration, National Weather Service, Silver Spring, MA

9) Climatic Data. National Climatic Data Center, National Oceanic & Atmospheric Administration, National Weather Service, Silver Spring, MA

9) Surface Water Data, U.S. Geological Survey, Reston, VA

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 4 OF 4 ENGINEERING CALCULATIONS AND REFERENCES

(Cont'd.)

GEOTECHNICAL REFERENCES

1) Design Memorandum (DM) "*General Information Flood Protection Project Paducah, Kentucky dated October 1939*"

2) Paducah, Kentucky LFPP As-Built drawings

3) Stratigraphy derived from Kentucky Geological Survey

4) Study by J.B. Harris and R.L. Street, Engineering Geology 46 dated 1997

5) EM 1110-1-1804, *Geotechnical Investigations,* dated 1 January 2001

6) EM 1110-2-1906, *Laboratory Soils Testing*, dated 20 August 1986

7) *A Comprehensive Geotechnical and Geological Investigation of High Horizontal Stress in Shallow Soils of the Upper Mississippi Embayment and its Influence on Pile Capacity*, authored by Jeffrey A. Shaefer, PhD, P.E., P.G.

8) EC 1110-2-6067, *USACE Process for the National Flood Insurance Program (NFIP) Levee System Evaluation*, dated 30 July 2009

9) Soil Survey of Ballard and McCracken Counties, Kentucky conducted by the United States Department of Agriculture Soil Conservation Service

10) EP-500-1-1, *Emergency Employment of Army and Other Resources Civil Emergency Management Program – Procedures*, dated 30 September 2001

11) ER 1105-2-101, *Risk Analysis for Flood Damage Reduction Studies,* dated 3 January 2006

12) EM 1110-2-1913 *Design and Construction of Levees,* dated 30 April 2000

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 4 OF 4 ENGINEERING CALCULATIONS AND REFERENCES

(Cont'd.)

13) EM 1110-2-1902 *Slope Stability*, dated 31 October 2003

14) ETL 1110-2-569 *Design Guidance for Levee Underseepage*, dated 01 May 2005

15) ER 1110-2-1150 Engineering and Design for Civil Works Projects, dated 31 August 1999

16) Eight borings conducted by Geotech Engineering & Testing, Inc. for the Proposed Ingram Office Building near Section B – Unit I, STA 78+85

17) Six borings conducted by Geotech Engineering & Testing, Inc. for the Proposed Crounse Corporation Headquarters near Section B – Unit II, STA 106+10

18) The Subsurface Investigation containing seventeen borings conducted by Florence & Hutcheson, Inc. for the Four Rivers Center Site No. 2 near Section B – Unit II, STA 114+98

19) USACE Proof Tests of Slip-lining Technology, Paducah, Kentucky LFPP Scope of Work (SOW)

STRUCTURAL REFERENCES

1) Draft EC 1110-2-6066, *Design or Evaluation of I-Walls*, dated 31 December 2008. U.S. Army Corps of Engineers.

2) EM 1110-2-2105, *Design for Hydraulic Steel Structures*, dated 31 May 1994. U.S. Army Corps of Engineers.

3) EM 1110-2-2705, *Structural Design of Closure Structures for LFPP*, dated 31 March 1994. U. S. Army Corps of Engineers.

4) EM 1110-2-2502, *Retaining and Flood Walls*, dated 29 September 1989. U.S. Army Corps of Engineers.

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 4 OF 4 ENGINEERING CALCULATIONS AND REFERENCES

(Cont'd.)

5) EM 1100-2-2100, *Stability Analysis of Concrete Structures,* dated 01 December 2005. U.S. Army Corps of Engineers.

6) EM 1100-2-6053, *Engineering and Design - Earthquake Design and Evaluation of Concrete Hydraulic Structures,* dated May 2007. U.S. Army Corps of Engineers.

7) ER 1110-2-1806, *Earthquake Design and Evaluation for Civil Works Projects,* dated 31 July 1995. U.S. Army Corps of Engineers.

8) Final Report Flood

9) Performance Wall Stability Investigation, U.S. Engineer Office Louisville, KY. 1941. *Evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System; Volume IV – "The Storm,"* Interagency Performance Evaluation Task Force (IPET), Washington, DC. U.S. Army Corps of Engineers, 2006.

10) ACI 318-08, *Building Code Requirements for Structural Concrete and Commentary.* American Concrete Institute.

11) ACI 437-03, *Strength Evaluation of Existing Concrete Buildings.* American Concrete Institute.

12) Spring Inspection of the Paducah, Kentucky, Flood Protection Project 15 July 1975. Ohio River Division, U.S. Army Corps of Engineers.

13) Fall Inspection Paducah Flood Protection Project, 22-23 October 1979. Ohio River Division, U.S. Army Corps of Engineers.

14) U.S. Army Corps of Engineers computer program CWALSHT (Version 11/9/2007) *Design/Analysis of Sheet-Pile Walls by Classical Methods.*

15) U.S. Army Corps of Engineers computer program CTWALL *A Microcomputer Program for the Analysis of Retaining and Floodwalls* (Version 10/30/1993).

16) *Steel Construction Manual* 13th Edition, American Institute of Steel Construction (AISC).

17) Computer structural analysis software *RAM AdvanSE version 9.0,* Bentley Systems, Inc.

18) *Operations and Maintenance Manual, Flood Protection Works, Paducah, KY.* Louisville District, Corps of Engineers, U.S. Army (1952, revised 1981).

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 4 OF 4 ENGINEERING CALCULATIONS AND REFERENCES

(Cont'd.)

19) *Phase II I-Wall Evaluation Report*, Louisville District (2007).

20) ERDC TR-07-15, *Fitness-for-Purpose Evaluation of Hydraulic Steel Structures*, November 2007.

21) *Seismic Evaluation of Existing Buildings* (ASCE 31-03), published by the American Society of Civil Engineers (2003).

ELECTRICAL AND MECHANICAL REFERENCES

1) EM 1110-2-3102, *General Principle of Pumping Station Design and Layout,* dated 28 February 1995

2) EM 1110-2-3105, *Mechanical and Electrical Design of Pumping Stations*, dated 30 November 1999

3) NFPA 70 – National Electrical Code, dated 2008

4) IEEE C2 – National Electrical Safety Code, dated 20 April 2006

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 4 OF 4 ENGINEERING CALCULATIONS AND REFERENCES

(Cont'd.)

LIST OF ACRONYMS/ABBREVIATIONS

AQI	Air Quality Index
CELRL	Corps of Engineers, Lakes and Rivers Division, Louisville District
cfs	cubic feet per second
CMP	Corrugated Metal Pipe
CWA	Clean Water Act
EA	Environmental Assessment
EAD	Expected Annual Damages
EAT	Eating and Recreation
EGM	Economics Guidance Memorandum
FCSA	Feasibility Cost Sharing Agreement
FEMA	Federal Emergency Management Agency
FONSI	Finding of No Significant Impact
FWPP	Flood Wall Pump Plant
GIS	Geographical Information System
GROC	Groceries and Gas Stations
HAZUS-MH	Hazards United States Multi-Hazard
HEC-FDA	Hydraulic Engineering Center Flood Damage Analysis
HTRW	Hazardous, Toxic, or Radiological Waste
IWR	Institute for Water Resources
L&D	Lock and Dam
LERRD	Lands, Easements, Rights of Way, Relocations, and Disposals
LFPP	Local Flood Protection Project
LRL	Lakes and Rivers Louisville
LSE	Levee System Evaluation
MSL	Mean Sea Level
NAVD	North American Vertical Datum
NED	National Economic Development
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 4 OF 4
ENGINEERING CALCULATIONS AND REFERENCES

(Cont'd.)

O&M	Operation and Maintenance
OMRR&R	Operating Maintaining Replacing Repairing & Rehabilitating
ORMSS	Ohio River Mainstem Systems Study
ORD	Ohio River Datum
OSE	Other Social Effects
OSHA	Occupational Safety and Health Administration
PED	Preconstruction, Engineering, and Design
PPA	Project Partnership Agreement
PROF	Professional Services
PVA	Property Valuation Administrator's Office
RED	Regional Economic Development
REP	Real Estate Plan
REPA	Repairs and Home Use
RETA	Retail and Personal Services
RM	River Mile
SHPO	State Historic Preservation Officer
SIP	Systems Integration Plan
SUV	Sports Utility Vehicle
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WARE	Warehouses and Contractors
WOPC	Without Project Condition
WRDA	Water Resources Development Act

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 1 OF 4 MAIN REPORT

EXECUTIVE SUMMARY

The city of Paducah is located in the northern part of McCracken County, Kentucky, along the left bank of the Ohio River, approximately 934 miles below Pittsburgh, Pennsylvania. Please refer to Figure ES-1 for a project vicinity map. Paducah has a population of more than 20,000 people.

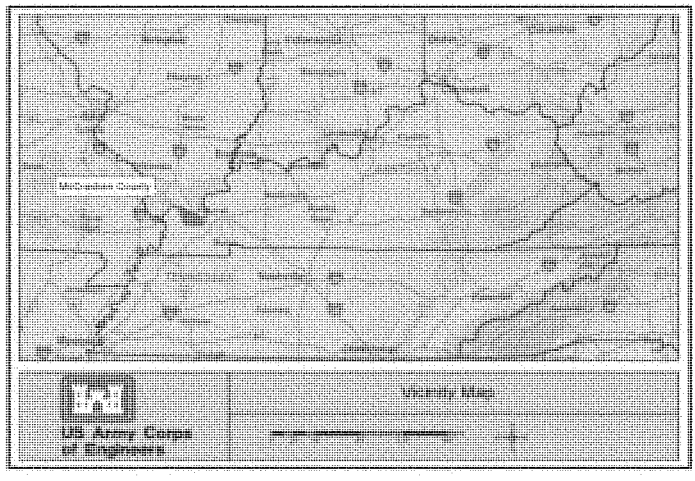


Figure ES-1: Vicinity Map of Project Area

The Ohio River Shoreline, Paducah, Kentucky Project (Paducah, Kentucky LFPP) consists of approximately 48,700 feet (9.2 miles) of earth levee, 15,870 feet (3 miles) of concrete flood wall, 12 pump stations, 47 closure and service openings, 8 ramps, 5 diversion channels and other necessary appurtenances. The Paducah LFPP system protects approximately 17 square miles of land.

The construction of this project started in August 1939 and was completed on 15 July 1949 for a total project cost of $ 5,398,028 (1949 construction dollars). The project has been locally operated and consistently well maintained for the last 60 years. Many of the original major components are still in service beyond their expected service life.

The primary purpose of the Paducah, Kentucky (KY) Local Flood Protection Project (LFPP) Feasibility Study is to evaluate the extent of Federal interest in reconstruction of the existing project for flood risk management in Paducah, KY. The Louisville District of the United States Army Corps of Engineers (USACE) and the City of Paducah have completed this feasibility report which evaluates reconstruction of the existing levee and floodwall system, facilities that are required under the present regulations that govern levees and floodwalls, and construction of a new pumping facility to prevent interior flooding.

The authority for the feasibility study is provided in Section 5077 of the Water Resources Development Act (WRDA) 2007 (Public Law 114-110) and Section 216 of the Flood Control Act of 1970 (Public Law 91-61).SEC.5077, PADUCAH, KENTUCKY states:

> *"The Secretary shall complete a feasibility report for rehabilitation of the project for flood damage reduction, Paducah, Kentucky, authorized by section 4 of the Flood Control Act of June 28, 1938 (52 Stat. 1217), and, if the Secretary determines that the project is feasible, the Secretary may carry out the project at a total cost of $3,000,000."*

The procedures to accomplish the feasibility study are based on a memorandum from CECW-P /CECW-E dated 15 August 2006, paragraph 3. According to memorandum CECW-PB, 16 Aug 2005, Subject: Reconstruction of U.S. Army Corps of Engineers Structural Flood Damage Reduction Projects for which Non-Federal Interests are Responsible for Operation, Maintenance, Repair, Rehabilitation, and Replacement, (hereafter, August 2005 Reconstruction Guidance, see Volume 4, References for memorandum in its entirety) Paragraph 3.e :

> *"Reconstruction will consist of addressing the major performance deficiencies caused by a long-term degradation of the foundation, construction materials, and engineering systems that have exceeded their expected service lives and the resulting inability of the project to perform its authorized project functions. In addressing reconstruction needs, the latest design standards and efficiency improvements should be incorporated into the project. "*

Problems and Opportunities: It is important to note that the Paducah LFPP functions as a comprehensive "system". There are no separate segments to this project. Therefore, if any part of the levee system fails, the entire levee system is impacted causing life safety issues for the community of Paducah. The recommended plan is a simple reconstruction of the existing project. There will be no impacts upstream or downstream of the project.

The community has a flood warning system in place to support the existing project. Given the potential depth and durations of the flooding the only other non-structural measure available in place of the reconstruction project would be to relocate the structures currently in the floodplain. This is impractical on its face given the number and value of structures involved.

Table 5-2, starting on page 5-4 of the Main Report, provides a list of Reconstruction items that have been analyzed and detailed in Volume 2, Appendix C, Engineering Evaluations. Below are some examples of problems experienced in various areas of the levee system which will affect other portions/components of the levee system, causing a "domino" effect of items which require reconstruction:

- All pump plants are operational as they exist today and they are integral to the overall functioning of the project. However, due to the age of the pumping plant equipment (pumps, motors, and electrical components) their condition is deteriorating. The pump plants are operating years beyond their service life; they were originally installed during the 1940's. Based on this and their deteriorating condition, reconstruction is a necessity to insure that the project provides its authorized level of protection, reducing the life safety risk to the community it protects, and preventing flood damage to numerous homes and commercial businesses.

- There are five operating sluice gates (two – 48-inch and three – 60-inch sluice gates) at the Bee Branch Sluice Gate Structure. During a flood event, emergency operations staff must access the structure by boat. The working platform on this structure has very limited space, restricting the number of people who can perform flood-related activities. Additionally the staff must hand-crank each individual sluice gate resulting in a large amount of time to close the gate. It is important to note that the sluice gate frame support structures, including those associated with the work platform, are severely corroded, thus compromising the stability and safety of the structure. Without safe access to close these sluice gates, structural interior flooding and life safety risk to the community it protects would exist. Failure to close these sluice gates would greatly impact the capability of nearby pumping plants to alleviate flooding from the interior.

- There are 47 closures on this project which equates to more closures per linear foot than any other flood protection system in the Louisville District. Because the local floodplain is generally flat, multiple closures must be installed in a very short amount of time. This causes a large burden on a community with a population at risk of 20,000 + with a limited emergency operations staff. By reducing the number of closures, the life safety risk to the community is decreased while maintaining the authorized level of protection. By not permanently eliminating these obsolete closures, the likelihood increases of some closures not being installed in time during a flood emergency, which could lead to interior flooding. This would not only be a direct increased life safety risk to the community, but would also impact nearby pump plants with aging equipment that have a higher chance of failure or issues with operations.

- Failing toe drains are beginning to impact the overall embankment stability causing sloughing of the levee which in turn causes a lowering of the level of

the USACE August 2005 Reconstruction Guidance, and taking into consideration the non-Federal sponsor's interests, the focus of the study team centered on the evaluation and comparison of two major alternatives: 1) No Action and 2) Reconstruction.

Alternative 1: No Action. The No Action alternative assumes local interests will continue to perform items of normal operation and maintenance as they have since 1949 and that there will be continued deterioration of existing project components. If no action is taken to bring the existing system into compliance with its originally intended protection level, the next major flood event could result in uncontrolled interior flooding should any of these aging components (in 60 plus years) fail to operate properly.

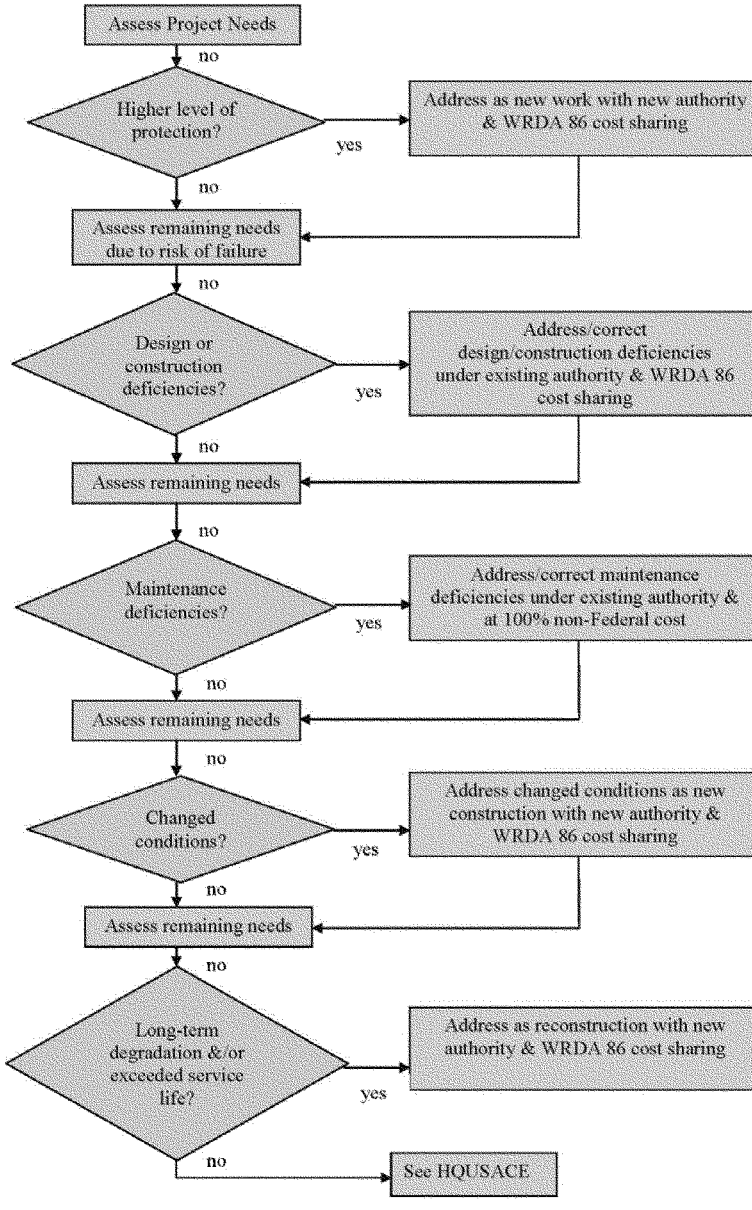
Alternative 2: Reconstruction. This alternative consists primarily of replacement/refurbishment of aging equipment, installation of one to two new pumping plants, and installation of various structures (gatewell structures) that are required by revised USACE standards. Items of work to be included in the reconstruction alternative are those items that are beyond normal operation and maintenance. Major reconstruction items were first identified during the 905(b) study report. In March 2009, as part of this Feasibility Study, a thorough field inspection was performed by all engineering disciplines to refine the reconstruction items previously identified in the May 2000 905(b) Analysis. The latest design standards and efficiency improvements were also assessed.

Reconstruction Assessment: Table 1 below shows the decision logic/process used in assessing project needs and determining which items qualify for reconstruction according to the following categories in the August 2005 Reconstruction Guidance:

1. If higher level of protection is required, address as New Work (see August 2005 Reconstruction Guidance, paragraph 3.g.);
2. If design or construction deficiency, address deficiency under existing authority cost shared (see August 2005 Reconstruction Guidance, paragraph 3.d.);
3. If maintenance deficiencies, address under existing authority cost shared (see August 2005 Reconstruction Guidance, paragraph 3.c.);
4. If changed conditions, address as New Construction with new authority cost shared (see August 2005 Reconstruction Guidance, paragraph 3.e.);
5. If long-term degradation &/or exceeded service life, address as reconstruction with new authority with current design and safety standards (see August 2005 Reconstruction Guidance, paragraph 3.e.).

Table 1

Eligibility for Reconstruction – Decision Process



A separate certification study (now known as Levee System Evaluation - LSE), was performed (and completed in May 2010) concurrently with this feasibility study to determine if this flood protection project meets FEMA and USACE criteria for certifying the project, for the National Flood Insurance Program (NFIP), based upon the occurrence of a 1% chance (100-year) flood to the 95% assurance level.

None of the proposed reconstruction items provide a higher level of protection. The proposed pump plant (#14) is not increasing the level of protection. It is only bringing the project to the level of its intended purpose for the originally constructed project. There were no design or construction deficiencies. There were no maintenance deficiencies. The Sponsor has very consistently and diligently addressed all operation and maintenance items throughout the years. There are no changed conditions at the project.

Table 5-2, in Section 5.1 (Plan Components) focuses on the project features that qualify for reconstruction as a "system". The pump plants, floodwalls, drainage outlets and discharge systems, and levees qualify for reconstruction based on the August 2005 Reconstruction Guidance. The items in the table have been identified, using the process shown in Table 1 above (Eligibility for Reconstruction – Decision Process) as having long-term degradation &/or exceeded service life. After these systems were identified as being eligible for reconstruction, then it was noted that other components of the system (such as trash racks, automatic shutoff instrumentation, gravity ventilation systems, etc.) will be reconstructed as necessary using current design and safety standards.

Recommendation: This feasibility report recommends reconstruction of a > 60 year old project. The work proposed is reconstruction of deteriorated components beyond their service life and one new pump plant to address an interior flooding situation which had not been fully identified during initial project construction. The addition of this one new pump plant increases project efficiency and brings it up to current USACE standards. This is not considered to be a change in the scope of the project or level of protection.

Some of the items being recommended for reconstruction are listed below. For a list of items to be included in reconstruction and new construction of the Paducah, KY LFPP, see Table 5-2 in this Main Report:

a. Rehabilitation of Pumps, Motors, Motor Control Systems, Major Pump Plant Components, and other miscellaneous items at each of the 12 Existing Pumping Plants.
b. Construction of a New Pumping Plant at Station 111+67A
c. Slip-lining 37 Existing Deteriorated Corrugated Metal Pipes *
d. Bank Protection
e. Floodwall Waterstop Joint Replacements

f. Plug and/or Address Existing Deteriorated Toe Drains
g. Replace Existing Drainage Inlet Structures (Two New Gatewell Structures) at Bee Branch – At Approximate Stations 32+12C and 32+38C.
h. Construction of New Gatewell Structures at Stations 111+67A (At Proposed Pump Plant #14) and 19+11B.
i. Other Miscellaneous Items

* This work has been completed by the non-Federal sponsor in accordance with the Memorandum of Understanding (MOU) signed on 17 November 2008. The District is recommending this work be considered integral to the project and eligible for work in kind credit. See Section 4.8 for further discussion of the work performed and the MOU.

The Reconstruction Alternative (Alternative 2) generates a Benefit-to-Cost ratio of 4.5 and produces annual net benefits ($5,507,000) to the Nation. It is therefore considered to be economically feasible and is viewed as the National Economic Development (NED) Plan. The recommended plan is also supported by the non-Federal sponsor.

The new additional pump plant at station 111+67A (item b. above) is recommended to deal with interior ponding issues indentified subsequent to the construction of the original project. The use of two 50 cfs pumps in the potential additional pump plant (item b. above), identified throughout this report as Pump Plant # 14, generates a Benefit-to-Cost ratio of 1.53 (this BCR is included in the BCR of the overall project of 4.5) and produces annual net benefits ($52,000) to the Nation. It is therefore considered to be economically feasible and is part of the NED Plan.

An authority for construction is also provided in Section 5077 of WRDA 2007. However, it should be noted that there is not a separable element that USACE can address with the current authorization of $3,000,000. Additional construction authority would be required to implement the recommended plan.

Estimated Implementation Costs: (2011 price level)

Federal	Cost Sharing
Corps of Engineers – flood risk management (65%)	$12,424,295
Non-Federal	
City of Paducah – flood risk management (35%)	$6,690,005
Total	$19,114,300

The cost of the project increased from $5.2 million in 2000, when the 905(b) Reconnaissance Study was completed, to $19.0 million in 2011. This increase in costs can be attributed to construction cost inflation, revised USACE criteria "Post Katrina", and identified reconstruction needs for the project. The identification of reconstruction needs, and the resultant cost increases were determined through a very thorough

investigation associated with the Feasibility Study after the completion of the original 905(b) Study.

It is important to note when evaluating the increase in costs subsequent to the 905(b) study estimate, that the 905(b) study was conducted more than ten years ago. Construction cost inflation for the ten years since the 905(b) study was completed should also be considered. The proposed project has been reviewed for compliance with federal legislation including the National Environmental Policy Act (NEPA), Endangered Species Act, Clean Air Act, Clean Water Act, and Section 106 of the National Historic Preservation Act of 1966, as amended.

USACE determined that the proposed work was covered by the NEPA categorical exclusion at 33 CFR 230.9(b), and that there were no extraordinary circumstances that warranted preparation of an Environmental Assessment, because the proposed work would cause, at most, minimal adverse effects on the human environment, individually and cumulatively. Nevertheless, the District completed an Environmental Assessment (EA), even though an EA was not legally required, in order to consolidate documentation demonstrating that the project would not produce any significant adverse effects on the human environment, and thus that no Environmental Impact Statement would be required for the project. The EA was made available for public review for thirty days. No comments were received from the public. The EA/Finding of No Significant Impact (FONSI) can be found in its entirety at the end of this report.

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 1 OF 4
MAIN REPORT

SECTION 1

1. STUDY AUTHORITY

This study was prepared under the authority of Section 5077 of the Water Resources Development Act (WRDA) of 2007 (Public Law 110-114) and Section 216 of the Flood Control Act of 1970 (Public Law 91-61).

Section 5077 provides authority to review the existing local protection project in the City of Paducah, KY, which has been locally operated and consistently well maintained by the local interests since 15 July 1949, and to evaluate the feasibility of rehabilitating the project. Section 5077 also provided authorization for construction of the project, subject to a finding that the project is feasible. Specifically, it states:

> *"SEC.5077, PADUCAH, KENTUCKY".*
>
> *The Secretary shall complete a feasibility report for rehabilitation of the project for flood damage reduction, Paducah, Kentucky, authorized by section 4 of the Flood Control Act of June 28, 1938 (52 Stat. 1217), and, if the Secretary determines that the project is feasible, the Secretary may carry out the project at a total cost of $3,000,000."*

Section 216 of the Flood Control Act of 1970 (Public Law 91-61) provides authority to conduct a feasibility study examining the reconstruction of structural flood risk management projects constructed by the Corps of Engineers. It states:

> *"The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significantly changed physical or economic conditions, and to report thereon to Congress with recommendations of the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest."*

A 905(b) study was initiated in 1999 and resulted in the finding that there was a federal interest in reconstruction of the existing Paducah Local Flood Protection Project (LFPP). The study found that there were sufficient indications that reconstruction of the existing project could be formulated, which would accrue benefits sufficient to exceed costs. It was recommended that reconstruction of the Paducah, KY LFPP, as described in the 905(b) study, be implemented in accordance with existing cost sharing and financing requirements.

The USACE approved the Section 905(b) study in May 2000. The City of Paducah, as the non-federal Sponsor/partner (the Sponsor), and USACE, Louisville District (the District) initiated the feasibility study on January 30, 2009, by executing a Feasibility Cost Sharing Agreement (FCSA).

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 1 OF 4 MAIN REPORT

SECTION 2

2. REPORT PURPOSE AND SCOPE

The purpose of this Feasibility Study is to investigate the feasibility and the extent of Federal interest in providing reconstruction of the project for flood risk management in Paducah, KY, originally authorized by section 4 of the Flood Control Act of June 28, 1938 (52 Stat. 1217). The scope of work includes: investigating the results of the 905(b) Analysis dated May 2000; performing a detailed analysis of the no action and reconstruction alternatives; and identifying a recommended plan that, if feasible, would be subsequently authorized, designed, and constructed. The study includes evaluating the current and anticipated water resource problems and community needs, development of an effective, feasible reconstruction alternative to address these problems and needs, and analyzing the economic, environmental, and engineering impacts of both alternatives, resulting in one recommended plan.

2.1. Report Content

This report has four volumes:

Volume 1 (Main Report) discusses the overall study process and includes coordination that occurred among the public, local officials, environmental groups, outside agencies, etc.; plan formulation; and the recommendations of the District Engineer. Volume 2 (Appendices) consists of five appendices, supplementing information in the main report with detailed data and analysis. Volume 3 (Engineering Drawings) consists of the engineering drawings, which supplement information in the Main Report and Appendices. Volume 4 (Engineering Calculations, References, and As-Builts – referred to throughout the report as Volume 4 - References), consists of engineering calculations and references used throughout the feasibility report.

2.2. Description of the Study Area

The city of Paducah is located in the northern portion of McCracken County, Kentucky, on the left bank of the Ohio River, approximately 934 miles below Pittsburgh, immediately below the mouth of the Tennessee River. The City of Paducah is bounded on the north and northeast

by the Ohio and Tennessee Rivers and lies within the alluvial valley of the Ohio River. A significant portion of its residential and commercial districts is situated on a level and relatively high flood plain terrace that extends to the low hills on the south. Island Creek flows through the eastern part of the city to join the Ohio River immediately below the mouth of the Tennessee River and Perkins Creek is located along the western portion of the city. According to the U.S. Census Bureau, in 2000, Paducah had a population of 26,275. Paducah, KY is the official county seat of McCracken County.

See Figure 2-1 for a map of the watersheds around the project area.

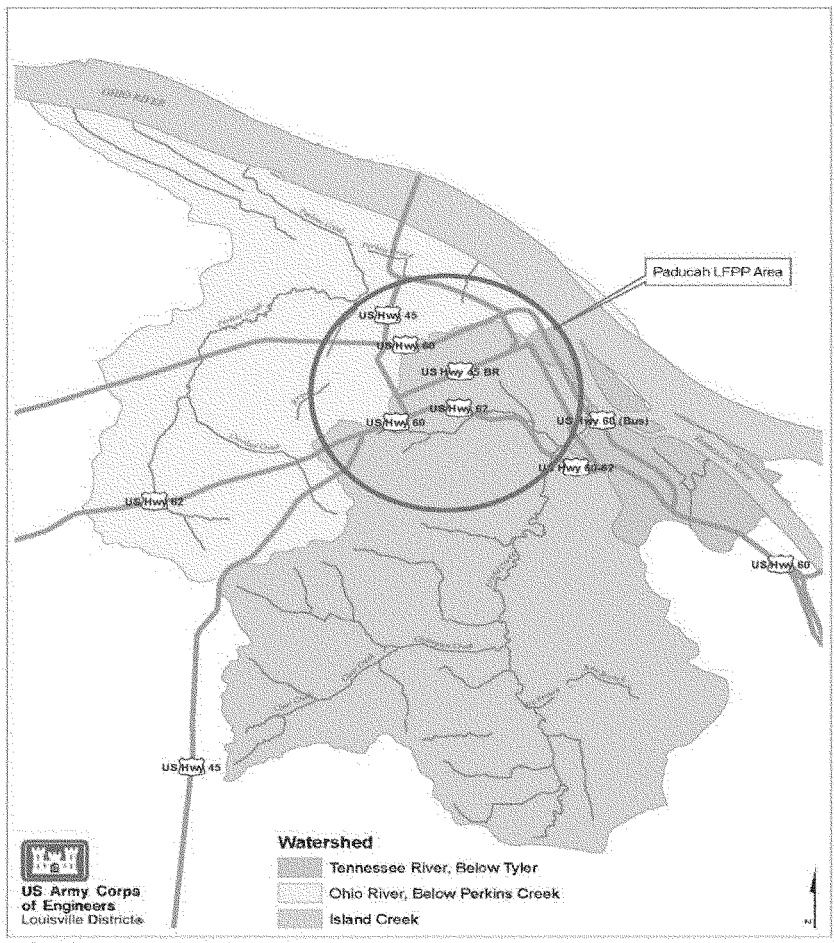


Figure 2-1: Watersheds for Paducah, Kentucky LFPP

The existing project/study area contains approximately 10,850 acres. The existing local protection project consists of approximately 48,700 feet of earthen levee, 15,870 feet of concrete flood wall, 12 pump stations, and approximately 47 total openings consisting of movable closures, man-ways, and service openings. The project also has several ramps, diversion channels and other necessary appurtenances.

Figure 2-2 shows the project area broken down into Sections A, B, and C along the line of protection. These sections are delineated as such because that is the order in which they were constructed.

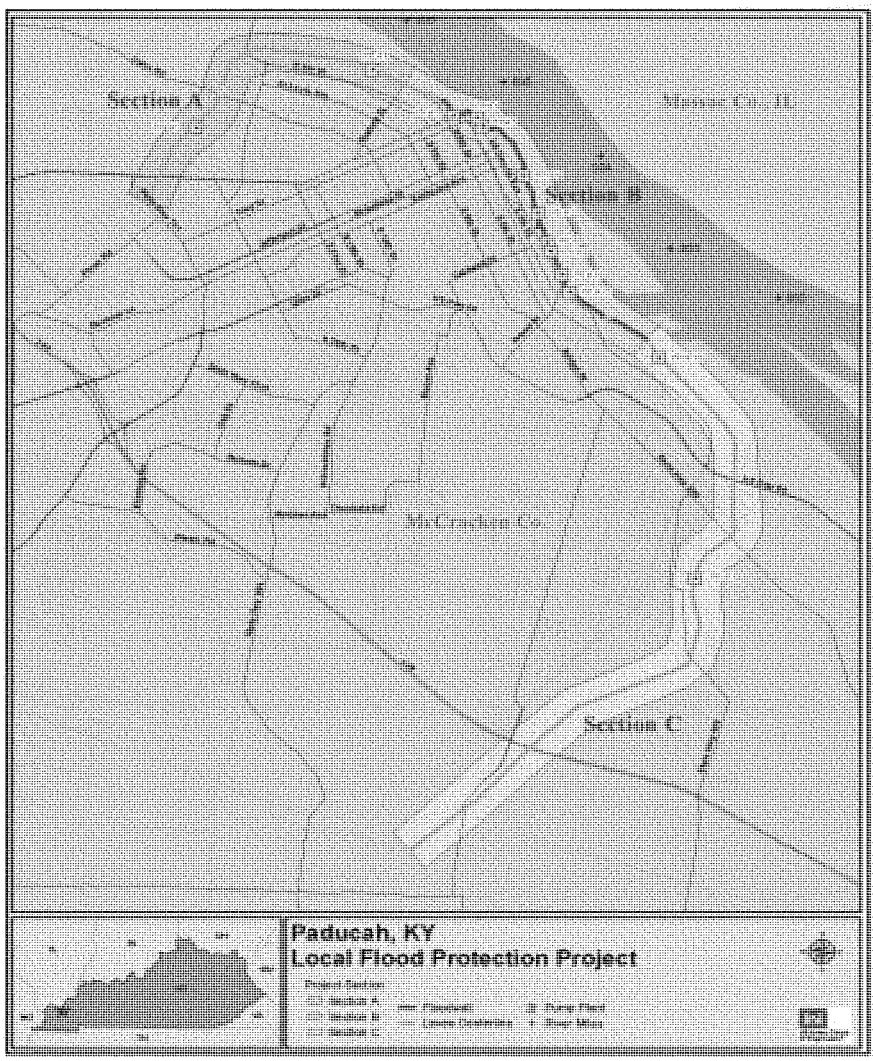


Figure 2-2: Project Map Delineating Sections Along Line of Protection
* Project Sections were labeled in the order they were constructed

A separate certification study (now known as Levee System Evaluation - LSE), was performed (and completed in May 2010) concurrently with this feasibility study to determine if this flood protection project meets FEMA and USACE criteria for certifying the project, for the National Flood Insurance Program (NFIP), based upon the occurrence of a 1% chance (100-year) flood to the 95% assurance level.

None of the proposed reconstruction items provide a higher level of protection. The proposed pump plant (#14) is not increasing the level of protection. It is only bringing the project to the level of its intended purpose for the originally constructed project. There were no design or construction deficiencies. There were no maintenance deficiencies. The Sponsor has very consistently and diligently addressed all operation and maintenance items throughout the years. There are no changed conditions at the project.

Table 5-2, in Section 5.1 (Plan Components) focuses on the project features that qualify for reconstruction as a "system". The pump plants, floodwalls, drainage outlets and discharge systems, and levees qualify for reconstruction based on the August 2005 Reconstruction Guidance. The items in the table have been identified, using the process shown in Table 1 above (Eligibility for Reconstruction – Decision Process) as having long-term degradation &/or exceeded service life. After these systems were identified as being eligible for reconstruction, then it was noted that other components of the system (such as trash racks, automatic shutoff instrumentation, gravity ventilation systems, etc.) will be reconstructed as necessary using current design and safety standards.

Recommendation: This feasibility report recommends reconstruction of a > 60 year old project. The work proposed is reconstruction of deteriorated components beyond their service life and one new pump plant to address an interior flooding situation which had not been fully identified during initial project construction. The addition of this one new pump plant increases project efficiency and brings it up to current USACE standards. This is not considered to be a change in the scope of the project or level of protection.

Some of the items being recommended for reconstruction are listed below. For a list of items to be included in reconstruction and new construction of the Paducah, KY LFPP, see Table 5-2 in this Main Report:

a. Rehabilitation of Pumps, Motors, Motor Control Systems, Major Pump Plant Components, and other miscellaneous items at each of the 12 Existing Pumping Plants.
b. Construction of a New Pumping Plant at Station 111+67A
c. Slip-lining 37 Existing Deteriorated Corrugated Metal Pipes *
d. Bank Protection
e. Floodwall Waterstop Joint Replacements

2.3. Historic Storms and Floods

Historical data and gage records indicate that flooding in the Ohio River Basin usually occurs between November and May. The rivers will rise in November and again in March and April due to rains which saturate the basin. Flooding can follow as precipitation continues. Major floods occurred on the Ohio River in 1937, 1950, 1955, 1962, 1963, 1964, 1975, 1979, 1991, 1997, 2005, and more recently, 2011. The flood of 1937 established the flood of record on most streams in the Paducah area, reaching an elevation of 346.0 NAVD 1988 on the Ohio River which equates to less than a 0.02% chance (500-year) flood. After this flood event, the Flood Control Act of August 1937 authorized construction of flood protection for communities along the Ohio River. The flood event in May 2011 was the greatest event since 1937, with an elevation of 340.5 feet NAVD 1988 which equates to a 0.33% chance (300-year) flood.

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 1 OF 4 MAIN REPORT

SECTION 3

3. PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

3.1. Prior Studies

The USACE and other federal, state, and local entities have conducted the following studies that are in the vicinity of this existing project and are relevant to this project feasibility study.

3.1.1. The Ohio River Mainstem System Study (ORMSS)

The Ohio River Mainstem System (ORMSS) Systems Integration Plan (SIP) was completed for approval in October 2009. This report is part of the larger, ongoing ORMSS, which includes a systems study covering the entire Ohio River Main Stem. The output will be a detailed review of the overall Operations, Maintenance, and Major Rehabilitation needs and costs of the entire Main Stem navigation system. This broad system review is ongoing and will assure the best and most prudent recommendations for maximizing system performance.

3.1.2. Ohio River Ecosystem Restoration Study

The Integrated Decision Document and Environmental Assessment for the Ohio River Ecosystem Restoration Program was completed in October 2000. The primary purpose of this study was the development of restoration plans for sites identified by individual states as part of the ORMSS. The main objective was to restore, enhance and protect terrestrial, wetland and aquatic habitats in the Ohio River Corridor. There are currently five potential projects listed that are located within the reach of the Ohio River Shoreline, Paducah, KY (Paducah, KY LFPP).

3.1.3. SE Illinois Shoreline 905(b) Analysis (1997)

This analysis assessed the conditions of five existing flood risk management projects in Southeastern Illinois. These projects are located in communities of Brookport, Golconda, Harrisburg, Reevesville/Cache River, and Rosiclare, Illinois. The lock for L&D 52 is located on the Illinois side of the Ohio River at Brookport.

3.1.4. Paducah 905(b) Analysis

This study was initiated in 1999 and completed in May 2000. The purpose of the 905(b) study was to assess the conditions of the existing LFPP in Paducah, Kentucky; determine the repair, rehabilitation, and/or replacement measures required, if any, to address the system's capacity to provide its original degree of protection in order to ensure its ability to deliver the full benefits expected by Congress at the time of authorization; determine an approximate cost for these measures; and evaluate the potential Federal interest in cost sharing the above measures. The major findings of the 905 (b) analysis were:

1) There was a federal interest in ensuring that the original constructed project would continue to deliver the full benefits intended by Congress at the time of the authorization.

2) There were sufficient indications that reconstruction of the existing project could be formulated, which would accrue benefits sufficient to exceed costs.

3) A reconstruction project covering all items previously identified in the study as in excess of normal local operation and maintenance requirements was justified and would be eligible for the receipt of federal funding (if authorized by Congress).

3.2. Existing Projects

The following federal and local flood protection projects have been or are currently being constructed within the study area.

3.2.1. Olmsted Locks & Dam

This navigation project in Pulaski County, Illinois will consist of new twin 1200' lock chambers with a navigable pass dam. Plans and specifications have been prepared for the project, and construction is underway. During high flows, the navigation pass will be in the down position and Olmsted L&D Project will have a negligible effect on the river as well as reducing the flood risk in and adjacent to the City of Paducah. The Dam construction is scheduled to be completed in 2015.

3.2.2. Lock and Dams 52 & 53

These L&D's are currently active and operating; however, these two existing low lift locks will be decommissioned once the Olmsted Locks & Dam project is completed in 2015. The decommissioning will have no impact relative to reducing the flood risk in and adjacent to the City of Paducah.

3.2.3. Kentucky and Lake Barkley Locks and Dams

Kentucky and Lake Barkley locks are operated as a system for passing barge traffic even though they are located on different rivers (they are located on the Tennessee River at river mile 25.3 and the Cumberland River at river mile 32.8, respectively). Kentucky Dam was constructed by the Tennessee Valley Authority in 1938 and is operated by the USACE, Nashville District. It could have a tremendous influence on flood risk in Paducah, KY depending on the timing of the flows in the main stem of the Ohio River and the Tennessee/Cumberland tributaries.

3.2.4. Paducah, Kentucky LFPP

The existing local protection project area contains approximately 10,850 acres and consists of approximately 48,700 feet (9.2 miles) of earth levee, 15,870 feet (3 miles) of concrete flood wall, 12 pump stations, 47 closure and service openings, 8 ramps, and other necessary appurtenances. The construction of this project started in August 1939 and was completed on 15 July 1949 for a total project cost of $5,398,028 (1949 construction dollars). The project has been locally operated and consistently well maintained for the last 60 years (since the sponsor commenced O&M in July 1949). Many of the original major components are still in service beyond their expected service life. Table 3-1 illustrates the diligence with which the local sponsor actively participates in O&M efforts on this project. This table shows costs incurred by the City of Paducah (totaling approximately $894,000 from 1994-2006) for additional efforts to maintain original project equipment.

This project includes closures that are required to be erected to provide protection to the top of the levee/floodwall. During flood-fighting events, the city has a regimented operations schedule for the closures that is based on the National Weather Service's crests forecasts.

Table 3-1: Paducah Flood Risk Management Project Costs From 1994 – 2006

Item/Activity	Date	Individual Item Costs	Year	Total Costs by Year
FWPP (Flood Wall Pump Plant (FWPP)) #1 - Purchase of Electrical Equipment	Mar-94	$12,315.00		
			1994	$12,315.00
FWPP#2 Engineering Design - Mechanical and Electrical Upgrades	Jun-95	$21,901.20		
FWPP#2 Purchase of Medium Voltage Starter Group	Oct-95	$49,925.00		
FWPP#2 Purchase of Variable Frequency Drive	Oct-95	$14,336.75		
FWPP#2 Purchase of Vertical Turbine Pump	Oct-95	$23,055.00		
			1995	$109,217.95
FWPP#2 Installation of a Stormwater Pump	Jul-96	$113,496.00		
			1996	$113,496.00
FWPP#2 30" Force Main Repair	Apr-97	$480.00		
Engineering Design - Mechanical and Electrical Upgrades	Aug-97	$73,545.50		
FWPP#2 30" Force Main Repair	Oct-97	$14,548.00		
			1997	$88,573.50
FWPP#11 Purchase of a Lubrication System	Feb-98	$13,871.00		
FWPP#11 Purchase of a Vertical Turbine Pump	Feb-98	$60,080.00		
FWPP#11 Purchase of a Vibration Detection System	Feb-98	$3,043.00		
FWPP#11 Purchase of a Programmable Logic Control System	Feb-98	$5,603.47		
FWPP#11 Purchase of a Motor Control Center	Feb-98	$22,761.40		
FWPP#11 Stormwater Pump Installation	Aug-98	$121,181.00		
FWPP#11 Air Pump for Lubrication System	Nov-98	$9608.00		
			1998	$247,163.87
FWPP#11 Main Breaker Replacement	Dec-99	$13,880.00		
			1999	$13,880.00
FWPP#5 & #6 Pump Upgrades	Jul-01	$192,509.00		
FWPP#5 & #6 Pump Upgrades	Aug-01	$2,494.56		
			2001	$195,003.56
FW 66" Corrugated Metal Pipe Emergency Repair	Mar-04	$68,146.90		
FWPP#2 30" Pipe Repair	Sep-04	$17,960.00		
FWPP#2 Pump Repair	Dec-04	$16,500.00		
			2004	$86,106.90
FWPP#4 Repair Electrical System Upgrade	Jun-05	$8,030.00		
FW Embankment work near Clarkline	Jul-05	$5,211.98		
			2005	$13,241.98
TOTAL COSTS 1994 - 2006				**$878,998.75**

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 1 OF 4 MAIN REPORT

SECTION 4

4. Plan Formulation

4.1. Flood Risk Management Plans

Flood Risk Management Plans must be found to be economically, environmentally, and socially feasible and must have been evaluated further, within this feasibility study, using a progressive screening process until a single National Economic Development (NED) Plan has been defined and documented (see Appendix B, Section 1 for further details of the economic analysis process). The NED Plan is the alternative that has the greatest net benefits and is the plan that the Federal Government is most supportive of constructing. Net benefits are defined as the average annual project benefits minus the average annual project costs. Those plans with average annual benefits greater than the average annual costs are considered to be economically feasible. Projects may deviate from the NED Plan if requested by the non-Federal sponsor and approved by the Assistant Secretary of the Army for Civil Works (ASA (CW)). In some instances, a non-Federal sponsor may not be able to afford or otherwise support the NED Plan. Plans that deviate from the NED Plan shall be identified as the Locally Preferred Plan (LPP). The LPP must have greater net benefits than plans with smaller scope and costs. If the sponsor prefers a plan more costly than the NED plan, and the increased scope of the plan is not sufficient to warrant full Federal participation, the ASA (CW) may grant an exception as long as the sponsor pays the difference in cost between the locally preferred plan and the NED plan.

When formulating a plan for flood risk management, it's important to inventory the problems and concerns of the stakeholders and to develop specific measures to address problems. It's also important to identify key existing water resources to determine if there are opportunities to improve or protect them.

The feasibility study team is comprised of representatives from the city of Paducah and the Louisville District USACE. S tudy disciplines include planning, engineering (geotechnical, hydrology and hydraulics, structural, mechanical, electrical, cost estimating, surveying, and civil), economics, real estate, environmental/cultural resources, social analysis, and public involvement.

4.2. Feasibility Study Plan Formulation

During Plan Formulation, the following steps were used to develop final plans for flood risk management: (1) identify problems, opportunities, objectives, and constraints; (2) inventory and forecast conditions (determine the existing [with project] and without project conditions); (3) formulate alternative plans - identify structural flood risk management measures (see Section 4.7.5 for discussion of consideration of non-structural alternatives in relation to guidance provided in CE-CWLRD Memorandum for Commander, Great Lakes and Ohio River Division, dated 11 June 2009, Subject: Implementation Guidance for Section 5077 of the Water Resources Development Act of 2007 (WRDA 2007)); (4) evaluate for effectiveness and combine effective measures into alternatives; (5) compare the alternative plans and screen the alternatives against the NED plan to determine which alternatives will have the greatest net benefits and a B/C ratio greater than 1.0; and (6) select the final plan.

The definition of reconstruction is documented in memorandum, CECW-PB, 16 August 2005, Subject: Reconstruction of U.S. Army Corps of Engineers Structural Flood Damage Reduction Projects for which Non-Federal Interests are Responsible for Operation, Maintenance, Repair, Rehabilitation, and Replacement (see Volume 4, DVD 1 of 3, Section 1, Reference 1.5) . The definition states that:

> *"reconstruction excludes design or construction deficiencies. Further, reconstruction is limited to addressing impediments that prevent a project from performing as authorized after all maintenance, as required by the project operation and maintenance manual and the Code of Federal Regulations, has been accomplished and any deficiencies resulting from lack of maintenance have been addressed. Reconstruction will consist of addressing the major performance deficiencies caused by long-term degradation of the foundation, construction materials, and engineering systems that have exceeded their expected service lives and the resulting inability of the project to perform its authorized project functions. In addressing reconstruction needs, the latest design standards and efficiency improvements should be incorporated into the project."*

Two alternative plans 1) No Action and 2) Reconstruction were evaluated initially at a low level of detail in the Paducah, KY (Reconnaissance) 905(b) Study, which was completed in May 2000 and focused on the determination of which plan, if any, was in the federal interest. For federal participation in a project, the primary requirement calls for plans to be formulated to alleviate problems and take advantage of opportunities in ways that contribute to study planning objectives and, consequently, to the Federal objective. The second requirement is to produce benefits which exceed costs. "Federal Interest" in the project is established by law and identified when both requirements are satisfied.

Following completion of the reconnaissance study, the Louisville District and the City of Paducah entered into a feasibility cost sharing agreement in January 2009. The feasibility study was conducted as a partnership to identify opportunities for continued/improved flood risk management within the City. This partnership approach was critical to

successful completion of the feasibility study by improving coordination between the District, the City, the public, and numerous stakeholders.

4.3. Existing Conditions

Some of the problems at the project include:

- a sloughing area located near Station 17+50B;

- multiple holes and depressions at the toe of the levee between Stations 150+00C and 174+80.5C, Stations 218+85C and 244+65C, and Stations 102+50B, 90+25A and 113+00A which appear to be from collapsed toe drains;

- significant differential movement between many monoliths in Section "B"; and the need for replacement of expansion joint material throughout the project;

- movement of numerous T-Wall Monoliths (relative to adjacent monoliths) in Section "B" between approximate Stations 7+40 and 16+15, and at Stations 22+18 through 22+49; failed waterstops;

- corrosion of all major structural members; corrosion of walkway support angles; an unsafe ladder; hand railing that does not meet current safety requirements; insufficient working space on the platform; and substandard safety equipment at Bee Branch at Stations 32+12 and 32+38 in Section "C" of the project;

- interior flooding at Station 111+67A;

- deterioration and heavy corrosion Pump discharge piping for pump plant numbers 1, 2, 3, 5, 6, 7 and 12; and

- aging pump equipment in pump plants that are in need of replacement or rebuilding

See Table 5-2 in Section 5.1 (Plan Components) of this Main Report (Volume 1) for a list of the proposed reconstruction items that the engineering team has determined need remediation for this project to continue to provide the full benefits intended by Congress at the time of the original authorization.

The 905(b) study established that the Paducah LFPP was in serious need of restoration and rehabilitation of several project components integral to the public safety for the citizens of the Paducah-McCracken County community. Upon the execution of the FCSA, in January 2009, USACE conducted a comprehensive and thorough investigation of ALL major and minor components of the Paducah LFPP. The thorough investigation conducted under the feasibility study, utilizing computer analysis and current Corps design guidance, resulted in a list of deficient LFPP components which were 16 years beyond their 50-year design life expectation and the identification of portions of the project that DO NOT comply with current USACE Guidance, "Post Hurricane Katrina."

The following items, identified in the feasibility report, were not given consideration during the 905(b) study:

- A proposed Pump Plant #14 and the Woodward Hollow discharge pipe that are necessary to relieve interior drainage problems
- Gatewell structures which were added to the project for large gravity pipes

4.3.1. Flooding and Flood Protection

Precipitation in the Paducah area is fairly well distributed throughout the year, with an average annual precipitation of approximately 49 inches and monthly averages ranging from 2.99 to 4.45 inches in August and July, respectively.

This study evaluates the levee/floodwall system for reconstruction of its existing facilities, construction of new facilities that are required under the present regulations that govern levees and floodwalls, and construction of new pumping facilities to prevent interior flooding. Based on the existing hydraulic model, the existing levee and floodwall system is constructed to an elevation approximately 7.5 feet above the 1% chance (100-year) frequency event, one requirement needed for levee system evaluation analysis. In addition, the top of protection elevations of the Paducah Levee System meets the requirements of the authorized project as discussed in Volume 2, Appendix C, Section 2.7 - "Existing Flood Control Measures." Therefore, only gate well structures; potential pumping facilities; and gravity outlets required a hydrologic and/or hydraulic evaluation. Many highwater events have occurred since the completion of the Paducah LFPP in January 1950. Table 4-1 shows the largest historical floods and their associated peak elevations for the Paducah area. As shown on Table 4-1, the February 1950 flood was the greatest of these events with an elevation of 339.0 feet NAVD which was about equal to a 0.83% chance (100-year) flood. According to City of Paducah officials, they were not aware of any flood problems that occurred during these historic events, with the system performing well (with no noticeable issues), protecting the interior from devastating inundation.

Table 4-1: Peak Historic Floods since Project Completion

Date	Gage Height (feet)	Elevation (NAVD 1988)	Flood Frequency
Jan. – Feb. 1937	60.5	346.0*	less than 0.02% (500-year)
Feb. 13, 1950	53.5	339.0	1% (100-year)
Mar. 11, 1997	51.7	337.2	1.67% (60-year)
Apr. 3, 1975	51.1	336.6	2% (50-year)
Mar. 19, 1963	49.9	335.4	2.86% (35-year)
Jan. 7, 1991	49.9	335.4	2.86% (35-year)
Mar. 8, 1979	49.3	334.8	3.3% (30-year)
Mar. 12, 1962	48.4	333.9	5% (20-year)
Mar. 22, 1964	47.8	333.3	less than 5% (20-year)
Mar. 29, 1955	47.7	333.2	less than 5% (20-year)
Jan. 16, 2005	47.7	333.2	less than 5% (20-year)
May 5, 2011	55.0	340.5	0.33% (300-year)

*** Historical Peak Elevation. Datum of the gage is 285.5 NAVD 1988.**

Flood waters or otherwise high water surface profiles from the Ohio River begin to adversely impact the City of Paducah starting at River Mile (RM) 931.0. It was determined by the Geographic Information Specialist (GIS) on the team, in conjunction with the Hydraulics and Hydrology Engineer, that no damages within the city limits take place prior to RM 931.0 or past RM 937.0. These river miles serve to delineate the 0.2% chance (500-year) floodplain into separable reaches whereby data can be attributed to structures within a specific, outlined area which share similar water surface profiles and other hydraulic and hydrological similarities. These river miles (931.0 through 937.0) were utilized for economic calculations involving the Future Without Project Condition. Further explanation of how each structure is associated with each river mile is discussed in Volume 2, Appendix B (Economics Analysis) Section 6.1 – "Structure Inventory". A map identifying this Future Without Project Condition 0.2% chance (500-year) floodplain is shown in Figure 4-1.

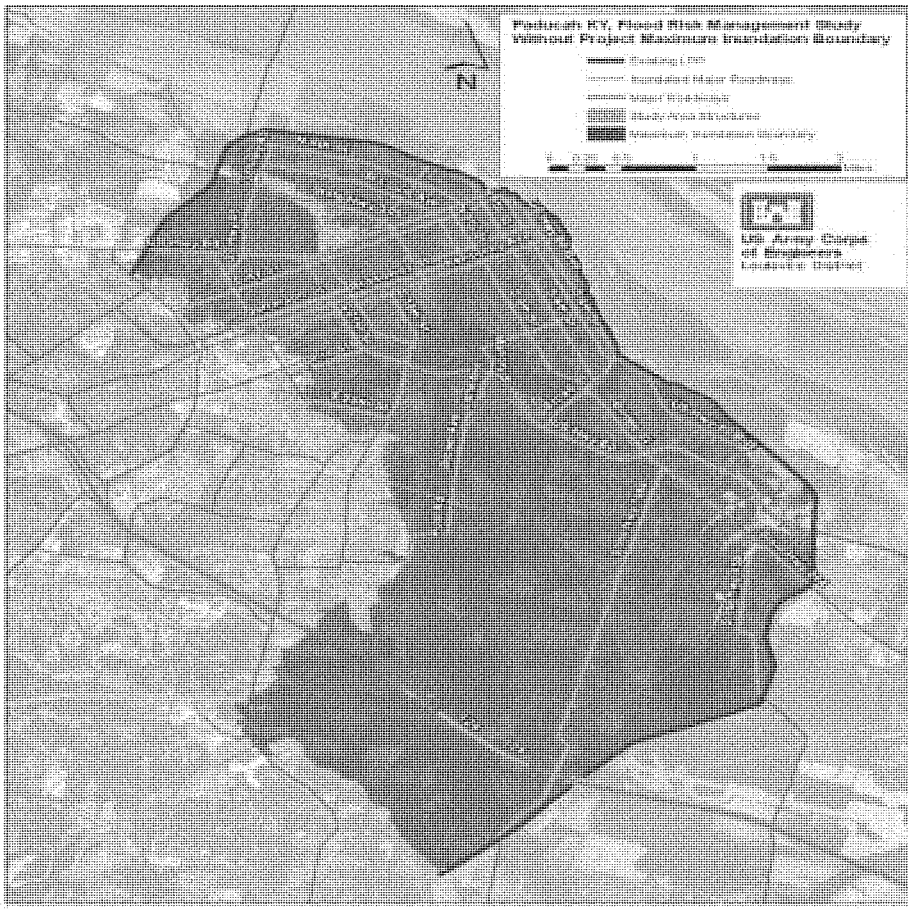


Figure 4-1 - Future without Project Condition Floodplain, 0.2%-chance (500-year) Event

As the project exists today, additional interior flooding is occurring at Station 111+67 in Section A where flooding would inundate commercial and industrial areas, and Station 19+11 in Section B which is a residential area. Flood problems occur at these locations when the Ohio River is above flood stage and the gravity outlets are closed. For more information on historic storms and floods, and interior flooding problems, see Section 2.3 of this main report and Volume 2, Appendix C, (Sections 2.5 and 2.8, respectively).

There are 12 pump plants currently in operation at the Paducah LFPP. Pump plant # 8 at Station 74+48 Section B Unit 1 was decommissioned in 2006 as its purpose was to service the toe drains in the area which generally had little or no flow and it had been infrequently utilized (four times in the twenty-two years preceding decommissioning of

the pump plant). The pump plant's wet well has been maintained in order to place a small pump to handle any discharge from the toe drain during flood events. F or correspondence and more information regarding the decommissioning of pump plant # 8, see Volume 4 - References.

Digital Topographic maps were developed using aerial black and white photographs taken in 2007 and color photographs taken in 2008. All base mapping was provided by the partner and Local Sponsor (the City of Paducah). From the digital topographic maps hydraulic models were prepared to compute water surface profiles and flood plain maps, and to update flood discharges.

4.3.2. Hazardous, Toxic, or Radiological Waste (HTRW)

A cursory review of possible hazardous, toxic, or radiological waste (HTRW) concerns was performed by the Louisville District. Due to the industrial nature of the proposed project area and because of a known sewer treatment plant located within the project area, the potential presence of HTRW exists near the project site. However, the project footprint consists primarily of maintenance items to the existing flood control system. No significant efforts outside of the project right of way are proposed. Therefore, no Phase I Environmental Assessment is warranted. Project specifications will require that excavated soils that will not be used on site will be disposed of at a licensed landfill. No other HTRW concerns are anticipated.

4.3.3. Environmental and Cultural Resources

Since a large portion of the proposed project area is within highly urbanized areas, available habitat has been significantly altered from natural conditions. The system of navigation locks and dams and associated operation and maintenance activities have altered aquatic resources within the Ohio River. A total of 100 species of fish have been reported from the lower Ohio River. The fish community is dominated in both numbers and weight by rough fish, particularly shads, gars, carp, river carpsucker, skipjack herring and drum. There are also large and important populations of game and commercial fish, including channel catfish, white bass and sauger. The lower Ohio River is also inhabited by a diverse mussel population. Approximately 33 s pecies are known to occur in the lower Ohio River.

The terrestrial habitat has also been greatly modified in the proposed project area. Undeveloped terrestrial habitats in the area consist essentially of a few areas of cultivated lands and pastures and scattered woodlots of various sizes. Types of trees in the forested areas adjacent to the line of projection consist of Oak, Gum, Cypress, and Hickory. Woody and emergent wetlands are located along the banks of the river but not within the project area. Terrestrial habitats of the area support species of birds, amphibians, reptiles, and small mammals that have adapted to urban encroachment.

The U.S. Fish and Wildlife Service reports that several Federal and state listed threatened and endangered animals may occur in the vicinity of the proposed project. The location of the proposed project is in close proximity to the Ohio River and therefore many known occurrences of several endangered species of freshwater mussels have been recorded within the county. Such species as the fatpocketbook, the orangefoot pimpleback, the pink mucket, and the ring pink freshwater mussels have known occurrences recorded within McCracken County. The clubshell, the rough pigtoe, and the fanshell mussel species have potential for occurrence within the county based upon their historic range. Other endangered or federally protected species that have been known to occur or have the potential to occur within the project area due to historic range include the Indiana bat, interior least tern and bald eagle.

Fish and Wildlife Coordination Act: Consultation with the U.S. Fish and Wildlife Service has been completed. Their comments are included in the environmental appendices, along with a follow up e-mail from USACE to USF&W. USACE has not received additional responses from USF&W.

The project reconstruction area is within a "good" air quality index (AQI) zone, with an AQI score of 29. Areas having an AQI score within the 0-50 range are reported to have satisfactory air quality and air pollution poses little or no risk.

USACE has determined that the existing project is environmentally sustainable. This determination was made based on the following considerations:

- Construction impacts of the existing project occurred many years ago and effects on the surrounding aquatic and terrestrial ecosystems have stabilized;
- The fish community, while dominated by rough fish, also has large and important populations of game and commercial fish;
- Terrestrial habitats of the area support species of birds, amphibians, reptiles, and small mammals that have adapted to urban encroachment;
- While several Federal and state listed threatened and endangered animals may occur in the vicinity of the proposed project, the existing project is not currently contributing to their decline or inhibiting their recovery;
- The project reconstruction area is within a "good" air quality index (AQI) zone; and while the industrial nature of the surrounding area and a known sewer plant near the project raise the potential presence of HTRW near the project, there are no HTRW concerns involving the existing project;
- The flood wall murals in downtown Paducah, which depict the history of development in western Kentucky, provide a common tourist attraction to the area with associated economic and aesthetic benefits. The economy of the surrounding area has adapted to the existing project being in place;
- The footprint of the existing levee system is not being expanded and would have no additional impacts to environmental resources, and;
- Failure to rehabilitate the existing levee system would ultimately result in impacts to the human environment due to losses from potential flooding.

In general, archaeologists and historians have developed a chronology for the region that provides a useful framework for organizing and describing data and historical events. The prehistoric cultural sequence is divided into the following chronological periods in Kentucky: Paleo-Indian (12,000-8000 B.C.), Archaic (8000-1000 B.C.), Woodland (1000 B.C - A.D. 900), Mississippian (A.D. 900-1500), and Protohistoric and Historic Aboriginal Indian (A.D. 1500+). These periods represent culturally distinct segments of more than 12,000 years of prehistoric human adaptation and re-adaptation to a changing environment.

The historic cultural sequence represents the time span from Euro-American settlement to the present day. General periods of development included early Euro-American settlement (1775-1830), Antebellum (1830-1860), Civil War and Reconstruction (1860-1890), Progressivism and World War I (1890-1925), the Depression and New Deal (1925-1940), World War Two and the Cold War(1940-1990). Regional variations of this historical sequence can occur.

The site of the Paducah LFPP has never been formally examined for cultural resources. The levee was itself constructed between 1939 and 1949 as a direct response to the Great Flood of 1937 along the Ohio River, and thus well before the implementation of federal compliance laws in the 1960's. The levee has been repaired, upgraded and renovated many times with pumps, pipes, gates (flapgates, sluice gates and movable closures). It is currently maintained by the city of Paducah.

There are several historic and cultural resources recorded within or adjacent to the Paducah LFPP, the most notable being Fort Anderson: a fort constructed by the Union Army during the Civil War and central to the Battle of Paducah. However, no remnants of the fort are visible on the surface. Its location is currently marked with a metal historic monument at the Paducah Convention Center and Executive Inn.

A common tourist attraction to the area is the flood wall murals in downtown Paducah that depicts the history of development in western Kentucky (see photo 4.3.1.). The murals were designed and painted by Mr. Robert Dafford and the Dafford Muralists of Lafayette, Louisiana. The project began in 1996 and was completed in 2007. Each mural panel has an interpretative plaque with a short history lesson on the scene depicted in the panel.

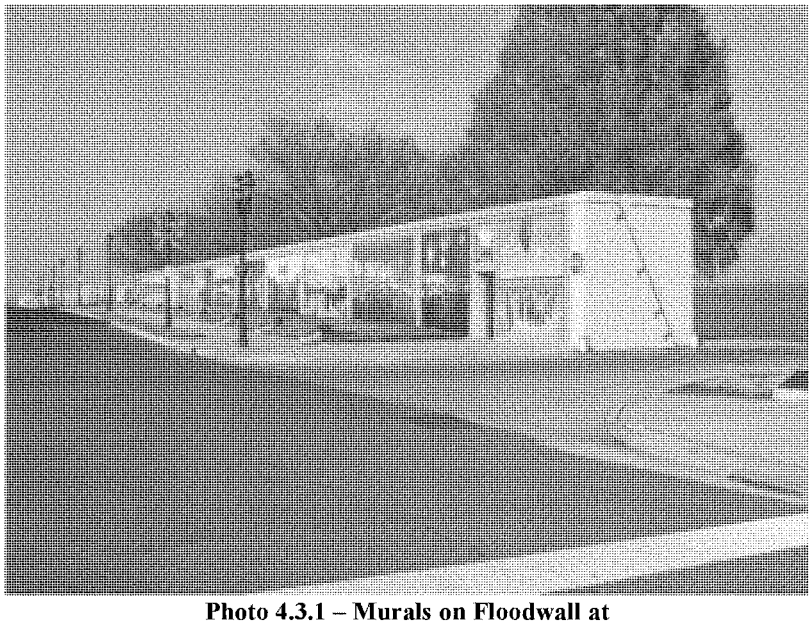


Photo 4.3.1 – Murals on Floodwall at Paducah, KY LFPP (Courtesy of City of Paducah)

A total of 25 historic properties listed to the National Register of Historic Places are recorded within McCracken County, Kentucky. However, none of these properties lie within the Area of Potential Effect (APE) for the proposed undertaking.

Five archaeological sites are recorded within the limits of the Paducah LFPP in McCracken County, Kentucky. Specifically, they are sites 15McN3, 15McN6, 15McN8, 15McN66, and 15McN124. Three of these sites – 15McN3, 15McN6, and 15McN8 – were recorded by the University of Kentucky as a part of reconnaissance survey of archaeological resources throughout the state (Funkhouser and Webb 1932). See the Appendix E (Environmental) for additional information of these sites.

Small segments of the levee have been examined for cultural resources as a part of compliance requirements for Section 106 of the National Historic Preservation Act, including a barge fleeting area (McNerney 1990), a water plant site and intake (Carstens and Hensley 1981), a nature trail (McHugh 1977), and a concrete batch plant (Schenian 1993). No cultural resources were identified during these investigations.

4.3.4. Social and Economic Conditions

Major state and federal highways, the Interstate Highway system, railway, and airlines serve the community area. In general, the existing conditions of the floodplain in Paducah are those of a moderate to densely developed urbanized setting.

In accordance with Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," the reconstruction of the levee would not adversely impact any residents of the city of Paducah regardless of race, national origin, religion, or level of income. The project consists of construction on or near the existing levee system and therefore, would not impact the local residents. There would be no displacement or condemnation action via governmental acquisition; disproportionate adverse effects to minority or low-income individuals would not occur. Further details regarding economic conditions can be found in Volume 2, Appendix B (Economic Analysis).

4.4. Problems and Opportunities

Problems that have been identified with the existing Paducah, KY levee system include: the high vulnerability of the Paducah LFPP due to failing equipment including pumps, pump motors and motor control systems largely due to their 60-years of service; existing interior flooding; potential interior flooding from malfunctioning outdated equipment; and erosion in some areas.

The sponsor was removed from the Rehabilitation and Inspection Program in September 2007 primarily due to the deterioration of the corrugated metal discharge pipes. The pipes were at the point of imminent failure. Repairs of the pipes and other deteriorating project features were completed in January 2010 by the sponsor and the city of Paducah was reinstated in the Rehabilitation and Inspection Program. If the pipes and other deteriorating project features were not rehabilitated, the highest elevation along the line of protection where the system should not fail would be approximately equal to the toe of the levee which corresponds to the invert of these drainage pipes. This elevation corresponds to less than a 99% chance (1-year) flood frequency.

Opportunities exist, in the City of Paducah, KY, for reducing flood risk to an immediate population of 20,237 and resulting property damages; reducing economic impact to more than 65,000 people; and for partnering with the sponsor for continued/improved flood risk management. This study culminates in the identification of a cost-effective action plan, one for which anticipated annual benefits exceed annualized costs, and this plan will result in a net increase to National Economic Development.

4.5. Planning Constraints

Alternatives to address the problems mentioned in Section 4.4 above are constrained by the fact that reconstruction policy (as defined in the August 2005 Guidance Memo) excludes any work on items that are considered to be normal operation and maintenance (O&M) responsibilities. Further, in accordance with this policy, this study is limited to the evaluation of a single modification plan. Any additional features to the original project (in this case, the proposed pump plant at Station 111+67A) must be economically analyzed with a determination of feasibility to be made on an individual, incremental level.

Planning constraints include all of the factors that could potentially limit the study effort's capacity to address indentified flooding issues and that would need to be resolved or addressed, as well as potential problems the USACE and the local Sponsor would wish to avoid throughout the course of the study.

Planning constraints identified for this feasibility study include the following requirements and factors. First, the plan alternatives must be economically and environmentally feasible and plan formulation must provide safe conditions in the interest of public safety and be socially acceptable to the community.

Second, there are limits associated with the availability and sufficiency of data. The most comprehensive, relevant and accurate data are gathered; however, these data can vary in quantity and quality.

Finally, to ensure quality, reliability and relevancy as well as to avoid adverse affects of any federal action, the conduct of Flood Risk Management Feasibility Studies is subject to all federal policies, guidelines and regulations governing water resources projects.

4.6. Future Without Project Condition

The first step in the economic process is to delineate the affected area. Once the area is delineated, the next step is the definition of Existing Conditions and the Future Without-Project Condition (WOPC), which is the expected future condition in the study area assuming no federal action, and the baseline to which the effects of proposed plans and alternatives will be compared. This WOPC is a holistic inventory of current conditions prevailing in the study area and expected future conditions, one that incorporates hydrologic and hydraulic (H&H) characteristics, land-use and development, demographics, environmental conditions, and historic and cultural resources. Once the WOPC is established, structural and non-structural measures to address identified water resource issues are formulated and a With Project reconstruction plan is developed. The WOPC is the expected future condition in the study area, covering a period of analysis of 50 years, and assuming no federal action. The With Project reconstruction plan is analyzed for its contribution to NED, its potential environmental and cultural resource impacts, and the preference of the local sponsor. The ultimate purpose of this Feasibility Study is to identify the NED plan. In so doing the water resource issues identified in the May 2000 Reconnaissance Study were studied in greater detail.

Over the next 50 years, flood damage potential expressed as expected annual flood damages would adversely impact the City of Paducah, and businesses and residences would be vulnerable to flooding, if the recommended action of reconstruction were not realized.

For the purposes of this study, 7,631 structures were documented and analyzed. These were categorized as residential (87%), commercial (9%), and public (4%). The analysis of both without project and with project anticipated damages included damages and costs

incurred from the following categories: damages to structures; damages to structure contents; damages to vehicles; traffic diversion costs; and emergency costs. The reliability of the Paducah, KY LFPP system was evaluated for the without project condition with floodwater to the top of the authorized level of protection. The condition and evaluation of the project features involved detailed analyses relative to deteriorating discharge pipes, underseepage, levee slope stability, floodwall and pump station stability, and interior drainage, and review of performance of the project during historical flood events which have occurred since the project was constructed. The highest flood loading on the Paducah LFPP system since the project was constructed occurred during the February 1950 event with a frequency of occurrence equal to a 1% chance (100-year) flood. No performance issues were recorded during this flood event.

The Paducah LFPP is highly vulnerable to failing equipment including pumps, pump motors, and motor control systems largely due to their 60-years of service. The city of Paducah has undertaken work during this feasibility study to address system components where there was an imminent risk of failure. T his work included rehabilitation of discharge pipes and bank stabilization work as discussed in Section 4.8.

If the discharge pipes, which were at the point of imminent failure, and other deteriorating project features were not rehabilitated, the highest elevation along the line of protection where the system should not fail is approximately equal to the toe of the levee which corresponds to the invert of these drainage pipes. This elevation corresponds to less than a 99% chance (1-year) flood frequency. The pipe used to determine the frequency of the flood protection at the toe of the levee is located at Station 19+11B where the invert of the pipe under the centerline of the levee is approximate elevation 309 (NAVD). Based on this study analysis, the without project condition affords less than a 99% chance (1-year) flood protection to the City of Paducah, Kentucky. Additional discussion of this topic can be found in Volume 2, Appendix C (Engineering Evaluations) of this report.

The Louisville District considers the slip-lining of the corrugated metal pipes and the bank stabilization, completed by the non-Federal sponsor, integral to the project and recommends that the slip-lining of the corrugated metal pipes be creditable as an in kind contribution. B ased on thisconsideration, the slip-lining of these 37 pipes is recommended as a reconstruction item of the recommended plan. Further, in accordance with the *Memorandum for the Deputy Commanding General for Civil Works and Emergency Operations, Subject: Paducah, KY, Flood Damage Reduction Project, Request for Exception to Policy on Timing of Execution of In-Kind Memorandum of Understanding (MOU),* dated 14 November 2008, the work accomplished by the Non-Federal Sponsor under the MOU is not to be considered part of the Without Project Condition.

Due to the frequency of failure noted in the systems performance, a sensitivity analysis was conducted around the likelihood of failure. If the Paducah project FWOP assumptions were altered to show the system failure point as occurring just above the 10% event, EAD would be reduced to approximately $7,702,000 (an 8% reduction from

the current estimate of $8,386,000). Net Project benefits would be $4,823,000, or roughly a 12% reduction in net benefits.

If the Paducah project FWOP assumptions were altered to show the system failure point as occurring just above the 25% event, EAD would be reduced to approximately $6,372,000 (a 24% reduction from the current estimate of $8,386,000). Net Project benefits would be $3,493,000, or roughly a 37% reduction in net benefits.

The FWOP used in the report reflects direction from OASACW, which said that the slip-lining work was NOT to be considered as part of the FWOP. This is an artificial planning construct for determining project benefits that does not reflect work performed by the local sponsor in advance of implementation of the recommended Federal project. The project did not fail during the 2011 Flood Event on the Ohio River due to various factors. The local sponsor had already spent over $2 million on items USACE had identified as critical to the performance of the project. If Paducah had not taken out a bond issue and performed this work our analysis is that the project could have failed and caused significant damages. In addition, the New Madrid Floodway was activated which dropped the water level at Paducah by approximately three feet. Heroic flood-fighting efforts were implemented by the sponsor and the community. The Flood Warning Emergency Evacuation Plan was also considered in making informed decisions pertaining to the flooding.

The Hydraulic Engineering Center's Flood Damage Analysis (HEC-FDA) software was used to satisfy the Corps of Engineers requirement that risk-based analysis be used to evaluate flood damages and flood damage reduction measures, as described in ER 1105-02-101 - Risk Analysis for Flood Damage Reduction Studies. The HEC-FDA compiles data generated during the Hydraulic and Hydrologic and Economic analyses which are then used to provide expected annual damages (EAD). Explanations of the details of this process are provided in Volume 2, Appendix B (Economic Analysis). Table 4-2 provides a distribution of structures flooded for each flood event in the Future Without Project Condition. Table 4-3 shows the estimated damages for structures flooded by each flood event. The area of the 0.2% chance (500-year) floodplain, shown in Figure 4-2 was overlaid on the structure map to identify all structures that would be flooded by any flood event less than or equal to the 0.2% chance (500-year) event. The Paducah, Kentucky LFPP Flood Warning and Emergency Evacuation Plan (FWEEP is also a means of public safety assurance for the unlikely event of levee overtopping. The Paducah, Kentucky FWEEP is included in Volume 4.

Table 4-2: Affected Structures by Event

Ohio River, Paducah, KY
Estimated Number of Structures Flooded
Without Project
by Structure Category and River Mile
(Based on zero damage elevations)

Residential

River Mile	Flood Events by Chance of Occurrence							
	99.9%	50%	20%	10%	4%	2%	1%	0.2%
931	0	1	4	37	193	378	661	1019
932	2	4	18	72	354	664	685	699
933	4	4	6	20	180	369	658	978
934	0	0	0	0	2	17	166	753
935	0	0	0	0	2	25	115	533
936	0	0	0	0	2	9	28	223
937	0	0	0	0	0	0	0	0
Totals:	**6**	**9**	**28**	**129**	**733**	**1,462**	**2,313**	**4,205**

Commercial

River Mile	Flood Events by Chance of Occurrence							
	99.9%	50%	20%	10%	4%	2%	1%	0.2%
931	0	0	0	0	8	14	20	36
932	0	0	1	1	5	26	55	66
933	0	0	0	0	11	26	52	84
934	0	0	1	1	3	54	151	259
935	0	0	0	2	6	9	29	58
936	0	0	0	0	8	21	41	69
937	0	0	0	0	0	0	0	0
Totals:	**0**	**0**	**2**	**4**	**41**	**150**	**348**	**572**

PUBLIC

River Mile	Flood Events by Chance of Occurrence							
	99.9%	50%	20%	10%	4%	2%	1%	0.2%
931	0	0	0	0	0	1	2	7
932	0	0	0	0	4	9	15	18
933	0	0	0	0	11	32	48	60
934	0	0	0	0	2	11	41	87
935	0	0	0	0	1	3	24	71
936	0	0	0	0	0	1	5	16
937	0	0	0	0	0	0	0	0
Totals:	**0**	**0**	**0**	**0**	**18**	**57**	**135**	**259**
All Structures	**6**	**9**	**30**	**133**	**792**	**1,669**	**2,796**	**5,036**

Tables showing the total value of inundated structures and total structure damages are available in Volume 2, Appendix B (Economic Analysis). Additionally, the computation

and data gathering processes are described in greater detail in Appendix B (Economic Analysis).

Table 4-3 - Estimated Structure Damages by Event

Ohio River, Paducah, KY
Estimated Damages ($1,000's) to Structures
Without Project
by Structure Category and River Mile
FY 2011 Price Levels

Residential

River Mile	Flood Events by Chance of Occurrence							
	99.9%	50%	20%	10%	4%	2%	1%	0.2%
931	-	19.32	80.25	599.17	3,447.87	8,481.44	15,311.13	30,796.13
932	24.68	12.73	144.55	1,928.85	10,088.95	18,163.53	27,024.82	33,233.94
933	52.55	61.87	64.38	157.58	998.38	3,058.24	7,871.23	16,765.59
934	-	-	-	-	117.68	604.34	6,273.37	27,300.24
935	-	-	-	-	30.57	1,123.05	5,016.87	21,751.18
936	-	-	-	-	188.89	704.77	1,466.70	10,810.34
937	-	-	-	-	-	-	-	-
Totals:	**$77.23**	**$93.92**	**$289.18**	**$2,685.60**	**$14,872.34**	**$32,135.37**	**$62,964.12**	**$140,657.41**

Commercial

River Mile	Flood Events by Chance of Occurrence							
	99.9%	50%	20%	10%	4%	2%	1%	0.2%
931	-	-	-	-	1,200.17	3,211.04	4,003.00	14,668.41
932	-	-	53.11	11.64	444.55	2,286.24	6,944.29	13,920.77
933	-	-	-	-	708.67	4,370.13	7,871.02	19,598.45
934	-	-	9.38	454.67	160.64	5,458.66	20,348.98	43,714.30
935	-	-	-	0.67	207.93	530.18	8,881.40	12,490.72
936	-	-	-	-	147.02	1,246.77	5,443.33	12,784.50
937	-	-	-	-	-	-	-	-
Totals:	**$0.00**	**$0.00**	**$62.49**	**$466.98**	**$2,869.00**	**$17,103.02**	**$53,492.03**	**$117,177.15**

PUBLIC

River Mile	Flood Events by Chance of Occurrence							
	99.9%	50%	20%	10%	4%	2%	1%	0.2%
931	-	-	-	-	-	0.37	2,250.25	6,999.51
932	-	-	-	-	617.89	343.19	1,075.13	4,104.96
933	-	-	-	-	70.91	368.68	1,150.34	1,603.49
934	-	-	-	-	9.72	403.32	1,419.57	5,595.53
935	-	-	-	-	2.24	26.72	183.79	1,406.66
936	-	-	-	-	-	5.52	32.03	1,467.11
937	-	-	-	-	-	-	-	-
Totals:	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$700.76**	**$1,147.80**	**$6,111.10**	**$21,177.26**
All Structures	**$77.23**	**$93.92**	**$351.67**	**$3,152.57**	**$18,442.10**	**$50,386.18**	**$122,567.26**	**$279,011.82**

4.7 Alternative Plans (Description of Available Measures and Plan Formulation Screening Criteria)

According to memorandum CECW-PB, 16 Aug 2005, Subject: Reconstruction of U.S. Army Corps of Engineers Structural Flood Damage Reduction Projects for which Non-Federal Interests are Responsible for Operation, Maintenance, Repair, Rehabilitation, and Replacement:

> "As projects age, it is recognized that the projects may not perform as intended due to long-term degradation of features which have exceeded their expected service life. The term 'reconstruction' applies to the measures to address the long-term degradation of project features, which have exceeded their expected service life.
>
> ....in general, a Federal project or separable element will only be eligible for reconstruction when the non-Federal sponsor has adequately maintained the project or separable element by accomplishing the items provided for in the operation and maintenance manual and Code of Federal Regulations (33 CFR 208.10 – Local flood protection works; maintenance and operation of structures and facilities) and by addressing operation and maintenance deficiencies noted in any inspection....
>
> ....Design or construction deficiencies will continue to be addressed according to ER 1165-2-119 and under the guidance presented in the annual budget EC under original/existing project authority.....
>
> .....Cost shared reconstruction will be defined by elimination. Reconstruction excludes design or construction deficiencies. Further, reconstruction is limited to addressing impediments that prevent a project from performing as authorized after all maintenance, as required by the project operation and maintenance manual and the Code of Federal Regulations, has been accomplished and any deficiencies resulting from lack of maintenance have been addressed. Reconstruction will consist of addressing the major performance deficiencies caused by long-term degradation of the foundation, construction materials, and engineering systems that have exceeded their expected service lives and the resulting inability of the project to perform its authorized project functions. In addressing reconstruction needs, the latest design standards and efficiency improvements should be incorporated into the project."

Based on this guidance, the formulation categories used were: design deficiencies, deferred maintenance, and reconstruction. Early on, it was determined that there were no design deficiencies. All items identified as deferred maintenance were referred to the non-Federal sponsor for action. The non-Federal sponsor has very diligently maintained the levee system. Table 5-1 (Section 5) illustrates the engineering rationale and criteria for considering which project features qualify for reconstruction.

The focus of the feasibility study was on the evaluation and comparison of two major alternatives: 1) No Action and 2) Reconstruction. According to the August 2005 Reconstruction Guidance, Paragraph g.:

> *"depending on the interest of the non-Federal sponsor, the feasibility study may be limited to examination of the reconstruction of the existing project with no change in its scope or function. Under this limited objective, evaluation would be limited to individual project features, (closure structures, pumping stations, gravity drains, relief wells, etc.) to establish the justification of reconstruction based on a comparison between the with and without reconstruction condition."*

4.7.1. Alternative 1: No Action

The No Action alternative assumes local interests will continue to perform items of normal operation and maintenance as they have since 1949. These typical items include repair of animal burrows in levees, removal of vegetation from levees and riprap, applying sealer protection to existing concrete surfaces, continued dependable operation during flood events, and other regularly scheduled operation and maintenance items according to local O&M manual. This No Action alternative assumes a continued deterioration of existing project components (pumps, motors, electrical components, etc.) and the project not meeting current USACE design standards relative to life safety issues. If no action is taken to bring the existing system into compliance, the next major flood event could result in uncontrolled interior flooding should any of these aging components (60 plus years old) fail to operate properly. Each component of the existing local flood protection project works together as a system to protect the City of Paducah. Should a breach in any portion of the system occur, a full failure of the entire system is a potential result. Given this circumstance, the lives and safety of more than 14,000 people and 17 square miles of residential/urban development would be at risk in addition to estimated expected annual damages (EAD) of over $1,856,000.00, according to the 905(b) Analysis completed in May 2000.

Overtopping of the levee would not be as catastrophic as a breach in the levee due to the fact that the water level would increase much more gradually and people would have more time to evacuate.

4.7.2. Alternative 2: Reconstruction

Items of work to be included in the reconstruction alternative are those items that are beyond normal operation and maintenance. During the Reconnaissance Study (905(b) Analysis) completed in May 2000, a preliminary list of reconstruction items was formulated. Major reconstruction items were identified during Engineering Division's Paducah team site investigations in 2000 and in the team's professional judgment. Annual inspection reports from both the Corps of Engineers and Paducah Floodwall team were reviewed for content relating to proper O&M throughout the history of the project. The local Sponsor has consistently and adequately performed all expected work with respect to the project's O&M manual. This project has aged and it is recognized that the LFPP cannot be expected to perform as intended due to long-term degradation of features

(including, but not limited to, construction materials and engineering systems) which have exceeded their expected service life. In addressing reconstruction needs, the latest design standards and efficiency improvements will be incorporated into the project. The following is a list of items determined to require reconstruction and/or further investigation: (1) slip line all corrugated metal pipes; (2) electrically and mechanically upgrade pump plants; (3) I-wall evaluations; and (4) other miscellaneous items. A list of action items and tasks to be performed can be found in this main report on pages 5-4through 5-6.

The project was designed to prevent damages from a recurrence of the 1937 flood (the flood of record for the Ohio River a - 500-year/0.02% event) plus three feet of freeboard. Subsequent to the construction of the flood project at Paducah, the Corps implemented a basin-wide strategy of regional detention projects located on tributary streams to the Ohio River. In total, 80 regional reservoir projects have been constructed upstream of Paducah that contribute to reductions in stage along the Ohio River during flood events. If the meteorological conditions of the 1937 Flood were to reoccur, it is estimated that, with the upstream reservoirs currently in place, there would be a seven-foot reduction in the flood elevation at Paducah. The basic project layout allows for no logical or rational way to decrease the scope/scale of the project so as to account for the change in the hydraulics of the Ohio River. Additionally, this theoretical increase in project effectiveness is offset somewhat by changes in national design standards resulting from the Hurricane Katrina event in 2005. Absent the decrease in flood levels due to the upstream reservoirs, additional work would have been required to strengthen the floodwalls/levees at Paducah. The recommended plan only restores the project to its originally authorized operational condition. It does not provide additional protection to the community since it does not change the physical scope, scale, or size of the project. If the Paducah project is reconstructed as recommended, the residual risk of the project would be minimal and more a factor of a possible system component failure than any defeat of the project by a large flood event. It is important to note that the Paducah LFPP functions as a single "system." There are no separable elements to this project. Therefore, if any part of the levee system fails, the entire levee system is impacted causing life safety issues for the community of Paducah.

The H&H Model used during the feasibility study for Paducah took into account the effects of the protective works at Paducah and all reservoirs constructed upstream subsequent to the completion of the Paducah project in 1948. However, the economic analysis prepared for the reconstruction evaluation of the Paducah project is based solely on the performance (or lack thereof) of the local flood works at Paducah, and does not include any benefits provided by the operation of the upstream reservoir system. For example, during the May 2011 flood event on the Ohio River, if the local project at Paducah had failed AND the upstream reservoirs were NOT in operation, then a total of $362.5M in flood related damages would have occurred in the vicinity of Paducah under current conditions of development. However, with the upstream reservoirs in place and operational in May 2011, the estimated flood damages at Paducah would have been approximately $200M if the floodwall had been in failure mode. It is this second scenario that was used for the calculations of the various flood events by the H&H Model, and is the basis for the economic analysis of the reconstruction project.

The statistical probability of coincident major flood events along the Ohio River AND Mississippi River mainstems is so low that it has always been considered to be an "outlier" for purposes of economic evaluations for the Paducah project location. Therefore, while implementation of the operation plan for the New Madrid Floodway did actually reduce the water level at Paducah by approximately three feet during the 2011 flood peak, this rare event will not alter the economic basis for the reconstruction recommendations contained in this feasibility report.

4.7.3. Pump Plant at Station 111+67A

The addition of a Pump Plant (# 14) at Station 111+67A, with a total of 100 cfs pumping capability, was also considered. The potential Pump Plant # 14 at Station 111+67A is the only feature remaining at this stage of analysis which is not an original feature of the Paducah, KY LFPP. An array of alternatives was required to be developed and analyzed to determine if it was economically justifiable. The pump plant was considered to address interior drainage at this location which had not been fully identified during initial construction. Installing a new pump plant at this location would not change the scope of the project. USACE is bringing the project up to current USACE standards and returning the efficiency of the project to the level of its original authorization.

Risk and uncertainty were assessed for the reconstruction of various components of the project. F or example, as part of the consideration for risks and uncertainty associated with replacement of the pumps and motors, uncertainty was determined to be lower (therefore risk was lower). However, uncertainty was determined to be higher with the pumps and motors that needed to be rebuilt (therefore risk was higher and a higher contingency was assigned) because the required parts wouldn't be known until the pumps and motors were torn down and examined.

The array of pump sizes considered included a 50 cfs, 100 cfs, 150 cfs, and 200 cfs pump plant. Determination of feasibility of each alternative on an individual, incremental level was a requirement per a CECW-PB guidance memorandum dated 16 August 2005 which states:

> *"...Any features considered by the study team which were not part of the original project must be economically analyzed with a determination of feasibility to be made on an individual, incremental level."*

(See Volume 4, DVD 3, Section 1, reference 1.5 for the August 2005 memorandum in its entirety).

Once each pump station alternative is determined to be feasible, all alternatives with feasible benefit-to-cost ratios must be compared to determine which alternative (which pump size) produces maximum net benefits to the Nation. This alternative will become the NED plan.

The pump plant size with the greatest net benefits is the 100 cfs pump plant with a benefit-to-cost ratio of 1.53 and net benefits of $52,000. This alternative is individually and incrementally justifiable and becomes the NED plan. For more information regarding the analysis of the pump plant alternatives, see Volume 2, Appendix B (Economic Analysis). Table 4-4 shows the costs and benefits produced from the analysis of the four pump plant alternatives. The second column represents the NED plan.

Table 4-4
Ohio River, Paducah, KY
Pump Station @ 111+67
Summary of Annual Benefits and Costs
FY 2011 Price Levels (x $1,000)
4 1/8% Interest Rate

Investment Cost	**50 cfs PS**	**100 cfs PS**	**150 cfs PS**	**200 cfs PS**
Construction First Cost	$1310	$1710	$2109	$2509
Interest During Construction	$27	$35	$43	$51
Total Investment Cost	$1337	$1745	$2152	$2560
Annual Charges				
Interest & Amortization	$64	$83	$102	$122
Operation & Maintenance	$12	$15	$18	$20
Total Annual Charges	$76	$98	$120	$142
Annual Benefits				
Structures				
-Residential	$1	$1	$1	$1
-Public	$0	$0	$0	$0
-Commercial	$117	$148	$157	$167
Traffic Diversion	$0	$0	$0	$0
Vehicles (Total)	$1	$2	$2	$2
-Minivans	*$0.1*	*$0.1*	*$0.1*	*$0.1*
-Pickups	*$0.1*	*$0.1*	*$0.1*	*$0.1*
-Sedans	*$0.5*	*$0.6*	*$0.6*	*$0.6*
-Sports Cars	*$0.6*	*$0.6*	*$0.7*	*$0.7*
-SUVs	*$0.1*	*$0.1*	*$0.1*	*$0.1*
Emergency Costs	$0	$0	$0	$0
Total Annual Benefits	$119	$150	$159	$169
Residual Estimated Annual Damages	$74	$43	$34	$24
Benefit vs. Cost Ratio	1.57	1.53	1.32	1.20
Net Benefits	$43	$52	$39	$28

4.7.4. Pump Plant at Station 19+11B

The economic analysis for the area that drains to the outlet at Station 19+11B revealed that very few structures would be flooded at the 0.2% chance (500-year) interior flood event. There were not enough economic benefits to support a pump plant to address ponding at this location. It was suggested that a portable pump platform be established to couple to a discharge pipe that would be permanently constructed to dispose of any interior flooding. The sponsor will provide the portable pump. The proposed discharge pipe would go under South 4th Street which would allow for uninterrupted vehicular traffic. As the project exists today, without this pipe, 300 feet of discharge hose would be ran across this road, blocking access while water is pumped through the hose when the drainage pipe is in the closed outlet position (due to flood waters).

4.7.5. Non-structural Alternatives

Evaluation of non-structural alternatives on flood projects is normally required by Section 219 of the Water Resources Development Act of 1974. Non-structural alternatives were not considered for the Paducah LFPP as a whole, based on guidance provided in CE-CWLRD Memorandum for Commander, Great Lakes and Ohio River Division, dated 11 Jun 2009, Subject: Implementation Guidance for Section 5077 of the Water Resources Development Act of 2007 (WRDA 2007) – Paducah, Kentucky which states:

"This study may be undertaken in accordance with existing budgetary policy and procedures. At such time that funds are provided, the Louisville District should negotiate and execute a Feasibility Cost Sharing Agreement with the non-Federal sponsor to initiate the feasibility study for the project consistent with memorandum CECW-PB memorandum, 16 Aug 2005,"

Per the memorandum CECW-PB dated 16 Aug 2005 (see Volume 4, DVD 3, Section 1, reference 1.5) mentioned above:

"Depending on the interest of the non-Federal sponsor, the feasibility study may be limited to examination of the reconstruction of the existing project with no change in its scope or function. Under this limited objective, evaluation would be limited to individual project features, (closure structures, pumping stations, gravity drains, relief wells, etc.) to establish the justification of reconstruction based on a comparison between the with and without reconstruction condition.....For levee and floodwall projects, the with and without reconstruction analysis should include consideration of both interior and exterior flooding……"

The non-Federal sponsor's interest lies in reconstruction of the levee system rather than pursuing non-structural alternatives. Therefore, only two alternatives were considered in examining the reconstruction of the Paducah, KY LFPP, No Action (Alternative 1) and Reconstruction (Alternative 2).

The only new component to the Paducah, KY LFPP is the potential new pump plant at Station 111+67A which was evaluated to address interior flooding that had not been fully identified during construction of the original project. It was determined during the economic analyses that the pump plant is economically viable.

A non-structural alternative of floodproofing structures was considered for the pump plant at Station 111+67A. The pump plant would protect a mix of primarily industrial and commercial structures. The non-structural alternative would require flood proofing 31 structures at an average cost of $62,000 or less in order to be less costly than the pump plant. Given the size and type of facilities involved, it was decided early on that this non-structural alternative was not practical.

4.8. Integral Determination

In a letter dated October 2, 2008, the city of Paducah requested to receive credit for the repair work to the existing drainage structures as an in-kind contribution under Section 221 of the Flood Control Act of 1970, as amended by Section 2003 of the Water Resources Development Act of 2007 (Section 221; 42 U.S.C. 1962d-5b), in advance of the PPA for a reconstruction project and in advance of a signed Chief's Report. In November, 2008 the Great Lakes and Ohio River Division Regional Integration Team requested approval of a one-time only waiver of USACE policy on the timing of execution of an In-Kind MOU as set forth in EC 1165-2-208, paragraph 4.a. (1), to allow execution of an In-Kind MOU with the city of Paducah, Kentucky prior to completion of the feasibility study. The In-Kind MOU would allow the city to perform necessary pipe repair work and preserve the right to request credit for this work at some point in the future.

A Memorandum of Understanding between the Department of Army and the City of Paducah, Kentucky for Work Provided or Performed Prior to Execution of a Project Partnership Agreement For Paducah, Kentucky Local Flood Protection Project (MOU) was executed on 17 November 2008 that covered the provision of credit for this work under Section 221(a) of the Flood Control Act of 1970, as amended by Section 2003 of the Water Resources Development Act of 2007, Public Law 110-114.

The city of Paducah performed the work covered by the MOU between November 2008 and January 2010. To be creditable as an in-kind contribution the work covered by the MOU must be determined integral to the project.

In 2009, the city of Paducah performed bank stabilization work. The bank stabilization work was not covered by a Section 221 In-Kind MOU.

The requirements set forth in EC 1165-2-208, paragraph 6(c) (1) for integral determinations are shown below followed by verbiage addressing each requirement.

Requirement (1): Description of the Federal project or separable element of which the in-kind contributions are a part in sufficient detail to allow a comparison with the description of the proposed in-kind contributions.

Items recommended for reconstruction of the levee project, include slip-lining 37 corrugated metal pipes and stabilization of the bank, is described in Section 4.7.2.
The slip-lining of the pipes and the bank stabilization have been completed by the sponsor. Both of these items would have been performed by the Corps as part of the reconstruction had conditions not required the work be undertaken prior to completion of this feasibility study.

Requirement (2): A detailed description of the work items proposed to be provided or performed as in-kind contributions.

The local sponsor performed slip-lining of 37 corrugated metal pipes and bank stabilization.

Slip-lining was completed in January, 2010. Both the replacement pipes specified by the City of Paducah and the four different methods of installation permitted by the construction contract meet current USACE engineering standards and specifications. For more information regarding the rehabilitation of the gravity discharge pipes, see Section 7.8 of Appendix C (Engineering Evaluations and References). Pipe inspection videos, inspection reports, and still pictures can be found in Volume 4 of this Feasibility Report.

Bank stabilization work was completed in 2009. See Appendix C, Section 4.3.2 for additional information on reconstruction of the bank and placement of riprap.

Requirement (3): A discussion of how each work item proposed to be provided or performed as an in-kind contribution is integral to the project (see Appendix D of EC 1165-2-208).

The slip-lining of the pipes would have been performed by the Corps as part of the reconstruction had the condition of the pipes not required repair prior to completion of this feasibility study.

The Paducah LFPP was removed from the Corps' Rehabilitation and Inspection Program (RIP) in September 2007, primarily as a result of the deteriorated condition of the project's discharge pipes. The condition of the pipes was verified by a CCTV video inspection of all of the pipes. T he pipes were rated using NASSCO's (National Association of Storm Sewer Companies) PACP (Pipeline Assessment Coding Program) ratings. Many of the pipes were rated as being in imminent failure. Pipe inspection videos, inspection reports, and still pictures can be found in Volume 4 of this Feasibility Report.

Based on this information, the age of the pipes (greater than 60 years), and the latest Corps guidance in EM 1110-2-2902, which allows CMP's for rural levees only, the Corps and local sponsor determined that 37 C MP's (of the total 60 pi pes that were video

inspected) required immediate rehabilitation. A contract was awarded by the sponsor on 20 November 2008 to slip-line the pipes after the MOU was executed. Both the replacement pipes specified by the City of Paducah and the four different methods of installation permitted by the construction contract meet current USACE engineering standards and specifications. For more information regarding the rehabilitation of the gravity discharge pipes, see Section 7.8 of Appendix C (Engineering Evaluations and References). The project was reinstated in the RIP when slip-lining of the pipes was completed in January of 2010.

If the pipes, which were at the point of imminent failure, and other deteriorating project features were not rehabilitated, the highest elevation along the line of protection where the system should not fail is approximately equal to the toe of the levee which corresponds to the invert of these drainage pipes. This elevation corresponds to less than a 99% chance (1-year) flood frequency. The pipe used to determine the frequency of the flood protection at the toe of the levee is located at Station 19+11B where the invert of the pipe under the centerline of the levee is approximate elevation 309 (NAVD). Additional discussion of this topic can be found in Volume 2, Appendix C (Engineering Evaluations) of this report.

The repairs to the drainage structures of the existing project between November 2008 and January 2010 were part of the reconstruction project recommended in the May 2000 Section 905(b) analysis prepared by the Louisville District. The items of work included in the repairs (including the deteriorated corrugated metal pipes) are items beyond normal project Operations & Maintenance (O&M). The local sponsor has consistently and adequately performed all expected work with respect to the project's O&M Manual.

The bank stabilization work would also have been performed by the Corps as part of the reconstruction had conditions not required the work be undertaken prior to completion of this feasibility study.

Observations of slope instabilities were noted on the Tennessee River bank between Stations 12+75B and 15+32B in 2009. Due to continued erosion along the bank adjacent to the floodwall and the proximity of the bank erosion to the floodwall, it was determined that immediate rehabilitation was required to protect the floodwall. USACE provided recommendations to the sponsor who constructed the riprap protection to reestablish stable conditions which meet current USACE standards. Reconstruction of this bank and placement of the riprap occurred during the development of this Feasibility Report due to the fact it required immediate attention.

The bank stabilization efforts were considered as a component of the reconstruction that would help keep an integral structure (which provides flood protection) from being compromised. If the sponsor had not taken such immediate action, a much more costly reconstruction effort related to rehabilitation of the adjacent T-wall monoliths would have been necessary. See Appendix C, Section 4.3.2 for additional information on reconstruction of this bank and placement of riprap.

Requirement (4): An estimate of the costs of each work item proposed to be provided or performed as an in-kind contribution.

The cost of slip-lining the pipes was approximately $2.1 M. The cost of the bank stabilization was approximately $100,000.

Requirement (5): The estimated amount of credit to be afforded for each work item proposed to be provided or performed as an in-kind contribution.

Total non-Federal cost share amount for design and implementation of the project is $6,690,005. After the minimum cash requirement (5%) and credit for LERRDs, the sponsor is allowed 100% credit for the work items proposed as an in-kind contribution. These dollar amounts are subject to audits by the government and the actual value of the in-kind contributions will be determined in accordance with the limitations and conditions of the Project Partnership Agreement (PPA).

Credit in the amount of $2.1M is proposed to be afforded for performing slip-lining of the pipes. No credit is currently proposed to be afforded for the bank stabilization work as it was undertaken without entering into a In-Kind MOU, which is required for credit under Section 221.

Final accounting will be performed as part of the financial closeout after completion of construction.

Requirement (6): A District recommendation identifying which of the proposed in-kind contributions should be considered integral to the project.

The Louisville District recommends that slip-lining of the corrugated metal pipes and the bank stabilization, both completed by the sponsor prior to completion of this feasibility study, be considered integral to the project and that the slip-lining of the corrugated metal pipes be creditable as an in kind contribution under the existing MOU.

4.9. Future With Project Condition

Economic evaluation methodologies utilized for generation of Without Project Condition were applied in the exact manner (unless otherwise noted in the Economics Analysis [Volume 2, Appendix B]) as for the production of Future With Project Conditions, also known as the Reconstruction Action. This alternative consists of numerous measures designed to return Paducah, KY LFPP infrastructure to reliable conditions and current engineering standards. These measures mostly involve refurbishment or replacement of aging equipment (such as pumps, motors, electrical components, and wall rehabilitation).

This report has been updated to include calculation and economic analysis of the study within a Fiscal Year 2011 (FY11) framework. This framework consists of presenting previously calculated benefits and all appropriate costs in FY11 price levels as well as utilization of the FY11 federal discount rate of 4 1/8%. With the exception of the

aforementioned modifications specifically highlighted above, all other economic assumptions and considerations from the original report remain unchanged.

Under expected Future Without Project Conditions, the City of Paducah would be structurally and financially decimated by flood events on the Ohio River on an annual basis. The Expected Annual Damages (EAD) of $8,386,000 produced from the economics analysis of this report represents an enormous average annual damage estimate.

Under expected Future Conditions for the Reconstruction, the city of Paducah will again be afforded reliable protection, within its design life, from the Ohio River. The represented With Project/Reconstruction Action EAD of $1,290,000 represents a tremendous decrease in the expected annual damage estimate, by comparison to the Without Project Condition EAD of $8,386,000. The total annual benefits associated with the Reconstruction Plan are $7,096,000. The reconstruction plan generates a positive benefit-to-cost ratio well above unity (4.5) and produces net benefits of $5,507,000 to the Nation.

For the With Project Condition economic calculations, the 0.2% chance (500-year) floodplain is reflected by the aggregation of twenty-six residual ponding areas which will remain after the project is constructed and complete. Further explanation of how each structure is associated with each ponding area is discussed in Section 6.1 of Volume 2, Appendix B (Economic Analysis). A map identifying this Future With Project Condition 0.2% chance (500-year) floodplain is shown in Figure 4-3.

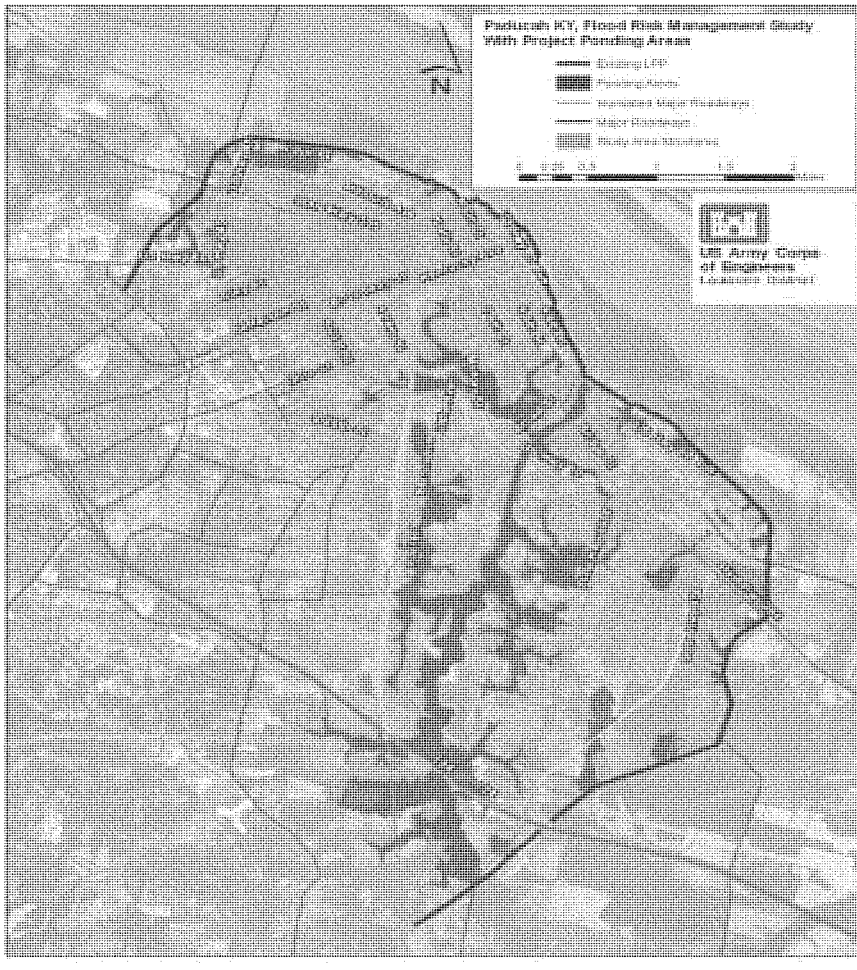


Figure 4-2 - Future With Project Condition Floodplain, 0.2% chance (500-year) event (26 ponding areas)

4.10. Other Impacts

The proposed project has been reviewed for compliance with federal legislation including the National Environmental Policy Act (NEPA), Endangered Species Act, Clean Air Act, Clean Water Act, and Section 106 of the National Historic Preservation Act of 1966, as amended.

USACE determined that the proposed work was covered by the NEPA categorical exclusion at 33 CFR 230.9(b), and that there were no extraordinary circumstances that warranted preparation of an Environmental Assessment, because the proposed work would cause at most minimal adverse effects on the human environment, individually and cumulatively. Nevertheless, the District completed an Environmental Assessment (EA), even though an EA was not legally required, in order to consolidate documentation demonstrating that the project would not produce any significant adverse effects on the human environment, and thus that no Environmental Impact Statement is required for the project. The EA was made available for public review for thirty days. No comments were received from the public. The EA/Finding of No Significant Impact (FONSI) can be found in its entirety at the end of this report.

Cultural resources do occur in the proposed project area (discussed further in the cultural resources section), however, none are expected to be impacted by the proposed project. For further description on how the proposed project complies with the above listed Acts, refer to section 5.6.4 and Table 5-4.

Consultation under Section 106 of the National Historic Preservation Act (NHPA) on effects to historic properties and cultural resources by the proposed undertaking has taken place. This consultation involved the State Historic Preservation Offices (SHPO), federally-recognized Native American tribes and other concerned parties and focused on avoiding impacts to significant historic properties and cultural resources. For additional information on these properties and resources, see Volume 2, Appendix E (Environmental Appendix). Refer to Appendix A (Public and Agency Coordination) for a copy of the letter to the SHPO and the SHPO's response.

4.11. National Economic Development (NED) Plan

Upon completion of the analysis of alternative plans, the apparent NED Plan consists of the reconstruction of the original Paducah, KY LFPP with the added feature of the new 100 cfs pump plant at Station 111+67A. This new feature was included in the Reconstruction Action as it was individually and incrementally justified by its own economic analysis. For a complete list of reconstruction items, see Table 5-1 in this main report (pages 5-2 through 5-8). A similar breakdown of structure inventory, values, and damages for the With Project Condition can also be found in Volume 2, Appendix B (Economics Analysis).

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 1 OF 4 MAIN REPORT

SECTION 5 DESCRIPTION OF RECOMMENDED PLAN

5. RECOMMENDED PLAN

5.1. Plan Components

Based on a collaborative effort of all team members on the feasibility project, the recommended plan is reconstruction of the LFPP. This plan consists of replacing aging equipment (see Table 5-1 on pages 5-2 though 5-8) and installing a new 100 cfs pump plant (with two 50 cfs pumps) at Station 111+67A.

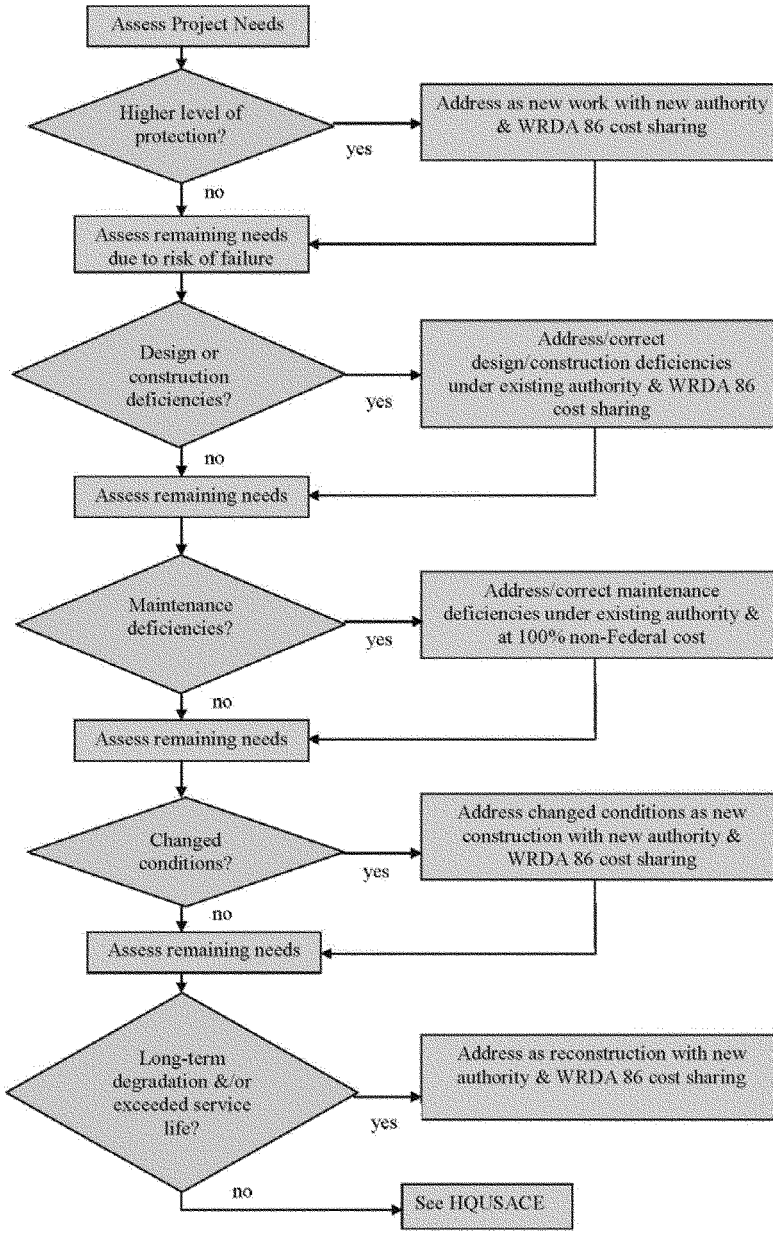
The Paducah LFPP consists of approximately 48,700 feet (9.2 miles) of earth levee, 15,870 feet (3 miles) of concrete flood wall, 12 pump stations, 47 closure and service openings, 8 ramps, 5 diversion channels and other necessary appurtenances. A reconnaissance study was initiated in 1999 as a result of the provision of funds for this purpose in the Energy and Water Development Appropriations Act of 1999 (P.L.105-581). The 905(b) Analysis, titled "Ohio River, Paducah, Kentucky Flood Damage Reduction Section 905(b) (WRDA 1996) Analysis" and completed inMay 2000, recommended reconstruction of some major project features of the Paducah, KY LFPP. Repair, reconstruction, or replacement of some project features was deemed necessary due to the fact that the components of the project were nearing the end of their useful service lives of 50 years. This feasibility report recommends reconstruction of a (> 60 year old) project. The work proposed is reconstruction of deteriorated components beyond their service life and one new pump plant to address an interior flooding situation which had not been fully identified during initial project construction. The addition of this one new pump plant increases project efficiency and brings it up to current USACE standards. This should not be considered to be a change in the scope of the project or level of protection.

Based on the August 2005 Reconstruction Guidance , the formulation categories used to determine if items are eligible for reconstruction were: design deficiencies, deferred maintenance, and reconstruction. Early on, it was determined that there were no design deficiencies. All items identified as deferred maintenance were referred to the non-Federal sponsor for action and are described in Appendix C. The non-Federal sponsor has very diligently maintained the levee system.

Table 5-1 below shows the decision logic/process used in assessing project needs and determining which items qualify for reconstruction according to the following categories in the August 2005 Reconstruction Guidance:

1. If higher level of protection is required, address as New Work (see August 2005 Reconstruction Guidance, paragraph 3.g.);
2. If design or construction deficiency, address deficiency under existing authority cost shared (see August 2005 Reconstruction Guidance, paragraph 3.d.);
3. If maintenance deficiencies, address under existing authority cost shared (see August 2005 Reconstruction Guidance, paragraph 3.c.);
4. If changed conditions, address as New Construction with new authority cost shared (see August 2005 Reconstruction Guidance, paragraph 3.e.);
5. If long-term degradation &/or exceeded service life, address as reconstruction with new authority with current design and safety standards (see August 2005 Reconstruction Guidance, paragraph 3.e.).

Table 5-1 – Eligibility for Reconstruction - Decision Process



A separate certification study (now known as Levee System Evaluation - LSE), was performed (and completed in May 2010) concurrently with this feasibility study to determine if this flood protection project meets FEMA and Corps of Engineers criteria for certifying the project, for the National Flood Insurance Program (NFIP), based upon the occurrence of a 1% chance (100-year) flood to the 95% assurance level.

None of the proposed reconstruction items provide a higher level of protection. The proposed pump plant (#14) is not increasing the level of protection. It is only bringing the project to the level of its intended purpose for the originally constructed project. There were no design or construction deficiencies. T here were no maintenance deficiencies. T he Sponsor has very consistently and diligently addressed all operation and maintenance items throughout the years. There are no changed conditions at the project.

Table 5-2 below focuses on the project features that qualify for reconstruction as a "system". The pump plants, floodwalls, drainage outlets and discharge systems, and levees qualify for reconstruction based on the August 2005 Reconstruction Guidance. The items in the table have been identified, using the process shown in Table 5-1 above (Eligibility for Reconstruction – Decision Process) as having long-term degradation &/or exceeded service life. A fter these systems were identified as being eligible for reconstruction, it was noted that other components of the system (such as trash racks, automatic shutoff instrumentation, gravity ventilation systems, etc.) will be reconstructed as necessary using current design and safety standards.

Table 5-2 – Summary of Reconstruction Items

PADUCAH, KENTUCKY LFPP SUMMARY OF RECONSTRUCTION ITEMS
Pump Plant #1 (Noble Park)
Volume 3 Sheets: CS127, S504, M601, E101, E601
Replace (corrugated wire glass) skylight with pre-engineered removable roof hatch; repair cracks in concrete parapet walls; remove existing discharge pipes from wall and cast new pipes in place; refurbish/recondition all pumps and motors (units 1 to 3); rehabilitate trash racks; replace cover plate and hardware on sluice gate and flap gate; central grease lubrication system; provide manual transfer switch (600 v, 600A); fused disconnect switch
Pump Plant #2 (Sixth Street)
Volume 3 Sheets: CS123, S505, M601, E102, E602
Replace existing (wire-reinforced Corrugated Glass) skylights with pre-engineered removable roof hatches; repair cracks in concrete parapet walls and install new flashing and roofing material; remove existing discharge pipes from wall and cast new pipes in place; replace pump plant discharge pipes; refurbish/recondition all pumps and motors (units 1 to 3); replace Unit 1 Economy Sump with new Submersible Pump; refurbish/ recondition Unit 2 through Unit 6 Economy Pumps and Motors; central grease lubrication system; replace 96" x 96" sluice gate; flap gates at # 1 and # 6; provide manual transfer switch (2400v, 600 A); fused disconnect switch; replace motor gate actuators and controls at Gatewell 66+17A; provide new motor starter circuit at Unit 1
Pump Plant #3 (Park Avenue)
Volume 3 Sheets: CS121, S506, M601, E103, E603
Replace existing (wire-reinforced Corrugated Glass) skylights with pre-engineered removable roof hatches; repair cracks in concrete parapet walls and install new flashing and roofing material; replace flap gates; replace MH lid and embedded angles; replace all 3 Economy units with submersible type pumps; provide manual transfer switch (600v, 300A); fused disconnect switch; new motor starter circuits

PADUCAH, KENTUCKY LFPP SUMMARY OF RECONSTRUCTION ITEMS
Pump Plant #4 (Clay Street)
Volume 3 Sheets: CS121, S507, M601, E604
Replace both Economy units 1 and 2 with submersible type pumps; manual transfer switch (600v, 250A); fused disconnect switch
Pump Plant #5 (Harrison Street)
Volume 3 Sheets: CS121, S508, M601, E104,E605
Repair cracks on concrete parapet walls and install new flashing and roofing material; remove existing pump plant discharge pipes from wall and cast new pipes in place; refurbish/recondition units 1 through 3 Economy pumps and motors; replace Unit 4 Economy sump with submersible type pump; provide manual transfer switch (600v, 600A); fused disconnect switch
Pump Plant #6 (Clark Street)
Volume 3 Sheets: S-509, M601, E105, E606
Replace existing MH cover and frame; remove existing pump plant discharge pipes from wall and cast new pipes in place; refurbish/recondition units 1 through 4 Economy pumps and motors; replace Unit 5 Economy Sump with submersible pump; replace flapgates; provide manual transfer switch (600v, 1200A); fused disconnect switch; replace motor gate actuators and controls on 84" x84" sluice gate
Pump Plant #7 (Tennessee Street)
Volume 3 Sheets: S510, M601, E107, E607
Remove existing pump plant discharge pipes from wall and cast new pipes in place; replace all 3 units with submersible type pumps; replace flapgates; provide manual transfer switch (600v, 300A); fused disconnect switch; provide new motor control center; provide new lighting panel for pump station lighting and convenience receptacles
Pump Plant #9 (Husband Road)
Volume 3 Sheets: CS117, S-511, M601, E107, E608
Replace skylight with pre-engineered removable roof hatch; repair/seal cracks on concrete parapet walls and install new flashing and roofing materials; replace both Economy units with submersible pumps; provide new motor start circuits; provide manual transfer switch (600v, 175A); fused disconnect switch; new power panel
Pump Plant #10 (George Street)
Volume 3 Sheets: CS116, S-512, M601, S-512
Replace both Economy units with submersible pumps; provide manual transfer switch (600v, 150A); fused disconnect switch
Pump Plant #11 (Island Creek)
Volume 3 Sheets: S513, M601, E108, E610
Replace existing hatch covers with new pre-engineered hatches; repair cracks and seal parapet walls and replace roofing material; rehabilitate existing pump plant discharge pipes; refurbish/recondition Economy pumps and motors at units 2 through 4; provide manual transfer switch (600v, 1200A); fused disconnect switch
Pump Plant #12 (Station 175+00C)
Volume 3 Sheets: CS107, S514, M601, E109, E116
Replace with pre-engineered removable roof hatch; repair cracks on concrete parapet walls and install new flashing and roofing material; remove existing pump plant discharge pipes from wall and cast new pipes in place; replace both Economy units with submersible pumps; new power panel boards; provide manual transfer switch (600v, 350A); fused disconnect switch; new lighting panel board
Pump Plant #13 (Station 291+75C)
Volume 3 Sheets: CS113, M601, E612
Sluice gate and flapgate access- replace cover plate, hinges, and support angles; crown pump - rebuild motor; fused disconnect switch
Pump Plant #14 (Station 111+67A) Submersible Pump Option
Volume 3 Sheets: CS125, CS125A, E110, E111, E613, E614
Construct new pump station with all equipment, pipes, and related material to be completely operational, to include gatewell, sluice gate, and flapgates
LEVEES - City of Paducah – Work Performed under MOU/Policy Waiver – Slip-line of Deteriorated CMP's - COMPLETED
Volume 3 Sheet: CZ003
See Slip-lined pipe schedule on Sheet CZ003
FLOODWALLS - Floodwall Waterstop Joints Type 2

PADUCAH, KENTUCKY LFPP SUMMARY OF RECONSTRUCTION ITEMS
Volume 3 Sheets: CS114, S503
Waterstop Joint Repair
LEVEES - Plug Existing Toe Drains
Volume 3 Sheets: CS106, CS110, CS114, CS116, CS117, CS118, CS122, CS126, CS127, CS128
Plug existing toe drains as noted
LEVEES - Replace Existing Toe Drain
Volume 3 Sheets: CS118, CS119, CS121
Replace existing toe drains as noted
LEVEES - Replace Existing Bee Branch Drainage Outlet Structures
Volume 3 Sheets: CS101, S517
Reconstruct Bee Branch Sluice Gate and replace two existing drainage outlet structures
LANDS & DAMAGES
Volume 3 Sheets: RW100 – RW 129
Right of Way requirements for reconstruction
LEVEES - MISCELLANEOUS ITEM Landside Blanket Filter
Volume 3 Sheets: CS109, CS126, CZ001
LEVEES - Gate wells (Station 111+67A) Proposed Pump Plant #14 Discharge
Landside Blanket Filter
Volume 3 Sheets: CS123, CZ002, S520
LEVEES - Gatewell (Station 19+11B) – Woodward Hollow Discharge Pipe
Volume 3 Sheets: CZ002, S518, CS115, CS115A
LEVEES – Bank Protection
Volume 3 Sheets: CS114, CS115A
Provide riprap in areas that need bank stabilization: STA 20+00B & 12-+75 to 15+32 (Work Completed)
FLOODWALLS - Floodwall Waterstop Joints Type I
Volume 3 Sheet: S500
FLOODWALLS - Permanently Close Closures
Volume 3 Sheets: CS114, CS115, CS117, CS118, CS121
Permanently close closures as noted. Also, these obsolete closure openings are adding unnecessary risk to the project.
LEVEES - Scour/Erosion Control Pad at Wall/Levee Transitions
Volume 3 Sheets: CS114, CS115, CS116, CS122
RELOCATIONS
Volume 3 Sheets: CS114, CS116, CS125

5.2. Design and Construction Considerations

Design and construction of this project would require a total of approximately 36 months, after receipt of funds, to complete. No unusual design or construction issues are anticipated at this time.

5.3. Lands, Easements, Rights-of-Way, Relocations, and Disposals (LERRD) Considerations

A three year temporary work easement is required for contractor staging and lay down areas, temporary access sites, and contractor work areas during construction. These areas are mainly comprised of industrial lands, with the addition of some residential areas. Additional permanent

levee easements will be required for future operation and maintenance activities for any portion of the repaired levee that is outside of the existing permanent easement limits. A perpetual road easement and two additional utility pipeline easements, as referenced in Exhibit RE-2 (in Volume 2, Appendix D), will also be required to support the proposed project. The Non-Federal Sponsor has the responsibility for acquiring the necessary real estate interests and providing documentation that the acquisition has been completed.

Property owned by the City of Paducah will be made available through Authorization for Entry for Construction, Attorney's Certificate of Authority, the Partnership Agreement and ownership documentation. For more information on LERRD considerations, see Volume 2, Appendix D.

5.4. Economic Summary

A detailed cost estimate, referred to as a baseline Micro-Computer Aided Cost Estimating System (MCACES) cost estimate, was prepared to accurately define the project costs associated with the recommended plan. MCACES is a multi-user software program used by the U.S. Army Corps of Engineers for the preparation of detailed construction cost estimates for military, civil works, and environmental projects. The system includes a project database and supporting databases. The supporting databases include a unit price book, crews, labor rates, equipment ownership, schedule costs, assemblies, and models. All databases work in conjunction with each other to produce a detailed cost estimate. Volume 2, Appendix C (Engineering Evaluations) contains the Cost Engineering breakouts prepared for the cost of implementing the recommended plan. Tables 5-3 and 5-4 below present the total project costs and the annual benefits and costs, respectively. These values are based on FY 11 price levels, and interest rate of 4 1/8% and a 50-year period for economic analysis, assuming intitiation of Corps Construction in FY 2014. The total cost of the recommended single purpose project, presented in 2011 dollars, is $19.1M as shown in Table 5-3.

It is important to note that the cost estimate will increase when the project is implemented due to higher construction costs in the future. Accordingly, the recommended plan costs have been inflated to arrive at a "fully funded" construction cost estimate of $20,019,000.

It is also important to note when evaluating the increase in costs from the 905(b) study estimate, that the 905(b) study was conducted ten years ago. Construction cost inflation for the ten years since the 905(b) study was done need to be considered. The cost increases associated with the Paducah LFPP from $5.2 million in 2000 to $19.0 million in 2010 can be attributed to construction cost inflation, revised USACE criteria "Post Hurricane Katrina", and identified restoration and reconstruction needs for the project. The identification of these restoration and reconstruction needs, and the resultant cost increases, were determined through a very thorough investigation associated with the Feasibility Study after the completion of the original 905(b) Study.

Table 5-3
Ohio River Shoreline, Paducah, KY
Project Cost Summary Report (000's)
FY 2011 Price Levels

Description	Cost
Relocations	20.5
Pump Plant #1 (Noble Park)	417.1
Pump Plant #2 (Sixth Street)	1763.2
Pump Plant #3 (Park Ave)	258.2
Pump Plant #4 (Clay Street)	209.6
Pump Plant #5 (Harrison Street)	445.5
Pump Plant #6 (Clark Street)	725.8
Pump Plant #7 (Tennessee Street)	674.8
Pump Plant #9 (Husbands Road)	241.6
Pump Plant #10 (George Street)	130.2
Pump Plant #11 (Island Creek)	671.7
Pump Plant #12 (SE of Paducah)	454.5
Pump Plant #13	47.5
Pump Plant #14 (at Sta.111+67) Submersible 100 cfs Pump	1709.6
Levees	3787.9
Floodwalls	3150.0
Bank Stabilization	100.0
Planning, Engineering, and Design	1341.3
Construction Management	1341.3
Miscellaneous Items (Pumping Station)	1180.7
Lands and Damages	443.3
Total Construction Costs	$19,114.3

** **Amounts shown for Pump Plant Nos. 1-7 and 9 -13** are for **Reconstruction Items Only** – these are not new pump plants; **Pump Plant # 14 is the only new pump plant** recommended in this Feasibility Study/Report*

Table 5-4: With Project Condition/Reconstruction Plan

Ohio River Shoreline, Paducah, KY
Feasibility Study
Summary of Annual Benefits and Costs
FY 2011 Price Levels (x $1,000)
4 1/8% Interest Rate

Investment Cost	**Rehabilitation**
Construction First Cost	$19,114
Interest During Construction	$1,206
Total Investment Cost	$20,320
Annual Charges	
Interest & Amortization	$966
Operation & Maintenance	$623
Total Annual Charges	$1,589
Annual Benefits	
Structures	
-Residential	$4,946
-Public	$426
-Commercial	$2,624
Traffic Diversion	$84
Vehicles	
-Minivans	$29
-Pickups	$26
-Sedans	$110
-Sports Cars	$117
-SUVs	$24
Emergency Costs	$0
Total Annual Benefits	$7,096
Residual Expected Annual Damages	$1,290
Benefit vs. Cost Ratio	4.5
Net Benefits	$5,507

5.5. Operation, Maintenance, Replacement, Repairs, and Rehabilitation (OMRR&R)

The city of Paducah will continue to have responsibility for operating, maintaining, replacing, repairing, and rehabilitating the project or completed functional portions of the project, including mitigation features without cost to the Government, in a manner compatible with the project's authorized purpose and in accordance with applicable federal and state laws and specific directions prescribed by the Government in the Operation and Maintenance manual and any subsequent amendments thereto.

The total estimated annual cost of operation and maintenance for the new proposed project feature which is included in the Alternative 2 – Reconstruction Plan – Pump Plant #14 is $15,050. The total estimated annual cost of operation and maintenance for the existing pump plants at the Paducah Project is $607,962. Therefore, the total estimated annual cost of operation and maintenance for the recommended reconstruction project (including all existing pump plants and the proposed pump plant # 14) is $623,012.

The LFPP Sponsor's FY2010 annual operations and maintenance budget is $460,000. Adding the estimated $15,050 for the proposed new pump plant would bring the estimated annual cost to $475,050. However, O&M will average between $476,000 - $520,000 annually depending on fluctuations caused by high river levels and the resultant need for additional labor and electricity. Maintenance will continue to include, but not be limited to annual routine inspections of and repairs to the permanent project levees, floodwalls and interior drainage facilities. Operation will continue to include, but not be limited to the operation of pumping plants, gates, and servicing of all project structures. See Volume 2, Appendix C, Section 4, Paragraph 4.3.1 for additional information on operation and maintenance items that were found during this feasibility study to require repair along with the project O&M manual for yearly maintenance activities.

5.6. Plan Accomplishments

In reviewing the planning objectives developed for this Feasibility Study outline earlier in this report, all objectives were met in formulation of the recommended plan. Problems were identified and potential structural alternatives that would continue to alleviate out-of-bank flooding problems within the study area were developed and evaluated (non-structural alternatives were not considered based on guidance mentioned in Section 4.7.5. of this Main Report). Coordination efforts with the City of Paducah took place throughout the study, taking into account the City's goals, to identify the recommended plan. Based on Local Sponsor input and District evaluations, the social and economic effects of the recommended plan will continue to be positive. The most important effect of implementation of the recommended plan would be a lower flood risk for 7.25 square miles of densely populated urban development and 8.5 square miles of rural development, which includes a total of 7,631 structures and a population of 26,725. It is important to note that the economic analysis completed as part of this study claims only national economic benefits from flood risk management.

5.6.1. National Economic Development (NED)

Future Without Project Conditions provide EAD of $8,174,000 in comparison to the Future With Project Conditions EAD of $1,257,000, yielding annual benefits of $6,951,000 (resulting from the Reconstruction action). Giving consideration to the total annual charges of $1,614,000 provides a Benefit-to-Cost ratio of 4.3. This Reconstruction Plan generates a Benefit-to-Cost ratio above unity and produces a positive net benefit of $5,303,000 to the Nation. It's therefore considered to be economically feasible and is viewed as the NED plan.

5.6.2. Regional Economic Development (RED)

The Regional Economic Development (RED) impacts are essentially the same as the National Economic Development (NED) benefits for this project. The Recommended Plan for flood risk management continues to provide benefits to impacted areas of the flood threatened community of Paducah, Kentucky.

5.6.3. Other Social Effects (OSE)

Other social effects (OSE) would include negative impacts to community businesses. Relocations of businesses or residences could impact employment in the area, property values, public facilities and services, tax revenues, community cohesion, and transportation. These threats would potentially increase under the "No Action Plan," as chances of failure of the levee become greater with increasingly deteriorating equipment. The Recommended Plan for Reconstruction will continue to reduce the threat to loss of health and economic standing.

5.6.4. Summary of Environmental Effects (Environmental Quality)

The proposed project has been reviewed for compliance with federal legislation including the National Environmental Policy Act (NEPA), Endangered Species Act, Clean Air Act, Clean Water Act, and Section 106 of the National Historic Preservation Act of 1966, as amended.

USACE determined that the proposed work was covered by the NEPA categorical exclusion at 33 CFR 230.9(b), and that there were no extraordinary circumstances that warranted preparation of an Environmental Assessment, because the proposed work would cause at most minimal adverse effects on the human environment, individually and cumulatively. Nevertheless, the District completed an Environmental Assessment (EA), even though an EA was not legally required, in order to consolidate documentation demonstrating that the project would not produce any significant adverse effects on the human environment, and thus that no Environmental Impact Statement is required for the project. The EA was made available for public review for thirty days. No comments were received from the public. The EA/Finding of No Significant Impact (FONSI) can be found in its entirety at the end of this report."

USACE has determined that the proposed project is environmentally sustainable. For a discussion of this determination please see Section 4.3.3. Table 5-5 summarizes effects on the environment from actions of the proposed plan.

Table 5-5: Summary of Environmental Effects

Types of Resources	Regulatory Authorities	Measurement of Effects
Air quality	Clean Air Act, as amended (42 U.S.C. 165h-7, et seq.) And Conformity Rule	No significant effect
Endangered and Threatened species critical habitat	Endangered Species Act of 1973, as amended (16 U.S.C. 1531, et seq.)	No significant effect
Fish and wildlife	Fish and Wildlife Coordination Act (16 U.S.C. 661, et seq.)	No significant effect
Floodplains	Executive Order 11988, Flood Plain Management	No significant effect
Historic and cultural properties	National Historic Preservation Act of 1966 as amended (16 U.S.C 470, et seq.)	No significant effect
Prime and unique farmland	CEQ Memorandum of Aug. 11, 1980: Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing the National Environmental Policy Act	No significant effect
Water quality	Clean Water Act of 1977, as amended (33 U.S.C. 1251, et seq.)	No significant effect
Wetlands	Executive Order 11990, Protection of Wetlands, Clean Water Act of 1977, as amended (43 U.S.C. 1857h-7, et seq.)	No significant effect
Socioeconomics	Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations	No significant effect
Wild and scenic rivers	Wild and Scenic Rivers Act, as amended (16 U.S.C. 1271, et seq.)	Not present in planning area

Clean Air Act: The Environmental Protection Agency has listed the proposed project area as being within an attainment zone for "criteria air pollutants." Emissions of criteria pollutants or

their precursors would not occur in a nonattainment or maintenance area of those pollutants. Therefore, the conformity determination requirements do not apply to the action.

Endangered Species Act: Due to the lack of suitable habitat for threatened or endangered species in the area, no impacts to those species are expected to occur. Construction would be taking place on or near the levee system and would not likely impact the wildlife of the area. Construction would not take place in the river and therefore, no impacts to threatened or endangered species that dwell in the river would be seen. Coordination with the U.S. Fish and Wildlife Service has taken place to ensure that no endangered or threatened species will be impacted by the proposed project. See Appendix A (Public and Agency Coordination) for their response.

Fish and Wildlife Coordination Act: Consultation with the U.S. Fish and Wildlife Service has been completed. Their comments are included in the environmental appendices, along with a follow up e-mail from USACE to USF&W. USACE has not received additional responses from USF&W. See Appendix A - Public and Agency Coordination for letters to and from USF&W.

Floodplain Management EO 11988: In order to achieve the desired objective of rehabilitating the existing levee system, the considered project must be located in the floodplain. No practical non-floodplain alternative exists. The floodplains of the area have been previously disturbed due to past construction of the levee. Further disturbance from the proposed project does not conflict with applicable state and local standards concerning floodplain protection.

National Historic Preservation Act: Cultural resources do occur in the proposed project area (discussed further in the cultural resources section), however, none are expected to be impacted by the proposed project. For further description on how the proposed project complies with the above listed Acts, refer to section 5.6.4 and Table 5-4.

Farmland Protection Act: The proposed project site is located within urban and commercial areas. The site does not contain farmland covered by the FPPA and therefore, no impacts would be seen.

Clean Water Act: No long term effects on water quality would occur from the construction of the proposed project. Short term effects could be seen due to construction, but would only be temporary. At the conclusion of construction activities such temporary impacts would cease. Clean Water Act permits are not required for the proposed project.

Protection of Wetlands EO11990: No wetlands occur within the proposed project location; therefore, no effects to wetlands would occur.

Wild and Scenic Rivers Act: No wild or scenic rivers are located within the proposed project area.

Environmental Justice EO12898: Reconstruction of the levee would not adversely impact any residents of the city of Paducah regardless of race, national origin, religion, or level of income. Construction would take on or near the levee and would not impact the local residents.

5.6.5. Residual Risk

The project was designed to prevent damages from a recurrence of the 1937 flood (the flood of record for the Ohio River - 500-year/0.02% event) plus three feet of freeboard. Subsequent to the construction of the Paducah project USACE has constructed a system of 80 multipurpose reservoirs on Ohio River tributaries upstream of Paducah, which further reduces the risk of overtopping of the project. If the meteorological conditions of the 1937 Flood were to reoccur, it is estimated that, with the upstream reservoirs currently in place there would be a seven-foot reduction in the flood elevation at Paducah. The impacts of the upstream reservoirs on flooding in the area of Paducah were included in the H&H model that was used for the FWOP condition, and considered in the reconstruction project formulation. The basic project layout allows for no logical or rational way to decrease the scope/scale of the project so as to account for the change in the hydraulics of the Ohio River. Additionally, this theoretical increase in project effectiveness is offset somewhat by changes in national design standards resulting from the Hurricane Katrina event in 2005. Absent the decrease in flood levels due to the upstream reservoirs, additional work would have been required to strengthen the floodwalls/levees at Paducah. T he recommended plan only restores the project to its originally authorized operational condition. It does not provide additional protection to the community since it does not change the physical scope, scale or size of the project. I f the Paducah project is reconstructed as recommended, the residual risk of the project would be minimal and more a factor of a possible system component failure than any defeat of the project by a large flood event. Specifically, the risk to human life under the existing condition would be greater due to the inevitable degradation of aging system components. The proposed plan recommends the replacement or rehabilitation of these components. Therefore, the risks to human life under the recommended plan of reconstruction would be lower than the risks under the existing condition.

The current condition of the project does pose a significant threat to human life. All levee projects that protect populated areas present a threat to human life. This is the very nature of inhabiting a flood plain protected by a levee. This reconstruction project is not proposing to change the alignment or to increase the protected height of the levee system; it is a reconstruction of the existing project. The Paducah project provides protection to greater than a 500 year event. With an event of this severe magnitude, the Ohio River will be an extremely slow rising river system that will permit for ample warning time of any potential overtopping events. Additionally, there are multiple routes to evacuate from the protected area in the case of an overtopping event. Furthermore, the city has in place a Flood Warning Emergency Evacuation Plan (FWEEP) that will provide several hours warning. The sponsor has always been an active player in maintaining and operating the protection system. As stated in paragraph 11.d (1) (a); the proposed project will provide a more reliable and safer structure for the people living and working behind the protection system. The report is proposing to bring the project up to current design standards. As a result, the current design standards will decrease the significant threat to human life based on its current condition.

5.6.6. Flood Warning Emergency Evacuation Plan (FWEEP)

a. Flood Warning System. With much of the area within the 100-year flood plain, McCracken County and the City of Paducah have developed a comprehensive flood warning and evacuation

plan. There are two gages currently located in the vicinity of the Paducah, Kentucky LFPP that can be used to monitor the level of the Ohio River during flood events. The USACE, National Weather Service (NWS), and United States Geological Survey (USGS) share the primary gage station. This gage station, PAHK2, is located in a gauge house located outside the floodwall at the foot of Jefferson Street. This gage is maintained by the NWS and stages for this gage are read by satellite every hour. This information can be obtained from the NWS twenty-four hours a day.

During flood periods, the NWS will also forecast river stages for the following five-day period. The continuous monitoring of the existing gage coupled with the Paducah LFPP General Plan Schedule of Operations (GSPO) have been in place since 1949 with minimal modifications that determines the activities that must be accomplished for this FWEEP.

The secondary gage is mounted on the outlet structure of Pump Plant 11 so that the local LFPP Sponsor may monitor the Tennessee River exterior head elevation with respect to the Island Creek interior head elevation. This monitoring is necessary so as to prevent Island Creek from forming an interior head pressure on the Pump Plant No. 11 Sluices Gates that are not designed for this condition.

The National Weather Service Forecast Office in Paducah, Kentucky has the primary responsibility for providing rainfall forecasts and flood warnings for Paducah, Kentucky. The City of Paducah consistently monitors this forecast on a daily basis during low to moderate river stages less than 39.0 feet. The elevation of 39.0 feet is identified as Paducah's Local Flood Stage based on the Paducah River Gage.

The two websites most widely utilized by the City of Paducah for advanced warnings for the Lower Ohio and Tennessee River forecasts are listed below.

http://www.crh.noaa.gov/ahps2/hydrograph.php?wfo=pah&gage=pahk2&view=1,1,1,1,1,1,1,1

http://www.srh.noaa.gov/lmrfc/?n=lmrfcmississippiandohioriverforecast

b. Evacuation Plan. In the event of an extreme high water event (Critical Stage or Greater) or potentially a rare overtopping event, evacuation of the protected areas could become necessary. Therefore, it should be noted it is beyond the scope of the FWEEP to show all of the possible scenarios for interior flooding that have the potential to occur. However, it is the intent of the FWEEP to prepare a reasonable plan of action that could be executed within an appropriate time that would provide public safety for those citizens subject to floodwater inundation.

In the event any key component(s) of the LFPP systems fail under extreme flood conditions or an unlikely event of a rare overtopping occurring, several areas along the levee system would be subject to flooding inside the line of protection from precipitation (heavy rains) or from the swelling of the Ohio and Tennessee Rivers flooding. Local officials and emergency preparedness organizations will be on the alert to notify home owners and businesses for any potential interior flooding of the flood protection project as it may become necessary. These warnings will be provided in a timely fashion allowing that contents of homes might be moved and again at a later

time to allow for an orderly evacuation of the protected area before overtopping occurs. Reference "Floodwall Closure Installation Order" located in Table II of Appendix C of the FWEEP (shown in its entirety in Volume 4 of this feasibility report.

c. Public Alert and Warning. The City of Paducah receives both radio and television broadcasts from area television media and broadcasting sources located in Paducah-McCracken County. WKYQ is the Official Broadcast Radio Station broadcasting on FM 93.3 Mhz. WPSD Local 6 television is the Official Broadcast Television Station that broadcast on DTV Channel 32 on TV Signal 578 – 584 Mhz. Both of these media broadcasting sources have their respective Emergency Alert System (EAS). The contact information for these two broadcast media sources are as follows:

Operator on Duty
WKYQ Radio
Bristol Broadcasting Company Inc.
6000 Bristol Drive
Paducah, Kentucky 42003
Telephone No. (270) 554-0959 (On Duty Operator's Line)
Telephone No. (270) 554-1433 (HOT LINE USED ONLY FOR MATTERS OF CIVIL DEFENSE)

Chief Meteorologist
WPSD Local 6
100 Television Lane
Paducah, Kentucky 42003
Telephone No. (270) 415-2001
Email address: wxcenter@wpsdlocal6.com

All area EASs are activated as threatening weather or flooding conditions require for advance (earliest possible) public notice regarding severe weather, rainfall, and/or potential flooding events that may threaten public safety. In the event it becomes necessary, the local broadcasting systems shall be activated to alert all homeowners and businesses of known threatening conditions for the potential of inundation due to flooding at the earliest possible moment.

d. Evacuation Routes. Emergency evacuation routes have been established throughout the county. Evacuation areas, evacuation routes, and rescue areas for Paducah, KY have been established.

For Safe Evacuation, Evacuees are to use local streets to make their way to major flood evacuation routes including the following routes:

- Cairo Road (KY Route 305) Westbound
- DO NOT ATTEMPT TO USE Hinkleville Road (U.S. HWY 60)
- Westbound beyond Noble Park as it is subject to inundation and may not be passable due to flooding.
- Blandville Road (U.S. HWY 62) Westbound

- Lone Oak Road (U.S. HWY 45) Southbound
- Old Mayfield Road (KY Route 994) Southbound
- Interstate 24 Eastbound and Westbound

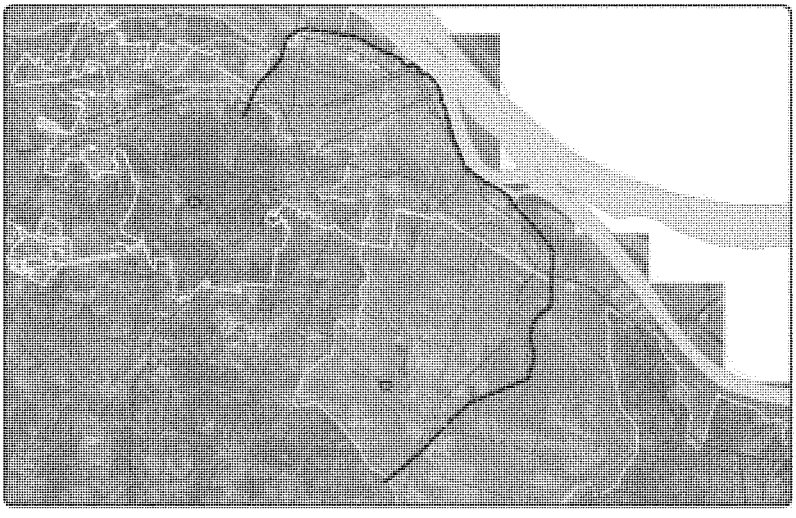
e. Mass Care and Shelter Management. In the event it becomes necessary for an evacuation to occur due to river stages projected to reach "Critical Stage" and/or a potential "Overtopping of the Floodwall/Levee" IS imminent, local government officials would direct its home and business owners to the best of its ability to area and surrounding organizations to use their facilities for a possible evacuation event. The services of the Red Cross and Salvation Army to provide food, clothing, and other assistance should be utilized.

Subject to the impacts of the flooding occurring prior to evacuation notifications and any flood related damages that may cause incapacitations of area utilities (availability to public power, water, gas, and sanitation facilities), evacuees would be directed to area government operated facilities that could be used for shelter for a brief period. Such buildings would include government owned and operated or similar facilities suitable for short-term temporary food and shelter stations including area schools, National Guard armory, and churches.

If it was known the evacuation was going to be for an extended period of time (in excess of 14 days), evacuees would be encouraged by local officials to seek food and shelter outside the Paducah-McCracken County area or any community impacted by the current flood event.

Unfortunately at this time the Paducah-McCracken County community does not have a facility capable of sustaining the food and shelter needs of an estimated 10,000 to 12,000 people for an extended period of time, nor would it prove feasible to build one.

f. Potential Flood Inundation Map.



(Shaded Area Approximates Flood Boundary Caused By the 1937 Flood)

5.6.7. Executive Order 11988

Executive Order 11988 requires federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities."

The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, as referenced in the Corps' ER 1165-2-26, require an eight-step process that agencies should carry out as part of their decision-making on projects that have potential impacts to or within the floodplain. The eight steps reflect the decision-making process required in Section 2(a) of the Order. The eight steps and responses to them are summarized below:

1. Determine if the proposed action is in the base flood plain.

The project would be in the theoretical 100-year floodplain of the Ohio River. However, this a simple reconstruction of an existing project that was part of a program of levee improvements in the Lower Ohio River Basin authorized by Congress in 1938..

2. If the action is in the base flood plain, identify and evaluate practicable alternatives to the action or to location of the action in the base flood plain.

Since this is a reconstruction project, the Louisville District followed the Reconstruction Guidance Memorandum of August 2005 which states:

> *"...depending on the interest of the non-Federal sponsor, the feasibility study may be limited to examination of the reconstruction of the existing project with no change in its scope or function..."*

Therefore, the only alternatives that were considered were 1) No Action, and 2) Reconstruction. Additionally, this is a reconstruction project that will primarily remain in the existing project footprint. Therefore, there were no other locations considered.

3. If the action must be in the flood plain, advise the general public in the affected area and obtain their views and comments.

The recommended plan for the Paducah Project consists of reconstruction of an existing project which restores the project to its originally authorized purpose and which is primarily within the existing project footprint.

Public involvement activities and agency coordination undertaken for this project are described in Section 7, "Summary of Coordination, Public Review, and Comments", of the Reconstruction Feasibility Report. Additionally, a notice was posted in the local newspaper, The Paducah Sun, and on the Louisville District website, announcing a public meeting which was held on 8 November 2010 and the availability of the draft reconstruction feasibility report for public review for a period of thirty days. Copies of the draft report were also available at the Public Library and City Hall in Paducah. There were no public comments regarding the public meeting or the draft feasibility report.

4. Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base flood plain will affect the base flood plain, impacts resulting from these actions should also be identified.

Since the Paducah Project is a reconstruction project which is primarily within the existing project footprint, no adverse impacts have been identified. The benefit to cost ratio (BCR) of the recommended plan is 4.5, producing net benefits of $5,507,000 to the nation. There are no expected losses of natural and beneficial flood plain values. As stated above, the Paducah Project would be located within the Lower Ohio River Basin; no project components would be located outside of the Lower Ohio River Basin.

5. If the action is likely to induce development in the base flood plain, determine if a practicable non-flood plain alternative for the development exists.

As described in Section 4.7, per the August 2005 Reconstruction Guidance Memorandum, two alternatives were considered: 1) No Action, and 2) Reconstruction. Since this is reconstruction of an existing project, it is not likely that the project will induce any further development in the base flood plain than that which would be induced by the original flood risk management project.

Within the Lower Ohio River Basin, population growth and urban development are driven by local, regional, and national economic conditions. Local land use decisions are within the jurisdiction of the city of Paducah and McCracken County. Each of these agencies has adopted a general plan consistent with state law. These general plans provide an overall framework for growth and development within the jurisdiction of each agency, including the project area.

6. As part of the planning process under the Principles and Guidelines, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial flood plain values. This should include reevaluation of the "no action" alternative.

No adverse impacts of the recommended plan are anticipated. As mentioned in item number five above, it is not likely that the project will induce any further development in the base flood plain than that which would be induced by the original flood risk management project.

The proposed project has been reviewed for compliance with other federal legislation including NEPA, Endangered Species Act, Clean Air Act, Clean Water Act, and Section 106 of the National Historic Preservation Act of 1966, as amended. NEPA compliance for this project is covered by a categorical exclusion for activities at completed Corps projects which carry out the authorized project purposes.

Cultural resources do occur in the proposed project area (discussed further in the cultural resources section), however, none are expected to be impacted by the proposed project. For further description on how the proposed project complies with the above listed Acts, refer to section 5.6.4 and Table 5-5 of Volume 1 of the Paducah Reconstruction Feasibility Report.

Consultation under Section 106 of the National Historic Preservation Act (NHPA) on effects to historic properties and cultural resources by the proposed undertaking has taken place. This consultation involved the State Historic Preservation Offices (SHPO), federally-recognized Native American tribes and other concerned parties and focused on avoiding impacts to significant historic properties and cultural resources. For additional information on these properties and resources, see Volume 2, Appendix E (Environmental Appendix). Refer to Appendix A (Public and Agency Coordination) for a copy of the letter to the SHPO and the SHPO's response.

Other social effects (OSE) would include negative impacts to community businesses. Relocations of businesses or residences could impact employment in the area, property values, public facilities and services, tax revenues, community cohesion, and transportation. T hese threats would potentially increase under the "No Action Plan," as chances of failure of the levee become greater with increasingly deteriorating equipment. The Recommended Plan for Reconstruction will continue to reduce the threat to loss of health and economic standing.

7. If the final determination is made that no practicable alternative exists to locating the action in the flood plain, advise the general public in the affected area of the findings.

See response to Item 3, above.

8. Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.

The objective of the project is to reduce flood risk to public health, safety, and property in the Lower Ohio River Basin. The project is responsive to the EO 11988 objective of "avoidance, to the extent possible, of long- and short-term adverse impacts associated with the occupancy and modification of the base flood plain and the avoidance of direct and indirect support of development in the base flood plain wherever there is a practicable alternative" because it would not induce development in the floodplain, would reduce the hazard and risk associated with floods thereby minimizing the impacts of floods on human safety, health, and welfare, and would restore and preserve the natural and beneficial values of the base floodplain.

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 1 OF 4 MAIN REPORT

SECTION 6

6. PLAN IMPLEMENTATION

This section summarizes action items and the schedule to complete the project; institutional requirements; Federal and non-Federal cost-sharing requirements; Real Estate requirements; Environmental requirements; and procedures necessary to implement the flood risk management measures of the selected/recommended plan. Table 6-1 summarizes the action items and the schedule to implement the project activities.

TABLE 6-1: SUMMARY OF ACTION ITEMS AND SCHEDULE TO COMPLETE PROJECT

Action Item	Estimated Completion Date
Combined Feasibility Scoping Meeting/ Alternative Formulation Briefing	12 Aug 2010 A
Draft Feasibility Report	Jul 2010 A
Washington Level Policy Review	Apr 2011
Chief of Engineers Report	Sep 2011
Congressional Authorization	Oct 2012
Federal Construction Funds Appropriation	Oct 2013
Submit draft Project Partnership Agreements (PPA) for review	Feb 2014
PPA Review and Approval	May 2014
Execute PPA	Aug 2014
Complete Plans & Specifications	Oct 2014
Real Estate Acquisition	Oct 2014
Construction Contract *, Advertisement & Bidding	Dec 2014
Construction Contract * Awards	Jan 2015
Complete Construction	Dec 2017

All dates subject to available funding

* Two contract awards are planned in FY 15 (one for construction of the proposed pump plant at Station 14A; the other will be for the reconstruction of the system components such that no more than 4 pump plants will be out of commission at one time).

Based on current budgeting guidance, we could assume the following:

- Oct 2013 Appropriation of Funds

- Project Completion in Dec 2017

The detailed cost estimate in Appendix C of the Feasibility Report assumed a construction completion date of July 2016, which is within the range of uncertainty associated with the administration's budget process and Congressional appropriation process. The latest timeframes are subject to change based on availability of funding.

The schedule for project implementation shown above assumes additional authorization for the Ohio River Shoreline, Paducah, KY project. After additional authorization the project would be eligible for construction funding. The project would be considered for inclusion in the President's budget based on: national priorities, magnitude of Federal commitment, economic and environmental feasibility, level of local support, willingness of the non-Federal sponsor to fund its share of the project cost and the budget constraints that may exist at the time of funding. Once Congress appropriates Federal construction funds, USACE and the non-Federal sponsor would enter into a project partnership agreement (PPA). This agreement would define the Federal and non-Federal responsibilities for implementing, operating and maintaining the project.

USACE would officially request the non-Federal sponsor to acquire the necessary real estate immediately after the signing of this agreement. The advertisement of the first construction contract would follow certification of real estate. USACE would provide a revised O&M Manual and as-built drawings to the non-Federal sponsor. The estimated schedule for project implementation is shown above in Table 6-1.

6.1. Institutional Requirements

The following are procedures necessary for authorization of the recommended plan *:

(1) USACE, Great Lakes and Ohio Rivers Division Commander will review the final report, and then issue a public notice announcing completion of the final Feasibility Report. This is referred to as the Division Engineer's Notice, or DE's Notice.

(2) This report will be submitted for review by the Headquarters of USACE, Washington D.C.

(3) The Chief of Engineers will seek formal review and comment by the City and interested federal agencies.

(4) Following City and other agency review, the report will be sent to the Assistant Secretary of the Army for Civil Works.

(5) Upon approval of the Assistant Secretary, the report will be forwarded to the Office of Management and Budget to obtain the relationship of the project to programs of the President.

(6) The Assistant Secretary of the Army for Civil Works will then forward the final report of the Chief of Engineers to Congress.

(7) Congressional review of the feasibility report and possible authorization of the recommended plan for the project would follow.

(8) Pending construction authorization, the Chief of Engineers could include funds where appropriate, in his budget requests for preconstruction engineering and design of the project.

(9) Following receipt of funds, a design agreement would be executed between the non-federal interests and the Government, preconstruction engineering and design would be initiated, and surveys and detailed engineering designs would be accomplished.

If the existing project authorization is modified to authorize construction of the recommended plan* the following procedures would be necessary for construction.

(10) The District Engineer would accomplish plans and specifications.

(11) Prior to construction, execution of a Project Partnership Agreement (PPA) would be required between non-federal interests and the Government.

(12) Bids for construction would be initiated and contracts awarded.

(13) Upon completion of construction, the District Engineer would notify the City that the project is complete (and provide an updated O&M manual) and the City would commence OMRR&R (operating, maintaining, replacing, repairing, and rehabilitating) in accordance with guidelines provided by the USACE.

* The project was authorized for construction in Section 5077 of WRDA 2007, subject to a finding that the project is feasible. This report concludes that there is a feasible reconstruction project for the existing Paducah, KY, flood project. However the current estimated implementation cost for the recommended plan exceeds the amount authorized in Section 5077 as limited by the requirements of Section 902 of WRDA 1986. Therefore, the existing authorizing legislation will need to be modified to authorize construction of the recommended plan before the Corps could enter into a PPA with the City of Paducah.

6. 2. Division of Plan Responsibilities Cost Allocation

6.2.1. Federal Responsibilities

Cost sharing for construction of this project would be in keeping with current USACE policy for flood control projects. The Federal Government will be responsible for preparation of the Feasibility Study, Project Partnership Agreement (Project Partnership Agreement), Design Documentation Report, and Plans and Specifications for this project.

6.2.2. Anticipated Non-Federal Responsibilities (PPA will govern)

It is recommended that the flood risk management improvements defined in this report be approved and that federal implementation of the recommended plan be subject to the non-Federal sponsor agreeing to comply with applicable Federal laws and policies, including but not limited to the following requirements:

(1) Provide a minimum of 35 percent, but not to exceed 50 percent of total project costs as further specified below:

(a) Provide 25 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

(b) Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs;

(c) Provide, during construction, a contribution of funds equal to 5 percent of total project costs;

(d) Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the project;

(e) Provide, during construction, any additional funds necessary to make its total contribution equal to at least 35 percent of total project costs;

(2) Shall not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefore, to meet any of the non-Federal obligations for the project unless the Federal agency providing the Federal portion of such funds verifies in writing that expenditure of such funds for such purpose is authorized;

(3) Not less than once each year, inform affected interests of the extent of protection afforded by the project;

(4) Agree to participate in and comply with applicable Federal floodplain management

and flood insurance programs;

(5) Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), which requires a non-Federal interest to prepare a floodplain management plan within one year after the date of signing a project cooperation agreement, and to implement such plan not later than one year after completion of construction of the project;

(6) Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the project;

(7) Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the level of protection the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function;

(8) Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

(9) For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

(10) Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

(11) Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

(12) Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative

Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

(13) Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 i ssued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.*), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c *et seq.*);

(14) Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

(15) Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project;

(16) Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

(17) Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, P ublic Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

6.2.3. Non-Federal Sponsor's Financial Self-Certification

Financial information on the non-federal Sponsor's ability to fund its share of the plan is required to proceed with the project as required by USACE Principles and Guidelines. The information includes a statement of financial capability by the Sponsor. The City has expressed their financial capability in their Letter of Intent. A Statement of Financial Capability will be submitted with the final Feasibility Report. The City intends to provide its financial requirements through issuing the sale of appropriate bonds applicable to municipalities for qualified projects such as this of which the debt service of these bonds will be met through its normal annual budget appropriations process. Table 6-2 shows the estimated distribution of the project costs.

Table 6-2: Project Cost Distribution, Paducah, Kentucky (January 2011 Price Level)

	Reconstruction Alternative (includes Pump Plant # 14)	
Total Project Cost Estimate	**$19,114,300**	
Federal Cost Share (65%)	**$12,173,200**	
Non-Federal Cost Share (35%)	**$ 6,690,005**	
Lands, Damages, Relocations, Rights-of-Way, and Disposals		**$436,000**
In-Kind Contribution*		**$2,100,000**
Cash Contribution		**$4,154,005**

*The In-Kind Contribution listed represents the cost of the slip-lining of the pipes performed by the Local Sponsor in accordance with the In-Kind MOU dated November 14, 2008. This work has been recommended as integral to the project as discussed in Section 4.8 and therefore creditable as an in-kind contribution.

Based on the provisions of Section 103 of Public Law 99-662, Paducah, Kentucky has the ability to provide the normal share percentage of project costs. This Public Law considers the magnitude of a project benefit-to-cost ratio and the per capita income of the state and county of the Sponsor. Paducah does not qualify for reduced cost-sharing.

6.2.4. Real Estate Requirements

The project is located in McCracken County, Kentucky. The non-Federal Sponsor has advised that they own right-of-ways or maintain existing easements for the existing levee and will provide documentation prior to real estate certification.

A three year temporary work area easement is required for contractor staging and lay down areas, temporary access sites, and contractor work areas during construction. These areas are mainly comprised of lands owned by the City, industrial lands, with the addition of some residential areas. Additional permanent levee easements will be required for future operation and maintenance activities for any portion of the repaired levee that is outside the existing permanent easements limits. A perpetual road easement

and two additional utility pipeline easements will also be required to support the proposed project. T he non-Federal Sponsor has the responsibility for acquiring the necessary real estate interests and providing documentation that the acquisition has been completed.

Property owned by the City of Paducah will be made available through Authorization for Entry for Construction, Attorney's Certificate of Authority, the Partnership Agreement and ownership documentation.

A full description of the project area and Real Estate Information is noted in the attached Real Estate Plan, included as Volume 2, Appendix D (Real Estate Plan).

6.2.5. Environmental Requirements

Consultation under Section 106 of the National Historic Preservation Act (NHPA) on effects to historic properties and cultural resources by the proposed undertaking has taken place. This consultation involved the State Historic Preservation Offices, federally-recognized Native American tribes and other concerned parties and focused on avoiding impacts to significant historic properties and cultural resources. See Appendix A (Public and Agency Coordination) for their response.

If cultural resources are discovered during construction and cannot be avoided, work will be suspended in that area until the properties are evaluated for eligibility for listing in the National Register of Historic Places in consultation with the Kentucky SHPO; and the Advisory Council on Historic Preservation will be provided the opportunity to comment.

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

VOLUME 1 OF 4 MAIN REPORT

SECTION 7

7. SUMMARY OF COORDINATION, PUBLIC VIEW, AND COMMENTS

7.1. Public Involvement

Since the findings of this feasibility study recommend reconstruction of major components of an existing levee system, public involvement has been minimal. However, the City of Paducah has been airing a 30 minute educational-documentary video on Paducah Public Access Channel 11 for several months. These airings occur two times a week and are titled "Your City at Work". They have featured the Paducah, Kentucky LFPP and they identify all aspects of the project including feasibility, restoration, and reconstruction.

The goals of the public involvement and coordination process were met via educational-documentary videos which were used to inform and educate the public. A public meeting was held on 8 November 2010 to give the public an opportunity to provide feedback to the study team. The feasibility study was also made available for concurrent public and HQUSACE review for a period of 30 days. No comments were received from the public. Comments from HQUSACE have been addressed within this report.

Public involvement and coordination will help to open and maintain channels of communication in order to consider public views and information in the planning process.

The Feasibility Study was conducted as a partnership between the City of Paducah and the Louisville District.

Appendix A, "Public and Agency Coordination", contains detailed information about how the outreach activities listed below were an integral part of the public involvement plan:

- Initial Coordination Letter to Resource Agencies
- U.S. Fish and Wildlife Service (USFWS)

7.1.1. State Historic Preservation Officer

The District determined that the proposed reconstruction flood risk management measures of the preferred (reconstruction) plan would have No Effect on hi storic properties. This determination was provided to the State Historic Preservation Officer (SHPO) and interested public for review and comment by letter dated 12 F ebruary 2010. A copy of this letter can be found in Volume 2, Appendix A (Public Involvement). A response from the SHPO concurring in the determination was received. The text in the SHPO's letter (dated 30 April 2010) states: "We conclude that the Paducah LFPP will have no adverse effect on any of the above-mentioned resources. Should plans change to include areas outside the existing levee, this office should be contacted to determine if further documentation is necessary." See Appendix A (Public and Agency Coordination) for a copy of their response.

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION DRAFT FEASIBILITY REPORT

VOLUME 1 OF 4 MAIN REPORT

SECTION 8

8. CONCLUSIONS AND RECOMMENDATIONS

This report concludes that there is a feasible reconstruction project for the existing Paducah, KY, LFPP; however the current estimated implementation cost for this project exceeds the amount authorized in Section 5077 as limited by the requirements of Section 902 of WRDA 1986. Additional authorizing legislation will be required before the Corps could enter into a Project Partnership Agreement (PPA) with the City of Paducah.

The Flood of 1997 demonstrated the need for continuing flood risk management for the City of Paducah.

I have considered all significant public interest aspects of the recommended plan for flood risk management at Paducah, Kentucky. This single-purpose project is feasible from an economic, engineering, environmental, and social perspective. The recommended plan will provide average annual net National Economic Development benefits of over $ 5,303,000. The total cost to implement the recommended reconstruction of the existing project and the recommended addition of a pump plant is $18.7 M of which an estimated $6.6M would be the Local Sponsor's responsibility.

I recommend that the current, existing authorization be revised to increase these project costs from $3 Million to $19 Million which includes one additional pump plant for interior ponding issues, as well as the recommended reconstruction items.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to Congress as proposals for authorization and implementation funding. However, prior to transmittal to Congress, the Sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

The Local Sponsor understands its responsibilities as discussed in Section 6.2 above and has indicated its willingness to execute a Project Partnership Agreement with the Federal Government for implementation of the recommended plan. I recommend approval of the recommended plan as presented in this report, with such modifications thereof as in the discretion of the Commander, HQUSACE, may be advisable.

5/9/11
(Date)

Keith A. Landry
Colonel, U.S. Army, Louisville
District Engineer

The following items in the Conclusions and Recommendations (preceding page) have changed since the report was originally completed in April 2011:

The recommended plan will provide average annual net National Economic Development benefits of over $5,507,000. The total cost to implement the recommended reconstruction of the existing project and the recommended addition of a pump plant is $19.1 M of which an estimated $6.7M would be the Local Sponsor's responsibility.

Ohio River Shoreline, Paducah, Kentucky (Paducah, KY LFPP) Reconstruction Project Environmental Assessment (EA) And Finding of No Significant Impact (FONSI)

July 2011

Environmental Assessment (EA)
And
Finding of No Significant Impact (FONSI)
For
Ohio River Shoreline, Paducah, Kentucky

Rehabilitation of Existing Local Flood Protection Project

Purpose and Need

This Environmental Assessment (EA) is prepared pursuant to the requirements of the National Environmental Policy Act (NEPA) and associated regulations 40 CFR Parts 1500-1508 and 33 CFR Part 230 to document findings concerning the environmental aspects of a proposed action. Originally the Louisville District determined that this action fit a categorical exclusion for NEPA documentation. Following direction received after and resulting from a final review of all documentation relating to the proposed action, the Louisville District volunteered to prepare this EA in order to formally document impacts on the human environment as a result of the rehabilitation of the existing Paducah Local Flood Protection Project (LFPP) thereby insuring compliance with NEPA. This EA will be incorporated into the Ohio River Shoreline, Paducah KY (Paducah, KY LFPP) Reconstruction Draft Feasibility Report when the feasibility report is sent forward for all necessary approvals.

The purpose of the Paducah, KY, LFPP Feasibility Study is to evaluate the extent of the Federal interest in rehabilitation of the existing project for flood risk management in Paducah to include new facilities required under current regulations that govern levees and floodwalls and construction of a new pumping facility to prevent interior flooding. The need for such action is to bring and/or keep the LFPP in satisfactory condition to provide protection to the residents of the City of Paducah during flooding including interior ponding of precipitation, run off, and/or seepage.

Alternatives

Preliminary screening of alternative plans as detailed within the Feasibility Report focused detailed analysis on plans that provided the most benefits and potential to be economically justified. The focus centered on the evaluation and comparison of two major alternatives: 1) No Action and 2) Reconstruction. During the plan formulation for the second alternative, items requiring reconstruction or rehabilitation were evaluated. Consideration was given to the need to replace/refurbish aging equipment, install new pumping plants, and install various structures (gatewell structures) that are required by revised U.S. Army Corps of Engineers standards. The planning process and the items considered during the plan formulation process are discussed in detail in Section 4 of the Feasibility Report.

Alternative 1: No Action. The No Action alternative assumes local interests will continue to perform items of normal operation and maintenance as they have since 1949 and that there will be continued deterioration of existing project components. If no action is taken to bring the existing system into compliance with its originally intended protection level, the next major flood event could result in uncontrolled interior flooding should any of these aging components (60+ years old) fail to operate properly.

Alternative 2: Reconstruction/Rehabilitation. This alternative consists primarily of replacement/refurbishment of aging equipment, installation of one new pumping station, and installation of various structures (gatewell structures) that are required by revised USACE standards. Items of work to be included in the reconstruction alternative are those items that are beyond normal operation and maintenance. Items requiring reconstruction were originally identified in the Paducah KY Flood Damage Reduction Section 5(b) Report & Analysis dated May 2000. In March 2009, as part of the Feasibility Study, a thorough field inspection was performed by all engineering disciplines to refine the reconstruction items previously identified in the May 2000 905(b) Analysis. The latest design standards and efficiency improvements were assessed for reconstruction of the project.

As part of the Feasibility Study, an incremental cost analysis was also performed for the number of pumping stations and the size of the pumps to be installed. Detailed information on the location of the pump stations, the pump sizes evaluated, and the incremental cost analysis is contained in the Feasibility Report. Through this analysis one new pump station with a 100 cubic foot per second pump was selected for inclusion in this alternative.

The major items being recommended for reconstruction or rehabilitation in the Feasibility Report are listed as follows:

a. Rehabilitation of Pumps, Motors, Motor Control Systems, Major Pump Plant Components, and other miscellaneous items at each of the 12 Existing Pumping Plants;
b. Construction of a New Pumping Plant within exiting LFPP boundaries;
c. Slip-lining 37 Existing Deteriorated Corrugated Metal Pipes * ;
d. Bank Protection;
e. Floodwall Waterstop Joint Replacements;
f. Plug and/or Address Existing Deteriorated Toe Drains;
g. Replace Existing Drainage Inlet Structures at Bee Branch;
h. Construction of two new Gatewell Structures;
i. Permanently Closing 8 Existing Closures and Raising an Existing Closure Sill;
j. Scour Erosion Control Pad at Wall/Levee Transitions;
k. Other Miscellaneous Items.

* This work has been completed by the City of Paducah in accordance with the Memorandum of Understanding (MOU) signed on 17 November 2008.

Environmental Setting

General. The City of Paducah is bounded on the north and northeast by the Ohio and Tennessee Rivers and lies within the alluvial valley of the Ohio River. A significant portion of its residential and commercial districts is situated on a level and relatively high flood plain terrace that extends to the low hills on the south. Island Creek flows through the eastern part of the city to join the Ohio River immediately below the mouth of the Tennessee River and Perkins Creek is located along the western portion of the city. According to the U.S. Census Bureau, in 2010, Paducah had a population of 25,024. Paducah, KY is the official county seat of McCracken County. Please refer to Figures 1 and 2 for a project vicinity maps.

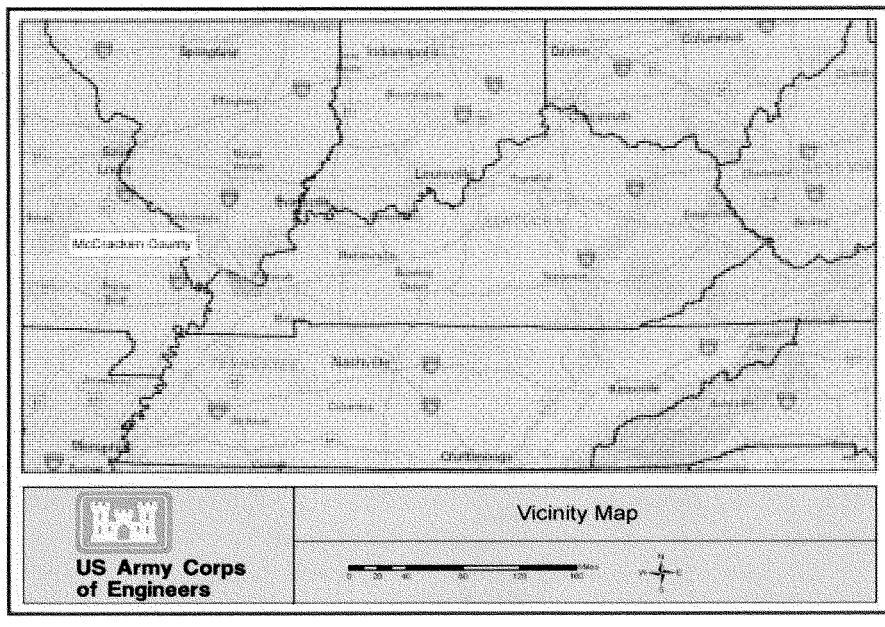


Figure 1: Vicinity Map of Project Area

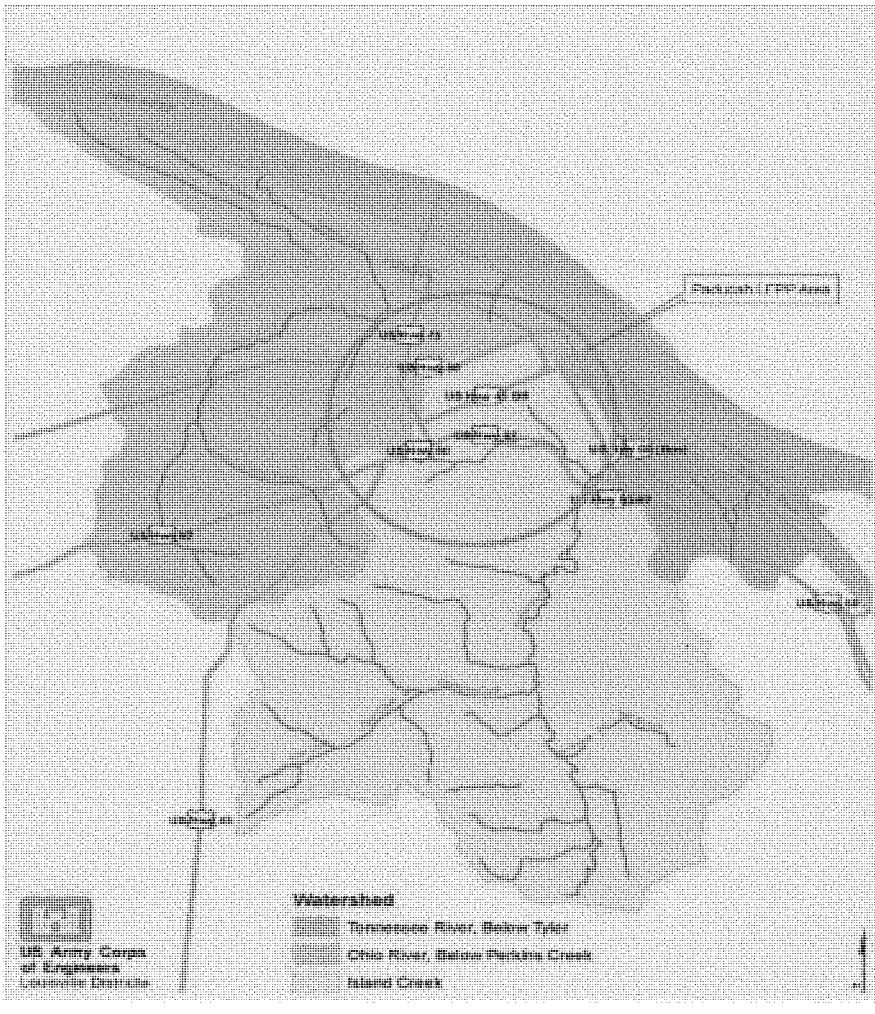


Figure 2: Watersheds for Paducah, Kentucky LFPP

The Paducah, Kentucky LFPP consists of approximately 48,700 feet (9.2 miles) of earth levee, 15,870 feet (3 miles) of concrete flood wall, 12 pump stations, 47 closure and service openings, 8 ramps, 5 diversion channels and other necessary appurtenances. The Paducah LFPP system protects approximately 17 square miles of land. Refer to Figure 3 for map of LFPP.

Figure 3 shows the project area broken down into Sections A, B, and C along the line of protection. These sections are delineated as such because that's the order in which they were constructed.

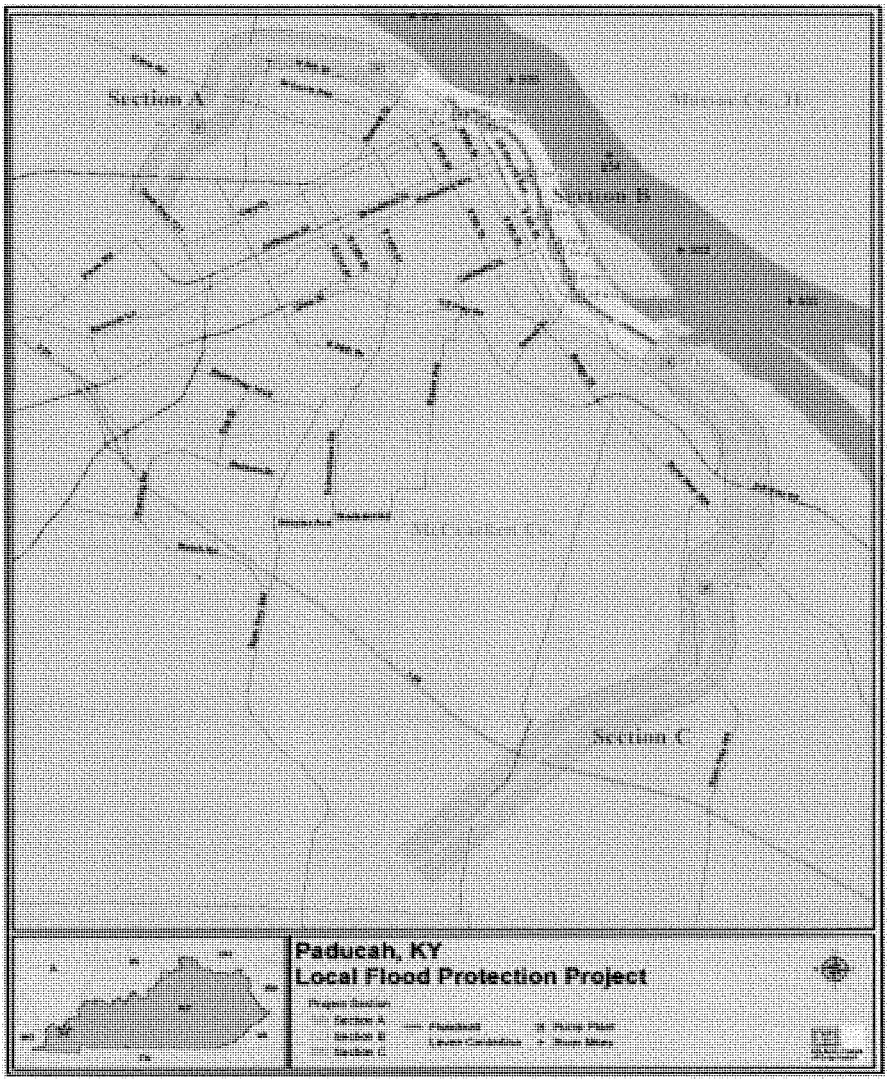


Figure 3. Project Map Delineating Sections Along Line of Protection
* Project Sections were labeled in the order they were constructed

Floods. Historical data and gage records indicate that flooding in the Ohio River Basin usually occurs between November and May. The rivers will rise in November and again in March and April due to rains which saturate the basin. Flooding can follow as precipitation continues. Major floods occurred on the Ohio River in 1937, 1950, 1955, 1962, 1963, 1964, 1975, 1979, 1991, 1997, and 2005. The flood of 1937 established the flood of record on most streams in the Paducah area, reaching an elevation of 346.0 NAVD 1988 on the Ohio River which equates to less than a 0.02% chance (500-year) flood. After this flood event, the Flood Control Act of August 1937 authorized construction of flood protection for communities along the Ohio River. The flood event in February 1950 was the greatest event since 1937, with an elevation of 339.0 feet NAVD 1988 which equates to a 0.83% chance (100-year) flood.

Hazardous, Toxic, and Radioactive Waste (HTRW). A cursory review of possible hazardous, toxic, or radiological waste (HTRW) concerns was performed by the Louisville District. Due to the industrial nature of the proposed project area and because of a known sewer treatment plant located within the project area, the potential presence of HTRW exists near the project site. Biological Resources. Since a large portion of the proposed project area is within highly urbanized areas, available habitat has been significantly altered from natural conditions. The system of navigation locks and dams and associated operation and maintenance activities have altered aquatic resources within the Ohio River. A total of 100 species of fishes have been reported from the lower Ohio River. The fish community is dominated in both numbers and weight by rough fishes, particularly shads, gars, carp, river carpsucker, skipjack herring and drum. There are also large and important populations of game and commercial fishes, including channel catfish, white bass and sauger. The lower Ohio River is also inhabited by a diverse mussel population. Approximately 33 species are known to occur in the lower Ohio River.

The terrestrial habitat has also been greatly modified in the proposed project area. Undeveloped terrestrial habitats in the area consist essentially of a few areas of cultivated lands and pastures and scattered woodlots of various sizes. Types of trees in the forested areas adjacent to the line of projection consist of Oak, Gum, Cypress, and Hickory. Woody and emergent wetlands are located along the banks of the river but not within the project area. Terrestrial habitats of the area support species of birds, amphibians, reptiles, and small mammals that have adapted to urban encroachment.

The U.S. Fish and Wildlife Service reports that several Federal and state listed threatened and endangered animals may occur in the vicinity of the proposed project. The location of the proposed project is in close proximity to the Ohio River and therefore many known occurrences of several endangered species of freshwater mussels have been recorded within the county. Such species as the fatpocketbook, the orangefoot pimpleback, the pink mucket, and the ring pink freshwater mussels have known occurrences recorded within McCracken County. The clubshell, the rough pigtoe, and the fanshell mussel species have potential for occurrence within the county based upon their historic range. Other endangered or federally protected species that have been

known to occur or have the potential to occur within the project area due to historic range include the Indiana bat, interior least tern and bald eagle.

Cultural Resources. In general, archaeologists and historians have developed a chronology for the region that provides a useful framework for organizing and describing data and historical events. The prehistoric cultural sequence is divided into the following chronological periods in Kentucky: Paleo-Indian (12,000-8000 B.C.), Archaic (8000-1000 B.C.), Woodland (1000 B.C - A.D. 900), Mississippian (A.D. 900-1500), and Protohistoric and Historic Aboriginal Indian (A.D. 1500+). These periods represent culturally distinct segments of more than 12,000 years of prehistoric human adaptation and re-adaptation to a changing environment.

The historic cultural sequence represents the time span from Euro-American settlement to the present day. General periods of development included early Euro-American settlement (1775-1830), Antebellum (1830-1860), Civil War and Reconstruction (1860-1890), Progressivism and World War I (1890-1925), the Depression and New Deal (1925-1940), World War Two and the Cold War(1940-1990). Regional variations of this historical sequence can occur.

The site of the Paducah LFPP has never been formally examined for cultural resources. The levee was itself constructed between 1939 and 1949 as a direct response to the Great Flood of 1937 along the Ohio River, and thus well before the implementation of federal compliance laws in the 1960's. The levee has been repaired, upgraded and renovated many times with pumps, pipes, gates (flapgates, sluice gates and movable closures). It is currently maintained by the City of Paducah.

There are several historic and cultural resources recorded within or adjacent to the Paducah LFPP, the most notable being Fort Anderson: a fort constructed by the Union Army during the Civil War and central to the Battle of Paducah. However, no remnants of the fort are visible on the surface. Its location is currently marked with a metal historic monument.

A common tourist attraction is the flood wall murals in downtown Paducah that depicts the history of development in western Kentucky. The murals were designed and painted by Mr. Robert Dafford and the Dafford Muralists of Lafayette, Louisiana. The project began in 1996 and was completed in 2007. Each mural panel has an interpretative plaque with a short history lesson on the scene depicted in the panel.

A total of 25 historic properties listed to the National Register of Historic Places are recorded within McCracken County, Kentucky. However, none of these properties lie within the Area of Potential Effect (APE) for the proposed undertaking.

Five archaeological sites are recorded within the limits of the Paducah LFPP in McCracken County, Kentucky. Specifically, they are sites 15McN3, 15McN6, 15McN8, 15McN66, and 15McN124. Three of these sites – 15McN3, 15McN6, and 15McN8 –

were recorded by the University of Kentucky as a part of reconnaissance survey of archaeological resources throughout the state (Funkhouser and Webb 1932).

Small segments of the levee have been examined for cultural resources as a part of compliance requirements for Section 106 of the National Historic Preservation Act, including a barge fleeting area (McNerney 1990), a water plant site and intake (Carstens and Hensley 1981), a nature trail (McHugh 1977), and a concrete batch plant (Schenian 1993). No cultural resources were identified during these investigations.

Social and Economic Conditions. Major state and federal highways, the Interstate Highway system, railway, and airlines serve the community area. In general, the existing conditions of the floodplain in Paducah are those of a moderate to densely developed urbanized setting. Land use is dominantly residential followed by commercial and public uses. For the purposes of this study, 7,631 structures were documented and analyzed. These were categorized as residential (86%), commercial (9%), and public (4%).

Environmental Impacts.

Alternative 1: No Action. The No Action alternative assumes local interests will continue to perform items of normal operation and maintenance as they have since 1949. These typical items include repair of animal burrows in levees, removal of vegetation from levees and riprap, applying sealer protection to existing concrete surfaces, continued dependable operation during flood events, and other regularly scheduled operation and maintenance items according to local O&M manual. These typical activities would maintain the appearance and integrity of the structure as it is today. This No Action alternative assumes a continued deterioration of certain existing project components (pumps, motors, electrical components, etc.) for which replacement parts are no longer readily available. If no action is taken to bring the existing system into compliance, the next major flood event could result in uncontrolled interior flooding should any of these aging components (60 plus years old) fail to operate properly. Each component of the existing local flood protection project works together as a system to protect Paducah. Should a breach in any portion of the system occur, a full failure of the entire system could potentially result. Given this circumstance, the lives and safety of more than 14,000 people and 17 square miles of residential/urban development would be at risk in addition to estimated expected annual damages of over $1,856,000.00, according to a previous Corps study (May 2000).

Overtopping of the levee would not be as catastrophic as a breach in the levee due to the fact that the water level would increase much more gradually and people would have more time to evacuate.

Alternative 2: Reconstruction/Rehabilitation. Impacts, if any, as a result of the proposed alternative are discussed in the remainder of this section.

General. Reconstruction and/or rehabilitation of the Paducah LFPP will have no impact upon the location of the city of Paducah. Further it will have no impact upon the

existing conditions of the interior drainage basins other than reduction of ponding of floodwaters behind the levee.

Floods. Reconstruction and/or rehabilitation of the Paducah LFPP will have no impact upon the frequency, duration or magnitude of floods at Paducah or its immediate vicinity. The 17 square miles protected by the LFPP are removed from the flood plain of the Ohio, Tennessee, and Clarks rivers for the purposes of flood plain storage of floodwaters; however the total floodplain area is so large that no impacts elsewhere are attributable to its presence.

Hazardous, Toxic and Radiological Waste (HTRW). The reconstruction and/or rehabilitation of the Paducah LFPP will consist primarily of maintenance items to the existing flood control system which would occur within the existing project boundaries. Therefore, it was determined that no Phase I Environmental Assessment was warranted. To the extent additional real estate interests are required for the project, the City of Paducah, as the sponsor would be required to perform investigations to identify the existence and extent of any hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act.

Project specifications will require that excavated soils that will not be used on site will be disposed of at a licensed landfill. No other HTRW concerns are anticipated.

Biological Resources. Reconstruction and/or rehabilitation of the Paducah LFPP will have minimal impact to biological resources including threatened or endangered species of plants and animals. Continued maintenance of a monoculture of mowed grasses within the LFPP results in very little habitat for most other species. Previous coordination with the U.S. Fish and Wildlife Service (USFWS) beginning on 29 March 2010 ultimately resulted in a joint determination of "not likely to adversely affect" any listed or candidate species known to possibly occur in the area (USFWS e-mail dated June 1, 2011).

Cultural Resources. Cultural resources do occur in the proposed project area; however, reconstruction and/or rehabilitation of the Paducah LFPP will have no impact to such as all activities will be conducted within the already highly disturbed setting of the LFPP. This determination has been coordinated with and agreed to by the Kentucky State Historic Preservation Officer (SHPO) by letter dated February 10, 2010. It was also coordinated with all federally recognized Native American tribes and other concerned parties. In the event of an inadvertent find during construction that cannot be avoided, work will be suspended until such can be evaluated by a Corps of Engineers archaeologist and their findings coordinated with the SHPO.

Social and Economic Resources. Major state and federal highways, the Interstate Highway system, railway, and airlines serve the community area. In general, the existing conditions of the floodplain in Paducah are those of a moderate to densely developed urbanized setting. This area includes 17 square miles covering the entire central business district of downtown Paducah, several high schools, residential areas and community

facilities. The proposed project will have no adverse impact to any of these facilities. It will maintain protection from flooding for same.

In accordance with Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," the reconstruction of the levee would not adversely impact any residents of the City of Paducah regardless of race, national origin, religion, or level of income. The project consists of construction on or near the existing levee system and therefore, would not impact the local residents.

Cumulative Effects. Cumulative impacts result when incremental impacts combine with those of other ongoing or planned activities in the same geographical area to create a collectively significant impact. Cumulative impacts would include negative impacts to community businesses. Relocations of businesses or residences could impact employment in the area, property values, public facilities and services, tax revenues, community cohesion, and transportation. These threats would potentially increase under the "No Action Plan," as chances of failure of the levee become greater with increasingly deteriorating equipment.

The proposed alternative would not have any significant adverse cumulative impacts. As discussed above and in the next section below, adverse impacts associated with the proposed alternative are potential short term impact to air and water quality from construction activities. Short-term impacts to air quality would result from operations of construction equipment and workers driving to and from the project while water quality impacts would result from run-off of precipitation from the project site. These short term impacts are of such a limited nature that even when combined with other activities, such as normal maintenance of city infrastructure, redevelopment efforts, or the activities of private landowners, they would not result in a significant cumulative impact.

The proposed activity would have beneficial cumulative impacts, as it continues to reduce the threat to loss of health and economic standing in the community. In other words, the primary cumulative effect of the reconstruction and rehabilitation of the LFPP is the continuation of the existing level of flood protection. The Paducah LFPP was designed to prevent damages from a recurrence of the 1937 flood (the flood of record for the Ohio River a - 500-year/0.02% event) plus three feet of freeboard. Subsequent to the construction of the project, the Corps has constructed a system of 55 multipurpose reservoirs on Ohio River tributaries upstream of Paducah, which further reduces the risk of overtopping of the project. If the meteorological conditions of the 1937 Flood were to reoccur, the Corps estimates that with the upstream reservoirs currently in place there would be a seven-foot reduction in the flood elevation at Paducah. The impacts of the upstream reservoirs on flooding in the area of Paducah were included in modeling that was used for the future without project condition (= no action alternative), and considered in the reconstruction project formulation. The basic project layout allows for no logical or rational way to decrease the scope/scale of the project so as to account for the change in the hydraulics of the Ohio River. Additionally, this theoretical increase in project effectiveness is offset somewhat by changes in national design standards resulting from

the Hurricane Katrina event in 2005. Absent the decrease in flood levels due to the upstream reservoirs, additional work would have been required to strengthen the floodwalls/levees at Paducah. The proposed alternative only restores the project to its originally authorized operational condition. It does not provide additional protection to the community since it does not change the physical scope, scale or size of the project. If the Paducah project is reconstructed as recommended, the residual risk of the project would be minimal and more a factor of a possible system component failure than any defeat of the project by a large flood event.

Compliance with Other Environmental Requirements

Summary of Environmental Effects (Environmental Quality). The proposed project has been reviewed for compliance with federal legislation including the National Environmental Policy Act (NEPA), Endangered Species Act, Clean Air Act, Clean Water Act, and Section 106 of the National Historic Preservation Act of 1966 (as amended). While this proposed alternative appears to meet the standard identified in Corps of Engineers Engineering Regulation 33 CFR 230, ER 200-2-2.9.a, for a categorical exclusion, it was determined after further review that preparation and circulation of this EA would be a safer course of action in documenting and completing NEPA compliance. Both the initial evaluations conducted during preparation of the feasibility study and this subsequent EA have not identified any significant impacts, and, therefore, no mitigation is required to support project implementation.

Clean Air Act: The proposed project area is in attainment for all measured and/or regulated air pollutants. The proposed project has been analyzed for conformity applicability pursuant to regulations implementing Section 176(c) of the Clean Air Act. It has been determined that the activities proposed would not exceed de minimis levels of direct emissions of a criteria pollutant or its precursors and are exempt by 40 C.F.R. Part 93.153 (c)(2).

Comprehensive Environmental Resource Compensation Liability Act and Resource Conservation and Recovery Act: These two acts pertain to hazardous and toxic materials. Based on the site investigation of the project area, there appears to be no evidence that would indicate the presence of HTRW contamination at the project site. No further investigation is warranted at this time.

Endangered Species Act: Due to the lack of suitable habitat for threatened or endangered species in the area, no impacts to those species are expected to occur. Construction would be taking place on or near the levee system. Construction would not take place in the river. Coordination with the U.S. Fish and Wildlife Service has taken place to ensure that no endangered or threatened species will be impacted by the proposed project.

Fish and Wildlife Coordination Act: Consultation with the U.S. Fish and Wildlife Service has been completed. All comments were resolved satisfactorily to both agencies.

Floodplain Management EO 11988: In order to achieve the desired objective of rehabilitating the existing levee system, the considered project must be located in the floodplain. No practical non-floodplain alternative exists. The floodplains of the area have been previously disturbed due to past construction of the levee. Further disturbance from the proposed project does not conflict with applicable state and local standards concerning floodplain protection.

National Historic Preservation Act: Cultural resources do occur in the proposed project area; however, none are expected to be impacted by the proposed project. The proposed action has been coordinated with the SHPO and Native American tribes. Proposed project is in compliance.

Farmland Protection Act: The proposed project site is located within urban and commercial areas. The site does not contain farmland covered by this act.

Clean Water Act: No long term effects on water quality would occur from the construction of the proposed project. Short term effects could be seen due to construction, but would only be temporary. At the conclusion of construction activities such temporary impacts would cease. Clean Water Act permits are not required for the proposed project.

Protection of Wetlands EO11990: No wetlands occur within the proposed project location; therefore, no effects to wetlands would occur.

Wild and Scenic Rivers Act: No wild or scenic rivers are located within the proposed project area.

Environmental Justice EO12898: Reconstruction of the levee would not adversely impact any residents of Paducah regardless of race, national origin, religion, or level of income. Construction would take place on or near the levee and would not impact the local residents.

SUMMARY OF COORDINATION, PUBLIC INVOLVEMENT, AND COMMENTS

Since the findings of the previously completed feasibility study recommend reconstruction of major components of an existing levee system, public involvement has been minimal. However, the City of Paducah aired a 30 minute educational-documentary video on Paducah Public Access Channel 11 for several months. These airings occurred twice weekly and were titled "Your City at Work." They featured the Paducah, KY LFPP and they identified all aspects of the project including feasibility, restoration, and reconstruction.

State and federal agency coordination regarding the proposed project as described in the feasibility report was previously completed in compliance with federal laws other

than NEPA, e.g., Section 106 of the National Historic Preservation Act and Section 7 of the Endangered Species Act.

The goals of the public involvement and coordination process were met via educational-documentary videos which were used to inform and educate the public. Further, a public meeting was held on 8 November 2010 to give the public an opportunity to provide feedback to the feasibility study team. The feasibility study was also made available for concurrent public and HQUSACE review for a period of 30 days. No comments were received from the public.

This EA and the unsigned Finding of No Significant Impact (FONSI) were circulated for a 30 day public and agency review period in accordance with 33 C.F.R. §230.11. This review period ended with the close of business on Monday August 1, 2011. No comments were received.

DETERMINATION AND CONCLUSION

I have reviewed and evaluated, in light of the overall public interest, the documents and factors concerning this EA and proposed action associated with the Paducah Local Flood Protection Project at Paducah, KY, as well as stated views of other interested agencies and concerned public. In doing so, I have considered the possible consequences of the proposed project and reasonably foreseeable future actions in accordance with regulations published in 33 CFR Part 230 (Corps of Engineers Regulations) and 40 CFR Parts 1500-1508 (Council on Environmental Quality Regulations). The following paragraph provides my conclusion and how the action complies with the above-cited regulations.

I have determined that the proposed project is environmentally sustainable. I have also determined that the proposed action does not constitute a major federal action that would significantly affect the quality of the human environment, nor is it expected to be controversial. This constitutes a Finding of No Significant Impact. As a consequence, I find that an Environmental Impact Statement is not required by the provisions of Section 102 of the National Environmental Policy Act, 42 U.S.C. 4332, or by the applicable implementing regulations and guidance. This FONSI was prepared in accordance with 33 CFR Part 230 and 40 CFR Parts 1500-1508.

_____ _____

LUKE T. LEONARD
Colonel, Corps of Engineers
Commander

Date

CERTIFICATION OF LEGAL REVIEW:

The Environmental Assessment and Finding of No Significant Impact for the Ohio River Shoreline, Paducah, KY Reconstruction Project, have been fully reviewed by the Office of Counsel, Louisville District and are approved as legally sufficient.

Janice Lengel
District Counsel

8/10/2011
Date

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX A

PUBLIC AND AGENCY COORDINATION

TABLE OF CONTENTS

LETTER TO STATE HISTORIC PRESERVATION OFFICER

LIST OF FIGURES

Figure No.	Title	
		4
Figure 1	Location of the Paducah Levee Project	
Figure 2	Western Portion of the Paducah LFPP with Anticipated Upgrades	5
Figure 3	Downtown Portion of the Paducah LFPP with Anticipated Upgrades	6
Figure 4	Downtown Portion of the Paducah LFPP with Anticipated Upgrades	7
Figure 5	Eastern Portion of the Paducah LFPP with Anticipated Upgrades	8
Figure 6	Eastern Portion of the Paducah LFPP with Anticipated Upgrades	9
Figure 7	Eastern Portion of the Paducah LFPP with Anticipated Upgrades	10
Figure 8	Push Pile at Recorded Location of Site 15McN3	11

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX A

PUBLIC AND AGENCY COORDINATION

TABLE OF CONTENTS

LIST OF FIGURES
(cont'd.)

Figure No.	Title	
Figure 9	Building at Recorded Location of Site 15McN8	11
Figure 10	Performing Arts Center at Recorded Location of Site 15McN124	12
Figure 11	Executive Inn at Reported Location Ft. Anderson	12
Figure 12	Proposed Location of Pump Plant 14 Site 15McN124	13
Figure 13	Proposed Contractor Lay Down Area	13

RESPONSE FROM STATE HISTORIC PRESERVATION OFFICE

CORRESPONDENCE WITH U. S. FISH AND WILDLIFE

LETTER FROM CHEROKEE NATION

LETTER INVITING COMMENTS ON DRAFT FEASIBILITY REPORT

MAILING LISTS

NEWS RELEASE

AGENDA – PUBLIC MEETING

COMMENTS CARDS – PUBLIC MEETING

INFORMATION SHEET

NEWS ARTICLES

- **PADUCAH SUN – 9 NOVEMBER 2010**
- **USACE LRL PUBLIC AFFAIRS OFFICE ARTICLE – 30 NOVEMBER 2010**

PROJECT DELIVERY TEAM MEMBERS' QUALIFICATIONS

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
P.O. BOX 59
LOUISVILLE, KENTUCKY 40201-0059

http://www.lrl.usace.army.mil/

February 12, 2010

Planning, Programs and
Project Management Division
Environmental Resources Section

Mr. Mark Dennen
State Historic Preservation Officer
Kentucky Heritage Council
300 Washington Street
Frankfort, Kentucky 40601

Dear Mr. Dennen,

The U.S. Army Corps of Engineers-Louisville District (USACE-Louisville District) has entered into a partnership with the city of Paducah to upgrade and rehabilitate portions of the Paducah Local Flood Protection Project (LFPP) in McCracken County, Kentucky. In accordance with Section 216 of the 1970 Flood Control Act (Public Law 91-611), we are assessing the extent of the federal government's interest on the project through a feasibility study. In turn, we are initiating Section 106 of the National Historic Preservation Act (as amended) with your agency and other consulting parties to determine the affects to historic properties eligible for listing to the National Register of Historic Places (NRHP)

The city of Paducah is located in the western part of the Kentucky along the left bank of the Ohio River near river mile marker 935. The Paducah LFPP consists of approximately 48,700 feet (9.2 miles) of earth levee, 15,058 feet (3 miles) of concrete flood wall, 13 pump stations, 47 closure and service openings, 8 ramps, 5 diversion channels and other necessary appurtenances. In all, the levee encompasses approximately 10,850 acres, and was initiated as a direct result of the Great Flood of 1937. The construction of the levee started in August 1939 and was completed in January 1950.

Figures 1, 2, 3, 4, 5, 6 and 7 show the location of the project and its upgrades. Photos of the project are provided in Figures 8, 9, 10, 11, 12, and 13. We have also included a copy of the engineering design and specifications for the project in this mailing. Much of the proposed undertaking with center around the levee itself: sealing and filling the levee toe, upgrades to pumps and structural features, and replacing discharge pipes.

An examination of the levee and the proposed upgrades was conducted on January 26 and 27, 2010. A cursory review of existing literature and records indicate that there are several historic and cultural resources recorded within or adjacent to the Paducah LFPP, the most

notable being Fort Anderson: constructed by the Union Army during the Civil War and central to the Battle of Paducah. However, no remnants of the fort are visible on the surface. Its location is currently marked with a metal historic monument at the Paducah Convention Center and defunct Executive Inn.

A common tourist attraction to the area is the flood wall murals in downtown Paducah that depict the history of development in western Kentucky. The murals were designed and painted by Mr. Robert Dafford and the Dafford Muralists of Lafayette, Louisiana. The project began in 1996 and was completed in 2007. Each mural panel has an interpretative plaque with a short history lesson on the scene depicted in the panel.

A total of 25 historic properties listed to the National Register of Historic Places are recorded within McCracken County, Kentucky. However, none of these will be affected by the proposed undertaking.

Five archaeological sites are recorded within the limits of the Paducah LFPP. Specifically, they are sites 15McN3, 15McN6, 15McN8, 15McN66, and 15McN124. Three of these sites – 15McN3, 15McN6, and 15McN8 – were recorded by the University of Kentucky as a part of reconnaissance survey of archaeological resources throughout the state (Funkhouser and Webb 1932). They are briefly described below.

Site 15McN3 is described as a "[c]amp or village site..." containing "[s]keletons, artifacts and layers of charcoal..." that were discovered and disturbed during "...building purposes" (Funkhouser and Webb 1932: 251). The site's recorded location is in a gravel parking lot for an auto parts store and a small batch of trees with invasive plants and earthen push piles. No evidence of the site was observed during the recent site visit.

Site 15McN6 was a prehistoric mound that was reported to have been destroyed prior to the 1932 survey. The mound was excavated by Colonel Fain King, a Paducah businessman and relic collector, in 1920. The mound was reported to contain "...bones, ashes, charcoal and a few fragments of flints" (Funkhouser and Webb 1932: 252). The site's recorded location is currently in a fallow field just east of the Husband Road and Lydon Road intersection. No evidence of the site was observed during the recent site visit.

Site 15McN8 was a large cemetery on the banks of the Ohio River and within the property of the former Fowler-Wolfe Plant. Placement of the foundations for the buildings revealed the presence of skeletons and artifacts. The site's recorded location is currently on the property of a trucking company along south 3rd Street/U.S. Highway 60 and is covered in concrete. Thus no evidence of the site was observed during this site visit.

Site 15McN66 was a multi-component artifact scatter dating mostly to the mid-twentieth century. The site was first identified by students at Murray State University in a gravel parking area for an industrial complex. It was severely disturbed at the time and thus not considered eligible for listing to the National Register of Historic Places.

Site 15McN124 was a historic city block related to the "Old Town" of Paducah, northeast of what had been the intersection of Clark and Second streets. The site's recorded location is currently on the property of the Four Rivers Performing Arts Center. Archival maps going back to 1832 showed a changing array of commercial and residential structures on this block throughout the nineteenth century. The block included Lots 70, 71, and 72 on City Block 8 of official city property maps. Archaeological investigations were carried out at the site in May of 2001 by TRC Garrow and Associates of Nashville, Tennessee (Ezell 2001). Four backhoe trenches were excavated across the site, labeled Area A during the study. One trench in particular, AI, in the lot's southwestern quadrant, uncovered a mid to late nineteenth century midden deposit at approximately one meter below the current surface. This deposit, Strata VI, ranged from between 35 to 95 cm thick and contained a relatively dense deposit of domestic and architectural debris, apparently undisturbed and unmixed with later material. The other three trenches dug within Area A produced more minimal signs of this rich artifact midden. Since the construction plans called for use of the area as a parking lot with disturbances limited to only 2 ft. below the surface, the Kentucky State Historic Preservation Officer concluded that the project would not impact the buried midden deposits. No further work was recommended for the project.

Small segments of the levee have been examined for cultural resources as a part of compliance requirements for Section 106 of the National Historic Preservation Act, including a barge fleeting area (McNerney 1990), a water plant site and intake (Carstens and Hensley 1981), a nature trail (McHugh 1977), and a concrete batch plant (Schenian 1993). No cultural resources were identified during these investigations.

Given that much of the proposed undertaking falls within narrow lineal footprint of the existing levee, and those known resources within the project have been either compromised or destroyed by prior development, the Louisville District has determined that the upgrades to the Paducah LFPP project will not have an affect to historic properties eligible for listing to the NRHP. In accordance with 36CFR800.4 (d) (1), no further coordination under section 106 of the NHPA on the proposed undertaking is required.

If you have any other questions or comments, please call Mr. Keith Keeney at (502) 315-6871 or by e-mail at Keith.A.Keeney@usace.army.mil. Please respond before **Friday, March 12, 2010**.

Sincerely,

Chief, Environmental Resources
Planning Branch

Enclosure

Figure 1. Location of the Paducah Levee Project in McCrackin County, Kentucky.

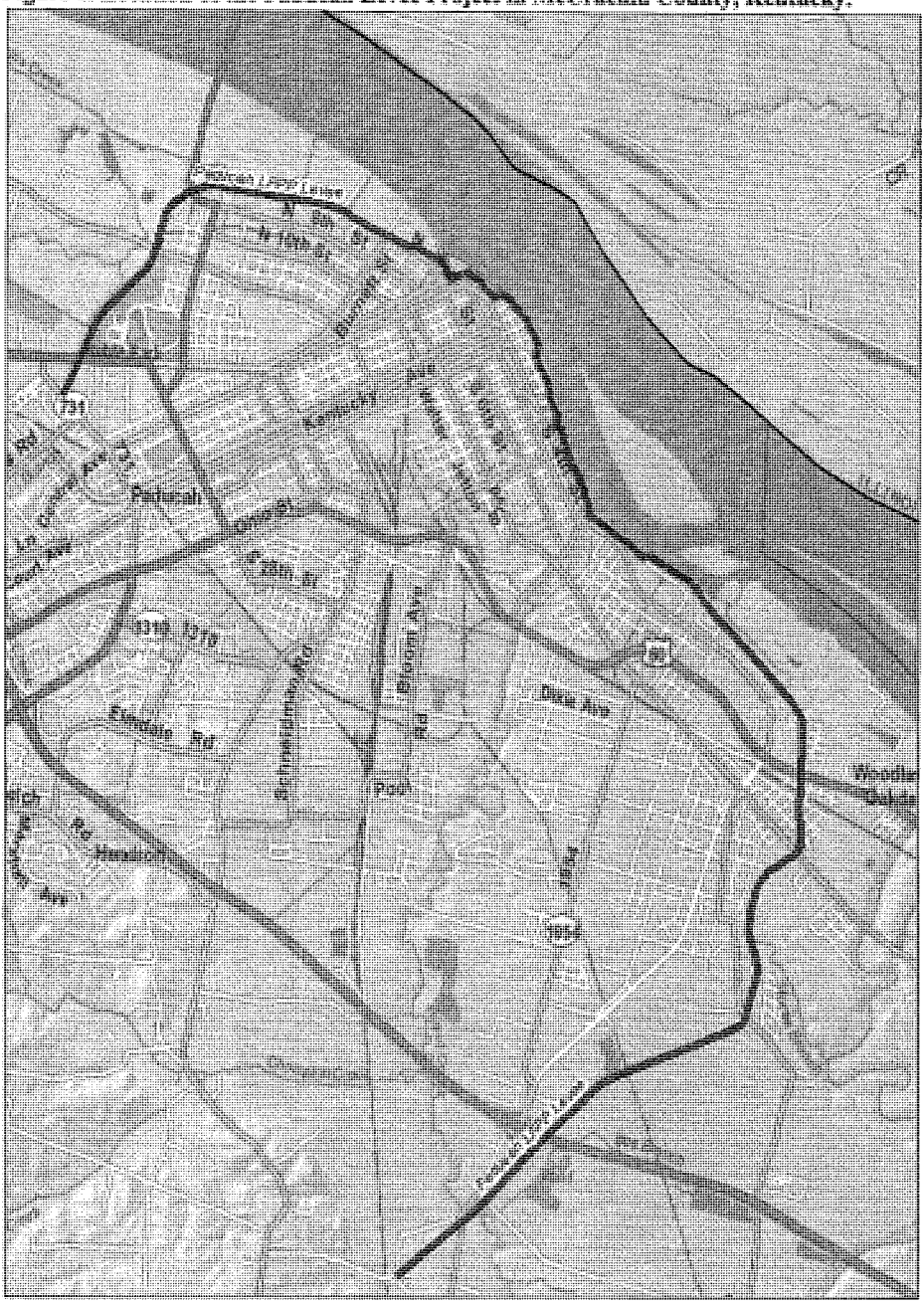


Figure 2. Western portion of the Paducah LFFP with anticipated upgrades.

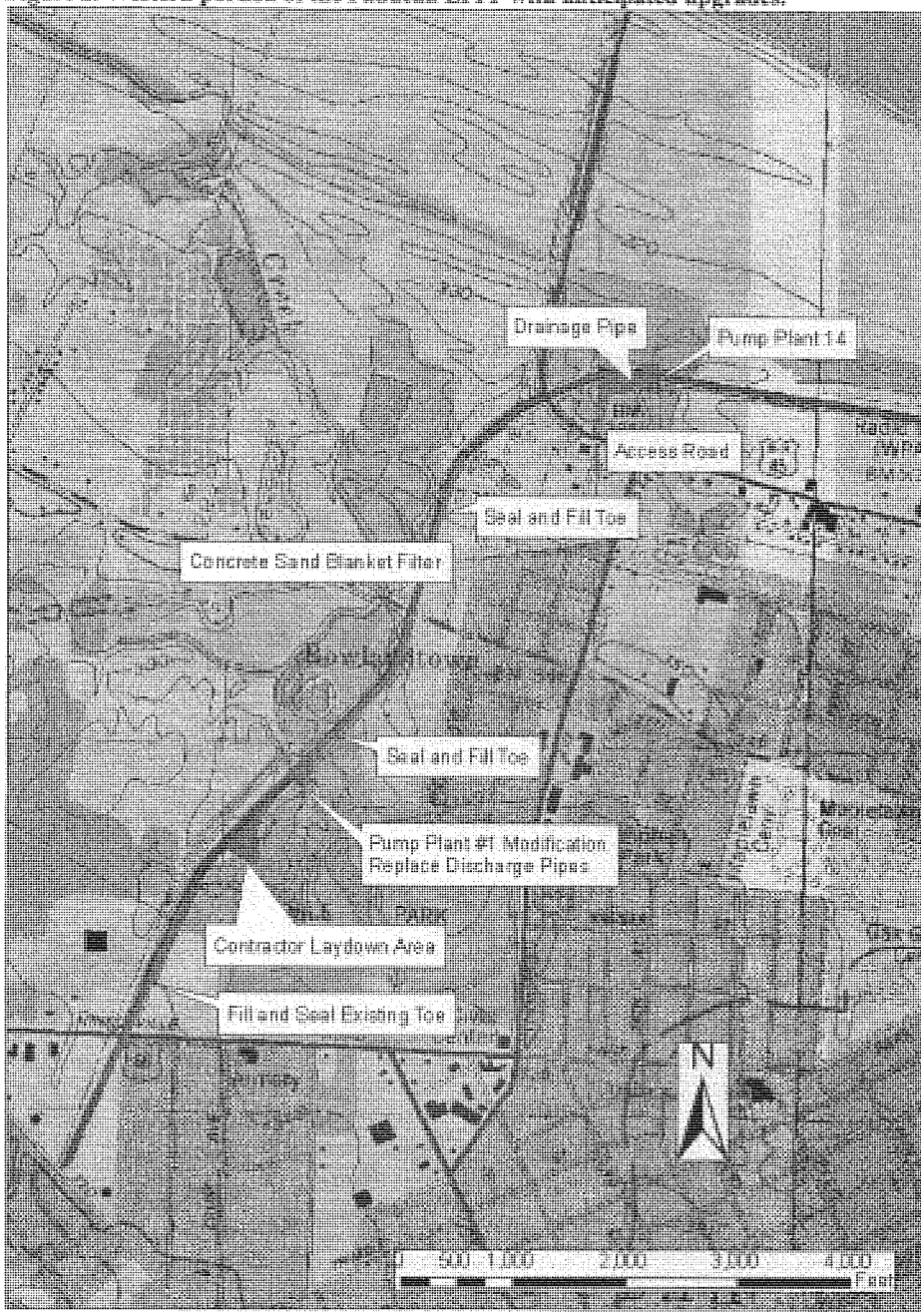


Figure 3. Downtown portion of the Paducah LFFP with anticipated upgrades.

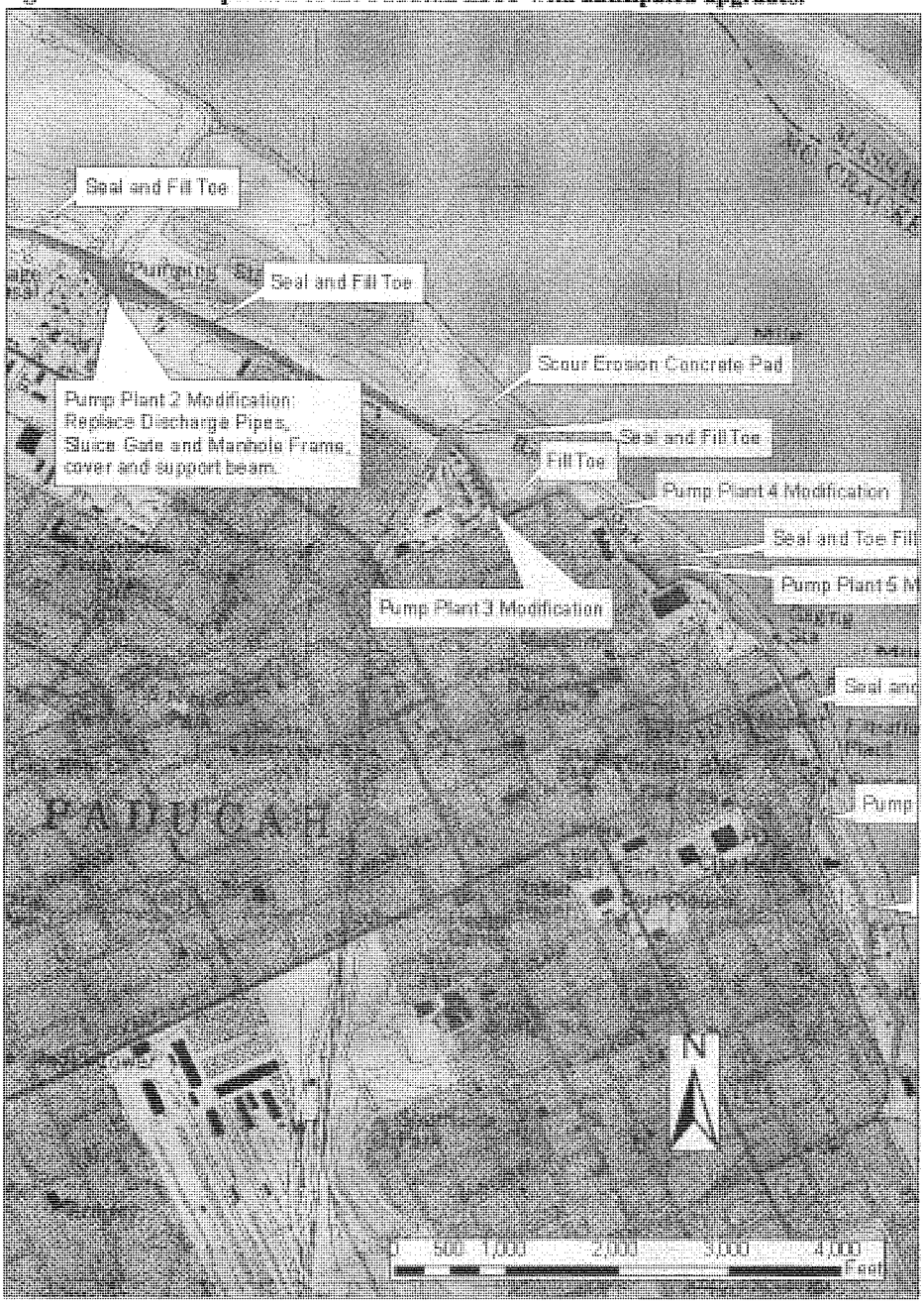


Figure 4. Downtown portion of the Paducah LFFP with anticipated upgrades.

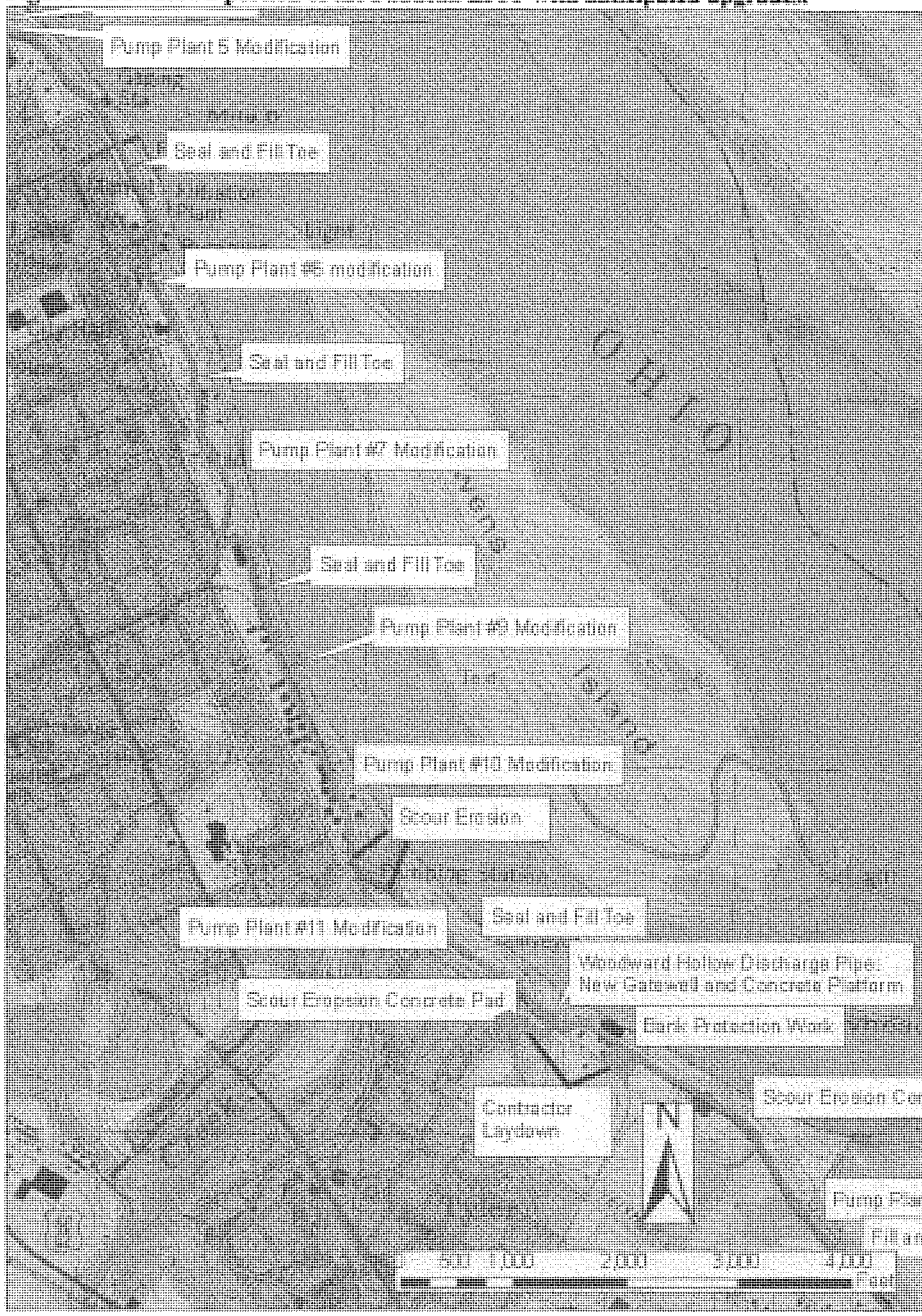


Figure 5. Eastern portion of the Paducah LFFP with anticipated upgrades.

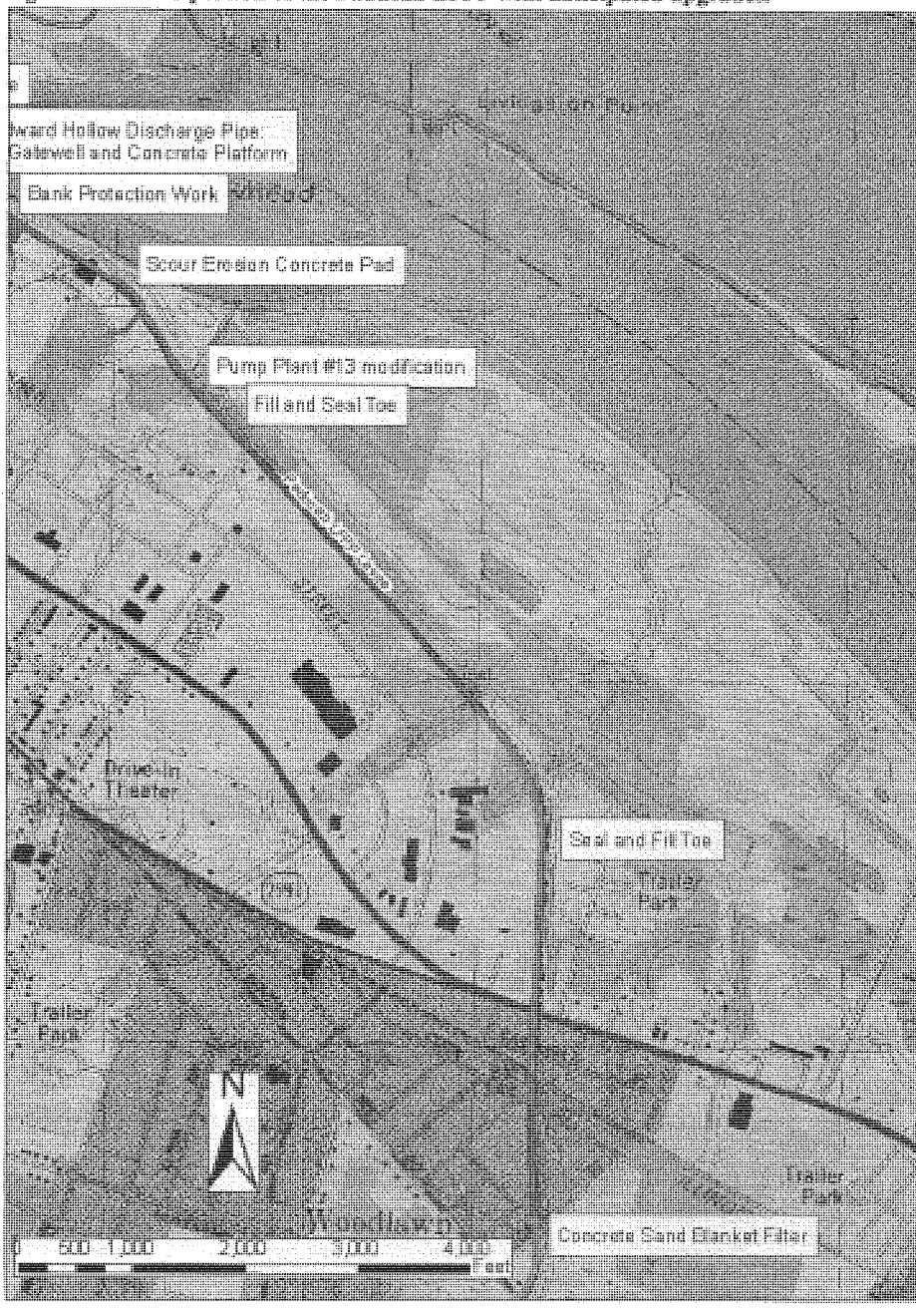


Figure 6. Eastern portion of the Paducah LFFP with anticipated upgrades.

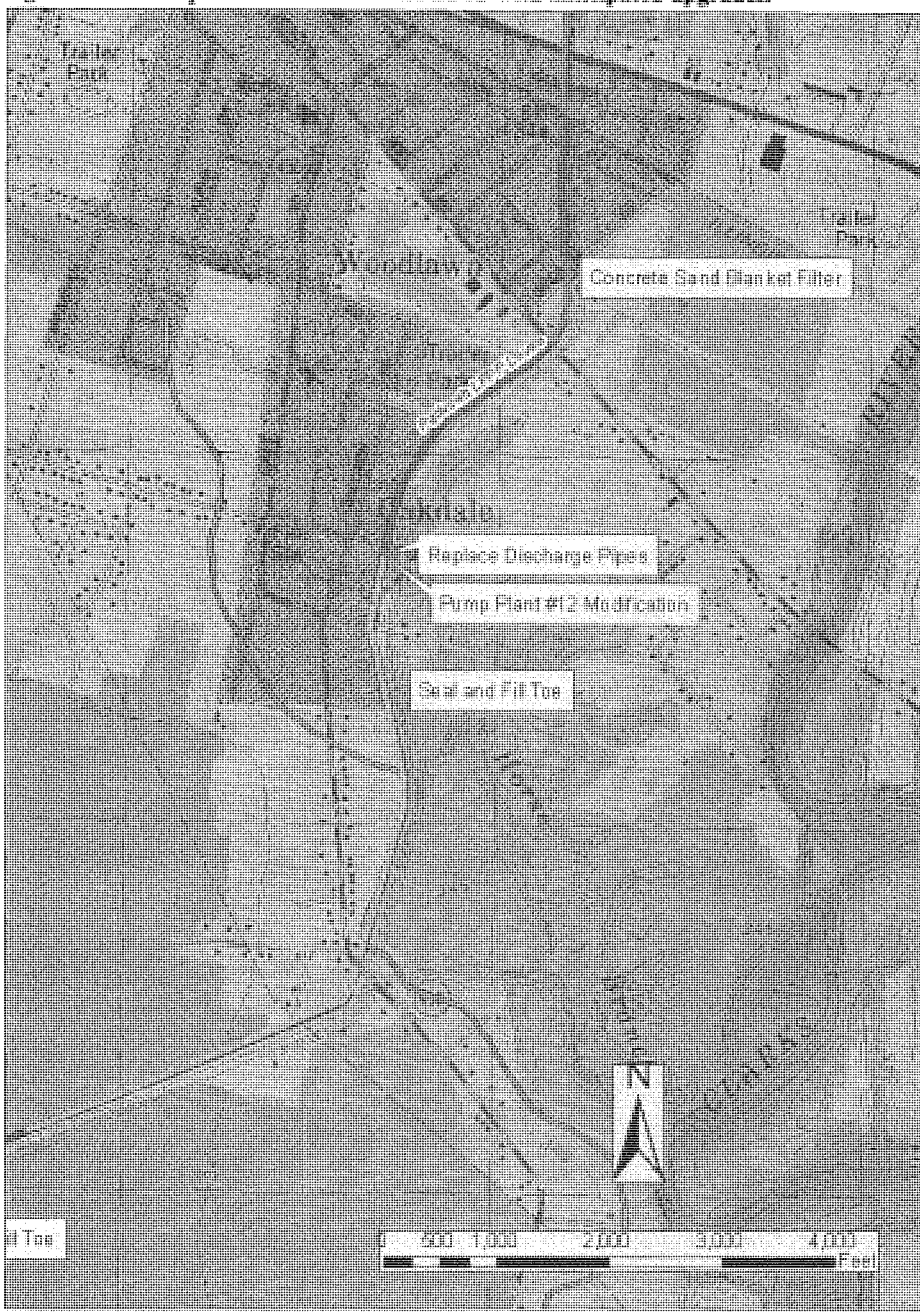


Figure 7. Eastern portion of the Paducah LFFP with anticipated upgrades.

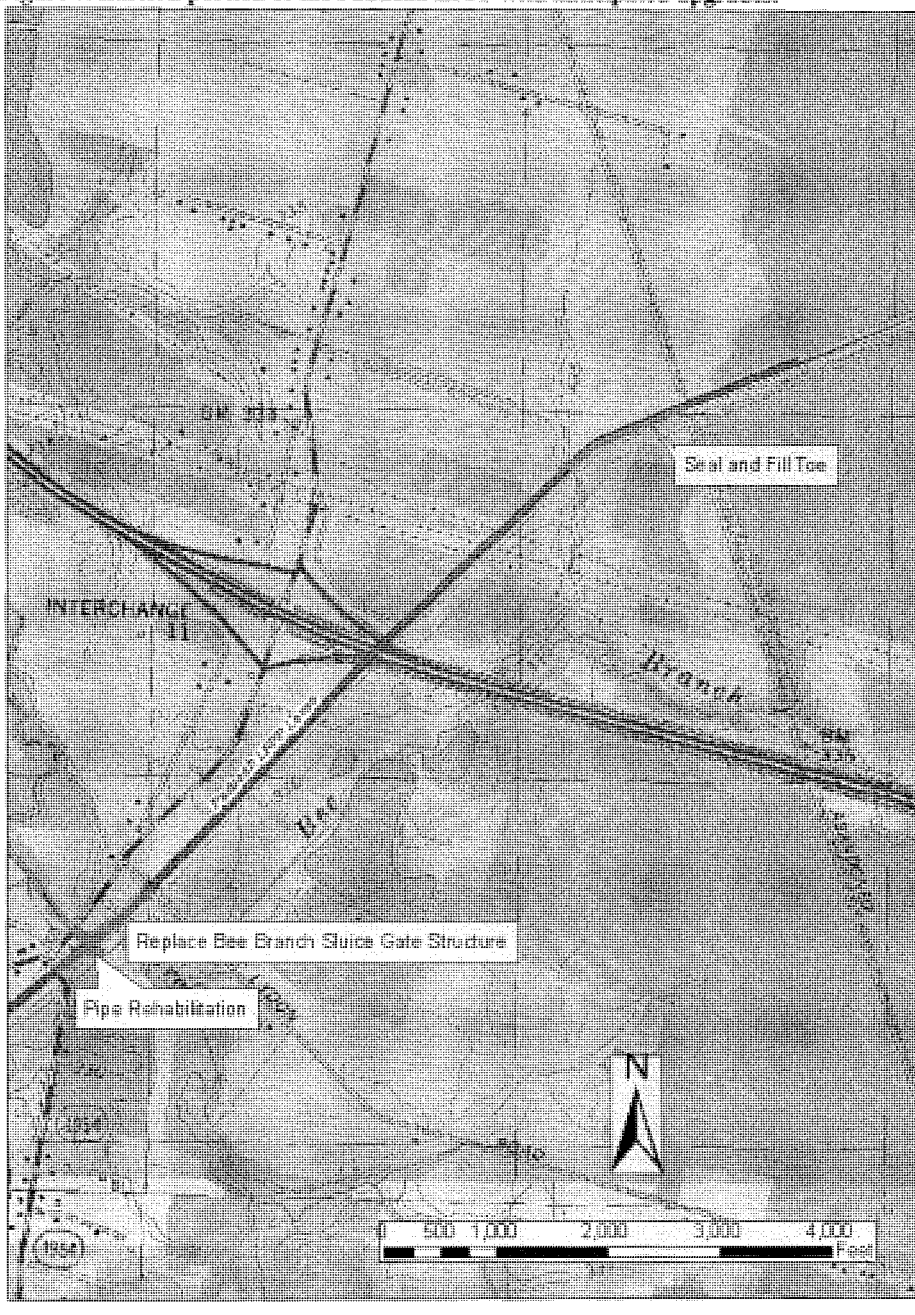


Figure 8. Push pile at recorded location of Site 15McN3.

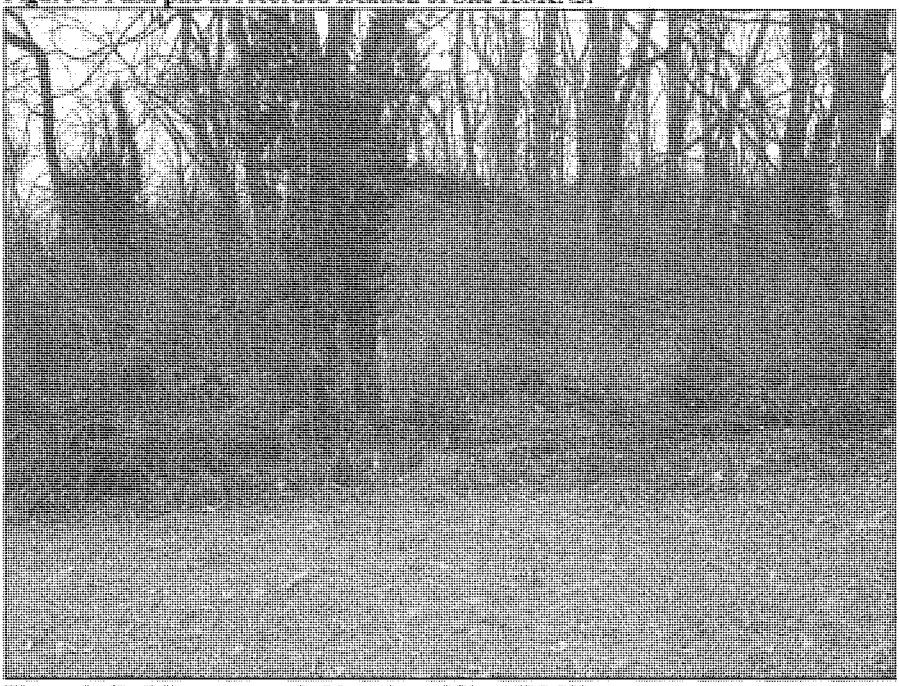


Figure 9. Building at recorded location of Site 15McN8.

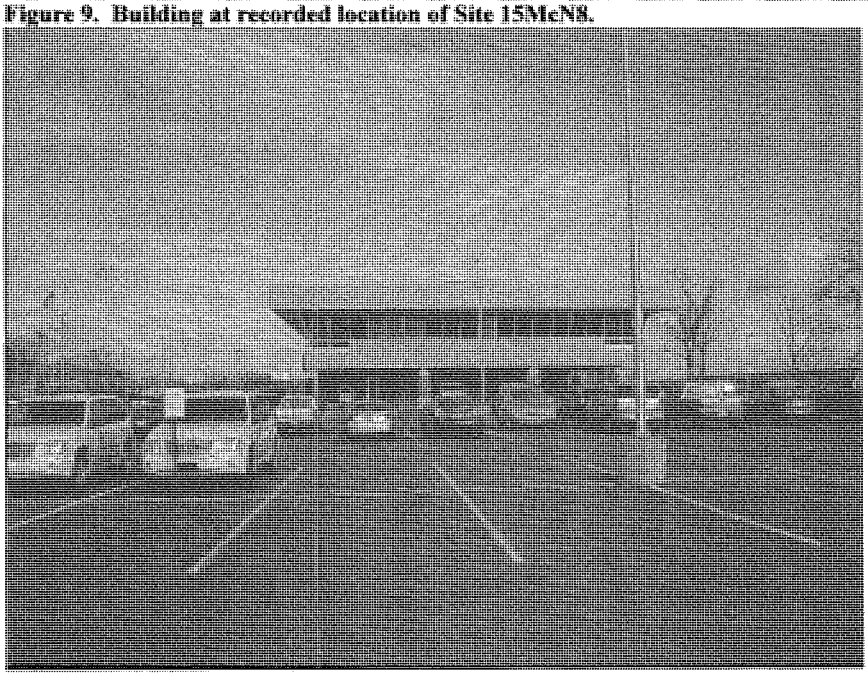


Figure 10. Performing Arts Center at recordedocation of Site 15McN124.

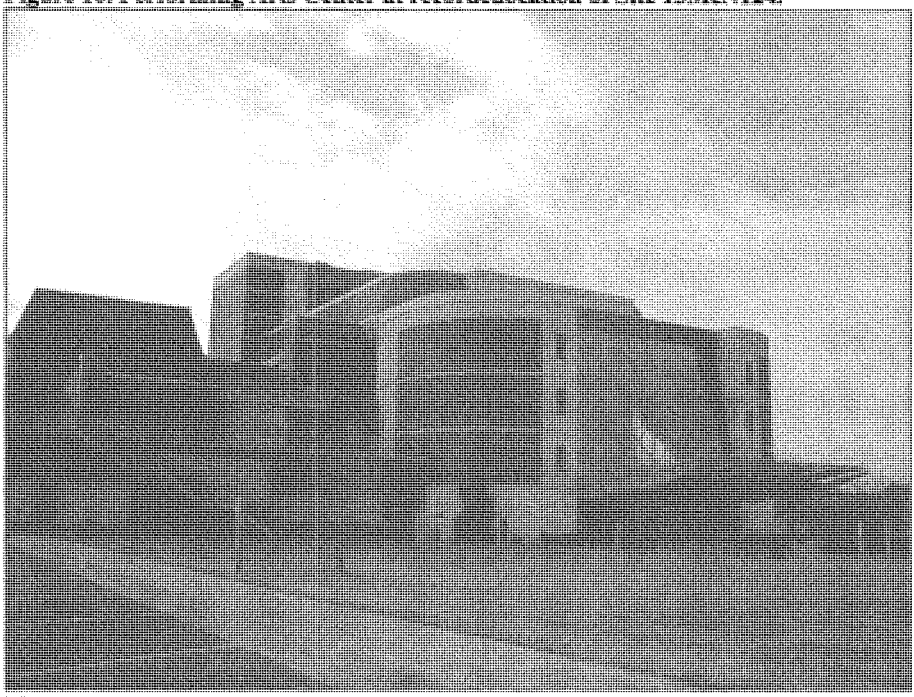


Figure 11. Executive Inn at reported location of Ft. Anderson.

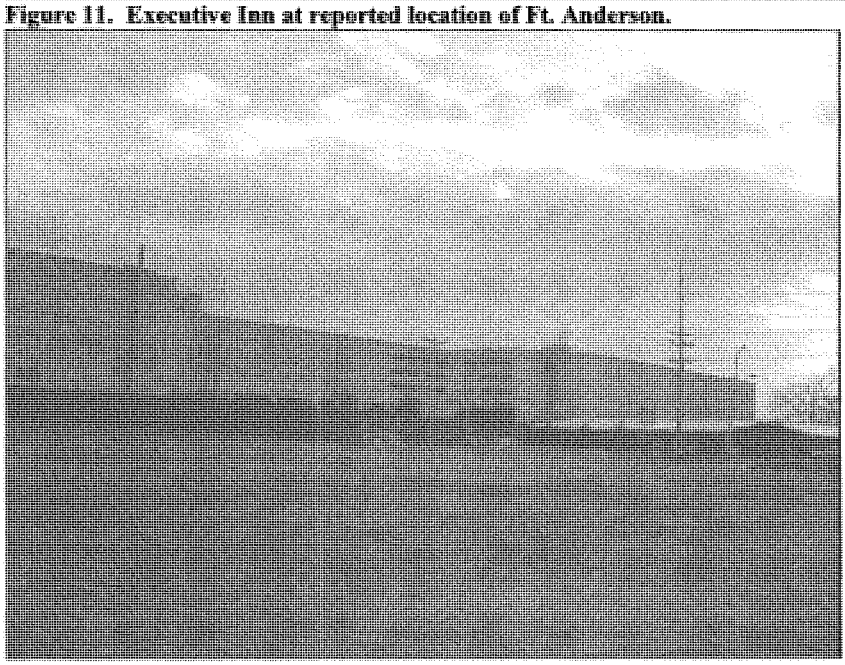


Figure 12. Proposed location of Pump Station 12.

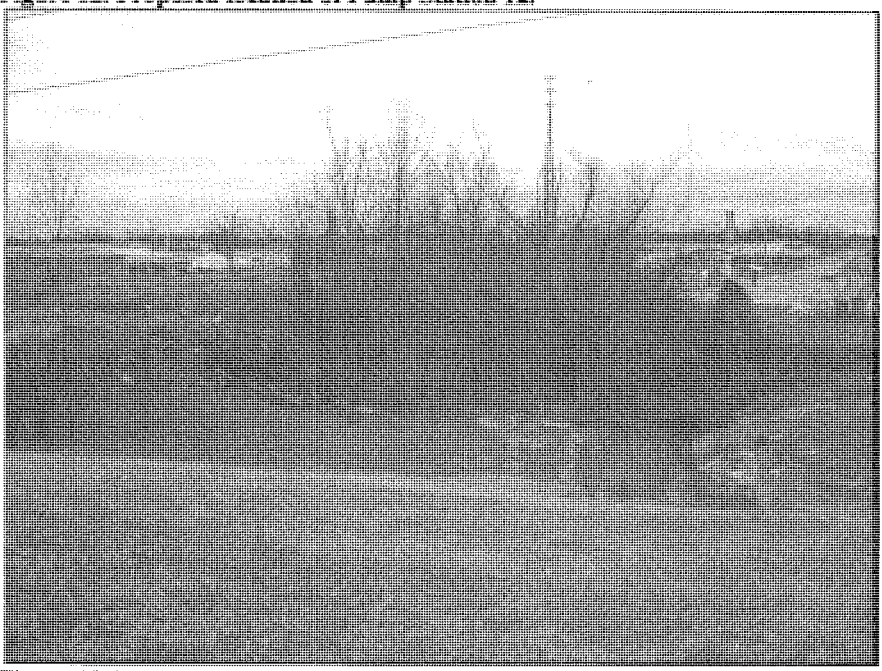
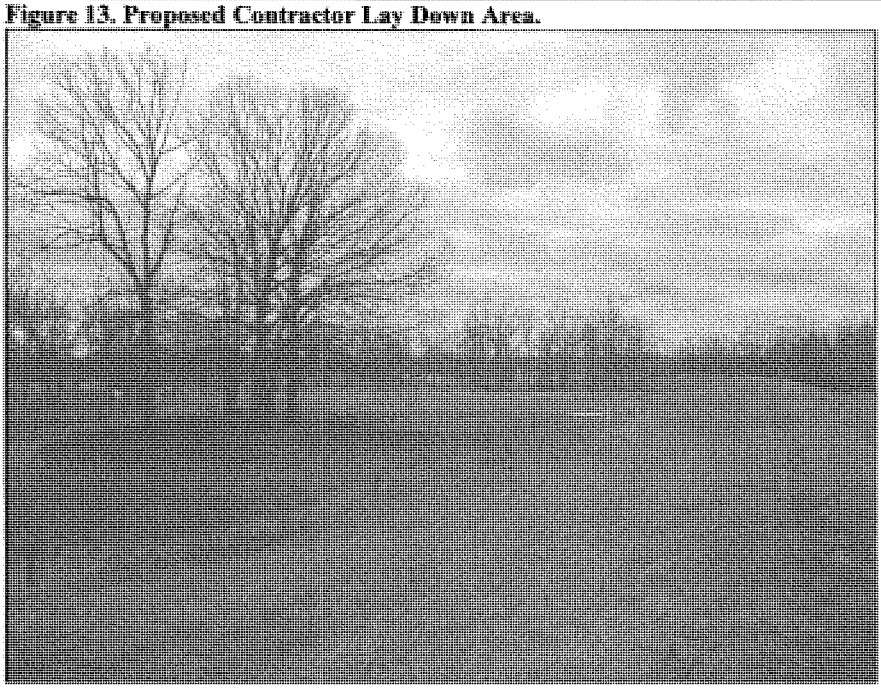


Figure 13. Proposed Contractor Lay Down Area.



STEVEN L. BESHEAR
GOVERNOR

TOURISM, ARTS AND HERITAGE CABINET
KENTUCKY HERITAGE COUNCIL

MARCHETA SPARROW
SECRETARY

THE STATE HISTORIC PRESERVATION OFFICE
300 WASHINGTON STREET
FRANKFORT, KENTUCKY 40601
PHONE (502) 564-7005
FAX (502) 564-5820
www.heritage.ky.gov

MARK DENNEN
EXECUTIVE DIRECTOR AND
STATE HISTORIC PRESERVATION OFFICER

April 30, 2010

Mr.
USACE Louisville District
PO Box 59
Louisville, Kentucky 40201-0059

Re: Paducah Local Flood Protection Project (LFPP) upgrade and rehabilitation, McCracken County, Kentucky

Dear Mr.

We have reviewed the proposed upgrades and rehabilitation to the Paducah Local Flood Protection Project (LFPP). The Paducah LFPP consists of approximately 9.2 miles of earth levee, 3 miles of concrete flood wall, 13 pump stations, 47 closure and service openings, 8 ramps, 5 diversion channels and other necessary appurtenances.

Six archaeological sites are recorded within the limits of the Paducah LFPP. The sites are 15McN3, 15McN6, 15McN8, 15McN66, 15McN124 and 15McN151. Site 15mcN151 was recently recorded subsequent to a site visit by staff members and representatives from the Office of State Archaeology. Site 15McNcovers a portion of the Paducah riverfront on the westerly side of 4th and 5th Streets including the area on either side of the flood wall. Located within this area was a Marine Hospital built in 1850, the Civil War era For t Anderson (1861-1864) which encompassed the Marine Hospital, the Riverside or Lourdes Hospital built between 1897 and 1906, at least one residence shown on the 1897 Sanborn Insurance Map and other as yet unidentified potential resources. Much of the site area is now covered by the Executive Inn and the floodwall.

It appears that the activities related to the upgrade and rehabilitation of the Paducah LFPP in the area of 15McN151 include a scour erosion concrete pad, seal and fill toe, fill toe, pump plant 3, 4 and 5 modifications. These activities should take place in areas previously disturbed by the construction of the levee in the mid-20th century. Additional activities for the remainder of the Paducah LFPP near other above historic and archaeological resources will also take place in the narrow lineal footprint of existing levee.

We conclude that the Paducah LFPP will have no adverse effect on any of the above-mentioned resources. Should plans change to include areas outside the existing levee, this office should be contacted to determine if further documentation is necessary.

Should you have any questions, feel free to contact Lori Stahlgren of my staff at (502) 564-7005, extension 151.

Sincerely,

, Executive Director
Kentucky Heritage Council and
State Historic Preservation Officer

LCS/lcs

An Equal Opportunity Employer M/F/D

From:
To:
Cc:
Subject: Re: Rehabilitation of Local Flood Protection Project, Paducah, KY (UNCLASSIFIED)
Date: Wednesday, June 01, 2011 9:52:17 AM
Attachments: document2011-05-27-091552.pdf

Mr. Turner,

Based on the best information available at this time and the information you provided below that identifies that potential adverse effects to federally listed species will be avoided during implementation of the proposed activities, we concur with the Corps determination of "not likely to adversely affect" for the five listed and two candidate/proposed mussel species listed below. Therefore, we believe that the requirements of Section 7 of the Endangered Species Act of 1973, as amended, are fulfilled. The obligations of the Corps of Engineers under Section 7 of the Act must be reconsidered if (1) new information reveals impacts of the proposed action that may affect listed species or critical habitat in a manner not previously considered, (2) the proposed action is subsequently modified to include activities which were not considered during this consultation, or (3) new species are listed or critical habitat designated that might be affected by the proposed action.

If you have any questions regarding our concurrence, please contact me or Leroy Koch of my staff at 502/695-0468. Thanks.

Jr.
Field Office Supervisor
U.S. Fish and Wildlife Service
Kentucky Field Office
330 West Broadway, Room 265
Frankfort, KY 40601

502/695-0468
502/695-1024 fax

05/27/2011 09:40 AM

To

cc

Subject

Rehabilitation of Local Flood Protection Project, Paducah, KY (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

By letter dated April 29, 2010, the US Fish and Wildlife Service (USFWS) offered comments relating to certain listed threatened or endangered species that might be affected by the subject project. I have reviewed the project engineering drawings, consulted with structural engineering, considered life cycle requirements and habitats of the five listed species and two candidate species. Following this review, I determined that the proposed rehabilitation project has little or no possibility of any impact to any of these seven species.

The five listed species referenced in your letter and addressed in this e-mail are the fat pocketbook mussel (Potamilus capax), orange-footed pearly pimpleback mussel (Plethobasus cooperianus), pink mucket mussel (Lampsilis abrupta), Indian bat (Myotis sodalis) and interior least tern (Sterna antillarum athalassos). The two candidate species of mussels are the sheepnose (Plethobasus cyphyus) and spectaclecase (Cumberlandia monodonta).

The basis for this determination is as follows. All actions to be completed by the Corps of Engineers involve replacement or repair of existing infrastructure associated with the levee. Items included are slip lining corroded drain pipes with new pipes, replacement of sluice gates, pump motors inside existing buildings or pump stations, and construction of one new pump station within the existing footprint (=right-of-way) of the levee. None of these actions will involve removal of trees, construction within the adjoining river, or any new discharge point to the river. All ground surfaces that may be disturbed are either mowed grasses or hard surface, i.e., concrete and asphalt.

Copies of previous correspondence relating to the subject project are enclosed.

I request your review and concurrence or comment regarding this determination.

Thanks.

Chief, Environmental Resources
Louisville District
US Army Corps of Engineers

DEPARTMENT OF THE ARMY
US ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
PO BOX 59
LOUISVILLE KY 40201-0059

http://www.lrl.usace.army.mil

29 March 2010

Planning, Programs and Project
Management Division
Environmental Resources Section

Supervisor, Kentucky Ecological Services Field Station
United States Fish & Wildlife Service
330 West Broadway, Suite 265
Frankfort, KY 40601

Subject: NEPA Section 7 Consultation for the Proposed Paducah, Kentucky Local Flood Protection Project (LFPP) Rehabilitation Feasibility Study

Dear Mr.

The U.S. Army Corps of Engineers Louisville District (The Corps), requests the U.S. Fish and Wildlife Service's comments under Section 7 of the Endangered Species Act 1973, 16 U.S.C. 1531 et seq. for the proposed action discussed below.

The Paducah LFPP is located in the city of Paducah in the northern part of McCracken County, Kentucky, along the left bank of the Ohio River, approximately 934 miles below Pittsburgh, Pennsylvania immediately below the mouth of the Tennessee River. See Figure 1 for proposed project location. The combination of earthen levees and concrete floodwalls was built along the far northern edge of Paducah to protect the city from extreme flooding from the Ohio River. The LFPP consists of approximately 48,700 feet (9.2 miles) of earthen levee and 15,870 feet (3 miles) of concrete floodwall along with other flood protection features. The City of Paducah and the LFPP is bounded on the north and northeast by the Ohio and Tennessee Rivers and lies within the alluvial valley of the Ohio River.

Repair, reconstruction, or replacement of some project components was deemed necessary by recent studies performed by the Corps; due to the fact that the components of the project were nearing the end of their useful design lives of 50 years. The primary purpose of the Paducah, Kentucky LFPP Feasibility Study is to evaluate the extent of Federal interest in rehabilitation of the existing project for flood risk management in Paducah, KY. The Corps and the City of Paducah have completed the feasibility report which evaluates rehabilitation of the existing levee and floodwall system, for construction of new facilities that are required under the present regulations that govern levees and floodwalls, and construction of a new pumping facility to prevent interior flooding. Some of the rehabilitation actions that would occur as part of the proposed project are listed below:

- Pump plant modifications and replacement of discharge pipes

- Filling and sealing of existing toe of levee
- Bank protection work
- Scour erosion
- Construction of a new pump plant
- Construction laydown areas

No construction would occur in the Ohio River or any other local water courses in the area, in relation to the proposed project. Work to be performed would be to rehabilitate the levee and pumping plants.

Investigations completed by the Corps found that many threatened or endangered species have been recorded within McCracken County. Freshwater mussel species such as the fatpocketbook, the orangefoot pimpleback, the pink mucket, and the ring pink freshwater mussels have known occurrences recorded within McCracken County. The clubshell, the rough pigtoe, and the fanshell mussel species have potential for occurrence within the county based upon their historic range. Other endangered or federally protected species that have been known to occur or have the potential to occur within the project area due to historic range include the Indiana bat, interior least tern and bald eagle.

The Corps would greatly appreciate the U.S. Fish and Wildlife Service's comments to the level of concern for endangered, threatened, or candidate species that maybe directly or indirectly affected by the proposed action. If you have any other questions or comments, please contact Andrea O'Bryan at (502) 315-7453 or by email andrea.m.obryan@usace.army.mil.

Sincerely,

Chief, Environmental Resources
Planning Branch

Enclosure

Figure 1 – Proposed Project Location.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Kentucky Ecological Services Field Office
330 West Broadway, Suite 265
Frankfort, Kentucky 40601
(502) 695-0468

April 29, 2010

Mr.
Chief, Environmental Resources – Planning Branch
U.S. Army Corps of Engineers
P.O. Box 59
Louisville, Kentucky 40201-0059

Subject: FWS# 2010-B-0478; Proposed Paducah, Kentucky Local Flood Protection Project (LFPP) Rehabilitation Feasibility Study; McCracken County, Kentucky

Dear

We have reviewed your request for Service comments regarding the proposed action at Paducah, Kentucky along the left bank of the Ohio River. It is our understanding that repair, reconstruction, or replacement of some project components of the existing earthen and concrete floodwall, along with other flood protection features, are needed. Some of the actions would include: pump plant modification and replacement of discharge pipes; filling and sealing of existing toe of the levee; bank protection work; scour erosion; construction of a new pump plant; and construction of laydown areas. No construction would occur in the Ohio River or any other local water courses in the area, in relation to the proposed project. Work to be performed would be to rehabilitate the levees and pumping plant.

We believe the federally listed species that you should address regarding this project include the following freshwater mussel species: fat pocketbook, *Potamilus capax*; orangefoot pimpleback, *Plethobasus cooperianus*; and pink mucket, *Lampsilis abrupta*. In addition, the Indiana bat, *Myotis sodalis*; and interior least tern, *Sterna antillarum athalassos*; should be addressed if habitat for these two species exists in the project's footprint or if such habitat would be indirectly impacted.

For your information, there are also at least one or two species of candidate mussels that likely occur in the immediate area of the project. They are the sheepnose, *Plethobasus cyphyus*, and spectaclecase, *Cumberlandia monodonta*. It is not necessary for you to consult with the Service on these species at this time; however, be aware that at some future time it is likely they will need to be addressed.

Since the proposed project lies largely within areas that have been subjected to intensive disturbances due to urbanization and agriculture, it is unlikely that the project will have significant adverse effects on local fish and wildlife resources. We recommend, however, that

you address the likely impacts of the project on the aforementioned federally listed species and coordinate that analysis with us as part of informal Endangered Species Act consultation.

If you have any questions, please contact

Sincerely,

Field Supervisor

GWY.D DBP
CHEROKEE NATION®

ᏅᏂᏅᏁ
Chad "Corntassel" Smith
Principal Chief

ᏁᏓᏍᏕ ᏁᏃᏂᏕ
Joe Grayson, Jr.
Deputy Principal Chief

November 2, 2010

Department of the Army
Theresa Beckham
P.O. Box 59
Louisville, KY 40201

To Whom It May Concern:

Thank you for the invitation for Principal Chief Chad Smith to attend the Informal Meeting. I am sorry to inform you that due to prior commitments Chief Smith will not be able to attend.

Once again, thank you for the invitation. Good luck with your meeting. I hope it is very successful. If you have any questions, please do not hesitate to contact me in the office at (918) 453-5204.

Sincerely,

Executive Assistant
Office of the Principal Chief

Dear _____

The U.S. Army Corps of Engineers Louisville District and City of Paducah invite you to attend an informal public meeting Monday, November 8th on the rehabilitation and reconstruction of the City of Paducah's floodwall/levee system referred to as the Paducah, KY Local Flood Protection Project. The meeting will be held at Paducah City Hall, 300 South 5th Street, Paducah, Kentucky from 6:00-7:30 p.m.

The meeting will include presentations to advise the public that the project will consist of rehabilitation work to the existing floodwall/levee including repair/replacement of pumping station equipment, concrete, and other appurtenant features. Part of the project includes a new pump plant to address an interior flooding situation. During the meeting, the Corps will explain the reconstruction project and ask for public comments.

Paducah's flood protection system was built between the years of 1939-1949. Repair and rehabilitation are critical to keep the system operating as designed during a flood or high water event. In 2007, assessment and rehabilitation work began to extend the life of the corrugated metal pipes running through the floodwall. The pipes were restored using the slip-lining method.

The draft feasibility report and additional information about the Paducah project are available for public review at the following website http://www.lrl.usace.army.mil/poi/default.asp?mycategory=449. The draft feasibility report will be available for review on this website for a period of 30 days. The draft will also be available at the McCracken County Public Library, 555 Washington Street, Paducah, KY 42003.

Please send comments for the public meeting and/or the feasibility report by November 29, 2010 to

Theresa Beckham

Project Manager, Ohio River Shoreline

Paducah, KY, Feasibility Study

P.O. Box 59

Louisville, KY 40201-0059

or email

For more information please call

Signed _____

Paducah Mailing List

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Bill.Caldwell@ky.gov

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State Historic Preservation Officer
Kentucky Heritage Council
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Honorable Mitch McConnell
United States Senate
601 W. Broadway, Rm 630
Louisville, Kentucky 40202

Honorable Rand Paul
United States Senate
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Honorable Steve Beshear
Governor of Kentucky State Capitol
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Governor's Office for Local Development
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William Straw
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Atlanta, GA 30341

Honorable Whitfield
U.S. House of Represenatives
301 Cannon House Office
Washington DC 20515-1701

Doug Harnice
Deputy Judge/Executive
300 South 7th Street
Paducah, KY 42003-1700
270-444-4707

Bill Paxton
Mayor
300 S 5th St
Paducah, KY 42003-1527

Richard Abraham
Commissioner
300 S 5th St
Paducah, KY 42003-1527

Carol Gault
Commissioner
300 S 5th St
Paducah, KY 42003-1527

Gayle Kaler
Commissioner
300 S 5th St
Paducah, KY 42003-1527

Gerald Watkins
Commissioner
300 S 5th St
Paducah, KY 42003-1527

Jonathan Perkins
City Manager
300 S 5th St
Paducah, KY 42003-1527

Mr. Steve Coleman
Director
Division of Conservation
Kentucky Natural Resources
And Environmental Protection Cabinet
Capitol Plaza Tower, 5ht Floor
Frankfort, Kentucky 40601

Mr. Loyd Cress
Commissioner
KY Dept for Environmental Protection
14 Reilly Road, Ash Building
Frankfort, Kentucky 40601

Mike Hardin
Kentucky Dept. of Fish & Wildlife Resources
#1 Game Farm Road
Frankfort, Kentucky 40601

Tamara Brock
City Clerk
P.O. Box 2267
Paducah, KY 42002-2267
270-444-8506

Doug Harnice
McCracken County Fiscal Court
300 South 7th Street
Paducah, KY 42003

Name 1: Greeting CC:	Name 2:	Agency/Tribe:	Address 1:	Address 2
Mr. Scott Miller Gov. Miller Karen Kaniatobe	Govenor	Absentee-Shawnee Tribe of Indians of Oklahoma	2025 S. Gordon Cooper Drive	Shawnee OK 74801-9381
Ms. Robin Dushane Ms. Dushane Glenna Wallace	Cultural Preservation Officer	Eastern Shawnee Tribe of Oklahoma	127 West Oneida	Seneca, MO 64865
Mr. Ron Sparkman Chairman Sparkman Kim Jumper	Chairman	Shawnee Tribe	P.O. Box 189	Miami OK 74355
Mr. Kerry Holton President Holton Tamara Francis	President	Delaware Nation of Oklahoma	P.O. Box 825	Anadarko, OK 73005
Mr. Thomas Gamble Chief Ganble Joshua Sutterfield	Chief	Miami Tribe of Oklahoma	P.O. Box 1326	202 S. Eight Tribes Trail Miami, OK 74355
Mr. John P. Froman	Chief	Peoria Indian Tribe of Oklahoma	P.O. Box 1527	Miami, OK 74355
Mr. Chadwick Smith Chief Smith Richard Allen	Principal Chief	Cherokee Nation of Oklahoma	P.O. Box 948	Tahlequah, OK 74465
Mr. Mitchell Hicks Chief Hicks Russell Townsend	Principal Chief	Eastern Band of Cherokee Indians	P.O. Box 455	Cherokee, NC 28719
Mr. George Wickliffe Chief Wickliffe Lisa Stopp	Chief	United Keetoowah Band of Cherokee	P.O. Box 746	Tahlequah, OK 74464-0746

Mr. Bill Anoatubby Gov. Anoatubby Julie Ray	Govenor	Chickasaw Nation of Oklahoma	P.O. 1548	Ada, OK 74821-1548

NEWS RELEASE

October 25, 2010
CITY OF PADUCAH, KY

Contact:
Public Information Officer
Phone:
Fax:

U.S. Army Corps of Engineers to Hold Public Meeting About Floodwall on November 8

(PADUCAH-KY)--The U.S. Army Corps of Engineers is asking for public comments regarding the rehabilitation and reconstruction of the City of Paducah's floodwall referred to as the Paducah, KY Local Flood Protection Project. **A public meeting will be held at City Hall, 300 South 5th Street, on Monday, November 8, 6:00 p.m.-7:30 p.m.** During the meeting, the Corps will explain the reconstruction project and ask for public comments.

The project consists of rehabilitation work to the existing floodwall/levee including repair/replacement of pumping station equipment, concrete, and other appurtenant features. Part of the project includes a new pump plant to address an interior flooding situation.

Paducah's flood protection system was built between the years of 1939-1949. Repair and rehabilitation are critical to keep the system operating as designed during a flood or high water event. In 2007, assessment and rehabilitation work began to extend the life of the corrugated metal pipes running through the floodwall. The pipes were restored using the slip-lining method.

The draft feasibility report and additional information about the Paducah project are available for public review at the following website http://www.lrl.usace.army.mil/poi/default.asp?mycategory=449. The draft feasibility report will be available for review on this website for a period of 30 days.

Please send comments for the public meeting and/or the feasibility report by November 29, 2010 to

Project Manager, Ohio River Shoreline
Paducah, KY, Feasibility Study
P.O. Box 59
Louisville, KY 40201-0059

or email

###

Agenda for Public Meeting at Paducah, KY

City Hall – 300 South 5th Street
8 November 2010 – 6:00 – 7:30 (CDT)

6:00-6:10 Opening Remarks – COL Landry (Rick Murphy will introduce him)
6:10-6:25 Local Sponsor/Partner Remarks – Rick Murphy
6:25-6:55 Overview of Reconstruction Project, Path Forward – Theresa Beckham
6:55-7:20 Questions/Comments from Public – Rick Murphy Facilitating Discussion
7:20-7:30 Closing Remarks Rick Murphy

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LOCAL FLOOD PROTECTION PROJECT)
RECONSTRUCTION PROJECT AND
DRAFT FEASIBILITY REPORT

US Army Corps of Engineers
Louisville District

PROPOSED PLAN

Nov. 8, 2010

We appreciate your questions and comments concerning the Ohio River Shoreline, Paducah, Kentucky (Paducah, Kentucky LFPP) Reconstruction Project and Draft Feasibility Report.

Write your comments below, or send us a letter. Our mailing address is on the reverse side. Your comments must be received no later than Nov.30, 2010. Comment sheets can also be turned in prior to leaving the public meeting.

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Your signature

Please provide your name and address on the reverse.

Optional information

(so we can send you announcements in the future):

Name: _____

Address: _____

_____

City, State, ZIP: _____

Business Phone # _____

Home Phone # _____

E-mail address: _____

fold here

Mailing Options:

1. **Simply fold this sheet and mail to the address below (attach correct postage).**

or

2. **Leave with one of the attendants at the public meeting on Nov. 8.**

fold here

Your complete return address:

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TAPE HERE

First-class postage required

TO:

U.S. Army Corps of Engineers
P.O. Box 59, Room 708
Louisville, KY 40201-0059

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LOCAL FLOOD PROTECTION PROJECT)
RECONSTRUCTION PROJECT AND
DRAFT FEASIBILITY REPORT
INFORMATION SHEET

US Army Corps of Engineers
Louisville District

- **Reconstruction Draft Feasibility Report is available for review at the following locations:**
  - Website: http://www.lrl.usace.army.mil/poi/default.asp?mycategory=449
  - McCracken County Public Library
    555 Washington Street
    Paducah, KY 42003
  - City Hall
    300 South 5th Street
    P.O. Box 2267
    Paducah, KY 42002-2267
- **Questions can be directed to:**
  -
  -
- **Information on the US Army Corps of Engineers Levee Safety Program:**

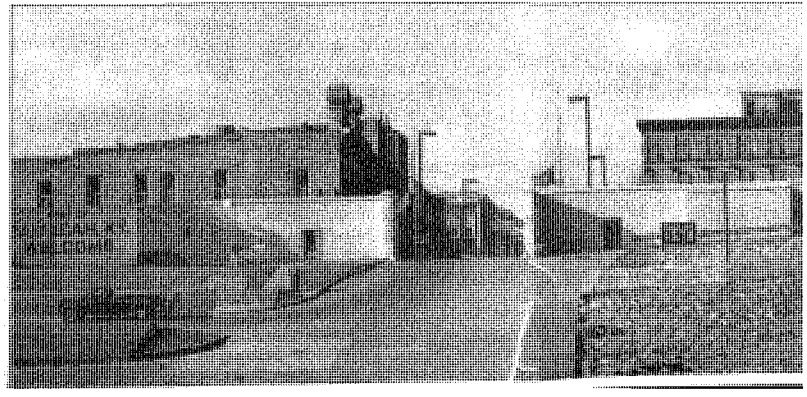
  http://www.usace.army.mil/leveesafety/Pages/main.aspx

TEAM COCO REJOICE: Conan O'Brien begins hosting new TBS late-night show. | 1

The Paducah Sun

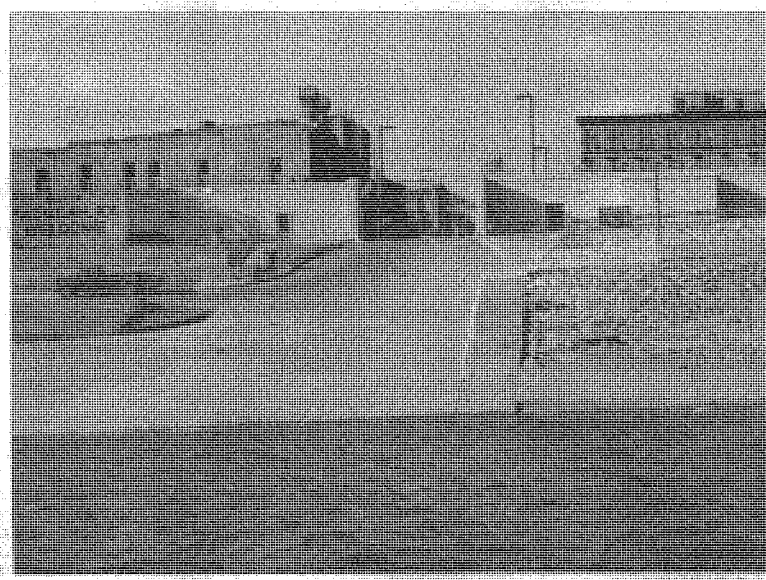
TUESDAY, November 9, 2010 www.paducahsun.com Vol. 114 No. 313

Another step forwar



Paducah Sun
www.paducahsun.com Vol. 114 No. 313

Another step forward

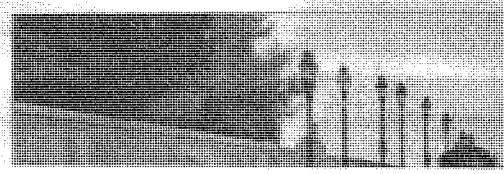


The historic buildings of downtown Paducah are seen beyond the riverfront floodwall Friday. The U.S. Army Corps of Engineers estimates repairs to the floodwall would cost $18.7 million.

Corps estimates $18.7M to repair floodwall

BY MICHAEL DE LOS REYES
mdelosreyes@paducahsun.com

The U.S. Army Corps of Engineers suggested during Monday night's presentation to City Hall that it could cost up to $18.7 million to repair or replace components of the Paducah



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SCHOOL | 14A

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e FUNDS | 14A

LANCE DENNEE | The Sun

The historic buildings of downtown Paducah are seen beyond the riverfront floodwall Friday. The U.S. Army Corps of Engineers estimates repairs to the floodwall would cost $18.7 million.

Corps estimates $18.7M to repair floodwall

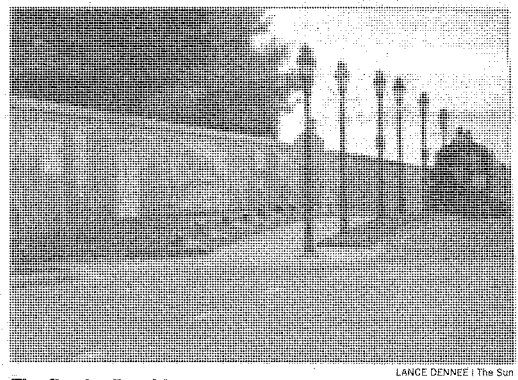
BY MICHAEL DE LOS REYES
mdelosreyes@paducahsun.com

The U.S. Army Corps of Engineers suggested during Monday night's presentation in City Hall that it could cost up to $18.7 million to repair or replace components of the Paducah floodwall.

Murphy

Corps project manager Theresa Beckham said the floodwall is working properly but outdated water pumps and pump motors should be replaced to minimize future flooding from the Ohio and Tennessee rivers.

"These are typical problems of an aging infrastructure," Beckham said. Repairing or replacing those components as quickly as possible would prevent the more expensive cost of a citywide flood, she said.



LANCE DENNEE | The Sun

The floodwall and levees protect about 12,000 acres in Paducah, Corps of Engineers project manager Theresa Beckham said.

She also recommended a new pump plant at 2300 N. Eighth St. and the installation of a water discharge pipe at 2059 S. Fourth St. to minimize flooding in the city.

About 12 miles of floodwall and

Please see **FLOODWALL** | 14A

FLOODWALL: Estimate would give Congress a cost ceiling for the project, city engineer said

CONTINUED FROM 1A

levees protect about 12,000 acres and 65,000 people in Paducah, Beckham said.

City Engineer Rick Murphy said the corps' report is among several steps toward obtaining federal funding for the project. The federal government would bear about 65 percent of the cost, while Paducah would pay the remaining 35 percent.

"This (the $18.7 million price tag) is the worst-case scenario in terms of cost," Murphy said.

The estimate would give Congress, which must approve the federal government's participation in the repairs, a cost ceiling for the project, Murphy said.

River cities, like Paducah and Louisville, must compete for federal financing for floodwall projects, he said.

If Congress approved and allocated project funding, the city would ask the state for financial assistance to defray project costs, Murphy said.

Paducah already completed about $2.1 million in repairs when it corrected two structural problems over the last two years, Murphy said. In 2009, the city laid a thick plastic liner and heavy boulders to prevent the river from causing erosion problems near the flood wall. In 2008, the city inserted durable plastic liners into corroded metal pipes used to carry floodwater.

The federal government would likely give Paducah financial and political credit for making those repairs, said Col. Keith Landry, Corps commander for the Louisville district.

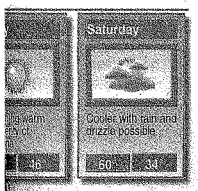
Objectively, the federal government will consider the cost-and-benefit of using tax dollars on numerous floodwall projects, Landry said.

"But subjectively, the government will consider which cities did maintain and repair their infrastructure against those who did not," he said.

Landry examined Paducah's entire flood protection system and commended Mayor Bill Paxton, who attended the presentation, for the work completed.

The city's actions will be included in the district's report to Corps headquarters and to Congress in the coming months, Landry said.

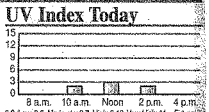
Contact Michael de los Reyes, a Paducah Sun staff writer, at 270-575-8652.



National Summary

...e rain will linger in New England ... while the South stays sunny and ... A bit of rain will also dampen the ...ern High Plains, with snow showers ...e Rockies. Rain will also fall along ...acific Northwest coast and will reach ...d by the afternoon. Meanwhile, the

UV Index Today



0-2, Low; 3-5, Moderate; 6-7, High; 8-10, Very High; 11+, Extreme. Values indicate the exposure to the sun's ultraviolet rays.

Regional Cities

City	Today Hi	Today Lo	Today W	Wed. Hi	Wed. Lo	Wed. W
Belleville, IL	70	45	s	74	52	s
Bowling Grn., KY	70	39	s	73	41	s
Bristol, TN	65	29	s	69	30	s
C. Girardeau, MO	70	43	s	71	45	s
Carbondale, IL	69	42	s	72	47	s
Chattanooga, TN	72	37	s	76	39	s
Columbia, MO	70	49	pc	67	50	pc
Evansville, IN	68	43	s	72	44	s
Ft. Smith, AR	75	52	pc	71	53	s
Indianapolis, IN	66	43	s	68	46	s
Jackson, KY	67	43	s	73	43	s
Jackson, TN	72	42	s	74	42	s

USACE – LRL Public Affairs News Article - 30 November 2010

Study could pave way for the reconstruction of the Paducah flood protection project

On Nov. 8 the Louisville District Corps of Engineers (COE) and the City of Paducah, the non-Federal sponsor, hosted a public meeting on the reconstruction of the Ohio River Shoreline, Paducah, KY Reconstruction Project, (originally the Paducah, KY. Local Flood Protection Project).

The public meeting was held to explain the Corps' recommendations of the feasibility study on the reconstruction/rehabilitation of the local flood protection project. Public review of the draft feasibility report was completed on Nov. 30. Headquarters review of the document will be completed by 3 December.

"Your voice will be heard," Project Manager Theresa Beckham assured attendees. "All of the public comments will be addressed in the report."

The $19 million project will consist primarily of rehabilitation of a more than 60-year-old project including reconstruction of deteriorated components that are beyond their service life, and a new pump plant to address interior flooding. The reconstruction project will be within the existing footprint of the original flood protection project (construction of the original project was completed in 1949), requiring minimal acquisition of property (primarily for access easements).

The existing 12.2-mile flood protection project minimizes flood risk for more than 11,000 acres in the City of Paducah and helps to minimize risk for more than 20,000 people who live behind the levee system, as well as 65,000 people that would be affected economically due to industry and residences located in this area. Risk of flooding can't be totally eliminated. However, the Corps mission is to minimize risk as much as possible.

"This levee system is so important," Beckham said. "What you're doing as a community is partnering with the U. S. Army Corps of Engineers to repair the levee system and to bring it up to current design criteria. This will provide continued and improved flood risk management for your community."

Beckham briefed the attendees on the project scope, benefits, cost and schedule as well as the Corps' recommendations. The Corps suggests the reconstruction of the existing project to include replacement

and/or repair of pumps and pump motors, slip-lining of corrugated metal pipes, bank stabilization, construction of a permanent discharge pipe at the Woodward Hollow site, and the addition of pump plant No. 14 on 8th St.

"We have to get authorization and appropriation so we can get the work done," District Commander, Colonel Keith Landry said. "What you see today is just sort of the first stage."

Paducah City Engineer Rick Murphy referred to a photo of a severely corroded corrugated discharge pipe and explained to attendees that "the justification [for the reconstruction] is all in one picture."

Additionally, Corps representatives praised the City of Paducah for being a responsible and diligent sponsor by maintaining and supporting the project. "We're very happy that the City of Paducah is a great partner," Landry said.

"The sponsor spent an average of $73,000 a year, between 1994 and 2006, for necessary replacement of system components to improve the reliability of the system. These expenditures were in addition to the annual average of $500,000 for normal operations and maintenance of the levee system" Beckham said.

The city had previously completed the slip-lining of 37 severely corroded discharge pipes throughout the levee system. Without the proposed reconstruction project, the cost of pipe slip-lining would be the sole responsibility of the City of Paducah. "That's a cost of $2.1 million."

"We have to put our best foot forward so we can move forward," Murphy said.

Prior to the meeting, Louisville District COE staff visited ten locations along the levee system/project including underground canned pump plants; sections of the floodwall with deteriorated water stops; slip-lined discharge pipes in the levee; Bee Branch sluice gate structure; several closures in the floodwall proposed to be permanently sealed; antiquated components in pumping plants; and the largest pump plant in the system, Pump Plant No. 2, where Colonel Landry was lowered into a confined space entry wet-well to see first-hand the condition of the deteriorating components.

Project Delivery Team Members' Qualifications

Position	Biography
P.M.P., Project Manager	Project Manager has been in the Louisville District for 31 years with combined Dam Safety, Water Management, Geotechnical, Environmental, and Project Management experience in the Louisville District and is a registered Project Management Professional in Kentucky. She has responsibility for levee rehabilitation, flood risk management, and environmental infrastructure projects.
GIS Specialist	GIS Specialist has been a GIS Specialist in the Hydrology and Hydraulics Section of the Civil Engineering Branch for the Louisville District, USACE for six years. She has a BS in Geography with a concentration in Environmental Analysis from the University of Louisville in 2003.
P.E., Electrical Engineer	Electrical Engineer has been in the Electrical Engineering Section of the Design Branch for the Louisville District, USACE since June, 2001. Prior to this position, he was an Electrical Engineer for twelve years with the Public Works Department at a Navy industrial facility, and worked in the private sector for approximately three years. He earned a BSAS from the University of Louisville in 1984 and has been a licensed Professional Engineer since 1994.
P.E., Senior Hydraulic Engineer	Senior Hydraulic Engineer has been in the Civil Engineering Branch of the Louisville District for 24 years. During this time he has been involved with a wide range of hydrologic and hydraulic studies and projects consisting of bank stabilization, construction of new levee's, evaluating existing levee/floodwall systems, stream channel modifications, and evaluation of reservoirs and detention basins. Prior to this position he worked for 1 year in the Construction Division of the Louisville District managing EPA construction grants for wastewater systems. He received a Masters of Engineering Degree in Civil Engineering in 1984 from the University of Louisville and has been a registered Professional Engineer since 1989.
P.E., Project Engineer/Civil Engineer	Project Engineer/Civil Engineer has worked in Engineering Division for the past fifteen years for the Huntington and Louisville Districts, USACE. She has served as a Project Engineer for the past five years. Prior to this position she worked five years in Design Division at the WV Division of Highways. She received a BS in Civil Engineering from Virginia Tech in 1990 and has been a registered Professional

Position	Biography
	Engineer since 1997.
Supervisory Archaeologist	Supervisory Archaeologist has been in the Environmental Section of Planning Branch for the Louisville District-U.S. Army Corps of Engineers. He has been with the District and Agency for nine years. He has a Master of Arts in North American Archaeology, emphasizing the lower Ohio and Mississippi river valleys, from the University of Memphis. He has worked professionally as an archaeologist in the field of cultural resource management for 20 years.
Regional Economist	Regional Economist has been in the Plan Formulation Section of the Planning Branch for the Louisville District USACE for one year. P rior to this position, he was an Economist in the aforementioned Planning Branch for six years. He has a BA in Economics from Bellarmine University in 1999.
City Engineer & Public Works Director, Sponsor for Paducah LFPP P.E., City Engineer & Public Works Director, Sponsor for the Paducah LFPP (cont'd.)	In May 1996, the sponsor was recruited by the then sitting Mayor and the Paducah City Commission to become the City of Paducah's City Engineer. U pon becoming City Engineer, he assumed all the responsibilities of the Engineering Department Administrations, Floodwall Operations, Floodplain Administrator, Street Department Operations, Storm, Sanitary, and Combined Sewers including their collections and treatment. He would not serve an entire year before Ohio River Flooding caused by a s ingle rainfall event that occurred March 1, 1997 would test him. Under his leadership the City of Paducah would erect 17 M ovable Closures within an initial 10 hour period followed by 22 a dditional closures as river elevation forecasts dictated. P aducah records show the Ohio River crested at 338.05 ORD on March 10, 1997. City forces installed 39 of its 56 Movable Closures preventing the City of Paducah from any serious impacts resulting from the 1997 Flood. Since the 1997 Flood, He has been working closely with the USACE Louisville District, Cincinnati Division and Washington DC Headquarters for the Paducah, Kentucky LFPP's for its restoration and rehabilitated to the original level of protection. For the past 12 years, He has served as the Paducah LFPP Sponsor's Representative to the USACE and to Paducah, KY's federally elected officials. R ecent LFPP's accomplishments under his leadership include: Initiated a collaborative effort for the development of a USACE nationally recognized Guideline to restore and rehabilitate CMP's in levees eliminating the need for excavation; Acquired an Exception to Policy/Memorandum of Understanding from the ASA, November 2008, in association

Position	Biography
P.E. , City Engineer & Public Works Director, Sponsor for the Paducah LFPP (cont'd.)	with the LFPP's Corrugated Metal Pipe Rehabilitation; Completed "Slip Lining and Grouting" 37 large gravity CMPs for the Paducah LFPP during the development of this Feasibility Report; Assisted USACE Louisville District personnel to develop criterion and "Scope of Work, Proof Test For Slip Lining of CMPs, Paducah LFPP CMP Restoration Project" to collect necessary data for verification of the methods and techniques to restore CMPs in levee systems are valid such that the USACE could write/adopt "New USACE Guidelines" for the use of all USACE districts. His recent accomplishments include his recent appointment by the Board of Commissioners to serve in an expanded role in city government as the City Engineer & Public Works Director. His recent success with his new appointment coupled with his many accomplishments over the past several years was awarded "Kentucky League of Cities, KLC's inaugural "City Employee of the Year for the State of Kentucky." Prior to joining the City of Paducah he began his Engineering career with Florence & Hutcheson in 1981. In 1984 he moved to Lexington, Kentucky to finish his B.S.C.E. at the University of Kentucky. While attending UK, he worked for American Engineering, Lexington, Kentucky where he assisted with the design of several heavy highway projects. In 1986, he completed his B.S.C.E. Degree from the University of Kentucky and assumed an Engineering Design position with GRW Engineers in Lexington, Kentucky. While working for these engineering firms, he participated in several large projects including Louisville's Watterson Expressway I-264/Crittenden Drive Interchange, I-264/I-64 Interchange, Georgetown Bypass Georgetown, Kentucky in conjunction with the construction of the Toyota Automobile Manufacturing Plant, and Airfield Improvements for 130th Tactical Airlift Group West Virginia Air National Guard, Charleston, WV for C-130 Hercules, C-141, and C-5A Galaxy cargo aircraft. In February 1987, he returned to Paducah, Kentucky where he assumed the position of a Structural Engineer/Heavy Highway Design Team Leader for Florence & Hutcheson, Inc. In 1991 he received his Professional Engineering License and became a Registered Professional Engineer in the states of Kentucky, Alabama, and Arkansas where he maintains these licensed registrations. Accomplishments while at Florence & Hutcheson include Louisville's Watterson Expressway Urban Diamond I-264/Poplar level Road assisted with structural analysis for Poplar Level bridge over I-264, Firms Lead Design Engineer

Position	Biography
	Louisville's Watterson Expressway I-264/US 60 (Shelbyville Road) including interchange geometry, structural analysis for interchanges P.C.I.B bridges, and multiphase maintenance of traffic sequencing for this project. He has completed and/or served as a Design Responsible Charge for, Non-Cannah Parkway, Memphis Tennessee I-85 Spartanburg South Carolina, and numerous other design assignments in Kentucky, Alabama, Arkansas, Tennessee, North Carolina, South Carolina, Virginia, and West Virginia until May 1996.
P.E., S.M.E. Project Engineer for Certification; Geotechnical Engineer GS-13 Levee Safety Subject Matter Expert P.E., S.M.E. Project Engineer for Certification; Geotechnical Engineer GS-13 Levee Safety Subject Matter Expert (cont'd.)	Project Engineer for Certification, Geotechnical Engineer, Levee Safety Subject Matter Expert has worked as a geotechnical engineer in the Geotechnical and Dam Safety Section of the Louisville District U. S. Army Corps of Engineers since 1985. Given her many years of experience and exposure to the vulnerabilities of levees and earthen dam structures, she has earned the confidence of the USACE to be considered a "Subject Matter Expert". She has worked on numerous Levee and Flood Control projects. Her expertise includes risk and reliability of existing levees per ETL 1110-2-556, levee eligibility inspections under ER 500-1-1 and EP 500-1-1, and levee flood fighting/emergency repairs. She is also tasked with working with LFPP sponsors and various professional consultants regarding the review and approval of permits to allow installation of utilities or construction features that are needed to support new infrastructure adjacent to flood control structures. Her review of the LFPP Sponsor's submittals to gain USACE approval of these permits includes a high level of complexity. Every submittal is unique in nature due to the need of the improvements having to pass under, over, or through existing levees/floodwall systems. She also has extensive knowledge for the design and construction of levees/floodwalls from the initial reconnaissance phase to the final construction phase. Her design experience includes slope stability analysis; most efficient and cost effective methods for slip-lining existing pipes through levee embankments; channel widening projects; finite element seepage analysis; bank protection and revetment; detention basin design; anchored sheet-pile walls; and borrow, and disposal site investigations. Her experience is also recognized and sought by other USACE districts as she is contacted regularly with requests for "In-House" quality assurance review of levees/floodwall designed outside the Louisville District. More recently she has become the Louisville District's lead on "Levee System Evaluations" of existing local flood protection projects, extensive writing of

Position	Biography
	specifications for levee/floodwall projects and designing closures over roads and railroads.
E.I.T., Geotechnical Engineer	Geotechnical Engineer has been in the Engineering Division for the Louisville District, USACE for nine years. She has a BS in Civil Engineering from the University of Louisville in 2001.
P.E., Chief, Hydrology & Hydraulic Design Section	P.E., Chief, Hydrology & Hydraulic Design Section has been the Chief of the Hydrology & Hydraulic Design Section for the past five years. Previous to this, he has been a h ydraulic engineer with the Louisville District for over 30 years starting his career with the Corps in 1972. He has a BS in Civil Engineering from Purdue University in 1972 a nd has been a registered Professional Engineer since 1977.
Team Lead, PPA, Survey and Support Team, GS-12	WORK EXPERIENCE: USAED, Louisville 05/23/2008 – Present Team Lead, PPA, Survey and Support Team, GS-12 Fort Campbell Real Estate Liaison, GS-12 07/01/2004 – 5/22/2008
Team Lead, PPA, Survey and Support Team, GS-12 (cont'd.)	Real Estate Appraiser, GS-11 12/16/2002 - 07/01/2004 J.M Waller and Associates, Inc. Project Coordinator, RPX Program 08/08/2002 - 12/16/2002 USAED, Louisville Recruiting Team, GS 5-9 11/19/1999 – 08/07/2002 EDUCATION AND TRAINING: Bachelor's Degree BGS, 1999, Indiana University (SE) Certificate in Supervision Management, 1999 Real Estate Appraisal Principles, April 2001 Real Estate Appraisal Procedures, April 2002 Basic Income Capitalization Course, June 2002 Income Capitalization Course, February 2003 General Applications, April 2004 Advanced Income Capitalization, June 2004

Position	Biography
	Uniform Standards of Professional Appraisal Practice, Nov 2004 General Market Analysis and Highest and Best Use, Nov 2007 U.S Army Material Command: Real Estate Disposal Management International Right of Way Association: Courses: 501,504, & 505, Sep 2005
Biologist	Biologist has been with the Corps for a short period. She began her work with the Louisville District Corps of Engineers in September of this year. She recently graduated in May 2009, with a BS in Biology from Campbellsville University.
E.I.T., Civil Engineer	E.I.T., Civil Engineer has been a Civil Engineer in the Geotechnical and Dam Safety Section of the Civil Branch for the Louisville District, USACE for one year. He was a Civil Engineer in the Civil Section of the Civil Branch for one year. Prior to working for USACE, he was employed in the construction industry for five years. He has a BS in Civil Engineering from the University of Louisville in 2008 and has been a registered Engineer-In-Training since 2008.
E.I.T., Electrical Engineer E.I.T., Electrical Engineer (cont'd)	Electrical Engineer in the Mechanical/Electrical Engineering Section of the Design Branch for the Louisville District, USACE for 2 years. Prior to this position, he was an Electrical Engineer for 14 months at a private environmental engineering consulting firm in Maryland. He has a BS in Electrical Engineering from Clarkson University in 2006 and has been an Engineer-In-Training (E.I.T.) since 2009.
C.C.E.T., Cost Estimator	He has been a cost estimator since August 1984, in the Cost Engineering Sections/Branch of the Louisville District U.S. Army Corps of Engineers. Preparing both military and civil works estimates for budgetary, interim, and final estimates in Excel spreadsheet and detailed MCACES formats using the appropriate databases. He has been a Certified Cost Engineering Technician since Jan 1996. P rimarily responsible for flood protection projects, and, as needed, military site work projects.

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION DRAFT FEASIBILITY REPORT

APPENDIX B ECONOMIC ANALYSIS

UPDATE PAGES with Updated Calculation of Economic Analysis (FY 11 Discount Rate)

These errata pages for the Economic Analysis (Appendix B) to the Ohio River Shoreline, Paducah, KY (Paducah, Kentucky LFPP) Reconstruction Draft Feasibility Report serve to provide an updated calculation of the economic analysis presented in the original report. The original report provided calculation and economic analysis of the study within a Fiscal Year 2010 (FY10) framework. These pages shall provide the same calculations and economic analysis within a Fiscal Year 2011 (FY11) framework. This framework consists of presenting previously calculated benefits and all appropriate costs in FY11 price levels as well as utilization of the FY11 federal discount rate of 4 1/8%. With the exception of the aforementioned modifications specifically highlighted above, all other economic assumptions and considerations from the original report remain unchanged.

As a result of updating the calculations and economic analysis within an FY11 framework, Future Without Project Conditions provide for an EAD of $8,386,000 while With Project Conditions produce an EAD of only $1,290,000. This difference represents total annual benefits of $7,096,000 resulting from the proposed Reconstruction action. When compared to total annual charges of $1,589,000 the resulting Benefit-to-Cost ratio is 4.5, which is well above unity. The Reconstruction plan calculated within an FY11 framework generates a Benefit-to-Cost ratio above unity and produces a positive net benefit ($5,507,000) to the Nation so it is therefore considered to be economically feasible and is viewed as the NED plan.

Table 1 displays the Project Cost Summary Report updated to FY11 price levels and Table 2 on the following page presents a numerical summary of the annual benefits and costs associated with the Reconstruction plan at FY11 price levels and the FY11 discount rate.

April 2011
Final Submittal
Revised September 2011

Table 1

Ohio River, Paducah, KY
Project Cost Summary Report (000's)
FY 2011 Price Levels

Description	Cost
Relocations	20.5
Pump Plant #1 (Noble Park)	417.1
Pump Plant #2 (Sixth Street)	1763.2
Pump Plant #3 (Park Ave)	258.2
Pump Plant #4 (Clay Street)	209.6
Pump Plant #5 (Harrison Street)	445.5
Pump Plant #6 (Clark Street)	725.8
Pump Plant #7 (Tennessee Street)	674.8
Pump Plant #9 (Husbands Road)	241.6
Pump Plant #10 (George Street)	130.2
Pump Plant #11 (Island Creek)	671.7
Pump Plant #12 (SE of Paducah)	454.5
Pump Plant #13	47.5
Pump Plant #14 (at Sta.111+67) Submersible 100 cfs Pump	1709.6
Levees	3787.9
Floodwalls	3150.0
Bank Stabilization	100.0
Planning, Engineering, and Design	1341.3
Construction Management	1341.3
Miscellaneous Items (Pumping Station)	1180.7
Lands and Damages	443.3
Total Construction Costs	$19,114.3

Table 2

Ohio River, Paducah, KY
Feasibility Study
Summary of Annual Benefits and Costs
FY 2011 Price Levels (x $1,000)
4 1/8% Interest Rate

Investment Cost	**Rehabilitation**
Construction First Cost	$19,114
Interest During Construction	$1,206
Total Investment Cost	$20,320
Annual Charges	
Interest & Amortization	$966
Operation & Maintenance	$623
Total Annual Charges	$1,589
Annual Benefits	
Structures	
-Residential	$4,946
-Public	$426
-Commercial	$2,624
Traffic Diversion	$84
Vehicles	
-Minivans	$29
-Pickups	$26
-Sedans	$110
-Sports Cars	$117
-SUVs	$24
Emergency Costs	$0
Total Annual Benefits	$7,096
Residual Expected Annual Damages	$1,290
Benefit vs. Cost Ratio	4.5 *
Net Benefits	$5,507

**A sensitivity analysis was performed to assess report recommendations against the changes in the discount rate. At 7%, the benefit to cost ratio is 3.3.*

The incremental justification of the pump plant at Station 111+67A, found in Section 11 of the original report, was also updated to current FY11 price levels for Addendum #1. For this analysis, Future Without Project Conditions provide for estimated EAD of $193,000. Total annual benefits for each alternative equal the difference between the Without Project EAD and the individual pump plant's residual EAD. Total annual benefits account for the expected annual damages that will be eliminated by the presence and operation of the respective pump plant in the study area. Residual EAD accounts for the respective amount of damages that the study area is expected to continue to experience even with the appropriate pump plant in place and fully operational. Total annual benefits and residual EAD's vary for each pump plant alternative considered in this effort. The 50 cfs pump plant at Station 111+67 produces total annual benefits of $119,000 and residual EAD of $74,000. The 100 cfs pump plant at Station 111+67A produces total annual benefits of $150,000 and residual EAD of $43,000. The 150 cfs pump plant at Station 111+67A produces total annual benefits of $159,000 and residual EAD of $34,000. The 200 cfs pump plant at Station 111+67A produces total annual benefits of $169,000 and residual EAD of $24,000. Total annual benefits are divided by total annual costs to determine each alternative pump plant's benefit-to-cost ratio (BCR). According to economic guidance, alternatives are not considered to be economically feasible unless they produce a BCR above unity, or 1.0. The resulting BCR for each alternative pump plant are as follows: 50 cfs pump plant – 1.6, 100 cfs pump plant – 1.5, 150 cfs pump plant – 1.3, and 200 cfs pump plant – 1.2. Each of the alternatives produces resulting BCRs which are considered to be economically feasible and justified. Net benefits for each alternative, which is the difference in total annual benefits and total annual costs, are next compared to each other so that the NED plan can be selected from the array of pump sizes. The NED plan is the alternative which maximizes net benefits to the Nation. The net benefits, as shown in Table 33, for each alternative are as follows: 50 cfs pump plant – $43,000, 100 cfs pump plant – $52,000, 150 cfs pump plant – $39,000, and 200 cfs pump plant – $28,000. From this comparison it is determined that the 100 cfs pump plant alternative is selected as the NED plan for pump plant #14 (at Station 111+67A). The 100 cfs alternative generates a positive BCR (1.5) and maximizes net benefits ($52,000) across all the alternative pump sizes. As per the requirements stated in memorandum "CECW-PB, 16 Aug 2005, Subject: Reconstruction of U.S. Army Corps of Engineers Structural Flood Damage Reduction Projects for which Non-Federal Interests are Responsible for Operation, Maintenance, Repair, Rehabilitation, and Replacement," the 100 cfs pump plant alternative is individually and incrementally justifiable. As a result, it is included in all With Project Reconstruction calculations in the previous section of this economic addendum. The numerical summary of the incremental analysis performed on the pump plant alternatives are shown in Table 3.

Table 3
Ohio River, Paducah, KY
Pump Station @ 111+67
Summary of Annual Benefits and Costs
FY 2011 Price Levels (x $1,000)
4 1/8% Interest Rate

Investment Cost	**50 cfs PS**	**100 cfs PS**	**150 cfs PS**	**200 cfs PS**
Construction First Cost	$1310	$1710	$2109	$2509
Interest During Construction	$27	$35	$43	$51
Total Investment Cost	$1337	$1745	$2152	$2560
Annual Charges				
Interest & Amortization	$64	$83	$102	$122
Operation & Maintenance	$12	$15	$18	$20
Total Annual Charges	$76	$98	$120	$142
Annual Benefits				
Structures				
-Residential	$1	$1	$1	$1
-Public	$0	$0	$0	$0
-Commercial	$117	$148	$157	$167
Traffic Diversion	$0	$0	$0	$0
Vehicles (Total)	$1	$2	$2	$2
Minivans	*$0.1*	*$0.1*	*$0.1*	*$0.1*
Pickups	*$0.1*	*$0.1*	*$0.1*	*$0.1*
Sedans	*$0.5*	*$0.6*	*$0.6*	*$0.6*
Sports Cars	*$0.6*	*$0.6*	*$0.7*	*$0.7*
-SUVs	*$0.1*	*$0.1*	*$0.1*	*$0.1*
Emergency Costs	$0	$0	$0	$0
Total Annual Benefits	$119	$150	$159	$169
Residual Estimated Annual Damages	$74	$43	$34	$24
Benefit vs. Cost Ratio	1.57	1.53	1.32	1.20
Net Benefits	$43	$52	$39	$28

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

APPENDIX B
ECONOMIC ANALYSIS

TABLE OF CONTENTS

1. ECONOMICS ANALYSIS PROCESS.....1
2. PLAN FORMULATION.....3
2.1 Planning Constraints.....3
2.2 Problems and Opportunities.....4
2.2.1 Problems.....4
2.2.2 Opportunities.....5
3. STUDY AREA DESCRIPTION.....6
3.1 Demographic Characteristics.....6
3.2 Study Area Characteristics.....7
4. DAMAGE CATEGORIES.....10
5. FUTURE WITHOUT PROJECT CONDITION.....11
5.1 Structure Inventory.....12
5.1.1 Structure Value.....13
5.1.2 Structure Location.....14
5.1.3 Structure Elevation.....15
5.1.4 Structure Depth-Damage Relationships.....16
5.2 Flood Damage Estimates.....18
5.2.1 HEC-FDA.....18
5.2.2 Structure and Content Damages.....19
5.2.3 Damages to Vehicles.....23
5.2.4 Traffic Diversion Costs.....26
5.2.5 Emergency Costs.....30
5.3 EQUIVALENT ANNUAL DAMAGES.....30
5.4 SUMMARY.....31
6. FUTURE WITH PROJECT CONDITION.....31
6.1 Structure Inventory.....32
6.1.1 Structure Value.....33
6.1.2 Structure Location.....33
6.1.3 Structure Elevation.....33
6.1.4 Structure Depth-Damage Relationships.....33
6.2 Flood Damage Estimates.....34

April 2011
Final Submittal
Revised September 2011

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

APPENDIX B ECONOMIC ANALYSIS

TABLE OF CONTENTS
(cont'd.)

6.2.1 HEC-FDA....34
6.2.2 Structure and Content Damages....34
6.2.3 Damages to Vehicles....41
6.2.4 Traffic Diversion Costs....46
6.2.5 Emergency Costs....46
6.3 EQUIVALENT ANNUAL DAMAGES....47
6.4 SUMMARY....49
7. INVESTMENT COSTS AND ANNUAL CHARGES....49
8. SUMMARY OF ANNUAL BENEFITS AND COSTS....50
9. ECONOMIC SUMMARY....52
10. PUMP PLANT #14A (at Sta. 111+67A) INCREMENTAL ANALYSIS....52
10.1. Structure Inventory....53
10.2. Structure Value....53
10.3. Structure Location....54
10.4. Structure Elevation....55
10.5. Structure Depth-Damage Relationships....55
10.6. FLOOD DAMAGE ESTIMATES....57
10.6.1. HEC-FDA....57
10.6.2. Structure and Content Damages....58
10.6.3. Damages to Vehicles....59
10.6.4. Traffic Diversion Costs....62
10.6.5. Emergency Costs....63
10.6.6. Equivalent Annual Damages....63
10.6.7. Future Without Project Condition....63
10.6.8. With Project Condition....63
10.7. INVESTMENT COSTS AND ANNUAL CHARGES....66
10.8. SUMMARY OF ANNUAL BENEFITS AND COSTS....66
10.9. ECONOMIC SUMMARY....68

April 2011
Final Submittal
Revised September 2011

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
APPENDIX B
ECONOMIC ANALYSIS

TABLE OF CONTENTS

LIST OF TABLES

Table No.	Title	Page No.
Table 1	Study Area Demographics	7
Table 2	Residential Structure Count	14
Table 3	Residential Structure Beginning Damage Depth	16
Table 4	Depth-Damage Relationship	
	Single-story, single-family, without basement	17
Table 5	Affected Structures by Event 4-23	20
Table 6	Value of Affected Structures by Event	21
Table 7	Estimated Structure Damages by Event	22
Table 8	Remaining Vehicles per Structure	25
Table 9	Per Structure Vehicle Values (2009 Price Level)	25
Table 10	Vehicle Damages ($1,000's) by Event	26
Table 11	Traffic Diversion Costs by Event	29
Table 12	Future Without Project EAD	31
Table 13	Affected Structures by Event (With Project)	35
Table 14	Value of Affected Structures by Event (With Project)	38
Table 15	Estimated Structure Damages by Event	39
Table 16	Vehicle Damages ($1000's) by Event	42
Table 17	Future With Project EAD (by ponding area)	47
Table 18	Future With Project EAD(With Project)	48
Table 19	Project Performance	48
Table 20	Project Cost Summary Report	50

April 2011
Final Submittal
Revised September 2011

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

APPENDIX B
ECONOMIC ANALYSIS

TABLE OF CONTENTS

LIST OF TABLES
(cont'd.)

Table No.	Title	Page No.
Table 21	Summary of Annual Benefits and Costs	51
Table 22	Depth-Damage Relationship Single-story, single-family, without basement	56
Table 23	Affected Structures by Event (Without Project)	58
Table 24	Value of Affected Structures by Event	59
Table 25	Estimated Structure Damages by Event Pump Plant 14A (Without Project)	59
Table 26	Per Structure Vehicle Values (2009 Price Level)	61
Table 27	Expected Annual Damages to Vehicles	62
Table 28	Future Without Project EAD (Without Project)	63
Table 29	50 cfs pump plant EAD (with Project)	64
Table 30	100 cfs pump plant EAD(with Project)	64
Table 31	150 cfs pump plant EAD(with Project)	65
Table 32	200 cfs pump plant EAD(with Project)	65
Table 33	Summary of Annual Benefits and Costs Pump Plant @ 111+67A	67

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

APPENDIX B
ECONOMIC ANALYSIS

TABLE OF CONTENTS

LIST OF FIGURES

Figure No.	Title	Page No.
Figure 1	Future Without Project Condition, 0.2% Chance (500 year) Event	9
Figure 2	Future With Project Condition Floodplain, 0.2% Chance Event (500 year)	10
Figure 3	HAZUS Vehicle Data	23
Figure 4	Traffic Diversion Cost Process	27
Figure 5	HAZUS Vehicle Data	60

April 2011
Final Submittal
Revised September 2011

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT

APPENDIX B ECONOMIC ANALYSIS

1. ECONOMIC ANALYSIS PROCESS

The federal objective of water and related land resources planning is to contribute to national economic development, consistent with protecting the Nation's environment, pursuant to national environmental statues, applicable executive orders, and other federal planning requirements. The Federal Government views prospective projects from a national point of view, including two requirements for federal participation. The primary requirement calls for plans to be formulated to alleviate problems and take advantage of opportunities in ways that contribute to study planning objectives and, consequently, to the Federal objective. The second requirement is to produce benefits which exceed costs. "Federal Interest" in the project is established by law and identified when both requirements are satisfied. Environmental Impacts are reduced with alternative designs or mitigated by replacement. The federal objective is stated in terms of an expressed desire to alleviate problems and realize opportunities related to the output of goods and services or to increased economic efficiency. The planning process consists of a series of steps that indentifies or responds to problems and an opportunity associated with the federal objective and specific State and local concerns, and culminates in the selection of a recommended plan. The process involves an orderly and systematic approach to making determinations and decisions at each step so that the interested public and decision makers in the planning organization can be fully aware of the basic assumptions employed; the date and information analyzed; the areas of risk and uncertainty; the reasons and rationales used; and the significant implications of other water resources improvements within the City, covering a period of analysis of 50 years.

The first step in the economic process is to delineate the affected area. Once the area is delineated, the next step is the definition of Existing Conditions and the Future Without-Project Condition (WOPC), which is the expected future condition in the study area assuming no federal action, and the baseline to which the effects of proposed plans and alternatives will be compared. This WOPC is a holistic inventory of current conditions prevailing in the study area and expected future conditions, one that incorporates hydrologic and hydraulic (H&H) characteristics, land-use and development, demographics, and environmental conditions and historic and cultural resources. Once the WOPC is established, structural and non-structural measures to address identified water resource issues are formulated and a With Project reconstruction plan is developed.

The With Project reconstruction plan is analyzed for its contribution to National Economic Development (NED), its potential environmental and cultural resource impacts, and the preference of the local sponsor, as represented by a "locally-preferred plan". The ultimate purpose of this Feasibility Study is to identify the NED plan. In so doing the water resource issues identified in the May 2000 Reconnaissance Study were studied in greater detail.

2. PLAN FORMULATION

2.1. PLANNING CONSTRAINTS

Planning constraints for the Ohio River, Paducah, KY Feasibility Study include all of the factors that could potentially limit the study effort's capacity to address identified flooding issues and that would need to be resolved or addressed, as well as potential problems the USACE and the local sponsor would wish to avoid throughout the course of the study. Planning constraints for the Ohio River, Paducah, KY Feasibility Study include:

Compliance with memorandum CECW-PB, 16 Aug 2005, Subject: Reconstruction of U.S. Army Corps of Engineers Structural Flood Damage Reduction Projects for which Non-Federal Interests are Responsible for Operation, Maintenance, Repair, Rehabilitation, and Replacement which states:

> *".....limited to examination of the reconstruction of the existing project with no change in its scope or function. Under this limited objective, evaluation would be limited to individual project features, (closure structures, pumping stations, gravity drains, relief wells, etc.) to establish the justification of reconstruction based on a comparison between the with and without reconstruction condition.....For levee and floodwall projects, the with and without reconstruction analysis should include consideration of both interior and exterior flooding....."*

Based on the language expressed in the memorandum above, this feasibility study is limited to the evaluation of a single modification plan, which will be titled "Reconstruction."

Availability and Sufficiency of Data
The definition of the WOPC, as well as a large component of the evaluation of measures and alternatives, depends on assumptions made by the study team, in particular hydrologic and hydraulic engineers and economists, however to a lesser extent assumptions are made in every stage of the process by every member of the project delivery team. In the case of both the H&H and economics analyses, predictive models are constructed to define existing conditions and forecast the prevailing conditions under various hypothetical future scenarios. To distill the complex systems these models attempt to forecast into a manageable form many simplifying assumptions must necessarily be made. These assumptions may be based in part on historical precedent, data gathered in the field and from other sources, and to some extent the intuition and experience of the study team. The most comprehensive, relevant and accurate data available are gathered; however these data can vary in quality and quantity.

Uncertainty in input variables is incorporated into the analysis, however not all uncertainties associated with assumptions made in the study are or can be

adequately quantified, and further, accounting for uncertainty is not the same as eliminating it. The lack of perfect information represents a constraint in that the analysis performed herein and the results and recommendations presented are only as reliable and accurate as the assumption that underlie them, and the study team must make every effort to make the best use of data available, as well as to effectively communicate these uncertainties.

Finally, to ensure quality, reliability and relevancy as well as to avoid adverse affects of any federal action, the conduct of Flood Risk Management Feasibility Studies is subject to all federal policies, guidelines and regulations governing water resources projects.

2.2. PROBLEMS AND OPPORTUNITIES

2.2.1. Problems

The objective of this feasibility study is to identify the NED plan and to further investigate the condition of the existing flood damage reduction project at Paducah, KY. Alternatives are constrained by the fact that reconstruction policy excludes any work on items that are considered to be normal operation and maintenance (O&M) responsibilities. The definition of reconstruction is documented in memorandum, CECW-PB, dated 16 Aug 2005, Paragraph e. (see Volume 4, REFERENCES). The definition states that:

> *"Reconstruction excludes design or construction deficiencies. Further, reconstruction is limited to addressing impediments that prevent a project from performing as authorized after all maintenance, as required by the project operation and maintenance manual and the Code of Federal Regulations, has been accomplished and any deficiencies resulting from a lack of maintenance have been addressed. Reconstruction will consist of addressing the major performance deficiencies caused by long-term degradation of the foundation, construction materials, and engineering systems that have exceeded their expected service lives and the resulting inability of the project to perform its authorized project functions. In addressing reconstruction needs, the latest design standards and efficiency improvements should be incorporated into the project."*

In March of 1997, major regional flooding occurred in the Ohio River Basin. For most of the basin, this flooding was the worst in over 47 years. Subsequent to this flood event, an annual government field inspection was performed and noted that the overall condition of maintenance of the project was in good shape. Prior to initiation of field inspections by personnel from both Louisville District Engineering Division and Parsons, Harland, Bartholomew, and Associates, Inc, a review was conducted of the annual inspection reports prepared by the Louisville District Emergency Operations Division. The scope of this study includes field structural, electrical, civil, mechanical, and civil evaluations/inspections of the floodwalls, closure structures,

corrugated metal pipes (CMP's), levees, and all necessary appurtenances. Parsons, Harland, Bartholomew, and Associates, Inc. performed the structural evaluation of the existing structural elements. Recommendations resulting from these detailed field investigations clearly identify the need for reconstruction of some major project features. Repair, reconstruction, or replacement of some project components was deemed necessary due to the fact that the components of the project were nearing the end of their useful design lives of 50 years. Corrugated metal drainage pipes and the pump switchgears are prime examples. Reconstruction of these components is costly, but vital since the components are critical to the viability of the project. Three CMP's collapsed as a result of the March 1997 flood event. These pipes were temporarily repaired (pipes were excavated and encased with concrete grout), but these temporary fixes resulted in unexpected O&M costs of over $19,000. Slip lining the existing CMP's is a feasible restoration as identified by the 905(b), USACE annual inspection reports from 1995 to present, USACE serving notice May 2006 to local sponsor instructing local sponsor to repair its pipes within 12 months, USACE serving notice to local sponsor that they are no longer eligible to participate in the P.L. 84-99 program and will not receive benefits provided by P.L. 84-99 September 2007 and is the requested action by the local sponsor. Switchgear and other electrical equipment, which is integral to the pump plant operation, even though adequately maintained, have become obsolete. A portion of the existing pumps revealed detrimental vibrations and/or malfunctions that necessitate repair, rehabilitation, or replacement. Operable switchgear, pumps, and pipes are crucial to the intended operation of the levee/floodwall system and its ability to provide the originally authorized level of protection.

2.2.2. Opportunities

The opportunity exists for reducing the above described flood-induced damages through reconstruction of the local protection project. Specific actions to be evaluated in this effort will be the rehabbing of 12 existing pumping plants by refurbishing and or replacing the existing pumps and motors; and the replacing the existing electrical switchgear with new; the construction of two gatewell structures; replacing two other multi-gate structures; slip lining 37 existing drainage structures; replacing both sides (16,200 lf) of the joint sealer at the all the waterstop joints in the existing T-Wall, L-Wall, and I-Wall units; and constructing a new waterstop joint at 14 existing, damaged waterstop joints in the existing flood wall. This reconstruction effort will involve almost all components, both large and small, of the Paducah Local Protection Project and will return it to a system that is fully functional, reliable, and consistent with current engineering standards.

An opportunity exists in the City of Paducah, KY to reduce annual flood risk and resulting property damages incurred by residents and resident business owners through this reconstruction measure. This analysis will identify a cost-effective action plan, one for which estimated annual benefits exceed annualized costs, and this plan would result in a net increase to National Economic Development.

3. STUDY AREA DESCRIPTION

3.1. DEMOGRAPHIC CHARACTERISTICS

Development within the study area is made up of residential, commercial, and public structures. Approximately 6,626 residences are represented inside the footprint of the 0.2%-chance (500-year) flood event, including single and multi-family residences and mobile homes. Approximately 701 commercial and 304 public structures are contained within the floodplain of the 0.2%-chance (500-year) flood event. The non-residential structure category in the study area is comprised primarily of small businesses, many of them service and retail oriented, a number of churches, hospitals and other medical facilities, schools, and a few light industrial properties. The current level of development and nature of the undeveloped terrain, largely consisting of ponding areas, significantly limit the potential for future development.

The population of the study area is predominantly white, high school educated and age 18 or older. Per capita income in the study area is approximately $18,417, with the median family income being approximately $34,092. In Table 1 below, demographic characteristics obtained from the 2000 US census for the study area are shown in greater detail. The study area spans the entire City of Paducah for which these census data were extracted.

Table 1 - Study Area Demographics

Sex	Percent
Male	45.5%
Female	54.5%
Age	
Median Age	
Under Five Years	6.5%
18 Years or Older	77.5%
65 Years or Older	20.3%
Race	
White	72.8%
Black or African American	24.1%
American Indian and Alaska Native	0.3%
Asian	0.6%
Native Hawaiian and Other Pacific Islande	0.1%
Some Other Race	0.5%
Two or More Races	1.6%
Housing	
Owner-Occupied Housing Units	52.9%
Renter-Occupied Housing Units	47.1%
Vacant Housing Units	10.6%
Education/Employment/Misc.	
High School Degree	76.6%
Bachelor's Degree or Higher	18.6%
Civilian Veteran	13.9%
Disability	27.3%
In Labor Force	53.4%
Below Poverty Level	22.4%

3.2. STUDY AREA CHARACTERISTICS

The city of Paducah is located in the northern portion of McCracken County, Kentucky, on t he left bank of the Ohio River, approximately 934 m iles below Pittsburgh, immediately below the mouth of the Tennessee River. T he City of Paducah is bounded on the north and northeast by the Ohio and Tennessee Rivers and lies within the alluvial valley of the Ohio River. A significant portion of its residential and commercial districts is situated on a level and relatively high floodplain terrace that extends to the low hills on the south. The average elevation of this alluvial terrace

is about 337 feet, msl. Island Creek flows through the eastern part of the city to join the Ohio River immediately below the mouth of the Tennessee River and Perkins

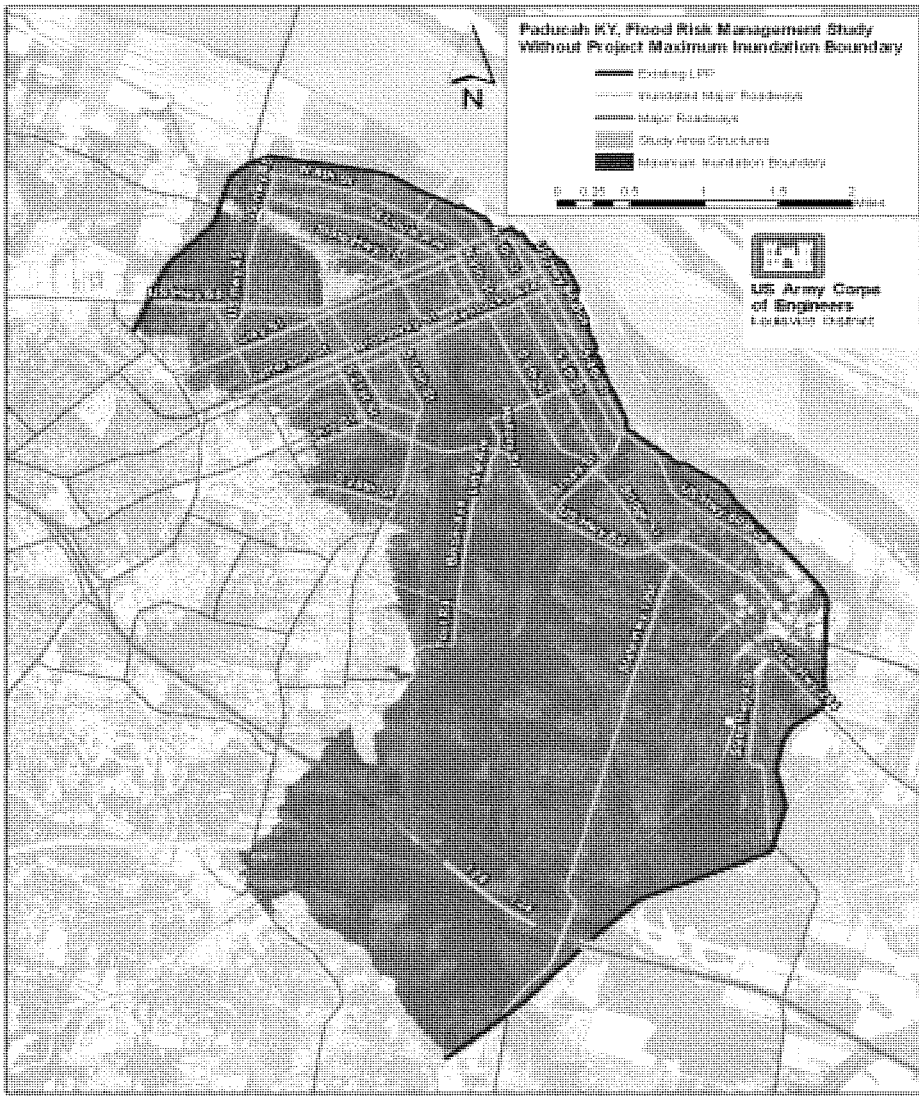
Creek is located along the western portion of the city. According to the U.S. Census Bureau, in 2000 Paducah had a population of 26,275. Paducah, KY is the official county seat of McCracken County.

The existing project/study area contains approximately 10,850 acres. The existing local protection project consists of approximately 48,700 feet of earthen levee, 15,870 feet of concrete flood wall, 12 pump plants, approximately 47 closure and service openings, 8 ramps, 5 diversion channels and other necessary appurtenances. The top elevation of the protective works is at elevation 350.06 msl.

For the purposes of this study, a total of 7,631 structures were included in the structure inventory and analyzed. Details of this process are explained in much detail in Section 7.1 of this appendix. Of those 7,631 structures, 6,626 of which were residential structures, or 86.8%. 701 structures, or 9.2%, were determined to be commercial structures while 304 structures, or 4.0%, were found to be public structures. Explanation of these category names (residential, commercial, and public) are also provided in Section 7.1 of this appendix.

Flood waters or otherwise high water surface profiles from the Ohio River begin to adversely impact the City of Paducah beginning at River Mile (RM) 931.0. As the Ohio River flow turns in a northwesterly direction and passes the City of Paducah, mostly to the east of the city, its out of bank flooding continues to adversely impact Paducah from RM 931.0 through RM 937.0. It was determined by the GIS specialist, in conjunction with the Hydraulics and Hydrology Engineer, that no damages within the city limits take place prior to RM 931.0 and past RM 937.0. These river miles serve to delineate the 0.2%-chance (500-year) floodplain. These river miles (931.0 through 937.0) were utilized for economic calculations involving the Future Without Project Condition. Further explanation of how each structure is associated with each river mile is discussed in Section 7.1 of this appendix. A map identifying this Future Without Project Condition 0.2%-chance (500-year) floodplain is shown in Figure 1.

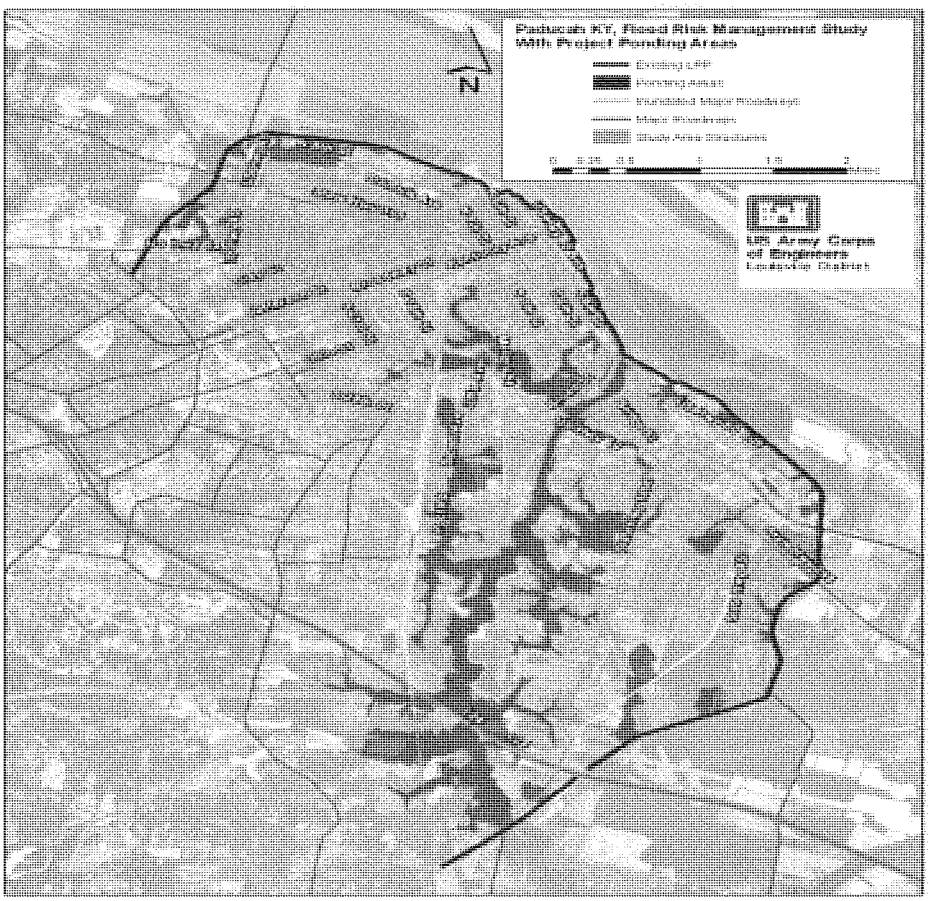
Figure 1 - Future without Project Condition Floodplain, 0.2%-chance (500-year) event



For the With Project Condition economic calculations, the 0.2%-chance (500-year) floodplain is reflected by the aggregation of twenty-six residual ponding areas which will remain after the project is constructed and complete. Further explanation of how

each structure is associated with each ponding area is discussed in Section 8.1 of this appendix. A map identifying this Future With Project Condition 0.2%-chance (500-year) floodplain is shown in Figure 2.

Figure 2 - Future With Project Condition Floodplain, 0.2%-chance (500-year) event (26 ponding areas)



4. DAMAGE CATEGORIES

The analysis of both without-project and with-project anticipated damages include damages or costs incurred from a range of categories. These categories are intended to capture the largest areas of impact to result from a flood event,

however they are not comprehensive in that they do not capture every cost or damage that could result from flooding in the area. Second-order effects are not considered. The categories analyzed for this study are:

Damages to Structures This damage category includes all damages caused to structures themselves, both residential and non-residential. Each structure is assigned a depth-damage relationship that estimates an economic loss as a percentage of the structure's value by depth of flooding.

Damages to Structure Contents This category includes all damages caused to a structure's contents. These contents can range from furniture and personal possessions for residences to industrial machinery or electronic equipment for commercial properties. Content damages are estimated similarly to structure damages.

Damages to Vehicles This category represents damages to vehicles not evacuated from the inundated area before a flood event occurs, instead assumed to be at either residences or places of employment. Vehicle damages use depth-damage relationships developed by the Institute for Water Resources.

Traffic Diversion Costs This category accounts for the operational and maintenance costs resulting from the extra mileage necessitated by traffic diversions due to flood events as well as operator and passenger delay costs. As major roadways are inundated and subsequently closed, traffic must be rerouted to less efficient routes, increasingly so when potential diversion routes are themselves inundated.

Emergency Costs Emergency costs represent additional costs due to a flood event including overtime hours for police, fire and other emergency responders, as well as the department of public works and other local agencies for flood fighting, debris clearance, and other extraneous activity initiated by a particular flood event.

5. FUTURE WITHOUT PROJECT CONDITION

According to memorandum CECW-PB, 16 Aug 2005, Subject: Reconstruction of U.S. Army Corps of Engineers Structural Flood Damage Reduction Projects for which Non-Federal Interests are Responsible for Operation, Maintenance, Repair, Rehabilitation, and Replacement, Paragraph g.

> *"Depending on the interest of the non-Federal sponsor, the feasibility study may be limited to examination of the reconstruction of the existing project with no change in its scope or function. Under this limited objective, evaluation would be limited to individual project features, (closure structures, pumping stations, gravity drains, relief wells, etc.) to establish the justification of reconstruction based on a comparison between the with and without reconstruction condition."*

The reliability of the Paducah, KY LFPP system was evaluated for the without project condition with floodwater to the top of the authorized level of protection. The condition and evaluation of the project features involved detailed analyses relative to deteriorating discharge pipes, underseepage, levee slope stability, floodwall and pump station stability, and interior drainage, and review of performance of the project during historical flood events which have occurred since the project was constructed. The highest flood loading on the Paducah LFPP system since the project was constructed occurred during the February 1950 event with a frequency of occurrence equal to a 1% chance (100-year) flood. No performance issues were recorded during this flood event. However, the project was removed from the Corps' Rehabilitation and Inspection Program (RIP) in September 2007, primarily as a result of the deteriorated condition of the project's discharge pipes. Additionally, the Paducah LFPP is highly vulnerable to failing equipment including pumps, pump motors and motor control systems largely due to their 60-years of service. If the pipes , which were at the point of imminent failure, and other deteriorating project features were not rehabilitated, the highest elevation along the line of protection where the system should not fail would be approximately equal to the toe of the levee which corresponds to less than a 99% chance (1-year) flood frequency. The pipe used to determine the frequency of the flood protection at the toe of the levee is located at Station 19+11B where the invert of the pipe under the centerline of the levee is approximate elevation 309 (NAVD). Based on this study analysis, the without project condition affords less than a 99% chance (1-year) flood protection to the City of Paducah, Kentucky. Additional discussion of this topic can be found in Section 2.2.1 of this appendix as well as in Volume 2, Appendix C (Engineering Evaluations) of this report. Also of particular interest regarding existing condition is the MOU agreement dated 17 November, 2008, which establishes the baseline existing project condition to be without any recent repair to the aforementioned discharge pipes.

5.1 STRUCTURE INVENTORY

The structure inventory for the Ohio River, Paducah, KY Feasibility Study is comprised of those structures, commercial, residential, and public, that fall within the 500 year or 0.2%-chance floodplain, as delineated by estimated hydrologic conditions as well as the Ohio River being at flood levels requiring the use of pumps to dispose of interior flood waters. In this way structures in and around the study area are limited to those that would receive damages in the lowest probability flood event or 'worst case scenario' considered in this analysis. To accomplish this, a structure footprint shapefile obtained from the City of Paducah was truncated using the ArcGIS program to the boundaries of the largest inundation area, the 0.2%-chance (500-year) floodplain. Any structures that intersected in any part with the inundation boundary layer were extracted and became the structure inventory.

As stated previously, this affected area contains 7,631 structures within the 0.2%-chance (500-year) floodplain. The array of structures included 6,626 residential structures, 701 commercial structures, and 304 public structures. For this study, residential structures include both single-family and multi-family housing units.

Commercial structures are comprised of all buildings which maintain some sort of business activity. This includes, but is not limited to, restaurants, grocery stores, office buildings, retail outfits, repair shops/garages, and industrial places of business. Public structures mostly consist of church buildings, hospitals, schools, and structures otherwise maintained by local officials. The structure inventory for both residential and non-residential structures and all associated data and characteristics are ultimately entered into the Hydrologic Engineering Center's Flood Damage Analysis program, or HEC-FDA (version 1.2.4 was used in this study), which will then use modeled flooding events to estimate damages to affected structures based on these characteristics and data. These data include, for each structure, an estimated depreciated replacement value, the stream on which the structure is located and the approximate stream station, the ground elevation of the structure and foundation height relative to this ground elevation, and finally a depth-damage relationship estimating damages to the structure as either a percentage of structure value or as a direct dollar figure for various stages of flooding. The computation process is described in greater detail later in this appendix. Depth-damage functions are referred to as occupancy types in HEC-FDA. The process of gathering these data is described in the following sections.

5.1.1 Structure Value

Residential and non-residential structure data required for FDA analysis can be subdivided into four primary components; the structure's depreciated replacement value, its location within the floodplain (stream name and stationing corresponding to that used in the H&H model), its elevation, and its susceptibility to flooding damages and the magnitude of those damages as represented by a depth-damage curve. The processes for developing these four components are detailed below.

Once the affected or potentially affected structures were isolated, more detailed data were assigned to the residential portion of the structure inventory from two sources, (1) from the City of Paducah via the Property Valuation Administrator's Office (PVA), and (2) from field surveys in the study area performed by Corps economists. Both of these data sources were used to estimate structure values.

PVA data were primarily used for classification, reference and valuation of individual structures, most significant amongst these data being the "Sale Price," "Date Sale," Owner Name," and "Address." The sale price and date sale categories were utilized in structure value determination. To adjust structure values to reflect current price and building cost levels, Marshall and Swift Comparative Cost Multipliers, from the Residential Cost Handbook were applied to all structures within the 0.2%-chance (500-year) floodplain based on the PVA reported sale date. According to ER 1105-2-100, Appendix E, page E-100, Subparagraph e. Requirement. "When structure value data is obtained from sources other than direct estimation of cost of physical replacement less depreciation, these data shall be verified as being reasonable estimates of replacement cost less depreciation. This can be done using a sampling procedure to select a relatively small number of structures for direct estimation of replacement cost less depreciation. The results can be used to compare to, and if

appropriate, adjust the data obtained from other sources." To satisfy this requirement, a sample of 92 structures (62 residential and 30 non-residential) was documented via windshield survey. From this survey sample, the depreciated replacement value of each of the aforementioned 92 structures was determined. These depreciated replacement values were compared to the previously calculated PVA values for each of the structures. It was determined via direct, respective comparison that the values calculated by the available PVA data averaged out to be 15% lower than the depreciated replacement values as determined from the sample survey. As this discrepancy trended in a conservative estimate of structure value, upward adjustment to be applied to the PVA data was deemed to be unnecessary. Owner name and address information were utilized to determine property class and occupancy type. Address information was also useful during field surveys. PVA data were associated to individual structures in the Paducah GIS structure shapefile data using a common 'PIN Number' identifier.

Field surveys were conducted by USACE economists in order to generate a sample from the 0.2%-chance (500-year) floodplain by which residential structures could be delineated by occupancy type. In a survey consisting of 300 residential structures, including 50 structures for each respective river mile studied (with the exception of RM 937), it was determined that 42% of the structures were one story with no basement, 26% of the structures were two stories with no basement, 23% of the structures were one story with a basement, and 9% of the structures were two stories with a basement. These percentages were applied to all residential structures within the database. As a result, it was determined that 2,783 structures were one story with no basement, 1,723 structures were two stories with no basement, 1,524 structures were one story with a basement, and the remaining 596 structures were two stories with a basement. Table 2 below shows the residential structure breakdown by occupancy type.

Table 2 - Residential Structure Count (by occupancy type)

Residential Occupancy Types

Paducah, KY

1 story, no basement	2,783	42%
2 story, no basement	1,723	26%
1 story, with basement	1,524	23%
2 story, with basement	596	9%
Total residential structs	6,626	100%

5.1.2. Structure Location

As mentioned previously, the without project study area is affected by one major river system, the Ohio River. For the purposes of this analysis, the Ohio River was subdivided into seven geographic areas by river mile. These river miles are stream-unique geographic areas within the floodplain that possess common geographic and hydrologic characteristics, including discharge and stage exceedance probabilities. Reaches can be delineated for a variety of reasons,

including existing flood damage reduction measures, concentrations of residential and nonresidential structures and uniform probabilities, and can be designated as either the right or left bank of the stream, or both. For the purposes of this study effort, it was determined by the PDT that only one reach would be utilized to represent the 0.2%-chance (500-year) floodplain of the study area. This determination was made as the floodplain is represented by a very minimal variance in elevation from the beginning of river (or stream) mile 931.0 to 937.0. Within the HEC-FDA program reaches are assigned index locations to facilitate the aggregation of individual structure stage-damage functions. Assumed stages at this index location are adjusted to each individual structure based on that structures associated stream mile, using the water surface profile (which contains stages at each station in the reach) for the corresponding flood event. In cases in which the structure falls between two stream miles or stations in the water surface profiles, the adjustment can be interpolated from the nearest two stations.

Each structure was assigned a stream, reach and station (also referenced as cross-sections or 'Stream ID') using the GIS program. Structures were assigned streams by geographic location. Stream stations, which correspond to those used in the H&H model, were also mapped in ArcView 9.2 and assigned to each structure based on geographic location. Reaches were assigned automatically based on the stream station.

5.1.3. Structure Elevation

The structure elevation component is a combination of three data points, the structures ground elevation, the foundation height relative to the ground elevation, and the beginning damage depth relative to the foundation height. The foundation height gives the elevation of the first floor, and for most structures in the study area was between one and three feet. Structure elevations, similar to stream and reach locations, were assigned using ArcView. Spot elevations and contour layers were used to create Tin points ('Triangulated Irregular Network'), points on a vector-based elevation model that correspond to the center point of each structure's footprint. The assigned elevation of this point was used as the structure's approximate ground elevation.

Foundation heights were estimated during the residential structure surveys. The aforementioned sample of 300 structures (50 in each river mile, outside of RM 937) was utilized again to determine foundation heights. The beginning damage depth for each structure, or the difference in height between the ground elevation and first floor elevation of a particular structure, were generated based on an average beginning damage depth for each structure within a particular river mile. Once the average of 50 structure beginning damage depths was determined for each river mile, this figure was applied to each residential structure within its respective stationing. The average beginning damage depth, represented as a negative number, was determined for each of the seven river stations. The beginning damage depth, which is the point at which damage begins, was assumed to be the same as the ground elevation, and so was set as equal to the inverse of the foundation height. The result of this is that depth-damage curves for each structure were truncated at the ground elevation of the structure, so that

structures with basements did not receive damages until the flood stage was above the ground stage. Only approximately 10% of the residential structures within the floodplain have basements. Average foundation heights were applied per stream mile with the assumption that damage estimates would be more conservative in nature. Table 3 below shows the average foundation heights used per river mile.

Table 3 - Residential Structure Beginning Damage Depth

Residential Structure Elevation above Ground	
Paducah, KY	
River Mile	Beginning Damage Depth
931	-2.7
932	-2.5
933	-2.4
934	-2.4
935	-2.6
936	-2.8
937	-3.1

5.1.4. Structure Depth-Damage Relationships

The final components are the depth-damage relationships for each structure. For residential structures standardized generic depth-damage curves published in Economic Guidance Memorandum (EGM) 04-01 were used. These damage curves were developed by the Institute for Water Resources' (IWR) Flood Damage Data Collection Program. Flood damage data were collected under this program from nationwide flooding events during the period of 1996 through 2001, and regression analysis was used to create these functions. Depth-Damage relationships were assigned to residential structures based on data gathered from the PVA database, as described above. The relevant variables were the number of floors and the presence or absence of a basement.

An example depth-damage relationship, for a single-story single-family residence without basement, is shown below in Table 4. The depth damage relationships associate damages as a percentage of structure value for both contents and the structure itself for a series of flood stages. These flood stages are relative to the foundation height. Each stage and percent damage has an associated standard deviation of error, which is used in the HEC-FDA risk-based analysis to account for uncertainty.

Table 4 - Depth-Damage Relationship
Single-story, single-family, without basement

One Story - No Basement - Single Family

Stage	Avg. % Structure Damage	Standard Deviation
-2	0.0%	0
-1	2.5%	2.7
0	13.4%	2
1	23.3%	1.6
2	32.1%	1.6
3	40.1%	1.8
4	47.1%	1.9
5	53.2%	2
6	58.6%	2.1
7	63.2%	2.2
8	67.2%	2.3

Stage	Avg. % Content Damage	Standard Deviation
-2	0.0%	0
-1	2.4%	2.1
0	8.1%	1.5
1	13.3%	1.2
2	17.9%	1.2
3	22.0%	1.4
4	25.7%	1.5
5	28.8%	1.6
6	31.5%	1.6
7	33.8%	1.7
8	35.7%	1.8

1. Flood stages are relative to the first floor elevation.

2. Both Structure and Content damages are estimated as a percentage of structure value.

For commercial and public structures, generic non-residential percent-depth damage curves were used for the appropriate non-residential structure category and type. Information gathered for the New Orleans District in support of recent feasibility studies was utilized. Since the urbanized areas of the City of Paducah study area contained a similar mix of commercial structures as in Jefferson and Orleans Parishes, these assignments were deemed appropriate. The value of contents for commercial properties was determined from on-site interviews with business operators of eight commercial categories in Jefferson and Orleans Parishes of southern Louisiana. The content-to-structure value ratios developed for each of the eight commercial content classifications can be found in the final report dated June 1996 entitled Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-To-Structure Value Ratios in Support of the Jefferson and Orleans Flood Control Feasibility Studies. These non-residential curves first differentiate the structure as being commercial or public in nature. Next each commercial structure was assigned one of six different occupancy name by which the depth-damage curve could reference and apply to the commercial structures within the inventory. The six occupancy names utilized were EAT - Eating and Recreation, GROC – Groceries and Gas Stations, PROF – Professional Services, REPA – Repairs and Home Use, RETA – Retail and Personal Services, and WARE – Warehouses and Contractors. A single depth-damage curve was applied to all public structures within the inventory. Depth-Damage relationships were assigned to non-residential structures based on data gathered from the PVA database, as described above. The relevant inputs were the occupancy name and beginning damage depth, which was assumed to be 0 for all non-residential structures.

As per guidance in EGM 04-01, content depth-damages were estimated as a percentage of structure value, rather than the previous method of first estimating content value via a content-to-structure value ratio. Thus for each structure the content-to-structure value ratio was entered into HEC-FDA as 100%.

The final structure inventory for import into the Hydrologic Engineering Center's Flood Damage Analysis program (HEC-FDA) contained, for each PIN number, the stream name and station; the ground elevation, foundation height, and beginning damage depth; the replacement value; and the structure category and occupancy type identifier.

5.2. FLOOD DAMAGE ESTIMATES

5.2.1. HEC-FDA

The Corps of Engineers requires the use of risk-based analysis for evaluating flood damages and flood damage reduction measures, as described in ER 1105-2-101 – Risk Analysis for Flood Damage Reduction Studies. A risk-based analysis quantifies uncertainty in key variables such as stage-exceedance probability, stage-damage relationships, structure characteristics, and other categories where possible for which uncertainty exists. This procedure further integrates them into an economic analysis for with and without-project conditions and a performance analysis for flood reduction measures. These computations were performed for this study by the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software package, version 1.2.4. The information described in the section above: estimated replacement values, occupancy types with associated stage-damage functions, structure ground and first floor elevations, and other data are input into FDA, along with water surface profiles, exceedance probability functions, and all associated uncertainties.

HEC-FDA integrates data generated during the hydrologic and hydraulic analyses with the structure inventory and associated data described above. The H&H components include the water surface profiles (WSP), which for every stream assigns a stage or water surface elevation for each of the eight analyzed probability flood events (from the 99.9%-chance (1–year) flood to the 0.2%-chance (500–year) flood) to each station along that stream; discharge exceedance probability functions, and the stage-discharge probability functions for the full range of flood events of the water surface profiles.

These compiled data are essentially a series of probabilistic curves defining relationships between flood stage and frequency of occurrence, and flood stage and damages. These are used ultimately to generate a curve relating probability of occurrence and total damages, the integration of which provides expected annual damages, or EAD. Stage-exceedance probability functions for each reach are used to generate a range of stages and probabilities at each index location which will be used in the creation of an aggregated stage damage function representing the total stage-damage relationship of that reach, including damages to all structures, contents, and all other considered damage categories, for a series of probability ordinates. FDA is essentially generating a reach-wide depth-

damage function similar to those estimated for each structure as described above. To generate these aggregated damages, total damages must be estimated for all structures and other damage categories within that reach for a given stage at the index station. To do this, accounting for the variation in stage throughout the reach, the water surface profiles are used to translate the index stage to corresponding stage at the stream station of each structure. These stages are then compared to that structure's foundation height, the difference applied the structure's individual depth-damage functions (content and structure), and percent damages computed using these functions. Dollar damages are computed by simply multiplying the percent damage by the total structure value.

These total dollar damages are then aggregated to the index location. HEC-FDA uses a Monte Carlo simulation to quantify uncertainty and calculate expected annual damages. This random sampling approach computes multiple thousands of successive iterations of each computation for which there is uncertainty, using the assigned standard deviations of error, and averages the results.

5.2.2. Structure and Content Damages

The damage categories considered in this analysis include damage to structures and contents, as described above, damages to automobiles, costs of road closures and diverted traffic as heavily trafficked roads are inundated, and emergency costs. The processes for computing damages to structures and contents have been largely covered in the preceding sections, and estimated damages are tabulated below. The remaining damage categories required additional assumptions and computations, and these will be described in detail in the corresponding subsections.

The number of inundated, or affected structures (Table 5), the total value of inundated structures (Table 6), and total structure damages (Table 7) (including both structure and content damages) by stream, and frequency flood event are presented below.

Table 5 - Affected Structures by Event

Ohio River, Paducah, KY
Estimated Number of Structures Flooded
Without Project
by Structure Category and River Mile
(Based on zero damage elevations)

Residential

River Mile	Flood Events by Chance of Occurrence							
	99.9%	50%	20%	10%	4%	2%	1%	0.2%
931	0	1	4	37	193	378	661	1019
932	2	4	18	72	354	664	685	699
933	4	4	6	20	180	369	658	978
934	0	0	0	0	2	17	166	753
935	0	0	0	0	2	25	115	533
936	0	0	0	0	2	9	28	223
937	0	0	0	0	0	0	0	0
Totals:	**6**	**9**	**28**	**129**	**733**	**1,462**	**2,313**	**4,205**

Commercial

River Mile	Flood Events by Chance of Occurrence							
	99.9%	50%	20%	10%	4%	2%	1%	0.2%
931	0	0	0	0	8	14	20	36
932	0	0	1	1	5	26	55	66
933	0	0	0	0	11	26	52	84
934	0	0	1	1	3	54	151	259
935	0	0	0	2	6	9	29	58
936	0	0	0	0	8	21	41	69
937	0	0	0	0	0	0	0	0
Totals:	**0**	**0**	**2**	**4**	**41**	**150**	**348**	**572**

PUBLIC

River Mile	Flood Events by Chance of Occurrence							
	99.9%	50%	20%	10%	4%	2%	1%	0.2%
931	0	0	0	0	0	1	2	7
932	0	0	0	0	4	9	15	18
933	0	0	0	0	11	32	48	60
934	0	0	0	0	2	11	41	87
935	0	0	0	0	1	3	24	71
936	0	0	0	0	0	1	5	16
937	0	0	0	0	0	0	0	0
Totals:	**0**	**0**	**0**	**0**	**18**	**57**	**135**	**259**
All Structures	**6**	**9**	**30**	**133**	**792**	**1,669**	**2,796**	**5,036**

Table 6 - Value of Affected Structures by Event

Ohio River, Paducah, KY
Total Value of Structures Flooded
Without Project
by Structure Category and River Mile
FY 2010 Price Levels

River Mile	Residential	Commercial	Public	Totals
931	143,907.50	85,434.63	5,989.53	**$ 235,331.66**
932	107,030.12	28,280.15	12,432.35	**$ 147,742.62**
933	78,601.26	60,486.29	15,488.65	**$ 154,576.20**
934	177,074.20	110,428.22	46,701.48	**$ 334,203.89**
935	151,240.62	31,281.19	28,204.63	**$ 210,726.44**
936	79,497.72	36,370.55	11,355.79	**$ 127,224.07**
937	-	-	-	**$ -**
Totals:	**$737,351.42**	**$352,281.03**	**$120,172.43**	**$1,209,804.88**

Table 7 - Estimated Structure Damages by Event

Ohio River, Paducah, KY
Estimated Damages ($1,000's) to Structures
Without Project
by Structure Category and River Mile
FY 2010 Price Levels

Residential

River Mile	Flood Events by Chance of Occurrence							
	99.9%	50%	20%	10%	4%	2%	1%	0.2%
931	-	18.83	78.22	584.05	3,360.90	8,267.49	14,924.91	30,019.29
932	24.06	12.41	140.90	1,880.19	9,834.45	17,705.35	26,343.11	32,395.61
933	51.23	60.31	62.76	153.61	973.19	2,981.10	7,672.67	16,342.68
934	-	-	-	-	114.71	589.10	6,115.13	26,611.58
935	-	-	-	-	29.80	1,094.72	4,890.32	21,202.51
936	-	-	-	-	184.13	686.99	1,429.71	10,537.64
937	-	-	-	-	-	-	-	-
Totals:	**$75.28**	**$91.55**	**$281.88**	**$2,617.85**	**$14,497.19**	**$31,324.75**	**$61,375.85**	**$137,109.31**

Commercial

River Mile	Flood Events by Chance of Occurrence							
	99.9%	50%	20%	10%	4%	2%	1%	0.2%
931	-	-	-	-	1,169.90	3,130.04	3,902.02	14,298.40
932	-	-	51.77	11.35	433.34	2,228.57	6,769.12	13,569.62
933	-	-	-	-	690.80	4,259.89	7,672.48	19,104.08
934	-	-	9.15	443.20	156.59	5,320.96	19,835.67	42,611.60
935	-	-	-	0.65	202.69	516.81	8,657.37	12,175.64
936	-	-	-	-	143.32	1,215.32	5,306.02	12,462.01
937	-	-	-	-	-	-	-	-
Totals:	**$0.00**	**$0.00**	**$60.91**	**$455.20**	**$2,796.63**	**$16,671.59**	**$52,142.68**	**$114,221.34**

PUBLIC

River Mile	Flood Events by Chance of Occurrence							
	99.9%	50%	20%	10%	4%	2%	1%	0.2%
931	-	-	-	-	-	0.36	2,193.49	6,822.95
932	-	-	-	-	602.31	334.53	1,048.01	4,001.41
933	-	-	-	-	69.12	359.38	1,121.32	1,563.04
934	-	-	-	-	9.47	393.14	1,383.76	5,454.39
935	-	-	-	-	2.18	26.05	179.15	1,371.17
936	-	-	-	-	-	5.38	31.22	1,430.10
937	-	-	-	-	-	-	-	-
Totals:	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$683.09**	**$1,118.84**	**$5,956.95**	**$20,643.07**
All Structures	**$75.28**	**$91.55**	**$342.80**	**$3,073.05**	**$17,976.90**	**$49,115.18**	**$119,475.48**	**$271,973.71**

5.2.3. Damages to Vehicles

Damages to vehicles were computed in a similar fashion to structure damages; a vehicle inventory was established, one containing vehicle values and broken down by type (occupancy type) with associated depth-damage relationships. This vehicle inventory was necessarily less detailed than the structure inventory, as the dataset used to generate it, FEMA's Hazard U.S. Multi-Hazard (HAZUS-MH) database provided vehicle counts and values at a census block level. To generate the vehicle inventory, the database of HAZUS vehicle data was assigned by census block number to a georeferenced census block layer in ArcMap. This layer was then clipped to the 0.2%-chance (500-year) WOPC flood event inundation boundary used to delineate the structure inventory. Census blocks that fell partially within this area were subdivided by the border of this inundation boundary and the resulting partial census block area was compared to that of the original census block to develop a percentage modifier. This modifier was then applied to the vehicle data associated with that census block. The resulting database consisted of census block and sub-census block areas, each containing vehicle counts and values for that area, broken down by vehicle type. These data were arranged, for each census block, in the format shown in Figure 3 (Figure 3 is shown as an example format only - no actual data is included):

Figure 3 – HAZUS Vehicle Data

Day	Cars	Total Value	New
			Used
		Count	
	Light Trucks	Total Value	New
			Used
		Count	
	Heavy Trucks	Total Value	New
			Used
		Count	
Night	Cars	Total Value	New
			Used
		Count	
	Light Trucks	Total Value	New
			Used
		Count	
	Heavy Trucks	Total Value	New
			Used
		Count	

As seen in Figure 3 above, both vehicle counts and total values are provided by the HAZUS database as day and night values, representing the often large variance in vehicle counts as commuters travel in and out of the floodplain moving vehicles from residences to commercial establishments. In the HAZUS MH MR3 Technical Manual it is stated that 'Day' vehicle counts and values are assumed to reflect normal business hours, while 'Night' values represent the

remainder of the day. To capture this variability, given the fact that a flood event has a roughly even chance of occurrence at any time of day or night, an estimated nine hour workday was assumed including commute to develop a 37.5/62.5 ratio modifier for day and night values, respectively. In this way the modified values for both can be combined to generate one set of counts and values for each vehicle type.

As can also be seen in Figure 3, vehicle values are provided in the HAZUS dataset as both new and used car values. These values represent the total values of all new and used cars in a census block. An analysis performed to measure variability in both value and vehicle type by census block found no significant variability, and as such vehicle values and percentage breakdowns by type were averaged across the study area rather than for each census block separately. This was done by summing the total values of new and used vehicles, and dividing the resulting total value by the total number of vehicles.

Depth damage curves for vehicles were recently published in Economic Guidance Memorandum 09-04 - Generic Depth-Damage Relationships for Vehicles. In the EGM, depth-damage relationships are provided for five classes of vehicles; Sedans, Sports Cars, SUVs, Minivans, and Pickups. HAZUS vehicle data is broken down into three categories, 'Cars', 'Light Trucks', and 'Heavy Trucks'. In order to marry the HAZUS data with the vehicle depth-damage functions, the Cars counts and values were divided evenly between the Sedans and Sports Cars depth-damage relationships, and the Light Trucks counts and values were divided evenly between the SUVs, Minivans, and Pickups depth-damage relationships.

As parked vehicles would typically be located at residences or businesses, five vehicle 'nodes' were created at each structure within the structure inventory, both residential and non-residential, in the study area, one for each vehicle type and associated depth damage curve. Essentially this assumes that at each structure there will be a percentage of each of the five vehicle types, a percentage that corresponds to that type's average distribution in the study area, and that will sum to the study area wide average number of vehicles per structure. In other words, at every structure there would be X% of one sedan, Y% of one pickup, and so forth, and each of these would be assigned the appropriate depth-damage function. These nodes were assigned ground elevations, the stream and reach, and stations duplicated from the corresponding structure. Foundation heights and beginning damage depths were each assigned as zero, assuming the vehicle would be parked at the ground elevation of the structure. This approach will likely understate damages slightly, as a result of vehicles parked on streets or on driveways at a lower elevation that the ground elevation of the structures they are assigned to. The 'structure value', in this case vehicle value to be assigned to each node, was computed by dividing the total vehicle values by the vehicle count to determine a per vehicle value. This was done twice, once for the Cars category, and once for the Light Trucks category.

These same vehicle counts were reduced by 80.6% in accordance with EGM 09-04 to account for vehicles moved to higher ground following advance warning. This reduction assumes a warning time of between 6 and 12 hours. The resulting

remaining vehicle counts were divided by the number of structures in the study area to arrive at per structure vehicle counts, one for Cars and one for Light Trucks. These are shown in Table 8 below.

Table 8 – Remaining Vehicles per Structure

Vehicle Type	Average Remaining Vehicles per Structure
Cars	
Day	0.19
Night	0.26
Light Trucks	
Day	0.08
Night	0.10

As these two categories were separated in the HAZUS database from the beginning there is no overlap in these values. These per structure counts for Cars and Light Trucks were then multiplied by the per vehicle value for the corresponding type to arrive at a per structure value. This value was then divided evenly as mentioned previously between the assigned depth-damage categories, Cars into Sedans and Sports Cars, Light Trucks into SUVs, Minivans, and Pickups. This yielded the following values shown in Table 9.

Table 9 – Per Structure Vehicle Values (2010 Price Level)

Vehicle Node	Value ($000's)
Sedans	0.307
Pickups	0.086
SUVs	0.086
Sports	0.307
Minivans	0.086

The resulting vehicle inventory, five vehicle nodes assigned to the ground elevation, stream, reach, and station of each structure, was input into FDA as 'dummy structures', so that estimated vehicle damages would also quantify uncertainty. E xpected Annual Damages to vehicles are detailed in Table 10 below for the without-project condition, broken down by category of vehicle damage.

Table 10 – Vehicle Damages ($1,000's) by Event

(2010 Price Level)

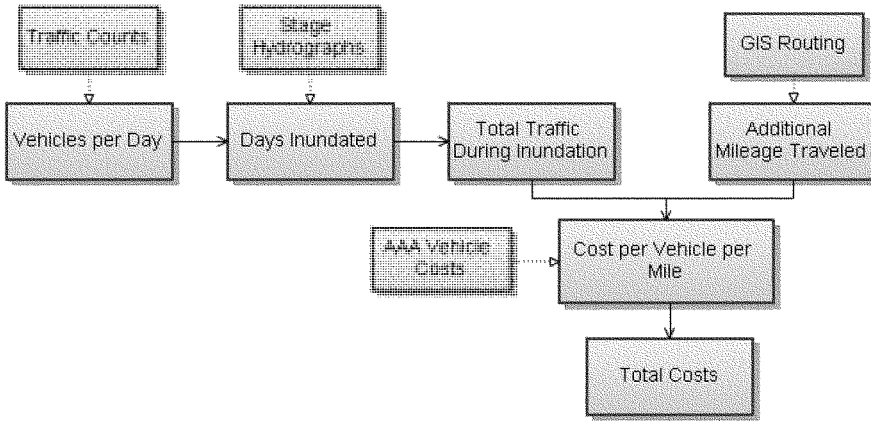
	Flood Event by Chance of Occurrence							
Vehicle Type	**99.9%**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**
Sedans	4.86	5.78	17.78	59.86	412.15	1,239.87	2,598.38	4,683.28
Pickups	1.37	1.58	4.30	13.80	91.76	278.82	598.88	1,151.48
SUVs	1.37	1.55	4.06	12.52	82.19	258.12	570.74	1,139.39
Sports	4.86	5.85	18.58	63.22	442.42	1,347.96	2,821.02	4,978.68
Minivans	1.38	1.59	4.61	14.73	99.69	312.23	680.70	1,297.82

5.2.4. Traffic Diversion Costs

During flooding events roads will be inundated by floodwaters and rendered impassable, and all traffic that would under normal circumstance have been routed through these inundated road segments must necessarily be rerouted. The economic loss under these circumstances would then be a factor of time and distance, or the net increase in time and mileage required by the traffic diversion. This diversion would mean an additional expenditure of fuel, as well as wear and tear on the rerouted vehicles, along with the cost of the delay to vehicle operators and passengers. These costs can be subdivided into two categories, vehicle costs and passenger costs. Vehicle costs account for increased fuel use, per mile maintenance costs and the per mile cost of tire replacement. These costs are a factor of the increased mileage for the diversions. Passenger costs assume a value for the time lost to vehicle operators and passengers, and are a factor of the increased travel time.

To estimate vehicle costs the increase in driving distance necessitated at each anticipated flooded road segment during each flood event must first be estimated. A chart illustrating the process used to estimate the total cost of traffic diversions for a given flood event is shown below as Figure 4.

Figure 4 - Traffic Diversion Cost Process



To accomplish this, the ArcView GIS program was used to locate areas of potential road inundation at the 500 year or .2% chance flood event and the 10 year or 10% chance event. Inundation boundaries for these two flood events were overlaid on polygon road layers and the inundated segments extracted. This was used both in identifying areas likely to result in significant traffic rerouting, as well as to ensure that computed traffic diversions did not divert through another road that was also inundated. To calculate the addition mileage required by the diversion at each identified area, the original mileage was first measured. To do this, beginning and end point were chosen at each end of the affected roadway. These points were chosen at intersections that would facilitate traffic rerouting and in such a way as to minimize route length while ensuring the minimum of backtracking for the diversion.

The measurement tool in ArcView was used to determine the mileage between the starting and ending nodes and thus establish the original route mileage. To estimate the reroute mileage, a diversion was mapped out for both of the flood events (.2% chance/500 year, and 10%/10 year) for which road inundations were mapped, both of the diversion routes avoiding other roads inundated in the corresponding flood event. For these diversion routes, the shortest possible route was selected, with a tendency towards larger, higher-trafficked roads. Rerouting distances for the 99% chance / 1 year event were assumed zero. For the 2 and 5 year events, the rerouting distances were linearly interpolated from zero (1 year event) to the 10 year event mileages. The remaining events were similarly interpolated from the 10 year to the 500 year event. In many cases during the 0.2% chance event, as the inundated area is so large, traffic diversions could not be realistically rerouted. Some rerouting was rendered impossible as entire roads, as well as connecting roads, were completely inundated. Other reroute mileages were very large relative to the original driving distance, as it became necessary to bypass large percentages of the inundated area. To account for these scenarios, it was assumed that any reroute exceeding 3 times the original route

mileage would lead to the driver abandoning the effort, and so reroutes in excess of 3 times the original mileage were truncated at this value.

Each major road subject to inundation during any of these flood events was then assigned a stream mile that best approximated the location of the overtopping. Contour mapping was then used to estimate road elevations at this stream station. Durations of inundation in excess of one foot for each of the above stream miles were provided by the study H&H engineer for the 10%, 1%, and 0.2% chance flood events. T he intervening inundation durations were fit to the curve approximated by these data points.

Traffic Counts for each of the inundated roads were obtained from the Kentucky Transportation Cabinet Division of Planning, which publishes traffic counts at index stations on m ajor roads throughout Kentucky. Traffic counts were taken from the indexing point nearest the flooded area. The costs per mile of operating a vehicle were obtained from the 2009 edition of the AAA publication 'Your Driving Costs'. The AAA methodology factors in both operating and ownership costs, including gas, maintenance, and tires as operating costs, and insurance, license, registration, and taxes, depreciation, and financial charge as ownership costs. F or this analysis only the operating costs were used, as increased use of a vehicle is not likely to significantly impact ownership costs. T he average per mile operating cost reported was 15.42 cents.

Passenger costs were computed in a similar fashion to vehicle costs. Once the increased mileages of reroutes were calculated, 35 mph was assumed as the original route average speed, and 25 m ph assumed as the average speed for the diversion route. T he resulting increase in time necessitated by the traffic diversion was then multiplied by an estimate of that time's value to a vehicle occupant, and further multiplied by an average number of vehicle occupants, and the corresponding traffic counts. The value of lost time to vehicle occupants was based, per Institute foe Water Resources (IWR) Manual 88-R-2, on one-third of the area average hourly income. Average daily income for the area was acquired from the Bureau of Labor Statistics, and divided by 24 hour s. A third of this value was used as the value to delayed passengers of each lost hour. 2001 Census data was used to estimate 1.09 w orking adults, ages 16 a nd older, per vehicle.

Road inundation locations were also input into FDA as 'dummy structures', with the stream, reach, and station of the expected road inundation area and the spot ground elevations. Beginning damage depth again was set as zero. Depth damage functions were generated as each road's traffic diversion cost for each of the eight flood events, input as direct dollar values. S tages were simply the difference between the flood stage extracted from the H&H model for each event less the ground elevation from contours. Standard deviations were estimated at 10% of the traffic diversion cost.

Total road closure/traffic rerouting costs are detailed below in Table 11, along with traffic counts for inundated roads, for the existing conditions by frequency flood event. Expected Annual Damages are shown in Table 11.

Table 11

Traffic Diversion Costs by Event ($1,000's)
(2010 Price Level)

		Flood Event by Chance of Occurrence							
Road Closure	**Traffic Count**	**99.9%**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**
Bloom Ave	728	-	-	-	-	-	2.43	3.85	5.43
Bridge St	9,100	-	-	-	-	-	45.65	72.12	101.89
Broadway St	5,610	-	-	-	-	-	48.83	77.43	109.39
Caldwell St	2,560	-	-	-	-	4.93	9.58	12.62	15.64
Chester Hack Dr	3,031	-	-	-	-	-	-	3.75	9.89
Clay St	5,870	-	-	-	-	59.30	92.51	112.69	131.51
Goebel Ave	4,810	-	-	-	-	0.87	1.70	2.24	2.78
HC Mathis Dr	7,385	-	-	-	-	-	-	16.74	44.25
Hovekamp Rd	1,480	-	-	-	-	-	5.31	8.38	11.84
Husband Rd	16,615	-	-	-	-	-	-	-	399.85
I24	35,900	-	-	-	-	-	101.61	522.37	1,373.24
Irvin Cobb Dr	18,100	-	-	-	-	-	261.28	412.80	583.18
Jefferson St	6,740	-	-	-	-	-	56.15	89.03	125.78
John L Puryear Dr	11,398	-	-	-	-	-	-	-	157.10
Julia St	5,949	-	-	-	-	-	7.65	12.19	17.22
Kentucky Ave	10,800	-	-	-	-	53.49	104.88	138.18	171.16
Land Rd	1,170	-	-	-	-	-	-	-	-
Madison St	623	-	-	-	-	-	-	3.44	9.08
N 13th St	4,560	-	-	-	-	-	-	-	18.30
N 21st St	4,800	-	-	-	-	5.90	11.65	15.35	19.02
N 28th St	14,496	-	-	-	-	10.77	21.26	28.01	34.70
N 4th St	6,200	-	-	-	-	-	10.33	16.38	23.14
N 6th St	2,990	-	-	-	-	-	-	-	15.12
N 7th St	1,290	-	-	-	-	-	-	-	3.47
N 8th St	5,339	-	-	-	-	-	38.15	60.74	85.80
N 9th St	1,630	-	-	-	-	-	-	4.52	11.94
Old Mayfield Rd	10,700	-	-	-	-	25.64	49.79	65.60	81.25
Park Ave	13,900	-	-	-	-	-	62.77	99.68	140.81
S 16th St	4,314	-	-	-	-	-	7.77	12.33	17.42
S 21st St	7,900	-	-	-	-	16.71	32.76	43.17	53.47
S 22nd St	10,200	-	-	-	-	-	-	-	8.78
S 3rd St	7,880	-	-	-	-	-	33.22	52.68	74.43
S 4th St	14,792	-	-	-	-	-	64.38	102.09	144.21
S 6th St	3,540	-	-	-	-	-	-	12.80	33.70
S 7th St	1,290	-	-	-	-	-	-	-	3.47
S 9th St	3,390	-	-	-	-	13.33	25.89	34.11	42.25
Water St	465	-	-	-	-	-	-	0.36	0.96
Wayne Sullivan Dr	15,400	-	-	-	-	124.85	194.54	236.98	276.56

5.2.5. Emergency Costs

Emergency costs represent flood fighting and costs incurred by local agencies as a result of flooding as well as other miscellaneous property damages not included in the above damage categories. Flood fighting costs account for labor hours and equipment use above standard day-to-day operations for the Paducah Police Department, the Fire Department, the Department of Public Works, and the Metropolitan Sewer District, as a direct result of flooding. The emergency cost category also includes damages incurred by and cost of flood response by Paducah Gas and Electric (PG&E), whose primary costs were anticipated to be repairs to utility boxes, power lines, and relighting pilot lights.

To best forecast emergency response costs, data must be gathered from the above listed agencies. At the time of this printing, no emergency costs have been calculated.

5.3. EQUIVALENT ANNUAL DAMAGES

Equivalent Annual Damage accounts for the yearly variation in damages/benefits and incorporate these into the annualized value. Expected annual damage for the base year and most likely future year are estimated. H EC-FDA calculates equivalent annual damage assuming straight-line growth of the annual damage stream to the most likely future year. Annual damage past the most likely future year is assumed to be constant for the balance of the period of analysis. This stream of expected annual damages computed in this way is discounted using present worth factors and annualized to generate Equivalent Annual Damage. Equivalent Annual Damages for the Future Without Project Condition are shown below in Table 12. This Future Without Project Condition EAD will next be subtracted by the With Project Condition EAD so as to determine the Reconstruction Action's total annual benefits.

Table 12 - Future Without Project EAD

Ohio River, Paducah, KY Estimated Equivalent Average Annual Damages ($1,000's) Without Project by Damage Category FY 2010 Price Levels		
Damage Category		**EAD**
Residential Structures	$4,821	
Public Structures	$415	
Commercial Structures	$2,558	
Traffic Diversion	$82	
Vehicles	$298	
Minivans		*$28*
Pickups		*$25*
Sedans		*$107*
Sports Cars		*$114*
SUVs		*$24*
Emergency Costs	$0	
Total EAD	**$8,174**	

5.4. SUMMARY

Under expected Future Without Project Conditions, the City of Paducah, KY will be decimated, both structurally and financially, by flood events from the Ohio River on an annual basis. The represented EAD of $8,174,000 represents an enormous average annual damage estimate. This estimate speaks to the magnitude of what is at risk with regard to the local protection project which is well beyond its functional design life.

6. FUTURE WITH PROJECT CONDITION

Unless noted otherwise in the following sections, economic evaluation methodologies utilized for Future Without Project Condition generation were re-applied in the exact fashion for the production of Future With Project Conditions, also known as the Reconstruction Action.

The Reconstruction Action consists of numerous measures designed to return the infrastructure associated with the Paducah LFPP to reliable conditions and current engineering standards. These measures are primarily centered around the existing pump plants, floodwall, and levee. In general, the pump plants are receiving either a new or refurbished pump motor, new mechanical and electrical upgrades and/or replacement features, and structural repairs. The affected pump plants include: Pump Plant #1 (Noble Park), Pump Plant #2 (Sixth Street), Pump Plant #3 (Park Ave), Pump Plant #4 (Clay Street), Pump Plant #5 (Harrison Street),

Pump Plant #6 (Clark Street), Pump Plant #7 (Tennessee Street), Pump Plant #9 (Husbands Road), Pump Plant #10 (George Street), Pump Plant #11 (Island Creek), Pump plant #12 (SE of Paducah), and Pump Plant #13. Also included in this Reconstruction Action is the addition of a new Pump Plant #14 at station 111+67A with a submersible 100 cfs pump. This new feature was included in the Reconstruction Action as it was found to be individually and incrementally justified by its own economic analysis, which can be viewed in much greater detail in Section 12 of this appendix. With regard to the existing floodwall, the reconstruction activities include: replacement gatewell structures are being placed at station 19+11B and 111+67A, replacement of existing Bee Branch drainage outlet structures, floodwall waterstop joint replacement and repair, plugging existing toe drains, and permanently closing structures. Levee reconstruction action involves scouring erosion control concrete pad on site.

6.1. STRUCTURE INVENTORY

The structure inventory of the Future With Project Conditions for the Ohio River, Paducah, KY Feasibility Study is comprised of those structures, commercial, residential, and public, that fall within 0.2%-chance (500 year) floodplain, as delineated by estimated hydrologic conditions consistent with anticipated future development as well as the Ohio River being at flood levels requiring the use of pumps to dispose of interior flood waters. In this way structures in and around the study area are limited to those that would receive damages in the lowest probability flood event or 'worst case scenario' considered in this analysis. To accomplish this, a structure footprint shapefile generated by the PDT Geographer/GIS specialist was truncated using GIS software (ArcView v9.2) to the boundaries of twenty-six ponding areas which will remain in the City of Paducah after reconstruction activity has taken place. These twenty-six ponding areas can be combined to create the With Project Condition 0.2%-chance (500 year) floodplain. Any structures that intersected any part of the twenty-six new inundation boundary layers were extracted and became the structure inventory. For the purposes of the With Project EAD calculation, each ponding area was assigned its own structure inventory so that separate HEC-FDA runs could be made for each respective ponding area.

The With Project Condition affected area contains only 69 structures within the 0.2%-chance (500 year) floodplain, across all twenty-six ponding areas. The array of structures included 52 residential structures, 14 commercial structures, and 3 public structures. Five of the twenty-six remaining ponding areas outlined by the GIS specialist actually contain no structures experiencing residual flooding impacts. The structure inventory for both residential and non-residential structures and all associated data and characteristics are ultimately entered into the Hydrologic Engineering Center's Flood Damage Analysis program, or HEC-FDA (version 1.2.4 was used in this study), which will then use modeled flooding events to estimate damages to affected structures based on these characteristics and data. These data include, for each structure, an estimated replacement value, the ponding area which the structure is located within, the ground elevation of the structure and foundation height relative to this ground elevation, and finally a depth-damage relationship estimating damages to the structure as either a

percentage of structure value or as a direct dollar figure for various stages of flooding.

6.1.1. Structure Value

Structure values for the remaining 69 structures within the residual With Project ponding areas (0.2%-chance or 500 year floodplain) where transferred from the original Future Without Project structure inventory. This was accomplished utilizing the unique PIN numbers associated with each structure and the aforementioned GIS referencing performed by the GIS Specialist.

6.1.2 Structure Location

As previously mentioned, each remaining structure was assigned to individual ponding areas (0.2%-chance or 500 year floodplain) which will exist after the Reconstruction Action has been construction.

Each structure was assigned a stream, reach and station (also referenced as ponding area for With Project Condition calculation) using the GIS program. Structures were assigned ponding areas by geographic location. Ponding areas, which correspond to those used in the H&H model, were also mapped in ArcGis and assigned to each structure based on geographic location. Reaches were assigned automatically based on the stream station.

6.1.3. Structure Elevation

Structure elevations for the remaining 69 structures within the residual With Project ponding areas (0.2% chance or 500 year floodplain) where transferred from the original Future Without Project structure inventory. T his was accomplished utilizing the unique PIN numbers associated with each structure and the aforementioned GIS referencing performed by the GIS Specialist.

6.1.4. Structure Depth-Damage Relationships

Structure Depth-Damage Curves for the remaining 69 structures within the residual With Project ponding areas (0.2%-chance or 500 year floodplain) where transferred from the original Future Without Project structure inventory. This was completed by utilizing the unique PIN numbers associated with each structure and the aforementioned GIS referencing performed by the GIS Specialist.

The final structure inventories for each ponding area for import into the HEC-FDA program contained, for each PIN number, the stream name and ponding area; the ground elevation, foundation height, and beginning damage depth; the replacement value; and the structure category and occupancy type, which are used to assign a depth-damage function.

6.2. FLOOD DAMAGE ESTIMATES

6.2.1. HEC-FDA

Twenty-two separate HEC-FDA runs were generated to determine the Paducah, KY With Project Condition. With residual ponding areas (0.2%-chance or 500 year floodplain), with varying and distinct discharges and water surface profiles, scattered and meandering throughout the With Project floodplain it was determined that precise EAD calculation would be best determined via separate HEC-FDA runs. The results of each individual ponding area run could be aggregated together upon completion of each for a total With Project Condition EAD. Only twenty-two HEC-FDA runs were generated as it was determined via GIS referencing that four of the twenty-six residual ponding areas did not adversely impact any structures or roads whatsoever.

6.2.2. Structure and Content Damages

The damage categories considered in this analysis include damage to structures and contents, as described above, damages to automobiles, costs of road closures and diverted traffic as heavily trafficked roads are inundated, and emergency costs. The processes for computing damages to structures and contents have been largely covered in the preceding sections, and estimated damages are tabulated below. The remaining damage categories required additional assumptions and computations, and these will be described in detail in the corresponding subsections.

The With Project Condition number of inundated structures (Table 13), the total value of inundated structures (Table 14), and total structure damages (Table 15) including both structure and content damages by stream, reach, and frequency flood event are displayed in the following pages.

Table 13 - Affected Structures by Event

Ohio River, Paducah, KY
Estimated Number of Structures Flooded
With Project
by Structure Category and River Mile
(Based on zero damage elevations)
Residential

	Flood Events by Chance of Occurrence							
Ponding Area	**99.9%**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**
7-54B	0	0	0	0	0	0	0	0
19-11B	0	0	0	0	0	1	1	1
51-28C	0	0	0	1	1	1	1	2
92-70C	0	0	0	1	1	1	2	2
111-67A	0	0	0	0	0	0	0	0
130-00A	0	0	0	0	0	0	0	0
140-45A	0	0	0	0	0	0	0	0
147-25A	0	0	0	0	0	0	0	0
150-05C	1	1	1	1	1	1	1	1
151-25A	0	0	0	0	0	0	0	0
157-63A	0	0	0	0	0	0	0	0
172-08C	0	0	0	0	0	0	0	0
175-40B	0	0	0	0	0	0	0	0
176-47C	0	0	2	3	3	3	3	3
176-90C	2	2	4	4	4	5	6	6
199-80C	0	0	0	0	0	0	0	2
224-50C	0	0	0	0	0	0	0	0
244-65C	0	0	0	0	0	0	0	0
254-06C	0	0	0	0	0	1	1	1
291-75C	0	0	0	0	0	0	0	0
43-50B Island Creek	3	6	11	16	19	20	22	26
200-55C	0	0	0	0	0	1	8	8
Totals:	**6**	**9**	**18**	**26**	**29**	**34**	**45**	**52**

Table 13 - Affected Structures by Event (cont'd.)

	Commercial							
	Flood Events by Chance of Occurrence							
Ponding Area	**99.9%**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**
7-54B	0	0	0	0	0	0	0	0
19-11B	0	0	0	0	0	0	0	1
51-28C	0	0	0	0	0	0	0	0
92-70C	0	0	0	0	0	0	0	0
111-67A	0	0	0	0	0	1	4	6
130-00A	0	0	0	0	0	0	0	1
140-45A	1	1	1	1	1	1	1	1
147-25A	0	0	0	0	0	0	0	0
150-05C	0	0	0	0	0	0	0	0
151-25A	0	0	0	0	0	0	0	0
157-63A	0	0	0	0	0	0	0	0
172-08C	0	0	0	0	0	0	0	0
175-40B	0	0	0	0	0	0	0	0
176-47C	0	0	0	0	0	0	0	0
176-90C	0	0	0	0	0	0	0	0
199-80C	0	0	0	0	0	0	0	1
224-50C	0	0	0	0	0	0	1	1
244-65C	0	0	0	0	0	0	0	0
254-06C	0	0	0	0	0	0	0	0
291-75C	0	0	0	0	0	0	0	0
43-50B Island Creek	0	1	2	2	2	2	2	2
200-55C	0	0	0	0	1	1	1	1
Totals:	**1**	**2**	**3**	**3**	**4**	**5**	**9**	**14**

Table 13 - Affected Structures by Event (cont'd.)

	PUBLIC							
	Flood Events by Chance of Occurrence							
Ponding Area	**99.9%**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**
7-54B	0	0	0	0	0	0	0	1
19-11B	0	0	0	0	0	0	0	0
51-28C	0	0	0	0	0	0	0	0
92-70C	0	0	0	0	0	0	0	0
111-67A	0	0	0	0	0	0	0	0
130-00A	0	0	0	0	0	0	0	0
140-45A	0	0	0	0	0	0	0	0
147-25A	0	0	0	0	0	0	0	1
150-05C	0	0	0	0	0	0	0	0
151-25A	0	0	0	0	0	0	0	0
157-63A	0	0	0	0	0	0	0	0
172-08C	0	0	0	0	0	0	0	0
175-40B	0	0	0	0	0	0	0	0
176-47C	0	0	0	0	0	0	0	0
176-90C	0	0	0	0	0	0	0	0
199-80C	0	0	0	0	0	0	0	0
224-50C	0	0	0	0	0	0	0	0
244-65C	0	0	0	0	0	0	0	0
254-06C	0	0	0	0	0	0	0	0
291-75C	0	0	0	0	0	0	0	0
43-50B Island Creek	0	0	0	0	0	0	0	1
200-55C	0	0	0	0	0	0	0	0
Totals:	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**
All Structures	**7**	**11**	**21**	**29**	**33**	**39**	**54**	**69**

Table 14 - Value of Affected Structures by Event

Ohio River, Paducah, KY
Total Value of Structures Flooded
With Project
by Structure Category and River Mile
FY 2010 Price Levels

Ponding Area	Residential	Commercial	Public	Totals
7-54B	-	-	-	-
19-11B	1,832.00	407.36	-	**2,239.36**
51-28C	558.00	-	-	**558.00**
92-70C	782.00	-	-	**782.00**
111-67A	-	370.46	-	**370.46**
130-00A	-	413.10	-	**413.10**
140-45A	-	198.44	-	**198.44**
147-25A	-	-	1,489.44	**1,489.44**
150-05C	56.00	-	-	**56.00**
151-25A	-	-	-	-
157-63A	-	-	-	-
172-08C	-	-	-	-
175-40B	-	-	-	-
176-47C	300.00	-	-	**300.00**
176-90C	756.00	-	-	**756.00**
199-80C	-	-	-	-
224-50C	-	-	-	-
244-65C	-	-	-	-
254-06C	164.00	-	-	**164.00**
291-75C	-	-	-	-
43-50B Island Creek	1,186.00	1,003.08	158.36	**2,347.44**
200-55C	362.00	74.36	-	**436.36**
Totals:	**$5,996.00**	**$2,466.80**	**$1,647.80**	**$10,110.60**

Table 15 - Estimated Structure Damages by Event

Ohio River, Paducah, KY
Estimated Damages ($1,000's) to Structures
With Project
by Structure Category and River Mile
FY 2010 Price Levels

Residential

	Flood Events by Chance of Occurrence							
Ponding Area	**99.9%**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**
7-54B	-	-	-	-	-	-	-	-
19-11B	-	-	-	-	-	64.00	174.08	277.07
51-28C	-	-	-	15.67	18.89	20.86	22.90	75.51
92-70C	-	-	-	0.20	1.61	3.37	62.46	78.93
111-67A	-	-	-	-	-	-	-	-
130-00A	-	-	-	-	-	-	-	-
140-45A	-	-	-	-	-	-	-	-
147-25A	-	-	-	-	-	-	-	-
150-05C	4.72	4.98	5.84	6.45	7.40	7.89	8.21	9.26
151-25A	-	-	-	-	-	-	-	-
157-63A	-	-	-	-	-	-	-	-
172-08C	-	-	-	-	-	-	-	-
175-40B	-	-	-	-	-	-	-	-
176-47C	-	-	16.76	18.20	20.55	21.33	22.12	24.47
176-90C	0.91	3.27	16.35	25.16	43.60	74.48	111.45	129.87
199-80C	-	-	-	-	-	-	-	-
224-50C	-	-	-	-	-	-	-	-
244-65C	-	-	-	-	-	-	-	-
254-06C	-	-	-	-	-	0.32	1.13	1.93
291-75C	-	-	-	-	-	-	-	-
43-50B Island Creek	12.64	63.79	92.24	105.32	143.44	158.16	184.31	222.76
200-55C	-	-	-	-	-	10.66	36.62	39.13
Totals:	**$18.27**	**$72.04**	**$131.19**	**$171.00**	**$235.50**	**$361.07**	**$623.27**	**$858.93**

Table 15 - Estimated Structure Damages by Event (contd.)

	Commercial							
	Flood Events by Chance of Occurrence							
Ponding Area	**99.9%**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**
7-54B	-	-	-	-	-	-	-	-
19-11B	-	-	-	-	-	-	-	34.22
51-28C	-	-	-	-	-	-	-	-
92-70C	-	-	-	-	-	-	-	-
111-67A	-	-	-	-	-	1.36	24.06	56.20
130-00A	-	-	-	-	-	-	-	4.59
140-45A	50.41	53.61	57.56	58.72	59.87	61.02	61.02	64.03
147-25A	-	-	-	-	-	-	-	-
150-05C	-	-	-	-	-	-	-	-
151-25A	-	-	-	-	-	-	-	-
157-63A	-	-	-	-	-	-	-	-
172-08C	-	-	-	-	-	-	-	-
175-40B	-	-	-	-	-	-	-	-
176-47C	-	-	-	-	-	-	-	-
176-90C	-	-	-	-	-	-	-	-
199-80C	-	-	-	-	-	-	-	-
224-50C	-	-	-	-	-	-	-	-
244-65C	-	-	-	-	-	-	-	-
254-06C	-	-	-	-	-	-	-	-
291-75C	-	-	-	-	-	-	-	-
43-50B Island Creek	-	59.98	330.83	416.20	473.58	501.79	530.82	599.50
200-55C	-	-	-	-	6.34	11.15	13.98	14.39
Totals:	**$50.41**	**$113.59**	**$388.39**	**$474.92**	**$539.79**	**$575.32**	**$629.88**	**$772.94**

Table 15 - Estimated Structure Damages by Event (cont'd.)

	PUBLIC							
	Flood Events by Chance of Occurrence							
Ponding Area	**99.9%**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**
7-54B	-	-	-	-	-	-	-	-
19-11B	-	-	-	-	-	-	-	-
51-28C	-	-	-	-	-	-	-	-
92-70C	-	-	-	-	-	-	-	-
111-67A	-	-	-	-	-	-	-	-
130-00A	-	-	-	-	-	-	-	-
140-45A	-	-	-	-	-	-	-	-
147-25A	-	-	-	-	-	-	-	118.41
150-05C	-	-	-	-	-	-	-	-
151-25A	-	-	-	-	-	-	-	-
157-63A	-	-	-	-	-	-	-	-
172-08C	-	-	-	-	-	-	-	-
175-40B	-	-	-	-	-	-	-	-
176-47C	-	-	-	-	-	-	-	-
176-90C	-	-	-	-	-	-	-	-
199-80C	-	-	-	-	-	-	-	-
224-50C	-	-	-	-	-	-	-	-
244-65C	-	-	-	-	-	-	-	-
254-06C	-	-	-	-	-	-	-	-
291-75C	-	-	-	-	-	-	-	-
43-50B Island Creek	-	-	-	-	-	-	-	11.63
200-55C	-	-	-	-	-	-	-	-
Totals:	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$130.04**
All Structures	**$68.68**	**$185.63**	**$519.58**	**$645.92**	**$775.29**	**$936.39**	**$1,253.15**	**$1,761.91**

6.2.3. Damages to Vehicles

For the with-project analysis, as described in Section 8.1 above, the study area was subdivided into twenty-six ponding areas associated with each of the pumping plants. Just as structures were assigned to these individual ponding areas, vehicles were also divided, with each of the five vehicle types again assigned to each structure. A part from this difference, the calculation was performed exactly as it was for the Without Project condition.

In the With Project condition vehicle damages decrease dramatically, with each category of vehicle experiencing roughly 99% less damages than in the Without Project condition for the 0.2%-chance flood event. As can be seen in the tables below, some of the ponding areas experienced no residual damages in the With Project condition. A s with Without Project damages, residual damages are highest for sedans and sports cars, or the 'Cars' category in the HAZUS Multi-Hazard data, with pickups, SUVs, and minivans (the 'Light Vehicles category in HAZUS) experiencing roughly a fourth of these damages. EAD for the damages to vehicles category in the with-project condition is approximately $900. With

Project vehicle damages are broken down in Table 16 below by ponding area and flood event for each vehicle type.

Table 16 – Vehicle Damages ($1000's) by Event (FY10 Price Level)

	Minivans							
	Flood Event by Chance of Occurrence							
Ponding Area	**99.9%**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**
7-54B	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19-11B	-	-	-	0.00	0.00	0.00	0.00	0.01
51-28C	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
92-70C	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
111-67A	-	-	-	-	-	-	-	0.01
130-00A	-	-	-	-	-	0.00	0.00	0.00
140-45A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
147-25A	-	-	-	-	-	-	-	-
150-05C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
151-25A	-	-	-	-	-	-	-	-
157-63A	-	-	-	-	-	-	0.00	0.00
172-08C	-	-	-	-	-	-	-	0.00
175-40B	-	-	-	0.00	0.00	0.00	0.00	0.00
176-47C	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
176-90C	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
199-80C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
224-50C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
244-65C	-	-	-	-	-	-	-	-
254-06C	-	-	0.00	0.00	0.00	0.01	0.01	0.01
291-75C	-	-	-	-	-	-	-	-
43-50B Island Creek	0.02	0.04	0.05	0.06	0.07	0.08	0.09	0.10
200-55C	0.01	0.02	0.03	0.04	0.05	0.05	0.06	0.07
Totals:	**$0.05**	**$0.07**	**$0.11**	**$0.13**	**$0.16**	**$0.18**	**$0.20**	**$0.25**

Table 16 – Vehicle Damages ($1000's) by Event (cont'd.)

	Pickups							
	Flood Event by Chance of Occurrence							
Ponding Area	**99.9%**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**
7-54B	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19-11B	-	-	-	0.00	0.00	0.00	0.00	0.01
51-28C	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
92-70C	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
111-67A	-	-	-	-	-	-	-	0.01
130-00A	-	-	-	-	0.00	0.00	0.00	0.00
140-45A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
147-25A	-	-	-	-	-	-	-	0.00
150-05C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
151-25A	-	-	-	-	-	-	-	-
157-63A	-	-	-	-	-	-	0.00	0.00
172-08C	-	-	-	-	-	-	-	0.00
175-40B	-	-	-	0.00	0.00	0.00	0.00	0.00
176-47C	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
176-90C	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
199-80C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
224-50C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
244-65C	-	-	-	-	-	-	-	-
254-06C	-	-	0.00	0.00	0.01	0.01	0.01	0.01
291-75C	-	-	-	-	-	-	-	-
43-50B Island Creek	0.02	0.03	0.05	0.05	0.06	0.07	0.08	0.10
200-55C	0.02	0.02	0.03	0.04	0.04	0.05	0.05	0.06
Totals:	**$0.05**	**$0.07**	**$0.10**	**$0.12**	**$0.15**	**$0.17**	**$0.19**	**$0.23**

Table 16 – Vehicle Damages ($1000's) by Event (cont'd.)

	Sedans							
	Flood Event by Chance of Occurrence							
Ponding Area	**99.9%**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**
7-54B	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19-11B	-	-	-	0.00	0.00	0.01	0.01	0.02
51-28C	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.04
92-70C	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
111-67A	-	-	-	-	-	-	0.01	0.03
130-00A	-	-	-	-	0.00	0.00	0.00	0.01
140-45A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
147-25A	-	-	-	-	-	-	-	0.00
150-05C	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
151-25A	-	-	-	-	-	-	-	-
157-63A	-	-	-	-	-	-	0.00	0.01
172-08C	-	-	-	-	-	-	-	0.00
175-40B	-	-	-	0.02	0.02	0.02	0.02	0.02
176-47C	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.03
176-90C	0.02	0.02	0.03	0.04	0.04	0.04	0.05	0.05
199-80C	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
224-50C	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
244-65C	-	-	-	-	-	-	-	-
254-06C	-	-	0.00	0.01	0.02	0.04	0.04	0.05
291-75C	-	-	-	-	-	-	-	-
43-50B Island Creek	0.08	0.13	0.19	0.22	0.26	0.29	0.33	0.41
200-55C	0.08	0.10	0.15	0.17	0.21	0.23	0.25	0.27
Totals:	**$0.23**	**$0.31**	**$0.45**	**$0.54**	**$0.66**	**$0.74**	**$0.84**	**$1.01**

Table 16 – Vehicle Damages ($1000's) by Event (cont'd.)

	Sports							
	Flood Event by Chance of Occurrence							
Ponding Area	**99.9%**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**
7-54B	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19-11B	-	-	-	0.00	0.01	0.01	0.01	0.03
51-28C	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.04
92-70C	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03
111-67A	-	-	-	-	-	-	0.01	0.03
130-00A	-	-	-	-	0.00	0.00	0.00	0.01
140-45A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
147-25A	-	-	-	-	-	-	-	0.00
150-05C	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
151-25A	-	-	-	-	-	-	-	-
157-63A	-	-	-	-	-	-	0.00	0.01
172-08C	-	-	-	-	-	-	-	0.00
175-40B	-	-	-	0.02	0.02	0.02	0.02	0.02
176-47C	0.01	0.02	0.03	0.03	0.03	0.04	0.04	0.04
176-90C	0.02	0.02	0.03	0.04	0.04	0.04	0.05	0.05
199-80C	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
224-50C	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
244-65C	-	-	-	-	-	-	-	-
254-06C	-	-	0.00	0.01	0.02	0.04	0.05	0.05
291-75C	-	-	-	-	-	-	-	-
43-50B Island Creek	0.09	0.14	0.20	0.23	0.28	0.31	0.35	0.43
200-55C	0.08	0.10	0.16	0.18	0.23	0.25	0.28	0.31
Totals:	**$0.24**	**$0.33**	**$0.48**	**$0.58**	**$0.71**	**$0.80**	**$0.90**	**$1.09**

Table 16 – Vehicle Damages ($1000's) by Event (cont'd.)

	SUVs							
	Flood Event by Chance of Occurrence							
Ponding Area	99.9%	50%	20%	10%	4%	2%	1%	0.2%
7-54B	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19-11B	-	-	-	0.00	0.00	0.00	0.00	0.00
51-28C	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
92-70C	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
111-67A	-	-	-	-	-	-	-	0.01
130-00A	-	-	-	-	-	0.00	0.00	0.00
140-45A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
147-25A	-	-	-	-	-	-	-	-
150-05C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
151-25A	-	-	-	-	-	-	-	-
157-63A	-	-	-	-	-	-	0.00	0.00
172-08C	-	-	-	-	-	-	-	0.00
175-40B	-	-	-	0.00	0.00	0.00	0.00	0.00
176-47C	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
176-90C	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
199-80C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
224-50C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
244-65C	-	-	-	-	-	-	-	-
254-06C	-	-	0.00	0.00	0.00	0.01	0.01	0.01
291-75C	-	-	-	-	-	-	-	-
43-50B Island Creek	0.02	0.03	0.04	0.05	0.06	0.07	0.07	0.09
200-55C	0.01	0.02	0.03	0.03	0.04	0.04	0.05	0.05
Totals:	**$0.04**	**$0.06**	**$0.09**	**$0.11**	**$0.13**	**$0.15**	**$0.17**	**$0.21**

6.2.4. Traffic Diversion Costs

To estimate traffic diversion/rerouting costs for the With Project condition, a similar methodology to that described for Future Without Project condition was used. A total inundation boundary was aggregated together from each of the 26 residual ponding areas (0.2%-chance or 500 year floodplain) and overlaid on street layers to identify potentially inundated roadways. Stage by event for these ponding areas were extracted from the With Project water surface profiles and assigned to the resulting 11 roads. Elevations for these roads were the same as estimated in the Future Without Project condition. Comparisons between the road elevations and stages however indicated that no road inundation would occur in the With Project condition, even during the 0.2%-chance (500 year) flood event.

6.2.5. Emergency Costs

As of this time, no emergency costs have been included in this study effort.

6.3. EQUIVALENT ANNUAL DAMAGES

Expected Annual Damage accounts for the yearly variation in damages/benefits and incorporate these into the annualized value. EAD past the future without project condition date through to the conclusion of the fifty year period of analysis is assumed static. Expected annual damages computed in this way are discounted to present worth using the current discount rate of 4 3/8 percent, and annualized to generate Equivalent Annual Damage. Equivalent Annual Damages for the Future With Project Condition are shown below in Table 17 by ponding area. Table 18 displays the With Project EAD with data from each ponding area aggregated together. This Future With Project Condition EAD will next be subtracted from the Without Project Condition EAD so as to determine the Reconstruction Action's total annual benefits. Table 19 presents the results associated with this project's performance.

Table 17 - Future With Project EAD (by ponding area)

Ohio River, Paducah, KY
Estimated Equivalent Average Annual Damages ($1,000's)
With Project
by Damage Category
FY 2010 Price Levels

	Structure Damages			Vehicle Damages					
Ponding Area	Residential	Commercial	Public	Minivans	Pickups	Sedans	Sports Cars	SUVS	Totals
7-54B	-	-	35.95	-	-	-	-	-	$35.95
19-11B	10.44	2.39	-	-	-	-	-	-	$12.83
51-28C	29.42	-	-	-	-	0.01	0.01	-	$29.44
92-70C	43.21	0.16	0.15	-	-	0.02	0.02	-	$43.56
111-67A	27.76	48.01	-	0.01	0.01	0.04	0.05	0.01	$75.89
130-00A	0.44	3.95	-	-	-	-	-	-	$4.39
140-45A	-	57.08	-	-	-	-	-	-	$57.08
147-25A	-	-	14.70	-	-	-	-	-	$14.70
150-05C	7.23	-	-	-	-	0.01	0.01	-	$7.25
151-25A	-	-	-	-	-	-	-	-	$0.00
157-63A	2.01	0.76	-	-	-	-	-	-	$2.77
172-08C	0.17	-	-	-	-	-	-	-	$0.17
175-40B	1.00	-	-	-	-	-	-	-	$1.00
176-47C	34.17	-	-	-	-	0.02	0.02	-	$34.21
176-90C	40.86	-	-	0.01	0.01	0.02	0.03	0.01	$40.94
199-80C	56.23	96.78	-	-	-	0.01	0.01	-	$153.03
224-50C	9.70	175.43	-	-	-	-	-	-	$185.13
244-65C	0.87	0.89	-	-	-	-	-	-	$1.76
254-06C	11.17	177.88	-	-	-	-	-	-	$189.05
291-75C	-	0.15	-	-	-	-	-	-	$0.15
43-50B Island Creek	117.72	138.00	1.94	0.04	0.03	0.14	0.14	0.03	$258.04
200-55C	100.50	7.53	1.56	0.02	0.02	0.11	0.11	0.02	$109.87
Totals:	$492.90	$709.01	$54.30	$0.08	$0.07	$0.38	$0.40	$0.07	$1,257.21

Table 18 - Future With Project EAD

Ohio River, Paducah, KY
Estimated Equivalent Average Annual Damages ($1,000's)
With Project
by Damage Category
FY 2010 Price Levels

Damage Category		EAD
Residential Structures	$493	
Public Structures	$54	
Commercial Structures	$709	
Traffic Diversion	$0	
Vehicles	$1	
Minivans		*$0*
Pickups		*$0*
Sedans		*$0*
Sports Cars		*$0*
SUVs		*$0*
Emergency Costs	$0	
Total EAD	**$1,257**	

Table 19 – Project Performance

Paducah, KY Project Performance
by Plans and Damage Reaches by Analysis Year
(Stages in ft.)

Event Exceedance Probability = 0.01
Residual Damage = 5.0%

	Damage Reach (W/O) / Ponding Area (W/)		Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probabi			
Plan Name	Name	Target Stage	Median	Expected	10	25	50	10%	4%	2%	1%
Without	Ohio River	330.64	0.0963	0.1022	0.6599	0.9325	0.9955	0.5273	0.0982	0.0277	0.0095
With Reconstruction	7-54 B	Floodwall	0.0001	0	0.0002	0.0005	0.0009	1	1	0.9998	0.9998
	19-11 B	Floodwall	0.0001	0	0.0001	0.0002	0.0003	1	0.9998	0.999	0.9981
	43-50 B	Floodwall	0.0001	0	0.0002	0.0005	0.0009	1	1	0.9999	0.9997
	51-28 C	Floodwall	0.0001	0	0	0.0001	0.0001	1	1	0.9999	0.9998
	92-70 C	Floodwall	0.0001	0	0	0.0001	0.0002	1	1	0.9999	0.9998
	111-67 A	Floodwall	0.0001	0	0.0001	0.0002	0.0003	1	0.9999	0.9993	0.9987
	130-00 A	Floodwall	0.0001	0.0001	0.0011	0.0028	0.0056	1	0.9994	0.9977	0.9961
	140-45 A	Floodwall	0.0001	0	0.0003	0.0007	0.0014	0.9999	0.9998	0.9995	0.9994
	147-25 A	Floodwall	0.0001	0	0.0002	0.0005	0.0009	1	1	0.9999	0.9998
	150-05 C	Floodwall	0.0001	0	0	0.0001	0.0001	1	1	0.9999	0.9999
	151-25 A	Floodwall	0.0001	0	0	0.0001	0.0002	1	0.9999	0.9998	0.9998
	157-63 A	Floodwall	0.0001	0	0.0001	0.0002	0.0005	1	0.9999	0.9993	0.999
	172-08 C	Floodwall	0.0001	0	0	0.0001	0.0002	1	1	0.9999	0.9998
	175-40 B	Floodwall	0.0001	0	0.0001	0.0002	0.0005	1	0.9997	0.9993	0.999
	176-47 C	Floodwall	0.0001	0	0	0	0	1	1	0.9999	0.9999
	176-90 C	Floodwall	0.0001	0	0	0.0001	0.0002	1	1	0.9998	0.9998
	199-80 C	Floodwall	0.0001	0	0	0.0001	0.0002	1	1	0.9999	0.9999
	200-55 C	Floodwall	0.0001	0.0001	0.001	0.0026	0.0052	0.9999	0.9993	0.9978	0.9971
	224-50 C	Floodwall	0.0001	0	0	0.0001	0.0002	1	1	0.9999	0.9998
	244-65 C	Floodwall	0.0001	0	0.0001	0.0002	0.0003	1	0.9999	0.9997	0.9994
	254-06 C	Floodwall	0.0001	0	0.0001	0.0002	0.0005	1	0.9999	0.9997	0.9993
	291-75 C	Floodwall	0.0001	0	0.0001	0.0002	0.0005	1	1	0.9999	0.9995

6.4. SUMMARY

Under expected Future With Project Conditions, the City of Paducah, KY will again be afforded reliable protection, within its design life, from the Ohio River. The represented With Project/Reconstruction Action EAD of $1,257,000 represents a tremendous decrease in the expected annual damage estimate, by comparison to the Future Without Project Condition EAD of $8,174,000. In fact, the difference between the Future Without Project Condition EAD ($8,174,000) and the With Project/Reconstruction Action EAD ($1,257,000) provides the total annual benefits associated with the Reconstruction action - $6,917,000.

7.0 INVESTMENT COSTS AND ANNUAL CHARGES

Project costs, or investment costs, were calculated via the sum of first costs and interest during construction. F irst costs consisted of three main phases: (1) preconstruction, engineering, and design (PED), (2) real estate (RE), and (3) construction (const). F or the purposes of this study, the With Project, or Reconstruction, plan's costs were calculated assuming the duration of time for each phase of first costs: PED – 1 year, RE – 1 year, construction – 3 years. First costs for the Reconstruction plan are $18,728,000. Under the same parameters, interest during construction was calculated based a total 60 month time period for the Reconstruction plan. T he addition of total first costs and interest during construction provides the total investment cost for the plan. Total investment costs for the Reconstruction plan are $19,983,000. To annualize charges, the Reconstruction plan's total investment cost was amortized over a 50 year period of analysis at the current federal interest rate of 4.375%. Annual O&M costs for the Reconstruction plan, provided by CELRL-ED-M-C, were applied to generate total annual charges. Total annual charges for the Reconstruction plan are $1,614,000. A summary of individual component costs is shown in Table 20.

Table 20 - Project Cost Summary Report

Ohio River, Paducah, KY
Project Cost Summary Report (000's)
FY 2010 Price Levels

Relocations	20.1
Pump Plant #1 (Noble Park)	405.7
Pump Plant #2 (Sixth Street)	1715.1
Pump Plant #3 (Park Ave)	251.2
Pump Plant #4 (Clay Street)	203.9
Pump Plant #5 (Harrison Street)	433.3
Pump Plant #6 (Clark Street)	706
Pump Plant #7 (Tennessee Street)	656.4
Pump Plant #9 (Husbands Road)	235
Pump Plant #10 (George Street)	126.6
Pump Plant #11 (Island Creek)	653.4
Pump Plant #12 (SE of Paducah)	442.1
Pump Plant #13	46.2
Pump Plant #14 (at Sta.111+67) Submersible 100 cfs Pump	1662.9
Levees	3762.2
Floodwalls	3102.1
Bank Stabilization	100
Planning, Engineering, and Design	1239.2
Construction Management	1382.1
Miscellaneous Items	1148.5
Lands and Damages	436
Total Construction Costs	$18,728.0

8.0. SUMMARY OF ANNUAL BENEFITS AND COSTS

A numerical summary of the annual benefits and costs associated with the With Project/Reconstruction plan is displayed in Table 21.

Table 21 - Summary of Annual Benefits and Costs

Ohio River, Paducah, KY
Feasibility Study
Summary of Annual Benefits and Costs

FY 2010 Price Levels (x $1,000)
4 3/8% Interest Rate

Investment Cost	**Reconstruction**
Construction First Cost	$18,728
Interest During Construction	$1,255
Total Investment Cost	$19,983
Annual Charges	
Interest & Amortization	$991
Operation & Maintenance	$623
Total Annual Charges	$1,614
Annual Benefits	
Structures	
-Residential	$4,328
-Public	$361
-Commercial	$1,849
Traffic Diversion	$82
Vehicles	
-Minivans	$28
-Pickups	$25
-Sedans	$107
-Sports Cars	$114
-SUVs	$24
Emergency Costs	$0
Total Annual Benefits	$6,917
Residual Expected Annual Damages	$1,257
Benefit vs. Cost Ratio	4.3
Net Benefits	$5,303

9.0. ECONOMIC SUMMARY

Future Without Project Conditions provide for an EAD of $8,174,000 while With Project Conditions produce an EAD of only $1,257,000. This difference represents total annual benefits of $6,917,000 resulting from the proposed Reconstruction action. When compared to total annual charges of $1,614,000 the resulting Benefit-to-Cost ratio is 4.3, which is well above unity. This Reconstruction plan generates a Benefit-to-Cost ratio above unity and produces a positive net benefit ($5,303,000) to the Nation so it is therefore considered to be economically feasible and is viewed as the NED plan.

10.0. PUMP PLANT #14 (at Station 111+67A) INCREMENTAL ANALYSIS WITH and WITHOUT PROJECT CONDITION

This portion of the study is focused on a single feature, a submersible Pump Plant (14) at Station 111+67A. This Pump Plant is the only feature of the With Project Reconstruction project which is not an original feature of the Paducah Local Protection Project. As such, an array of alternatives must be developed and analyzed for Pump Plant #14. For this effort, the study team developed and analyzed four different pump plant alternatives to serve locations affected from ponding water at Station 111+67A. These four alternatives were identified by increasing pump sizes. The array of pump sizes included a 50 cfs, 100 cfs, 150 cfs, and 200 cfs pump plant. From this array, each must be economically analyzed with a determination of feasibility to be made on an individual, incremental level as stated in memorandum CECW-PB, 16 Aug 2005, Subject: Reconstruction of U.S. Army Corps of Engineers Structural Flood Damage Reduction Projects for which Non-Federal Interests are Responsible for Operation, Maintenance, Repair, Rehabilitation, and Replacement.

Based on language expressed in memorandum CECW-PB, 16 Aug 2005 (see REFERENCES in Volume 4),

> *"...depending on the interest of the non-Federal sponsor, the feasibility study may be limited to examination of the reconstruction of the existing project with no change in its scope or function. Under this limited objective, evaluation would be limited to individual project features, (closure structures, pumping stations, gravity drains, relief wells, etc.) to establish the justification of reconstruction based on a comparison between the with and without reconstruction condition."*

There are currently 12 pump plants currently operating at the Paducah LFPP. By adding the one pump plant (14), USACE is only increasing the efficiency of the project and bringing it up to current USACE standards. This is not to be considered as a change in the project scope or level of protection. The pump plant at Station 111+67 A was evaluated, as well as a non-structural measure (floodproofing), to address an interior flooding situation which had not been fully identified during initial construction. See Section 4.5.5 for more information on evaluation of non-structural alternatives).

Once a d etermination of feasibility is made for each pump plant alternative, all alternatives producing feasible benefit-to-cost ratios must be compared to establish which pump size produces maximum net benefits to the Nation, thus becoming the NED plan. This section details the economic efforts put forth to analyze Pump Plant #14A.

10.1. Structure Inventory

The structure inventory for both the Without Project and With Project actions for Pump Plant #14A are identical. The inventory for Pump Plant #14A is comprised of those structures, commercial, residential, and public, that fall within the 500 year or 0.2%-chance floodplain, as delineated by estimated hydrologic conditions consistent with anticipated future development as well as the Ohio River being at flood levels requiring the use of pumps to dispose of interior flood waters. In this way structures in and around the study area are limited to those that would receive damages in the lowest probability flood event or 'worst case scenario' considered in this analysis. To accomplish this, a structure footprint shapefile was generated by the PDT GIS Specialist/Geographer to the boundaries of the largest inundation area, the 0.2%-chance (500 year) floodplain. A ny structures that intersected in any part the inundation boundary layer were extracted and became the structure inventory.

This affected area contains 31 structures within the 0.2%-chance (500 year) floodplain. T he array of structures includes 2 residential structures and 29 commercial structures. Residential structures include single-family housing units and commercial structures are comprised of all buildings which maintain some sort of business activity. T his includes, but is not limited to, restaurants, grocery stores, office buildings, retail outlets, repair shops/garages, and industrial places of business. The structure inventory for both residential and non-residential structures and all associated data and characteristics are ultimately entered into the Hydrologic Engineering Center's Flood Damage Analysis program, or HEC-FDA (version 1.2.4 was used in this study), which will then use modeled interior flooding events to estimate damages to affected structures based on these characteristics and data. These data include, for each structure, an estimated depreciated replacement value, the stream on which the structure is located and the approximate stream station, the ground elevation of the structure and foundation height relative to this ground elevation, and finally a depth-damage relationship estimating damages to the structure as either a percentage of structure value or as a direct dollar figure for various stages of flooding. T he computation process is described in greater detail later in this appendix. The process of gathering this data is described in the following sections.

10.2. Structure Value

Residential and non-residential structure data required for FDA analysis can be subdivided into four primary components; the structures depreciated replacement value, its location within the floodplain (stream name and stationing corresponding to that used in the H&H model), its elevation, and its susceptibility to flooding damages and the magnitude of those damages as represented by a depth-damage curve. The processes for developing these four components are detailed below.

Once the affected or potentially affected structures were isolated, more detailed data were assigned to the residential portion of the structure inventory from field surveys in the study area performed by Corps economists. These field surveys were primarily used for classification, reference, and valuation of individual structures. Field surveys were performed for each residential and non-residential structure within the 0.2%-chance (500 year) floodplain of the 111+67A ponding area. Structure surveys were conducted to estimate structure quality, stratified according to categories used in the Marshall and Swift Valuation Service methodology, which was used to estimate depreciated replacement values for structures in the study area (these categories being: low, fair, average, good, very good, and excellent quality); the approximate foundation height relative to the ground elevation; the number of floors; and finally the estimated effective age of the structure. Effective age, as described in the Marshall and Swift Residential Cost Handbook, refers to the property's "age as compared with other properties performing like functions. It is the actual age less the age which has been taken off by face-lifting, structural reconstruction, removal of functional inadequacies, modernization of equipment, etc." Effective age was used in the calculation of depreciation.

Data gathered from the field survey work were fed into the Marshall and Swift valuation methodology to generate estimated depreciated replacement values for each individual structure in the floodplain. The Marshall and Swift Residential Cost Handbook includes tables providing square foot values for structures by the above mentioned quality categories, the number of floors, the construction type (stucco, siding, brick, etc.) and by the structure's total square footage. It also includes value tables for fireplaces, garages, and basements. These tables are updated as needed by Marshall and Swift to reflect the most current variations in home values. The most recent updates used in this analysis are as of December 2009.

For each structure the value per square foot was determined based on the data gathered above, the construction type, structure quality, square footage, and number of floors. The full structure value is simply a sum of the structure's referenced value per square foot multiplied by the actual square footage, and the estimated value, if applicable, of a garage, fireplace, and/or basement. Each individual structure's value is modified by a locality adjustment to account for regional variations in housing values, and depreciated based on the estimated effective age obtained during field surveys. Garages, fireplaces, and basements are valued in the same way as the structure itself.

10.3. Structure Location

The without project study area for Pump Plant #14A is affected by ponding effects from one major river system, the Ohio River. For the purposes of this analysis, the Pump Plant 0.2% chance (500 year) floodplain was treated as one single damage reach. Damage reaches are stream-unique geographic areas within the floodplain that possess common geographic and hydrologic characteristics, including discharge and stage exceedance probabilities. Reaches can be delineated for a variety of reasons, including existing flood damage reduction measures, concentrations of residential and nonresidential structures and uniform probabilities, and can be designated as either

the right or left bank of the stream, or both. Reaches are assigned index locations to facilitate the aggregation of individual structure stage-damage functions. Assumed stages at this index location are adjusted to each individual structure based on that structure's associated stream mile, using the water surface profile (which contains stages at each station in the reach) for the corresponding flood event. Each structure was assigned to the same stream, reach, and station. All structures were assigned to the same stream in this analysis.

10.4. Structure Elevation

The structure elevation component is a combination of three data points, the structures ground elevation, the foundation height relative to the ground elevation, and the beginning damage depth relative to the foundation height. The foundation height is from the ground elevation to the elevation of the first floor, and for most structures in the study area was between zero and three feet. Structure elevations were assigned after the field study was conducted. Spot elevation and contour layers were used by the Economist during the field study to determine ground elevation. Foundation heights were estimated during the structure field survey. The beginning damage depth, which is the point at which damage begins, was assumed to correlate to the ground elevation, and so was set as equal to the inverse of the foundation height. The result of this is that depth-damage curves for each structure were truncated at the ground elevation of the structure, so that structures with basements did not receive damages until the flood stage was above the ground stage.

10.5. Structure Depth-Damage Relationships

The final components are the depth-damage relationships for each structure. For residential structures standardized generic depth-damage curves published in Economic Guidance Memorandum (EGM) 04-01 were used. These damage curves were developed by the Institute for Water Resources' (IWR) Flood Damage Data Collection Program. Flood damage data were collected under this program from nationwide flooding events during the period of 1996 through 2001, and regression analysis was used to create these functions. Depth-Damage relationships were assigned to residential structures based on data gathered from the field survey, as described above. The relevant variables were the number of floors and the presence or absence of a basement.

An example depth-damage relationship, for a single-story single-family residence without basement, is shown below in Table 22. The depth damage relationships associate damages as a percentage of structure value for both contents and the structure itself for a series of flood stages. These flood stages are relative to the first floor elevation. Each stage and percent damage has an associated standard deviation of error, which is used by HEC-FDA in risk-based analysis.

Table 22 - Depth-Damage Relationship
Single-story, single-family, without basement

One Story - No Basement - Single Family

Stage	Avg. % Structure Damage	Standard Deviation
-2	0.0%	0
-1	2.5%	2.7
0	13.4%	2
1	23.3%	1.6
2	32.1%	1.6
3	40.1%	1.8
4	47.1%	1.9
5	53.2%	2
6	58.6%	2.1
7	63.2%	2.2
8	67.2%	2.3

Stage	Avg. % Content Damage	Standard Deviation
-2	0.0%	0
-1	2.4%	2.1
0	8.1%	1.5
1	13.3%	1.2
2	17.9%	1.2
3	22.0%	1.4
4	25.7%	1.5
5	28.8%	1.6
6	31.5%	1.6
7	33.8%	1.7
8	35.7%	1.8

1. Flood stages are relative to the first floor elevation.
2. Both Structure and Content damages are estimated as a percentage of structure value.

For commercial and public structures, generic non-residential percent-depth damage curves were used for the appropriate non-residential structure category and type. These standardized generic depth-damage functions were developed by the Corps of Engineers New Orleans District. Use of these non-residential curves first requires differentiation of the structure as being commercial or public in nature. Next, each commercial structure was assigned one of six different occupancy type IDs by which the depth-damage curve could reference and apply to the commercial structures within the inventory. The six occupancy types utilized were EAT - Eating and Recreation, GROC – Groceries and Gas Stations, PROF – Professional Services, REPA – Repairs and Home Use, RETA – Retail and Personal Services, and WARE – Warehouses and Contractors. D epth-Damage relationships were assigned to non-residential structures based on da ta gathered from the field survey, as described above. Beginning damage depth was assumed to be 0 for all non-residential structures.

As per guidance in EGM 04-01, content depth-damages were estimated as a percentage of structure value, rather than the previous method of first estimating content value via a content-to-structure value ratio. T hus for each structure the content-to-structure value ratio was entered into HEC-FDA as 100%.

The final structure inventory for import into the Hydrologic Engineering Center's Flood Damage Analysis program (HEC-FDA) contained, for each structure, the stream name and station; the ground elevation, foundation height, and beginning damage depth; the replacement value; and the structure category and occupancy type, which are used to assign a depth-damage function.

10.6 FLOOD DAMAGE ESTIMATES

10.6.1. HEC-FDA

The Corps of Engineers requires the use of risk-based analysis for evaluating flood damages and flood damage reduction measures, as described in ER 1105-2-101 – Risk Analysis for Flood Damage Reduction Studies. A risk-based analysis quantifies uncertainty in key input variables, such as stage-exceedance probability, stage-damage relationships, and structure characteristics. This procedure further integrates them into an economic analysis for with and without-project conditions and a performance analysis for flood reduction measures. T hese computations were performed for this study by the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software package, version 1.2.4. The information described in the section above: estimated replacement values, occupancy types with associated stage-damage functions, structure ground and first floor elevations, and other data were input into FDA, along with water surface profiles, exceedance probability functions, and all associated uncertainties.

HEC-FDA compiles data generated during the H&H analyses as well as the structure inventory and associated data described above. The H&H components include the water surface profiles (WSP) for both Without Project and With Project actions, which for every stream assigns a stage or water surface elevation for each of the eight analyzed probability flood events (from the 1 year or 99% probability of occurrence flood to the 500 year or 0.2%-chance flood) to each station along that stream; and the stage-exceedance probability functions, which describe a range of stages for each reach and associated probabilities of exceeding that stage, ranging from a 99.9%-chance to a 0.1%-chance (1,000 year) event.

These compiled data are essentially a series of probabilistic curves defining relationships between flood stage and frequency of occurrence, and flood stage and damages. These are used ultimately to generate a curve relating probability of occurrence and total damages, the integration of which provides expected annual damages, or EAD. Stage-exceedance probability functions for each reach are used to generate a range of stages and probabilities at each index location which will be used in the creation of an aggregated stage damage function representing the total stage-damage relationship of that reach, including damages to all structures, contents, and all other considered damage categories, for a series of probability ordinates. FDA is essentially generating a reach-wide stage-damage function similar to those created for each structure as described above for both Without Project and With Project actions. To generate these aggregated damages, total damages must be estimated for all structures and other damage categories within that reach for a given stage at the index station. To do this, accounting for the variation in water surface elevation for each analyzed flood frequency throughout the reach, estimated stage-damage for each structure is translated to the index point of the reach.

HEC-FDA uses probability distributions and Monte Carlo simulation to account for uncertainty and derive expected annual damages. This random sampling approach computes multiple thousands of successive iterations of each computation for which there is uncertainty, using the assigned standard deviations of error, and averages the results. After accounting for changed future conditions, equivalent annual damage for the Without Project condition are subtracted by the resulting equivalent annual damage for With Project condition to determine flood damage reduction benefits for each of the four Pump Plant plan alternatives. Note that the Without Project condition in the evaluation of a new pump plant is with completed reconstruction of the existing LFPP.

10.6.2. Structure and Content Damages

The damage categories considered in this analysis include damage to structures and contents, as described above, damages to automobiles, costs of road closures and diverted traffic as heavily trafficked roads are inundated, and emergency costs. The processes for computing damages to structures and contents have been largely covered in the preceding sections. Estimated damages are tabulated below. The remaining damage categories required additional assumptions and computations, and these will be described in detail in the corresponding subsections.

The number of inundated, or affected structures (Table 23), the total value of inundated structures (Table 24), and total structure damages (Table 25) (including both structure and content damages) by stream, reach, and frequency flood event are presented below.

Table 23 - Affected Structures by Event
Pump Station #14A, Paducah, KY
Estimated Number of Structures Flooded
Without Project
by Structure Category

	Annual Exceedance Probability							
Structure Category	**99.9%**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**
Residential	0	0	0	0	0	1	1	1
Public	0	0	0	0	0	0	0	0
Commercial	0	0	0	12	16	18	24	27
Totals:	**0**	**0**	**0**	**12**	**16**	**19**	**25**	**28**

Table 24 - Value of Affected Structures by Event
Pump Station #14A, Paducah, KY
Total Value of Structures Flooded
Without Project
By Structure Category
FY2010 Price Levels

Pump Station	Residential	Public	Commercial	Total
#14A (at 111+67)	$72.72	$0.00	$7,046.87	$7,119.59

Table 25 - Estimated Structure Damages by Event
Pump Station #14A, Paducah, KY
Estimated Damages ($000) to Structures
Without Project
By Structure Category and Event
FY2010 Price Levels

	Annual Exceedance Probability							
Structure Category	**99.9%**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**
Residential	$0.00	$0.00	$0.00	$0.00	$0.00	$0.28	$0.72	$1.92
Public	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Commercial	$0.00	$0.00	$0.00	$323.30	$864.98	$986.41	$1,148.98	$1,728.40
Totals	**$0.00**	**$0.00**	**$0.00**	**$323.30**	**$864.98**	**$986.70**	**$1,149.70**	**$1,730.33**

10.6.3. Damages to Vehicles

Damages to vehicles were computed in a similar fashion to structure damages; a vehicle inventory was established, one containing vehicle values and broken down by type (occupancy type) with associated depth-damage relationships. T his vehicle inventory was necessarily more abstract than the structure inventory, as the dataset used to generate it, FEMA's Multi-Hazard Loss Estimation Methodology, or HAZUS-MH database, provided vehicle counts and values at a census block level. The process of generating the original WOPC vehicle inventory is described below, and modifications to this inventory to develop that used in the analysis of pumping plant #14A detailed later.

To develop the WOPC vehicle inventory, the database of HAZUS vehicle data was assigned by census block number to a georeferenced census block layer in ArcMap. This layer was then clipped to the 500 year or 0.2%-chance WOPC flood event inundation boundary used to delineate the structure inventory. Census blocks that fell partially within this area were subdivided by the border of this inundation boundary, and the resulting smaller subset's area was compared against that of the original

census block to develop a percentage modifier. This modifier was then applied to the vehicle data associated with that census block. The resulting database divided the inundation boundary into census block and sub-census block areas, each containing vehicle counts and values for that area, broken down by vehicle type. These data were arranged for each census block, as follows in Figure 5 (Figure 5 is shown to illustrate format only – no data is included):

Figure 5 – HAZUS Vehicle Data

Day	Cars	Total Value	New
			Used
		Count	
	Light Trucks	Total Value	New
			Used
		Count	
	Heavy Trucks	Total Value	New
			Used
		Count	
Night	Cars	Total Value	New
			Used
		Count	
	Light Trucks	Total Value	New
			Used
		Count	
	Heavy Trucks	Total Value	New
			Used
		Count	

As seen in Figure 5 above, both vehicle counts and average values are provided by the HAZUS database as day and night values, representing an often large variance in vehicle counts as commuters travel in and out of the floodplain moving vehicles from residences to commercial establishments. In the HAZUS MH MR3 Technical Manual it is stated that 'Day' vehicle counts and values are assumed to reflect normal business hours, while 'Night' values represent the remainder of the day. To capture this variability, given the fact that a flood event has a roughly even chance of occurrence at any time of day or night, an estimated nine hour workday was assumed including commute to develop a 25/75 ratio modifier for day and night values, respectively. In this way the modified values for both can be combined to generate one set of counts and values for each vehicle type.

As can also be seen in Figure 5, vehicle values are provided in the HAZUS dataset as both new and used car values. Both used and new car values were averaged together to generate the average vehicle values by census block. An analysis performed to measure variability in both value and vehicle type by census block found no significant variability, and as such vehicle values and percentage breakdowns by type were averaged across the study area rather than for each census block separately.

Depth damage curves for vehicles were recently published in Economic Guidance Memorandum 09-04 - Generic Depth-Damage Relationships for Vehicles. In the

EGM, depth-damage relationships are provided for five classes of vehicles; Sedans, Sports Cars, SUVs, Minivans, and Pickups. HAZUS vehicle data is broken down into three categories, 'Cars', 'Light Trucks', and 'Heavy Trucks'. In order to marry the HAZUS data with the vehicle depth-damage functions, the Cars counts and values were divided evenly between the Sedans and Sports Cars depth-damage relationships, and the Light Trucks counts and values were divided evenly between the SUVs, Minivans, and Pickups depth-damage relationships.

As parked vehicles would typically be located at residences or businesses, five vehicle 'nodes' were created within HEC-FDA at each structure, both residential and non-residential, in the study area, one for each vehicle type and associated depth damage curve. E ssentially this assumes that at each structure there will be a percentage of each of the five vehicle types, a p ercentage that corresponds to that type's average distribution in the study area, and that will sum to the study area wide average number of vehicles per structure. In other words, at every structure there would be X% of one sedan, Y% of one pickup, and so forth, and each of these would be assigned a unique depth-damage function. T hese nodes were assigned ground elevations, the stream and reach, and stations duplicated from the corresponding structure. Foundation heights and beginning damage depths were each assigned as zero, assuming the vehicle would be parked at the ground elevation of the structure. This approach will likely understate damages slightly, as a result of vehicles parked on streets or on driveways at a lower elevation that

the ground elevation of the structures they are assigned to. The 'structure value', in this case vehicle value to be assigned to each node, was computed by dividing the total vehicle values by the vehicle count to determine a per vehicle value. This was done twice, once for the Cars category, and once for the Light Trucks category.

These same vehicle counts were reduced by 50.5% in accordance with EGM 09-04 to account for vehicles moved to higher ground following advance warning. T his reduction assumes a warning time of 6 hours or less. The resulting remaining vehicle counts were divided by the number of structures in the study area to arrive at per structure vehicle counts, one for Cars and one for Light Trucks. As these two categories were separated in the HAZUS database from the beginning there is no overlap in these values. These per structure counts for Cars and Light Trucks were then multiplied by the per vehicle value for the corresponding type to arrive at a per structure vehicle value. This value was then divided evenly as mentioned previously between the assigned depth-damage categories, Cars into Sedans and Sports Cars, Light Trucks into SUVs, Minivans, and Pickups. This yielded the following values shown in Table 26.

Table 26– Per Structure Vehicle Values (2010 Price Level)

Vehicle Node	Value ($000's)
Sedans	0.808
Pickups	0.227
SUVs	0.227
Sports	0.808
Minivans	0.227

This inventory as developed for the without-project condition, as mentioned above, was also used for the analysis of pump plant #14A. To accomplish this, the vehicle nodes created were simply assigned as 'dummy structures' (five for each structure, one for each vehicle type) to the structures identified as falling within the ponding area associated with the pumping plant. Expected Annual Damages to vehicles resulting from HEC-FDA modeling are detailed in Table 27 below for the Without Project and for each of the four pump plant alternatives, broken down by category of vehicle damage.

Table 27 - Expected Annual Damages to Vehicles

	Vehicle EAD					
	Minivans	Pickups	Sedans	Sports	SUVs	Totals
Without	0.14	0.13	0.61	0.66	0.11	**1.65**
With 50 cfs Pump Station	0.02	0.02	0.10	0.10	0.01	**0.25**
With 100 cfs Pump Station	0.01	0.01	0.04	0.04	0.01	**0.11**
With 150 cfs Pump Station	0.01	0.01	0.03	0.03	0.00	**0.08**
With 200 cfs Pump Station	**0.00**	**0.00**	**0.02**	**0.02**	**0.00**	**0.04**

10.6.4. Traffic Diversion Costs

During flooding events roads will be inundated by floodwaters and rendered impassable, and all traffic that would have been routed through these inundated road segments under normal circumstance must necessarily be rerouted. The economic loss under these circumstances would then be a factor of additional time and distance, or the net increase of these required by the traffic diversion. Additional distance would mean an additional expenditure of fuel, as well as wear and tear on the rerouted vehicles. To estimate these 'damages' the increase in driving distance necessitated at each anticipated flooded road segment during each flood event must first be estimated.

To accomplish this, the ArcView GIS program was used to locate areas of potential road inundation at the 0.2%-chance (500-year) flood event. Inundation boundaries for this flood event were overlaid on polygon road layers and the potentially inundated segments extracted. This is used both in identifying areas likely to result in significant traffic rerouting, as well as to ensure that computed traffic diversions did not divert through another road that was also inundated. Water surface profiles for the 0.2%-chance (500 year) event assuming the pump plant alternative analyzed above reconstruction of the existing local protection project however indicated no road closures in the ponding area, as stages never exceeded low road elevations. For

this reason, no traffic diversion costs result from either the with or without conditions with regard to the addition of any of the #14A pump plant alternatives.

10.6.5. Emergency Costs

As of this time, no emergency costs have been included in this study effort.

10.6.6. EXPECTED ANNUAL DAMAGES

10.6.7. Without Project Condition

Expected Annual Damage accounts for the yearly variation in damages/benefits and incorporate these into the annualized value. EAD past the future without project condition date through to the conclusion of the fifty year period of analysis is assumed static. Expected annual damages computed in this way are discounted to present worth using the current discount rate of 4 3/8 percent, and annualized to generate Equivalent Annual Damage. Expected Annual Damages for the Future Without Project Condition are shown below in Table 28. This Future Without Project Condition EAD will next be subtracted by each respective alternative's EAD so as to determine total annual benefits for each alternative pump size.

Table 28 - Future Without Project EAD
Ohio River, Paducah, KY - Station 111+67
Estimated Expected Average Annual Damages ($000)
Without Project
by Damage Category
FY 2010 Price Levels

Damage Category		EAD
Residential Structures	$0.82	
Public Structures	$0.00	
Commercial Structures	$185.65	
Traffic Diversion	$0.00	
Vehicles	$1.68	
Minivans		*$0.14*
Pickups		*$0.13*
Sedans		*$0.62*
Sports Cars		*$0.68*
SUVs		*$0.11*
Emergency Costs	$0.00	
TOTAL EAD	**$188.15**	

Note: Without Project = without new pump plant but with reconstructed LFPP.

10.6.8. With Project Condition

Expected annual damages were computed in this way for each of the four pump plant size alternatives (50 cfs, 100 cfs, 150 cfs, and 200 cfs). Expected Annual Damages for each of the alternatives are shown in the following tables (Table 29, Table 30,

Table 31, and Table 32, respectively). Total Annual Benefits for each alternative, Without Project EAD subtracted by the alternative's residual EAD, are displayed in these tables as well.

Table 29 – 50 cfs pump plant EAD

Ohio River, Paducah, KY - Station 111+67
Estimated Expected Average Annual Damages ($000)
With Project -50 cfs Pump Station
by Damage Category
FY 2010 Price Levels

Damage Category		EAD
Residential Structures	$0.30	
Public Structures	$0.00	
Commercial Structures	$71.88	
Traffic Diversion	$0.00	
Vehicles	$0.26	
Minivans		*$0.02*
Pickups		*$0.02*
Sedans		*$0.10*
Sports Cars		*$0.10*
SUVs		*$0.02*
Emergency Costs	$0.00	
TOTAL EAD	**$72.44**	
Total Annual Benefits	**$115.71**	

Table 30 – 100 cfs pump plant EAD

Ohio River, Paducah, KY - Station 111+67
Estimated Expected Average Annual Damages ($000)
With Project -100 cfs Pump Station
by Damage Category
FY 2010 Price Levels

Damage Category		EAD
Residential Structures	$0.17	
Public Structures	$0.00	
Commercial Structures	$41.57	
Traffic Diversion	$0.00	
Vehicles	$0.12	
Minivans		*$0.01*
Pickups		*$0.01*
Sedans		*$0.04*
Sports Cars		*$0.05*
SUVs		*$0.01*
Emergency Costs	$0.00	
TOTAL EAD	**$41.86**	
Total Annual Benefits	**$146.29**	

Table 31 – 150 cfs pump plant EAD

Ohio River, Paducah, KY - Station 111+67
Estimated Expected Average Annual Damages ($000)
With Project -150 cfs Pump Station
by Damage Category
FY 2010 Price Levels

Damage Category		EAD
Residential Structures	$0.13	
Public Structures	$0.00	
Commercial Structures	$32.85	
Traffic Diversion	$0.00	
Vehicles	$0.08	
Minivans		*$0.01*
Pickups		*$0.01*
Sedans		*$0.03*
Sports Cars		*$0.03*
SUVs		*$0.00*
Emergency Costs	$0.00	
TOTAL EAD	**$33.06**	
Total Annual Benefits	**$155.09**	

Table 32 – 200 cfs pump plant EAD

Ohio River, Paducah, KY - Station 111+67
Estimated Expected Average Annual Damages ($000)
With Project -200 cfs Pump Station
by Damage Category
FY 2010 Price Levels

Damage Category		EAD
Residential Structures	$0.09	
Public Structures	$0.00	
Commercial Structures	$22.88	
Traffic Diversion	$0.00	
Vehicles	$0.04	
Minivans		*$0.00*
Pickups		*$0.00*
Sedans		*$0.02*
Sports Cars		*$0.02*
SUVs		*$0.00*
Emergency Costs	$0.00	
TOTAL EAD	**$23.01**	
Total Annual Benefits	**$165.14**	

10.7. INVESTMENT COSTS AND ANNUAL CHARGES

Project costs, or investment costs, were calculated via the sum of first costs and interest during construction for each pump size alternative at Pump Plant #14A (at Station 111+67). First costs consisted of three main phases: (1) preconstruction, engineering, and design (PED), (2) real estate (RE), and (3) construction (const). First costs for the four alternative pump sizes are as follows: 50 cfs pump plant - $1,274,000, 100 cfs pump plant - $1,663,000, 150 cfs pump plant - $2,052,000, and 200 cfs pump plant - $2,440,000. Under the same parameters, interest during construction was calculated based on a total 12 month time period for each alternative pump size for Pump Plant #14A. The addition of total first costs and interest during construction provides the total investment cost for the plan. Total investment costs for the four alternatives are as follows: 50 cfs pump plant - $1,302,000, 100 cfs pump plant - $1,699,000, 150 cfs pump plant - $2,097,000, and 200 cfs pump plant - $2,493,000. To annualize charges, each of the four alternative's total investment cost was amortized over a 50 year period of analysis at the current federal interest rate of 4.375%. Annual operation and maintenance costs for the four alternatives are as follows: 50 cfs pump plant - $12,000, 100 cfs pump plant - $15,000, 150 cfs pump plant - $18,000, and 200 cfs pump plant - $20,000. Annual operation and maintenance costs, provided by CELRL-ED-D-M, were applied to generate total annual charges. Total annual charges for the four alternative pump sizes are as follows: 50 cfs pump plant - $77,000, 100 cfs pump plant - $99,000, 150 cfs pump plant - $122,000, and 200 cfs pump plant - $144,000. First costs, interest during construction, total investment costs, interest and amortization, O&M costs, and total annual charges are displayed in Table 33.

10.8. SUMMARY OF ANNUAL BENEFITS AND COSTS

A numerical summary of all annual benefits and costs for each pump plant size alternative are displayed in Table 33.

Table 33 - Summary of Annual Benefits and Costs

Ohio River, Paducah, KY
Pump Station @ 111+67
Summary of Annual Benefits and Costs
FY 2010 Price Levels (x $1,000)
4 3/8% Interest Rate

Investment Cost	**50 cfs PS**	**100 cfs PS**	**150 cfs PS**	**200 cfs PS**
Construction First Cost	$1274	$1663	$2052	$2440
Interest During Construction	$28	$36	$45	$53
Total Investment Cost	$1302	$1699	$2097	$2493
Annual Charges				
Interest & Amortization	$65	$84	$104	$124
Operation & Maintenance	$12	$15	$18	$20
Total Annual Charges	$77	$99	$122	$144
Annual Benefits				
Structures				
-Residential	$1	$1	$1	$1
-Public	$0	$0	$0	$0
-Commercial	$114	$144	$153	$163
Traffic Diversion	$0	$0	$0	$0
Vehicles (Total)	$1	$2	$2	$2
-Minivans	*$0.1*	*$0.1*	*$0.1*	*$0.1*
-Pickups	*$0.1*	*$0.1*	*$0.1*	*$0.1*
-Sedans	*$0.5*	*$0.6*	*$0.6*	*$0.6*
-Sports Cars	*$0.6*	*$0.6*	*$0.7*	*$0.7*
-SUVs	*$0.1*	*$0.1*	*$0.1*	*$0.1*
Emergency Costs	$0	$0	$0	$0
Total Annual Benefits	$116	$146	$155	$165
Residual Estimated Annual Damages	$72	$42	$33	$23
Benefit vs. Cost Ratio	1.51	1.47	1.27	1.15
Net Benefits	$39	$47	$33	$22

10.9. ECONOMIC SUMMARY

Future Without Project Conditions provide for estimated EAD of $188,000. Total annual benefits for each alternative equal the difference between the Without Project EAD and the individual pump plant's residual EAD. Total annual benefits account for the expected annual damages that will be eliminated by the presence and operation of the respective pump plant in the study area. Residual EAD accounts for the respective amount of damages that the study area is expected to continue to experience even with the appropriate pump plant in place and fully operational. Total annual benefits and residual EAD's vary for each pump plant alternative considered in this effort. The 50 cfs pump plant at Station 111+67 produces total annual benefits of $116,000 and residual EAD of $72,000. The 100 cfs pump plant at Station 111+67A produces total annual benefits of $146,000 and residual EAD of $42,000. The 150 cfs pump plant at Station 111+67A produces total annual benefits of $155,000 and residual EAD of $33,000. The 200 cfs pump plant at Station 111+67A produces total annual benefits of $165,000 and residual EAD of $23,000. Total annual benefits are divided by total annual costs to determine each alternative pump plant's benefit-to-cost ratio (BCR). According to economic guidance, alternatives are not considered to be economically feasible unless they produce a BCR above unity, or 1.0. The resulting BCR for each alternative pump plant are as follows: 50 cfs pump plant – 1.5, 100 cfs pump plant – 1.5, 150 cfs pump plant – 1.3, and 200 cfs pump plant – 1.2. Each of the alternatives produces resulting BCRs which are considered to be economically feasible and justified. Net benefits for each alternative, which is the difference in total annual benefits and total annual costs, are next compared to each other so that the NED plan can be selected from the array of pump sizes. The NED plan is the alternative which maximizes net benefits to the Nation. The net benefits, as shown in Table 33, for each alternative are as follows: 50 cfs pump plant – $39,000, 100 cfs pump plant – $47,000, 150 cfs pump plant – $33,000, and 200 cfs pump plant – $22,000. From this comparison it is determined that the 100 cfs pump plant alternative is selected as the NED plan for pump plant #14 (at Station 111+67A). The 100 cfs alternative generates a positive BCR (1.5) and maximizes net benefits ($47,000) across all the alternative pump sizes. As per the requirements stated in memorandum "CECW-PB, 16 Aug 2005, Subject: Reconstruction of U.S. Army Corps of Engineers Structural Flood Damage Reduction Projects for which Non-Federal Interests are Responsible for Operation, Maintenance, Repair, Rehabilitation, and Replacement," the 100 cfs pump plant alternative is individually and incrementally justifiable. As a result, it is included in all With Project Reconstruction calculations in the previous 10 sections of this economic appendix.

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

ENGINEERING

TABLE OF CONTENTS

SECTION 1 - GENERAL

SECTION 2 - HYDROLOGY AND HYDRAULICS

SECTION 3 - SURVEYING AND MAPPING REQUIREMENTS

SECTION 4 - GEOTECHNICAL ENGINEERING

SECTION 5 - ENVIRONMENTAL ENGINEERING

SECTION 6 - CIVIL ENGINEERING

SECTION 7 - STRUCTURAL SECTION

SECTION 8 - ELECTRICAL AND MECHANICAL REQUIREMENTS

SECTION 9 - OPERATION AND MAINTENANCE

SECTION 10 - SUMMARY OF COST ESTIMATE

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX C

LIST OF ACRONYMS/ABBREVIATIONS

ACI	American Concrete Institute
AE	Architectural Engineering
ASTM	American Society for Testing Materials
BGS	Below Ground Surface
bpf	blows per foot
CAGIS	Cincinnati Area Geographic Information System
CASE	Computer Aided Structural Engineering
CCTV	Closed Circuit Television
CELRL	Corps of Engineers, Lakes and Rivers Division, Louisville District
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation and Liability Information System
CICAS	TSCA Chemicals in Commerce Information System
cfs	cubic feet per second
CL	low plasticity Clay
CL-M	low plasticity Clay with Silt
CMP	Corrugated Metal Pipe
CMU	Concrete Masonry Unit
COE	Corps of Engineers
CORRACTS	Corrective Action Report
CSO	Combined Sewer Overflow
CU	Consolidated Undrained
CWALSHT	Design/Analysis of Sheet-Pile Walls by Classical Methods
CWCCIS	Civil Works Construction Cost Index System
Cy	cubic yard
DERR	Division of Emergency and Remedial Response
DM	Design Memorandum
DN	Downstream
Dr.	Doctor
E	Extreme
EC	Engineer Circular
ED-D-S	Engineering Division, Design Branch, Structures Section
ED-T-G	Engineering Division, Civil Branch, Geotechnical and Dam Safety Section
ED-T-H	Engineering Division, Civil Branch, Hydraulics and Hydrology Section
EFARS	Engineering Federal Acquisition Regulation Supplement
EL	Elevation
EM	Engineer Manual

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX C

LIST OF ACRONYMS/ABBREVIATIONS

(cont.)

EP	Engineer Pamphlet
EPA	Environmental Protection Agency
ER	Engineer Regulation
ETL	Engineer Technical Letter
ERNS	Emergency Response Notification System
F	Fahrenheit
FATES	FIFRA and TSCA Enforcement System
FDA	Flood Damage Analysis
FEMA	Federal Emergency Management Agency
FINDS	Facility Index System
F&H	Florence & Hutcheson, Inc.
FS	Factor of Safety
ft	feet
FY	Fiscal Year
GC	Gravel with Clay
GFRP	Glass Fiber Reinforced Polymer
GW-GC	Well Graded Gravel with Clay
GRR	General Re-evaluation Report
GPS	Global Positioning System
HEC-HMS	Hydrological Engineering Center, Hydrological Modeling System
HDPE	High Density Polyethylene
HQ	Headquarters
I	Interstate
ICW	Inspection of Completed Works
I.D.	Inside Diameter
IFH	Interior Flood Hydrology
IHNC	Inner Harbor Navigational Canal
IPET	Interagency Performance Evaluation Taskforce
ITR	Independent Technical Review
i.e.	for example
ksi	kips per square inch
kw	kilowatt
kwh	kilowatt hour
KY	Kentucky
lf	linear feet
LFPP	Local Flood Protection Project

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX C

LIST OF ACRONYMS/ABBREVIATIONS

(cont.)

LQG	Large Quantity Generator
LRD	Lakes and Rivers Division
LS	Landside
LUST	Leaking Underground Storage Tank
MCACES	Micro Computer Aided Estimating System
MCC	Motor Control Center
MDE	Maximum Design Earthquake
MDF	Maximum Design Flood
MSD	Metropolitan Sewer District
MSITES	Master Sites List, Ohio
MSL	Mean Sea Level
NAD	North American Datum
NASSCO	National Association of Sewer Service Companies
NAVD	North American Vertical Datum
NED	National Economic Development
NEIC	National Earthquake Information Center
NFIP	National Flood Insurance Program
NFRAP	No Further Remedial Action Planned
NGVD	National Geodetic Vertical Datum
NLD	National Levee Database
NMSZ	New Madrid Seismic Zone
No.	Number
NOFA	No Further Action
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
OBE	Operating Basis Earthquake
O.D.	Outside Diameter
OHW	Ordinary High Water
OSHA	Occupational Safety and Health Administration
O&M	Operation and Maintenance
PACP	Pipeline Assessment Certification Program
pcf	pounds per cubic foot
PED	Pre-Engineering Design
PFP	Probable Failure Point
PGA	Peak Ground Acceleration
PMF	Probable Maximum Flood

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX C

LIST OF ACRONYMS/ABBREVIATIONS

(cont.)

PNP	Probable Non-failure Point
PP	Pump Plant
PSC	Pre-stressed Concrete
psf	pounds per square foot
psi	pounds per square inch
R	Run
RAS	River Analysis System
RCRA	Resource Conservation and Recovery Act
RCRIS	Resource Conservation and Recovery Information System
RQD	Rock Quality Designation
RS	Riverside
RWCIE	Right of Way – Channel Improvement Easement
RWLVE	Right of Way – Levee/Floodwall Easement
RWRDE	Right of Way – Road Easement
RWTWE	Right of Way – Temporary Work Easement
RWUPE	Right of Way – Utility and Pipe Easement
R&U	Risk and Uncertainty
SC	Sand with Clay
SCS	Soil Conservation Service
SH	Shear Wave
Sec	second
SPT	Standard Penetration Test/Testing
SQG	Small Quantity Generator
SSR	Seismic Safety Review
St.	Saint
STA.	Station
SW-SC	Well Graded Sand with Clay
SWMM	Storm Water Management Model
Sy	square yard
TDH	Total Dynamic Head
Trib.	Tributary
TRIS	Toxic Chemical Release Inventory System
TSD	Treatment Storage Disposal
UFGS	Unified Facilities Guide Specifications
U	Usual
UN	Unusual

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C
LIST OF ACRONYMS/ABBREVIATIONS

(cont.)

US	Upstream
U.S.	United States
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USGS	United States Geological Survey
UST	Underground Storage Tank
UU	Unconsolidated Undrained
W/D	Weight-to-Depth
WRC	Water Reclamation Facility
WSO	Weather Station Office
WWF	Welded Wire Fabric
WWTP	Waste Water Treatment Plant

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 1
GENERAL

TABLE OF CONTENTS

1.1. INTRODUCTION **1-1**
1.1.1. Adjustments for varying Datum's 1-2
1.2. COST ESTIMATE SUMMARY **1-4**
1.3. PROPOSED RECONSTRUCTION ITEMS **1-5**

LIST OF TABLES

Table No.	Title	Page No.
Table 1.1-1	Adjustment in feet to Convert Between Datum's	1-3
Table 1.1-2	Cost Estimate Summary of Reconstruction Items	1-4

LIST OF FIGURES

Figure No.	Title	Page No.
Figure 1-1	Overall Project Map	1-3

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 1
GENERAL

1.1. INTRODUCTION.

Appendix C covers the engineering team's evaluation of each component of the existing Paducah, Kentucky flood damage reduction project based on the study authority and guidance discussed in Volume 1, Main Report of the subject project. Each of these components works together as a system to reduce the flood risk for the City of Paducah.

To start the work effort on this project, the engineering team reviewed the following references for guidance and information on what was expected as part of the evaluation of existing project components.

1) Ohio River, Paducah, Kentucky Flood Damage Reduction Section 905(b) Report, (WRDA 1996) Analysis, dated May, 2000.
2) Memorandum from CECW-PB, 16 Aug 2005, Subject: Reconstruction of U.S. Army Corps of Engineers Structural Flood Risk Management Projects for which Non-Federal Interests are Responsible for Operation, Maintenance, Repair, Rehabilitation, and Replacement.
3) Memorandum For The Deputy Commanding General For Civil Works And Emergency Operations dated 14 November, 2008. Paragraph four of this memorandum states *"a one-time exception to the policy on the timing requirements contained in EC 1165-2-208 paragraph 4.a. (1) to allow execution on an In-Kind MOU with the city of Paducah prior to completion of the feasibility study is warranted."*
4) Memorandum of Understanding (MOU) Between the Department of the Army and the City of Paducah, Kentucky for Work Provided or Performed Prior to the Execution of a Project Partnership Agreement for Paducah, Kentucky Local Flood Protection Project executed 17 November 2008. This MOU identified the work associated with the sliplining of the CMP's

   .

   Section 7, paragraph 7.8.1 of this Appendix identifies the work associated with the sliplining of the deteriorating CMP's which are an integral component to the effective functioning of the subject flood damage reduction project.

5) Section 4, Paragraph 4.3.2 of this Appendix requires that reconstruction to the Tennessee River bank between Stations 12+75B and 15+32B is necessary and is an integral part of the successful rehabilitation effort for this project. The Sponsor and USACE have observed and have been noting slope instabilities occurring at this location. T herefore, reconstruction of this bank and placement of riprap occurred during the development of this Feasibility Report. This work was considered by both the USACE and the Sponsor as an integral part of the functioning of this project and required immediate attention due to the close proximity to the floodwall to prevent potential damage to "T" Wall Monoliths numbers 58 through 71.

During the week of 23 to 27 March 2009, the engineering team made a site visit to thoroughly inspect the project. T his appendix covers each engineering discipline's evaluation, analyses and recommendations in regards to items requiring reconstruction under the guidance shown in item 2) above.

For Reference, Figure 1-1 is an overall project map which denotes the limits of Sections A, B, and C of the project. Each of these Sections is referred to in this Appendix when the Stationing is stated with an "A", "B" or "C" designation attached to locate the area where the item that is being evaluated can be found along the line of protection.

All sheets identified in this appendix are located in Volume 3.

All references identified in this appendix including 1 through 4 listed above are located in Volume 4 with the exception of USACE and other agency guidance documents.

1.1.1. Adjustments for Varying Datum's

The Paducah LFPP was constructed using a datum developed by the Corps of Engineers, Louisville District, known as the Ohio River Datum or ORD. This datum was used for most of the construction projects along the Ohio River. While the Ohio River Datum was being used by the Corps of Engineers to construct these projects, other construction projects and topographic mapping were based on bench marks established by the U.S. Geological Survey and based on the National Geodetic Vertical Datum of 1929, most commonly referred to as NGVD 1929. Periodically, there have been other datum's established, and one of these is the North American Vertical Datum (NAVD) of 1988, upon which the updated mapping developed for Paducah references. With the as-built drawings for the Paducah LFPP based on the Ohio River Datum, the topographic mapping as well as most construction drawings based on the National Geodetic Vertical Datum, and the updated mapping being used in this Feasibility Study based on the North American Vertical Datum of 1988, it is imperative that the adjustments between the differing datum's be known. The adjustment between the three datum's are given in Table 1.1-1. The adjustments between the Ohio River Datum and the other Datum's varies based on the location along the Ohio River. Any elevation referenced in Volume 2 of Appendix C and in Volume 3 are in NAVD 88 datum.

TABLE 1.1-1
Adjustments in feet to Convert Between Datum's

ORD to NGVD1929	ORD to NAVD1988	NGVD 1929 to NAVD1988	NGVD1929 to ORD	NAVD1988 to ORD	NAVD1988 to NGVD 1929
- 0.7	- 0.8	- 0.1	+ 0.7	+ 0.8	+ 0.1

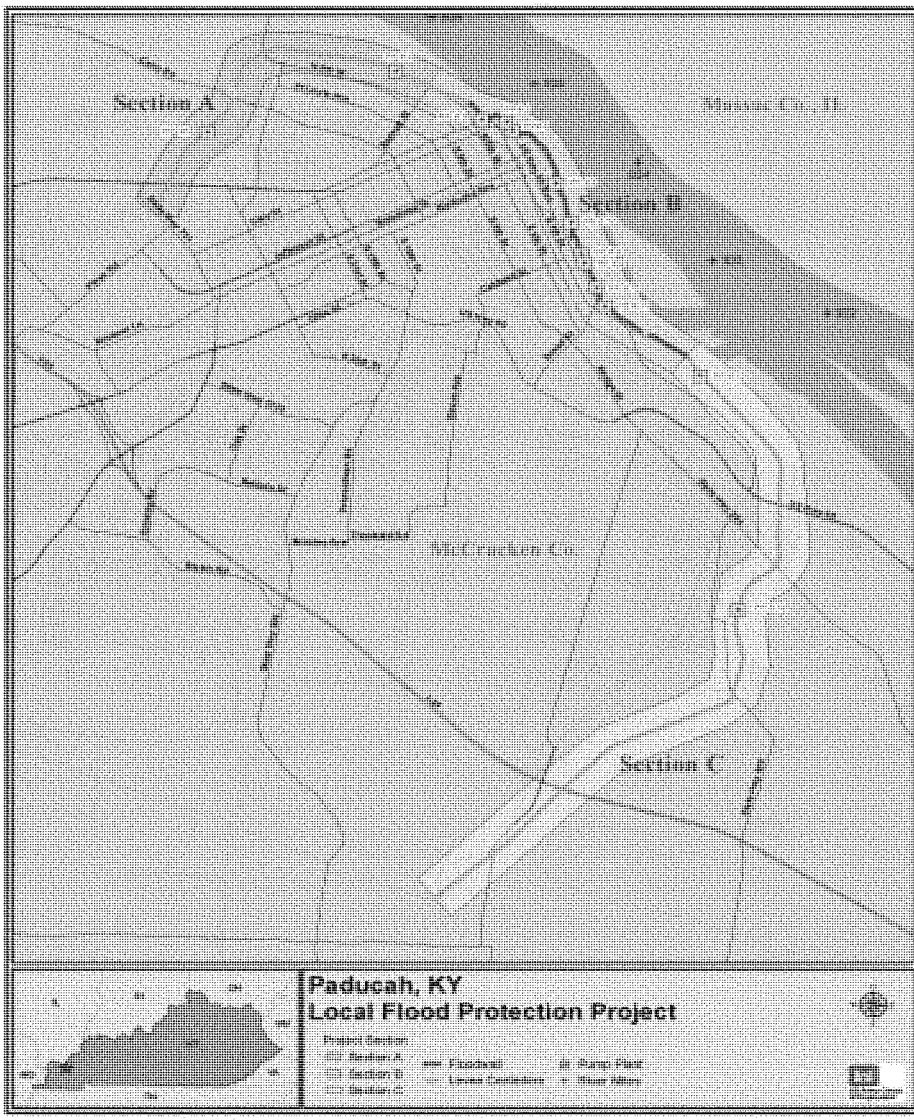


Figure 1-1 – Overall Project Map

1.2. COST ESTIMATE SUMMARY

Table 1.1-1 gives a summary of the generalized items for reconstruction and associated costs in descending order of costs. Reference Section 10 of this Appendix for the Baseline cost estimate.

Table 1.1-2 Cost Estimate Summary of Reconstruction Items

Summary – Items of Reconstruction	Project Cost (Oct 2009 Price Level)	Scope Narrative Location in Volume 2, Appendix C
TOTAL PROJECT RECONSTRUCTION COSTS	**$18,728,374**	
Pump Plants #1 - #7 and #9 - #13	$5,875,471	7.5, 8.1, 8.2
Proposed Pump Plant #14a (at Sta. 111+67A) Submersible Pump Option	$1,662,938	2.6, 2.8, 2.9, 2.10, 4.2.3, 4.4.2, 4.4.3, 4.6, 7.7, 8.1
Levees	$3,762,258	2.6, 2.9, 2.10, 3.15, 4.3.1.2, 4.3.3.2, 4.4.1, 4.6, 7.6.1, 7.6.2, 7.8.1, 8.1.3.14, 8.1.5, 8.2
Floodwalls	$3,102,197	7.3.1.5, 7.3.5.1, 7.3.5.2, 7.3.5.4, 7.4.3,
Lands & Damages	$436,000	6.5, and Appendix F
Miscellaneous Pump Items	$1,148,537	7.4.3.2, 7.4.3.3, 7.5.1.1, 7.5.5.2, 7.5.5.3, Section 8
Bank Stabilization	$100,000	4.3.2
Relocations	$20,174	Section 6

UPDATE

The project costs shown above were updated to FY 11 dollars in the Main Report (see tables 5-3 and 5-4 in Section 5 of Volume 1 - Main Report)

1.3 PROPOSED RECONSTRUCTION ITEMS

Table 1.1-2 provides a breakdown of the reconstruction items by discipline along with the corresponding sheet(s) for each item. See Volume 3 for these sheets. A summary of the reconstruction items is discussed in Volume 1, Main Report of the subject project. This summary in table form also provides a rationale description for the inclusion of each item as part of the reconstruction project.

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 2
HYDROLOGY AND HYDRAULICS

TABLE OF CONTENTS

2.1. REFERENCES **2-1**
2.2. GENERAL **2-1**
2.3. CLIMATE **2-2**
2.4. PRECIPITATION **2-3**
2.5. HISTORIC STORMS AND FLOODS **2-3**
2.6. HYDROLOGIC MODEL **2-4**
2.7. EXISTING FLOOD CONTROL MEASURES **2-5**
2.8. PRINCIPAL FLOOD PROBLEMS **2-5**
2.9. METHODS AND COMPONENTS OF PROTECTION **2-6**
2.9.1. Proposed Pump Plant #14 @ Station 111+67A 2-6
2.9.1.1. Conclusions from the Analysis of the Proposed Pump Plant #14 2-8
2.9.2. Proposed Woodward Hollow Discharge Pipe Pump Plant @ Station 19+11B 2-8
2.9.2.1. Conclusions from the Analysis of the Woodward Hollow Discharge Pipe Pump Plant 2-10
2.10. GRAVITY OUTLET PIPE CLOSURES **2-10**

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 2
HYDROLOGY AND HYDRAULICS

LIST OF TABLES

Table No.	Title	Page No.
Table 2.1	Mean Monthly Temperature (°F) for the Paducah, KY Area	2-3
Table 2.2	Mean Monthly Precipitation (Inches) for the Paducah, KY Area	2-3
Table 2.3	Annual Peak Stages – Ohio River @ Paducah, KY	2-4
Table 2.4	Drainage Areas	2-6
Table 2.5	Elevation-Storage-Discharge @ Proposed Pump Plant #14 Existing Condition	2-7
Table 2.6	Elevation-Frequency Data @ Proposed Pump Plant #14 for Existing and With Project Conditions	2-8
Table 2.7	Elevation-Storage-Discharge @ Proposed Woodward Hollow Discharge Pipe Existing Condition	2-9
Table 2.8	Elevation-Frequency Data @ Proposed Woodward Hollow Discharge Pipe Existing and With Project Conditions.	2-10
Table 2.9	Gravity Outlet Pipes	2-12

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 2
HYDROLOGY AND HYDRAULICS

LIST OF PLATES

Table No.	Title	Page No.
Plate 2.1	Elevation Frequency Curve @ Proposed Pump Plant #14 – Existing Conditions	2-16
Plate 2.2	Elevation Frequency Curve @ Proposed Pump Plant #14 – with 50 cfs capacity	2-17
Plate 2.3	Elevation Frequency Curve @ Proposed Pump Plant #14 – with 100 cfs capacity	2-18
Plate 2.4	Elevation Frequency Curve @ Proposed Pump Plant #14 – with 150 cfs capacity	2-19
Plate 2.5	Elevation Frequency Curve @ Proposed Pump Plant #14 – with 200 cfs capacity	2-20
Plate 2.6	Elevation Frequency Curve @ Proposed Woodward Hollow Discharge Pipe Pump Station Existing Conditions	2-21
Plate 2.7	Elevation Frequency Curve @ Proposed Woodward Hollow Discharge Pipe Pump Station with 50 cfs capacity	2-22
Plate 2.8	Elevation Frequency Curve @ Proposed Woodward Hollow Discharge Pipe Pump Station with 100 cfs capacity	2-23
Plate 2.9	Elevation Frequency Curve @ Proposed Woodward Hollow Discharge Pipe Pump Station with 150 cfs capacity	2-24

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX C

SECTION 2 HYDROLOGY AND HYDRAULICS

2.1. REFERENCES.

1) Design Memorandum (DM) *"General Information Flood Protection Project: Paducah, Kentucky dated October 1939*

2) Paducah, Kentucky LFPP As-Built drawings

3) Paducah 2-foot contour Mapping, GRW Arial Services & Photo Science (2006)

4) Hydraulic Calculation for Gravity Outlet Pipes by Florence and Hutcheson

5) HEC-HMS Hydrologic Modeling System User's Manual, Hydrologic Engineering Center, Davis, CA

6) EM 1110-2-1413 "*Hydraulic Analysis of Interior Areas*" U.S. Army Corps of Engineers, dated 15 January 1987

7) EM 1110-2-1913 "*Design and Construction of Levees*" U.S. Army Corps of Engineers, dated 30 April 2000

8) NOAA Atlas 14, National Oceanic & Atmospheric Administration, National Weather Service, Silver Spring, MA

9) Climatic Data. National Climatic Data Center, National Oceanic & A tmospheric Administration, National Weather Service, Silver Spring, MA

10) Surface Water Data, U.S. Geological Survey, Reston, VA

2.2. GENERAL.

The community of Paducah is located in the northern area of the Commonwealth of Kentucky in McCracken County, along the left banks of the Ohio, Tennessee and Clark Rivers. T he Ohio River flows in a southwesterly direction to its confluence with the Mississippi River approximately 981.4 m iles from its beginning; the Tennessee River

flows in a northerly direction to its confluence with the Ohio River at mile 934.7; and the Clark River flows in a northeasterly direction to its confluence with the Tennessee River at mile 4.4. Paducah is protected from flooding by a levee and floodwall system that extends for over 12 miles along the Ohio, Tennessee and Clark Rivers. However, since the levee was built to the 1937 flood elevation plus several feet of freeboard, the Ohio River is the controlling stream. As the controlling stream the Ohio River has a backwater effect for a significant distance upstream on the Tennessee and Clark Rivers. Therefore, the water surface elevation of the Ohio River at mile 930.0 is what the top of protection is based on for the Tennessee and Clark Rivers sections of the levee/floodwall system. The entire levee system is being evaluated in a separate study that will determine whether it will protect the City of Paducah from the 1% chance (100-year) frequency flood for certification purposes, now known as Levee System Evaluation.

This study evaluates the levee/floodwall system for reconstruction of its existing facilities, construction of new facilities that are required under the present regulations that govern levees and floodwalls, and construction of new pumping facilities to prevent interior flooding. Since there is already a hydraulic model of the Ohio River, no hydraulic modeling was required for this study. Based on the existing hydraulic model, the existing levee and floodwall system is constructed to an elevation approximately 7.5 feet above the 1% chance frequency event, one requirement needed for levee system evaluation analysis. In addition, the top of protection elevations of the Paducah Levee System meets the requirements of the authorized project as discussed in Section 2.7, Existing Flood Control Measures. T herefore, there were only three elements that required a hydrologic and/or hydraulic evaluation. T hese items are: 1) gate well structures; 2) potential pumping facilities; and 3) gravity outlets.

2.3. CLIMATE.

Located in Northwestern Kentucky, Paducah has a temperate climate with relatively cold winters and hot, humid summers. The mean annual temperature for the area is about 57 degrees F, with extremes ranging from 30 degrees F below zero to 108 degrees F above zero. Average monthly temperatures range from 78 degrees F in July to 33 degrees F in January. The National Oceanic and Atmospheric Administration (NOAA) using a period of record of 61 years (1947 through 2008) determined these monthly averages. Average monthly temperatures are shown in Table 2.1. A ll seasons are marked by weather changes resulting from passing weather fronts and associated centers of high and low pressure.

TABLE 2.1

MEAN MONTHLY TEMPERATURE (°F)
FOR THE PADUCAH, KY AREA

Month	Temperature	Month	Temperature
January	32.9	July	78.2
February	38.1	August	76.2
March	47.6	September	69.1
April	57.0	October	58.0
May	65.9	November	46.8
June	74.5	December	36.9

Average Annual Temperature – 56.8

2.4. PRECIPITATION.

While precipitation within the Ohio River Basin varies significantly because of the basin size, this study is concerned with the precipitation for the drainage area behind the line of protection. Precipitation in the Paducah area is fairly well distributed throughout the year. The average annual precipitation is 49.24 inches, with the monthly averages ranging from 2.99 inches in August to 4.95 inches in April. Table 2.2 gives the average monthly rainfall for Paducah, Kentucky. Because of the limited amount and duration of snowfall, snowmelt generally does not contribute significantly to runoff for this basin.

TABLE 2.2
MEAN MONTHLY PRECIPITATION (INCHES)
FOR THE PADUCAH, KY AREA

Month	Precipitation (Inches)	Month	Precipitation (Inches)
January	3.47	July	4.45
February	3.93	August	2.99
March	4.27	September	3.56
April	4.95	October	3.45
May	4.75	November	4.53
June	4.51	December	4.38

Average Annual – 49.24"

2.5. HISTORIC STORMS AND FLOODS.

The flood of record occurred in January–February 1937 reaching an elevation of 346.0 feet NAVD 1988. After this flood event, the Flood Control Act of August 1937 authorized construction of flood protection for communities along the Ohio River. Many high-water events have occurred since the completion of the Paducah, Kentucky LFPP in

January 1950. Table 2.3 shows the ten largest historical floods and their associated peak elevation. As shown on Table 2.3, the February 1950 flood was the greatest event since 1937, with an elevation of 339.1 feet NAVD 1988 which equates to a 1% chance (100-year) flood.

TABLE 2.3
ANNUAL PEAK STAGES
OHIO RIVER @ PADUCAH, KY

Date	Gage Height (feet)	Elevation (NAVD 1988)	Flood Frequency
Jan. – Feb. 1937	60.5	346.0	less than 0.02% (500-year)
Feb. 13, 1950	53.5	339.0	1% (100-year)
Mar. 11, 1997	51.7	337.2	1.67% (60-year)
Apr. 3, 1975	51.1	336.6	2% (50-year)
Mar. 19, 1963	49.9	335.4	2.86% (35-year)
Jan. 7, 1991	49.9	335.4	2.86% (35-year)
Mar. 8, 1979	49.3	334.8	3.3% (30-year)
Mar. 12, 1962	48.4	333.9	5% (20-year)
Mar. 22, 1964	47.8	333.3	less than 5% (20-year)
Mar. 29, 1955	47.7	333.2	less than 5% (20-year)
Jan. 16, 2005	47.7	333.2	less than 5% (20-year)

*** Historical Peak Elevation. Datum of the gage is 285.5 NAVD 1988.**

2.6. HYDROLOGIC MODEL.

Detailed hydrologic models were developed for each of the interior drainage areas that were evaluated for both existing and potential pumping plants. These potential pumping plants were for the areas that drained to existing gravity outlets at station 111+67 in levee section "A" (hereto to be called Pump Plant #14) and station 19+11 in levee section "B" (hereto to be called Woodward Hollow Discharge Pipe). These models utilize HEC-HMS to route the full range of rainfall frequency storms with a 10 day duration to the gravity outlet. The 10 day duration is based on EM 1110-2-1413 "Hydraulic Analysis of Interior Areas," and takes into account the size of the receiving stream's drainage area. For each location, an elevation-frequency curve is developed for existing and "with project" conditions. In the development of the frequency curves, open and closed gravity outlet conditions must be evaluated, with the open outlet condition remaining the same for both existing and "with project" conditions. In the analysis of each frequency event, the results are weighted for both the opened and closed outlet conditions. The weighting is based on the probability that the outlet will be opened or closed, which is determined

from the receiving stream's elevation duration curve. For the "with project" conditions, pumps are added into the storage routing for closed outlet conditions and the results weighted with the existing open outlet conditions to determine interior ponding elevation-frequency relationships.

The interior area was sub-divided by the Paducah city engineer based upon the gravity outlets and the existing storm sewer system. Included in the model are the drainage areas to the gravity outlets, time of concentration, lag time, SCS curve numbers for each sub-basin needed to compute the SCS dimensionless unit hydrograph, the gravity outlet's discharge rating curve, and the elevation vs. storage table (used for the Modified Puls Storage Routing). The SCS curve numbers were used to calculate precipitation losses throughout the duration of the storm event. The time of concentration was calculated for each sub-basin using the lengths of sheet, shallow concentrated, and channel flows. A map of the areas inundated as a result of interior drainage from a 1% chance interior event is shown in Appendix B.

2.7. EXISTING FLOOD CONTROL MEASURES.

As mentioned previously, Paducah is protected from flooding by a levee and floodwall system that extends for over 12 miles along the Ohio, Tennessee, and Clark Rivers. This protection was initiated after the devastating flooding that occurred along the Ohio River in 1937, including the Paducah area. This flood protection included approximately 48,700 feet of earth levee, 15,058 feet of concrete wall, 12 pumping plants, and other necessary appurtenances. The top elevation of the protection was designed to be at least 3 feet higher than the 1937 flood elevation, which included the impact of constructing the Brookport, Illinois levee/floodwall project on the opposite bank of the Ohio River at this location. In addition to these flood protection measures, Corps reservoirs were constructed throughout the Ohio River Basin, further reducing the impacts of flooding on the receiving streams of these reservoirs as well as along the Ohio River. It is the opinion of the Louisville District that with the reduction of the 1937 flood elevation resulting from the upstream reservoirs, this flood risk management project does meet the requirements of the original project authorization.

2.8. PRINCIPAL FLOOD PROBLEMS.

The flood problems that occur at the two locations identified by the City of Paducah and mentioned in Section 2.5, only occur when the Ohio River is above flood stage and the gravity outlets are closed. At these locations the City of Paducah uses portable pumps to prevent interior flooding. Most of the problem can be attributed to development within the protected area, which has increased the impervious area and decreased the available storage. For the area draining to the gravity outlet at the proposed Pump Plant #14, the flooding will primarily affect commercial and industrial property; while for the area draining through the gravity outlet at the proposed Woodward Hollow Discharge Pipe, the flooding would affect residential property. No other flood problems for existing conditions were noted.

2.9. METHODS AND COMPONENTS OF PROTECTION.

In the evaluation of the drainage areas and the two gravity outlets mentioned in Section 2.8, it is not economically feasible to increase the storage area which would reduce interior elevations. Also increasing the size of the gravity outlet would not reduce interior ponding elevations generated by interior runoff during a closed outlet condition. The only feasible alternative available to reduce interior flooding is to pump the rainfall-runoff from the interior area over the levee and into the Ohio River. With pumping being the only available method of reducing interior damages, the analysis became focused on the pumping capacity that would produce the greatest net benefits, while minimizing the residual damages. Table 2.4 shows the drainage area that contributes to each of the proposed pump plants.

TABLE 2.4
DRAINAGE AREAS

Proposed Pump Plant	Levee Station	Drainage Area (acres)
PP #14	111+67A	159.11
Woodward Hollow Discharge Pipe	19+11B	143.82

Once it was determined that pump plants were the only solution to the interior flooding problems at these locations, the analysis became an evaluation of various pumping capacities. In determining the capacity of a pump plant, one consideration is the zero damage elevation. With this elevation established, the maximum pumping capacity required to eliminate damages from interior runoff can be determined. In the analysis, the pumping capacity is based on having to pump the water from the minimum pumping elevation (pump stop) over the levee. The actual capacity of each pump will be greater for lower head differentials (higher interior ponding elevations). The exact capacity of the pumps could not be determined at the time the analysis was performed. Therefore, a conservative pump curve was used in the HEC-HMS analysis, resulting in the project elevations being slightly higher than they will be once the pumps are actually designed.

2.9.1. Proposed Pump Plant #14 @ Station 111+67A.

The area that drains to this outlet is considered fully developed, with primarily commercial and industrial development in the lower portion of the drainage area and residential in the upper basin. Table 2.5 contains Elevation-Storage-Discharge data for this gravity outlet. The discharge data is only used in the open gravity outlet condition; for a closed outlet condition the gravity outlet has no discharge capacity.

Based on the economic data, the zero damage elevation is approximately 330.0 NAVD 1988. While the goal is to maximize net benefits, there must be consideration given to

residual damages when sizing a pump plant. Therefore, four pumping capacities were evaluated and elevation-frequency curves developed. The elevation frequency data for each size pump plant was combined with the elevation frequency data developed for the open outlet conditions to create a "with project" elevation frequency curve for the interior area based on the capacity of the pump plant. Table 2.6 contains the elevation-frequency data and Plates 2.1 t hrough 2.5 s hows the elevation frequency curves for existing conditions and each of the four pump plant capacities evaluated.

TABLE 2.5

ELEVATION-STORAGE-DISCHARGE
@ PROPOSED PUMP PLANT #14 (LEVEE STATION 111+67A)
EXISTING CONDITION

Elevation (NAVD 1988)	Storage (acre-ft.)	Discharge (cfs)
316.3	0	0
316.9	0.0084	5
317.9	0.0177	20
319.0	0.1859	45
319.9	0.3365	75
320.6	0.5978	100
321.0	0.7608	115
321.8	1.0869	145
322.6	1.5487	175
323.7	2.2458	205
324.3	2.7506	220
325.8	4.3240	250
327.7	7.2682	285
328.6	9.5196	300
330.9	20.0080	325
336.0	196.9500	402

TABLE 2.6
ELEVATION-FREQUENCY DATA
@ PROPOSED PUMP PLANT #14 (LEVEE STATION 111+67A)
FOR EXISTING AND WITH PROJECT CONDITIONS

	Ponding Elevations (NAVD 1988)				
Frequency (% chance)	Existing	50 cfs Pump Plant	100 cfs Pump Plant	150 cfs Pump Plant	200 cfs Pump Plant
98 (1 year)	322.0	322.0	322.0	322.0	322.0
50 (2 year)	324.2	324.2	324.2	324.2	324.2
20 (5 year)	329.0	329.0	328.1	327.5	327.3
10 (10 year)	333.1	330.25	329.1	328.6	328.0
4 (25 year)	333.9	331.0	330.2	330.0	329.1
2 (50 year)	334.2	332.0	331.0	330.6	329.8
1 (100 year)	334.5	332.2	331.6	331.1	330.3
.2 (500 year)	335.1	332.75	332.4	332.1	331.6

2.9.1.1. Conclusions from the Analysis of the Proposed Pump Plant #14.

Based on the results of the analysis of the various pump plant capacities, there is only one pump plant capacity that has a high probability of eliminating all damages to structures for the design storm (1% chance frequency). This determination is based on information obtained from the economic analysis of the area. T herefore, constructing a pumping plant with a 200 cfs pumping capacity (two 100 cfs pumps) is the most effective way of eliminating interior flooding resulting from rainfall events that occur during high water periods on the Ohio River. However, while ideal the objective in constructing a new pump plant is not to eliminate interior flooding but rather to maximize the net benefits associated with constructing the pump plant. As a result, even though the other three pump plant capacities (50 cfs, 100 cfs, and 150 cfs) evaluated will result in there being residual damages for the design storm (1% chance frequency), they must be considered in the economic analysis. Ultimately, it will be the results of the economic analysis for each of the pump plant capacities combined with the cost estimates for each pump plant capacity that will determine the recommended plan. For the complete economic analysis of this proposed pumping plant, refer to Volume 1 of the Main Report.

2.9.2. Proposed Woodward Hollow Discharge Pipe Pump Plant @ Station 19+11B.

The area that drains to this outlet is considered fully developed, with primarily residential development with some industrial development in the lower portion of the drainage area around the ponding area. Table 2.7 contains Elevation-Storage-Discharge data for this gravity outlet. The discharge data is only used in the open gravity outlet condition; for a closed outlet condition the gravity outlet has no discharge capacity.

Based on the economic data, the zero damage elevation is approximately elevation 326.0 NAVD 1988. While the goal is to maximize the net benefits, there must be consideration

given to residual damages when sizing pumps Therefore, three pump plant capacities were evaluated and elevation-frequency curves developed. This elevation frequency data for each size pump plant was combined with the elevation frequency data developed for the open outlet conditions to create a "with project" elevation frequency curve for the interior area based on the capacity of the pump plant. Table 2.8 contains the elevation-frequency data for existing conditions and each of the three plans evaluated. Plates 2.6 through 2.9 show the elevation frequency curves for existing conditions and each of the three pump plant capacities.

TABLE 2.7
ELEVATION-STORAGE-DISCHARGE
@ PROPOSED WOODWARD HOLLOW DISCHARGE PIPE PUMP PLANT
(LEVEE STATION 19+11B)
EXISTING CONDITION

Elevation (NAVD 1988)	Storage (acre-ft.)	Discharge (cfs)
310.2	0	0
312.0	0.22	17.4
314.0	1.29	72.25
315.6	2.99	122.7
318.0	8.84	188.3
320.0	16.49	234.1
322.0	26.12	267.6
324.0	38.15	297.5
326.0	52.89	324.5
328.0	70.43	349.5
330.0	91.51	372.2
332.0	117.81	392.0

TABLE 2.8
ELEVATION-FREQUENCY DATA
@ PROPOSED WOODWARD HOLLOW DISCHARGE PIPE PUMP PLANT
(LEVEE STATION 19+11B) FOR EXISTING AND WITH PROJECT CONDITIONS

	Ponding Elevations (NAVD 1988)			
Frequency (% chance)	Existing	50 cfs Pump Plant	100 cfs Pump Plant	150 cfs Pump Plant
98 (1 year)	315.8	315.8	315.8	315.8
50 (2 year)	317.5	317.5	317.5	317.5
20 (5 year)	324.6	322.5	322.4	322.1
10 (10 year)	325.8	323.6	323.5	323.2
4 (25 year)	328.0	325.1	324.6	324.1
2 (50 year)	329.5	326.2	325.2	324.4
1 (100 year)	330.6	326.9	325.6	324.6
.2 (500 year)	332.0	328.9	327.0	325.0

2.9.2.1. Conclusions from the Analysis of the Woodward Hollow Discharge Pipe Pump Plant.

Based on the analysis of the pump plant and information obtained from the economic analysis of the area, it was apparent that very few structures were flooded even for the 0.2% chance interior flood event (500 year). Therefore, the potential economic benefits were limited and would not support a pump plant. However, instead of providing the City of Paducah with a pump plant, constructing a platform for a portable pump and a discharge pipe from the ponding area to the river would be beneficial. Under existing conditions, the City of Paducah installs a portable pump with intake and discharge piping. To be able to install everything necessary to pump the interior runoff into the river, a high traffic volume road must be closed. To eliminate the need to close the road and disrupt traffic, it would be relatively inexpensive to install a platform for the pump and a discharge pipe under the road and over the levee. For the complete economic analysis of this proposed Woodward Hollow Discharge Pipe, refer to Volume 1 of the Main Report.

2.10. GRAVITY OUTLET PIPE CLOSURES.

One of the unique features of the Paducah, Kentucky LFPP is that there are very few gatewell structures, and closures of the pipes are totally reliant on flap gates. Per EM 1110-2-1913 "Design and Construction of Levees," flap gates are not considered a positive closure. This is primarily because of the potential for debris to be present that will prevent the gate from functioning as designed, resulting in the gate being held partially open during a critical flood period. In most situations, a combination of a flap gate and a gatewell with a sluice gate are utilized to assure positive closure. In evaluating the need for installing gatewell structures to provide positive closure, there are several issues that need to be considered. The first issue is the potential for flooding of the

interior to occur as a result of a flap gate not closing properly, and the second issue is the operational procedures used by the City of Paducah.

There are several items that must be considered when evaluating the potential for back flooding from a partially open pipe. These are: the potential for damage, the inflow rate into the interior, and presence of pump plants. The first step in evaluating the pipe is to determine if there is even the potential for damages to occur in the interior. If the base flood elevation (1% chance frequency or 100-year) were below the "zero damage" elevation, there would be no need for a gatewell regardless of the pipe size. When the base flood elevation is above the zero damage elevation in the interior, an evaluation is necessary. In these cases, if the pipes are less than 36 inches in diameter, it is unlikely for the inflow rate to be sufficient enough that emergency measures could not be employed to either inhibit the inflow or utilize portable pumps. Therefore, for all pipes less than 36 inches, the flap gates alone are considered sufficient. For pipes 36 inches in diameter and greater, emergency measures to either inhibit the backflow or utilize portable pumps to pump the river water out of the interior are not considered to be reliable enough to prevent interior flooding. However, if there was an existing pump plant, as is the case at several locations, these pump plants could keep up with the inflow from the river and prevent interior flooding. Therefore, for pipes 36 inches and greater, a gatewell with a sluice gate would be considered necessary if there was not a pump plant in the area that could handle the backflows without causing damages. One of the unique features of the interior drainage system is that most of the flap gates are secured in an open position. As the river rises, the Flood Control District has specific directions as to when a crew goes to a pipe location and closes the flap gate. When the flap gate is closed, the crew verifies that everything is working properly. After a flap gate is closed, the only way that it could be lodged open is if sufficient flow from the interior opened the flapgate, and debris carried by the flow got lodged in the flapgate preventing it from closing properly. While the probability of this occurring is low, to insure that a flap gate is not lodged open the Flood Control District's crew could secure the flap gate in the closed position. Securing the flap gate in the closed position would not impact the interior analysis, which assumes that the river is at an elevation that would prevent the flap gate opening during an interior rainfall event. Securing a flap gate in the closed position is only viable for pipes up to 48 inches in diameter. Table 2.9 lists the locations of all the gravity outlet pipes, their size, type closure, whether positive closure is required, and comments.

TABLE 2.9
GRAVITY OUTLET PIPES

Station	Pipe Size** (inches)	Existing Closure Type	Positive Closure Required	Comments
SECTION "A"				
66+27A	96	Sluice Gate	-----	
84+00A	22	Flap Gate	no	The size of pipe combined with probability of failure does not warrant a gatewell with sluice gate.
111+67A	63	Flap Gate	yes	New Pump Plant #14 proposed. This pump plant will be constructed with a gatewell with sluice gate.
130+00A	24	Flap Gate	no	The size of pipe combined with probability of failure does not warrant a gatewell with sluice gate.
140+45A	18	Gate Valve & Flap Gate	-----	Pipe not slip-lined.
144+00A	24	Flap Gate	no	No damage from back flooding. Pipe not slip-lined.
147+25A	24	Flap Gate	no	No damage from back flooding. Pipe replaced.
151+25A	20	Flap Gate	no	No damage from back flooding.
157+63A Pipe #1	51	Flap Gate	no	Back flow would enter Pump Plant #1; therefore a gatewell structure with sluice gate is not required.
157+63A Pipe #2	48	Flap Gate	no	Same as for pipe #1.
157+63A Pipe #3	48	Flap Gate	no	Same as for pipe #1.
157+63A Pipe #4	51	Flap Gate	no	Same as for pipe #1.
157+63A Pipe #5	51	Flap Gate	no	Same as for pipe #1.
157+63A Pipe #6	51	Flap Gate	no	Same as for pipe #1.

** Pipe diameter is after slip-lining. The comments column in the table indicates if pipe was totally removed and replaced with a pipe of the same size or if it wasn't slip-lined.

TABLE 2.9 (continued)
GRAVITY OUTLET PIPES

Station	Pipe Size** (inches)	Existing Closure Type	Positive Closure Required	Comments
SECTION "A"				
187+49A	15	Sluice Gate	-----	Pipe not slip-lined.
SECTION "B"				
7+54B	18	Flap Gate	no	The size of the pipe combined with probability of failure does not warrant a gatewell with sluice gate. Pipe not slip-lined.
19+11B	54	Flap Gate	yes	Given the pipe size, even with a portable pump a gatewell with sluice gate is recommended.
28+49B	12	Sluice Gate	-----	Pipe not slip-lined.
57+98B	24	Sluice Gate	-----	Pipe not slip-lined.
69+86B	30	Sluice Gate	-----	Pipe not slip-lined.
74+40B	8	Sluice Gate	-----	Pipe not slip-lined.
80+00B	18	Flap Gate	no	Backflow would go to Pump Plant #9, plus the size of the pipe combined with probability of failure does not warrant a gatewell with sluice gate. Pipe not slip-lined.
90+36B	36	Sluice Gate	-----	Pipe not slip-lined.
108+58B	54	Sluice Gate	-----	Pipe not slip-lined.
115+26B	24	Gate Valve	-----	Pipe not slip-lined.
119+45B	24	Sluice Gate	-----	Pipe not slip-lined.
123+61B	30	Sluice Gate	-----	Pipe not slip-lined.
128+61B	30	Sluice Gate	-----	

** Pipe diameter is after slip-lining. The comments column in the table indicates if pipe was totally removed and replaced with a pipe of the same size or if it wasn't slip-lined.

TABLE 2.9 (continued)
GRAVITY OUTLET PIPES

Station	Pipe Size** (inches)	Existing Closure Type	Positive Closure Required	Comments
SECTION "B"				
144+12B	48	Sluice Gate	-----	Located in Pump Plant #5. Pipe not slip-lined.
145+61B	24	Sluice Gate	-----	Pipe not slip-lined.
145+93B	30	Sluice Gate	-----	Pipe not slip-lined.
149+69B	18	Sluice Gate	-----	Pipe not slip-lined.
150+60B	24	Sluice Gate	-----	Pipe not slip-lined.
161+66B	24	Sluice Gate	-----	Pipe not slip-lined
166+48B	8	Gate Valve	-----	Pipe not slip-lined.
175+40B	20	Sluice Gate	-----	
SECTION "C"				
32+12C (2 pipes)	41	Sluice Gate	-----	
32+31C Pipe #1	51	Sluice Gate	-----	
32+31C Pipe #1 & #2	48	Sluice Gate	-----	
51+28C	24	Flap Gate	no	The size of the pipe combined with probability of failure does not warrant a gatewell with sluice gate.
92+70C (2 pipes)	41	Flap Gate	yes***	If flap gate can be secured in the closed position a gatewell would not be required.

** Pipe diameter is after slip-lining. The comments column in the table indicates if pipe was totally removed and replaced with a pipe of the same size or if it wasn't slip-lined.
*** Positive closure could be accomplished by other means than a gate well structure. Consideration should be given to securing the flap gate closed when it is lowered into a closed position in preparation for high-water.

TABLE 2.9 (continued)
GRAVITY OUTLET PIPES

Station	Pipe Size** (inches)	Existing Closure Type	Positive Closure Required	Comments
126+00C	48	Flap Gate	no	No damage from back flooding. Pipe was replaced.
150+05C	24	Flap Gate	no	No damage from back flooding. Pipe was replaced.
176+47C *	20	Flap Gate	no	No damage from back flooding.
172+08C	22	Flap Gate	no	Size of pipe combined with probability of failure does not warrant a gatewell with sluice gate.
176+90C	41	Flap Gate	no	Pump Plant #12 would be capable of pumping any backflow. In addition, the size of the pipe combined with the probability of failure does not warrant a gatewell with sluice gate.
199+80C	22	Flap Gate	no	No damage from back flooding.
200+55C	20	Flap Gate	no	No damage from back flooding.
207+16C	30	Flap Gate	no	No damage from back flooding.
217+35C (2 pipes)	20	Flap Gate	no	No damage from back flooding.
220+00C	8	Sluice Gate	-----	Sewer Line.
224+71C	30	Flap Gate	no	No damage from back flooding.
244+65C	24	Flap Gate	no	No damage from back flooding.
254+06C	27	Flap Gate	no	No damage from back flooding.
291+75C	27	Flap Gate	no	The size of the pipe combined with probability of failure does not warrant a gatewell with sluice gate. Plus, there is Pump Plant #13 at this location.

* Stationing change, this culvert is upstream of 172+08.
** Pipe diameter is after slip-lining. The comments column in the table indicates if pipe was totally removed and replaced with a pipe of the same size or if it wasn't slip-lined.

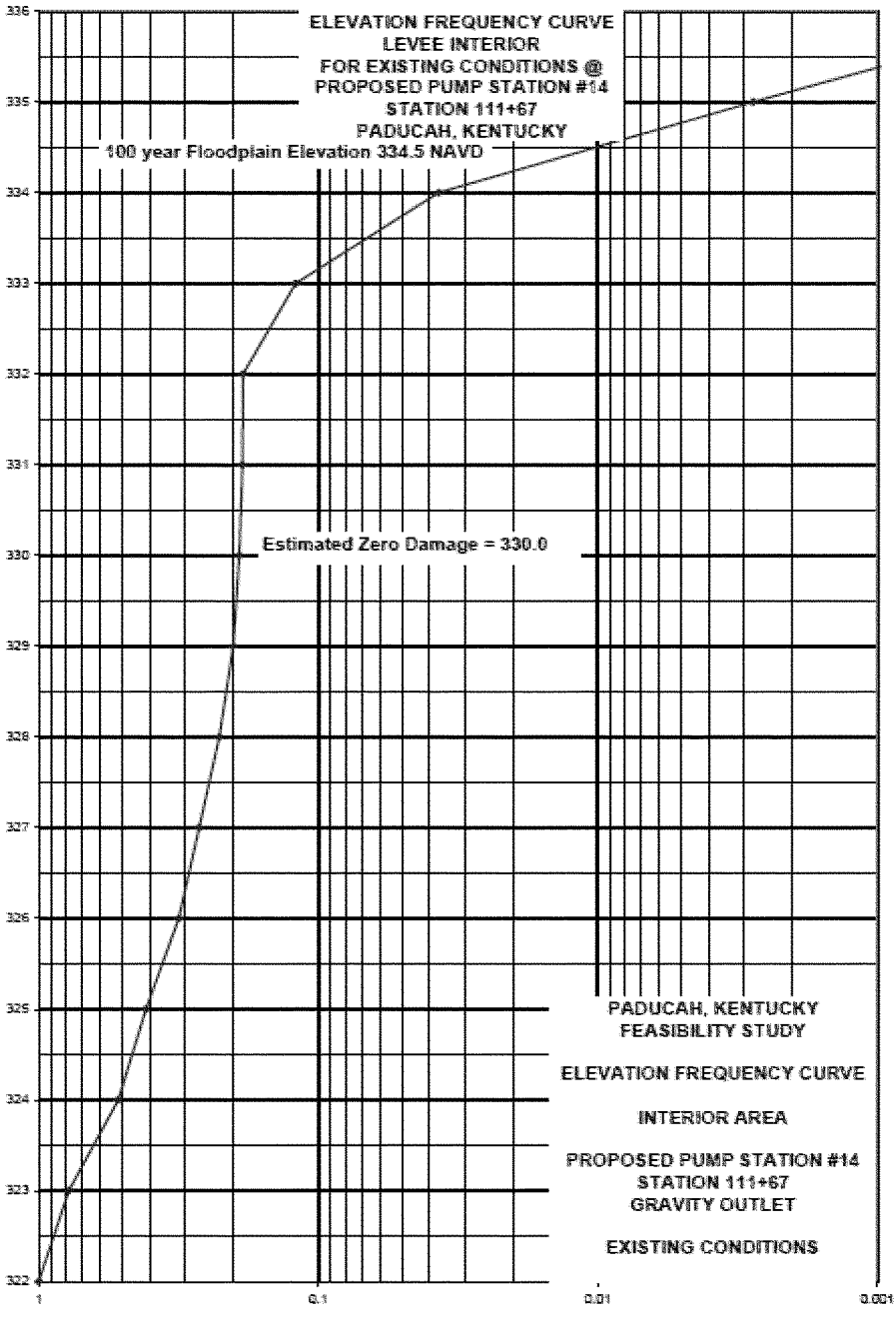

ELEVATION FREQUENCY CURVE
LEVEE INTERIOR
FOR EXISTING CONDITIONS @
PROPOSED PUMP STATION #14
STATION 111+67
PADUCAH, KENTUCKY
100 year Floodplain Elevation 334.5 NAVD
Estimated Zero Damage = 330.0
PADUCAH, KENTUCKY
FEASIBILITY STUDY
ELEVATION FREQUENCY CURVE
INTERIOR AREA
PROPOSED PUMP STATION #14
STATION 111+67
GRAVITY OUTLET
EXISTING CONDITIONS
336
335
334
333
332
331
330
329
328
327
326
325
324
323
322
1
0.1
0.01
0.001

Plate 2.1

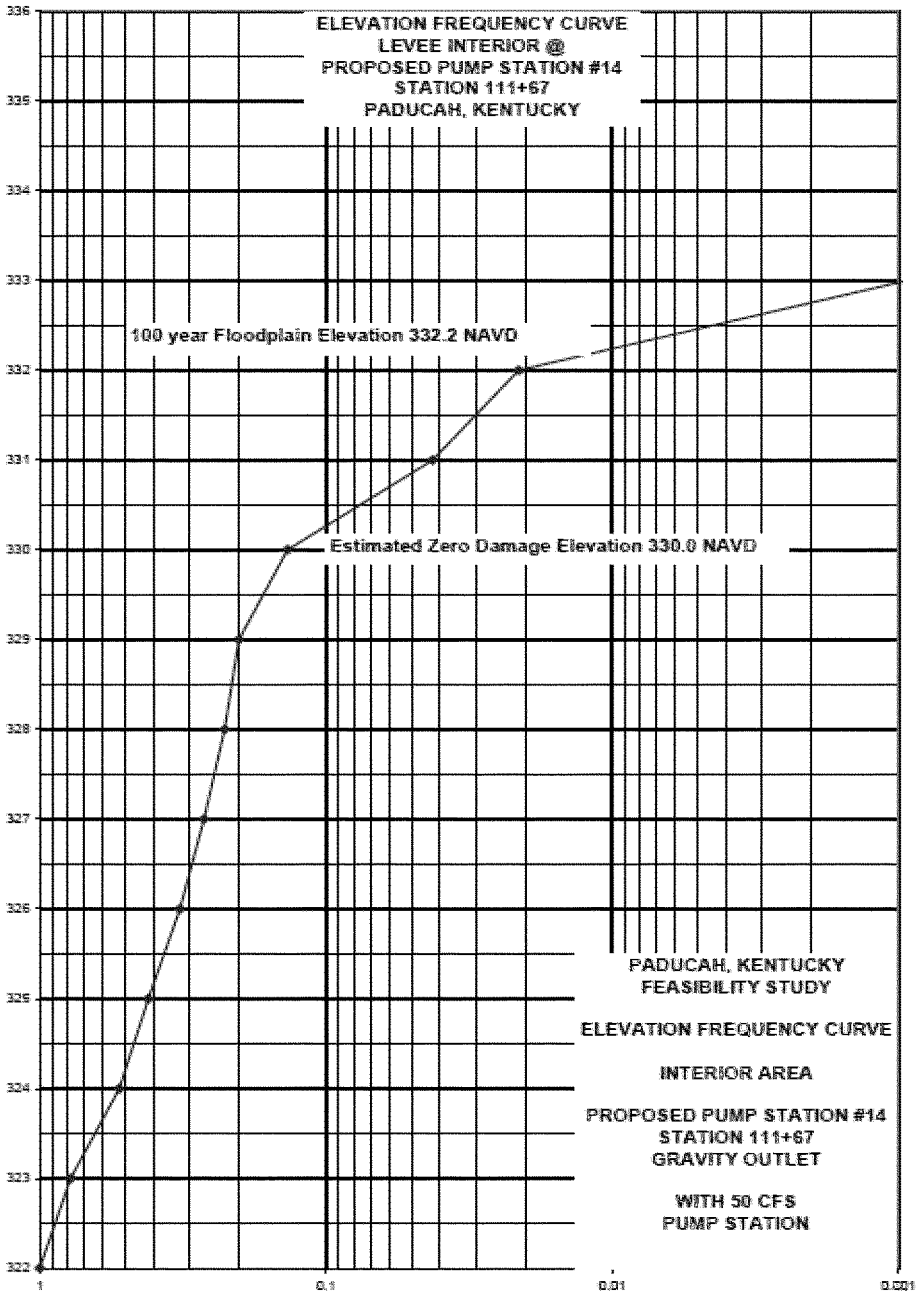

ELEVATION FREQUENCY CURVE
LEVEE INTERIOR @
PROPOSED PUMP STATION #14
STATION 111+67
PADUCAH, KENTUCKY
100 year Floodplain Elevation 332.2 NAVD
Estimated Zero Damage Elevation 330.0 NAVD
336
335
334
333
332
331
330
329
328
327
326
325
324
323
322
1
0.1
0.01
0.001
PADUCAH, KENTUCKY
FEASIBILITY STUDY
ELEVATION FREQUENCY CURVE
INTERIOR AREA
PROPOSED PUMP STATION #14
STATION 111+67
GRAVITY OUTLET
WITH 50 CFS
PUMP STATION

Plate 2.2

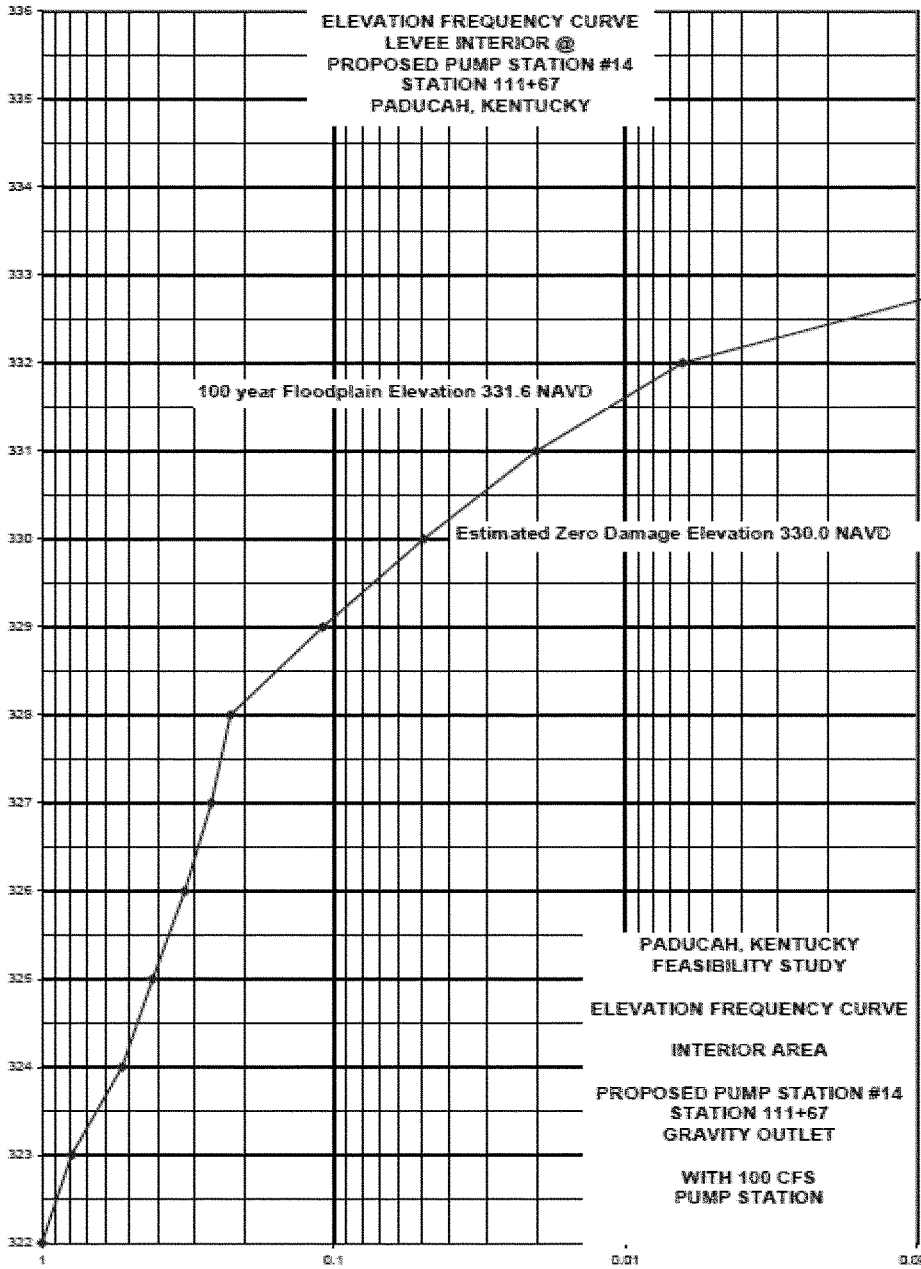

ELEVATION FREQUENCY CURVE
LEVEE INTERIOR @
PROPOSED PUMP STATION #14
STATION 111+67
PADUCAH, KENTUCKY
100 year Floodplain Elevation 331.6 NAVD
Estimated Zero Damage Elevation 330.0 NAVD
PADUCAH, KENTUCKY
FEASIBILITY STUDY
ELEVATION FREQUENCY CURVE
INTERIOR AREA
PROPOSED PUMP STATION #14
STATION 111+67
GRAVITY OUTLET
WITH 100 CFS
PUMP STATION
336
335
334
333
332
331
330
329
328
327
326
325
324
323
322
1
0.1
0.01
0.001

Plate 2.3

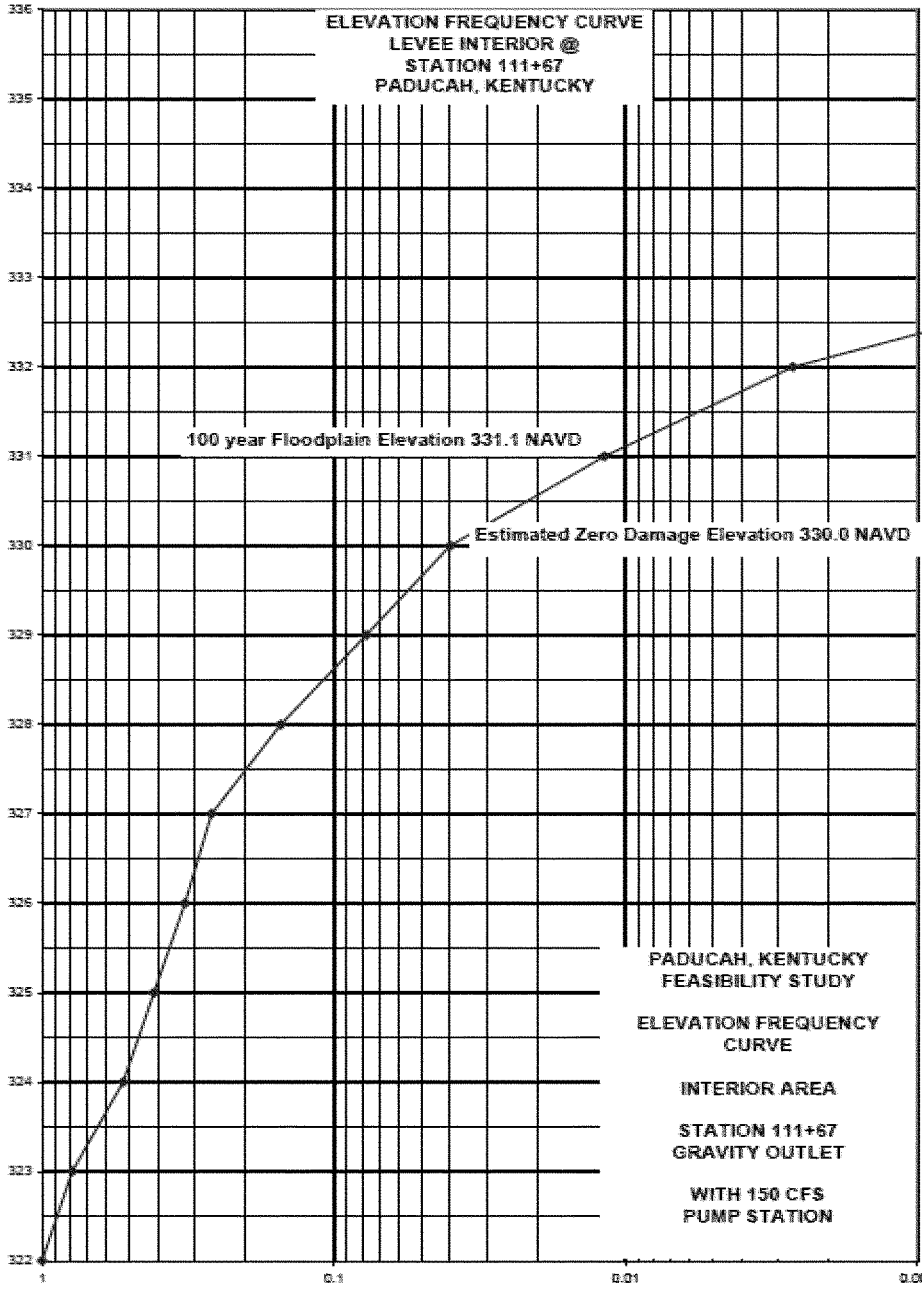
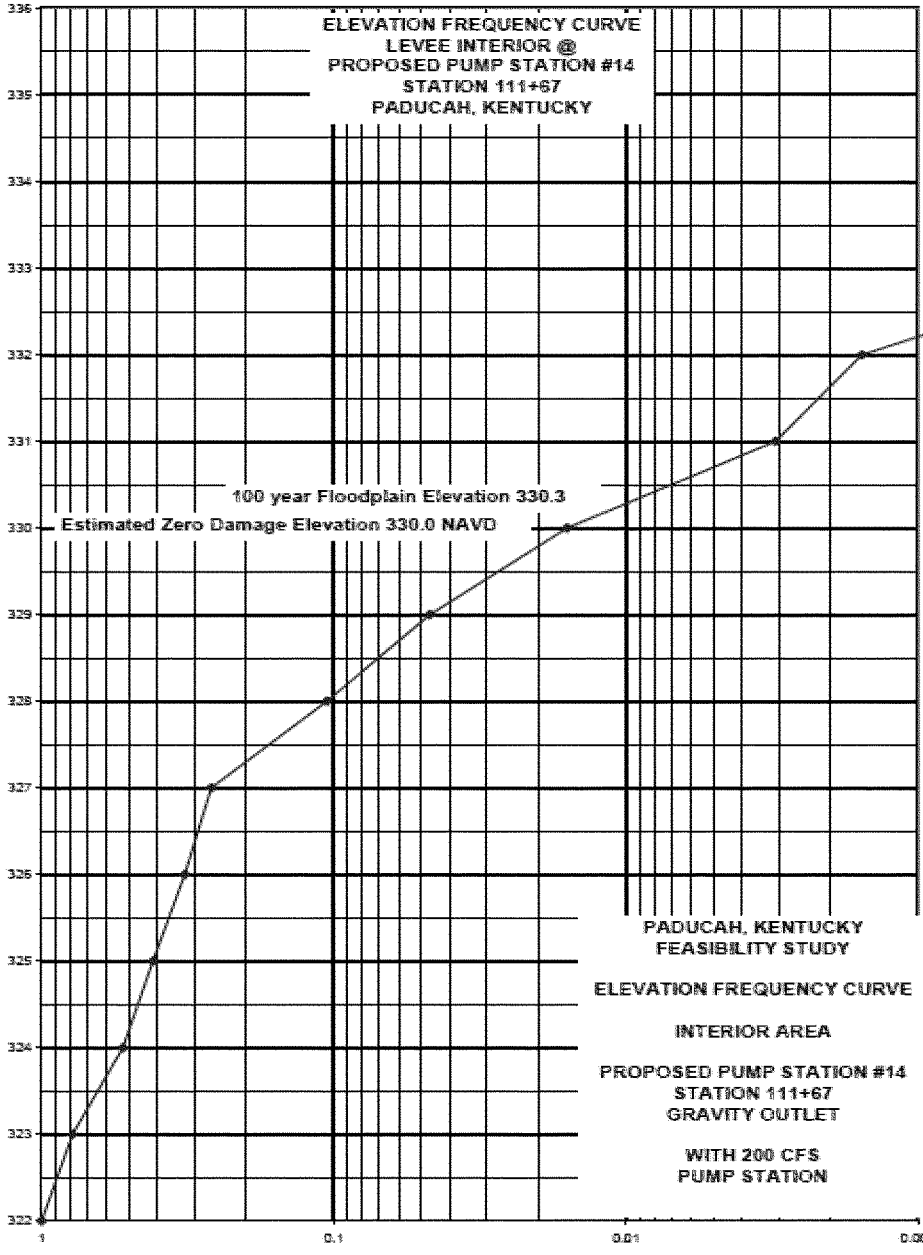

ELEVATION FREQUENCY CURVE
LEVEE INTERIOR @
STATION 111+67
PADUCAH, KENTUCKY
100 year Floodplain Elevation 331.1 NAVD
Estimated Zero Damage Elevation 330.0 NAVD
PADUCAH, KENTUCKY
FEASIBILITY STUDY
ELEVATION FREQUENCY
CURVE
INTERIOR AREA
STATION 111+67
GRAVITY OUTLET
WITH 150 CFS
PUMP STATION
336
335
334
333
332
331
330
329
328
327
326
325
324
323
322
1
0.1
0.01
0.001

Plate 2.4


ELEVATION FREQUENCY CURVE
LEVEE INTERIOR @
PROPOSED PUMP STATION #14
STATION 111+67
PADUCAH, KENTUCKY
100 year Floodplain Elevation 330.3
Estimated Zero Damage Elevation 330.0 NAVD
PADUCAH, KENTUCKY
FEASIBILITY STUDY
ELEVATION FREQUENCY CURVE
INTERIOR AREA
PROPOSED PUMP STATION #14
STATION 111+67
GRAVITY OUTLET
WITH 200 CFS
PUMP STATION
336
335
334
333
332
331
330
329
328
327
326
325
324
323
322
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0.1
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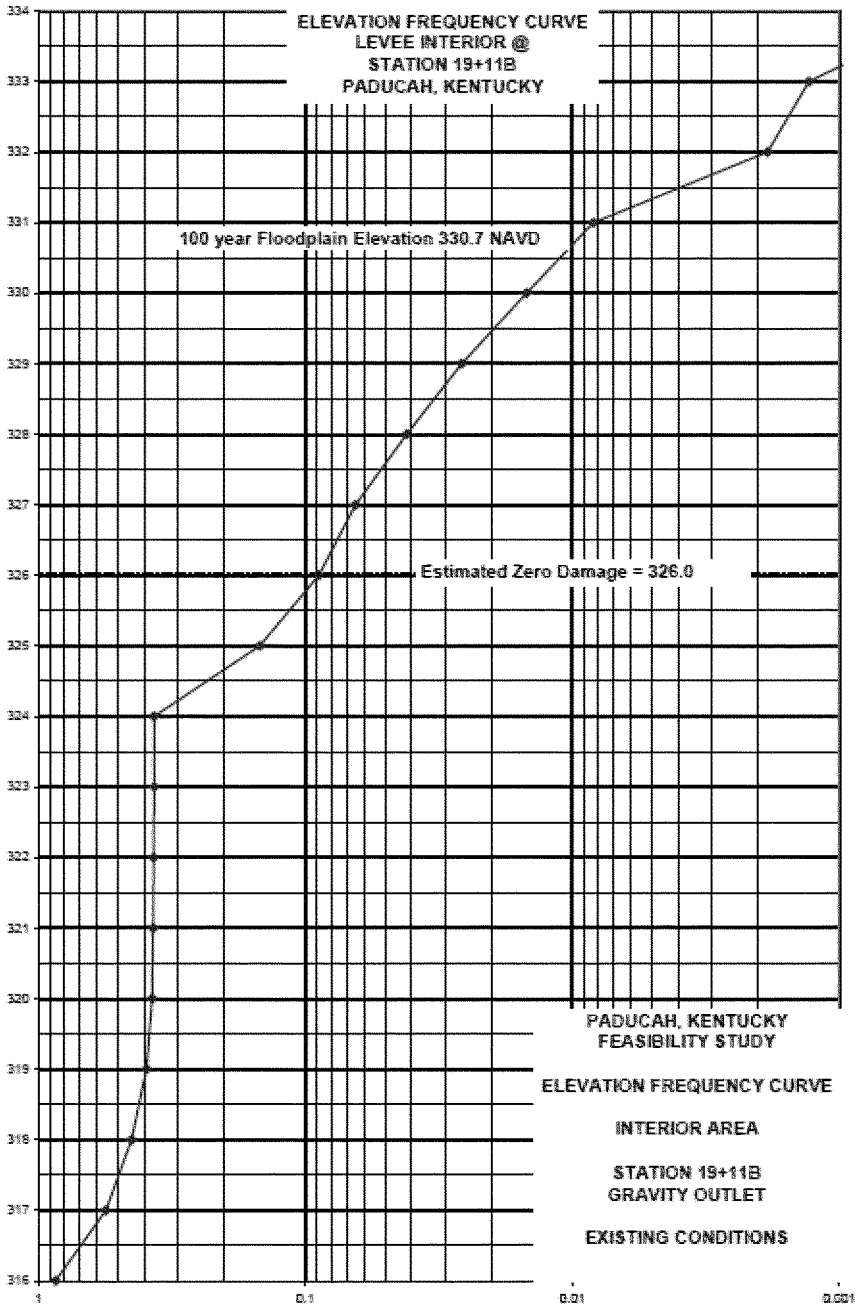
Plate 2.5


ELEVATION FREQUENCY CURVE
LEVEE INTERIOR @
STATION 19+11B
PADUCAH, KENTUCKY
100 year Floodplain Elevation 330.7 NAVD
Estimated Zero Damage = 326.0
334
333
332
331
330
329
328
327
326
325
324
323
322
321
320
319
318
317
316
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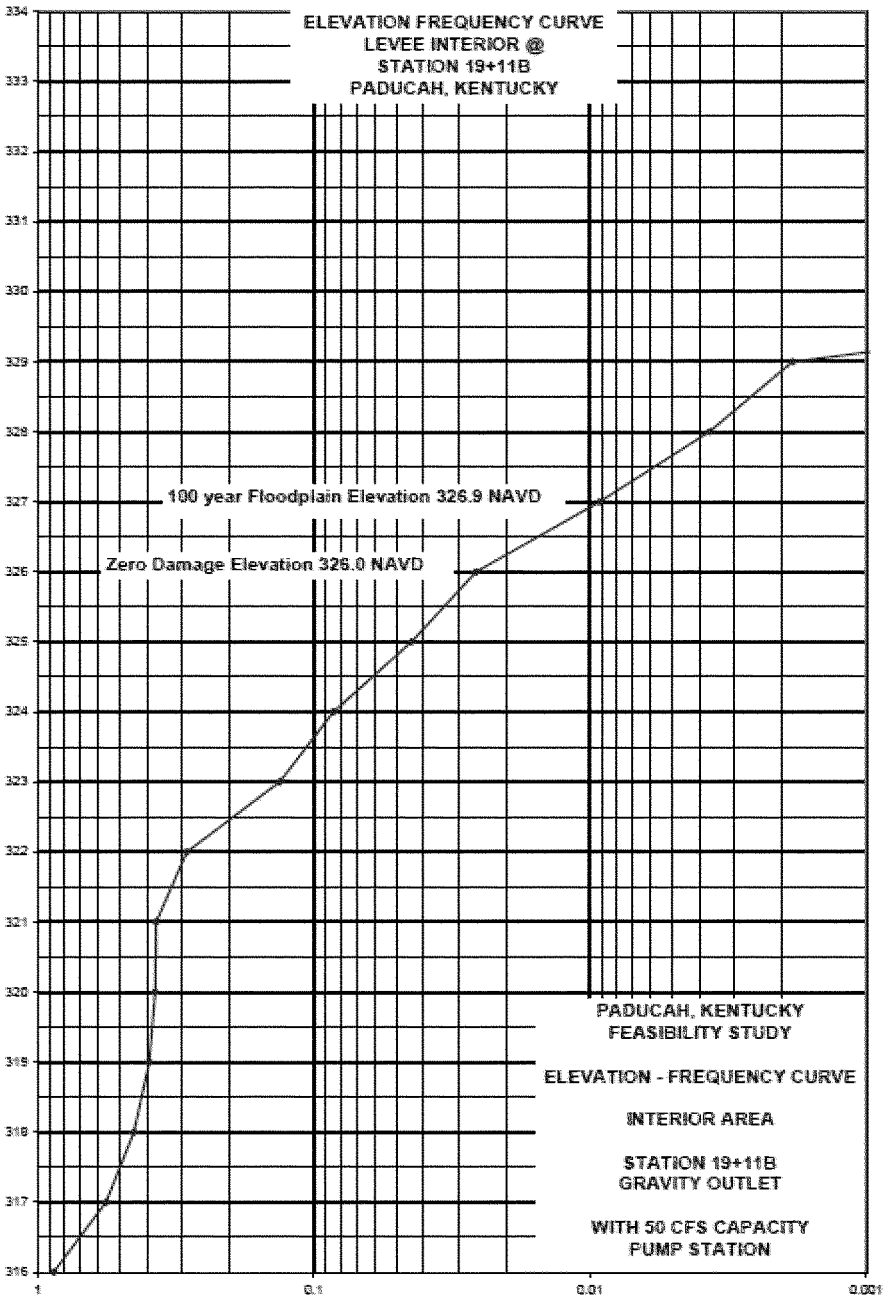
PADUCAH, KENTUCKY
FEASIBILITY STUDY
ELEVATION FREQUENCY CURVE
INTERIOR AREA
STATION 19+11B
GRAVITY OUTLET
EXISTING CONDITIONS

Plate 2.6


ELEVATION FREQUENCY CURVE
LEVEE INTERIOR @
STATION 19+11B
PADUCAH, KENTUCKY
100 year Floodplain Elevation 326.9 NAVD
Zero Damage Elevation 326.0 NAVD
334
333
332
331
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327
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325
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323
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318
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PADUCAH, KENTUCKY
FEASIBILITY STUDY
ELEVATION - FREQUENCY CURVE
INTERIOR AREA
STATION 19+11B
GRAVITY OUTLET
WITH 50 CFS CAPACITY
PUMP STATION

Plate 2.7

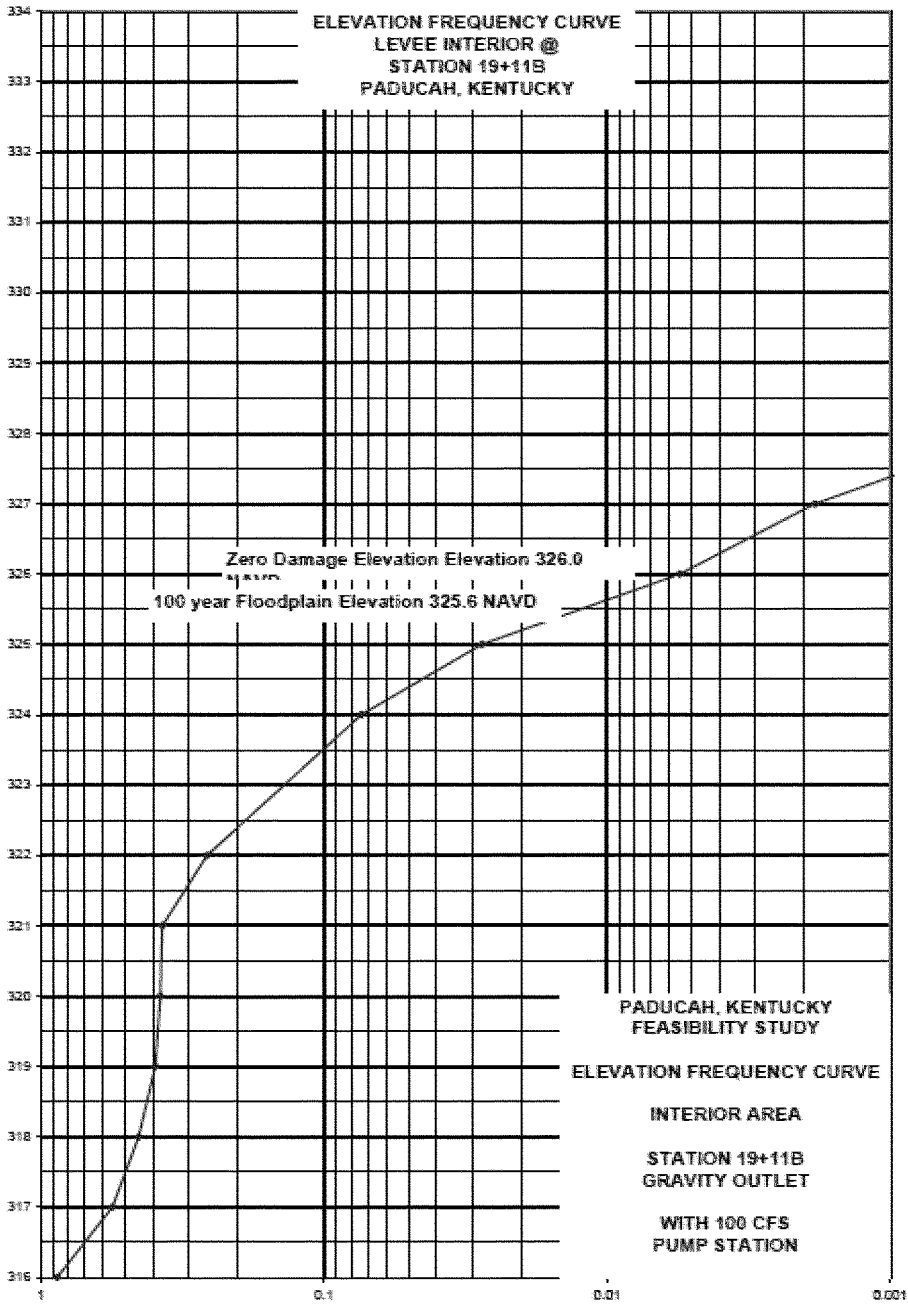
ELEVATION FREQUENCY CURVE
LEVEE INTERIOR @
STATION 19+11B
PADUCAH, KENTUCKY
Zero Damage Elevation Elevation 326.0
100 year Floodplain Elevation 325.6 NAVD
PADUCAH, KENTUCKY
FEASIBILITY STUDY
ELEVATION FREQUENCY CURVE
INTERIOR AREA
STATION 19+11B
GRAVITY OUTLET
WITH 100 CFS
PUMP STATION
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Plate 2.8

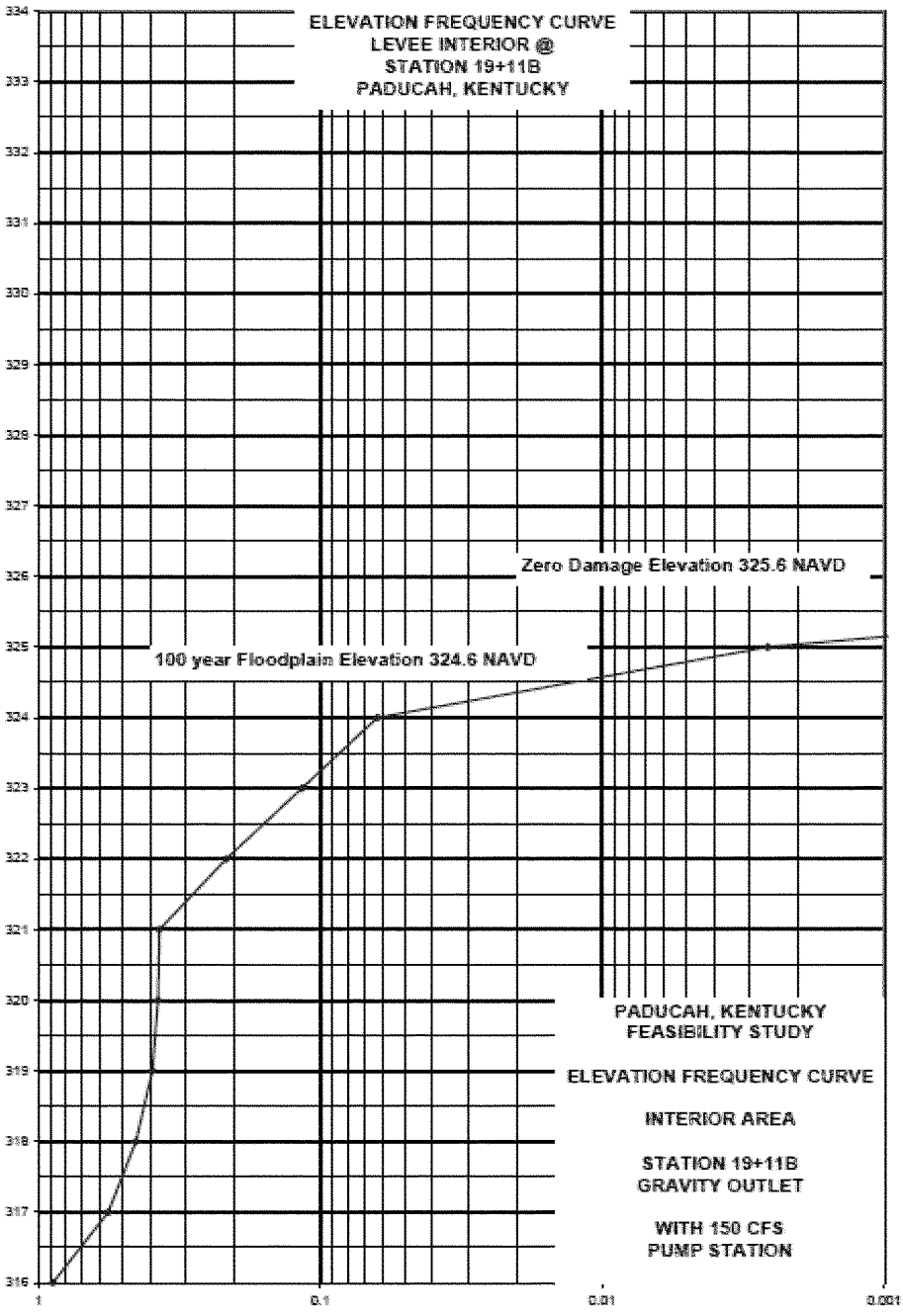
ELEVATION FREQUENCY CURVE
LEVEE INTERIOR @
STATION 19+11B
PADUCAH, KENTUCKY
Zero Damage Elevation 325.6 NAVD
100 year Floodplain Elevation 324.6 NAVD
PADUCAH, KENTUCKY
FEASIBILITY STUDY
ELEVATION FREQUENCY CURVE
INTERIOR AREA
STATION 19+11B
GRAVITY OUTLET
WITH 150 CFS
PUMP STATION
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Plate 2.9

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 3
SURVEYING AND MAPPING REQUIREMENTS

TABLE OF CONTENTS

3.1. EXISTING SURVEY AND MAPPING 1
3.2. FUTURE SURVEY AND MAPPING 1

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX C

SECTION 3 SURVEY AND MAPPING REQUIREMENTS

3.1. EXISTING SURVEY AND MAPPING.

The Corps of Engineers has obtained from the City of Paducah Engineering Department recent survey data, their existing GIS (Geographic Information Systems) information, and aerial photography which have been used for the development of the Volume 3 Feasibility Plans. The mapping used in the development of this Feasibility Report was produced in 2006 b y GRW and PhotoScience using aerial photogrammetry. The mapping has a 2-foot contour interval and uses a horizontal datum NAD 83, Kentucky South state plane coordinate system, and a vertical datum of NAVD 1988. The GIS mapping provided by the City of Paducah included utility information such as locations of water mains, storm and sanitary sewers, gas valves, electric pole, and substations. The City of Paducah also provided detailed right-of-way mapping for Sections A and C of the project.

The power and telephone utility companies were contacted in an attempt to obtain up-to-date, accurate utility information in the project area. Information was received from AT&T. However, it appears complete detailed information was not provided due to the large coverage area of the project. Also, due to time constraints, it was not possible to obtain more thorough utility information.

Paducah Power System information was received from the utility company. The location of the power facilities were from older power facility drawings which were scanned and then referenced into a proprietary GIS database at the power company. The mapping received from the power company did not line up with our survey data and therefore was not usable.

In summary, all utility relocations were determined based upon the available data and assumptions were made based on the uncertainty of the utility information.

3.2. FUTURE SURVEY AND MAPPING.

To continue to the next level of detailed design, it will be necessary to obtain comprehensive utility information for the project area. Also, for PED (Pre-Engineering

Design), it may be necessary to obtain detailed mapping in areas of significant new construction such as the Proposed Pump Station #14 a nd the Woodward Hollow Discharge Pipe.

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX C

SECTION 4 GEOTECHNICAL ENGINEERING

TABLE OF CONTENTS

4.1. REFERENCES 4-1
4.2. GEOLOGICAL CONDITIONS 4-2
4.2.1. Regional and Site Geology 4-2
4.2.2. Original Subsurface Exploration 4-3
4.2.3. Feasibility Report Subsurface Exploration 4-4
4.2.3.1. Feasibility Field Sampling and Testing 4-4
4.2.3.2. Feasibility Laboratory Testing 4-5
4.2.3.3. Feasibility Subsurface Conditions 4-5
4.2.4. Seismological Setting 4-6
4.2.5. Geophysical Investigations 4-9
4.2.6. Ground Water and Hydrology 4-9
4.3. EVALUATION AND REMEDIATION OF EXISTING PROJECT FEATURES 4-10
4.3.1. Embankment Erosion Protection 4-10
4.3.1.1. Sloughing Area 4-11
4.3.1.2. Depressions Parallel at the Levee Toe 4-12
4.3.1.3. Building Downspout 4-14
4.3.1.4. Discharge Pipes – Inlet and Outlet Ditch Erosion 4-14
4.3.1.5. Transition Armoring – Scour Erosion Protection 4-14
4.3.2. Riverbank Erosion 4-15
4.3.3. Settlement 4-16
4.3.3.1. Settlement of T-Wall Monoliths in Section B 4-16
4.3.3.2. Settlement Over Discharge Pipes 4-17
4.3.4. Embankment and Foundation Stability of Existing LFPP 4-17
4.3.4.1. Slope Stability 4-20
4.3.4.2. Seepage Analyses 4-24
4.4. DESIGN OF NEW PROJECT FEATURES 4-26
4.4.1. Filter Design Revision for Existing Pipes Through Levee 4-26
4.4.2. Construction of Pump Plant #14 at STA 111+67A 4-28
4.4.2.1. Shallow Spread Footings 4-29
4.4.2.2. Bearing Capacity 4-29
4.4.2.3. Settlement 4-29

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 4
GEOTECHNICAL ENGINEERING

TABLE OF CONTENTS

(cont'd)

4.4.3. Construction of New Pipelines Crossing Over Existing Levee for Pump Plant #14 at STA 111+67A and Woodward Hollow Discharge Pipe at STA 19+11B 4-29
4.5. CONSTRUCTION MATERIALS 4-30
4.5.1. Potential Borrow Sites 4-30
4.5.2. Potential Disposal Sites 4-31
4.5.3. Potential Sources for Concrete Materials 4-31
4.6. FURTHER STUDIES, FIELD WORK, TESTS AND ANALYSES AFTER THE FEASIBILITY STUDY 4-31

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX C

SECTION 4 GEOTECHNICAL ENGINEERING

LIST OF TABLES

Table No.	Title	Page No.
Table 4.1	Laboratory Testing Program	4-5
Table 4.2	Paducah LFPP Existing Toe Drains	4-13
Table 4.3	Summary of Boring Logs and Locations	4-20
Table 4.4	Summary of Slope Stability Analysis Material Properties	4-22
Table 4.5	Summary of Calculated Factors of Safety Slope Stability Analysis	4-23
Table 4.6	Summary of Calculated Factors of Safety Seepage Analysis	4-25
Table 4.7	Landside Blanket Filter- Pipe Analysis	4-28

LIST OF FIGURES

Figure No.	Title	Page No.
Figure 4-1	Epicenters of Historic Tectonic Events near Study Area	4-7
Figure 4-2	National Seismic Hazard Map for Study Area	4-8
Figure 4-3	Paducah, KY Seismic Hazard Curves and Uniform Hazard Response Spectra	4-9
Figure 4-4	Station 67+17A Cross-Section	4-18
Figure 4-5	Station 156+25A Cross-Section	4-18
Figure 4-6	Station 7+60B Cross-Section	4-18
Figure 4-7	Station 87+43B Cross-Section	4-19

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 4
GEOTECHNICAL ENGINEERING

LIST OF FIGURES

(cont'd)

Figure 4-8	Station 175+12B Cross-Section	4-19
Figure 4-9	Station 177+05C Cross-Section	4-19
Figure 4-10	Slope/W Output Cross-Section at Station 177+05C	4-23
Figure 4-11	Seep/W Output Cross-Section at Station 177+05C	4-25

LIST OF PHOTOS

Figure No.	Title	Page No.
Photo 4.1	Typical Overview of Levee Crown	4-11
Photo 4.2	Riverside Toe of Levee Erosion	4-11
Photo 4.3	Collapsed Toe Drain	4-12
Photo 4.4	Erosion from Downspout	4-14
Photo 4.5	Riverbank Erosion Prior to Repair	4-15
Photo 4.6	Repaired Riverbank	4-16
Photo 4.7	Depression of Levee Crown over Drainage Structure at 207+16C	4-17
Photo 4.8	Slip Liner Proof Test Photograph	4-27

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX C

SECTION 4 GEOTECHNICAL SECTION

4.1. REFERENCES.

1) Design Memorandum (DM) "*General Information Flood Protection Project Paducah, Kentucky dated October 1939*"

2) Paducah, Kentucky LFPP As-Built drawings

3) Stratigraphy derived from Kentucky Geological Survey

4) Study by J.B. Harris and R.L. Street, Engineering Geology 46 dated 1997

5) EM 1110-1-1804, *Geotechnical Investigations,* dated 1 January 2001

6) EM 1110-2-1906, *Laboratory Soils Testing*, dated 20 August 1986

7) *A Comprehensive Geotechnical and Geological Investigation of High Horizontal Stress in Shallow Soils of the Upper Mississippi Embayment and its Influence on Pile Capacity*, authored by Jeffrey A. Shaefer, PhD, P.E., P.G.

8) EC 1110-2-6067, *USACE Process for the National Flood Insurance Program (NFIP) Levee System Evaluation*, dated 30 July 2009

9) Soil Survey of Ballard and McCracken Counties, Kentucky conducted by the United States Department of Agriculture Soil Conservation Service

10) EP-500-1-1, *Emergency Employment of Army and Other Resources Civil Emergency Management Program – Procedures*, dated 30 September 2001

11) EM 1110-2-1913 *Design and Construction of Levees,* dated 30 April 2000

12) EM 1110-2-1902 *Slope Stability*, dated 31 October 2003

13) ETL 1110-2-569 *Design Guidance for Levee Underseepage,* dated 01 May 2005

14) ER 1110-2-1150 Engineering and Design for Civil Works Projects, dated 31 August 1999

15) Eight borings conducted by Geotech Engineering & Testing, Inc. for the Proposed Ingram Office Building near Section B – Unit I, STA 78+85

16) Six borings conducted by Geotech Engineering & Testing, Inc. for the Proposed Crounse Corporation Headquarters near Section B – Unit II, STA 106+10

17) The Subsurface Investigation containing seventeen borings conducted by Florence & Hutcheson, Inc. for the Four Rivers Center Site No. 2 near Section B – Unit II, STA 114+98

18) USACE Proof Tests of Sliplining Technology, Paducah, Kentucky LFPP Scope of Work (SOW)

4.2 GEOLOGICAL CONDITIONS.

4.2.1. Regional and Site Geology.

During the latter part of the Cretaceous Period about 130 million years ago, the Gulf of Mexico inundated much of the southern United States and covered all the Jackson Purchase and some of the Mississippian Plateaus with sands, clays, and gravels. The Tertiary Period began 70 million years ago, and deposits consisted of marine and fresh - to brackish-water sediments. The distribution of deposits indicates that Paducah, Kentucky was near the northern limit of the Gulf Embayment (also called the Mississippi Embayment). Portions of the embayment must have been swampy, because thin beds of lignite (brown coal) and carbonaceous clays occur in the western half of the eight-county Jackson Purchase Region. These geological deposits are a marked contrast to the underlying older hard rocks, because most of the Cretaceous and younger sediments remain unconsolidated and soft. Over the last million years, unconsolidated Quaternary sediments have been deposited along the larger streams and rivers. The City of Paducah, Kentucky is underlain by thick sequences of unconsolidated to poorly consolidated sands, clays, and gravels of the late Cretaceous to Holocene, which unconformably overlie Mississippian-age limestone bedrock (Warsaw Limestone). The thickness of unconsolidated deposits ranges from less than 280 feet to more than 520 feet.

Holocene alluvium or Pleistocene loess are the uppermost layers in the western and central parts of the City. The alluvium is found adjacent to the Ohio River or in its tributaries whereas the loess is typically located on terraces adjacent to the river. Continental deposits made up of Pleistocene silts, sands, clays, and gravels can be found in the south central part of Paducah. The continental deposits occur at the subsurface to the west creating a regional gravel aquifer. The surficial deposits in the east are composed of approximately 163 feet thick of alluvial and lacustrine material. An erosional surface of Eocene age or later underlies the loess continental deposits, alluvium,

and lacustrine deposits. To the south Eocene sands (Claiborne and Wilcox Formations) and Paleocene clay (Porters Creek Clay) are the sub-erosional strata, while in the north the surface is cut on sands and clays of the McNairy Formation (late Cretaceous). The McNairy Formation contains the majority of the soil column and lies over the Warsaw Limestone bedrock.

4.2.2. Original Subsurface Exploration.

Generalized subsurface information is available for the existing Paducah, Kentucky LFPP from the following references: 1) Design Memorandum (DM) "*General Information Flood Protection Project Paducah, Kentucky dated October 1939*"; 2) As-Built drawings; 3) Stratigraphy derived from Kentucky Geological Survey; and 4) A study by J.B. Harris and R.L. Street, Engineering Geology 46 d ated 1997. Foundation investigations as part of the DM included auger drilling and drive sampling operations. Most of the exploratory borings for this project were performed prior to the development of the currently accepted Standard Penetration Test (SPT) referenced in EM 1110-1-1804, *Geotechnical Investigations*, dated 1 January 2001.

The results from the original design foundation investigations for the Paducah, Kentucky LFPP revealed the following general conditions:

Prior to the construction of the levees, an inspection trench was excavated along the center line to verify foundation conditions and to determine the presence of foreign materials or possible sources that could allow underseepage to occur in the foundation. The levees were seeded for grass covering and stone paving was used along the riverside slopes at points where erosion was possible. Drains have been provided along the landside toe of the levees to facilitate foundation drainage and transport possible excessive under seepage.

The structural footprint of the levee embankment constructed in Section "C" is located on a layer of stiff clay 20 to 25 feet in depth from the continental deposits of the Pleistocene Period (See Sheet CS001 in Volume 3 of this report for the overall site map which depicts the limits of each Section of the existing project). This clay forms an excellent foundation for the levees in this area in the prevention of under seepage.

Most of Section "B" consists predominately of concrete floodwall. From the beginning of the wall at the upstream end and extending to Island Creek a stratum of brown clay of stiff consistency averaging about 25 feet in thickness underlies the first 4,000 feet of protection. This stratum is covered with fill consisting of cinders and debris to an average depth of about 4 feet for approximately 1,600 feet of its length. From the vicinity of Island Creek to the downstream end of Section "B", the native soil for the most part consists of clay to depths varying from 0 to 16 feet.

The foundation material for the levee embankment constructed in Section "A" is composed of a 6- to 12-foot layer of clay, overlying a stratum of gravel. This gravel bed appears to underlie the entire western portion of the City of Paducah.

4.2.3. Feasibility Report Subsurface Exploration.

As part of this Feasibility Report, the subsurface conditions were explored with eight soil test borings shown on Sheets G001 through G011 in Volume 3. The boring locations are shown on Sheets CS114, CS115, CS117, and CS125 in Volume 3. The primary focus of the drilling exploratory program for this report was to determine soil characteristics at the proposed location for Pump Plant #14 (STA 111+67A), potential Woodward Hollow Discharge pipe location (STA 19+11B), and at the locations of the critical T-wall cross-sections at STA 8+40B and STA 84+50B used for analyses. The boring locations and depths were selected by CELRL-ED-T-G personnel. The actual boring locations were surveyed by a handheld GPS unit. Additional borings in each section of the subject study area will be planned during the PED phase.

Laboratory testing on selected soil samples consisted of moisture content, unit weight, gradation, Atterberg limits, unconfined compressive strength, permeability, and shear strength determinations. A description of the subsurface conditions encountered with pertinent available physical properties is presented in the following sections.

4.2.3.1. Feasibility Field Sampling and Testing.

Field sampling and testing were performed in general accordance with EM 1110-2-1906, *Laboratory Soils Testing*, dated 20 A ugust 1986; ASTM procedures; and current established geotechnical engineering practice. T he samples obtained during the exploration included driven (split-spoon) and undisturbed (Shelby tube) sampling. The samples were visually classified in the field by a geologist and returned to the Contractor's office for laboratory testing.

SPT is one of the most widely used field tests in geotechnical engineering. At regular intervals, drilling tools are removed and soil samples obtained with a standard 1.4-inch-inside-diameter (I.D.), 2-inch-outside-diameter (O.D.), split-tube sampler. The sampler is first seated 6 inches to penetrate any loose cuttings and then driven an additional foot with blows of a 140-pound hammer free-falling 30 inches. The number of hammer blows required to drive the sampler the final one foot is designated the "penetration resistance" or *N*-value. The penetration resistance when properly evaluated is an index to the soil's strength.

Shelby Tube sampling is used to obtain undisturbed samples for laboratory testing. The sampler consists of a thin-walled tube with a cutting edge at the toe with a standard 3-inch O.D. tube. A sampler head attaches the tube to the drill rod, and contains a check valve and pressure vents. The sampler is advanced 6 inches less then the length of the tube. The vacuum created by the check valve and cohesion of the sample in the tube cause the sample to be retained when the tube is withdrawn providing and undisturbed sample.

4.2.3.2. Feasibility Laboratory Testing.

The laboratory testing performed on selected soil samples for this study assisted and verified the assigning of both classification and strength values associated with the native soils found along the existing project length. The laboratory testing program is summarized in the following table.

TABLE 4.1: LABORATORY TESTING PROGRAM

Classification Tests	Qty.	Strength Tests	Qty.
Natural Moisture Content	103	Unconfined Compression	2
Atterberg Limits	30	Q (UU) Triaxial Compression	2
Sieve and Hydrometer Analysis	31	R′ (CU) Triaxial Compression	2
Unit Weight	12		
Permeability	6		

4.2.3.3. Feasibility Subsurface Conditions.

The boring logs (see Sheets G001 through G011 of Volume 3 of this report) represent the geotechnical engineer's interpretation of the subsurface conditions based on the visual classification of field samples and laboratory tests of selected field samples. The interface between various strata on the boring logs represents the approximate interface location. Transitions between strata may be more gradual than shown. Water levels shown on the boring logs represent the conditions only at the time of exploration, unless otherwise indicated.

Section A.

Section A soil characterization was determined from Borings AD-1 and AD-2. These borings were drilled to predetermined depths of 25.5 feet.

Stratum I: The Stratum I soils generally consisted of brown or grey silty clay to depths of approximately 8 feet. The geotechnical engineer interpreted the Stratum I soils to be native soils. Field-measured SPT resistances (N-values) ranged from 5 blows per foot (bpf) to 8 bpf. These values are indicative of soils with medium stiff relative consistency per Table G-1 in EM 1110-1-1804, *Geotechnical Investigations*, dated 1 January 2001.

The moisture content of the samples tested ranged from 18.3 to 31.1 percent. These values are indicative of moist to wet samples. The Atterberg Limits and particle size analysis results indicate "CL" type soils, according to the Unified Soil Classification System (USCS).

Stratum II: The Stratum II soils generally started at an approximate depth of 8 feet and consisted of clayey gravel with sand or sand with clay and gravel which extended to the bottom of the boring. Field-measured SPT N-values ranged from 21 to 64 bpf. These values are indicative of soils with medium dense to very dense relative density.

The moisture content of the samples tested ranged from 13.6 to 32.2 percent. These values are indicative of moist samples. The Atterberg Limits and particle size analysis results indicate "GC", "GW-GC", and "SW-SC" type soils, according to the USCS.

Section B.

Section B soil characterization was determined from Borings AD-3, AD-3A, AD-4, AD-5, AD-6 and AD-6A. These borings were drilled to predetermined depths ranging from 17.0 to 51.0 feet.

Stratum I: The Stratum I soils generally extended the full depth of the bore holes and generally consisted of brown or grey silty clay. The Stratum I soils are native soils. Field-measured SPT N-values ranged from 1 to 24 bpf. These values are indicative of soils with very soft to very stiff relative consistency.

The moisture content of the samples tested ranged from 15.5 to 39.4 percent. These values are indicative of moist to wet samples. The Atterberg Limits and particle size analysis results indicate "CL" type soils, according to the USCS.

Section C.

No borings were drilled in this section as part of the subject study.

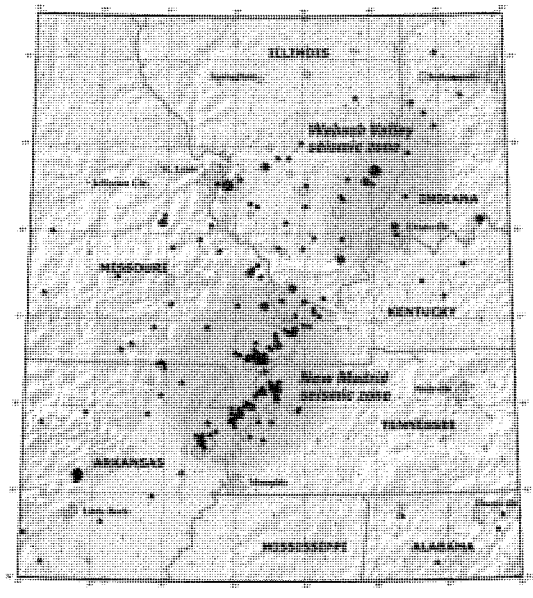
4.2.4. Seismological Setting.

The following discussion on seismological setting was developed from studies in the project vicinity. The appropriateness of the findings from these studies was reviewed and details pertinent to this project are presented below.

Olmsted Locks and Dam (currently under construction) is located about 25 miles northwest of the Paducah, Kentucky LFPP. The following report, written about the Olmsted project, was reviewed for pertinent seismic information: *A Comprehensive Geotechnical and Geological Investigation of High Horizontal Stress in Shallow Soils of the Upper Mississippi Embayment and its Influence on Pile Capacity*, authored by Jeffrey A. Shaefer, PhD, P.E., P.G.

EC 1110-2-6067, *USACE Process for the National Flood Insurance Program (NFIP) Levee System Evaluation*, dated 30 July 2009 provides guidance on performing seismic analysis of existing structures. The purpose of this review was to develop conclusions on the seismic safety of the levee/floodwall system foundation and appurtenant structures. Two of the issues related to seismic safety that are determined during a seismic safety review are proximity to seismic source zones and changes in state of knowledge of regional or local seismicity since the last review. The project is located near the northern edge of the New Madrid Seismic Zone (NMSZ). In 1812, the NMSZ produced the strongest North American earthquake in the recorded history of the contiguous United

States. The NMSZ is still active today and most events take place near the center of the fault zone. Figure 4-1 shows the epicenters of historic tectonic events.



This map of the New Madrid and Wabash Valley seismic zones shows earthquakes as circles. Red circles indicate earthquakes that occurred from 1974 to 2002 with magnitudes larger than 2.5 located using modern instruments (University of Memphis). Green circles denote earthquakes that occurred prior to 1974 (USGS Professional Paper 1527). Larger earthquakes are represented by larger circles.

Figure 4-1: Epicenters of Historic Tectonic Events near Study Area. From USGS, 2007

The tectonic setting of the study area requires design considerations for dynamic forces. The United States Geological Survey (USGS) provides software and information necessary for seismic design. The contours on Figure 4-2 represent the levels of horizontal shaking that have a 10% chance of being exceeded in a 50-year period. The contours are presented as a percentage of the gravitational acceleration constant. Figure 4-3 was obtained using the USGS probabilistic hazard curve calculation webpage for the 2002 data for the given latitude-longitude. Figures 4-2 and 4-3 both display the peak horizontal acceleration with a 10% Probability of exceedance in 50 years for the subject project area as 27.85% of the gravitational acceleration constant.

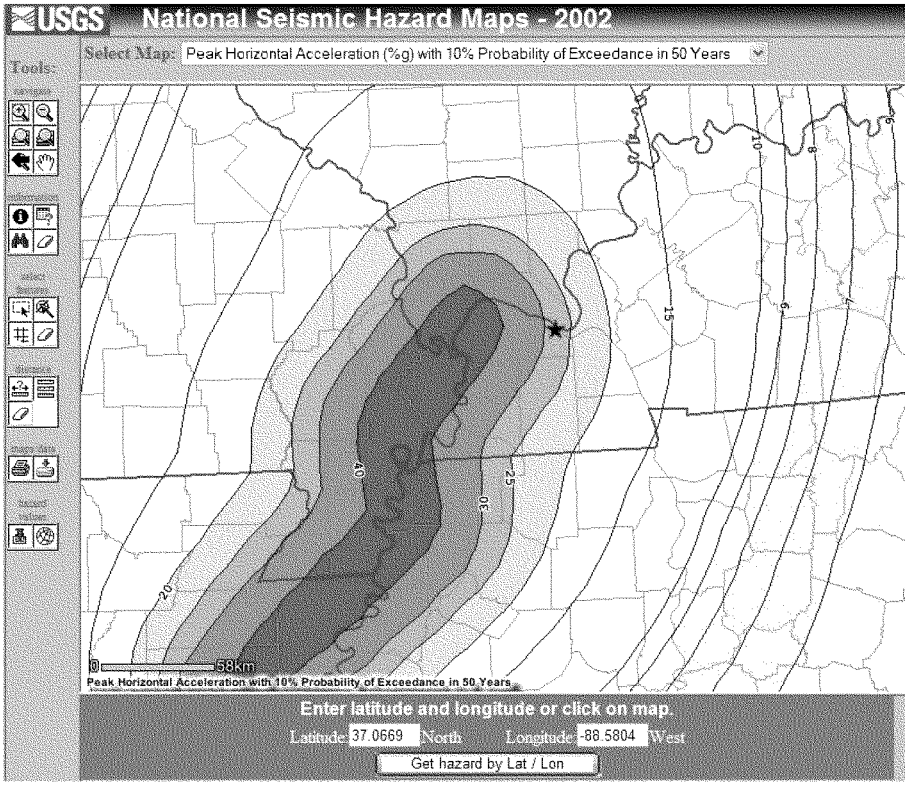


Figure 4-2: National Seismic Hazard Map for Study Area

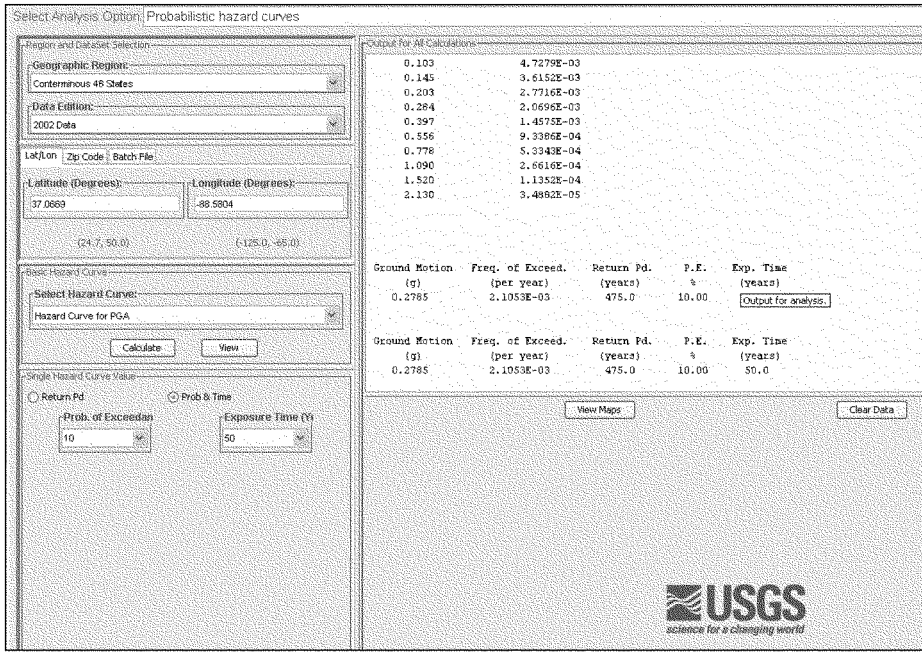


Figure 4-3: Paducah, KY Seismic Hazard Curves and Uniform Hazard Response Spectra

4.2.5. Geophysical Investigations.

The investigation area is situated on a thick stratum of clay, sand, and gravel layers. The stratum continues approximately 250 to 500 feet below ground surface to a foundation of Mississippian-age limestone. The project's foundation will not rely on the geophysical properties of the bedrock because of the significant depth of the overlying stratum. Based on t he depth to bedrock, further geophysical investigation has been deemed unnecessary.

4.2.6. Ground Water and Hydrology.

Ground water and hydrology data was gleaned from a variety of sources in order to make an accurate assessment of groundwater levels pertaining to the Paducah, Kentucky Feasibility Report.
Sources include:

- Eight borings conducted by the USACE Louisville District in the project area in June 2009.
- Eight borings conducted by Geotech Engineering & Testing, Inc. for the Proposed Ingram Office Building near Section B – Unit I, STA 78+85.

- Six borings conducted by Geotech Engineering & Testing, Inc. for the Proposed Crounse Corporation Headquarters near Section B – Unit II, STA 106+10.
- The Subsurface Investigation containing seventeen borings conducted by Florence & Hutcheson, Inc. for the Four Rivers Center Site No. 2 near Section B – Unit II, STA 114+98.
- The Soil Survey of Ballard and McCracken Counties, Kentucky conducted by the United States Department of Agriculture Soil Conservation Service (SCS).

The ground water table at the site varies seasonally and can extend to the ground surface during some periods. It has been determined that the ground water table should be considered to be at the ground surface for design considerations. This assessment is backed by analysis of the boring logs and is in agreement with conclusions reached by the Subsurface Investigation conducted by Florence and Hutcheson, Inc. as part of this Feasibility Report and the soil survey conducted by the SCS as listed above.

4.3. EVALUATION AND REMEDIATION OF EXISTING PROJECT FEATURES.

The initial site visit for the subject project was conducted on 23-27 March 2009. Several other site visits have also been made to the project to further evaluate existing features of the project. The scope of these site visits was based on the guidance provided in EC 1110-2-6067, *USACE Process for the National Flood Insurance Program (NFIP) Levee System Evaluation*, dated 30 July 2009 along with applying the use of the current ICW checklist per EP-500-1-1, *Emergency Employment of Army and Other Resources Civil Emergency Management Program – Procedures*, dated 30 September 2001.

4.3.1. Embankment Erosion Protection.

The general condition of the levee embankment surface was satisfactory. Throughout the length of the protective works, the riverside and landside slopes, as well as the crown of the levee, have good mown grass surface protection with few exceptions. A typical overview of the levee crown can be seen in Photograph 4.1. There is frequently damaged sod and slight rutting on the crown from vehicular traffic, and occasional rutting on the slopes from mowing operations. Specific areas of concern of the embankment and at the levee toe are discussed in the following paragraphs.

Photo 4.1: Typical Overview of Levee Crown

4.3.1.1. Sloughing Area.

There is a sloughing area which is located near Station 17+50B, as shown in Photograph 4.2 that has developed as a result of an extended high water event followed by a rapid drawdown in January-February 2009 at the riverside toe of levee. This portion of the project is located on the outside bend of the Tennessee River adjacent to Owens Island. Erosion of the riverside toe, which is typically responsible for upper bank instability, is occurring within an unprotected area of the levee between two protected (riprapped) sections. This area was left unprotected during the original project construction and as a result has allowed erosion of the toe and initiation of sloughing. Continued erosion of the toe will likely result in upper bank instability which may lead to a levee failure at this location. It is recommended that the unprotected area be protected with riprap as was performed on the adjacent areas during the original construction (Sheet CS115A of Volume 3), to prevent any further erosion of the toe and avoid upper levee embankment instability.

Photo 4.2: Sloughing Area

4.3.1.2. Depressions Parallel at the Levee Toe.

There are multiple holes and depressions at the toe of the levee between Stations 150+00C and 174+80.5C, between Stations 218+85C and 244+65C, and Stations 102+50B, 90+25A and 113+00A which appear to be from collapsed toe drains. In some of these areas where the toe drains have collapsed, water is ponding at the toe of the levee and cannot drain properly causing the soil in this area to remain saturated for long periods of time. This could lead to a weakening of the levee foundation soils and levee failure. Another issue with these collapsed toe drains is piping of soils at the toe of the levee into these broken toe drains. Without the support of the soils at the levee toe, upper bank instability may begin to occur leading to sloughing of the upper bank area that could eventually cause levee failure. A third factor is the risk to public safety with these deep depressions above the broken toe drains as shown in Photograph 4.3. The levee is located in areas of the city of Paducah where pedestrian traffic is common.

Photo 4.3: Collapsed Toe Drain

The toe drains, as shown on the As-Built drawings, were included in the design of the levee system to control underseepage. Based on the results of seepage analyses presented in Paragraph 4.3.4.2, toe drains are not required to relieve underseepage pressures. Therefore, as part of the Paducah, Kentucky LFPP Feasibility Report, it is recommended that all toe drains be filled and sealed except as noted below. Table 4.2 shows a list of the approximate station limits of the existing toe drains that were constructed as part of this project. Based on the structural analysis of the pump plants, the toe drains at locations near Pump Plants 3, 6, and 7 will need to be replaced as shown on Sheets CS118, CS119, and CS121 of Volume 3. Also, based on the structural analysis of the floodwalls, the toe drains at locations near monoliths 32, and 35-43 in Section B will need to be replaced as shown on Sheet CS114 of Volume 3. During PED, additional work will be performed such as utilizing ground penetrating radar and dye testing to

simplify Table 4.2 to only include sealing and abandoning toe drains which have collapsed. T his reconstruction item is not considered part of regular O&M by the Sponsor due to the fact that the subject project's O&M manual does not provide specific guidance for maintaining and keeping the toe drains in good working condition. Also, no clean outs were provided for the toe drains on the subject project. There are long lengths of toe drains without any access points for maintenance.

TABLE 4.2: PADUCAH LFPP EXISTING TOE DRAINS

Section	Station Limits	Sheet	Work Item	Protection
C	150+00 to 174+80.5	CS 105 to CS 107	Seal & Fill	Levee
C	218+85 to 244+65	CS 110 to CS 111	Seal & Fill	Levee
B	0+00 to 7+02.5	CS 114	Seal & Fill	Floodwall
B	7+02.5 to 9+38	CS 114	Replace	Floodwall
B	9+38 to 36+91.96	CS 114 to CS 116	Seal & Fill	Levee and Floodwall
B	54+47.31 to 72+12.12	CS 116 to CS 117	Seal & Fill	Floodwall
B	74+00 to 80+00	CS 117	Seal & Fill	Floodwall
B	90+31 to 92+00	CS 118	Replace	Floodwall & Pump Plant #7
B	92+00 to 108+00	CS 118 to CS 119	Seal & Fill	Floodwall
B	108+00 to 110+00	CS 119	Replace	Floodwall & Pump Plant #6
B	110+00 to 161+94	CS 119 to CS 121	Seal & Fill	Floodwall
B	161+94 to 163+00	CS 121	Replace	Floodwall & Pump Plant #3
B	163+00 to 170+00	CS 121 to CS 122	Seal & Fill	Floodwall
A	52+99 to 79+52	CS 122 to CS 124	Seal & Fill	Levee
A	131+00 to 138+00	CS 126	Seal & Fill	Levee
A	144+71 to 147+25	CS 127	Seal & Fill	Levee
A	148+25 to 157+63	CS 127	Seal & Fill	Levee
A	172+20 to 191+80	CS 128 to CS	Seal & Fill	Levee

		129		

4.3.1.3. Building Downspout.

At approximate Station 0+40B, a downspout from a building gutter adjacent to the landside toe of levee drains onto a makeshift drainage pad; see Photograph 4.4. This drainage is eroding an area at the toe of the levee, and therefore should be moved as part of normal O&M efforts by the sponsor.

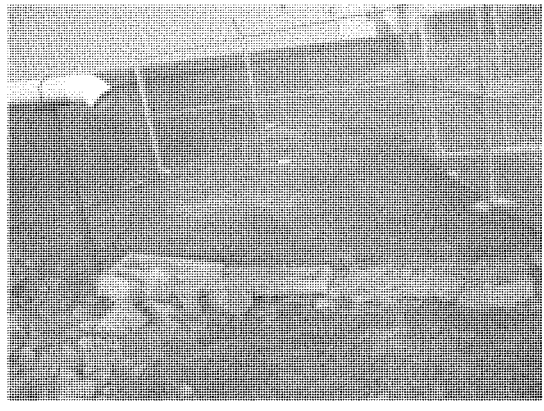


Photo 4.4: Erosion from Downspout

4.3.1.4. Discharge Pipes – Inlet and Outlet Ditch Erosion.

Inlet and outlet ditches of the drainage pipes have minimal to no erosion. Many of these discharge pipe drainage ditches (inlet and outlet) have been protected with riprap due to the increase in exit velocities associated with the slip-lining efforts that are part of this Feasibility Report. See Sheet CZ003 of Volume 3 in regards to information on the slip-lining efforts.

4.3.1.5. Transition Armoring – Scour Erosion Protection.

At each of the transitions from levee to structural wall in Section B, the landside levee side slope is not armored with riprap. Following the disaster of Hurricane Katrina in New Orleans, the Interagency Performance Task Group (IPET) recommended that at transitions from levee to structural walls, the transition zone be armored to prevent scour in the event of overtopping.

This repair will require a minimum of 6-inches of bedding stone Class 1 or 2 with 24-inches of Kentucky Class 3 riprap on the protected side from the crown to the toe of the levee slope where a structural I-wall transitions into a levee.

Locations where the scour protection is required is shown on s heets CS114, CS115, CS116 and CS122.

4.3.2. Riverbank Erosion.

Throughout the Paducah, Kentucky LFPP, the banks of the Ohio and the Tennessee Rivers are generally located at distances up to and greater than 100 feet from the toe of the levee and/or concrete floodwall when the river is at the normal Lock and Dam 52 pool elevation. During the site visit on 23-27 March 2009 and a previous site visit by an LRL ED-T-G employee on 10 July 2008, significant riverbank erosion was noted to be occurring between approximate Stations 12+75B and 15+32B (monoliths 58 through 71). See Sheets CS114 and CS115 in Volume 3 for the location of this bank erosion area. The bank had eroded to within approximately 10 feet of the heel of several T-wall monoliths. Due to the proximity of the bank erosion to the floodwall and continued erosion occurring on the bank adjacent to the floodwall, it was determined that the riverbank needed immediate rehabilitation to protect this public facility (the floodwall). USACE provided recommendations to the sponsor who constructed the riprap protection to reestablish stable bank conditions which meet current USACE standards. This work was completed in August 2009. This work was determined to be integral to the reconstruction of the existing federal project. Before and after pictures can be seen in Photographs 4.5 and 4.6.

Photo 4.5: Riverbank Erosion Prior to Repair

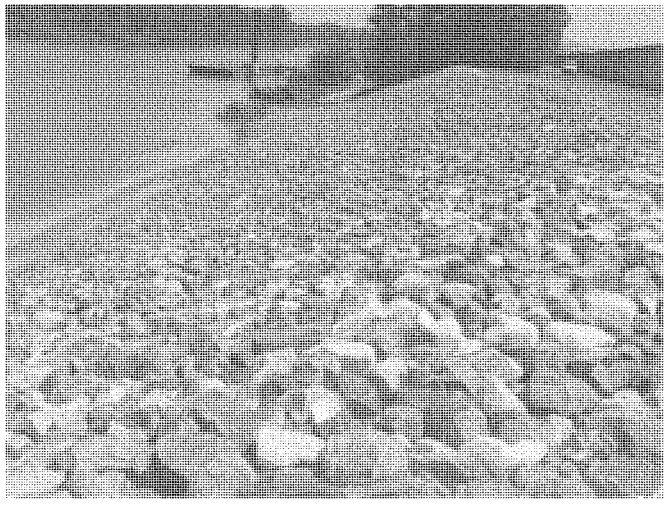


Photo 4.6: Repaired Riverbank

4.3.3. Settlement.

Earthen levee represents 48,700 feet of the Paducah, Kentucky LFPP which has a total length of approximately 64,570 feet and is therefore a major element in the line of protection. See Section 4.2.2 for a description of the principal foundation material beneath the levee.

Where foundation and embankment soils are pervious or semi-pervious, most of the settlement would have occurred during construction. For impervious soils, it is assumed that all the calculated settlement of a levee built in a normal sequence of construction operations will occur over an extended period of time after construction. Because construction of the project was completed in 1950, it is assumed that any settlement due to soil consolidation would have already occurred.

During the site visit there were several issues noted in regards to settlement that have occurred along the line of protection. The specific details of these areas are discussed in the following paragraphs.

4.3.3.1. Settlement of T-Wall Monoliths in Section B.

From Station 7+40B to 16+15B vertical and lateral displacements of many of the T-walls have occurred. The displacements, which are described in detail in Section 7, Paragraph 7.3.1.1 of Appendix C, appear to be the result of differential settlement, because the lateral offsets are associated with minor wall rotation. Based on boring AD-6 which was drilled at Station 8+40B, the material in this area where many T-walls have rotated both riverward and landward is predominately very soft to soft, lean clay for depths up to 50

feet. Settlement Analyses in this area are needed but will not be included as part of this report due to lack of consolidation laboratory data. During PED, additional drilling and laboratory testing will be required in this area along with settlement analyses. In the meantime, LRL has requested that the sponsor monitor T-wall movement in this area.

4.3.3.2. Settlement Over Discharge Pipes.

Settlement issues noted by the inspection team during the site visit included multiple depressions of the levee crown over drainage structures such as at Station 207+16C; see Photograph 4.7. These depressions in the crown of the levee occur at locations where the deteriorated CMP discharge pipes were penetrating at the base of the levee embankment. Since these pipes are currently being slip-lined as part of this Feasibility Report, no future settlement in these areas is expected to occur. For more information on the slip-lining efforts, see Sheet CZ003 in Volume 3 of this report. These localized depressions will need to be raised equal with the adjacent levee crown to reestablish a consistent level of protection as part of normal O&M efforts by the sponsor.

Photo 4.7: Depression of Levee Crown over Drainage Structure at STA 207+16C

4.3.4. Embankment and Foundation Stability of Existing LFPP.

Stability analyses were performed for six critical cross sections, including sections for I-wall, T-wall, and earthen embankment, in Sections A, B, and C. The Paducah, Kentucky LFPP was built to a level of protection corresponding to the 1937 maximum flood of record elevation plus three feet of freeboard. The level of protection evaluated for feasibility is the top of protection design elevation. Critical cross-sections were chosen

based on NLD cross-sections and project USACE As-Built drawings. Critical cross-sections are shown in Figures 4-4 through 4-9.

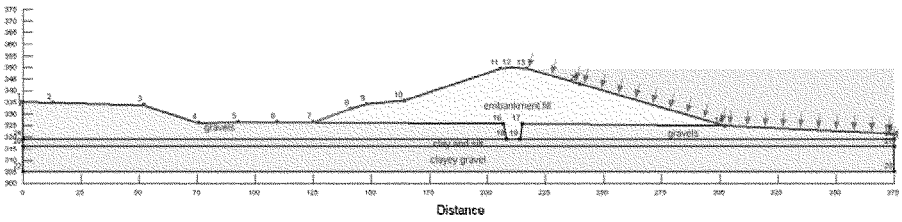


Figure 4-4: Station 67+17A Cross-Section

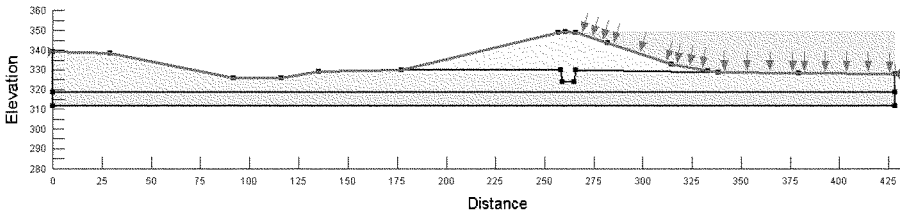


Figure 4-5: Station 156+25A Cross-Section

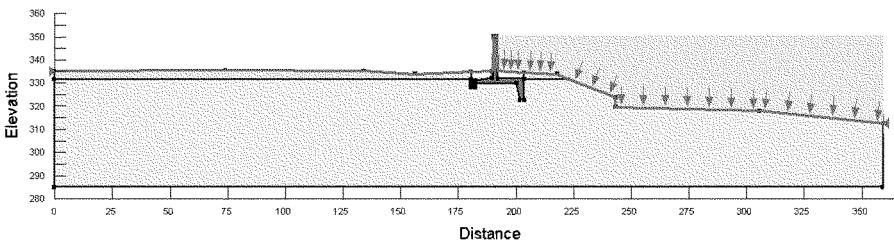


Figure 4-6: Station 7+60B Cross-Section

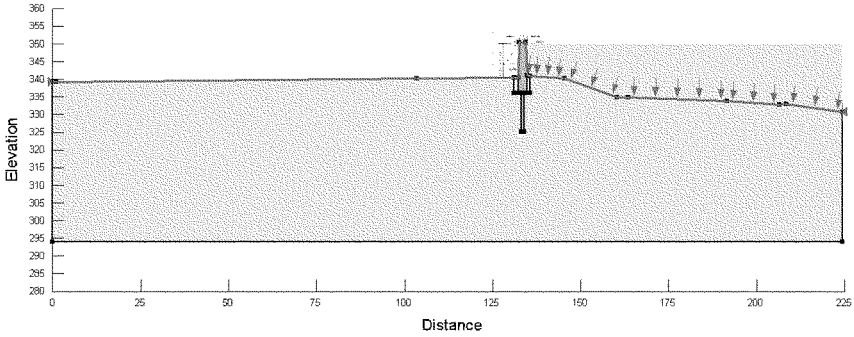


Figure 4-7: Station 87+43B Cross-Section

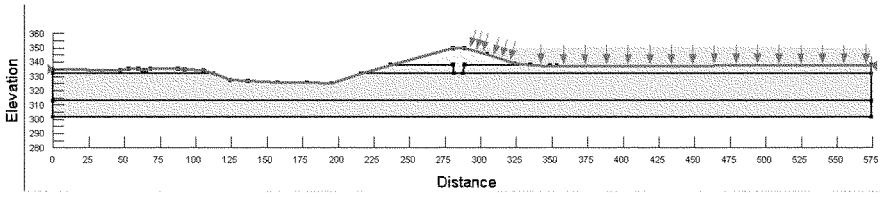


Figure 4-8: Station 175+12B Cross-Section

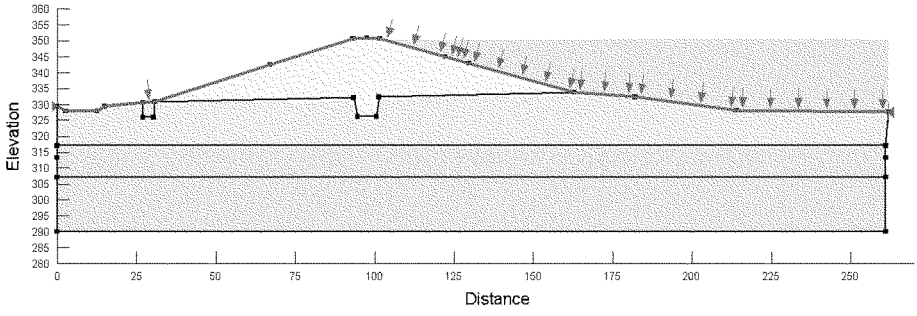


Figure 4-9: Station 177+05C Cross-Section

For the locations of all the boring logs and boring locations used from the As-Built drawings see Table 4.3.

TABLE 4.3: SUMMARY OF BORING LOGS AND LOCATIONS

Section	Station	Structure Type	As-Built Drawing
Section A	67+17	Embankment	934-12.2/2, 934-12/6
Section A	156+25	Embankment	934-12.1/4.1,934-12.2/6
Section B	7+60	T-Wall	933-12.3/65, 933-12.3/67
Section B	87+43	I-Wall	933-12.3/9, 933-12.3/11, 933-12.3/16
Section B	175+12	Embankment	933-12.3/2, 935-12.2/17
Section C	177+05 (after eq. sta.)	Embankment	934-12.2/5, 934 -12.2/7, 934-12.2/9

4.3.4.1. Slope Stability.

Slope stability analyses were performed in general accordance with EM 1110-2-1913 *Design and Construction of Levees,* dated 30 April 2000 and EM 1110-2-1902 *Slope Stability*, dated 31 October 2003. Per EM-1110-2-1913 various loading conditions to which a levee and its foundation may be subjected to and which should be considered in analyses are designated as: Case I - End of construction, Case II - Sudden rapid drawdown from full flood stage, Case III - Steady seepage from full flood stage (fully developed phreatic surface), and Case IV - Earthquake.

Case I was not considered for this levee because the project is an existing structure and pore water pressures have had ample time to stabilize since construction. Only two instances of instability have been reported in the project's history; see below for locations. Other than these instances, the Paducah, Kentucky LFPP has been stable since construction.

> 1975 Inspection Report: The monoliths between Stations 10+40B and 16+50B had shifted landward and riverward and settled unevenly. Wide pattern cracking was noted on monoliths 47, 48 and part of 49 at Stations 10+12B to 10+88B. Reference Paragraph 4.3.3.1 and Section 7.3.1.1 of the Structural Section for more detailed information.
>
> 1963 Inspection Report: Minor settlement of the concrete wall was noted at closures in the following locations: STA 104+96C, STA 170+04B, 169+52B, 151+77B, and 108+53B. No additional settlement in these areas have been noted in past inspections.

Case II and III load conditions were analyzed for critical levee sections using a computer program called SLOPE/W 2007. SLOPE/W is a slope stability software product developed by GEO-SLOPE International, Ltd. Load conditions were considered for an "existing levee" at the top of protection design elevation drained "long-term (steady state seepage)" and undrained "rapid drawdown" conditions. Steady state analysis means that the modeled system has been at its current state long enough for water pressures and flow rates to attain constant values that do not fluctuate with time. Rapid drawdown means that water at flood elevation at steady state conditions instantly returns to pool elevation, so that the stabilizing effect of the water on the riverside face is lost, but the pore water pressures within the embankment remain high. As a result, the stability of the riverside face of the levee can be greatly reduced.

For each critical section, two loading scenarios, Case II and III, were evaluated as stated above using steady-state conditions. The hydrograph used to determine the top of flood protection elevation has a 49-day duration, per CELRL-ED-T-H. Due to the limited duration of the flood hydrograph, the levee should not reach a steady-state condition. Therefore, the results for all of the steady-state analyses for the top of protection flood elevation are conservative.

For the Case II Rapid Drawdown Analysis, two piezometric lines were defined using the staged undrained strength method. Line 1 was modeled at the top of protection elevation. Line 2 was modeled to the upstream Lock and Dam 52 pool elevation. The soil between lines 1 and 2 would remain saturated and undrained during rapid drawdown from the piezometric line 1 to 2 elevations. This analysis models the water level at the top of protection flood elevation for a sufficient duration for steady state seepage through the levee to develop, and that the water level will fall at such a rapid rate that it will reach the upstream Lock and Dam 52 pool elevation before any water can drain out of the levee.

For Case III, long term drained slope stabilities were analyzed using steady state piezometric conditions for this site. Phreatic surfaces, geometries, and material data were defined using the SEEP/W results, described in the following section "Seepage Analysis", for the same cross section. For analysis, the upstream boundary condition was a constant total head equal to the top of protection flood elevation for the corresponding levee station. On the landside face and toe of the levee, a flux equals zero with a potential seepage face boundary condition was assumed.

For both Case II and III load conditions, Mohr-Coulomb was used to model each material's shear characteristic. Using Spencer's Method, SLOPE/W was allowed to auto locate the critical slip surface on both the landside and riverside. Soil properties used for each analysis are summarized below in Table 4.4. The associated references for establishing the soil parameters in this table can be found in Volume 4 of this report.

TABLE 4.4: SUMMARY OF SLOPE STABILITY ANALYSIS MATERIAL PROPERTIES

			Soil Properties					
			γ Unit Weight	c (undrained)	c' (drained)	Φ (undrained)	Φ' (drained)	k Permeability
		Material Model	(pcf)	(psf)	(psf)	degree °	degree °	(ft/sec)
Section A	Station 67+17	Embankment Clay	125	1000	200	0	26	1.6E-08
		Clay and Silt	125	250	225	0	28	1.2E-10
		Gravels	125	0	0	35	35	8.0E-04
		Clayey Gravel	125	0	0	31	31	1.6E-09
	Station 156+25	Embankment Clay	125	1000	200	0	26	1.6E-08
		Clay and Silt	125	250	225	0	28	1.2E-10
		Clayey Gravel and Sand	125	0	0	31	31	1.6E-09
Section B	Station 7+60	Embankment Clay	125	1000	200	0	26	1.6E-08
		Foundation Clay	127	670	285	14	27	5.5E-09
		Debris	120	0	0	27	27	9.0E-05
	Station 87+43	Embankment Clay	125	1000	200	0	26	1.6E-08
		Foundation Clay	130	250	225	21	28	8.1E-10
	Station 175+12	Embankment Clay	125	1000	200	0	26	1.6E-08
		Debris	120	0	0	27	27	9.00E-06
		Foundation Clay	125	250	225	0	28	1.2E-10
		Clayey Gravel and Sand	125	0	0	31	31	1.6E-09
Section C	Station 177+05	Embankment Clay	125	1000	200	0	26	1.6E-08
		Clay and Silt	125	250	225	10	28	5.5E-09
		Silty Mud	120	200	100	10	27	1.0E-07

Results of the computer computations indicate that the factors of safety (FS) against failure of the riverside slope of the levee under "rapid drawdown" conditions and against failure of the landside slope under "steady seepage" conditions are greater than 1.0. All levee sections analyzed met the minimum FS required for existing levees as dictated by EM 1110-2-1913 *Design and Construction of Levees*, Table 6-1b. Table 4.5 shows the results for all slope stability analyses performed. All analysis files are located in Volume 4 of this report.

TABLE 4.5: SUMMARY OF CALCULATED FACTORS OF SAFETY SLOPE STABILITY ANALYSIS

Section	Station	Structure Type	Analysis Condition	
			Long-Term Steady Seepage Required FS= 1.4	Rapid Drawdown Required FS=1.2
Section A	67+17	Embankment	2.5	1.7
Section A	156+25	Embankment	3.7	1.2
Section B	7+60	T-Wall	3.5	1.8
Section B	87+43	I-Wall	N/A	N/A
Section B	175+12	Embankment	2.0	1.4
Section C	177+05 (after eq. sta.)	Embankment	1.8	1.5

In Table 4.5, N/A indicates that a failure slip surface was not identified in an area that would compromise the stability of the T-wall, I-wall or embankment in question. Therefore, there are no geotechnical issues of slope instability affecting any of the I-walls for the subject project. Figure 4-10 is the typical output plot of a SLOPE/W analysis.

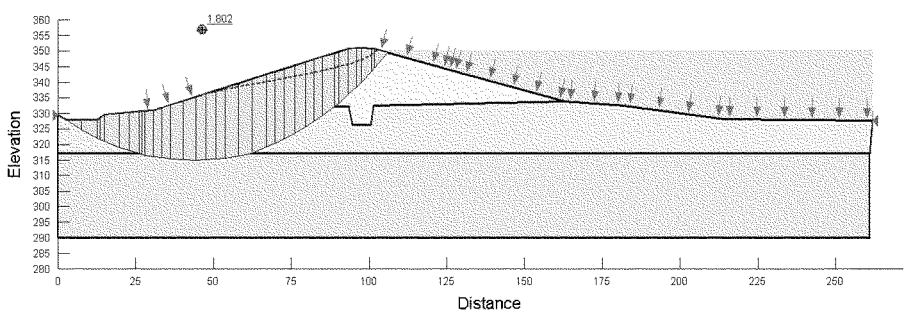


Figure 4-10: Slope/W Output Cross-Section at Station 177+05C

Case IV

The Paducah, Kentucky LFPP project is a flood protection project that is not subjected to water loading for extended periods of time every year. Therefore, per EC 1110-2-6067 titled *Engineering and Design, USACE Process for the National Flood Insurance Program (NFIP) Levee System Evaluation*, paragraph 9h(6), seismic stability analyses does not apply.

4.3.4.2. Seepage Analyses.

Seepage analyses were performed in general accordance with EM 1110-2-1913 *Design and Construction of Levees,* dated 30 April 2000 and ETL 1110-2-569 *Design Guidance for Levee Underseepage,* dated 01 May 2005. *SEEP/W* 2007 finite-element software product, developed by GEO-SLOPE International Ltd., was used to perform the seepage analyses for this Feasibility Report. The primary roles of SEEP/W are to assess at various flood elevations the change in hydraulic gradients experienced across the levee and to estimate the uplift pressures at the landside toe. At the same time, the predicted phreatic surface is plotted across the embankment, which is a vital component in assessing the potential for seepage activity. SEEP/W analyses were performed in order to evaluate the potential for piping failures through the embankment and also through the foundation.

In order to perform SEEP/W analyses, permeabilities were assigned to each material type. Soil properties used for these analyses are summarized in Table 4.4. In all analyses, the T-Wall and I-Wall were modeled as bedrock and were assumed to be impervious. All of the critical cross-sections that were modeled were shown to include a landside toe drain in the As-Built drawings, but the toe drains were not included in the models because the functionality of the drains is unknown. This is a conservative approach to the analysis of the system.

For each critical section, the loading scenario was evaluated using both steady-state and transient conditions. For the steady state analysis, the upstream boundary condition was a constant total head equal to the top of protection for the corresponding critical station. On the landside face of the levee, a flux equals zero with a potential seepage face boundary condition was assumed. As stated previously, the levee should not reach a steady-state condition at the top of protection flood elevation due to the limited duration of these loading conditions. Therefore, each cross section was evaluated using a transient analysis. The transient analysis is the same as the steady state analysis except that the upstream boundary condition was to evaluate the levee section using a flood hydrograph. The flood hydrograph is a bell shaped curve that shows the flood elevation versus the duration for a specific flood event. The flood hydrograph used for this analysis was based upon the 1937 flood event, which had duration of 49 days as shown is Volume 4 of this report. Using the transient analysis, steps along the flood hydrograph were evaluated and the phreatic line, uplift pressures and gradients were determined at these time steps. The SEEP/W steady state models for water to the top of protection were conservative; while the models for the transient analyses more accurately depicted the phreatic surface.

Based on EM 1110-2-1901 *Seepage Analysis and Control for Dams* and ETL 1110-2-569 *Design Guidance for Levee Underseepage*, the FS for exit gradient, $FS_G = i_{cr}/i_e$,. Where i_{cr} is the critical exit gradient and i_e is the modeled exit gradient. The allowable FS is 1.5. For all of the analyses performed, the critical exit gradient, i_{cr}, was assumed to be 1. Therefore, the FS against piping was equal to 1 divided by the exit gradient at the location of interest. For all of the critical sections evaluated, the exit gradients were less than 0.2 and the FS against piping were all greater than or equal to 5.0 which exceeds the stated requirements. The factor of safety against uplift of landside toe of the levee was evaluated for two reasons: 1.) Due to the thickness of the low permeability clay soil layer under the levee and 2.) The presence of the phreatic line near the ground surface at the landside toe of some of the levee sections. For areas of concern, the factor of safety against uplift was determined as the ratio of overburden pressure divided by the pore water pressure. Table 4.6 shows the results for all seepage analyses. All analysis files are located in Volume 4 of this report.

TABLE 4.6: SUMMARY OF CALCULATED FACTORS OF SAFETY SEEPAGE ANALYSIS

Section	Station	Structure Type	Analysis Condition		
			Escape Gradient, FS_G	Critical Exit Gradient, i_{cr}	Transient Analysis Uplift, F_{UT}
Section A	67+17	Embankment	>5.0	0.003	>2.0
Section A	156+25	Embankment	>5.0	0.001	>2.0
Section B	7+60	T-Wall	>5.0	0.003	>2.0
Section B	87+43	I-Wall	>5.0	0.151	>2.0
Section B	175+12	Embankment	>5.0	0.001	>2.0
Section C	177+05 (after eq. sta.)	Embankment	>5.0	0.067	>2.0

Figure 4-11 is the typical output plot of a SEEP/W analysis for the Paducah, Kentucky LFPP.

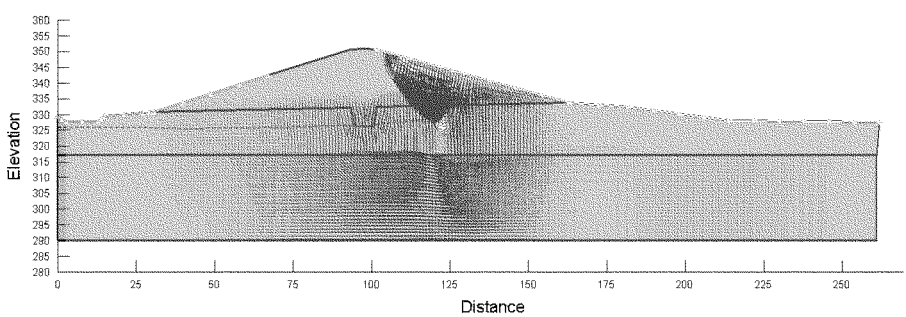


Figure 4-11: Seep/W Output Cross-Section for Station 177+05C

4.4. DESIGN OF NEW PROJECT FEATURES.

Below are the geotechnical evaluations of new project features that appear to be necessary as part of this study to reconstruct this project to current USACE standards. Further evaluations of these features will be performed during PED.

4.4.1. Filter Design Revision for Existing Pipes Through Levee.

All gravity discharge pipes were inspected during the site visit on 23-27 March 2009 to ensure that provisions for emergency closure were in place to protect against inoperative flap gates/sluice gates on the riverside end. Based on the current guidance in EM 1110-2-1913 *Design and Construction of Levees*, dated 30 April 2000, the Paducah, Kentucky LFPP does not meet the requirement stating that all pipelines which cross through the levee embankment shall have an 18 inch annular thickness of a pervious material provided around the landside third of the pipe. Based on the current condition of all pipelines through the Paducah, Kentucky LFPP as assessed during the pipe inspection and slip lining project and in order to avoid unnecessary disturbance of the existing levee embankment, this guidance will be altered as discussed in the following paragraphs for the Paducah, Kentucky LFPP Feasibility Report.

As-Built drawings were reviewed for all 60 storm drainage pipes on the subject project. The list of pipes which require the landside blanket filter was limited to those where stormwater drains into a headwall on the protected (landside) of the levee. As-Built drawings were then reviewed to determine which of these 36 stormwater drainage pipes were constructed with seep rings. It is important to note that two corrugated metal pipes have recently been excavated from the Paducah project levees as part of the "Slip Liner Proof Test" project, and both had multiple seep rings. These two pipes are each approximately 65 years old. It was observed that the steel plate from which the seep rings were fabricated had undergone only a minor level of corrosion as shown in Photograph 4.8. Additionally, it appeared that there was a high compactive effort of the clay soil around the seep rings. These two observations provide confidence that the purpose for which the seep rings were originally designed can still be fulfilled. These seep rings appear to have the capability to perform their intended function for many years to come.

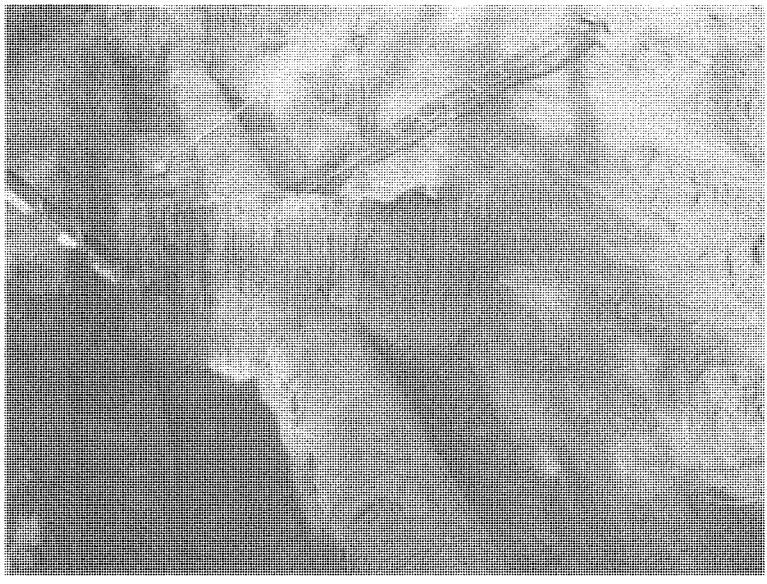


Photo 4.8: Slip Liner Proof Test Photograph

Based on the aforementioned information, it is recommended that none of the storm drainage pipes that have seep rings undergo rehabilitation to incorporate a landside blanket filter. Using this information, it was determined that only two pipes do not appear to have been constructed with seep rings and will require a landside blanket filter. These pipes are highlighted in Table 4.7.

The landside blanket filter requirement for the Paducah, Kentucky LFPP will be fulfilled by the installation of an 18 inch annular thickness of pervious backfill provided around the pipeline for a distance of five feet from the landside headwall or inlet structure as shown on Sheet CZ001 of Volume 3 of this report.

TABLE 4.7: LANDSIDE BLANKET FILTER - PIPE ANALYSIS

Station	Diameter (Inches)	No. Seep Rings	As-Built Page	Comments
84+00 A	24	6	934-12.2/7	
111+67 A	72	6	934-12.2/8	
130+00 A	30	4	934-12.2/10	
140+45 A	18	0		Placed when RR closure permanently sealed 2003
147+25 A	24			Reconstructed 2009 with landside blanket filter (Slip-lining Project)
151+25 A	24	2	934-12.2/12	
157+63 A-1	60	4	934-12.2/13	12" offset between adjacent pipe sheets
157+63 A-2	60	4	934-12.2/13	
157+63 A-3	60	4	934-12.2/13	
157+63 A-4	60	4	934-12.2/13	
157+63 A-5	60	4	934-12.2/13	
157+63 A-6	60	4	934-12.2/13	
175+40 B	24	6	935-12.2/124	Extended by permit 1997
166+48 B	8	1		RR closure permanently sealed with concrete 2002
32+12 C-1	48	5	934-12.2/11	24" offset between adjacent pipe seep rings
32+12 C-2	48	5	934-12.2/11	
32+38C1,2,3	60	3		Construction photos show seep rings visible.
51+28 C	30	4	934-12.2/14	
92+70 C-1	48	3	934-12.2/15	24" offset between adjacent pipe seep rings
92+70 C-2	48	3	934-12.2/15	
126+00 C	48			Reconstructed 2009 with landside blanket filter (Slip-lining Project)
150+05 C	24			Reconstructed 2009 with landside blanket filter (Slip-lining Project)
172+08 C	24	3	934-12.2/18	
176+47 C	24	2	934-12.2/19	
176+90 C	48	3	934-12.2/20	
199+80 C	24	2	934-12.2/22	
200+55 C	24	2	934-12.2/23	
207+16 C	36	0		Permitted and constructed 1980
217+35 C-1	24	2	934-12.2/24	
217+35 C-2	24	2	934-12.2/24	
224+71 C	24	2	934-12.2/26	
244+65 C	30	4	934-12.2/27	
254+06 C	36	4	934-12.2/28	
291+75 C	36	5	934-12.2/29	

4.4.2. Construction of Pump Plant #14 at STA 111+67A.

Based on the subsurface conditions encountered during drilling of borings AD-1 and AD-2, analyses performed during this study, and experience, the project site is suitable for construction of the proposed Pump Plant #14 at STA 111+67A. See Sheet CS125 in Volume 3 for the proposed location of Pump Plant #14.

4.4.2.1. Shallow Spread Footings.

Conventional shallow spread footings are recommended to support the proposed pump plant. Shallow foundations must satisfy two independent criteria. First, the footing contact pressure transmitted to the foundation bearing soils must not exceed the net allowable soil bearing capacity. Second, settlements due to compression of the foundation soils during the life of the structure should not be of sufficient magnitude to cause damage to the structure or impair its use or appearance. To perform adequately, foundations must be designed to satisfy each of these requirements. Design and construction recommendations are presented in the following sections.

4.4.2.2. Bearing Capacity.

Conventional shallow spread footings shall bear on approved native soil and be sized for a maximum net allowable bearing pressure of 2,000 psf. The bearing capacity analysis was based on the preliminary footing loadings and dimensions assumed based on the existing Pump Plant #1 design provided by CELRL-ED-D-S. All analysis files are located in Volume 4 of this report. Revisions to the recommended allowable bearing pressures may be required if these parameters are not accurate. The recommended allowable bearing pressure has been lowered to reduce the anticipated foundation settlements to acceptable ranges. Some shallow undercutting of native soils may be required to reach soils suitable for the recommended allowable bearing pressures.

4.4.2.3. Settlement.

A preliminary settlement analysis was performed for the proposed Pump Plant #14 at Station 111+67A. All analysis files are located in Volume 4 of this report. Based on borings AD-1 and AD-2 which were drilled at this location, the primary foundation material in this area is lean clayey gravel with sand. Based on the anticipated structure loads, the maximum net allowable bearing pressures, the results of the field and laboratory testing, and empirical correlations and experience with similar soil types, total post-construction settlements of foundations bearing on native soils are estimated to be less than about one inch, with differential settlements less than 0.5 inch. The structure should be designed to accommodate these settlement magnitudes. Experience and published data indicate these settlement magnitudes should be within the tolerable range for this structure. A more detailed settlement analysis using laboratory consolidation testing will be performed during PED.

4.4.3. Construction of New Pipelines Crossing Over Existing Levee for Pump Plant #14 at STA 111+67A and Woodward Hollow Discharge Pipe at STA 19+11B.

All new pipelines crossing the existing levee will be required to go up and over existing levee embankments where excavations do not go below the freeboard zone. Shut off valves shall be provided on the landside and riverside of an earthen levee embankment a minimum of 10 ft and no greater than 50 ft out from the levee toes. No sleeving/casing around the outside of pressure pipes going up and over earthen levees will be required.

Backfill material under, around and over the pressure pipe must be low permeability soils (e.g. SC, CL or CL-ML in accordance with ASTM 2488 - USCS classification system) with an estimated hydraulic conductivity less than 1×10^{-5} cm/sec. Backfill material under, around and over the pressure pipe must be carefully placed and compacted. This material shall be placed in loose lifts with thicknesses not to exceed 6 inches and compacted in the disturbed area to a minimum 95 percent Standard Proctor density determined at optimum moisture content according to ASTM D-698. Moisture control limits during placement and compaction are to be within -1% to +3% of optimum. The finished riverside or landside slope of the levee shall be graded vertically to match the existing levee slopes upstream and downstream of the hole where the disturbance occurred. The disturbed areas shall be seeded and covered with a bio-degradable geotextile.

Pipe materials shall be either ductile iron with a polyethylene coating or steel pipe cleaned primed and painted with USACE formula -C200A or equal. These materials must be used between 15 feet out from levee toes. All pressure piping shall have flexible mechanical couplings or restrained joints.

If pressure pipes require a depth of embedment deeper than the design freeboard limits, additional material can be added over the top of the pipe and smooth graded in with the levee embankment to allow for proper mowing of the levee crown and side slopes.

4.5. CONSTRUCTION MATERIALS.

4.5.1. Potential Borrow Sites.

Potential borrow sites for the construction/upgrade of the existing Paducah, Kentucky LFPP are listed below. Reference drawing GI005 for a location map for the potential borrow sites for this project. These are commercial sources near the subject project area. Borrow material for this project will consist of low permeability soils (e.g. SC, CL or CL-ML in accordance with ASTM 2488 - USCS classification system) with an estimated hydraulic conductivity less than 1×10^{-5} cm/sec. Pervious backfill will also be needed for the landside blanket filter. The gradation and design properties of the pervious backfill will be specified during PED. Verification of the availability and quality of materials required will be determined in the next phase of this study.

Donnie Edwards Excavating, Inc.
4955 Noble Road
Paducah, KY 42001
270-442-2943

Ohio Valley Gravel & Sand
205 Potter Lane
Paducah, KY 42001
270-575-0870

4.5.2. Potential Disposal Sites.

Potential disposal sites for the construction/upgrade of the existing Paducah, Kentucky LFPP are listed below. Verification of site availability will be determined in the next phase of this study.

Donnie Edwards Excavating, Inc.
4955 Noble Road
Paducah, KY 42001
270-442-2943

City of Paducah Inert Disposal Site
Northeast of Intersection of North 6th Street and Boyd Street
Paducah, KY

4.5.3. Potential Sources for Concrete Materials.

Materials required to make concrete are readily available in the city of Paducah. One possible source is listed below. Verification of the availability and quality of materials required to make concrete will be determined in the next phase of this study.

Federal Materials Concrete
2425 Wayne Sullivan Drive
Paducah, KY 42001
270-442-5496

4.6. FURTHER STUDIES, FIELD WORK, TESTS AND ANALYSES AFTER THE FEASIBILITY STUDY.

Additional borings will be required during the PED phase to better characterize the soil properties. Also, additional seepage and slope stability analyses are required to evaluate all critical cross-sections of the Paducah, Kentucky LFPP. Updated survey data for all critical cross-sections are required. As the designs for Pump Plant #14 and the new Bee Branch gatewell structures (see Section 7, Paragraph 7.6.1 for additional information on this structure) evolve during PED, bearing and settlement analyses have to be completed with the current design and updated soil parameters. Settlement analyses are also required for the T-wall monoliths in Section B as discussed in Paragraphs 4.3.3.1 and 7.3.1.1. During PED, additional work will be performed such as utilizing ground penetrating radar and dye testing to determine which toe drains will be required to be filled and sealed. Further investigation will be required for the potential sources for construction materials.

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 5
ENVIRONMENTAL

TABLE OF CONTENTS

5.1. SUMMARY. 5-1

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX C

SECTION 5 ENVIRONMENTAL

5.1. SUMMARY.

The Paducah, Kentucky LFPP consists primarily of maintenance items relating to the existing flood control system. No significant efforts outside of the project right-of-way are proposed. Therefore, no Phase I Environmental Assessment is warranted. Project specifications will require that excavated soils that will not be used on site will be disposed of at a licensed landfill.

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 6
CIVIL ENGINEERING

TABLE OF CONTENTS

6.1. UTILITY RELOCATION **6-1**
6.2. ACCESS ROAD AND PARKING **6-2**
6.3. EARTHWORK **6-2**
6.4. TOE DRAINS **6-2**
6.5. REAL ESTATE **6-2**
6.5.1. Railroad Crossing 6-3
6.5.2. Construction Laydown Areas 6-3

LIST OF TABLES

Table No.	Title	Page No.
Table 6.1	Utility Relocations	6-1

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 6
CIVIL ENGINEERING

6.1. UTILITY RELOCATION.

Utility information was provided by the City of Paducah from mapping through architect/engineers, Florence & Hutcheson, Inc. Utility information provided consisted of sanitary sewer, storm sewer, and water. Utility poles for power and telephone were located on the mapping. The locations of proposed reconstruction items are located in Volume 3, Sheets CS100 through CS129, and were checked against all available utility information to determine the extent of utility relocations.

Utility relocations (as per Engineering Federal Acquisition Regulation Supplement (EFARS), Appendix Q, Section 73-000 et. seq.) is applicable to utilities which involve relocation, abandonment, vacation, or an alteration of an existing utility. The term relocation also includes the raising, lowering, altering, adjusting, or protecting a facility, as well as changing its location. Based upon available utility information and scope of work of the reconstruction items, the following utility relocations were assumed to be required for this project.

TABLE 6.1: Utility Relocations

Sheet	Utility	Description of Work	Feet Affected
CS114**	Electrical/Telephone	At approximate Station 10+60, relocate approximately 200 line feet of overhead utility lines within CWL and Contractor Laydown areas	200
CS116**	Electrical/Telephone	At Station 55+35, de-energize existing overhead utility lines	NA
CS125A	Overhead Electric	Existing overhead power transmission lines to be de-energized during construction of the Proposed Pump Plant #14. Will require considerable coordination with power company.	NA
CS125A	Sanitary Sewer	Three Sanitary Sewer Lines to be concrete encased under access roads to the Proposed Pump Plant #14	50

*Length to be determined by owning utility company.
**Utility relocation not shown on drawings due to the drawing scale.

6.2. ACCESS ROAD AND PARKING.

A proposed access road and parking area will be required at Pump Plant #14 (as shown on sheets CS125A and CS125B) to provide permanent access to construct, operate, and maintain the proposed facility. It is estimated the required easement for this access road and parking area to be 1.0 acres which has been identified on sheet RW125 as RWRDE.

6.3 EARTHWORK.

For twelve monoliths numbered 32 through 43 in Section "B" of the project (station 7+04B through 9+36B), an additional 18-inches of engineered fill will be placed on both sides of the walls. This fill should be placed over a width no less than the T-Wall base width (21 feet) on both sides of the wall.

6.4 TOE DRAINS.

Approximately 36,000 linear feet of toe drain will be sealed and filled along the floodwall and levee as shown on sheet CZ004. An additional 710 linear feet of toe drain will be replaced in Section B between stations 7+02.5 through 9+38, 90+31 through 92+00, 108+00 through 110+00, and 161+94 through 163+00. All toe drains will need to be drained to an appropriate outlet.

6.5 REAL ESTATE.

Most of the required real estate property needed for this work will occur within the City of Paducah's existing levee right-of-way limits. For Sections A and C, the existing LFPP right-of-way and easement boundaries shown on the right-of-way drawings in Volume 3, sheets RW100 through RW129, were extrapolated by USACE Louisville District personnel from the City of Paducah's boundary surveys prepared by Florence & Hutcheson, Inc. For Section B, right-of-way and easement boundary surveys were not available at this time. For purposes of this feasibility report, approximate right-of-way limits were estimated by USACE Louisville District personnel from existing as-built drawings of the existing Paducah LFPP. For the purpose of this feasibility report, the existing Section B levee right-of-way (labeled as EX RWLVE on the right-of-way drawings) has been estimated to be 25' outside the toe of the existing levee or from the face of the existing floodwall.

Right-of-way was determined for how the contractor will access and construct the proposed work. Since most work will occur within the City of Paducah's right-of-way

limits, any additional areas needed (i.e., laydown areas, construction equipment access, etc.) will be identified on the plans as the appropriate easement. Right-of-way for how the City of Paducah will access and maintain the project was also taken into consideration. All construction access points were taken from City and State owned roads where possible, which will reduce land acquisition costs for the City of Paducah.

The proposed Pump Plant #14 is located primarily within the existing RWLVE with the exception of the access and parking area as stated in Paragraph 6.2 of this section.

It has been determined by Real Estate Division, that the ponding area, which has been identified on right-of-way sheet RW125, for the proposed Pump Plant #14 will not require a flowage easement. This area was based on the hydraulic/hydrology design parameters as required for interior ponding.

In accordance with Army Regulation 405-10, Paragraph 1-5 (d), minimum acreages/ownerships necessary to support the subject project are shown in order to estimate LERRD requirements. For additional information regarding real estate requirements, refer to Volume 1 of the Main Report.

6.5.1. Railroad Crossing.

As shown on the site layout sheets CS115 and CS115a, the proposed Woodward Hollow discharge pipe will be an 8-inch line which will cross under South Fourth Street and the Paducah and Louisville Railway. Per the local sponsor, this railroad line is not on the main line but is a spur and is not used on a daily basis. It is assumed the 8-inch line will require an open cut across South Fourth Street and the railroad. These facilities will be replaced to their original condition. Therefore, construction of the discharge pipe across the railroad facilities will be less intrusive to the operations of the railway company. A utility pipe easement will be necessary in this location.

6.5.2. Construction Laydown Areas.

Construction laydown areas are necessary to give the contractor sufficient room to construct the project. These areas are located and identified on the site layout and the right of way sheets in the plans in Volume 3 of this Feasibility Report. City-owned property was identified from McCracken County and Paducah GIS mapping. When possible, existing City of Paducah property, which lies outside the existing levee right of way, will be used for the laydown areas.

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 7
STRUCTURAL SECTION

TABLE OF CONTENTS

7.1. REFERENCES **7-1**
7.2. GENERAL DESCRIPTION OF STRUCTURAL FEATURES **7-2**
7.3. FLOODWALLS **7-7**
7.3.1. Field Inspections 7-7
7.3.1.1. Differential Movement 7-8
7.3.1.2. Joint Material 7-17
7.3.2. Stability and Strength Requirements 7-18
7.3.2.1. I-Walls 7-18
7.3.2.2. T-Walls and L-Walls 7-19
7.3.3. Soil Properties Assumed for Analysis 7-20
7.3.4. Structural Analyses 7-20
7.3.4.1. I-Walls 7-20
7.3.4.1.1. Consideration of Historic Load Test and Flood History 7-21
7.3.4.1.2. Conclusions 7-22
7.3.4.1.3. Recommendations 7-22
7.3.4.2. T-Walls 7-23
7.3.4.2.1. Conclusions 7-24
7.3.4.2.2. Recommendations 7-24
7.3.4.3. L-Walls 7-25
7.3.4.3.1. Conclusions 7-25
7.3.4.4. Seismic Analysis 7-25
7.3.5. Conclusions and Recommendations for Floodwalls 7-26
7.3.5.1. Expansion Joint Filler Material Replacement 7-26
7.3.5.2. External Waterstop 7-27
7.3.5.3. Monitoring Floodwall Movement 7-28
7.3.5.4. Additional Field Investigations in Regard to Floodwall Movement . 7-28
7.3.5.5. Waterproof Sealant to Prevent Further Cracking at Top of Wall 7-28
7.4. FLOODWALL CLOSURES **7-28**
7.4.1. Field Inspections 7-30
7.4.1.1. Closures 7-30
7.4.1.2. Closure Erection Exercises 7-35
7.4.2. Structural Analysis 7-38
7.4.2.1. Conclusions 7-39

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 7
STRUCTURAL SECTION

TABLE OF CONTENTS

(cont.)

7.4.3. Recommendations for Floodwall Closures 7-39
7.4.3.1. Permanently Sealing Unnecessary Closures 7-39
7.4.3.2. Closure Parts and Embedded Metals 7-40
7.4.3.3. Closure Modifications at 83+92B, 75+85B and 25+15B 7-41
7.4.3.4. Closure Modifications at 62+84.3 and 83+92B 7-41
7.5. PUMP PLANTS 7-41
7.5.1. Field Inspections 7-42
7.5.1.1. Watertightness 7-42
7.5.1.2. Trash Rack Replacement 7-46
7.5.1.3. Discharge Chamber Access Grating System Replacement 7-49
7.5.1.4. Access Hatch Replacement 7-51
7.5.1.5. Pump Plant Safety 7-55
7.5.2. Pump Plant Stability and Strength Requirements 7-58
7.5.3. Soil Properties Assumed for Analysis 7-60
7.5.4. Structural Analyses 7-61
7.5.4.1. Seismic Stability 7-61
7.5.5. Conclusions and Recommendations for Pump Plants 7-62
7.5.5.1. Pump Plant Safety 7-62
7.5.5.2. Miscellaneous Pump Plant Issues 7-63
7.5.5.3. Summary of Pump Plant Reconstruction Items 7-63
7.6. SLUICE GATES, FLAP GATES and GATEWELLS 7-64
7.6.1. Bee Branch Sluice Gate Control Structure Replacement 7-64
7.6.2. Woodward Hollow Gatewell 7-68
7.7. PROPOSED PUMP PLANT #14 AT STA 111+67A 7-68
7.7.1. Design Criteria 7-68
7.7.2. Stability and Strength Requirements 7-69
7.7.3. Soil Properties Assumed for Analysis 7-69
7.7.4. Structural Description 7-69
7.8. DISCHARGE PIPES 7-70

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 7
STRUCTURAL SECTION

TABLE OF CONTENTS

(cont.)

7.8.1. Condition Assessment and Rehabilitation of Existing Gravity Discharge Pipes 7-70
7.8.2. Condition Assessment of Discharge Pipes from Pump Plants..... 7-70
7.9. FURTHER STUDIES, TESTS, AND ANALYSES AFTER THE FEASIBILITY PHASE 7-71

LIST OF TABLES

Table No.	Title	Page No.
Table 7.2-1	Concrete Structure Analysis Criteria	7-7
Table 7.2-2	I-Wall Analysis Criteria	7-7
Table 7.3-3	Monolith Offsets	7-8
Table 7.3-4	Waterstop Coring Results	7-14
Table 7.3-5	Inland Flood Wall Stability Criteria	7-19
Table 7.3-6	I-Wall Analysis Results	7-21
Table 7.3-7	T-Wall Analysis Results	7-23
Table 7.3-7A	T-Wall Limited Remedial Analysis Results	7-24
Table 7.3-8	L-Wall Analysis Results	7-25
Table 7.5-9	Required Factors of Safety for Sliding – Critical Structures	7-58
Table 7.5-10	Required Factors of Safety for Flotation – All Structures	7-59

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 7
STRUCTURAL SECTION

LIST OF TABLES

Table No.	Title	Page No.
Table 7.5-11	Pumping Station Loading-Condition Classification, Structure Type: Pumping Plants, EM 1110-2-3104	7-59
Table 7.5-12	Pump Plant Stability Analysis Results	7-61

LIST OF FIGURES

Figure No.	Title	Page No.
Figure 7.1-1A	Typical T-Wall Section	7-3
Figure 7.1-1B	Typical L-Wall Section	7-4
Figure 7.1-2	Typical I-Wall Sections for Paducah	7-5
Figure 7.1-3	Typical Closure Configuration for Paducah	7-6
Figure 7.4-4	Typical Closure	7-33

LIST OF PHOTOS

Photo No.	Title	Page No.
Photo 7.3-1	T-Wall Monolith #60	7-11
Photo 7.3-2	T-Wall Monoliths #41-43	7-11
Photo 7.3-3	T-Wall Monoliths #46/47	7-12
Photo 7.3-4	T-Wall Monoliths #58/59	7-12

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 7
STRUCTURAL SECTION

LIST OF PHOTOS

(con't)

Photo No.	Title	Page No.
Photo 7.3-4A	T-Wall Monolith #81	7-13
Photo 7.3-5	Expansion/Monolith Joints between Monoliths #46/47	7-14
Photo 7.3-6	Cores from Monoliths #46/47	7-15
Photo 7.3-7	Cores from Monoliths #54/55	7-16
Photo 7.3-8	Expansion/Monolith Joints	7-17
Photo 7.3-9	Expansion/Monolith Joints	7-17
Photo 7.3-10	Monolith Joint #33/34	7-18
Photo 7.4-11	Service Opening at Station 2+87B	7-29
Photo 7.4-12	Service Opening at Station 15+32B	7-30
Photo 7.4-13	Former Railroad closure at Station 170+04.4B	7-31
Photo 7.4-14	Former Railroad closure at Station 170+04.4B	7-31
Photo 7.4-15	Closure at Station 83+92B	7-32
Photo 7.4-16	Closure at Station 9+44B	7-34
Photo 7.4-17	Closure at Station 9+44B	7-34
Photo 7.4-18	Closure at Station 71+74B	7-34
Photo 7.4-19	Closure at Station 71+74B	7-34
Photo 7.4-20	Closure at Station 83+92B	7-35
Photo 7.4-21	Closure at Station 83+92B	7-36
Photo 7.4-22	Trial Erection of Closure at Station 135+22B	7-36

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 7
STRUCTURAL SECTION

LIST OF PHOTOS
(con't)

Photo No.	Title	Page No.
Photo 7.4-23	Trial Erection of Closure at Station 135+22B	7-37
Photo 7.4-24	Trial Erection of Closure at Station 126+35B	7-37
Photo 7.4-25	Trial Erection of Closure at Station 126+35B	7-38
Photo 7.5-26	Roof Leakage at Pump Plant No. 5	7-43
Photo 7.5-27	Roof Leakage at Pump Plant No. 12	7-43
Photo 7.5-28	Skylight/Hatch at Pump Plant No. 12	7-44
Photo 7.5-29	Roof at Pump Plant No. 12	7-45
Photo 7.5-30	Roof at Pump Plant No. 2	7-46
Photo 7.5-31	Trash Rack at Pump Plant No. 2	7-47
Photo 7.5-32	Trash Rack at Pump Plant No. 7	7-47
Photo 7.5-33	Trash Rack at Pump Plant No. 12	7-48
Photo 7.5-34	Trash Rack at Pump Plant No. 1	7-49
Photo 7.5-35	Support angle at Pump Plant No. 6	7-50
Photo 7.5-36	Support angle at Pump Plant No. 3	7-50
Photo 7.5-37	Support angle at Pump Plant No. 5	7-51
Photo 7.5-38	Cover plate at Pump Plant No. 1	7-52
Photo 7.5-39	Support angle at Pump Plant No. 11	7-53
Photo 7.5-40	Cover plate at Pump Plant No. 2	7-53
Photo 7.5-41	Access Ladder at Pump Plant No. 9	7-54
Photo 7.5-42	Access Ladder at Pump Plant No. 9	7-54

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 7
STRUCTURAL SECTION

LIST OF PHOTOS

(con't)

Photo No.	Title	Page No.
Photo 7.5-43	Exterior View of Pump Plant No. 10	7-55
Photo 7.5-44	Access to Pump Plant No. 10	7-56
Photo 7.5-45	Pump Floor of Pump Plant No. 10	7-56
Photo 7.5-46	Paint System at Pump Plant No. 10	7-57
Photo 7.5-47	Structural Supports at Pump Plant No. 10	7-57
Photo 7.6-48	Bee Branch sluice gate frames	7-65
Photo 7.6-49	Bee Branch sluice gate structure	7-65
Photo 7.6-50	Bee Branch sluice gate structure	7-66
Photo 7.6-51	Bee Branch sluice gate frame	7-67
Photo 7.6-52	Bee Branch sluice gate frame	7-68

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX C

SECTION 7 STRUCTURAL SECTION

7.1. REFERENCES.

The following references were used in the compilation of this report:

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2. EM 1110-2-2105, *Design for Hydraulic Steel Structures*, dated 31 May 1994. U.S. Army Corps of Engineers.
3. EM 1110-2-2705, *Structural Design of Closure Structures for LFPP*, dated 31 March 1994. U. S. Army Corps of Engineers.
4. EM 1110-2-2502, *Retaining and Flood Walls*, dated 29 September 1989. U.S. Army Corps of Engineers.
5. EM 1100-2-2100, *Stability Analysis of Concrete Structures,* dated 01 December 2005. U.S. Army Corps of Engineers.
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10. ACI 318-08, *Building Code Requirements for Structural Concrete and Commentary.* American Concrete Institute.
11. ACI 437-03, *Strength Evaluation of Existing Concrete Buildings.* American Concrete Institute.

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13. *Fall Inspection Paducah Flood Protection Project*, 22-23 October 1979. Ohio River Division, U.S. Army Corps of Engineers.

14. U.S. Army Corps of Engineers computer program CWALSHT (Version 11/9/2007) *Design/Analysis of Sheet-Pile Walls by Classical Methods.*

15. U.S. Army Corps of Engineers computer program CTWALL *A Microcomputer Program for the Analysis of Retaining and Floodwalls* (Version 10/30/1993).

16. *Steel Construction Manual* 13th Edition, American Institute of Steel Construction (AISC).

17. Computer structural analysis software *RAM AdvanSE version 9.0,* Bentley Systems, Inc.

18. *Operations and Maintenance Manual, Flood Protection Works, Paducah, KY.* Louisville District, Corps of Engineers, U.S. Army (1952, revised 1981).

19. *Phase II I-Wall Evaluation Report*, Louisville District (2007).

20. ERDC TR-07-15, *Fitness-for-Purpose Evaluation of Hydraulic Steel Structures*, November 2007.

21. *Seismic Evaluation of Existing Buildings* (ASCE 31-03), published by the American Society of Civil Engineers (2003).

7.2. GENERAL DESCRIPTION OF STRUCTURAL FEATURES.

According to the project "As Built" drawings, there is a total of 15,058 lf of reinforced concrete floodwall. This includes the lengths of all closures, storage vaults, T-Walls, I-Walls and L-Walls. There are approximately 11,262 lf of T-Wall (approximately 551 monoliths ranging from 18 to 22 feet in length) ranging in height from 12 to 20 feet in height (measured from the bottom of the base to the top of wall). All monoliths were constructed with flat bases and keys – as shown in Figure 7.1-1A. Some of the T-Wall monoliths are founded on sheet piling.

There are three discrete stretches of L-Walls, on the Paducah, Kentucky LFPP, totaling 635 lf. A typical L-Wall monolith is shown in Figure 7.1-1B.

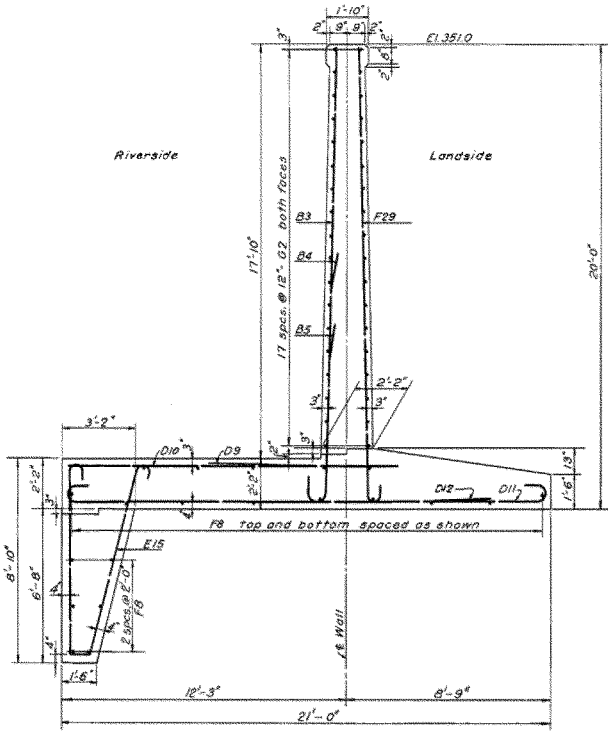


Figure 7.1-1A: Typical T-wall Section

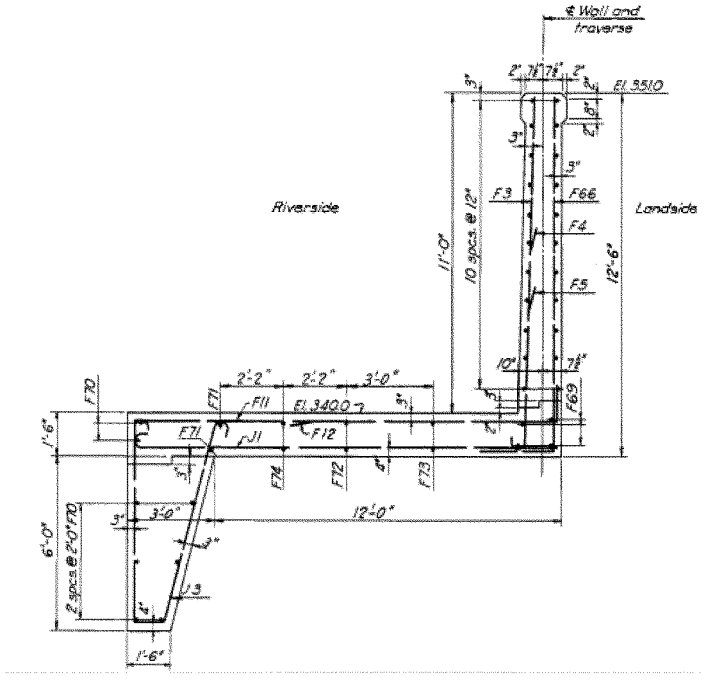


Figure 7.1-1B: Typical L-wall Section

There are six discrete stretches of I-Walls on the Paducah project, totaling 1,562 lf. These are generally shorter concrete walls than the prevalent T-Walls on the rest of the project. The typical I-Wall sections are shown in Figure 7.1-2.

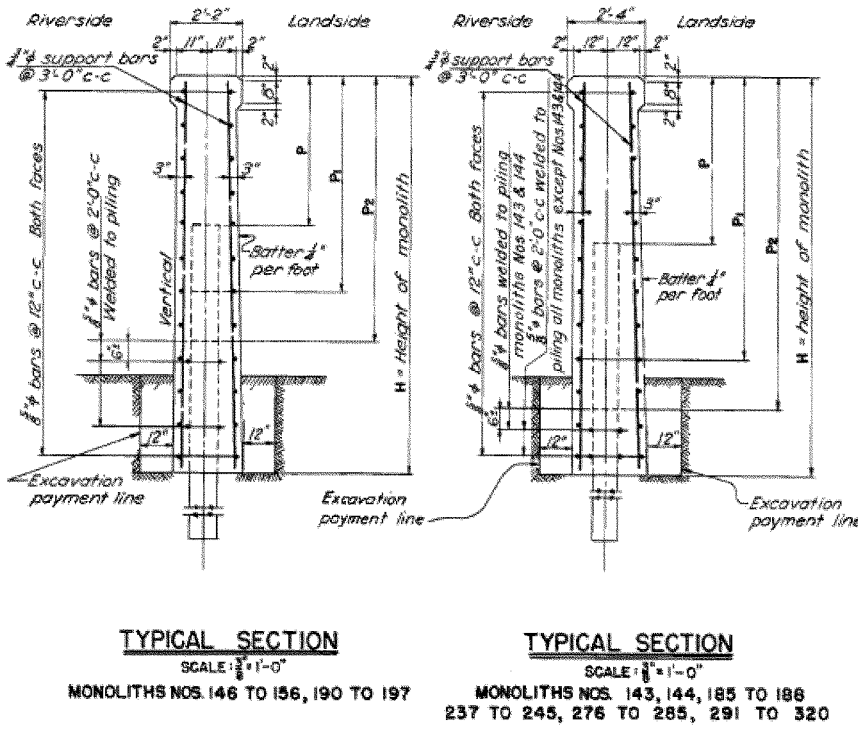


Figure 7.1-2: Typical I-wall Sections for Paducah

This project has a total of 37 removable roadway or abandoned railroad closures; the total length of all the closures is 1,099 lf. All of the structures are comprised of sheeting panels which bear on purlins which span between vertical supports either in the form of concrete abutment walls or metal trusses (see Figure 7.1-3 for a typical configuration). All closures are constructed with foundations similar to their adjacent I-Walls, T-Walls or L-Walls. There are ten service closures (manways) that are sealed off during floods by one piece bulkheads. Several original manways/service openings have previously been permanently sealed by the City of Paducah with plan approval by USACE.

There are also 31 reinforced concrete storage vaults constructed as integral parts of the floodwall, totaling 498 lf. All vaults are constructed with foundations similar to the adjacent I-Walls, T-Walls or L-Walls.

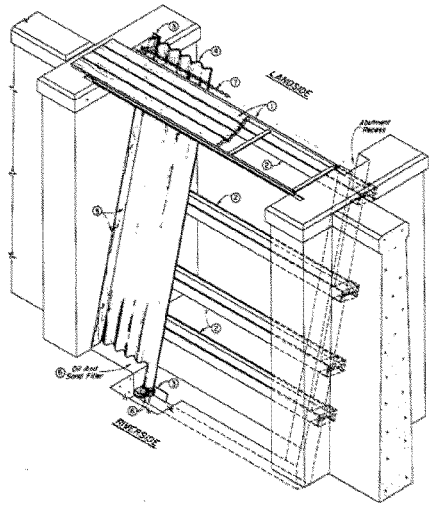


Figure 7.1-3: Typical Closure Configuration for Paducah

There are 25 cast-in-place concrete gatewells and 32 sluice gates on the project.

There are 12 pump plants on the project. Four of them, Pump Plants 3, 6, 7, and the Island Creek Dam (Pump Plant 11), were designed and constructed to be an integral part of the floodwall and levee system. The remaining pump plants are stand alone structures located on the protected side of the levee system. Pump plants 4 and 10 are both constructed completely underground.

Table 7.2-1 below shows the criteria for the "Unusual" load case (water to three feet below top of wall) and "Extreme" load case (water to top of wall) required for the T-Wall, L-Wall and pump plant portions of this study – assuming the site information is considered "Ordinary", and that all structures are considered "Critical". These will be discussed in greater detail in subsequent paragraphs of this section of the Appendix. The I-Wall analysis criteria are shown in Table 7.2-2. Pump plant criteria are presented in paragraph 7.5.2 of this section of the appendix.

TABLE 7.2-1: Concrete Structure Analysis Criteria (T-Walls, L-Walls and Pump Plants)

Requirement	Unusual Load	Extreme Load	Reference
Sliding	1.5	1.1	EM1110-2-2100
Flotation	1.2	1.1	EM1110-2-2100
Resultant Location	75% of Base in Compression	Resultant within Base	EM1110-2-2100
Bearing Capacity		2.0	EM1110-2-2502
Strength Design of Concrete	Applicable Code Requirements		ACI 318-05; ACI 437

TABLE 7.2-2: I-Wall Analysis Criteria

Requirement	Value	Reference
Rotational Stability	Factor of Safety >1.5	EC 1110-2-6066
Minimum Penetration Requirements	10 feet or Embedment/Height (E/H) of 2.0 for natural ground; E/H of 2.5 for a levee	EC 1110-2-6066

7.3. FLOODWALLS.

7.3.1. Field Inspections.

The USACE inspection of the project was mainly accomplished during the week of 23-27 March 2009. During this inspection three structural engineers examined the entire length of the project's concrete floodwalls, with one or two engineers on the landside and one or two engineers examining the riverside. Additionally a "manlift" was utilized to allow an "arms length" visual inspection of the top of most of the floodwall, and also allowed for a close view of the roofs of storage vaults and pump plants. The inspectors took numerous photographs and documented conditions continuously. The USACE inspection team was greatly assisted by personnel from the City of Paducah Flood Protection Department, members of whom operated the manlift, opened and closed locked gates, interceded with local property owners in matters involving security, procured and steadied ladders, and in general provided exemplary assistance in regard to everything needed.

In general the reinforced concrete floodwall was found to be in very good condition. There are some minor deterioration, wear and cracking issues observable in isolated locations, but all are characteristic of reinforced concrete floodwalls in the Ohio River valley exposed to weathering for 55 to 65 years. Two significant issues were observed for which remediation is recommended: 1) There is significant differential movement noted

between many monoliths in Section "B"; and 2) the expansion joint material needs to be replaced throughout the project. These issues are discussed in detail in the sections below.

7.3.1.1. Differential Movement.

In Section "B" between approximate Stations 7+40 and 16+15, many of the T-Wall Monoliths have moved both vertically and laterally relative to adjacent monoliths (see photos 7.3-1 through 4). Of the 45 monoliths in this section of the project (including two closure monoliths and one storage vault monolith), 15 have moved riverward, 12 have moved landward, and 18 appear not to have moved. Where differential movement is evident, the maximum offset (measured at a point 25 inches below the top of wall) varies between approximately one-half inch (½") and one and three-quarter inches (1¾"). The differential lateral movement between monoliths is summarized in Table 7.3-3.

TABLE 7.3-3: Monolith Offsets

Monolith No.	Joint Station	Lateral Offset (inches) (Measured 25" below TOW)	Lateral Offset (inches) (Measured 96" below TOW)	Movement Direction (relative to adjacent lower numbered monolith)	"X" if top offset >1"
34				34 Moved to RS	
	7+56	5/8"	1/4"		
35				35 Moved to LS	
	7+76	1/2"	1/4"		
36				36 Moved to RS	
	7+96	9/16"	7/16"		
37				37 Moved to LS	
	8+16	1/2"	1/4"		
38				38 Moved to RS	
	8+36	0	0		
39				NONE	
	8+56	1/4"	1/8"		
40				40 Moved to LS	
	8+76	5/8"	1/4"		
41				41 Moved to RS	
	8+96	1/2"	1/4"		
42				42 Moved to LS	
	9+16	1/2"	1/4"		
43				43 Moved to RS	
	9+36	5/8"	1/4"		
Closure @ 9+44				NONE	
	9+52	0	0		
44				NONE	
	9+72	0	0		
45				NONE	
	9+92	0	0		

Monolith No.	Joint Station	Lateral Offset (inches) (Measured 25" below TOW)	Lateral Offset (inches) (Measured 96" below TOW)	Movement Direction (relative to adjacent lower numbered monolith)	Check if top offset >1"
46				NONE	
	10+12	1-5/8	5/8		X
47				47 moved toward RS	
	10+32	indeterminate	indeterminate		
Closure @ 10+40				NONE	
	10+51	0	0		
Storage Vault				NONE	
	10+68	1-3/8"	1/8"		X
48				48 Moved to RS	
	10+88	0	0		
49				NONE	
	11+08	1-1/4"	1/2"		X
50				50 Moved to LS	
	11+28	1-1/4"	1/2"		X
51				51 Moved to RS	
	11+48	1-1/4"	1/2"		X
52				52 Moved to LS	
	11+68	0	0		
53				NONE	
	11+88	1-1/2"	3/8"		X
54				54 Moved to RS	
	12+08	1-5/16	1/4		X
55				55 moved toward LS	
	12+28	1-1/4"	3/8"		X
56				56 Moved to RS	
	12+48	3/4"	1/8"		
57				57 Moved to LS	
	12+68	1"	1/8"		
58				58 Moved to RS	
	12+88	1-1/2"	1/2"		X
59				59 Moved to LS	
	13+08	7/8"	1/4"	Vertical Offset	X
60				60 Moved to RS	
	13+28	1-3/4"	1/2"		X
61				61 Moved to LS	
	13+48	1-1/8"	1/2"		X
62				62 Moved to RS	
	13+68	0	0		
63				NONE	
	13+88	0	0		
64				NONE	
	14+08	0	0		
65				NONE	

Monolith No.	Joint Station	Lateral Offset (inches) (Measured 25" below TOW)	Lateral Offset (inches) (Measured 96" below TOW)	Movement Direction (relative to adjacent lower numbered monolith)	Check if top offset >1"
	14+28	1-1/2"	3/8"		X
66				66 Moved to LS	
	14+48	0	0		
67				NONE	
	14+68	0	0		
68				NONE	
	14+88	0	0		
69				NONE	
	15+02	0	0		
70				NONE	
	15+22	0	0		
71				NONE	
	15+42	0	0		
72				NONE	
	15+62	1-11/16"	5/8"		X
73				73 Moved to RS	
	15+82	7/16"	1/8"		
74					
	16+02	3/4"	1/4"		
75					
	16+15.5				

The vertical offset of approximately one inch noted between monoliths 59 and 60 may be sufficient to result in damage or failure of the copper waterstop (see Photo 7.3-1). This should be investigated further as part of any future studies. Additionally monolith 81 in Section "B" (Station 22+18.13 to 22+49.13) has tilted laterally approximately two inches toward the river; see Photo 7.3-4A.

These wall movements appear to be related to differential settlement, as the lateral offsets are associated with minor wall rotation. During a review of older USACE annual inspection reports (October 1979), the following observation is recorded: *"From Station 10+40B to Station 16+50B the monoliths have shifted landward or riverward. This movement has been reported several years ago and has not changed. Local interests take readings and have a record of this area. The records show no additional movement."* In the July 1975 inspection report, the following observation is recorded: *"The concrete sections of the project are in good condition and no additional movement was noted at the previously reported areas of movement (Stations 10+40B to 16+50B and 151+77B)."* A careful check of the project stationing revealed that the older annual inspection reports identified the problem correctly but did not identify a problem between stations 7+40B and 10+40B, nor at station 22+18B.

As there are records extending back no less than 34 years describing the identical problem, and USACE inspectors and the City of Paducah staff have not noted any changes over time, the problem between Stations 10+40B and 16+15B is judged not to be

an active failure of the wall foundations. However the movement observed between stations 7+40B and 10+40B was not indentified in older reports and therefore may be more recent and active. Therefore it is recommended that for monoliths 34 through 47; the closure monolith at Station 10+40B; the adjacent storage vault; and monoliths 80 through 82 all be monitored periodically to check for additional movement. Measurements of the lateral offsets should be compared to the baseline readings reported herein. See Section 4.3.3.1 for additional work recommended during the PED phase relative to these wall movements.

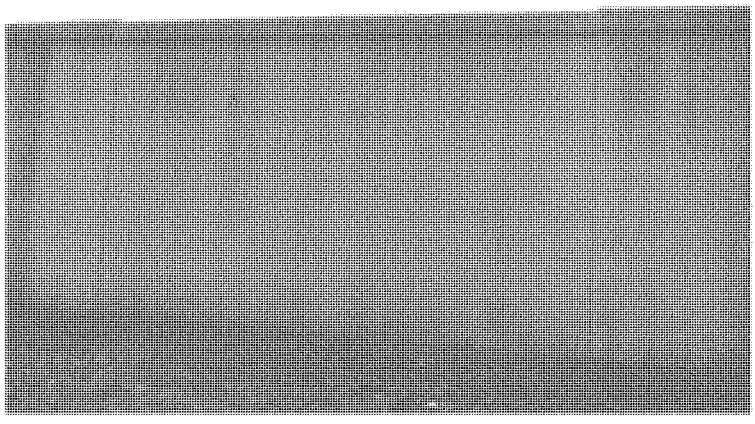


Photo 7.3-1: T-Wall monolith #60 appears to have dropped about one inch relative to monoliths #59 (left) and 61 (right). This is typical for monoliths 34 thru 75.

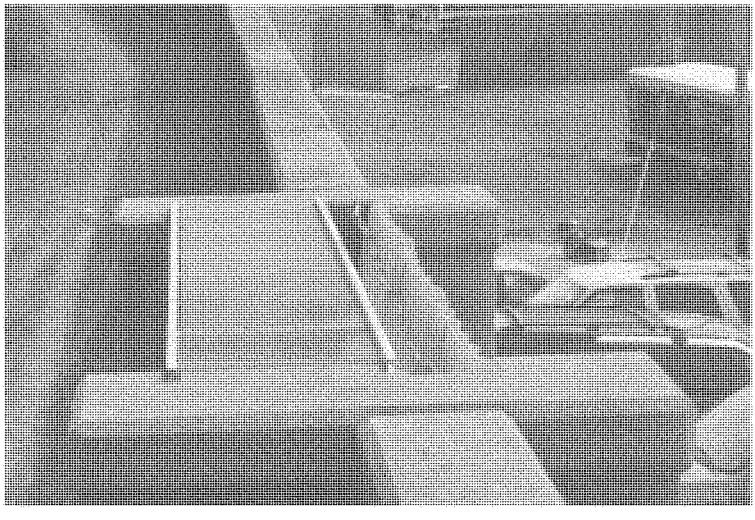


Photo 7.3-2: T-Wall monoliths #41-43 have moved relative to each other upstream of closure at Sta. 9+44. This is typical for monoliths 34 thru 75.

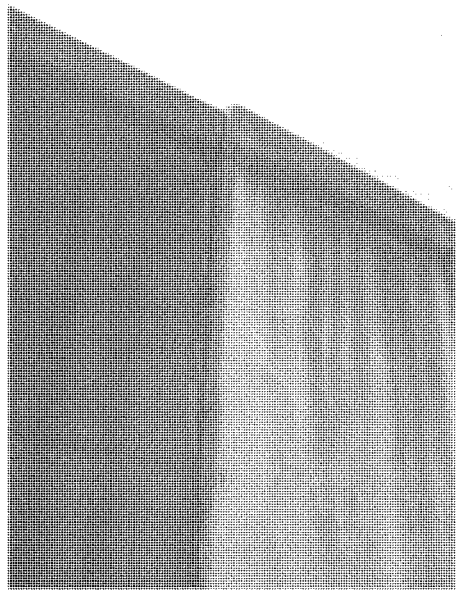


Photo 7.3-3: T-Wall monoliths 46/47 (from riverside) showing a lateral offset of nearly three inches at top; the lateral offset is zero at the ground line. This is typical for monoliths 34 thru 75.

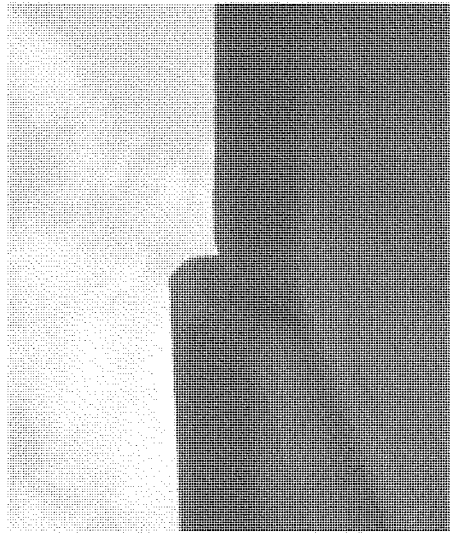


Photo 7.3-4: Looking up at T-Wall monoliths 58/59 joint from the riverside. Lateral offset 2-1/2 inches at top; zero offset at ground line. This is typical for monoliths 34 thru 75.

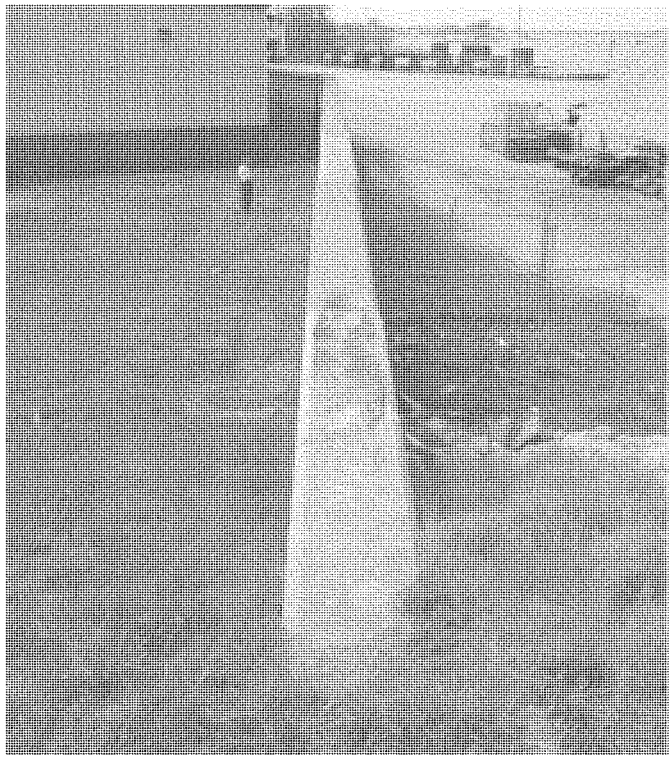


Photo 7.3-4A: Looking at the riverward movement of T-Wall monolith 81 (#79 is nearest to camera; riverside is to the right).

It is likely that the observed differential wall movements have in many locations exceeded the capacity of the copper waterstops to span the gaps. If the waterstops have failed, the resulting leakage could be unacceptable in the event of a flood. To determine the extent of the damage to the waterstops the City of Paducah performed coring at two selected monolith joints. This work was performed as "in kind" work by the project sponsor. Cores were drilled at two locations along each joint, 25-inches from the top of the wall and 96-inches from the top of the wall, in an attempt to determine a threshold offset above which the waterstops were damaged. The locations and results are shown in Table 7.3-4. A photo of the coring operation and the results of the cores are shown in Photos 7.3-5 through 7.

TABLE 7.3-4: Waterstop Coring Results

Location	Distance from Top of Wall	Wall Horizontal Offset	Waterstop Observations
STA 10+12B Monolith 46/47	25"	1 5/8"	Ruptured
STA 10+12 Monolith 46/47B	96"	5/8"	Displaced, but intact
STA 12+08 Monolith 54/55B	25"	1 5/16"	Torn
STA 12+08 Monolith 54/55B	96"	¼"	Displaced, but intact

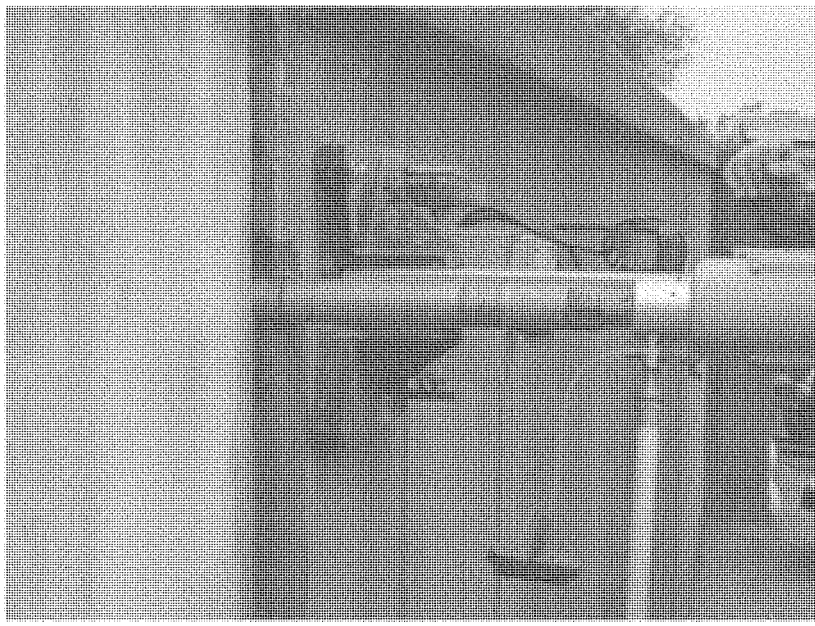


Photo 7.3-5: Coring through joint between T-Wall monoliths 46/47 from the landside. Lateral offset is 1-5/8 inches at this location 25-inches below the top of wall.

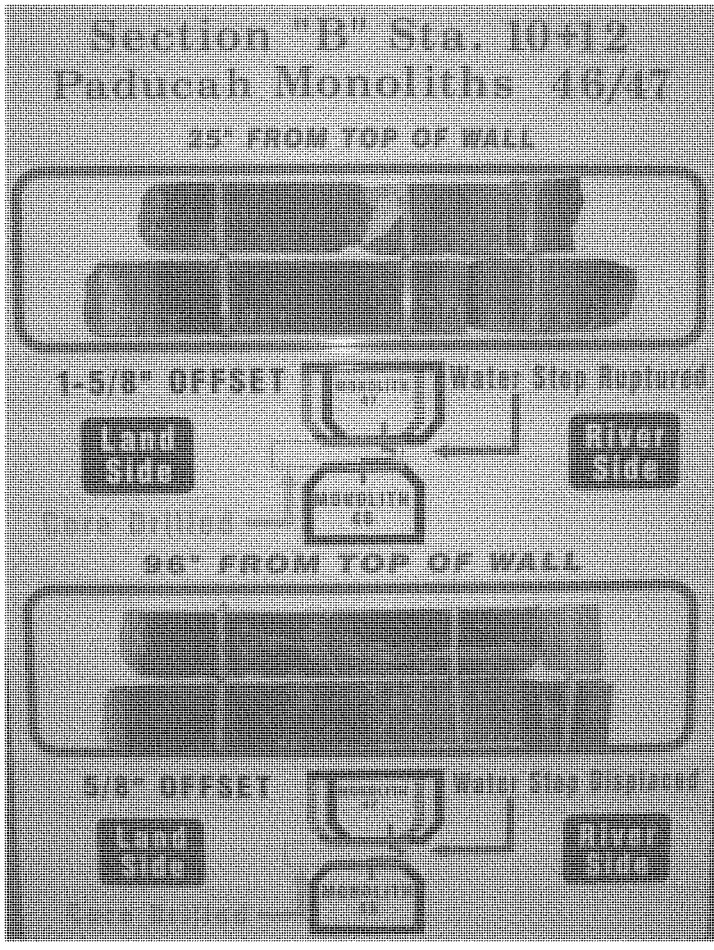


Photo 7.3-6: Display board with both cores from monoliths 46/47 joint. Note waterstop has failed at a lateral offset of 1-5/8 inches, but has not failed at a lateral offset of 5/8 inches.

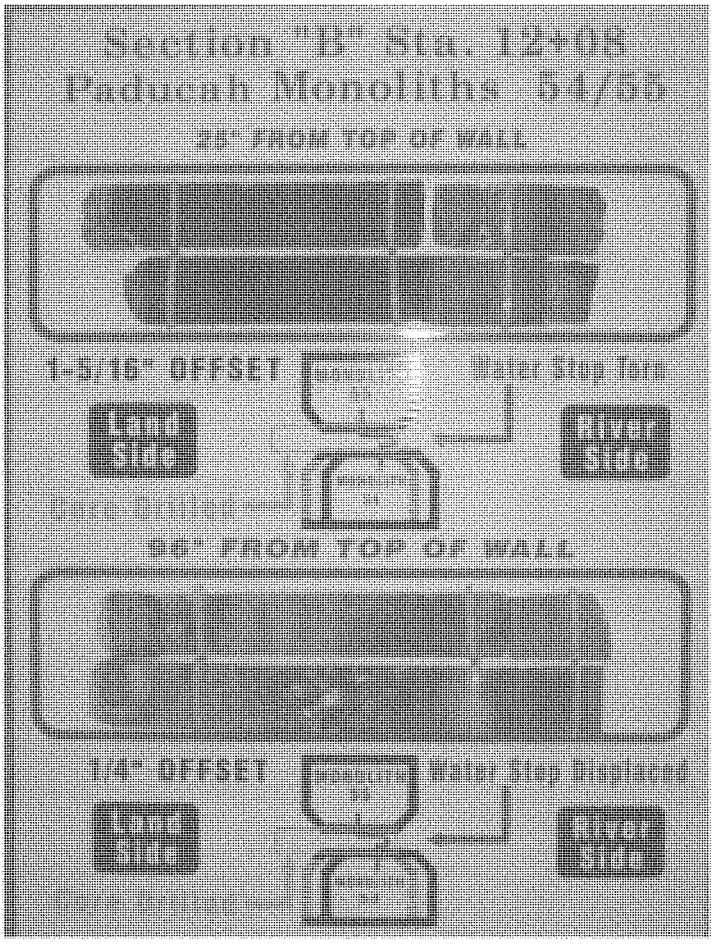


Photo 7.3-7: Display board with both cores from monoliths 54/55 joint. Note waterstop has been torn at a lateral offset of 1-5/16 inches, but has not failed at a lateral offset of 1/4 inch.

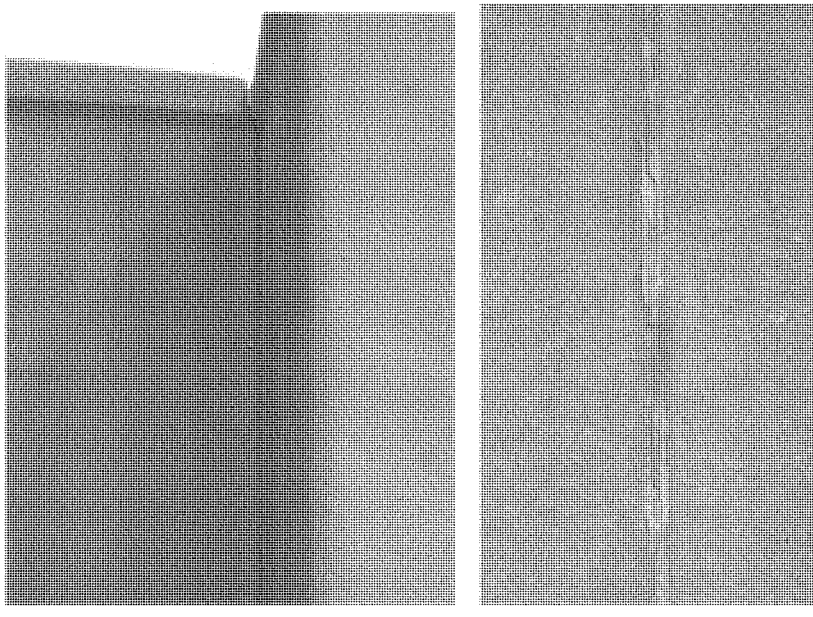
It was determined from the limited coring field investigation that at locations where a monolith joint has a lateral offset exceeding approximately one inch, the waterstop has either failed completely or has been fractured. In either case the waterstop is no longer functioning as it was intended, and remediation is required.

The precise lateral offsets were measured for all monolith joints in Section "B" between approximate Stations 7+40 and 16+15 (T-Wall Monoliths 34-75). The results are provided in Table 7.3-3. Additionally there is significant differential movement between monoliths 80, 81 and 82 at Stations 22+18 to 22+49. It was determined that the waterstops have likely failed at 15 monolith joints, based on t he one-inch criteria

previously discussed. With the additional vertical movement noted between monoliths 59 and 60, it is estimated that waterstops have likely failed at 16 monolith joints.

7.3.1.2. Joint Material.

Another significant problem observed was the desiccated and damaged condition of the monolith and expansion joint filler material and joint sealant throughout the entirety of the concrete floodwalls on this project (see Photos 7.3-8 through 10). The poor condition of these joints will lead to further water and freeze-thaw induced damage over time and attention should be given to overhauling all joints. However, despite the poor condition of the joint filler material and sealants, catastrophic leakage would not be expected to occur due to the presence of copper waterstops linking the monoliths together. For reasons discussed previously in Section 7.3.1.1, it is noted that significant leakage could occur at the monolith joints in Section "B" between approximate Stations 7+40 and 16+15 (T-Wall Monoliths 34-75) and between monoliths 80 and 82 at Stations 22+18 to 22+49.



Photos 7.3-8 and 9: Expansion/monolith joint filler/sealant should be replaced – typical at many monolith joints throughout the project.

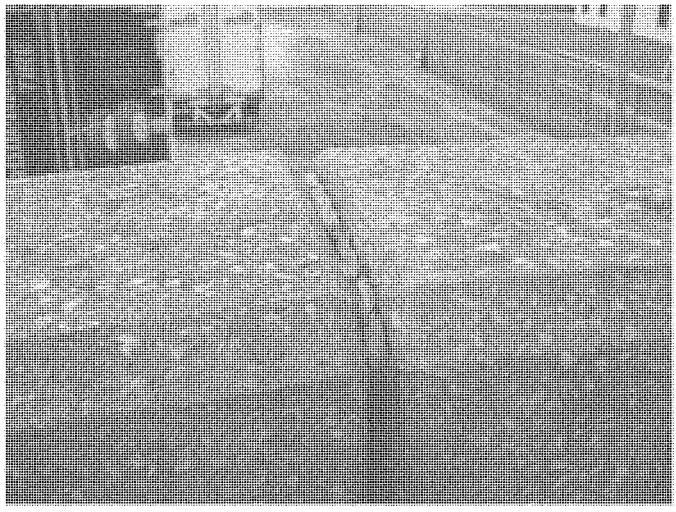


Photo 7.3-10: Expansion/monolith joint filler/sealant should be replaced at top of monolith joint 33/34. This is typical throughout the floodwall.

7.3.2. Stability and Strength Requirements.

The criteria used to analyze the walls, gates, closures and pump plants is the same criteria that would be used to design them today. However, consideration is also given to the structures' "fitness for purpose" which allows the evaluator some latitude in applying their own experience and engineering judgment. This is similar to the methodology proposed in ERDC TR-07-15, "Fitness-for-Purpose Evaluation of Hydraulic Steel Structures", published in November 2007. The basis for a Fitness for Purpose analysis is that hydraulic structures may have fabrication defects that, while not allowed based on stringent interpretation of the project specifications, may not in fact be harmful to the structure. Similarly while a structural floodwall element that was not designed and constructed strictly in accordance with current standards may not be expected to meet all of those standards, shortcomings in regard to those standards may not actually be harmful to the performance of the structure during a flood event. This type of analysis considers a particular structural component to be adequate as long as the conditions which would lead to failure are not reached. The method of this analysis is ultimately left to the judgment of the Engineer. In addition, the results of all analyses should be reviewed in light of the project's actual performance during past flood events.

7.3.2.1 I-Walls.

The I-Walls were evaluated using the USACE draft Engineering Circular (EC) 1110-2-6066, entitled "Design or Evaluation of I-Walls", dated 31 December 2008. The guidance requires that existing I-Walls be analyzed for both rotational failure and deep seated failure (global stability). The guidance mandates that a broad range of potential failure

modes should be considered for the floodwall design criteria. I-walls now must be designed to be stable with a gap between the I-wall and the soil/levee on the water side of the wall, with hydrostatic pressure acting through the depth of the gap. These conditions can lead to failure modes that should be included during design or evaluation.

There are some significant impacts from the publication of this new guidance. The most critical are the "Mandatory Requirements" in Chapter 6 (of EC 1110-2-6066), and in particular the "Minimum Penetration Requirements". It is now mandatory for either design of a new I-Wall or when analyzing an existing I-Wall that the penetration of the sheet piling at all locations be at least 10 feet, and the penetration must be deeper than or equal to a depth that results in a 2:1 ratio of embedment to "stick up".

Additional mandatory requirements from EC 1110-2-6066 concern the Geotechnical Investigation, as outlined in detail in Chapter 5 of that publication. Subsurface drilling and sampling is required to meet or exceed the minimum requirements set forth in Table 5-1. For a Feasibility or Reconnaissance study, the table requires that for fined-grained soils, one undisturbed 5" Shelby tube sample should be obtained for every 10 feet in depth, with disturbed sampling between the tube samples. Additionally a boring is required on both sides of the centerline of protection. Although there were eight new borings drilled specifically for this Feasibility Study, the geotechnical information available to the designers for this study does not meet either of the criteria in Table 5-1(of EC 1110-2-6066). As a result additional geotechnical investigations will have to be performed in the PED phase.

7.3.2.2. T-Walls and L-Walls.

The criteria for analysis of the T-Wall and L-Wall portions of the project are based on EM1110-2-2502, *Retaining and Flood Walls* and EM1110-2-2100, *Stability Analysis of Concrete Structures*. The flood wall sections are considered "critical structures" and the 1% chance (100-year flood case is, by definition, an unusual load condition and the soil information was considered to be ordinary. Criteria for factors of safety shown in Table 7.3-5 below, from EM 1110-2-2502, Table 4-2 were used, with water to top of wall.

TABLE 7.3-5: Inland Flood Wall Stability Criteria

			Shear Strength Test Required		Overturning (Min Base Area in Compression)		
Case No.	Loading Condition	Slidiug FS	Soil Foundation	Rock Foundation	Soil Foundation	Rock Foundation	Min. Bearing Cap. FS
I2	**Water to top of wall**	**1.33**	**Q &/or S**	**Direct Shear**	**75%**	**50%**	**2.0**

Surveyed elevations from the National Levee Database (NLD) were used when appropriate to determine ground and top of wall elevations for the T-Walls. In many

cases, the closest station obtained in the NLD survey did not represent the same type of wall as that being analyzed; therefore ground and top of wall elevations were determined using the as-built drawings. It was also assumed that the existing original toe drains are no longer functional (see discussion in Section 4, paragraph 4.3.1.2 in this Report). The result of this assumption is the analyses modeled water to the top of the ground on the landside.

7.3.3. Soil Properties Assumed for Analysis.

The soil properties provided by CELRL-ED-T-G for use in the Feasibility analysis can be found in Section 4, Table 4.4 of this Report.

As part of the Feasibility Study effort, new geotechnical boring "AD-6" was drilled on the riverside of the floodwall at approximate Station 8+40B, adjacent to where many T-Wall monoliths have rotated relative to each other since construction. The soil in this boring was characterized as soft to very soft clay from 8 to 30 feet in depth below the ground surface. Details on the laboratory tests for these soils are found in Section 4 of this Report.

The limited availability of soil information in locations adjacent to the I-Walls lead the evaluation team to model the soil profile as homogeneous from the ground surface to the tip of the sheet piles, with an average cohesion (c) value for the undrained condition and average effective angle of internal friction (φ') for the drained condition. Conservative values were used in the analyses.

7.3.4. Structural Analyses.

7.3.4.1. I-Walls.

All 1,562 linear feet of I-Wall in the Paducah project meet the minimum 10 foot mandatory embedment requirement mandated in Chapter 6 of EC 1110-2-6066. However there is a significant portion of the wall that does not meet the 2:1 embedment ratio requirement. In addition to the two sheet pile embedment mandatory requirements, additional analyses were performed to assess the safety of the design.

Structural integrity and rotational stability were both evaluated using the USACE tool CWALSHT (1991). For piling tip penetration evaluation, the gap depth can be estimated from CWALSHT as the depth at which active pressures in the cohesive soil are no longer zero. CWALSHT was also used to determine the required sheet piling embedment length. CWALSHT was first used in design mode to determine the sheet pile embedment depth, with minimum required safety factors applied to both the active and passive side soil appropriate for the load case. After determining the embedment length, the CWALSHT program was then run again in design mode, but with safety factors of 1.0 on both active and passive sides to develop design forces, shears and moments. The design output produced both plots and tables of shear forces and moments versus wall elevation. It was verified that the sheet piling sections at all locations have sufficient capacity to withstand the applied shear forces and maximum bending moments.

For the rotational failure mode, it was assumed that a flood-side gap will extend to the bottom of the sheet pile; this is an appropriate assumption because all of the Paducah I-Wall locations are founded within fine grained material. This is basically the same guidance used by Louisville District when the Phase II I-Wall study was performed in 2007, and is consistent with the findings of the IPET Report that some I-Walls failed in New Orleans as a result of the formation of such a gap.

Using CWALSHT the calculation of the required sheet pile penetration for the selected wall sections indicate the "As-Built" penetration depths provide less than the required FS of 1.5 for the drained condition. The analyses results are presented in Table 7.3-6.

TABLE 7.3-6: I-Wall Analysis Results

Wall Stations (all Section "B")		Height	Embed Depth	CWALSHT Req.	EC 1110-2-6066 Req. Embedment		Controlling	Meets
Begin	End	(ft)	(ft)	Embedment	Formula	Value	Case	Req.
51+00.14	51+47.64	7.0	20.0	17	2H	14	17	Yes
51+47.64	51+67.64	6.5	14.0	15.8	2H	13	15.8	NO
51+96.90	54+17.98	7.0	11.0	17	2H	14	17	NO
60+17.30	61+02.05	8.5	14.0	20.6	2H	17	20.6	NO
61+02.05	62+75.13	7.5	10.5	18.2	2H	15	18.2	NO
72+18.54	74+03.04	9.0	13.5	21.8	2H	18	21.8	NO
80+06.62	82+18.87	10.5	14.5	25.5	2H	21	25.5	NO
84+09.57	90+10.81	10.5	14.5	25.5	2H	21	25.5	NO
170+39.58	170+57.91	9.0	11.5	21.83	2H	18	21.83	NO

7.3.4.1.1 Consideration of Historic Load Test and Flood History.

In light of the failure of the project's I-Walls to meet the required criteria, an examination was made of the historical project flood loadings. A unique series of full scale hydrostatic load tests were performed at Paducah on a series of specially constructed I-Walls in the summers of 1938 and 1940 (see reference entitled *Final Report Flood Wall Stability Investigation*, U.S. Engineer Office Louisville, KY. 1941). It is noted that none of the tested I-Walls were incorporated into the actual flood protection project. A study of this series of tests was performed to evaluate whether the results could change the conclusions reached from the current Feasibility Study. The load test conditions were varied with respect to foundation material, sheet pile stiffness, head of water, sheet pile penetration and the type of I-Wall. The foundation soil consisted of firm clay-silt for Test Series No. I and porous, granular hydraulic fill for Test Series No. II. The test walls were constructed in the form of a cofferdam. Loads for the tests were applied by filling the cofferdam with water to the desired elevations, which ranged from about 9.5 to 20 ft. Sheet pile penetration depths tested ranged from about 10 to 20 ft.

Wall deflections to depths of as much as 14 ft below finished grade were measured during several of the load tests. Measurements at the ground line indicated lateral deflections of the wall of as much as 4-inches after sustained hydrostatic loads of 12 ft for up to a week. There were also measurable deflections at the bottoms of the piles. In all

cases the piles rebounded after unloading but some deflection remained. These test results tend to support the IPET Evaluation findings regarding formation of cracks in fine grained soils.

The maximum Ohio River elevation since the project was completed occurred during the February 1950 flood event, when the river reached a maximum elevation of 339.0 (NAVD 1988 datum). The tallest I-Wall on the Paducah project is only 10.5 feet high, with a top elevation of 350.1 (NAVD 1988). Therefore no significant flood loading has ever been imposed on any of the project's I-Walls.

7.3.4.1.2. Conclusions.

In conclusion a significant portion of the Paducah I-Wall fails to meet the 2:1 embedment ratio mandated by the "Minimum Requirements" in Chapter 6 of the EC; despite the eight new borings drilled specifically for this Feasibility Study, the geotechnical information is limited compared to the "Minimum Requirements" in Chapter 5 of the EC; and the deficiencies listed above from the CWALSHT analysis affect all of the I-Wall. The conclusions of the Feasibility Study as outlined above are not changed as a result of a review of the full scale load test program conducted on test I-Wall sections in 1938 and 1940. Additionally despite several significant flood events occurring since the project has been completed, significant flood loading has never been imposed on any of the project's I-Walls. Therefore neither an analysis of I-Wall full scale load tests, nor a review of the project flood history allows the evaluation team to overturn the conclusions reached by the I-Wall analysis. **The walls are considered deficient** when analyzed with a water level equal to the tops of the walls, which is the authorized level of protection.

7.3.4.1.3. Recommendations.

It is recommended that a more detailed geotechnical exploration and laboratory testing program be undertaken in the near future. Additionally, it is expected that a new "Phase III I-Wall Evaluation Guidance" document will be forthcoming from USACE Headquarters during FY 2010. This guidance is supposed to include new more accurate methods for evaluating and designing I-Walls. It is expected that the I-Walls will not require any structural remediation because a significant number of new soil samples will be obtained utilizing higher quality geotechnical sampling techniques than have been employed previously; these techniques are expected to yield higher soil strengths. Additionally this new soil strength data will be utilized in conjunction with more advanced analytical techniques. It is further recommended that additional research and communication with higher USACE authority be undertaken during the next phase of study to determine if the drained load case can be eliminated. This appears to be a reasonable line of reasoning, since the project's soils are typically fine-grained clays, and the flood duration may not be sufficiently long for truly drained conditions to develop in the soils.

7.3.4.2. T-Walls.

The USACE software CTWALL was used to evaluate selected representatives of T-Wall monoliths on the Paducah project. C TWALL was developed as part of the USACE Computer-Aided Structural Engineering (CASE) Task Group and has been in widespread use throughout the Corps of Engineers for almost 20 years. This program was developed to be used in conjunction with the previously referenced EM 1110-2-2502, *Retaining and Flood Walls*. The program also includes a graphical user interface which allows modelers to verify the geometry of both the structure and the ground with a visual frame of reference.

Ten representative monoliths were selected based on evaluating a wide range of wall heights, base widths and embedment, as well as representing different locations throughout the project. The ten selected monoliths are representative of approximately 200 project monoliths. The results of the monolith analyses for the load case with flood water to the top of the wall are presented in Table 7.3-7.

TABLE 7.3-7: T-Wall Analysis Results

T-Walls					Water Elevation @ Top of the T-Wall		
Project Constr. Contract Section	Drawing Number	File Name	Height (ft)	Monolith Numbers Represented by This Analysis	Overturning (% of base in Compression) (MIN=0.75)	Sliding Factor of Safety (MIN=1.1)	Bearing FS (MIN=2.0)
B-1	933-12.3/37	TB12	12.0	207-214, 228-234, 126-137, 170, 171, 174	0.76	3.16	3.00
	933-12.3/48	TB14	14.0	108-112, 138-140, 142, 182, 183, 260-270, 273	0.75	2.73	2.61
	933-12.3/55	TB15	15.0	21-23	0.75	4.00	2.70
	933-12.3/59	TB17	17.0	24-26, 44-68, 70, 72-74, 77	0.86	3.17	2.88
	933-12.3/64	TB18	18.0	27-31	0.79	3.94	2.21
	933-12.3/65	TB20	20.0	32, 35-43	0.55	3.28	1.42
B-2	935-12.2/37	TB2-14	14.0	17-24, 56-64	0.85	4.61	3.71
	935-12.2/37	TB2-15	15.0	1-2, 25-26, 66-73	0.75	2.39	2.16
	935-12.2/37	TB2-19	19.0	6-11, 31-40, 42-53, 76-79, 81-94, 97-113, 116-117, 133-139	0.92	3.27	2.90
	935-12.2/35	TB2-22	22.0	168-170, 172-179	0.97	1.77	4.04

All of the T-Walls passed the criteria set from EM 1110-2-2502, with the exception of the 20-foot high monoliths 32 and 35-43. These monoliths did not meet the criteria in overturning or in bearing. These monoliths were re-evaluated assuming some relatively minor remedial steps had been undertaken: an additional 18-inches of soil had been placed as engineered fill on both sides to a limited extent, and it was assumed the toe drains were 50% effective. These additional steps improved the stability of the 20-foot high monoliths, as shown in Table 7.3-7A.

TABLE 7.3-7A: T-Wall Limited Remedial Analysis Results

Section	Drawing Number	File Name	Height (ft)	Monoliths	Overturning (% of base in Compression) (MIN=0.75)	Sliding Factor of Safety (MIN=1.1)	Bearing FS (MIN=2.0)
B-1	933-12.3/65	TB20	20.0	32, 35-43	0.76	3.40	2.12

7.3.4.2.1 Conclusions.

With the exception of ten 20-foot high monoliths in Section B-1, all of the T-Wall monoliths that were analyzed met applicable stability and structural criteria for the imposed flood loads. It is noted that monoliths 35-43 are all monoliths that have moved differentially in relation to each adjacent monolith, as discussed in greater detail in Section 7.3.1.1 of this Report. The fact that these monoliths fail to meet bearing and overturning criteria appears to mesh well with the observed condition of the wall monoliths. In order for all of the monoliths to meet current criteria, some recommendations are provided in paragraph 7.3.4.2.2.

However even with the exceptions noted above, this study concludes that the City of Paducah would be at very low risk from flooding as a result of any T-Wall stability or structural issue. The conclusion is based on: 1) An evaluation of the structural drawings for the T-Walls; 2) the results of the structural analyses discussed above; 3) interviews with the local sponsor (City of Paducah) regarding the performance of these monoliths during various floods; and 4) the good level of maintenance observed during the March 2009 inspections.

7.3.4.2.2 Recommendations.

It is recommended that for the twelve monoliths numbered 32 through 43 in Section "B" of the project (station 7+04B through 9+36B), an additional 18-inches of engineered fill be placed on both sides of the walls. This fill should be placed over a width no less than the T-Wall base width (21 feet) on both sides of the wall. Additionally it is recommended that the existing toe drains for these monoliths be reconstructed to a fully functional state and then drained to an appropriate gravity outlet.

7.3.4.3. L-Walls.

The L-Walls were analyzed using the CASE program CTWALL, as described previously in paragraph 7.3.4.2. This program assumes there is a crack down to the bottom of the heel on the riverside, resulting in large driving and uplift water pressures. The results of the analyses for the load case with flood water to the top of the wall are presented in Table 7.3-8.

TABLE 7.3-8: L-Wall Analysis Results

Section	Begin Wall Station	End Wall Station	Height (ft)	Monoliths	Overturning (% of base in Compression) (MIN=0.75)	Sliding Factor of Safety (MIN=1.1)	Bearing FS (MIN=2.0)
B-1	0+00	4+00	11	1-19	0.890	3.53	2.81
	27+01.8	28+27.8	12	101-106	0.699	4.62	1.22
	82+18.87	83+74.57	12	286-290	0.790	5.92	2.08

7.3.4.3.1 Conclusions.

Two of the three L-Wall monoliths that were analyzed passed the criteria from EM 1110-2-2502, the applicable stability and structural criteria for the imposed flood loads. The 12 foot high wall at Station 27+01.8 did not meet current overturning or bearing criteria. However, the CTWALL analysis incorporated numerous conservative assumptions that should be evaluated in greater depth at the next phase. All three walls analyzed have very similar geometries but the soil properties assumed for the wall in question were conservatively low. Despite the results obtained for the L-Wall at Sta. 27+01.8, the evaluation team has a high level of confidence that the City of Paducah would be at very low risk from flooding as a result of any L-Wall stability or structural issue. The conclusion is based on: 1) An evaluation of the structural drawings for the L-Walls; 2) the results of the structural analyses discussed above; 3) interviews with the local sponsor (City of Paducah) regarding the performance of these monoliths during various floods; and 4) the good level of maintenance observed during the March 2009 inspections.

7.3.4.4. Seismic Analysis.

Engineering Regulation (ER) 1110-2-1806, *Earthquake Design and Evaluation for Civil Works Projects* (July 1995), is the guidance document for seismic evaluation for this study. It is noted that there is the potential for significant ground accelerations at the project site due to the proximity of the New Madrid Fault, located just over 60 miles away. The structural team coordinated the seismic evaluation with Ms. Anjana Chudgar of HQ-USACE. Ms. Chudgar recommended that engineers go through a process that includes determination of the Structure's Hazard Classification Potential. This requires use of ER 1110-2-1806, Appendix B, Table B-1. Ms. Chudgar further stated that flood loading of a flood wall, pump station or flood gate structure is assumed not to be

coincident with a seismic event, and the structure is assumed not to be occupied; therefore the Hazard is considered to be "LOW". Therefore it is appropriate to use the Operating Basis Earthquake (OBE) for the "Unusual" seismic event, and the Maximum Design Earthquake (MDE) for the "Extreme" event.

Paragraph 5.b of ER 1110-2-1806 includes the statement, "The magnitude of seismic motions and an initial evaluation of key project features shall be included in the feasibility stage in design of sufficient detail to determine whether seismic loads control the design." Table E-1 in the above referenced regulation provides guidance on the level of seismic analysis required for a project at each stage, and the basis for this is Seismic Zones from the Universal Building Code (UBC). Paducah is in Seismic Zone 2A, according to Figure C-1 in Appendix C of the ER. Table E-1 indicates that the "Seismic USACEfficient Method" of analysis will be sufficient for this feasibility study.

To obtain the seismic coefficients for the required return periods (144 years for OBE, 1000 year for MDE) Ms. Chudgar recommended that the downloadable program DEQAS from ERDC be used in accordance with EM 1110-2-6053 *Engineering and Design - Earthquake Design and Evaluation of Concrete Hydraulic Structures* (May 2007), Appendices B and C. The project's latitude and longitude are entered, along with the return period for the seismic event under consideration, and the program provides peak ground accelerations. Ms. Chudgar stated that it is appropriate to use 2/3 of the peak ground accelerations generated by DEQAS to obtain the seismic USACEfficient.

The seismic USACEfficients were multiplied by gravity loads (structural, earth and groundwater) to determine the seismic forces. The resulting seismic forces were compared to the flood-induced water and/or soil forces applied to the structures. Recalling that the seismic loads were not imposed simultaneously with the flood loads, it was determined that the seismic loads were actually lower than the flood loads. Since the seismic loads were smaller, seismic load cases did not control the stability or structural analyses of the floodwalls, closure structures or the pump stations.

Seismic analyses can be found in Volume 4 of this Report.

7.3.5. Conclusions and Recommendations for Floodwalls.

With the exception of the items in the following subparagraphs, the sponsor is advised to continue the current Operating and Maintenance procedures in regard to the I-Walls, T-Walls and L-Walls.

7.3.5.1. Expansion Joint Filler Material Replacement.

Throughout Section "B" every monolith joint needs to have its ½-inch thick pre-molded joint filler material and its surficial joint sealant removed and replaced. It was noted that many of the expansion joints no longer have the capacity to prevent water from entering the joint spaces. Not only was the surface sealant cracked and desiccated, in many locations it was apparent the underlying joint filler material was missing, damaged or otherwise lacking the capacity to perform its intended function. Over time water entering these spaces will go through cycles of freezing and thawing, with the expansion of ice causing degradation of the reinforced concrete. This item has been identified as one that may prevent the project from performing as authorized after all maintenance, as required

by the project O&M Manual and the Code of Federal Regulations, has been accomplished and any deficiencies resulting from a lack of maintenance have been addressed. This item will result in a major performance deficiency caused by a long-term degradation of construction materials that have exceeded their expected services lives. As the concrete deteriorates the project may no longer have the capacity to perform its authorized project functions.

There are approximately 800 reinforced concrete wall monoliths that must have the joints repaired.

The procedure for this repair is as follows:

1. Remove all existing joint sealant and joint filler material from the joint. Do not disturb existing lead or copper waterstop. Hand tools and/or water jet can be used. This is to be done on both wall faces.
2. Install a 1-inch bead of a gunnable expansion joint filler consisting of a one part polyurethane swelling waterstop. This is to be done on the riverside only directly on the surface of the waterstop.
3. Install new backer rods to fill open void to within approximately 1 inch of inside corner of chamfer. An estimated 10 to 12 pieces of backer rod will be required on each side. This is to be done on both wall faces.
4. Install an external grade silicone sealant against the outermost backer rod. This is to be done on both wall faces.
5. Install additional backer rod and a second application of silicone sealant. This is to be done on both wall faces.

Details for this repair are shown on sheet S-500.

7.3.5.2. External Waterstop.

In Section "B" between approximate Stations 7+40 and 16+15, and at Stations 22+18 through 22+49, numerous T-Wall Monoliths have moved relative to adjacent monoliths. In 16 locations these observed deflections have likely exceeded the capacity of the copper waterstops to adjust to the differential movements. Without remediation of the failed waterstops the resulting leakage could be unacceptable. Thus the project may not have the capacity to perform as authorized. This item could be considered a major performance deficiency caused by a long-term degradation of the foundation, or perhaps was caused by an engineered system that failed to account for the compressibility of the underlying soils.

At joints where the maximum differential offset exceeds one inch, a repair is required. The recommended reconstruction consists of adding a new rubber or PVC center-bulb waterstop embedded into two new external reinforced concrete pilasters. Reinforcement for the two concrete pilasters will be doweled into the riverside of the existing wall in two parts, and then two separate concrete placements will be made. This provides assurance that the ½-inch expansion joint is maintained throughout the wall cross-section. The joint

will need to be filled with pre-formed joint filler material. This repair will extend from the tops of the walls down to the bottoms of the riverside keyways.

Details for this repair are shown on sheet S-503.

7.3.5.3. Monitoring Floodwall Movement.

It is recommended that monoliths 34 through 75, the closure monolith at Station 10+40, the adjacent storage vault and monoliths 80 through 82 all be monitored periodically to check for additional differential movement. A series of baseline lateral offset readings have been established by the City of Paducah Floodwall Maintenance staff. Future readings should be compared to these baseline readings.

7.3.5.4. Additional Field Investigations in Regard to Floodwall Movement.

It is recommended that at the location of one pair of the T-Walls where significant differential movement has been observed, an excavation be performed. The purpose of the excavation would be to evaluate the condition of the floodwall bases, the joint filler material and the embedded copper waterstop. This should be accomplished for a pair of monoliths where a large magnitude of differential movement has been measured. If the movement below finished grade is less than the offsets observed in the stems, then the extent of the recommended external waterstop reconstruction (see paragraph 7.3.5.2) could be significantly reduced.

7.3.5.5. Waterproof Sealant to prevent further cracking at Top of Wall.

Cracking was observed near the upper faces of many floodwall monoliths, along the parapet walls on the tops of some closure storage vaults. This pattern of cracking is typical for many floodwalls of approximate similar age at other projects along the Ohio River. This cracking was caused by water entering the concrete matrix through shrinkage cracking; this is typical of the poorly consolidated concrete near the tops of walls. As the water penetrated into the concrete, it expanded during freezing weather, enlarging the cracks. This has been repeatedly exacerbated by annual (or more frequent) freeze-thaw cycles. At some point in the future this damage will impact the structural integrity of the wall. On the top surfaces of all concrete floodwall monoliths, all closure abutments, and the parapet walls of all pump plants and closure vaults, any damaged and cracked concrete should be removed to sound concrete and replaced. Any deeper cracks should be injected with pressure-injected epoxy crack filler. To prevent further water infiltration, a waterproof sealant should be rolled onto the top surfaces of all concrete floodwall monoliths; all closure abutments, and the concrete roofs of all closure vaults.

7.4. FLOODWALL CLOSURES.

- Closure Structures: There are 37 roadway and abandoned railway closure structures on the project. All of the structures are comprised of sheeting panels which bear on purlins which span between vertical supports.
- Closure storage vaults. Each of the above listed removable closures is constructed adjacent to a reinforced concrete vault where the removable closure parts are stored. The vaults were inspected in the summer of 2009.

- The project O&M Manual lists 17 "Service Openings" (which are generally manways) and 41 openings for either roadways or abandoned railroads; this would produce a total of 58 openings. Records kept by the local sponsor show that eight of the original openings have been permanently sealed with reinforced concrete; (of these four are service openings). Another three of the "Service Openings" shown in the O&M Manual were never actually constructed. This accounts for the difference (11) between the original O&M Manual total of 58 openings and the current total of 47 openings.

- There are ten service closures (manways) that are sealed off during floods by one piece bulkheads. Four original manways/service openings have previously been permanently sealed by the City (see Photo 7.4-11), and six remain open (see Photo 7.4-12).

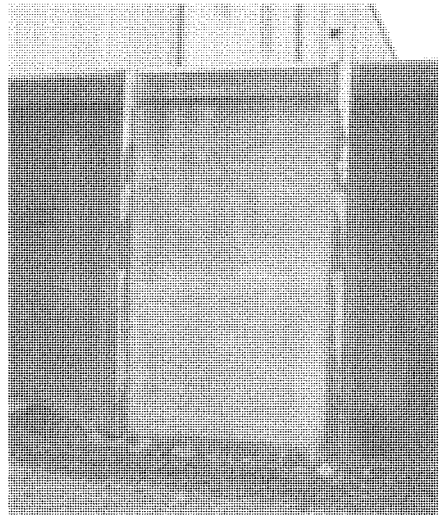


Photo 7.4-11: Service Opening at Station 2+87B was permanently sealed in October 2003

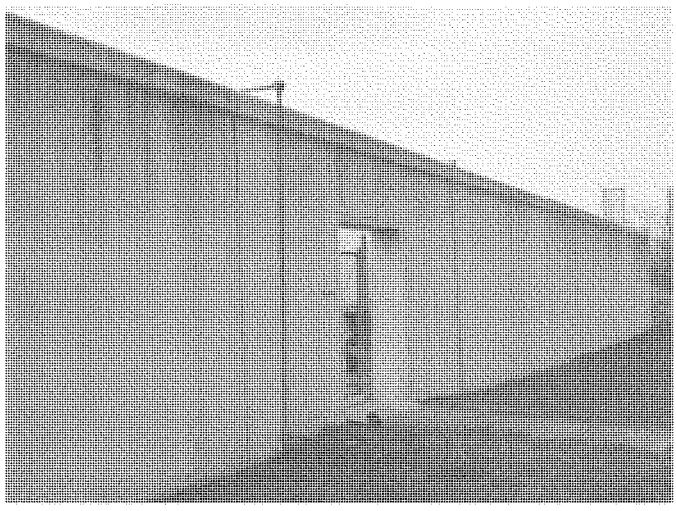


Photo 7.4-12: Service opening at Station 15+32B - typical

7.4.1. Field Inspections.

The first structural inspections by USACE personnel were performed during the week of 23-27 March 2009, and were limited to the concrete floodwall, the closure sills, the roofs of closure vaults and the pump plants. Detailed inspections of the interiors of the storage vaults, the closure sills and abutments and a limited number of erected closures occurred 17-19 August 2009 when the City of Paducah conducted closure erection training. Three closures at Stations 126+35B, 135+22B and 83+92B were erected by different teams in order to train the people that will be installing the closures at the time of a flood. In addition to observing the training exercises, all of the closure vaults and movable closure parts were inspected by a USACE structural inspection team.

7.4.1.1. Closures.

Several of the concrete sills needed to be cleaned before they could be thoroughly inspected. A prime example of this is the former railroad closure at Station 170+04.4B, next to Campbell Street. The sill for this closure appeared to be buried beneath several feet of sand and gravel (see Photo 7.4-13). During the August 2009 visit, the sills were partially cleaned in order to inspect them as well (see Photo7.4-14).

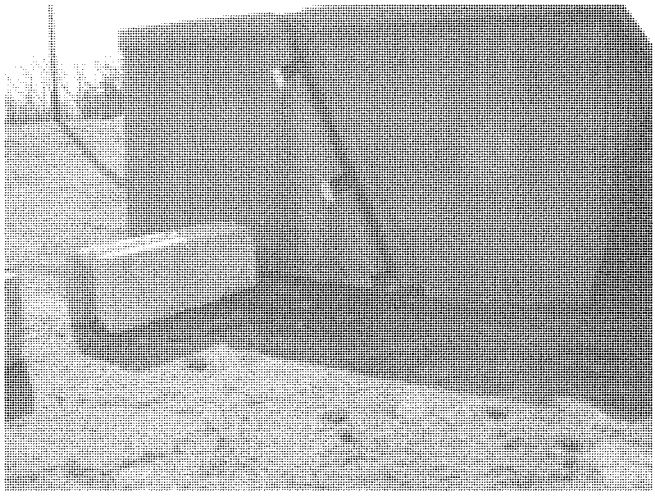


Photo 7.4-13: Former railroad closure at Station 170+04.4B, next to Campbell Street. The sill for this closure appeared to be buried beneath several feet of sand and gravel.

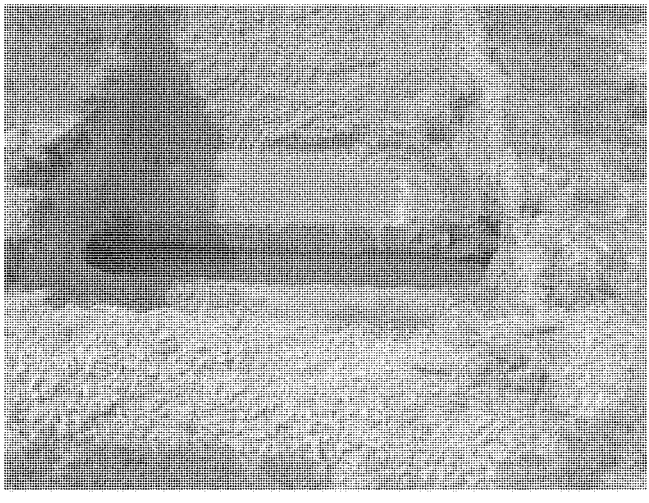


Photo 7.4-14: Former railroad closure at Station 170+04.4B, next to Campbell Street. The sill for this closure had been partially cleared in August 2009 to inspect the condition of the concrete sill.

Of the concrete that was inspected in March 2009, the closures were generally observed to be in good condition with minimal cracking, weathering and spalling. The sills for the following closures were observed to have some minor cracking: 83+92B, 119+93B, 132+41B, and 157+26B (see Photo 7.4-15). The road closure at Station 83+92B was previously a railroad opening. Since the railroad has abandoned this area, the Sponsor

caused this sill to be raised by two feet, which also changed the order of closure erection in the O&M Manual. The sill observed represents work performed by the Sponsor.

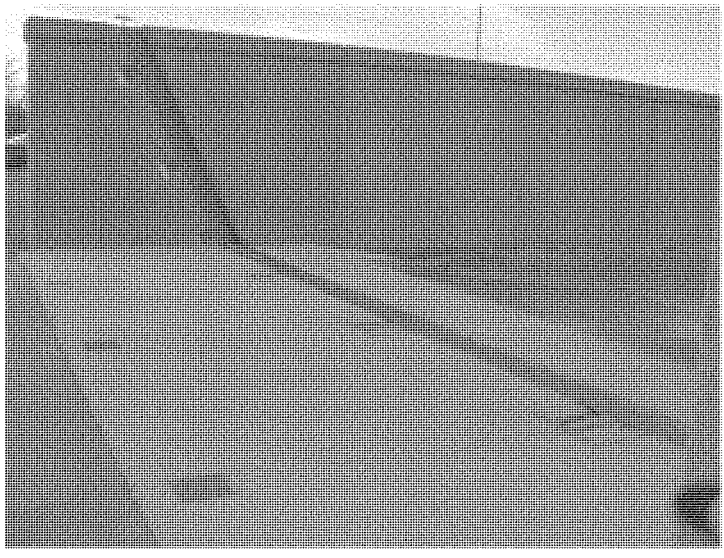


Photo 7.4-15: Closure at Station 83+92B, next to Norton Street. There is some damage and cracking of the sill apparent.

The corner of the landside abutment wall at the closure at 25+15B has been damaged by impact. The sill and wall on both sides of the line of protection have some spalling at 138+23B.

Nearly all of Paducah's closures were designed with a horizontal slot cast into the concrete sill. Within these slots the sheeting panels bear on flexible belting seal material and are wedged in by timbers. A similar arrangement of near vertical slots provide the side seals at each abutment (see Figure 7.4-4).

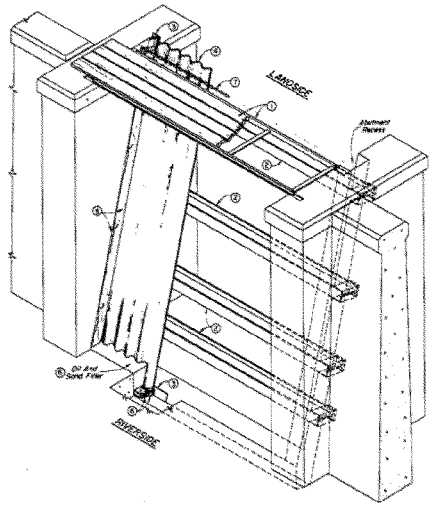
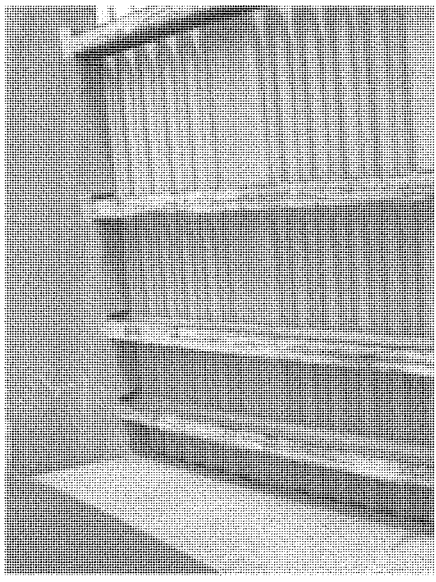
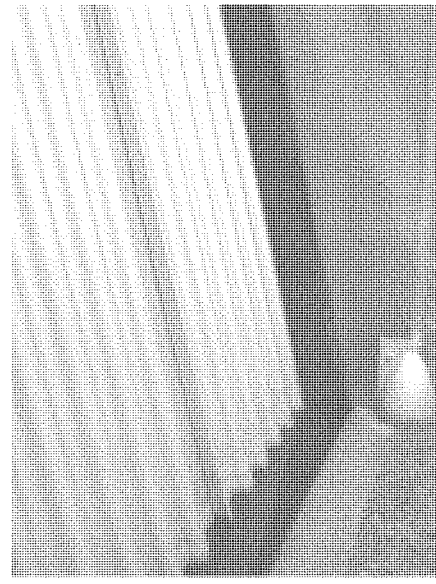


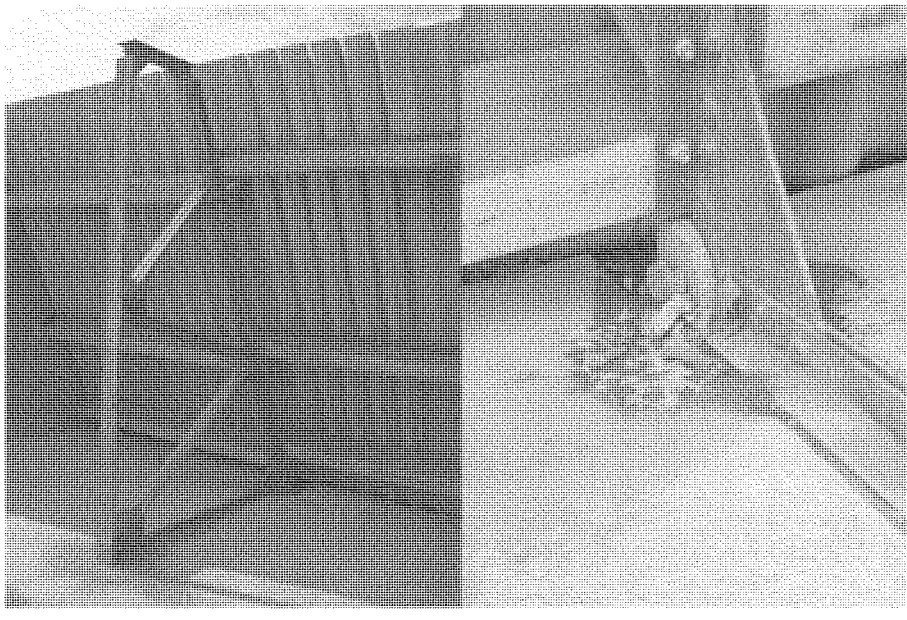
Figure 7.4-4: Typical Closure

The horizontal slots in the sills retain rainwater because they do not have a means to drain the water. The closures at Stations 9+44B and 71+75B have been erected by the local sponsor, and remain in place in a semi-permanent condition (see Photos 7.4-16 through 19). The removable closure parts, both metal and wood, were not designed or intended to be exposed to weather for long periods of time. The lower portions of the sheeting panels for these two erected closures are submerged and are beginning to show corrosion, as are the purlins. T he wooden sealing timbers need to be removed and inspected for weathering damage and replaced if necessary. The metal closure pieces should be removed, sand-blasted, painted and returned to the proper storage vault locations. Alternatively, the openings should be permanently sealed with concrete following USACE approved procedures. This alternative is recommended because these closures no longer serve a useful purpose; railroad tracks that formerly operated in these areas have been abandoned.





Photos 7.4-16 and 17: Closure at Station 9+44B has been erected by the local sponsor and left in place; landside (left) and riverside (right). Note corrosion visible on the purlins and also note that sheeting panels are partially submerged in slot.



Photos 7.4-18 and 19: Closure at Station 71+74B has been erected by the local sponsor and left in place; Note there is significant corrosion visible on the trusses.

In addition to this, much of the embedded metal in the closure sills and abutment walls shows signs of corrosion and should be sandblasted and painted in accordance with USACE approved standards.

7.4.1.2. Closure Erection Exercises.

The second field inspection occurred August 17-19, 2009. T his inspection included a training exercise in which three separate closures were installed, two of them multiple times, in order to train the crews that would be installing the closures at the time of a flood. Three closures at Stations 126+35B, 135+22B and 83+92B were erected by different teams. The floodwall maintenance staff was present with teams from the Paducah Parks Department, Paducah Fire Department, Paducah Sanitation Department, and Paducah Streets Department to install the closures. Some of the closure erection drills can be seen in Photos 7.4-20-25. In general the closure components were found to be in good structural condition; however most truss, bracing and purlin components have failing paint systems and will require sandblasting and painting. This is noted as an O&M item for the Sponsor.

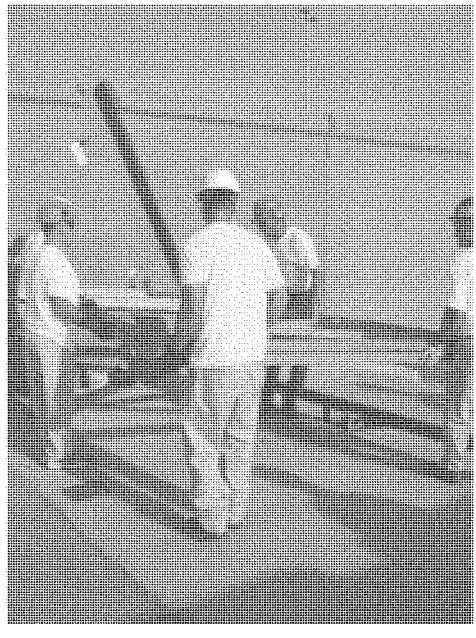


Photo 7.4-20: Installation of trusses during the trial erection of closure at STA 83+92B.

Photo 7.4-21: Trial erection of closure at STA 83+92B. Purlins are installed after all trusses are in place.

Photo 7.4-22: Trial erection of closure at Station 135+22B. Workers have installed all three trusses and are preparing to erect purlins.

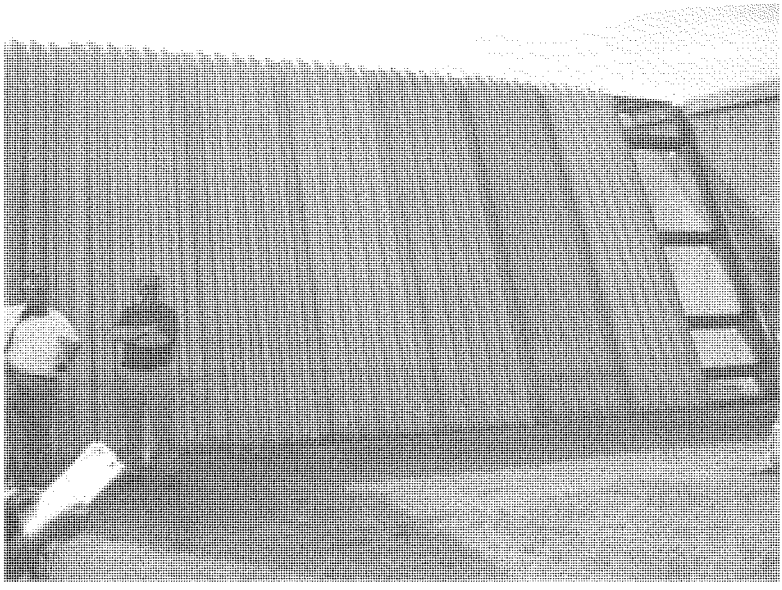


Photo 7.4-23: Trial erection of closure at Station 135+22B is nearly complete.

Photo 7.4-24: Trial erection of closure at Station 126+35B. Work has proceeded to the point where all trusses have been set, all cross-bracing has been installed, and lower purlins are being installed. All structural components for this newer closure are fabricated from aluminum. Note that this closure does not have a slot in the sill.

Photo 7.4-25: Trial erection of closure at Station 126+35B. Viewed from the riverside, workers have installed two panels and are preparing to install the third.

The closure vaults were also inspected during the August 2009 inspections. In general, the vaults were in good condition with only a few minor issues. The metal closure parts stored in the vaults were generally showing some signs of corrosion due to failure of the paint systems. The closure components should be sandblasted and repainted with a paint system meeting current USACE standards. This is noted as an O&M item for the Sponsor.

One closure vault at STA 93+57B did show some signs of water leakage on the left wall and the one at STA 62+84B behind Trans Montaigne that has some drainage issues from the ground which needs to be addressed. It has not damaged the metal parts yet, but there is evidence of previous water infiltration in the bottom of the vault, and corrosion-induced damage to the components is inevitable. Additional more detailed inspections are required to provide specific remedial measures for each vault.

7.4.2. Structural Analysis.

A total of 37 roadway and railroad closures were evaluated using Microsoft Excel and the structural software RAM AdvanSE. This analysis was performed using LRFD design methodologies and incorporated both RAM AdvanSE and the AISC Steel Manual 13th Edition. A flood elevation equal to the top of the wall was assumed. Such a flood is considered an "Extreme" event, and therefore the stability criteria are adjusted to allow a lower factor of safety for this case. For water up to the Design Flood elevation, which is

three feet below the top of the wall, the flood is considered an "Unusual" event. The stability criteria require a higher factor of safety for the "Extreme" case. All of the evaluated closures met the requirements for EM 1110-2-2105 *Engineering and Design—Design of Hydraulic Steel Structures* and EM 1110-2-2705 *Structural Design of Closure Structures for Flood Control Projects.*

7.4.2.1. Conclusions

The 37 closures are judged to be well performing and the evaluation team has a high level of confidence that the City of Paducah would be at very low risk from flooding as a result of any closure issue. The conclusion is based on: 1) The field inspections performed in March and August of 2009; 2) An evaluation of the structural drawings for the closures; 3) A review of the meticulous records kept by the City Engineer and the Floodwall Maintenance crew; 4) the results of the structural analyses discussed above; and 5) interviews with the local sponsor (City of Paducah) regarding the performance of these closures during various floods.

7.4.3. Recommendations for Floodwall Closures.

With the exception of the items in the following subparagraphs, the sponsor is advised to continue the current Operating and Maintenance procedures in regard to the floodwall closures.

7.4.3.1. Permanently Sealing Unnecessary Closures.

Eleven of the original closures were constructed for the passage of railroad tracks. During the inspections, it was noted that the trackage no longer exists through any of these closures; two have already been permanently closed; two more have had their sills raised by two feet; the City of Paducah plans to permanently seal three more. During a high water event, the presence of all of these closures would necessitate that a crew with a mobile crane or other similar equipment be mobilized to install the trusses, purlins and sheeting panels. The former railroad closure at Station 170+04B near Campbell Street is an excellent example of a large closure (41 feet wide) that no longer serves any positive purpose. Additionally the presence of more openings than necessary means more maintenance of closure parts and closure vaults, additional time for inspection and inventory of parts, and during flood events, more opportunities for nuisance flooding to occur. It is recommended that as many of these railroad openings as possible be permanently sealed with reinforced concrete. This item has been identified as one that may prevent the project from performing as authorized after all maintenance, as required by the project operation and maintenance manual and the Code of Federal Regulations, has been accomplished and any deficiencies resulting from a lack of maintenance have been addressed. This item is the result of a significant change in the community being protected.

Also, 14 of the original closures were constructed as service openings. During the inspections it was noted that four of these closures have been permanently sealed. Many of the remaining openings are constructed adjacent to larger openings that used to be used for docking operations that no longer exist. During a high water event, the presence of all of these man sized openings would necessitate that a crew install bulkheads. Additionally the presence of more openings than necessary means more maintenance of closure parts

and closure vaults, additional time for inspection and inventory of parts, and during flood events, more opportunities for nuisance flooding to occur. It is recommended that as many of these service openings as possible be permanently sealed with reinforced concrete.

At Stations 9+44B and 71+74B the metal truss closure systems have been erected in a semi-permanent state. This is not recommended since the metal parts were not designed to withstand long-term exposure to the weather. These two openings should be permanently sealed with reinforced concrete.

In addition to these two, it is recommended that the closures at Stations 4+49B, 31+01.3B, 91+96B, 93+57B, 106+10B and 170+04B be permanently closed with reinforced concrete.

This remediation would require a reinforced concrete panel to be dowelled into the floodwall and depending on the width of the closure, may need additional support. Conceptual details for permanent closures are provided on drawing S-519.

7.4.3.2. Closure Parts and Embedded Metals.

During the inspections, it was noted that the embedded steel and cast iron parts at all of the closures were showing signs of corrosion. These metal pieces should be sandblasted and repainted to protect them from further damage. This process will have to occur in place for all the embedded metal parts on all remaining road and railway closures and nine service openings.

Of particular concern are the anchor recesses at the "New Mural Opening" at 126+85B. There is water almost constantly present in these recesses and it is causing some significant corrosion on the anchorage system. A drainage system for these recesses should be installed or some other means of protecting them from the water should be implemented. At many flood protection projects in the Louisville District the local sponsors fill the anchorage recesses with a mixture of sawdust and motor oil, or a mixture of sand and motor oil. When the closure needs to be erected the filler is removed with a vacuum truck. These systems have been observed to adequately perform the function of protecting the embedded components from corrosion.

In addition to the embedded metal parts, the steel parts for all of the closures are showing signs of corrosion and should be sandblasted and painted as well. The sheeting panels are aluminum and do not show signs of corrosion and do not necessarily need to be repainted at this time. All trusses, purlins, anchorage, and cross bracing parts should be sandblasted and painted to prevent further corrosion. Note that these components are generally at least 50 years old and were originally coated with lead paint. The paint should be removed by sandblasting down to "white metal" prior to application of a new coating system. The sandblasting medium as well as the paint that is removed will have to be disposed of properly. The new paint system should be one of the Corps-approved paint systems. First choice would be to use USACE Paint System 5-E-Z (Vinyl) which should provide in excess of 40 years of maintenance free service. The second choice would be USACE Paint system 21-A-Z be used, with a final coating of Polyurethane.

The closure vault at 62+84B is situated in such a way that there is water ponding in the bottom of the closure vault. This will lead to damaged parts due to accelerated corrosion. The area surrounding this vault should be re-graded in order to correct this water flow problem.

7.4.3.3. Closure Modifications at 83+92B, 75+85B and 25+15B.

The closures at STA 83+92B, STA 75+85B, and STA 25+15B were all modified by the City of Paducah by raising the sills approximately two feet. These changes were done by permit, but the trusses for the removable closures were not modified as shown in the approved permit drawings. T hese closure trusses were analyzed as a part of this Feasibility Study because they have been modified. The structural members themselves can support the design flood; however there is some concern about the bolted connections, particularly on the trusses at 83+92B. The bolt spacing and minimum edge distance can potentially lead to a failure. It is recommended that all the gusset plates or structural members on all three trusses that were moved for the new truss configuration be replaced with new fabricated components in order to ensure proper connections meeting AISC standards. This will affect a total of five trusses.

7.4.3.4. Closure Modifications at 62+84.3 and 83+92B

The closures at these locations either have already been raised (in the case of Sta. 83+92B) or are planned to be raised (Sta. 62+84.3). The existing sills have to be drilled for insertion of grouted reinforcement to bond the new concrete to the original. New truss anchorages need to be installed in the surfaces of the raised sills. The existing steel or aluminum trusses need to be altered to allow the purlins to spread the loads to the abutments. Finally the sheeting panels need to be shortened to fit the new elevation of the sills. Conceptual details for permanently raising the sills are provided on drawings S-501 and S-502, respectively.

7.5. PUMP PLANTS.

There are 12 pump plants on the project. Four of them, Pump Plants #3, #6, #7, and the Island Creek Dam (Plant #11) were designed and constructed to be integral parts of the floodwall and levee system. A detailed series of global stability analyses were performed for each of these pump plants. The remaining pump plants are stand alone structures located on t he protected side of the levee system, and the pump plant buildings themselves do not actually serve as integral pieces of the flood protection system. In fact Pump Plants #4 and #10 are both constructed completely underground.

All of the pump plant structures were inspected as a part of the site inspection in March and again in November of 2009 and were generally found to be in very good to excellent overall structural condition, with no s ettlement or stability issues observed. As such a decision was made by the structural evaluation team to perform stability analyses as a part of this study only on Pump Plants #3, #6, #7 and #11.

It should be noted here that there were numerous other problems observed at the pump plants, but none that were judged to impact the serviceability or overall structural integrity of the buildings. For details of the structural inspections of the pump plants and recommendations for remediation of the problems observed, see paragraphs 7.5.1.1 through 7.5.1.5. For discussion of the pumps, motors, discharge pipes, flapgates and sluice gates, see the Mechanical write up in Section 8 of this Appendix.

7.5.1. Field Inspections.

All pump plants were inspected by a team of Structural Engineers in two separate visits in March and November 2009. In general the pump plant structures were found to be in very good to excellent overall structural condition, with no settlement or stability issues or structural component damage observed. However several problems were repeatedly observed which will require remediation to bring the pump plants up to current standards.

7.5.1.1. Watertightness.

Watertightness of the buildings is one of the most prevalent issues observed. Leakage of rainwater was evident at the interface between the roof and walls at Pump Plants #1, #2, #5, #6, #11 and #12 (see photos 7.5-26 and 27). Although there was no visible evidence of roof leakage within Pump Plants #3 and #9, the roofing material was in a deteriorated condition. Original corrugated, wire-reinforced glass skylight/hatches were found on the roofs of Pump Plants #1, #2, #3, #9, #11 and #12; all of these are in need of replacement (see photo 7.5-28). Cracking of the concrete parapet walls on the Pump plant roofs is also prevalent (see photo 7. 5-29) and is contributing to leakage and long-term deterioration of the buildings. No flashing could be observed around the roofing material on the roofs and the roofing material is typically separating from the concrete parapets, allowing rainwater to reach the underlying concrete roof (see Photo 7.5-30).

As part of the project reconstruction, a general roofing and parapet wall rehabilitation program should be developed and undertaken at all pump plants. This program would include:

- Removal of damaged concrete on the parapet walls, and replacement with new concrete, followed by application of pressure injected epoxy crack filler, and then followed by application of a surface sealant that is resistant to ultraviolet light.
- Replacement of all corrugated wire-reinforced glass skylights/hatches with new watertight permanent closures.
- Installation of flashing to direct rainwater towards newly installed roofing material to prevent rainwater from leaking into the interface between the concrete roof and the building walls.
- Replacement of roofing material.

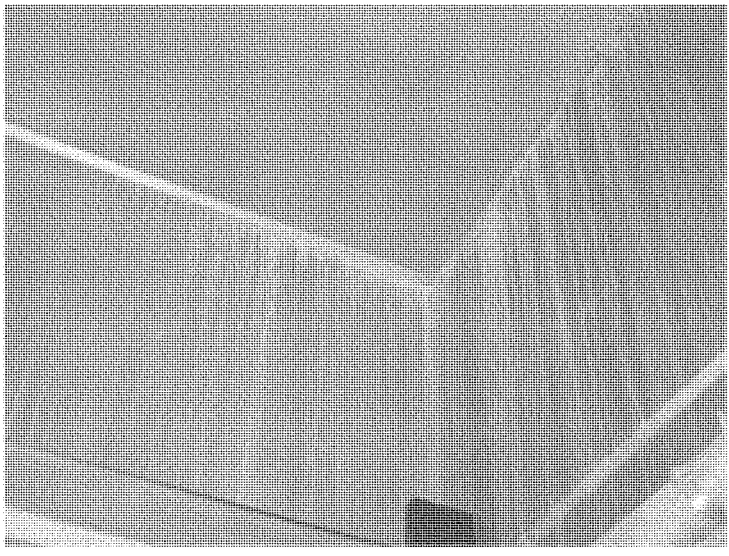


Photo 7.5-26: Leakage evident at interface between roof and wall at Pump Plant #5 is typical of many pump plants.

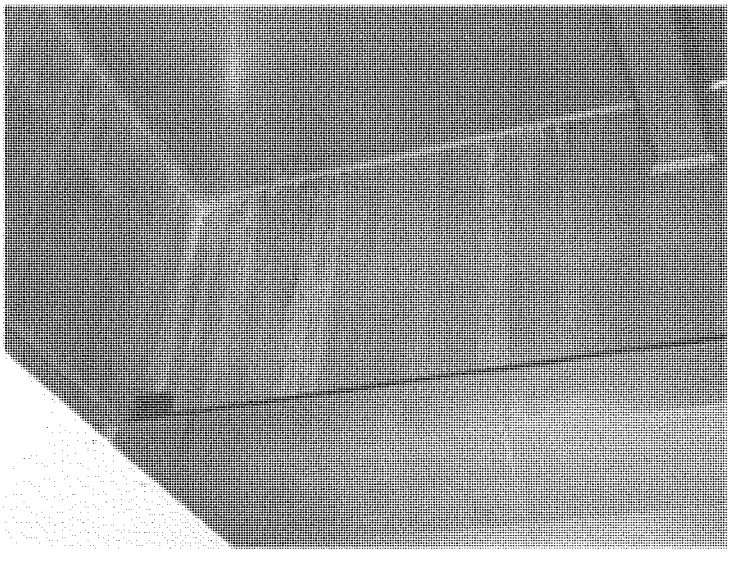


Photo 7.5-27: Leakage evident at interface between Roof and wall at Pump Plant #12. This is a commonly observed phenomenon and is associated with poor condition of roofing materials, lack of flashing and cracking of the parapets.

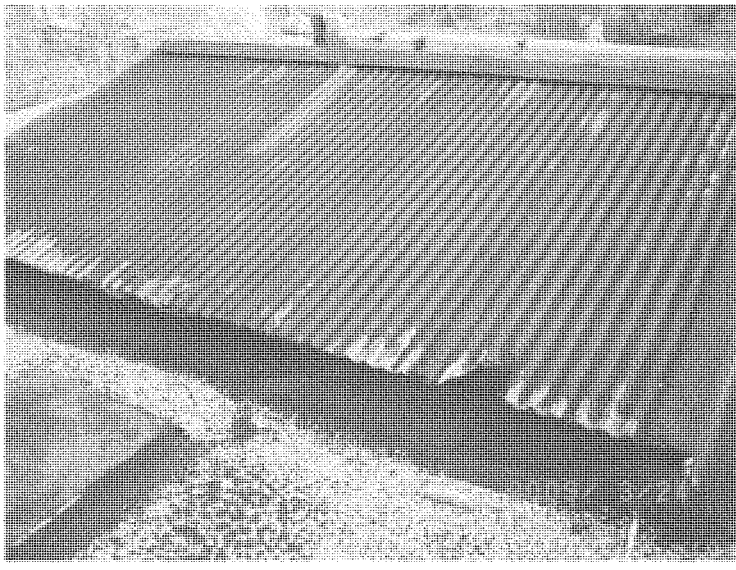


Photo 7.5-28: Original wire-reinforced corrugated glass skylight/hatch at Pump Plant #12 is typical of hatches that need to be replaced on the roofs of several pump plants.

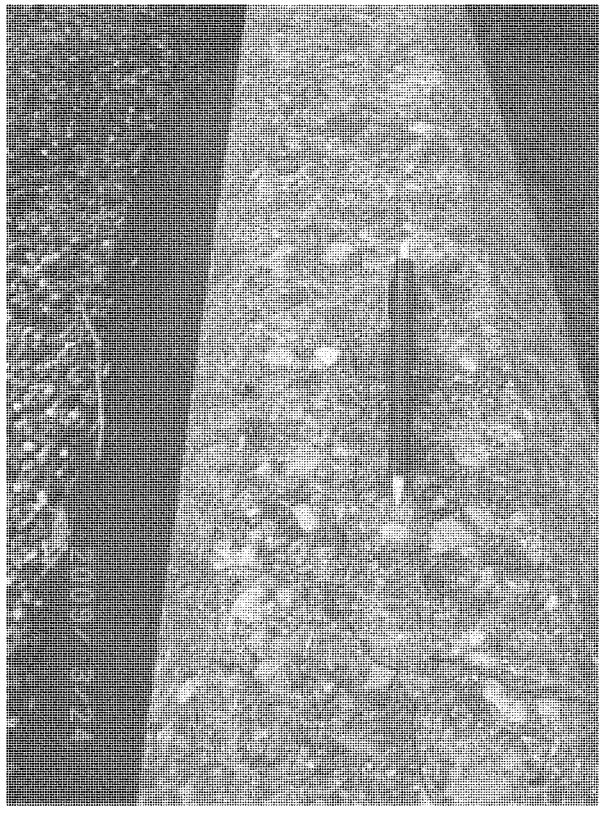


Photo 7.5-29: Cracking on the parapet wall at roof of Pump Plant #12 is typical of cracking found on many pump plant parapets and should be repaired.

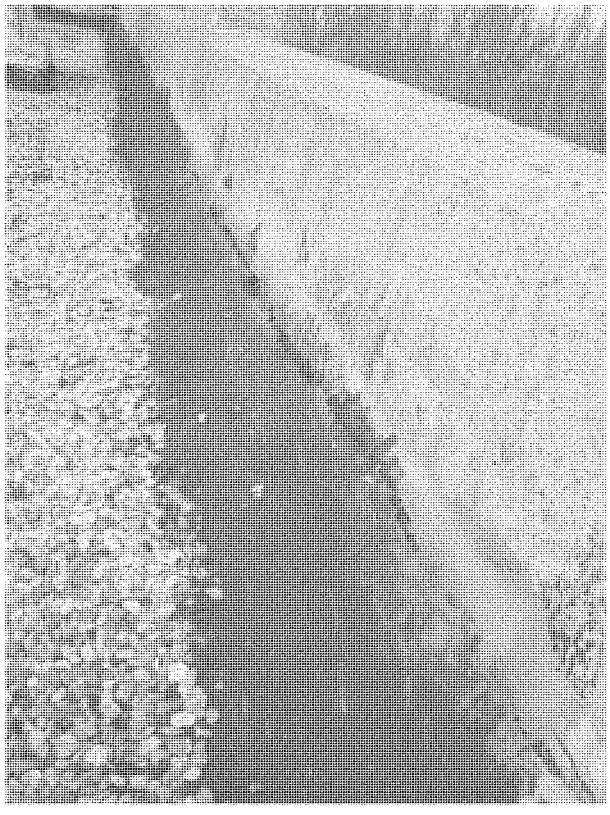


Photo 7.5-30: Roofing material on Pump Plant #2 is pulling away from concrete and no flashing is visible. This condition is common and corresponds to leakage staining observed inside building at several pump plants.

7.5.1.2. Trash Rack Replacement.

Trash Racks at almost every pump plant are in need of rehabilitation or replacement. Although it was reported that the local sponsor fabricated new trash racks and painted them, the paint systems are failing on almost every trash rack observed, with heavy section loss evident at Pump Plants #2, #7 and #12 (see Photos 7.5-31, 32 and 33). Additionally the spacing between the individual vertical bars appears to be wider than the current standard of two inches. Spacing between rack sections was excessive in many locations (see Photo 7.5-34). The risk is that during a flood event a large piece of wood or other oversized debris could get sucked into the impellers, damaging or even destroying the pumps. More detail on issues regarding trash rack replacements can be found in the Mechanical write up in Section 8 of this Appendix. This work is considered a reconstruction item.

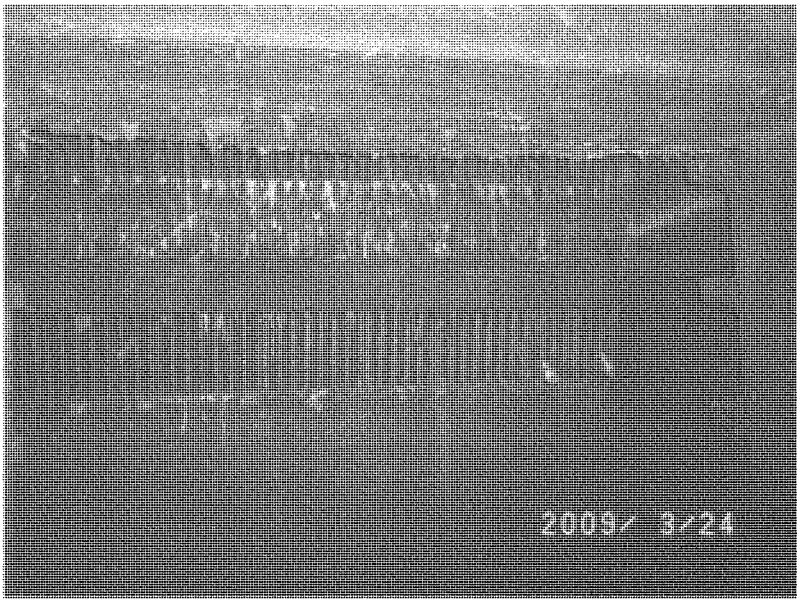


Photo 7.5-31: Trash Racks at Pump Plant #2 are clogged with debris and heavily corroded with notable section loss.

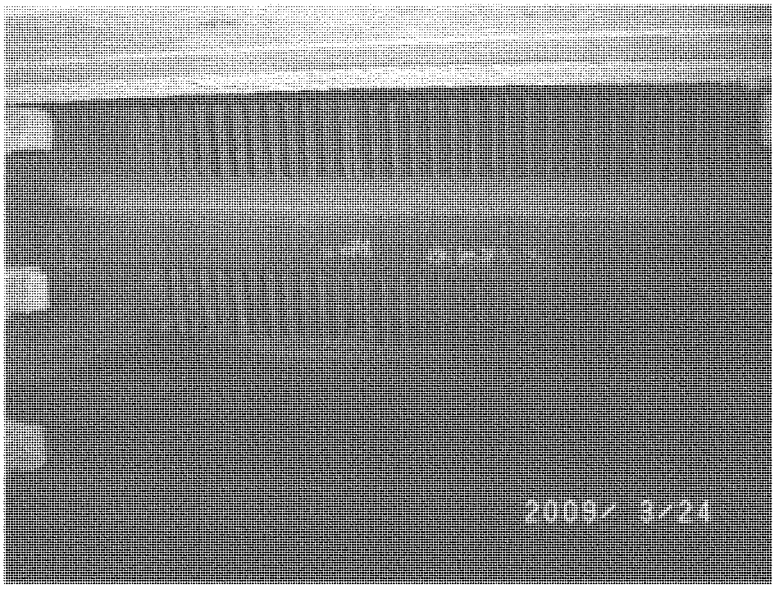


Photo 7.5-32: Trash Racks at Pump Plant #7 have no protective coating and are heavily corroded with notable section loss.

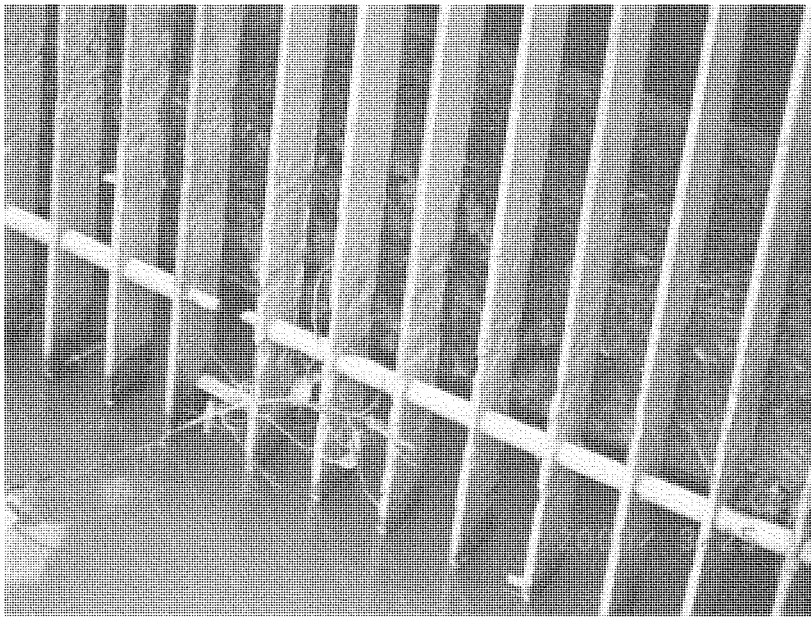


Photo 7.5-33: Bottom four feet of Pump Plant #12 Trash Rack has corroded with notable section loss. Also note the excessive spacing between bars.

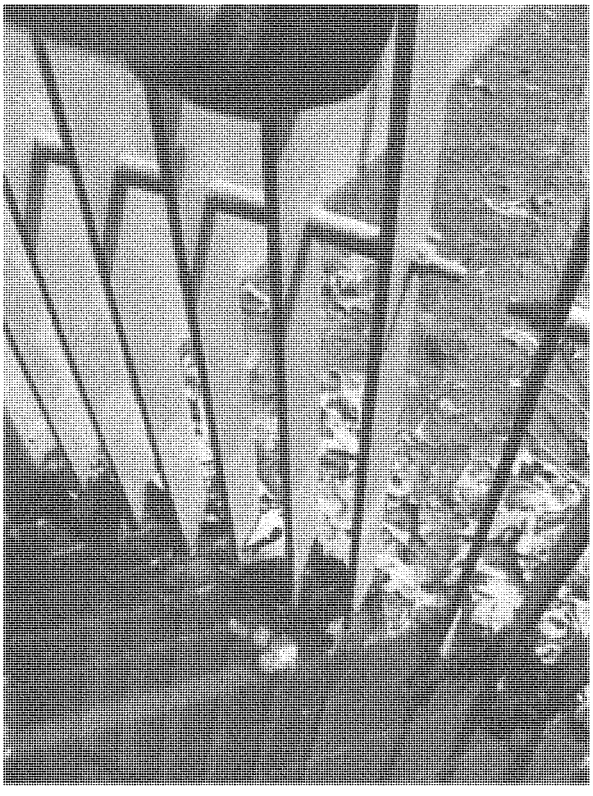


Photo 7.5-34: Excessive spacing between individual vertical bars and between adjacent trash racks – this photo is taken at Pump Plant #1.

7.5.1.3. Discharge Chamber Access Grating System Replacement.

In Pump Plants #3, #5 and #6 the pumps discharge through pipes that empty into discharge chambers that are monolithic parts of the pump plants. Access to these discharge chambers is necessary in order to maintain and inspect the flap gates. Access is accomplished via a ladder down from the top. In order to reach the ladders in each plant, it is necessary for workers to walk across a series of steel grates. The grates are in turn supported by steel structural angles that are mounted on anchor bolts. The ladders had been replaced at each of the plants and the gratings all appeared to be in good condition, with no visible section loss and good paint coatings. The support angles and their appurtenant anchor bolts in general were undergoing corrosion (see Photos 7.5-35 through 37) and should be replaced by new support angles with higher section moduli and by a more redundant series of new anchor bolts. This is considered to be a reconstruction item.

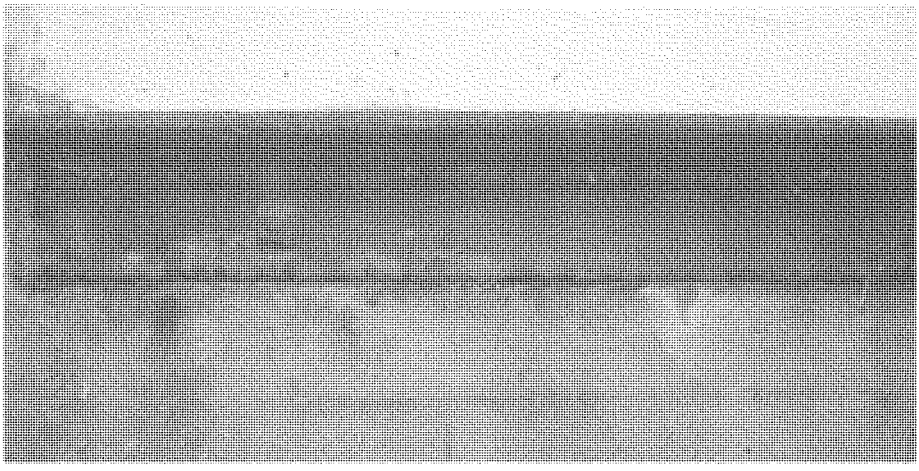


Photo 7.5-35: Support angle for grating over discharge bay at Pump Plant #6 is typical of support angles. Paint system has failed, and corrosion is prevalent. Replacement is needed and more redundancy is necessary for the anchor bolts.

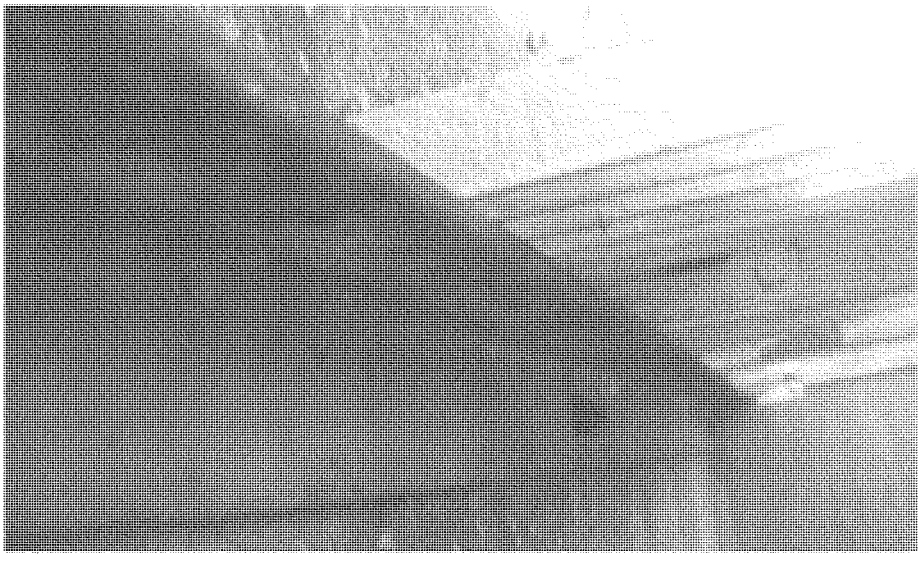


Photo 7.5-36: Support angle for grating over discharge bay at Pump Plant No. 3 is typical of support angles. Replacement is needed and more anchor bolts should be provided for redundancy.

Photo 7.5-37: Support angle for grating over discharge bay at Pump Plant #5 is typical of support angles. Replacement is needed due to corrosion of both the angles and the anchor bolts. Additional anchor bolts should be provided for redundancy.

7.5.1.4. Access Hatch Replacement.

At Pump Plants #2 and #11, the general condition of all cover plates and associated hardware, fittings and support angles can be characterized as being in poor condition due to corrosion (see Photos 7.5-38 through 40). These items are all in need of immediate replacement as they represent significant safety hazards. This is considered to be a reconstruction item.

Photo 7.5-38: The cover plate, hinges and support angles for the Pump No. 1 sluice gate and flap gate access should all be replaced at Pump Plant #11. This is typical at other locations in this pump plant.

Photo 7.5-39: Detail of the rust packing evident under the support angle for a sluice/flap gate access hatch at Pump Plant #11.

Photo 7.5-40: Trash Rack access cover plate in highly deteriorated condition at Pump Plant #2.

In Pump Plant #9 the ladder from the motor floor down to the pump floor does not meet current standards and should be replaced with a modern ladder that meets current safety requirements (see Photo 7.5-41). The access hatch lid has a broken hinge (see Photo 7.5-42) and consideration should be given to a complete replacement of the lid, seats and support angles. This is considered to be a reconstruction item.

Photo 7.5-41: Access Ladder at Pump Plant #9.

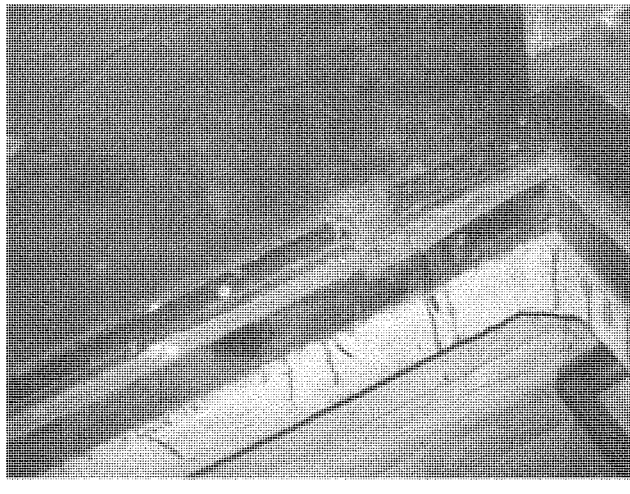


Photo 7.5-42: Access ladder cover plate hinge has broken and is generally in deteriorated condition at Pump Plant #9.

7.5.1.5. Pump Plant Safety.

Pump Plants #4 and #10 are both underground structures, accessible only by manhole (see Photo 7.5-43). It was noted during the inspection of Pump Plant #10 that entry was not possible without violating numerous safety standards outlined in Corps of Engineers EM 385-1-1. When descending the ladder from the surface, the climber is located over the lower level of the plant, a distance of greater than 20 feet below the surface (27 feet according to drawing 934-12.7/25), and there is no climbing device or protective cage (see Photo 7.5-44). Additionally a side step from the ladder to the motor flood platform is required when entering the plant. The plant is also a co nfined space, and special ventilation and air monitoring equipment are necessary when workers enter this work place. The very tight working spaces (see Photo 7.5-45) make operation of this pumping plant difficult and hinder workers from performing their duties to the highest standards. Additionally the steel "can" that makes up the substructure of the pump plant is showing signs of corrosion – the paint system is failing (see Photo 7.5-46). A dditionally, the motor floor supports are in poor condition (see Photo 7.5-47).

Photo 7.5-43: Exterior View of Pump Plant #10.

Photo 7.5-44: Access into Pump Plant #10 is down a long, unbroken ladder. It is also a confined space and requires continuous air monitoring; note that air monitoring is being performed in this photo.

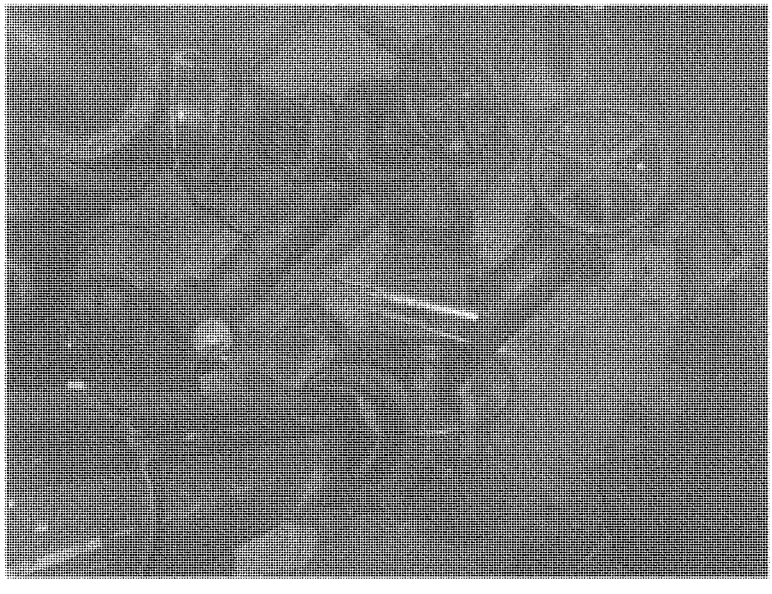


Photo 7.5-45: Looking down at the highly congested work space on the pump floor within Pump Plant #10.

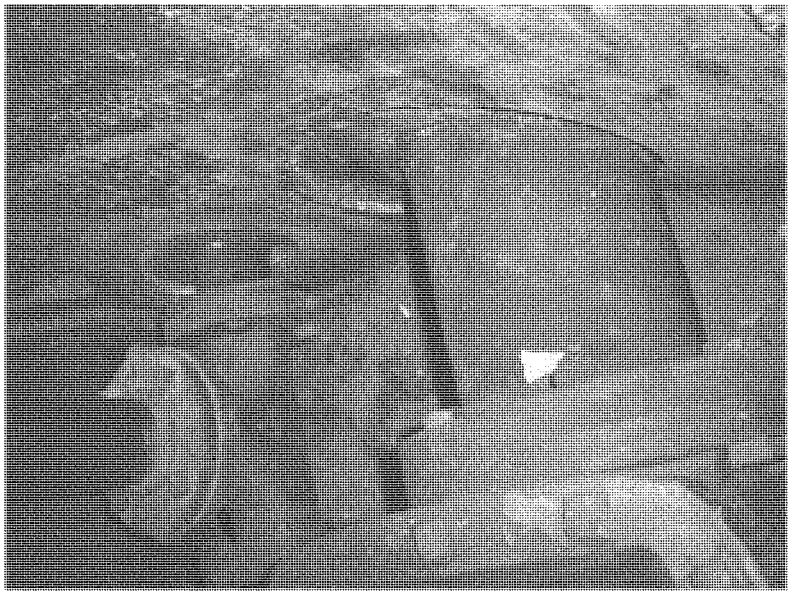


Photo 7.5-46: The paint system is failing everywhere on the structural steel liner within Pump Plant #10.

Photo 7.5-47: The structural supports for the motor floor are corroding within Pump Plant #10.

7.5.2. Pump Plant Stability and Strength Requirements.

Pump Plants #1, #2, #4, #5, #9, #10 and #12 are all structures that are not integral with the line of protection for the City of Paducah. All have been in place for at least 50 years, and are in very good to excellent structural condition, with no stability or settlement issues. Because they have performed well and do not undergo differential loading other than wind, snow and seismic loading, they were analyzed for seismic loads only. A discussion of those analyses is included in paragraph 7.5.4.1 of this Feasibility Report.

Pump Plants #3, #6, #7, and #11 were designed and constructed as integral parts of the line of protection. The stability of Pump Plants #3, #6, #7, a nd #11 were analyzed in accordance with EM 1100-2-2100, *Stability Analysis of Concrete Structures,* dated 01 December 2005. This document provides guidance for the evaluation of many types of structures, and includes specific guidance in regard to pump plants. The safety factors provided in the referenced manual are "based on the assumption that for critical and normal structures, the strength of the materials in the foundation and structure has been conservatively established through explorations and testing. This may not be the case for older existing structures, or, if adequate explorations and testing were performed, the records may not be available. When the stability of an existing structure is in question, a phased, systematic approach to evaluating stability should be performed before any remedial actions are undertaken to improve stability." These four pump plants (#3, #6, #7, and #11) are considered "Critical Structures." Structures designated as "Critical" are those structures on hi gh hazard projects whose failure will result in loss of life. These pump plants are considered critical structures because if a stability related failure occurs, a breach could result, leading to partial inundation of the City of Paducah.

As detailed in Section 4 of this Feasibility Report, eight new soil borings were drilled for this Feasibility Study, and all were followed by geotechnical laboratory testing. Many borings were drilled for the original project, and although lab testing was not found for those older borings, there is a large quantity of those borings. Additionally soil boring data for several non-USACE projects located near the floodwall were provided by the Sponsor. All of these sources, taken together with the more detailed new soil boring information, provide an "ordinary" level of site information.

Required Factors of Safety for Sliding and Flotation are in Tables 7.5-9 and 7.5-10, respectively (from Chapter 3 of EM 1100-2-2100. The load cases to be analyzed are in Table 7.5-11.

TABLE 7.5-9: Required Factors of Safety for Sliding - Critical Structures

***Load Condition Categories* Site Information Category**	**Usual**	**Unusual**	**Extreme**
Well Defined	1.7	1.3	1.1
Ordinary	2.0	1.5	1.1
For preliminary seismic analysis without detailed site-specific ground motion	-	1.7	1.3
Limited	-	-	-

TABLE 7.5-10: Required Factors of Safety for Flotation – All Structures

Load Condition Categories Site Information Category	Usual	Unusual	Extreme
All Categories	1.3	1.2	1.1

TABLE 7.5-11: Pumping Plant Loading -Condition Classification Structure Type: Pumping Plants, EM 1110-2-3104

Load Case	Loading Description	Classification
4-4a	Construction Condition	UN
4-4b	Normal Operating Condition	U
4-4e	Maximum Design Flood (MDF)	U/UN/E
4-4f	Maximum Pump Thrust	U/UN/E
4-4g	Maintenance Condition	UN
4-4j	Pumping Plant Inundated	E
4-4k	Coincident Pool + Operating Basis Earthquake (OBE)	UN
4-4l	Coincident Pool + Maximum Design Earthquake (MDE)	E

Load Cases:
Appendix B ("Loading Conditions and Loading-Condition Classification") from EM 1110-2-2100 includes the following description of load cases to be analyzed for pump plant structures. The "Construction Condition" load case in the Manual has been omitted from the Feasibility Analysis since these are existing structures.

(b) Loading Condition 4-4b - Normal Operating Condition.
- Plant operating to discharge routine local floods over a range of exterior flood levels with a maximum 2-year return period.

(c) Loading Condition 4-4e - Maximum Design Flood.
- Maximum water level outside protection line.
- Minimum pumping level inside.

(d) Loading Condition 4-4f - Maximum Pump Thrust.
- Maximum operating floods both inside and outside protection line.
- Maximum pump thrust.

(e) Loading Condition 4-4g - Maintenance Conditions.
- Maximum design water level inside.

- One, more, or all intake bays unwatered.

(f) Loading Condition 4-4j - Pumping Plant Inundated.
- Maximum flood levels inside and outside protection line.
- Pumping plant inoperative.
- Foundation drains inoperative.
- Protection line intact.

(g) Pool + OBE.
- Coincident pool
- OBE in most critical direction.

(h) Loading Condition 4-4l- Coincident Pool + MDE.
- Coincident pool
- MDE in most critical direction.

Pump Plant #3 incorporates a sheet pile cutoff below the building foundation. For the global stability analysis, it was found that the sheet piling would need to be effective in reducing the seepage through the sheet interlocks to reduce the uplift pressures on the structure by approximately 95%. The design team felt confident in this assumption. The only reason to assume a smaller uplift reduction would be if the sheet piling had become severely corroded with 100% section loss in multiple locations. This scenario cannot be checked without excavating below the pump plant. However the designers do not feel this is necessary as the sheet piling is not exposed to oxygen due to relatively high water table.

The high water table was confirmed in both the new geotechnical borings and a study of Soil Conservation Service reports for the local soils. Resistance to uplift was an important and complex issue in the Pump Plant Stability analysis; the reviewers utilized the following text from Chapter 7 of the referenced EM: "To avoid unnecessary modifications, all types of resisting effects, including those described below, should be considered. These include vertical friction, side friction, or three-dimensional effects." Side friction between the pump plant backfill and the walls was computed by multiplying the lateral earth load (assuming at-rest pressures) on each side of the building perimeter by the coefficient of friction of a concrete/earth interface.

7.5.3. Soil Properties Assumed for Analysis.

The soil properties provided by CELRL-ED-T-G for use in the Feasibility analyses can be found in Section 4, Table 4.4 of this appendix.

7.5.4. Structural Analyses.

Pump Plants #3, #6, #7 and #11 were evaluated with respect to global stability, using standard two-dimensional analyses. Pump Plants #7 and #11 met or exceeded the requirements for sliding, flotation, overturning and bearing capacity in their present

configurations with no alterations. This is documented in Table 7.5-12. However the other two pump plants failed to meet one or more of the requirements. All of the analyses assumed that the toe drains on the landside of each plant are 50% effective. In order for this assumption to be realistic, replacement or rehabilitation of the existing toe drains in the areas of these pump plants will have to be accomplished. However because hydrostatic uplift is the primary contributing factor in the failure of Pump Plants 3 and 6 to meet current stability criteria, new toe drains that are both deeper and larger than the original drains will have to be provided for them. An additional step that should be considered is to perform three-dimensional stability analyses of Pump Plants 3 and 6. Finally it is recommended that discussions with USACE Headquarters personnel be undertaken during the next phase of study to determine whether the assumptions used in the Feasibility Study stability analyses were too conservative.

TABLE 7.5-12: Pump Plant Stability Analysis Results

Requirement	Value Required	P.S. 3 Analysis Result	P.S. 6 Analysis Result	P.S. 7 Analysis Result	P.S. 11 Analysis Result
Sliding	2	Fail	Fail	Pass	Pass
Flotation	1.3	Pass	Fail	Pass	Pass
Resultant Location (Overturning)	75% of Base in Compression	Pass	Pass	Pass	Pass
Bearing Capacity	3	Pass	Fail	Pass	Pass

7.5.4.1. Seismic Stability.

As previously discussed in paragraph 7.3.4.4, a seismic analysis was performed for the project. Seismic forces were developed using pseudo statically-derived accelerations. The resulting seismic forces were compared to the flood-induced water and/or soil forces applied to the pump plant structures. Recalling that the seismic loads were not imposed simultaneously with the flood loads, it was determined that the seismic loads were actually lower than the flood loads. Since the seismic loads were smaller, seismic load cases did not control the stability or structural analyses of the pump plants.

Seismic analyses can be found in Volume 4 of this Report.

Although seismic loads do not control the stability of the pump plants, it is recommended that evaluations in accordance with the publication *"Seismic Evaluation of Existing Buildings"* (ASCE 31-03) be performed for each *typical* pump plant building prior to commencing any remedial work on or in the buildings. All of the pump plant buildings (with the exceptions of Pump Plants 10 and 13) are robustly constructed of reinforced concrete, and all have their entire structural systems exposed to view. It was noted previously in paragraph 7.5.1 of this Appendix that no structural deficiencies were observed in any pump plant during the Feasibility Study process. Because of the robust

reinforced concrete walls - which are generally thicker than required from a structural support basis - it is also expected that none of the pump plants' structural systems will require seismic remediation. However it is the opinion of the Structural Design Team that the project's proximity to the New Madrid fault area, combined with the age of the project, mandates this extra step in the evaluation process.

7.5.5. Conclusions and Recommendations for Pump Plants.

With the exception of the items in the following subparagraphs, the sponsor is advised to continue the current Operating and Maintenance procedures in regard to structural issues in the Pump Plants.

7.5.5.1. Pump Plant Safety.

It is recommended that the configuration of Pump Plant #10 be revised. The existing pumps should be replaced with removable submersible pumps. The two new pumps would be connected to the existing intake and discharge piping. All components within the existing underground pump plant should be demolished, and the existing exterior steel "can" that forms the pump plant walls should be used as a stay-in-place exterior concrete form for the construction of new reinforced concrete walls. Access to the pump floor should be provided with new ladders with safety cages and an intermediate landing. The top of the existing buried pump plant should be modified with access hatches that would allow removal and maintenance or replacement of the new submersible pumps. Specific recommendations regarding the pumps are included in the Mechanical portion of this Report. A concept of the proposed revised configuration is shown on drawing S-512. Replacement of this plant with a s tructure that meets current safety and operations standards will allow the project to perform as authorized after all maintenance, as required by the project operation and maintenance manual and the Code of Federal Regulations, has been accomplished and any deficiencies resulting from a lack of maintenance have been addressed. T he safety and operations issues associated with Pump Plant #10 are major performance deficiencies caused by a change in the standards of acceptability and safety for engineering systems.

In Pump Plants #5, #6 and #7 the pumps discharge through pipes that empty into discharge chambers that are monolithic parts of the pump plants. Access to these discharge chambers is necessary in order to maintain and inspect the flap gates. Access is accomplished via a ladder down from the top. In order to reach the ladders in each plant, it is necessary for workers to walk across a series of steel grates. The grates are in turn supported by steel structural angles that are mounted on anchor bolts. The ladders had been replaced at each of the plants and the gratings all appeared to be in good condition, with no visible section loss and good paint coatings. The support angles and their appurtenant anchor bolts in general were undergoing corrosion and should be replaced by new support angles with higher section moduli and by a more redundant series of new anchor bolts.

Additionally all pump plants with access cover plates should have them individually evaluated to check for corrosion and section loss of the support elements, including the hinges, the checkered or flat cover plates themselves, the support angles and any stiffeners. Consideration should be given to complete replacement of all gratings as well

with upgraded, heavier grating with deeper sections. Additionally the support angles should be replaced with support angles that have higher section moduli. Additionally more anchor bolts should be installed for each support angle to provide some redundancy in the event of section loss.

Most of the original ladders have been replaced by the local sponsor but some are still in service. Replacement of alternate step ladders such as those found in some access pits should be undertaken.

7.5.5.2. Miscellaneous Pump Plant Issues.

Most of the pump plants originally had wire-reinforced corrugated glass skylights. Skylights were observed on the roofs of Pump Plants #1, #2, #3, #9, #11 and #12. As a result of excessive ultraviolet light and heat gain, all were coated with asphaltic roofing material at some time in the distant past. Now some of these skylights are broken and leaking. It is recommended that all of these original skylights be removed and replaced with permanent closures.

Leakage of rainwater was evident at the interface between the roof and walls at several of the pump plants. Cracking of the concrete parapet walls on the pump plant roofs is also prevalent and is contributing to leakage and long-term deterioration of the buildings. No flashing could be observed around the roofing material and the material is being separated from the concrete parapets, allowing rainwater to reach the underlying roof. In general a rehabilitation program for the roofing, roof hatch and parapet walls should be developed and undertaken at all pump plants except #4, #10 and #13. This program would include:

- Removal of damaged concrete on the parapet walls, and replacement with new concrete, followed by application of pressure injected epoxy crack filler, and then followed by application of a surface sealant that is resistant to ultraviolet light.
- Replacement of all corrugated wire-reinforced glass skylights/hatches with new watertight permanent closures.
- Installation of flashing to direct rainwater towards newly installed roofing material to prevent rainwater from leaking into the interface between the concrete roof and the building walls.

The intake trash racks and supporting purlins for all pump plants (with the exception of Pump Plant #1) are in need of replacement due to bar spacing and corrosion issues.

7.5.5.3. Summary of Pump Plant Reconstruction Items.

Drawings are presented which summarize the miscellaneous replacements required for each pump plant, all of which are considered to be reconstruction items: sheet S-504 for Pump Plant (PP) No. 1; sheet S-505 for PP No. 2; sheet S-506 for PP No. 3; sheet S-507 for PP No. 4; sheet S-508 for PP No. 5; sheet S-509 for PP No. 6; sheet S-510 for PP No. 7; sheet S-511 for PP No. 9; sheet S-513 for PP No. 11; and sheet S-514 for PP No. 12.

Pump Plant #8 is no longer in service. Pump Plant #13 had no structural reconstruction items.

7.6. SLUICE GATES, FLAP GATES and GATEWELLS.

There are numerous cast-in-place concrete gatewells housing either sluice gates or flapgates on the project. The sluice gates and flap gates associated with the gatewells were all evaluated as a part of the March 2009 site inspections; for details and photographs of the inspection of the gatewells, sluice gates and flap gates, see the Mechanical write up in Section 8 of this Appendix. The concrete gatewell structures themselves were generally found to be in very good to excellent structural condition, with the exception of the unique Bee Branch sluice gate control structure (see paragraph 7.6.1 for discussion of this structure).

7.6.1. Bee Branch Sluice Gate Control Structure Replacement.

There are unique discharge structures located at Bee Branch at Stations 32+12 and 32+38 in Section "C" of the project. The two sluice gate structures are tied together by an overhead access walkway. The structural steel platform was designed to allow flood emergency workers to work from an elevated position to operate the sluice gates (see Photos 7.6-48 through 52). Problems noted included corrosion of all major structural members; corrosion of walkway support angles; an unsafe ladder; hand railing that does not meet current safety requirements; insufficient working space on the platform; and substandard safety equipment. This entirety of both structures should be replaced with modern reinforced concrete structures meeting all current safety standards. This work is considered to be a reconstruction item. A conceptual layout of appropriate replacement structures is presented on sheet S-517.

Photo 7.6-48: Bee Branch sluice gate frames at Station 32+12C and 32+38C are unique but do not meet current standards.

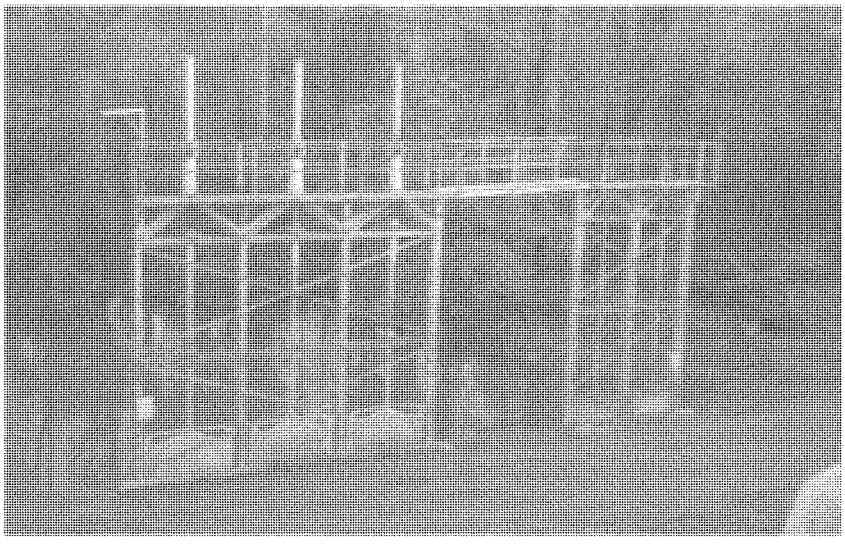


Photo 7.6-49: Bee Branch sluice gate structures with access platform.

Photo 7.6-50: The protective paint coating system on the Bee Branch sluice gate frame is failing and significant corrosion is occurring. Fall protection handrails on the access platform do not meet current standards.

Photo 7.6-51: The access walkway support angles on the Bee Branch sluice gate frames have suffered complete section loss in several locations around bolt holes. The major structural members are all undergoing significant corrosion. The access ladder rungs are also undergoing corrosion. This entire structure is a safety hazard.

Photo 7.6-52: Structural bracing members on the Bee Branch sluice gate frame were field modified to allow installation of a staff gage.

7.6.2. Woodward Hollow Gatewell.

At Station 19+11 in Section "B" of the project there is a need to construct a new gatewell. The existing 66-inch diameter pipe has recently been slip-lined to a new inside diameter of 54-inches. Hydraulic analysis was performed and it was determined that the risk of flooding during a design flood event was high enough that a sluice gate structure should be constructed. The gatewell structure should be sited approximately mid-way between the levee crown and the riverside toe. A reinforced concrete structure with both an exterior access ladder and an interior maintenance and inspection ladder should be provided. A motor operator should be provided on t he top of the structure. A recommended configuration for the 10-foot by 7-foot by 46-foot high structure is presented on sheet S-518. This work is considered to be a reconstruction item.

7.7. PROPOSED PUMP PLANT #14 AT STA 111+67A.

7.7.1. Design Criteria.

Feasibility level designs for two different optional pump plant configurations have been completed. One configuration assumes that a vertical column pumps will be employed. The other optional configuration assumes that submersible pumps will be used. The layout of the two configurations was developed by the project Mechanical Engineer.

Computations of the structures' stability were utilized to develop wall and slab thicknesses. Estimates of the concrete and other material quantities were completed.

7.7.2. Stability and Strength Requirements.

The criteria used to analyze the pump plant stability are based on E M1110-2-2100, *Stability Analysis of Concrete Structures* and EM1110-2-3104, *Structural and Architectural Design of Pumping Stations*. The proposed pump plant is considered a critical structure and the design flood case is, by definition, an unusual load condition and the soil information was considered to be "ordinary". The Required Factors of Safety for Sliding and Flotation are outlined in Tables 7.5-9 and 7.5-10, respectively, in an earlier section of this Appendix. These tables are excerpted from Chapter 3 of EM 1100-2-2100. The load cases to be analyzed were outlined in detail previously in Table 7.5-11.

It is noted that the stability requirements based on EM 1110-2-3104 are more stringent than those in the newer EM 1110-2-2100; however the Transmittal letter accompanying EM 1110-2-2100 states the newer document was developed to "provide adequate safety factors for all types of structures and loading conditions, while reducing excess conservatism for infrequent loadings of short duration. This will result in project cost savings when compared to some structures designed using previous criteria. Stability criteria in other manuals are being revised to be consistent with this manual. In the interim, where there are conflicting stability criteria, the provisions of this manual shall govern."

As detailed in Section 4 of this Appendix, new soil borings were drilled specifically at the proposed pump plant site for this Feasibility Study, and all were followed by geotechnical laboratory testing. The site information is therefore considered "Ordinary."

Both of the two proposed optional layouts have been designed to the Feasibility level without sheet pile cutoffs or toe drains. Global stability is achieved by increasing the structural mass to resist external loads. A high water table was assumed to the ground surface on the protected or resisting side of the plant, even though it was also assumed that the pump bay was only full up to the minimum pump elevation. Thus the analyses are conservative.

7.7.3. Soil Properties Assumed for Analysis.

The soil properties provided by CELRL-ED-T-G for use in the Feasibility analysis can be found in Section 4, Table 4.4 of this appendix.

7.7.4. Structural Description.

Both configurations consist of reinforced, cast-in-place concrete substructures – which include the pump bays, walls and building floor slabs and, for the vertical column pump configuration only, entrance wing walls. Shallow foundations were recommended by the Geotechnical Section, and were assumed in the stability analyses. Each configuration is assumed to have a superstructure building constructed of reinforced CMU block with

roofing made from precast decking and built up roofing. Each pump plant configuration includes structural steel trash racks, assumed to be fabricated from steel bars a minimum of 3-inches deep, spaced no f urther than 2-inches center-to-center, and galvanized. Conceptual drawings for the Vertical Column Pump and Submersible Pump options are presented on sheets S-515 and S-516, respectively.

7.8 DISCHARGE PIPES

7.8.1 Condition Assessment and Rehabilitation of Existing Gravity Discharge Pipes

Between the dates of November and December of 2007, 60 gravity discharge pipes were video inspected by a specialty contractor. A Final Inspection Report was received by the City of Paducah in December 2008. D igital copies of all the pipe inspection videos, inspection reports, and still pictures can be found in Volume 4 of this Feasibility report. Additionally Volume 4 includes a summary table of the field inspections. This table is a data sheet on the pipes (containing pipe type, size, depth in embankment, etc) with the results of the condition assessments for each of the existing gravity drainage pipes. Based on t he video pipe inspections, the pipes were assigned condition codings in accordance with the National Association of Sewer Service Companies' (NASSCO) Pipeline Assessment Certification Program (PACP). There are five PACP defect grades are shown in Table 7.8-13,

Table 7.8-13. PACP Defect Grades

Grade	Description	Estimated Time to Failure
1	EXCELLENT: Minor Defects.	Unlikely in the foreseeable future
2	GOOD: Defects that have not begun to deteriorate.	20 years or more
3	FAIR: Moderate defects that will continue to deteriorate.	10 to 20 years
4	POOR: Severe defects that will become grade 5 defects within the foreseeable future.	5 to 10 years
5	IMMEDIATE ATTENTION: Defects requiring immediate attention.	Has failed or will likely fail within the next 5 years

Many of the pipes on this project were found to have a defect grade of "5". Using the PACP coding system and the video reports on the pipes, the engineering team determined that the safe and reliable level of protection of this flood protection system is basically equal to the height at the toe of the levee which, corresponds to the invert of these drainage pipes. Based on this and the poor condition of many of the other pipes, USACE

and the local sponsor jointly decided that all corrugated metal pipes (CMP's) should be rehabilitated. This decision was based on the age of the pipes (greater than 60 years) and the latest Corps guidance in EM 1110-2-2902, which allows CMP's for rural levees only. Based on these criteria, it was determined that 37 CMP pipes (of the total 60 pipes that were video inspected) required rehabilitation. A contract was let in 2008 which specified four allowable methods for sliplining. The sliplining of the thirty-seven CMP's was completed in December, 2009. A final inspection video of these pipes is also provided in Volume 4 of this Feasibility Report to provide a baseline of the pipes' conditions when the construction efforts were complete.

Both the replacement pipes specified by the City of Paducah and the four different methods of installation permitted by the construction Contract meet current USACE engineering standards and specifications. The sliplining of these 37 pipes is considered a reconstruction item.

7.8.2 Condition Assessment of Discharge Pipes from Pump Plants

Based on the observed levels of deterioration at Pump Plants #1, #2, #3, #5, #6, #7 and #12, it is recommended that the discharge pipes be replaced. For detailed information on the replacement of these discharge lines, reference paragraph 8.2.2 of Section 8 in this Appendix. The replacement of these discharge pipes is considered a reconstruction item.

All other discharge pipes will be video inspected during PED. Based on District experience with numerous similarly designed and constructed pump plants of similar age that carry only storm drainage, it has been assumed that the discharge pipes associated with pump plants that handle only storm drainage do not require replacement. These pipes are typically cast iron or steel.

7.9. FURTHER STUDIES, TESTS, AND ANALYSES AFTER THE FEASIBILITY PHASE.

There are four significant structural items that should be completed after the Feasibility Phase:

- It is recommended that at the location where significant differential movement has been observed between T-Walls in Section "B" of the project, an excavation be performed to evaluate the condition of the floodwall components below grade. This should be accomplished for a pair of monoliths where a large magnitude of differential movement has been measured. This was discussed previously in paragraph 7.3.5.4 in this section of the Appendix.
- It is recommended that a more detailed geotechnical exploration and laboratory testing program be undertaken in the near future for the soils in the I-Wall

locations. The requirements for this are detailed in EC 1110-2-6066. This was discussed previously in paragraph 7.3.4.1.3 in this section of the Appendix.

- The finalized "Phase III I-Wall Evaluation Guidance" should be available from USACE Headquarters some time in FY2010. This evaluation guidance should be utilized to evaluate all of the project's I-Walls. This was discussed previously in paragraph 7.3.4.1.3 in this section of the Appendix.
- Evaluations in accordance with the publication *"Seismic Evaluation of Existing Buildings"* (ASCE 31-03) should be performed for each *typical* pump plant building prior to commencing any remedial work on or in the buildings. This was discussed previously in paragraph 7.5.4.1 in this section of the Appendix.

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 8
ELECTRICAL AND MECHANICAL SECTION

TABLE OF CONTENTS

8.1. ELECTRICAL ENGINEERING.....8-1
8.1.1. References.....8-1
8.1.2 Summary.....8-1
8.1.3. Evaluation and Recommendations.....8-2
8.1.3.1. Pump Plant # 1 - Noble Park.....8-2
8.1.3.2. Pump Plant # 2 - Sixth Street.....8-3
8.1.3.3. Pump Plant # 3 - Park Avenue.....8-6
8.1.3.4. Pump Plant # 4 - North Third Street & Executive Boulevard.....8-7
8.1.3.5. Pump Plant # 5 - Harrison Street.....8-8
8.1.3.6. Pump Plant # 6 - Clark Street.....8-9
8.1.3.7. Pump Plant # 7 - Tennessee Street.....8-12
8.1.3.8. Pump Plant # 8 - Norton Street.....8-13
8.1.3.9. Pump Plant # 9 - Husbands Street.....8-13
8.1.3.10. Pump Plant # 10 - George Street.....8-14
8.1.3.11. Pump Plant # 11 - Island Creek.....8-16
8.1.3.12. Pump Plant # 12 - STA 175+00C.....8-17
8.1.3.13. Pump Plant # 13 - STA 291+75C.....8-19
8.1.3.14. Pump Plant # 14 - Proposed @ STA 111+67A.....8-20
8.1.4. Emergency Power.....8-20
8.1.5. Additional Electrical Equipment.....8-21
8.1.6. Pump Pant Repair Drawing List.....8-21
8.2. MECHANICAL ENGINEERING EVALUATION.....8-22
8.2.1. References.....8-22
8.2.2. Summary.....8-22
8.2.3. Evaluation and Recommendations.....8-24
8.2.3.1. Pump Plant # 1 - Noble Park.....8-24
8.2.3.2. Pump Plant # 2 - Sixth Street.....8-26
8.2.3.3. Pump Plant # 3 - Park Avenue.....8-28
8.2.3.4. Pump Plant # 4 - North Third Street & Executive Boulevard.....8-30
8.2.3.5. Pump Plant # 5 - Harrison Street.....8-30
8.2.3.6. Pump Plant # 6 - Clark Street.....8-32
8.2.3.7. Pump Plant # 7 - Tennessee Street.....8-34
8.2.3.8. Pump Plant # 8 - Norton Street.....8-36

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 8
ELECTRICAL AND MECHANICAL SECTION

TABLE OF CONTENTS

(con't)

8.2.3.9. Pump Plant # 9 - Husbands Street..... 8-36
8.2.3.10. Pump Plant # 10 - George Street..... 8-37
8.2.3.11. Pump Plant # 11 - Island Creek..... 8-38
8.2.3.12. Pump Plant # 12 - STA 175+00C 8-39
8.2.3.13. Pump Plant # 13 - STA 291+75C 8-40
8.2.3.14. Pump Plant # 14 - Proposed @ STA 111+67A 8-41
8.2.3.15. Woodward Hollow Pipeline..... 8-41
8.2.3.16. Manholes with Gated Outlets that Require Repair or not Inspected... 8-42

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 8
ELECTRICAL AND MECHANICAL SECTION

LIST OF TABLES

Table No.	Title	Page No.
Table 8.1-1	Pump Plant #1 Motor Current Data	8-2
Table 8.1-2	Pump Plant #2 Motor Current Data	8-4
Table 8.1-3	Pump Plant #2 System Voltage Data	8-4
Table 8.1-4	Pump Plant #3 Motor Current Data	8-6
Table 8.1-5	Pump Plant #3 System Voltage Data	8-6
Table 8.1-6	Pump Plant #4 Motor Current Data	8-7
Table 8.1-7	Pump Plant #4 System Voltage Data	8-7
Table 8.1-8	Pump Plant #5 Motor Current Data	8-9
Table 8.1-9	Pump Plant #5 System Voltage Data	8-9
Table 8.1-10	Pump Plant #6 Motor Current Data	8-10
Table 8.1-11	Pump Plant #6 System Voltage Data	8-10
Table 8.1-12	Pump Plant #7 Motor Current Data	8-12
Table 8.1-13	Pump Plant #9 Motor Current Data	8-13
Table 8.1-14	Pump Plant #9 System Voltage Data	8-14
Table 8.1-15	Pump Plant #10 Motor Current Data	8-15
Table 8.1-16	Pump Plant #10 System Voltage Data	8-15
Table 8.1-17	Pump Plant #11 Motor Current Data	8-16
Table 8.1-18	Pump Plant #11 System Voltage Data	8-17
Table 8.1-19	Pump Plant #12 Motor Current Data	8-18
Table 8.1-20	Pump Plant #12 System Voltage Data	8-18

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
SECTION 8
APPENDIX C

ELECTRICAL AND MECHANICAL SECTION

LIST OF TABLES

(con't)

Table 8.1-21	Pump Plant #13 System Voltage Data	8-19
Table 8.1-22	Pump Plant Emergency Power Provision Equipment Sizing	8-21
Table 8.2-1	Manhole Cover Inspections	8-43
Table 8.2-2	Paducah Pump Plants – Pump Performance & Manufacturing Data	8-45

LIST OF FIGURES

Figure No.	Title	Page No.
Figure 8.2-1	Original Trash Rack Grating Design	8-23

LIST OF PHOTOS

Photo No.	Title	Page No.
Photo 8.1-1	PP#1 - Interior of Motor Control Center - Excellent Condition	8-3
Photo 8.1-2	PP#2 - Medium Voltage Switchgear	8-3
Photo 8.1-3	PP#2 - Gate Operators	8-5
Photo 8.1-4	PP#2 - Gate Operator Controls	8-5

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C
SECTION 8
ELECTRICAL AND MECHANICAL SECTION

LIST OF PHOTOS
(con't)

Photo 8.1-5	PP#3 - Outdated Motor Control Circuit	8-6
Photo 8.1-6	PP#4 - New Outdoor Panel - Pump Plant Power	8-8
Photo 8.1-7	PP#5 - New Motor Control Center	8-8
Photo 8.1-8	PP#6 - MCC Interior	8-11
Photo 8.1-9	PP#6 - New MCC	8-11
Photo 8.1-10	PP#6 - Gate Controls Interior - Poor Condition	8-12
Photo 8.1-11	PP#7 - Extremely Outdated Motor Control Center	8-13
Photo 8.1-12	PP#9 - Outdated Motor Starter	8-14
Photo 8.1-13	PP#10 - Outdated Motor Control Circuits	8-16
Photo 8.1-14	PP#11 - Gate #4 Operator	8-17
Photo 8.1-15	PP#12 - Older Style Motor Controls	8-18
Photo 8.1-16	PP#12 - Covered Service Conductors	8-19
Photo 8.1-17	PP#13 - Damaged Motor Control Circuit	8-20
Photo 8.2-1	Grease Storage Tank and Motor	8-23
Photo 8.2-2	Grease Solenoid Panel	8-23
Photo 8.2-3	Typical Air Vent extremely corroded	8-24
Photo 8.2-4	Air Vents	8-25
Photo 8.2-5	Siphon Breakers	8-25
Photo 8.2-6	Discharge Headwall	8-25
Photo 8.2-7	Trash Screen	8-25
Photo 8.2-8	Divided Wall	8-25
Photo 8.2-9	Pump Column & Umbrella	8-25

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C
SECTION 8
ELECTRICAL AND MECHANICAL SECTION

LIST OF PHOTOS

(con't)

Photo 8.2-10	Pump Column & Umbrella	8-25
Photo 8.2-11	Pump Discharge Elbow & Piping	8-25
Photo 8.2-12	Pump Discharge Piping Through Wall	8-25
Photo 8.2-13	Pump Impeller	8-26
Photo 8.2-14	Pump Discharge Piping Looking from Gate Well with Raised Flap Gate	8-26
Photo 8.2-15	Pump Discharge Piping Headwall and Flap Gates	8-27
Photo 8.2-16	Pump Discharge Piping Headwall and Flap Gates	8-27
Photo 8.2-17	Pump Column	8-27
Photo 8.2-18	Pump Sump	8-27
Photo 8.2-19	Pump Column	8-27
Photo 8.2-20	Pump Impeller	8-28
Photo 8.2-21	Pump Impeller	8-28
Photo 8.2-22	Pump Discharge Elbow Connection to Piping	8-28
Photo 8.2-23	Trash Screen	8-28
Photo 8.2-24	Non-Clog Sump Pump	8-28
Photo 8.2-25	Trash Screen	8-29
Photo 8.2-26	Pump Column	8-29
Photo 8.2-27	Sump Pump	8-29
Photo 8.2-28	Pump Column	8-29
Photo 8.2-29	Pump Impeller	8-29
Photo 8.2-30	Pump Discharge and Elbow	8-29

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C
SECTION 8
ELECTRICAL AND MECHANICAL SECTION

LIST OF PHOTOS

(con't)

Photo 8.2-31	Bypass Sluice Gate for Pump Sump	8-29
Photo 8.2-32	Pump Motor and Stand	8-30
Photo 8.2-33	Pump Stand	8-30
Photo 8.2-34	Discharge Piping	8-30
Photo 8.2-35	Trash Screen	8-31
Photo 8.2-36	Sluice Gate Opening	8-31
Photo 8.2-37	Sluice Gate	8-31
Photo 8.2-38	Sump Piping and Bypass	8-31
Photo 8.2-39	Discharge Piping and Flexible Coupling	8-31
Photo 8.2-40	Pump Column and Suction	8-31
Photo 8.2-41	Pump Impeller	8-32
Photo 8.2-42	Pump Sump	8-32
Photo 8.2-43	Pump Discharge Piping	8-32
Photo 8.2-44	Pump Discharge Flap Gate	8-32
Photo 8.2-45	Pump Discharge Piping	8-32
Photo 8.2-46	Pump Discharge Flap Gate	8-33
Photo 8.2-47	Pump Discharge Piping Flap Gate	8-33
Photo 8.2-48	Sump Pump Discharge Piping Flap Gate	8-33
Photo 8.2-49	Pump Elbow and Discharge Piping	8-33
Photo 8.2-50	Trash Screen	8-34
Photo 8.2-51	Trash Screen	8-34
Photo 8.2-52	Support Bracket for Pump Column	8-35

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C
SECTION 8
ELECTRICAL AND MECHANICAL SECTION

LIST OF PHOTOS

(con't)

Photo 8.2-53	Pump Column	8-35
Photo 8.2-54	Close Up of Pump Column	8-35
Photo 8.2-55	Pump Discharge Piping and Rusted Flexible Coupling	8-35
Photo 8.2-56	Trash Screen	8-35
Photo 8.2-57	Pump Column Heavy Section Loss on Bracket and Rust Packing	8-35
Photo 8.2-58	Bypass Sluice Gate	8-35
Photo 8.2-59	Pump Discharge Piping	8-35
Photo 8.2-60	Discharge Piping Through Wall	8-36
Photo 8.2-61	Pump and Discharge Piping	8-37
Photo 8.2-62	Air Vent	8-37
Photo 8.2-63	Pump and Stand at Bottom of Plant Well	8-37
Photo 8.2-64	Discharge	8-38
Photo 8.2-65	Pump Discharge Piping	8-38
Photo 8.2-66	Pump Discharge Piping and Flexible Coupling	8-38
Photo 8.2-67	Pump Discharge Piping and Flexible Coupling	8-39
Photo 8.2-68	Pump Support Bracket	8-39
Photo 8.2-69	Pump Column	8-39
Photo 8.2-70	Trash Screen and Approach Walls	8-40
Photo 8.2-71	Discharge Piping	8-40
Photo 8.2-72	Float Well	8-40

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C
SECTION 8
ELECTRICAL AND MECHANICAL SECTION

LIST OF PHOTOS

(con't)

Photo 8.2-73	Pump with Motor and Discharge Piping Through Wall	8-40
Photo 8.2-74	Intake Piping and Screen	8-40
Photo 8.2-75	Woodward Hollow Intake Area for Gravity Drainage	8-42
Photo 8.2-76	Woodward Hollow View Looking Down Fourth Street	8-42
Photo 8.2-77	Looking Towards River and Railroad Tracks at Woodward Hollow	8-42
Photo 8.2-78	Headwall for 66-Inch Flap Gate at Sta. 19+11-B	8-42
Photo 8.2-79	Sluice Gate at Sta. 66+17-A	8-44

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX C

SECTION 8 ELECTRICAL AND MECHANICAL SECTION

8.1. ELECTRICAL ENGINEERING.

8.1.1. References.

The following references were used in the compilation of this report:

1. EM 1110-2-3102, *GENERAL PRINCIPLE OF PUMPING STATION DESIGN AND LAYOUT*, dated 28 February 1995

2. EM 1110-2-3105, *MECHANICAL AND ELECTRICAL DESIGN OF PUMPING STATIONS*, dated 30 November 1999

3. NFPA 70 – National Electrical Code, dated 2008

4. IEEE C2 – National Electrical Safety Code, dated 20 April 2006

8.1.2 Summary.

The Paducah, KY Flood Protection Project consists of electrical systems at each of the twelve pump plants. Pump plants are fed with either 480 V AC, 3 phase power, 240 VAC, 3 phase power, or 2400 VAC, 3 phase power provided by Paducah Power System. Presently, the pump plants do not have emergency backup power. Instead, they have the ability to connect to an alternate primary feed source due to a grid distribution system. This allows utility crews to swap primary power from one line to another line in the event of a power outage. Distribution equipment at each pump plant is owned by Paducah Power System. Presently, most of the electrical equipment (MCCs, panelboards, pump motors, etc.) are in good physical condition. Older style pump motor controls and motor control centers are still in use, and need to be replaced due to age and lack of availability for spare parts.

All pumping plants except Pump Plant #10 are manually controlled in a flooding event. Pumps are manually started at certain elevations and have the ability to either be manually stopped or automatically stopped. Usual operation is manual start/stop. Pump plant #10 is controlled by a float system during flooding events.

8.1.3. Evaluation and Recommendations.

8.1.3.1. Pump Plant #1 – Noble Park.

Pump Plant #1 is fed from a bank of 167kVA, 12.47/7.2 kV primary, 480/277 VAC secondary transformers. It consists of three 150HP pumps fed from a 3 section MCC with 800A horizontal and vertical buses. Pump motors 1 thru 3 were run and motor current measurements were taken. Motor current data is presented in Table 8.1-1.

TABLE 8.1-1: Pump Plant #1 Motor Current Data

Equipment	Line Current 1	Line Current 2	Line Current 3	Average	% UNBAL
Motor #1	76.7	73.3	75.8	75.27	2.6
Motor #2	72.2	75.8	79.1	75.7	4.6
Motor #3	77.1	74.3	77.2	76.2	2.5

Voltage measurements were not taken at Pump Plant #1due to missing PPE, at that time.

Physical Condition of Electrical Equipment/ Recommended Changes:

Visual inspection of all electrical equipment located in the pump plant showed that it is in good physical condition. All electrical conduit is intact. There was no corrosion on panelboards, control panels, motor control centers, service transformers or equipment. The motor control center appears to be fairly new and does not require replacement (Photo 8.1-1). The present control instrumentation will be replaced under feasibility.

Pump plant pump motors were also inspected and are in good operating condition despite age. It is recommended that motors be rebuilt due to age. Motor rebuild will include but not limited to: rotor balancing, re-dipping and baking of motor winding insulation, upper and lower bearing replacement, replacement of motor leads, cleaning and repainting of motor.

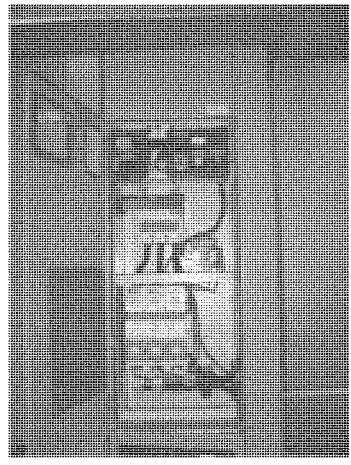


Photo 8.1-1: PP#1 - Interior of Motor Control Center in Excellent Condition

8.1.3.2. Pump Plant #2 – Sixth Street.

Pump Plant #2 is fed from a bank of 833kVA, 12.47/7.2 kV primary, 2400VAC secondary transformers. It consists of five 2400 VAC pumps (2 – 800HP, 2 – 500HP, and 1 – 200HP), a 20 HP pump on 240VAC, and a 100HP motor driven off of a 480 VAC variable frequency drive. All 2400 volt equipment is fed from a 5 section medium voltage MCC (Photo 8.1-2).

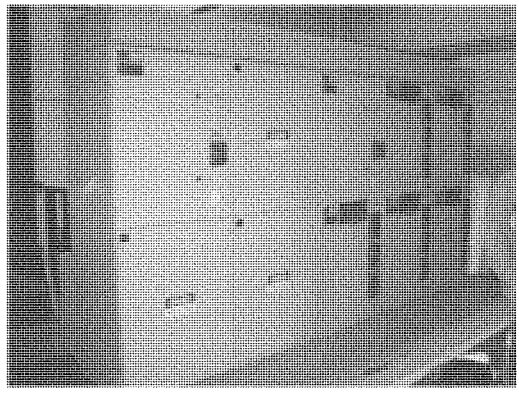


Photo 8.1-2: PP#2 - Medium Voltage Switchgear

The 20 HP pump is controlled by an externally mounted motor starter. The plant also consists of 4 electrical driven sluice gates at 240 volt power. The 4 gate drives and Pump #1 were run and motor current measurements were taken. Current measurements are presented in Table 8.1-2.

TABLE 8.1-2: Pump Plant #2 Motor Current Data

Equipment	Line Current 1	Line Current 2	Line Current 3	Average	% UNBAL
Motor #1	27.2	26.0	27.5	26.9	3.35
Gate #1 (Up)	13.3	12.96	13.52	13.26	2.26
Gate #1 (Down)	13.66	12.85	13.15	13.22	3.33
Gate #2 (Up)	13.16	12.50	12.61	12.75	3.16
Gate #2 (Down)	12.97	12.73	12.74	12.8	1.22
Gate #3 (Up)	13.46	12.7	13.28	13.15	3.4
Gate #3 (Down)	13.07	12.78	13.08	12.97	1.5
Gate #4 (Up)	13.24	13.24	13.12	13.2	0.61
Gate #4 (Down)	13.33	13.09	12.96	13.13	1.55

Service Voltage:

Power for Motor #1 and the electrically operated gates is from a 240 volt, 45kVA transformer which has been stepped down twice from the main service voltage of 2400kV. Voltage measurements were taken on Motor #1 and service gates, and are presented in Table 8.1-3.

TABLE 8.1-3: Pump Plant #2 System Voltage Data

	A – B	A – C	B – C	A – G	B – G	C - G
Motor #1	**213.1**	**213.5**	**212.6**	**123.1**	**122.5**	**122.7**
Gate #1	**214.8**	**215.2**	**214.2**	-	-	-
Gate #2	**213.8**	**213.9**	**213.3**	-	-	-
Gate #3	**213.0**	**213.3**	**212.6**	-	-	-
Gate #4	**212.3**	**212.3**	**211.6**	-	-	-

Physical Condition of Electrical Equipment/ Recommended Changes:

Visual inspection of all electrical equipment located in the pump plant showed that it is in good physical condition. All electrical conduit is intact. There was no corrosion on panelboards, control panels, motor control centers, service transformers or equipment. Pump #1 motor controls are of older style. The circuit breaker portion of the combination motor starter was only rated for overload and not short circuit current. Starter is presently in working condition, but it is recommended to be replaced due to age and lack of availability of parts.

Pump plant pump motors were also inspected and are in good operating condition despite age. Motor 1 along with pump will be replaced with a new submersible pump/motor package. It is recommended that motors 2 through 6 be rebuilt due to age. Rebuilding will ensure satisfactory operation for another 50 years. Motor rebuild will include but not limited to: rotor balancing, re-dipping and baking of motor winding insulation, upper and

lower bearing replacement, replacement of motor leads, and cleaning and repainting of motor. Pump motor 7 along with its pump was installed in 1996 and does not need work.

Visual inspection of the pump plant gate actuators and controls show that they are in deteriorating conditions. Presently, there are 4 gate actuators with controls located on the exterior wall of Pump Plant #2 (Photos 8.1-3 & 8.1-4). While operating the electrical gates, the torque-limit switch for Sluice Gate #2 opened due to binding in the gatewell. The actuator would not electrically reverse, and the reverse-starter contacts had to be brought in manually to permit the torque-limit switch to reset. It is recommended that actuators and controls be replaced due to age, condition, and experienced failure. It is also recommended that an electric actuator be provided for the gate well at station # 66+17A, which is located outside of Pump Plant #2.

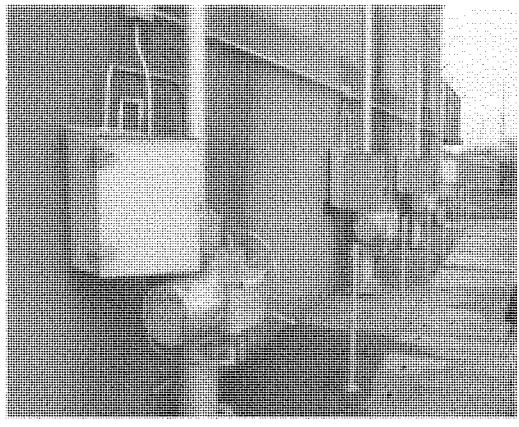


Photo 8.1-3: PP#2 - Gate Operators

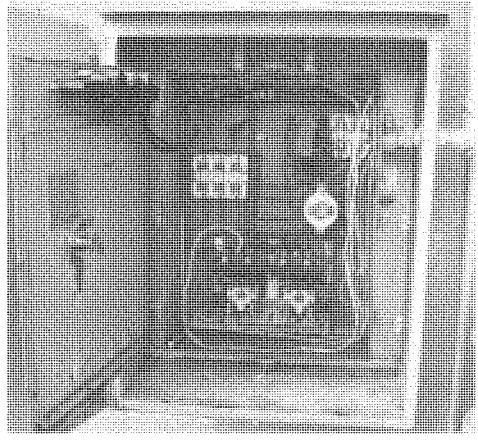


Photo 8.1-4: PP#2 - Gate Operator Controls

8.1.3.3. Pump Plant # 3 – Park Avenue.

Pump Plant #3 is fed from a bank of 25kVA, 12.47/7.2 kV primary, 240/120 VAC secondary center tapped transformer. It consists of two 25HP pumps, and a 5HP pump, each run off wall mounted motor starter panels. Pump motors 1 and 2 were run and motor current measurements were taken. Motor current data is presented in Table 8.1-4.

TABLE 8.1-4: Pump Plant #3 Motor Current Data

Equipment	Line Current 1	Line Current 2	Line Current 3	Average	% UNBAL
Motor #1	12.0	11.8	11.0	11.6	5.17
Motor #2	25.2	28.7	27.6	27.17	7.24
Motor #3	26.7	26.8	28.4	27.3	4.03

System voltage measurements were taken, and are presented in Table 8.1-5:

TABLE 8.1-5: Pump Plant #3 System Voltage Data

A – B	A – C	B – C	A – G	B – G	C - G
245.1	244.0	245.3	211.4	122.5	122.5

Physical Condition of Electrical Equipment/ Recommended Changes:

Visual inspection of all electrical equipment located in the pump plant indicates that motor controls are obsolete and in deteriorating condition (Photo 8.1-5). Equipment labels also indicated that circuit breakers for combination starters are not rated for short circuit current faults, only for motor overload. It is recommended that the motor starters be replaced due to age and condition.

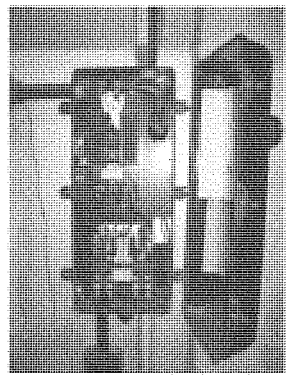


Photo 8.1-5: PP#3 - Outdated Motor Control Circuit

Pump plant pump motors were also inspected and are in good operating condition despite age. It is recommended that pump motors 1 thru 3 be replaced due to age. These motors, along with associated pumps will be replaced with new submersible pump/motor packages.

8.1.3.4. Pump Plant # 4 – Clay Street.

Pump Plant #4 is fed from a bank of 37.5kVA, 12.47/7.2 kV primary, 480/277 VAC secondary transformer. It consists of two 50HP pumps fed from an outdoor panelboard. Pump motors 1 and 2 were run and motor current measurements were taken. Motor current data is presented in Table 8.1-6.

TABLE 8.1-6: Pump Plant #4 Motor Current Data

Equipment	Line Current 1	Line Current 2	Line Current 3	Average	% UNBAL
Motor #1	49.1	46.2	47.7	47.67	3.07
Motor #2	49.8	46.2	48.3	48.1	3.95

System voltage measurements were taken, and are presented in Table 8.1-7:

TABLE 8.1-7: Pump Plant #4 System Voltage Data

A – B	A – C	B – C	A – G	B – G	C - G
488	491	487	283	281	283

Physical Condition of Electrical Equipment/ Recommended Changes:

Visual inspection of all electrical equipment located in the pump plant showed that it is in good physical condition. All electrical conduit is intact. There was no corrosion on panelboards, control panels, service transformers or equipment. Pump control panels are new, as well as power distribution panelboard (Photo 8.1-6).

Pump plant pump motors were also inspected and are in good operating condition despite age. It is recommended that motors be replaced. Motors 1 and 2, along with pump will be replaced with new submersible pump/motor packages.

Photo 8.1-6: PP#4 - New Outdoor Panel – Pump Plant Power

8.1.3.5. Pump Plant # 5 – Harrison Street.

Pump Plant #5 is fed from a bank of 167 kVA, 12.47/7.2 kV primary, 480/277 VAC secondary transformer. It consists of two 200HP pumps, a 100HP pump, and a 25HP pump. The pumps are powered by a 3 section MCC (Photo 8.1-7).

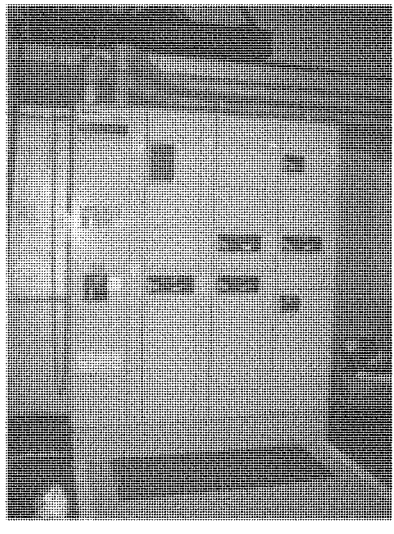


Photo 8.1-7: PP#5 - New Motor Control Center

Pump motors 1 thru 4 were run and motor current measurements were taken. Motor currents are presented in Table 8.1-8.

TABLE 8.1-8: Pump Plant #5 Motor Current Data

Equipment	Line Current 1	Line Current 2	Line Current 3	Average	% UNBAL
Motor #1 (M)	72	74	68	71.33	4.67
Motor #2 (M)	70	74	68	70.67	4.72
Motor #2 *	68	72	63	67.67	6.9
Motor #3 (M)	41	43	41	41.67	3.2
Motor #3 *	38.5	41.5	Could not get on conductor		
Motor #4 (M)	23	22.3	23.5	22.93	2.76

(M) – Designates MCC mounted power meter measurement
* - Designates handheld DMM measurements

System voltage measurements were taken, and are presented in Table 8.1-9:

TABLE 8.1-9: Pump Plant #5 System Voltage Data

A – B	A – C	B – C	A – G	B – G	C - G
494	490	493	284	286	284

Physical Condition of Electrical Equipment/ Recommended Changes:

Visual inspection of all electrical equipment located in the pump plant showed that it is in good physical condition. All electrical conduit is intact. There was no corrosion on panelboards, motor control centers, service transformers or equipment. The new motor control center has integral pump motor controls and does not need replacing.

Pump plant pump motors were also inspected and are in good operating condition despite age. It is recommended that pump motors 1 thru 3 be rebuilt due to age. Rebuilding will ensure satisfactory operation for another 50 years. Motor rebuild will include but not limited to: rotor balancing, re-dipping and baking of motor winding insulation, upper and lower bearing replacement, replacement of motor leads, cleaning and repainting of motor. Motor 4 along with pump will be replaced with new submersible pump/motor packages.

8.1.3.6. Pump Plant # 6 – Clark Street.

Pump Plant #6 is fed from a bank of 333kVA, 12.47/7.2 kV primary, 480/277 VAC secondary transformer. It consists of three 250HP pumps, a 125HP pump, and a 10HP pump, fed from a 5 section MCC. Pump motors 1 thru 5, as well as electrical operated

gates were run and motor current measurements were taken, and are presented in Table 8.1-10.

TABLE 8.1-10: Pump Plant #6 Motor Current Data

Equipment	Line Current 1	Line Current 2	Line Current 3	Average	% UNBAL
Motor #1	152	156	152	153.33	1.73
Motor #2	70	66	66	67.33	3.96
Motor #3	149	149	149	149	0
Motor #4	149	152	149	150	1.33
Motor #5	15.9	16.1	16.2	16.1	1.24
Gate #1 (Up)	10.46	10.75	10.96	10.72	2.46
Gate #1 (Down)	10.60	10.60	10.80	10.67	1.25
Gate #2 (Up)	9.87	10.05	9.95	9.96	0.94
Gate #2 (Down)	9.88	9.97	9.90	9.92	0.54
Both (Up)	20.20	20.84	20.85	20.63	2.08
Both (Down)	20.43	20.62	20.70	20.58	0.74

System voltage measurements were taken, and are presented in Table 8.1-11:

TABLE 8.1-11: Pump Plant #6 System Voltage Data

A – B	A – C	B – C	A – G	B – G	C - G
490	494	492	283	284	285

Physical Condition of Electrical Equipment/ Recommended Changes:

Visual inspection of all electrical equipment located in the pump plant showed that it is in good physical condition. All electrical conduit is intact. There was no corrosion on panelboards, control panels, motor control centers, service transformers or equipment. A new motor control center has integral pump motor controls and does not need replacing (Photos 8.1-8 & 8.1-9).

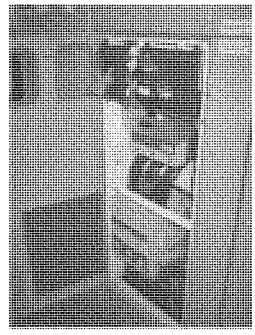


Photo 8.1-8: PP#6 - MCC Interior

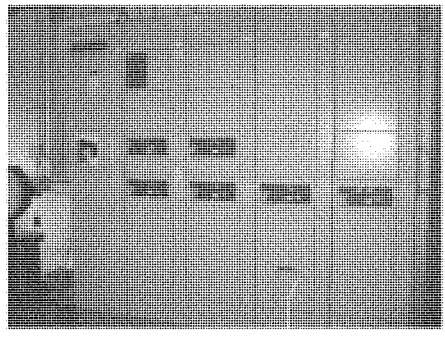


Photo 8.1-9: PP#6 - New MCC

Pump plant pump motors were also inspected and are in good operating condition despite age. It is recommended that pump motors 1 thru 4 be rebuilt due to age. Rebuilding will ensure satisfactory operation for another 50 years. Motor rebuild will include but not limited to: rotor balancing, re-dipping and baking of motor winding insulation, upper and lower bearing replacement, replacement of motor leads, cleaning and repainting of motor. Motor 5 along with pump will be replaced with new submersible pump/motor packages.

Visual inspection of the pump plant gate actuators and controls show that, presently, they are in deteriorating condition (Photo 8.1-10). While operating electrical gates, Sluice Gate #2 limit switch experienced a failure. It is recommended that actuators and controls be replaced due to age, condition, and experienced failure.

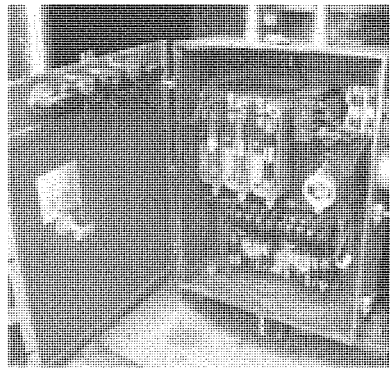


Photo 8.1-10: PP#6 - Gate Controls Interior – Poor Condition

8.1.3.7. Pump Plant #7 – Tennessee Street.

Pump Plant #7 is fed from a bank of 75kVA, 12.47/7.2 kV primary, 480/277 VAC secondary transformers. It consists of a 125HP pump, a 50 HP pump (both fed from an older style motor control center), and a 10HP pump fed from an externally mounted motor starter panel. Pump motors 1 thru 3 were run and motor current measurements were taken. Motor current data is presented in Table 8.1-12.

TABLE 8.1-12: Pump Plant #7 Motor Current Data

Equipment	Line Current 1	Line Current 2	Line Current 3	Average	% UNBAL
Motor #1	58.3	55.4	56.1	56.6	3.0
Motor #2	29.4	29.1	30.3	29.6	2.36
Motor #3	15.6	16.4	15.8	15.93	2.92

System voltage measurements were not taken due to inaccessible line side lugs within the motor control center.

Physical Condition of Electrical Equipment/ Recommended Changes:

Visual inspection of all electrical equipment located in the pump plant showed that the motor control center and external motor starter panel are extremely old and in deteriorating condition (Photo 8.1-11). In addition, motor controls from MCC are wired so that motor circuit breakers are acting like motor starter contacts.

It is recommended that all power distribution and controls for pump motors be replaced. A new 3 section motor control center, which includes a main circuit breaker, metering devices, starter circuits and controls for the three existing pump motors, and a lighting transformer, is recommended. The present control instrumentation will be replaced as well.

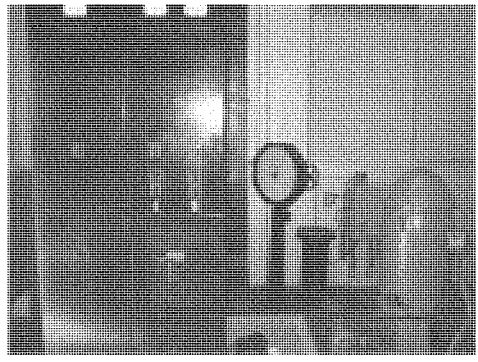


Photo 8.1-11: PP#7 - Extremely Outdated Motor Control Center

Pump plant pump motors were also inspected and are in good operating condition despite age. It is recommended that pump motors 1 thru 3 be replaced due to age. Motors 1 thru 3, along with associated pumps will be replaced with new submersible pump/motor packages.

8.1.3.8. Pump Plant #8 - Norton Street.

This pump plant is no longer in operation (See Volume 4 of this report for more information).

8.1.3.9. Pump Plant # 9 – Clay Street.

Pump Plant #9 is fed from a bank of 3-25kVA, 12.47/7.2 kV primary, 480/277 VAC secondary transformer. It consists of two 40/46HP pumps, each fed from wall mounted motor starter panel. Pump motors 1 and 2 were run and motor current measurements were taken, and are presented in Table 8.1-13.

TABLE 8.1-13: Pump Plant #9 Motor Current Data

Equipment	Line Current 1	Line Current 2	Line Current 3	Average	% UNBAL
Motor #1	18.4	19.8	20.2	19.47	5.48
Motor #2	17.6	18.0	20.1	18.57	8.26

System voltage measurements were taken, and are presented in Table 8.1-14:

TABLE 8.1-14: Pump Plant #9 System Voltage Data

A – B	A – C	B – C	A – G	B – G	C - G
486	489	491	244.5	243.4	416

Physical Condition of Electrical Equipment/ Recommended Changes:

Visual inspection of all electrical equipment located in the pump plant showed that motor starters are obsolete and in deteriorating condition (Photo 8.1-12). Equipment labels also indicated that circuit breakers for combination starters are not rated for short circuit current faults, only for motor overload.

Photo 8.1-12: PP#9 - Outdated Motor Starter

It is recommended that the existing power distribution system, including motor starters, power panelboards, and lighting panelboards be replaced. The present pump configuration could also drive the service transformers past 100% operating capacity, and therefore should be upsized to 3-37.5kVA. The present control instrumentation will be replaced as well.

Pump plant pump motors were also inspected and are in good operating condition despite age. It is recommended that pump motors 1 and 2 be replaced due to age. These motors, along with associated pumps will be replaced with new submersible pump/motor packages.

8.1.3.10. Pump Plant # 10 – George Street.

Pump Plant #10 i s fed from a bank of kVA, 12.47/7.2 kV primary, 240/120 VAC secondary center tapped transformer. It consists of two 10HP pumps, each fed from a

wall mounted motor starter panel. Pump motors 1 and 2 were run and motor current measurements were taken, and are presented in Table 8.1-15.

TABLE 8.1-15: Pump Plant #10 Motor Current Data

Equipment	Line Current 1	Line Current 2	Line Current 3	Average	% UNBAL
Motor #1	17.2	17.3	16.2	16.9	4.14
Motor #2	17.0	17.2	15.7	16.63	5.61

System voltage measurements were taken, and are presented in Table 8.1-16:

TABLE 8.1-16: Pump Plant #10 System Voltage Data

A – B	A – C	B – C	A – G	B – G	C - G
242.6	243.2	241.9	211.7	120.9	120.9

Physical Condition of Electrical Equipment/ Recommended Changes:

Visual inspection of all electrical equipment located in the pump plant showed that motor starters are obsolete and in deteriorating condition (Photo 8.1-13). Equipment labels also indicated that circuit breakers for combination starters are not rated for short circuit current faults, only for motor overload. Floatless control equipment is also old, corroded, and outdated. Main service disconnect is also worn and weathered.

It is recommended that all power distribution and motor controls be replaced due to age and present condition under feasibility. The present control instrumentation will be replaced under feasibility as well.

Pump plant pump motors were also inspected and are in good operating condition despite age. It is recommended that pump motors 1 and 2 be replaced due to age. These motors, along with associated pumps will be replaced with new submersible pump/motor packages.

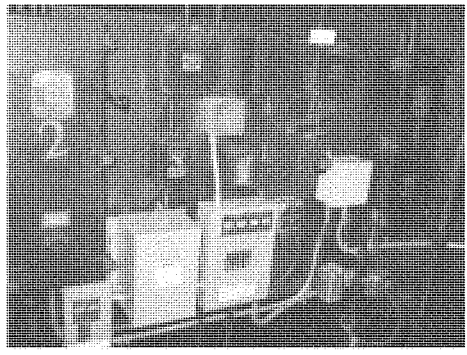


Photo 8.1-13: PP#10 - Outdated Motor Control Circuits

8.1.3.11. Pump Plant # 11 – Island Creek.

Pump Plant #11 is fed from a bank of 333kVA, 12.47/7.2 kV primary, 480/277 VAC secondary transformer. It consists of four 300HP pumps, and 4 electrically driven gates fed from a 5 section MCC. Pump motors 2 thru 4, as well as electrical operated gates were run and motor current measurements were taken, and are presented in Table 8.1-17. Pump motor #1 could not be run due to the fact it has water cooled bearings, and water in the sump was not high enough to run the pumps wet.

TABLE 8.1-17: Pump Plant #11 Motor Current Data

Equipment	Line Cnrrent 1	Line Current 2	Line Current 3	Average	% UNBAL
Motor #2	151.4	155.0	161.7	156.03	3.63
Motor #3	155.0	156.7	155.7	155.8	0.58
Motor #4	161.7	161.9	160.8	161.47	0.91
Gate #1 (Up)	11.71	11.88	11.98	11.86	1.24
Gate #1 (Down)	11.11	11.13	11.11	11.12	0.12
Gate #2 (Up)	11.39	11.85	11.74	11.66	2.32
Gate #2 (Down)	11.04	10.85	11.14	11.01	1.45
Gate #3 (Up)	11.81	11.61	11.62	11.68	1.11
Gate #3 (Down)	10.95	10.85	11.11	10.97	1.28
Gate #4 (Up)	11.40	11.51	11.87	11.59	2.38
Gate #4 (Down)	10.52	10.98	10.83	10.78	2.38

System voltage measurements were taken, and are presented in Table 8.1-18:

TABLE 8.1-18: Pump Plant #11 System Voltage Data

	A – B	A – C	B – C	A – G	B – G	C - G
MCC	483	485	486	278.2	278.5	279.9
Gate #1	208.0	208.5	208	120.8	121.0	120.8
Gate #2	208.8	208.9	208.2	120.8	121.0	120.7
Gate #3	205.3	206.1	206.1	119.1	119.6	119.4
Gate #4	205.6	205.8	206.3	119.3	119.4	119.6

Physical Condition of Electrical Equipment/ Recommended Changes:

Visual inspection of all electrical equipment located in the pump plant showed that it is in good physical condition. All electrical conduit is intact. There was no corrosion on panelboards, control panels, motor control centers, service transformers or equipment. Pump controls are integral to motor control center, which is fairly new.

While taking current and voltage readings on the electric gates, it was noticed that Gate #4 would draw about 3 times its FLA (~36A) when approaching completely shut position. It operated normally when being raised to the fully open position. It is recommended that actuator controls be replaced due to age, condition, and high current draw (Photo 8.1-14).

Photo 8.1-14: PP#11 - Gate #4 Operator

Pump plant pump motors were also inspected and are in good operating condition. It is recommended that motors 2 t hrough 4 be rebuilt due to age. Rebuilding will ensure satisfactory operation for another 50 years. Motor rebuild will include but not limited to: rotor balancing, re-dipping and baking of motor winding insulation, upper and lower bearing replacement, replacement of motor leads, and cleaning and repainting of motor. Motor 1 was installed in 1998 and does not require any work.

8.1.3.12. Pump Plant # 12 – SE of Paducah.

Pump Plant #12 is fed from a bank of 50kVA, 12.47/7.2 kV primary, 480/277 VAC secondary transformer. It consists of two 50HP pumps, each fed from a wall mounted

motor starter panel. Pump motors 1 and 2 were run and motor current measurements were taken, and are presented in Table 8.1-19.

TABLE 8.1-19: Pump Plant #12 Motor Current Data

Equipment	Line Current 1	Line Current 2	Line Current 3	Average	% UNBAL
Motor #1	50.2	52.3	50.7	51.07	2.41
Motor #2	46.3	46.7	46.3	46.43	0.57

System voltage measurements were taken, and are presented in Table 8.1-20:

TABLE 8.1-20: Pump Plant #12 System Voltage Data

A – B	A – C	B – C	A – G	B – G	C - G
490	490	492	282	283	284

Physical Condition of Electrical Equipment/ Recommended Changes:

Visual inspection of all electrical equipment located in the pump plant showed that motor starters are obsolete and in a deteriorated condition (Photo 8.1-15). Equipment labels also indicated that circuit breakers for combination starters are not rated for short circuit current faults, only for motor overload. It was also noticed that the incoming power lines were covered with brush and tree limbs (Photo 8.1-16). It is recommended that the existing power distribution system, including motor starters, power panelboards, and lighting panelboards be replaced. The present control instrumentation will be replaced as well.

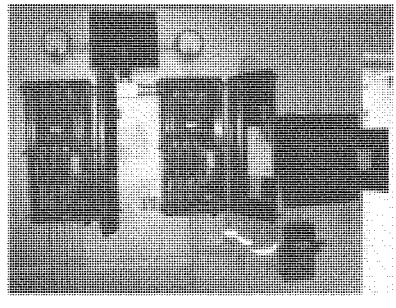


Photo 8.1-15: PP#12 - Older Style Motor Controls

Photo 8.1-16: PP#12 – Tree Limbs on Service Conductors

Pump plant pump motors were also inspected and are in good operating condition despite age. It is recommended that pump motors 1 and 2 be replaced due to age. These motors, along with associated pumps will be replaced with new submersible pump/motor packages.

8.1.3.13. Pump Plant # 13 – STA 291+75C.

Pump Plant #13 is fed from a bank of 25kVA, 12.47/7.2 kV primary, 480/277 VAC secondary transformer with ungrounded neutral conductor. It consists of one 60HP pumps, fed from a wall mounted motor starter panel. Pump motor #1 was not able to run because of low water level. System voltage measurements were taken, and are presented in Table 8.1-21:

TABLE 8.1-21: Pump Plant #13 System Voltage Data

A – B	A – C	B – C	A – G	B – G	C - G
489	488	487	349	419	138

Physical Condition of Electrical Equipment/ Recommended Changes:

Visual inspection of all electrical equipment located in the pump plant showed that motor starter is obsolete and in deteriorating condition (Photo 8.1-17).

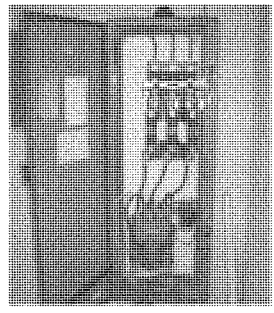


Photo 8.1-17: PP#13 - Damaged Motor Control Circuit

Equipment label also indicated that circuit breakers for combination starters are not rated for short circuit current faults, only for motor overload. It was also noticed that the A phase fuse was corroded, and there was indication that water had been within the starter case. The reset button was also broken and disabled. It is recommended that the motor starter be replaced due to age and condition.

The pump plant pump motor was also inspected and is in good operating condition. It is recommended that the motor be rebuilt due to age. Rebuilding will ensure satisfactory operation for another 50 years. Motor rebuild will include but not limited to: rotor balancing, re-dipping and baking of motor winding insulation, upper and lower bearing replacement, replacement of motor leads, and cleaning and repainting of motor.

8.1.3.14. Proposed Pump Plant #14 at 111+67A.

In addition to the changes mentioned above, the feasibility will also include plans for a proposed pump plant – Pump Plant #14. The plant will be equipped with a medium voltage distribution motor control center fed from 3-250kVA, 12.47kV-2400/277 VAC transformers located in a new substation adjacent to the proposed pump plant. The plant will have two 250 horsepower pump motors, along with a 25kVA, 480-240/120VAC lighting transformer for lighting power, 120 volt power receptacles, and a motor actuated sluice gate.

8.1.4. Emergency Power.

Emergency power provisions will also be included for the feasibility study. Manual transfer switches, generator receptacles, and fused disconnects have been sized in the table below for each plant. Portable rental generators will be procured by the city of Paducah in an emergency situation and will be sized according to Table 8.1-22.

TABLE 8.1-22: Pump Plant Emergency Power Provision Equipment Sizing

Pump Plant	System Voltage	Rental Generator Size	Transfer Switch Size	Fused Disconnect Size	Minimum Startup kVA (at 90% Rated Voltage)
2	2400 V	2000 kW	5 kV, 600 A	5 kV, 600 A	7100 kVA
1	480 V	400 kW	600 V, 600 A	600 V, 600 A	1300 kVA
4	480 V	100 kW	600 V, 250 A	600 V, 300 A	500 kVA
5	480 V	400 kW	600 V, 600 A	600 V, 600 A	1600 kVA
6	480 V	800 kW	600 V, 1200 A	600V, 1200A	2300 kVA
7	480 V	200 kW	600 V, 300 A	600 V, 300 A	850 kVA
9	480 V	100 kW	600 V, 175 A	600 V, 200 A	280 kVA
11	480 V	800 kW	600 V, 1200 A	600 V, 1200 A	4300 kVA
12	480 V	125 kW	600 V, 350 A	600 V, 350 A	400 kVA
13	480 V	60 kW	600 V, 350 A	600 V, 350 A	350 kVA
14 (Proposed)	480 V	600 kW	600 V, 1200 A	600 V, 1600 A	1600 kVA
3	240 V	60 kW	600 V, 300 A	600 V, 300 A	210 kVA
10	240 V	40 kW	600 V, 150 A	600 V, 150 A	85 kVA

8.1.5. Additional Electrical Equipment.

In addition to the above mentioned changes, it is recommended that an additional 6 new electric gate actuators with controls be provided for the project. These actuators will operate sluice gates in existing gate wells. One will be provided at Woodward Hollow discharge pipe at station 19+11B; three will be located in Bee Branch at station 32+12C; and two will be located in Bee Branch at station 32+38C.

8.1.6. Pump Plant Repair Drawing List.

Drawings are presented which summarize the miscellaneous repairs and replacements required for each pump plant: sheet E-101 for Pump Plant (PP) No. 1; sheet E-102 for PP No. 2; sheet E-103 for PP No. 3; sheet E-104 for PP No. 5; sheet E-105 for PP No. 6; sheet E-106 for PP No. 7; sheet E-107 for PP No. 9; sheet E-108 for PP No. 11; and sheet E-109 for PP No. 12.

8.2. MECHANICAL ENGINEERING EVALUATION.

8.2.1. References.

The following references were used in the compilation of this report:

1. EM 1110-2-3102, *GENERAL PRINCIPLE OF PUMPING STATION DESIGN AND LAYOUT*, dated 28 February 1995

2. EM 1110-2-3105, *MECHANCIAL AND ELECTRICAL DESIGN OF PUMPING STATIONS*, dated 30 November 1999

8.2.2. Summary.

There are twelve existing pump plants, gate wells and manholes (confined space entries) in the Paducah Flood Protection Project. F loodwall Superintendent and numerous maintenance operators were present and operated the required equipment for inspection and testing. One new plant is being proposed as Pump Plant No. 14 at STA 111+67A. All pump plants due to age of equipment will have the pumps reconditioned to practically new, or a new submersible design type will be installed. S ee paragraph 8.2.3 f or Evaluations and Recommendations for each pump plant along with sheet M601 in Volume 3 of this report for information on each individual pump plant relative to Mechanical reconstruction items.

Reconditioning of a pump will be accomplished by removing and sandblasting the entire pump stand, column, elbow, diffuser, impeller and suction bowls to white metal. Sandblasting of material will allow inspection to insure proper thickness and to check for possible porosity within the castings or metal. After sandblasting a primer coating will be applied to the pump components, flanges and machine register fits shall be checked for allowable tolerances to insure proper alignment when reassembled. New components installed on each reconditioned pump will include shafts, couplings, bearings, enclosing tubes/housings, grease lines and fittings, along with a protective cover for the grease lines on the outside of the pump. T he impeller(s) will be removed and reconditioned as required for any bent blades, nicks or cavitation damage by welding. Pumps that are being rebuilt will also require impellers to be dynamically rebalanced and new flexible couplings installed on the discharge piping.

Pump discharge piping for pump plant numbers 1, 2, 3, 5, 6, 7 a nd 12 are to be replaced due to deterioration and heavy corrosion; see information on each individual station in this section for pipe sizes and approximate lengths. The discharge pipes were typically cast into the pump plant walls. Therefore extensive concrete demolition work will have to be undertaken to remove the pipes from the reinforced concrete walls. This most likely would be accomplished using wire-line sawing methods to remove not only the pipe but some limited amount of the surrounding reinforced concrete. An attempt would be made to confine the removals to the areas of the original block out. After proper alignment of the pumps and installation of the new discharge piping, then new concrete would be placed between the discharge pipe and the extent of the removed area to restore the integrity of the pump plant wall.

New centralized grease lubrication systems shall be installed in pump plant number 1. See photos 8.2-1 and 2 for an example of the current system used at existing pump plants.

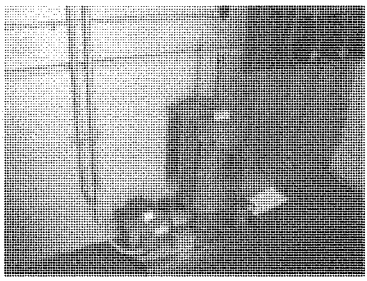


Photo 8.2-1: Grease Storage Tank and Motor

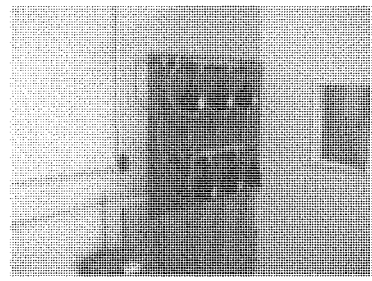


Photo 8.2-2: Grease Solenoid Panel

Trash racks were rebuilt in 1999 at pump plants nos. 1, 2, 3, 5, 6, 7 and 12 in accordance with as-builts, see Figure 8.2-1 for original design. They currently have greater spacing than required by Engineering Manual 1110-2-3102, paragraph 6-4.b which states that "The clear opening between bars should be approximately 1-3/4 inches but may be greater if justified by the size and type of pumps to be protected, but should not exceed 75 mm (3 in.) in any case. Bar spacing should be coordinated with the pump manufacturer." Therefore, in conformance to this guideline, all trash racks for pump plants indicated above, except pump plant no. 1 will be redesigned, made of mild steel and galvanized after fabrication to insure longevity. Pump plant 1 due to leaf debris will remain with the original spacing, but will be removed, sandblasted and galvanized.

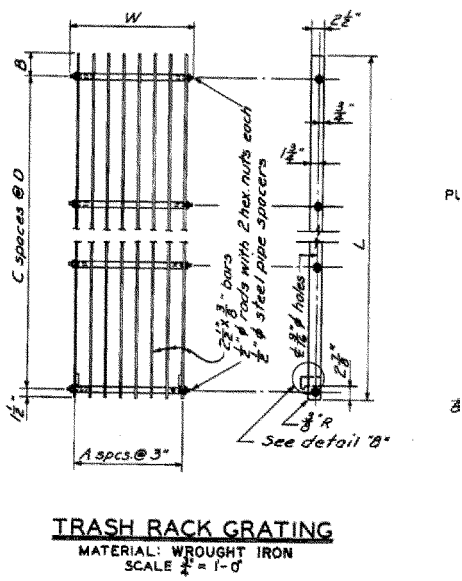


Figure 8.2-1: Original Trash Rack Grating Design

Pump Plant Numbers 1, 2, 3, 5, 6, 7, 9, 11 and 12 gravity ventilation systems for the buildings and sumps (Photo 8.2-20) shall be replaced in kind due to extreme corrosion.

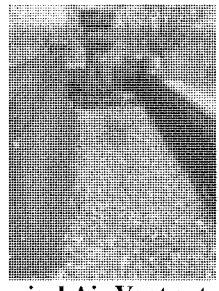


Photo 8.2-3: Typical Air Vent extremely corroded

All manually operated sluice gates except for ones being replaced shall be pressure washed. Pressure washing shall include but not limited to the gate, gate frame, stems and gear head after the removal of the gear head to remove old grease. After washing is completed and gear head has had new grease installed, the gate shall be closed to properly align wedges as required to insure proper fit against the sluice gate frame. Manual hoist actuator shall be primed and repainted. All electrically actuated gates shall have the gates pressure washed as noted above and adjusted as required to insure proper closure.

The pump plants super and sub-structures were inspected by structural engineers on the team. See, Section 7, paragraph 7.5 of this Appendix for structural information on condition and recommendations for the structures. The electrical motor control centers for each pump plant was evaluated by electrical engineers on the team, see paragraph 8.1 for the electrical evaluation of this Appendix.

8.2.3. Evaluation and Recommendations.

8.2.3.1. Pump Plant #1; Noble Park.

Equipment in Pump Plant (Photos 8.2-4 through 14):

1) Three vertical column pumps; see Table 1 at the end of 8.2.3 for pump performance and manufacturing data. All three pumps shall be reconditioned.
2) Manual Farval Grease Lubrication system shall be removed and an automated centralized greasing system shall be installed.
3) The 30-inch discharge pipes approximately 125 feet in length and 8-inch air vents shall be replaced with new lines.
4) The original dial indicator provides the plant operator with the sump water levels for starting and stopping of the equipment. The original mercury type float controls are no longer operational and require a replacement with a new type of control system to automatically stop pumps without relying on operation personnel.

5) Current pump operation start and stops are accomplished manually.
6) Flap Gates located on the headwall are in good condition and do not need to be replaced.
7) The divider walls between pumps are made of wood which has deteriorated. They shall be removed and a new vortex suppressor rack will be designed and installed within the sump.

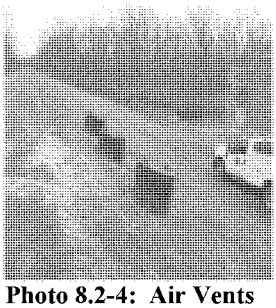


Photo 8.2-4: Air Vents

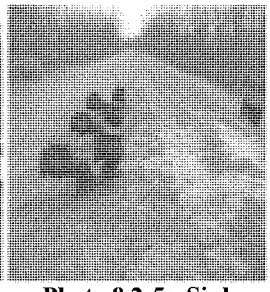


Photo 8.2-5: Siphon Breakers

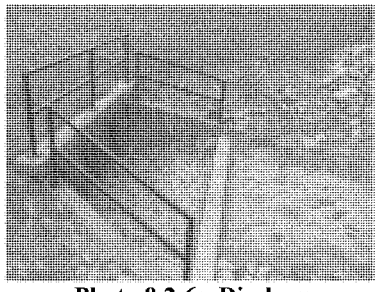


Photo 8.2-6: Discharge Headwall

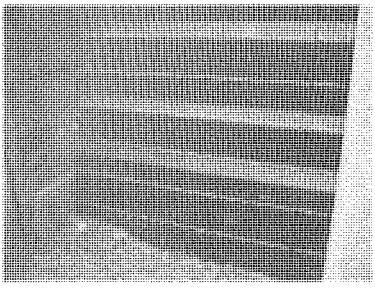


Photo 8.2-7: Trash Rack

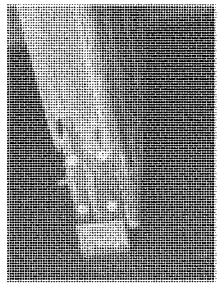


Photo 8.2-8: Divider Wall

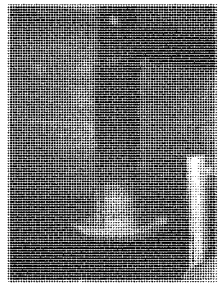


Photo 8.2-9: Pump Column & Umbrella

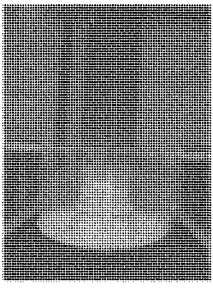


Photo 8.2-10: Pump Column and Umbrella Piping

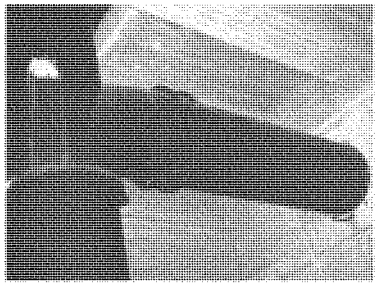


Photo 8.2-11: Pump Discharge Elbow and Piping

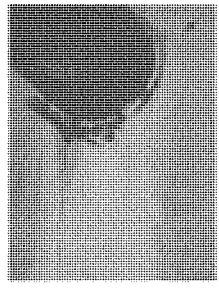


Photo 8.2-12: Pump Discharge

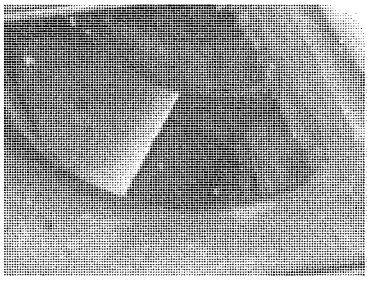


Photo 8.2-13: Pump Impeller (Note Nicks in Blade)

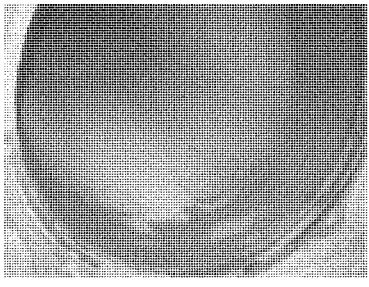


Photo 8.2-14: Pump Discharge Piping Looking from Gate Well with Raised Flap Gate (Note Corrosion in Piping)

8.2.3.2. Pump Plant #2; Sixth Street.

Equipment in Pump Plant (Photos 8.2-15 through 24):

1) Six vertical column pumps (# 2 thru 7) and one non-clog type sump pump (# 1) with a shafted motor and pump stand on sump floor; see table 2 for pump performance and manufacturing data. Pump number 7 is a water lubricated pump was installed in 1996 and does not require any work during this project. Pump numbers 2 thru 6 shall be reconditioned and pump #1 shall be replaced with a new submersible type design.
2) Currently the pumps are lubricated with a manual type grease system. Install a new centralized automated grease lubrication system, similar to the ones installed in pump stations 5, 6 and 11during the upgrades.
3) The discharge pipes associated with the pumps shall be removed and new ones installed up and over the levee, along with air vents. The following discharge pipe sizes and lengths shall be replaced in the sump: Two 60-inch lines are both 150 feet, two 48-inch lines are both 170 feet, one 30-inch line is 150 feet and the 10-inch line is 200 feet.
4) The original dial indicator provides the station operator with the sump water levels for starting and stopping of the equipment. The original mercury type float controls are no longer operational and has been replaced with a PLC type system.
5) Current pump operation starts manually and stops automatically with the new PLC system installed during a station upgrade in 1999. Flap Gates for pumps 1 thru 6 are located on the headwall and shall be replaced.

6) The four 8 foot by 8 foot sluice gate with electric hoist actuators shall be sandblasted and repainted with coal tar epoxy. The gate nut, stem, and electric actuator shall be removed and replaced. The new components shall have a bronze gate nut and a stainless steel stem. See electrical section for more information on electrical actuator.

Photo 8.2-15: Pump Discharge Piping Headwall and Flap Gates

Photo 8.2-16: Pump Discharge Piping Headwall and Flap Gates (Note Corrosion and Welded Repair of Gate)

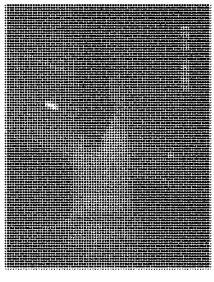


Photo 8.2-17: Pump Column

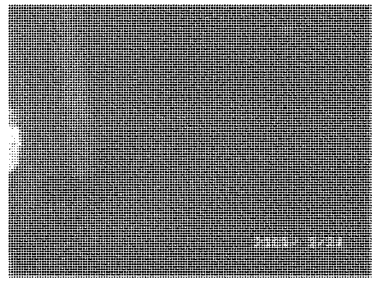


Photo 8.2-18: Pump Sump (Note Debris in Sump)

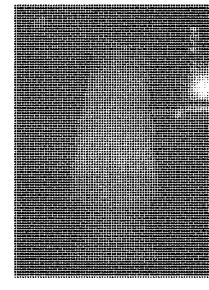


Photo 8.2-19: Pump Column

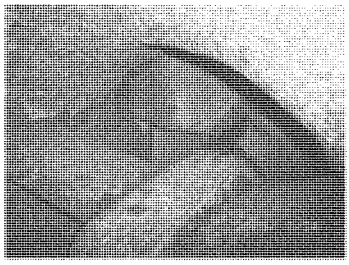


Photo 8.2-20: Pump Impeller

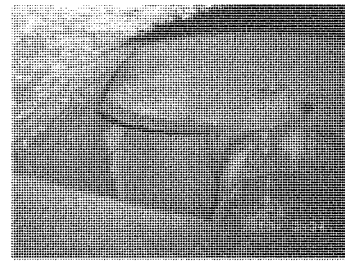


Photo 8.2-21: Pump Impeller (Note Nicks on Blades Column and Umbrella)

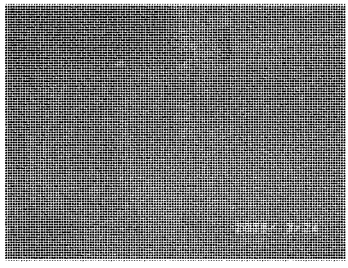


Photo 8.2-22: Pump Discharge Elbow Connection to Piping (Note Corrosion of Flexible Coupling)

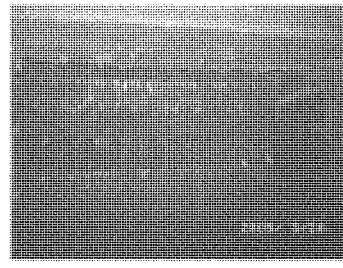


Photo 8.2-23: Trash Rack (Note Corrosion)

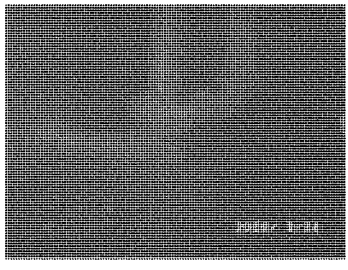


Photo 8.2-24: Non-Clog Sump Pump

8.2.3.3. Pump Plant #3; Park Avenue.

Equipment in Pump Plant (Photos 8.2-25 through 31):

1) Three vertical column pumps and one non-clog type sump pump with a shafted motor and pump stand on s ump floor; see table 2 for pump performance and manufacturing data. These three pumps and motors shall be removed along with associated equipment and replaced with a submersible non-clog type design with the motor attached directly to the pump. This will eliminate the need for a lubrication system.
2) Current manual type grease lubrication systems will be removed.

3) The discharge pipes associated with the pumps shall be removed and new ones installed. T he following discharge pipe sizes and lengths shall be replaced in the sump: Two 18-inch lines are both 3 feet and the 6-inch is 20 feet.
4) The original dial indicator provides the station operator with the sump water levels for starting and stopping of the equipment is still functional. Provide a new type of control system to automatically stop pumps without relying on operation personnel.
5) Current pump operation start and stop are done manually.
6) Flap gates located in the gate well associated with the pump plant shall be replaced when new discharge piping is installed.

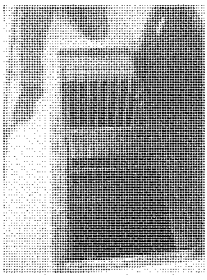


Photo 8.2-25: Trash Rack

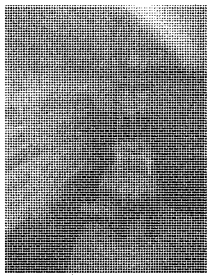


Photo 8.2-26: Pump Column (Note Corrosion)

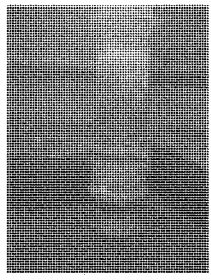


Photo 8.2-27: Sump Pump (Note Debris in Sump)

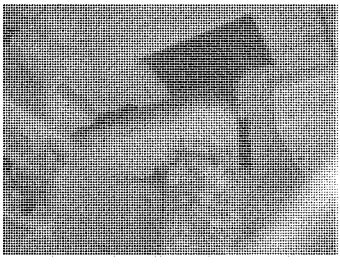


Photo 8.2-28: Pump Column (Note Corrosion)

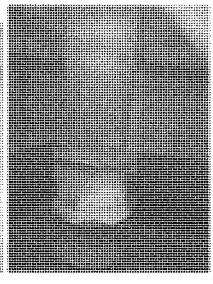


Photo 8.2-29: Pump Impeller

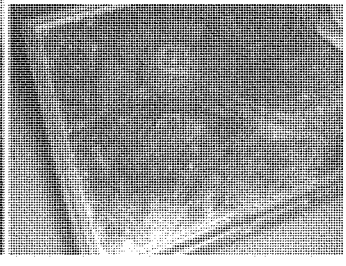


Photo 8.2-30: Pump Discharge and Elbow; (Note Corrosion at Flexible Coupling)

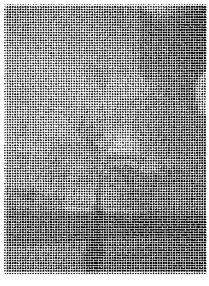


Photo 8.2-31: Bypass Sluice Gate for Pump Sump (Note Corrosion and Leakage at Bottom Corner)

8.2.3.4. Pump Plant #4; North 3rd St. and Executive Blvd.

Equipment in Pump Plant (Photos 8.2-32 through 34):

1) There are two non-clog type pumps with a shafted motor and pump stand on the sump floor located within the dry well; see table 2 for pump performance and manufacturing data. These two pumps and motors shall be removed along with associated equipment and replaced with a submersible non-clog type design with the motor attached directly to the pump. This will eliminate the need for a lubrication system.
2) Current manual type grease lubrication systems will be removed.
3) The discharge piping located within the dry well is in good condition and will be reconnected to the new submersible pumps.
4) The original spark plug pod type level indicator shall remain and provide automated stop and start as currently accomplished once plant is placed in operation.
5) Backflow prevention is done with a check valve on the dry side of the pump plant along with emergency closure by a gate valve if required. There are no flap gates on the discharge line. Current valving will not be required to be replaced.

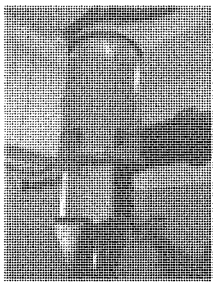


Photo 8.2-32: Pump Motor and Stand

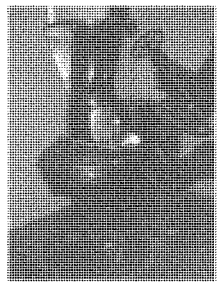


Photo 8.2-33: Pump Stand

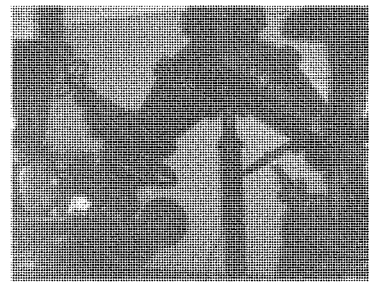


Photo 8.2-34: Discharge Piping (Note Excellent Condition of Piping)

8.2.3.5. Pump Plant #5; Harrison Street.

Equipment in Pump Plant (Photos 8.2-35 through 45):

1) There are three vertical column pumps and one non-clog type sump pump with a shafted motor and pump stand on sump floor; see table 2 for pump performance and manufacturing data. All three pumps shall be reconditioned and a new submersible type design shall be installed for the sump pump.
2) A centralized automated grease lubrication system was installed during station upgrade in 1999 and does not require any additional work.

3) The discharge pipes associated with the pumps shall be removed and new ones installed. T he following discharge pipe sizes and lengths shall be replaced in the sump: Two 36-inch lines are both 8 feet, 24-inch is 15 feet and the 12-inch is 2 feet.
4) The original dial indicator which provides the station operator with the sump water levels for starting and stopping elevations of the equipment is operational but was modified during the upgrade to provided automated stopping.
5) Current pump operation starts manually and stops automatically with the new PLC system installed during a station upgrade in 1999.
6) Flap gates located in the gate well associated with the pump plant shall be replaced when new discharge piping is installed.

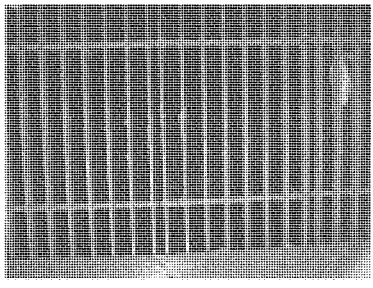


Photo 8.2-35: Trash Rack (Note, Corrosion)

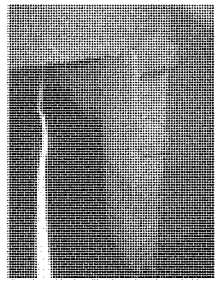


Photo 8.2-36: Sluice Gate Opening (Note Corrosion)

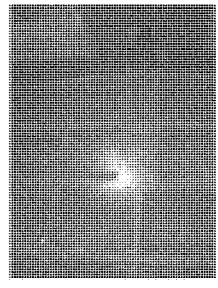


Photo 8.2-37: Sluice Gate (Note Corrosion)

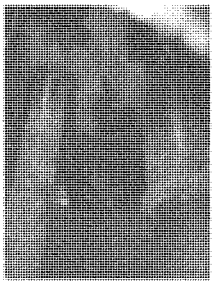


Photo 8.2-38: Sump Piping and Bypass Gate (Note Corrosion)

Photo 8.2-39: Discharge Piping and Flexible Coupling (Note Corrosion)

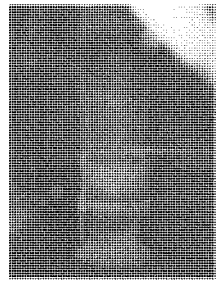


Photo 8.2-40: Pump Column and Suction (Note Corrosion)

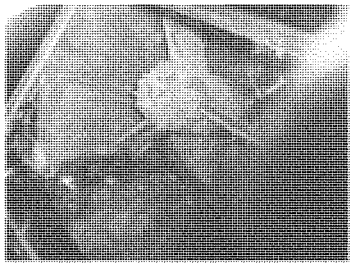


Photo 8.2-41: Pump Impeller (Note Damage to Blade)

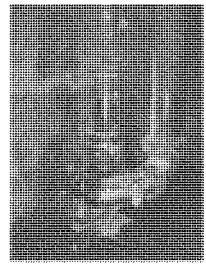


Photo 8.2-42: Sump Pump

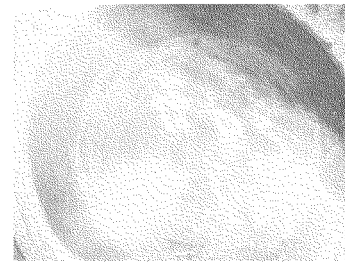


Photo 8.2-43: Pump Discharge Piping (Note Corrosion)

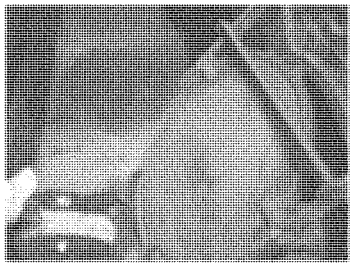


Photo 8.2-44: Pump Discharge Flap Gate (Note Minor Corrosion)

Photo 8.2-45: Pump Discharge Piping (Note Rust Packing on Pipe)

8.2.3.6. Pump Plant #6; Clark Street.

Equipment in Pump Plant (Photos 8.2-46 through 51):

1) There are four vertical column pumps and one non-clog type sump pump with a shafted motor and pump stand on s ump floor; see Table 2 for pump performance and manufacturing data. All four pumps shall be reconditioned and a new submersible type design shall be installed for the sump pump.
2) A centralized automated grease lubrication system was installed during station upgrade in 1999 and does not require any additional work.
3) The discharge pipes associated with the pumps shall be removed and new ones installed. T he following discharge pipe sizes and lengths shall be replaced in the sump: Three 42-inch lines are 5 feet, 5 feet and 15 feet, 36-inch is 15 feet and the 8-inch is 25 feet.
4) The original dial indicator which provides the station operator with the sump water levels for starting and stopping of the equipment is operational but was modified during the upgrade.
5) Current pump operation starts manually and stops automatically with the new PLC system installed during a station upgrade in 1999.

6) Flap gates located in the gate well associated with the pump plant shall be replaced when new discharge piping is installed.
7) The two 7 foot by 7 foot sluice gates with electric hoist actuators shall be sandblasted and repainted with coal tar epoxy. The gate nut, stem and electric actuator shall be removed and replaced. The new components shall have a bronze gate nut and a stainless steel stem. See electrical section for more information on electrical actuator.

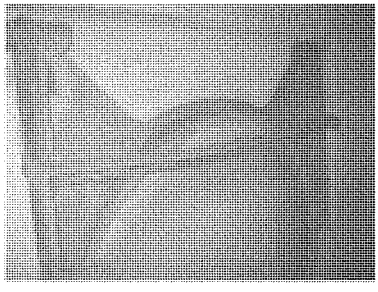


Photo 8.2-46: Pump Discharge Flap Gate (Note Corrosion)

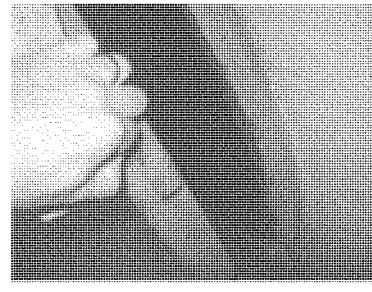


Photo 8.2-47: Corrosion around Pipe and Seat, Seat Needs Machining

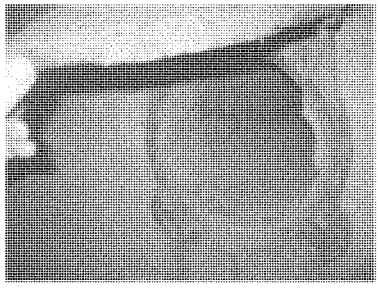


Photo 8.2-48: Sump Pump Discharge Piping Flap Gate (Note Heavy Corrosion and Rust Packing on Pipe)

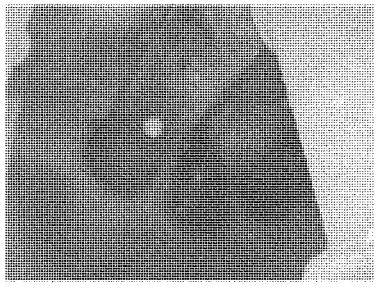


Photo 8.2-49: Pump Elbow and Discharge Piping (Note Corrosion on Pump Column)

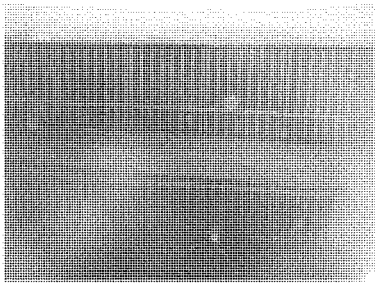


Photo 8.2-50: Trash Rack (Note Corrosion on Bottom of Rack)

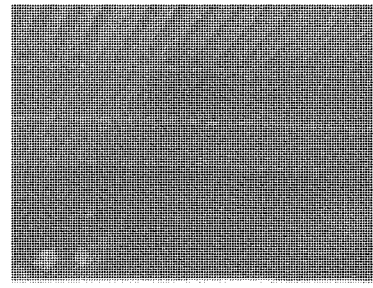


Photo 8.2-51: Trash Rack (Note Corrosion on Bottom of Rack)

8.2.3.7. Pump Plant #7; Tennessee Street.

Equipment associated with Pump Plant (Photos 8.2-52 through 59):

1) There are two vertical column pumps and one non-clog type with a shafted motor and pump stand on sump floor; see table 2 for pump performance and manufacturing data. These three pumps and motors shall be removed along with associated equipment and replaced with a submersible non-clog type design with the motor attached directly to the pump. This will eliminate the need for a lubrication system.
2) Current lubrication systems shall be removed.
3) The discharge pipes associated with the pumps shall be removed and new ones installed. Current sizes are 30, 21 and 10-inches. Lengths of piping are 6, 5 and 20 feet respectively.
4) The original dial indicator which provides the station operator with the sump water level elevations for starting and stopping of the equipment is still functional. The pumps are operated manually. Since the pumps are being replaced with a submersible type, a float system can be installed for automatic operation of the station, except maintenance personnel will still be responsible for removal of debris on the trash racks.
5) Current pump operation start sump elevation are done manually.
6) Currently, the operators stop the pump when amperage readings on the motor start "jumping" or when they hear cavitation noise. See Table 8.2-3 for more information.
7) Flap gates located in the gate well associated with the pump plant shall be replaced when new discharge piping is installed.

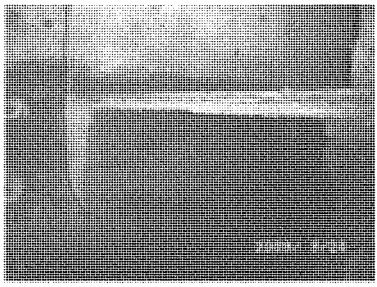


Photo 8.2-52: Support Bracket for Pump Column (Note Heavy Section Due to Corrosion)

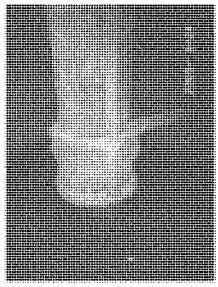


Photo 8.2-53: Pump Column (Note Corrosion)

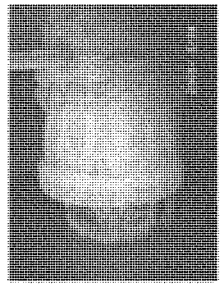


Photo 8.2-54: Close Up of Pump Column Heavy Rust Packing

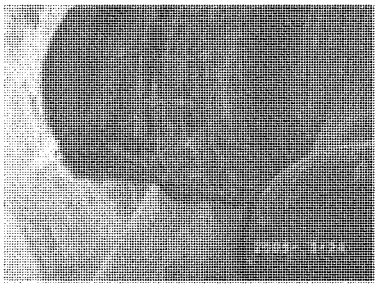


Photo 8.2-55: Pump Discharge Piping and Rusted Flexible Coupling

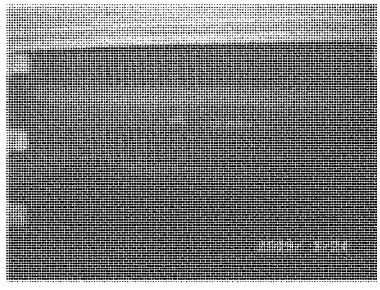


Photo 8.2-56: Trash Rack (Note Corrosion)

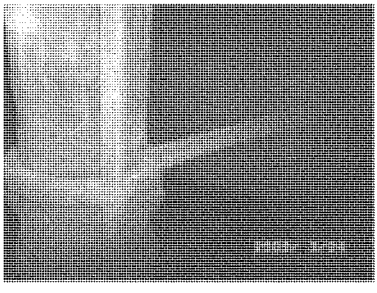


Photo 8.2-57: Pump Column Heavy Section Loss on Bracket and Rust Packing

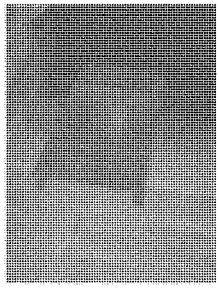


Photo 8.2-58: Bypass Sluice Gate (Note Corrosion)

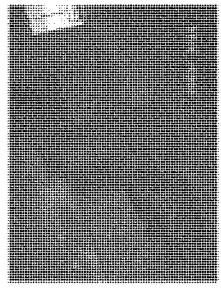


Photo 8.2-59: Pump Discharge Piping

8.2.3.8. Pump Plant #8; Norton Street.

This pump plant is no longer in operation and the well and associated piping has been permanently sealed under Ingrams Parking lot. The associated gravity manholes are still in place and allow gravity drainage to the river.

8.2.3.9. Pump Plant #9; Husbands Street.

Equipment in Pump Plant (Photos 8.2-60 through 62):

1) There are two non-clog type pumps with a shafted motor and pump stand on the sump floor located within the dry well; see table 2 for pump performance and manufacturing data. These two pumps and motors shall be removed along with associated equipment and replaced with a submersible non-clog type design with the motor attached directly to the pump. This will eliminate the need for a lubrication system.
2) Current lubrication system is automatic oil for line shaft bearings and manual grease type for tail bearing and will be removed.
3) The discharge piping located within the dry well is in good condition and will be reconnected to the new submersible pumps.
4) The original dial indicator which provides the station operator with the sump water level elevations for starting and stopping of the equipment is still functional. The pumps are operated manually. Since the pumps are being replaced with submersible type pumps, a float system can be installed for automatic operation of the station, except maintenance personnel will still be responsible for removal of debris on the trash racks.
5) Current pump operation start and stop are done manually. Maintenance personnel indicated that they start at 3.0 feet for one to two days when there is no rain after a rain event to help the wastewater treatment plant eliminate Combined Sewer Overflow (CSO).
6) Backflow prevention is done with a check valve on the dry side of the pump plant along with emergency closure by a gate valve if required. There are no flap gates on the discharge line. Current valving will not be required to be replaced.

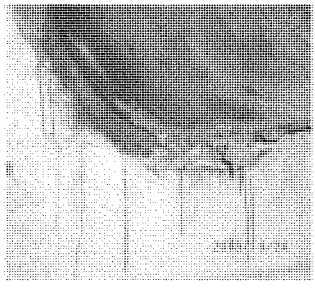


Photo 8.2-60: Discharge Piping Through Wall (Note Corrosion)

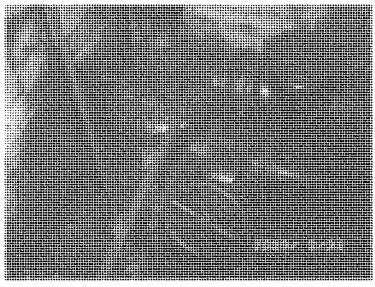


Photo 8.2-61: Pump and Discharge Piping (Note Lubrication on Walls and Equipment)

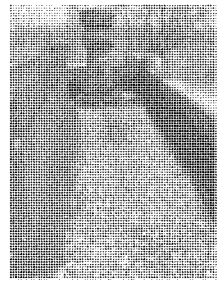


Photo 8.2-62: Air Vent (Note Heavy Corrosion)

8.2.3.10. Pump Plant #10; George Street.

Equipment in Pump Plant (Photos 8.2-63 through 65):

1) There are two non-clog type pumps with a shafted motor and pump stand on the sump floor located within the dry well; see table 2 for pump performance and manufacturing data. These two pumps and motors shall be removed along with associated equipment and replaced with a submersible non-clog type design with the motor attached directly to the pump. This will eliminate the need for a lubrication system.

2) Current manual type grease lubrication systems will be removed.
3) The discharge piping located within the dry well is in good condition and will be reconnected to the new submersible pumps.
4) The original spark plug pod type level indicator shall remain and provide automated stop and start as currently accomplished once plant is placed in operation.
5) Backflow prevention is done with a check valve on the dry side of the pump plant along with emergency closure by a gate valve if required. There are no flap gates on the discharge line. Current valving will not be required to be replaced.

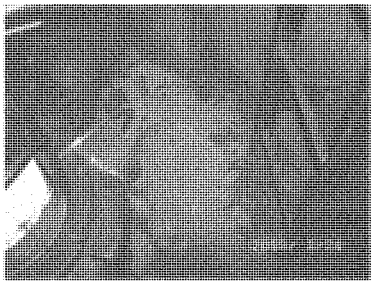
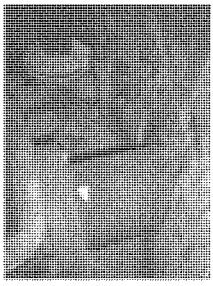


Photo 8.2-63: Pump and Stand at Bottom Station Well



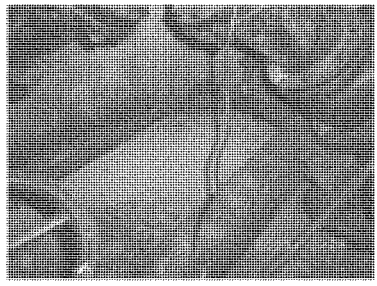


Photo 8.2-64: Discharge

Photo 8.2-65: Pump Discharge Piping

8.2.3.11. Pump Plant #11; Island Creek.

Equipment in Pump Plant (Photos 8.2-66 through 69):

1) There are four vertical column pumps see; Table 8.2-2 for pump performance and manufacturing data. Since pump no. 1 was installed in 1998, only the original three (nos. 2 thru 4) shall be reconditioned.
2) The station has already been converted to an automated centralized greasing system and does not require any reconditioning.
3) The discharge pipes shall be sandblasted and repainted.
4) The original dial indicator, which provides the station operator with the sump water levels for starting and stopping of the equipment, has been modified with automated controls for stopping only. Starting is done manually.
5) Flap gates located in the gate well associated with the pump plant will be sandblasted and repainted.

Pump #1 has a water lubricating system. Manufacturer has indicated that the pumps shall not be run in a dry condition; therefore during this investigation the pump was not operated. According to operating staff, no problems were noted when Pump #1 was last operated.

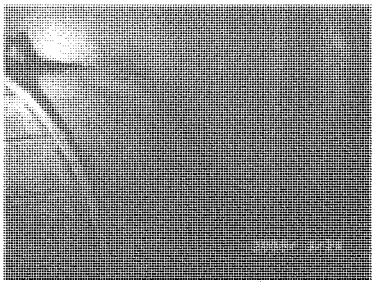


Photo 8.2-66: Pump Discharge and Flexible Coupling (Note Corrosion) Corrosion)

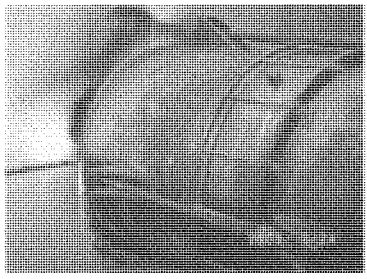


Photo 8.2-67: Pump Discharge Piping Piping and Flexible Coupling (Note Corrosion)

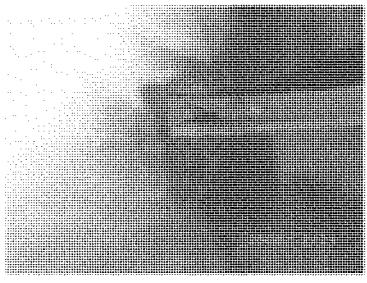


Photo 8.2-68: Pump Support Bracket (Note Corrosion)

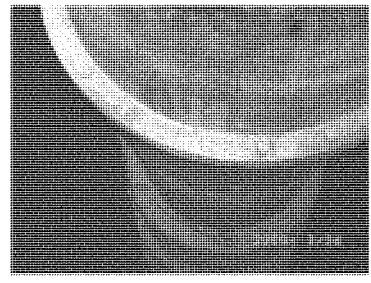


Photo 8.2-69: Pump Column

8.2.3.12. Pump Plant #12.

Equipment in Pump Plant (Photos 8.2-70 through 72):

1) There are two vertical column pumps; see table 2 for pump performance and manufacturing data. Both pumps shall be replaced with a new submersible type design.
2) Automated oiler and manual grease lubrication systems shall be removed.
3) The two 24-inch discharge pipes associated with the pumps shall be removed and new ones installed in place up and over the levee, along with air vents. The approximately length for each pipe is 105 feet.
4) The original dial indicator, which provides the station operator with the sump water levels for starting and stopping of the equipment, is still functional. The pumps are operated manually. Since the pumps are being replaced with submersible type pumps, a float system can be installed for automatic operation of the station, except maintenance personnel will still be responsible for removal of debris on the trash racks.
5) Current pump operations start and stop are done manually.
6) Flap Gates located on the headwall are in good condition and do not need to be replaced.

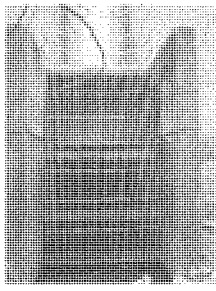


Photo 8.2-70: Trash Well Rack and Approach Walls

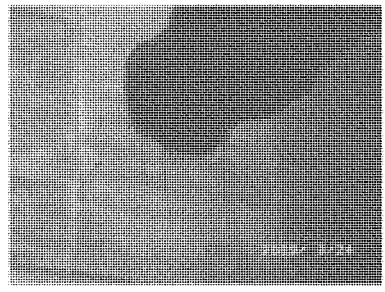


Photo 8.2-71: Discharge Piping

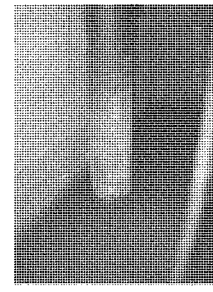


Photo 8.2-72: Float Well

8.2.3.13. Pump Plant #13.

Equipment in Pump Plant (Photos 8.2-73 and 74):

Station consists of one self-priming horizontal driven in-line pump; see table 2 for pump performance and manufacturing data. Lubrication system is a manual grease type and is in good condition. Pumps are started and shutdown manually on an as required basis to reduce ponding. See Table 3 at end of section 8.2.3 for more information.

This station was built in 1960's and pump has been used very infrequently. Maintenance personnel have indicated that the equipment operates without any problems; therefore this pumping equipment will not require any reconditioning.

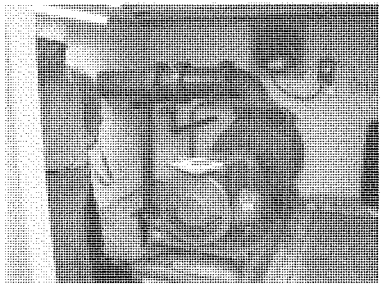


Photo 8.2-73: Pump with Motor and Discharge Piping through Wall

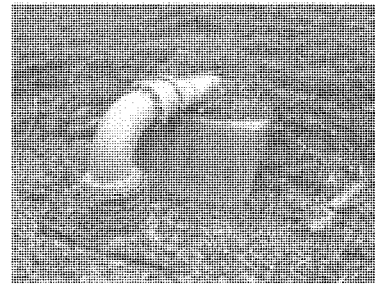


Photo 8.2-74: Intake Piping and Screen

8.2.3.14. Pump Plant #14 (Proposed).

(1) Station Design Capacity: Maximum pumping requirements and pump starting and stopping elevations were established in Hydrology and Hydraulics Section. Station capacity is 100 cfs and will be accomplished with two 50 cfs pumps.

(2) Sump Design and Number of Pumps: The sump design configuration of the pump plant is based on earlier model studies conducted by ERDC in Vicksburg, MS. T wo designs and costs associated with each have been developed for feasibility study which includes a flow thru type design utilizing two 50 cfs (2 – 250 HP pumps) pumps. One design consists of the use submersible pumps and the other utilizes vertical column pumps.

(3) Operation Characteristics: The station design will be modified as required for either type of pumping equipment to operate from a range of start to stop elevations of 327.5 ft to 323.0 ft respectively in the ponding area and pump sump.

(4) Pump Discharge Lines: There will be twin 30-inch discharge lines from the pump sump over the levee to a discharge well that is to be connected to the existing slip lined 72 gravity pipe which discharges in the Ohio River. Each 30-inch discharge will terminate in the discharge well with a pump type operated flap gate to prevent backflow into the pump sump.

(5) Final Design and pump selection will be based on costs and maintenance of the new equipment. The design will meet all the requirements of Corps of Engineers Engineering Manuals (EM) and Industry Standards.

(6) Miscellaneous Features: A manually operated trash rack will be provided and designed to meet the requirements of EM 1110-2-3102. Ladders will be provided to access sumps for maintenance.

8.2.3.15. Woodward Hollow Discharge Pipe (Photos 8.2-75 through 78).

Construct an 8 inch pipeline approximately 375 feet by open cut method across 4th Street, under railroad tracks, up and over the levee to an existing headwall at Sta. 19+11B.

Photo 8.2-75: Woodward Hollow Intake Area for Gravity Drainage

Photo 8.2-76: Woodward Hollow View Looking Down Fourth Street

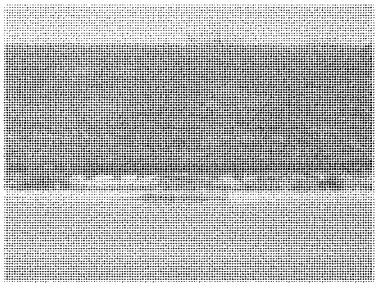


Photo 8.2-77: Looking Towards River and Railroad Tracks at Woodward Hollow

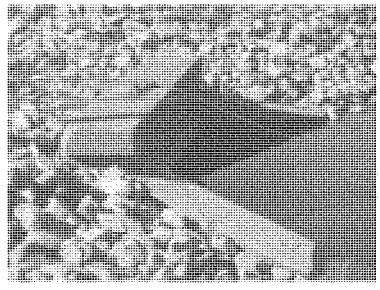


Photo 8.2-78: Headwall for 66-Inch Flap Gate at Sta. 19+11B

8.2.3.16. Manholes with Gated Outlets that Require Repair.

Inspections were made of all confined space entries in manholes that have gated outlets and visual inspections made of all headwalls that contain flap gates. Table 8.2-1 is a list of locations and new equipment to be installed at each structure:

TABLE 8.2-1: Manhole Cover Inspections
(Notes Follow)

MH NO.	LOCATION	DESCRIPTION	REMARKS
8-A	Sta. 123+61B2	20" Flap Gate	Leaks, Install New
7-A	Sta. 119+37B2	24" Flap Gate	Replace Gate
6-B2	Sta. 115+26B	8" Gate Valve	Leaks, Install New
6-A	Sta. 115+06B2	8" Shear Gate	Replace Gate
3-B2	Sta. 108+58B	2-36x36 Sluice	Leaks, Install New
3-A	Sta. 108+58B2	54" Flap Gate	Leaks, Install New
City	Sta. 74+40B1	8" Flap Gate	Replace Gate
5-A	Sta. 69+86B1	30" Flap Gate	Leaks, Install New
4-A	Sta. 57+98B1	24" Flap Gate	Leaks, Install New
	Sta. 187+34A	15" Sluice Gate	Replace Gate, See Note 1
	Pine St Headwall	16" Shear Gate	Remove Debris, Sandblast and repaint
23-B2	Sta. 66+27A	102"x102" Sluice	See Note 2
24-B2	Sta. 66+17A	102"x102" Sluice	See Note 3
16-A	Sta. 150+38B2	24" Flap Gate	See Note 4, Install New Flap Gate
PP#6-1P	Sta. 108+58 River	54" Flap Gate	Replace Gate
	Sta. 32+38C	3-60" Sluice	See Note 5
	Sta. 32+12C	2-48" Sluice	See Note 5

Table 8.2-1 Notes:

1. Install new ladder rungs and replace gate with non-rising stem type.
2. Install new electric actuator.
3. The 102 by 102 inch sluice gate located near pump plant number 2 has broken part of its casting near the top of the gate, see photo 8.2-79. This gate, frame, guides and stem shall be replaced and a new electric hoist actuator shall be installed to facilitate the opening and closing of such a large gate. Gates typically larger than 60-inches use electric actuators to eliminate safety problems, since a heavy motor operated device has to be brought to this location to operate the gate.
4. Manhole # 16-A is located under the Executive Inn Parking Lot. After reviewing video the flap gate will need to be replaced.
5. Requires sandblasting and painting of the outfall structure and sluice gates. Adjust wedges as required to seal sluice gates.

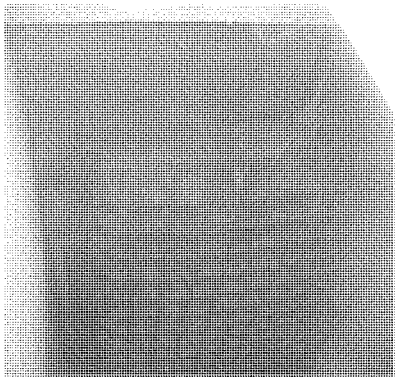


Photo 8.2-79: Sluice Gate at Sta. 66+17A (Note Heavy Corrosion and the Gate Casting is Broken at the Top Near the Gate Stem)

TABLE 8.2-2: Paducah Pump Plants
Pump Performance and Manufacturing Data

Facility Number Equipment ID	Manufacturer	Model and Size	Date of Rehab	Design Flow (GPM)	TDH (Ft of Water)	HP	Speed (rpm)	Serial Number	Remarks
PP #1; Noble Park									
Unit #1	Fairbanks Morse	FM 30	New 1954	22,000	20.5	150	703	PR6704	Pump will be rehabilitated
Unit #2	Fairbanks Morse	FM 30	New 1954	22,000	20.5	150	703	PR6705	Pump will be rehabilitated
Unit #3	Fairbanks Morse	FM 30	New 1954	22,000	20.5	150	703	PR6706	Pump will be rehabilitated
PP #2; Sixth Street									
Unit #1	Economy (Sump)	SSV-8		1,500	26.7	20	880	E-4892	Pump will be replaced with a new submersible type
Unit #2	Economy	SAFV – 26 x 30	Motor Shaft in 93	18,500	26.7	200	706	E-4794	Pump will be rehabilitated
Unit #3	Economy	SAFV – 54 x 60		90,000	26.7	800	355	E-4782	Pump will be rehabilitated
Unit #4	Economy	SAFV – 54 x 60		90,000	26.7	800	355	E-4783	Pump will be rehabilitated
Unit #5	Economy	SAFV – 42 x 48		90,000	26.7	500	443	E-4784	Pump will be rehabilitated
Unit #6	Economy	SAFV – 42 x 48		50,000	26.7	500	443	E-4785	Pump will be rehabilitated
Unit #7	WDM Pumps	20KLD/1	1996	8,600	32.5	100	1200	950435971; 95-469-1	Pump was installed new in 1996, no work required

Facility Number Equipment ID	Manufacturer	Model and Size	Date of Rehab	Design Flow (GPM)	TDH (Ft of Water)	HP	Speed (rpm)	Serial Number	Remarks
PP #3; Park Avenue									
Unit #1	Economy (Sump)	SSV – 6		600	18.7	5	870	E-4895	Pump will be replaced with a new submersible type
Unit #2	Economy	SAFV – 16 x 18		4,400	13.8	25	880	E-4803	Pump will be replaced with a new submersible type
Unit #3	Economy	SAFV – 16 x 18		4,400	13.8	25	880	E-4804	Pump will be replaced with a new submersible type
PP #4; 3rd St. & Exec. Blvd.									
Unit #1	Economy	SSV – 10 x 12	Lower Brg in 79	4,500	19.6	50	885	E-4888	Pump will be replaced with a new submersible type
Unit #2	Economy	SSV – 10 x 12	Lower Brg and Shaft in 84	4,500	19.6	50	885	E-4887	Pump will be replaced with a new submersible type
PP #5; Harrison Street									
Unit #1	Economy	SAFV – 26 x 36		20,000	21.4	200	694	E-4793	Pump will be rehabilitated
Unit #2	Economy	SAFV – 26 x 36		20,000	21.4	200	694	E-4792	Pump will be rehabilitated
Unit #3	Economy	SAFV – 18 x 24		9,500	21.4	100	870	E-4801	Pump will be rehabilitated
Unit #4	Economy (Sump)	SSV – 8		2,200	21.4	25	710	E-4891	Pump will be replaced with a new submersible type

Facility Number Equipment ID	Manufacturer	Model and Size	Date of Rehab	Design Flow (GPM)	TDH (Ft of Water)	HP	Speed (rpm)	Serial Number	Remarks
PP #6; Clark Street									
Unit #1	Economy	SAFV – 30 x 42		31,100	22.1	250	501	E-4790	Pump will be rehabilitated
Unit #2	Economy	SAFV – 26 x 36		15,600	22.1	125	700	E-4797	Pump will be rehabilitated
Unit #3	Economy	SAFV – 30 x 42		31,100	22.1	250	501	E-4791	Pump will be rehabilitated
Unit #4	Economy	SAFV – 30 x 42		31,100	22.1	250	501	E-4789	Pump will be rehabilitated
Unit #5	Economy (Sump)	SSV – 6		1,000	22.1	10	875	E-4894	Pump will be replaced with a new submersible type
PP #7; Tennessee Street									
Unit #1	Economy	SAFV – 26 x 36		15,000	19.6	125	700	E-4798	Pump will be replaced with a new submersible type
Unit #2	Economy	SAFV – 16 x 21		7,000	19.6	50	1170	E-4802	Pump will be replaced with a new submersible type
Unit #3	Economy	SSV – 8 x 10		1,300	19.6	10	705	E-4893	Pump will be replaced with a new submersible type
PP #9; Husbands Road									
Unit #1	Economy	SSV – 10	Brg in 97	3,900	21.5	40/46	870	E-4889	Pump will be replaced with a new submersible type
Unit #2	Economy	SSV – 10	Line Brg in 89	3,900	21.5	40/46	870	E-4890	Pump will be replaced with a new submersible type

Facility Number Equipment ID	Manufacturer	Model and Size	Date of Rehab	Design Flow (GPM)	TDH (Ft of Water)	HP	Speed (rpm)	Serial Number	Remarks
PP #10; George Street									
Unit #1	Economy	SSV – 6 x 8		1,200	11.7	10	875	E-4897	Pump will be replaced with a new submersible type
Unit #2	Economy	SSV – 6 x 8		1,200	11.7	10	875	E-4896	Pump will be replaced with a new submersible type
PP #11; Island Creek									
Unit #1	Cascade	36 MF	New in 98	33,000	26.7	300	590	L5272	Pump will not require any type of reconditioning
Unit #2	Economy			33,000	28	300	600	E-4786	Pump will be rehabilitated
Unit #3	Economy		Rehab in 65	33,000	28	300	600	E-4787	Pump will be rehabilitated
Unit #4	Economy		Diffuser Cracked Repaired in 90	33,000	28	300	600	E-4788	Pump will be rehabilitated
PP #12; STA 175+00C									
Unit #1	Economy			9,700	14	50	880	E47-98	Pump will be replaced with a new submersible type
Unit #2	Economy			9,700	14	50	880	E47-99	Pump will be replaced with a new submersible type

Facility Number Equipment ID	Manufacturer	Model and Size	Date of Rehab	Design Flow (GPM)	TDH (Ft of Water)	HP	Speed (rpm)	Serial Number	Remarks
PP #13 STA 291+75C									
Unit #1	Crown	P08 - 60	Installed in 65	2,000	80	60	1760	192469	Pump will not require any type of reconditioning

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 9
OPERATION AND MAINTENANCE

TABLE OF CONTENTS

9.1. OPERATION AND MAINTENANCE SCHEDULE. 9-1
9.1.1. Pump Plant O&M per Corps of Engineers 9-1
9.2. PROPOSED PUMP PLANT #14 9-2
9.2.1. Annual Operation and Maintenance Cost 9-2
9.2.2. Repair, Rehabilitation, Replacement Costs 9-2
9.3. EXISTING PUMP PLANTS #1 THRU #7 AND #9 THRU #12 9-3
9.3.1. Annual Operation and Maintenance Cost 9-3
9.3.2. Repair, Rehabilitation, Replacement Costs 9-3
9.3.3. Pump/Motor Replacement or Reconditioning Costs 9-4
9.4. PROPOSED WOODWARD HOLLOW DISCHARGE PIPE 9-5

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX C

SECTION 9 OPERATION AND MAINTENANCE

9.1. OPERATION AND MAINTENANCE SCHEDULE.

For the purpose of this study, a preliminary Operation and Maintenance (O&M) cost matrix was developed. (Reference the Paducah, Kentucky, Detailed Life-Cycle Costs Table in the main report). This table provides the detailed life-cycle cost which includes an estimate of the below proposed items for future operations, maintenance, and repair costs to be incurred over a 50-year period of analysis. It is assumed that all O&M costs will be borne by the City of Paducah.

9.1.1 Pump Plant Operation and Maintenance Requirements per Corps of Engineers.

The pumping station shall be inspected by the local sponsor at intervals not to exceed 30 days during flood seasons and 90 days during off-flood seasons to ensure that all equipment is in order for instant use. At regular intervals, proper measures shall be taken to provide for cleaning of station and equipment, repainting as necessary and lubricating all machinery. Adequate supplies of lubricants for all types of machines, and flash lights or lanterns for emergency lighting shall be kept on hand at all times. All equipment including switch gear, transformers, motors, pumps, and valves shall be trail operated and checked at least once every 90 days. Megger tests on all insulation shall be made whenever wiring has been subjected to undue dampness and otherwise at intervals not to exceed one year. A record shall be kept showing such tests. Wiring disclosed to be in an unsatisfactory condition by such tests shall be brought to a satisfactory condition or shall be promptly replaced. Only skilled electricians and mechanics shall be employed on tests and repairs. Operating personnel for the station shall be present during tests. Any equipment removed from the station for repair or replacement shall be returned or replaced as soon as practicable and shall be trial operated after reinstallation. Repairs requiring removal of equipment from the station shall be made during off-flood seasons, insofar as practicable.

The intake and discharge drainage structures related to the pump station shall have periodic inspections to be made certain that silt or debris deposited during flood conditions has been removed in accordance with the Corps of Engineers Operation and Maintenance Manuals for the City of Paducah, so that the channels remain open for water

flow and pipes, headwalls and riprap are in good condition. Immediate steps will be taken to repair damage; ore remedy adverse conditions disclosed by such inspections.

9.2. PROPOSED PUMP PLANT #14.

9.2.1. Annual Operation and Maintenance Cost

The local sponsor will have the responsibility for performing operation, maintenance, repair, replacement and rehabilitation activities as outlined above. A nnual costs are estimated based on the following assumptions:

Inspect/Test Pumps at Station – (16 man-days @ 120/day)	$ 1,920
Pump Station Operator Costs – (4 man-days @ 80/day)	$ 320
Total Annual Operation/Maintenance	$ 2,240
Total Annual Federal Inspection Costs	$ 500

9.2.2. Repair, Rehabilitation, Replacement Costs

Replace (2) Pumps and motors (year 35, as indicated by Requirements in EM 1110-2-3105)	$ 480,000
Total Repair, Rehabilitation and Replacement Costs	$ 500,000
Total Annual Repair/Rehabilitation/Replacement Costs Amortized Over 50 Year Economic Life of Project	$ 24,789

The annual repair, rehabilitation, and replacement cost is calculated as follows:

Interest and amortization factor for 50 year economic life x present worth factor for expenditure occurring in year 35 is $ 9,793.

Total Annual Operation, Maintenance, Repair, Rehabilitation, and Replacement Costs (OMRRR) are summarized below:

Total Annual Operation/Maintenance	$ 2,240
Total Annual Federal Inspection Costs	$ 500
Total Annual Repair, Rehabilitation, Replacement	$ 9,800
Contingency (20%)	$ 2,510
Total OMRRR Costs	$15,050

The estimated annual OMRRR Costs applicable to the Pump Station are $14,450 for the Local Sponsor and $ 600 (including contingencies) for the Federal Government.

9.3. EXISTING PUMP PLANTS #1 THRU #7 AND #9 THRU #12

9.3.1. Annual Operation and Maintenance Cost

The local sponsor will have the responsibility for performing operation, maintenance, repair, replacement and rehabilitation activities as outlined above. A nnual costs are estimated based on the following assumptions:

Inspect/Test/Operate Pumping Plants and Perform Operation and Maintenance On Levee/Floodwalls (Based on Average Annual Cost Provided by Paducah City Engineer	$ 460,000
Total Annual Operation/Maintenance	$ 460,000
Total Annual Federal Inspection Costs	$ 5,000

9.3.2. Repair, Rehabilitation, Replacement Costs

Replace submersible pump/motor and recondition pumps and motors (year 35, as indicated by Requirements in EM 1110-2-3105), See Table 9-1 for individual pump plant breakout costs	$ 2,125,738
Total Repair, Rehabilitation and Replacement Costs	$ 2,125,738
Total Annual Repair/Rehabilitation/Replacement Costs Amortized Over 50 Year Economic Life of Project	$ 105,388

The annual repair, rehabilitation, and replacement cost is calculated as follows:

Interest and amortization factor for 50 year economic life x present worth factor for expenditure occurring in year 35 is $ 41,635.

Total Annual Operation, Maintenance, Repair, Rehabilitation, and Replacement Costs (OMRRR) are summarized below:

Total Annual Operation/Maintenance	$ 460,000
Total Annual Federal Inspection Costs	$ 5,000
Total Annual Repair, Rehabilitation, Replacement	$ 41,635
Contingency (20%)	$ 101,327
Total OMRRR Costs	$ 607,962

The estimated annual OMRRR Costs applicable to the Pump Station are $ 601,962 for the Local Sponsor and $ 6,000 (including contingencies) for the Federal Government.

9.3.3. Pump/Motor Replacement or Reconditioning Costs

Facility Number	Motor Reconditioning	Pump Refurbishing	Pump Replacement
Pump Plant #1 Noble Park			
Unit #1	$7,000	$38,750	
Unit #2	$7,000	$38,750	
Unit #3	$7,000	$38,750	
Pump Plant #2 Sixth Street			
Unit #1			$ 15,210
Unit #2			$148,035
Unit #3	$34,837	$72,459	
Unit #4	$34,837	$72,459	
Unit #5	$23,900	$72,459	
Unit #6	$23,900	$66,248	
Pump Plant #3; Park Avenue			
Unit #1			$ 6,855
Unit #2			$31,975
Unit #3			$31,975
Pump Plant #4; Clay Street			
Unit #1			$32,270
Unit #2			$32,270
Pump Plant #5; Harrison Street			
Unit #1	$7,390	$38,750	
Unit #2	$7,390	$38,750	
Unit #3			$127,360
Unit #4			$ 14,590
Pump Plant #6; Clark Street			
Unit #1	$12,900	$44.125	
Unit #2			$149,152
Unit #3	$12,900	$46,853	
Unit #4	$12,900	$46,853	
Unit #5			$ 6,666
Pump Plant #7; Tennessee Street			
Unit #1			$130,656
Unit #2			$ 81,860
Unit #3			$ 14,250
Pump Plant #9; Husbands Road			
Unit #1			$32,225
Unit #2			$32,225
Pump Plant #10; George Street			

Unit #1			$15,21
Unit #2			$15,210
Pump Plant #11; Island Creek			
Unit #1	$13,133	$65,455	

Pump/Motor Replacement or Reconditioning Costs. Continued…

Unit #2	$14,133	$65,455	
Unit #3	$14,133	$65,455	
Pump Plant #12; SE of Paducah			
Unit #1			$81,860
Unit #2			$81,860
Totals	$232,453	$811,571	$1,081,714

9.4. PROPOSED WOODWARD HOLLOW DISCHARGE PIPE

The local sponsor will have the responsibility for performing operation, maintenance, repair, replacement and rehabilitation activities for the 8 inch gate valve associated with discharge concrete pad and piping located at Woodward Hollow. A nnual costs are estimated based on the following assumptions:

Inspect/Test Gate Valve – (1 man-hour at $15/hour, four times/year)	$60
Total Annual Operation/Maintenance	$60

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2
APPENDIX C

SECTION 10
COST ESTIMATE

TABLE OF CONTENTS

10.1. COST ESTIMATE 10-1
10.1.1. Basis of Estimate 10-1
10.1.2. Pricing 10-1
10.1.3. Markups 10-3
10.1.4. Schedule 10-3
10.1.5. Baseline Estimate 10-3
10.1.6. Total Project Cost Summary 10-10

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX C

SECTION 10 COST ESTIMATE

10.1. COST ESTIMATE SUMMARY.

10.1.1. Basis of Estimate.

The Baseline estimate is based on the design indicated in the Feasibility Report dated Apr 12, 2010 and described in the drawings and previous work completed on site by the sponsor.

WBS: The estimate is organized per the Civil Works Work Breakdown Structure (WBS) guideline/template.

Acquisition Strategy: Per discussion with the PM and the PDT this project is projected to be awarded by "Full and Open Competitive Bidding" process.

Contractor Hierarchy: This estimator assumed this project to have a Prime Contractor as broker and a primary subcontractor performing the major pump/motor installation and subcontracting out to secondary subcontractors the other work items.

10.1.2. Pricing.

Quotes have been received concerning the new/replacement of pumps, motors, and electrical switchgear, as well as quotes detailing the cost of refurbishing the existing pumps and motors.

The size of the crew and the duration for performing the removal and installation of new or refurbished pumps and motors were assumed by this estimator. A listing for all pumps indicating location, pump characteristics and motor size along with assumed crew sizes and productivities for pump and motor removal and installation was prepared. This listing was reviewed by Mark Robertson, a USACE employee, and Subject Matter Expert on pumps. It was also forwarded to S & K Equipment Co, the main supplier/vendor quoting the replacement or refurbishment of the existing pumps and motors for his review. (See Table 10.1) No revisions were received. Additionally a similar listing identifying needed electrical upgrades was prepared and provided to Eaton/Cutler-

Hammer Products. Eaton/Cutler-Hammer Products (Mr. Steven Dunsford, tel. nr. 502-961-5535) responded with a materials and installation quote for the scope identified. See Table 10.2. Due to limited access and/or confined maneuvering conditions at the various pump plants this estimator assumed only the use of a small bobcat/forklift/high lift needed as the equipment necessary to perform the removal, moving, loading, unloading, and installation work. The use of this equipment would be only few hours per day. The rest of the time it would be in "Stand-By", thus the cost for equipment is minimal.

The construction of the new water stop joints for the replacement of damaged or broken existing water-stop joints, and the replacement of joint seals at the existing water stop joints are based on similar work performed recently on other completed projects.

Actual construction costs from completed work were the basis in the estimate for the cost of slip-lining the existing pipes and erosion protection embankment areas.

Cost sources: Used the 2006 Cost Book - English. Revised material costs, per quotes received and or production rates as appropriate per estimator's judgment.

Wage Rates: As indicated on the Labor, used /Revised labor rate per Heavy & Highway KY20080025 1/22/2010 KY25 Modif. Nr 20 for McCracken Co., Ky.

Equipment: Used the 2005 Equipment Ownership and Operating Expense database Region 2. Revised fuel costs to current dollar values per gallon.

Material: Used the 2006 Cost Book – English (Effective Pricing Date Jan 2006). Revised material costs, per quotes received for the major and/or various items as noted in the estimate costs items.

The "Slip Lining of Existing Pipes" and the "Bank Protection at Sta 12+12B to Sta 15+32B; Riprap" items are identified as "City of Paducah - Work Perform By" are total costs to owner. These costs provided by the local Sponsor (the City of Paducah). This work has been accomplished. These items are included in this estimate in order the local sponsor to received credit said items. No contractor assigned.

All costs identified Feature 01 - Lands and Damages are total costs to owner, provided by LRL Real Estate Division. No contractor assigned.

Project PED at 10% of estimated construction cost ($10,327,000 consisting of Feature 02; Feature 11, less Levee Drainage Sliplining by Sponsor; and Feature 13). Work completed by sponsor not included in cost basis for PED.

Construction Management: 10% construction management was used. The project consists of 91% Operation and Maintenance work. Therefore, this includes approx. 7% for the Construction Division and Planning, Programs and Management Division during construction; and 3% for Engineering Division during construction.

10.1.3. Markups.

Price Level Adjustment: For the cost items in the cost estimate base on the 2006 Cost Book database a "Price Level" adjustment of 10% was applied (used 10% for 4 years). For those items in the cost estimate base quotes received from suppliers or subcontractors no "Price Level" adjustment was used.

Contingencies: Range from 10% to 50%. Individual contingency percentage amounts set at the definable work item levels. A significant portion of the cost estimate involves the refurbishment of the existing or the replacement with new for the pumps, motors, and electrical switching components at the 13 existing pumping plants involved. The basis for the unit costs used in the cost estimate was from quotes supplied by a pump supplier representing a major pump manufacture and an electrical supplier based on information provided to them by the Corps of Engineers personnel from information compiled from extensive site inspection. These supplied unit costs are only preliminary or budgetary costs in nature and the actual equipment to be replaced and the field conditions at each location may have a significant impact on the final individual unit costs. Therefore different contingency factors were used for refurbishment of unit verses replacement with new.

An Abbreviated Risk Analysis was performed by the PDT, which identified and documented the basis for the Contingencies assigned. The analysis was performed in accordance with the procedures identified by the Civil Works Cost DCX in accordance with ER1110-2-1302. The analysis documents project risks and uncertainties used in the development of contingencies for this project. This analysis is provided on the pages following the Baseline Estimate.

10.1.4. Schedule.

This is the projected project schedule:
Start of PED: Jan 2012;
Midpoint of PED: Sep 2012;
RTA: May 2013;
Start of Construction: Jul 2013;
Midpoint of Construction: Jan 2015;
Completion of Construction: Jul 2016.

10.1.5. Baseline Estimate.

The Baseline estimate summarized at the subfeature level is provided on the following pages.

THIS ESTIMATE IS FOR THE FEASIBILITY STUDY - SUBMERSIBLE PUMPS AT PROPOSED PUMP PLANT #14 AT STA 111+67A; INCLUDES PROFIT. Revised Pump Plant #14 for 100 CSF cap.

473

Estimated by	CORPS OF ENGINEERS, LOUISVILLE DISTRICT ED-M-C
Designed by	CORPS OF ENGINEERS, LOUISVILLE DISTRICT
Prepared by	Michael Witcher
Preparation Date	4/13/2010
Effective Date of Pricing	10/1/2009
Estimated Construction Time	1,100 Days

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Path: Z:/ED-M-C/Civil/FY10/112546 Paducah Feas Study/Estimate/Feasibility/

Checked By: Jim Vermillion

Designed by
CORPS OF ENGINEERS, LOUISVILLE DISTRICT

Estimated by
CORPS OF ENGINEERS, LOUISVILLE DISTRICT ED-M-C

Prepared by
Michael Witcher

Design Document CORPS OF ENGINEERS, LOUISVILLE DISTRICT ED-DC
Document Date 2/10/2010
District Louisville District
Contact Michael Witcher
Budget Year 2010
UOM System Original

Direct Costs
LaborCost
EQCost
MatlCost
SubBidCost
PED/CM
By Owner

Timeline/Currency
Preparation Date 4/13/2010
Escalation Date 9/30/2009
Eff. Pricing Date 10/1/2009
Estimated Duration 1100 Day(s)

Currency US dollars
Exchange Rate 1.000000

Costbook CB06EB: MII English Cost Book 2006

Labor LB06NatFD: Labor National 2006
Note: Revised labor rate per Heavy & Highway KY20080025 1/22/2010 KY25 Modif. Nr 20 for McCracken Co., Ky.

Labor Rates
LaborCost1
LaborCost2
LaborCost3
LaborCost4

Equipment EP05R02: MII Equipment Region 2 2005
Note: REVISED FUEL COST TO $3.00/GAL FOR GAS AND $3.30/GAL FOR DIESEL.

02 MIDEAST

Sales Tax	5.45
Working Hours per Year	1,450
Labor Adjustment Factor	1.07
Cost of Money	4.25
Cost of Money Discount	25.00
Tire Recap Cost Factor	1.50
Tire Recap Wear Factor	1.80
Tire Repair Factor	0.15
Equipment Cost Factor	1.00

Fuel

Electricity	0.070
Gas	3.000
Diesel Off-Road	3.300
Diesel On-Road	3.300

Shipping Rates

Over 0 CWT	2.21
Over 240 CWT	2.31
Over 300 CWT	2.98
Over 400 CWT	3.22
Over 500 CWT	3.54
Over 700 CWT	2.68
Over 800 CWT	2.55

Standby Depreciation Factor 0.50

Date	Author	Note
12/10/2009	Michael Witcher	Paducah Feasibility Study Scope of Work: This estimate is for the "Feasibility Study" level of design on the Paducah Flood Protection project, Paducah, Kentucky. The work involves the rehabbing of 12 existing pumping plants by refurbishing and/or replacing the existing pumps and motors; and the replacing the existing electrical switchgear with new at these 12 existing pumping plants; the construction of a new 150 CSF pump plant; the construction of two new gatewell structures; replacing two other multi-gate structures; slip lining 37 existing drainage structures; replacing both sides (16,200 lf) of the joint sealer at the all the waterstop joints in the existing T-Wall, L-Wall, and I-Wall units; and constructing a new waterstop joint at 14 existing damaged waterstop joints in the existing flood wall. Basis of Estimate: The estimate is a detail estimate in MCACES format based on the design shown on the drawings, spreadsheets, quotes from suppliers, similar work completed elsewhere, previous work completed, and on various quantities and information provided to Cost Engineering. Pricing: Received quotes on replacement of pumps, motor, and electrical switchgear, refurbishment of the existing pumps and motors; actual slip-lining construction costs; and the replacement of the electrical items. For the construction of the new water-stop joints item to replace damage or broken water-stop joints, received pricing info for similar work done elsewhere. For the replacement of the joint seals at the existing water-stop joint on both sides of the flood wall, used recent previous construction work performed elsewhere for similar a work item. Remaing work priced from the 2006 Cost Book (Jan 2006 Cost Basis). Markups: Price Level Adjustment: used 10% (Jan 2006 to Oct 2009) per Mike Braden. Based on a calculation from tables using EM 1110-2-1304 Civil Works Construction Cost Index System (CWCCIS). Planning Engineering and Design (PED): used 10% per Project Manager Contingencies: used 20% per Table 13-1, page 13-5 of EI 01D010 dated 1 Sep 1997, Construction Cost Estimates. SIOH (Supervision and Administration): Used 10%; Includes 5.7% for Construction Division and PPMD during construction; and 4.3% for Engineering Division during construction. Assumptions: Pumps and Motors: The smaller pumps and motor are to be replaced with new submersible pumps and new motors at the pump stations. The larger pumps and motors are to be refurbished or rebuild at the pump stations.
2/9/2010	Michael Witcher	Project Scope: The estimate revised only Pumping Plant # 14 to reduces the pumping capacity to 100 CFS. Received quotes on the submersible pumps and motors and the electrical switchgear components.
3/30/2010	Michael Witcher	The "Slip Lining of Existing Pipes" and the "Bank Protection at Sta 12+12B to Sta 15+32B; Riprap" items are identified as "City of Paducah - Work Perform By" are total costs to owner. These costs provided by the local Sponsor (the City of Paducah). This work has been accomplsihed/completed. Is included in this estimate

Date	Author	Note

in order the local sponsor to received credit said items. No contractor assigned.

All costs identified Feature 01 - Lands and Damages are total costs to owner, provided by LRL Real Estate Division. No contractor assigned.

Per ATR Comments, Discussion of the Preparation of and/or the Basis of the Estimate:
References:

WBS: This is estimate organized per the WBS guideline/templete.

Acquisition Strategy: Per discussion with the PM and the PDT this project projected to be awarded by "Free and Open Bidding".

Contractor Hierarchy: As indicated in the Contractor's Tab, this project to have a Prime Contractor as broker and a primary subcontractor performing the major pump/motor installation and subcontracting out secondary subcontractor the other work items.

Work performed by sponsor was isolated for reporting purposes.
Markups:

Costs sources: Used the 2006 Cost Book - English. Revised material costs, per quotes received and or production rates as appropriate per estimator's judgement.

Wage Rates: As indicated on the Labor, used/Revised labor rate per Heavy & Highway KY20080025 1/22/2010 KY25 Modif. Nr 20 for McCracken Co., Ky.

Equipment:

Material: Used the 2006 Cost Book - English. Revised material costs, per quotes received.

Contingencies:

This is the projected project schedule:
Start of PED: Jan 2012;
Midpoint of PED: Sep 2012;
RTA: May 2013;
Start of Construction: Jul 2013;
Midpoint of Construction: Jan 2015;
Completion of Construction: Jul 2016.

The size of the crew and the duration for performing the removal and installation of new or refurbished pumps and motors were assumed by this estimator. The spread sheet listing each pump, motor, size, and HP indicating these assumptions was reviewed by Mark Robertson, a CORPS employee, a Subject Matter Expert on pumps. It was also forwarded to S & K Equipment Co, the main supplier/vendor quoting the replacement or refurbishment of the existing pumps and motors for his review. No revisions were received. Due to limited access and/or confined maneuvering conditions at the various pump plants this estimator assumed only the used of a small bobcat/forklift/high lift needed as the equipment necessary to perform the removal, moving, loading, unloading, and installation work. The use of this equipment would be only several hours per day. The rest of the time it would be in "Stand-By". Thus the cost for equipment is minimal.

10.1.6. Total Project Cost Summary.

The Total Project Cost Summary is provided on the following pages.

Update

The project costs shown on the following pages were updated to FY 11 dollars in the Main Report (Volume 1 - see tables 5-3 and 5-4 in Section 5) in September 2011.

Description	UOM	DirectCost	SubCMU	PrimeCMU	ContractCost	Contingency	ProjectCost
Project Cost Summary Report		11,868,856	2,053,018	1,821,634	15,743,508	2,984,866	18,728,374
01 Lands and Damages	LS	436,000	0	0	436,000	0	436,000
0123 Construction Contract(s) Documents	LS	436,000	0	0	436,000	0	436,000
02 Relocations	LS	13,758	0	2,754	16,512	3,662	20,174
0203 Cemetery, Utilities, & Structure	LS	13,758	0	2,754	16,512	3,662	20,174
11 Levees and Floodwalls	LS	4,449,822	1,005,137	671,456	6,126,415	738,040	6,864,455
1101 Levees	LS	793,343	343,012	227,428	1,363,784	298,475	1,662,258
110102 Levees - Drainage - Sliplinning of Existing Pipes - City of Paducah - Work Perform By	LS	2,100,000	0	0	2,100,000	0	2,100,000
1102 Floodwalls	LS	1,556,479	662,125	444,028	2,662,632	439,565	3,102,197
13 Pumping Plant	LS	4,685,276	1,047,881	1,147,424	6,880,581	1,806,363	8,686,945
1300 Pumping Plant #1 (Noble Park)	LS	213,653	44,900	51,746	310,300	95,428	405,728
1300 Pumping Plant #2 (Sixth Street)	LS	937,050	196,926	226,952	1,360,928	354,216	1,715,144
1300 Pumping Plant #3 (Park Ave)	LS	143,941	30,250	34,862	209,053	42,226	251,279
1300 Pumping Plant #4 (Clay Street)	LS	114,658	24,096	27,770	166,524	37,453	203,977
1300 Pumping Plant #5 (Harrison St)	LS	229,250	48,178	55,524	332,952	100,352	433,305
1300 Pumping Plant #6 (Clark St)	LS	378,754	79,597	91,734	550,084	155,985	706,069
1300 Pumping Plant #7 (Tennessee St)	LS	370,615	77,887	89,762	538,264	118,141	656,405
1300 Pumping Plant #9 (Husbands Rd)	LS	133,774	28,113	32,400	194,287	40,756	235,043
1300 Pumping Plant #10 (George St)	LS	73,657	15,479	17,840	106,976	19,712	126,687
1300 Pumping Plant #11 (Island Creek)	LS	341,621	71,793	82,740	496,154	157,275	653,429
1300 Pumping Plant #12 (SE of Paducah)	LS	248,526	52,229	60,193	360,947	81,185	442,132
1300 Pumping Plant #13	LS	28,704	6,032	6,952	41,689	4,584	46,273
Misc Pump Station Items Not Shown	LS	565,325	118,249	136,809	820,383	328,153	1,148,537
1300 Pumping Plant #14a (at Sta 111+67A) Submersible Pump Option	LS	905,749	254,151	232,141	1,392,041	270,897	1,662,938
16 Bank Stabilization - City of Paducah - Work Perform By	LS	100,000	0	0	100,000	0	100,000
1600 Bank Stabilization - City of Paducah - Work Perform By	LS	100,000	0	0	100,000	0	100,000
30 Planning, Engineering and Design	LS	1,092,000	0	0	1,092,000	218,400	1,310,400
31 Construction Management	LS	1,092,000	0	0	1,092,000	218,400	1,310,400

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: Local Flood Protection Project Rehabilitation
LOCATION: Paducah, KY

DISTRICT: LRL
POC: CHIEF, COST ENGINEERING, Michael E. Braden

PREPARED: 4/9/2010

This Estimate reflects the scope and schedule in report: Feasibility Report

Program Year (Budget EC): 2012
Effective Price Level Date: 1 OCT 11

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FULLY FUNDED PROJECT ESTIMATE Spent Thru: 1-Oct-09 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
02	RELOCATIONS	17	3	20%	20	2.5%	17.4	3.5	20.9			18.4	3.7	22.1
11	LEVEES & FLOODWALLS (by Sponsor)	2,100			2,100		2100.0		2100.0	2100.0				2100.0
11	LEVEES & FLOODWALLS (New Work)	4,025	738	18%	4,754	2.5%	4125.7	756.3	4881.9			4356.6	798.6	5155.2
13	PUMPING PLANT	6,861	1,806	26%	8,667	2.5%	7031.3	1850.7	8882.0			7446.1	1954.3	9400.4
16	BANK STABILIZATION (by Sponsor)	100			100		100.0		100.0	100.0				100.0
	CONSTRUCTION ESTIMATE TOTALS:	13,124	2,547		15,671	2.1%	13394.4	2610.5	16004.9	2200.0		11821.1	2756.6	16777.7
01	LANDS AND DAMAGES	436			436	2.5%	446.8		446.8			454.2		454.2
30	PLANNING, ENGINEERING & DESIGN	1,092	218	20%	1,310	2.5%	1119.0	223.8	1342.8			1140.9	228.2	1369.1
31	CONSTRUCTION MANAGEMENT	1,092	218	20%	1,310	2.5%	1119.0	223.8	1342.8			1161.7	236.3	1418.0
	PROJECT COST TOTALS:	15,744	2,984	19%	18,728	2.2%	16079.3	3058.1	19137.4	2200.0		14597.9	3221.1	20019.0

CHIEF, COST ENGINEERING, Michael E. Braden
PROJECT MANAGER, Theresa C. Beckham
CHIEF, REAL ESTATE, Patty S. Smith
CHIEF, PLANNING, Sharon M. Bond
CHIEF, ENGINEERING, Stephen G. Durrett
CHIEF, CONSTRUCTION, George J. Jagerman
CHIEF, CONTRACTING, Mark R. Yates
CHIEF, PM-C, Linda R. Murphy
CHIEF, DPM, David F. Dale

ESTIMATED FEDERAL COST: **13012**
ESTIMATED NON-FEDERAL COST: **7007**

ESTIMATED TOTAL PROJECT COST: 20019

480

Filename: ATR_TPCS-Paducah 4-9-2010a.xls
TPCS

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Local Flood Protection Project Rehabilitation
LOCATION: Paducah, KY
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: LRL
POC: CHIEF, COST ENGINEERING, Michael E. Braden
PREPARED: 4/9/2010

Estimate Prepared: 9-Apr-10
Effective Price Level: 1 OCT 09

Program Year (Budget EC): 2012
Effective Price Level Date: 1 OCT 11

FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	P	L	M	N	O
	PHASE 1													
02	RELOCATIONS	$ 17	$ 3	20%	$ 20	2.5%	17.4	3.5	20.9	2015Q2	5.6%	18.4	3.7	22.1
11	LEVEES & FLOODWALLS (by Sponsor)	$ 2,100	$ -		$ 2,100		2100.0		2100.0			2100.0		2100.0
11	LEVEES & FLOODWALLS (New Work)	$ 4,026	$ 738	18%	$ 4,764	2.5%	4125.7	756.3	4881.9	2015Q2	5.6%	4356.6	798.6	5155.2
13	PUMPING PLANT	$ 6,881	$ 1,806	26%	$ 8,687	2.5%	7051.3	1850.7	8902.0	2015Q2	5.6%	7446.1	1954.3	9400.4
16	BANK STABILIZATION (by Sponsor)	$ 100	$ -		$ 100		100.0		100.0			100.0		100.0
	CONSTRUCTION ESTIMATE TOTALS:	13,124	2,547	19%	15,671		13394.4	2610.5	16004.9			14021.1	2756.6	16777.7
01	LANDS AND DAMAGES	$ 436	$ -		$ 436	2.5%	446.8		446.8	2013Q1	1.7%	454.2		454.2
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	109	$ 22	20%	131	2.5%	111.7	22.3	134.0	2012Q4	1.2%	113.0	22.6	135.7
0.1%	Planning & Environmental Compliance	11	$ 2	20%	13	2.5%	11.3	2.3	13.5	2012Q4	1.2%	11.4	2.3	13.7
6.4%	Engineering & Design	598	$ 140	20%	838	2.5%	715.3	143.1	858.3	2012Q4	1.2%	723.9	144.8	868.7
0.6%	Engineering Tech Review ITR & VE	66	$ 13	20%	79	2.5%	67.6	13.5	81.2	2012Q4	1.2%	68.5	13.7	82.1
0.2%	Contracting & Reprographics	22	$ 4	20%	26	2.5%	22.5	4.5	27.1	2012Q4	1.2%	22.8	4.6	27.4
1.2%	Engineering During Construction	131	$ 26	20%	157	2.5%	134.2	26.8	161.1	2015Q2	5.6%	141.8	28.4	170.1
0.5%	Planning During Construction	55	$ 11	20%	66	2.5%	56.4	11.3	67.6	2015Q2	5.6%	59.5	11.9	71.4
	Project Operations		$ -	20%										
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	874	$ 175	20%	1,049	2.5%	895.6	179.1	1074.8	2015Q2	5.6%	945.8	189.2	1134.9
	Project Operation:		$ -	20%										
2.0%	Project Management	218	$ 44	20%	262	2.5%	223.4	44.7	268.1	2015Q2	5.6%	235.9	47.2	283.1
	CONTRACT COST TOTALS:	15,744	2,984		18,728		16079.3	3058.1	19137.4			16797.9	3221.1	20019.0

481

Filename: ATR_TPCS-Paducah 4-9-2010a.xls
TPCS

Paducah, KY - LFPP Reconstruction
Project Development Stage: Feasibility
Abbreviated Risk Analysis

Project Manger:	Theresa C. Beckham
Meeting Date:	16-Dec-10

PDT Members

Construction:	John N. Briggs
Contracting:	Lisa A. Roseberry
Cost Engineering:	Michael D. Witcher
Engineering:	Bonnie F. Jennings
Operations:	Not Applicable - Local Sponsor O&M
Real Estate:	Patty S. Smith
Relocations:	Christina M. Neutz

Paducah, KY - LFPP Reconstruction
Project Development Stage: Feasibility
Abbreviated Risk Analysis

WBS	Item		Contract Cost		Percent	Contingency Amount	Total
01	Lands and Damages		$ 436,000		0.00%	$ -	$ 436,000.00
02	Power Line De-energize		$ 3,600	Note	30.00%	$ 1,080.00	$ 4,680.00
11 & 16	Work Performed by Sponsor		$ 2,200,000		0.00%	$ -	$ 2,200,000.00
11	Misc Levee & Floodwall Impr		$ 2,306,364		20.00%	$ 461,272.80	$ 2,767,637
11	Levee Sand Blanket		$ 85,727	Note	50.00%	$ 42,863.50	$ 128,590.50
11	Floodwall Waterstop Repair Type 1		$ 224,898		10.00%	$ 22,489.80	$ 247,387.80
11	Floodwall Waterstop Repair Type 2		$ 1,409,426		15.00%	$ 211,413.90	$ 1,620,839.90
13	Pump & Motor Refurbishing		$ 2,048,249		35.00%	$ 716,887.15	$ 2,765,136.15
13	New Pumps and Motors		$ 1,704,056		25.00%	$ 426,014.00	$ 2,130,070.00
13	New Pump Station (Less Pumps & Elec)		$ 624,154		20.00%	$ 124,830.80	$ 748,984.80
13	Pump Station Electric Work		$ 1,262,696		10.00%	$ 126,269.60	$ 1,388,965.60
13	Misc Pump Station Items		$ 820,383		40.00%	$ 328,153.20	$ 1,148,536.20
30 & 31	PED & CM		$ 2,184,000		20.00%	$ 436,800.00	$ 2,620,800.00
	Remaining Items	2.8%	$ 433,955		20.00%	$ 86,791.00	$ 520,746.00
		Total Construction Estimate	$ 15,743,508			Total: $ 2,984,866	Total: $ 18,728,374

Weighted Contingency = 19.0%

Note - Power Line De-enegize and Levee Sand Blanket isolated to capture unique contingencies.

Paducah, KY - LFPP Reconstruction
Project Development Stage: Feasibility
Abbreviated Risk Analysis

Meeting Date: 16-Dec-10

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Concerns	Affected WBS Item	PDT Discussions	Likelihood	Impact	Risk Level
Project Scope						
PS-1	Per Real Estate Division Common Practices Contingency Included	Lands and Damages	Per Real Estate Division Common Practices Contingency Included	Unlikely	Negligible	0
PS-2	Recurrence	Power Line De-energize	Uncertain recurrence.	LIKELY	Negligible	1
PS-3	None	Work Performed by Sponsor	Work Completed by Sponsor	Very Unlikely	Marginal	0
PS-4	Revised design requirements arising from additional investigations; Additional site investigation may yield toe drain replacement versus plugging and abandoning.	Misc Levee & Floodwall Impr	Potential for drainage structure piling foundations; Concept Design Developed; Re-using existing Sluice Gates; Potential for New Sluice Gates	Unlikely	Marginal	1
PS-5		Levee Sand Blanket		Very LIKELY	Significant	4
PS-6	Design change to address site specific issues	Floodwall Waterstop Repair Type 1	Nature of repair based on similar work by City of Louisville, KY Metropolitan Sewer District	Unlikely	Negligible	0
PS-7	Repair detail may change materials & methods used.	Floodwall Waterstop Repair Type 2	Nature of repair based on similar work by City of Louisville, KY Metropolitan Sewer District and Corps project in Jeffersonville, IN	Unlikely	Marginal	1
PS-8	Refurbishing effort may exceed assumptions of vendors.	Pump & Motor Refurbishing	Vendors were provided an equipment list for pricing purposes.	Very Unlikely	Significant	1
PS-9	Change in pump and motor size	New Pumps and Motors	Scope clearly identified	Unlikely	Marginal	1
PS-10	Final Design may change item character	New Pump Station (Less Pumps & Elec)	Design development changes	LIKELY	Negligible	1
PS-11	Additional investigation may reveal more work on electrical systems	Pump Station Electric Work	Designed as remove and replace	Very Unlikely	Marginal	0
PS-12	No work identified on plans	Misc Pump Station Items	Significant Estimator Assumptions	Very LIKELY	Marginal	3
PS-13	None	PED & CM	Percentage of remaining construction cost	Unlikely	Marginal	1
PS-14	General Scope Variability; Nothing Specific	Remaining Items	Average of overall impact of other components	LIKELY	Negligible	1

Paducah, KY - LFPP Reconstruction
Project Development Stage: Feasibility
Abbreviated Risk Analysis

Meeting Date: 16-Dec-10

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Concerns	Affected WBS Item	PDT Discussions	Likelihood	Impact	Risk Level
Acquisition Strategy						
AS-1	Per Real Estate Division Common Practices Contingency Included	Lands and Damages	Per Real Estate Division Common Practices Contingency Included	Unlikely	Negligible	0
AS-2	Three construction contracts anticipated; Likely restricted competition environment	Power Line De-energize	Fairly small contracts; MATOC or 8(a) Possible	LIKELY	Marginal	2
AS-3	None	Work Performed by Sponsor	Work Completed by Sponsor	Very Unlikely	Marginal	0
AS-4	Three construction contracts anticipated; Likely restricted competition environment	Misc Levee & Floodwall Impr	Fairly small contracts; MATOC or 8(a) Possible	LIKELY	Marginal	2
AS-5	Three construction contracts anticipated; Likely restricted competition environment	Levee Sand Blanket	Fairly small contracts; MATOC or 8(a) Possible	LIKELY	Significant	4
AS-6	Three construction contracts anticipated; Likely restricted competition environment	Floodwall Waterstop Repair Type 1	Fairly small contracts; MATOC or 8(a) Possible	LIKELY	Negligible	1
AS-7	Three construction contracts anticipated; Likely restricted competition environment	Floodwall Waterstop Repair Type 2	Fairly small contracts; MATOC or 8(a) Possible	LIKELY	Marginal	2
AS-8	Three construction contracts anticipated; Likely restricted competition environment	Pump & Motor Refurbishing	Fairly small contracts; MATOC or 8(a) Possible	LIKELY	Significant	4
AS-9	Three construction contracts anticipated; Likely restricted competition environment	New Pumps and Motors	Fairly small contracts; MATOC or 8(a) Possible	LIKELY	Marginal	2
AS-10	Three construction contracts anticipated; Likely restricted competition environment	New Pump Station (Less Pumps & Elec)	Fairly small contracts; MATOC or 8(a) Possible	LIKELY	Negligible	1
AS-11	Three construction contracts anticipated; Likely restricted competition environment	Pump Station Electric Work	Fairly small contracts; MATOC or 8(a) Possible; Electrical work subcontracted either way	LIKELY	Negligible	1
AS-12	Three construction contracts anticipated; Likely restricted competition environment	Misc Pump Station Items	Fairly small contracts; MATOC or 8(a) Possible	LIKELY	Marginal	2
AS-13	Three construction contracts anticipated; Likely restricted competition environment	PED & CM	Percentage of remaining construction cost; Minor cost increase possible; All projects within close proximity for single CD-Q action	LIKELY	Negligible	1
AS-14	Three construction contracts anticipated; Likely restricted competition environment	Remaining Items	Average of overall impact of other components	LIKELY	Negligible	1

Paducah, KY - LFPP Reconstruction
Project Development Stage: Feasibility
Abbreviated Risk Analysis

Meeting Date: 16-Dec-10

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Concerns	Affected WBS Item	PDT Discussions	Likelihood	Impact	Risk Level
Construction Complexity						
CC-1	Per Real Estate Division Common Practices Contingency Included	Lands and Damages	Per Real Estate Division Common Practices Contingency Included	Unlikely	Negligible	0
CC-2	Nature of Work	Power Line De-energize	Moderately complex work	Unlikely	Marginal	1
CC-3	None	Work Performed by Sponsor	Work Completed by Sponsor	Very Unlikely	Marginal	0
CC-4	Additional site investigation may yield toe drain replacement versus plugging and abandoning.	Misc Levee & Floodwall Impr	Toe drain replacement potential for specialized equipment or restricted site access.	Unlikely	Marginal	1
CC-5		Levee Sand Blanket		Unlikely	Negligible	0
CC-6	Change in the nature of the repair leading to different repair design or methods.	Floodwall Waterstop Repair Type 1	Specialized equipment and methods required.	LIKELY	Negligible	1
CC-7	None	Floodwall Waterstop Repair Type 2	Relatively simple work	Very Unlikely	Marginal	0
CC-8	None - Refurbishing in shop environment.	Pump & Motor Refurbishing	Vendors were provided an equipment list for pricing purposes.	Very Unlikely	Significant	1
CC-9	None - Equipment Installation	New Pumps and Motors	Adapting new pumps and motors to existing infrastructure	LIKELY	Marginal	2
CC-10	None	New Pump Station (Less Pumps & Elec)	New Construction	LIKELY	Negligible	1
CC-11	None	Pump Station Electric Work	Nothing special anticipated; Typical panels and wiring	Very Unlikely	Marginal	0
CC-12	Undetailed items	Misc Pump Station Items	Undetailed work expected, to be low complexity; Estimator assumed costs generally priced high	LIKELY	Negligible	1
CC-13	None	PED & CM	Percentage of remaining construction cost	Unlikely	Negligible	0
CC-14	Nothing specific	Remaining Items	Average of overall impact of other components	LIKELY	Negligible	1

Paducah, KY - LFPP Reconstruction
Project Development Stage: Feasibility
Abbreviated Risk Analysis

Meeting Date: 16-Dec-10

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Concerns	Affected WBS Item	PDT Discussions	Likelihood	Impact	Risk Level
Volatile Commodities						
VC-1	Per Real Estate Division Common Practices Contingency Included	Lands and Damages	Per Real Estate Division Common Practices Contingency Included	Unlikely	Negligible	0
VC-2		Power Line De-energize		Very Unlikely	Marginal	0
VC-3	None	Work Performed by Sponsor	Work Completed by Sponsor	Very Unlikely	Marginal	0
VC-4	Inflation/Construction Market Conditions. Additional site investigation may yield toe drain replacement versus plugging and abandoning.	Misc Levee & Floodwall Impr	Moderate construction materials inflation. Toe drain replacement potential for fluctuating Commodity pricing.	Unlikely	Marginal	1
VC-5	None	Levee Sand Blanket	Readily available material	Unlikely	Negligible	0
VC-6	Pricing variability on repair materials.	Floodwall Waterstop Repair Type 1	Some specialized materials anticipated.	Unlikely	Negligible	0
VC-7	Pricing variability on repair materials.	Floodwall Waterstop Repair Type 2	Material Change may affect commodity pricing	Unlikely	Marginal	1
VC-8	Copper and Steel Pricing	Pump & Motor Refurbishing	Motors and windings affected by copper pricing	Very Unlikely	Significant	1
VC-9	Copper and Steel Pricing	New Pumps and Motors	Motors and windings affected by copper pricing	Unlikely	Marginal	1
VC-10	Construction materials volatility	New Pump Station (Less Pumps & Elec)	Concrete	LIKELY	Negligible	1
VC-11	Copper and Steel Pricing	Pump Station Electric Work	Quote basis, inherent contingencies expected in quotes.	Unlikely	Marginal	1
VC-12	Unidentified project items.	Misc Pump Station Items	Significant estimator assumptions; Potential added items not likely tied to volatile commodity pricing	Unlikely	Marginal	1
VC-13	None	PED & CM	Percentage of remaining construction cost	Unlikely	Marginal	1
VC-14	Nothing specific	Remaining Items	Average of overall impact of other components	LIKELY	Negligible	1

Paducah, KY - LFPP Reconstruction
Project Development Stage: Feasibility
Abbreviated Risk Analysis

Meeting Date: 16-Dec-10

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Concerns	Affected WBS Item	PDT Discussions	Likelihood	Impact	Risk Level
Quantities						
Q-1	Per Real Estate Division Common Practices Contingency Included	Lands and Damages	Per Real Estate Division Common Practices Contingency Included	Unlikely	Negligible	0
Q-2		Power Line De-energize		LIKELY	Marginal	2
Q-3	None	Work Performed by Sponsor	Work Completed by Sponsor	Very Unlikely	Negligible	0
Q-4	Revised design requirements arising from additional investigations. Additional site investigation may yield toe drain replacement versus plugging and abandoning.	Misc Levee & Floodwall Impr	Normal design progression; Potential New Work Items	Unlikely	Marginal	1
Q-5		Levee Sand Blanket		LIKELY	Significant	4
Q-6	Additional site investigation may yield additional quantity.	Floodwall Waterstop Repair Type 1	Quantity assumption subject to change	LIKELY	Negligible	1
Q-7	Additional site investigation may yield additional quantity.	Floodwall Waterstop Repair Type 2	Quantity assumption subject to change	Very Unlikely	Marginal	0
Q-8	None - Refurbishing in shop environment.	Pump & Motor Refurbishing	Vendors were provided an equipment list for pricing purposes.	Very Unlikely	Significant	1
Q-9	Change in pump and motor quantities	New Pumps and Motors	Scope clearly identified	Very Unlikely	Marginal	0
Q-10	Changes in component sizes	New Pump Station (Less Pumps & Elec)	Preliminary design	LIKELY	Negligible	1
Q-11	Change in electrical component requirements	Pump Station Electric Work	Preliminary Design basis	Unlikely	Negligible	0
Q-12	No Design indicated on plans	Misc Pump Station Items	Estimator Assumptions	Very LIKELY	Marginal	3
Q-13	Typical project development issues	PED & CM	Percentage of remaining construction cost	LIKELY	Negligible	1
Q-14	Nothing specific	Remaining Items	Average of overall impact of other components	LIKELY	Negligible	1

Paducah, KY - LFPP Reconstruction
Project Development Stage: Feasibility
Abbreviated Risk Analysis

Meeting Date: 16-Dec-10

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Concerns	Affected WBS Item	PDT Discussions	Likelihood	Impact	Risk Level
Fabrication & Project Installed Equipment						
FI-1	Per Real Estate Division Common Practices Contingency Included	Lands and Damages	Per Real Estate Division Common Practices Contingency Included	Unlikely	Negligible	0
FI-2	Equipment	Power Line De-energize	Specialized Equipment Possible	Unlikely	Marginal	1
FI-3	None	Work Performed by Sponsor	Work Completed by Sponsor	Very Unlikely	Marginal	0
FI-4	None	Misc Levee & Floodwall Impr	Nothing significant expected	Very Unlikely	Marginal	0
FI-5	None	Levee Sand Blanket	No manufactuing element	Very Unlikely	Negligible	0
FI-6	None	Floodwall Waterstop Repair Type 1	Nothing unusual expected.	Very Unlikely	Negligible	0
FI-7	None	Floodwall Waterstop Repair Type 2	Nothing unusual expected.	Very Unlikely	Marginal	0
FI-8	None - Refurbishing in shop environment.	Pump & Motor Refurbishing	Vendors were provided an equipment list for pricing purposes.	Very Unlikely	Significant	1
FI-9	Fitting into existing infrastructure	New Pumps and Motors	Adapting new pumps and motors to existing infrastructure	LIKELY	Marginal	2
FI-10	None - New Construction	New Pump Station (Less Pumps & Elec)	Typical for New Construction	Unlikely	Negligible	0
FI-11	Nothing unusual	Pump Station Electric Work	Typical switchgear and circuits	Very Unlikely	Marginal	0
FI-12	Misc items may have significant lead times	Misc Pump Station Items	Most complex items have been addressed in project design documents.	Unlikely	Marginal	1
FI-13	None	PED & CM	Percentage of remaining construction cost	Unlikely	Marginal	1
FI-14	Nothing specific	Remaining Items	Average of overall impact of other components	LIKELY	Negligible	1

Paducah, KY - LFPP Reconstruction
Project Development Stage: Feasibility
Abbreviated Risk Analysis

Meeting Date: 16-Dec-10

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Concerns	Affected WBS Item	PDT Discussions	Likelihood	Impact	Risk Level
Cost Estimating Method						
CE-1	Per Real Estate Division Common Practices Contingency Included	Lands and Damages	Per Real Estate Division Common Practices Contingency Included	Unlikely	Negligible	0
CE-2	Cost Basis	Power Line De-energize	Lump Sum Allowance	Very LIKELY	Marginal	3
CE-3	None	Work Performed by Sponsor	Work Completed by Sponsor	Very Unlikely	Marginal	0
CE-4	Normal construction conditions	Misc Levee & Floodwall Impr	Preliminary design; Detailed QTO; Cost Book sources	Very Unlikely	Marginal	0
CE-5	Material Cost	Levee Sand Blanket	Cost Book Items; Not quoted	Very LIKELY	Significant	4
CE-6	Quotes may not hold true for repair anticipated.	Floodwall Waterstop Repair Type 1	Quote from City of Louisville Metropolitan Sewer District.	Very Unlikely	Negligible	0
CE-7	Quotes may not hold true for repair anticipated.	Floodwall Waterstop Repair Type 2	Quote from City of Louisville Metropolitan Sewer District and awarded cost for similar work in Jeffersonville, IN	Very Unlikely	Marginal	0
CE-8	None - Quote	Pump & Motor Refurbishing	Quotes from equipment vendors used for pricing, including inherent contingencies.	Very Unlikely	Significant	1
CE-9	None - Quote	New Pumps and Motors	Quotes from equipment vendors used for pricing	Very Unlikely	Marginal	0
CE-10	Normal construction conditions	New Pump Station (Less Pumps & Elec)	Preliminary design; Detailed QTO; Cost Book sources; miscellaneous items not designed	Very LIKELY	Negligible	2
CE-11	None	Pump Station Electric Work	Preliminary design; Detailed QTO; Quotes from equipment vendors used for pricing.	Very Unlikely	Marginal	0
CE-12	No work identified on plans	Misc Pump Station Items	Significant Estimator Assumptions	Very LIKELY	Marginal	3
CE-13	None	PED & CM	Percentage of remaining construction cost	Unlikely	Marginal	1
CE-14	Nothing specific	Remaining Items	Average of overall impact of other components	LIKELY	Negligible	1

Paducah, KY - LFPP Reconstruction
Project Development Stage: Feasibility
Abbreviated Risk Analysis

Meeting Date: 16-Dec-10

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Concerns	Affected WBS Item	PDT Discussions	Likelihood	Impact	Risk Level
External Project Risks						
EX-1	Per Real Estate Division Common Practices Contingency Included	Lands and Damages		Unlikely	Negligible	0
EX-2	Continuing Resolution Authority - Uncertain Federal Support	Power Line De-energize	Constrained funding stream	LIKELY	Marginal	2
EX-3	None	Work Performed by Sponsor	Work Completed by Sponsor	Very Unlikely	Marginal	0
EX-4	Continuing Resolution Authority - Uncertain Federal Support	Misc Levee & Floodwall Impr	Constrained funding stream	LIKELY	Marginal	2
EX-5	Continuing Resolution Authority - Uncertain Federal Support	Levee Sand Blanket	Constrained funding stream	LIKELY	Significant	4
EX-6	Continuing Resolution Authority - Uncertain Federal Support	Floodwall Waterstop Repair Type 1	Constrained funding stream	LIKELY	Negligible	1
EX-7	Continuing Resolution Authority - Uncertain Federal Support	Floodwall Waterstop Repair Type 2	Constrained funding stream	LIKELY	Marginal	2
EX-8	Continuing Resolution Authority - Uncertain Federal Support	Pump & Motor Refurbishing	Constrained funding stream	LIKELY	Significant	4
EX-9	Continuing Resolution Authority - Uncertain Federal Support	New Pumps and Motors	Constrained funding stream	LIKELY	Marginal	2
EX-10	Continuing Resolution Authority - Uncertain Federal Support	New Pump Station (Less Pumps & Elec)	Constrained funding stream	LIKELY	Negligible	1
EX-11	Continuing Resolution Authority - Uncertain Federal Support	Pump Station Electric Work	Constrained funding stream	LIKELY	Marginal	2
EX-12	Continuing Resolution Authority - Uncertain Federal Support	Misc Pump Station Items	Constrained funding stream	LIKELY	Marginal	2
EX-13	None	PED & CM	Percentage of remaining construction cost	LIKELY	Marginal	2
EX-14	Continuing Resolution Authority - Uncertain Federal Support	Remaining Items	Constrained funding stream	LIKELY	Negligible	1

Paducah, KY - LFPP Reconstruction
Project Development Stage: Feasibility
Abbreviated Risk Analysis

Selected Work Breakdown Structure Items

Typical Risk Elements	Lands and Damages	Power Line De-energize	Work Performed by Sponsor	Misc Levee & Floodwall Impr	Levee Sand Blanket	Floodwall Waterstop Repair Type 1	Floodwall Waterstop Repair Type 2	Pump & Motor Refurbishing	New Pumps and Motors	New Pump Station (Less Pumps & Elec)	Pump Station Electric Work	Misc Pump Station Items	PED & CM	Remaining Items
Project Scope	-	1	-	1	4	-	1	1	1	1	-	3	1	1
Acquisition Strategy	-	2	-	2	4	1	2	4	2	1	1	2	1	1
Construction Complexity	-	1	-	1	-	1	-	1	2	1	-	1	-	1
Volatile Commodities	-	-	-	1	-	-	1	1	1	1	1	1	1	1
Quantities	-	2	-	1	4	1	-	1	-	1	-	3	1	1
Fabrication & Project Installed Equipment	-	1	-	-	-	-	-	1	2	-	-	1	1	1
Cost Estimating Method	-	3	-	-	4	-	-	1	-	2	-	3	1	1
External Project Risks	-	2	-	2	4	1	2	4	2	1	2	2	2	1

	Lands and Damages	Power Line De-energize	Work Performed by Sponsor	Misc Levee & Floodwall Impr	Levee Sand Blanket	Floodwall Waterstop Repair Type 1	Floodwall Waterstop Repair Type 2	Pump & Motor Refurbishing	New Pumps and Motors	New Pump Station (Less Pumps & Elec)	Pump Station Electric Work	Misc Pump Station Items	PED & CM	Remaining Items
Summation	0	12	0	8	20	4	6	14	10	8	4	16	8	8
%	0.00%	30.00%	0.00%	20.00%	50.00%	10.00%	15.00%	35.00%	25.00%	20.00%	10.00%	40.00%	20.00%	20.00%

Maximum Allowable Contingency	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
% Contingency	0.0%	30.0%	0.0%	20.0%	50.0%	10.0%	15.0%	35.0%	25.0%	20.0%	10.0%	40.0%	20.0%	20.0%

REAL ESTATE PLAN

1. General

The City of Paducah is located in the northern portion of McCracken County, Kentucky, on the left bank of the Ohio River, approximately 934 miles below Pittsburgh, immediately below the mouth of the Tennessee River. The City of Paducah is bounded on the north and northeast by the Ohio and Tennessee Rivers and lies within the alluvial valley of the Ohio River. A significant portion of its residential and commercial districts are situated on a level and relatively high flood plain terrace that extends to the low hills on the south. The average elevation of this alluvial terrace is about 337 feet, msl. Island Creek flows through the eastern part of the city to join the Ohio River immediately below the mouth of the Tennessee River and Perkins Creek is located along the western portion of the city. According to the U.S. Census Bureau, in 2000 Paducah had a population of 26,275. Paducah, Kentucky is the official county seat of McCracken County.

2. Purpose of Real Estate Plan (REP)

This REP will accompany the Paducah, Kentucky Feasibility Study which purpose is to investigate the feasibility and the extent of Federal interest in providing rehabilitation of the project for flood risk management in Paducah, Kentucky, originally authorized by section 4 of the Flood Control Act of June 28, 1938 (52 Stat. 1217). The scope of the Feasibility Study includes investigating the results of the May 2000 "905(b) Analysis" (reconnaissance-phase report) in greater detail and performing a detailed analysis of with and without project conditions, culminating with the identification of one recommended plan that would be subsequently authorized, designed, and constructed.

3. Property Description/Acreages

The information obtained in support of this real estate plan was derived from the Right of Way sheets, found in Volume 3 of this report. The existing project/study area contains approximately 10,850 acres. The existing local protection project consists of approximately 48,700 feet of earthen levee, 15,870 feet of concrete flood wall, 12 pump stations and approximately 47 total openings consisting of movable closures, manways, and service openings, 8 ramps, and other necessary appurtenances. The top elevation of the protective works is at elevation 349.26 msl (NAVD 88). The original design of the existing project afforded protection to the City of Paducah against Ohio River floods equal to the maximum on record, elevation 346.8 msl (NAVD 88) in January-February 1937, with a freeboard of three feet.

A map of the project is attached as **Exhibit RE-2**.

A three (3) year temporary work area easement is required for contractor staging and lay down areas, temporary access sites, and contractor work areas during construction. These areas are mainly comprised of industrial lands, with the addition of some residential areas. Additional permanent levee easements will be required for future operation and

maintenance activities for any portion of the repaired levee that is outside the existing permanent easement limits. A perpetual road easement and two additional utility pipeline easements, as referenced in Exhibit RE-2, will also be required to support the proposed project. The Non-Federal Sponsor has the responsibility for acquiring the necessary real estate interests and providing documentation that the acquisition has been completed.

Property owned by the City of Paducah will be made available through Authorization for Entry for Construction, Attorney's Certificate of Authority, the Partnership Agreement and ownership documentation.

4. Estates/ Valuation

The standard estates: Temporary Work Area Easement TWAE (6.23-acres), Right of Way Levee Easement RWLVE (0.27-acres), Right of Way Utility Pipeline Easement RWUPE (0.11-acres), and Right of Way Road Easement RWRDE (1.0-acres), will be acquired for this project. A breakdown of the estimated real estate costs is attached as **Exhibit RE-3**.

The City of Paducah will be required to provide proof of ownership and an Authorization for Entry for Construction prior to real estate certification.

The federal real estate administrative costs for this project are estimated at $60,000.

5. Navigational Servitude

Navigational Servitude does not apply to this project.

6. Induced Flooding

The project is limited to repair work to an existing levee and the construction, operation, and maintenance of the proposed project will not result in any induced flooding. As ~~shown on sheet 125 of the ROW plans, a ponding area was created when the original~~ levee was constructed. This area is comprised of approximately 45.9 acres. The project ~~calls for upgrading this area with a new pump station, which will decrease the inundated~~ area to approximately 5.3 acres. Using the 1% chance frequency, the inundated area will be reduced for all frequency floods.

7. Mineral/ Timber Activity

There is no present or anticipated mineral or timber activity in the vicinity that could affect the proposed project.

8. Landowner's Concerns

This project is limited to repair/ rehabilitation of an existing levee. Currently, the City of Paducah is attempting to rehabilitate the existing levee that protects the entire community. The landowners want the levee repaired to protect their land from flooding.

9. Existing Government Interests and Rights

The original project was constructed by the Federal Government. No LERRD credit will be provided for property that was provided for the original project.

No other existing Federal project lies within the project area and the Federal Government does not own land within the proposed project area. The non-Federal Sponsor has advised that it owns easements for the existing levee and will provide documentation prior to real estate certification.

10. Public Law 91-646 Relocation Assistance Benefits

There are no residences or businesses that require relocation assistance.

11. Outstanding Conditions

There are no known outstanding conditions that will affect the project. No borrow site is required. Any potential disposal material will be taken to an approved commercial site.

12. Facility/ Utility/ Cemetery Relocations

For cost-shared projects, the Non-Federal Sponsor has the responsibility to perform or assure the performance of relocations. The term "relocation" generally means providing a functionally equivalent facility to the owner of an existing utility, cemetery, highway or other eligible public facility, and railroad (excluding existing railroad bridges and approaches thereto) when such action is authorized in accordance with applicable legal principles of just compensation. Providing a functionally equivalent facility may take the form of alteration, lowering, raising, or replacement (and attendant removal) of the affected facility or part thereof. An Attorney's Opinion of Compensability is required to support any public facility or utility relocation.

a. Relocation of Facilities/ Utilities: There are no utilities or public facilities that will require relocation.

b. Cemeteries: There are no cemeteries to be relocated.

13. Hazardous, Toxic, and Radioactive Waste (HTRW) Impacts

In accordance with ER-200-2-2, Paragraph 9.a., activities at completed Corps projects which carry out the authorized project purposes, (routine operation and maintenance actions, general administration, equipment purchases, custodial actions, erosion control, paining, repair, rehabilitation, replacement of existing structures and facilities such as buildings, roads, levees, utilities, and installation of new buildings utilities, or roadways in developed areas), this proposed action is categorically excluded from NEPA documentation.

A cursory review of possible hazardous, toxic, or radiological waste (HTRW) concerns was performed by the Louisville District. Due to the industrial nature of the proposed project area and because of a known sewer treatment plant located within the project area, the potential presence of HTRW exists near the project site. However, the project footprint consists primarily of maintenance items to the existing flood control system. No significant efforts outside of the project right of way are proposed. Therefore, no Phase I Environmental Assessment is warranted. Project specifications will require that excavated soils that will not be used on site will be disposed of at a licensed landfill. No other HTRW concerns are anticipated.

14. Environmental and Historical Preservation Considerations

A survey of anticipated areas impacted by the proposed project will be required. A subsequent report of findings will be submitted to the State Historic Preservation Office, when completed.

15. Acquisition Schedule

Upon execution of the Project Partnership Agreement, the Non-Federal Sponsor will be advised in writing to proceed with acquisition. The Sponsor has indicated that it should ~~take approximately 6-months to provide deed ownership and Rights of Entry for~~ Construction. Real Estate Division anticipates that it will take approximately 4 weeks to ~~certify the real estate after receiving deeds and authorization from the non-Federal~~ Sponsor.

16. Non-Federal Sponsor

The City of Paducah, Kentucky is the Non-Federal Sponsor. The City of Paducah, Kentucky has authority to enter into a Project Partnership Agreement. It has the capability to complete its portion of the project within the designated time frame.

17. Administration

For cost-shared projects, real estate acquisition and performance of facility and utility relocations are major responsibilities of the Non-Federal Sponsor. The Non-Federal

Sponsor is required to furnish all lands, easements, and rights of way and dredge or borrow areas (LERRD) required to accommodate construction, operation and maintenance of the project and to provide all necessary relocations. The Sponsor will be required to document its ownership of the project real estate requirements and provide an Authorization for Entry for construction. Sponsor has been advised that Public Law 91-646 and Corps acquisition policies and procedures must be followed for all property acquisition. The Sponsor will be apprised of Corps acquisition policies and procedures, LERRD crediting procedures, HTRW responsibilities and milestones for land acquisition. It has been determined that the Sponsor has the ability to perform the land acquisition requirements of this project within the required schedule.

A Quality Control Checklist for Sponsor Ability Determination has been provided by the Sponsor and is attached as **Exhibit RE-1.**

REAL ESTATE
QUALITY CONTROL CHECKLIST FOR:

SPONSOR ABILITY DETERMINATION
LOCAL COOP PROJECTS

PROJECT: Paducah Rehabilitation Report, County of McCracken, State of Kentucky.

A. LEGAL AUTHORITY

1. It has been determined that the sponsor has legal authority to acquire and hold title to real property for project purposes.
(Yes/No) Initials B.S. Date: 01 DEC 09

2. It has been determined that the sponsor has the power of eminent domain for this project.
(Yes/No) Initials B.S. Date: 01 DEC 09

3. It has been determined that the sponsor has "quick-take" authority for this project.
(Yes/No) Initials B.S. Date: 01 DEC 09

* Will Be Determined Prior to Final Feasibility Rpt.

4. A determination has been made as to whether some of the lands/interests in land required for the project are outside the sponsor's political boundary, and whether this limits its ability to acquire property?
(Yes/No) Initials B.S. Date: 01 DEC 09

5. A determination has been made as to whether any of the lands/interests in land required for the project are owned by an entity whose property the sponsor cannot condemn.
(Yes/No) Initials B.S. Date: 01 DEC 09

B. FINANCIAL CAPABILITY

1. It has been established by the responsible district element that the local sponsor is financially capable of fulfilling all requirements of local cooperation.
(Yes/No) Initials B.S. Date: 01 DEC 09

EXHIBIT RE-1

(Yes/No) Initials B.S. Date: 01 DEC 09

5. A determination has been made as to whether USACE assistance will likely be requested by the local sponsor in acquiring real estate.
(Yes/No) Initials B.S. Date: 01 DEC 09

E. SCHEDULE CAPABILITY

1. Sponsor has indicated in writing their willingness and ability to incorporate their financial, acquisition, and condemnation capability to provide the necessary project LERRDs in accordance with proposed project schedules so the Government can advertise and award the construction contract as required by overall project schedules and funding limitations.
(Yes/No) Initials B.S. Date: 01 DEC 09

F. LERRD CREDITS

1. Sponsor has indicated their understanding of LERRD credits and their capability and willingness to gather the necessary information to submit as LERRD credits within six months after possession of all real estate and completion of relocations in order that the project manager can financially close out the project and there can be a final financial accounting with a proper settlement with the sponsor.
(Yes/No) Initials B.S. Date: 01 DEC 09

G. COORDINATION

1. This assessment has been coordinated with the local sponsor and they concur with the assessment.

Initials B.S. Date: 01 DEC 09

Patty Smith
REVIEWED & APPROVED BY

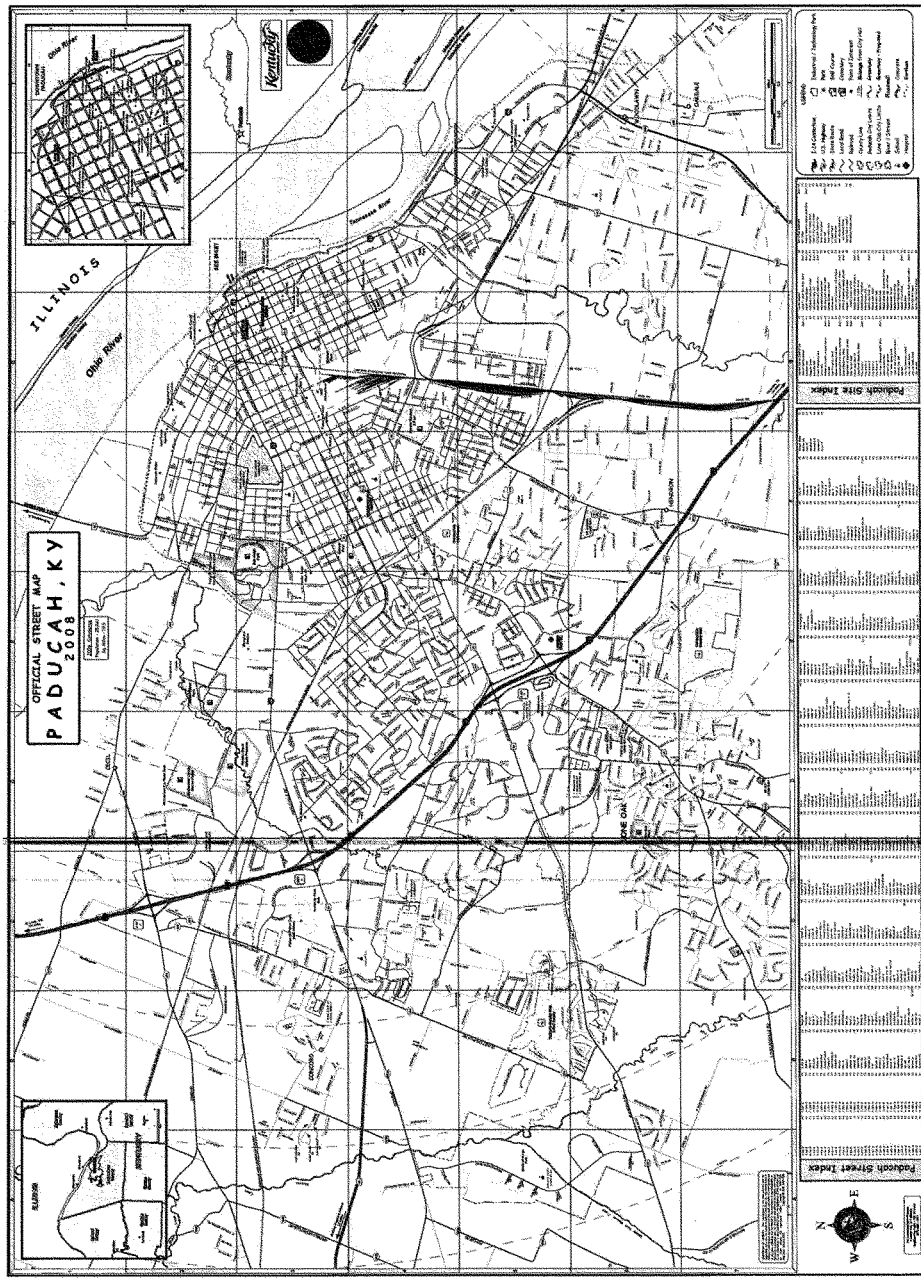
Civil + Support
TITLE

DATE Dec 15, 2009

Prepared by:
Brett D. Scharlow
Brett D. Scharlow
Team Leader
Real Estate Division

SPONSOR: RICK MURPHY
270/ 444-8511
RMURPHY@CI.PADUCAH.KY.US

EXHIBIT RE-1


OFFICIAL STREET MAP
PADUCAH, KY
2008
ILLINOIS
Ohio River
Kentucky
Paducah Site Index
Paducah Street Index

Based on ROW plans dtd 20 Nov 2009
01 December 2009

Paducah, Kentucky
Feasibility Study & Certification of Levee System
Real Estate Estimate

Fee Simple	ROW Sheet Volume 3	Acres	Term	Value
N/A	N/A	0		$ 0.00
Easements				
Temporary Work Area Easement (TWAE)			3-Years	
	113	0.29		$ 5,685.00
	114	1.16		$ 45,477.00
	115	1.40		$ 32,017.00
	116	0.25		$ 4,901.00
	117	0.31		$ 10,128.00
	121	0.17		$ 5,554.00
	122	0.51		$ 14,996.00
	127	2.14		$ 34,957.00
				$ 153,712.00
Levee Easement (RWLVE)			Perpetuity	
	115	0.22		$ 16,172.00
	116	0.05		$ 3,675.00
				$ 19,847.00
Utility Pipeline Easement (RWUPE)			Perpetuity	
	115	0.11		$ 5,391.00
				$ 5,391.00
Road Easement (RWRDE)			Perpetuity	
	125	1.00		$ 54,450.00
				$ 54,450.00

Subtotal	**$ 233,400.00**	
Incremental Costs (20%)	**$ 46,680.00**	
TOTAL ESTIMATED LAND COSTS:	**$ 280,000.00**	
Acquisition Cost (Sponsor) $8k per tract @ 12 tracts		**$ 96,000.00**
TOTAL LERRD:		**$ 376,000.00**
Acquisition Cost (Gov't) $5k per tract @ 12 tracts		**$ 60,000.00**
TOTAL REAL ESTATE COSTS ®		**$ 436,000.00**

EXHIBIT RE-3

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX E

ENVIRONMENTAL

Update (September 2011):

USACE determined that the proposed work was covered by the NEPA categorical exclusion at 33 CFR 230.9(b), and that there were no extraordinary circumstances that warranted preparation of an Environmental Assessment, because the proposed work would cause at most minimal adverse effects on the human environment, individually and cumulatively. Nevertheless, the District completed an Environmental Assessment (EA), even though an EA was not legally required, in order to consolidate documentation demonstrating that the project would not produce any significant adverse effects on the human environment, and thus that no Environmental Impact Statement is required for the project. The EA was made available for public review for thirty days. No comments were received from the public. The EA/Finding of No Significant Impact (FONSI) can be found in its entirety at the end of Volume 1 – Main Report.

April 2011
Final Submittal
Revised September 2011

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 2 APPENDIX E

ENVIRONMENTAL

1. Cultural Resources

In general, archaeologists and historians have developed a chronology for the region that provides a useful framework for organizing and describing data and historical events. The prehistoric cultural sequence is divided in to the following chronological periods in Kentucky: Paleo-Indian (12,000-8000 B.C.), Archaic (8000-1000 B.C.), Woodland (1000 B.C. - A.D. 900), Mississippian (A.D. 900-1500), and Protohistorc and Historic Aboriginal Indian (A.D. 1500+). These periods represent culturally distinct segments of more than 12,000 years of prehistoric hum an adaptation and re-adaptation to a changing environment.

The historic cultural sequence represents the time span from Euro-American settlement to the present day. General periods of development included early Euro-American settlement (1775-1830), Antebellum (1830-1860), Civil War and Reconstruction (1860-1890), Progressivism and W orld War I (1890-1925), the Depression and New Deal (1925-1940), World War Two and the Cold W ar(1940-1990). Regional variations of this historical sequence can occur.

The Paducah Flood Control Levee has never been formally examined for cultural resources. The levee was itself constructed between 1939 and 1949 as a direct response to the Great Flood of 1937 along the Ohio River, and thus well before the implementation of federal compliance laws in the 1960's. The levee has been repaired, upgraded and renovated many times with pumps, pipe gates and vehicle openings. It is currently maintained by the city of Paducah.

There are several historic and cultural resources recorded within or adjacent to the Paducah Flood Control Levee, the most notable being Fort Anderson: a fort constructed by the Union Army during the Civil War and central to the Battle of Paducah. However, no remnants of the fort are visible on the surface. Its location is currently marked with a metal historic monument at the Paducah Convention Center and defunct Executive Inn.

In March 1864, Confederate Lieutenant General Nathan Bedford Forrest set out from Columbus, Mississippi, with a force of less than 3,000 men on a multi-purpose expedition (recruit, "disperse Yankees", etc.) into western Tennessee and Kentucky. They arrived in Paducah on March 25, and quickly occupied the town. The Confederates began destroying unwanted supplies, and took what they wanted, mainly horses and mules.

Fort Anderson was commanded by Union officers Colonel Stephen G. Hicks and Lieutenant Commander James W. Shirk, who had the support of two gunboats on the Ohio River. They refused to surrender and thus at 4:30pm the Confederates charged the fort. Led by Colonel Albert P. Thompson, of Paducah, the Confederate cavalrymen swooped down on the fort and were met with a barrage of grapeshot and canister fire from newly-converted gunboats. They fell back, and then charged once more, only to meet with the same fierce barrage. The Confederates then entered homes near the fort and began firing under cover of the houses. Eventually Forrest gave the order to cease firing and retreated. Although the battle is considered to be a Confederate victory, it was not a conflict that made any lasting changes to the area.

A common tourist attraction to the area is the flood wall murals in downtown Paducah that depicts the history of development in western Kentucky. The murals were designed and painted by Mr. Robert Dafford and the Dafford Muralists of Lafayette, Louisiana. The project began in 1996 and was completed in 2007. Each mural panel has an interpretative plaque with a short history lesson on the scene depicted in the panel.

A total of 25 historic properties listed to the National Register of Historic Places are recorded within McCracken County, Kentucky. However, none of these lie within the Area of Potential Effect (APE) for the proposed undertaking.

Five archaeological sites are recorded within the limits of the Paducah Flood Protection Levee in McCracken County, Kentucky. Specifically, they are sites 15McN3, 15McN6, 15McN8, 15McN66, and 15McN124. Three of these sites – 15McN3, 15McN6, and 15McN8 – were recorded by the University of Kentucky as a part of reconnaissance survey of archaeological resources throughout the state (Funkhouser and Webb 1932).

Site 15McN3 is described as a "[c]amp or village site..." containing "[s]keletons, artifacts and layers of charcoal..." that were discovered and disturbed during "...building purposes" (Funkhouser and Webb 1932: 251). The site's location is divided between in a gravel parking lot for an auto parts store and a small batch of trees with invasive plants and earthen push piles.

Site 15McN6 was a prehistoric mound that was reported to have been destroyed prior to the 1932 survey. The mound was excavated by Colonel Fain King, a Paducah businessman and relic collector, in 1920. The mound was reported to contain "...bones, ashes, charcoal and a few fragments of flints" (Funkhouser and Webb 1932: 252). The site's location is currently in a fallow field just east of the Husband Road and Lydon Road intersection.

Site 15McN8 was a large cemetery on the banks of the Ohio River and within the property of the former Fowler-Wolfe Plant. Placement of the foundations for the buildings revealed the presence of skeletons and artifacts. The site's recorded location is currently on the property of a trucking company along south 3rd Street/U.S. Highway 60 and is covered in concrete.

Site 15McN66 was a multi-component artifact scatter dating mostly to the mid-twentieth century. The site was first identified by students at Murray State University in a gravel parking area for an industrial complex. It was severely disturbed at the time and thus not considered eligible for listing to the National Register of Historic Places.

Site 15McN124 was a historic city block related to the "Old Town" of Paducah, northeast of what had been the intersection of Clark and Second streets. The site's recorded location is currently on the property of the Four Rivers Performing Arts Center. Archival maps going back to 1832 showed a changing array of commercial and residential structures on this block throughout the nineteenth century. The block included Lots 70, 71, and 72 on City Block 8 of official city property maps. Archaeological investigations were carried out at the site in May of 2001 by TRC Garrow and Associates of Nashville, Tennessee (Ezell 2001). Four backhoe trenches were excavated across the site, labeled Area A during the study. One trench in particular, AI, in the lot's southwestern quadrant, uncovered a mid to late nineteenth century midden deposit at approximately one meter below the current surface. This deposit, Strata VI, ranged from between 35 to 95 cm thick and contained a relatively dense deposit of domestic and architectural debris, apparently undisturbed and unmixed with later material. The other three trenches dug within Area A produced more minimal signs of this rich artifact midden. Since the construction plans called for use of the area as a parking lot with disturbances limited to only 2 ft. below the surface, the Kentucky State Historic Preservation Officer concluded that the project would not impact the buried midden deposits. No further work was recommended for the project.

Small segments of the levee have been examined for cultural resources as a part of compliance requirements for Section 106 of the National Historic Preservation Act, including a barge fleeting area (McNerney 1990), a water plant site and intake (Carstens and Hensley 1981), a nature trail (McHugh 1977), and a concrete batch plant (Schenian 1993). No cultural resources were identified during these investigations.

Consultation under Section 106 of the National Historic Preservation Act (NHPA) on affects to historic properties and cultural resources by the proposed undertaking has taken place. This consultation involved the State Historic Preservation Offices, federally - recognized Native American tribes and other concerned parties and focused on avoiding impacts to significant historic properties and cultural resources.

2. Environmental

The proposed project has been reviewed for compliance with other federal legislation including the National Environmental Policy Act (NEPA), Endangered Species Act, Clean Air Act, Clean Water Act, Resource Conservation and Recovery Act, etc., in addition to Section 106 of the National Historic Preservation Act of 1966 (as amended).

NEPA compliance for this proposed action is covered by categorical exclusion ER -200-2-2 paragraph 9a. – activities at completed Corps projects which carry out the authorized project purposes. This includes installation of new buildings (recommended pump plant at Station 111+67A) in developed areas. At this time no significant impacts have been

identified, and no mitigation is required to support project implementation. For further discussion regarding Categorical Exclusions, please see Section 4.7 (Other Impacts) in Volume 1 - Main Report.

Clean Air Act: The Environmental Protection Agency has listed the proposed project area as being within an attainment zone for "criteria air pollutants." Emissions of criteria pollutants or their precursors would not occur in a nonattainment or maintenance area of those pollutants. Therefore, the conformity determination requirements do not apply to the action.

Endangered Species Act: Due to the lack of suitable habitat for threatened or endangered species in the area, no impacts to those species are expected to occur. Construction would be taking place on or near the levee system and would not likely impact the wildlife of the area. Construction would not take place in the river and therefore, no impacts to threatened or endangered species that dwell in the river would be seen. Coordination with the U.S. Fish and Wildlife Service has taken place to ensure that no endangered or threatened species will be impacted by the proposed project. Their response can be found in Appendix A (Public and Agency Coordination).

Fish and Wildlife Coordination Act: Consultation with the U.S. Fish and Wildlife Service has taken place. Their comments can be found in Appendix A (Public and Agency Coordination).

Floodplain Management EO 11988: In order to achieve the desired objective of rehabilitating the existing levee system, the considered project must be located in the floodplain. No practical non-floodplain alternative exists. The floodplains of the area have been previously disturbed due to past construction of the levee, further disturbance from the proposed project does not conflict with applicable state and local standards concerning floodplain protection.

National Historic Preservation Act: Cultural resources do occur in the proposed project area (discussed further in the cultural resources section), however, none that are listed on the National Register of Historic Places are expected to be impacted by the prop osed action. Other archaeological resources that are located with in the proposed project area but are not on the National Register will also not be impacted by the proposed project.

Farmland Protection Act: The proposed projects site is located within urban and commercial areas. The site does not contain farmland covered by the FPPA and therefore, no impacts would be seen.

Clean Water Act: No long term effects on water quality would occur from the construction of the proposed project. Short term effects could be seen due to construction, but would only be temporary. At the conclusion of construction activities such temporary impacts would cease.

Protection of Wetlands EO11990: No wetlands occur withint the proposed project location, therefore, no effects to wetlands would occur.

The Corps has determined that the proposed pr oject is environmentally sustainable. This proposed action does not constitute a major federal action that would significantly affect the quality of the human environment, nor is it expected to be controversial

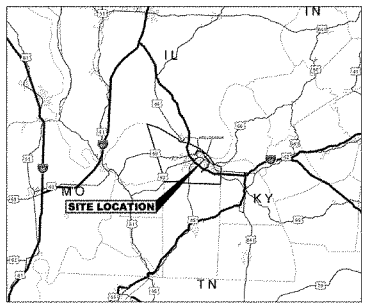
Wild and Scenic Rivers Act: No wild or scenic rivers are located with in the proposed project area.

Environmental Justice EO12898: Rehabilitation of the levee would not adversely impact any residents of the city of Paducah regardle ss of race, national origin, religion, or level of income. Construction would take on or near the levee and would not impact the local residents.

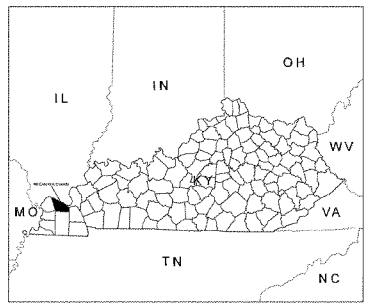
*** SAFETY PAYS ***

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FINAL FEASIBILITY REPORT VOLUME 3 OF 4

US Army Corps of Engineers
Louisville District



LOCATION PLAN
NO SCALE



VICINITY MAP
NO SCALE

US Army Corps of Engineers
Louisville District

COVER SHEET

SHEET REFERENCE NUMBER:
GI001
SHEET 1 OF 124

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

INDEX OF DRAWINGS

FILE NAME	SH.REF	DESCRIPTION
Index and General		
112546GI001.DGN	GI001	COVER SHEET
112546GI002.DGN	GI002	INDEX OF DRAWINGS
112546GI004.DGN	GI003	STANDARD SYMBOLS
112546GI004.DGN	GI004	STANDARD ABBREVIATIONS
112546GI005.DGN	GI005	BORROW & DISPOSAL SITES
	CS001	SITE LAYOUT KEY MAP
	CS100	SITE LAYOUT -SECTION C
	CS101	SITE LAYOUT -SECTION C
	CS102	SITE LAYOUT -SECTION C
	CS103	SITE LAYOUT -SECTION C
	CS104	SITE LAYOUT -SECTION C
	CS105	SITE LAYOUT -SECTION C
	CS106	SITE LAYOUT -SECTION C
	CS107	SITE LAYOUT -SECTION C
	CS108	SITE LAYOUT -SECTION C
	CS109	SITE LAYOUT -SECTION C
	CS110	SITE LAYOUT -SECTION C
	CS111	SITE LAYOUT -SECTION C
	CS112	SITE LAYOUT -SECTION C
	CS113	SITE LAYOUT -SECTION C & B
	CS114	SITE LAYOUT -SECTION B
	CS115	SITE LAYOUT -SECTION B
	CS115A	ENLARGED SITE PLAN - WOODWARD HOLLOW DISCHARGE PIPE
	CS116	SITE LAYOUT -SECTION B
	CS117	SITE LAYOUT -SECTION B
	CS118	SITE LAYOUT -SECTION B
	CS119	SITE LAYOUT -SECTION B
	CS120	SITE LAYOUT -SECTION B
	CS121	SITE LAYOUT -SECTION B
	CS122	SITE LAYOUT -SECTION B & A
	CS123	SITE LAYOUT -SECTION A
	CS124	SITE LAYOUT -SECTION A
	CS125	SITE LAYOUT -SECTION A
	CS125A	ENLARGED SITE PLAN - PUMP PLANT #14 ALT #1 AND ALT #2
	CS126	SITE LAYOUT -SECTION A
	CS127	SITE LAYOUT -SECTION A
	CS128	SITE LAYOUT -SECTION A
	CS129	SITE LAYOUT -SECTION A
	CV001	PROFILE - PUMP PLANT #14 SUBMERSIBLE PUMP ALT #1
	CV002	PROFILE - PUMP PLANT #14 COLUMN PUMP ALT #2
	CV003	PROFILE - WOODWARD HOLLOW DISCHARGE PIPE
	CZ001	LANDSIDE BLANKET FILTER DETAILS
	CZ002	GATEWELL DETAILS
	CZ003	PIPE REHABILITATION SUMMARY
	CZ004	TOE DRAIN DETAILS
Structural		
112546S-S00.DGN	S-S00	TYPICAL JOINT FILLER REPAIR - SECTIONS & DETAILS
112546S-S01.DGN	S-S01	NOT USED
112546S-S02.DGN	S-S02	NOT USED
112546S-S03.DGN	S-S03	EXTERNAL WATERSTOP DETAILS
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112546S-S05.DGN	S-S05	PUMP PLANT #2 -REPAIR DETAILS
112546S-S06.DGN	S-S06	PUMP PLANT #3 -REPAIR DETAILS
112546S-S07.DGN	S-S07	PUMP PLANT #4 -REPAIR DETAILS
112546S-S08.DGN	S-S08	PUMP PLANT #5 -REPAIR DETAILS
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112546S-S11.DGN	S-S11	PUMP PLANT #9 -REPAIR DETAILS
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112546S-S14.DGN	S-S14	PUMP PLANT #12 -REPAIR DETAILS
112546S-S15.DGN	S-S15	PROPOSED PUMP PLANT #14 - VERTICAL COLUMN PUMP OPTION
112546S-S16.DGN	S-S16	PROPOSED PUMP PLANT #14 - SUBMERSIBLE PUMP OPTION
112546S-S17.DGN	S-S17	BEE BRANCH SLUICE GATE CONTROL STRUCTURE
112546S-S18.DGN	S-S18	WOODWARD HOLLOW GATEWELL DETAILS
112546S-S19.DGN	S-S19	PERMANENT CLOSURES
112546S-S20.DGN	S-S20	SLUICE GATE DETAILS - PUMP PLANT #14
Mechanical		
112546MM01.dgn	MG01	PUMP PLANT REHABILITATION SUMMARY

FILE NAME	SH.REF	DESCRIPTION
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112546E102.dgn	E102	PUMP PLANT #2 PLAN
112546E103.dgn	E103	PUMP PLANT #3 PLAN
112546E104.dgn	E104	PUMP PLANT #5 PLAN
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112546E107.dgn	E107	PUMP PLANT #9 PLAN
112546E108.dgn	E108	PUMP PLANT #11 PLAN
112546E109.dgn	E109	PUMP PLANT #12 PLAN
112546E110.dgn	E110	PROPOSED PUMP PLANT #14 SUBMERSIBLE
112546E111.dgn	E111	PROPOSED PUMP PLANT #14 VERT. COLUMN
112546E501.dgn	E501	MOTOR STARTER AND ACTUATOR CONTROL DETAILS
112546E502.dgn	E502	GENERATOR CONNECTION DIAGRAM
112546E601.dgn	E601	PUMP PLANT #1 ONE LINE DIAGRAM
112546E602.dgn	E602	PUMP PLANT #2 ONE LINE DIAGRAM
112546E603.dgn	E603	PUMP PLANT #3 ONE LINE DIAGRAM
112546E604.dgn	E604	PUMP PLANT #4 ONE LINE DIAGRAM
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112546E611.dgn	E611	PUMP PLANT #12 ONE LINE DIAGRAM
112546E612.dgn	E612	PUMP PLANT #13 ONE LINE DIAGRAM
112546E613.dgn	E613	SUBMERSIBLE PUMP PLANT #14 ONE LINE DIAGRAM (NEW)
112546E614.dgn	E614	VERTICAL COLUMN PUMP PLANT #14 ONE LINE DIAGRAM (NEW)
Geotechnical		
112546GG001.DGN	GG01	SOIL & ROCK CLASSIFICATION SHEET
112546GG002.DGN	GG02	BORING LOGS
112546GG003.DGN	GG03	BORING LOGS
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112546GG009.DGN	GG09	BORING LOGS
112546GG010.DGN	GG10	BORING LOGS
112546GG011.DGN	GG11	BORING LOGS
Real Estate		
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112546RW116.DGN	RW116	RIGHT OF WAY -SECTION B
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112546RW127.DGN	RW127	RIGHT OF WAY -SECTION A
112546RW128.DGN	RW128	RIGHT OF WAY -SECTION A
112546RW129.DGN	RW129	RIGHT OF WAY -SECTION A

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Chk

Designed by: B. JOHANNES | Date: APRIL 2011
Drawn by: C. ROBINSON | Scale: NONE
Checked by: K. LOWDEN | Drawing Code:
B. JOHANNES
Supervisor/Architect | Date

INDEX OF DRAWINGS

OHIO RIVER WATERLINE
INDIANA, KENTUCKY
(INDIANA PORTION ONLY)
RECONSTRUCTION
FINAL SUBMITTAL
VOLUME 3 OF 4

SHEET REFERENCE NUMBER
GI002
SHEET 2 OF 134

DATE: 03-MAY-2011 08:40
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FINAL SUBMITTAL

TOPOGRAPHIC SYMBOLS

GAS LINE — G
LOW PRESSURE GAS — G(LP)
MEDIUM PRESSURE GAS — G(MP)
HIGH PRESSURE GAS — G(HP)
INDUSTRIAL WASTE — IW
POWER LINE - AERIAL — P
POWER LINE - UNDERGROUND — UP
POWER LINES DUCTS — DS (3-4")
SANITARY SEWER LINE — SS
POWER MAIN — P
STEAM LINE — S
STORM DRAINAGE LINE — SD
TELEPHONE LINE - UNDERGROUND — TU
TELEPHONE LINE - AERIAL — TA
TELEPHONE DUCTS — TD (2-4")
TELEPHONE AND POWER - AERIAL — AC
WATER LINE — W
FIRE MAIN — F
SOIL OR GRAVEL
SUBGRADE — SG
CLEANOUT — C.O.
FIRE HYDRANT — FH
CATCH BASIN
LIFT STATION — LS
MANHOLE W/DESIGNATION — MH
POST INDICATOR VALVE — PIV
POWER POLE
POWER POLE WITH GUY
SPIGOT
VALVE
CONTOUR — 550
BENCHMARK
RIPRAP
SPOT ELEVATION — × 505
CONTRACTOR WORK LIMITS
CHAIN LINK FENCE
FLOW DIRECTION — FLOW
BORING
HEADWALL
CUT & BLOPE INDICATORS

HEATING, VENTILATING AND AIR CONDITIONING

FANS, HEATERS AND VENTILATORS

CENTRIFUGAL ROOF EXHAUST FAN W/DESIGNATION — EF-1
CENTRIFUGAL WALL EXHAUST FAN W/DESIGNATION — EF-2
PROPELLER TYPE EXHAUST FAN W/DESIGNATION — EF-3
TWO COIL UNIT W/DESIGNATION — FC-1
UNIT HEATER-HORIZONTAL W/DESIGNATION — UH-2
CONVECTOR W/DESIGNATION — CV-1
UNIT HEATER-VERTICAL W/DESIGNATION — UH-3
UNIT VENTILATOR
CENTRIFUGAL CEILING EXHAUST FAN W/DESIGNATION — EF-4

DUCT WORK

DIRECTION OF FLOW
SWITCHGEAR FIGURE 10 SERIE SHOWN — 350/150
FLEXIBLE DUCT
EXHAUST INLET
RETURN INLET
SUPPLY OUTLET
CHANGE IN ELEVATION RISE (R) OR DROP (D)
CEILING DIFFUSER RECTANGULAR OR ROUND, NOMINAL INDICATE THROW — 20 × 250/150 — 17ft
CEILING RETURN REGISTERS (RR) OR RETURN GRILLE (RG) — RR 1 × 250/150 — 17ft
THERMOSTAT — T
CEILING DIFFUSER - ROUND — CD 18RD — FT20
SUPPLY REGISTER (SR) IN SUPPLY GRILLE (SG) - SIDE WALL — SR 350/150 — 17ft
OUTSIDE AIR INTAKE LOUVER — 350/150 — 17ft
EXHAUST (E) IN RETURN (R) DUCT SECTION — 150/240
OUTSIDE AIR DUCT SECTION — 150/150
FLEXIBLE CONNECTIONS
AIR DEFLECTION
TURNING VANES
AUTOMATIC DAMPERS - MOTOR OPERATED — A.D.
FIRE DAMPER — FD
MODULATING CONTROL DAMPER — MOD
SMOKE DAMPER — SD
VOLUME CONTROL DAMPER (MANUAL) — VCD

VALVES

CONNECTION TYPES: FLANGED, SCREWED, BELL & SPIGOT, WELDED, SOLDERED

NOTES:
SCREWED END REPRESENTATION MAY BE USED FOR ALL TYPES OF CONNECTIONS PROVIDED THE TYPE OF CONNECTION IS DENOTED BY CHANGING LEADING, NOTE OR SPECIFICATIONS.

ANGLE GATE
AIR OUTLET
BACK PRESSURE
BALANCING
CHECK
DIAPHRAGM
GATE
GATE STOP RUNNING WATER
GLOBE
MOTOR OPERATED VALVE W/DESIGNATION — MOV-1
PRESSURE REDUCING W/DESIGNATION — PRV-1
REDUCED PRESSURE PRINCIPLE BACKFLOW PREVENTER
RELIEF (R) OR SAFETY (S)
THREE WAY

PIPE FITTINGS AND SPECIALTIES

CONNECTION TYPES: FLANGED, SCREWED, BELL & SPIGOT, WELDED, SOLDERED, SOLVENT CEMENT

NOTES:
SCREWED END REPRESENTATION MAY BE USED FOR ALL TYPES OF CONNECTIONS PROVIDED THE TYPE OF CONNECTION IS DENOTED BY CHANGING LEADING, NOTE OR SPECIFICATIONS.

PIPE FITTINGS:
BASE ELBOW
CLEANOUT — C.O.
CLEANOUT — C.O.
CROSS
DOUBLE BRANCH ELBOW
ELBOW - 45 DEGREES
ELBOW - 90 DEGREES
ELBOW - LONG RADIUS
ELBOW - TURNED DOWN
ELBOW - TURNED UP
FLEXIBLE CONNECTION
FLOOR DRAIN (FD) OR SIGHT DRAIN (SD) — FD
HOSE OR LAWN FAUCET, WALL HYDRANT AND DESIGNATION
INCREASER - CONCENTRIC
INCREASER - ECCENTRIC
LATERAL
REDUCER - CONCENTRIC
REDUCER - ECCENTRIC
REDUCING ELBOW
REDUCING FLANGE
SIDE OUTLET ELBOW OUTLET - DOWN
SIDE OUTLET ELBOW OUTLET - UP
SIDE OUTLET TEE OUTLET - DOWN
SIDE OUTLET TEE OUTLET - UP
SINGLE SWEEP TEE
SLEEVE — SL
SPRINKLER HEAD
STRAINER
TEE
TEE OUTLET - DOWN
TEE OUTLET - UP
UNION - FLANGED
UNION SCREWED
WATER HAMMER ARRESTER — WH (2-3)

ARCHITECTURAL SYMBOLS

ARCHITECTURAL REPRESENTATIONS

BATHTUB
CENTER LINE
COLUMN CENTERLINE DESIGNATION
DEAWATER
DOOR DESIGNATION — 104
DRINKING FOUNTAIN (WALL TYPE)
ELECTRIC WATER COOLER (EWC) — EWC
EYE WASH/EMERGENCY SHOWER
ELEVATION TARGET
FIRE EXTINGUISHER CABINET — FEC
FOLDING PARTITION
HAND DRYER
HANDICAP RAMP
HANDICAP RAIL
HANDICAP SHOWER
HANDICAP SINK
HANDICAP URINAL
SIGNAGE MARKER
LAVATORY — ON
PARTITION TYPE
PLATE
ROOM DESIGNATION — 100C
SERVICE SINK — CS
SHOWER HEAD
SHOWER STALL
SINK COUNTER TOP ON FLOOR (CT)
SPECIAL STEMS
SQUARE
URINAL (WALL TYPE) — ON
UTILITY SINK
VACUUM OUTLET
WATER CLOSET (FIXTURES)
WATER CLOSET (WALL MOUNT TYPE) — ON
WATER CLOSET (TANK TYPE)
WINDOW DESIGNATION — 101

MATERIAL SYMBOLS

WOOD - ROUGH
WOOD - FINISHED
PLYWOOD
STEEL
CERAMIC TILE
ROTATING MOCK (STRUCTURE MATERIAL)
RIGID INSULATION
BLANKET, MAT OR LOOSE FILL INSULATION
SPRAY APPLIED FIREPROOFING
GRAVEL/SAND/SOIL FILL/CAPILLARY WATER BARRIER
BRICK OR CAST IRON
CMU
ORIGINAL EARTH
FILL EARTH/FINISHED GRADE
CONCRETE
BRICK/ARM. BD.
ROCK
GWB
GLASS BLOCK
SHEARS, BRASS OR COPPER
ALUMINUM
CAST STONE

BUILDING PIPING

NOTE:
WHENEVER SYMBOLICAL REPRESENTATION IS NECESSARY TO DISTINGUISH BETWEEN SERVICES, THE FOLLOWING SYMBOLS SHALL BE USED EXCEPT THAT THE PRINCIPAL SYSTEM IN ANY PIPING DRAWING MAY BE INDICATED BY A SOLID LINE IF DESIRED WHEN SUCH INDICATION WILL NOT CAUSE CONFLICT.

CHILLED WATER RETURN — CWR
CHILLED WATER SUPPLY — CWS
COLD WATER — C
COMPRESSED AIR — A
CONDENSER WATER SUPPLY — C
CONDENSER WATER RETURN — CR
GAS — G
HIGH PRESSURE RETURN — HPR
HIGH PRESSURE STEAM — HPS
HOT WATER — H
HOT WATER RETURN OR RECIRCULATING
HOT WATER RETURN — HWR
HOT WATER SUPPLY — HWS
LOW PRESSURE RETURN — LPR
LOW PRESSURE STEAM — LPS
MEDIUM PRESSURE RETURN — MPR
MEDIUM PRESSURE STEAM — MPS
PIPE ANCHOR
PUMPED CONDENSATE — PC
ROOF DRAIN — RD
SANITARY SEWER — SS
STORM SEWER — SD
VACUUM (AIR) — VAC
VENT — V
WASTE LINE (ABOVE & BELOW GRADE) — W
WASTE ANTIFREEZE — WA
WASTE OIL LINE — WO

PLAN VIEW

SHEET NUMBER DETAIL IS SHOWN
DETAIL NUMBER
ELEVATION NUMBER
BUILDING SECTION NUMBER
WALL SECTION NUMBER

CROSS REFERENCING

DETAIL NO.
COMPONENT TITLE
SHEET NUMBER DETAIL IS OUT
1/8" = CIRCLE
DETAIL, SECTION, OR ELEVATION VIEW

GENERAL NOTES:

1. EXISTING CONDITIONS WILL BE SHOWN LIGHT AND NEW WORK SHOWN HEAVY.
2. WHEN ADDITIONAL SYMBOLS ARE NECESSARY, A LEGEND WILL BE LOCATED ON THE RESPECTIVE DRAWINGS.

US Army Corps of Engineers Louisville District

REVISIONS		
NUMBER	DATE	BY

Designed by: STANDARD
Drawn by: STANDARD
Checked by: K. DONASCH
Date: APRIL 2011
Scale:
Drawing Code: NONE
S. JENKINS
Project Manager
Date

STANDARD SYMBOLS

DALLAPIAN AUDITORIUM (FORMERLY ALTERATION OF FACILITIES FOR HANDICAPPED) RECONSTRUCTION PHASE I VOLUME 3 OF 8

SHEET REFERENCE NUMBER: G1003

SHEET 3 OF 134

DATE: 03-MAY-2011 08:40
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FINAL SUBMITTAL

*** SAFETY PAYS ***

ABBREVIATIONS

&	AND
#	AT
AB	ANCHOR BOLT
ABSW	AIR BREAK SWITCH
ABV	ABOVE
A/C	AIR CONDITIONING
ACST	ACOUSTIC
ACU	AIR CONDITIONING UNIT
ADDL	ADDITIONAL
ADJ	ADJACENT, ADJUSTABLE
AFB	AIR FORCE BASE
A.F.F.	ABOVE FINISHED FLOOR
AFFF	AQUEOS FILM FORMING FOAM
AGGR	AGGREGATE
AHR	ANCHOR
AHU	AIR HANDLING UNIT
AL	ALUMINUM
ALTN	ALTERNATE
AMP	AMPERE
AP	ACCESS PANEL
APPROX	APPROXIMATELY
APVD	APPROVED
ARCH	ARCHITECTURE,ARCHITECTURAL
ASPH	ASPHALT
ASSY	ASSEMBLY
ASTM	AMERICAN SOCIETY FOR TESTING MATERIALS
ATC	ACOUSTICAL TILE CEILING
ATTEN	ATTENUATE, ATTENUATION
AUTO	AUTOMATIC
AUX	AUXILIARY
AVG	AVERAGE
AWG	AMERICAN WIRE GAGE
BCCMP	BITUMINOUS COATED CORRUGATED METAL PIPE
BD	BOARD
BEJ	BRICK EXPANSION JOINT
BG	BUMPER GUARD
BLDG	BUILDING
BLK	BLOCK
BLKG	BLOCKING
BM	BEAM, BENCH MARK
BOT	BOTTOM
BRG	BEARING
BRK	BRICK
BSMT	BASEMENT
BTU	BRITISH THERMAL UNIT
BUR	BUILT - UP ROOF
CL	CENTERLINE
C	CONVENTOR
CAP	CAPACITY, CAPACITOR
CAV	CAVITY
CC	COOLING COIL
C-C	CENTER TO CENTER
CEM	CEMENT
CFCI	CONTRACTOR FURNISHED,CONTRACTOR INSTALLED
CFGI	CONTRACTOR FURNISHED,GOVERNMENT INSTALLED
CFH	CUBIC FEET PER HOUR
CFM	CUBIC FEET PER MINUTE
CG	CORNER GUARD
CHAN	CHANNEL
CHG	CHARGE
CHW	CHILLED WATER
CI	CAST IRON
CIP	CAST IRON PIPE
CJ	CONTROL JOINT
CKT	CIRCUIT
CLG	CEILING
CLO	CLOSET
CLR	CLEAR
CLWG	CLEAR WATER GLASS
CMP	CORRUGATED METAL PIPE
CMU	CONCRETE MASONRY UNIT
CND	CONDUIT
CNDS	CONDENSATE
CO	CLEANOUT
CLWG	CLEAR WIRE GLASS
CW	COLD WATER
COL	COLUMN
CONC	CONCRETE
COND	CONDUCTOR, CONDENSER
CONN	CONNECTION
CONSTR	CONSTRUCTION
CONT	CONTINUOUS, CONTROL
CONTD	CONTINUED
CONV	CONVERTER
COP	COPPER
CORR	CORRUGATE
CP	CIRCULATING PUMP
CPE	CHLORINATED POLYETHYLENE
CPLG	COUPLING
CR	COLD ROLLED
CSPE	CHLOROSULFONATED POLYETHYLENE
CSK	COUNTERSINK
CT	CERAMIC TILE
CTR	CENTER
CU	CUBIC
CU FT	CUBIC FEET
CU YD	CUBIC YARD
CUR	CURRENT
CV	CHECK VALVE
D	DEEP
DA	DRIP ASSEMBLY
DB	DRY BULB
DET	DETAIL
DF	DRINKING FOUNTAIN
DIA	DIAMETER
DIM	DIMENSION
DIP	DUCTILE IRON PIPE
DISC	DISCONNECT
DISCH	DISCHARGE
DIST	DISTANCE
DISTR	DISTRIBUTION
DK	DECK
DL	DEAD LOAD
DN	DOWN
DOD	DEPARTMENT OF DEFENSE
DP	DEPTH
DPNL	DISTRIBUTION PANEL
DR	DOOR
DS	DOWNSPOUT
DWP	DRINKING WATER DISPENSER
DWG	DRAWING
DWH	DOMESTIC WATER HEATER
E	EAST
EA	EACH
EF	EACH FACE, EXHAUST FAN
EJ	EXPANSION JOINT
EL	ELEVATION, EXHAUST LOUVER
ELEC	ELECTRIC
ELEV	ELEVATE, ELEVATOR
EMER	EMERGENCY
EMT	ELECTRICAL METALLIC TUBING
ENGR	ENGINEER,ENGINEERING
ENTR	ENTRANCE
EPDM	ETHELENE PROPOLENE DIARENE MONOMER
EQ,EQL	EQUAL
EQPT	EQUIPMENT
ER	EXHAUST REGISTER
ESV	EXTRUDED SHEET VINYL WALL COVERING
EW	EACH WAY
EWC	ELECTRIC WATER COOLER
EXH	EXHAUST
EXST	EXISTING
EXP	EXPANSION
EXT	EXTERIOR
F	FAHRENHEIT, FACE
F.B.	FLAT BRACKET
FB	FIELD BOLTED
FC	FLEXIBLE CONNECTION
FD	FLOOR DRAIN
FDN	FOUNDATION
FDR	FEEDER
FEC	FIRE EXTINGUISHER CABINET
FE	FIRE EXTINGUISHER
FF	FINISH FLOOR, FACTORY FINISHED
FFE	FINISH FLOOR ELEVATION
FHC	FIRE HOSE CABINET
FH	FIRE HYDRANT
FIG	FIGURE
FL	FLOOR
FLA	FULL - LOAD AMPERES
FLEX	FLEXIBLE
FLL	FLOW LINE
FLMB	FLAMMABLE
FLUOR	FLUORESCENT
FNSH	FINISH
FR	FRAME
FRP	FIBERGLASS REINFORCED POLYESTER
FRT	FIRE RETARDENT TREATMENT
FS	FULL SIZE, FLOOR SINK
FT	FORT, FOOT, FEET, FLASH TANK
FTG	FOOTING
FU	FUSE
GA	GAGE
GAL	GALLON
GALV	GALVANIZED
GFGI	GOVERNMENT FURNISHED,GOVERNMENT INSTALLED
GFRP	GLASS-FIBER REINFORCED POLYMER
GL	GLASS
GMU	GLAZED MASONRY UNITS
GND	GROUND
GP	GUARD POST
GPH	GALLONS PER HOUR
GPM	GALLONS PER MINUTE
GR	GRADE
GSU	GLAZED STRUCTURAL UNIT
GV	GATE VALVE, GLOBE VALVE
GWB	GYPSUM WALL BOARD
GYP	GYPSUM
HB	HOSE BIB
HC	HEATING COIL,HANDICAPPED
HDND	HARDENED
HDW	HARDWARE
HDWL	HEADWALL
HGT	HEIGHT
H.I.D.	HIGH INTENSITY DISCHARGE
HM	HOLLOW METAL
HORIZ	HORIZONTAL
HP	HORSEPOWER, HIGH PRESSURE
HR	HOUR
HSS	HOLLOW STRUCTURAL SECTIONS
HTG	HEATING
HTR	HEATER
HW	HOT WATER
HVY	HEAVY
IAW	IN ACCORDANCE WITH
ID	INSIDE DIAMETER
IDENT	IDENTIFICATION
IL	INTAKE LOUVER
IN	INCH
INCAND	INCANDESCENT
INSUL	INSULATION
INTR	INTERIOR
INVT	INVERT
JT	JOINT
J,JST	JOIST
JB	JUNCTION BOX
JC	JANITOR CLOSET
JCT	JUNCTION
KCP	KEENE'S CEMENT PLASTER
KG	KILOGRAM
KIT	KITCHEN
KO	KNOCK OUT
KV	KILOVOLT
KVA	KILOVOLT - AMPERE
KW	KILOWATT
LA	LIGHTNING ARRESTOR
LAV	LAVATORY
LB	POUND
LG	LENGTH, LONG
LIQ	LIQUID
LP	LOW PRESSURE
LTG	LIGHTING
LV	LOW VOLTAGE
LVR	LOUVER
LVRD	LOUVERED
M	METER
mm	MILLIMETER
MACH	MACHINE
MAINT	MAINTENANCE
MAN	MANUAL
MFD	MANUFACTURED
MFG	MANUFACTURING
MFR	MANUFACTURER
MATL	MATERIAL
MAX	MAXIMUM
MBH	THOUSAND BTU PER HOUR
MECH	MECHANICAL
MET	METAL
MH	MANHOLE
MIN	MINIMUM, MINUTE
MISC	MISCELLANEOUS
MK	MARK
MN	MAIN
MO	MOTOR-OPERATED, MASONRY OPENING, MONTH
MOD	MODEL (FOR GENERAL USE ONLY), MODIFY, MOTOR OPERATED DAMPER
MP	MEDIUM PRESSURE
MT	MOUNT
MTD	MOUNTED
MTG	MOUNTING
MTL	METAL
MUA	MAKE UP AIR UNIT
MSRY	MASONRY
N	NORTH
N.B.P.	NITRILE THERMOPLASTIC (FOR FUTURE FIRE RATING)
NC	NORMALLY CLOSED
NEC	NATIONAL ELECTRIC CODE
NEMA	NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
NEUT	NEUTRAL
NFPA	NATIONAL FIRE PROTECTION ASSOCIATION
NIC	NOT IN CONTRACT
NO	NORMALLY OPEN, NUMBER
NOM	NOMINAL
NTS	NOT TO SCALE
OA	OUTSIDE AIR
OC	ON CENTER
OD	OUTSIDE DIAMETER
OFCE	OFFICE
OPN	OPERATION
OPNG	OPENING
OPP	OPPOSITE
OPP HND	OPPOSITE HAND
OVHD	OVERHEAD
PB	PULL BOX, PUSH BUTTON
PD	PUMP DISCHARGE
PH	PHASE
PI	POINT OF INTERSECTION
PIB	POLYISOBUTLENE
PIV	POST INDICATOR VALVE
PL	PLATE, PLASTIC LAMINATE
PLAS	PLASTER
PLSTC LAM	PLASTIC LAMINATE
PLD	PLATED
PLYWD	PLYWOOD
PNL	PANEL
PNT,P	PAINT
P.O.C.	POINT OF CONNECTION
POL	POLISH
PR	PAIR
PRELIM	PRELIMINARY
PRESS	PRESSURE
PRI	PRIMARY
PRV	PRESSURE REDUCING VALVE
PS	PULL SWITCH
PSF	POUND FORCE PER SQUARE FOOT
PSI	POUND FORCE PER SQUARE INCH
P.T.	PRESERVATIVE TREATMENT
PT	POINT,PRESERVATIVE TREATMENT
PTD	PAINTED
P.U.F.	POLYURETHANE FOAM
PVC	POINT OF VERTICAL CURVE, POLYVINYL CHLORIDE
PVI	POINT OF VERTICAL INTERSECTION
PVT	POINT OF VERTICAL TANGENT
PVMT	PAVEMENT
QT	QUARRY TILE, QUART
QTY	QUANTITY
QTB	QUARRY TILE BASE
QUAL	QUALITY
R	RISER, RADIUS
R & R	REMOVE & REPLACE
RA	RETURN AIR
RAD	RADIUS
RCP	REINFORCED CONCRETE PIPE, RECIRCULATING PUMP
RCPT	RECEPTACLE
RD	ROAD, ROOF DRAIN
RDC	REDUCE
RDCN	REDUCTION
RECM	RECOMMEND, RECOMMENDATION
REF	REFERENCE
REINF	REINFORCE
REPL	REPLACE
REQD	REQUIRED
RESIL	RESILIENT
RET	RETAIN
REV	REVISION
RG	RETURN GRILLE
RM	ROOM
RO	ROUGH OPENING
RND	ROUND
RPM	REVOLUTIONS PER MINUTE
RWM	RECESSED WALK-OFF MAT
S	SOUTH
SAN	SANITARY
SATC	SUSPENDED ACOUSTICAL TILE CEILING
SC	SEALED CONCRETE
SCHED	SCHEDULE
SCRN	SCREEN
SD CFM	SUPPLY DIFFUSER (HVAC)
SECT	SECTION
SF	STORE FRONT
SVCE	SERVICE
SGL	SINGLE
SH	SHEET, SHOWER
SIM	SIMILAR
SLP	SLOPE
SMH	SANITARY MANHOLE
SOL	SOLENOID
SP	SINGLE POLE, SPACING, SPARE
SPEC	SPECIFICATION
SPR	SINGLE PLY ROOF
SPRT	SUPPORT
SQ	SQUARE
SQ FT	SQUARE FOOT
SR	SUPPLY REGISTER
SS	SERVICE SINK
SST	STAINLESS STEEL
ST	STEAM, STREET
STA	STATION
STD	STANDARD
STL	STEEL
STOR	STORAGE
ST PR	STATIC PRESSURE
STR	STRAIGHT, STRENGTH, STREAM, STRAINER
STRL	STRUCTURAL
SUSP	SUSPENDED
SYS	SYSTEM
SV	SEAMLESS VINYL
SW	SWITCH
T	TOILET
TAN	TANGENT
T & B	TOP AND BOTTOM
TBM	TEMPORARY BENCH MARK
TC	TOP OF CURB
TEL	TELEPHONE
TEMP	TEMPERATURE
TERM	TERMINAL
TG	TRANSFER GRILLE
THK	THICK
THR	THRESHOLD
THRU	THROUGH
TMPRD	TEMPERED
TOM	TOP OF MASONRY
TOS	TOP OF STEEL
TOW	TOP OF WALL
TSCT	THIN SET CERAMIC TILE
TYP	TYPICAL
U	UNION
UGND	UNDERGROUND
UL	UNDERWRITERS LABORATORY
UNO	UNLESS NOTED OTHERWISE
URN	URINAL
US	UNITED STATES
UTIL	UTILITY
V	VOLT, VALVE
VAC	VACUUM
VAR	VARIES
VC	VITRIFIED CLAY
VCB	VINYL COVE BASE
VCP	VITRIFIED CLAY PIPE
VCT	VINYL COMPOSITION TILE
VEL	VELOCITY
VENT	VENTILATION
VERT	VERTICAL
VEST	VESTIBULE
VOL	VOLUME
VR	VAPOR RETARDER
VS	VENT STACK
VTR	VENT THROUGH ROOF
VWC	VINYL WALL COVERING
W	WEST, WATT, WIDTH, WASTE
W/	WITH
W/O	WITHOUT
WC	WATER CLOSET
WD	WOOD, WINDOW DIMENSION
WDO	WINDOW
WHA	WATER HAMMER ARRESTOR
WI	WROUGHT IRON
WL	WATER LEVEL
WS	WASTE STACK, WATER SURFACE
WT	WEIGHT
WTHPRF	WEATHERPROOF
WTR	WATER
WWM	WELDED WIRE MESH
XBRA	CROSS BRACING
XFMR	TRANSFORMER
XSTR	EXTRA STRONG
YD	YARD
YR	YEAR

US Army Corps of Engineers
Louisville District

Revisions: Symbol | Description | Date | Appr.

Designed by: STANDARD
Drawn by: STANDARD
Checked by: K. DORSCH
B. JENNINGS
Project Engineer/Architect
Date: APRIL 2011
Scale:
Drawing Code: NONE

STANDARD ABBREVIATIONS

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LPPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 3 OF 4

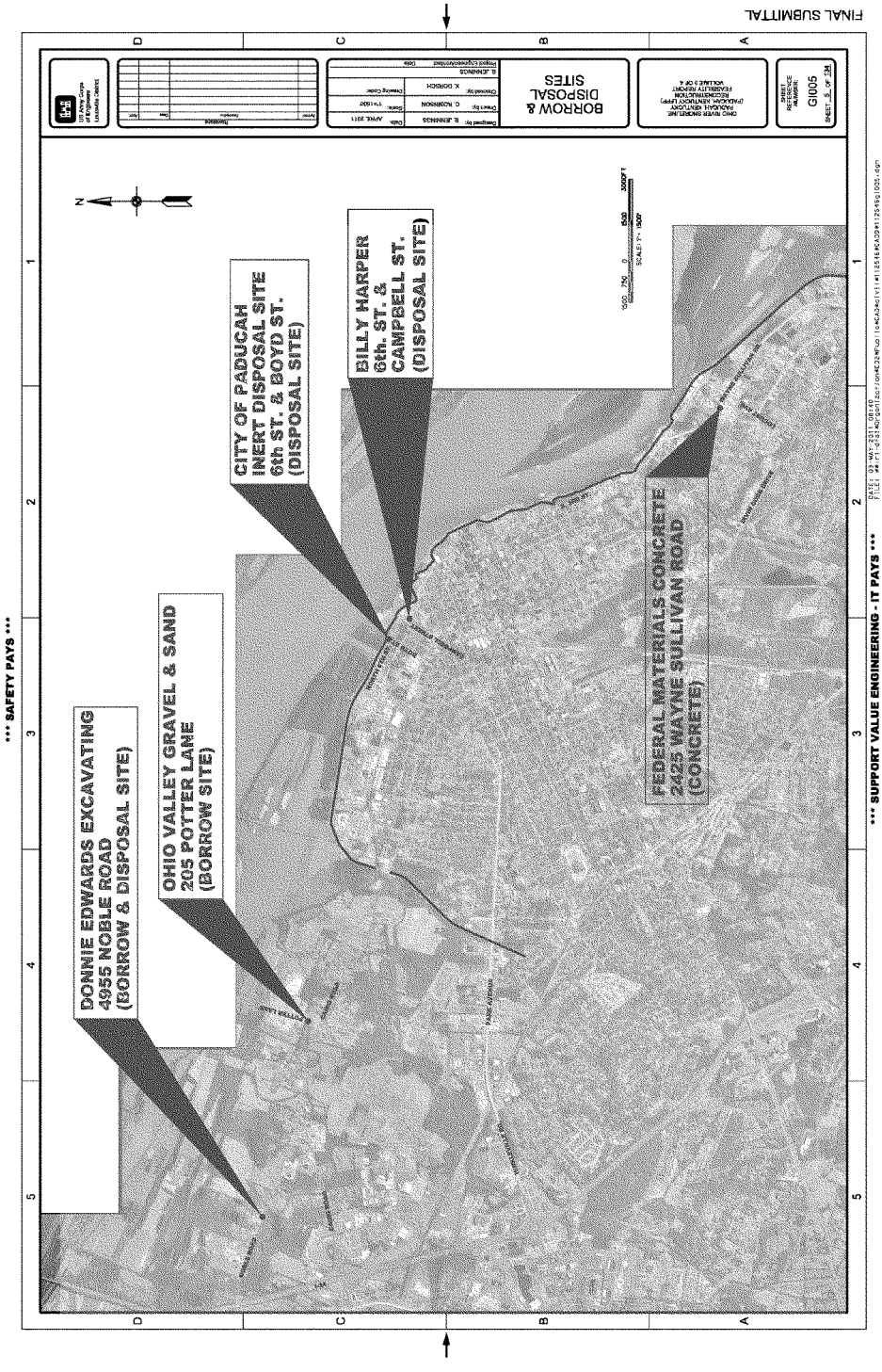
SHEET REFERENCE NUMBER: GI004

SHEET 4 OF 134

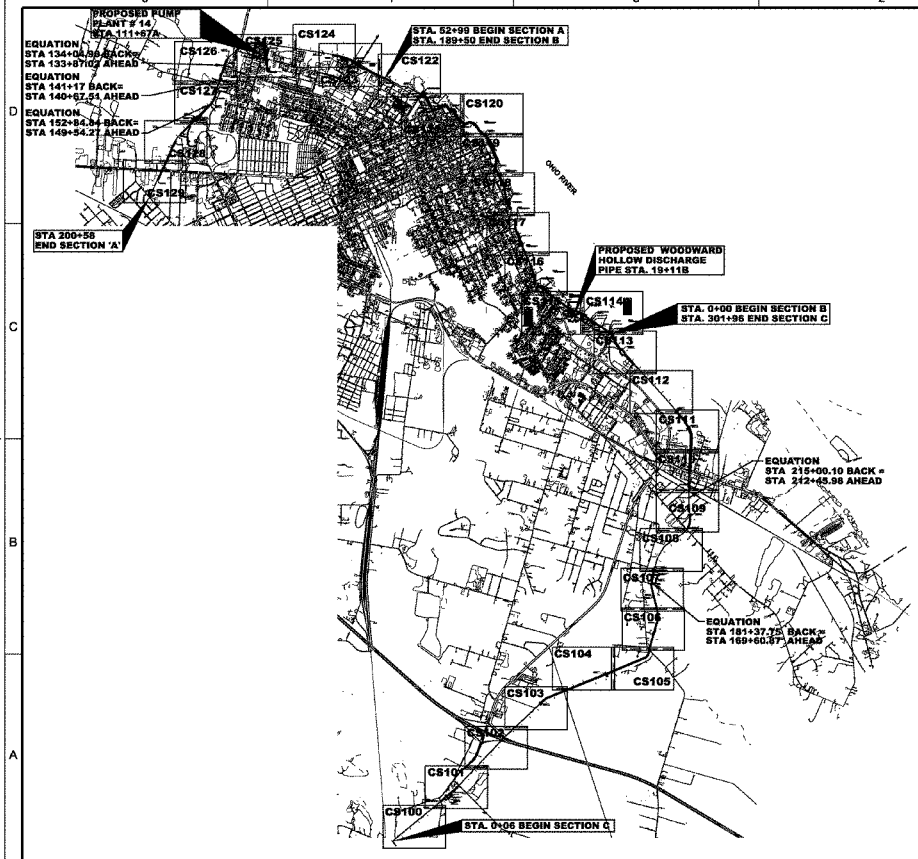
*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:40
FILE: ##iri-df#1#organization#E02#Public#CAD#civil#112546#CADD#112546gi004.dgn

FINAL SUBMITTAL


FINAL SUBMITTAL
*** SAFETY PAYS ***
*** SUPPORT VALUE ENGINEERING - IT PAYS ***
DONNIE EDWARDS EXCAVATING
4955 NOBLE ROAD
(BORROW & DISPOSAL SITE)
OHIO VALLEY GRAVEL & SAND
205 POTTER LANE
(BORROW SITE)
CITY OF PADUCAH
INERT DISPOSAL SITE
6th ST. & BOYD ST.
(DISPOSAL SITE)
BILLY HARPER
6th. ST. &
CAMPBELL ST.
(DISPOSAL SITE)
FEDERAL MATERIALS CONCRETE
2425 WAYNE SULLIVAN ROAD
(CONCRETE)
BORROW &
DISPOSAL
SITES
SCALE: 1"= 1500'
GI005

*** SAFETY PAYS ***



EXISTING PUMP PLANT LOCATIONS	
PUMP PLANT	SHEET
1	CS127
2	CS123
3	CS121
4	CS121
5	CS121
6	CS119
7	CS118
9	CS117
10	CS116
11	CS116
12	CS107
13	CS113

NOTE: PUMP PLANT #8 IS ABANDONED

US Army Corps of Engineers Louisville District

Revisions: Number | Date | Description

Designed by: B. JENNINGS
Drawn by: B. K. LUCAS
Checked by: K. CORSICH
B. JENNINGS
Project Engineer/Manager
Date: APRIL 2011
Scale: 1"=2000'
Drawing Code:

SITE LAYOUT KEY MAP

OHIO RIVER SHORELINE STABILIZATION PROJECT (PADUCAH, KENTUCKY (PP) HUGHES PLANT PADUCAH, KENTUCKY

SHEET REFERENCE NUMBER: CS001
SHEET 6 OF 134

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:42
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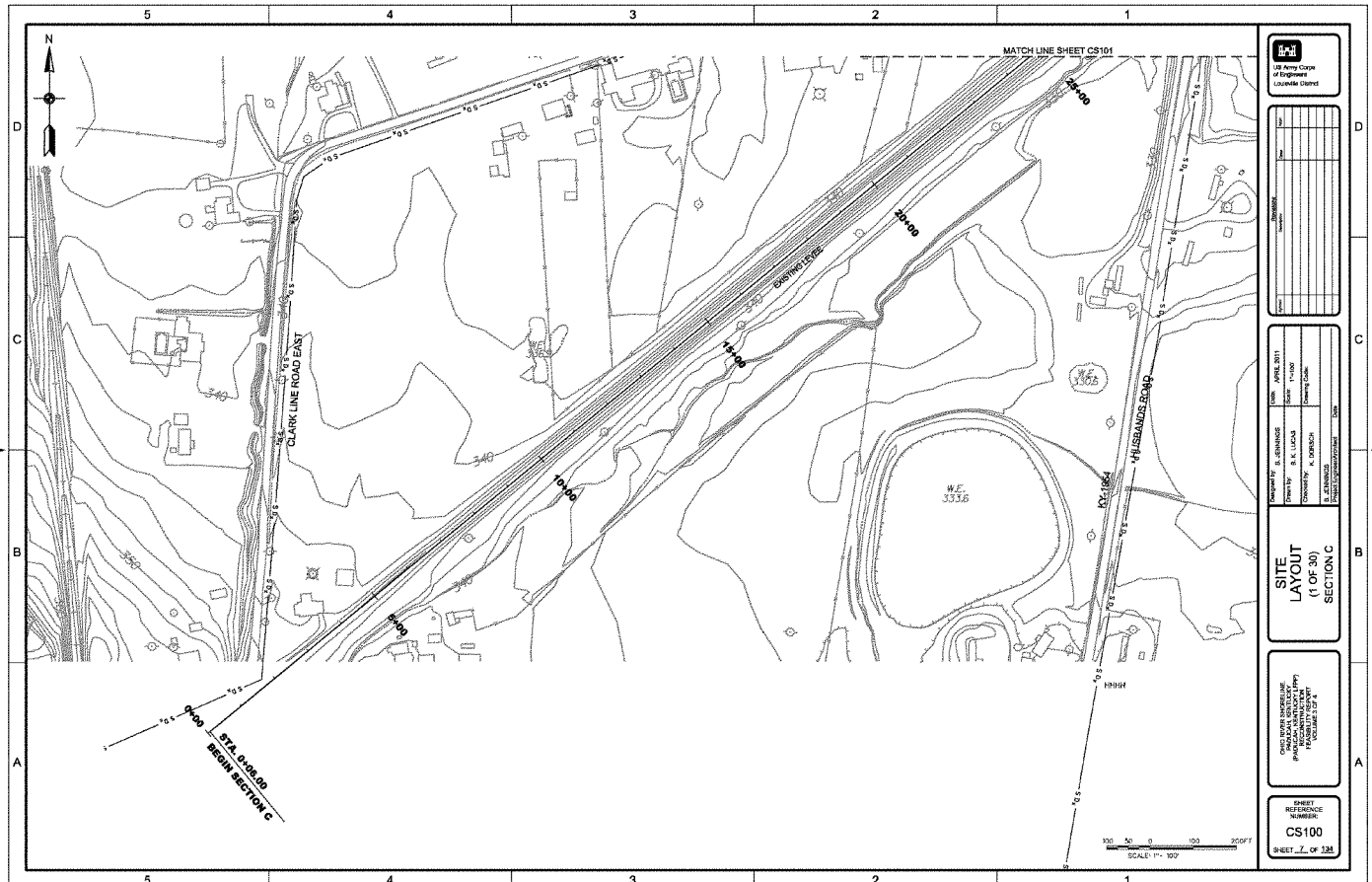

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FINAL SUBMITTAL

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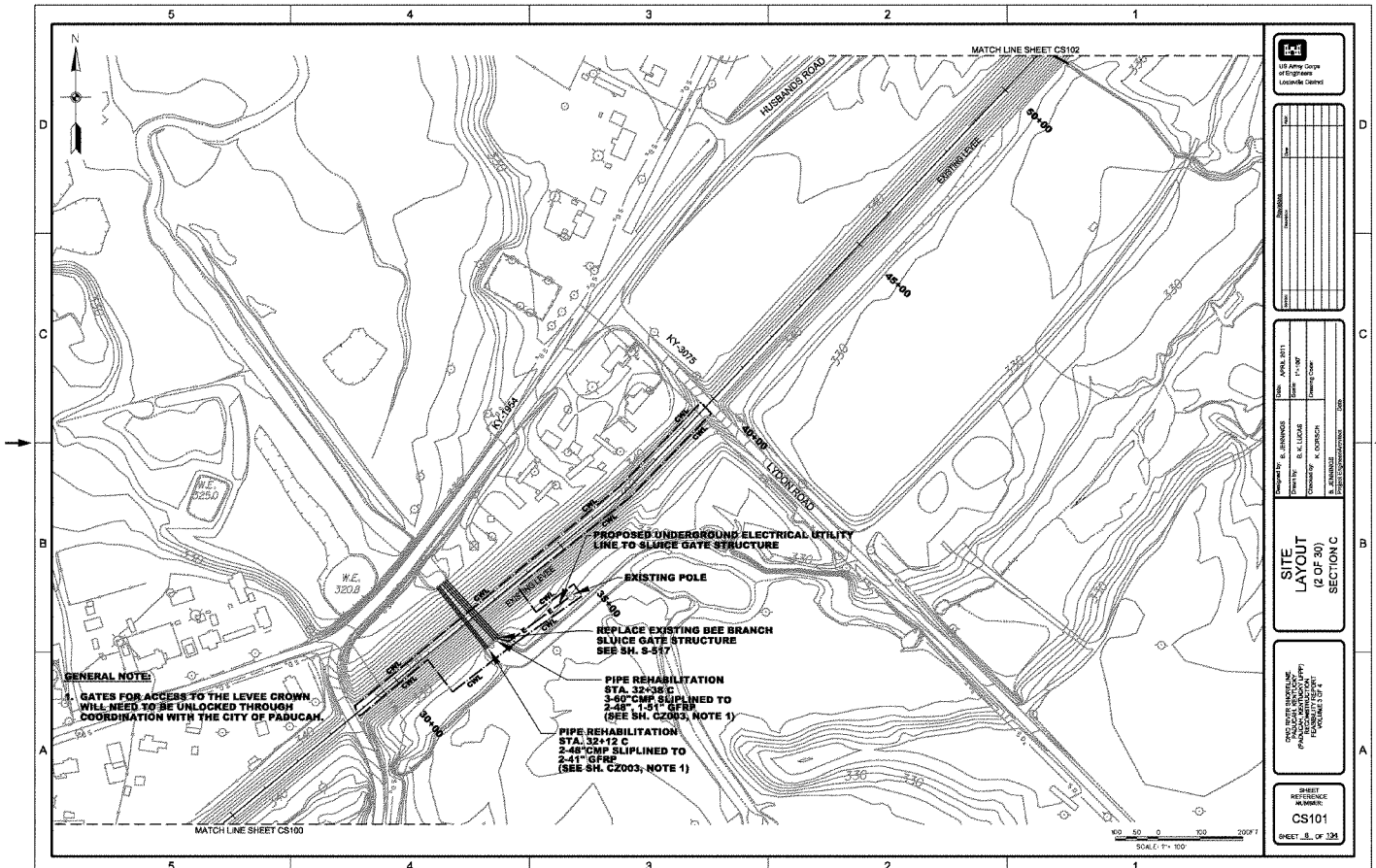

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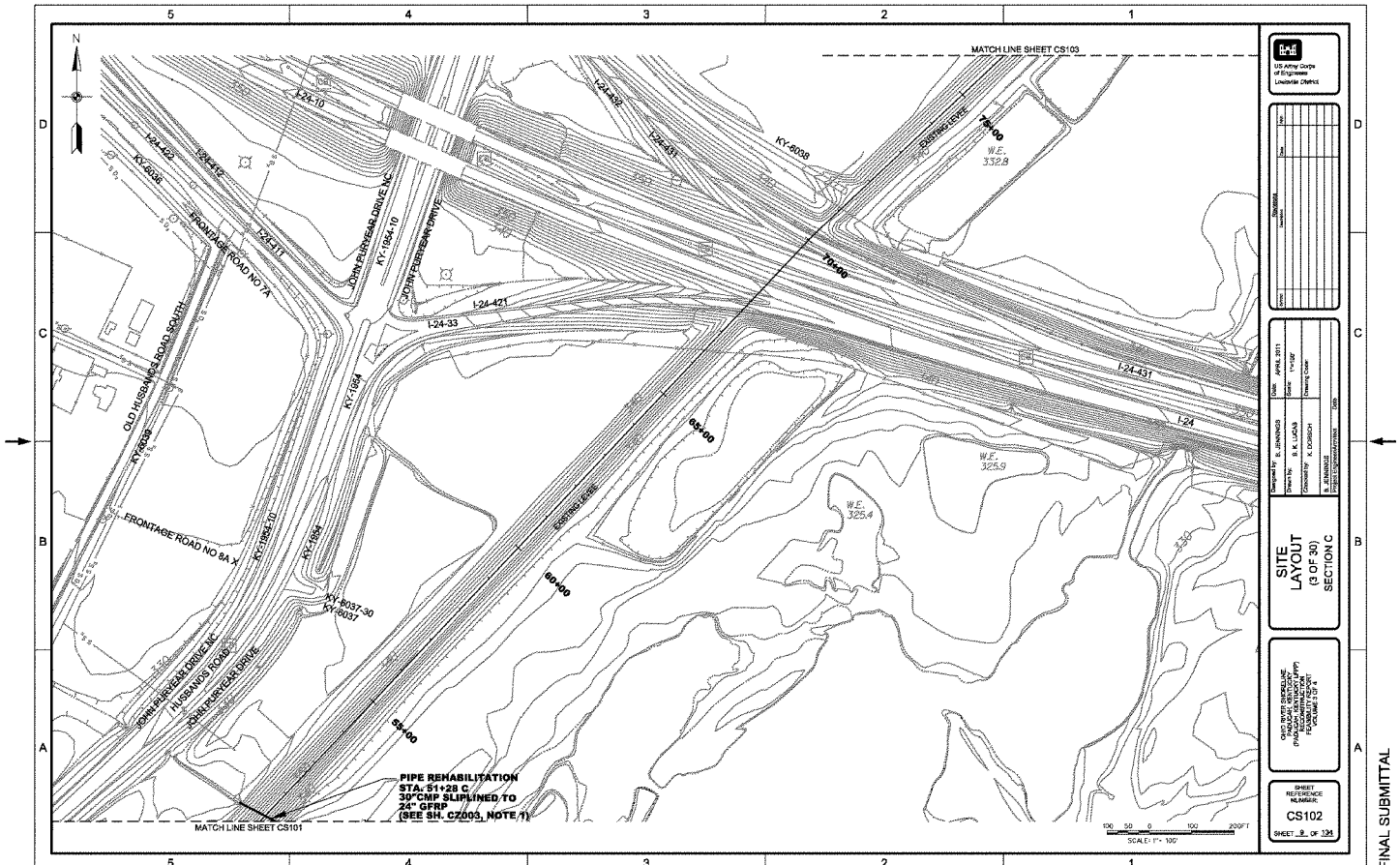
FINAL SUBMITTAL

*** SAFETY PAYS ***



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FINAL SUBMITTAL

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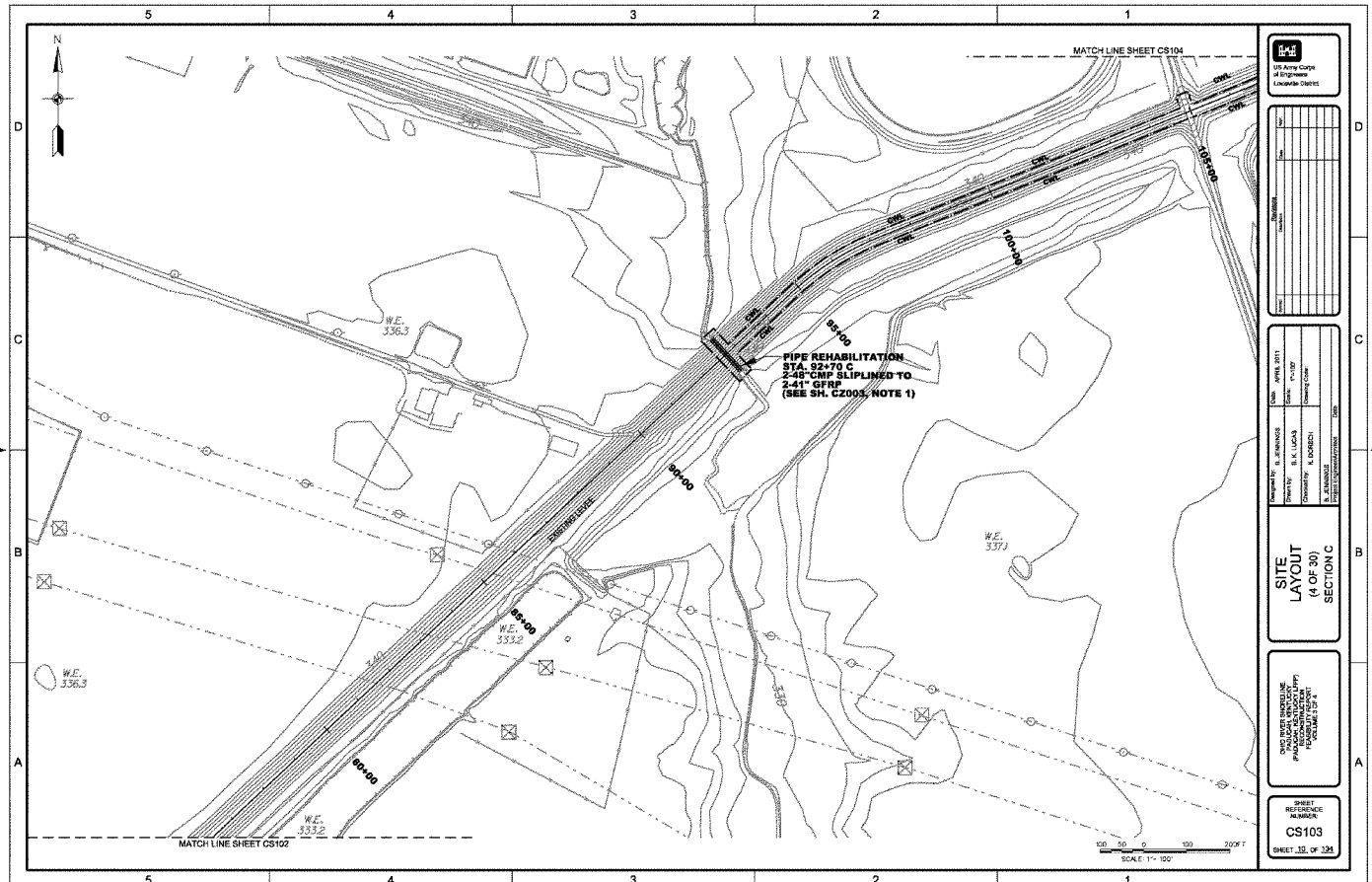

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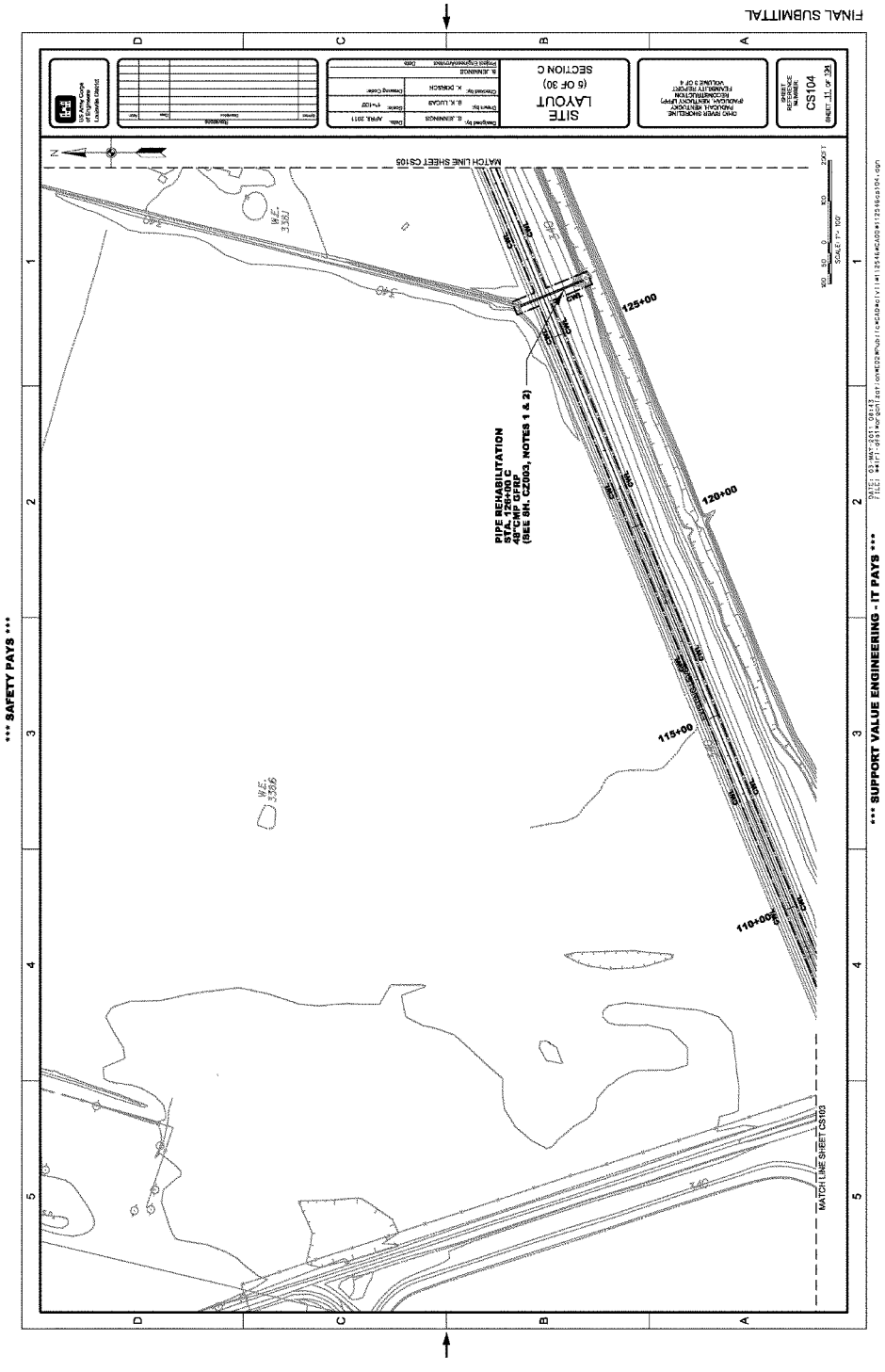
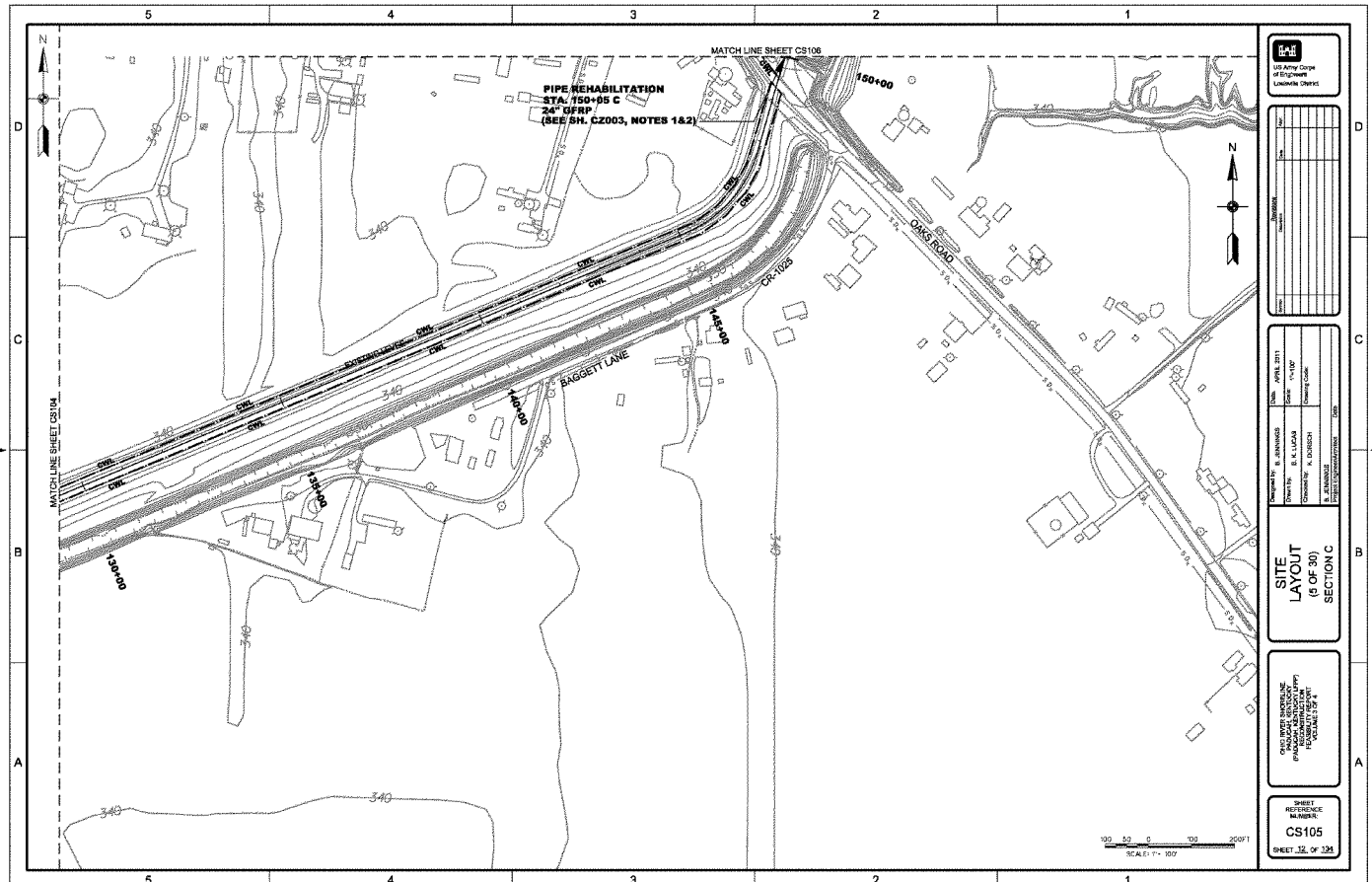
FINAL SUBMITTAL


FINAL SUBMITTAL
*** SAFETY PAYS ***
*** SUPPORT VALUE ENGINEERING - IT PAYS ***
SITE LAYOUT
(5 OF 30)
SECTION C
CS104
MATCH LINE SHEET CS105
MATCH LINE SHEET CS103
PIPE REHABILITATION
STA. 126+00 C
48"CMP GFRP
(SEE SH. CZ003, NOTES 1 & 2)
125+00
120+00
115+00
110+00
W.E. 3381
W.E. 3386
SCALE: 1"= 100'

*** SAFETY PAYS ***



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FINAL SUBMITTAL

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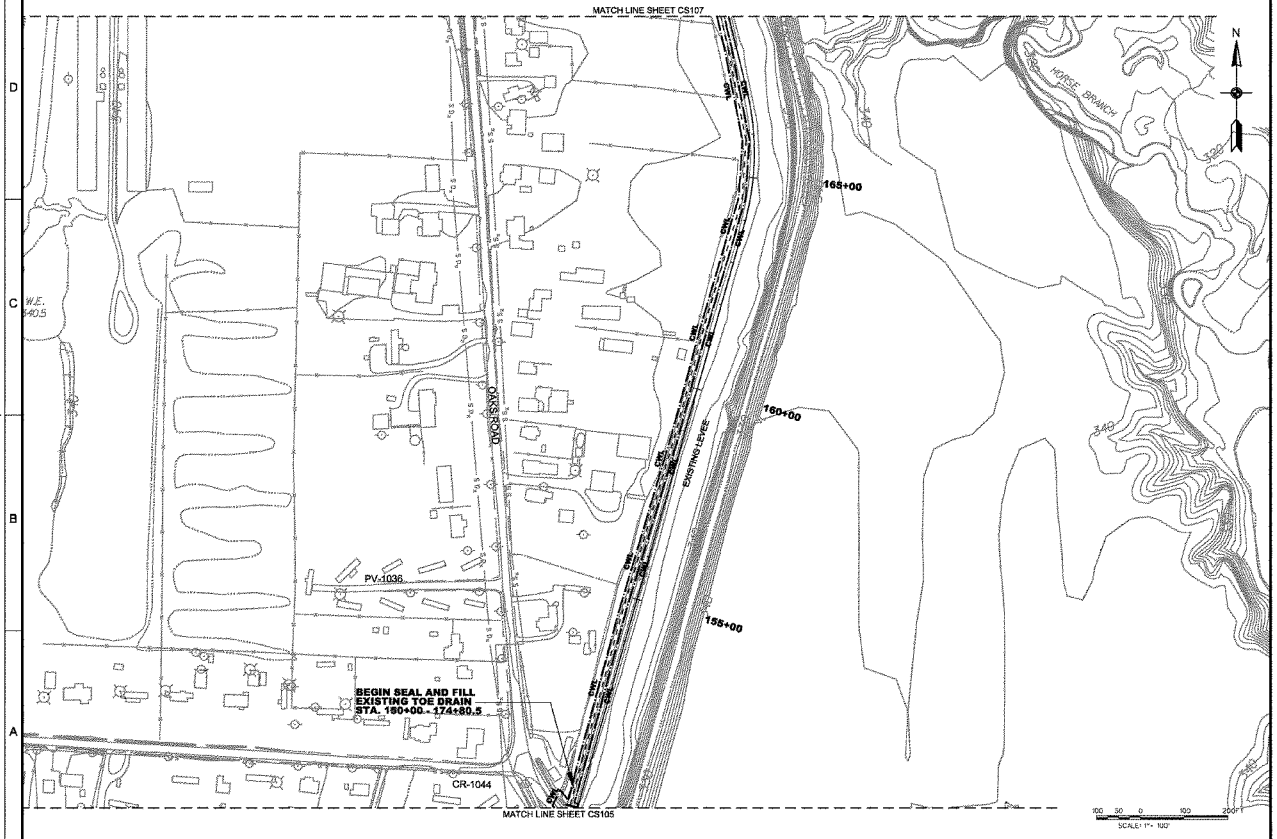

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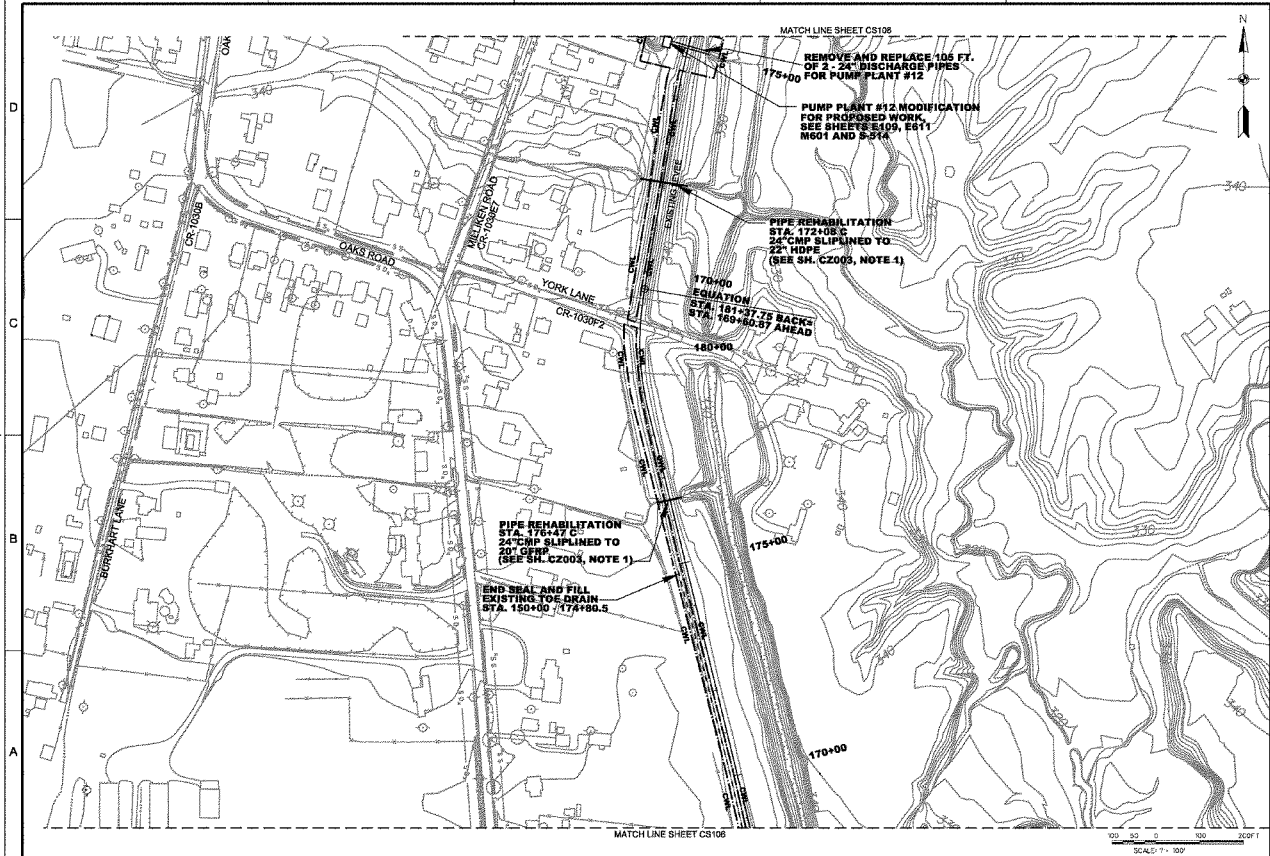
FINAL SUBMITTAL



US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Appr

Designed by: B. JENNINGS
Drawn by: B.K. LUCAS
Checked by: K. DORSON
B. JENNINGS
Project Engineer/Architect
Date
Date: APRIL 2011
Scale: 1" = 100'
Drawing Code

SITE LAYOUT (7 OF 30) SECTION C

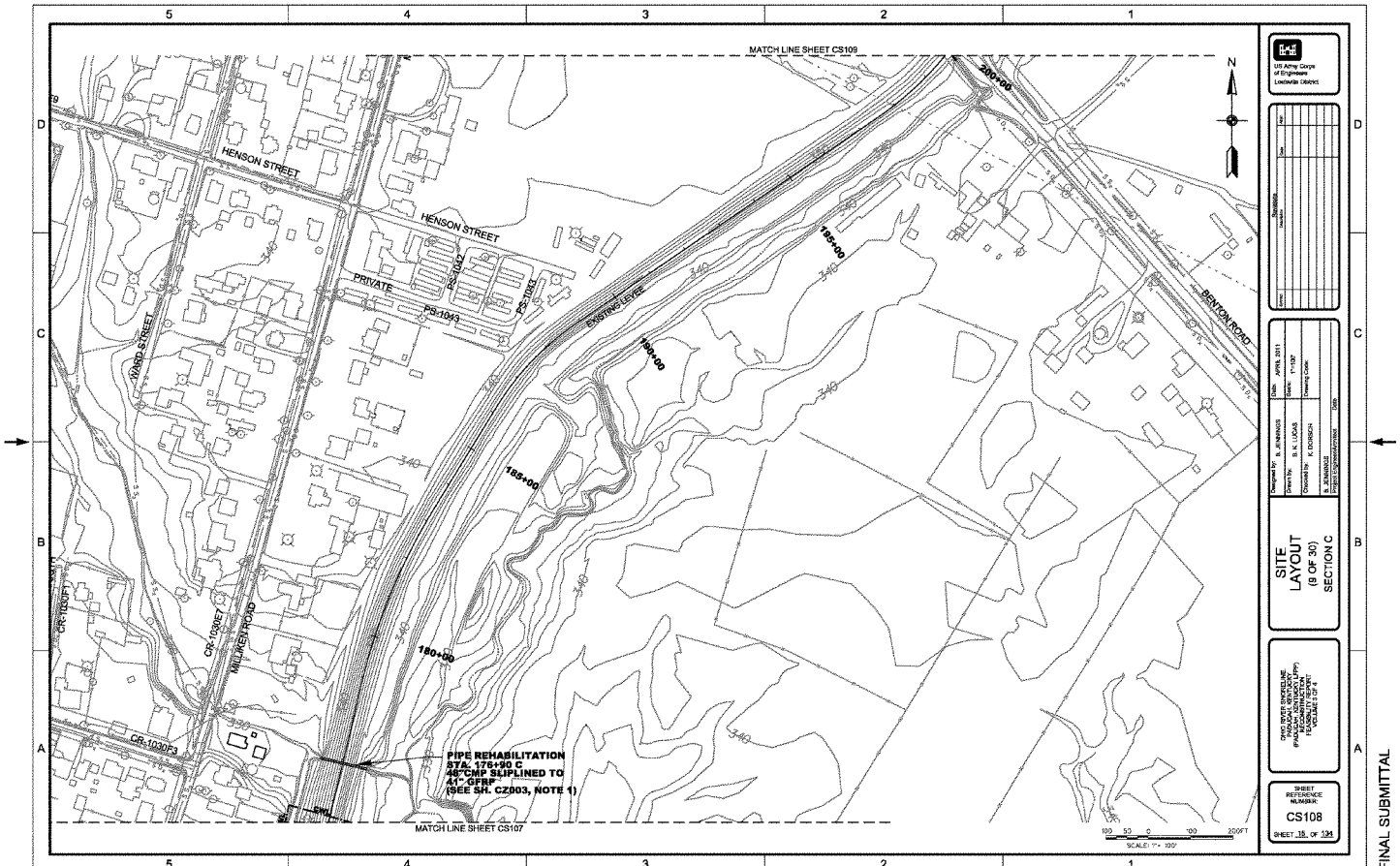
OHIO RIVER SHORELINE MAYSVILLE, KENTUCKY (PIKE) (PADUCAH, KENTUCKY UPP) FEASIBILITY REPORT
SHEET 7 OF 7

SHEET REFERENCE NUMBER: CS107
SHEET 11 OF 134

DATE: 03-MAY-2011 08:43
FILE: \\irf-dfs1\organization\E02\Public\CADD\civil\112546\CADD\112546cs107.dgn

FINAL SUBMITTAL

*** SAFETY PAYS ***



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FINAL SUBMITTAL

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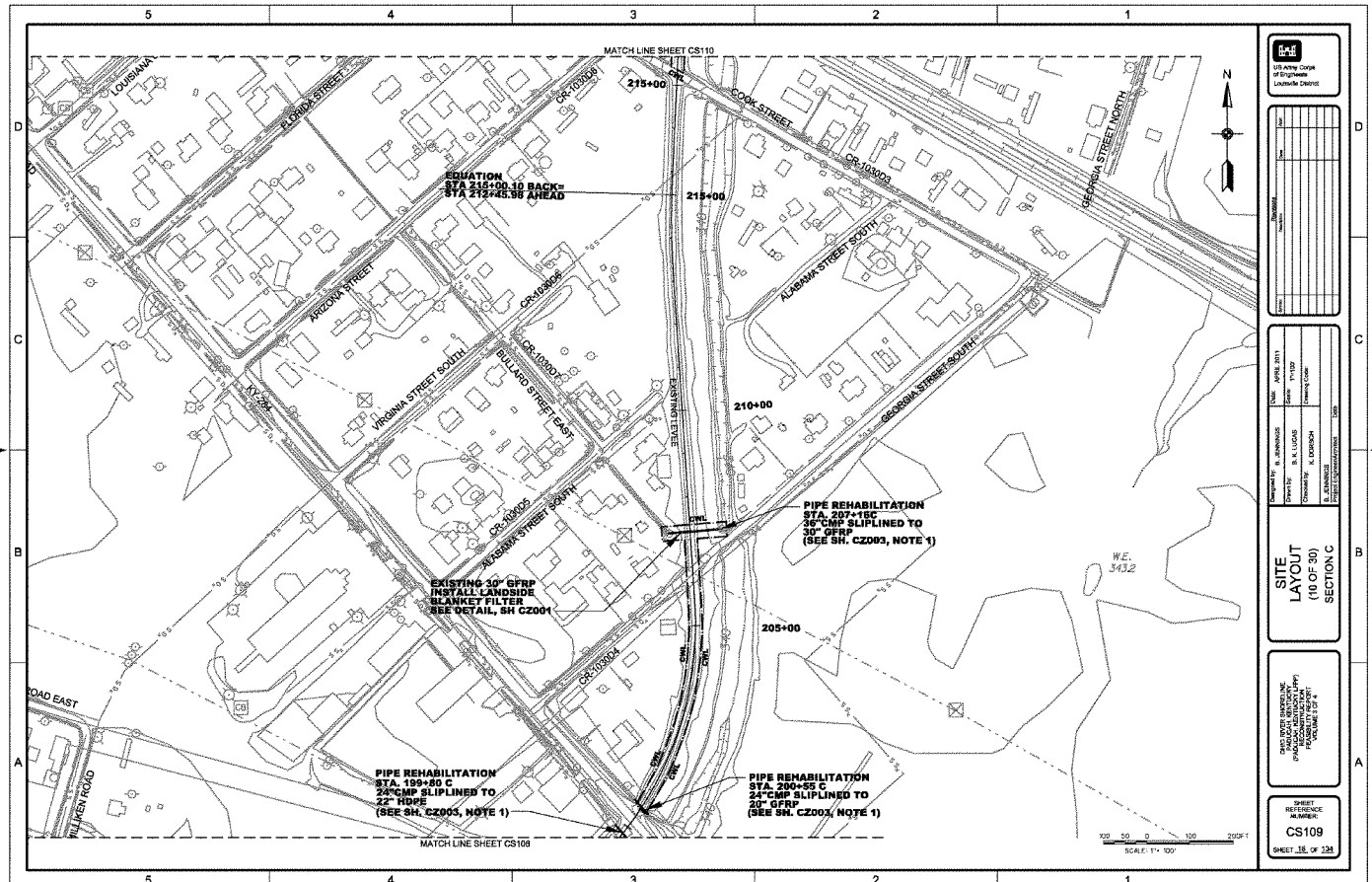

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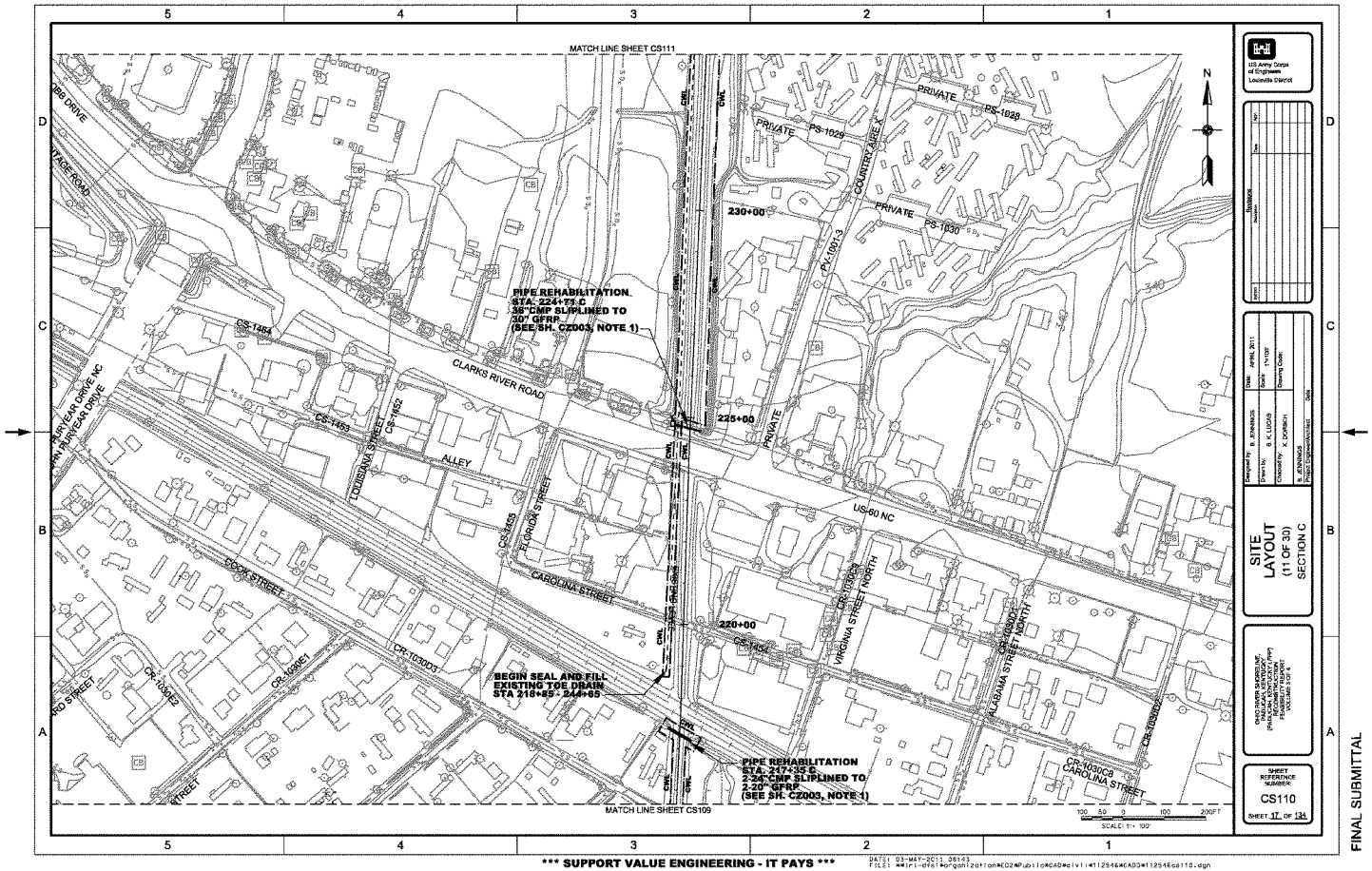
FINAL SUBMITTAL

*** SAFETY PAYS ***



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FINAL SUBMITTAL

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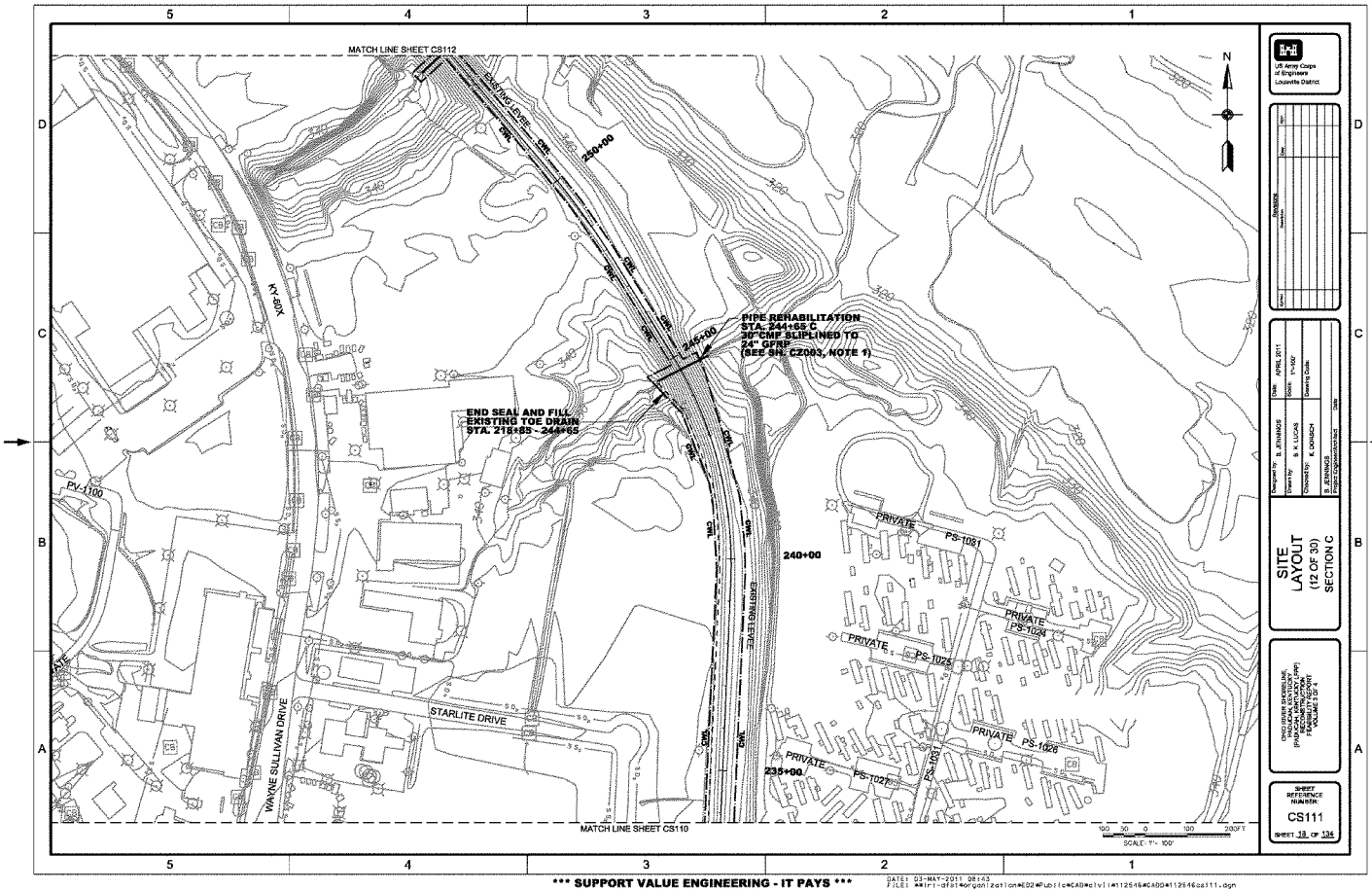

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:43
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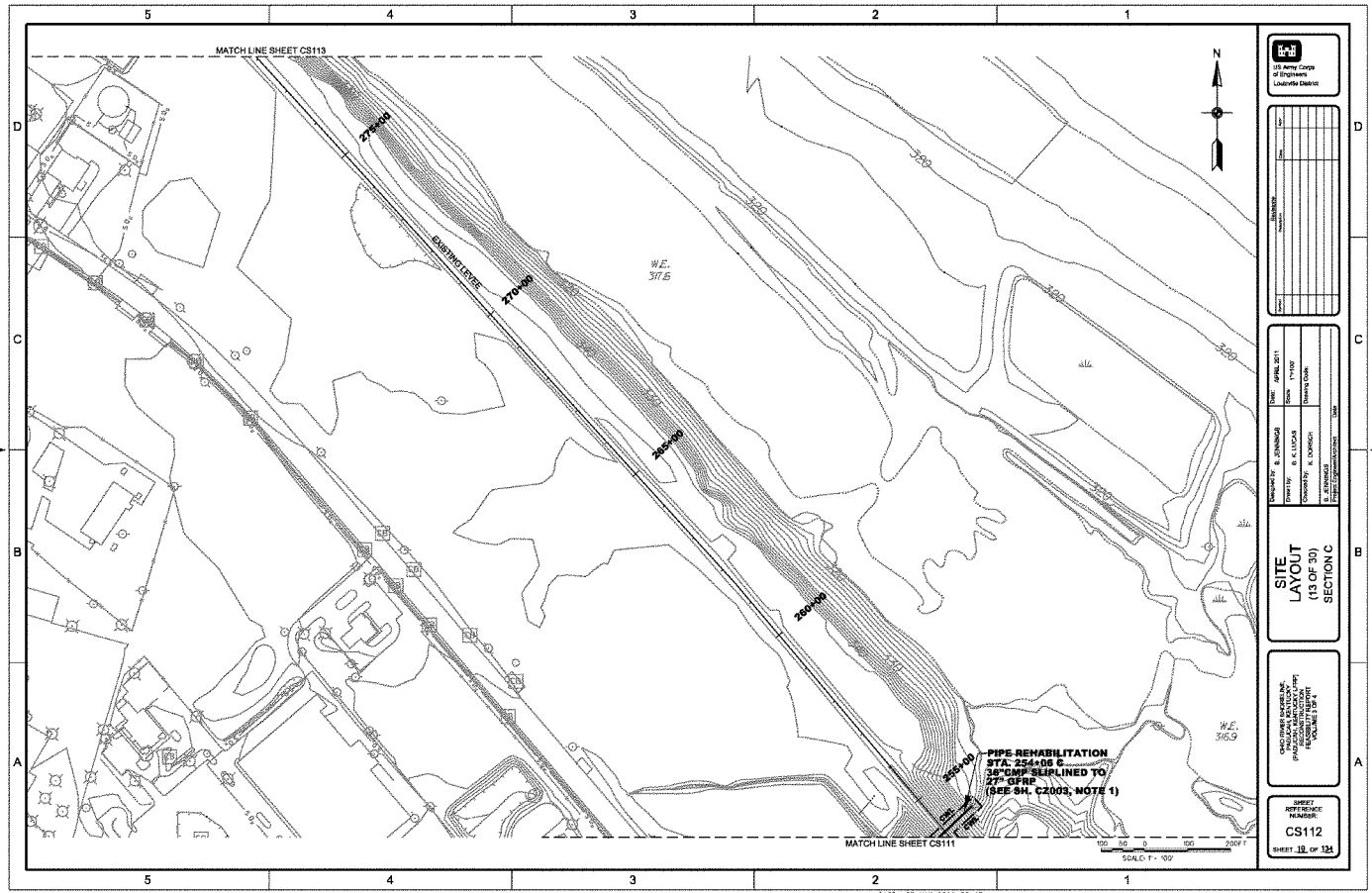
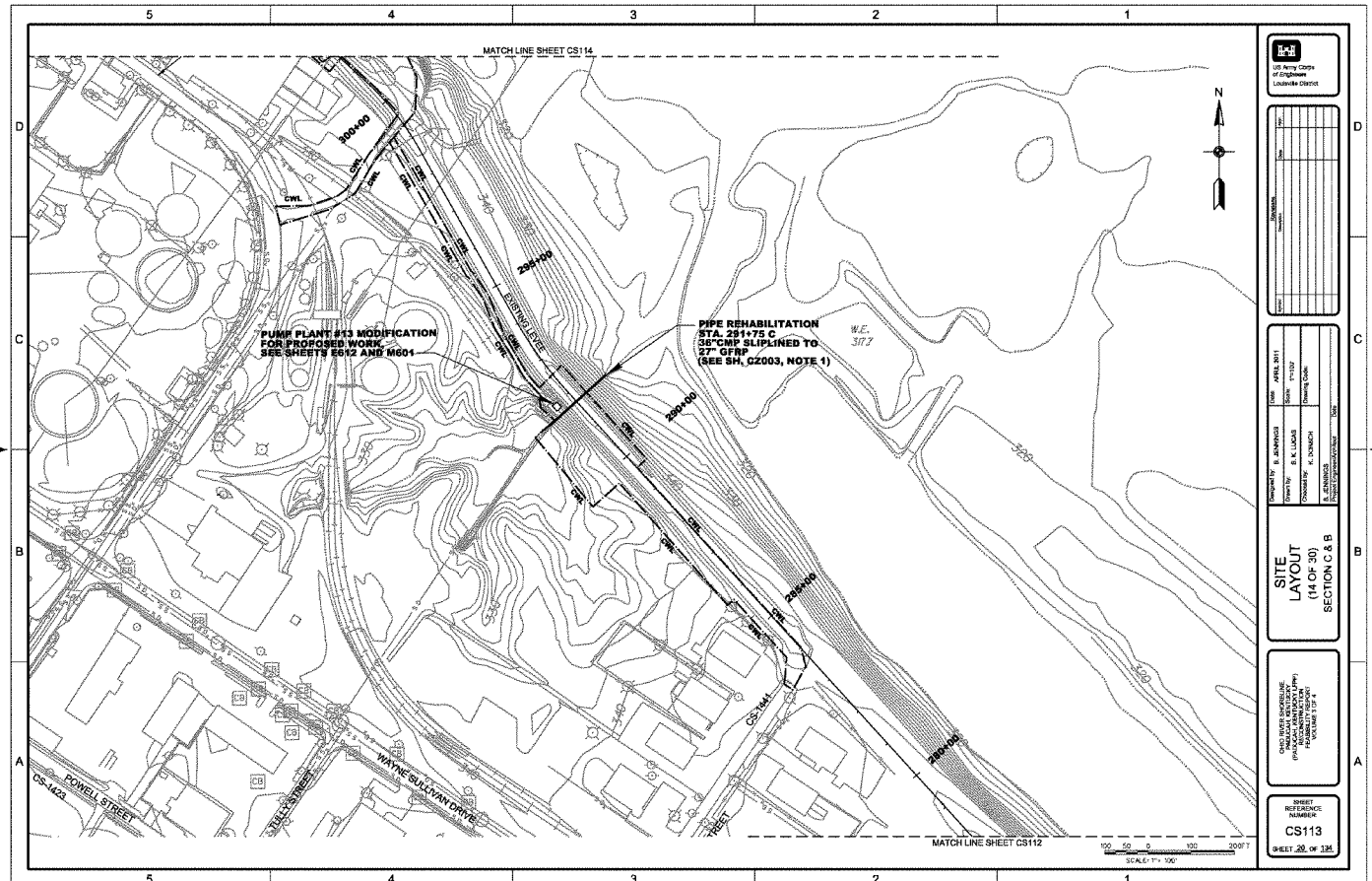


*** SUPPORT VALUE ENGINEERING - IT PAYS ***

*** SAFETY PAYS ***



*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:43
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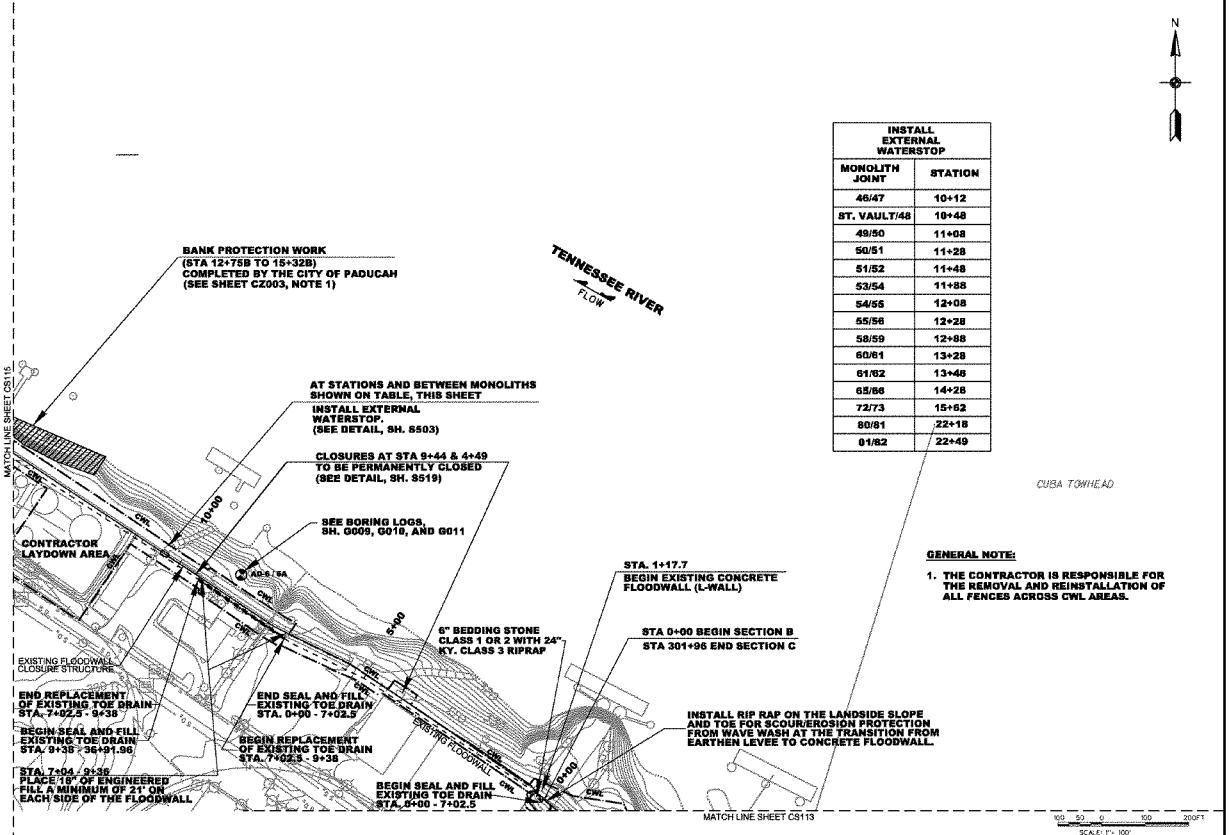
FINAL SUBMITTAL



INSTALL EXTERNAL WATERSTOP	
MONOLITH JOINT	STATION
46/47	10+12
ST. VAULT/48	10+48
49/50	11+08
50/51	11+28
51/52	11+48
53/54	11+88
54/55	12+08
55/56	12+28
58/59	12+88
60/61	13+28
61/62	13+48
65/66	14+28
72/73	15+62
80/81	22+18
81/82	22+49

GENERAL NOTE:

1. THE CONTRACTOR IS RESPONSIBLE FOR THE REMOVAL AND REINSTALLATION OF ALL FENCES ACROSS CWL AREAS.

US Army Corps of Engineers
Louisville District

Symbols

Symbol	Description	Date	Sym	Description	Date

Designed by: B. JENKINS
Drawn by: R. K. LUCAS
Checked by: K. DOMSON
B. JENKINS
Project Engineer(Architect)
Date: APRIL 2011
Scale: 1"=100'
Drawing Code:

SITE LAYOUT
(14 OF 30)
SECTION B

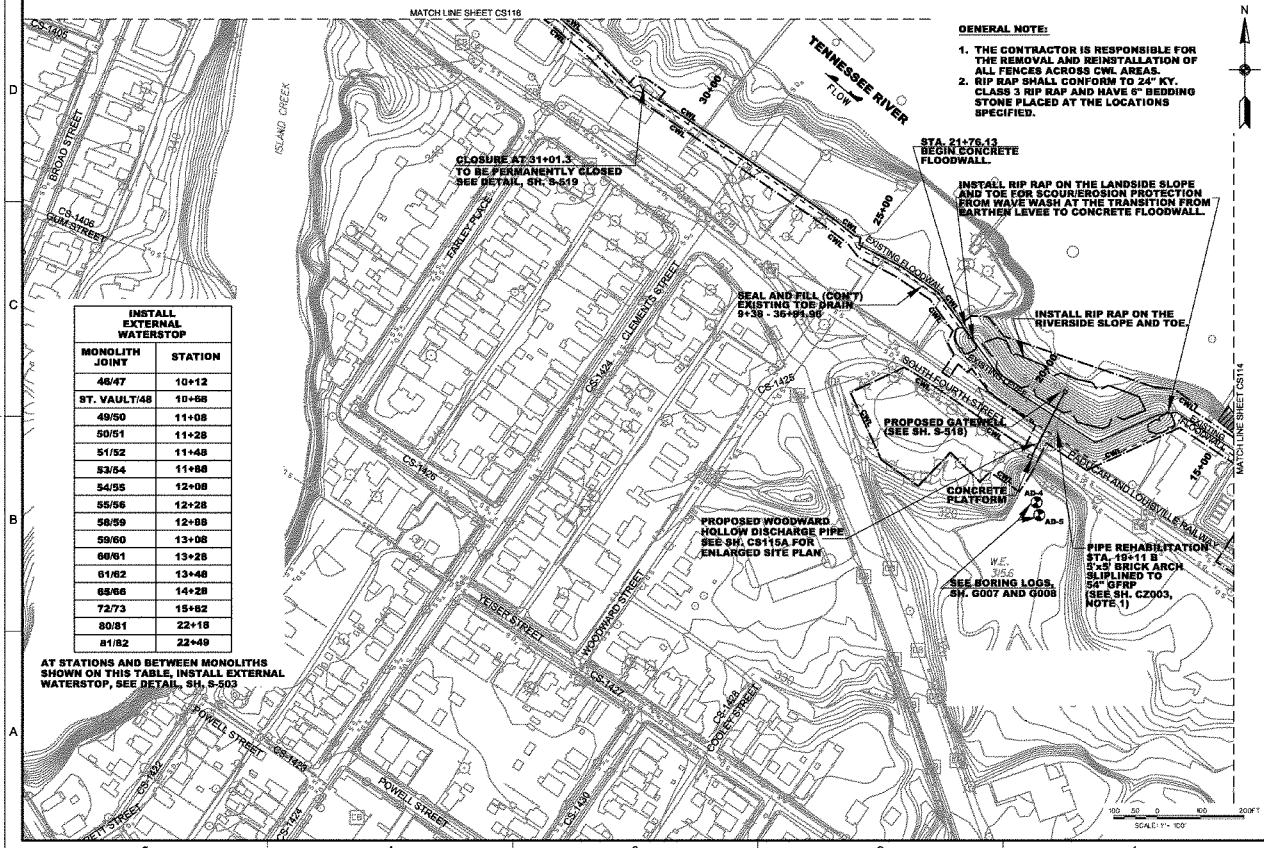
OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PRP)
(PARKER PORTAGE PUMPING STATION)
HUDSON / 15-PRP
MODULE 1 OF 4

SHEET REFERENCE NUMBER
CS114
SHEET 21 OF 134

DATE: 03-MAY-2011 08:43
FILE: awirl-dfsl#orgdfldrtionMED2MPublicCADMcivil#112545MCADM112546cs114.dgn

FINAL SUBMITTAL

*** SAFETY PAYS ***



INSTALL EXTERNAL WATERSTOP	
MONOLITH JOINT	STATION
46/47	10+12
ST. VAULT/48	10+66
49/50	11+08
50/51	11+28
51/52	11+48
53/54	11+88
54/55	12+08
55/56	12+28
58/59	12+88
59/60	13+08
60/61	13+28
61/62	13+48
65/66	14+28
72/73	15+52
80/81	22+18
81/82	22+49

AT STATIONS AND BETWEEN MONOLITHS SHOWN ON THIS TABLE, INSTALL EXTERNAL WATERSTOP, SEE DETAIL, SH. S-503

GENERAL NOTE:

1. THE CONTRACTOR IS RESPONSIBLE FOR THE REMOVAL AND REINSTALLATION OF ALL FENCES ACROSS CWL AREAS.
2. RIP RAP SHALL CONFORM TO 24" KY. CLASS 3 RIP RAP AND HAVE 6" BEDDING STONE PLACED AT THE LOCATIONS SPECIFIED.

US Army Corps of Engineers
Louisville District

Symbol	Description	Date	Initial

Designed by: B. JENNINGS
Drawn by: B. K. LUCAS
Checked by: K. DONSON
Project Engineer/Architect: B. JENNINGS
Date: APRIL 2011
Scale: 1"=100'
Drawing Code:
Date

SITE LAYOUT
(16 OF 30)
SECTION B

OHIO RIVER BASIN, NN-
MAINSTEM LEVEE SYSTEM
PADUCAH, KENTUCKY (PRP)
MODIFIED FINDING
CONTRACT 1

SHEET REFERENCE NUMBER:
CS115
SHEET 32 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:43
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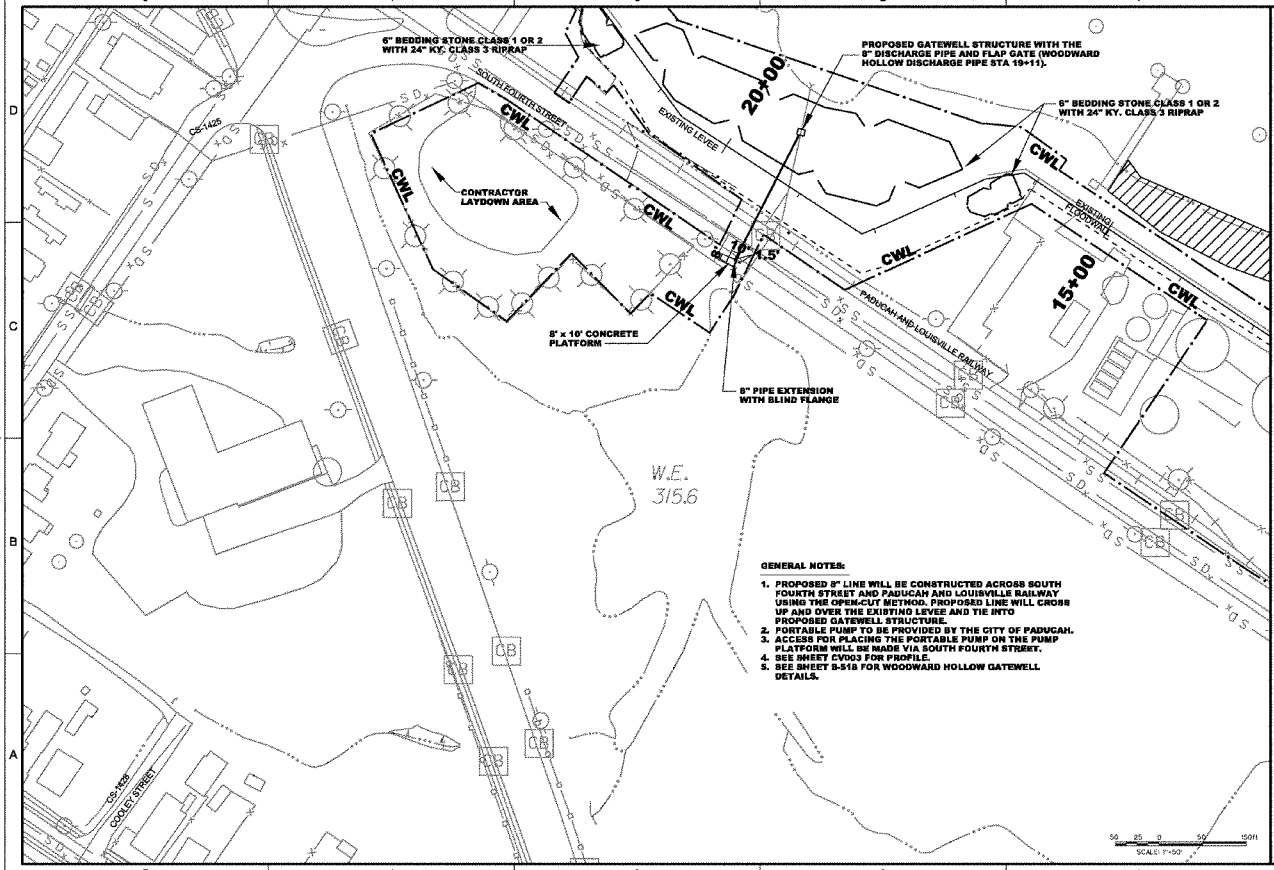
FINAL SUBMITTAL

*** SAFETY PAYS ***



GENERAL NOTES:

1. PROPOSED 8" LINE WILL BE CONSTRUCTED ACROSS SOUTH FOURTH STREET AND PADUCAH AND LOUISVILLE RAILWAY USING THE OPEN-CUT METHOD. PROPOSED LINE WILL CROSS UP AND OVER THE EXISTING LEVEE AND TIE INTO PROPOSED GATEWELL STRUCTURE.
2. PORTABLE PUMP TO BE PROVIDED BY THE CITY OF PADUCAH.
3. ACCESS FOR PLACING THE PORTABLE PUMP ON THE PUMP PLATFORM WILL BE MADE VIA SOUTH FOURTH STREET.
4. SEE SHEET CV003 FOR PROFILE.
5. SEE SHEET S-518 FOR WOODWARD HOLLOW GATEWELL DETAILS.

US Army Corps of Engineers Louisville District

Symbol	Revisions	Date	Approved

Designed by: B. JENNINGS
Drawn by: B. K. LUCAS
Reviewed by: K. DORSCH
Date: APRIL 2011
Scale: 1"=50'
Drawing Code:
B. JENNINGS
Project Engineer/Architect
CIRS

ENLARGED SITE PLAN WOODWARD HOLLOW DISCHARGE PIPE

OHIO RIVER SHORELINE PROTECTION PROJECT (PADUCAH, KENTUCKY LPP)
FLOOD CONTROL & COASTAL EMERGENCIES
NUMBER: 96-1

SHEET REFERENCE NUMBER:
CS115a
SHEET 22 OF 138

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:43
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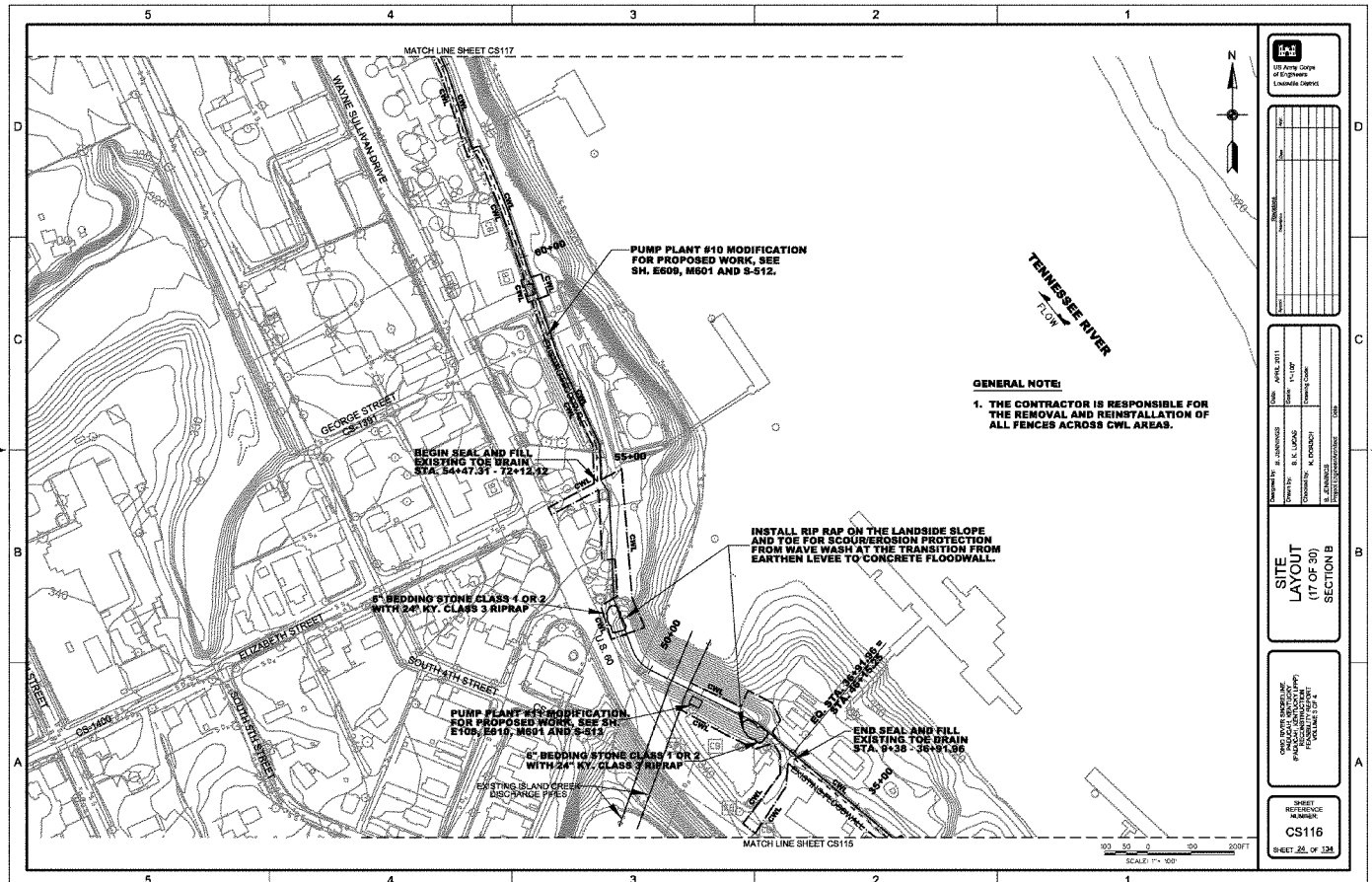
FINAL SUBMITTAL

*** SAFETY PAYS ***



GENERAL NOTE:

1. THE CONTRACTOR IS RESPONSIBLE FOR THE REMOVAL AND REINSTALLATION OF ALL FENCES ACROSS CWL AREAS.

US Army Corps of Engineers
Louisville District

Revisions

Number	Date	Year

Designed by: B. JENKINS/CS
Drawn by: B. K. LUCAS
Checked by: K. DONSCH
S. JENKINS
Project Engineer/Architect
Date: APRIL 2011
Scale: 1"=100'
Drawing Code:

SITE LAYOUT
(17 OF 30)
SECTION B

OHIO RIVER SHORELINE
ASHLAND, KENTUCKY
(PIKEVILLE, KENTUCKY UPP)
FLOOD CONTROL PROJECT
CONSTRUCTION
VOLUME 1 OF 2

SHEET REFERENCE NUMBER
CS116
SHEET 24 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:43
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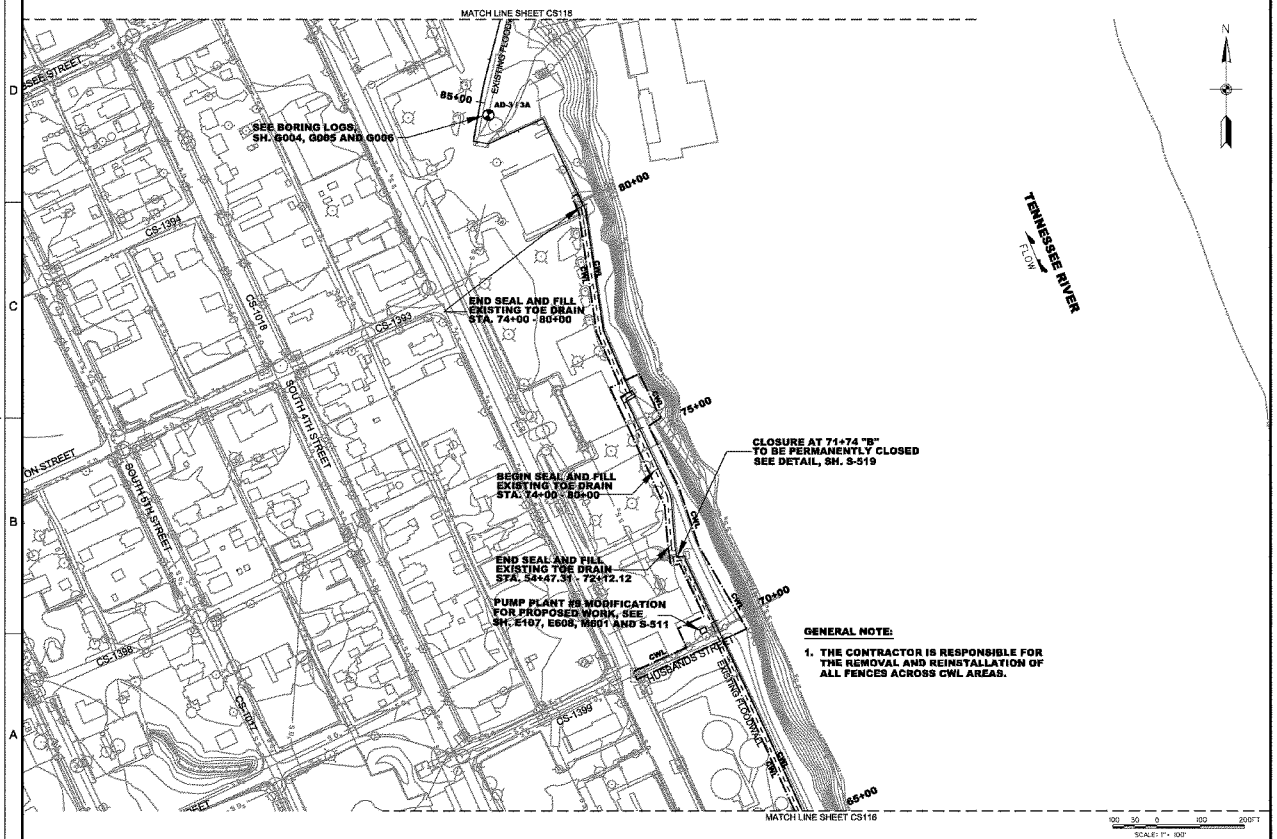
FINAL SUBMITTAL

*** SAFETY PAYS ***



GENERAL NOTE:

1. THE CONTRACTOR IS RESPONSIBLE FOR THE REMOVAL AND REINSTALLATION OF ALL FENCES ACROSS CWL AREAS.

US Army Corps of Engineers
Louisville District

Revisions			
Symbol	Description	Date	Appr

Designed by: B. JENKINS
Drawn by: B. K. LUCAS
Checked by: K. SCHMICH
Date: APRIL 2011
Scale: 1"=100'
Drawing Code:
S. JENKINS
Project Engineer/Architect
CDR

SITE LAYOUT
(18 OF 30)
SECTION B

OHIO RIVER NAVIGATION
PROJECT, MAINTENANCE
PADUCAH, KENTUCKY (OPP)
FLOODWALL & LEVEE
WORK, 1 OF 2

SHEET REFERENCE NUMBER
CS117
SHEET 29 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

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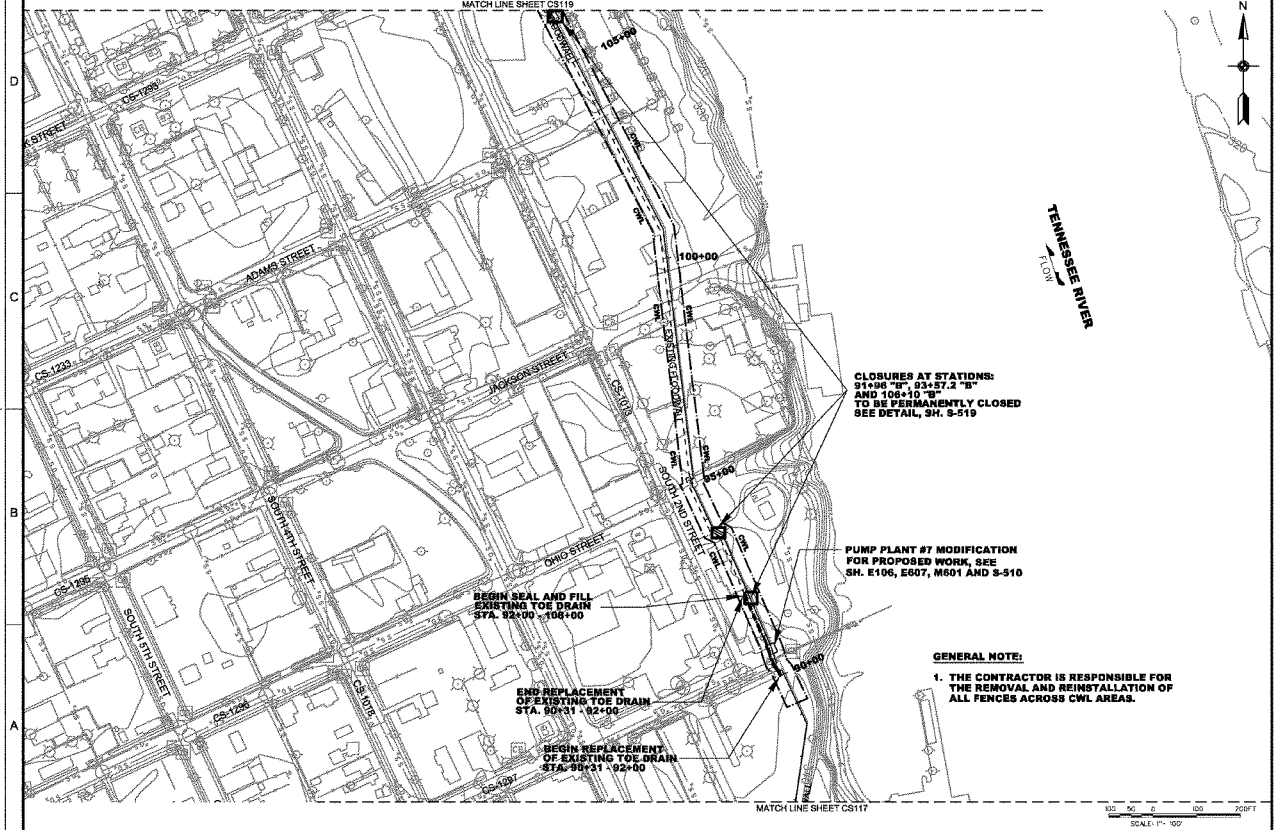
FINAL SUBMITTAL

*** SAFETY PAYS ***



US Army Corps of Engineers
Louisville District

Revisions

Number	Description	Date	Year

Designed By: B. JENKINS
Drawn By: R. K. LUCAS
Checked By: K. KONISCH
Project Engineer/Architect: R. JENKINS
Date: APRIL 2011
Scale: 1"=100'
Drawing Code:

SITE LAYOUT
(19 OF 30)
SECTION B

OHIO RIVER ENDRELINE
MAINTENANCE DREDGING
BRACKEN, KENTUCKY (FPP)
FACILITY REPORT
CONTRACT NO. 2

SHEET REFERENCE NUMBER:
CS118
SHEET 28 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:43
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FINAL SUBMITTAL

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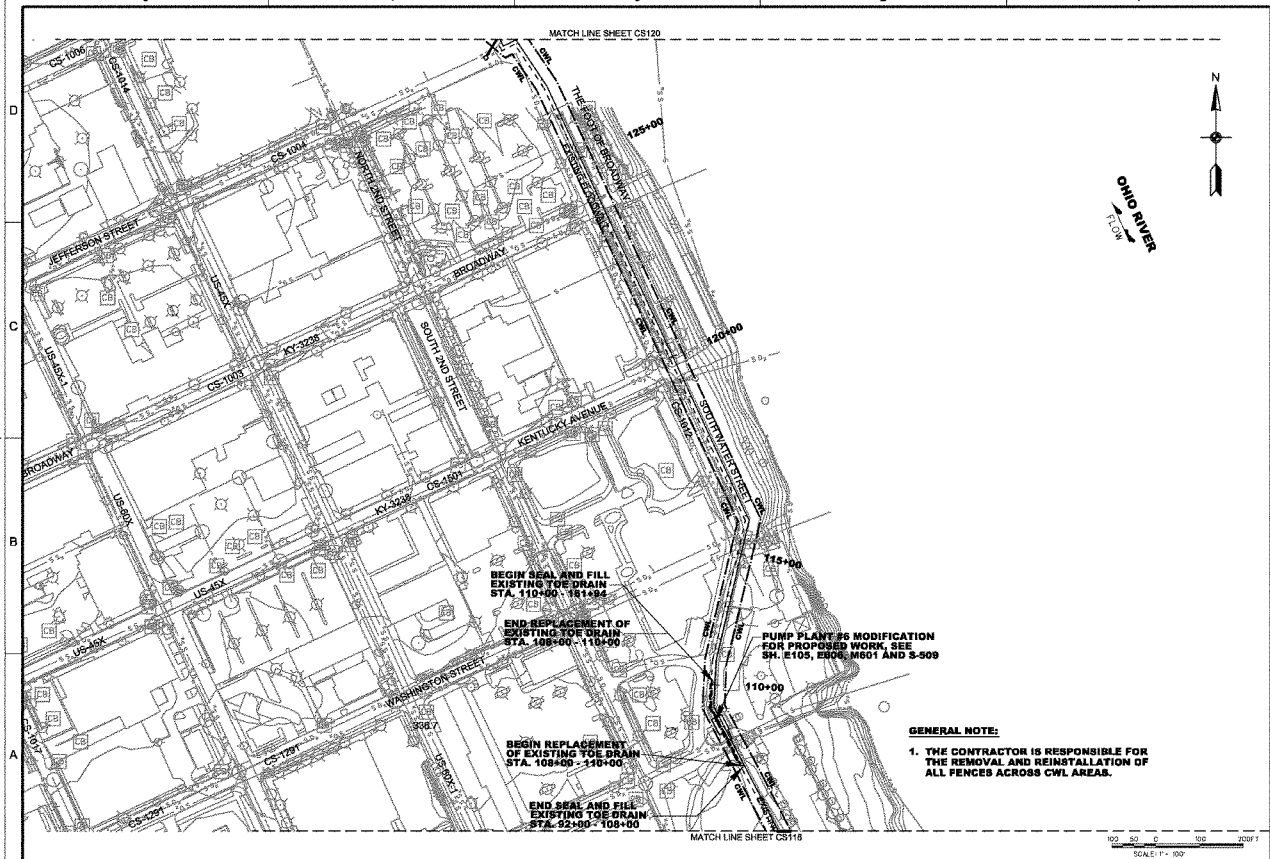

GENERAL NOTE:

1. THE CONTRACTOR IS RESPONSIBLE FOR THE REMOVAL AND REINSTALLATION OF ALL FENCES ACROSS CWL AREAS.

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Approved

Designed by: S. JOHNSON
Drawn by: B.K. LUCAS
Checked by: K. DORNICH
S. JOHNSON
Project Engineer/Manager
Date: APRIL 2011
Scale: 1"=100'
Drawing Code:

SITE LAYOUT
(20 OF 30)
SECTION B

OHIO RIVER SHORELINE
PROTECTION PROJECT
(PADUCAH, KENTUCKY FPP)
FEASIBILITY REPORT
VOLUME 2 OF 2

SHEET REFERENCE NUMBER:
CS119
SHEET 27 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:42
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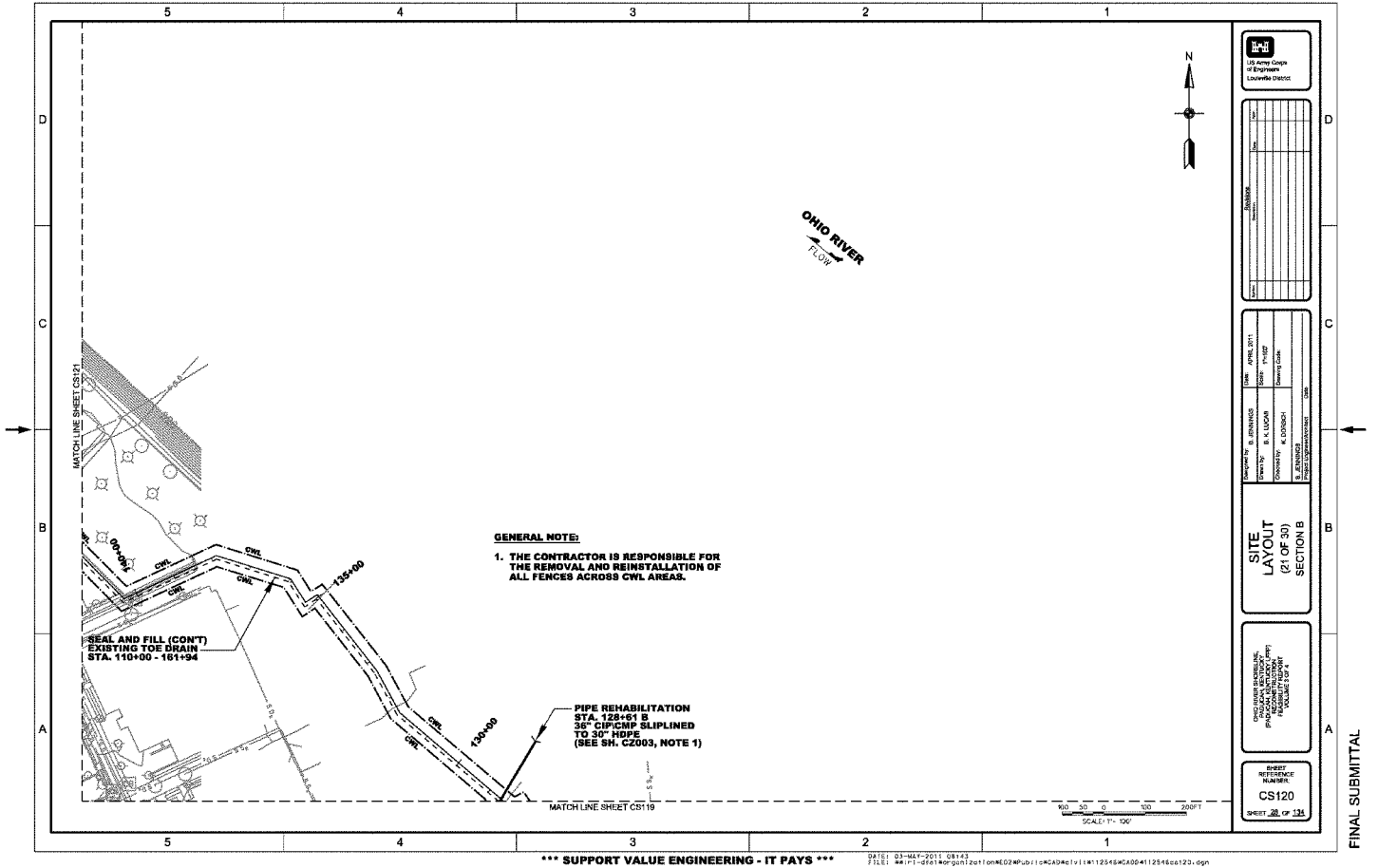
FINAL SUBMITTAL

*** SAFETY PAYS ***



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FINAL SUBMITTAL

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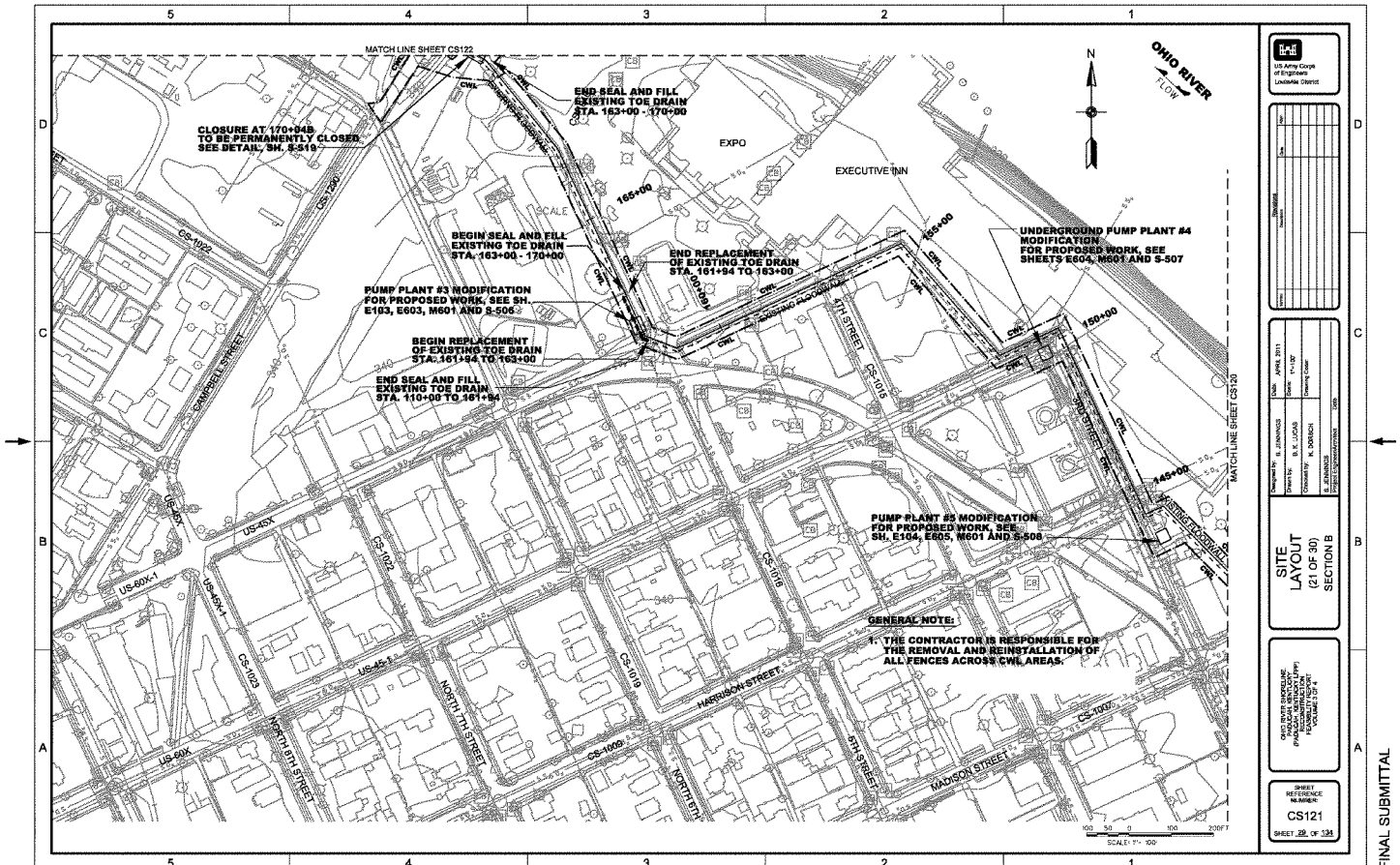

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FINAL SUBMITTAL

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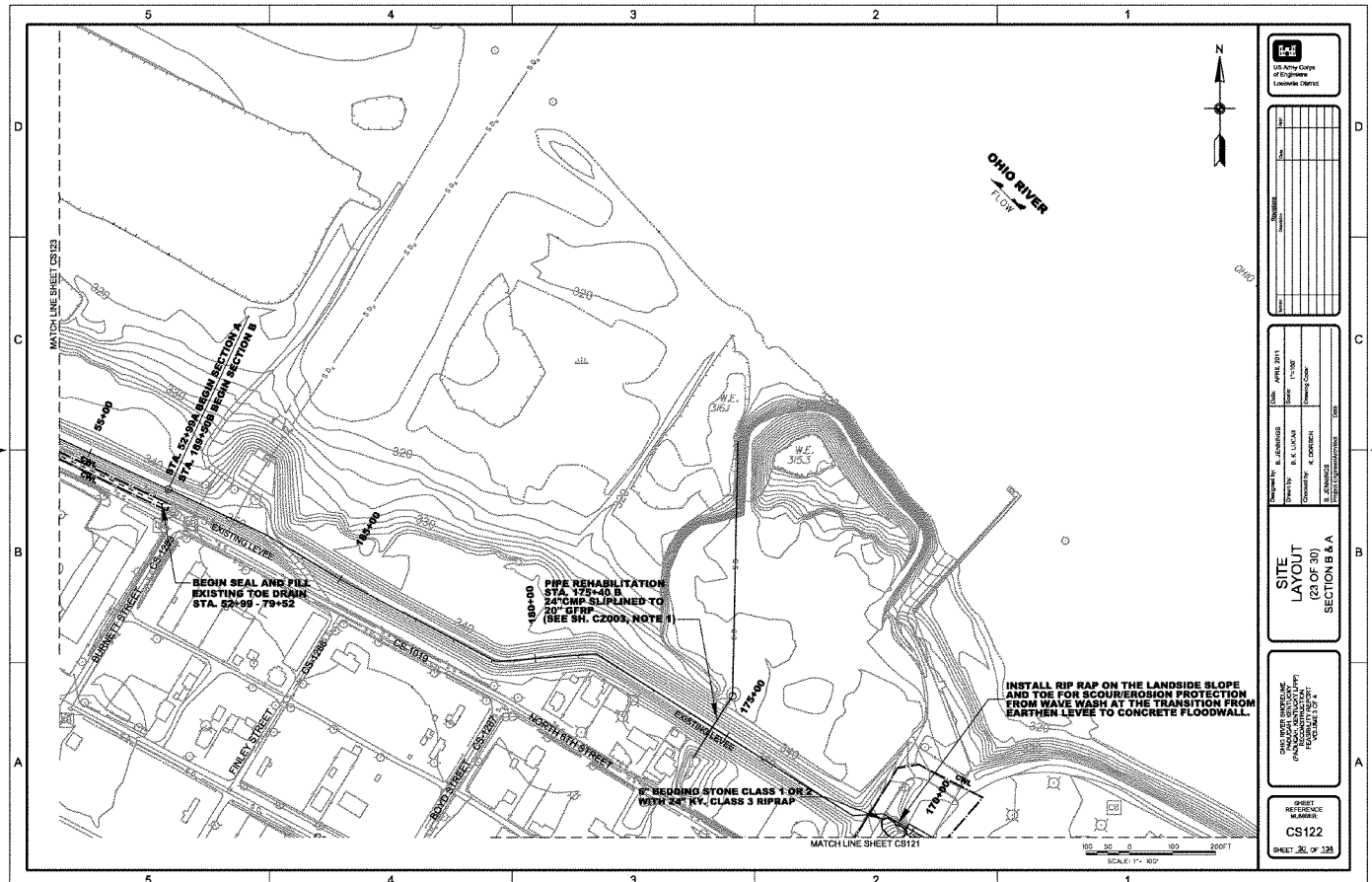

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DATE: 03-MAY-2011 08:44
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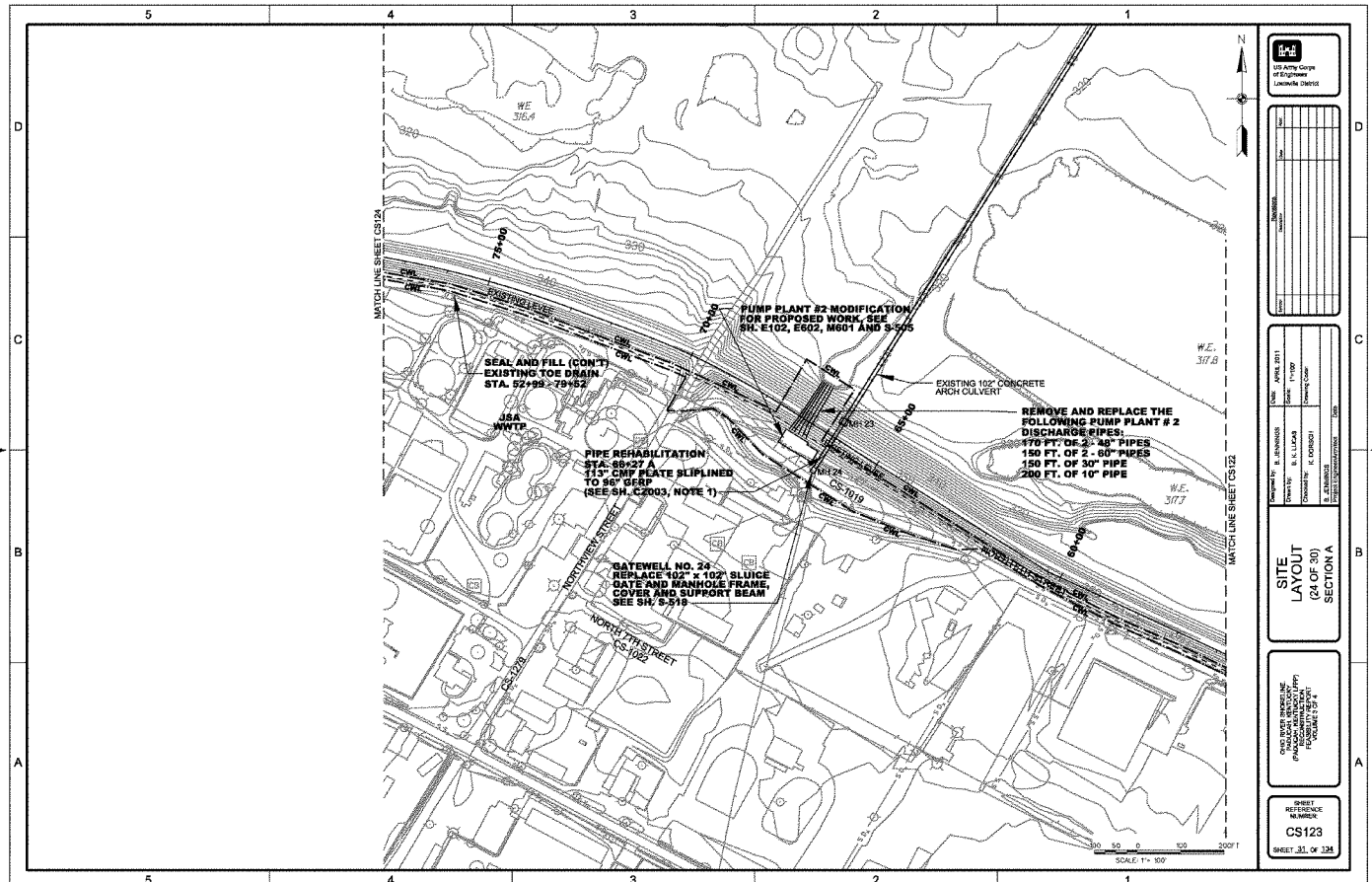
FINAL SUBMITTAL

*** SAFETY PAYS ***



*** SUPPORT VALUE ENGINEERING - IT PAYS ***

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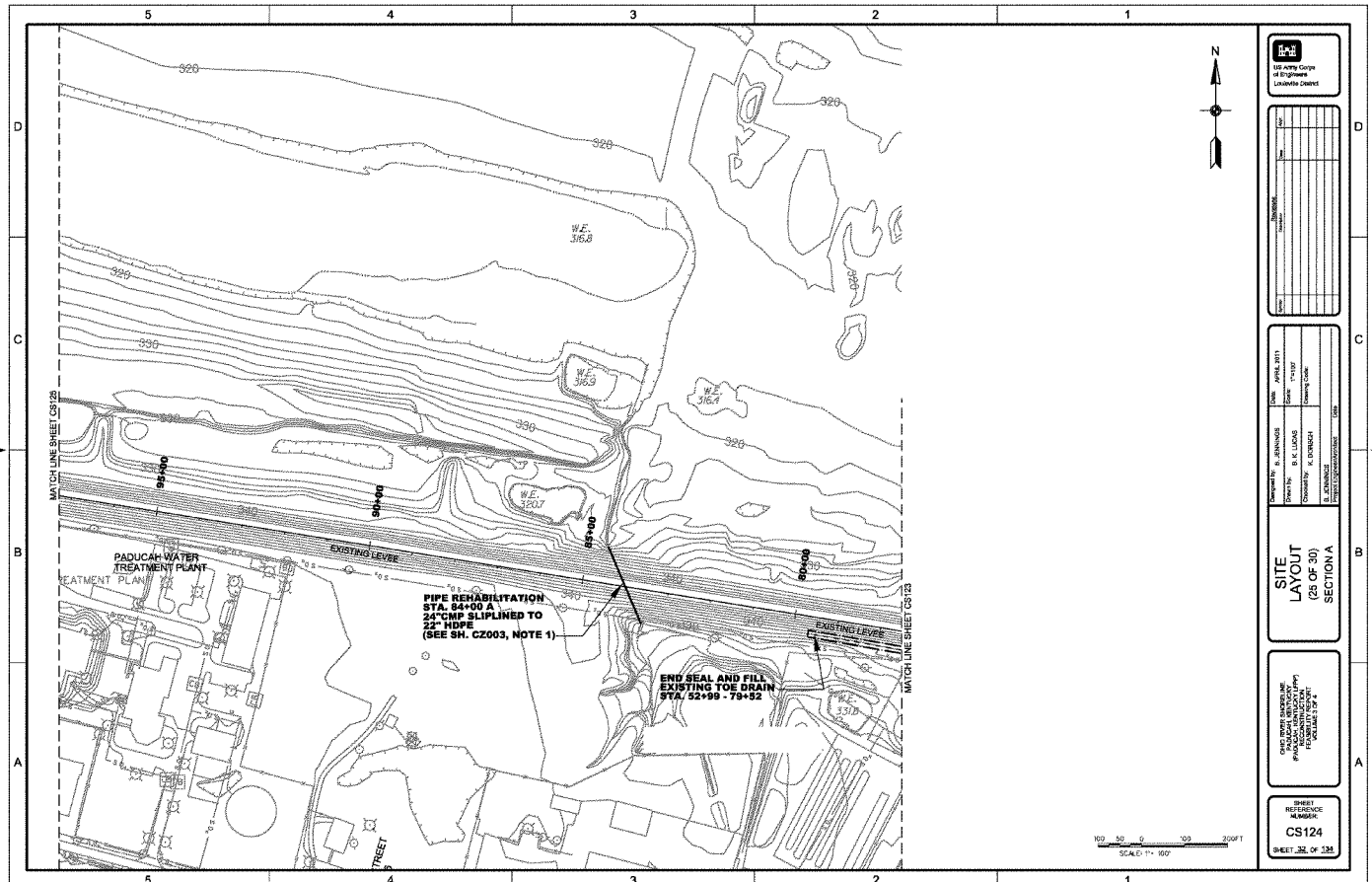
FINAL SUBMITTAL

*** SAFETY PAYS ***

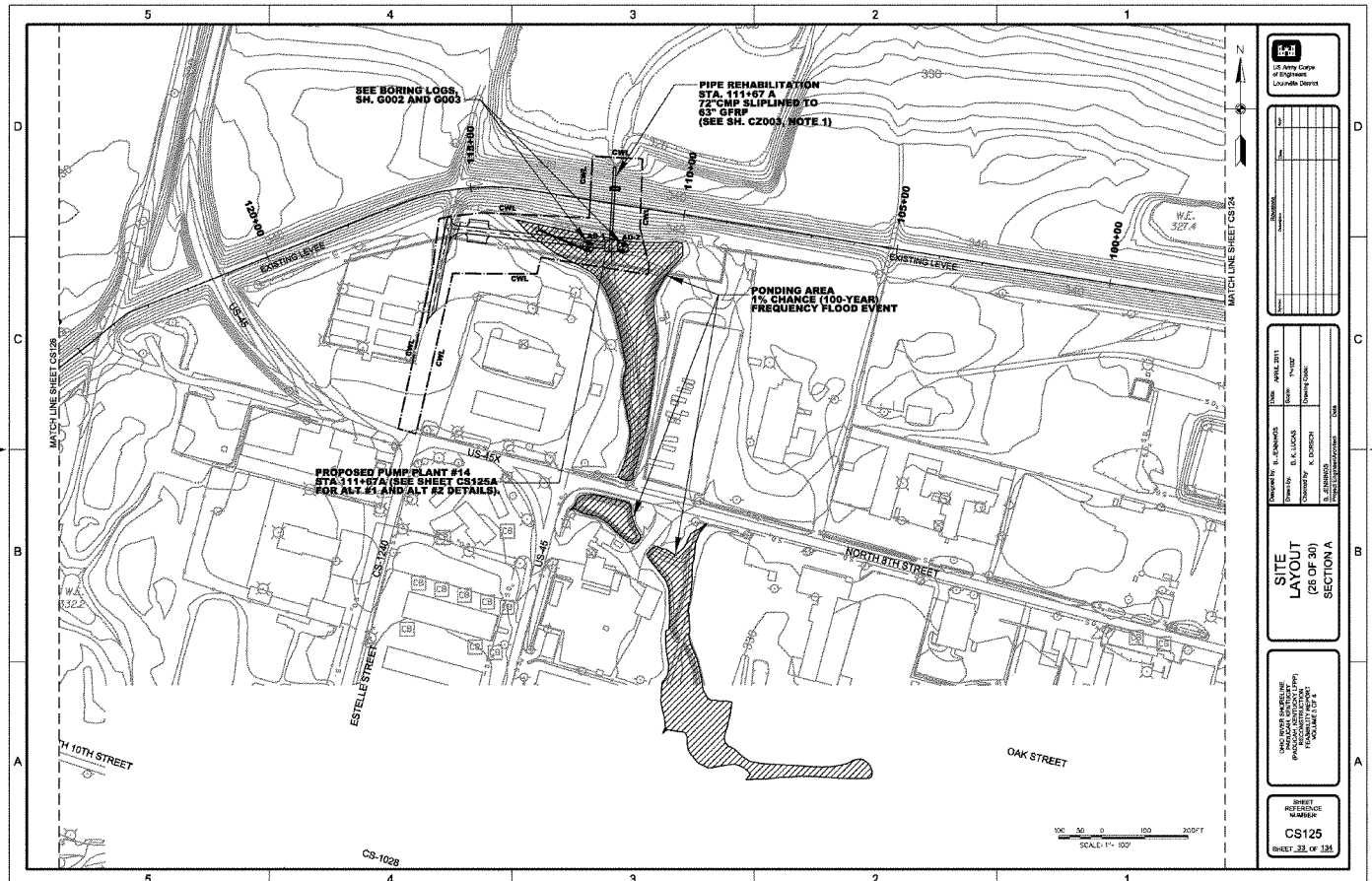


*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:44

FINAL SUBMITTAL

*** SAFETY PAYS ***



*** SUPPORT VALUE ENGINEERING - IT PAYS ***

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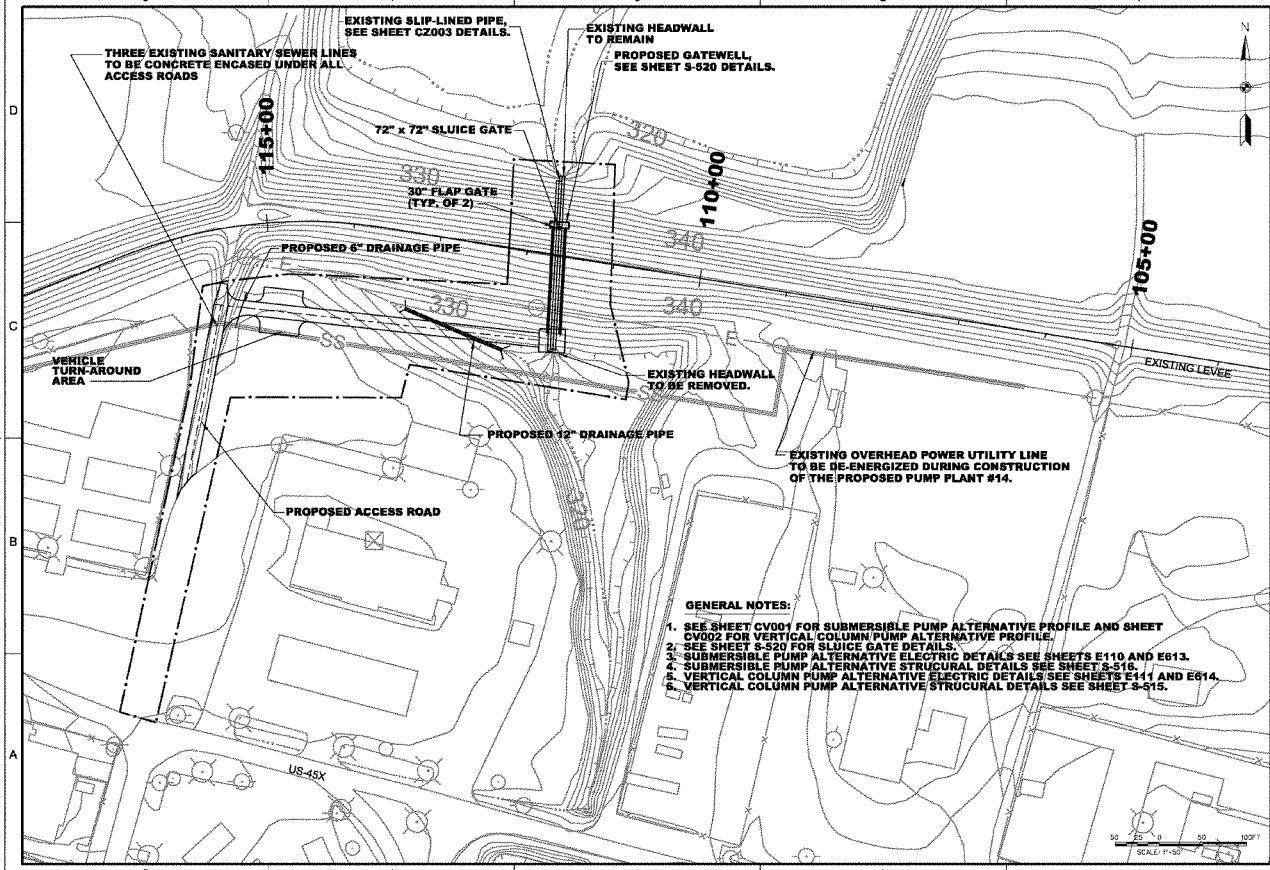
FINAL SUBMITTAL

*** SAFETY PAYS ***



GENERAL NOTES:

1. SEE SHEET CV001 FOR SUBMERSIBLE PUMP ALTERNATIVE PROFILE AND SHEET CV002 FOR VERTICAL COLUMN PUMP ALTERNATIVE PROFILE.
2. SEE SHEET S-520 FOR SLUICE GATE DETAILS.
3. SUBMERSIBLE PUMP ALTERNATIVE ELECTRIC DETAILS SEE SHEETS E110 AND E613.
4. SUBMERSIBLE PUMP ALTERNATIVE STRUCURAL DETAILS SEE SHEET S-516.
5. VERTICAL COLUMN PUMP ALTERNATIVE ELECTRIC DETAILS SEE SHEETS E111 AND E614.
6. VERTICAL COLUMN PUMP ALTERNATIVE STRUCURAL DETAILS SEE SHEET S-515.

US Army Corps of Engineers Louisville District

Revisions

Symbol	Description	Date	Approved

Designed by: B. LEWIS/CAB
Date: APRIL 2011
Drawn by: B. K. LUCAS
Scale:
Checked by: K. JOERICH
Drawing Code:
Approved by: S. JENKINS, Project Engineer/Architect
Date

ENLARGED SITE PLAN
PUMP PLANT #14
ALT #1 AND ALT #2

OHIO RIVER SHORELINE
MCCRACKEN COUNTY, KY
(PADUCAH, KENTUCKY TPP)
FLOOD RISK MANAGEMENT
SUBMITTAL NO. 2

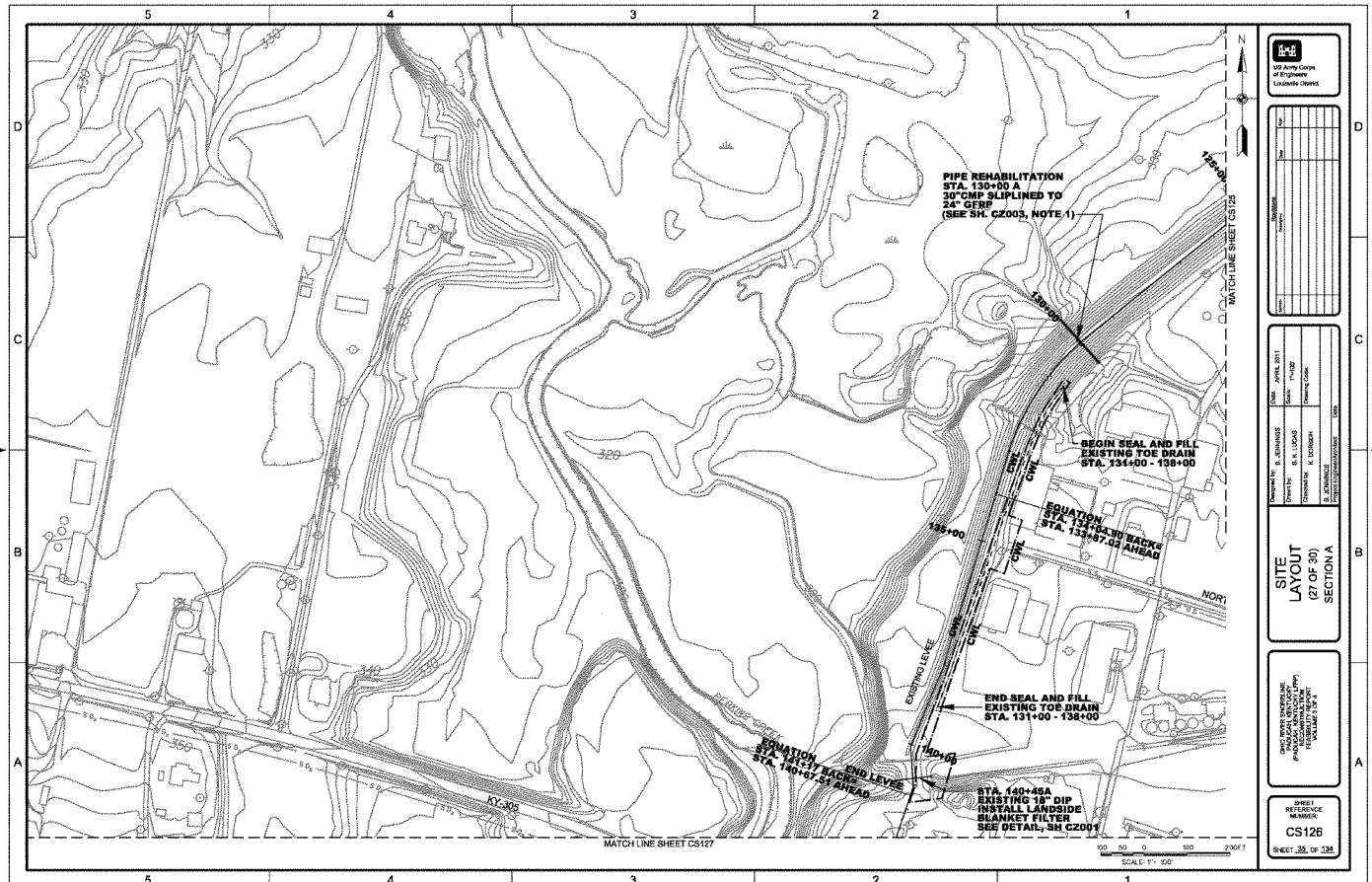
SHEET REFERENCE NUMBER:
CS125A
SHEET 34 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03 MAY-2011 08:44
FILE: ##rl-gfs1#organization#CD2#Public#CAD#Civil#112546#CADD#112546cs125a-.dgn

FINAL SUBMITTAL

*** SAFETY PAYS ***

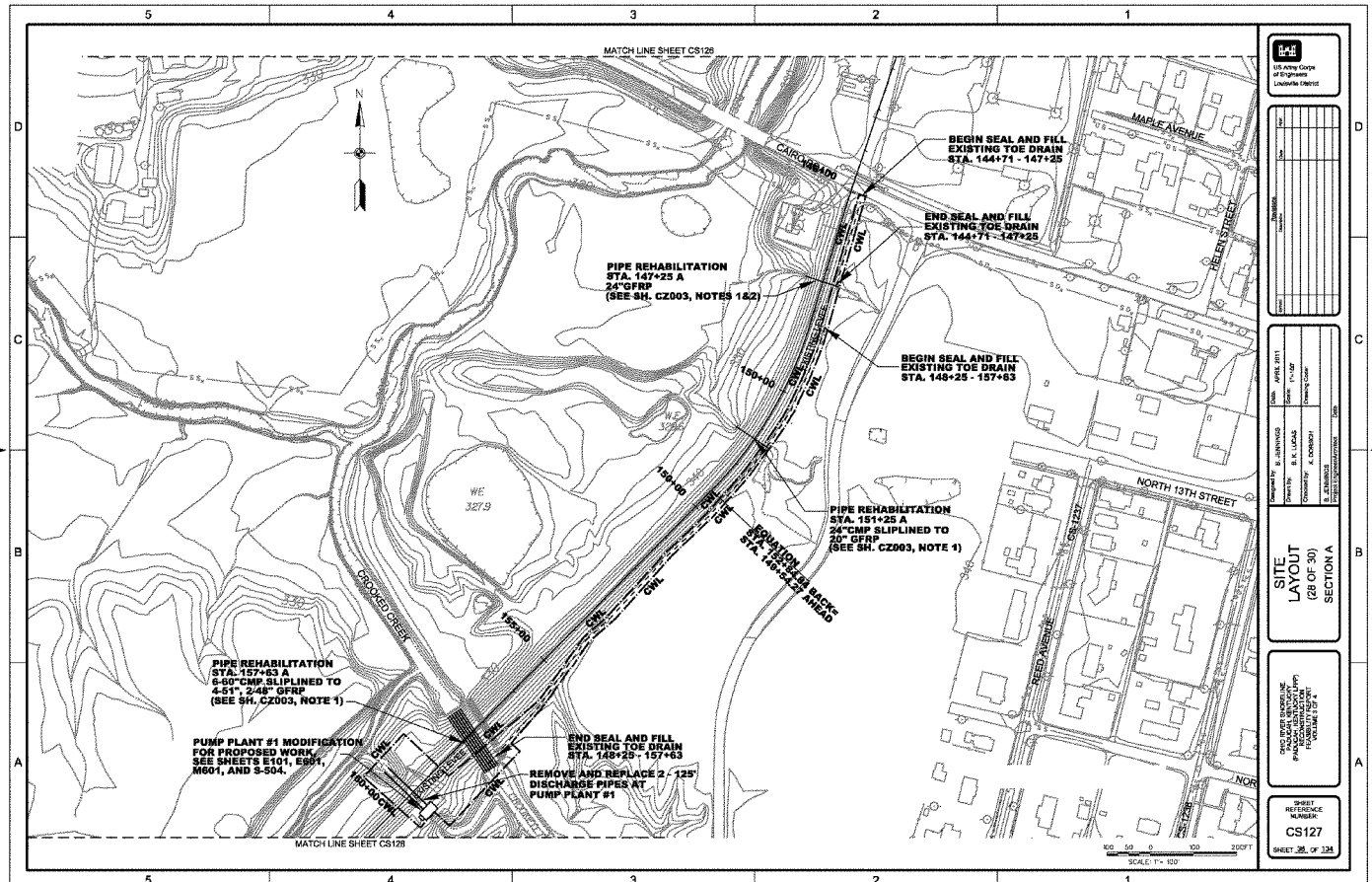


*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:44

FINAL SUBMITTAL

*** SAFETY PAYS ***



*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:44
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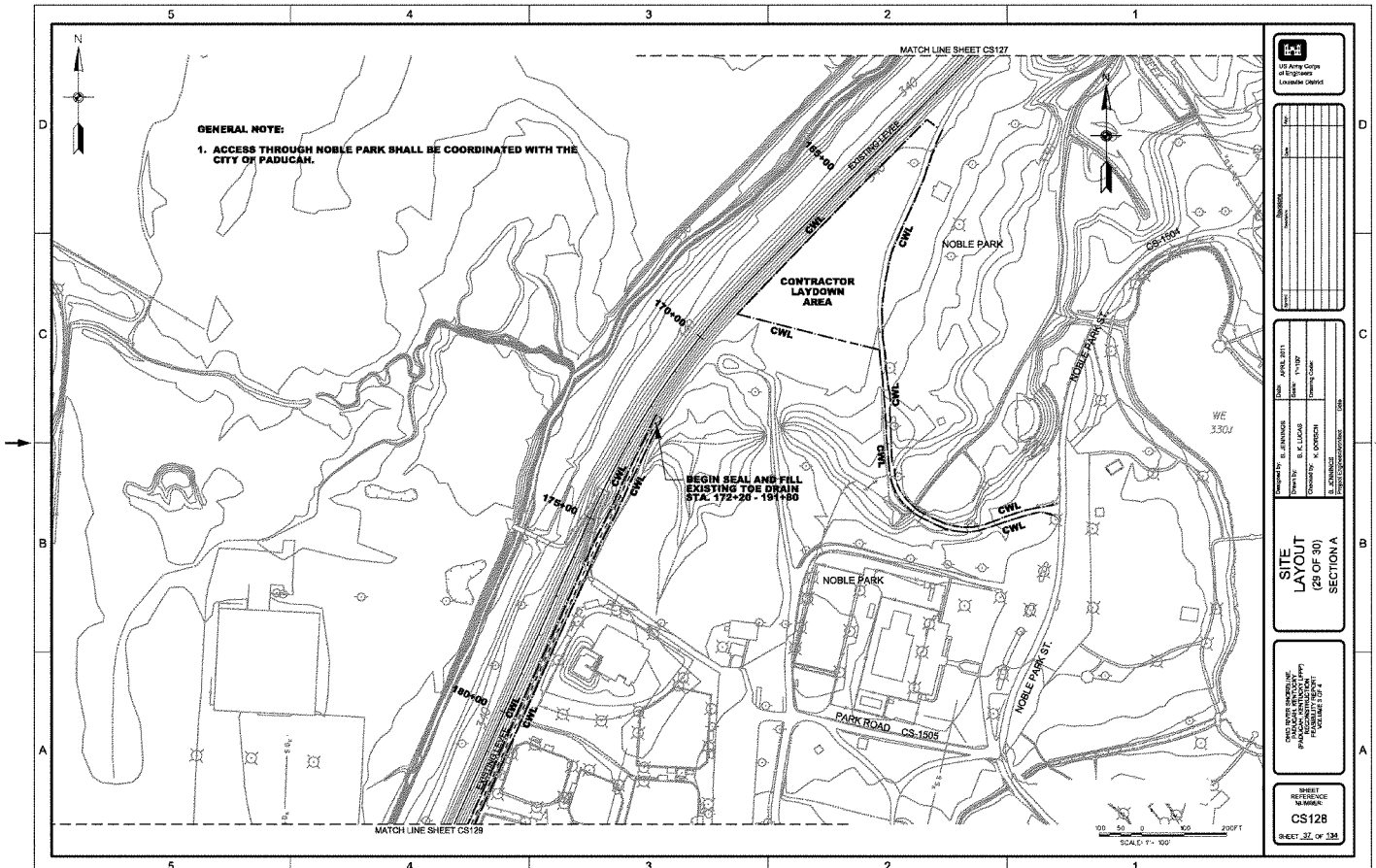
FINAL SUBMITTAL

*** SAFETY PAYS ***

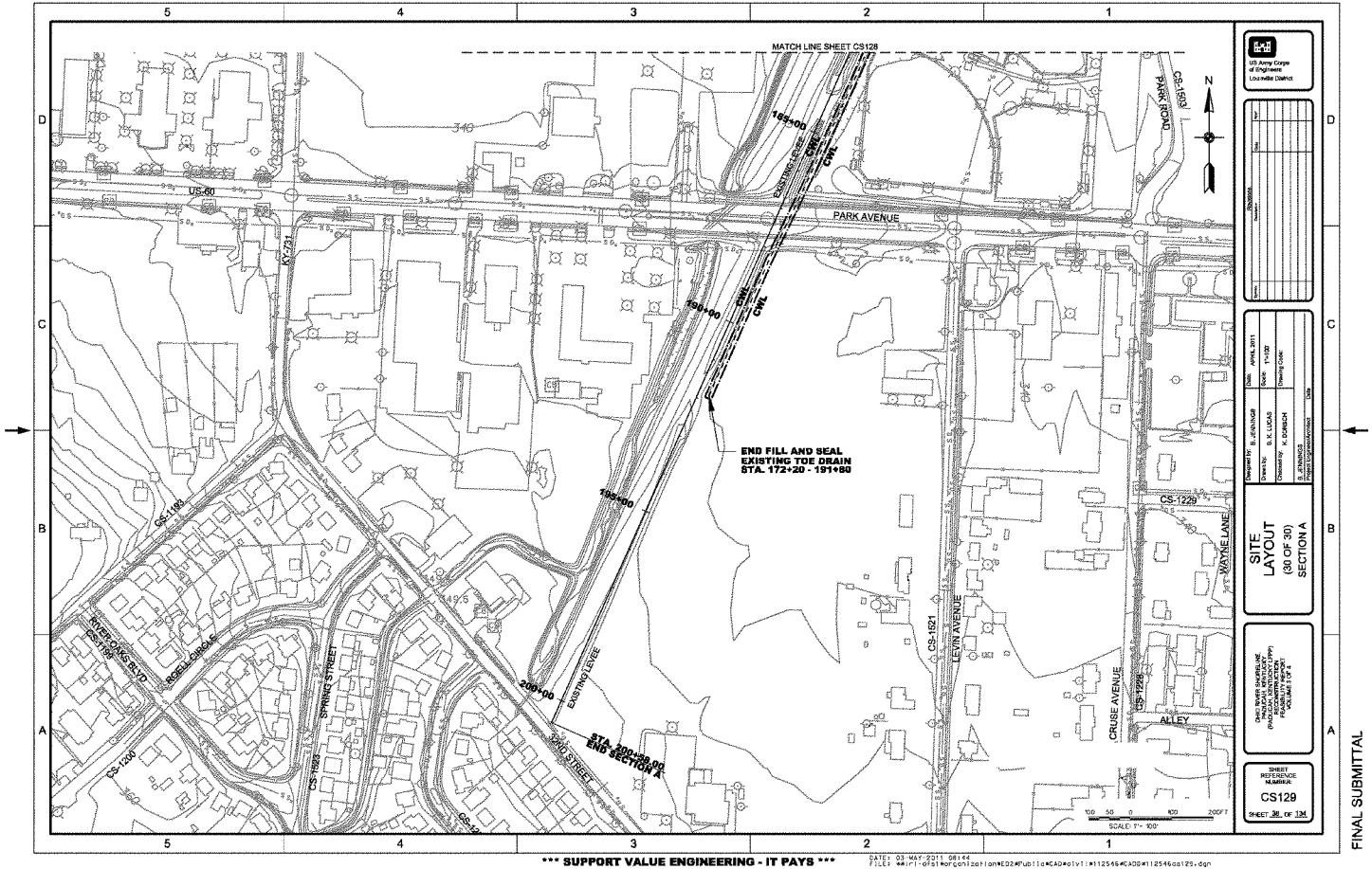


FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:44

*** SAFETY PAYS ***



FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:44
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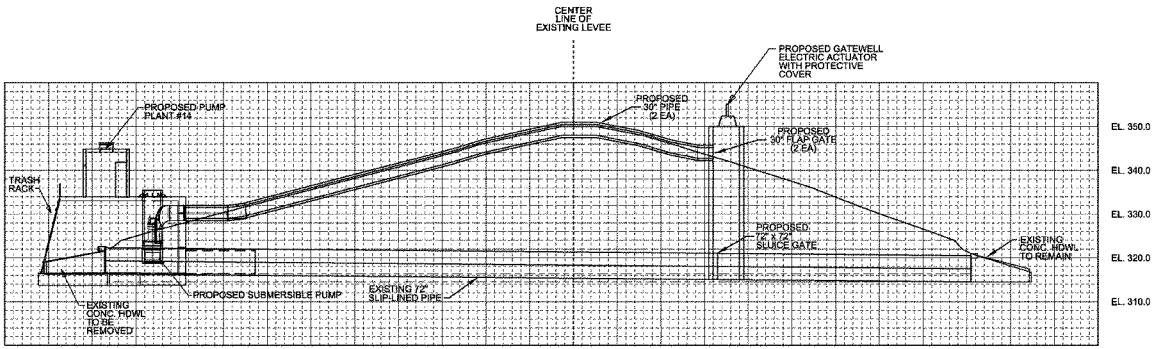
*** SAFETY PAYS ***



GENERAL NOTES:

1. TWO 30" PIPES ARE TO BE PLACED ON LEVEE AND COVERED WITH A MINIMUM OF 24" OF TOPSOIL.
2. FOR DETAILS OF PROPOSED GATEWELL, SEE SH. S-520.

SCALE: 1" = 10'

US Army Corps of Engineers
Louisville District

Designed by: B. JENNINGS
Drawn by: C. MORRISON
Checked by: K. DONSON
Date: APRIL 2011
Scale: 1"=10'
Drawing Code:
B. JENNINGS
Project Engineer/Architect
Date

PROFILE
PUMP PLANT #14
SUBMERSIBLE
PUMP, ALT. #1

OHIO RIVER SHORELINE, PADUCAH KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 3 OF 4

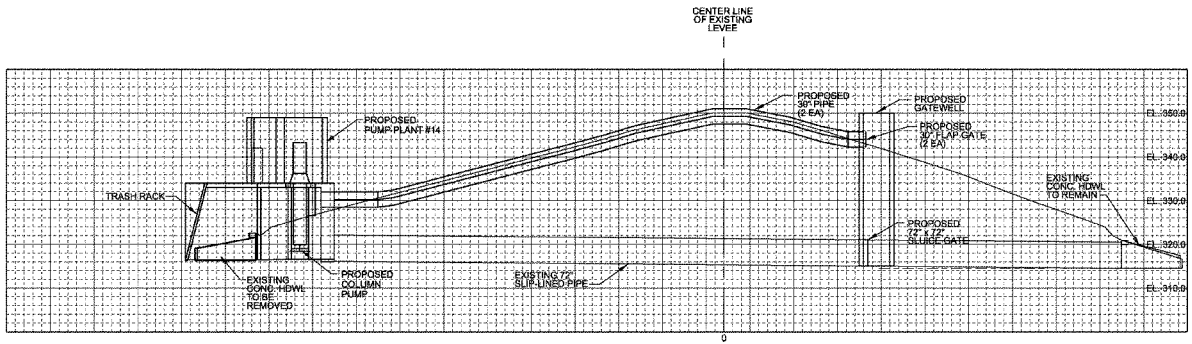
SHEET REFERENCE NUMBER:
CV001
SHEET 39 OF 134

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:44
FILE: **iri-dfs1*organization*ED2*Public*CAD*civil*112546*CADD*112546cv001.dgn

*** SAFETY PAYS ***



GENERAL NOTES:

1. TWO 30" PIPES ARE TO BE PLACED ON LEVEE AND COVERED WITH A MINIMUM OF 24" OF TOPSOIL.
2. FOR DETAILS OF PROPOSED GATEWELL, SEE SH. S-520.

SCALE: 1" = 10'

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Appr.

Designed by: B. JENNINGS
Drawn by: C. ROBINSON
Checked by: K. DORSCH
Date: APRIL 2011
Scale: 1"=10'
Drawing Code:
B. JENNINGS
Project Engineer/Architect
Date

PROFILE
PUMP PLANT #14
COLUMN PUMP
ALT. #2

OHIO RIVER SHORELINE
PADUCAH VERTICAL
(PADUCAH RESTRICTED LEVEE)
FLOOD CONSTRUCTION
FEASIBILITY REPORT
VOLUME 3 OF 4

SHEET REFERENCE NUMBER:
CV002
SHEET 40 OF 134

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:44
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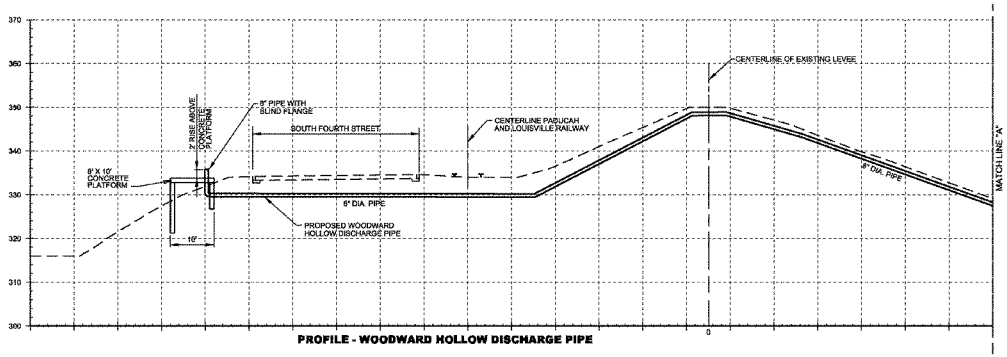
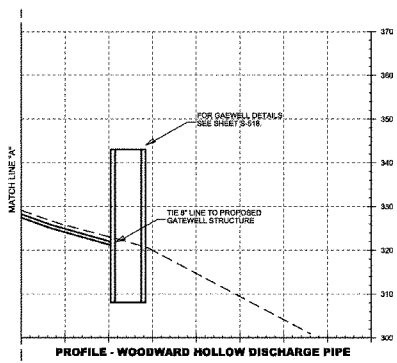
*** SAFETY PAYS ***



PROFILE - WOODWARD HOLLOW DISCHARGE PIPE



PROFILE - WOODWARD HOLLOW DISCHARGE PIPE

GENERAL NOTES:

1. 8" PIPE IS TO BE COVERED WITH A MINIMUM OF 24" OF TOPSOIL.

10 5 0 10 20FT
SCALE: 1"= 10'

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Appr.

Designed by: C. NEUTZ
Drawn by: C. ROBINSON
Checked by: J. WEINAUER
S. JENNINGS
Project Engineer/Architect
Date: APRIL 2011
Scale: 1"=10'
Drawing Code:

WOODWARD HOLLOW DISCHARGE PIPE

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY FPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 3 OF 4

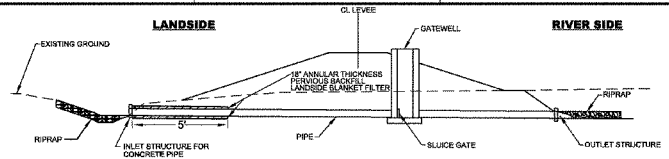
SHEET REFERENCE NUMBER:
CV003
SHEET 41 OF 134

FINAL SUBMITTAL

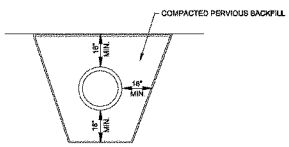
*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:44
FILE: **irl-dfs1*organization*ED2*Public*CAD*civil*112546*CADD*112546cv003.dgn

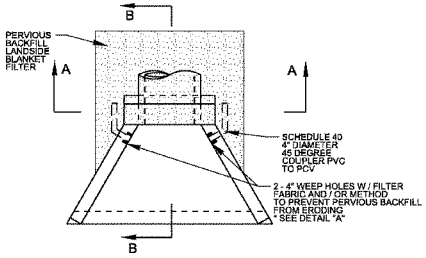
*** SAFETY PAYS ***



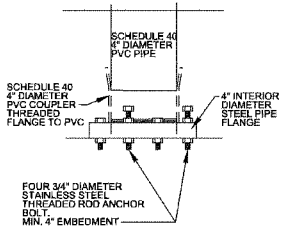
TYPICAL SECTION
EXISTING DRAINAGE STRUCTURE THROUGH LEVEE
MODIFICATION FOR LANDSIDE BLANKET FILTER
PIPES IMPLEMENTED AT STATION 140+45A AND 207+16C



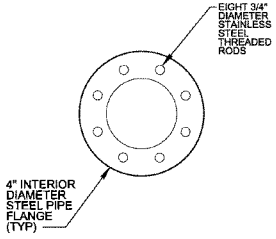
BLANKET FILTER DETAIL
NO SCALE



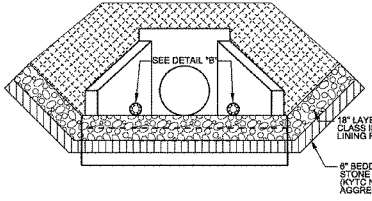
PLAN VIEW - 30 DEGREE WING WALL



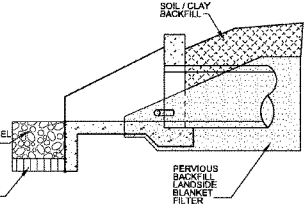
DETAIL "A"



DETAIL "B"



SECTION A-A - 30 DEGREE WING-WALLS



SECTION B-B - 30 DEGREE WING-WALLS

NOTE: CONNECT PVC TO DRAINAGE PIPE USING SILICONE CAULKING AND STAINLESS STEEL HOSE CLAMP

NOTE: GLUE CONNECTION FOR ALL PVC TO PVC CONNECTIONS

US Army Corps of Engineers
Louisville District

Symbol	Description	Date	Appr.

Revisions
Location:

Designed by: B. JENKINS
Date: APRIL 2011
Drawn by: C. HUMPHRIES
Scale: NONE
Checked by: K. HORSCH
Drawing Code:
G. JENKINS
Project Engineer/Architect
Date

LANDSIDE BLANKET FILTER DETAILS

GAC RIVER SHORELINE, MAYFIELD, KENTUCKY (PADUCAH, KENTUCKY HPP) FEASIBILITY STUDY
HEC/USACE

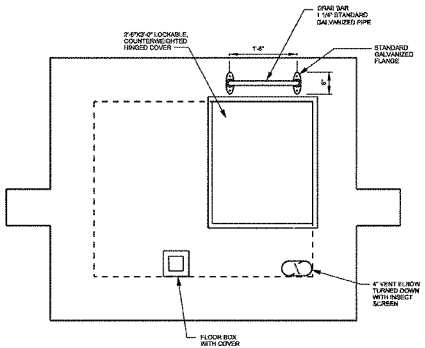
SHEET REFERENCE NUMBER:
CZ001
SHEET 42 OF 134

FINAL SUBMITTAL

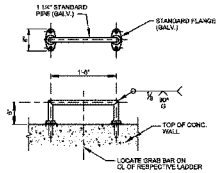
*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:44
FILE: \\irf-dfs1\organization\ED2\Public\CAD\civil\112546\CADD\112546cz001.dgn

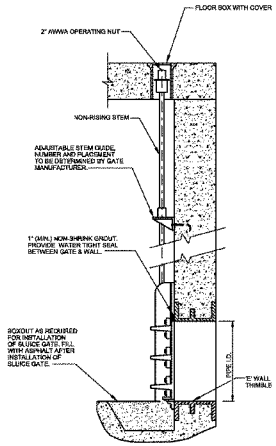
*** SAFETY PAYS ***



PLAN
SCALE: NONE



GRAB BAR DETAIL
SCALE: 1" = 1'-0"



SLUICE GATE DETAIL
(FLUSH MOUNTED)
SCALE: NONE

US Army Corps of Engineers
Louisville District

Revisions		
Symbol	Description	Date	Rev

Designed by: B. JENNINGS
Date: APRIL 2011
Scale: NONE
Drawn by: C. BURNSIDE
Checked by: K. DONGHI
Drawing Code:
S. JENNINGS
Project Engineer/Inspector
Title

GATEWELL DETAILS

OHIO RIVER NAVIGATION
(ALL AMERICAN LOCK & DAM)
(PADUCAH, KENTUCKY (PRP)
FLOOD CONTROL PROJECT
CAIRO, ILLINOIS

SHEET REFERENCE NUMBER:
CZ002
SHEET 43 OF 134

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:44
FILE: ##irl-dfs1#organization$02#Public#CAD#civil#112546#CAD#112546cz002.dgn

PADUCAH FLOODWALL PIPE REHABILITATION SUMMARY

Item	Location	"As-Built" Nominal diameter (in)	Length (ft)	Original Material	Pipe Liner Data		Install Landside Blanket Filter (Y/N)
					Nominal Size (in)	Material	
1	66+27A	113	154	CMP Plate	96	GFRP	N
2	84+00A	24	199	CMP	22	HDPE	N
3	111+67A	72	195	CMP	63	GFRP	N
4	130+00A	30	138	CMP	24	GFRP	N
5	140+45A	18	87	DIP	N/A	N/A	Y
6	144+00A	24	81	CIP	N/A	N/A	N
*7	147+25A	24	79	CMP	20	GFRP	**
8	151+25A	24	89	CMP	20	GFRP	N
9	157+63A-1	60	162	CMP	51	GFRP	N
10	157+63A-2	60	162	CMP	48	GFRP	N
11	157+63A-3	60	162	CMP	48	GFRP	N
12	157+63A-4	60	162	CMP	51	GFRP	N
13	157+63A-5	60	162	CMP	51	GFRP	N
14	157+63A-6	60	162	CMP	51	GFRP	N
15	187+49A	15	46	CIP	N/A	N/A	N
16	19+11B	5'x5' ARCH	115	Brick & FRP	54	GFRP	N
17	128+61B	36	149	CI & CMP	30	HDPE	N
18	175+40B	24	166	CMP	20	GFRP	N
19	32+12C-1	48	185	CMP	41	GFRP	N
20	32+12C-2	48	185	CMP	41	GFRP	N
21	32+38C-1	60	181	CMP	51	GFRP	N
22	32+38C-2	60	181	CMP	48	GFRP	N
23	32+38C-3	60	181	CMP	48	GFRP	N
24	51+25C	30	140	CMP	24	GFRP	N
25	92+70C-1	48	101	CMP	41	GFRP	N
26	92+70C-1	48	101	CMP	41	GFRP	N
*27	126+00C	48	134	CMP	36	GFRP	**
*28	150+05C	24	60	CMP	20	GFRP	**
29	172+08C	24	110	CMP	22	HDPE	N
30	176+47C	24	56	CMP	20	GFRP	N
31	176+90C	48	107	CMP	41	GFRP	N
32	199+80C	24	56	CMP	22	HDPE	N
33	200+55C	24	48	CMP	20	GFRP	N
34	207+16C	36	120	CMP	30	GFRP	Y
35	217+35C-1	24	68	CMP	20	GFRP	N
36	217+35C-2	24	68	CMP	20	GFRP	N
37	224+71C	36	51	CMP	30	GFRP	N
38	244+65C	30	141	CMP	24	GFRP	N
39	254+09C	36	172	CMP	27	GFRP	N
40	291+75C	36	176	CMP	27	GFRP	N

* PIPES PART OF USACE PROOF TEST.

** PREVIOUSLY CONSTRUCTED AND INCLUDES LANDSIDE BLANKET FILTER .

GENERAL NOTES:

1. PIPE REHABILITATION WORK (SEE TABLE THIS SHEET) AND BANK PROTECTION WORK (APPROX. STA. 12+75B TO STA 15+32B TO BE COMPLETED BY THE CITY OF PADUCAH PER THE MEMORANDUM OF UNDERSTANDING DATED 17 NOV 2008 FOR WORK COMPLETED PRIOR TO THE EXECUTION OF THE FEASIBILITY PROJECT PARTNERSHIP AGREEMENT.

* 2. THESE THREE PIPES HAVE BEEN SLIPLINED AND SUBSEQUENTLY BEEN REPLACED TO THE AS-BUILT DIAMETERS WITH GFRP IN ASSOCIATION WITH THE USACE LOUISVILLE DISTRICT'S PROOF TEST FOR PIPE REHABILITATION FOR USE OF SPECIFICATION AND GUIDANCE CREATION FOR FUTURE SIMILAR USACE PROJECTS. THESE PIPES WERE REPLACED BY THE OPEN CUT METHOD TO CURRENT USACE SPECIFICATIONS INCLUDING THE LANDSIDE BLANKET FILTER REQUIREMENT.

US Army Corps of Engineers
Louisville District

Symbols			
Symbol	Description	Date	Rev

Designed by: S. ALLIP
Date: APRIL 2011
Drawn by: S. ALLIP
Scale: AS SHOWN
Checked by: C. NEUTZ
Drawing Code:
R. JENKINS
Chief Engineering Section
Date

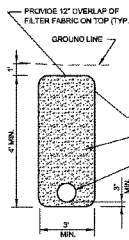
PIPE REHABILITATION SUMMARY

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PIPP) FEASIBILITY REPORT VOLUME 3 OF 3

SHEET REFERENCE NUMBER:
CZ003
SHEET 44 OF 134

FINAL SUBMITTAL

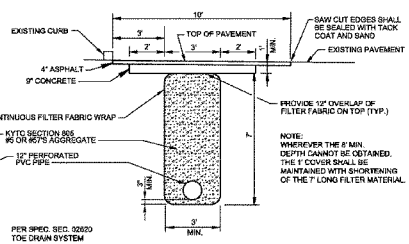
DATE: 03-MAY-2011 08:45
FILE: \\lrl-cfs1\organization\ED2\Public\CAD\civil\112546\CAD\112546cz003.dgn



FOR GRASSED AREAS, TOP 1' (MINIMUM) IS BACKFILLED SOIL, 95% COMPACTED SOIL PER SPECS AND 5" TOPSOIL AND SEEDED)

TOE DRAIN TYPICAL DETAIL FOR NON PAVED AREAS

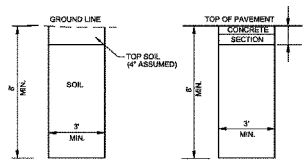
TYPE I 4' MIN. DEPTH
SCALE: NONE



PER SPEC. SEC. 02620 TOE DRAIN SYSTEM

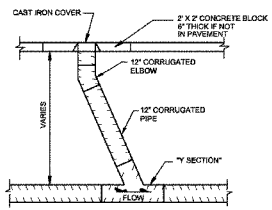
TOE DRAIN TYPICAL DETAIL FOR PAVED AREAS

TYPE I 4' MIN. DEPTH
SCALE: NONE



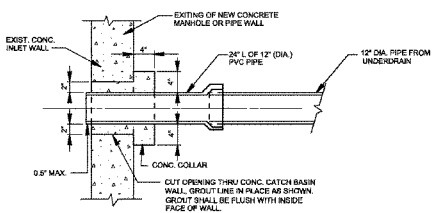
EXCAVATION LIMITS FOR TOE DRAIN

SCALE: NONE



THROUGH FLOW CLEANOUT DETAIL

SCALE: NONE



CONCRETE COLLAR DETAIL

SCALE: NONE

TOE DRAIN CHART

SECTION	APPROXIMATE STATION LIMITS	APPROX. LIN. FT.	WORK ITEM	SHEET	PROTECTION
C	150+00 to 174+50	2480.50	SEAL AND FILL	CS-106 to CS-107	LEVEE
C	218+85 to 244+65	2580.00	SEAL AND FILL	CS-110 to CS-111	LEVEE
B	0+00 to 7+02.5	702.5	SEAL AND FILL	CS-114	FLOODWALL
B	7+02.5 to 9+38	235.5	REPLACE	CS-114	FLOODWALL
B	9+38 to 36+91.96	2753.96	SEAL AND FILL	CS-114 to CS-116	LEVEE AND FLOODWALL
B	54+47.31 to 72+12.12	1764.81	SEAL AND FILL	CS-116 to CS-117	FLOODWALL
B	74+00 to 82+00	800	SEAL AND FILL	CS-117	FLOODWALL
B	90+31 to 92+00	169	REPLACE	CS-118	FLOODWALL & P.P. #7
B	92+00 to 108+00	1600	SEAL AND FILL	CS-118 to CS-119	FLOODWALL
B	108+00 to 110+00	200	REPLACE	CS-119	FLOODWALL & P.P. #6
B	110+00 to 161+84	5184	SEAL AND FILL	CS-119 to CS-121	FLOODWALL
B	161+84 to 163+00	116	REPLACE	CS-121	FLOODWALL & P.P. #3
B	163+00 to 170+00	700	SEAL AND FILL	CS-121 to CS-122	FLOODWALL
A	52+99 to 79+52	2653	SEAL AND FILL	CS-122 to CS-124	LEVEE
A	131+00 to 138+00	700	SEAL AND FILL	CS-126	LEVEE
A	144+71 to 147+25	254	SEAL AND FILL	CS-127	LEVEE
A	149+29 to 157+63	838	SEAL AND FILL	CS-127	LEVEE
A	172+20 to 191+80	1960	SEAL AND FILL	CS-128 to CS-129	LEVEE

US Army Corps of Engineers Louisville District

Symbol	Revisions	Date	Appr.

Designed by: B. JENKINS
Drawn by: C. HORNSON
Checked by: K. DORSCH
R. JENKINS
Project Engineer/Architect
Date: APRIL 2011
Scale: NONE
Drawing Code:

TOE DRAIN DETAILS

OHIO RIVER SHORELINE, JEFFERSONVILLE, INDIANA (PAULSON, KENTUCKY LFP) FEASIBILITY REPORT VOLUME 1 OF 7

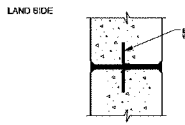
SHEET REFERENCE NUMBER: CZ004

SHEET 49 OF 134

DATE: 03-MAY-2011 08:45
FILE: \\ri-dfs1\organization\ED2\Public\CAD\Civil\112545\CAD\112545cz004.dgn

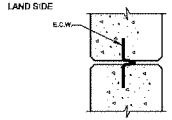
FINAL SUBMITTAL

*** SAFETY PAYS ***



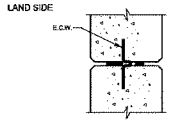
STEP 1:

REMOVE ALL EXISTING JOINT SEALANT AND JOINT FILLER MATERIAL FROM JOINT. DO NOT DISTURB EXISTING COPPER WATERSTOP. HAND TOOLS AND/OR WATER JET CAN BE USED. THIS IS TO BE DONE ON BOTH FACES OF THE WALL.



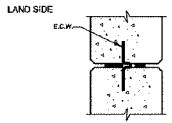
STEP 2:

INSTALL A 1-INCH BEAD OF QUINNABLE EXPANSION JOINT FILLER CONSISTING OF A ONE PART POLYURETHANE SWELLING THAT EKSTOP IF EXISTING COPPER WATERSTOP IS DAMAGED. THIS IS TO BE DONE ON THE RIVERSIDE ONLY, DIRECTLY ON THE SURFACE OF THE WATERSTOP. IF COPPER WATERSTOP IS NOT DAMAGED, DELETE THIS STEP.



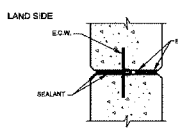
STEP 3:

INSTALL NEW BACKER RODS TO FILL OPEN VOID TO WITHIN APPROX. 1 INCH OF INSIDE CORNER OF CHAMFER. AN ESTIMATED 10 TO 12 PIECES OF BACKER ROD WILL BE REQUIRED ON EACH SIDE. THIS IS TO BE DONE ON BOTH WALL FACES AND TOP OF WALL.



STEP 4:

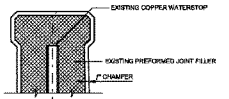
INSTALL AN EXTERNAL GRADE SILICON SEALANT AGAINST THE OUTERMOST BACKER ROD. THIS IS TO BE DONE ON BOTH WALL FACES AND TOP OF WALL.



STEP 5:

INSTALL ADDITIONAL BACKER ROD AND A SECOND APPLICATION OF SILICON SEALANT. THIS IS TO BE DONE ON BOTH WALL FACES AND TOP OF WALL.

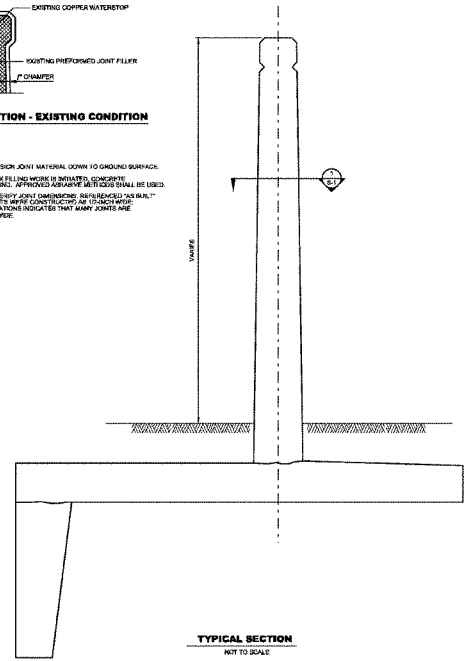
REPAIR STEPS 1 -5 (S-1)
NOT TO SCALE



TYPICAL EXPANSION JOINT SECTION - EXISTING CONDITION
SCALE: NONE

NOTES:

1. REMOVE EXISTING EXPANSION JOINT MATERIAL DOWN TO GROUND SURFACE.
2. BEFORE JOINT AND CRACK FILLING WORK IS INITIATED, CONCRETE SHALL BE CLEAN AND SOUND. APPROVED ABRASIVE METHODS SHALL BE USED.
3. CONTRACTOR TO FIELD VERIFY JOINT DIMENSIONS. REFERENCED "AS BUILT" DRAWINGS INDICATE JOINTS WERE CONSTRUCTED AS 1/2-INCH WIDE. HOWEVER FIELD OBSERVATIONS INDICATES THAT MANY JOINTS ARE APPROXIMATELY 1-INCH WIDE.



TYPICAL SECTION
NOT TO SCALE

US Army Corps of Engineers
Louisville District

Monitoring
Location:

Symbol	Description	Date	Approved

Designed by: M. STUART
Date: APRIL 2011
Drawn by: C. HOWDSHOW
Scale:
Checked by: T. SULLIVAN
Drawing Code:
S. JENNINGS
Project Engineer/Inspector
Date:

TYPICAL JOINT FILLER REPAIR SECTION & DETAILS

CONC RIVER SHEPS INC
(PACIFICA, PINTICKY, FPP)
FLOOD CONTROL PROJECT
LOUISVILLE, KY

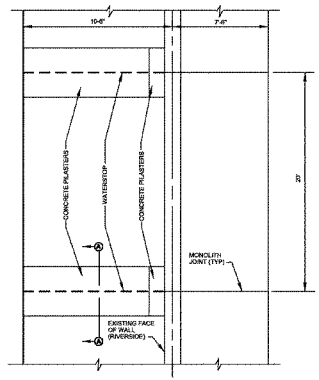
SHEET REFERENCE NUMBER:
S-500
SHEET 46 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:49
FILE: N:\rri-dfs1\organization\ED2\Public\CAD\civil\112546\CAD\112546s-500.dgn

FINAL SUBMITTAL

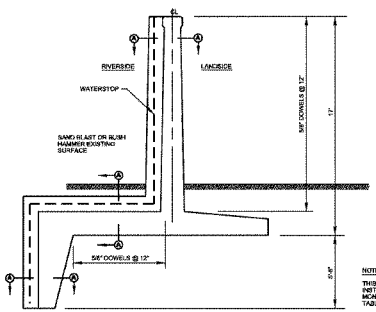
*** SAFETY PAYS ***



PLAN
SCALE: NONE

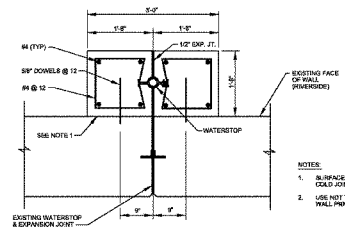
INSTALL EXTERNAL WATERSTOP	
MONOLITH JOINT	STATION
46/47	10+12
ST. VAULT/46	10+66
49/50	11+08
50/51	11+28
51/52	11+48
53/54	11+88
54/55	12+08
55/56	12+28
58/59	12+68
59/60	13+08
60/61	13+28
61/62	13+48
65/66	14+28
72/73	15+62
80/81	22+18
81/82	22+49

AT STATIONS AND BETWEEN MONOLITHS SHOWN ON THIS TABLE, INSTALL EXTERNAL WATERSTOP, SEE DETAIL, SHT. S-503



TYPICAL SECTION
SCALE: NONE

NOTE:
THIS *EXTERNAL WATERSTOP IS TO BE INSTALLED ON THE RIVERSIDE OF THE MONOLITH JOINT AS SHOWN ON THE TABLE, THIS SHEET.



SECTION (A)
SCALE: NONE

NOTES:
1. SURFACE ROUGHENING REQUIRED FOR COLD JOINT.
2. USE NOT TO LOCATE STEEL IN EXISTING WALL PRIOR TO DRILLING FOR DOWELS.

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Appr.

Designed by: M. STUART
Drawn by: C. HUMPHRIES
Checked by: T. SULLIVAN
Project Engineer/Manager: D. JENNINGS
Date:
Scale: NONE
Drawing Code:
Date:

EXTERNAL WATERSTOP DETAILS

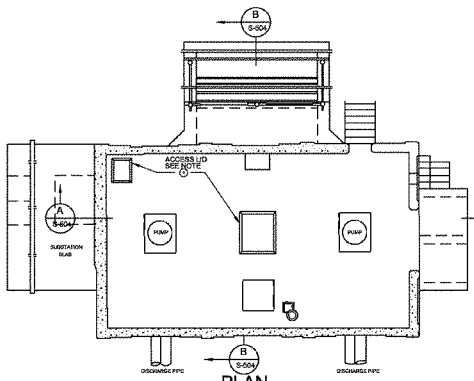
OHIO RIVER SCHEDULING PROJECT, MAXIMUM POOL (FAVUCKA, KENTUCKY TWP) FLOOD WALL, PHASE I, CONTRACT 1, STAGE 1

SHEET REFERENCE NUMBER:
S-503
SHEET 47 OF 134

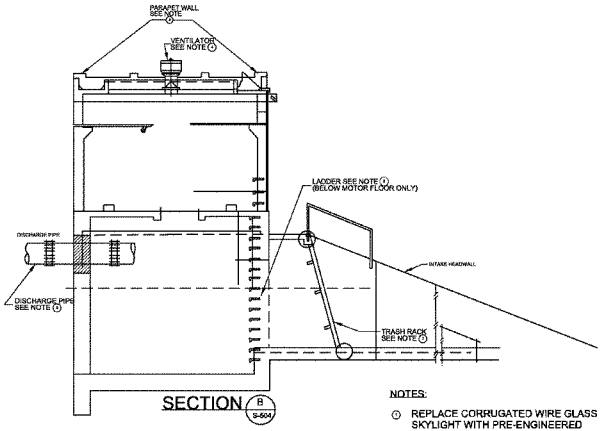
FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

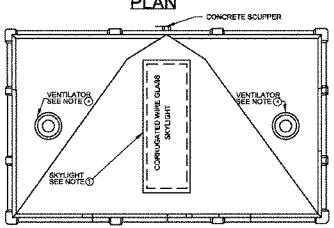
DATE: 03-MAY-2011 08:45
FILE: ##irf-dfs1#orgph/zation#CD2#Public#CAD#civil#112546#CADD#1125469-S03.dgn



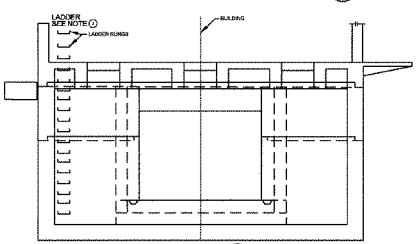
PLAN



SECTION B S-504



ROOF PLAN



SECTION A S-504

NOTES:

1. REPLACE CORRUGATED WIRE GLASS SKYLIGHT WITH PRE-ENGINEERED REMOVABLE ROOF HATCH.
2. REPAIR CRACKS ON CONCRETE PARAPET WALLS AND INSTALL NEW FLASHING AND ROOFING MATERIAL.
3. REPLACE LADDER.
4. REPLACE VENTILATORS.
5. REPLACE EXISTING ACCESS LIDS/COVER PLATES AND EMBEDDED SUPPORT ANGLES.
6. EXISTING DISCHARGE PIPES TO BE REMOVED FROM WALL AND NEW PIPES TO BE CAST IN PLACE.
7. REMOVE AND GALVANIZE EXISTING TRASH RACK.

US Army Corps of Engineers
Louisville District

Symbol	Revisions Description	Date	Apr

Designed by: M. STUART
Drawn by: E. THOMPSON
Checked by: T. SULLIVAN
Project Engineer/Manager: S. JENNINGS
Date: APRIL 2011
Scale:
Drawing Code:

PUMP PLANT # 1
REPAIR DETAILS

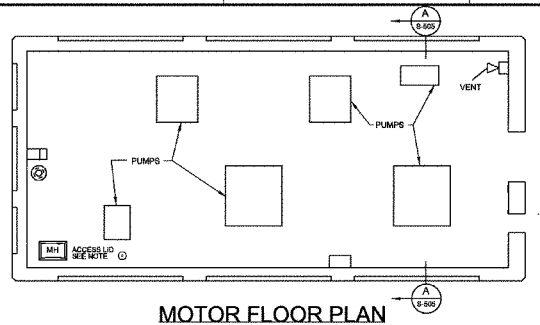
OHIO RIVER SHORELINE
MCCRACKEN COUNTY, KY
(PADUCAH, KY/BOOKER TIPP)
FLOOD CONTROL PROJECT
VOIGHT & CO.

SHEET REFERENCE NUMBER:
S-504
SHEET 48 OF 134

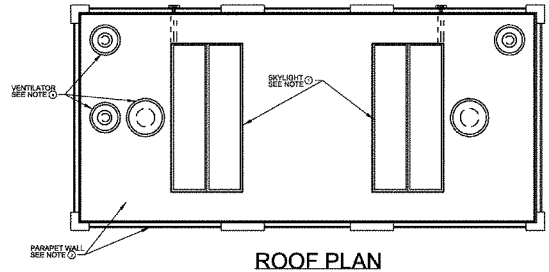
FINAL SUBMITTAL

DATE: 03-MAY-2011 08:45
FILE: \\mirl-dfs1\organization\ED2\PublicWCAD\civil\112546\CADD\1125465-S04.dgn

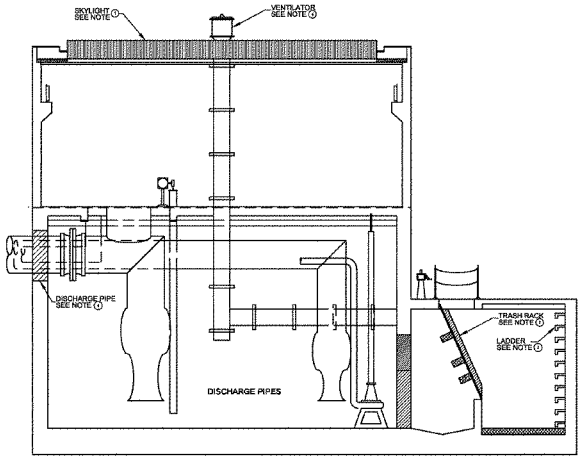
*** SAFETY PAYS ***



MOTOR FLOOR PLAN



ROOF PLAN



SECTION A S-505

NOTES:

1. REPLACE EXISTING WIRE-REINFORCED CORRUGATED GLASS SKYLIGHTS WITH PRE-ENGINEERED REMOVABLE ROOF HATCHES.
2. REPAIR CRACKS ON CONCRETE PARAPET WALLS AND INSTALL NEW FLASHING AND ROOFING MATERIAL.
3. REPLACE LADDER.
4. REPLACE VENTILATORS.
5. REPLACE ACCESS LIDS/COVER PLATES AND EMBEDDED SUPPORT ANGLES.
6. EXISTING DISCHARGE PIPES TO BE REMOVED FROM WALL AND NEW PIPES TO BE CAST IN PLACE.
7. REPLACE TRASH RACK AND SUPPORTING PURLINS.

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Appr

Designed by M. STUART | Date APRIL 2011
Drawn by E. THOMPSON | Scale
Checked by T. SULLIVAN | Drawing Code:
S. JENNINGS | Sheet Type/Subsection/Discipline

PUMP PLANT #2
REPAIR DETAILS

OHIO RIVER SHIPPING INC.
PUMP PLANT #2 (PP2)
(PAUDEAU, KY/TYLICK) (PP2)
FLOOD PROTECTION PROJECT
LOUISVILLE, KY

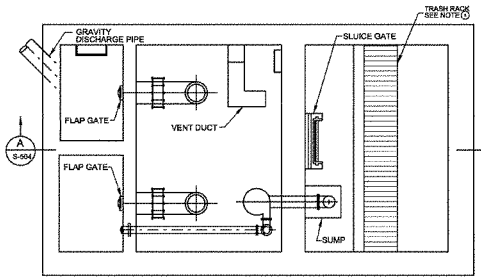
SHEET REFERENCE NUMBER:
S-505
SHEET 49 OF 134

FINAL SUBMITTAL

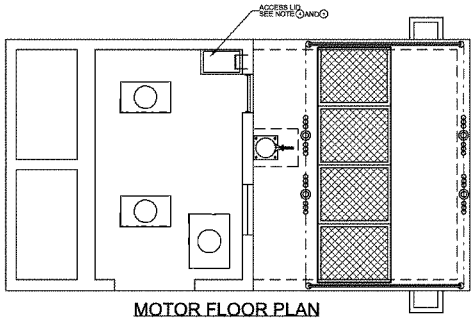
*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:49
FILE: \\irl-dfs1\organization\ED2\Public\CAD\Civil\1125546\CADD\1125465-S05.dgn

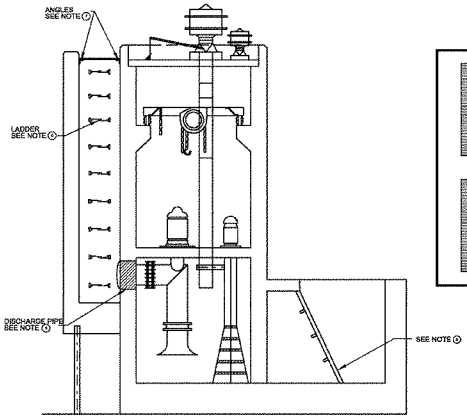
*** SAFETY PAYS ***



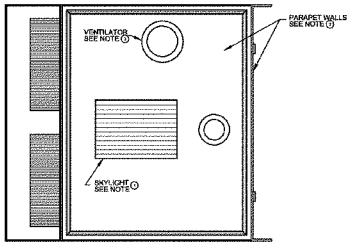
PLAN



MOTOR FLOOR PLAN



SECTION A S-504



ROOF PLAN

NOTES:

1. REPLACE EXISTING WIRE-REINFORCED CORRUGATED GLASS SKYLIGHT WITH PRE-ENGINEERED REMOVABLE ROOF HATCH.
2. REPAIR CRACKS ON CONCRETE PARAPET WALLS AND INSTALL NEW FLASHING AND ROOFING MATERIAL.
3. REPLACE VENTILATORS.
4. REPLACE MANHOLE LID AND EMBEDDED ANGLES.
5. REPLACE LADDER.
6. EXISTING DISCHARGE PIPES TO BE REMOVED FROM WALL AND NEW PIPES TO BE CAST IN PLACE.
7. REPLACE EXISTING ANGLES WITH NEW HIGHER SECTION MODULUS ANGLES.
8. REPLACE TRASH RACK AND SUPPORTING PURLINS.

US Army Corps of Engineers
Louisville District

Symbol	Location	Date	Rev

Designed by M. STUART | Date APRIL 2011
Drawn by B. THOMPSON | Scale
Checked by T. SULLIVAN | Drawing Code:
S. JENNINGS | Project Engineer/Architect | Date

PUMP PLANT # 3
REPAIR DETAILS

OHIO RIVER SHORELINE
(FULTON COUNTY, KENTUCKY)
FUSELAGE TASK FORCE
HURRICANE IKE

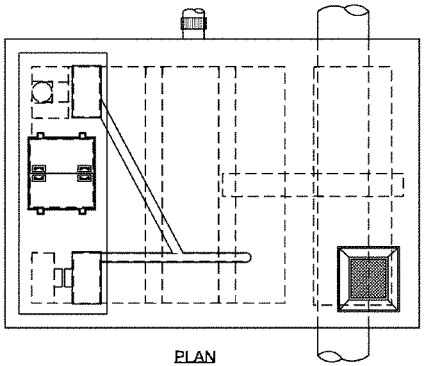
SHEET REFERENCE NUMBER:
S-506
SHEET 50 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

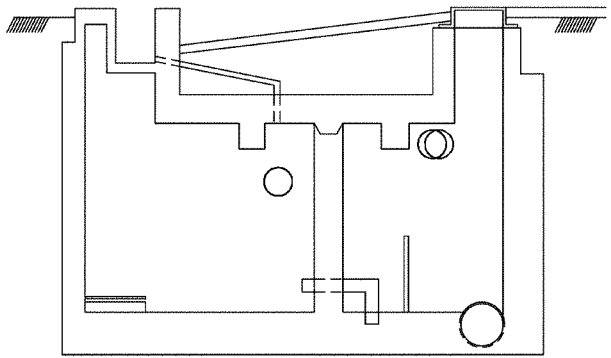
DATE: 03-MAY-2011 08:49
FILE: \\mvr1-dfs1\morganizer\ion\ED2\Public\CAD\civil\112546\CADD\112546S-506.dgn

FINAL SUBMITTAL

*** SAFETY PAYS ***



PLAN



SECTION

NOTE:

1. NO STRUCTURAL WORK IS PLANNED OR ANTICIPATED FOR P.S. #4.

US Army Corps of Engineers
Louisville District

Symbols

Symbol	Description	Date	Rev

Designed by: M. STUART
Drawn by: E. THOMPSON
Checked by: T. SULLIVAN
S. JENNINGS
Project Engineer/Architect
Date: APRIL 2011
Scale:
Drawing Code:
Date

PUMP PLANT # 4
REPAIR DETAILS

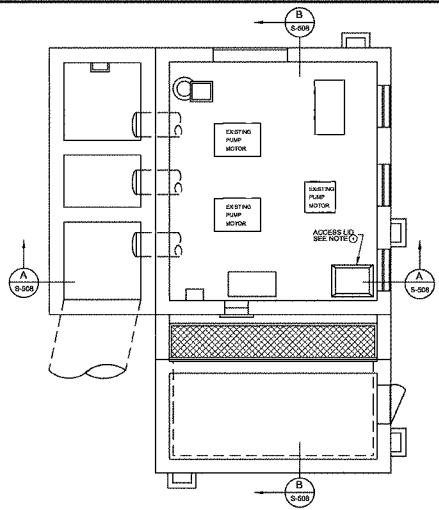
OHIO RIVER SPOILLINE
PHOLACH RESTRICTOR
(PADUCAH, KENTUCKY LPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 2 OF 4

SHEET REFERENCE NUMBER:
S-507
SHEET 51 OF 134

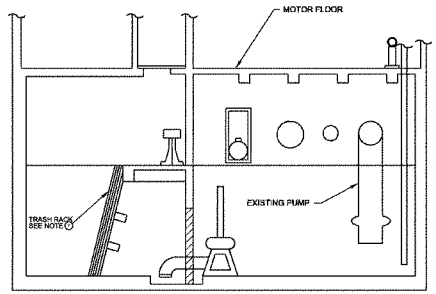
FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

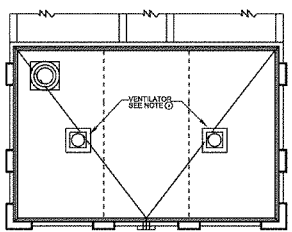
DATE: 03-MAY-2011 08:45
FILE: \\lri-dfs1\organization\ED2\Public\CAD\civil\112546\CADD\112546S-507.dgn



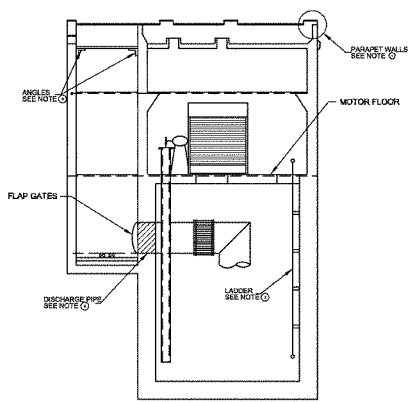
MOTOR FLOOR PLAN



SECTION B S-508



ROOF PLAN



SECTION A S-508

NOTES:

1. REPAIR CRACKS ON CONCRETE PARAPET WALLS AND INSTALL NEW FLASHING AND ROOFING MATERIAL.
2. REPLACE LADDER.
3. REPLACE VENTILATORS.
4. REPLACE EXISTING ACCESS LIDS/COVER PLATES AND EMBEDDED SUPPORT ANGLES.
5. EXISTING DISCHARGE PIPES TO BE REMOVED FROM WALL AND NEW PIPES TO BE CAST IN PLACE.
6. REPLACE EXISTING SUPPORT ANGLES WITH NEW, HIGHER SECTION MODULUS ANGLES.
7. REPLACE TRASH RACK AND SUPPORTING PURLINS.

US Army Corps of Engineers
Louisville District

Symbol	Location	Date	Rev

Designed by: M. STUART
Date: APRIL 2011
Drawn by: E. THOMPSON
Checked by: T. SULLIVAN
Scale:
Drawing Code:
Chief Engineering Division: S. JENNINGS
Date:

PUMP PLANT # 5 REPAIR DETAILS

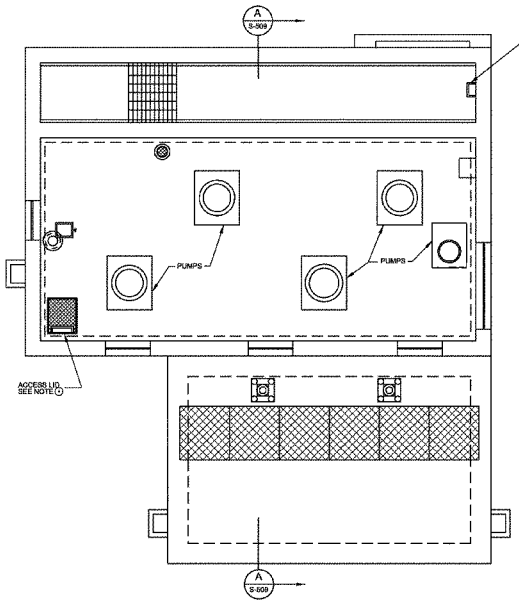
OHIO RIVER SHEPHERD INC. (PACESAL STRETCH) (FRP) PACESAL STRETCH PORT FLOODWALL PORT NUMBER 1 OF 4

SHEET REFERENCE NUMBER: S-508

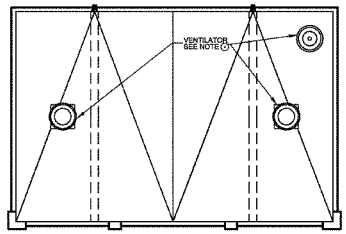
SHEET 52 OF 134

DATE: 03-MAY-2011 08:49
FILE: \\mlrl-dfs1\organization\ED2\Public\CAD\civil\112546\CADD\112546S-508.dgn

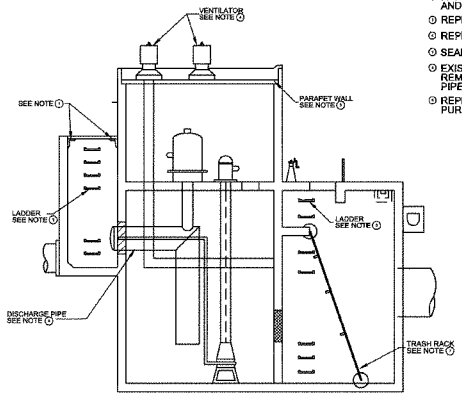
FINAL SUBMITTAL



PLAN



ROOF PLAN



SECTION A S-509

NOTES:

1. REPLACE EXISTING SUPPORT ANGLES WITH LARGER SECTION MODULUS ANGLES.
2. REPLACE EXISTING MANHOLE COVER AND FRAME.
3. REPLACE EXISTING LADDERS.
4. REPLACE EXISTING VENTILATORS.
5. SEAL TOP OF PARAPET WALLS.
6. EXISTING DISCHARGE PIPES TO BE REMOVED FROM WALL AND NEW PIPES TO BE CAST IN PLACE.
7. REPLACE TRASH RACK AND SUPPORTING PURLINS.

US Army Corps of Engineers
Louisville District

Revisions			
Symbol	Location	Date	Rev

Designed by: M. STUBBT
Drawn by: E. THOMPSON
Checked by: T. SULLIVAN
Date: APRIL 2011
Scale:
Drawing Code:
S. JENNINGS
Project Engineer/Inspector
Date

PUMP PLANT #6 REPAIR DETAILS

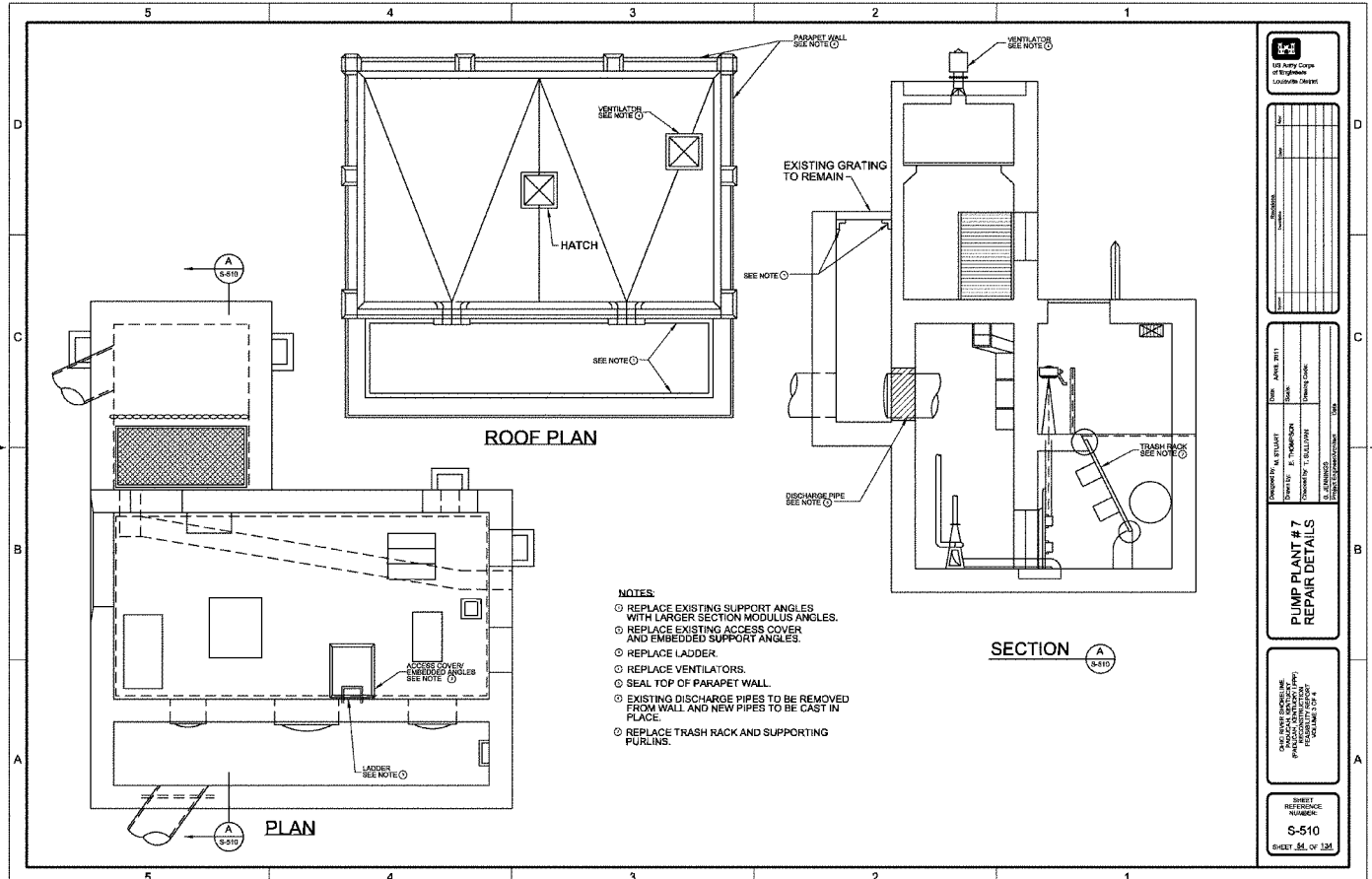
OHIO RIVER SHORELINE (ORS) FLOOD PROTECTION (FP) (PADUCAH, KENTUCKY (TPP)) PADUCAH, KENTUCKY FLOOD WALL SHEET

SHEET REFERENCE NUMBER:
S-509
SHEET 53 OF 134

DATE: 03-MAY-2011 08:45
FILE: \\nirl-dfs1\organization\ED2\Public\CAD\civil\112546\CAD\112546S-509.dgn

FINAL SUBMITTAL

*** SAFETY PAYS ***



*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:45
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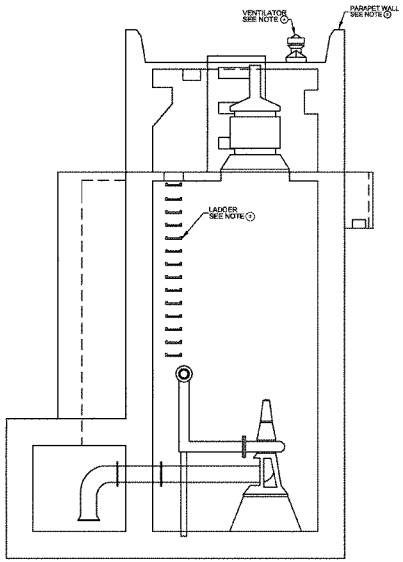
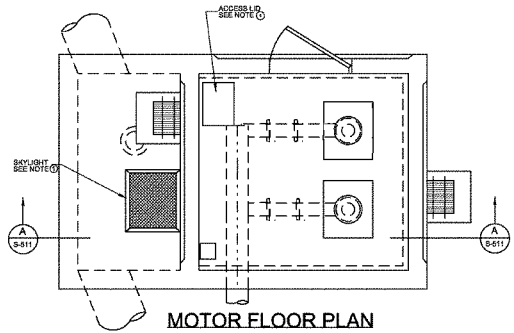
FINAL SUBMITTAL

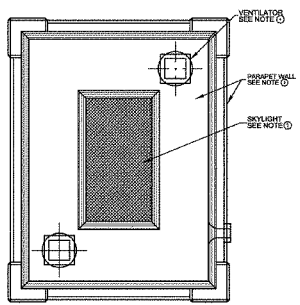
*** SAFETY PAYS ***



SECTION A S-511



MOTOR FLOOR PLAN



ROOF PLAN

NOTES:

1. REPLACE CORRUGATED WIRE GLASS SKYLIGHT WITH PRE-ENGINEERED REMOVABLE ROOF HATCH.
2. REPAIR CRACKS ON CONCRETE PARAPET WALLS AND INSTALL NEW FLASHING AND ROOFING MATERIAL.
3. REPLACE LADDER.
4. REPLACE VENTILATORS.
5. REPLACE EXISTING ACCESS LIDS/COVER PLATES AND EMBEDDED SUPPORT ANGLES.

US Army Corps of Engineers Louisville District

Symbol	Revisions Location	Date	Apr

Designed by: M. STUART
Date: APRIL 2011
Drawn by: D. THOMPSON
Scale:
Reviewed by: T. SULLIVAN
Drawing Code:
Project Engineer/Architect: B. JENNINGS
Date

PUMP PLANT # 9
REPAIR DETAILS

OHIO RIVER SHORELINE, MAYSVILLE, KENTUCKY (PARLEAK, KENTUCKY TPP) FEASIBILITY STUDY
CONTRACT NO.

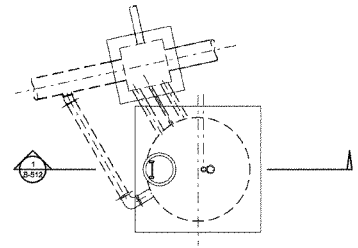
SHEET REFERENCE NUMBER:
S-511
SHEET 58 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

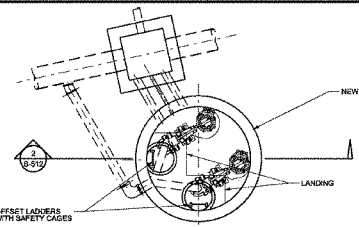
DATE: 03-MAY-2011 08:45
FILE: #a:\rl-dfs1#organization#CD2#PUBLIC#CAD#civil#112546#CADD#1125465-511.dgn

FINAL SUBMITTAL

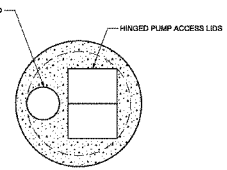
*** SAFETY PAYS ***



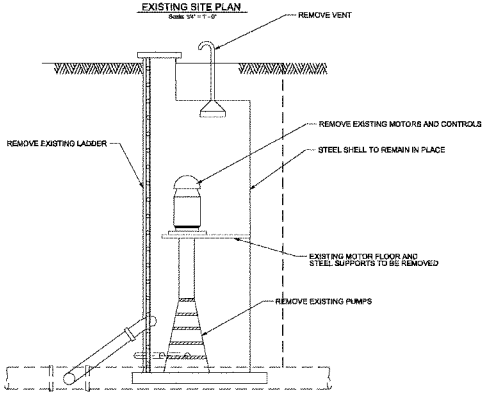
EXISTING SITE PLAN
Scale: 1/4" = 1'-0"



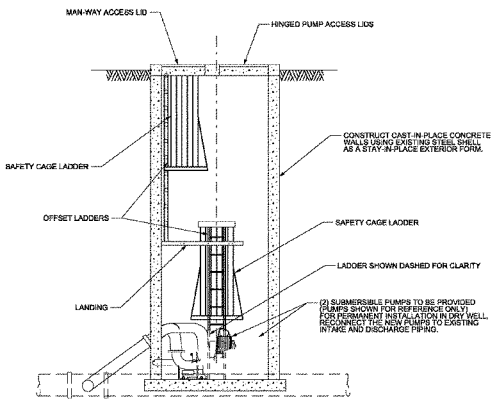
PROPOSED SITE PLAN
Scale: 1/4" = 1'-0"



PROPOSED SLAB PLAN
Scale: 1/4" = 1'-0"



1 S-512 EXISTING SECTION
Scale: 1/4" = 1'-0"



2 S-512 PROPOSED SECTION
Scale: 1/4" = 1'-0"

4 3 2 1 0 4 8FT
SCALE: 1/4"=1'-0"

US Army Corps of Engineers
Louisville District

Revisions			
Location	Date	Rev	

Designed by: M. STUART
Drawn by: T. JOHNSON
Checked by: T. SULLIVAN
Project Engineer/Leader: S. JENNINGS
Date: APRIL 2011
Scale: AS SHOWN
Drawing Code:
Title

PUMP PLANT #10 REPAIR DETAILS

CINCINNATI RIVER SHORELINE
(PACELCAL CONTROLS PPP)
FLOOD CONTROL PROJECT
MIAMI, OHIO

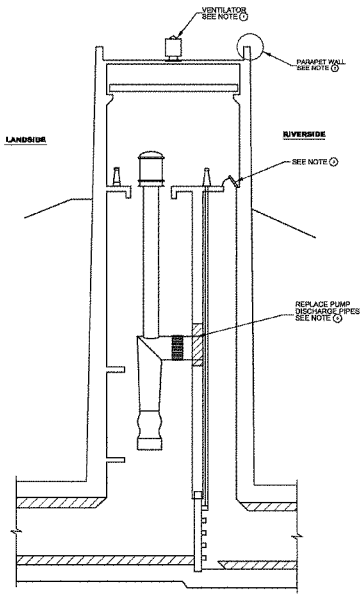
SHEET REFERENCE NUMBER:
S-512
SHEET 56 OF 134

FINAL SUBMITTAL

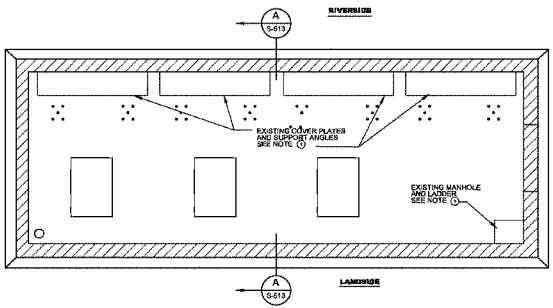
*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:45
FILE: $$irf-dfs1$organization$ED2$Public$CAD$civil$112546CAD112546S-512.dgn

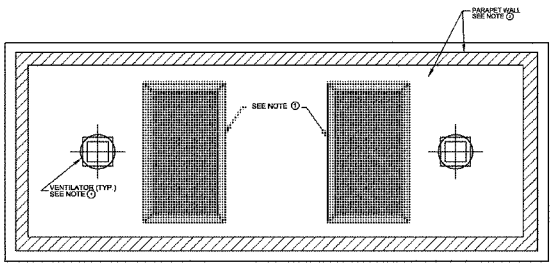
*** SAFETY PAYS ***



SECTION A S-513



MOTOR FLOOR PLAN



ROOF PLAN

NOTES:

1. REPLACE EXISTING HATCH COVERS WITH NEW PRE-ENGINEERED HATCHES.
2. REPAIR CRACKS AND SEAL PARAPET WALLS AND REPLACE ROOFING MATERIAL.
3. REPLACE EXISITING ACCESS COVERS, HINGES AND EMBEDDED SUPPORT ANGLES.
4. REPLACE VENTILATORS.
5. EXISTING DISCHARGE PIPES TO BE REMOVED FROM WALL AND NEW PIPES TO BE CAST IN PLACE.
6. REPLACE EXISTING MANHOLE COVER AND FRAME AND LADDER.

US Army Corps of Engineers
Louisville District

Revisions			
Symbol	Location	Date	Rev

Designed by: M. STUART
Date: APRIL 2011
Drawn by: E. THOMPSON
Scale:
Checked by: T. SULLIVAN
Drawing Code:
S. JENNINGS
Project Engineer/Architect
Date:

PUMP PLANT # 11
REPAIR DETAILS

CADD FILE NAME: S-513.DGN
(PARTICIPATING PROJECT)
FILE SIZE: 11.0" x 17.0"
VERSION: 8.11

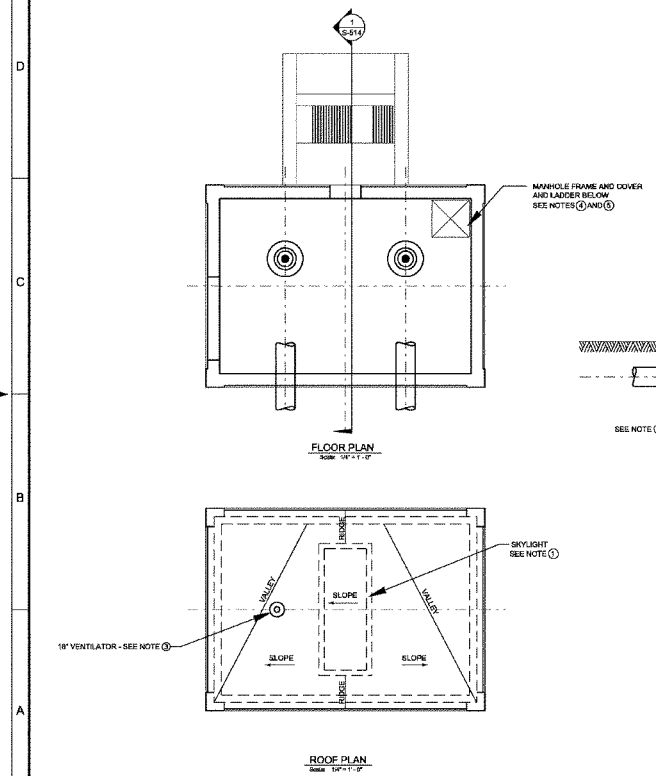
SHEET REFERENCE NUMBER:
S-513
SHEET 67 OF 134

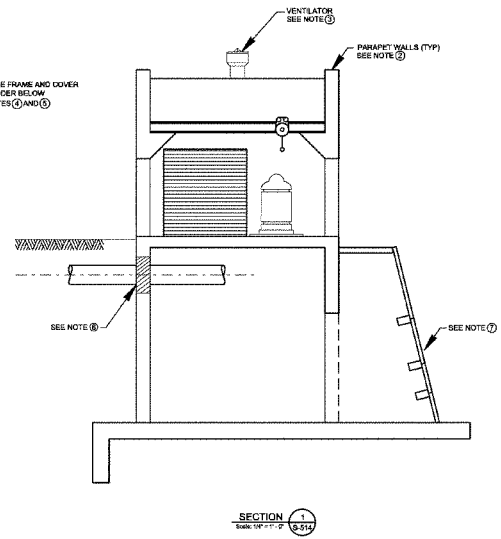
*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:49
FILE: \\irl-dfs1\organization\ED2\Public\CAD\civil\112546\CADD\112546S-513.dgn

FINAL SUBMITTAL

*** SAFETY PAYS ***





NOTES:

1. REPLACE CORRUGATED WIRE GLASS SKYLIGHT WITH PRE-ENGINEERED REMOVABLE ROOF HATCH
2. REPAIR CRACKS ON CONCRETE PARAPET WALLS AND INSTALL NEW FLASHING AND ROOFING MATERIAL
3. REPLACE VENTILATOR
4. REPLACE ACCESS LID AND EMBEDDED ANGLES
5. REPLACE LADDER
6. EXISTING DISCHARGE PIPES TO BE REMOVED FROM WALL AND NEW PIPES TO BE CAST IN PLACE
7. REPLACE TRASH RACKS AND SUPPORTING PURLINS.

SCALE: 1/4"=1'-0"

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Rev

Designed by: M. STUART
Drawn by: T. JOHNSON
Checked by: T. SULLIVAN
S. JENNINGS
Project Engineer/Architect
Date: APRIL 2011
Scale: AS SHOWN
Drawing Code:

PUMP PLANT #12 REPAIR DETAIL

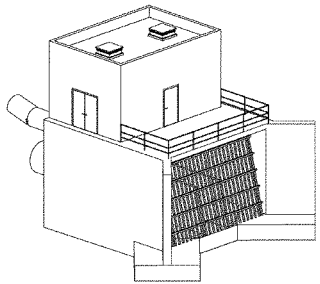
CMC RIVER SHORELINE, PADUCAH VENTILATOR (PADUCAH, KENTUCKY FIRST) RECONSTRUCTION FEASIBILITY REPORT VOLUME 3 OF 4

SHEET REFERENCE NUMBER:
S-514
SHEET 58 OF 134

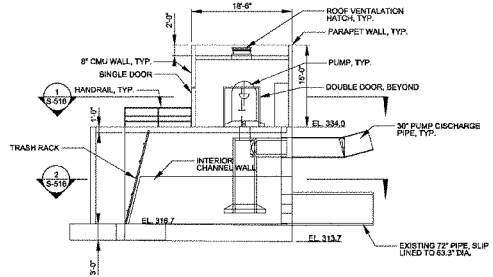
FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

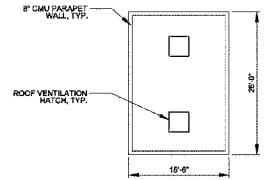
DATE: 03-MAY-2011 08:45
FILE: *irl-dfs1*organization\ED2\Public\CAD\civil\112546\CADD\112546S-514.dgn



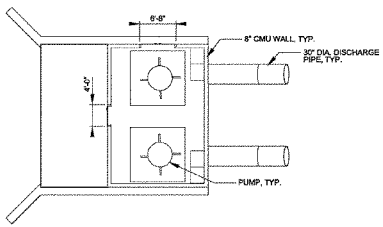
ISOMETRIC VIEW



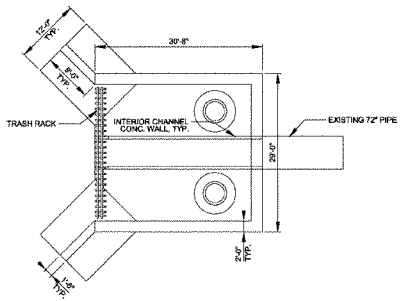
LONGITUDINAL SECTION



ROOF PLAN



SECTION 1 / S-515



SECTION 2 / S-515

NOTES:

1. SEE CIVIL DRAWINGS FOR PUMPSTATION LOCATION AND SITE DETAILS.
2. SEE MECHANICAL DRAWINGS FOR PUMP DETAILS. PUMPS SHOWN ARE FOR INFORMATION ONLY.
3. SEE ELECTRICAL DRAWINGS FOR ELECTRICAL DETAILS.
4. CONCRETE REINFORCEMENT NOT SHOWN.

US Army Corps of Engineers
Louisville District

Symbol	Description	Date	Appr.

Designed by: B. ADAIR
Date: APRIL 2011
Drawn by: B. ADAIR
Scale: NONE
Checked by: T. BULLARD
Drawing Code:
S. JENKINS
Project Engineer/Architect
Date

PROPOSED PUMP PLANT 14 - VERT. COLUMN PUMP OPTION

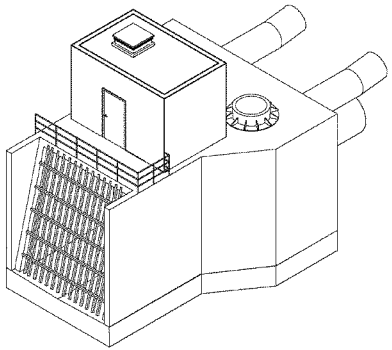
OHIO RIVER SHORELINE, MAYSVILLE, KENTUCKY (FRP) (PADUCAH, KENTUCKY (FRP)) FLOODWALL & LEVEE, MASON COUNTY, KY

SHEET REFERENCE NUMBER:
S-515
SHEET 56 OF 134

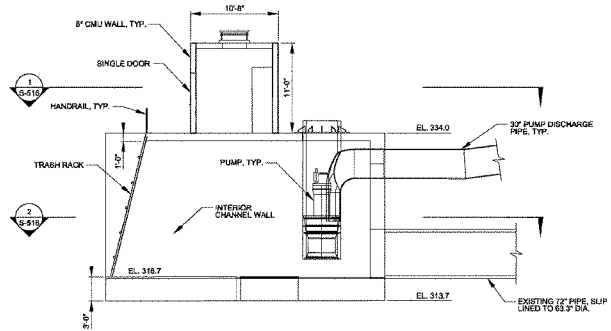
DATE: 03-MAY-2011 08:45
FILE: \\irl-dfs1\Organization\CD2\Public\CADD\civil\1125469\CADD\1125465-515.dgn

FINAL SUBMITTAL

*** SAFETY PAYS ***



ISOMETRIC VIEW
SCALE: NONE



LONGITUDINAL SECTION
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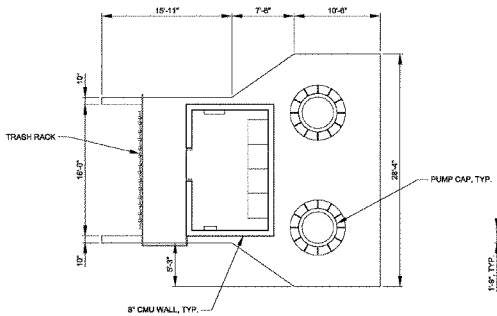
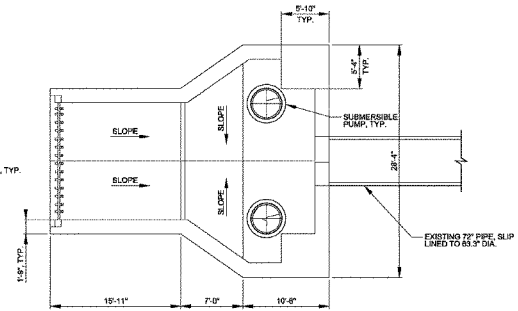
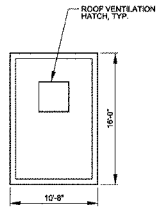


SECTION 1 S-516
SCALE: NONE



SECTION 2 S-516
SCALE: NONE



ROOF PLAN
SCALE: NONE

NOTES:

1. SEE CIVIL DRAWINGS FOR PUMPSTATION LOCATION AND SITE DETAILS.
2. SEE MECHANICAL DRAWINGS FOR PUMP DETAILS. PUMPS SHOWN ARE FOR INFORMATION ONLY.
3. SEE ELECTRICAL DRAWINGS FOR ELECTRICAL DETAILS.
4. CONCRETE REINFORCEMENT NOT SHOWN.

US Army Corps of Engineers
Louisville District

Symbol	Description	Date	Rev

Designed by: N. CASH
Drawn by: N. CASH
Checked by: T. SULLIVAN
Date: APRIL 2011
Scale: NONE
Drawing Code:
Project Engineer/Architect: S. JENKINS
Date:

PROPOSED PUMP PLANT 14 SUBMERSIBLE PUMP OPTION

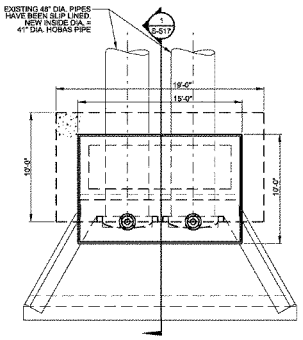
DAVID ROYER ENGINEERS INC.
(PUBLICAN, KENTUCKY 1 PPP)
FLOYD COUNTY, KENTUCKY
KENTUCKY 3 CP 4

SHEET REFERENCE NUMBER:
S-516
SHEET 52 OF 134

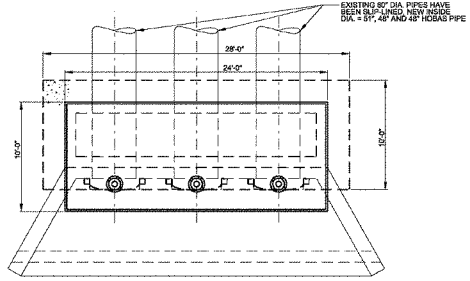
FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:49
FILE: %kirl-dfs1%organization%ED2%Public%CAD%civil%112546%CAD%112546S-516.dgn



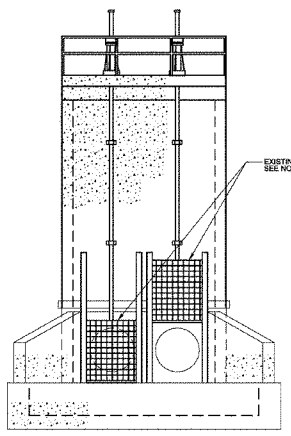
PLAN
Scale: 1/8" = 1'-0"



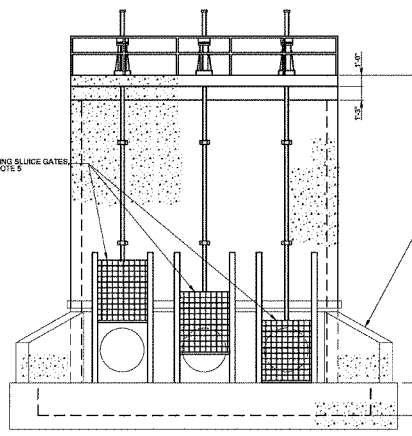
PLAN
Scale: 1/8" = 1'-0"

SCALE: 1/4"=1'-0"

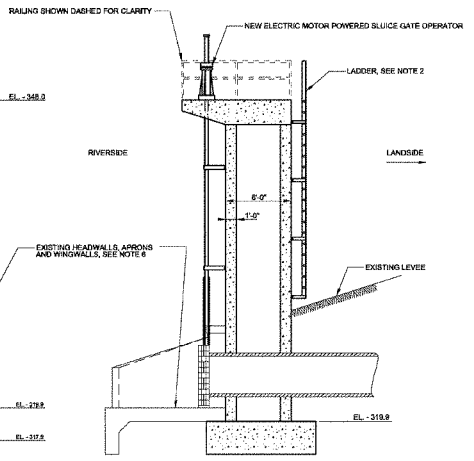
NOTES:
1. EXISTING STRUCTURAL STEEL GATE CONTROL TOWERS TO BE DEMOLISHED.
2. ALL LADDERS SHALL HAVE FALL PROTECTION CAGES.
3. ALL CONCRETE SHALL BE CAST-IN-PLACE.
4. CONCRETE REINFORCEMENT NOT SHOWN.
5. EXISTING SLUICE GATES AND STEMS TO BE REUSED.
6. EXISTING HEADWALLS, APRONS AND WINGWALLS ARE NOT TO BE DISTURBED.



ELEVATION
Scale: 1/4" = 1'-0"



ELEVATION
Scale: 1/4" = 1'-0"



TYPICAL SECTION 1 S-517
Scale: 1/4" = 1'-0"

US Army Corps of Engineers
Louisville District

Revisions: Number | Date | Rev.

Designed by: N. SULIAN | Date: APRIL 2011
Drawn by: T. JENSEN | Scale: AS SHOWN
Checked by: T. SULIVAN | Drawing Code:
S. JENNINGS | Chief Engineering Division | Date

BEE BRANCH SLUICE GATE CONTROL STRUCTURES

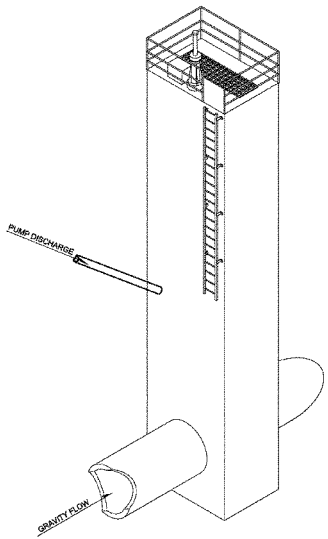
DAVID BAKER SHEPELWIC (PARSONS BRINCKERHOFF) (PARSONS BRINCKERHOFF) FLORENCE, KENTUCKY

SHEET REFERENCE NUMBER:
S-517
SHEET 61 OF 134

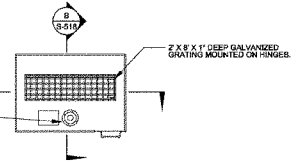
DATE: 03-MAY-2011 08:46
FILE: \\irl-dfs1\organization\ED2\Public\CAD\civil\112546\CADD\112546s-517.dgn

FINAL SUBMITTAL

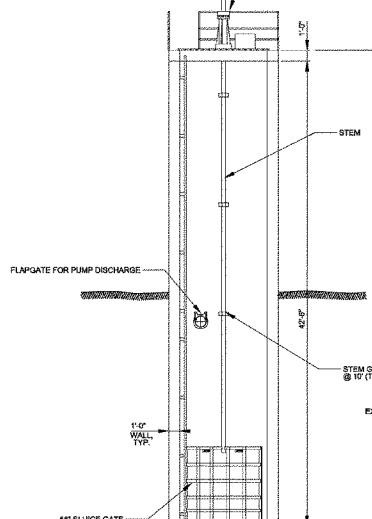
NOTES:
1. ALL LADDERS SHALL HAVE FALL PROTECTION CAGES.
2. ALL CONCRETE SHALL BE CAST-IN-PLACE.
3. CONCRETE REINFORCEMENT NOT SHOWN.



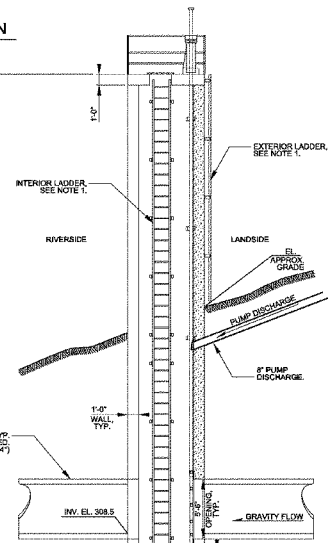
ISOMETRIC



PLAN



SECTION A



SECTION B

US Army Corps of Engineers
Louisville District

Symbol	Revisions	Date	Approved
	Initiation		

Designed by: B. SLAUR
Drawn by: B. SLAUR
Checked by: T. SULLIVAN
Date: APRIL 2011
Scale: 1/4" = 1'-0"
Drawing Code:
S. JENKINS
Project Engineer/Architect
Date

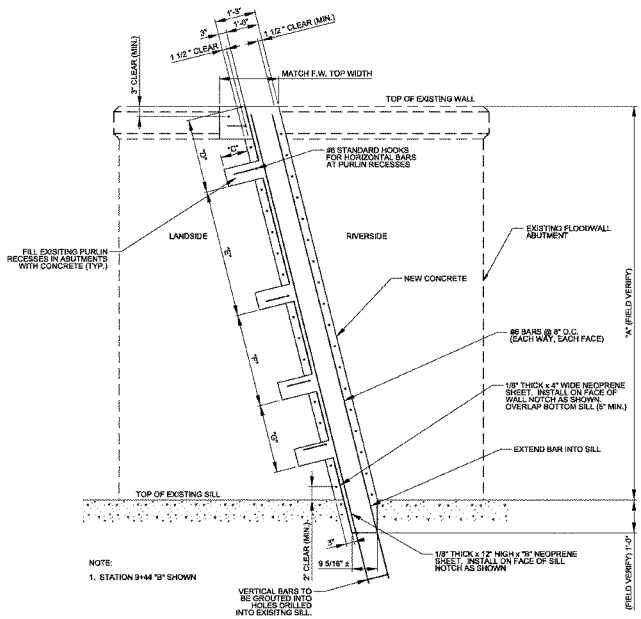
WOODWARD HOLLOW GATEWELL DETAILS

OHIO RIVER SHORELINE, MCCRACKEN COUNTY (PADUCAH), KENTUCKY (FRP) FEASIBILITY STUDY VOLUME 3 OF 4

SHEET REFERENCE NUMBER:
S-518
SHEET 82 OF 134

FINAL SUBMITTAL

DATE: 03-MAY-2011 08:46
FILE: #\\fil-dfs1\Morganlzcr\Con#ED2#Pub\Io#CAD#Civil\#112546#CADD#1125465-518.dgn

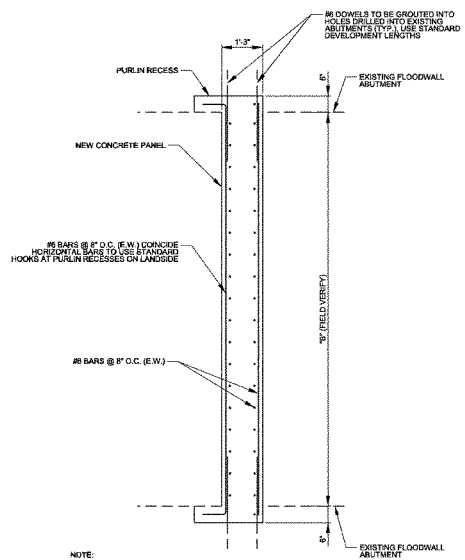


NOTE:

1. STATION 9+44 "B" SHOWN

TYPICAL ELEVATION SECTION AT CONCRETE PANEL

SCALE: 3/4" = 1'-0"



NOTE:

1. STATION 9+44 "B" SHOWN

TYPICAL PLAN SECTION AT CONCRETE PANEL

SCALE: 3/4" = 1'-0"

STATION	A	B	C	D	E	F	G	SLOPE	VOLUME
4+89 "B"	12'-0"	16'-0"	8"	2'-6" *	4'-9"	3'-7"	2'-0"	3 ON 1	6.9 CY
9+44 "B"	12'-0"	12'-0"	10"	2'-3"	3'-10 1/2"	2'-11"	2'-1"	4 ON 1	6.7 CY
31+01 "B"	11'-0"	12'-0"	10"	2'-3"	4'-4"	2'-10"	-	4 ON 1	6.1 CY
71+74 "B"	9'-6"	16'-0"	8"	2'-6" *	4'-3 1/2"	3'-0"	-	2 ON 1	7.0 CY
91+96 "B"	14'-0"	17'-0"	11 7/8"	2'-3"	4'-3 1/2"	3'-7"	2'-5"	4 ON 1	7.6 CY
93+37 "B"	14'-0"	31'-0"	8 1/8"	2'-2"	5'-4"	4'-3"	2'-5"	2 ON 1	30.1 CY
109+10 "B"	10'-0"	20'-0"	8 1/8"	2'-6" *	4'-7"	2'-3 1/4"	-	2 ON 1	9.3 CY
110+54 "B"	12'-0"	40'-0"	8"	2'-6"	4'-5"	3'-7"	2'-0"	2 ON 1	22.3 CY
								TOTAL VOLUME OF REINFORCED CONCRETE	98.1 CY

* 2'-0" OPPOSITE ABUTMENT

US Army Corps of Engineers
Louisville District

Symbol	Revisions Description	Date	Appr

Designed by: M. STUART
Drawn by: N. CASH
Checked by: T. SULLIVAN
Project Engineer/Architect: S. JENNINGS
Date: APRIL 2011
Scale: NONE
Drawing code:
Date

PERMANENT CLOSURES

OHIO RIVER SHORELINE, CINCINNATI, OHIO (PARADISE, KENTUCKY FRP) FLOODWALL REPAIR
CONTRACT NO. W

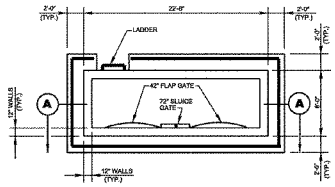
SHEET REFERENCE NUMBER:
S-519
SHEET 63 OF 134

DATE: 03-MAY-2011 08:46
FILE: \\irl-dfs1\organization\CD2\Public\CAD\civil\112546\CADD\112546a-519.dgn

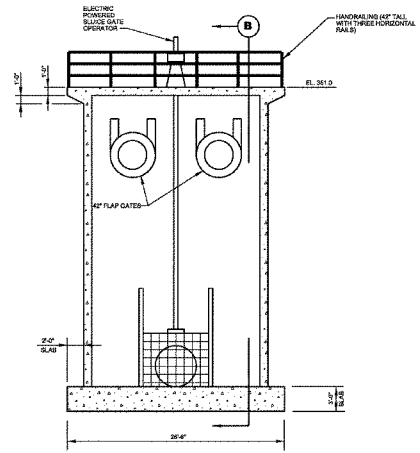
FINAL SUBMITTAL

*** SAFETY PAYS ***

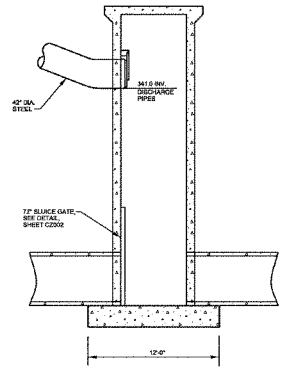
NOTES:
1. ALL LADDERS SHALL HAVE FALL PROTECTION CAGES.
2. ALL CONCRETE SHALL BE CAST-IN-PLACE.
3. CONCRETE REINFORCEMENT NOT SHOWN.



PLAN



SECTION A



SECTION B

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Location	Date	Rev

Designed by: M. STUART
Date: APRIL 2011
Scale: AS SHOWN
Drawn by: C. ROBINSON
Checked by: T. SULLIVAN
Drawing Code:
S. JENKINS
Project SYS/Geometrics
Date

SLUICE GATE DETAILS PUMP PLANT # 14

OHIO RIVER SHORELINE REHABILITATION PROJECT (PADUCAH, KENTUCKY FPP) FLOODWALL SYSTEM McCRACKEN COUNTY, KY

SHEET REFERENCE NUMBER:
S-520
SHEET 81 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:46
FILE: ##irl-gis#organization#CD2#Public#CADD#civil#112546#CADD#112546a-S20.dgn

FINAL SUBMITTAL

Paducah Pump Stations										
Facility Number Equipment ID	Manufacturer	Model and Size	Date of Rehab	Design Flow (GPM)	TDH (ft of Water)	HP	Speed (rpm)	Serial Number	Remarks
PP #1: Noble Park									
Unit #1	Fairbanks Morse	FM 30	New 1984	22,500	20.5	150	760	FR6764	Pump will be rehabilitated
Unit #2	Fairbanks Morse	FM 30	New 1984	22,500	20.5	150	760	FR6765	Pump will be rehabilitated
Unit #3	Fairbanks Morse	FM 30	New 1984	22,500	20.5	150	760	FR6766	Pump will be rehabilitated
PP #2: Bath Street									
Unit #1	Economy (Gamp)	SDV-9		1,500	20.7	10	690	E-4490	Pump will be replaced with a new submersible type
Unit #2	Economy	SAFV - 25 x 30	Motor Shaft in 99	16,000	29.7	200	705	E-4794	Pump will be rehabilitated
Unit #3	Economy	SAFV - 26 x 30		20,000	29.7	250	705	E-4792	Pump will be rehabilitated
Unit #4	Economy	SAFV - 34 x 60		90,000	29.7	800	395	E-4783	Pump will be rehabilitated
Unit #5	Economy	SAFV - 42 x 42		90,000	29.7	500	445	E-4784	Pump will be rehabilitated
Unit #6	Economy	SAFV - 42 x 66		90,000	29.7	500	445	E-4785	Pump will be rehabilitated
Unit #7	PBW Pumps	20B-50H	1989	9,000	23.5	100	1200	89A33371-35-460-1	Pump was installed new in 1989, no work required
PP #3: Park Avenue									
Unit #1	Economy (Gamp)	SDV - 8		800	18.7	5	870	E-4486	Pump will be replaced with a new submersible type
Unit #2	Economy	SAFV - 16 x 18		4,400	13.8	25	695	E-4800	Pump will be replaced with a new submersible type
Unit #3	Economy	SAFV - 16 x 18		4,400	13.8	25	695	E-4804	Pump will be replaced with a new submersible type
PP #4: City Street									
Unit #1	Economy	SDV - 10 x 12	Lower Bag in 79	4,500	19.6	50	695	E-4488	Pump will be replaced with a new submersible type
Unit #2	Economy	SDV - 10 x 12	Lower Bag and Shaft in 84	4,500	19.6	50	695	E-4487	Pump will be replaced with a new submersible type
PP #5: Harrison Street									
Unit #1	Economy	SAFV - 26 x 30		20,000	21.4	200	694	E-4793	Pump will be rehabilitated
Unit #2	Economy	SAFV - 26 x 30		20,000	21.4	200	694	E-4792	Pump will be rehabilitated
Unit #3	Economy	SAFV - 18 x 24		9,500	21.4	100	870	E-4801	Pump will be rehabilitated
Unit #4	Economy (Gamp)	SDV - 8		2,000	21.4	25	710	E-4491	Pump will be replaced with a new submersible type
PP #6: Clark Street									
Unit #1	Economy	SAFV - 30 x 42		31,100	22.1	250	564	E-4790	Pump will be rehabilitated
Unit #2	Economy	SAFV - 26 x 36		16,900	22.1	125	705	E-4787	Pump will be rehabilitated
Unit #3	Economy	SAFV - 30 x 42		31,100	22.1	250	564	E-4791	Pump will be rehabilitated
Unit #4	Economy	SAFV - 30 x 42		31,100	22.1	250	564	E-4789	Pump will be rehabilitated
Unit #5	Economy (Gamp)	SDV - 8		1,000	22.1	10	870	E-4490	Pump will be replaced with a new submersible type
PP #7: Tennessee Street									
Unit #1	Economy	SAFV - 26 x 36		15,000	19.6	125	705	E-4798	Pump will be replaced with a new submersible type
Unit #2	Economy	SAFV - 16 x 21		7,000	19.6	50	1170	E-4802	Pump will be replaced with a new submersible type
Unit #3	Economy	SDV - 8 x 10		1,000	19.6	10	705	E-4493	Pump will be replaced with a new submersible type
PP #8: Husbands Road									
Unit #1	Economy	SDV - 10	Bag in 97	3,900	21.5	40HP	870	E-4499	Pump will be replaced with a new submersible type
Unit #2	Economy	SDV - 10	Lower Bag in 99	3,900	21.5	40HP	870	E-4500	Pump will be replaced with a new submersible type
PP #10: George Street									
Unit #1	Economy	SDV - 9 x 8		1,200	11.7	10	870	E-4497	Pump will be replaced with a new submersible type
Unit #2	Economy	SDV - 9 x 8		1,200	11.7	10	870	E-4496	Pump will be replaced with a new submersible type
PP #11: Island Creek									
Unit #1	Cornelle	36 MP	New in 98	20,000	28.7	500	550	15-72	Pump will not require any type of reconditioning
Unit #2	Economy			20,000	28	300	600	E47-95	Pump will be rehabilitated
Unit #3	Economy		Rehab in 95	20,000	28	300	600	E47-97	Pump will be rehabilitated
Unit #4	Economy		Bifilar Cleaned Required in 98	20,000	28	300	600	E47-98	Pump will be rehabilitated
PP #12: SE of Paducah									
Unit #1	Economy			9,700	14	60	885	E47-96	Pump will be replaced with a new submersible type
Unit #2	Economy			9,700	14	60	885	E47-99	Pump will be replaced with a new submersible type
PP #13									
Unit #1	Crane	PCB - 60	Installed in 93	1,600	50	60	1750	152469	Pump will not require any type of reconditioning

MH NO.	LOCATION	DESCRIPTION	REMARKS
8-A	Sta. 123+61B2	20" Flap Gate	Leaks, Install New
7-A	Sta. 119+37B2	24" Flap Gate	Replace Gate
6-B2	Sta. 115+26B	8" Gate Valve	Leaks, Install New
6-A	Sta. 115+06B2	8" Shear Gate	Replace Gate
3-B2	Sta. 108+58B	2-36x36 Sluice	Leaks, Install New
3-A	Sta. 108+58B2	54" Flap Gate	Leaks, Install New
City	Sta. 74+40B1	8" Flap Gate	Replace Gate
5-A	Sta. 69+86B1	30" Flap Gate	Leaks, Install New
4-A	Sta. 57+98B1	24" Flap Gate	Leaks, Install New
	Sta. 187+34A	15" Sluice Gate	Replace Gate, See Note 1
	Pine St Headwall	16" Shear Gate	Remove Debris, Sandblast and repaint
23-B2	Sta. 66+27A	102"x102" Sluice	See Note 2
24-B2	Sta. 66+17A	102"x102" Sluice	See Note 3
16-A	Sta. 150+38B2	24" Flap Gate	See Note 4, Install New Flap Gate
PP#6-1P	Sta. 108+58 River	54" Flap Gate	Replace Gate
	Sta. 32+38C	3-60" Sluice	See Note 5
	Sta. 32+12C	2-48" Sluice	See Note 5

Notes:

1. **Install new ladder rungs and replace gate with non-rising stem type.**
2. **Install new electric actuator.**
3. **The 102 by 102 inch sluice gate located near pump station number 2 has broken part of its casting near the top of the gate. This gate, frame, guides and stem shall be replaced and a new electric hoist actuator shall be installed to eliminate facilitate the opening and closing of such a large gate. Gates typically larger than 60-inches use electric actuators to eliminate safety problems, since a heavy motor operated device has to be brought to this location to operate the gate.**
4. **Manhole # 16-A is located under the Executive Inn Parking Lot (location is not known). Check video to determine if gate needs to be replaced?**
5. **Requires sandblasting and painting of the outfall structure and sluice gates. Adjust wedges as required to seal sluice gates.**

US Army Corps of Engineers Louisville District

Symbol	Location	Description	Date	Rev

Designed by: M. ATCHISON
Date: APRIL 2011
Drawn by: M. MAUVE
Source:
Checked by: V. NGUYEN
Drawing Code:
Project Engineer/Manager: S. JENNINGS
Filed:

PUMP PLANT REHABILITATION SUMMARY

CHIEF, RIVER ENGINEERING (PADUCAH, KENTUCKY FPW) PADUCAH, KENTUCKY 42001 FILE NUMBER: 1-5-4

SHEET REFERENCE NUMBER: M601

SHEET 68 OF 134

FINAL SUBMITTAL

572

DATE: 03-MAY-2011 08:46
FILE: \\irl-dfs1\organization\ED2\Public\CAD\Civil\112546\CAD\Mechanical\M601.dgn

FINAL SUBMITTAL

*** SAFETY PAYS ***

ELECTRICAL SYMBOL LEGEND

- CIRCUIT BREAKER
- X STARTER CONTACTOR
  X = STARTER NEMA SIZE
- OVERLOAD RELAY
- (M) MOTOR (M=HORSEPOWER)
- POWER TRANSFORMER

NOTES:

1. EQUIPMENT TO BE REPLACED SHOWN IN BOLD LINEWEIGHT AND BOLD TEXT. EXISTING EQUIPMENT TO REMAIN SHOWN IN LIGHT LINEWEIGHT AND ITALIC TEXT.
2. GATE ACTUATORS TO BE REPLACED NOT SHOWN ON POWER DISTRIBUTION ONE LINE DIAGRAMS.
3. DESCRIPTIONS OF CHANGES FOR EXISTING PUMP PLANTS ON PLAN SHEETS. PUMP PLANTS #4, #10, AND #13 DO NOT HAVE PLAN SHEETS. THEREFOR CHANGES DESCRIPTIONS ARE ON ONE LINE DIAGRAMS FOR ABOVE MENTIONED PUMP PLANTS.
4. ELECTRICAL MOTORS SHOWN ON PLANS REPRESENT EXISTING MOTORS. ALL MOTORS HAVE BEEN SCHEDULED TO BE REHABILITATED OR REPLACED. MOTOR REHAB/REPLACEMENT TABLE IS SHOWN ON DRAWING M001.

EMERGENCY POWER NOTES:

1. FEASIBILITY STUDY SHALL INCLUDE PROVISIONS FOR EMERGENCY BACKUP POWER TO BE PROVIDED TO ALL PUMP PLANTS. EACH STATION PLAN AND POWER ONE LINE SHOW PROVISIONS FOR PORTABLE GENERATORS TO CONNECT TO.
2. SEE SHEET E-502 FOR TEMPORARY CONNECTION SCHEMATIC.
3. SEE PUMP STATION POWER ONE LINES FOR SIZING OF CONDUCTORS, SWITCHES, CIRCUIT BREAKERS, FUSES, AND RECEPTACLES.
4. GENERATOR SIZING IS SHOWN IN EMERGENCY POWER SECTION OF ELECTRICAL WRITE UP (TABLE VIII.a-23) IN FEASIBILITY REPORT.

US Army Corps of Engineers
Louisville District

Symbol	Description	Date	Appr.

Designed by: J. RUSHAB
Drawn by: M. MALONE
Checked by: J. GOBSON
Date: APRIL 2011
Scale: N/A
Drawing Code:
Project Engineer/Architect: G. JENNINGS
Date

ELECTRICAL NOTES AND LEGEND

OHIO RIVER SHORELINE
PADUCAH, KENTUCKY (TRP)
FEASIBILITY STUDY
CONTRACT 10-01

SHEET REFERENCE NUMBER:
E001
SHEET 86 OF 134

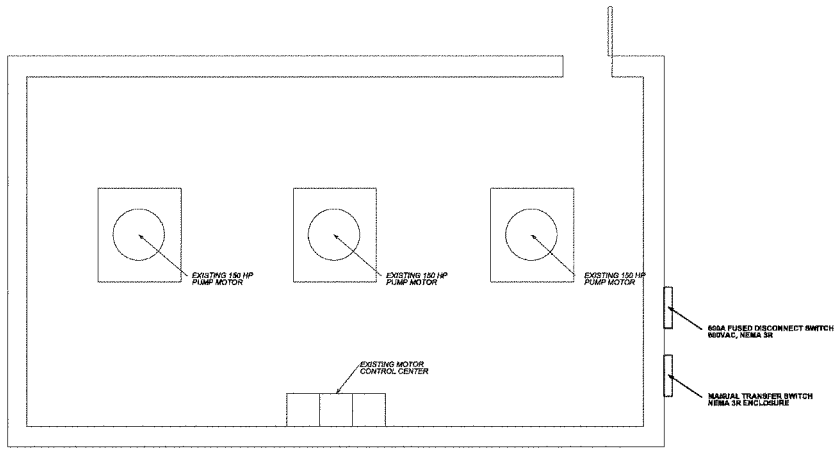
*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:46
FILE: \\irl-dfs1\organization\ED2\Public\CAD\Civil\112546\CADD\Electrical Folder\112546e001.dgn

*** SAFETY PAYS ***

NOTES:

1. PUMP PLANT#1 CHANGES:
   - PROVIDE MANUAL TRANSFER SWITCH, FUSED DISCONNECT AND GENERATOR PLUG / RECEPTACLE TO CONNECT STATION TO 400KW EMERGENCY GENERATOR RENTED BY CITY OF PADUCAH.
   - CONTROL INSTRUMENTATION SHALL BE PROVIDED TO PROVIDE AUTOSHUTOFF FOR PUMP CONTROL.



PUMP PLANT #1 FLOORPLAN

2 0 2 4FT
SCALE: 3/8"= 1'-0"

US Army Corps of Engineers
Louisville District

Symbols

Symbol	Description	Date	Rev

Designed by: J. TIMBAS
Drawn by: M. MALONE
Checked by: J. DOBSON
S. JENNINGS
Project Engineer/Architect
Date: APRIL 2011
Scale: 3/8" = 1'-0"
Drawing Code:

PUMP PLANT #1 PLAN

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY UPP) RECONSTRUCTION FEASIBILITY STUDY VOLUME 3 OF 4

SHEET REFERENCE NUMBER:
E101
SHEET 67 OF 134

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:46
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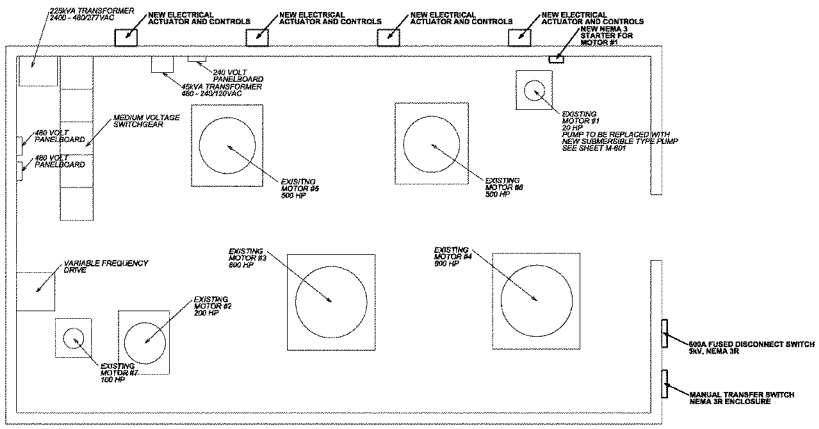
*** SAFETY PAYS ***

NOTES:

1. PUMP PLANT #2 CHANGES:
   - PROVIDE MANUAL TRANSFER SWITCH, FUSED DISCONNECT, AND GENERATOR RECEPTACLE TO CONNECT STATION TO MEDIUM VOLTAGE 2000kW EMERGENCY GENERATOR RENTED BY THE CITY OF PADUCAH.
   - REPLACE MOTOR GATE ACTUATORS AND CONTROL BOXES FOR ACTUATORS #1 THRU 4. SEE SHEET E-501 FOR ACTUATOR DETAILS.
   - REPLACE MOTOR #1 COMBINATION STARTER CIRCUIT AND WALL MOUNTED CONTROL BUCKET. SEE SHEET E-501 FOR MOTOR STARTER DETAILS



PUMP PLANT #2 FLOORPLAN

SCALE: 1/4"=1'-0"

US Army Corps of Engineers
Louisville District

Symbol	Description	Date	Rev

Designed by: J. SHIELS
Drawn by: M. MALONE
Checked by: J. LOCKSON
Project Engineer/Architect: B. JENNINGS
Date: APRIL 2011
Scale: 1/4" = 1'-0"
Drawing Code:

PUMP PLANT #2 PLAN

OHIO RIVER SHORELINE
PADUCAH, KENTUCKY (RPP)
FLOODWALL REPAIR
KENTUCKY

SHEET REFERENCE NUMBER:
E102
SHEET 98 OF 134

FINAL SUBMITTAL

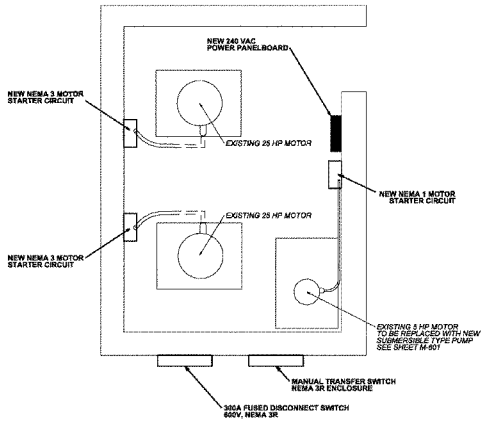
*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:46
FILE: \\mirl-dfs1\organization\ED2\Public\CAD\Solvi\112546\CADD\Electrical Folder\112546e102.dgn

*** SAFETY PAYS ***

NOTES:

1. PUMP PLANT #3 CHANGES:
   - PROVIDE MANUAL TRANSFER SWITCH, FUSED DISCONNECT AND GENERATOR RECEPTACLE TO CONNECT STATION 50kW EMERGENCY GENERATOR RENTED BY CITY OF PADUCAH.
   - REPLACE MOTOR COMBINATION STARTER CIRCUITS/CONTROLS FOR PUMP MOTORS #1 THRU 3. SEE SHEET E-501 FOR MOTOR STARTER DETAILS.
   - REPLACE 240 VAC PANELBOARD WITH NEW PANELBOARD. SEE ONE LINE DIAGRAM FOR MORE INFORMATION.



PUMP PLANT #3 NEW POWER PLAN

SCALE: 1/2"=1'-0"

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Rev.

Designed by: J. TIBBIAS
Drawn by: M. MALONE
Checked by: J. DOBSONA
B. JENNINGS
Project Engineer/Architect
Date: APRIL 2011
Scale: 1/2" = 1'-0"
Drawing Code:

PUMP PLANT #3 PLAN

OHIO RIVER SUREG (N), OHIO RIVER MILE 0.0 PADUCAH, KENTUCKY (PP#) PUGSLEY'S CREEK MILE 0.1

SHEET REFERENCE NUMBER
E103
SHEET 39 OF 134

FINAL SUBMITTAL

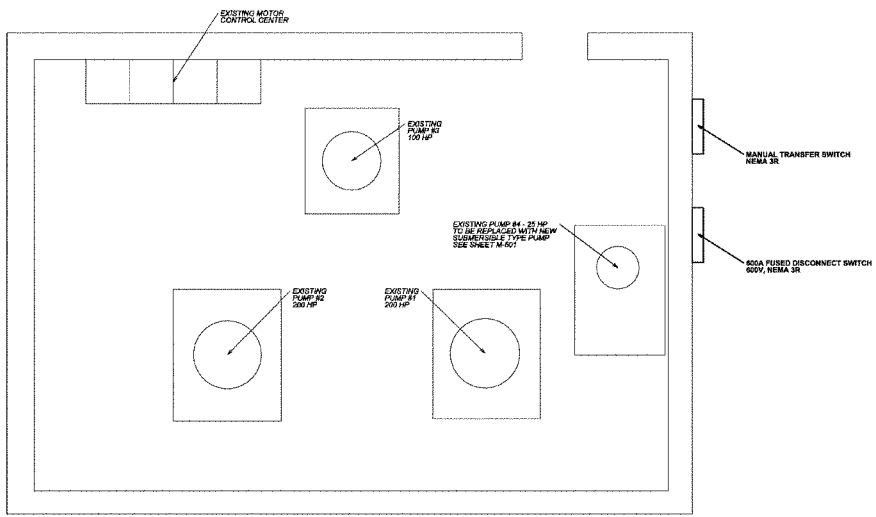
*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:46
FILE: ##ln1-cfs1#orgnization#ED2#Public#CAD#city1:#112546#CAD#Electrical Folder#112546e103.dgn

*** SAFETY PAYS ***

NOTES:

1. PUMP STATION #5 CHANGES:
   - PROVIDE MANUAL TRANSFER SWITCH, FUSED DISCONNECT, AND GENERATOR PLUG/RECEPTACLE TO CONNECT STATION TO 400kW EMERGENCY GENERATOR RENTED BY CITY OF PADUCAH.



PUMP PLANT #5 PLAN

US Army Corps of Engineers
Louisville District

Designed by: J. TIMBAS
Drawn by: M. MALONE
Checked by: J. DOBSON
Date: APRIL 2011
Scale: 1/2" = 1'-0"
Drawing Code:
B. JENNINGS
Project Engineer/Contract Date

PUMP PLANT #5 PLAN

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY EPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 3 OF 4

SHEET REFERENCE NUMBER:
E104
SHEET 70 OF 134

SCALE: 1/2"=1'-0"

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:46
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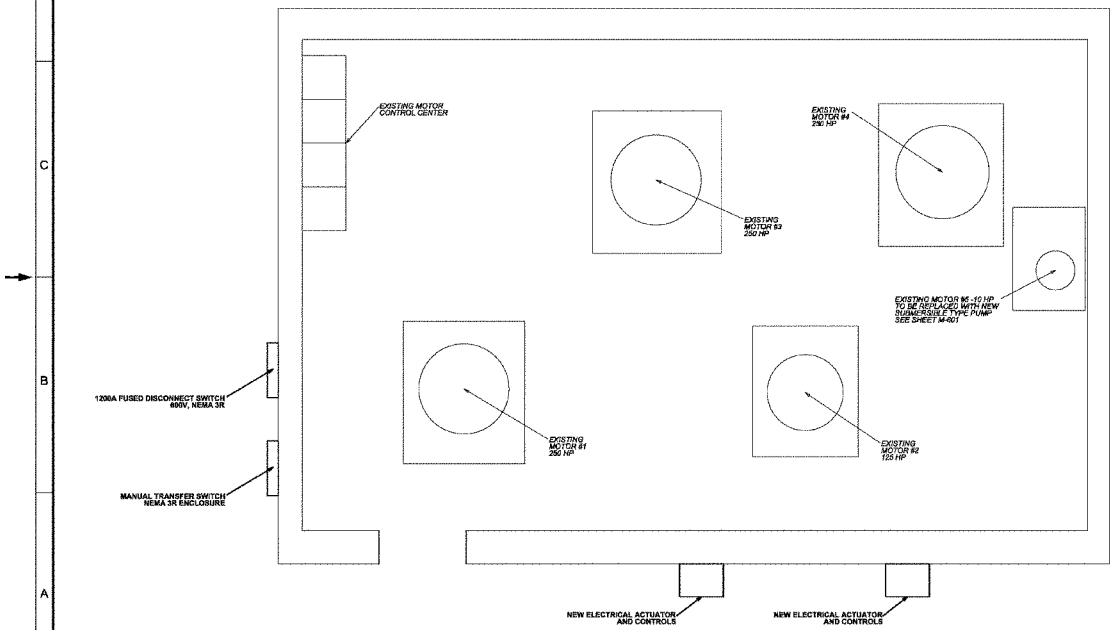
*** SAFETY PAYS ***

NOTES:

1. PUMP PLANT #6 CHANGES:
   - PROVIDE MANUAL TRANSFER SWITCH, FUSED DISCONNECT, AND GENERATOR PLUG/RECEPTACLE TO CONNECT STATION TO SCGAW GENERATOR RENTED BY CITY OF PADUCAH.
   - REPLACE MOTOR GATE ACTUATORS AND CONTROL FOR ACTUATORS #1 AND #2. SEE SHEET E-501 FOR ACTUATOR DETAILS.



NEW POWER PLANT/PUMP STATION #6

SCALE: 1/2"=1'-0"

US Army Corps of Engineers
Louisville District

Symbol	Description	Date	Appr.

Designed by: J. T. NIBAG
Date: APRIL 2011
Drawn by: M. MALONE
Scale: 1/2" = 1'-0"
Checked by: J. DOBSON
Drawing Code:
S. JENNINGS
Project Engineer/Architect
Date

PUMP STATION #6 PLAN

DAVID BOVIN SIEBERT, INC.
ARCHITECTS & ENGINEERS
(PADUCAH, CONTRACT FIRM)
FLOOD WALL & PUMP STATIONS
CONTRACT 12-01

SHEET REFERENCE NUMBER:
E105
SHEET 71 OF 134

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:46
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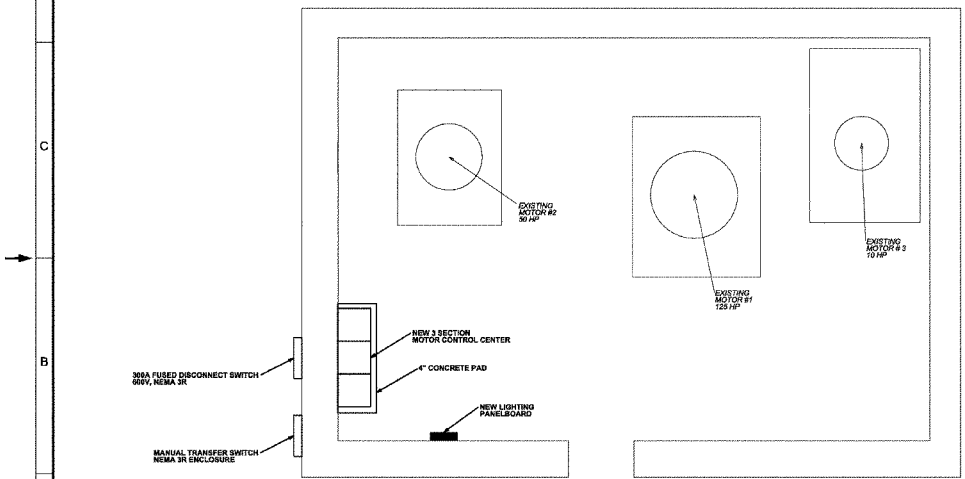
NOTES:

1. PUMP PLANT #7 CHANGES:
   - PROVIDE MANUAL TRANSFER SWITCH, FUSED DISCONNECT, AND GENERATOR RECEPTACLE TO CONNECT STATION TO A 200kW EMERGENCY GENERATOR TO BE RENTED BY CITY OF PADUCAH.
   - PROVIDE NEW MOTOR CONTROL CENTER WITH 400AT MAIN CIRCUIT BREAKER, 3 INTEGRAL MOTOR STARTERS (RATED NEMA 1, NEMA 3, NEMA 3) AND 70AT FRAME CIRCUIT BREAKER AND MCC MOUNTED LIGHTING TRANSFORMER (RATED 25kVA, 480, 240/120VOLT) FOR NEW LIGHTING PANEL.
   - PROVIDE NEW LIGHTING PANEL FOR PUMP STATION LIGHTING AND CONVENIENCE RECEPTACLES.
   - CONTROL INSTRUMENTATION SHALL BE PROVIDED TO PROVIDE AUTOSHUTOFF FOR PUMP CONTROL.
   - ALL PUMPS TO BE REPLACED WITH SUBMERSIBLE TYPE PUMPS. SEE SHEET M-801



PUMP PLANT # 7 PLAN

SCALE: 3/8"= 1'-0"

US Army Corps of Engineers Louisville District

Revisions

Symbol	Location	Date	Appr

Designed by J. TIBBAS
Drawn by N. MALONE
Checked by J. DOBSON
Date APRIL 2011
Scale 3/8" = 1'-0"
Drawing Code
S. JENNINGS
Project Engineer/Manager
Date

PUMP PLANT #7 PLAN

OHIO RIVER SHORES (NR) PADUCAH, KENTUCKY (TRP) FLOOD PROTECTION FLOOD WALL SYSTEM

SHEET REFERENCE NUMBER: E106

SHEET 72 OF 134

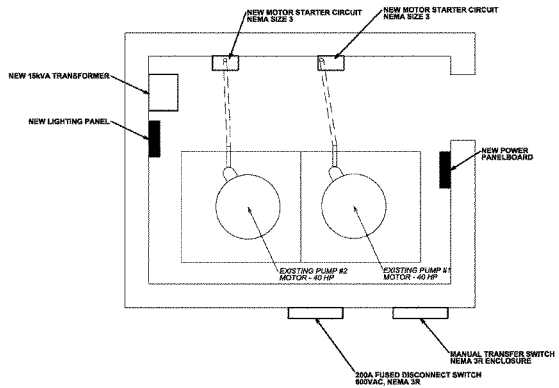
DATE: 03-MAY-2011 08:47
FILE: \\kyrl-dfs1\organization\ED2\Public\CAD\Solvil\112546\CADD\Electrical Folder\112546e106.dgn

FINAL SUBMITTAL

*** SAFETY PAYS ***

NOTES:

1. PUMP PLANT #9 CHANGES:
   - UTILITY PROVIDE 3 NEW 37.5kVA SERVICE TRANSFORMERS.
   - PROVIDE MANUAL TRANSFER SWITCH, FUSED DISCONNECT, AND GENERATOR RECEPTACLE TO CONNECT STATION 100kW EMERGENCY GENERATOR.
   - PROVIDE NEW POWER PANELBOARD TO FEED MOTOR STARTER CIRCUITS AND LIGHTING TRANSFORMER.
   - PROVIDE NEW WALL MOUNTED COMBINATION MOTOR STARTER CIRCUITS FOR BOTH PUMPS. MOTOR STARTER CIRCUITS SHALL BOTH BE NATED NEMA 3.
   - PROVIDE NEW 15kVA, 480, 240/120VOLT LIGHTING TRANSFORMER
   - PROVIDE NEW LIGHTING PANEL FOR PUMP STATION LIGHTING AND CONVIENCE RECEPTACLES.
   - CONTROL INSTRUMENTATION SHALL BE PROVIDED TO PROVIDE AUTOSHUTOFF FOR PUMP CONTROL.
   - BOTH PUMPS SHALL BE REPLACED WITH NEW SUBMERSIBLE TYPE PUMPS SEE SHEET M-501.



PUMP PLANT #9 PLAN

SCALE: 1/2"=1'-0"

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Rev

Designed by: J. THOMAS
Drawn by: M. MALONE
Checked by: J. DOBSON
Date: APRIL 2011
Scale: 1/2"=1'-0"
Drawing Code:
S. JENNINGS
F:\2005\Projects\Kentucky

PUMP PLANT #9 PLAN

OHIO RIVER SHORELINE, ANALYSIS & DESIGN (PACKAGE) KENTUCKY (PPP) FLOOD PROTECTION, LOUISVILLE, KENTUCKY

SHEET REFERENCE NUMBER:
E107
SHEET 73 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

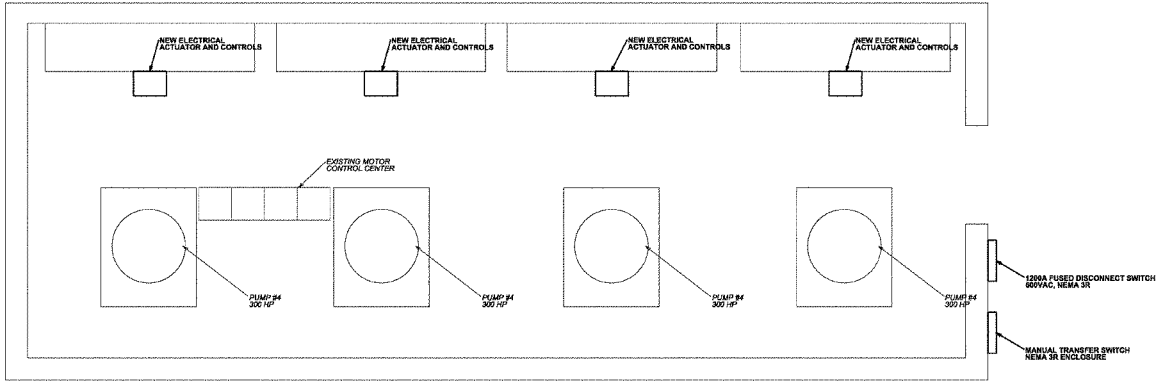
DATE: 03-MAY-2011 08:47
FILE: \\irf-cfs1\organization\ED24\Public\CAD\dwlf\112546\CAD\Electrical Folder\112546e107.dgn

FINAL SUBMITTAL

*** SAFETY PAYS ***

NOTES:

1. PUMP PLANT #11 CHANGES:
   - PROVIDE MANUAL TRANSFER SWITCH, FUSED DISCONNECT, AND GENERATOR PLUG/RECEPTACLE TO CONNECT STATION TO 800KW EMERGENCY GENERATOR RENTED BY CITY OF PADUCAH.
   - REPLACE MOTOR GATE ACTUATORS AND CONTROL FOR ACTUATORS #1 THRU #4. SEE SHEET E-501 FOR ACTUATOR DETAILS.



NEW POWER PLAN PUMP STATION #11

2 0 2 4FT
SCALE: 3/8"= 1'-0"

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Appr

Designed by: J. TARGAS
Drawn by: M. MALONE
Checked by: J. DOBSON
Date: APRIL 2011
Scale: 3/8" = 1'-0"
Drawing Code:
S. JENNINGS
Project Engineer/Architect
Date

PUMP PLANT #11 PLAN

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY FPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 3 OF 4

SHEET REFERENCE NUMBER:
E108
SHEET 74 OF 134

FINAL SUBMITTAL

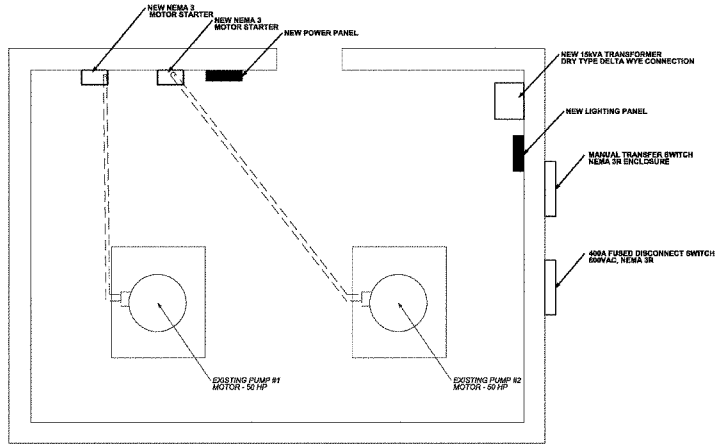
*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:47
FILE: \\iri-dfs1\organization\CD2\Public\CAD\civil\112546\CAD\Electrical Folder\112546e108.dgn

*** SAFETY PAYS ***

NOTES:

1. PUMP PLANT #12 CHANGES:
   - PROVIDE MANUAL TRANSFER SWITCH, FUSED DISCONNECT, AND GENERATOR RECEPTACLE TO CONNECT STATION TO 125kW EMERGENCY GENERATOR RENTED BY CITY OF PADUCAH.
   - PROVIDE NEW POWER PANELBOARD TO FEED MOTOR STARTER CIRCUITS AND LIGHTING TRANSFORMER.
   - PROVIDE NEW WALL MOUNTED COMBINATION MOTOR STARTER CIRCUITS FOR BOTH PUMPS. MOTOR STARTER CIRCUITS SHALL BOTH BE RATED NEMA 3.
   - PROVIDE NEW 15kVA, 480, 240/120VOLT LIGHTING TRANSFORMER
   - PROVIDE NEW LIGHTING PANEL FOR PUMP STATION LIGHTING AND CONVENCE RECEPTACLES.
   - CONTROL INSTRUMENTATION SHALL BE PROVIDED TO PROVIDE AUTOSHUTOFF FOR PUMP CONTROL.
   - BOTH PUMPS SHALL BE REPLACED WITH NEW SUBMERSIBLE TYPE PUMPS SEE SHEET M-001.



PUMP PLANT #12 PLAN

SCALE: 1/2"=1'-0"

US Army Corps of Engineers
Louisville District

Symbol	Description	Date	Rev

Designed by: J. TIBBAS
Drawn by: M. MALONE
Checked by: J. DODSON
Date: APRIL 2011
Scale: 1/2" = 1'-0"
Drawing Code:
S. JENNINGS
Project Engineer/Architect
Date

PUMP PLANT #12 PLAN

OHIO RIVER SHORELINE (PADUCAH, KENTUCKY) (PPP) FLOODWALL PROJECT
SUBMITTAL 100% A

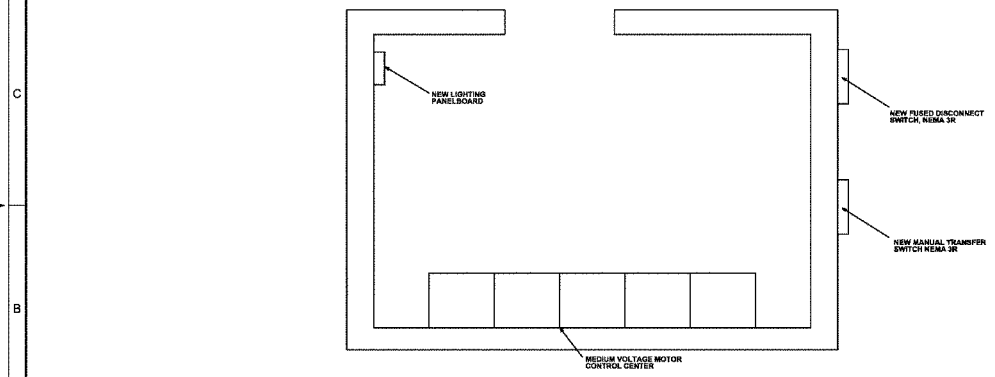
SHEET REFERENCE NUMBER:
E109
SHEET 75 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:47
FILE: \\irl-dfs1\organization\CO2\Public\CAD\civil\112546\CADD\Electrical Folder\112546e109.dgn

FINAL SUBMITTAL

*** SAFETY PAYS ***



PROPOSED PUMP PLANT #14 - SUBMERSIBLE PUMPS

US Army Corps of Engineers
Louisville District

Revisions

Designed by: J. TIMBAS
Drawn by: M. MALONE
Checked by: J. DOBSON
Date: APRIL 2011
Scale: 1/2" = 1'-0"
Drawing Code:
B. JENNINGS
Project Engineer/Architect
Date

PROPOSED PUMP PLANT #14 - SUBMERISBLE

OHIO RIVER BRIDGELINE, PADUCAH VICTORY (PADUCAH VICTORY) (PPP) REDOMESTICATION FACILITY REPORT VOLUME 3 OF 4

SHEET REFERENCE NUMBER:
E110
SHEET 78 OF 134

SCALE: 1/2"=1'-0"

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:47
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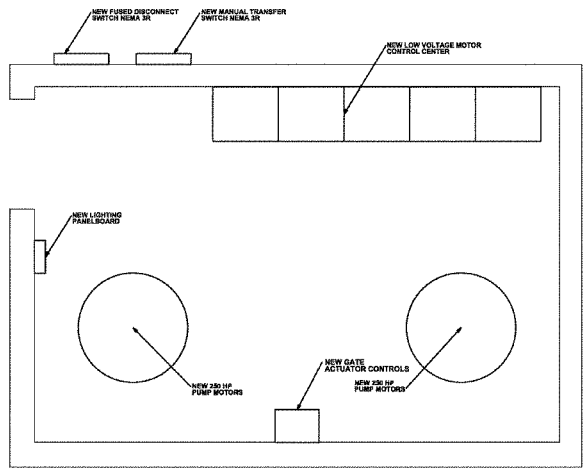
*** SAFETY PAYS ***



PROPOSED PUMP PLANT #14 - VERTICAL COLUMN

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Appr

Designed by: J. TAMBAS
Drawn by: M. MALONE
Checked by: J. DOBSON
S. JENNINGS
Project Engineer/Architect
Date: APRIL 2011
Scale: 1/2" = 1'-0"
Drawing Code:

PROPOSED PUMP PLANT #14 - VERT COLUMN

OHIO RIVER BASIN INF. PANELCAK KENTUCKY (PAKEDAH, KENTUCKY FPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 3 OF 4

SHEET REFERENCE NUMBER:
E111
SHEET 77 OF 134

SCALE: 1/2"=1'-0"

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:47
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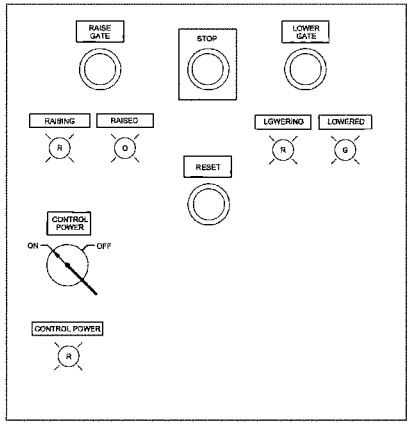
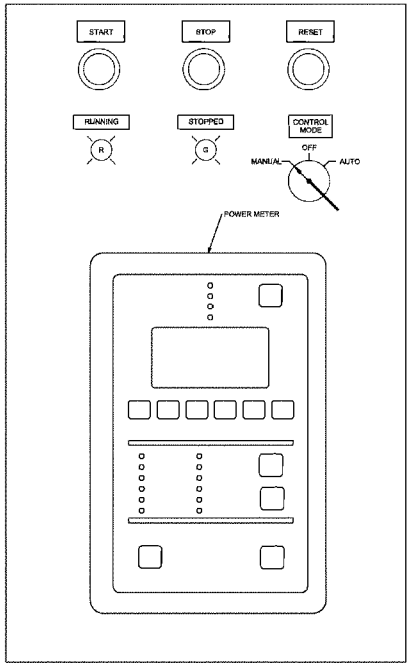
*** SAFETY PAYS ***



GATE ACTUATOR MOTOR STARTER CIRCUIT AND CONTROL PANEL



COMBINATION MOTOR STARTER CIRCUIT AND CONTROL PANEL

NOTES:

1. GATE ACTUATOR CONTROL PANEL SHOWN SHALL BE PROVIDED FOR NEW GATE ACTUATORS. NEW GATE ACTUATORS SHALL REPLACE EXISTING GATE ACTUATORS 1 THRU 4 AT PUMP PLANT #2, 1 THRU 4 AT PUMP PLANT #11, AND 1 AND 2 AT PUMP PLANT #9.
2. NEW WALL MOUNTED COMBINATION STARTERS AND MOTOR CONTROL PANELS SHALL BE PROVIDED AT PLANTS 5, 7, 10, AND 13. NEW MOTOR CONTROL CENTER SHALL BE PROVIDED AT PLANT 7. CONTROLS AND METERING SHOWN SHALL BE PROVIDED FOR BOTH EXTERNAL WALL MOUNTED MOTOR STARTER CIRCUIT/CONTROL PANEL, AND STARTER CIRCUIT/CONTROL PANEL INTERNAL TO MOTOR CONTROL CENTER.
3. POWER METER SHOWN SHALL BE CAPABLE OF SHOWING THE FOLLOWING:
   a. SYSTEM VOLTAGE
   b. CURRENT DRAW
   c. POWER IN kVA
   d. POWER FACTOR

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Rev

Designed by: J. LIMBAUGH
Date: APRIL 2011
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Scale: NONE
Checked by: J. DOBSON
Drawing Code:
Project Engineer/Architect: S. JENNINGS
Date:

MOTOR STARTER AND ACTUATOR CONTROL DETAILS

OHIO RIVER SHIPPING INT. PROJECT (ORSIP) (FAUCIER CHUTCHUT I PPP) REGULATE CHUTCHUT REGULATE CHUTCHUT

SHEET REFERENCE NUMBER:
E501
SHEET 78 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

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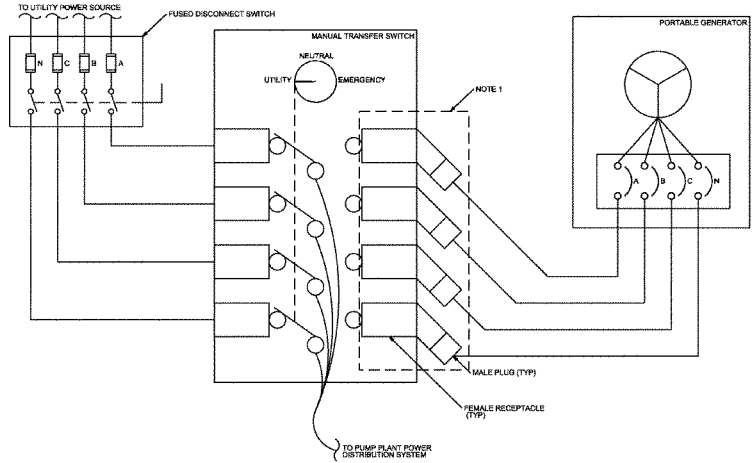


EMERGENCY POWER HOOK UP SCHEMATIC
SCALE: N.T.S

NOTES:

1. SCHEMATIC ONLY SHOWS ONE SET OF CONDUCTORS. MULTIPLE SETS OF PARALLEL CONDUCTORS MAY BE PRESENT. SEE INDIVIDUAL POWER ONE LINE DIAGRAMS FOR MORE INFORMATION. THERE SHALL BE ONE CONDUCTOR PER RECEPTACLE.
2. PLUG/RECEPTACLE TYPE SHALL BE DURALINE SINGLE POLE HIGH POWER CONNECTOR OR EQUAL FOR LOW VOLTAGE APPLICATIONS (<600 VOLTS), AND PLM 415 SERIES MEDIUM VOLTAGE CABLE COUPLERS RATED 5KV OR EQUAL FOR MEDIUM VOLTAGE (>600 VOLTS) APPLICATIONS. MALE PLUG SHALL BE PROVIDED ON LINE SIDE OF GENERATOR CONNECTION TO TRANSFER SWITCH. FEMALE RECEPTACLE SHALL BE PROVIDED ON LOAD SIDE OF GENERATOR CONNECTION TO TRANSFER SWITCH. SEE INDIVIDUAL POWER ONE LINE DIAGRAMS FOR CONDUCTOR AND RECEPTACLE SIZE. PHASE PLUG RECEPTACLE SHALL HAVE COORDINATED COLORING AND ASSOCIATED LABELING INCLUDING PHASE LETTERING AND SET NUMBERING (IF MULTIPLE SETS ARE PRESENT).
3. SEE INDIVIDUAL POWER ONE LINE SCHEMATICS FOR GENERATOR, TRANSFER SWITCH, CONDUCTOR, FUSED DISCONNECT, AND CIRCUIT BREAKER SIZING

US Army Corps of Engineers
Louisville District

Revisions			
Symbol	Location	Date	Rev

Designed by: J. LINNAS
Drawn by: M. MALONE
Checked by: J. DOBSON
Date: APRIL 2011
Scale: NONE
Drawing Code:
S. JENNINGS
Project Engineer/Architect
Date

GENERATOR CONNECTION DIAGRAM

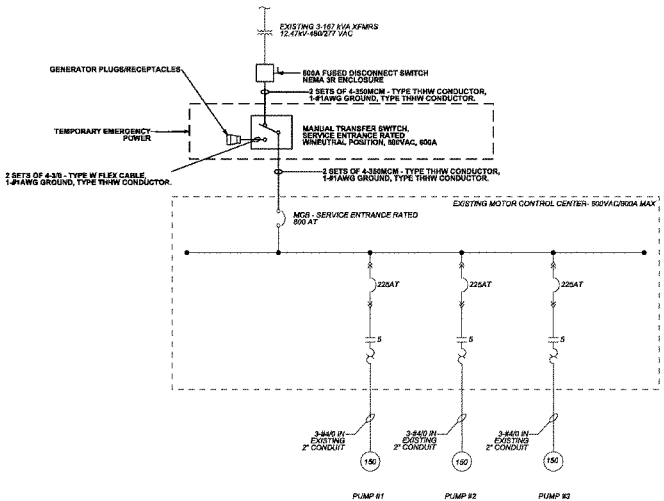
DND BUYER SNIPER INC
(FORMERLY DOUGLAS ARMY DEPOT)
(PARCEL KENTUCKY 1 FRP)
FACILITY NO. 1
BARDSTOWN, KENTUCKY

SHEET REFERENCE NUMBER:
E502
SHEET 79 OF 134

DATE: 03-MAY-2011 08:47
FILE: \\mrl-dfs1\organization\ED2\Public\CAD\Civil\112546\CAD\Electrical Folder\112546e502.dgn

FINAL SUBMITTAL

*** SAFETY PAYS ***



ONE-LINE DIAGRAM - PUMP PLANT #1
SCALE: NTS

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Location	Date	Approved

Designed by: J. LINNAS
Date: APRIL 2011
Drawn by: M. MALUFIC
Scale: NONE
Checked by: J. DOBSON
Drawing Code:
S. JENNINGS
Project Engineer/Architect
Title:

PUMP PLANT #1 ONE LINE DIAGRAM

CPND (RIVER BENDS) INC
PUMP PLANT #1 (PP#1)
(PADUCAH, KENTUCKY) (PPP)
FLOOD PROTECTION PROJECT
CONTRACT 13-P-9

SHEET REFERENCE NUMBER:
E601
SHEET 92 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:47
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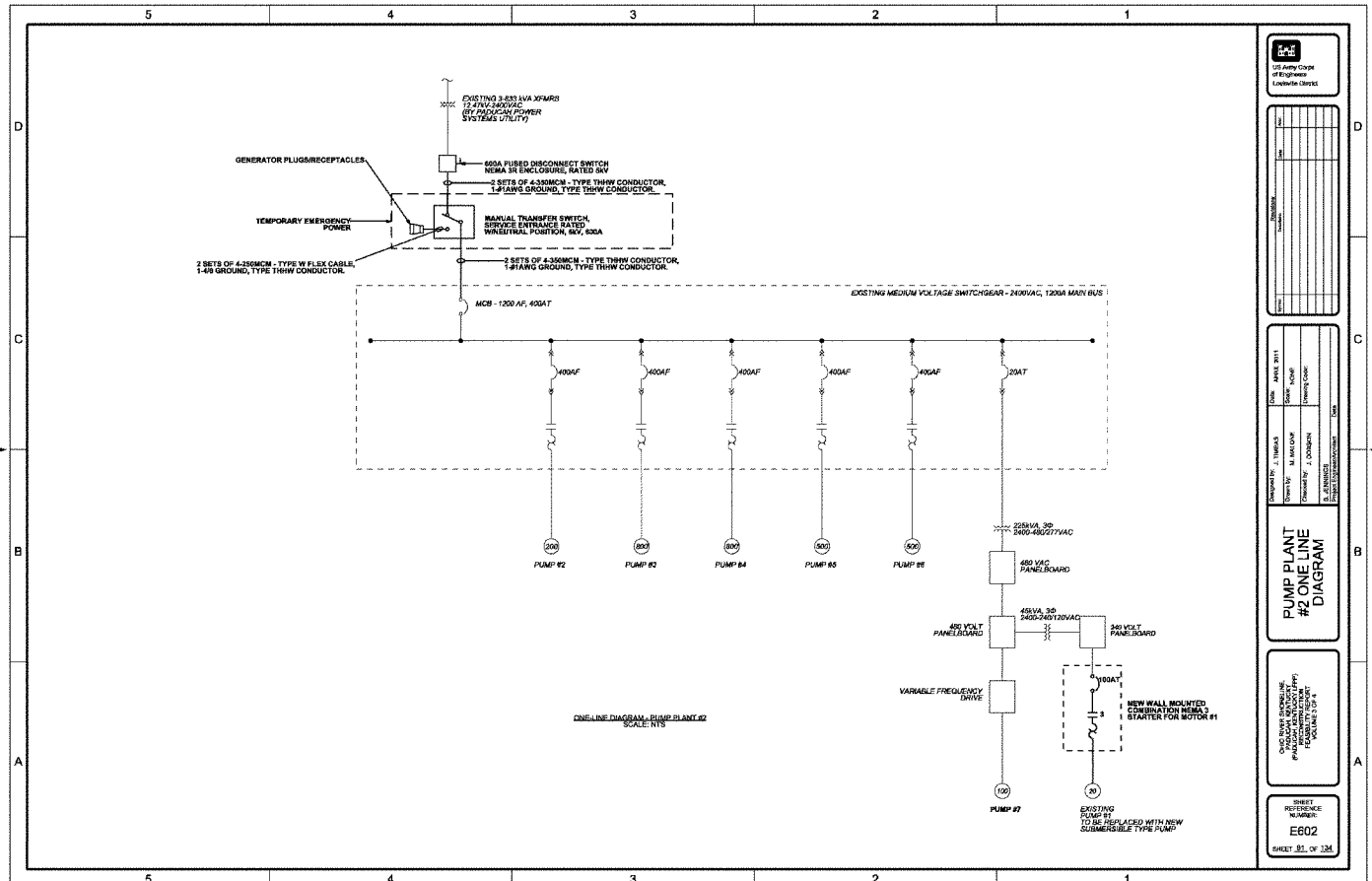
FINAL SUBMITTAL



DATE: 03-MAY-2011 08:47
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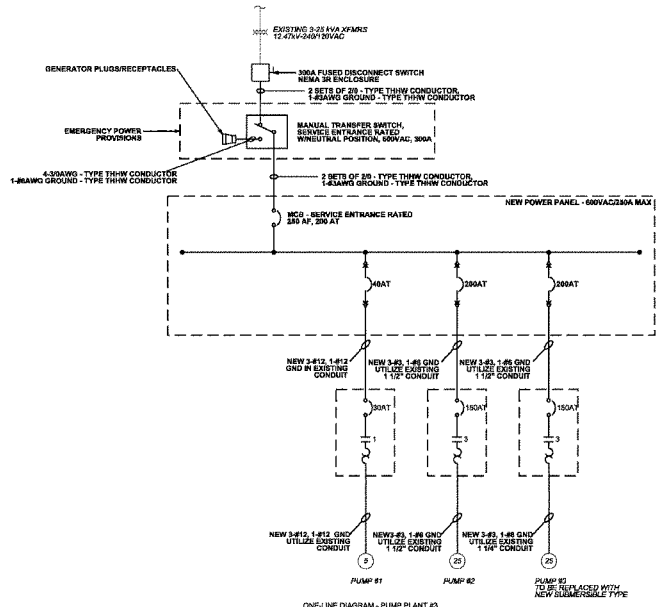
FINAL SUBMITTAL



ONE-LINE DIAGRAM - PUMP PLANT #3
SCALE: NTS

US Army Corps of Engineers
Louisville DISTRICT

Revisions			
Symbol	Location	Date	Year

Designed by: J. LINKAS
Date: APRIL 2011
Drawn by: M. MALOVIC
Scale: NONE
Checked by: J. DOBSON
Drawing Code:
S. JENNINGS
Project Engineer/Architect
Title

PUMP PLANT #3 ONE LINE DIAGRAM

OHIO RIVER SHIPPING INC.
(FORMERLY ALLIED TERMINALS)
(PACKAGE INSTALLED TPP)
FOOT OF 12th STREET
OWENSBORO, KY

SHEET REFERENCE NUMBER:
E603

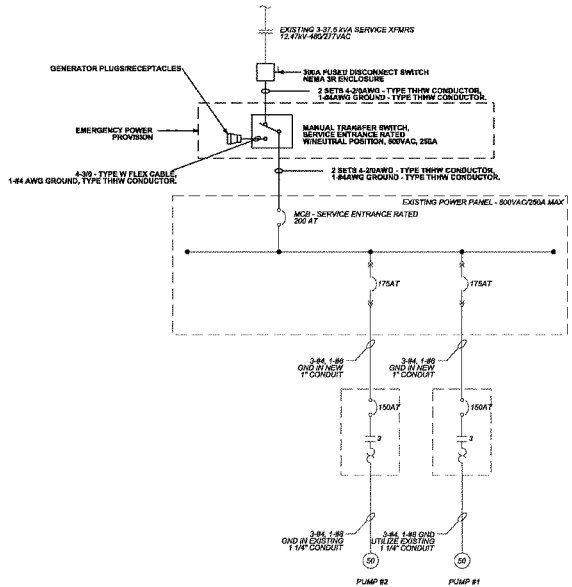
SHEET 62 OF 134

FINAL SUBMITTAL

DATE: 03-MAY-2011 08:47
FILE: \\mirl-dfs1\organization\ED2\Public\CAD\civil\112546\CADD\Electrical Folder\112546E603.dgn

NOTES:

1. PUMP PLANT #4 CHANGES:
   - PROVIDE MANUAL TRANSFER SWITCH, FUSED DISCONNECT, AND GENERATOR RECEPTACLE TO CONNECT STATION TO 100kW EMERGENCY GENERATOR RENTED BY CITY OF PADUCAH.



ONE-LINE DIAGRAM - PUMP PLANT #4
SCALE: NTS

US Army Corps of Engineers
Louisville District

Symbols	Description	Date	Rev

Designed by: J. THOMAS
Drawn by: M. MALONE
Checked by: J. DODSON
Date: APRIL 2011
Scale: NONE
Drawing Code:
S. JENNINGS
Project Engineer/Architect
Date

PUMP PLANT #4 ONE LINE DIAGRAM

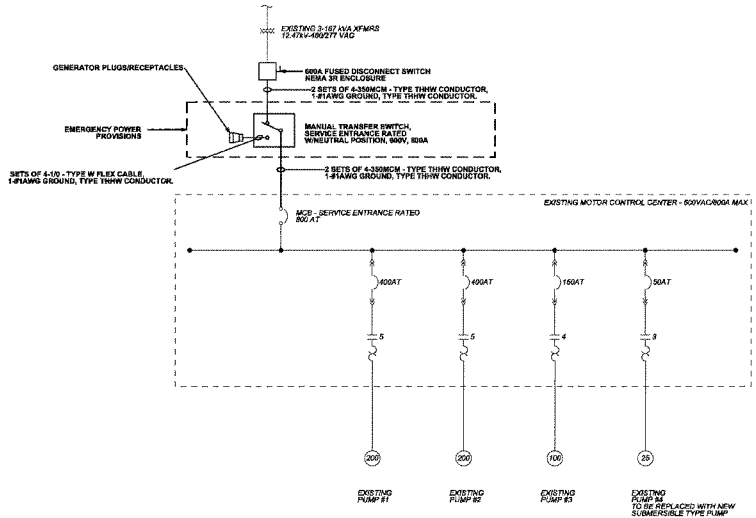
OHIO RIVER SHORELINE
PUMP PLANT #4 (PP#4)
(PADUCAH, KENTUCKY (PPP))
FLOOD PROTECTION
CABLE TV SET
MARSHALL, KY

SHEET REFERENCE NUMBER:
E604
SHEET 83 OF 134

DATE: 03-MAY-2011 08:47
FILE: \\mirf-dfs1\organization\ED2\Mobile\CAD\Civil\112546\CADD\Electrical Folder\112546e604.dgn

FINAL SUBMITTAL

*** SAFETY PAYS ***



ONE-LINE DIAGRAM - PUMP PLANT #5
SCALE: NTS

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Appr.

Designed by: J. TIMMS
Drawn by: M. MULTNIF
Checked by: J. DOBSON
Date: APRIL 2011
Scale: NONE
Drawing Code:
Project Engineer/Architect: B. JENNINGS
Date

PUMP PLANT
#5 ONE LINE
DIAGRAM

DAD RIVER BYPASS INC.
MISSISSIPPI RIVER
(PADDEN, CHIPPIDOCK) (PP#)
FLOOD CONTROL
FLOOD WALL TO PP#
COLUMBUS, KY

SHEET
REFERENCE
NUMBER:
E605
SHEET 84 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:47
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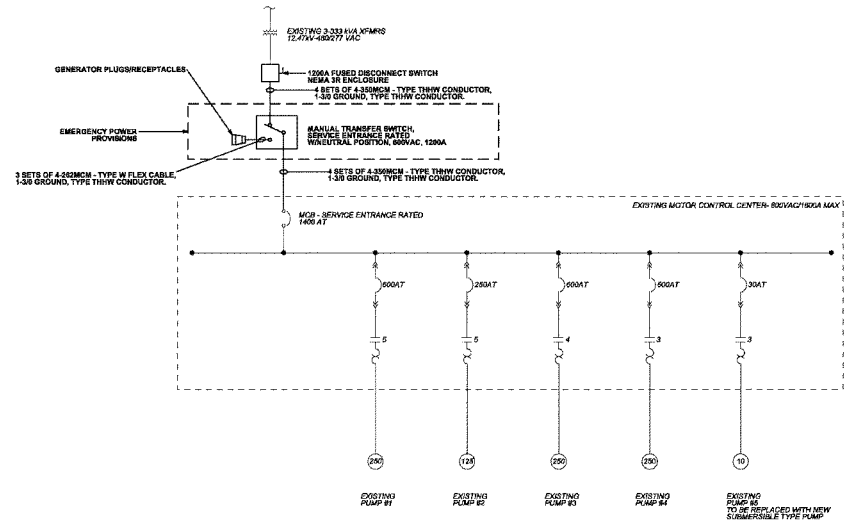

ONE-LINE DIAGRAM - PUMP PLANT #6
SCALE: NTS

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Approved

Designed by: J. LIMBAG
Drawn by: M. MALUSE
Checked by: J. DOBSON
Date: APRIL 2011
Scale: NONE
Drawing Code:
S. JENNINGS
Project Engineer/Architect
Date

PUMP PLANT #6 ONE LINE DIAGRAM

OHIO RIVER SHIPPING INC.
MILEPOST 0.0 OHIO RIVER
(PADUCAH, KENTUCKY TPP)
FLOOD PROTECTION PROJECT
CAIRO, IL 62401

SHEET REFERENCE NUMBER:
E606
SHEET 89 OF 134

DATE: 03-MAY-2011 08:47
FILE: *#irl-dfs1*organizations*ED2*Public*CAD*Civil*112546*CADD*Electrical Folder*112546606.dgn

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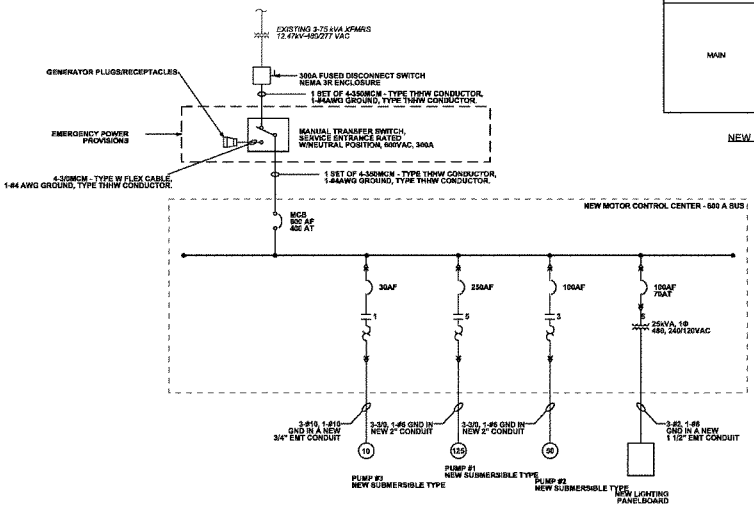

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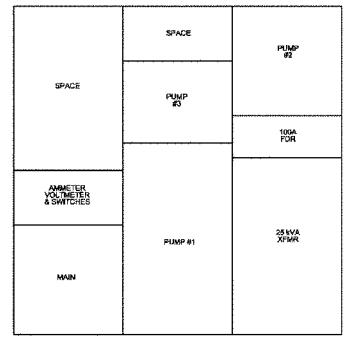
SCALE: NTS



NEW MOTOR CONTROL CENTER ELEVATION
PUMP PLANT #7
SCALE: NTS

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Location	Date	Description

Designed by J. DUPAS
Date APRIL 2011
Drawn by M. MATCHT
Scale NONE
Checked by J. DOBSON
Drawing Code
S. JENNINGS
Project Engineer/Architect
Date

PUMP PLANT #7 ONE LINE DIAGRAM

OHIO RIVER SHIPPING INC.
MAYFIELD, KENTUCKY (PPP)
FLOOD WALL & PUMP
CAPACITY 75 CFS
SHEET 1 OF 1

SHEET REFERENCE NUMBER:
E607
SHEET 36 OF 134

DATE: 03-MAY-2011 08:47
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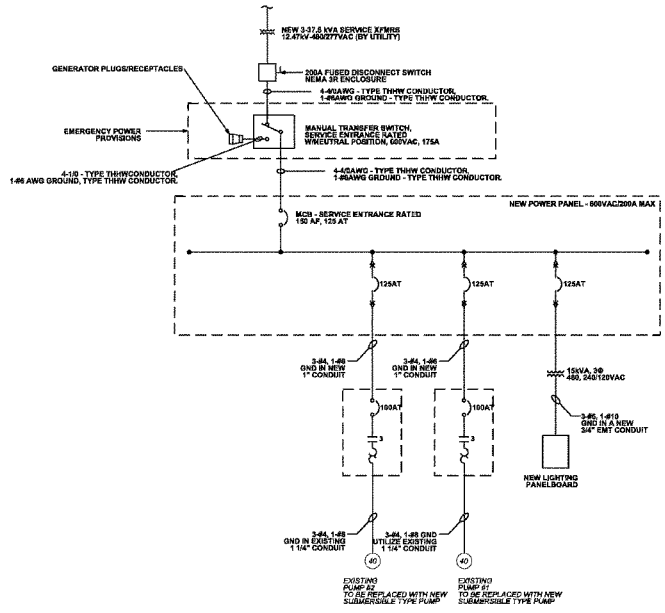
FINAL SUBMITTAL



ONE-LINE DIAGRAM PUMP PLANT #9
SCALE: NTS

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Approved

Designed by: J. LIBBAS
Date: APRIL 2011
Drawn by: M. MAUDIE
Scale: NONE
Checked by: J. DOBSON
Drawing Code:
Project Engineer/Architect: S. JENNINGS
Date:

PUMP PLANT #9 ONE LINE DIAGRAM

OHIO RIVER SHEPHERD (MC) MAINTENANCE CENTER (PACKER CENTRALIZED FIRM) FRANKFORT, KENTUCKY
KENTUCKY, 40601

SHEET REFERENCE NUMBER:
E608

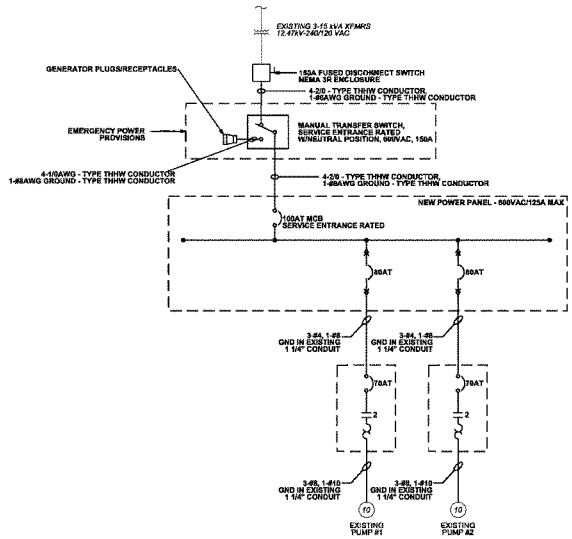
SHEET 87 OF 134

DATE: 03-MAY-2011 08:47
FILE: \\lrl-dfs1\organization\CD2\Public\CAD\Civil\112546\CAD\Electrical Folder\112546e608.dgn

FINAL SUBMITTAL

NOTES:

1. PUMP PLANT #10 CHANGES:
   - PROVIDE MANUAL TRANSFER SWITCH, FUSED DISCONNECT, AND GENERATOR RECEPTACLE TO CONNECT STATION TO 40kW EMERGENCY GENERATOR RENTED BY CITY OF PADUCAH.
   - PROVIDE NEW WALL MOUNTED MOTOR STARTER COMBINATION CIRCUITS FOR BOTH PUMP MOTORS. BOTH STARTERS SHALL BE NEMA 2 SIZE.
   - CONTROL INSTRUMENTATION SHALL BE PROVIDED TO PROVIDE AUTOSHUTOFF FOR PUMP CONTROL.



ONE-LINE DIAGRAM - PUMP PLANT #10
SCALE: NTS

US Army Corps of Engineers
Louisville District

Revisions			
Symbol	Location	Date	Approved

Designed by: J. LINNAS
Drawn by: M. MAUCKE
Checked by: J. DOBSON
Date: APRIL 2011
Scale: NONE
Drawing Code:
S. JENNINGS
Project Engineer/Architect
Date

PUMP PLANT #10 ONE LINE DIAGRAM

OHIO RIVER SHORELINE
PROTECTION PROJECT
(PADUCAH, KENTUCKY FPP)
FLOODWALL SECTION
KUSSEMA TO P-9

SHEET REFERENCE NUMBER:
E609
SHEET 98 OF 134

DATE: 03-MAY-2011 08:47
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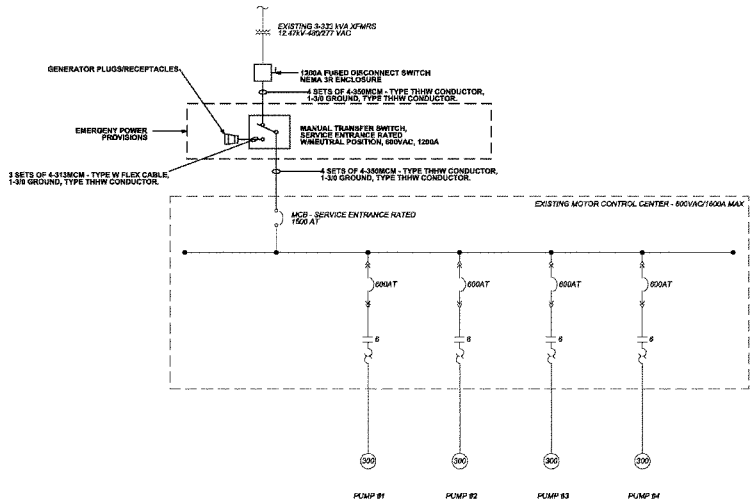


ONE LINE DIAGRAM - PUMP PLANT #11
SCALE: NTS

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Appr

Designed by J. THOMAS
Drawn by M. MALONE
Checked by J. DOBSON
Project Engineer/Architect R. JOHNSON
Date APRIL 2011
Scale NONE
Drawing Code
Date

PUMP PLANT #11 ONE LINE DIAGRAM

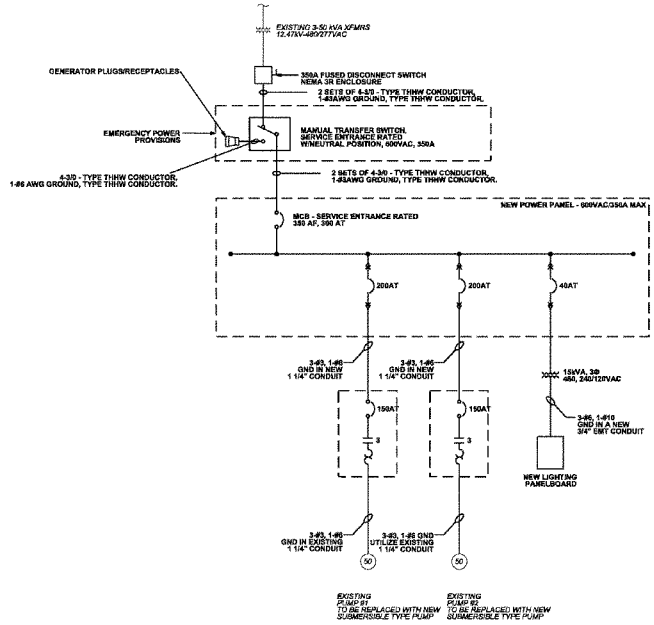
OHIO RIVER SHIPPING INC.
BARGE LOADING FACILITY
#PUMP PLANT #11 (TYPICAL)
FEASIBILITY REPORT
SCALE: NTS

SHEET REFERENCE NUMBER:
E610

SHEET 89 OF 134

DATE: 03-MAY-2011 08:47
FILE: \\mirl-dfs1\organization\ED2\Public\CAD\Activ\#112546\CAD\Electrical folder\112546E610.dgn

FINAL SUBMITTAL



ONE-LINE DIAGRAM - PUMP PLANT # 12
SCALE: NTS

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Approved

Designed by: J. TIBBS
Drawn by: M. MALOUIC
Checked by: J. DICKSON
Date: APRIL 2011
Scale: NONE
Drawing Code:
S. JENNINGS
Chief of Contracting Section

PUMP PLANT
#12 ONE LINE
DIAGRAM

OHIO RIVER BARGES INC.
PAGE KY LOCK & DAM
(PAGESON, KENTUCKY) (TPP)
FUEL FACILITY REPORT
VOLUME 2 OF 4

SHEET
REFERENCE
NUMBER:
E611

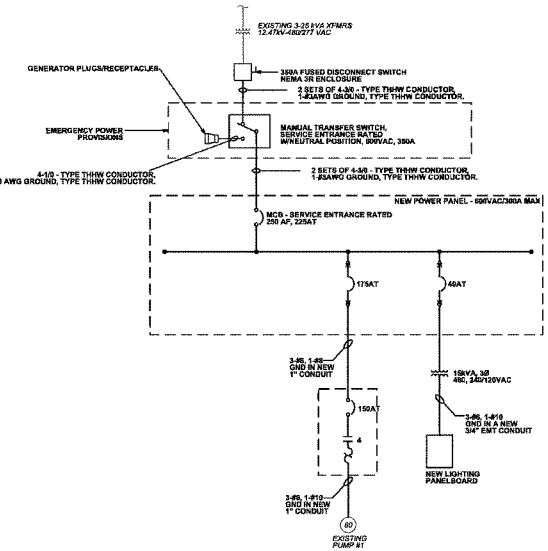
SHEET 80 OF 134

DATE: 03-MAY-2011 08:47
FILE: #mirl-dfs1#organization#ED2#Public#CADD#C:\11#112546#CADD#Electrical Folder#112546e611.dgn

FINAL SUBMITTAL

NOTES:

1. PUMP PLANT #13 CHANGES
   - PROVIDE NEW MANUAL TRANSFER SWITCH, FUSED DISCONNECT, AND NEW EMERGENCY POWER RECEPTACLES TO CONNECT STATION TO ROAM EMERGENCY GENERATOR NEXTED BY CITY OF PADUCAH
   - PROVIDE NEW WALL MOUNT MOTOR STARTER COMINATION CIRCUIT FOR PUMP MOTOR
   - PROVIDE NEW CONTROL SWITCHES FOR PUMP CONTROL AND OPERATION.



ONE-LINE DIAGRAM - PUMP PLANT #13
SCALE: NTS

US Army Corps of Engineers
Louisville District

Revisions			
Symbol	Description	Date	Appr

Designed by: J. LINDAS
Drawn by: M. MALOVIC
Checked by: J. DOBSON
Date: APRIL 2011
Scale: NONE
Drawing Code:
Project Engineer/Architect: S. JENNINGS
Title:

PUMP PLANT #13 ONE LINE DIAGRAM

OHIO RIVER SHORELINE
PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY (PPK))
FLOODWALL SYSTEM
KENTUCKY

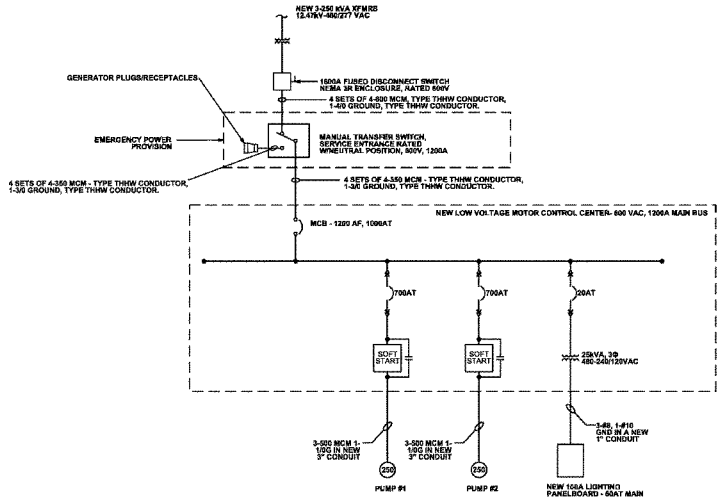
SHEET REFERENCE NUMBER:
E612
SHEET 91 OF 134

DATE: 03-MAY-2011 08:47
FILE: #AIT1-dfs1#organization#ED2#Public#CAD#civil#112546#CADD#Electrical Folder#112546612.dgn

FINAL SUBMITTAL

NOTES:

1. PUMP STATION EMERGENCY POWER PROVISIONS SHALL BE SIZED FOR A 1293KW, MEDIUM VOLTAGE GENERATOR TO BE RENTED BY CITY OF PADUCAH.



ONE-LINE DIAGRAM - PROPOSED PUMP PLANT #14 SUBMERSIBLE PUMPS
SCALE: NTS

US Army Corps of Engineers
Louisville District

Symbol	Description	Date	Appr.

Designed by: J. HIBBARD
Drawn by: M. MALONE
Checked by: J. DOBSON
Date: APRIL 2011
Scale: NONE
Drawing Code:
S. JENNINGS
Chief Engineering/Architecture
Date

PROPOSED PUMP PLANT #14 (SUBMERS. TYPE)

CPKC RIVER SHORES INC
(PADUCAH, KENTUCKY FPP)
PADUCAH, KENTUCKY
FLOOD WALL SYSTEM

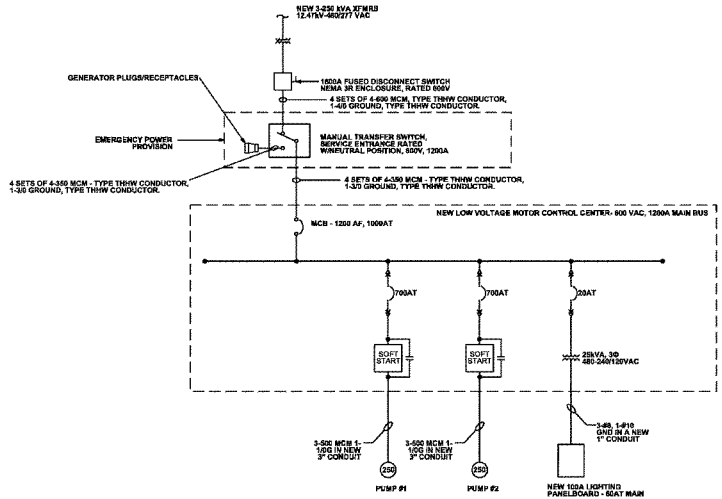
SHEET REFERENCE NUMBER:
E613
SHEET 92 OF 134

DATE: 03-MAY-2011 08:47
FILE: *Wirl-Ofs1*Organization*CO2*Public*CADD*Civil*112546*CADD*Electrical Folder*112546e613.dgn

FINAL SUBMITTAL

NOTES:

1. PUMP STATION EMERGENCY POWER PROVISIONS SHALL BE SIZED FOR A 1250kW MEDIUM VOLTAGE GENERATOR TO BE RENTED BY CITY OF PADUCAH.



ONELINE DIAGRAM - PROPOSED PUMP PLANT #14 VERTICAL COLUMN PUMPS
SCALE: NTS

US Army Corps of Engineers
Louisville District

Symbol	Description	Date	Rev
	Revisions		
	Location		

Designed by: J. HUMAS
Drawn by: M. MALONE
Checked by: J. DOBSON
Approved by: S. JENNINGS
Project Engineer/Architect
Date: APRIL 2011
Scale: NONE
Drawing Code:

PROPOSED PUMP PLANT #14 (VERT. COLUMN)

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (FRP) FLOOD PROTECTION PROJECT, SEGMENT 3 OF 4

SHEET REFERENCE NUMBER:
E614
SHEET 99 OF 134

DATE: 02-MAY-2011 08:47
FILE: #airl-dfs1#organization#ED2#Public#CAD#civil#112546#CADD#Electrical Folder#112546e614.dgn

FINAL SUBMITTAL

*** SAFETY PAYS ***

UNIFIED SOIL CLASSIFICATION
(INCLUDING IDENTIFICATION AND DESCRIPTION)

MAJOR DIVISIONS (1)	MAJOR DIVISIONS (2)		GROUP SYMBOLS (3)	TYPICAL NAMES (4)	FIELD IDENTIFICATION PROCEDURES (EXCLUDING PARTICLES LARGER THAN 3 INCHES AND BASING FRACTIONS ON ESTIMATED WEIGHTS) (5)
COARSE-GRAINED SOILS MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE. THE NO. 200 SIEVE SIZE IS ABOUT THE SMALLEST PARTICLE VISIBLE TO THE NAKED EYE.	GRAVELS MORE THAN HALF OF COARSE FRACTION IS LARGER THAN NO.4 SIEVE SIZE. (FOR VISUAL CLASSIFICATION, THE ¼" SIZE MAY BE USED AS EQUIVALENT TO THE NO. 4 SIEVE SIZE)	CLEAN GRAVELS (LITTLE OR NO FINES)	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OF NO FINES.	WIDE RANGE IN GRAIN SIZES AND SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES.
		CLEAN GRAVELS (LITTLE OR NO FINES)	GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.	PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING.
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES.	NONPLASTIC FINES OF FINES WITH LOW PLASTICITY (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES.	PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)
	SANDS MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO.4 SIEVE SIZE.	CLEAN SANDS (LITTLE OR NO FINES)	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES.	WIDE RANGE IN GRAIN SIZE AND SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES.
		CLEAN SANDS (LITTLE OR NO FINES)	SP	POORLY-GRADED SANDS GRAVELLY SANDS, LITTLE OR NO FINES.	PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING.
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES.	NONPLASTIC FINES OR FINES WITH PLASTICITY (FOR IDENTIFICATION PROCEDURES SEE ML BELOW).
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	SC	CLAYEY SANDS, AND-CLAY MIXTURES.	PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW).

IDENTIFICATION PROCEDURES ON FRACTION SMALLER THAN NO. 40 SIEVE SIZE.

MAJOR DIVISIONS (1)	MAJOR DIVISIONS (2)	GROUP SYMBOLS	TYPICAL NAMES	DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PL)
FINE-GRAINED SOILS MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE. THE NO. 200 SIEVE SIZE IS ABOUT THE SMALLEST PARTICLE VISIBLE TO THE NAKED EYE.	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS,ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY.	NONE TO SLIGHT	QUICK TO SLOW	NONE
		CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS.	MEDIUM TO HIGH	NONE TO VERY SLOW	MEDIUM
		OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.	SLIGHT TO MEDIUM	SLOW	SLIGHT
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS. ELASTIC SILTS.	SLIGHT TO MEDIUM	SLOW TO NONE	SLIGHT TO MEDIUM
		CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.	HIGH TO VERY HIGH	NONE	HIGH
		OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.	MEDIUM TO HIGH	NONE TO VERY SLOW	SLIGHT TO MEDIUM
HIGHLY ORGANIC SOILS		PT	PEAT AND OTHER HIGHLY ORGANIC SOILS.	READILY IDENTIFIED BY COLOR, ODOR, SPONGY FEEL AND FREQUENTLY BY FIBROUS TEXTURE.		

LABORATORY CLASSIFICATION CRITERIA (6)

USE GRAIN-SIZE CURVE IN IDENTIFYING THE FRACTIONS AS GIVEN UNDER FIELD IDENTIFICATION.

DETERMINE PERCENTAGES OF GRAVEL AND SAND FROM GRAIN-SIZE CURVE. DEPENDING ON PERCENTAGE OF FINES (FRACTION SMALLER THAN NO. 200 SIEVE SIZE) COARSE-GRAINED SOILS ARE CLASSIFIED AS FOLLOWS:
LESS THAN 5% GW, GP, SW, SP.
MORE THAN 12% GM, GC, SM, SC.
5% TO 12% BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS.

GW: $C_U = \frac{D_{60}}{D_{10}}$ GREATER THAN 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN ONE AND 3

GP: NOT MEETING ALL GRADATION REQUIREMENTS FOR GW

GM: ATTERBERG LIMITS BELOW "A" LINE WITH PI LESS THAN 4

GC: ATTERBERG LIMITS ABOVE "A" LINE WITH PI GREATER THAN 7

ABOVE "A" LINE WITH PI BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS.

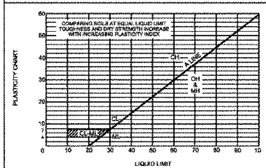
SW: $C_U = \frac{D_{60}}{D_{10}}$ GREATER THAN 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN ONE AND 3

SP: NOT MEETING ALL GRADATION REQUIREMENTS FOR SW

SM: ATTERBERG LIMITS BELOW "A" LINE WITH PI LESS THAN 4

SC: ATTERBERG LIMITS ABOVE "A" LINE WITH PI GREATER THAN 7

LIMITS PLOTTING IN HATCHED ZONE WITH PI BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS.



PLASTICITY CHART

FOR LABORATORY CLASSIFICATION OF FINE-GRAINED SOILS

GENERAL NOTES

1. REFUSAL IS DEFINED AS THE POINT BEYOND WHICH FURTHER PENETRATION WAS IMPRACTICAL WITH THE EXPLORATION METHOD USED. SEE "METHODS OF EXPLORATION" THIS SHEET INDICATING MEANS BY WHICH THE BORINGS WERE ADVANCED.
2. WATER ELEVATIONS INDICATED (V..EIN CORE (C), STANDARD PENETRATION (SPT), FISHTAIL (F), DENISON (U) AND WASH (W) BORINGS MAY HAVE BEEN INFLUENCED BY DRILLING OPERATIONS AND SHOULD NOT BE CONSTRUED AS INDICATING THE TRUE GROUND WATER LEVEL.
3. GROUND WATER LEVELS WILL VARY IN ACCORDANCE WITH RAINFALL AND STREAM STAGES, THEREFORE, ACTUAL LEVEL OF GROUND WATER ON ANY DATE OTHER THAN THAT SHOWN ON THE LOGS MUST BE DETERMINED BY SEPARATE OBSERVATIONS. THE OMISSION OF GROUND WATER ELEVATIONS SHALL NOT NECESSARILY BE CONSTRUED AS INDICATING THE ABSENCE OF GROUND WATER AT A PARTICULAR BORING LOCATION.
4. WHEREVER THE METHOD OF EXPLORATION PRECLUDED THE POSSIBILITY OF RECOVERING SAMPLES ABOVE ROCK, SUITABLE FOR EXAMINATION OR TESTS, THE MATERIAL IS DENOTED AS OVERBURDEN.
5. CLASSIFICATIONS AND PHYSICAL CHARACTERISTICS OF SOIL AND ROCK AS SHOWN ON THE LOGS WERE DETERMINED IN THE FIELD AND LATER SUPPLEMENTED BY ANALYSIS MADE BY THE DISTRICT GEOLOGIST AND THE LABORATORY TECHNICIANS.
6. FIELD BOOKS, FIELD LOGS, LABORATORY LOGS (PRESENTING THE RESULTS OF LABORATORY TESTS FOR SHEAR, CONSOLIDATION, PERMEABILITY, ETC. WHEN PERFORMED) AND EDITED LOGS MAY BE VIEWED IN THE OFFICE OF THE DISTRICT ENGINEER, U.S. ARMY ENGINEER DISTRICT, LOUISVILLE, CORPS OF ENGINEERS, FEDERAL OFFICE BUILDING, LOUVILLE, KY. FAILURE OF THE CONTRACTOR TO AVAIL HIMSELF OF THE INFORMATION REPRESENTED BY THE BORING LOGS, INCLUDING LABORATORY TEST RESULTS, SHALL NOT BE GROUNDS FOR A CLAIM THAT THE GOVERNMENT WITHELD INFORMATION ON SUBSURFACE CONDITIONS.
7. THE TERM "LOST WATER" AS SHOWN ON THE LOGS INDICATES A QUANTITY OF DRILLING WATER LOST IN THE DRILL HOLE.
8. DRIVE SAMPLES WERE TAKEN WITH A 1 3/8" I.D. 2" O.D. X 2'-6" SPLIT SPOON SAMPLER USING A 140# HAMMER WITH A 30" DROP, UNLESS OTHERWISE INDICATED ON GRAPHIC LOGS.
9. CORE HOLES WERE COMPLETED BY AN NXM OR NQ WIRE LINE SIZE CORE BARREL WITH DIAMOND BIT, UNLESS OTHERWISE INDICATED ON THE GRAPHIC LOG.
10. WATER CONTENT (WC) AS SHOWN ON GRAPHIC LOG REPRESENTS THE MOISTURE CONTENT OF MATERIAL ON DATE MADE.
11. "X-RAY DIFFRACTION ANALYSIS" PERFORMED ON SAMPLES DENOTED BY DOUBLE ASTERISK.
12. TOP OF GROUND SHOWN ON THE GRAPHIC LOGS IS THE ELEVATION AT THE TIME OF DRILLING. THE ELEVATION MAY HAVE CHANGED SINCE THAT TIME.
13. OPTIMUM MOISTURE WAS OBTAINED BY STANDARD PROCTOR OR CE 56 COMPACTION TESTS IN ACCORDANCE WITH EM 1110-2-1906, APP. VI OR MIL. STD. 621 A METHOD 100 RESPECTIVELY, AS NOTED ON BORING LOG.
14. THE LETTER DESIGNATION USED BEFORE BORING NUMBER INDICATES THE METHOD OF EXPLORATION FOR EXAMPLE: DC=DRIVE SAMPLER AND CORE BORING.

    DC-10 / 7-20-56 = BORING NO. & DATE MADE
15. GENERAL NOTES 5 AND 6 MAY NOT BE APPLICABLE WHEN EXPLORATION AND TESTING IS PERFORMED BY OTHERS.

WEATHERING

SEVERE WEATHERING - LOSS OF ROCK COHERANCE, MATERIAL CAN BE REMOVED BY HAND TOOLS. RETAINES SOME EVIDENCE OF ROCK STRUCTURE

MODERATE WEATHERING - MATERIAL MAY BE OXIDIZED BUT MOST PHYSICAL CHARACTERISTIC REMAIN. OCCASIONAL BLOCKS MAY BE REMOVED WITH HAND TOOLS.

SLIGHT WEATHERING - MATERIAL GENERALLY FRESH, WITH VARIOUS DEGREES OF WEATHERING ALONG JOINTS AND BEDDING.

TERMS FOR HARDNESS OF BEDROCK

VERY SOFT OR PLASTIC- CAN BE INDENTED EASILY WITH THUMB.

SOFT- CAN BE SCRATCHED WITH FINGERNAIL.

MODERATELY HARD- CAN BE SCRATCHED EASILY WITH KNIFE; CANNOT BE SCRATCHED WITH FINGERNAIL.

HARD- DIFFICULT TO SCRATCH WITH KNIFE.

VERY HARD- CANNOT BE SCRATCHED WITH KNIFE.

TERMS FOR THICKNESS OF ROCK BEDDING

PARTING	< 0.02'
BAND	0.02'-0.2'
THIN BED	0.2'-0.5'
MEDIUM BED	0.5'-1.0'
THICK BED	1.0'-3.0'
MASSIVE	> 3.0'

CORRELATION OF PENETRATION RESISTANCE (ASTM D 1586) WITH RELATIVE DENSITY AND CONSISTENCY

PENETRATION RESISTANCE,N Blows per foot	RELATIVE DENSITY	PENETRATION RESISTANCE,N Blows per foot	
0 - 4	Very Loose	0 - 2	Very Soft
5 - 10	Loose	3 - 4	Soft
SANDS AND 11 - 30	Med Dense	SILTS AND 5 - 8	Med Stiff
GRAVELS 31 - 50	Dense	CLAYS 9 - 15	Stiff
Over 50	Very Dense	16 - 30	Very Stiff
		31+	Hard

LEGEND

F = FILL
T = TOP SOIL
OB = OVERBURDEN (SEE GENERAL NOTE 4)
SS = SANDSTONE
SH = SHALE
SLS = SILTSTONE
LS = LIMESTONE
CO = COAL
UC = UNDERCLAY
IC = INDURATED CLAY
DOL = DOLOMITE
CON = CONGLOMERATE
QTZ = QUARTZ
RQD = ROCK QUALITY DESIGNATION
NOD = NODULES
GRAV = GRAVEL OR GRAVELLY
LT = LIGHT
DK = DARK
SL = SLIGHTLY
MOD = MODERATELY
MED = MEDIUM
TR = TRACE
HD = HARD
NUM = NUMEROUS
WOR = WEIGHT OF RODS
WOH = WEIGHT OF HAMMER
WT = WEIGHT
VIS = VISCOSITY (MARSH)

WP = WELL POINT
(W) = WEATHERED
W/ = WITH
GR = GRAIN
OCC = OCCASIONAL
BD = BEDDED OR BEDS
INTBD = INTERBEDDED
LAM = LAMINAE
XLYN = CRYSTALLINE
ARGL = ARGILLACEOUS
V = VERY
BLK = BLACK
BR = BROWN
GRY = GRAY
BLU = BLUE
GRN = GREEN
YEL = YELLOW
OBP = OPEN BEDDING PLANE
CAL = CALCAREOUS
CARBO = CARBONACEOUS
FREQ = FREQUENT
FOS = FOSSILIFEROUS
CMTD = CEMENTED
MOT = MOTTLED
FRAG = FRAGMENTS

DIAG = DIAGONAL
ALT = ALTERNATING
VERT = VERTICAL
HOR = HORIZONTAL
FRAC = FRACTURE
X-BD = CROSSBEDDING
SP = SHEAR PLANE
VJ = VERTICAL JOINT
JT = JOINT
SOL = SOLUTION
(hatched symbol) = CAVITY (OPEN OR FILLED)
MICA = MICACEOUS
STY = STYLOLITIC
BP = BEDDING PLANE
FW = FREE WATER
HA = HIGH ANGLE
PIEZ = PIEZOMETER
BOH = BOTTOM OF HOLE
TOR = TOP OF ROCK
ST = STAIN, STAINED
ANG = ANGULAR
RND = ROUNDED
** = X-RAY DIFFRACTION ANALYSIS (SEE GENERAL NOTE 11)

METHODS OF EXPLORATION

VEL = SEISMIC
S = SHELBY TUBE OR PISTON SAMPLER
HA = HAND AUGER
A = POWER AUGER
C = CORE BORING
D = DRIVE SAMPLER
F = FISHTAIL
U = UNDISTURBED DENISON
W = WASH BORING
T = TRENCH
TP = TEST PIT
R = ROCK BIT
P = PROBE ROD

SOIL DESCRIPTIVE TERMS

SOIL DESCRIPTIVE TERMS	SIZE
BOULDER	>8 INCHES
COBBLE	3 INCHES TO 8 INCHES
COARSE GRAVEL	3/4 INCH TO 3 INCH
FINE GRAVEL	#4 INCH TO 3/4 INCH
COARSE SAND	2 MM TO 1 ... INCH
MEDIUM SAND	0.4 MM TO 2 MM
FINE SAND	0.075 MM TO 0.4 MM
TRACE	1 TO 10%
OCCASIONAL	11 TO 35%
AND	35 TO 50%
LAMINAE	2 TO 10 MM
LENSE	10 MM TO 50 MM
BAND	50 MM TO 2.5 INCH
LAYER	2.5 INCH TO 6 INCH+

SAMPLE TYPE

DS = DRIVE SAMPLE (STANDARD PENETRATION TEST)
S = UNDISTURBED SHELBY TUBE
A = AUGER
F = FISHTAIL
U = UNDISTURBED DENISON
CU = UNDISTURBED CLAY
C = CORE
J = JAR
BX = BOX (CORE)

US Army Corps of Engineers Louisville District

Revisions: Symbol | Description | Date | Appr.

Designed by: S. ALSIP | Date: APRIL 2011
Drawn by: C. ROBINSON | Scale: NONE
Checked by: R. WHEELER | Drawing Code:
B. JENNINGS, Project Engineer/Architect | Date

SOIL AND ROCK CLASSIFICATION SHEET

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LPPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 3 OF 4

SHEET REFERENCE NUMBER: G001

SHEET 94 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:47
FILE: ...112546g001.dgn

FINAL SUBMITTAL

BORING NO. **AD-1** SHEET 1 OF 2

1. PROJECT: Paducah LTPP Feasibility Study	11. DATUM FOR ELEVATION SHOWN (TBM OR MSL): MSL
2. LOCATION: N: 1002350.31 E: 400556.39	12. DRILL METHOD: 3 5/8" I.D. HSA, 1" Spoon, 2" Tube
3. DRILLING AGENCY: Florence & Hutcheson, Inc.	13. ELEVATION TOP OF HOLE: 318
4. NAME OF DRILLER: D. Harbor	14. TOTAL NUMBER CORE BOXES: N/A
5. DRILL TYPE: CME 45C	15. ELEVATION GROUND WATER: 313.34 hr.
6. THICKNESS OF OVERBURDEN: 25.5	16. DATE HOLE: STARTED 6/8/09 COMPLETED 6/9/09
7. DEPTH DRILLED INTO ROCK: N/A	17. INSPECTOR:
8. TOTAL DEPTH OF HOLE: 25.5	
9. DIRECTION OF HOLE: VERTICAL ☒ INCLINED ☐ ___ DEG. FROM VERT.	

ELEVATION	CLASSIFICATION OF MATERIALS	LEGEND	PLACE CODE	UNIFIED CLASS	SAMPLE TYPE	BLOWS PER 6 INCH	WATER LINE (%)	PENETRATION	RECOVERY (%)	RQD (%)	REMARKS	DEPTH SCALE (FT)
313.3	Brown, gray & tan, lean CLAY.	CL	1	D	2 / 3 / 3	28.8	1.6				Poor recovery, rock in end of spoon.	0
			2	D	1 / 2 / 3	19.0	1.5					1
			3	D	3 / 4 / 4	29.0	1.6					2
310.3	Large, gray & tan, lean CLAY.	CL	4	U		25.1	2.0	60				3
310.0	Brown, clayey GRAVEL with sand.	GC	5	D	5 / 8 / 13	26.7	1.3					4
308.3	Tan, well-graded GRAVEL with clay and sand (and/or silty clay and sand).	GW-GC	6	D	12 / 36 / 36	12.6	1.6					5
305.7	Tan, well-graded SAND with clay and gravel (and/or silty clay and gravel).	SW-SC			9							6

LTL FORM 1259 JUNE 2000 — PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: V - WATER LEVEL AT COMPLETION; > - PARTIAL LOSS OF DRILL FLUID — PROJECT: Paducah LTPP Feasibility Study — HOLE NO. AD-1

BORING NO. **AD-1** SHEET 2 OF 2

1. PROJECT: Paducah LTPP Feasibility Study	11. DATUM FOR ELEVATION SHOWN (TBM OR MSL): MSL
2. LOCATION: N: 1002351.31 E: 400550.79	12. DRILL METHOD: 3 5/8" I.D. HSA, 1" Spoon, 2" Tube
3. DRILLING AGENCY: Florence & Hutcheson, Inc.	13. ELEVATION TOP OF HOLE: 318
4. NAME OF DRILLER: D. Harbor	14. TOTAL NUMBER CORE BOXES: N/A
5. DRILL TYPE: CME 45C	15. ELEVATION GROUND WATER: 313.34 hr.
6. THICKNESS OF OVERBURDEN: 25.5	16. DATE HOLE: STARTED 6/8/09 COMPLETED 6/9/09
7. DEPTH DRILLED INTO ROCK: N/A	17. INSPECTOR:
8. TOTAL DEPTH OF HOLE: 25.5	
9. DIRECTION OF HOLE: VERTICAL ☒ INCLINED ☐ ___ DEG. FROM VERT.	

ELEVATION	CLASSIFICATION OF MATERIALS	LEGEND	UNIFIED CLASS	SAMPLE TYPE	BLOWS PER 6 INCH	WATER LINE (%)	PENETRATION	RECOVERY (%)	RQD (%)	REMARKS	DEPTH SCALE (FT)
	Tan, well-graded SAND with clay and gravel (and/or silty clay and gravel). (continued)		T	D	50	17.0	1.5				21
											22
											23
											24
											25
			S	D	9 / 27 / 28	20.0	1.5				26
	No Auger Refusal & Boring Terminated @ 25.5' (Elev. 292.5).										27
											28
											29
											30
											31
											32
											33
											34
											35
											36
											37
											38
											39

LTL FORM 1259 JUNE 2000 — PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: V - WATER LEVEL AT COMPLETION; > - PARTIAL LOSS OF DRILL FLUID — PROJECT: Paducah LTPP Feasibility Study — HOLE NO. AD-1

US Army Corps of Engineers Louisville District

Revisions

Number	Description	Date	Appr.

Designed by: G. MINGES
Drawn by: C. ROBINSON
Checked by: C. MELTZ
Project Engineer/Architect: D. JENNINGS
Date: APRIL 2011
Scale: NONE
Drawing Code:
Date

BORING LOGS

OHIO RIVER SHIPPING CHANNEL IMPROVEMENTS (PAHUCKY, KENTUCKY) FEASIBILITY STUDY
CONTRACT NO. W912HN-10-D-0001

SHEET REFERENCE NUMBER: G002
SHEET 95 OF 134

FINAL SUBMITTAL

602

DATE: 03-MAY-2011 08:48
FILE: \\irl-dfs1\Organization\ED2\Public\CAD\Civil\112546\CADD\112546g002.dgn

*** SAFETY PAYS ***

BORING NO. **AD-2** SHEET 1 OF 2

1. PROJECT: Paducah LTPP Feasibility Study	11. DATUM FOR ELEVATION SHOWN (TBM OR MSL): MSL
2. LOCATION: N 1022246.44 E 650631.77	
3. DRILLING AGENCY: Plankow & Hutchison, Inc.	12. DRILL METHOD: 3 1/2" I.D. HSA, 1" Spoon
4. NAME OF DRILLER: D. Harder	13. ELEVATION TOP OF HOLE: 315
5. DRILL TYPE: CME 45C	14. TOTAL NUMBER CORE BOXES: N/A
6. THICKNESS OF OVERBURDEN: 35.5	15. ELEVATION GROUND WATER: 315.34 hr
7. DEPTH DRILLED INTO ROCK: N/A	16. DATE HOLE: STARTED 8/6/03 COMPLETED 8/6/03
8. TOTAL DEPTH OF HOLE: 35.5	
9. DIRECTION OF HOLE: VERTICAL ☒ INCLINED ☐ — DEG. FROM VERT.	17. INSPECTOR:

ELEVATION	CLASSIFICATION OF MATERIALS	LEGEND	USCS CLASS	SAMPLE #	SAMPLE TYPE	BLOWS PER 6 INCH	MOISTURE (%)	PENETRATION	RECOVERY (%)	RQD (%)	REMARKS	DEPTH SCALE (FT)
315.0	Brown, lean CLAY with sand.		CL	1	D	2 3 3	21.1	1.0				0 1
				2	D	3 5 2	25.0	1.0				2 3
314.2	Brown & tan, clayey GRAVEL with sand.		GC	3	D	1 3 6	16.3	1.0				4 5 6
				4	D	12 6 17	15.2	1.0				9 10
				5	D	20 26 29	14.8	1.0				14 15
						7						18 19

LRL FORM 1202 JUNE 2000 — PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: V - WATER LEVEL AT COMPLETION; ▽ - PARTIAL LOSS OF DRILL FLUID — PROJECT: Paducah LTPP Feasibility Study — HOLE NO. AD-2

BORING NO. **AD-2** SHEET 2 OF 2

1. PROJECT: Paducah LTPP Feasibility Study	11. DATUM FOR ELEVATION SHOWN (TBM OR MSL): MSL
2. LOCATION: N 1022246.44 E 650631.77	
3. DRILLING AGENCY: Plankow & Hutchison, Inc.	12. DRILL METHOD: 3 1/2" I.D. HSA, 1" Spoon
4. NAME OF DRILLER: D. Harder	13. ELEVATION TOP OF HOLE: 315
5. DRILL TYPE: CME 45C	14. TOTAL NUMBER CORE BOXES: N/A
6. THICKNESS OF OVERBURDEN: 35.5	15. ELEVATION GROUND WATER: 315.34 hr
7. DEPTH DRILLED INTO ROCK: N/A	16. DATE HOLE: STARTED 8/6/03 COMPLETED 8/6/03
8. TOTAL DEPTH OF HOLE: 35.5	
9. DIRECTION OF HOLE: VERTICAL ☒ INCLINED ☐ — DEG. FROM VERT.	17. INSPECTOR:

ELEVATION	CLASSIFICATION OF MATERIALS	LEGEND	USCS CLASS	SAMPLE #	SAMPLE TYPE	BLOWS PER 6 INCH	MOISTURE (%)	PENETRATION	RECOVERY (%)	RQD (%)	REMARKS	DEPTH SCALE (FT)
	Brown & tan, clayey GRAVEL with sand. (continued)			6	D	18	13.1	1.0				20 21
299.5	Gray & tan, silty SAND.		SM									22 23
				7	D	2 7 14	23.2	1.0				24 25
	No Auger Refusal & Boring Terminated @ 35.5' (Elev. 280.31)											26 27 28 29 30 31 32 33 34 35

LRL FORM 1202 JUNE 2000 — PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: V - WATER LEVEL AT COMPLETION; ▽ - PARTIAL LOSS OF DRILL FLUID — PROJECT: Paducah LTPP Feasibility Study — HOLE NO. AD-2

US Army Corps of Engineers Louisville District

Revisions			
Symbol	Description	Date	Appr

Designed by: G. MYNGES — Date: APRIL 2011
Drawn by: C. ROBINSON — Scale: NONE
Checked by: C. HRUTZ — Drawing Code:
S. JENNINGS — Filed in Subdirectory:

BORING LOGS

OHIO RIVER SHORELINE (PADUCAH, KENTUCKY) LTPP FEASIBILITY STUDY

SHEET REFERENCE NUMBER: G003

SHEET 96 OF 134

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:40
FILE: ##ir1-dfs1*organization#ED2#Public#CAD#civil#112546#CADD#112546G003.dgn

*** SAFETY PAYS ***

BORING NO. **AD-3** SHEET 1 OF 3

1. PROJECT: Paducah LTFP Feasibility Study
2. LOCATION: N: 1924318.69 E: 811961.93
3. DRILLING AGENCY: Florence & Hutcheson, Inc.
4. NAME OF DRILLER: D. Hedler
5. DRILL TYPE: CME 45C
6. THICKNESS OF OVERBURDEN: 51
7. DEPTH DRILLED INTO ROCK: N/A
8. TOTAL DEPTH OF HOLE: 51
9. DIRECTION OF HOLE: VERTICAL ☒ INCLINED ☐ ___ DEG. FROM VERT.
10. DATUM FOR ELEVATION SHOWN (TBM OR MSL): MSL
11. DRILL METHOD: 3 5/8" I.D. HSA, 1" Spoon
12. ELEVATION TOP OF HOLE: 359
13. TOTAL NUMBER CORE BOXES: N/A
14. ELEVATION GROUND WATER: 334.74 ft
15. DATE HOLE: STARTED 8/5/09 COMPLETED 8/10/09
16. INSPECTOR: ___

ELEVATION	CLASSIFICATION OF MATERIALS	LEGEND	LOCK CLASS	SAMPLE #	SAMPLE TYPE	BLOWS PER 6 INCH	SPT N-VALUE (N)	PENETRATION	RECOVERY (%)	RQD (%)	REMARKS	DEPTH SCALE (FT)
358.0	Black topsoil, silt & sand.											0
			1	D	2	2	18.8	1.5				1
357.5	Tan, brown, olive & grey, gravelly lean CLAY with sand.	CL										
			2	D	2	1	25.3	1.5				2
			3	D	1	1	35.0	1.5				3
			4	D	1	0	27.9	1.5				4
350.0	Grey & tan, lean CLAY.	CL										9
			5	D	1	1	31.2	1.5				6
			6	D	5	1	28.3	1.5				7
			7	D	3	6	29.6	1.5				8
328.5	Tan & brown, lean CLAY.	CL										11
			8	D	1	2	36.1	1.5				12
			9	D	4	5	34.9	1.5				13
326.5	Tan, lean CLAY.	CL										14
			10	D	2	5	27.5	1.5				15
			11	D	6	7	20.0	1.5				16
			12	D	6	7	22.7	1.5				17
			13	D	3	5	22.8	1.5				18
					4							19

LRL FORM 1202 JUNE 2000 — PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: V - WATER LEVEL AT COMPLETION, ▸ - PARTIAL LOSS OF DRILL FLUID — PROJECT: Paducah LTFP Feasibility Study — HOLE NO. AD-3

BORING NO. **AD-3** SHEET 2 OF 3

1. PROJECT: Paducah LTFP Feasibility Study
2. LOCATION: N: 1924318.69 E: 811961.93
3. DRILLING AGENCY: Florence & Hutcheson, Inc.
4. NAME OF DRILLER: D. Hedler
5. DRILL TYPE: CME 45C
6. THICKNESS OF OVERBURDEN: 51
7. DEPTH DRILLED INTO ROCK: N/A
8. TOTAL DEPTH OF HOLE: 51
9. DIRECTION OF HOLE: VERTICAL ☒ INCLINED ☐ ___ DEG. FROM VERT.
10. DATUM FOR ELEVATION SHOWN (TBM OR MSL): MSL
11. DRILL METHOD: 3 5/8" I.D. HSA, 1" Spoon
12. ELEVATION TOP OF HOLE: 359
13. TOTAL NUMBER CORE BOXES: N/A
14. ELEVATION GROUND WATER: 334.74 ft
15. DATE HOLE: STARTED 8/5/09 COMPLETED 8/10/09
16. INSPECTOR: ___

ELEVATION	CLASSIFICATION OF MATERIALS	LEGEND	LOCK CLASS	SAMPLE #	SAMPLE TYPE	BLOWS PER 6 INCH	SPT N-VALUE (N)	PENETRATION	RECOVERY (%)	RQD (%)	REMARKS	DEPTH SCALE (FT)
	Tan, lean CLAY, (partSand)		14	D	3	7	34.9	1.5				21
			15	D	4	9	32.7	1.5				22
			16	D	5	6	21.7	1.5				23
			17	D	9	12	21.9	1.5				24
333.5	Tan, lean CLAY.	CL										25
			18	D	5	9	28.7	1.5				26
			19	D	11	13	25.0	1.5				27
			20	D	9	13	21.1	1.5				28
			21	D	9	11	26.0	1.5				29
			22	D	9	7	27.7	1.5				30
			23	D	7	9	21.7	1.5				31
			24	D	5	13	26.3	1.5				32
			25	D	7	10	22.2	1.5				33
321.5	Brown, tan & grey, lean CLAY.	CL										34
			26	D	7	10	22.1	1.5				35
			27	D	3		21.8	1.5				36

LRL FORM 1202 JUNE 2000 — PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: V - WATER LEVEL AT COMPLETION, ▸ - PARTIAL LOSS OF DRILL FLUID — PROJECT: Paducah LTFP Feasibility Study — HOLE NO. AD-3

US Army Corps of Engineers Louisville District

Revisions: Number | Description | Date | Approved

Designed by: G. JENNINGS
Drawn by: C. ROBINSON
Checked by: C. HELTZ
Date: APRIL 2011
Scale: NONE
Drawing Code: G. JENNINGS
Project Engineer/Architect
Date

BORING LOGS

OHIO RIVER NAVIGATION PROJECT, MAINTENANCE (PADUCAH, KENTUCKY LTFP) FEASIBILITY STUDY
SHEET 3 OF 4

SHEET REFERENCE NUMBER: G004
SHEET 87 OF 134

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:49
FILE: ##irl-dfs1##organization#ECD##Public#CAD#Activ1#112546#CACD#112546g004.dgn

BORING NO. **AD-3** SHEET 3 OF 9

1. PROJECT: Paducah LTFP Feasibility Study	11. DATUM FOR ELEVATION SHOWN (TBM OR MSL): MSL
2. LOCATION: N 1624316.00 E 811901.00	12. DRILL METHOD: 3.125"ID, HSA, 1" Batch
3. DRILLING AGENCY: Pioneros & HydroVision, Inc.	13. ELEVATION TOP OF HOLE: 339
4. NAME OF DRILLER: C. Harbor	14. TOTAL NUMBER CORE BOXES: N/A
5. DRILL TYPE: CME 45C	15. ELEVATION GROUND WATER: 334.04 hr
6. THICKNESS OF OVERBURDEN: 51	16. DATE HOLE: STARTED 8/8/09 COMPLETED 8/10/09
7. DEPTH DRILLED INTO ROCK: N/A	17. INSPECTOR:
8. TOTAL DEPTH OF HOLE: 51	
9. DIRECTION OF HOLE: VERTICAL ☒ INCLINED ☐ ___ DEG. FROM VERT.	

ELEVATION	CLASSIFICATION OF MATERIALS	MOISTURE	USCS CLASS	SAMPLE #	SAMPLE TYPE	BLOW COUNTS (6 INCH)	SHEAR STR. (%)	PENETRATION RESISTANCE (%)	RECOVERY (%)	RQD (%)	REMARKS	DEPTH SCALE (FT)
	Brown, tan & gray, lean CLAY. (continued)											41
				28	D	6 8 8	22.6	1.5				42
				29	D	3 4 5	25.8	1.5				43
				30	D	3 5 6	22.4	1.6				44
294.0	Gray & tan, lean CLAY.		CL									45
				31	D	3 3 4	27.6	1.6				46
				32	D	3 5 4	30.6	1.5				47
				33	D	1 2 2	33.7	1.5				48
				34	D	1 2 4	30.2	1.6				49
	No Auger Refusal & Boring Terminated @ 51.0' (Elev. 288.0).											50
												51
												52
												53
												54
												55
												56
												57
												58
												59

USL FORM 1303 JUNE 2009 — PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: ▼ - WATER LEVEL AT COMPLETION, ▽ - PARTIAL LOSS OF DRILL FLUID — PROJECT: Paducah LTFP Feasibility Study — HOLE NO. AD-3

US Army Corps of Engineers Louisville District

Revisions

Number	Description	Date	Appr.

Designed by: G. ANNIGES — Date: APRIL 2011
Drawn by: C. ROBINSON — Scale: NONE
Checked by: C. NEUTZ — Drawing Code:
R. JENNINGS — Date
Project Engineer/Architect

BORING LOGS

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PARADISE, KENTUCKY LFPP) FEASIBILITY REPORT VOLUME 2 OF 2

SHEET REFERENCE NUMBER: G005

SHEET 89 OF 134

DATE: 03-MAY-2011 08:48
FILE: %%(rl-dfs1%Organization%ED2%Public%CAD%civil%112545%CADD%112545g005.dgn

FINAL SUBMITTAL

BORING NO. **AD-3A** SHEET 1 OF 1

1. PROJECT: Paducah LPPF Feasibility Study	11. DATUM FOR ELEVATION SHOWN (TBM OR MSL): MSL
2. LOCATION: N 1406258.88 E 815961.80	
3. DRILLING AGENCY: Parsons & Hutchison, Inc.	12. DRILL METHOD: 3 1/2" I.D. HSA, 2" Tube
4. NAME OF DRILLER: D. Hotter	13. ELEVATION TOP OF HOLE: 359
5. DRILL TYPE: CME 45C	14. TOTAL NUMBER CORE BOXES: N/A
6. THICKNESS OF OVERBURDEN: 17	15. ELEVATION GROUND WATER:
7. DEPTH DRILLED INTO ROCK: N/A	16. DATE HOLE: STARTED 5/13/09 COMPLETED 5/13/09
8. TOTAL DEPTH OF HOLE: 17	
9. DIRECTION OF HOLE: VERTICAL ☒ INCLINED ☐ ____ DEG. FROM VERT.	17. INSPECTOR:

ELEVATION	CLASSIFICATION OF MATERIALS	REMARKS	UNCO CLASS	SAMPLE #	SAMPLE TYPE	BLOWS PER 6 INCH	SCR/CORE (%)	PENETRATION	RECOVERY (%)	RQD (%)	REMARKS	DEPTH SCALE (FT)
359.0	Gray, tan & brown, sandy lean CLAY with sand.											1 2 3 4 5
				1	U		24.9	2.0	80			6 7 8 9 10
358.4	Tan & gray, lean CLAY		CL									11 12 13 14
				2	U		24.1	2.0	80			15 16 17 18 19
	No Auger Refusal & Boring Terminated @ 17.0 (Elev. 342.0)											

LRL FORM 1392 JUNE 2002 — PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: V - WATER LEVEL AT COMPLETION; > - PARTIAL LOSS OF DRILL FLUID — PROJECT: Paducah LPPF Feasibility Study — HOLE NO. AD-3A

US Army Corps of Engineers Louisville District

Revisions

Symbol	Description	Date	Apr

Designed by: C. LEWIS | Date: APRIL 2011
Drawn by: C. ROBINSON | Scale: NONE
Checked by: C. HELTZ | Drawing Code:
S. JENNINGS
Project Engineer/Architect | Date

BORING LOGS

DAVIS RIVER SHORELINE PROTECTION FEASIBILITY (PADUCAH, KENTUCKY) LPPF FEASIBILITY STUDY
HOWARD CREEK

SHEET REFERENCE NUMBER: G006

SHEET 39 OF 134

FINAL SUBMITTAL

609

DATE: 03-MAY-2011 08:48
FILE: \\tfrl-sfs1\Organization\CDZ\Public\CAD\civil\112546\CADD\112546g009.dgn

BORING NO. **AD-4** SHEET 1 OF 2

1. PROJECT: Paducah LPPP Feasibility Study	11. DATUM FOR ELEVATION SHOWN (TBM OR MSL): MSL
2. LOCATION: N: 1918026.98 E: 614765.5	12. DRILL METHOD: 3 1/2" I.D. HSA, 1" Sploon, 2" Tube
3. DRILLING AGENCY: Parsons & Hutchison, Inc.	13. ELEVATION TOP OF HOLE: 319
4. NAME OF DRILLER: D. Rotter	14. TOTAL NUMBER CORE BOXES: N/A
5. DRILL TYPE: CME 45C	15. ELEVATION GROUND WATER: 317.24 hr
6. THICKNESS OF OVERBURDEN: 25.5	16. DATE HOLE: 5/7/99
7. DEPTH DRILLED INTO ROCK: N/A	17. INSPECTOR
8. TOTAL DEPTH OF HOLE: 33.5	STARTED: 5/7/99 COMPLETED: 5/13/99
9. DIRECTION OF HOLE: VERTICAL ☒ INCLINED ☐ ___ DEG. FROM VERT.	

ELEVATION	CLASSIFICATION OF MATERIALS	LEGEND	USCS CLASS	SAMPLE #	SAMPLE TYPE	BLOWS PER 6 INCH	MOISTURE (%)	PENETRATION	RECOVERY (%)	RQD (%)	REMARKS	DEPTH SCALE (FT)
318.0	Black topsoil, silt & sand.											
				1	D	1 1 1	29.9	1.0				1
317.3	Brown & tan, lean CLAY with sand.		CL									2
				2	D	1 1 1	37.0	1.0				3
313.2	Tan, lean CLAY.		CL									4
				3	D	2 3 6	24.1	1.0				5
				4	D	4 5 7	27.0	1.0				10
309.5	Light brown, lean CLAY.		CL									11
				5	J		23.3	2.0	98			12
306.3	Gray, lean CLAY.		CL									13
				6	D	4 4 6	36.2	1.0				14
						2						

UPL FORM 1202 JUNE 2000 — PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: V - WATER LEVEL AT COMPLETION; > - PARTIAL LOSS OF DRILL FLUID — PROJECT: Paducah LPPP Feasibility Study — HOLE NO. A34

BORING NO. **AD-4** SHEET 2 OF 2

1. PROJECT: Paducah LPPP Feasibility Study	11. DATUM FOR ELEVATION SHOWN (TBM OR MSL): MSL
2. LOCATION: N: 1918026.98 E: 614765.5	12. DRILL METHOD: 3 1/2" I.D. HSA, 1" Sploon, 2" Tube
3. DRILLING AGENCY: Parsons & Hutchison, Inc.	13. ELEVATION TOP OF HOLE: 319
4. NAME OF DRILLER: D. Rotter	14. TOTAL NUMBER CORE BOXES: N/A
5. DRILL TYPE: CME 45C	15. ELEVATION GROUND WATER: 317.24 hr
6. THICKNESS OF OVERBURDEN: 25.5	16. DATE HOLE: 5/7/99
7. DEPTH DRILLED INTO ROCK: N/A	17. INSPECTOR
8. TOTAL DEPTH OF HOLE: 33.5	STARTED: 5/7/99 COMPLETED: 5/13/99
9. DIRECTION OF HOLE: VERTICAL ☒ INCLINED ☐ ___ DEG. FROM VERT.	

ELEVATION	CLASSIFICATION OF MATERIALS	LEGEND	USCS CLASS	SAMPLE #	SAMPLE TYPE	BLOWS PER 6 INCH	MOISTURE (%)	PENETRATION	RECOVERY (%)	RQD (%)	REMARKS	DEPTH SCALE (FT)
	Gray, lean CLAY, (continued)											
				7	D	4	21.1	1.0				21
296.0	Tan & gray, lean CLAY.		CL									22
												23
												24
				8	D	3 4 8	28.7	1.0				25
	No Auger Refusal & Boring Terminated @ 33.5' (Elev. 285.5).											26
												27
												28
												29
												30
												31
												32
												33
												34
												35
												36
												37
												38
												39

UPL FORM 1202 JUNE 2000 — PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: V - WATER LEVEL AT COMPLETION; > - PARTIAL LOSS OF DRILL FLUID — PROJECT: Paducah LPPP Feasibility Study — HOLE NO. A34

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Appr.

Designed by: J. ARVUSS
Drawn by: C. ROBINSON
Checked by: C. NEVITZ
Date: APRIL 2011
Scale: NONE
Drawing Code:
S. JENNINGS
Project Engineer/Manager
Date

BORING LOGS

DIKE/LEVEE SHORELINE
PADUCAH, KENTUCKY (PPP)
(PARTIAL VERTICAL EXPANSION)
FEASIBILITY REPORT
APPENDIX D

SHEET REFERENCE NUMBER:
G007
SHEET 102 OF 134

FINAL SUBMITTAL

607

DATE: 03-MAY-2011 08:40
FILE: ***rl-cfs1*Agroup1zction*ED2*Public*CAD*civil*112546*CAD0*112546g007r.dgn

BORING NO. **AD-5** SHEET 1 OF 2

1. PROJECT: Paducah LFFP Feasibility Study	11. DATUM FOR ELEVATION SHOWN (TBM OR MSL): MSL
2. LOCATION: N: 1015750.95 E: 814765.9	
3. DRILLING AGENCY: Florence & Hutcheson Inc.	12. DRILL METHOD: 3 1/8" I.D. HSA, 1" Spoon
4. NAME OF DRILLER: D. Herber	13. ELEVATION TOP OF HOLE: 318
5. DRILL TYPE: CME 45C	14. TOTAL NUMBER CORE BOXES: N/A
6. THICKNESS OF OVERBURDEN: 26.5	15. ELEVATION GROUND WATER: 316.24 fv
7. DEPTH DRILLED INTO ROCK: N/A	16. DATE HOLE: STARTED 6/10/09 COMPLETED 6/10/09
8. TOTAL DEPTH OF HOLE: 25.0	17. INSPECTOR:
9. DIRECTION OF HOLE: VERTICAL ☒ INCLINED ☐ ___ DEG. FROM VERT.	

ELEVATION	CLASSIFICATION OF MATERIALS	LEGEND	SOIL CLASS. (USCS)	SAMPLE NO.	SAMPLE TYPE	BLOWS PER 6 INCH	SHORTING (%)	PENETRATION	RECOVERY (%)	RQD (%)	REMARKS	DEPTH (SCALE FT)
318.0	Brown & tan, lean CLAY with sand.			1	D	2 1 3	30.0	1.5				1
				2	D	1 2 2	30.0	1.5				2 3
313.2	Gray, lean CLAY with sand.		CL									4
				3	D	2 3 3	28.0	1.5				5 6 7 8
311.5	Tan, lean CLAY.		CL									9
				4	D	3 3 3	28.0	1.5				10 11
307.0	Brown, lean CLAY.		CL									12
				5	D	2 3 5	30.0	1.5				13 14 15 16 17 18
293.7	Gray, lean CLAY.		CL									19
						3						20

LRL FORM 1262 JUNE 2000 — PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: V - WATER LEVEL AT COMPLETION; > - PARTIAL LOSS OF DRILL FLUID — PROJECT: Paducah LFFP Feasibility Study — HOLE NO. AD-5

BORING NO. **AD-5** SHEET 2 OF 2

1. PROJECT: Paducah LFFP Feasibility Study	11. DATUM FOR ELEVATION SHOWN (TBM OR MSL): MSL
2. LOCATION: N: 1015750.95 E: 814765.9	
3. DRILLING AGENCY: Florence & Hutcheson, Inc.	12. DRILL METHOD: 3 1/8" I.D. HSA, 1" Spoon
4. NAME OF DRILLER: D. Herber	13. ELEVATION TOP OF HOLE: 318
5. DRILL TYPE: CME 45C	14. TOTAL NUMBER CORE BOXES: N/A
6. THICKNESS OF OVERBURDEN: 25.0	15. ELEVATION GROUND WATER: 316.24 fv
7. DEPTH DRILLED INTO ROCK: N/A	16. DATE HOLE: STARTED 6/10/09 COMPLETED 6/10/09
8. TOTAL DEPTH OF HOLE: 25.0	17. INSPECTOR:
9. DIRECTION OF HOLE: VERTICAL ☒ INCLINED ☐ ___ DEG. FROM VERT.	

ELEVATION	CLASSIFICATION OF MATERIALS	LEGEND	SOIL CLASS. (USCS)	SAMPLE NO.	SAMPLE TYPE	BLOWS PER 6 INCH	SHORTING (%)	PENETRATION	RECOVERY (%)	RQD (%)	REMARKS	DEPTH (SCALE FT)
	Gray, lean CLAY. (continued)			6	D	3 3 3	25.0	1.5				21 22 23 24
				7	D	3 4 4	31.0	1.5				25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
	No Auger Refusal & Boring Terminated @ 25.0' (Elev. 293.0).											

LRL FORM 1262 JUNE 2000 — PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: V - WATER LEVEL AT COMPLETION; > - PARTIAL LOSS OF DRILL FLUID — PROJECT: Paducah LFFP Feasibility Study — HOLE NO. AD-5

US Army Corps of Engineers Louisville District

Revisions: Symbol | Date | Year

Date: APRIL 2011 | Scale: NONE | Drawing Code: | Date

Designed By: G. GRAVES | Drawn By: C. RUBISHAW | Checked By: C. KEUTZ | Project Engineer/Architect: S. JENNINGS

BORING LOGS

OHIO RIVER SHORELINE PHASE I DESIGN, LFFP, PADUCAH, KENTUCKY (TPP) FEASIBILITY STUDY FEASIBILITY REPORT COMMON FILE

SHEET REFERENCE NUMBER: G008

SHEET 101 OF 134

DATE: 03-MAY-2011 08:48
FILE: \\irl-dfs1\Organization\ED2\Public\CAD\civil\112546\CADD\112546g009.dgn

FINAL SUBMITTAL

BORING NO. **AD-6** SHEET 1 OF 3

1. PROJECT Paducah LTPP Feasibility Study	11. DATUM FOR ELEVATION SHOWN (TBM OR MSL) MSL
2. LOCATION N: 1010955.76 E: 818734.56	12. DRILL METHOD 3 1/2" I.D. HSA, 1" Spoon
3. DRILLING AGENCY Fitzenrice & Hutchinson, Inc.	13. ELEVATION TOP OF HOLE 339
4. NAME OF DRILLER D. Hartley	14. TOTAL NUMBER CORE BOXES N/A
5. DRILL TYPE CME 45C	15. ELEVATION GROUND WATER 317, Immediate
6. THICKNESS OF OVERBURDEN 51	16. DATE HOLE STARTED 6/1/09 COMPLETED 6/15/09
7. DEPTH DRILLED INTO ROCK N/A	17. INSPECTOR
8. TOTAL DEPTH OF HOLE 51	
9. DIRECTION OF HOLE VERTICAL ☒ INCLINED ☐ ___ DEG. FROM VERT.	

ELEVATION	CLASSIFICATION OF MATERIALS	USCS CLASS	SAMPLE #	SAMPLE TYPE	BLOWS PER 6 INCH	MOISTURE (%)	PENETRATION	RECOVERY (%)	RQD (%)	REMARKS	DEPTH SCALE (FT)
338.0	Brown & gray, lean CLAY with sand.	CL	1	D	4 6 10	15.5	1.5				1
			2	D	6 6 10	27.0	1.5				2
			3	D	4 6 10	19.0	1.5				3
			4	D	3 4 8	20.8	1.5				4
335.0	Brown & gray, lean CLAY with sand.	CL	5	D	4 5 6	31.6	1.5				6
329.5	Brown & gray, lean CLAY.	CL	6	D	2 4 6	23.8	1.5				8
			7	D	1 2 4	23.3	1.5				9
			8	D	0 0 4	33.2	1.5				10
			9	D	2 3 5	34.5	1.5				11
322.5	Brown & gray lean CLAY.	CL	10	D	2 3 5	33.6	1.5				12
			11	D	1 3 5	33.1	1.5				13
			12	D	0 3 3	26.5	1.5				14
			13	D	1 2 3	27.0	1.5				15
318.0	Brown, lean CLAY.	CL			2						16

UFL FORM 1202 (JUNE 2000) PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: ▽ - WATER LEVEL AT COMPLETION ▸ - PARTIAL LOSS OF DRILL FLUID

PROJECT: Paducah LTPP Feasibility Study HOLE NO. AD-6

BORING NO. **AD-6** SHEET 2 OF 3

1. PROJECT Paducah LTPP Feasibility Study	11. DATUM FOR ELEVATION SHOWN (TBM OR MSL) MSL
2. LOCATION N: 1010955.76 E: 818734.56	12. DRILL METHOD 3 1/2" I.D. HSA, 1" Spoon
3. DRILLING AGENCY Fitzenrice & Hutchinson, Inc.	13. ELEVATION TOP OF HOLE 339
4. NAME OF DRILLER D. Hartley	14. TOTAL NUMBER CORE BOXES N/A
5. DRILL TYPE CME 45C	15. ELEVATION GROUND WATER 317, Immediate
6. THICKNESS OF OVERBURDEN 51	16. DATE HOLE STARTED 6/1/09 COMPLETED 6/15/09
7. DEPTH DRILLED INTO ROCK N/A	17. INSPECTOR
8. TOTAL DEPTH OF HOLE 51	
9. DIRECTION OF HOLE VERTICAL ☒ INCLINED ☐ ___ DEG. FROM VERT.	

ELEVATION	CLASSIFICATION OF MATERIALS	USCS CLASS	SAMPLE #	SAMPLE TYPE	BLOWS PER 6 INCH	MOISTURE (%)	PENETRATION	RECOVERY (%)	RQD (%)	REMARKS	DEPTH SCALE (FT)
	Brown, lean CLAY, (continued)	CL	14	D	2 3 3	29.9	1.5				21
			15	D	0 0 1	31.5	1.5				22
			16	D	2 2 3	29.6	1.5				23
			17	D	0 2 3	27.3	1.5				24
			18	D	0 2 3	31.6	1.5				25
			19	D	2 2 3	28.4	1.5				26
			20	D	1 2 3	32.4	1.5				27
308.0	Gray, lean CLAY.	CL	21	D	0 1 3	38.3	1.5				28
			22	D	0 3 5	34.4	1.5				29
			23	D	0 4 7	37.0	1.5				30
			24	D	0 3 6	34.8	1.5				31
			25	D	0 4 5	34.0	1.5				32
			26	D	0 7 5	39.4	1.5				33
			27	D	0 2 3	39.2	1.5				34

UFL FORM 1202 (JUNE 2000) PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: ▽ - WATER LEVEL AT COMPLETION ▸ - PARTIAL LOSS OF DRILL FLUID

PROJECT: Paducah LTPP Feasibility Study HOLE NO. AD-6

US Army Corps of Engineers Louisville District

Symbol	Revisions Location	Date	Approved

Designed by: S. HENNICKS | Date: APRIL 2011
Drawn by: C. ROBINSON | Scale: NONE
Checked by: C. KEUTZ | Drawing Code:
S. JENNINGS Project Engineer/Architect | Date

BORING LOGS

DMC RIVER SHORELINE PADUCAH, KENTUCKY (PADUCAH INTERIOR) LTPP FEASIBILITY REPORT VOLUME 1 OF 4

SHEET REFERENCE NUMBER: G009
SHEET 102 OF 134

FINAL SUBMITTAL

609

DATE: 03-MAY-2011 08:48
FILE: \\irl-fs1\organization\ED2\Public\CAD\civil\112546\CADD\112546g009.dgn

*** SAFETY PAYS ***

BORING NO. **AD-6** SHEET 3 OF 3

1. PROJECT: Paducah LTPP Feasibility Study	11. DATUM FOR ELEVATION SHOWN (TBM OR MSL): MSL
2. LOCATION: N 1418990.78 E 818734.58	12. DRILL METHOD: 3 1/2" I.D. HSA, 1" Bacon
3. DRILLING AGENCY: Florence & Hutcheson, Inc.	13. ELEVATION TOP OF HOLE: 336
4. NAME OF DRILLER: D. Hunter	14. TOTAL NUMBER CORE BOXES: N/A
5. DRILL TYPE: CME 45C	15. ELEVATION GROUND WATER: 317 Immediate
6. THICKNESS OF OVERBURDEN: 51	16. DATE HOLE: STARTED 6/1/09 COMPLETED 6/1/09
7. DEPTH DRILLED INTO ROCK: N/A	17. INSPECTOR:
8. TOTAL DEPTH OF HOLE: 51	
9. DIRECTION OF HOLE: VERTICAL ☒ INCLINED ☐ ___ DEG. FROM VERT.	

ELEVATION	CLASSIFICATION OF MATERIALS	LEGEND	UNIFIED CLASS	SAMPLE #	SAMPLE TYPE	BLOWS PER 6 INCH	WASH (%)	PENETRATION	RECOVERY (%)	RQD (%)	REMARKS	DEPTH (BELOW ELEV)
	Gray, lean CLAY. (continued)											
				28	C	6 1 2	33.9	1.5				41
294.0	Gray & brown, sandy, silty CLAY.		CL ML									42
				29	C	0 0 2	37.1	1.5				43
				30	D	3 4 4	31.1	1.5				44
				31	D	6 9 9	31.8	1.5				45
				32	D	3 5 5	30.6	1.5				46
				33	D	5 9 11	22.2	1.5				47
				34	D	3 5 6	23.3	1.5				48
	Six Auger Refusal & Boring Terminated @ 51.0 (Elev. 285.0).											49
												50
												51
												52
												53
												54
												55
												56
												57
												58
												59

LRL FORM 1203 JUNE 2000 — PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: ▽ - WATER LEVEL AT COMPLETION; ▷ - PARTIAL LOSS OF DRILL FLUID — PROJECT: Paducah LTPP Feasibility Study — HOLE NO. AD-6

US Army Corps of Engineers Louisville District

Revisions: Symbol | Description | Date | Appr.

Designed by: G. MINGUS | Date: APRIL 2011 | Scale: NONE | Drawn by: C. RUNNIGUM | Drawing Code: | Checked by: C. MEUTZ | Project Engineer/Architect: B. JENNINGS | Date

BORING LOGS

DAM/LOCK SHEPHERDSVILLE (PADUCAH, KENTUCKY) (PADUCAH, KENTUCKY (TPP) FEASIBILITY STUDY

SHEET REFERENCE NUMBER: G010

SHEET 103 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:49
FILE: ##lrl-dfs14drgnlzgtion#G2##Public#CAD#civil#112546#CADD#112546g010.dgn

FINAL SUBMITTAL

*** SAFETY PAYS ***

BORING NO. **AD-6A** SHEET 1 OF 2

1. PROJECT: Paducah LTFP Feasibility Study	11. DATUM FOR ELEVATION SHOWN (TBM OR MSL): MSL
2. LOCATION: N: 1919855.76 E: 818734.99	12. DRILL METHOD: 3 1/2" I.D. HSA, 3" Tube
3. DRILLING AGENCY: Florence & Hutcheson, Inc.	13. ELEVATION TOP OF HOLE: 339
4. NAME OF DRILLER: D. Hedler	14. TOTAL NUMBER CORE BOXES: N/A
5. DRILL TYPE: CME 460	15. ELEVATION GROUND WATER: 23
6. THICKNESS OF OVERBURDEN: 23	16. DATE HOLE: N/A
7. DEPTH DRILLED INTO ROCK: N/A	17. INSPECTOR: 22
8. TOTAL DEPTH OF HOLE: 22	18. STARTED: 6/12/09 COMPLETED: 6/12/09
9. DIRECTION OF HOLE: VERTICAL ☒ INCLINED ☐ ___ DEG. FROM VERT.	

ELEVATION	CLASSIFICATION OF MATERIALS	LEGEND	USCS CLASS	SAMPLE #	SAMPLE TYPE	BLOWS PER 6-INCH	MOISTURE (%)	PENETRATION	RECOVERY (%)	RQD (%)	REMARKS	RECOVERY (%)	RQD (%)	DEPTH SCALE (FT)
335.0	Tan, beige & brown, lean CLAY.													1
														2
														3
														4
														5
														6
														7
														8
				1	U		56.5	2.0						9
														10
														11
														12
														13
														14
														15
320.0	Tan, beige & brown, lean CLAY.		CL											16
														17
														18
														19

USLI FORM 1202 JUNE 2000 — PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: ▽ - WATER LEVEL AT COMPLETION; ⊢ - PARTIAL LOSS OF DRILL FLUID. PROJECT: Paducah LTFP Feasibility Study. HOLE NO. AD-6A

BORING NO. **AD-6A** SHEET 2 OF 2

1. PROJECT: Paducah LTFP Feasibility Study	11. DATUM FOR ELEVATION SHOWN (TBM OR MSL): MSL
2. LOCATION: N: 1919855.76 E: 818734.99	12. DRILL METHOD: 3 1/2" I.D. HSA, 3" Tube
3. DRILLING AGENCY: Florence & Hutcheson, Inc.	13. ELEVATION TOP OF HOLE: 339
4. NAME OF DRILLER: D. Hedler	14. TOTAL NUMBER CORE BOXES: N/A
5. DRILL TYPE: CME 460	15. ELEVATION GROUND WATER:
6. THICKNESS OF OVERBURDEN:	16. DATE HOLE:
7. DEPTH DRILLED INTO ROCK:	17. INSPECTOR:
8. TOTAL DEPTH OF HOLE:	18. STARTED: 6/12/09 COMPLETED: 6/12/09
9. DIRECTION OF HOLE: VERTICAL ☒ INCLINED ☐ ___ DEG. FROM VERT.	

ELEVATION	CLASSIFICATION OF MATERIALS	LEGEND	USCS CLASS	SAMPLE #	SAMPLE TYPE	BLOWS PER 6-INCH	MOISTURE (%)	PENETRATION			REMARKS	DEPTH SCALE (FT)
	Tan, beige & brown, lean CLAY. (continued)											21
												22
				2	U		27.6	1.5				23
315.0	Dark orange & beige lean CLAY.		CL	2	U		27.4	0.5				24
	Hot Auger Refusal & Boring Terminated @ 23.0' (Elev. 315.0).											25
												26
												27
												28
												29
												30
												31
												32
												33
												34
												35
												36
												37
												38
												39

USLI FORM 1202 JUNE 2000 — PREVIOUS EDITIONS ARE OBSOLETE. SYMBOLS: ▽ - WATER LEVEL AT COMPLETION; ⊢ - PARTIAL LOSS OF DRILL FLUID. HOLE NO. AD-6A

US Army Corps of Engineers Louisville District

Revisions			
Symbol	Description	Date	Appr.

Designed by: G. MANGES
Drawn by: C. ROBINSON
Checked by: C. NEUTZ
R. JENNINGS
Project Engineer/Architect
Date
Date: APRIL 2011
Scale: NONE
Drawing code:

BORING LOGS

OHIO RIVER SHORELINE, PHASE I, REACH D, (PADUCAH, KENTUCKY LTFP) FEASIBILITY REPORT VOLUME 1 PART 1

SHEET REFERENCE NUMBER: G011

SHEET 134 OF 134

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:48
FILE: \\irl-dfs1\Organization\ED2\Public\CAD\civil\112546\CADD\112546g011.dgn

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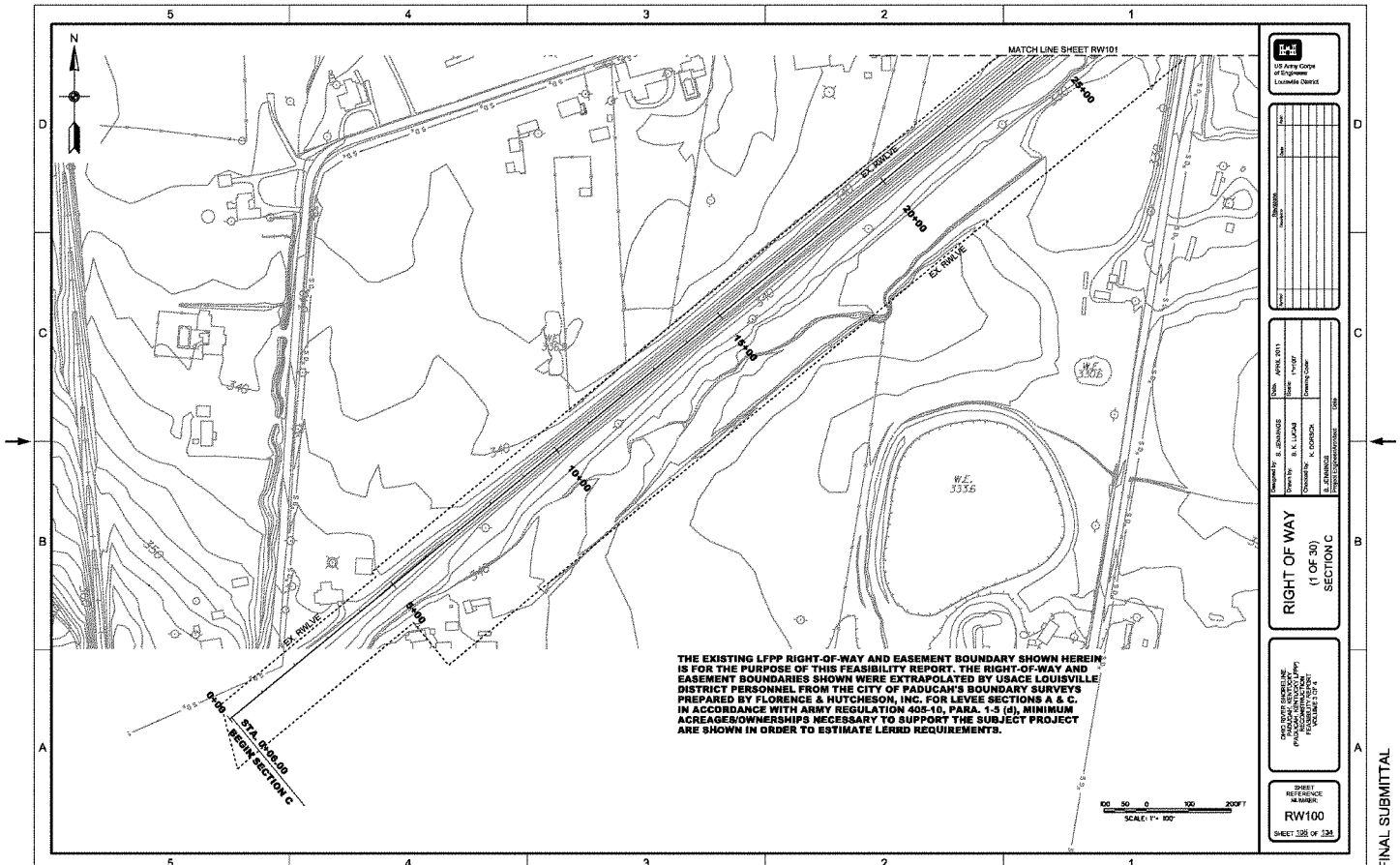

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:48
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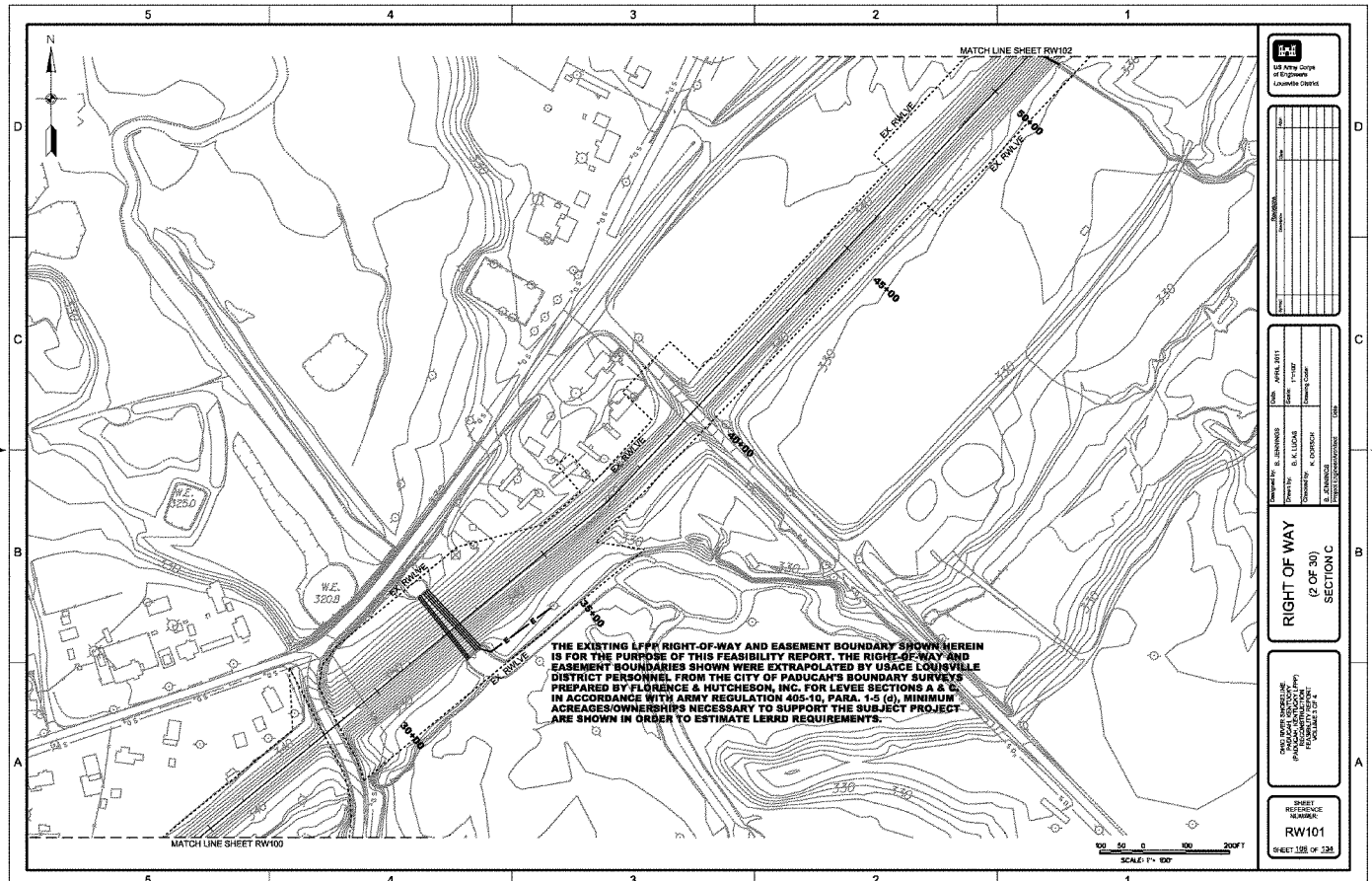

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

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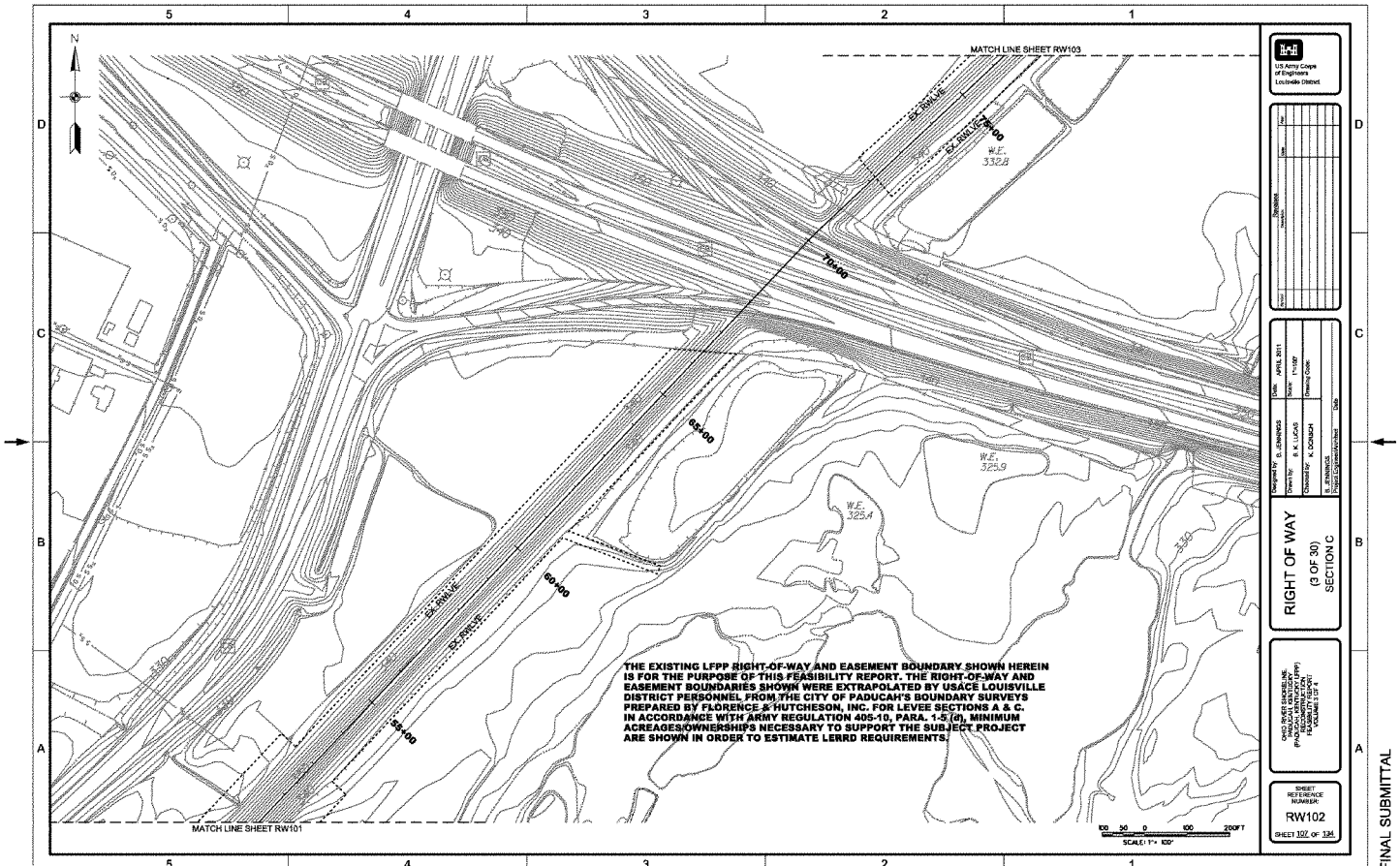

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

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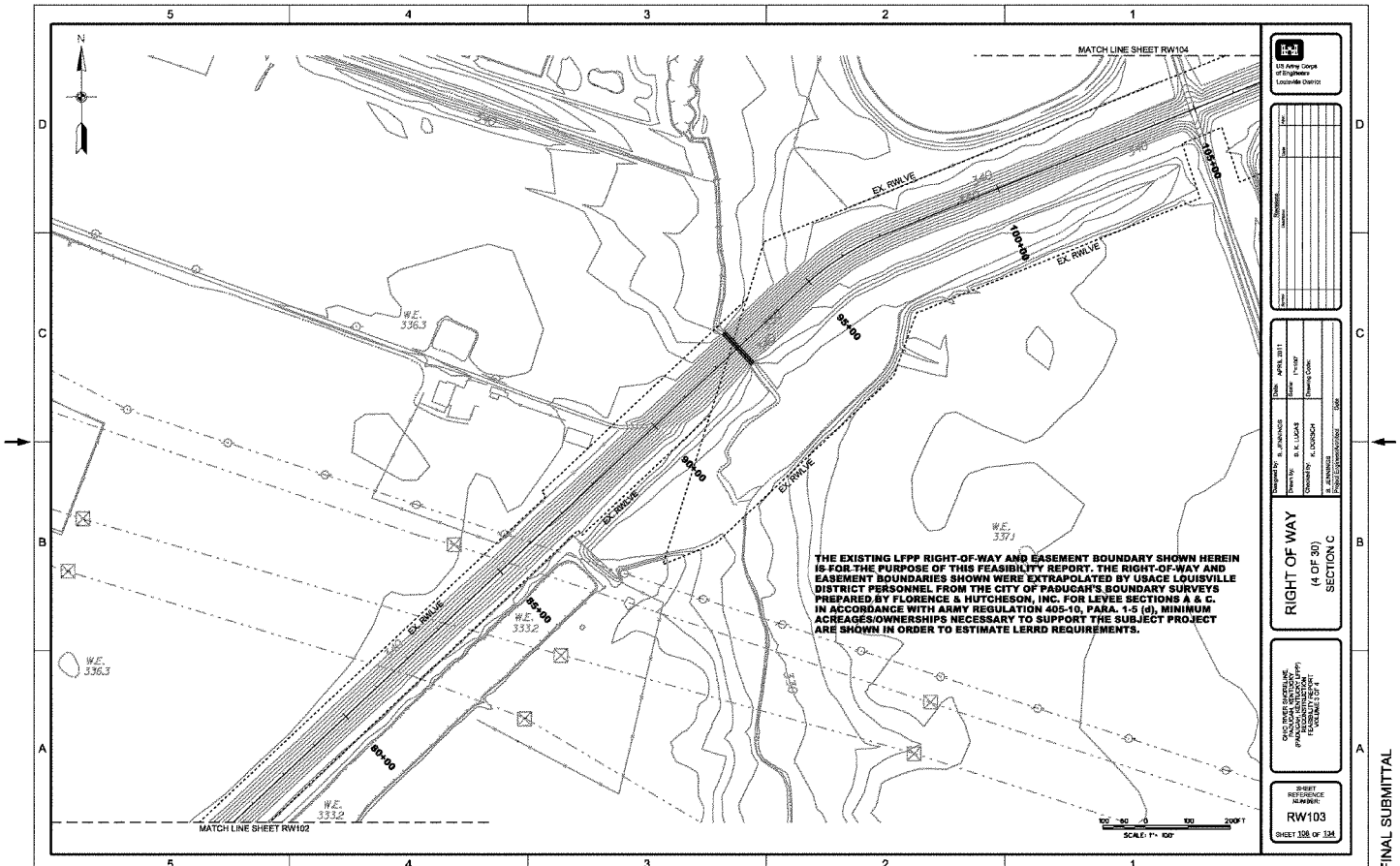

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FINAL SUBMITTAL

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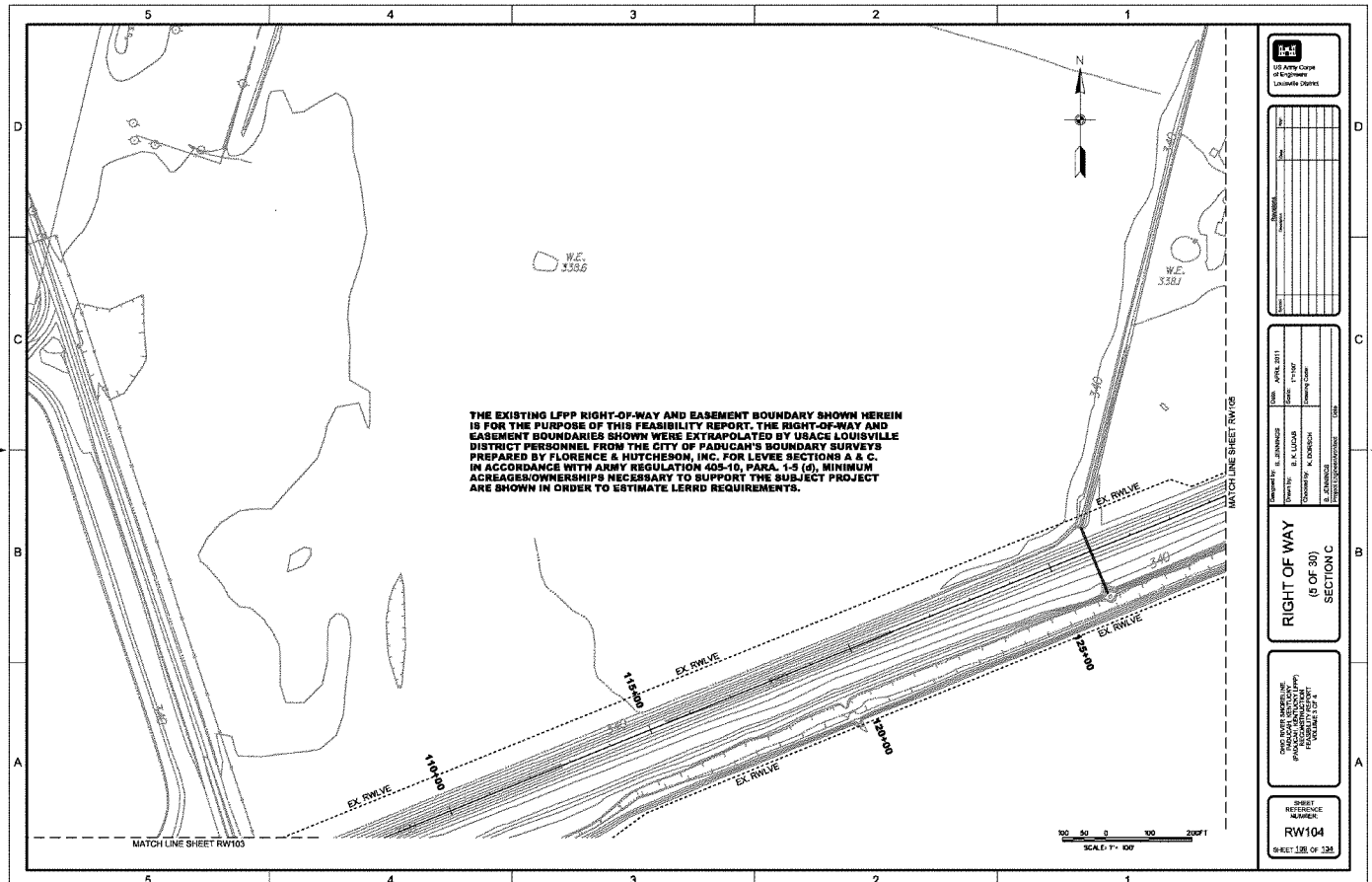

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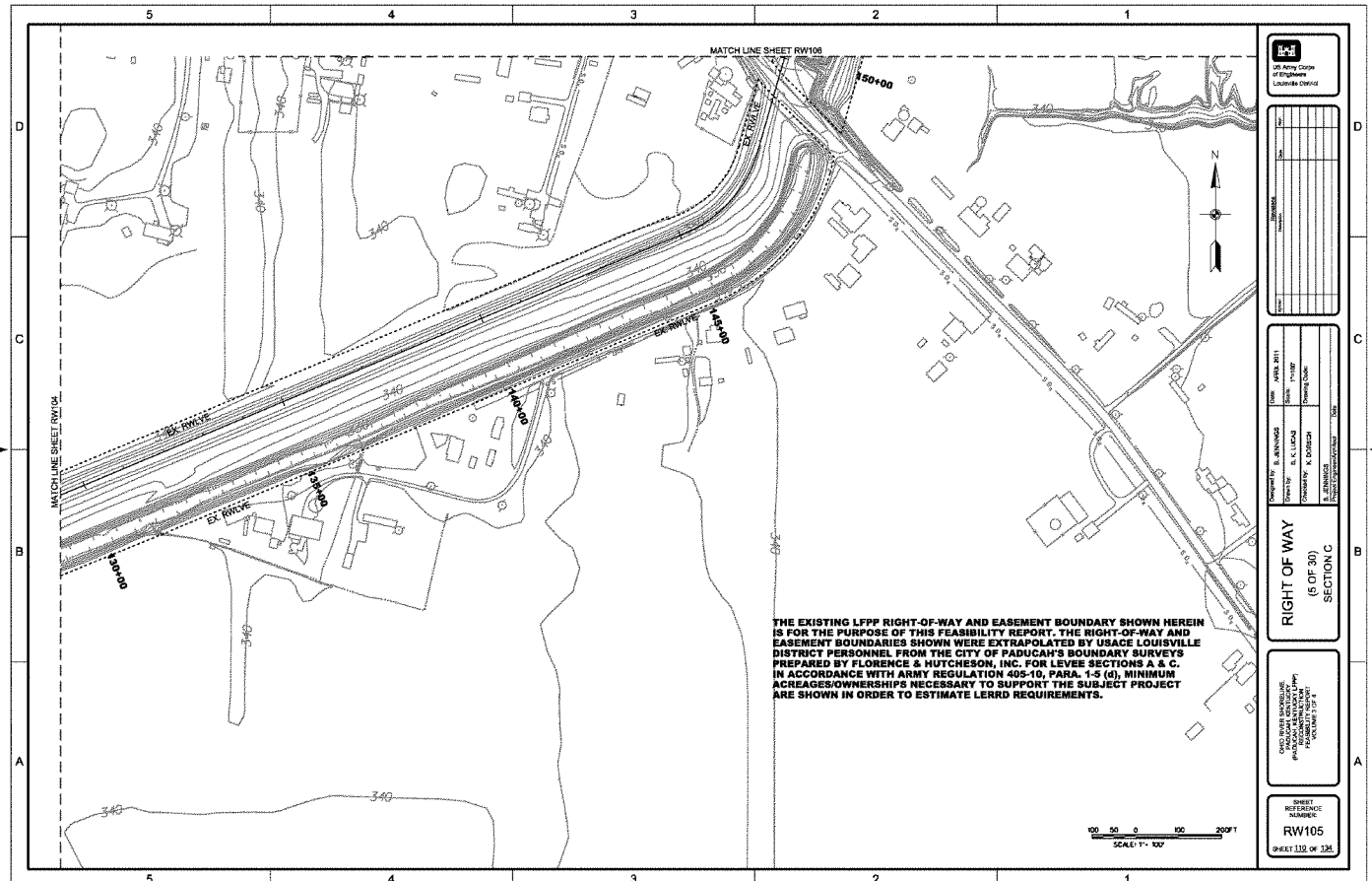
FINAL SUBMITTAL

*** SAFETY PAYS ***



FINAL SUBMITTAL

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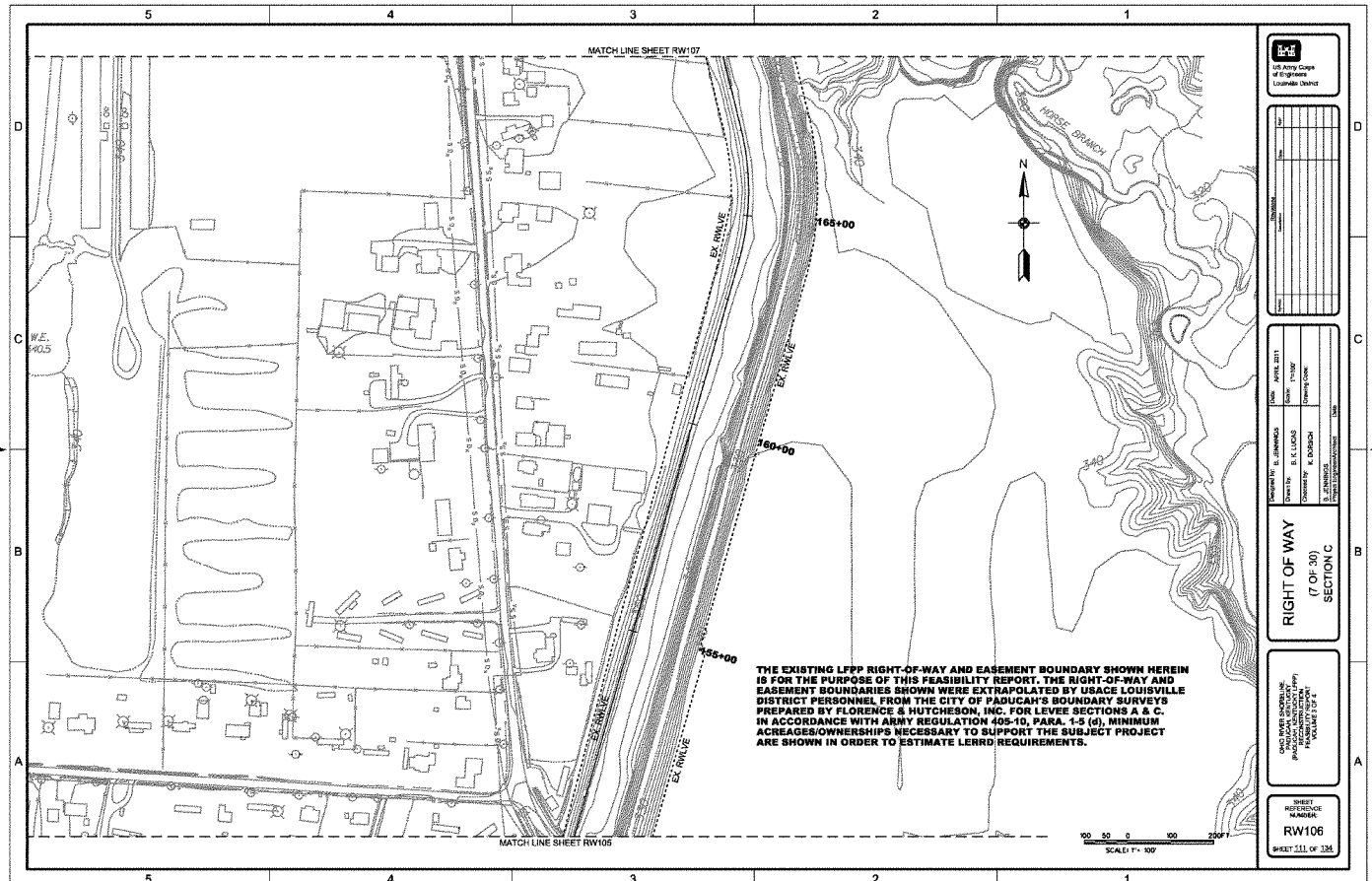

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 09:49
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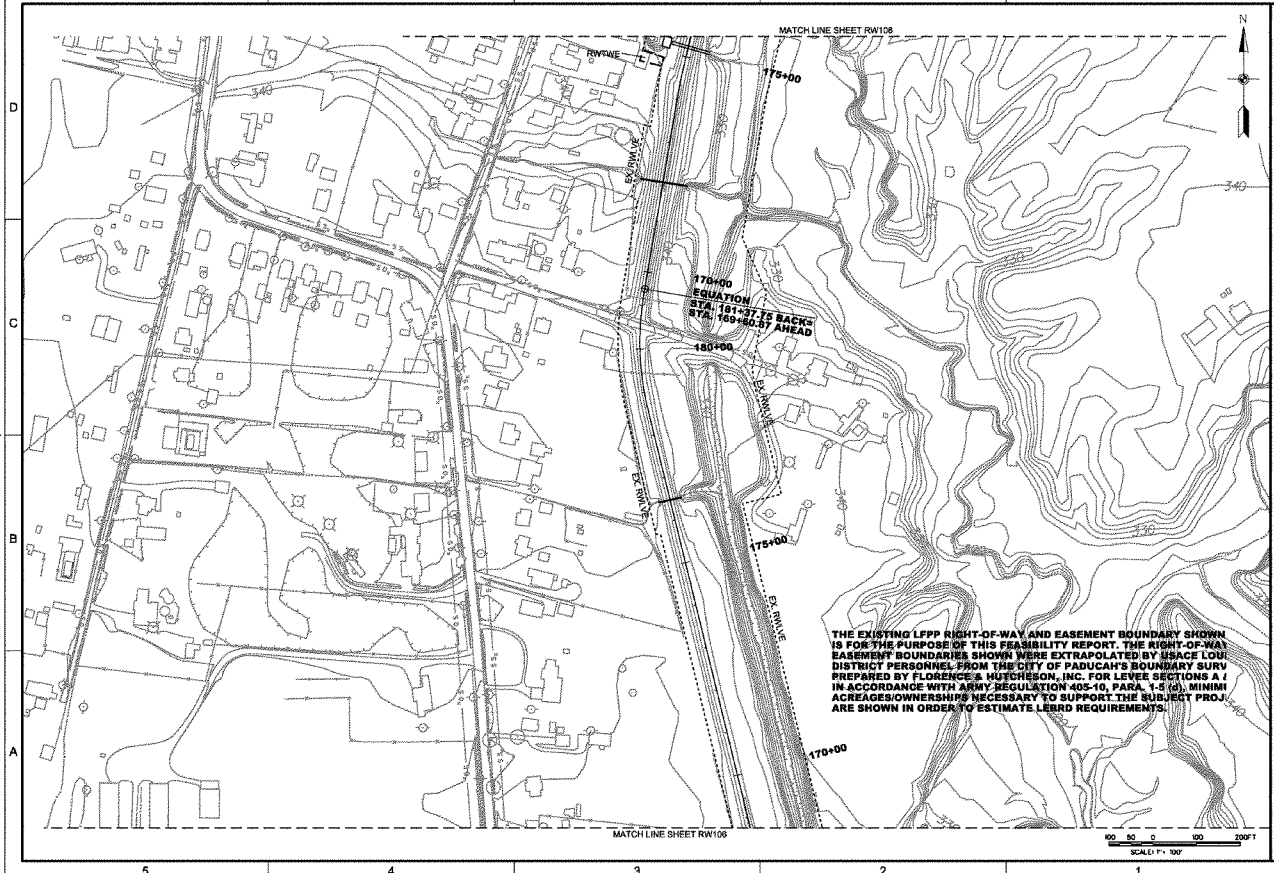
*** SAFETY PAYS ***



US Army Corps of Engineers
Louisville District

Revisions			
Symbol	Description	Date	Appr

Designed by: B. JENNINGS	Date: APRIL 2011
Drawn by: B. K. LUCAS	Scale: 1"=100'
Checked by: K. DORSCH	Drawing Code:
B. JENNINGS Project Engineer/Architect	Date

RIGHT OF WAY
(7 OF 30)
SECTION C

OHIO RIVER SHORELINE
PADUCAH, KENTUCKY
(PADUCAH, KENTUCKY LFPP)
FLOOD CONTROL
LEVEE SYSTEM
VICINITY PLAN

SHEET REFERENCE NUMBER:
RW107
SHEET 112 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:49
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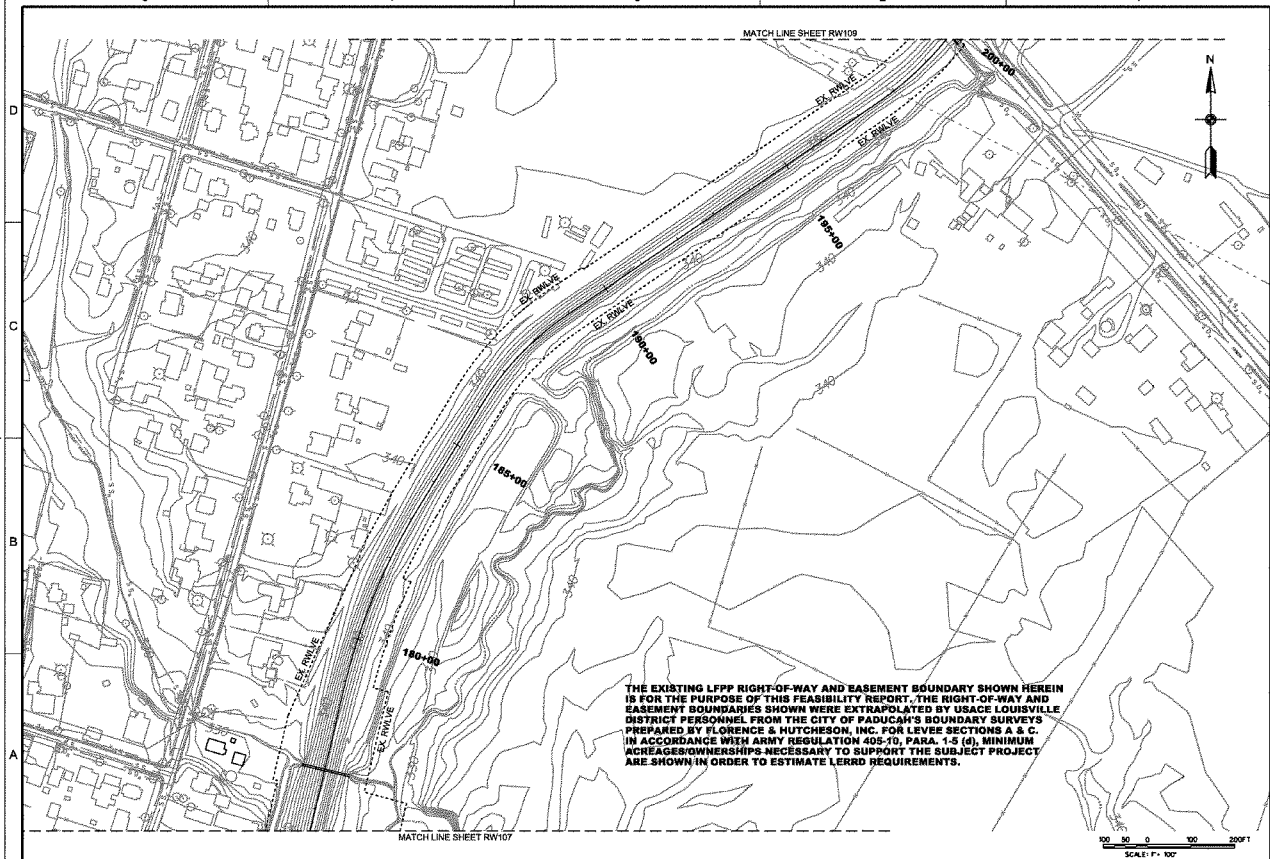
FINAL SUBMITTAL

*** SAFETY PAYS ***



US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Appr.

Designed by: B. JENNINGS
Drawn by: B. K. LUCAS
Checked by: K. DORSCH
Date: APRIL 2011
Scale: 1"=100'
Drawing Code:
B. JENNINGS
Project Engineer/Architect
Date

RIGHT OF WAY
(9 OF 30)
SECTION C

OHIO RIVER SHORELINE
PADUCAH VENTURY
(PADUCAH VENTURY LFPP)
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 3 OF 4

SHEET REFERENCE NUMBER:
RW108
SHEET 113 OF 134

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:49
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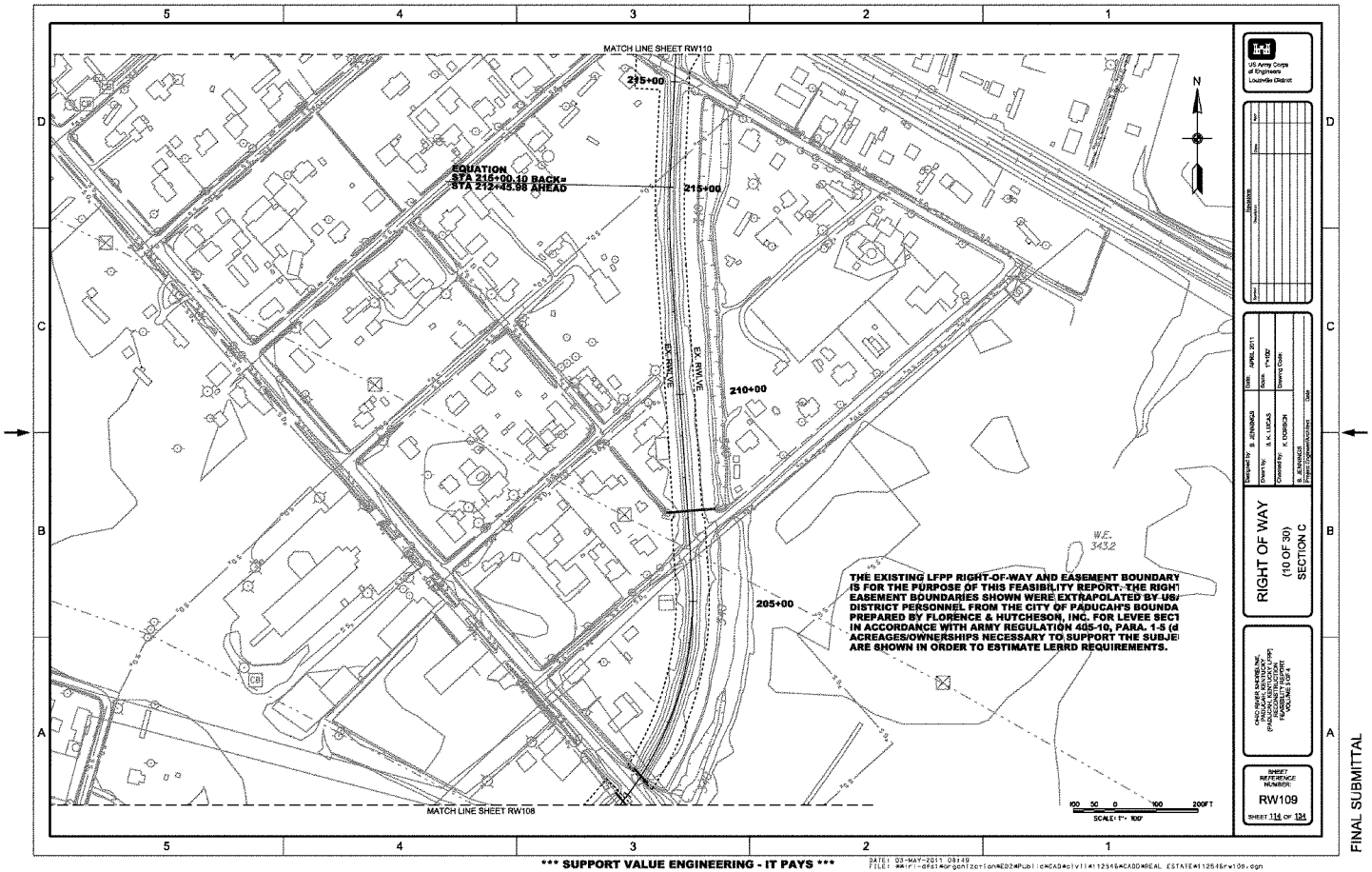
*** SAFETY PAYS ***



FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

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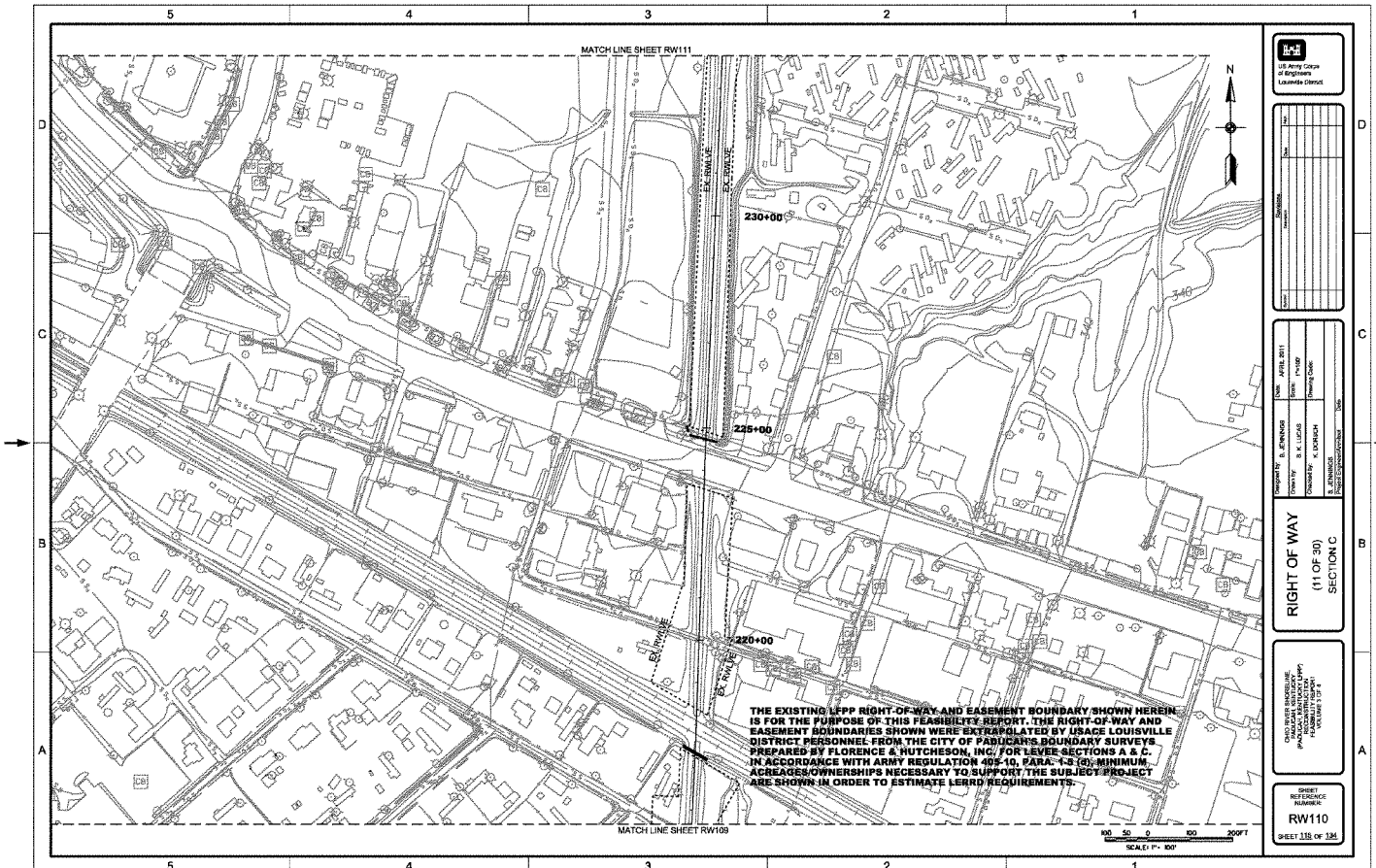
*** SAFETY PAYS ***



FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

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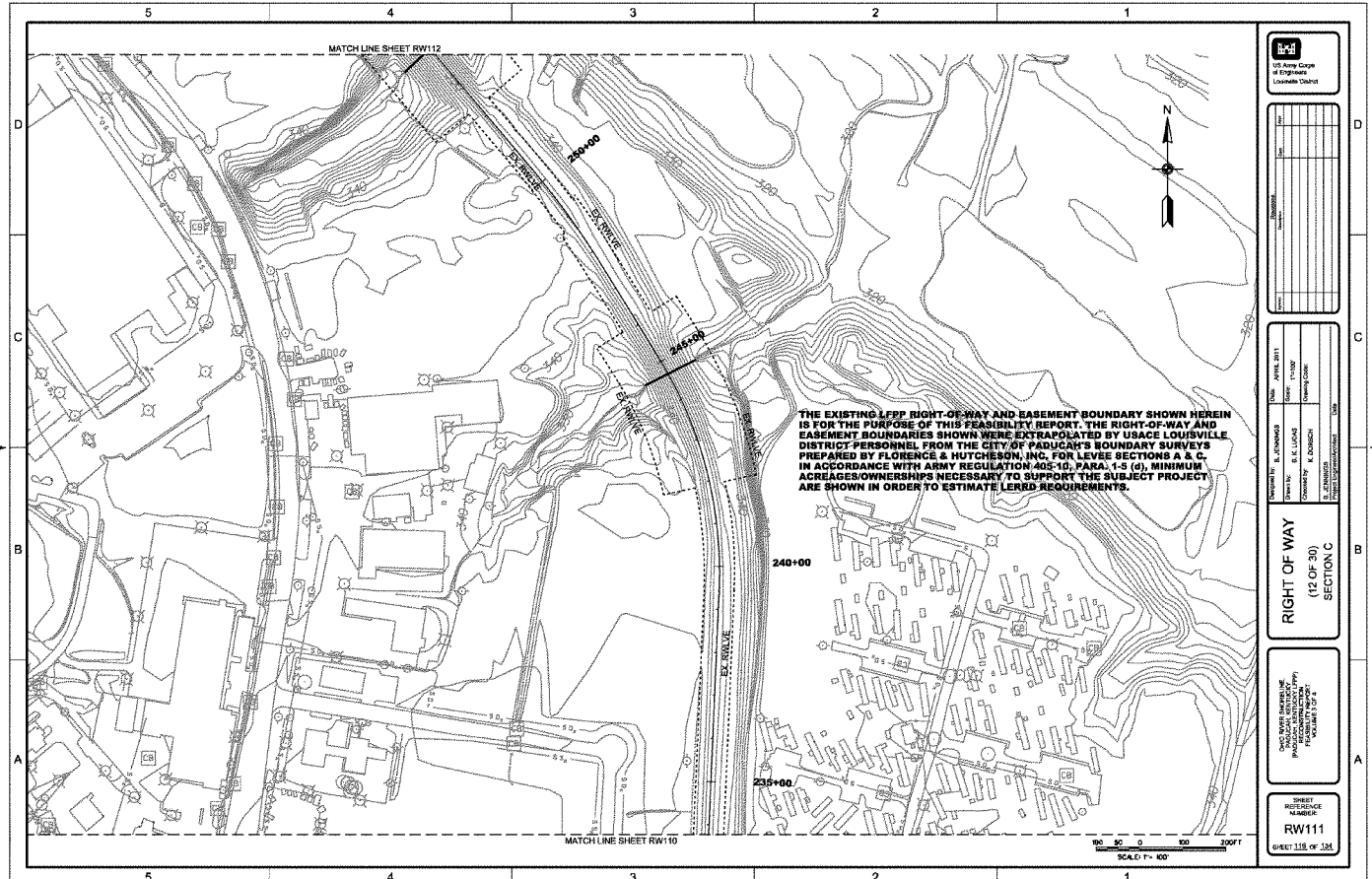
*** SAFETY PAYS ***



FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:49
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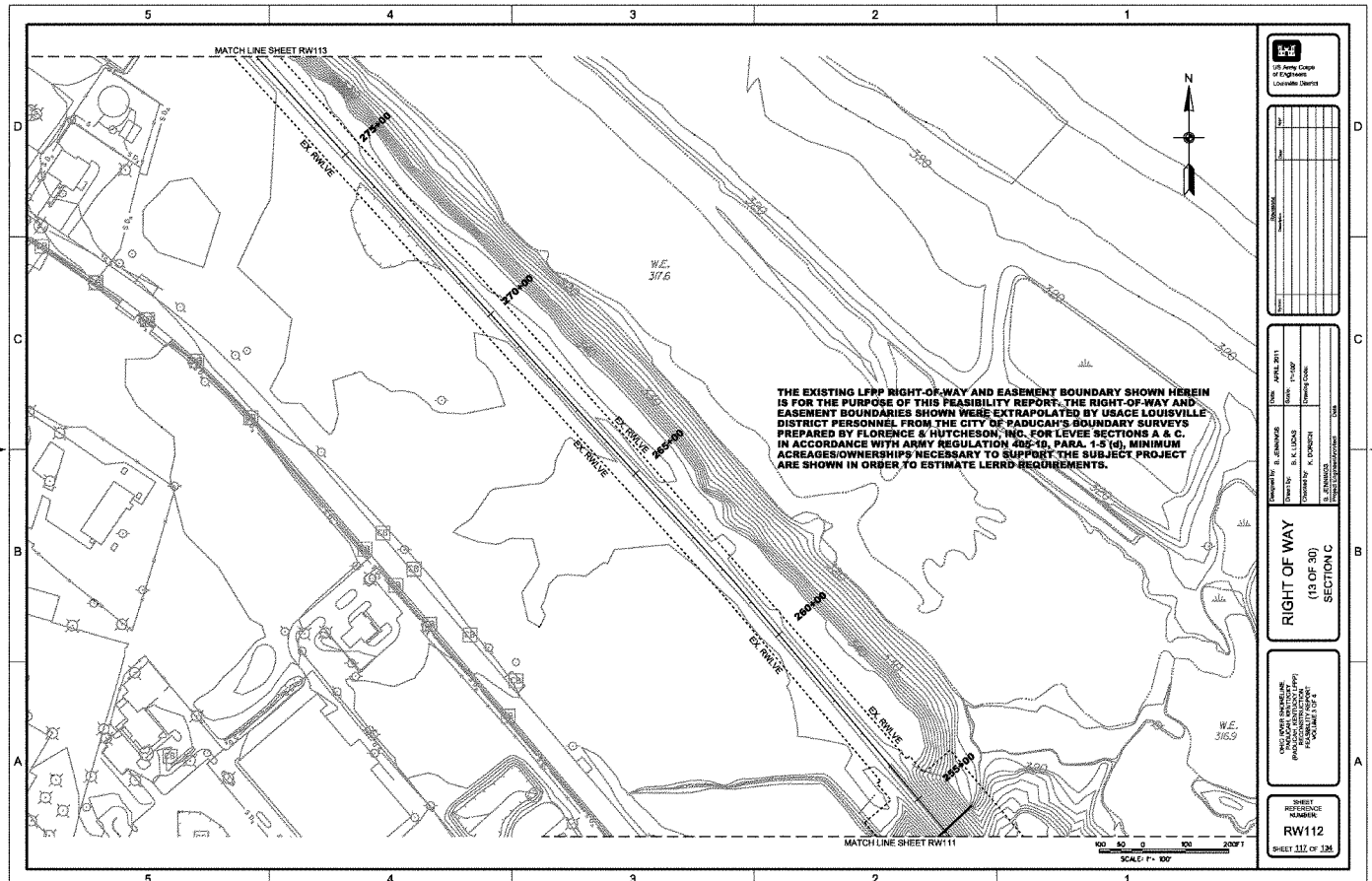
*** SAFETY PAYS ***



FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:49
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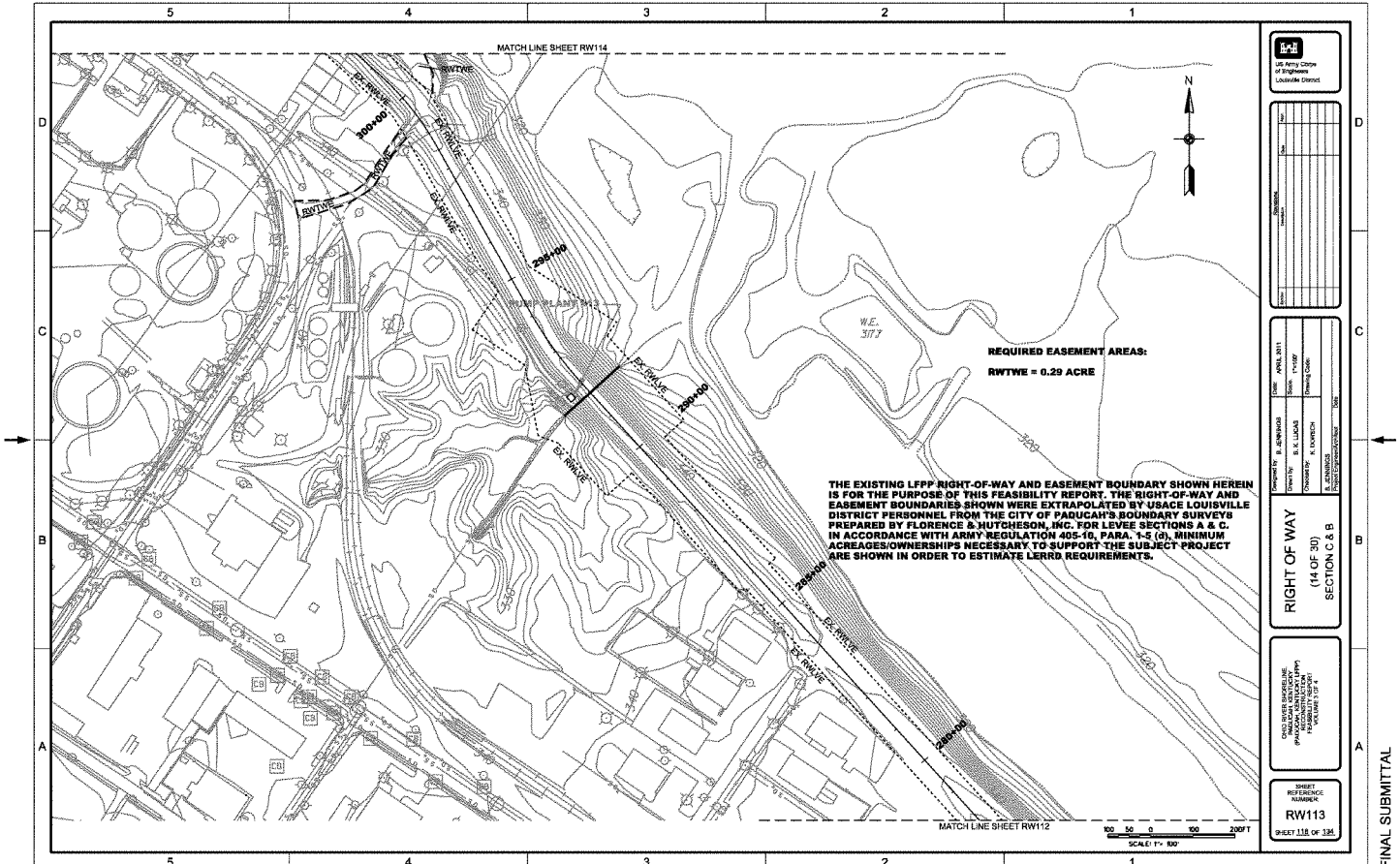
*** SAFETY PAYS ***



*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:49
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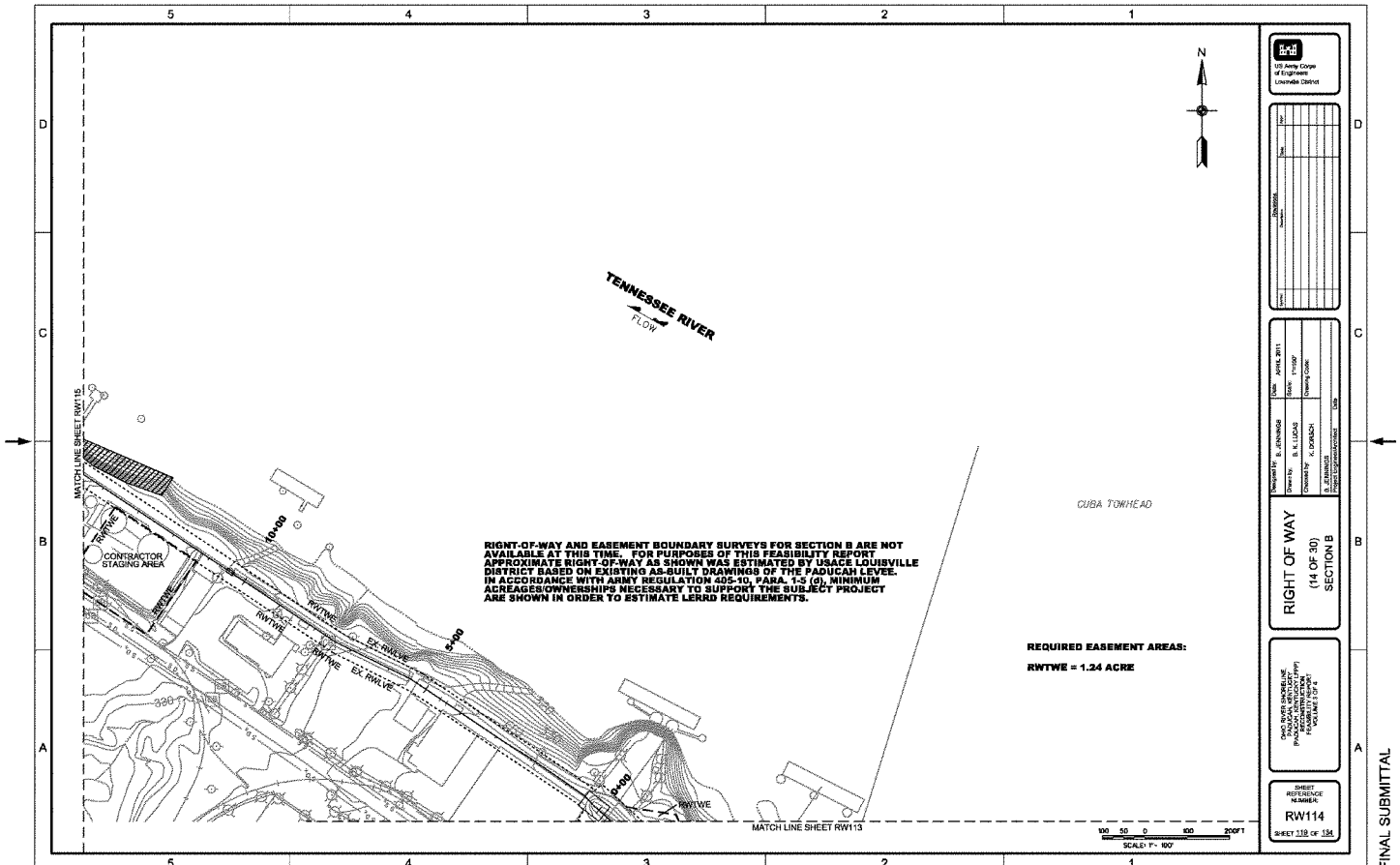
FINAL SUBMITTAL

*** SAFETY PAYS ***



*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:49
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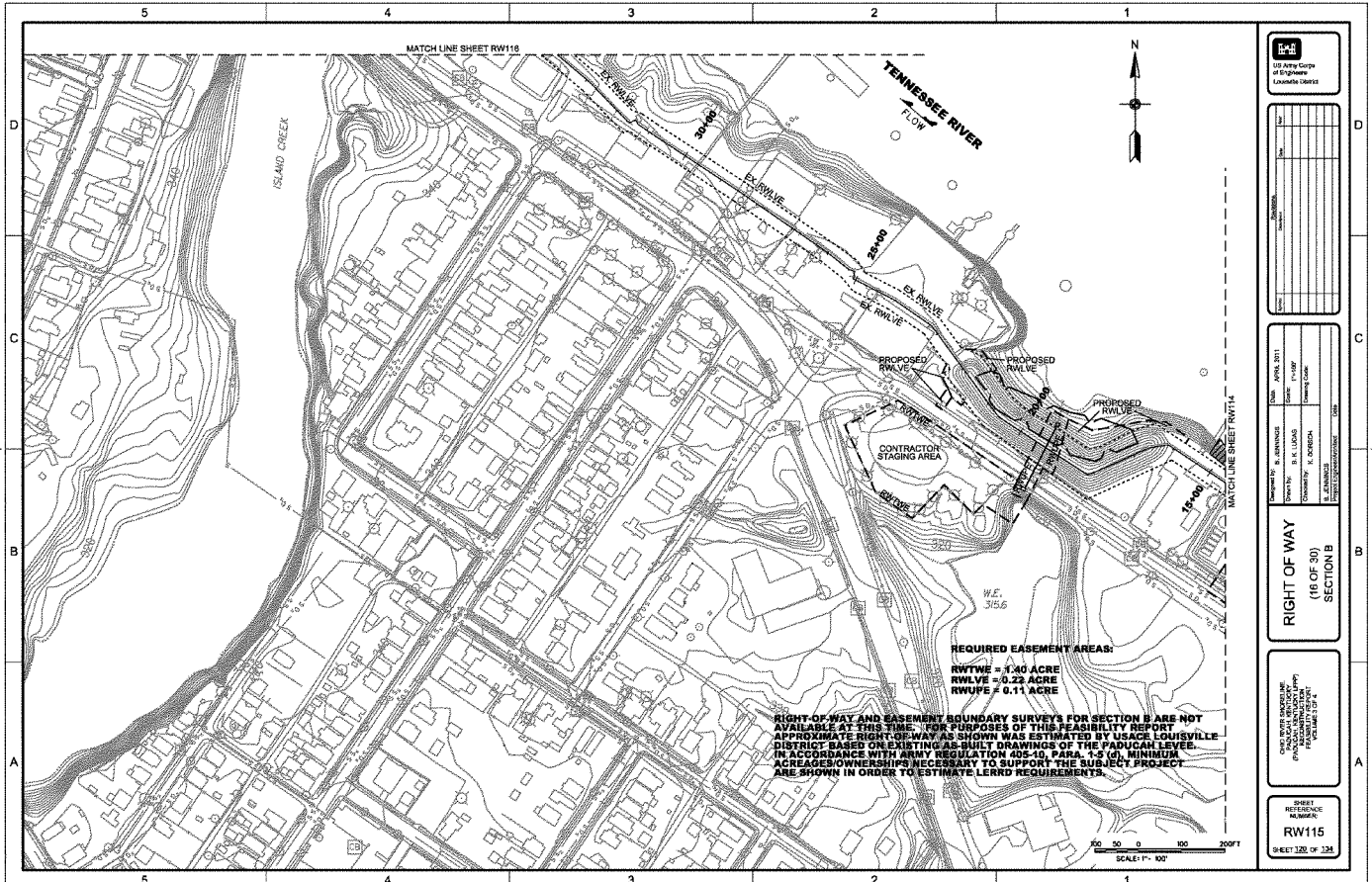
FINAL SUBMITTAL

*** SAFETY PAYS ***



US Army Corps of Engineers
Louisville District

Revisions
Symbol | Date | Year

Designed by: B. JENNINGS
Drawn by: B.K. LUCAS
Checked by: K. DOBSCH
B. JENNINGS
Project Engineer/Architect
Date

Date: APRIL 2011
Scale: 1"=100'
Drawing Code:

RIGHT OF WAY
(16 OF 30)
SECTION B

CHESTNUT SNOPELINE
PADUCAH, KENTUCKY (PPP)
(PADUCAH, KENTUCKY LEVEE)
FEASIBILITY STUDY
VARIES FT.

SHEET REFERENCE NUMBER:
RW115
SHEET 120 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

DATE: 03-MAY-2011 08:49
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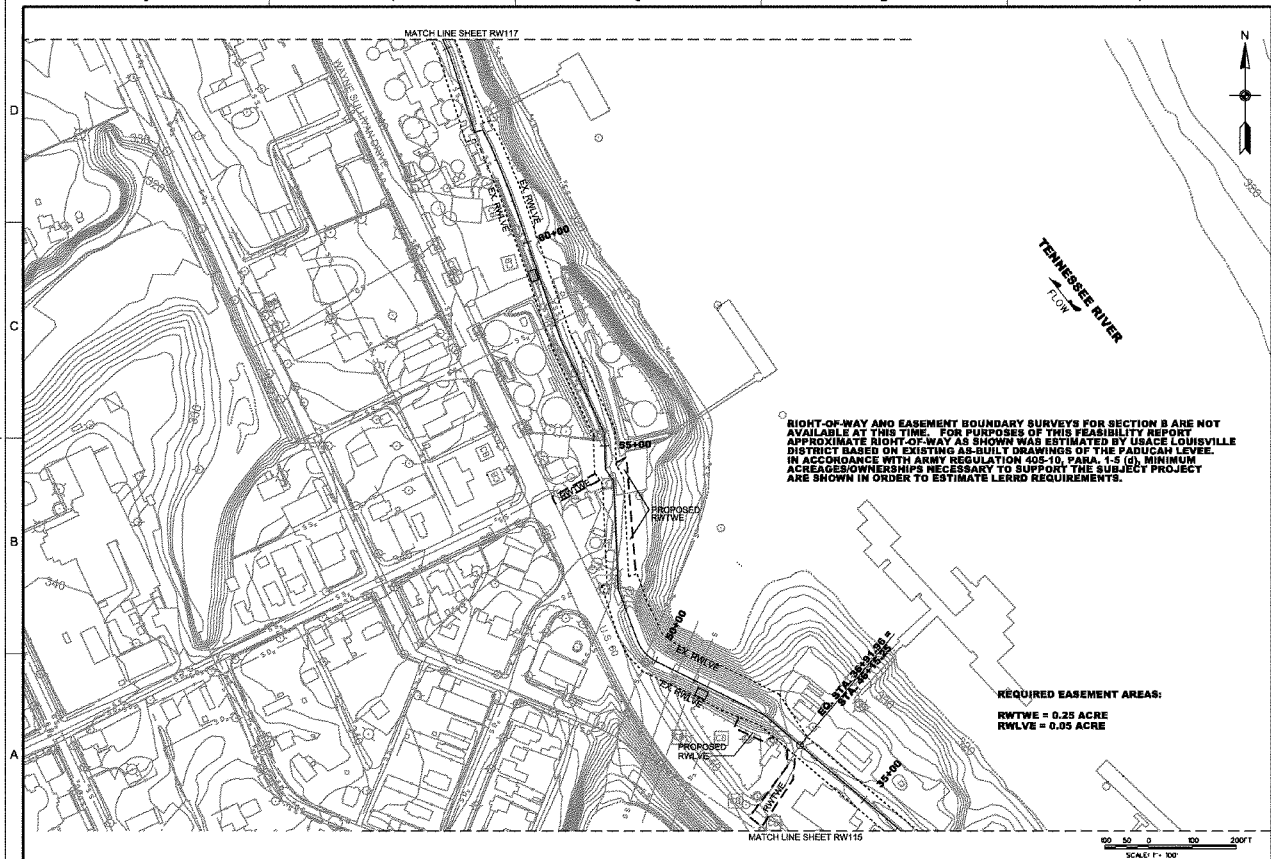

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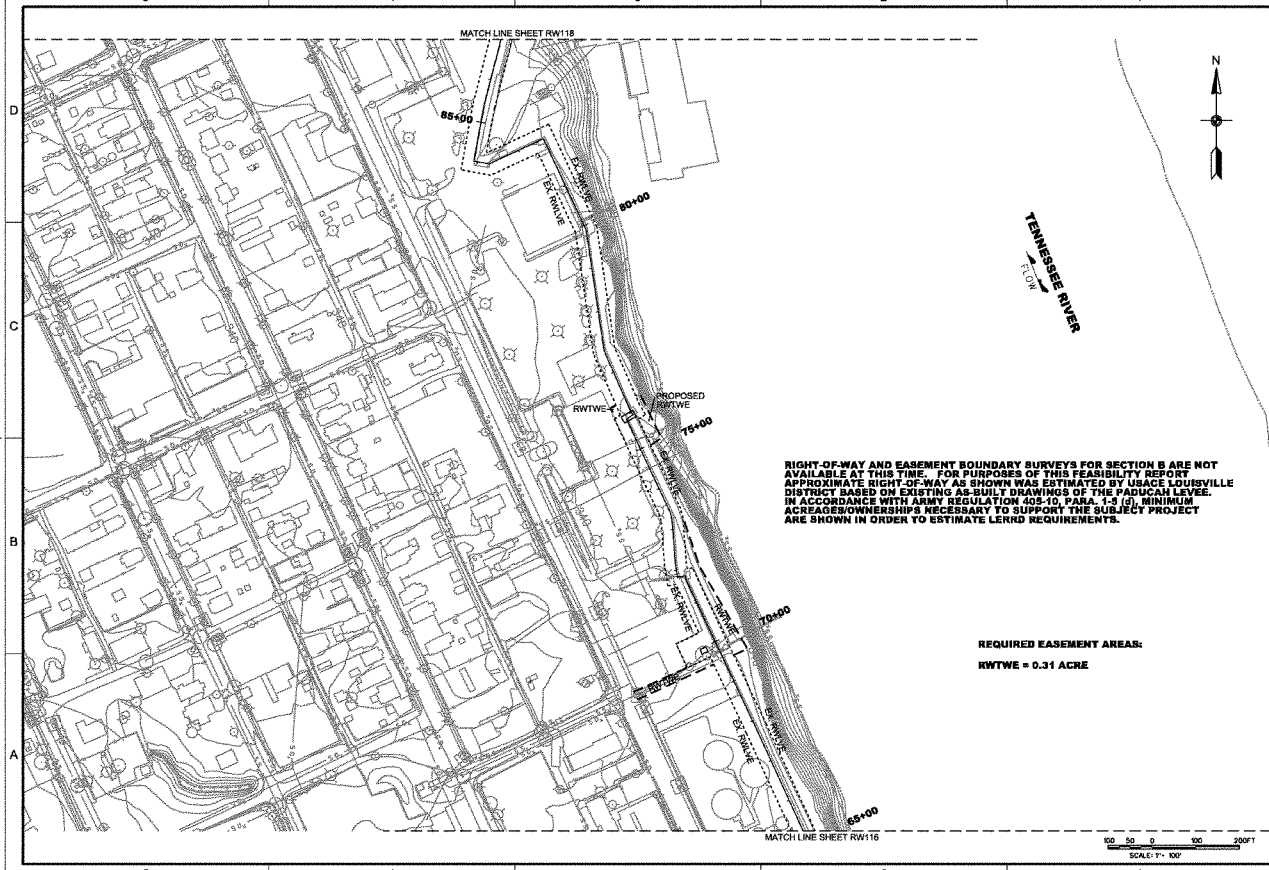

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REQUIRED EASEMENT AREAS:

RWTWE = 0.31 ACRE

US Army Corps of Engineers Louisville District

Designed by: B. JENNINGS
Drawn by: B. K. LUCAS
Checked by: K. DORSCH
Date: APRIL 2011
Scale: 1"=100'
Drawing Code:
B. JENNINGS
Project Engineer/Architect
Date

RIGHT OF WAY
(18 OF 30)
SECTION B

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 3 OF 4

SHEET REFERENCE NUMBER:
RW117
SHEET 122 OF 134

FINAL SUBMITTAL

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DATE: 03-MAY-2011 08:49
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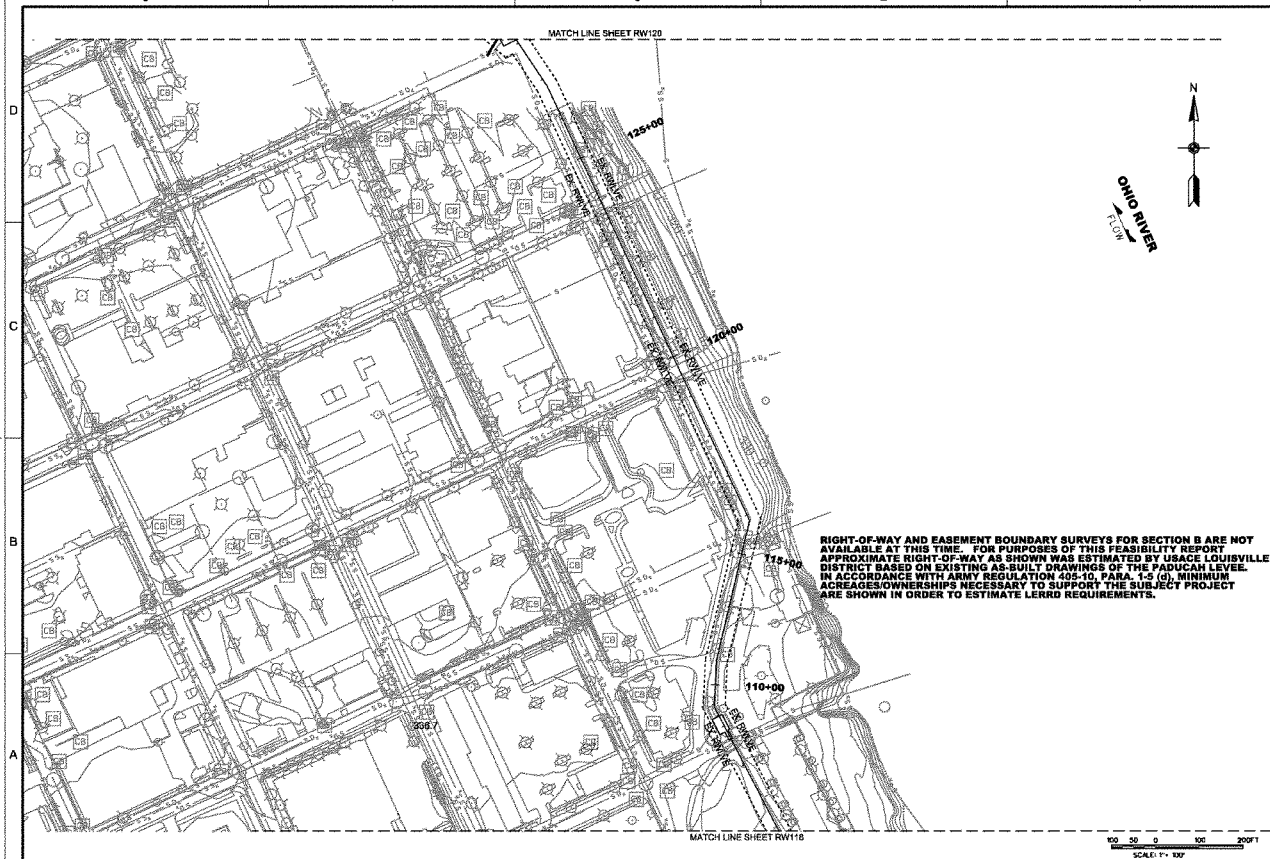

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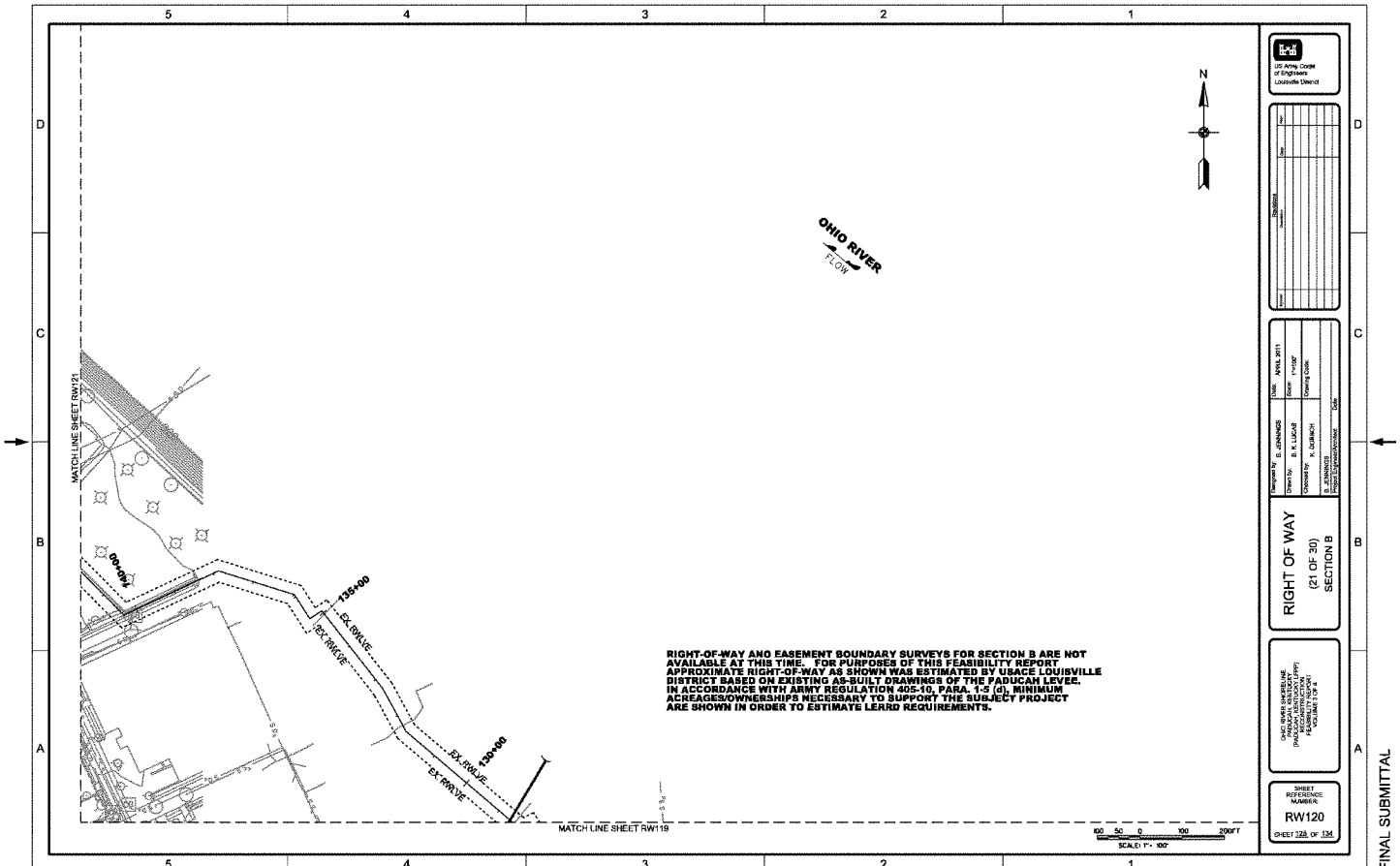

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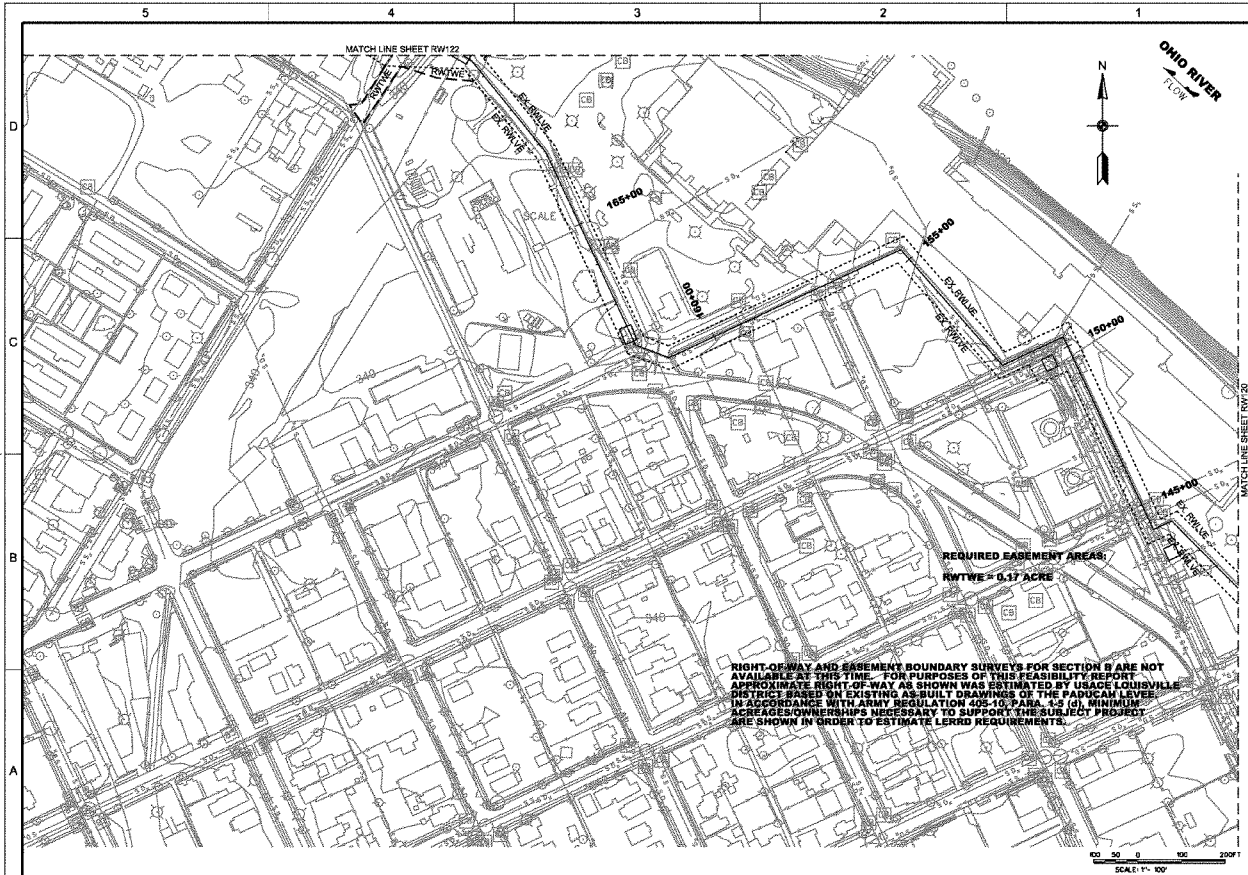

US Army Corps of Engineers
Louisville District

Symbol	Revisions Description	Date	Approved

Designed by: B. JOHNSON
Date: APRIL 2011
Drawn by: B.K. LUCAS
Scale: 1"=100'
Checked by: K. DOUNCH
Drawing Code:
S. FAWNOS
Project Engineer/Architect
Date

RIGHT OF WAY
(21 OF 30)
SECTION B

OHIO RIVER SHORELINE
PADUCAH, KENTUCKY (FPP)
PADUCAH, KENTUCKY
FACILITY TYPE: LEVEE
VOLUME 1 OF 2

SHEET REFERENCE NUMBER:
RW121
SHEET 128 OF 134

FINAL SUBMITTAL

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

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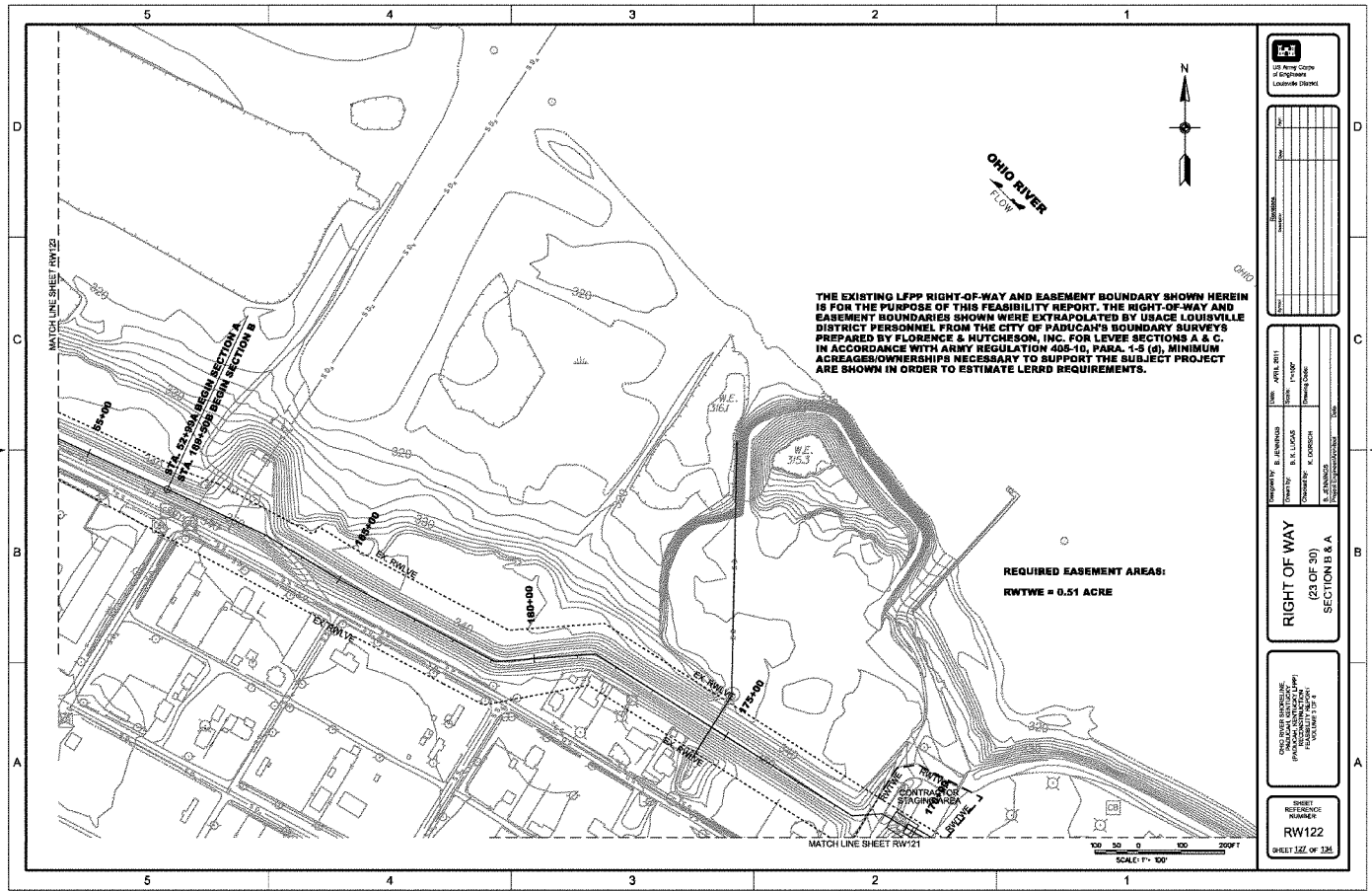

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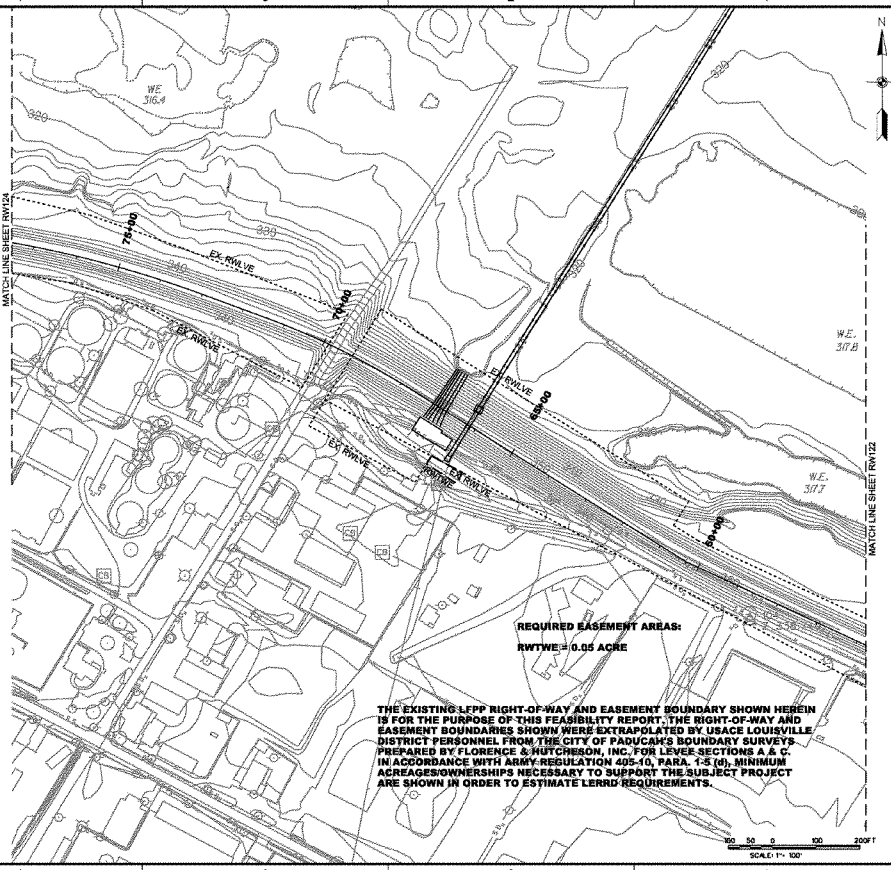

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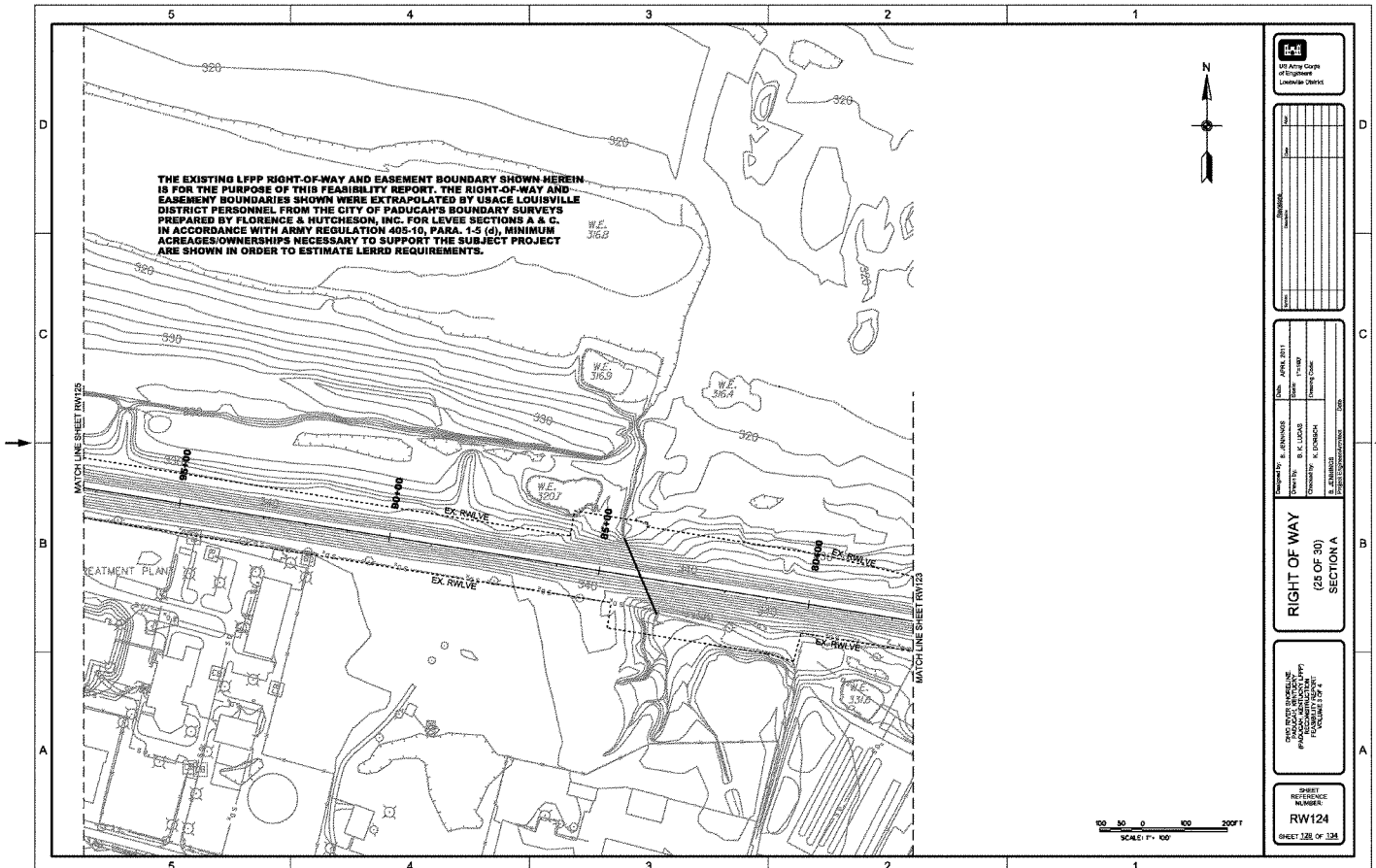

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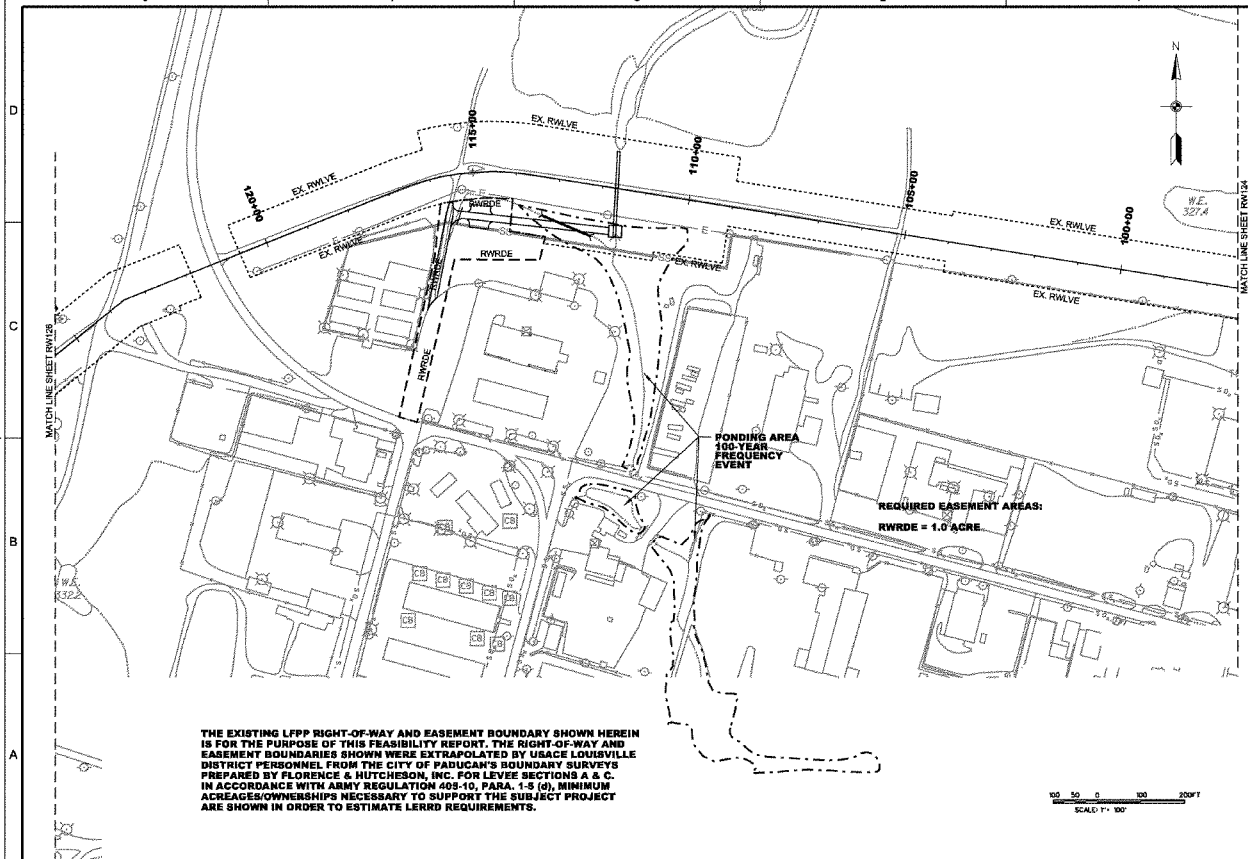

US Army Corps of Engineers
Louisville District

Revisions

Symbol	Description	Date	Char

Designed by: S. JENNINGS
Drawn by: B. K. LUCAS
Checked by: K. DORNICH
Project Engineer: S. JENNINGS
Date: APRIL 2011
Scale: 1"=100'
Drawing Code:
Date:

RIGHT OF WAY
(28 OF 30)
SECTION A

CHICKASAW BIKEPATH
PADUCAH, KENTUCKY
FLORENCE & HUTCHESON, INC.
FLORENCE & HUTCHESON
SURVEY DATE:
NOVEMBER 2010

SHEET REFERENCE NUMBER:
RW125
SHEET 132 OF 134

*** SUPPORT VALUE ENGINEERING - IT PAYS ***

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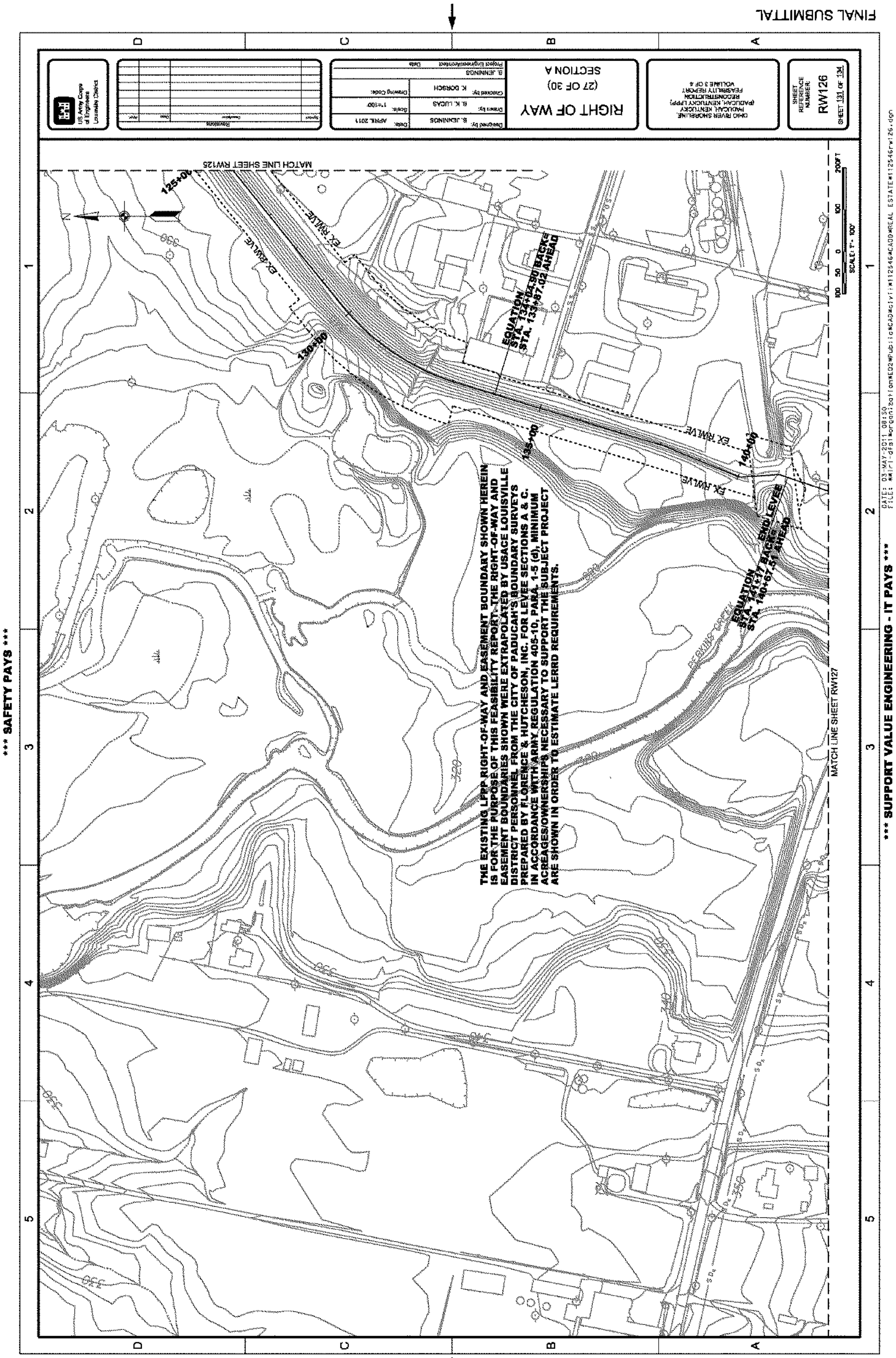
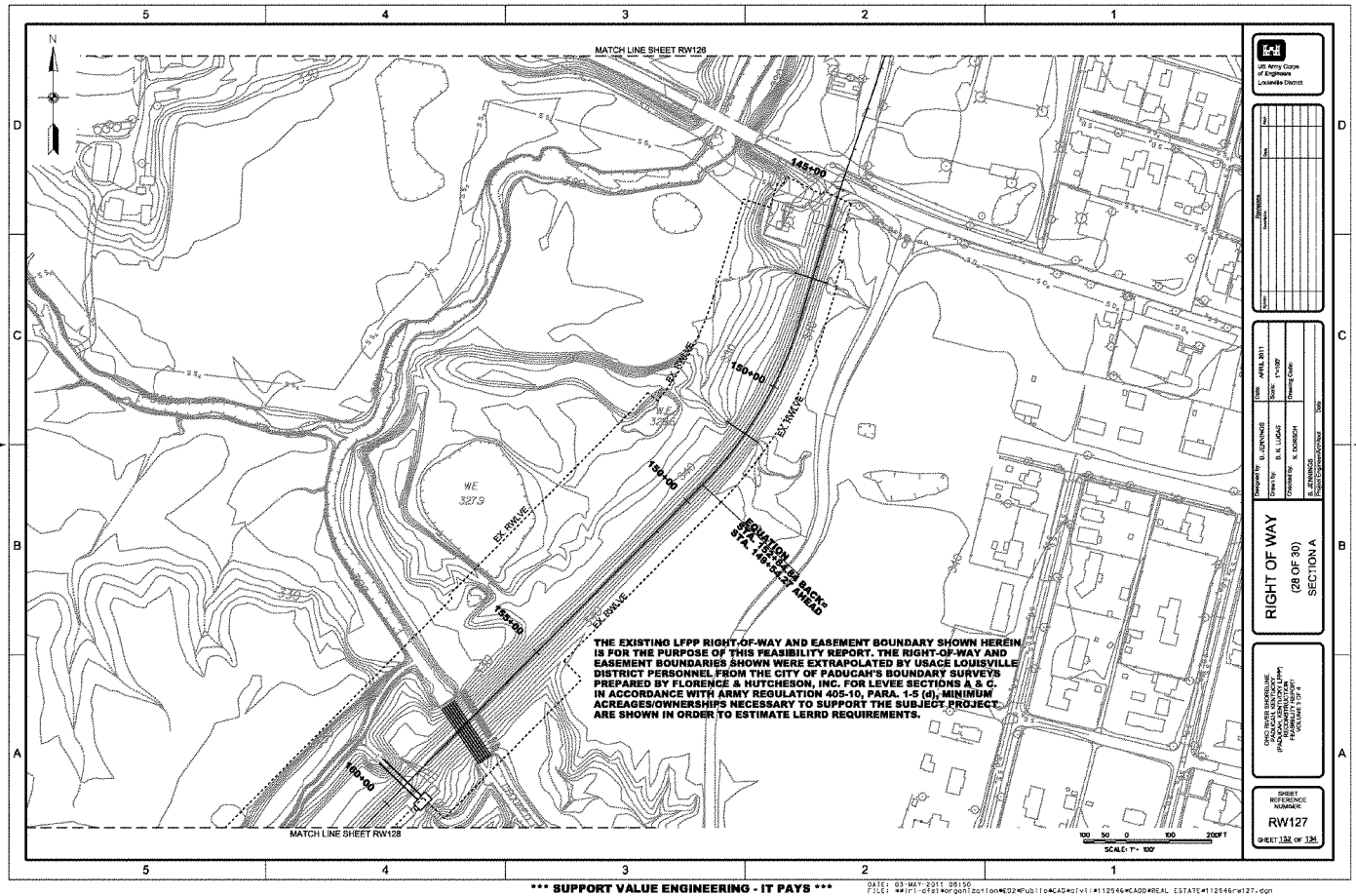

FINAL SUBMITTAL
RIGHT OF WAY
(27 OF 30)
SECTION A
OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KENTUCKY LFPP) RECONSTRUCTION FEASIBILITY REPORT VOLUME 3 OF 4
SHEET REFERENCE NUMBER: RW126
SHEET 131 OF 134
US Army Corps of Engineers Louisville District
Designed by: S. JENNINGS
Date: APRIL 2011
Drawn by: B. K. LUCAS
Scale: 1"=100'
Checked by: K. DORSCH
Drawing Code:
S. JENNINGS
Project Engineer/Architect
Date
MATCH LINE SHEET RW125
MATCH LINE SHEET RW127
125+00
130+00
135+00
140+00
EX RWLVE
EQUATION STA. 134+04.80 BACK STA. 133+87.02 AHEAD
EQUATION STA. 141+17.77 BACK STA. 140+67.51 AHEAD
END LEVEE
PERKINS CREEK
THE EXISTING LFPP RIGHT-OF-WAY AND EASEMENT BOUNDARY SHOWN HEREIN IS FOR THE PURPOSE OF THIS FEASIBILITY REPORT. THE RIGHT-OF-WAY AND EASEMENT BOUNDARIES SHOWN WERE EXTRAPOLATED BY USACE LOUISVILLE DISTRICT PERSONNEL FROM THE CITY OF PADUCAH'S BOUNDARY SURVEYS PREPARED BY FLORENCE & HUTCHESON, INC. FOR LEVEE SECTIONS A & C. IN ACCORDANCE WITH ARMY REGULATION 405-10, PARA. 1-5 (d), MINIMUM ACREAGES/OWNERSHIPS NECESSARY TO SUPPORT THE SUBJECT PROJECT ARE SHOWN IN ORDER TO ESTIMATE LERRD REQUIREMENTS.
SCALE: 1"= 100'
*** SAFETY PAYS ***
*** SUPPORT VALUE ENGINEERING - IT PAYS ***

*** SAFETY PAYS ***



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FINAL SUBMITTAL

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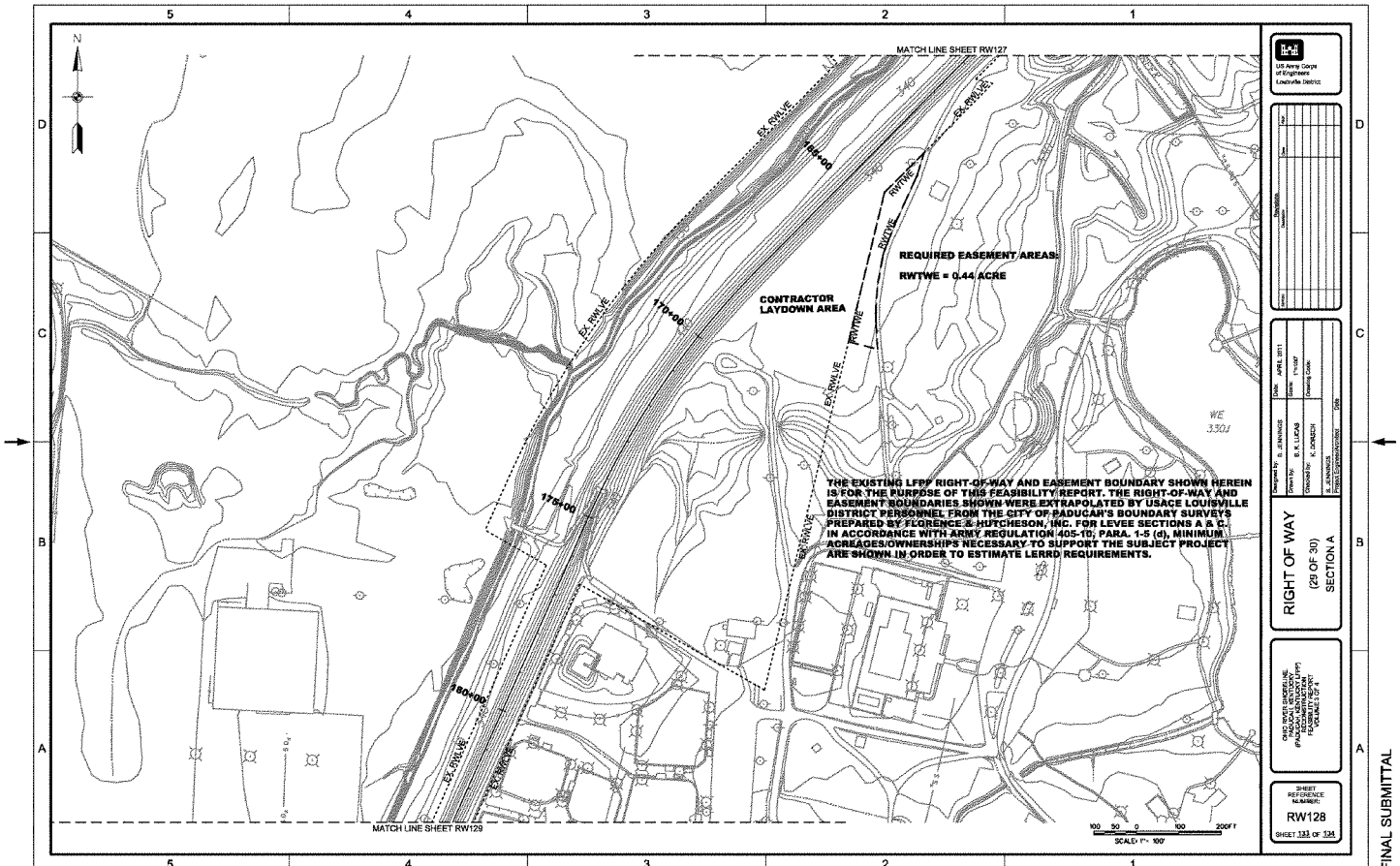

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FINAL SUBMITTAL

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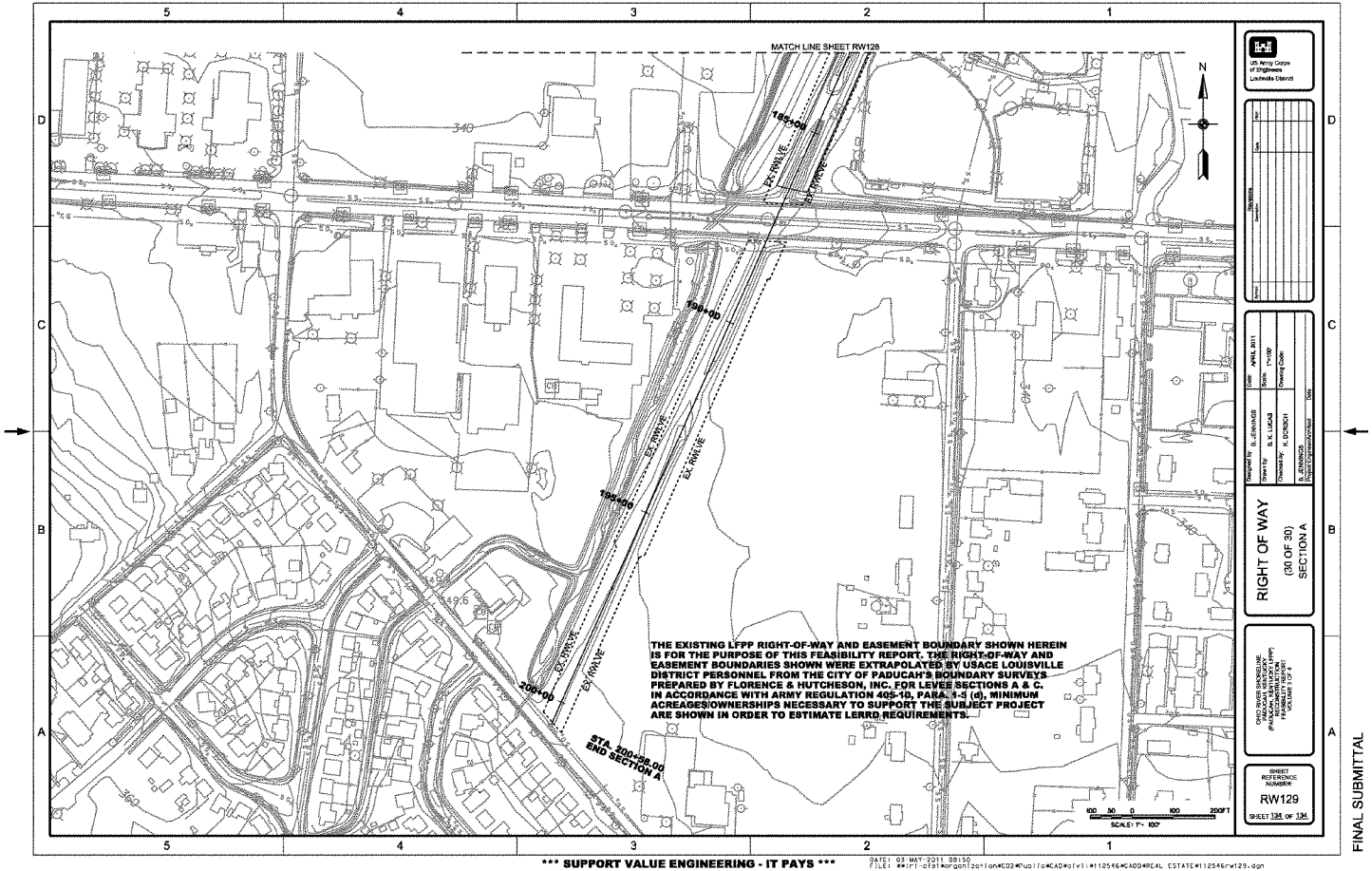

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US Army Corps
of Engineers
Louisville District

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY (PADUCAH, KY LFPP) RECONSTRUCTION FINAL FEASIBILITY REPORT

VOLUME 4 of 4
ENGINEERING CALCULATIONS
REFERENCES AND AS-BUILTS

DEPARTMENT OF THE ARMY
U.S. ARMY DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
P.O. BOX 59
LOUISVILLE, KENTUCKY 40201-0059

April 2011
Final Submittal

OHIO RIVER SHORELINE
PADUCAH, KENTUCKY LFPP
RECONSTRUCTION
FEASIBILITY REPORT
VOLUME 4
APPENDIX C

ENGINEERING CALCULATIONS AND REFERENCES

TABLE OF CONTENTS

DVD 1 of 3

SECTION 1 – GENERAL REFERENCES

1.1 - Flood Protection Plan
1.2 - Operation and Maintenance Manual
1.3 – MOU USACOE Dated 17 November 2008
1.4 – ASA – CW Approved Request Exception to Policy
1.5 – Reconstruction of FDR 16 August 2005

1.6 – Ohio River, Paducah, Kentucky Flood Damage Reduction Section 905(b) Report, WRDA 1996, dated May 2000

1.7 - Implementation Guidance for Section 5077 of the Water Resources Development Act of 2007 (WRDA 2007) – Paducah, Kentucky

1.8 - CECW-PG Memorandum, Subject: Economic Guidance Memorandum (EGM) 04-01, Generic Depth-Damage Relationships for Residential Structures with Basements, dated 10 October 2003

1.9 – Documentation for Decommissioning of Pump Plant #8

SECTION 2 - GEOTECHNICAL CALCULATIONS

2.1 – Seep and Slope Calculations
2.2 - Paducah, Kentucky Hydrograph
2.3 - Settlement & Bearing Calculations
2.4 – Referenced Geotechnical Reports and Data
2.4.1 – Seismic Investigation, Paducah, KY by Harris/Street
2.4.2 – Feasibility Boring Location Plan & Boring Logs
2.4.3 – Feasibility Lab Testing Results by Florence & Hutcheson
2.4.4 – Geotechnical Report for Four Rivers Center, Paducah, KY
2.4.5 – Geotechnical Report for Crounse Headquarters, Paducah, KY
2.5 – USACE Slip Liner Proof Test SOW

April 2011
Final Submittal

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY LFPP RECONSTRUCTION FEASIBILITY REPORT VOLUME 4 APPENDIX C

ENGINEERING CALCULATIONS AND REFERENCES

TABLE OF CONTENTS

(cont'd)

SECTION 3 - STRUCTURAL CALCULATIONS
- **3.1 - Closure Calculations**
- **3.2 - L Walls**
- **3.3 - Pump Station Global Stability**
- **3.4 - KY CWALSHT**
- **3.5 - Paducah Closures**
- **3.6 - Seismic Stability**
- **3.7 - T Wall Calculations**

SECTION 4 - AS-BUILT DRAWINGS

SECTION 5 - SECTION A AND C RIGHT-OF-WAY DRAWINGS
- **5.1 - Section C Right-Of-Way Drawings**
- **5.2 - Section A Right-Of-Way Drawings**

DVD 2 of 3

Pipe Inspection Reports and Videos

DVD 3 of 3

Pipe Inspection Reports and Videos (cont'd)
Hydraulics and Hydrology Analysis Models
Geotechnical Analysis Models

April 2011
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OHIO RIVER SHORELINE, PADUCAH, KENTUCKY LFPP RECONSTRUCTION FEASIBILITY REPORT VOLUME 4 APPENDIX C

SECTION 1 GENERAL REFERENCES

April 2011
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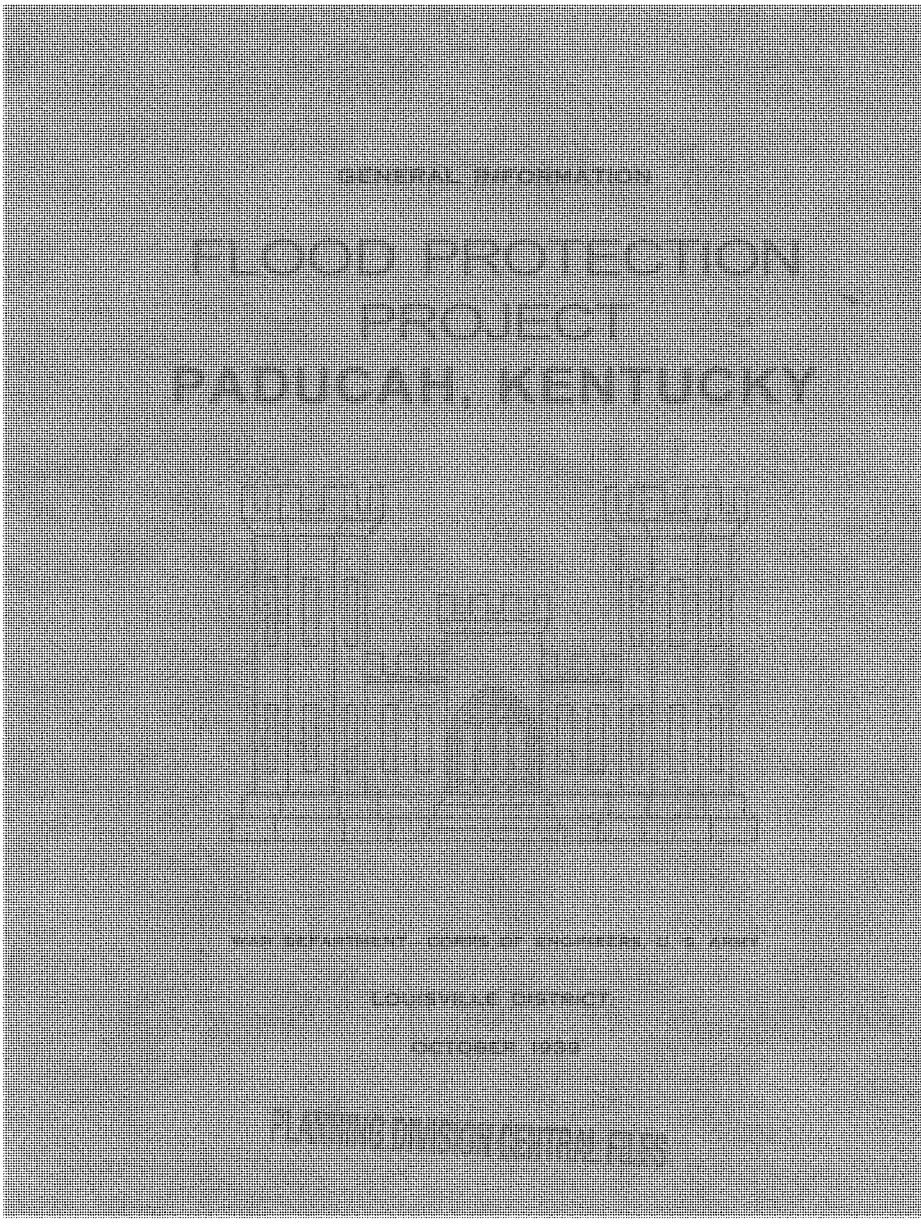


WAR DEPARTMENT
U. S. ENGINEER OFFICE
LOUISVILLE, KENTUCKY

OCTOBER 1939

FLOOD PROTECTION PROJECT
PADUCAH, KENTUCKY

PREPARED UNDER THE DIRECTION OF
LT. COL. D. A. DAVISON
DISTRICT ENGINEER

I N D E X

	Page
Authorization	1
General	1
Flood Situation	2
Photographs	3
Preliminary Measures	8
Engineering Features	9
Structural Details	10
Rights-of-Way	12
Estimates of Cost	12

EXHIBITS

1. General Plan
2. Typical Levee Sections
3. Typical Levee and Wall Sections
4. Typical Closure Works for Railroad
5. Typical Closure Works for Railroad, Part of Movable Closure in Place
6. Typical Section of a Pumping Plant

FLOOD PROTECTION PROJECT
PADUCAH, KENTUCKY

AUTHORIZATION

Following the disastrous Ohio River flood of January - February, 1937, Congress amended the Flood Control Act of 1936 by the passage of H. R. 7646 (Public No. 406, 75th Congress, 1st Session), approved August 28, 1937. This latter Act authorized the construction of levees, flood walls, and drainage structures for the protection of cities and towns in the Ohio River Basin, the projects to be selected by the Chief of Engineers with the approval of the Secretary of War, in accordance with the report of the Chief of Engineers in House Committee on Flood Control document Numbered 1, 75th Congress, 1st Session, at a cost not to exceed $24,877,000 for construction, which was thereby authorized to be appropriated for that purpose. The project for the construction of flood protection works at Paducah, Kentucky (a writ in the above plan) was selected by the Chief of Engineers and was approved by the President on December 8, 1937.

GENERAL

The City of Paducah is located in the northern part of McCracken County, Kentucky, on the left bank of the Ohio River, approximately 934 miles below Pittsburgh, immediately below the mouth of the Tennessee River and four miles upstream from Dam No. 52, Ohio River.

Bounded on the north and northeast by the Ohio and Tennessee Rivers, this city of approximately 38,000 population in 1937 lies within the alluvial valley of the Ohio River. The major portion of its residential and business districts is situated on a level and relatively high flood plain terrace that extends to the low hills on the south. The average elevation of this alluvial terrace is about 337 feet, m.s.l., or 35 feet above the normal upper pool of Dam No. 52, Ohio River. Island Creek flows through the eastern part of the city to join the Ohio River immediately below the mouth of the Tennessee River, and Perkins Creek is located just west of the city limits.

Paducah is on the main line of the Gulf, Mobile and Northern Railroad, and on branch lines of the Illinois Central, the Nashville, Chattanooga and St. Louis, and the Chicago, Burlington, and Quincy Railroads. Water transportation on the canalized Ohio River is available at Paducah to points on the Ohio, Tennessee, Cumberland, and Mississippi Rivers. The City is served by five bus lines and ten truck lines. U.S. Highways Nos. 60, 62, and 68 carry the major portion of the east and west traffic in this vicinity. North and south traffic moves over U. S. Highway No. 45 which connects Paducah to a network of roads in western Kentucky and southern Illinois.

Paducah is principally an industrial community, but also serves as a trading center and source of supply for a large surrounding rural territory. Located within

the city are 70 industries, 69 wholesale establishments, 538 retail stores, and the main shops of the Illinois Central Railroad.

The Kentucky Utilities Company provides electric power for approximately 9,250 consumers in Paducah. This supply is brought into the city over two 66,000 volt transmission lines. The company has a reserve steam generating plant situated at Second and Monroe Streets in Paducah, but this station is operated only during peak, loads. The Kentucky Utilities Company also supplies 2,800 customers with manufactured gas produced by a plant located at Second and Madison Streets, near the Ohio River.

Paducah is served by the Southern Bell Telephone Company, and the Western Union and Postal Telegraph Companies. There is a commercial radio broadcasting station in the city with call letters WPAD.

The Paducah Water Works Company, which is municipally owned, supplies an average of 3,000,000 gallons of water per day to about 8,000 consumers. Water is taken directly from the Ohio River, purified and treated in a purification plant located at First Street and Kentucky Avenue, and pumped into the distribution system.

The sewer system for Paducah is comprised of both separate and combined storm and sanitary sewers. These sewers carry off sanitary flows from 80 per cent of the city's populated area and drain storm waters from 50 per cent of the city's area. No treatment is provided and the sewage is discharged directly into Island Creek and the Ohio River.

FLOOD SITUATION

Three major floods have occurred at Paducah in the past 65 years. The floods of 1884 and 1913, which reached about the same elevation in this vicinity, 340.5 feet, m.s.l., inundated approximately 70 per cent of the city to an average depth of 3 feet. The flood of January-February 1937, the naximum of record, having a crest elevation of 346.8 feet, m.s.l., covered 7.6 square miles of the metropolitan area or about 95 per cent of the entire city to average depths of 6 to 10 feet, caused the suspension of all business, and necessitated a complete evacuation of the population residing in the flooded area. (See photograph 1.) All utilities such as electric light, gas, water, telephone, and telegraph service were cut off in the flooded area and only two of them, light and telephone service, were maintained without interruption on the high ground to the south. At one time the only communication with the outside world was by radio and by automobile and truck over U. S. Highway No. 45, which remained open to the south from the high ground in the southwestern portion of the city. All other forms of communication, all other roads, and all railroads were cut off during the crest of this flood. Approximately 33,000 refugees were evacuated from the inundated portions of the city and housed in other communities in western Kentucky and in parts of Tennessee and Alabama. Eighteen deaths were reported as resulting from this disaster. Of these, seven were due to drowning and the remainder to other causes.

An extensive flood damage survey was made under the direction of the District Engineer, Louisville District, subsequent to the flood of January-February 1937. The results of this survey indicate that the direct damages caused by this flood in the City of Paducah amounted to $10,638,000. The value of the property in this community prior to this flood, is estimated to have been $72,369,000. The following tabulation indicates the various types of property flooded, together with the number of units and the total direct damage to each type:

Type	Number	Direct Damages
Residences	6,730	$5,417,000
Business	702	2,665,000
Industries	79	1,047,000
Public Property	88	590,000
Public Utilities	6	301,000
Common Carriers;	12	618,000
	Total	$10,638,000

In addition to the direct damages listed above, the city suffered certain indirect losses which include such items as loss of life, loss of business, loss of wages, and depreciation of property values. The total damages due to the 1937 flood, Including direct and indirect losses, are estimated at approximately $25,000,000.

PHOTOGRAPHS

Photograph No. 1 is an aerial view of Paducah showing the extent to which the city was inundated, and was taken when the flood of January and February 1937 was at Its crest.

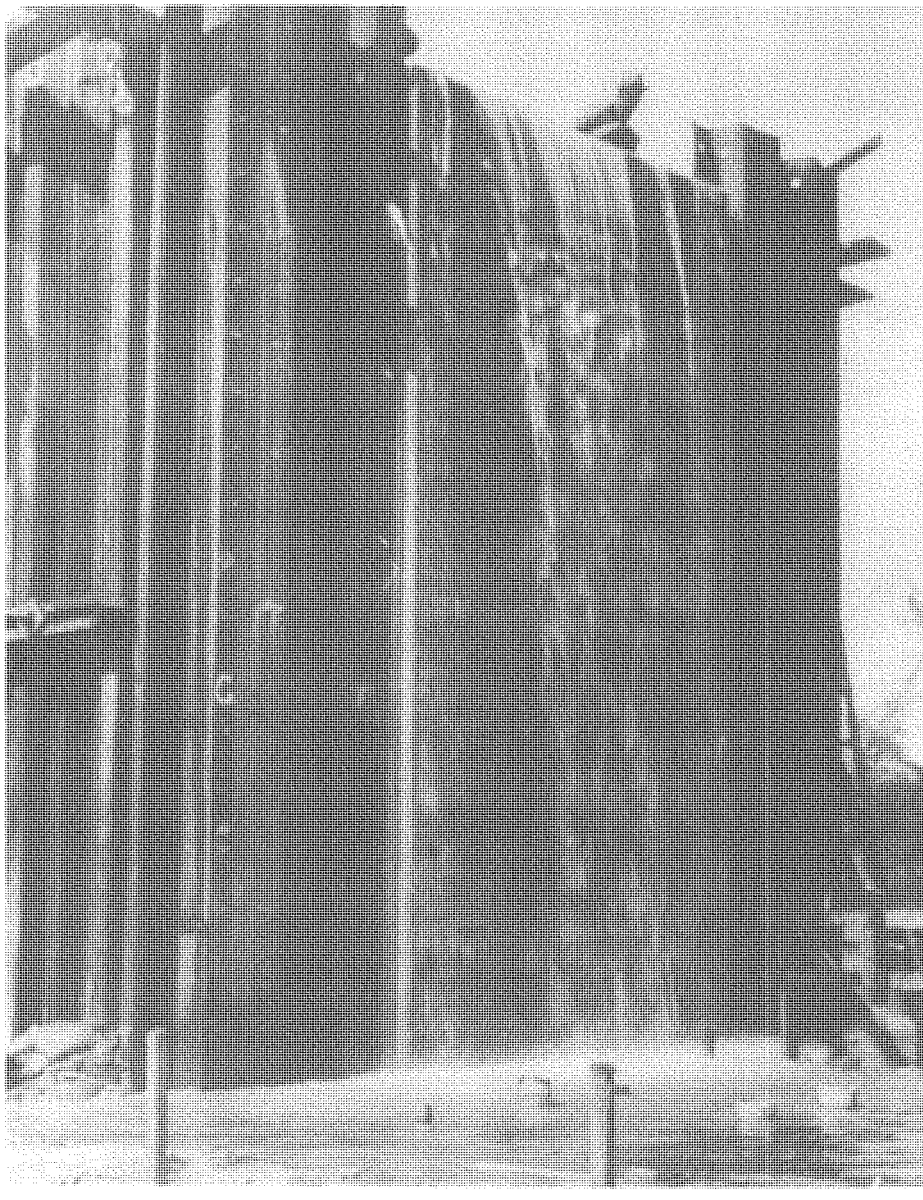
Photographs Nos. 2 and 3 show two views of a completed section of embankment which forms a part of the levee now under construction.

Photograph No. 4 shows a view of a full scale model test of the "I" type wall under maximum head.

#1. Paducah, Ky., General View

#2. Looking southwest along landside of levee. Section "C" Paducah, Ky. Station 140+00. Levee complete except dressing and seeding.

#3. Looking southwest along riverside adjacent Borrow Pit which will be used as a diversion channel. Section "C" Paducah, Ky. Station 140+00. Levee complete except dressing and seeding.



#4. Full Scale Model test of "I" type wall, concrete section extends 20 feet above the ground line.

PRELIMINARY MEASURES

Having been commissioned with the task of designing and constructing the authorized protective system for Paducah, Kentucky, the Louisville District of the Corps of Engineers, U. S. Army, accordingly undertook the necessary preliminary measures In December 1937.

Local interests at Paducah were contacted to ascertain their attitude in regard to flood protection for that city and to obtain the necessary assurances of local cooperation required by existing law. On January 8, 1938, a resolution was passed by the City Council of Paducah approving the proposed project and granting assurances of local cooperation. This resolution and assurance complied with the requirements of the Flood Control Act of June 22, 1936, as amended by the Act of August 28, 1937. On April 22, 1938, the President of the United States authorized the waiver of the requirements of Section 3 of the Flood Control Act of June 22, 1936, to the extent of 40 per cent of the estimated cost of lands, easements, and rights-of-way for Paducah, and the City Council amended their resolution of January 8, 1938, and the accompanying assurance to agree with the terms of the approved Presidential waiver.

The government of the City of Paducah having furnished the necessary assurances of local cooperation and these assurances having been approved by the President, the Louisville District undertook the preparation of plans for a flood protection system for that city.

The grades for the top of the protective works were established at an elevation 3 feet above the confined flow of a flood equivalent to that of January-February 1937, with the flood protection works for the cities of Brookport (on opposite shore of the Ohio River) and Paducah, in place. The obstruction to the free flow of the river, caused by the Paducah-Brookport Highway Bridge, was considered in establishing these grades. This 3-foot safety factor will be increased from time to time as additional units of the comprehensive reservoir plan for the Ohio River Basin are completed and placed in operation.

Before the final location of the protective works for Paducah was determined, three general plans were considered and the necessary surveys were made to locate the protective lines contemplated under each of these plans. After carefully weighing the advantages and disadvantages of each, a plan was adopted that protects the entire city, allows adequate space for future growth, and permits uninterrupted access to the city during major floods. The trace of the works under this plan is shown on Exhibit 1.

A public hearing was held in Paducah by the Louisville District on May 12, 1938, at which time all interested parties were informed as to the location of the proposed protective works.

ENGINEERING FEATURES

The flood protection project for the City of Paducah consists of a line of protective works approximately 12 miles long, composed of earth levees and concrete walls, together with the necessary appurtenances, such as drainage structures, pumping plants, sewer connections, traffic openings, and ramps.

Detailed location surveys were made by the Louisville District in the spring of 1938 as a basis for the location and design of the protective works. Foundation investigations undertaken in connection with the surveys consisted of auger borings and test pits along the trace of the protective works and in proposed borrow pit areas.

To expedite the construction and acquisition of the necessary rights-of-way for the Paducah project, the protective works for this city were divided into three sections which are referred to hereafter as Sections "A", "B", and "C". The location of the protective works for each of these sections is shown on Exhibit 1.

Section "C", the upstream division of these protective works, begins on the left bank of Island Creek, approximately 6 miles due south of the center of the city, and extends from this point in a general northeasterly and then northwesterly direction, a distance of approximately 31,700 feet, to a point on the riverfront near the foot of Mill Street. This section is composed entirely of levee embankment, together with the necessary drainage structures, traffic openings, and ramps.

Section "B", consisting of combinations of concrete walls with two short sections of levee embankment, together with the necessary appurtenant structures, is approximately 18,120 feet in length and extends along the river front from the lower end of Section "C", near the foot of Mill Street, to the beginning of Section "A", in the vicinity of Burnett Street.

Section "A" consists entirely of levee embankment, with the necessary appurtenant structures, and is approximately 14,810 feet in length. It begins at the downstream end of Section "B" and extends in a westerly and then a southwesterly direction to the high ground near the western limits of the city.

The foundation investigations carried on in connection with the location survey for Paducah revealed the following general conditions: The trace of the protective works for Section "C" is located on a layer of stiff clay 20 to 25 feet in depth. This clay forms an excellent foundation for the levees in this area. In Section "B" a stratum of brown clay of stiff consistency averaging about 25 feet in thickness underlies the first 4,000 feet of protection. This stratum is covered with a fill of cinders and debris to an average depth of about 4 feet throughout about 1,600 feet of its length. On the right bank of Island Creek a pocket of loose red sand 10 feet in thickness was found at a depth of approximately 10 feet below the surface; however, there was no evidence of this pocket on the left bank. From the vicinity of Island Creek to the end of Section "B", the native soil for the most part consists of an ex-

cellent quality of clay covered at a number of points by fills of various materials to depths varying from 0 to 16 feet; The material found along the line of Section "A" is composed of a 6 to 12 foot layer of clay, lying over a stratum of gravel. This gravel bed appears to underlie the entire western portion of the City of Paducah No serious difficulties from the standpoint of seepage are anticipated, however, inasmuch as the gravel contains an appreciable amount of clay.

Interior drainage during normal periods, that is, when the Ohio River is below flood stage, is accomplished by means of gravity outlets. These outlets are provided with flood gates so that they may be closed during flood periods. At such times the surface drainage and the sewage will be pumped from the protected area.

The natural drainage of branches of Island Creek and Bee Branch will be prevented from entering the protected area during times of floods by means of a system of flood gates and diversion channels. (See Exhibit 1.)

In time of emergency the protective works will form a watertight barrier between the city and the river. All storm water falling within the city and all domestic sewage will be pumped over the protection. Twelve pumping stations have been provided along the route to give the most practical and economical disposition of the interior drainage from Paducah's ten storm, two sanitary, and two combined sewer systems. A plan was considered which involved intercepting all of the city's waste by constructing one large interceptor sewer along the line of protection, this interceptor to carry the sewage to one pumping plant of sufficient size to discharge the entire flow. After a careful study of the interceptor plan it was concluded that such a plan was both impracticable and uneconomical, and accordingly the scheme was abandoned in favor of the twelve pumping stations.

STRUCTURAL DETAILS

Typical levee sections are shown on Exhibits 2 and 3. As indicated thereon, the standard levees have been provided with a crown width of 8 feet and side slopes of 1 on 3, and 1 on 4. Special sections were provided for the crossing of Island Creek and the low ground near the beginning of Section "B". All levee embankments are carefully compacted by the use of sheepsfoot rollers. Prior to the construction of the levees an inspection ditch is excavated along the center line to verify foundation conditions and to determine the presence of foreign materials or possible sources of seepage. The levees are seeded and stone paving has been provided along the riverside slopes at points where erosion is possible. Drains have been provided along the landside toe of the levees to facilitate foundation drainage and carry off excessive seepage.

Two types of walls are employed on this project; sections of each type are shown on Exhibit 3.

The "I" type wall is a composite structure of interlocking steel sheet piling

and reinforced concrete, designed as a cantilever beam, and prevented from sliding and overturning by the penetration of the piling below the ground surface. Where limited rights-of-way conditions were encountered and where the height of the wall was not excessive the "I" type wall was employed.

During the summer of 1938, the Louisville District erected test sections of the "I" type wall at Paducah, Kentucky, and subjected these sections to extensive loading tests simulating actual flood conditions. Heads of 20 feet were attained without excessive stresses in either the structures or the soil. Photograph No. 5 shows the test wall under maximum head. As a result of these tests it was concluded that the "I" type wall could be advantageously constructed to heights of 16 feet, with an ample factor of safety, using commercially available steel sheet piling sections.

At points along the protective line where the height of the wall was in excess of 16 feet, the "T" type wall was used. As its name implies this type of wall resembles an inverted T. Both vertical stem and horizontal base are constructed of reinforced concrete. A continuous steel sheet piling cut-off has been provided along the riverside of this wall to prevent percolation of water beneath it, and a drain has been placed along the landside to control seepage and to improve the drainage of the foundation materials.

Openings in the protective line, to permit the free passage of traffic during normal conditions, have been provided at a total of 42 points along the trace of the system. Railroads pass through eleven of these openings, twelve are devoted to industrial use, and the remainder permit uninterrupted street and highway travel.

In time of emergency these openings will be closed by means of portable steel trestles, supporting horizontal "I" beam purlins faced with interlocking steel sheeting. When not in use these movable gates are stored in vaults that have been provided as an integral part of the closure structures.

The gates have been designed for erection and removal entirely by man-power, in a short time, and result in a safe, watertight wall, with few parts, all of which are readily replaceable. The arrangement as a whole provides an economical, compact, and readily assembled unit. Details of a typical movable closure are shown on Exhibits 4 and 5.

In addition to the openings described above, six ramps have been provided to carry existing highways over the top of the levee.

Details of a typical pumping station are shown on Exhibit 6. During normal periods sewage passes through the station and discharges into the river. At times of extreme high water in the river the flood gate in the station is closed and sewage rises in the pump chamber. The pumps come into action and the sewer flow is pumped through the wall and into the river.

RIGHTS-OF-WAY

The average width of the rights-of-way required for the levees, walls, and borrow pits under this project is about 200 feet. A total of some 296 acres of land is required for the construction of these works. The cost of all rights-of-way amounts to approximately $400,000, of which the City of Paducah provides $260,000, and the Federal Government the remainder, but not exceeding $160,000. A bond issue to raise the necessary funds for Paducah's share of the rights-of-way cost was approved by popular vote and the City of Paducah accordingly undertook the task of purchasing lands along the line of protection. Acquisition of the rights-of-way has been completed for Sections "A" and "C". Acquisition of rights-of-way for Section "B" is under way and was, on the date of issue of this pamphlet, about 25 per cent complete.

ESTIMATE OF COST

The estimated construction cost of the Paducah project is shown by the following tabulation:

	Section A	Section B	Section C	Entire Project
Protective Structures	$267,950	$2,256,500	$357,550	$2,882,000
Pumping Plants	297,850	664,200	37,950	1,000,000
Total	$565,800	$2,920,700	$395,500	$3,882,000

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

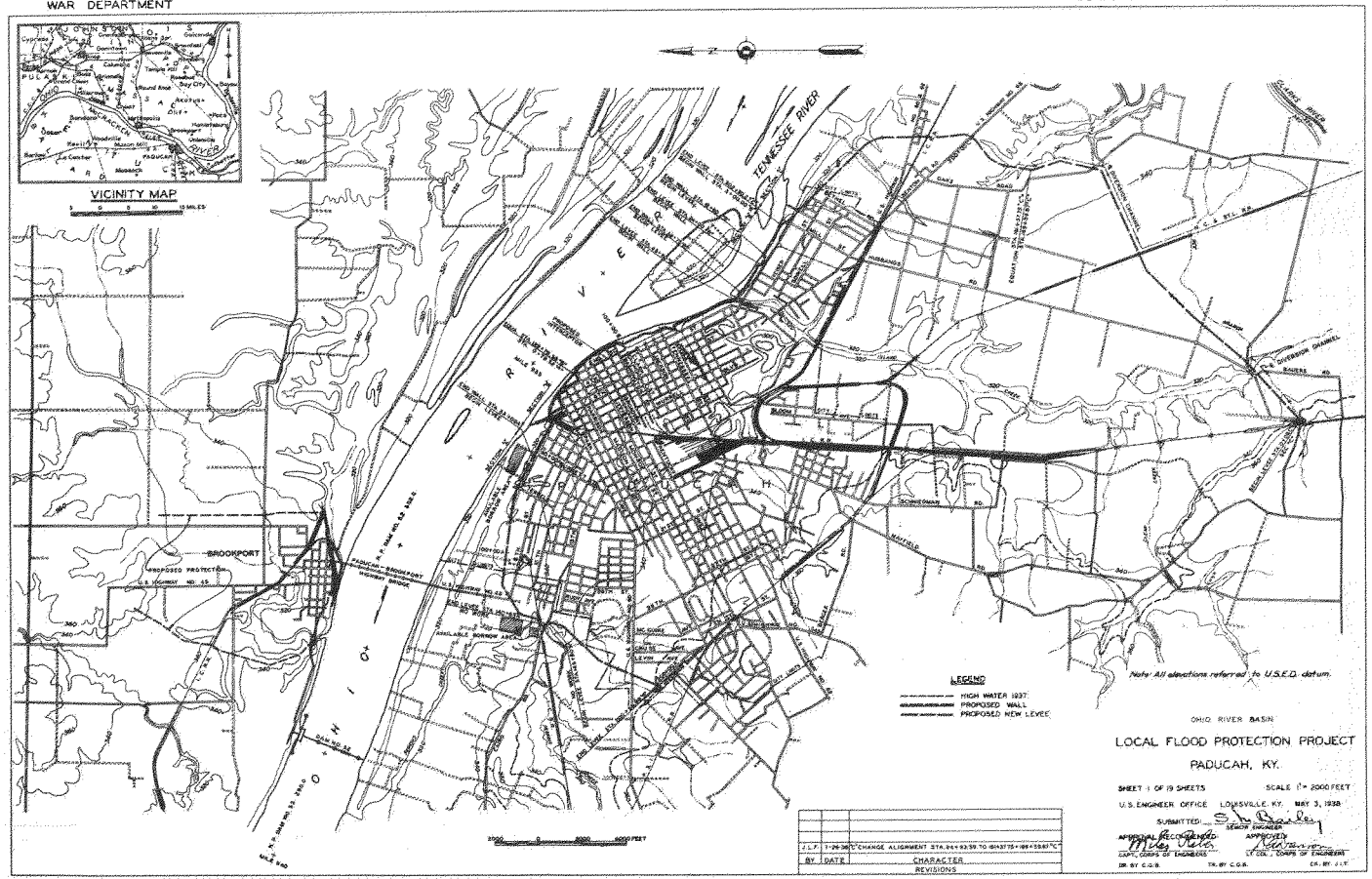
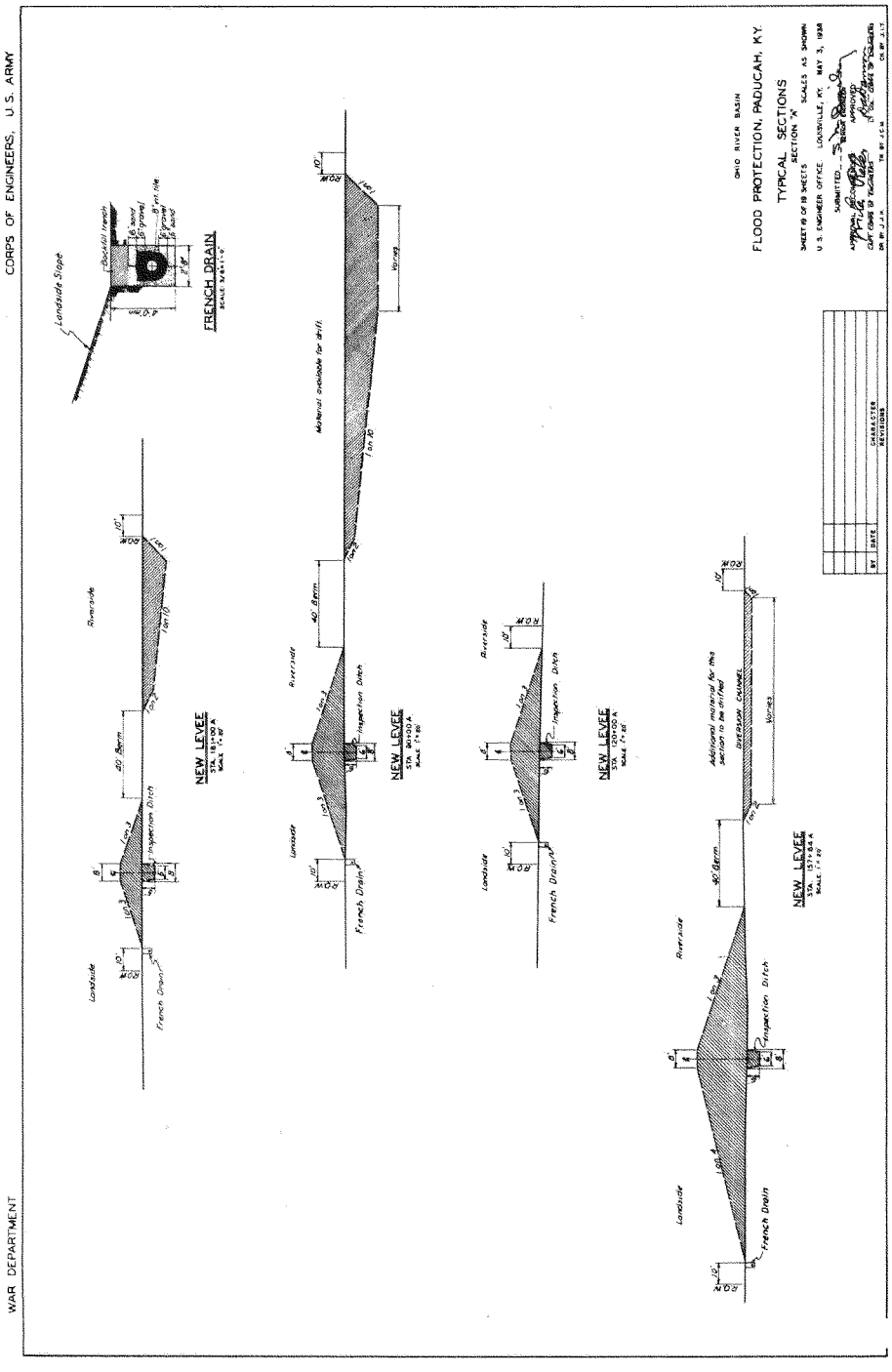


EXHIBIT 1


WAR DEPARTMENT
CORPS OF ENGINEERS, U.S. ARMY
OHIO RIVER BASIN
FLOOD PROTECTION, PADUCAH, KY.
TYPICAL SECTIONS
SECTION "A"
SHEET 19 OF 19 SHEETS
SCALES AS SHOWN
U.S. ENGINEER OFFICE LOUISVILLE, KY. MAY 3, 1938
SUBMITTED
APPROVED
EXHIBIT 2
FRENCH DRAIN
Landside Slope
NEW LEVEE
Riverside
Landside
Inspection Ditch
French Drain
Material available for drift
Varies
DIVERSION CHANNEL
Additional material for this section to be drifted
BY
DATE
CHARACTER
REVISIONS

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

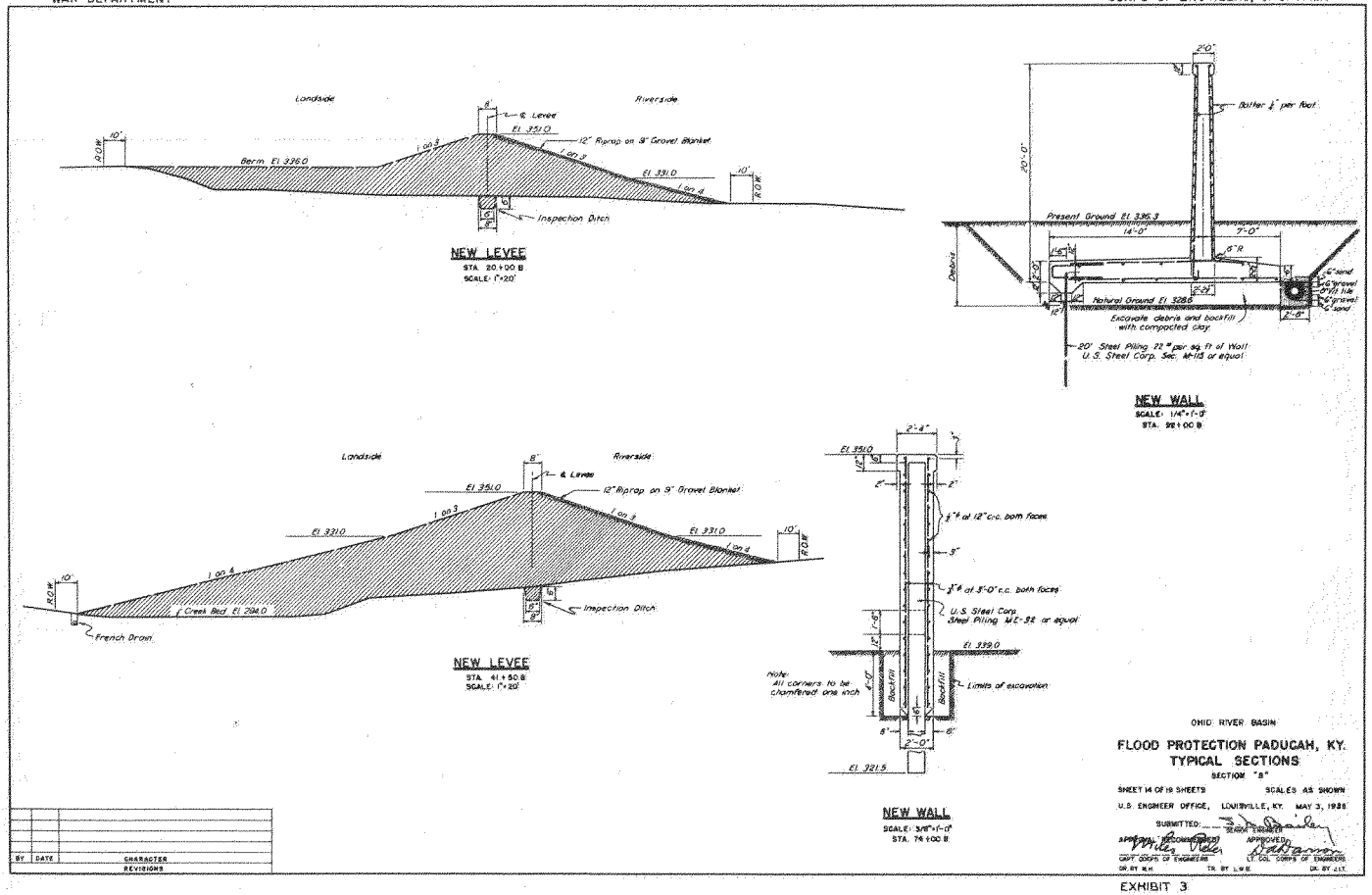


EXHIBIT 3

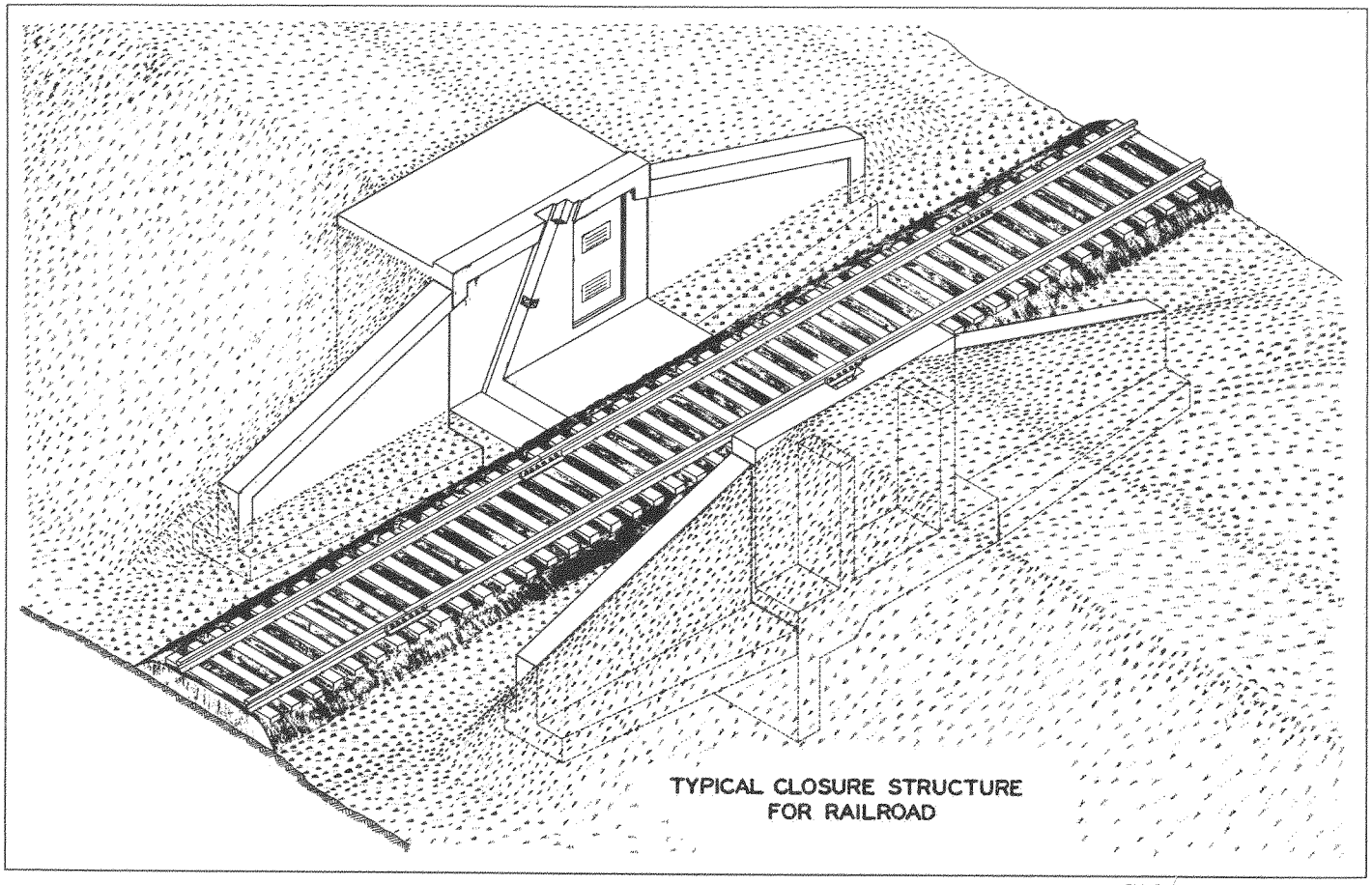


EXHIBIT 4

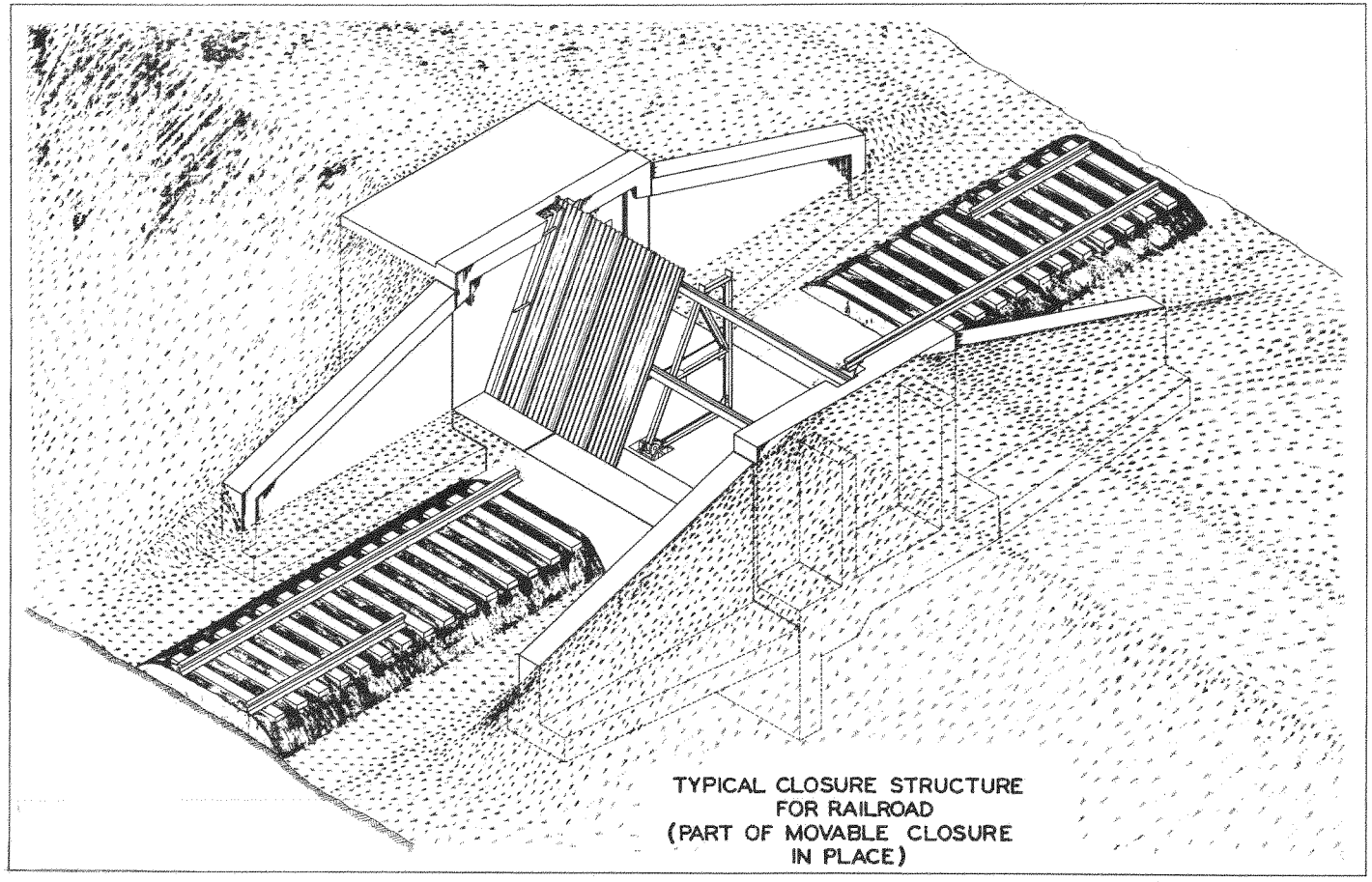
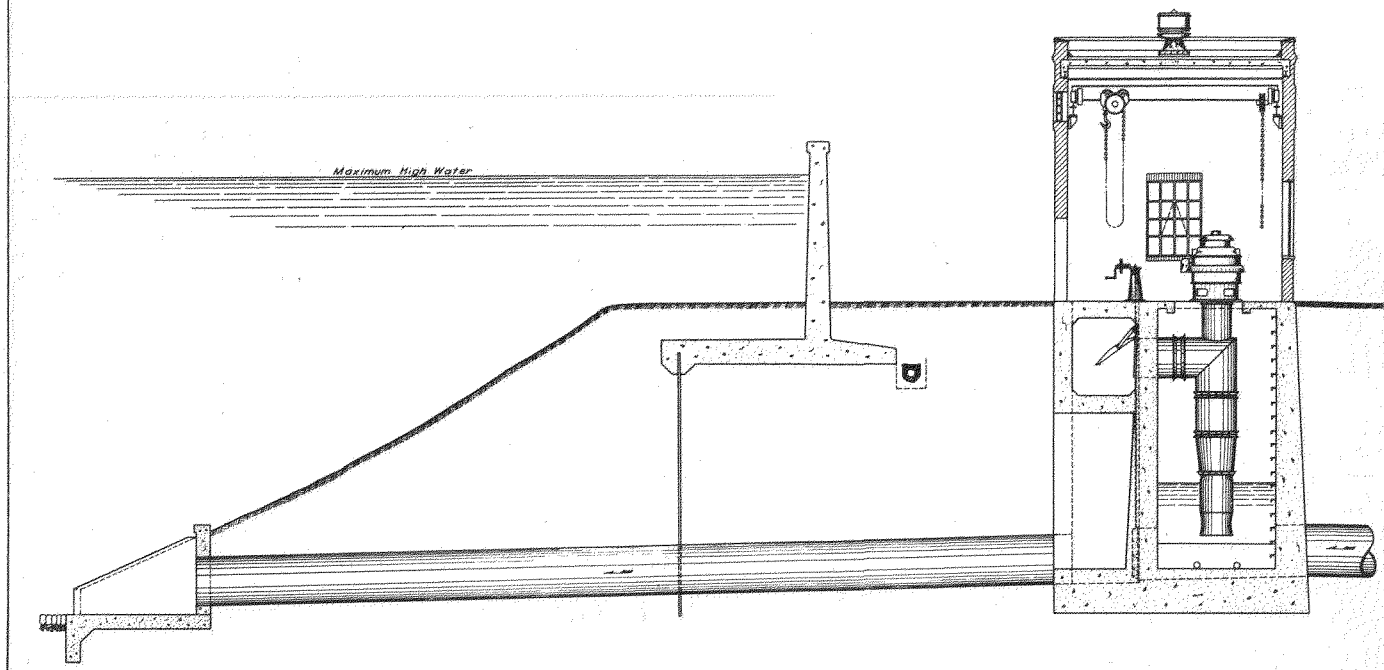

TYPICAL CLOSURE STRUCTURE
FOR RAILROAD
(PART OF MOVABLE CLOSURE
IN PLACE)

EXHIBIT 5



TYPICAL PUMPING STATION

EXHIBIT 6

OPERATION AND MAINTENANCE MANUAL

FLOOD PROTECTION WORKS

PADUCAH, KENTUCKY

LOUISVILLE DISTRICT

CORPS OF ENGINEERS U. S. ARMY

1952

U.S. ARMY ENGINEER DISTRICT, NASHVILLE
ATTN: JOHN FARLEY
CEORN-EP-H
P.O. BOX 1070
NASHVILLE, TN 37202-1070

* 1981 REVISIONS
OPERATION AND MAINTENANCE MANUAL
FLOOD PROTECTION WORKS
PADUCAH, KENTUCKY

NOTE: A single * denotes a revision to the manual as of the date shown on the lower corner of the page.

1. Cover.

Revision date changed.

2. Table of Contents.

Changed to reflect revisions made.

3. Page I-1.

Paragraph 1-03. Changed 12 pumping plants to 13.

4. Page II-1.

Paragraph 2-01. Authority was corrected.

5. Section 3.

Paragraph 3-03. Quotes from Federal Regulations were changed to agree with latest publication.

Paragraph 3-05 thru 3-10 were rewritten.

Paragraph 3-11 was rewritten.

Paragraph 3-13 deleted the word "Periodic".

Paragraph 3-14 was reworded.

Paragraph 3-16 added the last sentence.

Paragraphs 3-17, 3-18, and 3-19 were reworded.

Paragraph old 3-20 was deleted. This information is listed in the operating instructions.

6. Section 4.

Paragraph 4-03 added sentence (xi).

Paragraph 4-04 added "Protection of Sod".

Paragraph 4-08 reworded the first sentence.

Paragraphs 4-10, 4-12, and 4-13. Revisions were made with respect to the fertilizer composition, rate of application of mulch, seed mixture and time of seeding.

Paragraph 4-15. Added "stone replacement should be of similar size, weight, gradation and quality as the original stones."

Paragraph 4-19 was rewritten.

7. Page VI-3.

Table 1. Added two flap gates and corrected 7 operating stages.

8. Page VII-4.

Table 2. Added "erection of closure should be completed by stage indicated" and note.

9. Section 8.

Paragraph 8-13A was rewritten.

Paragraph 8-15 was rewritten.

Paragraph 8-20 was rewritten and 820A was added.

Table 3 sample megger reading was deleted and new Table 3 humidity chart was added.

Paragraph 8-23. Added the warning note at the bottom of the paragraph.

Paragraph 8-28. Changed inspection dates to agree with flood season.

Paragraph 8-32. Added pumping plant No 13 to Table 4.

Paragraph 8-33. Changed Weather Bureau to National weather service.

Paragraph 8-35 a(2) was rewritten.

Paragraph 8-39 was rewritten.

Paragraph 8-45 was rewritten.

10. Section 10.

An updated Section 10 was added.

11. Appendix A.

An updated Appendix A was added.

12. Appendix C.

An updated Appendix C was added.

13. Page D-1.

Weather service and telephone number was corrected and location of gage was added.

14. Page F-1.

Paragraph 3 changed inspection dates to agree with flood season.

15. Page F-8.

Added two flap gates.

16. Page H-1.

Added new permits.

17. Plate 1-A.

Plate 1-A was deleted as it lack clarity and duplicate information shown on Plate 1.

18. Plates 4 and 5.

Added note on plastic sheeting.

19. Plate 11.

Sandbag requirement was corrected.

20. Plate 12.

Added note on earth fill.

21. Plate 26.

Added third pump and control equipment.

Paragraph II.4.b. Added Fairbanks Morse Farval greasing units.

Paragraph IV 1. Changed 7 feet to 4 feet.

22. Plates 27, 28, and 30.

Paragraph III.4 was rewritten.

23. Plate 31.

Paragraph III.5 was rewritten.

24. Plate 32.

Paragraph III.4 was rewritten.

25. Plate 35.

Paragraph IV.5 and 6. Location of manholes were corrected.

26. Plate 36.

Paragraph II.5b was rewritten.

Paragraph III.1. Changed amperes to volts.

27. Plate 38.

Added pump plant No. 13 and operation stage, two flap gates and inspection stages, added note and operation stage for sandbagging ramps. Operation stage for pump plant No. 10 was corrected.

28 Plate 39
plate was added

OPERATAION AND MAINTENANCE MANUAL
FLOOD PROTECTION WORKS
PADUCAH, KENTUCKY

TABLE OF CONTENTS

Paragraph		Page
	I - INTRODUCTION	
1-01	Authorization	I-1
1-02	Location	I-1
1-03	Description of Project	I-1
1-04	Dates of Construction	I-1
1-05	Protection Provided	I-1
1-06	General Plan	I-1
1-08	River Gage	I-1
	II - LOCAL COOPERATION	
2-01	Authority	II-1
2-02	Assurance of Local Cooperation	II-1
2-03	Resolution	II-1
	III - GENERAL	
3-01	General	III-1
3-02	Purpose of Manual	III-1
3-03	Regulations for Maintenance and Operation	III-1
3-04	Local Responsibility	III-3
3-05	Permits for Use of Rights-of-Way	III-3
3-06	Permit Forms	III-3
3-07	Permit Applications	III-3
3-08	Permit Bond	III-4
3-09	Permit Issuance	III-4
3-10	Adjacent Construction by Others	III-4
3-11	Duties of Superintendent	III-4
3-12	Semiannual Reports	III-5
3-13	Inspections	III-5
3-14	Flood Season	III-6
3-15	Checklist Forms	III-6
3-16	Federal Government Inspection	III-6
3-17	River Stage Predictions	III-6
3-18	Procedure at Various River Stages	III-7
3-19	General Operations During Floods	III-7
3-20	Drawings	III-7
3-21	Elevations	III-7

TABLE OF CONTENTS (Cont'd)

Paragraph		Page
	IV - LEVEES	
4-01	Description	IV-1
4-03	Maintenance	IV-1
4-04	Protection of Sod	IV-2
4-05	Drift	IV-2
4-06	Repairs	IV-3
4-10	Seeding	IV-3
4-11	Sodding	IV-4
4-12	Overseeding	IV-5
4-13	Fertilizing	IV-5
4-14	Grass Mowing	IV-5
4-15	Riprap	IV-6
4-16	Inspection	IV-6
4-17	Operation	IV-6
4-18	Levee Damage Due to High Water	IV-6
4-19	Sand Boils and Seepage Areas	IV-7
	V - FLOODWALL	
5-01	Description	V-1
5-02	Maintenance	V-1
5-03	Wall Repairs	V-2
5-04	Adjacent Land Maintenance	V-2
5-05	Inspection	V-2
5-06	Operation	V-2
5-07	Adjacent Land Damage Due to High Water	V-2
	VI - DRAINAGE STRUCTURES	
6-01	Description	VI-1
6-02	Maintenance	VI-1
6-03	Sluice Gates	VI-1
6-04	Flap Gates	VI-2
6-05	Inspection	VI-2
6-06	Operation	VI-2
6-07	Submergency Stages	VI-2
	VII - CLOSURE STRUCTURES	
7-01	Description	VII-1
7-02	Maintenance	VII-1
7-03	Gate Storage Vaults	VII-1

TABLE OF CONTENTS (Cont'd)

Paragraph		Page
	VII - CLOSURE STRUCTURES (Cont'd)	
7-04	Storage Vault Keys	VII-2
7-05	Gate Closures	VII-2
7-06	Inspection and Trial Erection	VII-2
7-07	Operation	VII-2
7-08	Gate Erection	VII-3
7-09	Ohio River Rate of Rise - Gate Closure Operation	VII-3
7-10	Gate Closure Data	VII-3
7-11	Cleanup	VII-3
	VIII - PUMPING PLANTS	
8-01	General	VIII-1
8-02	Pump Plant No. 1	VIII-1
8-03	Pump Plant No. 2	VIII-1
8-04	Pump Plant No. 3	VIII-1
8-05	Pump Plant No. 4	VIII-1
8-06	Pump Plant No. 5	VIII-1
8-07	Pump Plant No. 6	VIII-2
8-08	Pump Plant No. 7	VIII-2
8-09	Pump Plant No. 8	VIII-2
8-10	Pump Plant No. 9	VIII-2
8-11	Pump Plant No. 10	VIII-2
8-12	Pump Plant No. 11	VIII-2
8-13	Pump Plant No. 12	VIII-3
8-13A	Pump Plant No. 13	VIII-3
8-14	Maintenance	VIII-3
8-15	Readiness	VIII-4
8-16	Manufacturer's Instructions	VIII-4
8-17	Pump Plant	VIII-4
8-18	Grounds and Access Roads	VIII-5
8-19	Crane and Chain Hoists	VIII-5
8-20	"Megger" Tests - General	VIII-5
8-20A	Dehumidification	VIII-7
8-21	Electrical Equipment	VIII-9
8-22	Pumps and Motors	VIII-9
8-23	Control Equipment	VIII-9
8-25	Repairs	VIII-10
8-26	Trial Tests	VIII-10
8-27	Air Relief Valves	VIII-10
8-28	Inspection and Trial Operation	VIII-10

TABLE OF CONTENTS (Cont'd)

Paragraph		Page
	VIII - PUMPING PLANTS (Cont'd)	
8-29	Operation	VIII-11
8-30	Operating Instructions	VIII-11
8-31	Operation Log	VIII-11
8-32	Ohio River - Rate of Rise Pumping Plant Operation	VIII-12
8-33	Pumping Plant Preparation	VIII-12
8-34	Sump Preparation	VIII-13
8-35	Instructions in Starting Motors	VIII-13
8-36	Sluice Gate Operation	VIII-19
8-37	Pump Operation Precautions	VIII-20
8-38	Lubrication	VIII-20
8-39	Electric Service	VIII-20
8-40	Automatic Stop Control	VIII-20
8-41	Protection Devices	VIII-20
8-42	Air Relief Valves	VIII-21
8-43	Closing Down Pumping Plants	VIII-21
8-44	Nameplate Data	VIII-21
8-45	Safety Equipment and Precaution	VIII-21
	IX - MISCELLANEOUS FACILITIES	
9-01	General	IX-1
9-02	Maintenance	IX-1
9-03	Operation	IX-2
	X - SPECIAL MAINTENANCE AND OPERATIONS DURING HIGH WATER PERIODS	
10-01	General	X-1
10-02	Levee System	X-1
10-03	Preparedness	X-1
10-04	Materials	X-2
10-05	Lumber	X-2
10-06	Sacked Earth or Loose Earth	X-2
10-07	Sandbags	X-2
10-08	Wire	X-3
10-09	Preliminary Preparations When High Water is Imminent	X-3
10-10	Initial Work	X-3
10-11	Method of Treatment	X-4

TABLE OF CONTENTS (Cont'd)

Paragraph		Page
	X - SPECIAL MAINTENANCE AND OPERATIONS DURING HIGH WATER PERIODS (Cont'd)	
10-12	Seepage	X-4
10-14	Sloughing	X-4
10-15	Sand Boils	X-5
10-16	Sacked Earth Ring	X-5
10-17	Method of Laying Sandbags	X-5
10-22	Wave Wash	X-6
10-23	Sandbags and Cotton Bagging or Plastic Sheeting	X-6
10-24	Log Boom	X-6
10-25	Movable Panels	X-7
10-26	Portable Board Panel	X-7
10-27	Scour	X-7
10-28	Sack Paving, Board Revetment	X-7
10-29	Bush Deflection Dikes	X-8
10-30	Overtopping	X-8
10-31	Sandbag Topping	X-8
10-32	Lumber and Sack Topping	X-9
10-33	Mud Box Topping	X-9
10-34	Caving Banks and Slides - Temporary Protection	X-10
10-35	Excessive and Pronounced Floodwall Seepage	X-10
10-36	Floodwall and Gate Closure Extension	X-11
10-37	Transportation	X-11
	XI - PREVENTIVE MAINTENANCE	
11-01	General	XI-1
11-02	Recordkeeping	XI-2
11-03	Power Failure	XI-2
11-04	Spare Parts	XI-2
11-05	Care of Functional Structures	XI-3
11-06	Painting	XI-3
11-07	Valve and Gate Maintenance	XI-4
11-08	Lubrication	XI-6
11-09	Bearings	XI-7
11-10	Packing	XI-7
11-11	Electrical System	XI-9
11-12	Pumping Equipment	XI-16

TABLE OF CONTENTS (Cont'd)

Paragraph		Page
	XII - EQUIPMENT FAILURE DIAGNOSIS	
12-01	General	XII-1
12-02	Very Little or No Water Being Discharged	XII-1
12-03	Not Enough Water Being Discharged	XII-2
12-04	Pump Starts, Loses Suction and Stops	XII-2
12-05	Pump Requires Too Much Power	XII-2
12-06	Pump Vibrates	XII-3
12-07	Excessive Wear	XII-3
12-08	Reverse Flow through Pump-Current Off	XII-3
12-09	Motor Will Not Start	XII-3
12-10	Motor Noisy	XII-4
12-11	Motor Temperature Too High	XII-5
12-12	Bearings Heat Up	XII-5

TABLE INDEX

Table	Title	Page
1	Gated Outlets	VI-3
2	Gate Closures	VII-4
3	Humidity Chart	VIII-8
4	Order of Plant Pumping Operations	VIII-12
5	Motor-Pump-Switchgear and Substation Data	VIII-25

APPENDIX INDEX

Appendix	Title
A	Flood Control Regulations, Maintenance and Operation of Flood Control Works
B	Resolution and Assurance of Local Cooperation
C	Specifications for Installation of Pipeline or Conduit Across Completed Levees
D	Pertinent Data
E	Pumping Plant Operations Report (Sample)
F	Inspection Report and Checklists (Sample)
G	List of Corps of Engineers' Drawings and Manufacturers' Plan, Specifications, Bulletins and Instructions
H	Pressure Lines Through or Over Levee or Wall (By Permit)

TABLE OF CONTENTS (Cont'd)

Plate	Title
1	Rock-Filled Crib
2	Sandbag and Brush Mat
3	Sacked Earth Ring
4	Sandbag and Cotton Bagging - No. 1
5	Sandbag and Cotton Bagging - No. 2
6	Log Boom
7	Movable Panel
8	Portable Board Panel
9	Board Deflection Wall
10	Brush Deflection Dike
11	Sandbag Topping
12	Lumber and Sack Topping
13	Mud Box Topping
14	Seepage and Stabilization Corrective Measures
15	Wall and Closure Extensions
16	Motor Winding Insulation Resistance - Pumping Plant Nos. 1, 3 and 4
17	Motor Winding Insulation Resistance - Pumping Plant No. 2
18	Motor Winding Insulation Resistance - Pumping Plant No. 5
19	Motor Winding Insulation Resistance - Pumping Plant No. 6
20	Motor Winding Insulation Resistance - Pumping Plant Nos. 7, 8 and 9
21	Motor Winding Insulation Resistance - Pumping Plant Nos. 10, 11 and 12
22	Insulation Resistance Record (Sample Form)
23	Typical Movable Closure (Without Trusses)
24	Typical Movable Closure (With Trusses)
25	Typical Service Opening
26	Operating Instructions, Pumping Plant No. 1
27	Operating Instructions, Pumping Plant No. 2
28	Operating Instructions, Pumping Plant No. 3
29	Operating Instructions, Pumping Plant No. 4
30	Operating Instructions, Pumping Plant No. 5
31	Operating Instructions, Pumping Plant No. 6
32	Operating Instructions, Pumping Plant No. 7
33	Operating Instructions, Pumping Plant No. 8
34	Operating Instructions, Pumping Plant No. 9
35	Operating Instructions, Pumping Plant No. 10
36	Operating Instructions, Pumping Plant No. 11
37	Operating Instructions, Pumping Plant No. 12
38	General Plan, Schedule of Operations
39	Plan and Profile, Pumping Plant No. 13

SECTION I

INTRODUCTION

1-01. Authorization. The Paducah Flood Protection Project was authorized under the general authorization for the Ohio River Basin contained in the Flood Control Act approved August 28, 1937.

1-02. Location. The flood protection project is located in McCracken County, Kentucky, on the left bank of the Ohio River, 934.4 miles below Pittsburgh, Pennsylvania.

1-03. Description of Project. The project consists of approximately 48,700 feet of earth levee, 15,870 feet of concrete wall, 8 ramps, 5 diversion channels, 55 closure and service openings, 13 pumping plants, and other necessary appurtenances. The line of protection begins on the left bank of Island Creek approximately 6 miles due south of the center of the city, then extends in a general northerly direction to a point on the riverfront near the foot of Mill Street, thence along the riverfront to the vicinity of Burnett Street and, in westerly and southwesterly directions to high ground near the western limits of the city.

1-04. Dates of Construction. Construction of the project was started August 1939 and the assignment to local interests for maintenance was made on 15 July 1949.

1-05. Protection Provided. The project will provide protection for the City of Paducah, Kentucky, against Ohio River floods equal to the maximum of record, which occurred in 1937.

1-06. General Plan. The general plan, Plate 38, presents the entire project. It shows the plan of the protected area, omitting all details not essential to flood protection operations. The necessary data for the operation of the pumping plants and other appurtenances are shown in the schedule of operations.

1-07. Each pumping plant is identified on the map by number.

1-08. River Gage. The river stages referred to herein correspond to readings on the gage located at the foot of Jefferson Street. The zero reading on the gage maintained by the United States Geological Survey Bureau, corresponds to elevation 286.26, Ohio River datum.

SECTION II

LOCAL COOPERATION

* 2-01. Authority. Section 3 of the Flood Control Act of 22 June 1936 (Title 33, United States Code, Section 701c) authorized the Secretary of the Army to prescribe regulations as published in the Code of Federal Regulations, Title 33, Section 208.10 included as Appendix A of this manual.

2-02. Assurance of Local Cooperation. Assurance of local cooperation was given by the city in the resolution adopted 2 May 1938 and the pursuant assurance of 17 May 1938 in which the city agreed to comply with the provisions of Section 3 of the Flood Control Act of 22 June 1936 and to obligate the city as follows:

(a) To furnish and pay 60 percentum of the cost of all lands, easements, and rights-of-way necessary for the construction of the project.

(b) To assume 60 percentum of the cost of relocating all transportation lines, utilities, and structures as may be required to prosecute the work of improvement.

(c) Hold and save the United States free from damages to construction works, and maintain and operate all the works after completion in accordance with the regulations prescribed by the Secretary of the Army (formerly Secretary of War).

2-03. Resolution. A copy of the resolution and of the assurance adopted by the city is included in Appendix B.

SECTION III

GENERAL

3-01. General. The successful functioning of the flood protection system can be assured by following the procedure set forth in this manual. By so doing, all of the benefits and protection against floods can be secured. Failure to maintain and operate the project properly can result in severe property losses, in loss of life, and in irreparable loss of confidence by the citizens in the levee system.

3-02. Purpose of Manual. Proper maintenance and operations require that responsible local persons have a thorough understanding of the functions of the various units of the system, of maintenance required during normal river stages, and of operation procedure during flood emergencies. It is with this purpose in mind that this manual has been prepared for the guidance of the Local Flood Control Authority in the maintenance and operation of the flood protection project. The manual undertakes to assemble and correlate all of the details essential for satisfactory maintenance and operation of the project.

3-03. Regulations for Maintenance and Operation. A copy of The Code of Federal Regulations, as promulgated in Chapter II - Corps of Engineers, Department of the Army, Section 208.10 - Flood Control Regulations for Local Flood Protection Works; Maintenance and Operation of Structures and Facilities, is contained as Appendix A. These regulations were issued under authority of Sec. 3, 49 Stat. 1571, as amended; 33 U.S.C. 701c (9 F.R. 9999, Aug. 17, 1944); 9 F.R. (10203, Aug. 22, 1944).

The general requirements of the regulations for the maintenance and operations of local flood protection works provide as follows:

"(1) The structures and facilities constructed by the United States for local flood protection shall be continuously maintained in such a manner and operated at such times and for such periods as may be necessary to obtain the maximum benefits.

"(2) The State, political subdivision thereof, or other responsible local agency, which furnished assurance that it will maintain and operate flood control works in accordance with regulations prescribed by the Secretary of the Army, as required by law, shall appoint a permanent committee consisting of or headed by an official hereinafter called the 'Superintendent,' who shall be responsible for the development and maintenance of, and directly in charge of, an organization responsible for the efficient operation and

* maintenance of all of the structures and facilities during flood periods and for continuous inspection and maintenance of the project works during periods of low water, all without cost to the United States.

"(3) A reserve supply of materials needed during a flood emergency shall be kept on hand at all times.

"(4) No encroachment or trespass which will adversely affect the efficient operation or maintenance of the project works shall be permitted upon the rights-of-way for the protective facilities.

"(5) No improvement shall be passed over, under, or through the walls or levees, improved channels or floodways, nor shall any excavation or construction be permitted within the limits of the project right-of-way, nor shall any change be made in any feature of the work without prior determination by the District Engineer of the Department of the Army or his authorized representative that such improvement, excavation, construction, or alteration will not adversely affect the functioning of the protective facilities. Such improvements or alterations as may be found to be desirable and permissible under the above determination shall be constructed in accordance with standard engineering practice. Advice regarding the effect of proposed improvements or alterations on the functioning of the project and information concerning methods of construction acceptable under standard engineering practice shall be obtained from the District Engineer or, if otherwise obtained, shall be submitted for his approval. Drawings or prints showing such improvements or alterations as finally constructed shall be furnished the District Engineer after completion of the work.

"(6) It shall be the duty of the Superintendent to submit a semiannual report to the District Engineer covering inspection, maintenance, and operation of the protective works.

"(7) The District Engineer or his authorized representative shall have access at all times to all portions of the protective works.

"(8) Maintenance measures or repairs which the District Engineer deems necessary shall be promptly taken or made. *

"(9) Appropriate measures shall be taken by local authorities to insure that the activities of all local organizations operating public or private facilities connected with the protective works are coordinated with those of the Superintendent's organization during flood periods.

"(10) The Department of the Army will furnish local interests with an Operation and Maintenance Manual for each completed project, or separate useful part thereof, to assist them in carrying out their obligations under this part."

3-04. Local Responsibility. The regulations established the responsibilities of the Local Flood Control Authority with respect to the proper maintenance and operation of the flood protection project. The Local Flood Control Authority shall be responsible for the development of an organization capable of providing for the efficient operation and maintenance of the project during flood periods and the necessary maintenance of the work during normal stages of the river. The regulations have been made sufficiently general to cover practically all types of local flood protection works. They are supplemented in this manual by technical data and instructions pertinent to the local flood control project which are necessary for its efficient maintenance and operation.

3-05. Permits for Use of Rights-of-Way. The rights-of-way of flood protection projects have been procured and protective works have been constructed thereof for the protection of life and property in times of flood inside the inclosed area. The legitimate use of the rights-of-way for crossing by gaslines, oil lines, and utilities or other uses of a similar nature should be allowed only under the terms of a permit. In order to establish a standard procedure for processing and approving requests to construct, maintain, or operate any feature on, over, or through the levee, and for any excavation or construction within the project rights-of-way, this office has established a permit system to facilitate the carrying out of the intent of the instructions as contained in paragraph 208.10(a) General 5 of the Regulations of the Secretary of the Army. This permit system greatly expedites the processing of these requests both by the Local Flood Control Authority and the Federal Government.

3-06. Permit Forms. There are contained in the appendices of this manual a copy of a suggested permit form and the minimum specifications for the installation of pipelines or conduits over or through the completed levees. Permit forms may be obtained from the District Engineer, Corps of Engineers, P.O. Box 59, Louisville, Kentucky 40201 (ATTN: ORLOP-AF).

3-07. Permit Application. Applications for use of the right-of-way should be addressed to the Mayor, City of Paducah, Kentucky. The Local Flood Control Authority will then forward the application to the District Engineer, Corps of Engineers, P.O. Box 59, Louisville, Kentucky

40201 with its recommendations. A draft copy of the proposed permit should be included on which is stated the exact use of the rights-of-way, for which permission is being requested, together with any condition or restriction of the permit. A drawing or sketch should also be furnished showing the exact location and proposed method of construction. If approval is recommended by the Local Flood Control Authority and this office has no objection, the draft form of the permit will be returned for preparation in final form. Five copies of the final permit, bearing the signature of the applicant and an official of the Local Control Authority, should then be forwarded to this office. Three copies will be returned after being signed by the District Engineer. This will enable each party concerned to have a fully executed copy of the permit.

* 3-08. Permit Bond. In any case where a permit is requested for any purpose which might cause disfigurement or damage to the flood protection right-of-way or structure in its erection, use, or removal, it is suggested that the applicant be required to post a bond of sufficient amount to protect the Local Flood Control Authority from any cost of repair or removal, and to guarantee faithful performance of the permit conditions. In such cases, the permit should state the amount and conditions of the bond. In the event that the application for a permit for proposed work is disapproved by the Local Flood Control Authority, it will not be necessary to forward the rejected application to the District Engineer for review.

* 3-09. Permit Issuance. The flood protection works and the rights-of-way are under the jurisdiction of the Local Flood Control Authority, and will be operated and maintained by them in accordance with the Regulations of the Secretary of the Army; therefore, any permit to use any part of the right-of-way will be issued by the Local Flood Control Authority, with the restriction that no permit will be issued without the prior approval of the District Engineer, Louisville, Kentucky.

* 3-10. Adjacent Construction by Others. When owners of property adjacent to the floodwall initiate new construction, particularly if it involves deep excavation, the Local Flood Control Authority shall take such action as may be necessary to assure that there is no encroachment on right-of-way, that adequate shoring is used to prevent disturbing flood protection foundations, and that the work, insofar as possible, is performed outside of flood periods. The District Engineer, Louisville, Kentucky, shall be consulted if necessary.

* 3-11. Duties of the Superintendent. The duties of the Superintendent shall include the operation and maintenance oversight, records keeping, and correspondence with the District Office. He should have available the names, addresses, and telephone numbers of all his key men, and a reasonable number of substitutes therefor. These key men

should have similar information on all of the men who will be required for assistance in the discharge of their duties. These men should include the following:

a. An assistant to act in the Superintendent's place in cases of his absence or indisposition.

b. Sector Foremen in sufficient number to oversee maintenance and patrol of the entire levee during flood operations. High quality of leadership ability and responsibility are necessary for these positions.

c. A sufficient number of experienced men to direct the erection of the closure structures.

d. A sufficient number of experienced men to operate the pumping plants for 24 hours a day during flood periods.

The Superintendent should be well familiar with this manual in its entirety and should ascertain that all of his keymen have read those portions of the manual that pertain to their duties.

3-12. Semiannual Reports. The regulations require that semiannual reports covering inspection, maintenance, and operation of the works, be submitted by the Superintendent to the District Engineer. These reports should be submitted on 15 April and 15 October, and should include inspection checklists similar to the sample forms contained in Appendices E and F of this manual, supplemented by accounts of maintenance and operation activities during the period covered. The report should also include dated copies of all inspection checklists made during the period covered by the report. The report should further include detailed plans for any necessary remedial work which has been revealed by the inspection. (Note: Permanent construction or major repairs shall not be performed until approved by the District Engineer, except in cases of minor maintenance work or replacement with identical parts. Remedial measures may be taken in case of emergency.) The nature, dates of construction, and removal of all temporary repairs and the dates of construction of permanent repairs, should be included Other items of interest or suggestions resulting from the operation of the protection system should be added to the report. One copy of the semiannual report, including all inspection checklists made during the period covered, should be sent to the District Engineer, Louisville District, Corps of Engineers, P.O. Box 59, Louisville, Kentucky 40201. A duplicate copy of these reports should also be made for the files of the Local Flood Control Authority.

* 3-13. Inspections. Inspections by the Superintendent, as required by the Regulations and as outlined in this manual for each feature of the protective works, should be made at the following times:

a. Immediately prior to the beginning of the flood season.

b. Immediately following each major high water period.

c. Otherwise at periods not exceeding 90 days.

d. Intermediate times as necessary. Certain features of the protection works, such as the pumping plant, require inspection at intervals not exceeding 30 days during flood season.

* 3-14. Flood Season. The flood season normally occurs during the months of December through May; however, major flooding can occur at any time.

3-15. Checklist Forms. It is suggested that checklist forms, similar to those contained in Appendix F, be used in each inspection in order to insure that no item in any feature of the protective system is overlooked. All blank spaces should be filled in, and all items of equipment that are in satisfactory condition may be so indicated by a checkmark. Items requiring maintenance should be noted and the nature of the maintenance required described on an additional sheet, if necessary.

* 3-16. Federal Government Inspection. The District Engineer or his authorized representative will make detailed inspections of the work semiannually and at such other times as he may deem necessary. Maintenance measures or repairs which the District Engineer considers necessary to place the works in a satisfactory operating condition should be promptly performed by the Committee. It is suggested that the local authorities can greatly aid the District Engineer in furnishing advice and counsel pertaining to required remedial work by keeping an accurate record of the functioning of the works, high water elevations or marks, the exact location of any excessive seepage areas, and the locations of any sand boils or other adverse conditions that may occur during high water periods. Civil works structures whose failures or partial failure would endanger the lives of the public or cause substantial property damage will be inspected periodically (in addition to above-mentioned inspections), by an inspection team, to evaluate their structural safety and stability and operational adequacy.

* 3-17. River Stage Predictions. It is the responsibility of the Local Flood Control Authority to keep itself advised of possible river stages and of local expected rain conditions. This information will enable the Superintendent to make the preparations required for the operation and erection of those features of the system provided for the protection of the area against high river stages. The schedule of operations (Plate 38) shows that the first operation occurs at stage 20.0 feet on the Paducah gage. When this stage is reached, the Superintendent requires daily forecasts as to whether the river will recede

or rise. The Superintendent may obtain river stage forecasts and information on reported rainfall from the National Weather Service at Cairo, Illinois.

* 3-18. Procedure at Various River Stages. The levee should be inspected along its entire length when the Ohio River rises to a stage of 55.0 feet on the Paducah gage (zero elevation 286.30), or before if necessary, for the purpose of discoverying weak spots or other deficiencies arising from various causes. At this stage, the force of men organized for high water operation should be alerted; and the District Engineer, Louisville, Kentucky, contacted immediately. Adequate personnel should be deployed along the levee to observe the conditions of the levee structures and the riverbanks as the river rises. As the flood develops, the forces should be expanded to required strength. The actual time of mobilization of the various personnel will, of course, depend upon the rate of rise of the river, the various functions to be performed the condition of the flood protection system and pertinent requirements of Section X of this manual. This section also describes measures for special maintenance and operation during high water periods. Plate 38 lists the operation to be performed at various river stages.

* 3-19. General Operations During Floods. Detailed operations to be performed for the various features of the project are given under the section pertaining to the particular part of the system described. The work to be done during a flood consists mainly of the following items:

a. Inspection and closing of drainage gates.

b. Inspection and closing of traffic openings.

c. Operation of pumping plant.

d. Routine patrol of flood protection system and adjacent vicinity to check for leaks in closures, leaks through levee, boils, and any other unusual conditions.

3-20. Drawings. A list of construction drawings and other information for the project is included as Appendix G. These drawings have been furnished the Local Flood Control Authority and are to be considered a part of this manual. Operating instructions for the pumping plants have been mounted in plastic to be placed in the plants.

3-21. Elevations. All elevations shown on the construction drawings for the project refer to elevation in feet above mean sea level (m.s.l.) Ohio River Datum. As it is customary for river stages to be spoken in terms of river gage reading, elevations above mean sea level (m.s.l.) have been translated into river gage readings.

SECTION IV

LEVEE

4-01. Description. The total length of levee, broken by gate openings, is about 48,700 lineal feet, starting on the left bank of Island Creek, approximately 6 miles due south of the center of the city, extends in a general northeasterly and then a northwesterly direction, a distance of about 31,700 feet to a point on the riverfront near the foot of Mill Street; two short sections located in the vicinities of Woodward and Campbell Streets; and a section of about 14,810 feet in length which starts at the foot of Burnett Street and extends in a westerly and southwesterly direction to the high ground near the western limits of the city.

4-02. The levee is a rolled fill embankment with an impervious core, with a crown width of 8 feet, side slopes of 1 on 3. In locations where erosion from the flow of water is anticipated, riprap protection has been provided on the riverside.

4-03. Maintenance. The regulations provide that:

"The Superintendent shall provide at all times such maintenance as may be required to insure serviceability of the structures in time of flood. Measures shall be taken to promote the growth of sod, exterminate burrowing animals, and to provide for routine mowing of the grass and weeds, removal of wild growth and drift deposits, and repair of damage caused by erosion or other forces. Where practicable, measures shall be taken to retard bank erosion by planting of willows or other suitable growth on areas riverward of the levees. Periodic inspections shall be made by the Superintendent to insure that the above maintenance measures are being effectively carried out and, further, to be certain that:

"(i) No unusual settlement, sloughing, or material loss of grade or levee cross section has taken place;

"(ii) No caving has occurred on either the land side or the river side of the levee which might affect the stability of the levee section;

"(iii) No seepage, saturated areas, or sand boils are occurring;

"(iv) Toe drainage systems and pressure relief wells are in good working condition, and that such facilities are not becoming clogged;

"(v) Drains through the levees and gates on said drains are in good working condition;

"(vi) No revetment work or riprap has been displaced, washed out, or removed;

"(vii) No action is being taken, such as burning grass and weeds during inappropriate seasons, which will retard or destroy the growth of sod;

"(viii) Access roads to and on the levee are being properly maintained;

"(ix) - - - - - - -

"(x) Crown of levee is shaped so as to drain readily, and roadway thereon, if any, is well shaped and maintained;

"(xi) There is no unauthorized grazing or vehicular traffic on the levee;

"(xii) Encroachments are not being made on the levee right-of-way which might endanger the structure or hinder its proper and efficient functioning during times of emergency.

"Such inspections shall be made immediately prior to the beginning of the flood season; immediately following each major high water period, and otherwise at intervals not exceeding 90 days, and such intermediate times as may be necessary to insure the best possible care of the levee. Immediate steps will be taken to correct dangerous conditions disclosed by such inspections. Regular maintenance repair measures shall be accomplished during the appropriate season as scheduled by the Superintendent."

4-04. Protection of Sod. The measures relating to the extermination of burrowing animals and the prevention of burning of grass are, at first, apparently of minor importance, but have been found to be major factors in levee maintenance. Burrowing animals have been known to cause levee failures and can be especially harmful when driven to the levee crest during periods of extremely high water. Burning of the grass should be prevented as it will result in destruction of the sod and consequent damage of the levee due to erosion. A covering of sod is needed on the levee at all times, especially during the winter flood season.

4-05. Drift. Drift should be removed from the levee and other grassed areas on the right-of-way at the end of each winter flood

season, before the new growth of grass starts in the spring, and after each flood occurring during the growing season. The drift should be removed from the levee and not burned on the levee slope or berm.

4-06. Repairs. Minor repairs required to correct conditions disclosed by the inspections should receive immediate attention, especially during nonflood season, in anticipation that high water may retard or prevent their later accomplishment.

4-07. Gullies, holes, and washes in the levee, slopes, and berms should be repaired by filling with impervious material such as silt, clay, sandy silt, or sandy clay tamped or compacted into place.

4-08. Gaps occurring where road crossings have been worn down or where the levee may be below grade should be remedied. It is advisable to run levels occasionally to ascertain where depressions have occurred in the top of the levee. The profile of the top of the levee should be maintained as initially constructed.

4-09. All areas deficient in sod should be overseeded, reseeded, or resodded. Such reseeding or resodding will be of permanent value in the prevention of levee erosion if performed at the proper time, but of little value if delayed until just before high water is anticipated. Seeding and sodding should be performed as described herein.

4-10. Seeding. The levee has been fertilized, limed, and seeded and it is expected that the soil will be capable of maintaining a good stand of grass. When new seeding is necessary to obtain cover for bare areas, it is recommended that such work be done in the fall between 15 August and 15 October or in the spring between 20 March and 15 April. Local experience will indicate the best time to seed. All sticks and stones and other objectionable material should be removed. The area should be fully "dressed" and all gullies and irregularities in the surface should be removed. The ground should be loosened to a depth of apprroximately 2 inches. Fertilizer or lime, or both, should be applied when necessary. Fertilizer should be the product of a recognized manufacturer and shall have an approximate analysis of 10-10-10. Agricultural-grade limestone ground to pass an 8-mesh sieve with 25 percent passing a 100-mesh sieve shall be furnished. In addition, calcareous limestone shall contain not less than 50 percent calcium oxide, and dolomitic limestone shall contain not less than 40 percent magnesium oxide. Coarser materials will be acceptable provided the specified rates of application are increased proportionately, on the basis of quantities passing the 8- and 100-mesh sieves. The fertilizer or lime, or both, should be spread in advance of sowing the grass seed. Fertilizers should be distributed uniformly to supply a minimum of 100 pounds each of available nitrogen phosphorous, and potash per acre. Lime should be applied at the rate of 3,000 pounds per acre. After spreading

the fertilizer or lime, or both, it should be raked into the upper 2 inches of soil by using iron rakes, or a light drag harrow on large areas. Raking or harrowing should be done parallel to the length of the levee and not up and down the slope. Grass seed percentages, by weight of the several recommended species in the mixtures, are given in the table below for hundred weight of mixture to be used.

Seed Kind	Percentage by Weight of Each Seed Kind in Mixture	Percent of Pure Live Seed of Each Kind	Percent by Weight of Mixture
Kentucky Blue Grass	10	68	6.8
Kentucky 31 Fescue	70	87	60.9
Red Top	3	83	2.5
White Clover	5	86	4.3
Domestic Ryegrass	12	88	10.6
Total pure live seed in Mixture			85.1
Weed seed, not to exceed 1% by weight			0.5
Other than weed and pure live seed, Maximum			14.4
Total			100.0

Grass seed mixture should be sown at the rate of 125 pounds per acre. It is preferable that the seed be sown in two applications, with the second application being made while traveling at right angles to the initial line of travel. Seed should preferably be broadcast over the area by mechanical seeder. If broadcast by hand, previous mixing of the seed with dry silt should be done to insure more even distribution of the seed. In the event that large areas require seeding or the foregoing instructions do not bring satisfactory results, it is recommended that samples be taken from the embankment and analyzed. The County Agricultural Agent should be consulted for the determination of seed mixture, lime requirements, type of fertilizer, and rates of application. After the seed is sown, straw in the amount of 4,000 pounds per acre shoud be spread uniformly over the seeded area. The straw should be held in place by string webbing tied to wooden pegs, or by applying an asphalt adhesive at the rate of 10 to 13 gallons per 1,000 square feet. The straw should not be removed after the seed has sprouted and the roots have taken hold, but allowed to serve as mulch and as added protection to the levee against surface erosion. *

4-11. Sodding. Where sodding is considered the most favorable method of reestablishing a good stand of grass on the levee, it should be performed sufficiently in advance of the flood season to insure knitting of the transplanted sod with the prepared base. Sodding should preferably be done between 20 March and 15 April if there is no flood. Fairly good results may be obtained by planting sod between 15 September and 1 November.

The bed should be prepared by establishing a graded surface upon which the sod is to be placed, about 2 inches below the established surface grade. The ground should then be scarified to a depth of approximately 2 inches. Where fertilizer is required, it should be applied as specified under "Seeding." Strips of sod should then be laid in parallel rows at right angles to the slope of the levee. Soil of good quality should be used to fill all cracks between sods. The sod should immediately be pressed into contact with the sod bed by tamping and/or rolling so as to eliminate all air pockets and insure knitting without displacement of the sod. Where slopes are steeper than 2:1, the sod shall be fastened in place with suitable wooden pegs.

The sod for this purpose should be living or growing sod and procured from areas where the soil is reasonably fertile and contains a high percentage of loamy topsoil. Five days before the sod is to be stripped and lifted it should be mowed to a height of approximately 3 inches. The sod should be thickly matted turf relatively free of weeds or other undesirable plants, large stones, roots, or other material detrimental to the development of the sodding or to future maintenance. The sod should be cut into strips (or squares where required) with at least 2 inches of soil adhering firmly to the roots. The sod should be transplanted within 24 hours from the time it is cut. Sod should not be cut when the soil is too dry.

4-12. Overseeding. Overseeding should be done in the fall between 15 September and 15 October, whenever moisture will be sufficient for germination, but allowing adequate time for rooting before hard winter freezing. Soil samples should be taken and analyzed. If it is determined that the soil is well fertilized and limed, a grass seed mixture consisting of two parts Kentucky Blue Grass and one part White Dutch Clover should be sown at the rate of 30 pounds per acre. If the soil is not fertile, the County Agriculture Agent can determine the seed mixture, lime requirement, type of fertilizer, and rate of application. Where it is found desirable in order to produce a balanced sod, either seed may be planted alone. The seed should be sown as described under paragraph 4-10.

4-13. Fertilizer. It is recommended that a feeder application of fertilizer consisting of a 10-10-10 mixture, or some other similar mixture with a high nitrogen content, be applied about every third year and at a rate of about 200-300 pounds per acre.

4-14. Grass Mowing. Grass should be mowed as necessary to help maintain a good stand of sod. It should not be permitted to attain a height of more than 14 inches. The grass should be cut back to a height of about 4 inches, but should be allowed to grow to 8 inches, when going into winter, for adequate protection to the levee against erosion.

4-15 Riprap. A layer of riprap over a gravel blanket has been placed at points of possible erosion due to water action. Particular attention should be given to maintaining this surfacing in good condition. Removal, or even displacement of any of the stone, particularly the larger ones, may affect the stability of the adjacent surfacing and thereby endanger the levee area if erosive action should result at these points during flood periods. Dislodged filler pieces in the joints between the larger stones should be replaced as soon as possible. Stone replacement should be of similar size, weight, gradation, and quality as the original stones and should be fitted tightly into place so they cannot be dislodged readily.

4-16. Inspection. Levees should be inspected at least once every 90 days. Such inspections should be made at the beginning of the months of January, April, July, and October. Sample checklist forms for use in performing inspections of levee are inclosed as Appendix F.

4-17. Operation. The regulations provide that:

"During flood periods the levee should be patrolled continuously to locate possible sand boils or unusual wetness of the landward slope and to be certain that:

"(i) There are no indications of slides or sloughs developing;

"(ii) Wave wash or scouring action is not occurring;

"(iii) No low reaches of levee exist which may be overtopped;

"(iv) No other conditions exist which might endanger the structure;

"Appropriate advance measures will be taken to insure that availability of adequate labor and materials to meet all contingencies. Immediate steps will be taken to control any condition which endangers the levee and to repair the damaged section."

4-18. Levee Damage Due to High Water. Where sand boils, scouring, or other hazardous conditions are occurring, immediate steps shall be taken to control the situation and to repair or correct any damage. The District Engineer, Louisville, Kentucky, is to be advised of the situation by telephone or other rapid means. Suggested methods of operations for combatting such flood conditions are given in Section X of this manual. The methods presented herein have been developed during many years of experience in flood activities on rivers in the United States.

4-19. Sand Boils and Seepage Areas. When sand boils or other seepage areas are observed which are of small magnitude, posing no major threat to structure safety, and therefore are not economically feasible to repair, their locations should be permanently marked at the site and noted on Plate 38. The Superintendent should make certain that adequate sandbagging materials are available at these locations during future floods. For larger sand boils and seepage areas, or for small ones which, in successive floods, appear to be increasing in magnitude, the District Engineer, Louisville District, should be consulted for advice regarding permanent repair.

SECTION V

FLOODWALLS

5-01. Description. Reinforced concrete walls have been constructed in the levee system in those areas where the protective structure must be confined in width.

5-02. Maintenance. The pertinent requirements for maintenance of the floodwalls are stated in the regulations as follows:

"Periodic inspections shall be made by the Superintendent to be certain that:

"(i) No seepage, saturated area, or sand boils are occurring;

"(ii) No undue settlement has occurred which affects the stability of the wall or its watertightness;

"(iii) No trees exist, the roots of which might exceed under the wall and offer accelerated seepage paths;

"(iv) The concrete has not undergone cracking, chipping, or breaking to an extent which might affect the stability of the wall or its watertightness;

"(v) There are no encroachments upon the right-of-way which might endanger the structure or hinder its functioning in time of flood;

"(vi) Care is being exercised to prevent accumulation of trash and debris adjacent to walls, and to insure that no fires are being built near them;

"(vii) No bank caving conditions exist riverward of the wall which might endanger its stability;

"(viii) Toe drainage systems are in good working condition, and that such facilities are not becoming clogged.

"Such inspections shall be made immediately prior to the beginning of the flood season, immediately following each major high water period, and otherwise at intervals not exceeding 90 days. Measures to eliminate encroachments and effect repairs found necessary by such inspections shall be undertaken immediately. All repairs shall be accomplished by methods acceptable in standard engineering practice."

5-03. Wall Repairs. It is anticipated that the walls or other concrete structures should need very little repair. However, when and if such repairs are needed, they should be performed as soon as possible after determining the cause of the trouble and the nature of the repairs, and upon obtaining the approval of the District Engineer for such work.

5-04. Adjacent Land Maintenance. Maintenance of the land area adjacent to the floodwalls shall comply with Section IV of this manual. This area shall be kept free of all obstruction so as to provide access during inspection, maintenance of the wall, and to provide passageway for any high water operation. This passageway should not be used for the storage of materials as the accumulation of such materials could be a source of possible damage, either from heavy objects striking the wall or from fire. Also, care should be exercised to prevent the burning of trash against the concrete wall as this would damage the wall.

5-05. Inspection. Floodwalls shall be inspected at least once every 90 days. Such inspections should be made at the beginning of the months of January, April, July, and October. Sample checklist forms for use in making inspections of the floodwalls are shown as Appendix F.

5-06. Operation. The regulations provide that:

> "Continuous patrol of the wall shall be maintained during flood periods to locate possible leakage at monolith joints or seepage underneath the wall. Floating plant or boats will not be allowed to lie against or tie up to the wall. Should it become necessary during a flood emergency to pass anchor cables over the wall, adequate measures shall be taken to protect the concrete and construction joints. Immediate steps shall be taken to correct any condition which endangers the stability of the wall."

5-07. Adjacent Land Damage Due to High Water. If it is found that seepage, saturated areas, sand boils, bank caving, or other situations detrimental to wall stability are occurring during high water periods, emergency treatment as described in Section X of this manual shall be employed immediately. The District Engineer, Corps of Engineers, shall be notified immediately of such situations so that he may suggest methods to alleviate the causes and thereby possibly prevent additional damage and expense. A report of such damage shall be made as required by the regulations.

SECTION VI

DRAINAGE STRUCTURES

6-01. Description. Drainage structures function in the protective system during low river stages by disposing of internal drainage through gravity flow by a system of collector sewers, gated manholes, diversion channels, and drainage pipes generally equipped with flap gates on concrete headwalls at the river outlet ends.

6-02. Maintenance. The regulations state the following pertinent requirements for maintenance of the drainage structures:

> "Adequate measures shall be taken to insure that inlet and outlet channels are kept open and that trash, drift, or debris is not allowed to accumulate near drainage structures. Flap gates and manually operated gates and valves on drainage structures shall be examined, oiled and trial operated at least once every 90 days. Where drainage structures are provided with stop log or other emergency closures, the condition of the equipment and its housing shall be inspected regularly and a trial installation of the emergency closure shall be made at least once each year. Periodic inspections shall be made by the Superintendent to be certain that:
>
> "(i) Pipes, gates, operating mechanism, riprap, and headwalls are in good condition;
>
> "(ii) Inlet and outlet channels are open;
>
> "(iii) Care is being exercised to prevent the accumulation of trash and debris near the structures and that no fires are being built near bituminous coated pipes;
>
> "(iv) Erosion is not occurring adjacent to the structure which might endanger its watertightness or stability.
>
> "Immediate steps will be taken to repair damage, replace missing or broken parts, or remedy adverse conditions disclosed by such inspection."

6-03. Sluice Gates. All sluice gates, except those at pumping plants, Nos. 2 (Sixth Street), 6 (Clark Street), and 11 (Island Creek), are manually operated. In order to insure proper operation, they should be trial-operated, serviced, and lubricated as required during the regular quarterly inspections. Care must be taken in opening and particularly in closing the gates, so as not to overrun the travel and so damage the stem mechanism.

6-04. Flap Gates. The outlet ends of certain drainage structures are equipped with automatic-operation flap gates. These gates should be inspected regularly to be certain they operate properly. Caution: In order to prevent possible damage, do not let the flaps slam against their seats.

6-05. Inspection. Drainage structures should be inspected at least once every 90 days. Such inspections should be made at the beginning of the months of January, April, July, and October. Sample checklist forms for use in making inspections of drainage structures are shown as Appendix F.

6-06. Operation. The regulations provide that:

> "Whenever high water conditions impend, all gates will be inspected a short time before water reaches the invert of the pipe and any object which might prevent closure of the gate shall be removed. Automatic gates shall be closely observed until it has been ascertained that they are securely closed. Manually operated gates and valves shall be closed as necessary to prevent inflow of floodwater. All drainage structures in levees shall be inspected frequently during floods to ascertain whether seepage is taking place along the lines of their contact with the embankment. Immediate steps shall be taken to correct any adverse condition."

6-07. Submergency Stages. Table 1 lists the stages at which the gated outlets become submerged at their seats and their positions in normal and flood seasons.

TABLE I

GATED OUTLETS

Location	Description	Position		River Stage	
		All Season	Flood Season	Inspection	Operation
Sta. 200+35-A	60" Flap Gate	--	--	51.5	--
Sta. 187+34-A	15" Sluice Gate (2)	Open	Closed	47.3	48.3
Sta. 157+63-A	6-60" Flap Gates	--	--	34.7	--
Sta. 151+25-A	24" Flap Gates	--	--	45.6	--
Sta. 147+25-A	24" Flap Gates	--	--	46.0	--
Sta. 130+00-A	30" Flap Gate	--	--	37.9	--
Sta. 111+67-A	72" Flap Gate	--	--	27.8	--
On headwall near Pine Street	16" Shear Gate	Operated as required to drain local area.			
Sta. 84+00-A	24" Flap Gate	--	--	32.8	--
Manhole No. 23-B2, Sta. 66+27-A	102" Sluice Gate (1)	Open	Closed	24.7	34.0
Manhole No. 24-B2, Sta. 66+17-A	102"x102" Sluice Gate (1)	Closed	Open	25.3	34.0
Northwest of I.C.R.R., Sta. 175+40-B	24" Flap Gate	--	--	34.8	--
Manhole No. 20-B2, Sta. 161+66-B	24" Sluice Gate (2)	Closed	Open	43.0	45.9
Manhole No. 21-B2, Sta. 161+66-B	24" Sluice Gate (2)	Open	Closed	42.7	45.9
Manhole No. 16-B2, Sta. 150+60-B	24" Sluice Gate (3)	Open	Closed	27.9	34.2
Manhole No. 16-A, Sta. 150+38-B2	24" Flap Gate	--	--	28.3	--
Manhole No. 15-B2, Sta. 149+69-B	18" Sluice Gate (2)	Open	Closed	41.1	48.5
Manhole No. 15-A, Sta. 149+72-B2	18" Sluice Gate (2)	Open	Closed	40.4	41.4
*Manhole No. 13-P, Sta. 145+92-B	30" Sluice Gate (3)	Open	Closed	36.2	39.5
*Manhole No 14-B2, Sta. 145+92-B	30" Sluice Gate (4)	Closed	Open	37.6	39.5
*Manhole No. 12-P, Sta. 145+61-B	24" Sluice Gate (3)	Open	Closed	34.9	39.5
*Manhole No. 13-B2, Sta. 145+61-B	36"x36" Sluice Gate (4)	Closed	Open	36.3	39.5
Manhole No. 25-B2, Sta. 135+00-B	8" Sluice Gate (2)	Open	Closed	31.4	45.7
Manhole No. 12-B2, Sta. 131+73-B	12" Sluice Gate (2)		Closed permanently		
Manhole No. 11-B2, Sta. 128+61-B	36" Sluice Gate (5)	Open	Closed	34.0	40.9
Sta. 128+61-B2	36" Flap Gate	--	--	30.5	--
Manhole No. 1-P, 2nd & Jefferson Sts.	18" Sluice Gate (2)	Closed	Open	40.9	40.9
Manhole No. 2-P, 2nd & Jefferson Sts.	18" Sluice Gate (2)	Closed	Open	40.9	40.9
Manhole No. 8-B2, Sta. 123+61-B	20" Sluice Gate (2)	Open	Closed	41.6	43.9

TABLE 1

GATED OUTLETS
(Continued)

Location	Description	Position		River Stage	
		All Season	Flood Season	Inspection	Operation
Manhole No. 8-A, Sta. 123+61-B2	20" Flap Gate	--	--	40.7	--
Manhole No. 3-P, 2nd St. & Broadway	24" Sluice Gate (2)	Closed	Open	43.9	43.9
Manhole No. 4-P, 2nd St. & Broadway	24" Sluice Gate (2)	Closed	Open	43.9	43.9
Manhole No. 7-B2, Sta. 119+45-B	24" Sluice Gate (3)	Open	Closed	34.8	39.4
Manhole No. 7-A, Sta. 119+37-B2	24" Flap Gate	--	--	34.9	--
Manhole No. 5-P, 2nd St. & Kentucky Ave.	18" Sluice Gate (2)	Closed	Open	39.4	39.4
Manhole No. 6-P, 2nd St. & Kentucky Ave.	18" Sluice Gate (2)	Closed	Open	39.4	39.4
Manhole No. 5, Sta. 115+27-B2	24" Flap Gate	--	--	38.6	--
Manhole No. 6-B2, Sta. 115+26-B	8" Gate Valve	Open	Closed	44.5	45.0
Manhole No. 6-B2, Sta. 115+26-B	24" Sluice Gate (2)	Open	Closed	38.6	39.4
Manhole No. 6-A, Sta. 115+06-B2	8" Shear Gate	Open	Closed	44.2	45.2
Manhole No. 7-P, 2nd & Washington Sts.	18" Sluice Gate (2)	Closed	Open	39.4	39.4
Manhole No. 8-P, 2nd & Washington Sts.	18" Sluice Gate (2)	Closed	Open	39.4	39.4
Manhole No. 3-B2, Sta. 108+58-B	2-36"x36" Sluice Gates (3)	Open	Closed	32.7	38.5
Manhole No. 3-B2, Sta. 108+58-B	54" Sluice Gates (3)	Closed	Open	32.7	38.5
Manhole No. 3-A, Sta. 108+58-B2	54" Flap Gate	--	--	32.2	--
Manhole No. 2-B2, Sta. 99+70-B	10" Sluice Gate (2)	Open	Closed	44.0	45.2
*Manhole No. 14-P, Sta. 90+36-B	36" Sluice Gate (3)	Open	Closed	37.1	41.5
*Manhole No. 1-B2, Sta. 90+36-B	36" Sluice Gate (5)	Closed	Open	37.1	41.5
Sta. 80+00-B	6" Gate Valve	Open	Closed	--	53.0
Sta. 80+00-B	18" Flap Gate	--	--	38.7	--
Manhole No. 6-B1, Sta. 74+40-B	8" Sluice Gate (2)	Open	Closed	41.8	47.5
City Manhole, Sta. 74+40-B1	8" Flap Gate	--	--	42.7	--
Manhole No. 5-B1, Sta. 69+86-B	30" Sluice Gate (3)	Open	Closed	27.9	34.5
Manhole No. 5-A, Sta. 69+86-B1	30" Flap Gate	--	--	29.0	--
Manhole No. 4-B1, Sta. 57+98-B	24" Sluice Gate (3)	Open	Closed	27.1	39.0
Manhole No. 4-A, Sta. 57+98-B1	24" Flap Gate	--	--	28.1	--
Yeiser St. Diversion Sewer	18" Flap Gate (6)	Open	Closed	37.0	37.0

TABLE 1

GATED OUTLETS
(Continued)

Location	Description	Position		River Stage	
		All Season	Flood Season	Inspection	Operation
*Manhole No. 2-B1, Sta. 28+49-B	12" Sluice Gate (2)	Open	Closed	42.3	48.0
Manhole No. 2-A, Sta. 28+52-B1	12" Flap Gate	--	--	42.5	--
Manhole No. 1-B1, Sta. 26+87-B	6" Sluice Gate (2)	Open	Closed	48.6	53.0
Sta. 19+11-B	66" Flap Gate	--	--	20.0	--
Sta. 7+54-B	18" Flap Gate	--	--	33.1	--
Sta. 3+91-B	8" Flap Gate	--	--	41.4	--
Sta. 291+75-C	36" Flap Gate	--	--	30.5	--
Sta. 254+06-C	36" Flap Gate	--	--	32.7	--
Sta. 244+65-C	30" Flap Gate	--	--	38.5	--
Sta. 224+50-C	36" Flap Gate	--	--	54.3	--
Sta. 219+80-C	8" Sluice Gate (2)	Open	Closed	39.9	40.9
Sta. 217+35-C	2-24" Flap Gates	--	--	52.1	--
* Sta. 206+90-C	36" Flap Gate	--	--	50.5	--
Sta. 200+55-C	24" Flap Gate	--	--	53.4	--
Sta. 199+80-C	24" Flap Gate	--	--	52.7	--
Sta. 176+90-C	48" Flap Gate	--	--	40.0	--
Sta. 176+47-C	24" Flap Gate	--	--	52.5	--
Sta. 172+08-C	24" Flap Gate	--	--	43.5	--
Sta. 150+05-C	24" Flap Gate	--	--	51.9	--
* Sta. 125+95-C	48" Flap Gate	--	--	48.0	--
Manhole at Bridge & Locust Sts.	10" Flap Gate (6)	Open	Closed	39.0	39.0
Sta. 92+70-C	2-48" Flap Gates	--	--	42.0	--
Sta. 51+28-C	30" Flap Gate	--	--	39.6	--
On headwall Sta. 32+38-C	3-60" Sluice Gates (7)	Open	Closed	32.5	45.5
On headwall, Sta. 32+12-C	2-48" Sluice Gates (7)	Open	Closed	32.5	45.5

Notes:
(1) Rising stem two speed crank operated.
(2) Nonrising stem, wrench operated.
(3) Rising stem, handwheel.
(4) Nonrising stem, handwheel.
(5) Nonrising stem, crank operated.
(6) Closed by releasing hanger chain.
(7) Rising stem, crank operated.

SECTION VII

CLOSURE STRUCTURES

7-01. Description. Closure structures are prepared gaps in the levees or walls for the purpose of allowing normal traffic during low water periods. They are closed by prefabricated panels when floodwater rises to predetermined heights. The closures in the Paducah protection system consist of 27 roadway, 14 railway, and 14 service openings.

7-02. Maintenance. The regulations state the following pertinent requirements for the maintenance of closure structures:

"Closure structures for traffic openings shall be inspected by the Superintendent every 90 days to be certain that:

"(i) No parts are missing;

"(ii) Metal parts are adequately covered with paint;

"(iii) All movable parts are in satisfactory working order;

"(iv) Proper closure can be made promptly when necessary;

"(v) Sufficient materials are on hand for the erection of sandbag closures and that the location of such materials will be readily accessible in times of emergency.

"Tools and parts shall not be removed for other use. Trial erection of one or more closure structures shall be made once each year, alternating the structures chosen so that each gate will be erected at least once in each 3-year period. Trial erection of all closure structures shall be made whenever a change is made in key operating personnel. Where railroad operation makes trial erection of a closure structure not feasible, rigorous inspection and drill of operating personnel may be substituted therefor. Trial erection of sandbag closures is not required. Closure materials will be carefully checked prior to and following flood periods, and damaged or missing parts shall be repaired or replaced immediately."

7-03. Gate Storage Vaults. The vault doors should be kept adequately painted and the hardware satisfactorily oiled or greased to prevent corrosion and to facilitate ease of operation. Any cracks that may develop in the vault walls, floor, or roof, allowing water to leak into the vault, should be sealed with a waterproof material. The vaults

are of sufficient size to hold all the closure parts for storage in an arrangement to facilitate rapid erection of the closures. An orderly manner of storage will greatly facilitate the periodic inspections and inventories. The vaults should be kept locked when not in use and should be made inaccessible to trespassers at all times.

7-04. Storage Vault Keys. The gate storage vault locks are keyed alike and one complete set of keys is located at the office of the Superintendent.

7-05. Gate Closures. The gate closures are of metal framing and aluminum corrugated panel construction. All metal assembly parts, except those constructed of aluminum should be adequately protected with paint to preserve them from corrosion. Bolts should be left in their respective holes or placed into marked containers and tied to the members with which they are to be used.

7-06. Inspection and Trial Erection. Closure structures shall be inspected at least once every 90 days. Such inspections should be made at the beginning of the months of January, April, July, and October. Sample checklist forms for use in making inspections of gate closures are shown in the appendix. The forms contain an inventory of all parts necessary for the erection and operation of the closures. All parts should be checked against the checklist to ascertain their presence in the vault. It is advisable to check the storage vaults immediately before impending high water to see that no parts are missing. Any irregularities observed during inspections should be removed from the vault and each part checked thoroughly for evidence of corrosion or warping to determine whether the part is still usable. The necessary remedial measures should be taken for cleaning, painting, and oiling or greasing the parts. Trial erections of one or more closure structures shall be made once each year, alternating the structures chosen so that each gate will be erected at least once in each 3-year period.

7-07. Operation. The regulations provide that:

> "Erection of each movable closure shall be started in sufficient time to permit completion before floodwaters reach the top of the structure sill. Information regarding the proper method of erecting each individual closure structure, together with an estimate of the time required by an experienced crew to complete its erection will be given in the Operation and Maintenance Manual, which will be furnished local interests upon completion of the project. Closure structures will be inspected frequently during flood periods to ascertain that no undue leaking is occurring and that drains provided to care for ordinary leakage are functioning properly. Boats or floating plant shall not tie up to closure structures or to discharge passengers or cargo over them."

7-08. Gate Erection. Erection of each movable gate closure shall be made in accordance with instructions mounted on the walls of the storage vaults and contained in this manual. All gates have been given one trial erection and parts have been adjusted to fit. Although some leakage can be expected, excessive leakage can be prevented by the use of sandbags, cinders, mastic or other sealing material, sufficient stocks of which should be kept on hand where they will be immediately available during an emergency.

7-09. Ohio River Rate of Rise - Gate Closure Operation. It is imperative that ample time be allowed to erect the gate closure before the water reaches the sills. Due consideration must be given to the rate of rise of the river. Records indicate that the rate of rise may be expected to average about 0.20 foot per hour over the period required to affect closure. Consideration must also be given to possible delays in the operation because of inexperienced help and other contingencies.

7-10. Gate Closure Data. Table 2 gives the order of erection, minimum estimated time required for a trained crew with the necessary tools, and the approximate size of the crews necessary to efficiently erect the gate closures. Since many gate sill elevations are in a close range to each other, it is advisable to provide five crews to effect the closures.

7-11. Cleanup. Upon final recession of floodwaters, the timbers, trusses, etc., shall be cleaned, metal surfaces shall be painted where necessary and all material shall be inventoried against the checklist forms as they are restored to the storage vaults. Sill and anchorage recesses in streets and sidewalks shall be cleaned and painted and cover plates shall be replaced. Surface paving or structures shall be restored to their original condition. Gate recess corner angles in the abutments shall be cleaned and painted. Stocks of sealing materials shall be replenished and damaged units immediately replaced.

TABLE 2

GATE CLOSURES

* ERECTION OF CLOSURE SHOULD BE COMPLETED BY STAGE INDICATED

ORDER OF ERECTION	LOCATION	APPROX. STATION	PLATE NO.	ERECTION TIME (HOURS)	CREW REQ'D (NO. MEN.)	TYPE	GAGE
1	Tenn. & Ohio Sts.	91+96-B	23	4	6	Roadway	49.5
	Tenn. & Ohio Sts.	93+57-B	24	3	6	Roadway	49.5
	Ohio St.	94+64-B	24	4	6	Roadway	49.5
	Jackson St.	98+89-B	24	4	6	Roadway	49.5
	Clark St.	108+53-B	24	4	6	Roadway	49.5
	Washington St.	114+99-B	24	6	6	Roadway	49.5
	Kentucky St.	*119+63-B	24	5	6	Roadway	49.5
	Near Kentucky St.	119+93-B	25	1	2	Service	49.5
	Near Broadway	123+50-B	25	1	2	Service	49.5
	Broadway	*123+80-B	24	4	6	Roadway	49.5
	Near Broadway	124+10-B	25	1	2	Service	49.5
	Jefferson St.	*128+20-B	24	4	6	Railroad	49.5
	Monroe St.	*132+41-B	24	3	6	Roadway	49.5
	Near Monroe St.	*135+23-B	24	4	6	Railroad	49.5
	Near 2nd St.	137+93-B	25	1	2	Service	49.5
	2nd St.	*138+23-B	24	5	6	Roadway	49.5
	Near 2nd St.	138+54-B	25	1	2	Service	49.5
	Harrison St.	*145+74-B	24	5	6	Roadway	49.5
	Near Clay St.	149+57-B	25	1	2	Service	49.5
	Clay St.	149+87-B	24	5	6	Roadway	49.5
	Near Clay St.	150+18-B	25	1	2	Service	49.5
	5th St. & Park Ave.*	161+53-B	24	8	10	Roadway	49.5
1	Near Park Ave.	*166+49-B	23	3	6	Roadway	49.5
2	Near Locust St.	4+50-B	24	4	6	Railroad	51.0
	Near Locust St.	5+35-B	24	4	6	Railroad	51.0
	Btwn. Locust St. & Woodward	9+44-B	23	4	6	Roadway	51.0
	Btwn. Locust St. & Woodward	10+40-B	23	4	6	Roadway	51.0
	Near Woodward	15+32-B	25	1	2	Service	51.0
	Near Woodward	25+15-B	24	4	6	Railroad	51.0
	Near Norton St.	83+92-B	24	6	6	Railroad	51.0
	Near 4th St.	156+96-B	25	1	2	Service	51.0
	4th St.	157+26-B	24	5	6	Roadway	51.0
	Near 4th St.	157+57-B	25	1	2	Service	51.0
2	Campbell St.	170+04-B	24	8	8	Railroad	51.0
3	Near Cairo Rd.	140+46-A	24	3	6	Railroad	52.5
	Near Clements St.	29+80-B	23	4	6	Railroad	52.5
	Near Clements St.	31+01-B	23	4	6	Roadway	52.5
	Near Farley Pl.	36+85-B	23	4	6	Roadway	52.5

ORDER OF ERECTION	LOCATION	APPROX. STATION	PLATE NO.	ERECTION TIME (HOURS)	CREW REQ'D (NO. MEN.)	TYPE	GAGE
	Tennessee St.	90+39-B	24	5	6	Roadway	52.5
3	Adams St.	103+64-B	24	4	6	Roadway	52.5
4	Near Locust St.	2+87-B	25	1	2	Service	53.5
	Near Locust St.	3+21-B	25	1	2	Service	53.5
	Near Clements St.	26+90-B	24	4	6	Roadway	53.5
	Near Clements St.	31+51-B	24	4	6	Railroad	53.5
	Near George St.	62+84-B	24	5	6	Railroad	53.5
	Near Husbands St.	71+75-B	24	4	6	Railroad	53.5
	Near Norton St.	75+85-B	24	4	6	Railroad	53.5
4	Near Adams St.	106+10-B	24	4	6	Roadway	53.5
5	Near Elizabeth St.	51+87-B	24	4	6	Roadway	55.0
	Elizabeth St.	54+38-B	24	4	6	Roadway	55.0
	Near Husbands St.	67+73-B		(Closed Permanently)			
	Near Husbands St.	69+64-B	23	5	6	Roadway	55.0
	Near Husbands St.	73+31-B	25	1	2	Service	55.0
	Near Norton St.	79+27-B	25	1	2	Service	55.0
5	N.C. & St. L. Ry.	104+96-C	24	4	6	Railroad	55.0

* NOTE: At some of the ramps over the levee the roadways may be as much as 2 feet below the top of the levee. These ramps may require sandbagging under extreme high water conditions, gage 61.8. See Plate 11 for sandbag instructions. Ramps in Section A are located at U.S. Hwy 45, Cairo Road, and U.S. Hwy 60 in Section C at U.S. Hwy 60, Benton Rd., and Oaks Road.

SECTION VIII

PUMPING PLANTS

8-01. General. Twelve pumping plants were constructed to remove interior drainage from the protected area during periods when the river exceeds the stage at which the gravity outlets must be closed to prevent flood damage. The City of Paducah built a small pump plant No. 13 to alleviate ponding in the area behind the 36-inch drainage structure at Station 291+75-C.

8-02. Pumping Plant No. 1 (Noble Park) is located near the Cairo Road. Discharge from the plant is accomplished through the levee by three 30-inch pipes equipped with flap gates at the discharge headwall. The drainage area of approximately 733 acres serves as a storage pool. Three pumps capable of discharging about 66,000 gallons per minute are started manually and stopped automatically.

8-03. Pumping Plant No. 2 (Sixth Street) is located near Terrell Street. Discharge from the plant is through the levee by one 10-inch, one 30-inch, two 48-inch, and two 60-inch steel pipes equipped with flap gates at the discharge headwall. The plant serves a drainage area of about 2,071 acres with six pumps capable of discharging about 313,000 gallons per minute. The pumping operations are automatically or manually controlled.

8-04. Pumping Plant No. 3 (Park Avenue) is located near Fifth Avenue. Discharge from the pumping plant is accomplished from a discharge chamber by 24-inch wrought iron discharge pipe which empties into manhole No. 21-B2 at Fifth and Park Avenues and from there by conduit into the river. The plant, completely automatic in operation, serves a discharge area of about 11.3 acres with three pumps capable of discharging about 8,800 gallons per minute.

8-05. Pumping Plant No. 4 (Clay Street) is an underground unit capable of discharging about 7,000 gallons per minute from two automatically controlled pumps. Discharge is through a 20-inch wrought iron pipe.

8-06. Pumping Plant No. 5 (Harrison Street), located at Third and Harrison Streets, has four pumps capable of discharging 51,700 gallons per minute. The pumps are equipped to start and stop automatically. Flow is pumped directly from a sewer (there is no storage available). Discharge lines from the four pumps enter a discharge chamber which is connected to manhole 12-P on a sewer on the riverside of the floodwall by a 48-inch wrought iron pipe passing underneath the wall. The pumping plant is a combined storm water and sanitary unit pumping the runoff from an area of about 100 acres.

8-07. Pumping Plant No. 6 (Clark Street) is located on the line of protection at Clark Street and is a combined storm water and sanitary plant pumping the runoff from about 273 acres. There are five pumps capable of discharging about 106,000 gallons per minute, and equipped to start and stop automatically. Flow is pumped directly from 54-inch and 60-inch intercepting sewers (there is no storage available). Discharge lines from the five pumps enter a chamber discharging directly into the river through a 72-inch semielliptical outfall sewer.

8-08. Pumping Plant No. 7 (Tennessee Street) is a combined storm and sanitary plant pumping the runoff from an area of about 54 acres. Discharge is accomplished by three pumps capable of pumping 23,300 gallons per minute. The pumps are equipped to start and stop automatically. Flow is pumped directly from a 36-inch sewer (there is no storage available). Discharge lines from the three pumps enter a discharge chamber, which empties into a manhole by 36-inch wrought iron pipe, on the riverside of the floodwall in the 36-inch sewer.

8-09. Pumping Plant No. 8 (Norton Street) near Norton and Third Streets is an underground unit. Access to it is through a hinged manhole cover. The plant has two 300 gallons per minute centrifugal pumps which are for sanitary sewage only. The intakes are connected to a manhole on the landside of the wall at Station 74+40. The discharge line from the pumps is connected to the 8-inch cast iron sewer that passes under the wall. Both pumps are equipped to operate automatically.

8-10. Pumping Plant No. 9 (Husbands Street) is located near Third and Husbands Streets and pumps sanitary sewage only. There are two centrifugal pumps capable of discharging 7,800 gallons per minute and a separate intake chamber so arranged that sewage flows through at all times. The discharge line from the pumps is connected to the 30-inch wrought iron sewer on the riverside of the floodgate manhole by a Y-branch. Both pumps are equipped to operate automatically.

8-11. Pumping Plant No. 10 (George Street), near Third and George Streets. This plant is an underground unit and access to it is through a manhole with a hinged cover. There are two centifugal pumps for pumping sanitary sewage at a rate of 2,400 gallons per minute. The intakes are connected to a floodgate manhole on the sewer landside of the floodwall. The discharge line from the pumps is connected to the 24-inch cast iron sewer that passed under the floodwall on the riverside of the floodgate manhole. Both pumps are equipped to operate automatically.

8-12. Pumping Plant No. 11 (Island Creek) is located along the centerline of the levee where it crosses Island Creek. The plant comprises a gravity outlet structure for normal, all-season runoff and a storm water pumping arrangement. The gravity outlet consists of four

conduits 10 feet square and 123 feet in length with electrically operated pressure seating sluice gates, recessed at both ends of the conduits for stop logs. A headwall structure is located at the landward end of the conduits and there is a stilling basin at their riverward end. The plant pumps storm water only and makes use of the storage available in the Island Creek channel. There are three 33,000 gallons per minute axial flow pumps. Each pump is located vertically over one of the square conduits with the top of the conduit open so that flow from Island Creek can flow upward into the pump sump. Discharge lines from the pumps enter discharge chambers which are also located vertically over the conduits and are open on the riverside of the sluice gates. Flap gates on the pump discharge lines in the discharge chambers prevent backflow from the river into pump sumps. The plant pumps runoff from an area of 14,200 acres during periods of high Ohio River stages, and has a total capacity of 99,000 gallons per minute. All pumps are equipped for manual starting and automatic stopping.

8-13. Pumping Plant No. 12 (SE of Paducah) is equipped with two axial flow pumps and capable of pumping 9,700 gallons per minute, manually started and automatically stopped.

8-13A. Pumping Plant No. 13 (Station 291+75C). A pumping plant (built by HUD for the City of Paducah) is provided to alleviate ponding in the area behind the 36-inch drainage structure with flap gate at Sta. 291+75C. A self-priming centrifugal pump with a 60 hp motor rated at 1,800 GPM at 60-foot head is provided to pump water from the ponding area through a 10-inch steel line. A 10-inch gate valve and a 3-inch air relief valve are provided on the discharge line at the top of the levee. The maximum ponding elevation is 334. The pump will start pumping at elevation 330.

8-14. Maintenance. The regulations state the following pertinent requirements for maintenance of the pumping plants:

> "Pumping plants shall be inspected by the Superintendent at intervals not to exceed 30 days during flood seasons and 90 days during off-flood seasons to insure that all equipment is in order for instant use. At regular intervals, proper measures shall be taken to provide for cleaning plant, buildings, and equipment, repainting as necessary, and lubricating all machinery. Adequate supplies of lubricants for all types of machines, fuel for gasoline or diesel-powered equipment, and flashlights or lanterns for emergency lighting shall be kept on hand at all times. Telephone service shall be maintained at pumping plants. All equipment, including switchgear, transformers, motors, pumps, valves, and gates shall be trial-operated and checked at least once every 90 days. Megger tests of all insulation shall be made whenever wiring has been subjected to undue

dampness and otherwise at intervals not to exceed 1 year. A record shall be kept showing the results of such tests. Wiring disclosed to be in an unsatisfactory condition by such tests shall be brought to a satisfactory condition or shall be promptly replaced. Diesel and gasoline engines shall be started at such intervals and allowed to run for such length of time as may be necessary to insure their serviceability in times of emergency. Only skilled electricians and mechanics shall be employed on tests and repairs. Operating personnel for the plant shall be present during tests. Any equipment removed from the station for repair or replacement shall be returned as soon as practicable and shall be trial-operated after reinstallation. Repairs requiring removal of equipment from the plant shall be made during off-flood seasons insofar as practicable."

8-15. Readiness. Regular inspections, tests, and maintenance of the pumping plants should be accomplished as directed herein to provide a reasonable indication of the readiness of the pumping facilities for uninterrupted operation, and to reduce the possibility of failure of vital electrical and mechanical equipment during critical flood periods. The thoroughness and care with which the inspector does his work will determine the reliability of the equipment. Inspectors should be familiar with the manufacturer's instructions in both the function and adjustment of various devices. In order to insure thorough inspection, the checklists for inspection of pumping plants should be used.

(NOTE: Insurance against breakdown of equipment in the pumping plant is available through insurance companies. Such insurance provides for inspection of pumping plant and equipment at regular intervals by the company.)

8-16. Manufacturer's Instructions. The general instructions herein cover the normal operation and maintenance of the pumping equipment. The operators should also be familiar with the equipment manufacturers' drawings, literature, and instructions in case more detailed information may be required for maintenance and operation. In case of major operating difficulties or repairs of a particular item of equipment, the manufacturer should be consulted.

8-17. Pumping Plants. The pumping plants should be properly maintained. The doors, metal, and wood parts should be adequately protected with paint to prevent corrosion or rotting. All hardware should be well oiled or greased for ease of movement and to prevent corrosion. Any cracks or leaks that may develop in the walls, roof, or floor, allowing water to leak or seep into the structure, should be sealed with waterproofing material. The lighting system should be maintained in good

working order and all defective lamps should be replaced promptly. The plant should be kept free of fire hazards, locked when not in use, and made inaccessible to trespassers at all times. One complete set of keys is located in the office of the Superintendent.

8-18. Grounds and Access Roads. The roads leading to the pumping plant, grounds around the plant, and ponding area should be maintained in good condition at all times. Drainage and surface repairs should receive immediate attention when conditions requiring remedial measures arise. This will insure access for heavy rolling equipment at any time and under all weather conditions.

8-19. Crane and Chain Hoists. The pumping plants are equipped with hand-operated crane and chain hoists of sufficient capacity to handle the heaviest pump or motor in the plants. When it becomes necessary to remove the pumps for repairs, the motors should be hoisted separately from the pumps. No attempt should be made to handle the motor, base plate, and pump together. The crane and hoist should be inspected at the regular quarterly inspections. Parts should be adequately protected with paint or oiled or greased as required to prevent corrosion. Moving parts should be oiled or greased for free movement.

8-20. "Megger" Tests - General. "Megger" readings, as called for by the regulations, should be taken at the times of regular quarterly inspection - but not less often than once a year - and at such other times as when wiring has been subjected to undue dampness or excessive dirt conditions. "Megger" tests, properly recorded, show a continuous graphic picture of the condition of the insulation. A study of this picture may make it possible to detect approaching trouble before a breakdown occurs. Plate 22 in this manual shows a sample record form.

a. Insulation Resistance - Temperature Curves - Above 1,000 Volts. Factory tests have been made of the pump motor installed on the project and, based on these tests, minimum safe operating values of insulation resistance have been drawn as curves and are shown on Plates 16 through 21. These minimum safe value curves conform to the requirements of the ASA, which state that the minimum safe value of insulation resistance in megohms at 75 degrees Centigrade for polyphase induction machines is equal to the value obtained by dividing the rated voltage of the machine by the sum of 1,000 and the quotient of rated kW divided by 100. With the aid of these curves, an immediate and accurate check of the condition of the motor insulation can be readily made. The curves can also be used to correct any given reading for temperature by projecting the reading to the base temperature of 75 degrees Centigrade. When the corrected values of insulation resistance are plotted against time, any trend of the readings can be accurately observed. This knowledge is important, as the gradual deteriorating effect of an

insulation can be observed and corrective measures taken. The values to be entered on the Insulation Resistance Report, for the motor windings, should be corrected values. The corrected values should also be plotted against time on a sheet of rectangular coordinate paper (see Plate 22).

b. Insulation Resistance-Temperature; Below 1,000 Volts. It is recommended that a series of megger readings be made on each piece of equipment at various temperature and humidity conditions, to establish an adjusted "base" for interpretation of future readings. This should be done while the equipment is relatively new. When future resistance readings are made, they should be compared to the base data. If the reading at any time is less than 50 percent of the base value, further checks should be made. If the low value appears to be the result of excessive moisture and/or dirt, the insulation should be cleaned and dried. If the readings continue to drop over a period of time, indicating a breakdown of insulating material, major repair is indicated and should be undertaken as soon as possible. General practice is to consider equipment unsafe for operation when insulation resistance is less than 1 megohm per 1,000 volts of apparatus rating, but never less than 1 megohm. When necessity for equipment use outweighs possible damage to equipment, it may be used in unsafe range with extreme precaution.

c. Taking "Megger" Readings. The Megger Insulation Tester is aa compact lightweight instrument that tells at a glance just what the resistance of the insulation is. All that is required for operation is to connect one of the test leads to the terminal of the machine or wiring to be checked and the other test lead to ground. Then, upon turning the crank, the resistance of the insulation is shown on the direct-reading scale.

d. Drying Windings. Dampness of the windings may be indicated by low insulation resistance. An unsafe low resistance due to this condition will require that the insulation be dried out. It is recommended that drying of windings be accomplished through the application of external heat. External heat should be applied under a canvas cover, properly vented. Heating should not go beyond 85° C. (185°F.), as water might be boiled in the insulation. Keep a check on the temperature. Portable strip heaters or special infrared-ray lamps may be used for this purpose. When damp insulation is being dried, the resistance will generally fall rapidly as the temperature is raised to a drying value. After falling to the minimum for a given temperature, the resistance will rise as moisture is expelled from the insulation. The motor can be placed in service as soon as the resistance measurement rises to the minimum value herein and the remainder of the drying will be accomplished by the heat generated through the operation of the motor.

e. Should low resistance readings be obtained regularly at similar yearly periods, it may be advisable to operate electric space heaters in the pumping plants at these times or to increase the capacity of dehumidification. This will prevent deterioration of the insulation and prolong its useful life.

8-20A Dehumidification. Dehumidifiers have been installed in the pumping plants in order to remove water vapor from the air to protect the equipment from corrosion or other damage caused by condensation or the effects of high relative humidity.

a. The relative humidity should be checked during each quarterly inspection or more often if desirable. When entering the plant for the purpose of obtaining the relative humidity, it is important that the door be closed as quickly as possible and that it be kept closed while psychrometer readings are being taken. The following Table 3 gives instructions and a chart for the use of the sling psychrometer. The reading obtained by the use of the psychrometer should be treated as follows:

(1) Check the relative humidity obtained against the value set on the humidistat. Reset or recalibrate humidistat if necessary.

(2) Write the building temperature on the "megger" report card in the space provided.

(3) Write the relative humidity on the "megger" report card in the space provided.

RELATIVE HUMIDITY PERCENT - FAHRENHEIT TEMPERATURES

DEPRESSION (DRY BULB - WET BULB)

DRY BULB TEMPERATURE t°	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
20	83	70	53	40	26																					
22	86	71	58	44	31																					
24	87	73	60	47	35	22																				
26	87	75	63	51	39	27																				
28	88	76	65	54	43	32																				
30	89	78	67	56	46	36	26																			
32	89	79	69	59	49	39	30																			
34	90	81	71	62	52	43	34																			
36	91	82	73	64	55	46	38	29																		
38	91	83	75	66	58	50	42	33																		
40	92	83	75	68	60	52	45	37	29																	
42	92	85	77	69	62	55	47	40	33																	
44	93	85	78	71	63	56	49	43	36	30																
46	93	86	79	72	65	58	52	45	39	32																
48	93	86	79	73	66	60	54	47	41	35	29															
50	93	87	80	74	67	61	55	49	43	38	32															
52	94	87	81	75	69	63	57	51	46	40	35	29														
54	94	88	82	76	70	64	59	53	48	42	37	32														
56	94	88	82	76	71	65	60	55	50	44	39	34														
58	94	88	83	77	72	66	61	56	51	46	41	37	32													
60	94	89	83	78	73	68	63	58	53	48	43	39	34													
62	94	89	84	79	74	69	64	59	54	50	45	41	36	32												
64	95	90	84	79	74	70	65	60	56	51	47	43	38	34												
66	95	90	85	80	75	71	66	61	57	53	48	44	40	36	32											
68	95	90	85	80	76	71	67	62	58	54	50	46	42	38	34											
70	95	90	86	81	77	72	68	64	59	55	51	48	44	40	36	33										
72	95	91	86	82	77	73	69	65	61	57	53	49	45	42	38	34										
74	95	91	86	82	78	74	69	65	61	58	54	50	47	43	39	36	33									
76	96	91	87	82	78	74	70	66	62	59	55	51	48	44	41	38	34									
78	96	91	87	83	79	75	71	67	63	60	56	53	49	46	43	39	36	33								
80	96	91	87	83	79	75	72	68	64	61	57	54	50	47	44	41	38	35	32							
82	96	92	88	84	80	76	72	69	65	61	58	55	51	48	45	42	39	36	33							
84	96	92	88	84	80	76	73	69	66	62	59	56	52	49	46	43	40	37	35	32						
86	96	92	88	84	81	77	73	70	66	63	60	57	53	50	47	44	42	39	36	33						
88	96	92	88	85	81	77	74	70	67	64	61	57	54	51	48	46	43	40	37	35	32					
90	96	92	89	85	81	78	74	71	68	65	61	58	55	52	49	47	44	41	39	36	34					
92	96	92	89	85	82	78	75	72	68	65	62	59	56	53	50	48	45	42	40	37	35	32				
94	96	93	89	85	82	79	75	72	69	66	63	60	57	54	51	49	46	43	41	38	36	33				
96	96	93	89	86	82	79	76	73	69	66	63	61	58	55	52	50	47	44	42	39	37	35	32			
98	96	93	89	86	83	79	76	73	70	67	64	61	58	56	53	50	48	45	43	40	38	36	34			
100	96	93	89	86	83	80	77	73	70	68	65	62	59	56	54	51	49	46	44	41	39	37	35	33		
102	96	93	90	86	83	80	77	74	71	68	65	62	60	57	55	52	49	47	45	42	40	38	36	34		
104	97	93	90	87	83	80	77	74	71	69	66	63	60	58	55	53	50	48	46	43	41	39	37	35	33	
106	97	93	90	87	84	81	78	75	72	69	66	64	61	58	56	53	51	49	46	44	42	40	38	36	34	
108	97	93	90	87	84	81	78	75	72	70	67	64	62	59	57	54	52	49	47	45	43	41	39	37	35	33
110	97	93	90	87	84	81	78	75	73	70	67	65	62	60	57	55	52	50	48	46	44	42	40	38	36	34
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

Hygrometers and Psychrometers

These instruments consist of two mercury thermometers - the dry bulb which measures the actual air temperature, and the wet bulb which measures a temperature lowered by the evaporation of the wetness of the wick. The wicking attached to the wet bulb thermometer must be immersed in clean water so that the bulb is completely saturated. Care must be taken that the wick does not become dirty or it will not absorb water, and will give incorrect readings.

The difference between the dry bulb and the wet bulb readings is the depression. This is indicated on the line at the top of the chart, and the air or dry bulb temperature is in the column at the left. To determine the percent of relative humidity, determine, from the readings of the two bulbs, the depression (dry bulb - wet bulb). The intersection of the column under the depression and the line for the dry bulb reading is the percent of relative humidity. For example, if the dry bulb reading is 100°F and the wet bulb reading is 90°F, the depression is 10° and the relative humidity is 68%.

Where sling psychrometers are used, it is necessary to whirl the instrument several times for about 10 seconds duration each, taking readings after each time until there is no further drop in temperature. The lowest temperature reading is the one used to find the depression.

TABLE 3

8-21. Electrical Equipment. All electrical equipment, including transformers, and all component parts of the power supply, the switchgear, circuit breakers, automatic controls, cutouts, insulators, switches, meters, etc., should be checked at the regular quarterly inspections to assure that these facilities are in satisfactory operating condition and ready for service. The float control equipment is described below. The transformers, circuit breakers, and other component parts of the switchgear should be maintained and serviced as prescribed by the manufacturer. Pumping plant operators should not adjust any plant equipment during inspections and trial operations. Switchgear should be kept in condition, including cleaning by component maintenance personnel. Equipment should be adjusted or serviced only by skilled mechanics. In cleaning circuit breakers, relay contacts and control switches, silvered surfaces should not be sandpapered. All electrical equipment, particularly the switchgear, should be kept as dry as possible. It is recommended that arrangements be made with the power company for the inspection of the electrical equipment and transformers and that data pertaining to these items be added to the inspection reports.

8-22. Pumps and Motors. Pumps and motors should be maintained and serviced in accordance with the manufacturer's instructions furnished the city. The pumps and motors should be trial operated and parts inspected as outlined under the operating instructions in this section of the manual.

8-23. Control Equipment. There are two different types of control for the pumping plants. Pumping plant Nos. 1, 11, and 12 are manually started and automatically stopped. All of the other pumping plants are fully automatic in operation. Automatic starting and stopping of pumps is accomplished through electric floatless control equipment. This equipment should be checked at regular intervals to ensure successful automatic pumping control. The equipment consists of an induction relay with one or two contact bridges, and one or more electrodes set at proper elevations in the sump or wet-well to control the starting and stopping of the pumps. When the relay is energized - by closing the switch for automatic operation - and the sump water level is below the starting elevation, contacts will be in the open position. When water in the sump rises to the bottom of the starting electrode, the relay circuit is completed, closing the contacts and thus completing the motor circuit. For automatic stop operation, the relay is deenergized when water in the sump drops below the level of the stopping electrode, thereby breaking the motor starting circuit.

WARNING: The following check should be made while wearing rubber gloves and no part of the body should be allowed to touch the electrodes.

8-24. To check fully automatic equipment, set the pump controls for automatic operation, with rubber gloves on, ground the electrodes - in sequence - from the lowest to the uppermost to simulate rising water. The pumps should then start and stop according to the pumping schedule. To check "automatic stop" equipment, ground the electrodes and start the pumps, then remove the grounds. The pumps should stop when the grounds are removed. Check the connections and contacts as necessary and described in paragraph 11-11, f. 11. See that the armature and contact arm move freely. Ascertain that the insulators supporting each electrode are clean and free from moisture at all times. Should the insulator surface be capable of electrical conduction, the motor may not operate as required. To check manually operated equipment, push the undervoltage reset buttons outside the cabinet, pull down the circuit breaker handle to the bottom position, then swing it up rapidly and smoothly clockwise until the breaker latches close. The motor should then start. To stop the motor, push the trip button.

8-25. Repairs. Replacements or repairs of the equipment described herein as determined by the inspections and tests are to be effected by trained personnel without undue delay. In taking remedial measures during periods of imminent high water, repairmen should bear in mind that use of the plant may be required at any time, and therefore, repairs or replacements should be accomplished with the utmost speed without sacrificing quality of workmanship.

8-26. Trial Tests. Each item of pumping equipment shall be trial operated for a period of at least 5 minutes as required herein. It is suggested that, in these trials, the motors be run consecutively and not concurrently. Procedures for operation during testing will be essentially similar to those described herein for normal plant operation. During these trial runs, the inspector should search for danger signals that will give warning of possible failure of equipment.

8-27. Air Relief Valves. Pump discharge lines of pumping plant Nos. 1, 2, and 12 are equipped with check valves located at the maximum elevation of each line on the riverside of the levee crown. Their function is to remove automatically any air trapped in the line during pumping operations. These valves should be inspected at the regular quarterly inspections to be sure that they are in satisfactory operating condition. The discs, in particular, should not be worn and should operate freely.

8-28. Inspection and Trial Operation. Pumping plants shall be inspected at intervals not to exceed 30 days during the flood season and 90 days during off-flood season. Such inspections should be made at the beginning of the months of December to May, inclusive, and in July and October. In addition, all equipment, including switchgear, transformers, motors, pumps, valves, and gates shall be trial-operated and checked at least once every 90 days. Such trial operations shall be made at the beginning of the months of October, January, April, and

July. Sample checklist and log forms for use in making inspections and trial operations of pumping plants are shown in the appendix. The checklist forms contain an inventory of tools and spare parts necessary for the operation and maintenance of the plants. Missing parts and tools should be replaced as quickly as possible. Any irregularities or damage should be noted thereon. A report of any damage noted should be made as required by the regulations and, in addition, the proposed method of effecting repairs shall be furnished to the District Engineer, Louisville, Kentucky, for approval prior to initiating remedial work.

8-29. Operation. The regulations provide that:

> "Competent operators shall be on duty at pumping plants whenever it appears that necessity for pump operations is imminent. The operator shall thoroughly inspect, trial operate, and place in readiness all plant equipment. The operator shall be familiar with the equipment manufacturer's instructions and drawings with the "Operating Instructions" for each station. The equipment shall be operated in accordance with the above-mentioned "Operating Instructions" and care shall be exercised that proper lubrication is being supplied all equipment, and that no overheating, undue vibration or noise is occurring. Immediately upon final recession of floodwaters, the pumping station shall be thoroughly cleaned, pump house sumps flushed, and equipment thoroughly inspected, oiled and greased. A record or log of pumping plant operation shall be kept for each station, a copy of which shall be furnished the District Engineer following each flood."

8-30. Operating Instructions. Pumping plant operating instructions for each pumping plant is included in this manual. A larger copy has been mounted and placed in the applicable pump plant where it will readily be available. The operating diagram shows a layout of equipment, identification of control equipment, operating instructions, and pumping schedule. The flood stage at which each pump shall be prepared to go into operation is shown on the pertinent pumping plant operation diagram and also on the general plan.

8-31. Operation Log. The operator of each pumping plant shall keep a complete log of operations for the entire period over which pumping plant requirements are carried out, i.e., from the time of notification of the operator to report for duty to closing down and locking the pumping plants. The log of operation, (see sample log, Appendix E) should include readings at 1-hour intervals, a record of all operational and maintenance duties performed, and the exact time of starting and automtic or manual stopping for each pump.

8-32. Ohio River - Rate of Rise - Pumping Plant Operation. It is imperative to allow ample time to prepare the pumping plants for operation for such time when pumping will be required. Due consideration must be given to the rate of rise of the river. Records indicate that the rate of rise may be expected to range up to 0.20 foot per hour over the period required to prepare the pumping plants. Consideration must also be given to possible delays in operation due to inexperienced help and other contingencies. It is advisable to prepare the pumping plants at least 24 hours in advance of any anticipated operation in order that sufficient time will be available for any required minor repairs. The pumping plants should be inspected, the transmission line and substation energized, the pumps lubricated, trial operated, and made ready for operation at the pumping elevations as follows:

TABLE 4

ORDER OF PLANT PUMPING OPERATIONS

Pumping Plant	River Elev.	River Stage
No. 11 - Island Creek	320.0	33.0
No. 2 - Sixth Street	320.5	34.0
No. 4 - Clay Street	320.6	34.2
No. 9 - Husbands Street	321.6	34.5
No. 6 - Clark Street	325.5	38.5
No. 10 - George Street	321.6	34.5
No. 5 - Harrison Street	325.8	39.5
No. 7 - Tennessee Street	328.3	41.5
No. 1 - Noble Park	330.0	44.5
No. 3 - Park Avenue	333.4	45.9
No. 12 - Southeast of Paducah	334.0	46.5
No. 8 - Norton Street	334.6	47.5

Note: City built pumping plant (Sta 291+75C) starts pumping at elevation 330.0, river stage 43.0.

8-33. Pumping Plant Preparation. When National Weather Service predictions indicate that the river will attain stages at which pumping may be required, competent operating personnel should be on hand at each pumping plant in ample time to prepare the pumping plants and to trial-operate the equipment for pumping operations. Such stages are given in Table 4. The extent of pumping plant operations will be dependent upon the local rainfall during high river stages. Operators should keep each plant in operation or in constant readiness for operation until the river has receded to the maximum pumping elevation for the respective pumping plant and predictions indicate that another increase in river stage is not anticipated from the current flood.

8-34. Sump Preparation. Prior to admitting water to the sump, the sump should be inspected and cleaned of any debris which might be drawn into the pumps and damage them. Each plant has been provided with a trashrack rake. As the debris collects on the trashrack during pumping operations, it should be removed with the rake so as not to diminish the intake capacity nor damage the pumps. Personnel should not be permitted to enter the sump until precautions have been taken against danger from toxic and explosive gases and a possible deficiency of oxygen.

8-35. Instructions in Starting Motors.

a. General.

(1) Prior to energizing any pumping plant, check the control panels and make sure that all switches are in the "OFF" position. Also, that the airbreak switch on the substation tower is open.

(2) Notify power company (24 hours in advance) and request energizing of the pumping plants.

(3) Make sure that pumps are free to rotate, that impellers are up and no foreign matter has lodged in the pump to cause damage. Preliminary oiling by hand oil pump will always be necessary before operation of the pumps. Oil should be forced to all bearings until a slight increase in turning effort is noticed.

(4) All motors and their corresponding controls have the same number.

(5) Always allow motors to attain their full speed before stopping them.

(6) All DK series circuit breakers may be tripped to stop the motors by giving the operating handle a sharp twist in a counter-clockwise direction. This applies to the motor control switches and lighting transformer switches in pumping plants 1, 5, 6, 7, and 11. The lighting transformer switch in plant No. 7 is a snap switch type and it must be "ON" to operate the control circuit.

(7) The ammeters should be energized at all times during operation. Any sharp rise in current consumption to a motor indicates an increase in load. The unit should be stopped immediately and investigated to determine the cause. It is advisable to apply extra oil to the bearings in this case in order to prevent the possibility of a bearing freezing. The full load

current rating of each motor should be checked against the value read at the ammeter for that motor. Readings more than about 10 percent above the rated full load will indicate the unit is operating under an overload.

b. Pumping Plant No. 1 (Noble Park).

(1) Read the "general" instructions above.

(2) To close the airbreak switch on the substation tower, unlock it and, when closing it, replace the pin to hold the switch in the closed position.

(3) Energize the lighting transformer by turning the switch marked "LIGHTING TRANSFORMER" on the control panel one-quarter turn clockwise. The lights in the plant may then be controlled from the lighting panel just inside the door. The line voltage should be 396-484.

(4) For dry operation of the pump, it will be necessary while running to hold in the button marked "RELAY RESET." These buttons are located at about the center of the upper right cell of the control panel.

(5) Hold in the button for the desired motor to be started, then pull sharply the handle of the corresponding circuit breaker in a clockwise direction. The motor should start immediately. To stop the motor in dry conditions, release the button.

(6) When there is water in the plant sump and it is over the electrode, it is necessary only to close the circuit breaker to the motor being started. The motors may be stopped by either pressing the button located at the bottom of the upper right cell marked "STOP" or by tripping the circuit breaker at the control handle.

c. Pumping Plant No. 2 (Sixth Street).

(1) Read the general instructions above.

(2) To close the airbreak switch on the substation tower unlock it and, when closing it, replace the pin to hold the switch in the closed position.

(3) Turn the voltmeter switch located on the left cell of the panel to each of the three phase positions. Voltage readings on the meter at the top of the cell should be between 2,200 and 2,400. The voltmeter should stay energized in order to check voltages regularly.

(4) Select motor to be operated, open control panel, push switch located on left side and about 4 feet above floor, to the "ON" position. Green indicator light should be on.

(5) To start the motor, turn the switch just below the indicator lights to "MANUAL." The circuit breaker in the panel should close and the motor should start.

(6) The motor may be stopped by returning the switch to the center or "OFF" position. However, there is a time lag of approximately 5 seconds after the control switch is turned off before the main circuit breaker will open.

(7) When the circuit breaker trips out immediately after closing, turn the control now to "OFF," then back to "MANUAL." An additional protective device built into the circuit breaker causes the trip out under heavy current surges. However, if several attempts to start the motor fail in this way, then indicators are that there is some trouble in the line and no further efforts should be made to start until the cause has been determined.

(8) The glass covers in each cell door house a thermal overload device and an instantaneous overload device. The left unit protects the motor against overload during operation and will trip out if the motors operate under the 15 percent over the rated load for a period of about 10-30 minutes. Tripping of this device will be indicated when the slotted spring plate is released from its bar. Resetting may be accomplished by depressing the rod which extends through one of the cover holding units. The right unit protects the motor against short circuits, or other surges current above the normal starting value. Tripping of this device will be indicated by the raising of two metal flags into a nearly upright position. Resetting may be accomplished by depressing the rod which extends through the glass cover plate nut.

(9) <u>To operate sluice gates.</u>

(a) Open "dog house" doors to each hoist unit.

(b) Turn breaker handle to "ON" position.

(c) Depress appropriate button for UP travel or DOWN travel. If the gate is fully open or closed, it will travel only in the opposite direction until it moves out of the stops. Limit of travel in either direction is controlled automatically. Indicator lights show when the gate is fully open or closed, and a mechanical indicator on the right side of each hoist shows the gate position at any point of travel.

NOTE: (For WET operation only.) Paducah Power System should be notified before operating this station as the current which the large motors draw make it necessary for them to set their own protective devices to carry a higher than normal load.

d. Pumping Plant No. 3 (Park Avenue).

(1) Read the general instructions above.

(2) This pumping plant must be energized by the Paducah Power System as there is no "hotstick" of usable length.

(3) Push the lever on the front of the control box to the "ON" position. Throw this lever up rapidly in order to make the switch snap into position. The lever should stay up.

(4) Turn the rotary switch attached to the panel circuit to either "MANUAL" or "AUTOMATIC" position, whichever desired. The controls nearest a motor are for that motor. Either fully automatic operation (leave selector switch in "AUTO" position) or manual operation (turn selector to "HAND" position) may be used as required.

(5) Each motor may be stopped by turning the selector switch to the "OFF" position. Do not stop any motor by the line interrupting switch as it is not made to interrupt such current.

e. Pumping Plant No. 4 (Clay Street).

(1) Read the general instructions above. Lighting transformers and control panel are always energized.

(2) Motors are controlled the same as for pumping plant No. 3.

(3) Before entering plant, clear noxious fumes by turning on fan from top of ladder.

f. Pumping Plant No. 5 (Harrison Street).

(1) Read the general instructions above.

(2) To close the airbreak switch on the substation tower unlock it and, when closing it, replace the pin to hold the switch in the closed position.

(3) Energize the lighting transformer by turning the switch marked "LIGHTING TRANSFORMER" on the control panel one-quarter turn clockwise. The lights in the plant may then be

controlled from the lighting panel just inside the door. The line voltage should be 396-484.

(4) To start a selected motor, turn the control knob located near the bottom of the upper cells to the "MANUAL" position. The numbers on the knobs correspond to the numbers of the motors.

(5) To stop a selected motor, turn the appropriate knob to the center, or "OFF" position. Do not stop the motor until it has reached full speed or damage may occur to the circuit breaker upon repetition.

g. Pumping Plant No. 6 (Clark Street).

(1) Read the general instructions above.

(2) To close the airbreak switch on the substation tower, unlock it and, when closing it, replace the pin to hold the switch in the closed position.

(3) A DA-50 breaker, located in the lower left panel energizes the entire panel. Close the breaker by lifting the handle up, then forcing it down until the breaker locks in. It may be tripped by pushing in the button just below the shaft.

(4) All other operations are the same as for pumping plant No. 5.

(5) The sluice gates may be energized by snapping the switch in the lower right panel to the "ON" position. The gates are operated as in pumping plant No. 2.

h. Pumping Plant No. 7 (Tennessee Street).

(1) Read the general instructions above.

(2) This pumping plant must be energized by the Paducah Power System as there is no "hotstick" of usable length.

(3) This plant is operated the same way as pumping plant Nos. 5 and 6, except that the control transformer switch is located in the left panel.

(4) Operate the sump pump as in pumping plant No. 3.

i. Pumping Plant No. 8 (Norton Street).

(1) Make sure the pole disconnects are in.

(2) Unlock the switch handle of the pole switch and turn to the "ON" position.

(3) Enter the station and turn the two switch handles on the control panels to the "ON" position. Operate as in pumping plant No. 3. This plant has humidistat controlled fan.

j. Pumping Plant No 9 (Husbands Street).
Operate in the same way as pumping plant No. 3.

k. Pumping Plant No. 10 (George Street).

(1) Operate in the same way as pumping plant No. 8. Fan same as No. 8. CAUTION: The lighting service is 220 volts - use 220V lamps - do not plug in any 110V appliances.

l. Pumping Plant No. 11 (Island Creek).

(1) Read the general instructions above.

(2) The right hand cell contains a main circuit breaker. Press the button in the lower left corner of the panel which contains the circuit breaker. The indicator should show green.

(3) Unlock the airbreak switch in the substation and pin in the closed position.

(4) Close the main breaker by raising the handle as high as it will go, then pulling down with force until it remains in the down position after the switch has closed. The indicator on this switch should show red.

(5) FOR DRY RUN ONLY have someone hold in any button marked "DRY WELL TEST."

(6) Grasp firmly the handle to the circuit breaker on the motor circuit it is desired to operate, take up the slack in the handle, then pull rapidly one-quarter turn clockwise to the locked in position. This is important as failure to follow through to the end may result in burning or fusing the contacts.

(7) While the motor is running check amperage. It should read between 175.0 to 374.0.

(8) During dry operation, the motors will stop when the dry test Bender-Warrick control button is released. In wet operation, it is not necessary to depress the test button. The motors may be stopped by either tripping the circuit breakers or by depressing the red stop button to the appropriate motor.

(9) Operation of the sluice gates is as follows:

(a) Check the switches on the hoist panels to see that they are in the "OFF" position.

(b) Close the snap switch on the main plant control panel, located in the center.

(c) Push the switch located at each hoist motor control panel to the "ON" position. One or both indicator lights will show.

(d) OPERATE ONE UNIT AT ONE TIME in either direction by depressing the switch on the hoist control panel. The unit will stop automatically when the gate is fully open or closed. If a gate stops in any intermediate position, there is an obstruction or the overload relay has tripped. Travel in either direction may be stopped at any time by depressing the stop switch on the panel of the unit. Gates can be operated manually in case of motor failure. Disconnect motor drive with clutch.

m. Pumping Plant No. 12 (S.E. of Paducah).

(1) Read the general instructions above.

(2) This pumping plant must be energized by the Paducah Power System as there is no "hotstick" of suitable length.

(3) To energize motor circuits, move the lever near the top of the motor control panel sharply upwards until the switch is in the "ON" position.

(4) To start either motor, push in and hold button on relay. The upper Bender-Warrick relay is a portion of the circuit to the right control panel. The bottom switch controls the unit nearest the switch panels.

(5) In wet operation, stop either motor by turning off the appropriate snap switch. The motor should stop within about 5 seconds.

8-36. Sluice Gate Operation. To control water to the sump, the motor-operated sluice gates in pumping plant Nos. 2, 6, and 11 must be operated. Reversing magnetic contactors and limit switches to limit travel in either direction control the gate motors. Pushbutton control switches with red and green indicating lamps are provided at each sluice gate stand for complete independent operation. The red and green lamps indicate the fully open and fully closed positions of the gate, respectively. Both lamps burn at intermediate positions of the gate. Similar red and green lights are installed on the switchboard control panel to indicate the sluice gate positions. A manually operating handwheel is provided for emergency operation. Only one gate should be in operation at any one time.

8-37. Pump Operation Precautions. The pumps should not be operated unnecessarily when the water surface in the sump is below the minimum sump elevation shown on the operation diagrams and above the bottom of the suction bowl. Exceptions may be made during periods when the pumping equipment is being tested in expectation of high water, and then only for short periods of time. The continued operation of the pumps when the impellers are submerged but with the water surface below minimum design sump elevation may result in excessive vibration and also in cavitation of the pump impellers and bowls. Unless the water surface is above minimum sump elevation, pump tests during routing inspections should be made preferably when the water surface is below the bottom of the suction bell.

8-38. Lubrication. All axial pump lower bearings and sump pump bearings are grease lubricated. Prior to placing the pumps into operation, the following precautions should be observed.

a. Thoroughly lubricate all pump bearings and check oil levels in motors.

b. Rotate the pump shaft by hand to be sure it does not bind.

c. Operate the manual control.

8-39. Electric Service. Electricity for the pumping plants is furnished by the Paducah Power System at the voltages shown in Column 29, Table 5, and is reduced to operating voltages through transformer substations. When a pump station is to be placed in operation, the power company should be notified 24 hours in advance to allow its employees to close the necessary cut-out switches for energizing the transmission line. The power company should also furnish a qualified individual to be present when each plant is energized in case of short circuit or some other electrical difficulty. The substation is energized by closing the air-break disconnect switch at the substation after the transmission line has been energized.

8-40. Automatic Stop Control. Automatic stopping of pumps at minimum pumping elevations is accomplished through the floatless switch equipment. For detailed instructions as to how to place the pumps into operation, see the "Operating Instructions" on Plates 26 through 37 in this manual. In the event that pump motors fail to stop automatically at minimum pumping elevation, they should be stopped manually either by returning the selector switch to the "OFF" position, or by rotating the circuit breaker handle in a counter-clockwise direction until it "trips."

8-41. Protection Devices. Pump motors are protected against undervoltage overload and short circuit. Protection is obtained

by undervoltage release and dual thermal-magnetic overcurrent tripping device built into the breakers. The undervoltage release and the dual thermal-magnetic tripping device are automatically reset. Should a breaker trip, determine and correct the cause then restart the pump motor by rotating the circuit breaker handle rapidly and smoothly one-quarter turn in a clockwise direction until it locks into place.

8-42. Air Relief Valves. Pumping operations should not be interrupted when the valves are not operating correctly and the cover plates have been removed. This condition, however, should be corrected at an early opportunity.

8-43. Closing Down Pumping Plants.

a. When the floodwaters have finally receded and it has been decided to close down the pumping plant, turn all switches to the "OFF" positions and notify the power company to deenergize the substations. The pumping plants and sumps should be thoroughly cleaned and the equipment completely inspected, oiled, and greased. After each flood period and at periodic inspections, all parts of the pumps should be checked. The pump bowls should be inspected for cracks, pitting, or other damage. The impellers should be examined for possible damage, pitting, or looseness on the shaft, etc. The bearings and grease lines should receive close examination for possible damage by floating debris, vibration, or excessive strain.

b. A log of pumping plant operation, a sample of which is included as Appendix E, should be furnished the District Engineer following each flood. It is advisable that a log of operations be also submitted for all trial operations of each pumping plant in order to be certain that all inspections and operations are carried out and that a complete record of the operations is available for future reference.

8-44. Nameplate Data. Motor, pump, switchgear, and substation nameplate data are shown on Table 5.

8-45. Safety Equipment and Precautions. Safety equipment such as guardrails, precautionary signs, fire extinguishers, etc., have been incorporated into the plants. Principal safety precautions are:

a. A guardrail has been provided around the trashraking platform. It should be inspected periodically for corrosion and anchor bolt security.

b. A permanent galvanized steel ladder provided in the sump with a grab bar in the wall above. It should be inspected periodically for corrosion and anchor bolt security. If there is any doubt about ladder or anchorage conditions, a portable ladder should be used until repairs can be made.

c. The hinged ladder access hatch through the raking platform should be kept closed when the plant is operating. Hinges should be inspected and greased periodically. During maintenance work or inspection when the sump must be entered, horses or other protective warning devices should be placed around opening.

d. Fused disconnect switches on the substation primary and an unfused disconnect switch inside the pump plant structure on the substation secondary are provided to isolate the pump plant electrical system. Safe operation requires the following:

(1) A power company representative should be present each time substation is energized (fused disconnect closed). Before energizing substation primary, be sure that unfused disconnect on substation secondary is open. It is desirable that company representative remains until secondary disconnect is closed and it is ascertained that all electrical circuits are in operating condition.

(2) Be sure that all motor starter switches are in "OFF" position before closing the unfused disconnect switch and never open it when pumps are running. It is not constructed to handle opening or closing under load.

(3) Use fuse pullers when replacing fuses.

e. Secondary circuits of ammeter current transformers should be complete at all times to prevent induction of excessively high voltage in these circuits. Before removing meter or meter switches for servicing, be sure to short-circuit the transformer secondary.

f. Paint, grease, and oil should be kept in closed containers. Oily rags should be removed from the plant. Plant should be swept out and aired daily while in operation.

g. Dangerous Gases and/or Oxygen Deficiencies. Manholes, sumps, and other confined areas with no positive ventilation shall be recognized as potentially dangerous due to possible presence of gases and/or oxygen deficiencies. Prior to entry into confined or inclosed spaces such as manholes, sumps, etc., a positive procedure to eliminate or control the hazards shall be established.

(1) Hazards considered shall include toxic material and vapors, flammable materials and vapors, asphyxiating, corrosive, or radioactive material, and lack of oxygen.

(2) Inclosed spaces shall be tested for contaminants and periodic check tests shall be made to assure an acceptable atmospheric condition.

(3) Adequate mechanical exhaust ventilation shall be provided.

(4) Protective clothing and respiratory protection shall not be used as a substitute for cleaning and ventilating or spaces.

(5) No one shall enter an inclosed space containing a flammable atmosphere or one which, because of oxygen deficiency or contamination, may be immediately harmful to life in case of failure of the respiratory equipment.

(6) Persons working in confined or inclosed spaces shall have a safety harness and lifeline with an attendant if the atmosphere has oxygen deficiency or contamination sufficient to require respiratory protection. The attendant shall be assigned no other duties. A signal system shall be established.

h. Warning and Safety Signs. See that adequate warning and safety signs are properly placed near energized or other hazardous equipment and that the signs are maintained in good condition.

i. Carbon Dioxide Fire Extinguisher. A carbon dioxide type fire extinguisher has been provided for use on electrical and oil type fires which might occur in the plant. Due to a large amount of electrical service shall be disconnected (either to the affected equipment for a small fire or at the substation for larger fires) before using fire extinguisher.

MAINTENANCE SCHEDULE

	INSPECTION FREQUENCY
a. Visual inspection for proper location and condition. Check seals.	Monthly (Operational)
b. Weigh units and recharge any unit weighing less than 90 percent of normal weight.	Semiannually

c.	Fire extinguishers shall be returned to the manufacturer or to an approved fire equipment company for hydrostatic cylinder test.	5 Years
	Fire extinguishers shall be inspected and maintained as required by EM 385-1-1 and by the National Fire Protection Association	

TABLE 5

MOTOR - PUMP - SWITCHGEAR AND SUBSTATION DATA

PUMPING PLANTS			MOTORS																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
NO.	LOCATION	UNIT	MAKE	HP	RPM	VOLTS	PHASE	CYCLE	AMPS PER TERM	TYPE	STYLE	FRAME	INSTR. BOOK	SERIAL NO.	MAKE	SIZE (INS.)	CAPACITY (GPM)	HEAD (FT.)	TYPE	SERIAL NO.
1	Noble Park	1	Fairbanks Morse	150	703	440	3	60	191.5	QZKV	-	ZG3086PV	-	599368	FM	30	22,000	20.5	-	PR6704
		2	Fairbanks Morse	150	703	440	3	60	191.5	QZKV	-	ZG3086PV	-	599370	FM	30	22,000	20.5	-	PR6705
		3	Fairbanks Morse	150	703	440	3	60	191.5	QZKV	-	ZG3086PV	-	599369	FM	30	22,000	20.5	-	PR6076
2	Sixth Street	1	Westinghouse	20	880	220	3	60	53	CS	8G1169	405	-	18G1169		8	1500	26.7	SSV	E-4892
		Oiler 1	Master Elec. Co.	1/4	1725/280	230/115	1	60	4.4/2.2	RA	ND109	5820-SP	-	SG13167						
		2	Westinghouse	200	706	2200	3	60	51.9	CS	28P765	10-32-10	7099	1S28P765		26 x 30	18500	26.7	SAFV	E-4794
		Oiler 2	Master Elec. Co.	1/4	1725/280	230/115	1	60	4.4/2.2	RA	13A181	5820-SP	-	UA5613						
		3	Westinghouse	800	355	2200	3	60	196.2	CS	28P761	20-62 1/2-18	7099	2S28P761		54 x 60	90000	26.7	SAFV	E-4782
		Oiler 3	Master Elec. Co.	1/4	1725/280	230/115	1	60	4.4/2.2	RA	13A181	5820-SP	-	UA5611						
		4	Westinghouse	800	355	2200	3	60	196.2	CS	28P761	20-62 1/2-18	7099	1S28P761		54 x 60	90000	26.7	SAFV	E-4783
		Oiler 4	Master Elec. Co.	1/4	1725/280	230/115	1	60	4.4/2.2	RA	13A181	5820-SP	-	UA5618						
		5	Westinghouse	500	443	2200	3	60	124.4	CS	28P762	16-51-18	7099	1S28P762		42 x 48	50000	26.7	SAFV	E-4784
		Oiler 5	Master Elec. Co.	1/4	1725/280	230/115	1	60	4.4/2.2	RA	13A181	5820-SP	-	UA5607						
		6	Westinghouse	500	443	2200	3	60	124.4	CS	28P762	16-51-18	7099	2S28P762		42 x 48	50000	26.7	SAFV	E-4785
		Oiler 6	Master Elec Co.	1/4	1725/280	230/115	1	60	4.4/2.2	RA	13A181	5820-SP	-	UA5608						
3	Park Avenue	1	Westinghouse	5	870	220	3	60	14.2	CS	8G1172	324	-	18G1172		6	600	18.7	SSV	E-4895
		Oiler 1	Master Elec. Co.	1/4	1725/280	230/115	1	60	4.4/2.2	RA	13A181	5820-SP	-	5609						
		2	Westinghouse	25	880	220	3	60	68	CS	8G1168	444	-	18G1168		16 x 18	4400	13.8	SAFV	E-4803
		Oiler 2	Master Elec. Co.	1/4	1725/280	230/115	1	60	4.4/2.2	RA	13A181	5820-SP	-	5610						
		3	Westinghouse	25	880	220	3	60	65	CS	8G1168	444	-	2BG1168		16 x 18	4400	13.8	SAFV	E-4804
		Oiler 3	Master Elec. Co.	1/4	1725/280	230/115	1	60	4.4/2.2	RA	13A181	5820-SP	-	5612						
4	Clay Street	1	Westinghouse	50	885	440	3	60	75	CS	8G6001	505	-	1S8G6001		10 x 12	4500	19.6	SSV	E-4886
		2	Westinghouse	50	885	440	3	60	75	CS	8G6001	505	-	2S8G6001		10 x 12	4500	19.6	SSV	E-4887
5	Harrison Street	1	Westinghouse	200	694	440	3	60	240	CS	28P766	10-32A-10	7099	2S28P766		26 x 36	20000	21.4	SAFV	E-4793
		Oiler 1	Master Elec. Co.	1/4	1725/280	440/220	1	60	2.3/1.15	RA	14A616	5820-SP	-	UA10746						
		2	Westinghouse	200	694	440	3	60	240	CS	28P766	10-32A-10	7099	1S28P766		26 x 36	20000	21.4	SAFV	E-4792
		Oiler 2	Master Elec. Co.	1/4	1725/280	440/220	1	60	2.3/1.15	RA	14A616	5820-SP	-	UA10758						
		3	Westinghouse	100	870	440	3	60	116	CS	8G1163	780	7099	1S8G1163		18 x 24	9500	21.4	SAFV	E-4801
		Oiler 3	Master Elec. Co.	1/4	1725/280	440/220	1	60	2.3/1.15	RA	14A616	5820-SP	-	UA10750						
		4	Westinghouse	25	710	440	3	60	34	CS	8G1167	445	7099	1S8G1167		8	2200	21.4	SSV	E-4891
		Oiler 4	Master Elec. Co.	1/4	1725/280	440/220	1	60	2.3/1.15	RA	14A616	5820-SP	-	UA10763						

SWITCHGEAR					SUBSTATION AND LIGHTING TRANSFORMERS								
22	23	24	25	26	27	28	29	30	31	32	33	34	35
MAKE	TYPE & SIZE	VOLTS	BREAKER AMPS	SERIAL NO.	MAKE	KVA	HIGH VOLTS	LOW VOLTS	TYPE	STYLE	SERIAL NO.	SERIAL NO.	SERIAL NO.
Westinghouse	DB25	600	225	22Y3526B2	Stand. Tranf. Co.	167	12,500	240/480	A	-	116060	-	-
Westinghouse	DB25	600	225	22Y3526B2	Stand. Tranf. Co.	167	12,500	240/480	A	-	116061	-	-
Westinghouse	DB25	600	225	22Y3526B2	Stand. Tranf. Co.	167	12,500	240/480	A	-	116062	-	-
Westinghouse	3DK-AB1	600	100	1032804A	Westinghouse	833	12,500	2400	SL	L. Spacs. 401612	3141295	3141293	3141294
Westinghouse	F124A-OCB	15000	75	30285Y587									
Westinghouse	F124A-OCB	15000	300	30385Y587	Westinghouse	10	2400	240/120	S	119121AA	3139030	3139035	3139028
Westinghouse	F124A-OCB	15000	300	30585Y587									
Westinghouse	F124A-OCB	15000	150	30685Y587	Westinghouse	7-1/2	2400	240/120	S	1118285A	3131386	(Lighting transformer located in switchgear)	
Westinghouse	F124A-OCB	15000	150	30885Y587									
Westinghouse	DE10W Size 1	600	35	958172C	Westinghouse	25	12,500	440/220	S	-	3105348	3108910	3105349
Westinghouse	DE10W 11206T3	600	100	1032804A									
Westinghouse	DE10W 11206T3	600	100	1032805A									
General Electric	CR-7008C3J	600	100	GEN-975A	General Electric	37-1/2	12,500	480/240	HS	Form W-2	7503807	7503796	7503797
General Electric	CR-7008C3J	600	100	GEN-975A									
Westinghouse	DK-25E	600	300	1306Y7562	Westinghouse	180	12,500	480/240	S	1118496A	3080257	3080255	30100555
Westinghouse	DK-25E	600	300	2306Y7562									
Westinghouse	DK-15E	600	175	1306Y7550	Westinghouse	5	460/230	230/115	JR	911417A	3236732	(Lighting transformer located in switchgear)	
Westinghouse (FOR LIGHTING ONLY)	DK-15E	600	50	13085Y591									
	DK-15	600	70	23085Y582									

TABLE 5 (Continued)
MOTOR - PUMP - SWITCHGEAR AND SUBSTATION DATA

PUMPING PLANTS			MOTORS													PUMPS					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
NO.	LOCATION	UNIT	MAKE	HP	RPM	VOLTS	PHASE	CYCLE	AMPS PER TERM	TYPE	STYLE	FRAME	INSTR. DOCK	SERIAL NO.	MAKE	SIZE (INS.)	CAPACITY (GPM)	HEAD (FT.)	TYPE	SERIAL NO.
6	Clark Street	1	Westinghouse	250	501	440	3	60	323	CS	28P764	14-34C-141	7099	2S28P764		30 x 42	31100	22.1	SAFV	E-4790
		Oiler 1	Master Elec. Co.	1/4	1725/280	440/220	1	60	2.3/1.15	RA	141416	5820-SP	-	UA10751						
		2	Westinghouse	125	700	440	3	60	151	CS	8G1161	876-C	7099	2S8G1161		26 x 36	15600	22.1	SAFV	E-4797
		Oiler 2	Master Elec. Co.	1/4	1725 280	440/220	1	60	2.3/1.15	RA	141616	5820-SP	-	UA 10754						
		3	Westinghouse	250	501	440	3	60	323	CS	28P764	14-34C-14	7099	1S28P764		30 x 42	31100	22.1	SAFV	E-4791
		Oiler 3	Master Elec. Co.	1/4	1725/280	440/220	1	60	2.3/1.15	RA	141616	5820-SP	-	UA10760						
		4	Westinghouse	250	501	440	3	60	323	CS	28P764	14-34C-14	7099	3S28P764		30 x 42	31100	22.1	SAFV	E-4789
		Oiler 4	Master Elec. Co.	1/4	1725/280	440/220	1	60	2.3/1.15	RA	141616	5820-SP	-	UA10761						
		5	Westinghouse	10	875	440	3	60	14.4	CS	8G1170	365	7099	18G1170		6	1000	22.1	SSV	E-4894
		Oiler 5	Master Elec. Co.	1/4	1725/280	440 220	1	60	2.3/1.15	RA	141616	5820-SP	-	UA10747						
7	Tennessee Street	1	Westinghouse	1[illegible]	700	440	3	60	151	CS	8G1161	876-C	-	1S8G1161		26 x 30	15000	19.6	SAFV	E-4793
		Oiler 1	Master Elec Co	1/4	1725/280	440 220	1	60	2.3/1.15	RA	141616	5820-SP	-	UA10755						
		2	Westinghouse	50	1170	440	3	60	70	CS	8G1165	445	-	18G1165		16 x 21	7000	19.6	SAFV	E-4802
		Oiler 2	Master Elec. Co	1/4	1725/280	440/220	1	60	2.3/1.15	RA	141616	5820-SP	-	UA10766						
		3	Westinghouse	10	705	440	3	60	17.4	CS	8G6002	404	-	18G6002		8 x 10	1300	19.6	SSV	E-4893
		Oiler 3	Master Elec. Co.	1/4	1725/280	440/220	1	60	2.3/1.15	RA	141616	5820-SP	-	UA10745						
8	Near Norton St.	1	Westinghouse	2	1150	440/220	3	60	6.8/3.4	CS	8G6004	225	-	28G6004		3	300	7.6	SSV	E-4898
		2	Westinghouse	2	1150	440/220	3	60	6.8/3.4	CS	8G6004	225	-	38G6004		3	300	7.6	SSV	E-4899
9	Near Husbands St.	1	Westinghouse	40-46	670	440	3	60	47.3	CS	8G1166	504	-	2S8G1166		10	3900	21.5	SSV	E-4869
		Oiler 1	Master Elec. Co.	1/4	1725/280	440 220	1	60	2.3/1.15	RA	141616	5820-SP	-	2A10784						
		2	Westinghouse	40-46	870	440	3	60	47.8	CS	8G1166	504	-	1S8G1166		10	3900	21.5	SSV	E-4800
		Oiler 2	Master Elec. Co.	1/4	1725/280	440/220	1	60	2.3/1.15	RA	141616	5820-SP	-	2A10784						
10	Near George St.	1	Westinghouse	10	875	220	3	60	28.8	CS	8G6003	365	-	18G6003		6 x 8	1200	11.7	SSV	E-4897
		2	Westinghouse	10	875	220	3	60	28.8	CS	8G6003	365	-	28G6003		6 x 8	1200	11.7	SSV	E-4896
11	Island Creek	1	Westinghouse	300	584	440	3	60	374	CS	28P763	12-34C-14	7099	3S28P763		30 x 42	3300	28	SAFV	E-4787
		Oiler 1	Master Elec. Co.	1/4	1725/280	440/220	1	60	2.3/1.15	RA	141616	5820-SP	-	U10752						
		2	Westinghouse	300	584	440	3	60	374	CS	28P763	12-34C-14	7099	2S28P763		30 x 42	3300	28	SAFV	E-4787
	Grease Unit	Oiler 2	Master Elec. Co.	1/4	1725/280	440/220	1	60	2.3/1.15	RA	141616	5820-SP	-	U10759						
		3	Westinghouse	300	584	440	3	60	374	CS	28P763	12-34C-14	7099	1S28P763		30 x 42	3300	28	SAFV	E-4785
		Oiler 3	Master Elec. Co.	1/4	1725 280	440 220	1	60	2.3/1.15	RA	141616	5820-SP	-	U10753						
		Gate 1	Elec. Spec. Co.	6	1800	220	3	60	15	BL-4	-	-	-	62434						
		Gate 2	Elec. Spec. Co.	6	1800	220	3	60	15	BL-4	-	-	-	62435						
		Gate 3	Elec. Spec. Co.	6	1800	220	3	60	15	BL-4	-	-	-	62437						
		Gate 4	Elec. Spec. Co.	6	1800	220	3	60	15	BL-4	-	-	-	62434						
12	S.E. of Paducah	1	Westinghouse	50	885	440	3	60	75	CS	8G1164	505	-	2S8G1164		10 x 24	9700	14	AFV	E-4800
		Oiler 1	Master Elec. Co.	1/4	1725/280	440 220	1	60	2.3/1.15	RA	141616	5820-SP	-	U10762						
		2	Westinghouse	50	885	440	3	60	75	CS	8G1164	505	-	1S8G1164		18 x 24	9700	14	AFV	E-4799
		Oiler 2	Master Elec. CO.	1/4	1725/280	440/220	1	60	2.3/1.15	RA	141616	5820-SP	-	U10749						

SWITCHGEAR				SUBSTATION AND LIGHTING TRANSFORMERS									
22	23	24	25	26	27	28	29	30	31	32	33	34	35
MAKE	TYPE & SIZE	VOLTS	BREAKER AMPS	SERIAL NO.	MAKE	KVA	HIGH VOLTS	LOW VOLTS	TYPE	STYLE	SERIAL NO.	SERIAL NO.	SERIAL NO.
Westinghouse	DK-25E	600	400	3308SY594	Westinghouse	333	12,500	480	SL	L. Specs. 401856	3141290	3141291	3141292
Westinghouse	DK-25E	600	225	1308SY595									
Westinghouse	DK-25E	600	400	1304Y5501									
Westinghouse	DK-25E	600	400	1308SY594	Westinghouse	5	460/230	230/115	JR	911417A	3236735	(Lighting transformer located in switchgear)	
Westinghouse (FOR LIGHTING ONLY)	DK-25E	600	25	1308SY596									
Westinghouse (MAIN BREAKER)	DK-25	600	70	1308SY593									
Westinghouse	DA-50	600	1200	689692									
Westinghouse	DE10K	600	35	1222055A									
Westinghouse	DK-15E	600	200	1306Y7551	Westinghouse	75	12,500	480/240	S	-	3010281	3010284	3010280
Westinghouse	DK-15E	600	90	1308SY599									
Westinghouse	2DK DE10K	600	35	54097A	Westinghouse	5	460/230	230/115	JR	911417A	3236736	(Lighting transformer located in switchgear)	
	AB DE10K	600	70	-									
Square D	KRD-4B-50HP	220	30 Amp Fuses										
Square D	KRD-4B-50HP	220	30 Amp Fuses										
General Electric	CR-7008C3J-50HP	600	100	-	General Electric	37-1/2	12,500	480/240	HS	Form W-2	7503798	7503806	7503804
General Electric	CR-7008C3J-50HP	600	100	-	General Electric	2	460/230	230/115	-		PC	(Lighting transformer located in switchgear)	
	KTD-B-15HP	250	100 Amp Fuses	-	General Electric	7-1/2	12,500	480/240	HS	Form W-2F	7474689	7474687	6967040
Square D	KTD-B-15HP	250	100 Amp Fuses	-									
Square D	DK-25M	600	550	1306Y4585	General Electric	333	12,500	480/240	HS	Form W-40	7529031	7529030	7529029
Westinghouse													
Westinghouse	DK-25M	600	550	1306Y4585	Westinghouse	5	460/230	230/120	AIR	1304344A	3787743	3787745	(Transformer bank located in switchgear)
Westinghouse	DK-25M	600	550	3306Y4585									
Westinghouse (INCOMING LINE)	DA-50	600	1600	6Y4583	Westinghouse	5	480/240	240/120	AIR	1308SK5A	3815448	(Transformer located in switchgear)	
Westinghouse (TRANSFER BANK)	DK-25	600	70	1306Y458A									
Westinghouse	3DK DE10K	600	80		Westinghouse	37-1/2	12,500	480/240	S	910148D	3148929	3148928	3148930
Westinghouse	3DK DE10K	600	80		Westinghouse	2	460/230	230/115	JR	911415A	3219285	(Lighting transformer)	
Westinghouse													

SECTION IX

MISCELLANEOUS FACILITIES

9-01. General. Diversion channels and ponding areas utilized for storage of large runoff quantities are included under miscellaneous facilities.

a. Diversion channels have been provided for the purpose of channeling runoff towards drainage areas and removal facilities provided for those purposes.

b. Ponding areas utilized for storage of large runoff quantities are available in the vicinities of pumping plant Nos. 1, 11, and 12. The 32-acre low area within Noble Park will store runoff for pumping plant No. 1 to elevation 336.0; the 1,000-acre low areas in the Island Creek gullies will store peak runoff during periods of high river stages to elevation 330.0; the 32-acre low area in the vicinity of pumping plant No. 12 will store runoff to elevation 339.0. Storage elevations are those at which no appreciable damage will occur.

9-02. Maintenance. The regulations state the following pertinent requirements for maintenance of channel improvements and ponding areas:

"Periodic inspections of improved channels and floodways shall be made by the Superintendent to be certain that:

"(i) The channel or floodway is clear of debris, weeds and wild growth;

"(ii) The channel or floodway is not being restricted by the depositing of waste materials, building of unauthorized structures or other encroachments;

"(iii) The capacity of the channel or floodway is not being reduced by the formation of shoals;

"(iv) Banks are not being damaged by rain or wave wash, and that no sloughing of banks has occurred;

"(v) Riprap sections - - - are in good condition;

"(vi) Approach and egress channels adjacent to the improved channel or floodway are sufficiently clear of obstructions and debris to permit proper functioning of the project works.

"Such inspections shall be made prior to the beginning of the flood season and otherwise at intervals not to exceed 90 days. Immediate steps will be taken to remedy any adverse

conditions disclosed by such inspections. Measures will be taken by the Superintendent to promote the growth of grass on bank slopes. The Superintendent shall provide for periodic repair and cleaning of debris basins, - - -, and related structures as may be necessary.

"Areas used for ponding in connection with pumping plants or for temporary storage of interior runoff during flood periods shall not be allowed to become filled with silt, debris, or dumped material."

9-03. Operation. The regulations provide that:

"Both banks of the channel shall be patrolled during periods of high water, and measures shall be taken to protect those reaches being attacked by the current or by wave wash. Appropriate measures shall be taken to prevent the formation of jams of ice or debris. Large objects which become lodged against the bank shall be removed. The improved channel or floodway shall be thoroughly inspected immediately following each major high water period. As soon as practicable thereafter, all snags and other debris shall be removed and all damage to banks, riprap, - - - and walls, drainage outlets, or other flood control structures repaired."

"Miscellaneous facilities shall be operated to prevent or reduce flooding during periods of high water. Those facilities constructed (or utilized) as a part of the protective works shall not be used for purposes other than flood protection without approval of the District Engineer unless designed therefor."

SECTION X

SPECIAL MAINTENANCE AND OPERATIONS DURING HIGH WATER PERIODS

10-01. General. This section of the manual is supplementary in nature and describes standard practices that have been used to advantage on levees during high water emergencies. Most of the methods described herein have been developed during years of experience with the various problems that arise during periods of high water, but they are not intended to restrict the Superintendent, or others concerned, to a rigid set of rules for every possible circumstance. If problems not covered by these suggestions arise and there is doubt as to the proper procedure, the Superintendent should consult the District Engineer, Corps of Engineers, Louisville District, Louisville, Kentucky, and should follow standard engineering practices in meeting emergency situations. It should be noted that it is much better to be overprepared for high water than to find at the last moment that preparations were incomplete or otherwise unsatisfactory. Confidence of the protected population and industry is a valuable asset that should not be impaired through inefficient operation of the protection system in time of emergency.

10-02. Levee System. The levee system may be subjected to certain dangers during flood periods from current or wave action. These dangers diminish with the degree of maintenance that the levee system receives during normal river stages. Properly constructed levees, if adequately maintained, should withstand any major flood. However, certain unexpected conditions that arise during floods and threaten the levee system may be met with assurance if prompt action is taken and proper methods of treatment are used. Measures to cope with sand boils, seepage, sloughs, wave wash, scour, and possible overtopping of neglected low spots in the levee are described herein. It cannot be stressed too strongly that prompt and adequate maintenance will result in minimizing the necessity for such measures during high water periods.

10-03. Preparedness. It will be noted in the following paragraphs that various materials and equipment are required to combat such unforeseen conditions as may arise during a flood emergency. It is imperative to know in advance just where such materials and equipment as described herein may be secured in emergencies, even though such emergencies may never arise. A definite plan should be prepared by the Superintendent that will enable him to foresee just what materials he will need, where they may be obtained in time for use, what manpower and transportation will be needed, what routes will be open at particular river stages, etc. This information will be particularly vital as the possibility of levee overtopping is approached. Such a plan, once formed, must be checked prior to each flood season since the sources of material supply may change from time to time. The essential element in a flood emergency is time; therefore, local interests should give early attention to the preparation of a list of sources from which the necessary labor,

lumber, hardware, cotton bagging, sacks, suitable earth for sacking, equipment, etc., can readily be secured to cover any contingency. Such items should be provided as rapidly as is possible when the need arises.

10-04. Materials. For all practical purposes, the materials of consequence used during flood emergencies are sandbags, lumber, sacked or loose earth, wire, and nails. A reserve supply of emergency materials should be kept on hand or be immediately available through arrangements with local suppliers or manufacturers. The principal consideration in obtaining lumber and other materials for emergency construction is their availability. Stored materials subject to damage or deterioration should be checked, and damaged portions replaced before the start of each high water season.

10-05. Lumber. When available, rough common pine lumber is a suitable structural material for use in high water construction. Ordinarily, rough lumber is less expensive than dressed lumber.

10-06. Sacked Earth or Loose Earth. The most suitable type of earth to be used for flood emergency construction is a silty loam or a silty clay loam. Sacks filled with earth can be used in almost every phase of emergency high water work. Loose dry earth confined by boards, as in a box levee, may be more economically placed, and is more impervious when compacted, than is sacked earth. It may best be used when the point of placement is readily accessible by truck. It is advisable to use sacked earth under other conditions. Sacks should be filled about two-thirds full, with the material shaken down into the sack loosely (never tamped). Sacks need not be tied or sewn together at the top if used for capping or on the landside of the levee. Earth-filled sacks used for wave wash, or as weights, should be filled and the ends tied. Sand should be used only if earth is not available, or if the time element is an important factor as in the distance required for hauling. In some cases, it may be better to fill sacks elsewhere and haul them to the site.

10-07. Sandbags. The term "sandbags" as used in flood emergency construction might be considered as misnomer in that the bags are ordinarily filled with silty loam or a silty clay loam. Sand is used only when they are used as weights or when earth availability is a problem. Sacks used for sandbags are mildew-treated burlap. Sandbags should contain approximately one-third cubic foot of earth. Any type and suitable size of sack can be used if burlap is not available. An adequate initial supply of sandbags should be maintained to make all necessary sandbag closures. Bags must be checked annually to detect any deterioration. They should be stored in a dry location where there is free passage of air around them to prevent spontaneous combustion. Any bags that are damp, wet, or oily should not be returned to storage with the main supply as they create a fire hazard.

10-08. Wire. Number 9 wire is generally used where this item is required.

10.09. Preliminary Preparations When High Water is Imminent. The Local Flood Control Authority should have a trained skeleton organization of Sector Foremen who may readily be assembled by the Superintendent immediately upon receipt of information that high water is imminent. Each foreman should have charge of a definite section of levee or structures that may be endangered, the operation of which is essential during high water. This organization should be capable of quick expansion so that each foreman will have sufficient personnel to carry out his function. As his initial activity, each Sector Foreman should go over his entire sector, and part of adjacent sectors, making a detailed inspection, particularly with reference to the following matters:

a. Sector limits· ascertain that the dividing line between sectors is plainly determined and, if necessary, marked.

b. Condition of levees and recent repairs.

c. Condition of drainage structures.

d. Transportation facilities; roads, rail, and water communication.

e. Material supply quantity, location, and condition.

f. Communications; locate and inspect all available telephones in the sector that may be needed.

10-10. Initial Work. After initial inspection, the Sector Foreman should perform the following work immediately where required. To accomplish such work, he should have recruited a labor gang and obtained such supplies and equipment as may be necessary.

a. Where new levee construction has been performed on the riverside of levee, preparations should be made in advance to combat wave wash by facing with sandbags.

b. Inspect all drainage gates before the seats are submerged to ascertain that they are clear of obstructions and will seat properly.

c. Ascertain that all roads to and along the levee are in good condition. The Superintendent should obtain the assistance of the local road forces to put all necessary roads in usable condition. The Superintendent should be informed at all times of all roads in the vicinity that are closed for repairs. An up-to-date route layout should be available at all times showing routes over which any and all types of equipment can be sent to any point in the protection system.

d. Locate necessary tools and materials (cotton bagging, sandbags, lumber, lights, etc.) and distribute and store them at points where active maintenance is anticipated.

e. Check and obtain repair of all telephone lines necessary for operation; obtain lists of all team forces, motorboats, motorcars, and truck transportation that can be made available.

f. Make thorough arrangements with reliable citizens of the community for supply, transportation, subsistance, and shelter for the necessary labor.

g. Investigate all drainage ditches on the landside of the levee and open these drains when obstructions exist.

h. Remove all dynamite and explosives of any kind from the vicinity of the levee.

10-11. Method of Treatment. After the above preliminary organizations and precautions have been completed, the various methods of combating possible flood emergencies are ready to be employed. Temporary treatments of emergency situations are described in the following paragraphs.

10-12. Seepage. Seepage emerging from the slope or at the landside toe of the embankment can cause sloughing of the slope or even lead to piping (internal erosion) of fine sand or silt material. In many cases, high water stages do not act against the levee long enough for this to happen, but the possibility of the combination of high water and a period of heavy precipitation may bring this about. In order to prevent sloughing where the slope is deeply saturated, small V-shaped drains should be cut in the landside slope to remove the seepage water. If the levee should become saturated over a relatively large area, it may become necessary to take the measures outlined in paragraph 10-14 to prevent sloughing.

10-13. Drainage of the slopes should be provided at all places on the landside of the levee and berm where seepage appears. The drains should be V-shaped, no deeper than necessary, and never more than 6 inches deep. Care must be taken not to cut the sod unnecessarily. In all instances, drains should be cut straight down the levee slope, or nearly so. Where possible, near the toe of the slope, the small drains should be Y'd together and lead into large drains which lead to ponding areas or pumping plants.

10-14. Sloughing. Sloughing is the slipping or flowing out of position, of the landside slope of the levee due to its being saturated through seepage to the point where that part of the levee becomes unstable. Reaches in the levee, where the material is of such nature

that prolonged high water may cause sloughing, should be thoroughly drained as described in 10-13. After this operation, a single layer of willow brush, if obtainable, or any small trees or limbs should be laid up and down the slopes, butts upward, and weighed with earth-filled sacks. Wood strips may be used if willows, small trees, or limbs are not available. If the slope begins to slough down, a log or heavy timber should be laid on top of the willows at the toe of the material sloughed off and fastened to long stakes which have been driven several feet into the ground. A buttress of earth-filled sacks should then be built at the toe and extended up the slope The buttress at the toe should be built in the shape of a small berm. Sandbags or weights should not be placed more than two-thirds of the distance from the toe of the material sloughed off to the bottom of the slough. (See Plate 2.)

10-15. Sand Boils. A sand boil is a definite stream of seepage water issuing from the earth, usually near the landside toe of the levee. The source of this water is usually from pervious materials underlying the levee. Sand boils are serious in any location and should be watched closely, especially if they are within 100 feet of the levee toe. A sand boil which discharges clear water in a small steady flow ordinarily is not a serious threat to the safety of the levee and need not be treated. However, if the flow increases or carried a substantial load of sand and silt, corrective action should be taken immediately to prevent levee failure. A neglected sand boil may gradually undermine a levee and cause failure by a caving-in of a portion of the levee.

10-16. Sacked Earth Ring. The accepted method of treating a sand boil is to construct a watertight ring of sacked earth around the boil, high enough to create a head of water within the ring sufficient to reduce the velocity of flow so that no more material is displaced and the water runs clear. (See Plate 3.) The ring should not be built to a height which stops the flow of water completely. A head thus created will cause additional failures and boils nearby.

10-17. Method of Laying Sandbags. The sacks are filled about two-thirds full of earth and are laid flat around the boil in a ring with the joints staggered, each layer being placed in alternate directions. The sacks should be lapped at least one-third. The ends are left untied, and are lapped under the sacks. Each complete layer should be tramped or tamped into place after laying.

10-18. The base width of the ring should be not less than one and one-half times, and preferably twice, the contemplated height. A drain is provided by omitting one bag in the top layer, or by constructing a V-shaped drain of two boards or a piece of sheet metal inserted near the top of the ring.

10-19. If soil weakness is indicated close to the sand boil, it is well to include the unstable area within the ring, thereby avoiding the possibility of a breakthrough later.

10-20. Sand boils at the toe of the levee are sacked in the same manner as those away from the levee, using the levee slope as one side of the inclosure.

10-21 Several sand boils within a relatively small radius should be inclosed as a group in a sublevee or single sack ring.

10-22. Wave Wash. Wave wash, the erosion of the side slope of a levee by wave action, may damage a levee and seriously threaten its stability if the water surface is near the levee crown. Wave action will not usually damage a well-sodded slope. Sections of levee that are more likely to be damaged by wave wash should be determined in advance, and a reserve supply of cotton bagging, filled and tied sacks, lumber, and other materials kept on hand. The necessity for wave wash protection cannot be foreseen in some cases, and its prevention or stabilization is often an emergency operation. The Superintendent or Sector Foreman can usually predict, from experience, the localities where wave wash is liable to occur. During periods of high wind, high water, and ice flow when damage to the levee is more likely to occur, ample personnel should stand by. Experienced watchmen should observe, and if need be, determine by sounding where the washouts are beginning.

10-23. Sandbags and Cotton Bagging or Plastic Sheeting. Sections of cotton bagging or plastic sheeting should be placed over the washed areas as shown on Plate 4. If the washed area is considerable, or protection is desired to a predicted higher stage, the bagging may be cut into lengths and laid up and down the slope to cover the area. The strips should be lapped with the current to prevent lifting. (See Plate 5.) Bagging so laid must be thoroughly weighed down with stone or sandbags to be effective. In using this method, stakes should be driven through the bagging approximately 6 feet apart below the water surface and at the top of protection to be sure that the bagging is being held in place while the sacks are placed thereon. As an alternative, sacked earth material may be used as a means of minor wave wash protection, or to fill small washed areas or holes. The sacks should be placed close together beginning about 2 feet under the water surface. Each succeeding row of sacks should overlap the preceding row like shingles on a roof. The joints should be staggered. All holes should be filled with sufficient sacked earth to meet the original grade line. All sacks should be tamped into place so that wave action will not readily wash them away.

10-24. Log Boom. If sacking for the prevention of washes caused by waves and ice cannot be placed or used effectively, it is desirable to make a boom of logs or any available large timbers. The logs should be fastened together with steel staples and coil chain, or heavy wire, with

a distance of about 12 inches between end faces. The staples at each end of the log should be driven on a line parallel to the axis of the log, and should be allowed to protrude sufficiently to permit enough play for rotation of the logs. Wire or chain should be passed or wrapped around the logs as staples may pull out. The boom should be strung along the levee slope and anchored about 15 feet out from the water's edge by means of logs or timbers, spaced not more than 50 feet apart, tied to stakes near the shoreline. (See Plate 6.) The booms should also be anchored to the slope approximately every 200 feet, or as conditions may require, with cables placed at angles of about 45 degrees. Additional stakes can be driven up the levee slope in anticipation of a rising river, and the anchor logs and cable ties adjusted as required. This method of protection is particularly effective against ice flows.

10-25. Movable Panels. Wave wash may also be effectively controlled by the use of movable panels, constructed of lumber as shown on Plate 7. These are anchored to stakes driven into the slopes and weighed with sandbags or stone. These movable panels are advantageous in that they may be built rapidly at any convenient place and hauled to and placed as needed on the job.

10-26. Portable Board Panel. Where severe wave action exists or is anticipated, the protection generally used is the horizontal board panel and sandbag type. These panels may be constructed elsewhere and hauled to points where needed. The construction and placement of the panel is illustrated on Plate 8. The panel should be placed so that the bottom is about 1 foot below the wash (or below the water surface if wave action is anticipated), with top extending about 2 feet above the predicted high water stage. Earth-filled sacks should be placed behind the base of the panel and across the top board to help hold it in place.

10-27. Scour. Current scour, or erosion of the riverside slope of the levee, is caused by abnormally high current velocities. Conditions which cause scouring may be detected by the appearance of eddies and general turbulence of the water. Immediate steps should be taken to protect the levee when current scour appears.

10-28. Sack Paving, Board Revetment. Ordinarily, current scour can be prevented or arrested by the use of sack paving, board panels, or by vertical board deflection walls, similar to measures described in the paragraphs on wave wash protection. These methods may be used in cases where the current action is minor and the water is shallow. These types of construction should extend as far under water as practicable in an attempt to restore the original levee cross section. The vertical board protection (see Plate 9) should be placed as far out as necessary, and at the angle required to deflect the current away from the levee. Sacked-earth material or rock should be placed at its base on both

sides. The panel should extend about 2 feet above the anticipated high water surface. The fence should be held in place by cable or heavy wire anchored to deadmen in the slope of the levee.

10-29. Brush Deflection Dikes. Deflection dikes, constructed as shown on Plate 10, are generally used where sack paving or vertical board protection is ineffective. A double line of 4- x 4-inch or 3- x 6-inch posts is driven on 4-foot centers, the lines of posts being about 4 feet apart and placed at the angle required to deflect the current away from the levee. The posts should be driven to the maximum practicable penetration, with their tops about 2 feet above anticipated high water. They should be braced as required with cross members, wiring and downstream bracing. Additional anchorage, if needed, may be provided by use of cable or heavy wire, placed at an angle of 45 degrees and tied to stakes in the slope. The dike frame is filled with layers of willow or similar brush, each layer being weighed down with one or two layers of stones or sacks filled with gravel or earth. The bundles of brush filler in each layer should be rammed tightly into place so as to form a solid mat about 1 foot thick. The filler should extend about 1 foot above anticipated high water. The bottom layer of filler should consist of sacks of earth or gravel, so placed as to eliminate surface irregularities and provide a level base for the brush filler. The outer end of the dike is revetted to a mat of stone or sacked earth to retard scour at this point.

10-30. Overtopping. Overtopping or the flow of water over the levee crown, is a serious threat to the stability of the levee. The danger from overtopping and the necessity for preventive action cannot be overemphasized. It is very difficult, if not impossible, to close a breach in the levee after a substantial amount of material has been washed out. The various methods of increasing the height of the levee to prevent overtopping are described in the following paragraphs. The required height of topping can best be described by running a line of levels and setting grade stakes, so that a topping grade parallel to a predicted high water profile can be established. A freeboard of about 2 feet above predicted high water is sufficient for determining height of topping.

10-31. Sandbag Topping. This method of raising levees may be used when only minor wave action is anticipated and the required additional height is less than 3 feet. It is constructed of layers of earth-filled sacks, which form a small berm on the crown of the levee as shown on Plate 11. The top layer should be at least 3 feet wide and the side slopes should be about 1 on 1, or not less than required to provide a base width sufficient to prevent failure. In no case should the base width be less than three times the height. The landside slopes should be about 1 on 2-1/2 when the topping is placed on a smooth surface, such as concrete or asphalt instead of earth.

The earth levee crown is prepared by stripping the sod to the required width and to within 1 foot of the riverside edge. The surface is then scarified by plowing furrows, or by similar means to a depth of at least 2 inches. A trench should be dug to accommodate a row of sandbags parallel to the axis of the levee. These steps are very important as they provide a good bond between the topping and the levee surface. The sacks are filled two-thirds full of earth, and should be well tramped or tamped into place. They are laid in alternate directions, those in the bottom layer being lengthwise of the levee, the next layer crosswise, etc. Gravel-filled sacks should be placed on the riverside slope of the topping if wave action becomes more severe than anticipated.

10-32. Lumber and Sack Topping. This is one of the most common emergency methods of raising low reaches in levees, especially when severe wave action is anticipated and when the height required is less than 3 feet. It is constructed as shown on Plate 12, and consists of a board fence erected on the levee crown about 1 foot from the riverside edge, backed with sacked earth or earthfill, placed on a surface stripped of side and scarified as described in 10-31. A row of 2- x 4-inch x 6-foot stakes is driven, in as straight a line as practicable, to a minimum penetration of 2 feet, 6 inches. The stakes are spaced at 6-foot intervals for boards 12 feet long. A trench for a row of sandbags is dug adjacent to the landward edges of the stakes, with the riverside edge of the bottom being made as level as possible in order to provide a secure and even seat for the bottom boards of the fence. The bottom 1-x 12-inch x 12-foot boards are placed firmly on edge and end to end in the trench, and nailed to the stakes. The required additional rows of boards are nailed to the stakes with joints staggered. The fence should be braced as required with 2- x 4-inch x 10-foot back braces nailed to 2- x 4-inch x 2-foot stakes as shown on Plate 12. The bottom edge of the fence should be sealed with well-tamped earthfill on the riverside face. The landside backing is usually composed of earth-filled sacks, filled and laid as described in 10-31. In some instances, it may be more practicable to use tamped earthfill in lieu of sacked earth, in which case a single thickness of burlap or sack material should be nailed to the landside face of the fence.

10-33. Mud Box Topping. When the topping is 3 feet or more in height, or is placed on a narrow levee crown, the mud box type as shown on Plate 13 is used. A board fence is erected near both the riverside and landside edges of the levee crown, with loose earthfill well-tamped into place between the two fences. The size of the box is controlled by functional requirements, available materials, and methods of placing the fill. The width of the box should be about the same height as the earthfill, but in no case less than 3 feet. In general, the higher the cap, the wider the box should be. The fences or flashboards are constructed as described in the preceding paragraph, except that the location of the landward fence is determined by the height of box. The posts on the landside fence should be placed on the landside of the

boards. The posts on both fences should be fastened together with tie wires. A single thickness of burlap or sack material should be nailed to the landside face of the riverside fence before the earthfill is placed.

10-34. Caving Banks and Slides - Temporary Protection. Caving banks and slides can cause considerable damage and create hazardous conditions which should be remedied immediately upon discovery. Slides, as distinguished from sloughs (see 10-14) are characterized by the shearing of a mass of the embankment on a slip plane. Slides are brought about generally by undercutting due to current scour over a period of time. This action is particularly dangerous if the undercutting reaches the base of the levee proper, which may result in levee failure. These conditions should be noted and brought to the attention of the District Engineer. As a temporary remedial measure against active caving of riverbanks, a rock-filled crib, as illustrated on Plate 1, is very effective when properly placed. This will serve to alleviate bank or levee damage until permanent corrective measures can be taken. Cribs are usually 14 x 14 feet in plan by 10 to 14 inches in inside depth. The cribs are constructed of a double thickness of 1- x 4-inch x 14-foot lumber, equivalent to 2- x 4-inch pieces, lapped "rail fence" fashion at all corners and intersections. They are divided into four compartments of about equal areas by two perpendicular cross walls constructed in the same manner as the side walls. The floors and covers are built up of double 1- x 4-inch boards spaced about 9 inches center-to-center. Under the floor and perpendicular to the direction of the floorboards, are five equally spaced pairs of 1- x 4-inch boards about 3 feet center-to-center. On top of the cover, perpendicular to the direction of the cover boards, are three pairs of top boards, one over each of the side walls and one over the central division wall. The compartments are filled with rock before covering. Each wall intersection of the fabricated crib is securely fastened by a loop of No. 9 wire.

10-35. Excessive and Pronounced Floodwall Seepage. The possibility that excessive and pronounced seepage may develop in a floodwall section during its life cannot be discounted. It may be due to rodent holes, new basement construction nearly, utility changes, or other unforeseen circumstances. Excessive seepage connected with a wall section is considered more serious than similar seepage at levee sections. It is, therefore, highly desirable that a specific program of patrol and observation of concrete wall sections be established during flood periods and also that adequate supplies of emergency treatment materials that may be required for corrective measures be provided. Any of the following measures or combination thereof may be used to advantage in emergency. (See Plate 14 for illustrations.)

a. Stop leakage through joints or small flow channels on riverside of wall by means of cinders, coal dust, sawdust, or other similar materials.

b. Where flow entry holes are too large for the treatment outlined above, sink a canvas or similar barrier over the hole and place backfill thereon until flow is retarded.

c. Place confined pervious fill (sand and sandbags) over base area landside of stem to restrict flow and to provide additional stability. A blanket of pervious material (bank run gravel or similar material) not less than 1 foot thick may be placed over ground surface and confined by sandbags, the height and width as required for stability of the wall. Boil areas beyond the wall limits should be ringed with sandbags as described for levee seepage control.

d. Place heavy fill of sandbags over both landside and riverside area of base to weight down wall and restrict movement where it appears that movement may develop.

10-36. Floodwall and Gate Closure Extension. The methods for raising concrete walls and closure gates in emergencies are shown on Plate 15. The wall treatment is similar to that described in 10-33, in that a board box is built and filled with loose earth, well-tamped into place. The closure extensions require more prior preparations since the use of prefabricated steel sections is specified.

10-37. Transportation. In instances where it is necessary to send equipment over roads that are impassable due to mud or sand, as over the crown of the levee, passage may be provided for by means of steel or wire mats, or by the use of planks laid in the roadbed. Telephone communication should be provided along dangerous stretches of the levee when travel or other satisfactory means of communication cannot be maintained.

SECTION XI

PREVENTIVE MAINTENANCE

11-01. General. a. Purpose. This section of the manual is intended as a guide for the personnel responsible for operation and maintenance of pumping plant and other equipment used in the flood protective system. It outlines basic maintenance procedures that are in general practice in plants of this nature in order to guide the operating personnel in systematically detecting and correcting incipient defects before they occur or develop into major failures. It is not intended that instructions contained herein are to take the place of the manufacturers' instructions on maintenance but to be a compilation of general procedure advocated by manufacturers and found necessary through experience. Although some manufacturers' instruction books have been furnished the City, the Superintendent shall procure and maintain for reference a manufacturers' instruction file on all equipment installed. In cases of variance herein from the manufacturers' instructions the latter should be followed.

b. Basic Equipment Care. Preventive maintenance is the systematic inspection and servicing required to keep equipment in continuous service or ready for service. It includes proper care, use, operation, inspection of equipment, cleaning and lubrication. The following paragraphs describe the basic operations making up preventive maintenance.

c. Inspection. Regularly scheduled inspections are necessary to detect and correct mechanical and electrical defects or conditions which prevent efficient operation. The thoroughness and care with which the inspector performs his work may make more frequent inspection than prescribed in the manual unnecessary, while on the other hand, hasty and haphazard inspection will eventually result in trouble even if performed often. Inspections and repairs should be entrusted only to a competent person. The inspector should have, at least, a general understanding of the electrical and mechanical characteristics of the apparatus being inspected, and sufficient information concerning its correct operating performance to enable him to know whether adjustments and repairs are necessary. The inspector should have access to, or provide himself with, such instruction books (manufacturers' and other publications) pertaining to the apparatus requiring inspection as may be necessary for the satisfactory performance of his duties. Attention should be given to the following items at all inspections.

d. Sound and Appearance. Motors and pumps of different sizes have their own characteristic operating sound when in operation under various conditions. An operator, after a time, will become accustomed to this sound and should immediately investigate any noticeable change from this normal sound. Cleanliness increases the efficiency and life of apparatus.

e. Cleanliness. Moisture, dirt, dust, cobwebs, bugs, or oil causes deterioration and corrosion of mechanical and electrical equipment. Unnecessary oil on surfaces always collects dirt. Cleaning and painting is a most important element needed in preventive maintenance to keep equipment in operation.

f. Heat. Conditions which cause excessive heat in operating equipment must be eliminated. Since excessive heat cannot always be determined by touch, thermometers should be used for measuring temperature.

g. Condition of Parts. Adjustment or replacement of defective parts is a requirement of every preventive maintenance schedule. Disassembling equipment at regularly scheduled intervals by a factory representative, or a mechanic of equal skill on the equipment being checked, may be necessary for complete inspection.

h. Testing and Adjustment. Testing for proper operation is important. Testing procedures may show that equipment is out of adjustment and not capable of full efficient performance. Trouble may then be located and corrected before a breakdown results.

11-02. Record Keeping. a. Records. Preventive maintenance programs are effective only if careful, accurate, and complete records are kept of all work done. In no other way can the Superintendent insure that all personnel are carrying out their individual responsibilities and that all equipment is being properly inspected and maintained.

b. Frequency of Inspection. It is recommended that the manufacturer be consulted as to the physical features of the equipment that should be inspected and the required frequency of the inspection. The instructions set forth in the preceding sections of the manual give the minimum frequencies of inspection for the various features of the works. In no case should inspections be made at a rate less than the frequency prescribed therein.

c. Inspection Records. The check list forms exhibited in this manual as appendix F have been prepared with due reference to past experience on similar projects although they are not considered as complete as they might be for a thoroughly effective maintenance program. They should serve, however, until the Superintendent has had the opportunity to study the installed equipment, manufacturers' recommendations, and local conditions and establish a program of inspection particularly applicable to the local project. It is suggested that for an effective preventive maintenance program a record system be set up by the City covering inspection and service for each piece of equipment as described hereinafter. Usually these systems are set up on cards with the inspection schedule on one side and the service performance record on the other. The inspection side sets up the schedule and shows, 1) the equipment and description, 2) the various parts of the equipment to be inspected, 3) the work to be done (lubrication, adjustment, operation, cleaning, etc.), 4) the frequency of inspection, and 5) the date or dates when the inspections should be made. The reverse or service side should record 1) the date of actual service, 2) the part of the equipment on which the maintenance has been performed, 3) by whom performed, 4) type of repairs, if any required, and 5) the date and by whom the repairs were made.

11-03. Power Failure. Power failures during an emergency may be a cause of considerable damage to areas dependent on pumping plants for protection. In order to prevent or hold damage to a minimum, the Superintendent should prepare a list of actions, in their order of importance, to be followed in case of sudden power interruption. This list should be posted prominently in each plant.

11-04. Spare Parts. a. Availability. In order to be assured of operation of the plant equipment when required, it may be necessary to carry a stock of certain spare parts or know where such parts may be obtained quickly and the time required to procure them. The Superintendent should obtain a parts list with their order number from the manufacturer so that any part may be obtained in an emergency without harmful delay.

b. Parts on Hand. A sufficient number of all sizes of fuses should be kept on hand at all times since these are more apt to need replacement than any other part. The necessity for having other parts on hand may be judged better after consulting with the manufacturers.

11-05. Care of Functional Structures. a. General. Pumping plants and flood protection structures, such as gate wells, walls, etc., require periodic inspection as prescribed by Regulations. Pumping plant sumps, that contain seepage, should be emptied for such inspections. Masonry structures should be checked for spalling, porosity, cracks and breaks in expansion-joint seals. Wood structural appurtenances such as parts of gate closures, added plant fixtures, etc., should be checked for rot, warping, and checking. In particular, wood installations in the pumping plant sumps should be checked for possibilities of loosening and entering or clogging the pump intake.

b. Masonry Structures. No large masonry repair job should be undertaken without prior approval of the District Engineer.

1. Spalling. When spalling is allowed to continue, progressively greater damage is caused to the structure. It should, therefore, be repaired as follows:

(a) Repair concrete surfaces with shallow spalling with special cements such as Cameo, Ruggedwear, Standard, or similar materials, which permit carrying the patch to a feather edge.

(b) Patch deeply spalled or porous concrete with ordinary cement, using approximately the same mix as the original concrete. Avoid rich grouts as they cause shrinking.

(c) Keep checked concrete from spalling by sealing the surface with bituminous asphalt, or synthetic resin base paint, suitable for contact with water, making due allowance in the selection for finished appearance.

2. Cracks. Cracks also lead to more serious damage, especially when structures are exposed to heavy freezing. Therefore, it is important that all cracks be repaired immediately on discovery. Cracks may readily be repaired with the special cements listed above. Where water is flowing from the crack, use special quick-setting mortars or alternately pump sodium silicate and calcium chloride solutions into the crack. (For information on the latter method write to The Philadelphia Quartz Company, Philadelphia, Pennsylvania.)

c. Wood Structures. Wood does not deteriorate under water, but wood used elsewhere may rot quickly unless it is coated with creosote, paint, or other preservative, as may be required, depending on its use and location.

11-06. Painting. Periodic painting is required of the parts of pumping plants, storage vaults, closure materials, and other structures that require this type of protection in order to protect metal parts from corrosive action of water and other elements. Frequency of painting varies, depending on type of paint used, method of application, and condition of wear. Always paint metal surfaces before corrosion becomes so severe that equipment is damaged. Prepare metal surfaces by sandblasting, if practical, or by cleaning them thoroughly with sandpaper and wire brush. Only specially prepared paints should be used on damp surfaces that will be encountered in the protection works. Corrosion-preventive compounds may be used in moist or wet places and in gate wells where paint would not last.

11-07. Valve and Gate Maintenance. a. General. Since conditions may not arise with sufficient frequency to require operation of the various gates and valves it is essential that these valves and gates be given several complete cycles of operation at the regularly scheduled quarterly inspections to prevent them from sticking or becoming difficult to operate. If flowage conditions make complete closing of sluice gates impractical, they should be operated to as complete a closure as possible. Check for corrosion of threaded stems and keep steel stems coated with grease to prevent corrosion.

b. Gate Valves. 1. Should leakage occur around the stem, packing may have to be replaced. These valves can be repacked without removing them from service. Open the valve wide to draw the stem collar of a non-rising stem-valve tightly against the bonnet; or on a rising stem-valve the stem base is tightly drawn against the bonnet bushing, preventing excessive leakage when the packing, or the entire stuffing box is removed. Remove all the old packing from the stuffing box. Clean the valve stem of all adhering particles and polish with fine emery cloth. Replace with new packing and assemble the valve.

2. Repairing Gate Valves. Where the gate valve seats leak they may be refaced using the method described below.

(a) Remove bonnet. Clean and examine gates and body. If too much metal has been corroded, repairs may be impossible or impractical.

(b) Remove stem from bonnet. If stem is scored or pitted, polish lightly with fine emery cloth.

(c) Remove old packing and clean stuffing box. Clean all other parts, removing all dirt and scale.

(d) Remove and discard old gasket. Replace with one of proper quality and size.

(e) Set each gate in a vise with face level. Wrap a piece of fine emery cloth around a flat tool and rub or lap the entire bearing surface to a smooth, even finish. Remove as little of the metal as possible.

(f) Remove any cuts and scratches found on body rings by lapping. Rub ring surfaces all around with small emery block. Work carefully and watch progress closely. Avoid removing too much metal as this may cause the gates to seat too low. Make both gates seat at the same depth.

(g) When seating surfaces appear to be properly lapped in, coat the faces of the gates with Prussian blue and lower them into the body to check the bearing. When a good continuous contact has been obtained, the valve is tight and ready for reassembling. Clean parts.

(h) To assemble, insert stem in bonnet, install new packing, assemble other parts, attach gates to stem and place assembly in body. Raise the gates to prevent contact with the seats. Tighten the bonnet joint. Test repaired valve.

c. Globe Valves. Glove valves are used on the city water supply lines serving some of the pumping plants. These are of small size and maintenance or repair is generally limited to the replacement of the washer and refacing the seat. Repairs can be made along the same lines as outlined under gate valves above.

d. Check Valves. Check valves must be in good operable condition at all times during high water periods. It is recommended that these valves be opened for inspection just before the flood season and the operations as are described below are performed.

1. Remove bolted cover and observe conditions of disc and seat ring.

2. Remove and discard old gasket. Replace with one of the proper quality and size. Suitable gaskets may be cut from 1/16-inch asbestos sheeting.

3. If seat ring or disc is scarred, unscrew side plug, withdraw hanger pin, and remove disc and hanger assembly.

4. If disc and seat ring needs refacing, remove hanger nut to separate disc from hanger assembly and unscrew seat ring from body of valve. If too much metal has been corroded, replace disc or seat ring as necessary.

5. If regrindable, dress with a fine file and lap with fine emery cloth wrapped around a flat tool or use an emery block. Remove as little metal as possible.

6. When surfaces appear to be lapped in, coat the seating surfaces with Prussian blue and check bearing area. When a good continuous contact has been made, the valve may be reassembled.

7. Check hanger pin wear since disc must be accurately positioned on seat to prevent leakage. Replace pin if worn.

8. Clean interior of valve body, removing all dirt and scale. In reassembling, coat hanger pin with a thin film of lubricant.

e. Automatic Flap Gates. Automatic flap gate operation is similar to that of check valves. Gates are generally of cast iron or cast steel. These gates require very little attention other than cleaning and lubrication.

1. Lubrication. At regular intervals the hinged parts should be lubricated with grease. Some hinges are provided with fittings, or with openings, whereby they may be lubricated by use of a grease gun. In other cases it may be necessary to unbolt the pins and remove the links in order to apply grease to the bushings. Disassemble only one side at a time and provide a stable support for the flap while the pins are removed.

2. Just before the flood season, and more often if necessary, clean all the parts with a wire brush, removing all dirt and scale.

3. Wire-brush the bearing surfaces of the flap and seat and check for continuous contact. If flaps and seat rings do not line up properly, check bushings or hinge pins for excess wear and replace if necessary.

4. Paint all steel parts with the proper type of corrosion-resistant paint.

f. Sluice Gates. Sluice gate principle of closure is somewhat similar to that of the gate valve.

1. Just before the flood season clean all the parts with a wire brush removing all dirt and scale. Clean the wedges and the slides thoroughly. Paint all the steel parts with a suitable corrosion resistant paint.

2. Remove all hardened grease and replace it with proper grade and type grease. Examine the grease box in two-speed flood stands especially for hardened grease and repack when necessary. Grease the slides and wedges of the gates thoroughly to facilitate ease of operation. Use non-hardening grease.

3. Check and adjust the wedges so that, when the gate is in a closed position, each wedge will apply uniform pressure against the gate and cause the gate to bear against all points on the gate seat. Proper wedge adjustment must be particularly provided for sluice gates installed for unseating pressures.

11-08. Lubrication. a. General. Lubrication is an important part of preventive maintenance. The types of equipment and the conditions under which they operate make proper and regular lubrication practices extremely important. Proper lubrication prevents metal-to-metal contact, eliminates wear, and reduces corrosion. Improper lubrication causes damage to wearing surfaces, increases maintenance costs and power consumption, and results in insulation failure. Contaminants in lubricants assist in the ultimate failure of equipment.

b. Selection of Lubricant. Lubrication instructions given herein include recommended types and intervals for certain equipment. However, these are to be considered only as guides and may require modification. The manufacturer's instructions, or the manufacturer , should be consulted and the advice of oil companies sought to determine the types of lubricants to be used on all equipment. Lubricated mechanisms generate heat which reduces the viscosity of the lubricant. Knowledge of temperatures to be encountered is necessary to enable the oil companies to correctly determine whether the proper grades of lubricants are being used. The maximum temperatures at the points of lubrication should be determined with the aid of a thermometer when the equipment has been operated under load for any length of time. In general it is recommended that SAE No. 20 oil, Gulf Harmony DWRF, distributed by the Gulf Oil Company, or equal be used for oil lubricated motor bearings, and a low temperature pressure gun grease such as Starfak Regal No. 2, distributed by the Texas Company, or equal be used on grease lubricated pump bearings.

c. Precautions. It is axiomatic that efficient lubrication is a matter of using good lubricants, properly selected, in the correct quantity, and at the right intervals. Neglect or omission, of any of these factors means accelerated breakdown. Too much lubricant causes antifriction bearings (ball and roller) to heat through increased friction and may damage them as well as the grease seals. Pump sleeve bearings cannot be over-lubricated, but too much lubricant is wasteful. Over-lubrication of motors may result in leaks and cause damage to windings and insulation. Records show that in installations where proper lubricating procedure and frequency of application were not in accordance with manufacturer's instructions a great majority of motor or pump failures were caused by over-lubrication. Always keep machinery wiped clean of oil. Investigate and correct oil leaks. Oil should be changed whenever there is any sign of contamination, stickiness or gumming.

d. Condensation. It may seem proper that as long as the correct amount of oil or grease is in a bearing and no noise or heat is noticeable that the machine would operate indefinitely. This however, is not true as the pumping plants are usually damp and condensation is present. Should the lubricating film break down, the presence of moisture would probably lead to corrosion of the metal surface.

e. Deterioration. The principal deteriorating elements in lubricants are dirt, water, oxygen, and excessive heat. If these are controlled, lubricant deterioration between lubrication periods is less likely. Guard against dust, grit, and abrasives getting into containers used for storing lubricants. Wipe spouts and lips clean before using container; wipe fittings clean before filling with lubricant.

11-09. Bearings. a. Flushing. When the pump or motor is disassembled it is advisable to flush the bearings with warm thin oil or flushing oil, under pressure. When clean, the bearings should be repacked with proper lubricant and replaced.

b. Grease Lubricated Bearings. Grease lubricated bearings require very little attention. They should be freshly lubricated after long shutdown periods before starting the pumps, and every six hours of operation. Every 1000 hours of operation, or at three year intervals the old grease should be removed and replaced. Remove the drain plugs, and fill the bearings until fresh grease runs out of the drain plug. Rotate the motor by hand to free bearing. Run the pump for about five minutes. Remove excess grease from the overflow sump and replace the drain plug.

c. Bearing Temperature. Bearing temperatures should be checked if there is any indication that they are overheating or are not running smoothly when the bearing housing is felt. After a pump has been in operation long enough for the bearings to be at normal temperatures, the bearing temperature should be checked with a thermometer and not by hand. Should the bearing attain temperatures in excess of 90° C. (195° F.), the operating conditions should be investigated. If anti-friction bearings are running hot, check for too much lubricant and remove the excess. If sleeve bearings are hot, check for need of lubricant. If proper lubrication does not correct the condition, disassemble and inspect the bearing. Check the alignment of the pump and motor if the high temperature should continue.

11-10. Packing. Packing is a close-fitting bearing and, as in the case of other bearings, requires adequate lubrication, especially if the packing is in contact with a rotating shaft.

a. Type. Use the kind of packing recommended by the equipment or packing manufacturer for each packing application. The kind generally used is the braided type. The metallic type may score rotating shafts if improperly used.

b. Packing Care. Observe the following precautions in using packing and caring for packing glands.

1. Keep follower bolts clean. When the follower bolts are not clean, it may not be possible to ascertain the amount of gland pressure that is being applied. Keep bolts well oiled.

2. Dry packing causes excessive friction between shaft and packing. Proper lubrication will prolong the life of the packing.

3. Undue leakage can usually be stopped by tightening the stuffing-box nuts in order to force the packing gland against the packing. A slight water leakage at the packing is desirable.

c. Replacing Packing. When it is necessary to replace packing, use the following procedure for woven or braided packing. If the manufacturer should recommend another type, follow the manufacturer's instructions.

1. Remove all used packing with a packing removal tool. Clean the inside of the stuffing box and gland. Clean the surface of the shaft. Clean and oil follower bolts so they work easily.

2. Dip each ring in oil, or lubricate packing while inserting it, and push it into bottom of box. All packings have some lubricants in them. Packing with about 35% lubrication should be selected. Packing must be lubricated; improper or insufficient lubrication can result in heating and shaft scoring. Tamp the packing into position with the packing gland. Cut the ends square, not beveled. Stagger the ring splits.

3. When the box is half full, draw rings up snug by tightening packing sleeves and gland. Rings of woven or braided packing need not be compressed individually. Repeat operation and pack remainder of box. Draw up snug by tightening all packing nuts uniformly. Tighten gland bolts, one flat at a time. When gland is snug, back off gland until finger-tight. Glands should never be pulled down with a wrench except to affect proper seating when new packing is installed. Never use more packing than is absolutely necessary to keep the pump from leaking.

4. Packing on a shaft should not be allowed to run excessively hot. Packing expands with heat so that a box that is little more than finger-tight when cold will generally smoke when equipment is started. As the packing wears in, tighten as necessary. Allow enough time between each turn for the pressure to be transmitted through the packing. Packing that is too tight will cause a braking effect on the pump shaft and overload the motor.

5. When repacking stuffing boxes, be sure all used packing has been removed and the shaft or shaft sleeve has not been damaged. Sometimes a number of the used rings may be replaced in the box, but usually replacement with new packing is recommended. Never repack a pump by renewing only the last three or four rings.

d. Grease-Sealed Packing Gland. Where grease is used as a packing gland seal, sufficient grease should be maintained in the packing box during operation to prevent undue leakage. Grease cups, where provided, should be kept filled.

e. Leather-Sealed Packing Gland. Leather discs are used as packing gland seals in some instances. The packing and leather discs are generally kept lubricated by oil from an oil reservoir or automatic feed. The leather discs may need replacement when undue leakage during operation occurs at the packing glands.

f. Leather-Seals. Where the shaft and its sleeve bearings are placed in a hollow tube that serves as an oil well, the bottom of the tube above the impeller bearings is generally sealed off to retain the oil by means of a leather disc and threaded gland. This leather disc should be inspected at regular intervals for possible oil leakage. Whenever the pumps are assembled after inspection or repair, these leather discs are generally renewed.

11-11. Electrical System. Where electrical equipment is to be handled, or where contact is possible during inspection, the equipment must be de-energized and effectively grounded. Grounding harness should be applied where applicable.

a. Switchgear Equipment. A test check and inspection should be made of switchgear equipment at all regular inspections. A thorough general check and inspection should be made at least once every year. Switchgear equipments include all component parts of the switchboard itself and all auxiliary equipment. These equipments consist of switchboard panels, instruments and meters, control switches, indicating lamps, wiring and insulation, bus bars, drawout devices, switches, relays, and circuit breakers. Circuit breakers and transformers are discussed elsewhere in this section.

1. The switchboard and component parts should be cleaned regularly. This should be done preferably with a vacuum cleaner having an insulated nozzle. Check the general condition of all parts. See that all covers are in place and in good condition, that there are no broken parts and no loose or missing screws and nuts. Metal-enclosed switchgear should be opened at intervals and all internal parts inspected for surface cleanliness. Any accumulated dust should be removed and all insulators carefully cleaned. These precautions are especially necessary if the equipment is located where metallic dust, cement dust, fine powder dust, salt spray, or acid fumes are present in the vicinity.

2. Instruments and meters should be examined to see that all are in good condition, are registering properly, and have no broken or cracked glass, or damaged cases. Voltmeters, ammeters, and watthour meters should be tested and calibrated if necessary.

3. The operation of control and instrument switches should be checked, and the contacts of all switches inspected. Damaged parts should be repaired or replaced. The inspection should also include the operation of the controlled device.

4. All indicating lamps should be examined, and weak or burned out lamps replaced. The operation test of controlled devices should include checking of the proper indication by the lamps of the "open position" (green light) and "closed position" (red light).

5. Bus bars and connections should be examined. If they appear to be overheating, the cause of overheating should be found and corrected. If due to poor or loose connections (loose bolts and nuts in the bolted joints), these should be tightened. Where joints are badly overheated, it may be advisable to dismount them, clean the surfaces and reassemble them, making sure that all nuts are properly tightened. Should oxidation recur at any electrical joint after having been cleaned of oxide formation, it is advisable to cover such parts with a protective coating of a non-corrosive lubricant (vaseline, slushing compound, or the like). "Cup" grease or other grease which hardens on exposure to air, should not be used.

b. Motors. The motors are of the squirrel-cage induction type and will demand special attention in order to keep in condition for efficient operation. Due to being located in a damp atmosphere and because of infrequent operation,

they require particular care so that moisture will not prevent or impede their operation or affect the life of the insulation. Should the insulation resistance value fall below that specified in this manual the motors might be "burned out" if operated. A regularly scheduled test of motor winding insulation will be essential, the frequency being dependent on the degree of dampness of the atmosphere in the pumping plant and on the necessity for operating the pumps. A regular system of inspection will tend to make motor operation, when needed, a practical certainty. In order to facilitate locating the cause of forced shut-downs of pump motors, it is advisable to keep records of all troubles and cures of chronic cases. The most dependable motor service with a longer period of motor life can be provided by adhering to the following rules: (1) Keep the motor clean and dry; (2) Keep it properly lubricated; (3) Keep a regular inspection schedule; (4) At all times know the condition of the apparatus; (5) Correct any indication of weakness before the motor fails; (6) Motor repairs should be made only by a competent technician

1. When windings need cleaning, use suction or mild blowing.

2. Motor distress warning will often be given by unusual noises caused by metal-to-metal contact or in the odor from scorching insulation varnish. Pump and motor shaft misalignment can be a contributory cause to motor drag or excessive vibration. When the latter is noted the rotor should be turned by hand in order to locate possible misalignment or rubbing.

3. Rotors. Rotors may give trouble due to open circuits or high resistance points between the end rings and rotor bars. Symptoms of such conditions are slowing down under load, and reduced starting torque. Fractures in rotor bars will be found either at the point of connection to the end ring or at the point where the bar leaves the laminations. Such conditions can usually be detected by looking for evidence of heating at the end ring connections, particularly noticeable when shutting down after operating under load. Since considerable technique is required for the repairs of this nature it is recommended that the manufacturer be consulted before attempting repairs.

4. Air Gap. Check the air gap dimension between the rotor and the stator for concentricity of the air gap. This will give an indication of wearing condition in the bearings. An occasional check will insure against a worn bearing that permits the rotor to rub the laminations. Even a very slight rubbing will generate sufficient heat to destroy the stator winding insulation. Four measurements should be taken at approximately 90° apart at each end of the rotor. Revolving air gap measurements may be made by taking the measurements at one reference point on the rotor and then revolving the rotor to measure four points on the stator. Stationary air gap measurements may be made by measuring four points on the rotor from one point on the stator. All measurements should be recorded. A comparison of new measurements with those previously recorded will permit the early detection of bearing wear. These measurements should always be taken just before disassembling and again upon assembling the motor, for comparison purposes.

5. Stator Windings. Check the cable connections for tightness. Dust and dirt are usually contributing factors to stator troubles. Some forms of dust are highly conductive and contribute materially to insulation breakdown. The effect of dust on the motor temperature through restriction of ventilation is another reason for keeping the machine clean. The windings, and the motor in general, should be blown out periodically with dry compressed air applied at a reasonably low pressure in order not to damage the insulation. One

of the worst enemies of motor insulation is moisture, mold or water standing in the motor. Check the insulation surfaces for cracks and other evidence of need for repair or coating of the insulating materials. The useful life of the motor depends largely upon the condition of its insulation.

6. Insulation Tests. A check of the insulation resistance will determine the necessity for drying out the windings before the motor may be safely operated. Tests should be performed to determine the condition of the stator windings as well as switchgear insulation with regard to moisture. Operating the motor with too low a resistance may "burn out" the motor. The resistance may be readily measured by use of a megohmeter - generally referred to as a "megger" - (similar to that manufactured by the James G. Biddle Co., Philadelphia), a self-contained instrument which gives a direct reading of insulation resistance. (Power companies use these instruments in checking their own equipment.) In obtaining "megger" readings follow the instructions furnished with the instrument. Insulation resistances will vary inversely with the temperature. That is, the insulation resistance will decrease with increase in temperature of the apparatus (cold motor). Factors that affect "megger" readings are dirt, air temperatures, the weather, humidity, and whether tests are made while the apparatus is hot or cold. The periods of the year most critical can be determined from "megger" readings obtained over a period of time. It is recommended that sufficient readings be obtained for each motor under varying weather conditions so that the results of future periodic tests may be properly interpreted. It is important to obtain sufficient readings when the apparatus is cold so that comparison may be made when it is desired to start a motor. A low insulation resistance, resulting from exposure to moist air does not necessarily mean that the insulation is not suitable for operation, particularly if the insulation resistance, as shown by reference to periodic test data, is reasonably high. It is believed that the general practice of considering motors unsafe for operation when the insulation resistance is less than one megohm per 1000 volts of apparatus rating should be adhered to until sufficient readings obtained over a period of time may indicate otherwise. If the "megger" tests indicate that the insulation resistance is gradually dropping, adequate steps should be taken, as soon as practicable, to correct the conditions causing the lowering of the resistance. If the cause is moisture the insulation should be dried out. The method to be employed and the rapidity with which this should be done is dependent on the necessity for operating the pumps.

7. Drying Windings. Dampness of the windings may be indicated by low insulation resistance. An unsafe low resistance due to this condition will require that the insulation be dried out. It is recommended that drying of winding be accomplished through the application of external heat. External heat should be applied under a canvas cover, properly vented. Heating should not go beyond 85° C. (185° F.), as water might be boiled in the insulation. Keep a check on the temperature. Portable strip heaters or special infrared-ray lamps may be used for this purpose. When damp insulation is being dried, the resistance will generally fall rapidly as the temperature is raised to a drying value. After falling to the minimum for a given temperature, the resistance will rise as moisture is expelled from the insulation. The motor can be placed in service as soon as the resistance measurement rises to the minimum value indicated herein and the remainder of the drying will be accomplished by the heat generated through the operation of the motor.

8. Should low resistance readings be obtained regularly at similar yearly periods, it is advisable to operate space heaters in the pumping plants at these times. This will prevent deterioration of the insulation and prolong its useful life.

c. Lighting System. Maintenance of the lighting system in good condition is an important factor in preventing accidents. Lighting reflectors should be kept clean and lamps replaced when burned out. All wiring should be maintained free of conditions conducive to damage or faulty operation of the system.

d. Transformers. As compared with most electric apparatus, transformers require relatively little attention. The extent of the inspection and maintenance required is governed by the importance of instantaneously available and continuous service, operating conditions, such as ambient temperature, unusually dirty atmosphere, and heavy fogs. In flood protection project installations, availability of immediate and continuous service is of utmost importance and a greater degree of attention is justified than would ordinarily be given where life and property were not endangered by a power failure. Transformers mounted in the open and exposed to the atmosphere are provided with weatherproof casings.

1. Temperature. If there is any doubt as to whether the operating temperature of a transformer is within safe limits, a check with a temperature gage should be made. Where a well is not provided for this purpose, tank temperature may be obtained by carefully attaching temperature gage at top of tank, below oil level. A factor of 5° Centigrade (9° Fahrenheit) should be added to tank temperature to get approximate oil temperature in tank. Test temperatures should only be taken when transformers are operating at full load. Temperatures of oil immersed, self-cooled transformers should not be permitted to exceed 95° C. (203° F.) nor should they be operated long at temperatures above 90° C. (194° F.).

2. Oil Level and Leakage. Keep oil at level required by the manufacturer. If low, inspect all valves and tank for leaks and make necessary repairs immediately. When adding oil to electrical equipment, use same type and grade as is then being used (and as recommended by the manufacturer).

3. If, due to high operating temperatures, or for any other reason, the condition of the oil is open to suspicion, samples should be drawn and tested. At least every 5 years, the oil should be given a dielectric test and, if satisfactory, may be filtered and re-used. If excessive sludge is present, it is an indication that operating conditions are not satisfactory.

e. Fused Disconnect Switches. Fused disconnect switches are installed on the incoming power transmission lines at the transformers and are used to protect the transformers from excessive overload. They are of the knife-switch variety and carry cartridge-type fuses.

1. Operation. The disconnect switches are used to open the live lines when the pumping plant is out of operation; otherwise current will be consumed by the transformers. The disconnect switches should only be operated when the switches in the pumping plant are in the open position. The pole top switches should be operated with the hot-line pole hooks provided for this purpose. These pole hooks are located in the pumping plants.

2. Care. These switches require very little maintenance. They should be inspected at the time the transformers are inspected. Inspection consists of examining the contact, insulators, mountings and operating mechanism. The contact surfaces should be cleaned when necessary. This may be done by opening and closing the switch several times in succession. In replacing fuses, use the size and type that will furnish adequate protection for the transformer. Be sure that the surfaces of insulators are clean. This is especially necessary when the switches are located where cement or metallic dust, salt spray, or acid fumes are prevalent. Such conditions may cause flashovers or current flows across the insulator.

f. Circuit Breakers. Circuit breakers perform the double purpose of a switching and protective device for the pump motors. They are intended to open the circuit should the current exceed a predetermined rate through these safety devices. The breakers must be given proper care and maintenance. Quite often trouble is forestalled by tightening a wire or switch, replacing spring cotter pins, readjusting and cleaning contacts, keeping latches free of corrosion, etc., when regular periodic inspections are made. The contacts are held closed by means of a holding latch. Overload protection is provided by means of overload relays or overload release devices which release the holding catch and allow the contacts to open. The frequency of complete inspection depends a great deal on local conditions, but, in general, a complete inspection should be made at least once a year, preferably just before the flood season. An inspection should always be made immediately when it is determined that the circuit breaker has been opened by a severe short circuit. Inspections should only be made by a qualified electrician.

1. Since operating conditions are such that the breakers are kept in the open position for long periods of time, they should be opened and closed several times in succession at the regular inspections. This will aid in keeping all parts in working order.

2. All adjustments should be made to comply with the requirements of the manufacturer and construction specifications.

3. Air Circuit Breakers. Air circuit breakers have been installed as controls for the operation of pump motors. Ventilation of breaker cabinets should be maintained by keeping the cabinets free from obstructions.

4. Examine the main current-carrying contacts, checking for proper alignment and especially the amount of "wipe" in closing and opening. Contacts should be free from dust and dirt accumulation, and should be clean and bright. Check the condition of the arcing contacts (which open after and close before the main current-carrying contacts). If they are badly pitted or burned, it may be necessary to dress or replace them. Surfaces (except silver) that may have become pitted or rough may be smoothed with a clean fine file or No. 00 sandpaper; do not use emery cloth.

5. One of the best ways to check contact impression is to close the contacts on a piece of thin tissue paper and a thin carbon paper, with carbon next to the tissue. When the breaker is closed and opened, it is a simple matter to determine the amount of impression made on the paper. Good impressions will show 75 percent or more of the length of each bar on the contacts.

6. Check the cable connections to see that cable terminal connectors are not overheating, and that all joints in connections are intact and in good conditions.

7. See that all nuts and bolts are in place and tight; that no pins or cotter pins have worked out of place; and that all cotter pins have sufficient spread to hold them in. All moving parts should be free from binds, and the mechanism should be in good working order. Circuit breaker mechanisms require little lubrication. A general recommendation is to use a few drops of good grade light machine oil at bearing points, and to wipe off all excess oil with a clean rag. This should be done at the regular inspection periods.

8. Check the tripping device and the trip latches to see that the parts move freely, and that the armature of each trip device has sufficient travel to assure a positive blow that will release the breaker latch. Check the calibration setting to make sure that proper protection is obtainable without undue tripping. Measure the length of the breaker stroke and the opening and closing speed to see that they comply with the manufacturer's specification. Adjustments, if necessary, should only be made by a skilled electrician.

9. Check the control switch and the closing relay to see that they are functioning properly; check proper operation of indicating lamps, replacing those that are burned out.

10. Observe conditions while the breakers are carrying their full-load current to make sure that they are not overheating, and that connecting conductors are not feeding heat into the breakers.

11. Knife Switches. All switches should be thoroughly cleaned periodically by wiping with a clean cloth to prevent accumulation of dust. Avoid touching the contacts with the fingers. Disconnecting switches should never be opened or closed unless the circuit is open at some other point.

12. See that the blades make good contact. The condition of contact can be checked by attempting to insert a 0.002-inch feeler gage between the blade and the contact at all accessible points. If the gage can be inserted, adjustment should be made.

13. Some switches are provided with silver-to-silver contacts. These contacts do not tarnish, like copper, but they should be wiped clean occasionally. Never grind or sand the surfaces of silvered contacts. The contact surfaces of copper switches frequently need cleaning to remove oxide. This can be done by opening and closing the switch several times in succession. Do not attempt to grind the blades with powdered emery or other abrasives. Such practice inevitably results in poor contact and overheating.

14. Check contact pressure, and when contact clips, whose efficiency depends upon the tension of the spring, are used, make sure that these spring clips have not been annealed by overheating.

15. In "safety enclosed switches" make sure that the operating handle and mechanism are in good working order, that the cover and interlock are in good condition and that the enclosure ground connection is intact.

16. Fuses. The contacts on fuses (indoor and outdoor) should be kept clean and tight.

17. Insulators. Inspect insulators for cleanliness, especially insulated surfaces on which switches are mounted.

18. Insulating Oil. Dielectric tests and visual inspection of the insulating oil of the oil circuit breakers should be made at the quarterly inspection and after short circuits. If the oil shows signs of moisture, carbonization or dirt, remove the oil, filter and retest it before replacing it in service. At least once a year remove all the oil and thoroughly clean the tanks, tank liners, lift rods terminal bushings, etc.

19. Do not operate oil circuit breakers excessively electrically when the oil tank is removed.

g. Reversing Magnetic Contactors. Reversing magnetic contactors have been installed in the switchgear cabinets for the control of the sluice gate motors. They serve the purpose of a switching and protective device for these motors. The contacts and other operating mechanisms should be inspected and maintained as described elsewhere in this section.

h. Relays. The primary function of protective relays, which cause the circuit breakers to operate, is to protect the expensive motors. Keeping these relays in proper working condition, therefore, is extremely important. A thorough general check of all relays should be made at least once a year. Since many of these relays are of the precision type they should be examined, tested and repaired by a relay technician. The following precautions must be taken (a) See that the contacts align properly and that they are clean and bright. If they are dirty, or slightly tarnished, they should be cleaned as described elsewhere for contact surface. (b) The moving parts of the relay should not be impeded by accumulation of dirt or dust. If the movement of the parts is sluggish or impeded because of a damaged jewel bearing, the latter should be replaced. (c) No lubrication of relays is usually required during service.

i. Insulation. A dielectric test should be made of all insulated wiring and coils of the switchgear as well as the motor windings. The purpose of dielectric tests is to determine whether insulation will withstand voltage stresses occurring during normal or assumed abnormal conditions of operation. "Megger" readings for switchboard insulation should be taken at the time when they are made for motor winding insulation.

j. Bushings and Insulators. Bushings at transformer installations ordinarily require little, if any, attention. Maintenance is ordinarily limited to cleaning. The frequency of this operation depends on the prevelance of cement or metallic dust, salt spray or acid fumes in the atmosphere.

1. Examine housing for chipping, shattering, cracks, or other damage, and for loose bolts on assembly or mounting hardware. Dirt deposits under moist conditions tend to form a conductive coating

and should be cleaned off to prevent flashover. Check visually for cracked or broken porcelain. The porcelain transformer bushings should be tested with special testing equipment.

2. Clean bushings and insulators as required by local conditions.

k. Grounds. Ground resistance to all equipment should be tested occasionally. See that transformer tank, outdoor switch gear housing, operating levers, lightning arresters, and metal fencing (around ground level substation) are properly connected to grounds. Ground resistance should not exceed 15 ohms for driven grounds. Test for accidental grounds on ungrounded equipment. Grounds can best be tested with equipment similar to that used by the Power Company.

l. Cable and Wire. Periodic inspection of cable and wire is the best method of preventing failure. Such inspection should be made for poor thermal conditions and potential danger spots. Exterior wiring should be noted for tension between anchor points which might be off-standard. Wires which are too slack or too tight should be adjusted to proper tension. If cables appear to be carrying excessive temperature, determine the cable temperature by attaching a suitable thermometer to the cable surface. Check with the Power Company for the proper temperature for cable size and amperage load. Overheating can be caused by overloads or the presence of external sources of heat and will dry and harden the insulation. This in turn either increases the dielectric losses or produces cracks in the insulation and thus hastens ultimate failure. Oil on rubber insulated cables will cause swelling and softening of rubber.

11-12. Pumping Equipment. The pumps installed in the plants are either vertical centrifugal or the axial flow type depending on the capacity of the unit. Their dependability when operation is imminent is of major importance. Pumping equipment operates with little trouble if it receives proper preventive care. Too little attention is paid to the necessity for completely dismantling pumps at regular intervals. This may eventually result in failure during a critical flood period. Loose shaft joints and shaft-enclosing pipe joints, bearing wear, corrosive and erosive action, metal chipping and fractures, and the like are extremely difficult to detect by external visual inspection. The matter of keeping necessary records and following rules pointed out in paragraph 11-11b, with reference to motors, are just as applicable to pumps.

a. In order to facilitate inspections requiring disassembly, the local operating agency should utilize the service handbooks supplied with this manual and should procure replacements, when needed, from the manufacturer or from other reliable sources for complete detailed disassembly instructions for all types of pumps installed.

b. The necessity for having instructions of this nature cannot be fully appreciated until a flood emergency arises combined with damaged pumps that cannot be placed in service until repairs are made. Replacement or repair of some part that may appear to be a simple matter may resolve itself into a prolonged operation due to the lack of knowledge on proper procedure in dismantling and assembling the pump. This is well illustrated by an incident that occurred during a flood emergency in which two full days were spent in removing the tension nut from a pump because the proper procedure for removal of the nut was not known beforehand.

c. Should pump failures occur or undue wear of parts be observed, the mere replacement of the affected parts is not considered adequate toward a program of good preventive maintenance. The determination of the cause of such failures or damage and its correction are considered as essential as the repair of the pump in order to guard against identical future failures.

d. Pump and Motor Alignment. Check the alignment of the pump and motor when bearings run hot or when excessive vibration occurs. If misalignment should recur frequently, inspect the entire piping system. Unbolt the piping at the suction and discharge nozzles of the pump to see if it springs away, indicating a strain on the casing. Check all pump and piping supports for soundness and effective support of the load. Shim the units as needed.

e. Bowls, Water Passage and Impeller. Look for pitting, wear and corrosion on bowls, water passages, and impellers. Corrosive water affects performance and dependability of pump. If pitting occurs only in the lower sections of the pump (bowl and impeller) cavitation may be taking place.

f. Cavitation. Cavitation may result from operating the pump when the level of the water in the sump is too low. Cavitation causes severe pitting and a characteristic spongy appearance in the metal. It generally affects the entrance portion of the impeller, though it may also occur in the casing. Pumps may be operated for the dry test runs when the sump water is below the intake of the suction bell.

g. Power Consumption. An indication of either electrical or mechanical difficulties may be determined by comparing ammeter and voltmeter readings for each motor during no load test runs with past records for similar conditions. A noticeable increase in the ammeter reading with a normal voltage indicates an undesirable condition, which should be traced. Under full load the current demand should not exceed that shown on the data plate of the motor.

h. Disassembling and Inspecting Pump. The frequency of completely disassembling the pump for a thorough inspection will be dependent on local conditions. It is cautioned that such inspections should not be deferred for long periods as costly breakdowns may result at a most critical time. These inspections should be made under experienced supervision and the manufacturer's instructions followed closely. CAUTION: No one should be permitted to enter the pump chamber to make inspections or repairs until it has been ascertained that the chamber is free from harmful gases and, also, unless an assistant is posted on the pump floor.

SECTION XII

EQUIPMENT FAILURE DIAGNOSIS

12-01. General. This section of the manual is intended as a guide in determining the causes and effects of pump and motor difficulties encountered during plant operations. Outlined herein are basic hints on the diagnosis of certain pump and motor ailments that are characteristic of a great majority of pump starting and operating difficulties. Following this procedure may enable one to locate the source of trouble in many cases.

12-02. Very Little or No Water Being Discharged.

a. Lack of prime.
   1. See that suction pipe and impeller casing are completely filled with water. Water level in sump should be above minimum pumping elevation.

b. Motor speed too low.
   1. Check whether motor is receiving full voltage. Test voltage on all phases.
   2. Open on high resistance point in rotor circuit.

c. Packing where used too tight.
   1. Release gland pressure. Tighten reasonably.

d. Discharge head too high.
   1. Gate valves should be wide open.
   2. Check valves and flap gates should operate freely.

e. Suction lift too high.
   1. Sump water level too low.
   2. Obstruction at suction bell of pump.

f. Clogged inlet.
   1. Trash Rack may be clogged and does not permit sufficient flow. Keep rack raked clean.

g. Impellers improperly adjusted.
   1. Rubbing on top or bottom.

h. Impeller wrapped in debris.
   1. On vertical centrifugal pumps - shut valves on suction and discharge lines, open hand holes and clean impeller and inside of casing.
   2. On axial-flow pumps - clean impeller from pump intake entrance.
   3. If the sump cannot be unwatered, it may be necessary to use portable pump.

i. Wrong direction of rotation.
   1. This may occur when the wiring has been disconnected from the motor and is reconnected improperly.

12-03. Not Enough Water Being Discharged.

a. Air leaks in stuffing boxes, casing, or flanged joints.
   1. Due to the nature of most of the installations, this can only develop after the sump has been pumped down and there is negative suction head. These air leaks will generally show up as water leaks when the sump water elevation is at or above minimum pumping elevation.
   2. There should be a very slight leakage from the stuffing boxes while the pumps are operating and discharging water. If there is none, adjust packing gland. If there is still no flow new packing probably is needed.
   3. Leaks at joints may require tightening of bolts or new gaskets.

b. Defective impeller.
   1. Replace the impeller if worn, damaged, or the blade sections are badly eroded.
   2. Incorrect size impeller installed.

c. Incorrect axial adjustment of impeller or rotating element.

d. Suction inlet not immersed deeply enough.
   1. Pumping below minimum pumping elevation. Swirling eddies at pump intake indicates air is being sucked into the line, causing severe pounding.
   2. Shut off pumps at some higher elevation.
   3. Inspect automatic pump controls for adjustment.

e. Check for conditions listed under paragraph 12-02.

12-04. Pump Starts, Loses Suction and Stops.

a. Incomplete priming.
   1. Free pump, piping and valves of all air.

b. Leaky suction line.
   1. See paragraph 12-03a.

c. Gases in water being pumped.
   1. Causes creating condition should be remedied.

12-05. Pump Requires Too Much Power.

a. Lubricating oil being used is too heavy.

b. Specific gravity of storm water too high.
   1. Considerable quantity of sand being carried by water.

c. Vibration.

d. Misalignment

e. Stuffing boxes too tight. Release gland pressure, tighten reasonably.

f. Impellers improperly adjusted.
   1. Rubbing on top or bottom.

12-06. Pump Vibrates.

a. Worn bearings.

b. Pump not resting securely on supports in sump or on base plate.

c. Motor or pump out of balance.

d. Air or gas in water.

e. Motor shaft not lined up with pump shaft.

f. Impeller out of balance due to foreign material.

12-07. Excessive Wear.

a. Improper lubrication.

b. Sand in water being pumped.

c. Vibration.

d. Misalignment.
   1. May be due to crossed threads on pump shaft.

12-08. Reverse Flow through Pump - Current Off.

a. Siphon action taking place.
   1. Check valve or flap gate will not close. Debris holding flap gate open.
   2. Break siphon by one of the following means:
      (a) Close gate valve at pump.
      (b) Open siphon breaker gate valve at top of levee.

12-09. Motor Will Not Start.

a. Power not connected.
   1. Check power to controls and controls to motor.
   2. Check clip contacts.

b. Faulty (open) fuses.
   1. Test fuses.

c. Low voltage.
   1. Check voltage with meter.

d. Protection devices holding circuit open.
   1. Overload, short circuit, or undervoltage relay tripped.
   2. Determine and correct cause.

e. Defective starting or control equipment.
   1. Check with manufacturer's information and adjustments.

f. Loose terminal-lead connection.
   1. Tighten connections.

g. Pump locked.
   1. Try turning motor and pump shaft with wrench.
   2. If the shaft will not turn, disconnect motor from pump.
   3. If motor starts satisfactorily, check pump.

h. Open or short circuit in stator windings.

i. Bearings frozen to shaft.
   1. Free bearings or replace.

12-10. Motor Noisy.

a. Motor funning single phase.
   1. Stop motor, then try to start it. It will not start on single phase.
   2. Check for "open" in one of the lines or circuits.
   3. Check primary fuses.

b. Vibration.
   1. Pump may be unbalanced.
   2. Remove motor from load.
   3. Check for foreign matter caught on rotor.

c. Air gap not uniform. (Magnetic noise).
   1. Check the rotor and if necessary replace bearings.

d. Noisy ball bearings.
   1. Check for thrust on proper bearing.
   2. Check lubrication. Replace bearing if rusted, pitted, or flat ball is observed.

e. Loose rotor on shaft.
   1. Disassemble and investigate cause.

f. Rotor rubbing on stator.
   1. Check registers, center the rotor.
   2. Replace bearings if necessary.

g. Objects caught between fan and end shields.
   1. Disassemble motor and clean it. Foreign material around motor should be removed.

h. Motor loose on foundation.
   1. Tighten hold down bolts. Motor and pump unit may possibly have to be realigned with connecting piping.

i. Coupling loose (on vertical centrifugal pumps).
   1. Insert feeler gage at four places in coupling joint before pulling up bolts to check alignment. Tighten coupling bolts securely.

12-11. Motor temperature too high.

a. Overload. May be due to mechanical pump defects.
   1. Motor stalled by "frozen" pump (tight bearing or packing).
   2. Measure motor loading with ammeter.

b. Electrical load unbalance.
   1. Check for voltage unbalance or single phasing. Check for "open" in one of the lines or circuits.
   2. Fuse blown, faulty control, etc.

c. Restricted ventilation.
   1. Clean air passages.

d. Incorrect voltage.
   1. Check voltage under full load.

e. Stator winding shorted or grounded.
   1. Check with proper instruments.

12-12. Bearings Heat Up.

a. Bent shaft.

b. Too much lubricant.
   1. Remove relief plug and let motor run. If excess lubricant does not run out, flush and relubricate.

c. Wrong grade of lubricant.
   1. Follow manufacturer's recommendations.

d. Insufficient lubricant.
   1. Fill with proper quantity.

e. Foreign material in lubricant.
   1. Flush bearings thoroughly, relubricate.

f. Bearings misaligned.
   1. Align motor and pump and check bearing-housing assembly. See that races are exactly 90° with shaft.

g. Bearing damaged (corrosion, etc.)
   1. Replace bearings.

FLOOD CONTROL REGULATIONS;
MAINTENANCE AND OPERATION
OF FLOOD CONTROL WORKS

(USE ONLY AS APPLICABLE TO THIS PROJECT)

The Code of Federal Regulations, as promulgated in Chapter II - Corps of Engineers, Department of the Army, Section 208.10, of Title 33, prescribes the following regulations covering maintenance and operation of structures and facilities on local flood protection works.

AUTHORITY: Authority is cited in parentheses following the regulations.

208.10 Local flood protection works; maintenance and operation of structures and facilities.

(a) General. (1) The structures and facilities constructed by the United States for local flood protection shall be continuously maintained in such a manner and operated at such times and for such periods as may be necessary to obtain the maximum benefits.

(2) The State, political subdivision thereof, or other responsible local agency, which furnished assurance that it will maintain and operate flood control works in accordance with regulations prescribed by the Secretary of the Army, as required by law, shall appoint a permanent committee consisting of or headed by an official hereinafter called the "Superintendent," who shall be responsible for the development and maintenance of, and directly in charge of, an organization responsible for the efficient operation and maintenance of all the structures and facilities during flood periods and for continuous inspection and maintenance of the project works during periods of low water, all without cost to the United States.

(3) A reserve supply of materials needed during a flood emergency shall be kept on hand at all times.

(4) No encroachment or trespass which will adversely affect the efficient operation or maintenance of the project works shall be permitted upon the rights-of-way for the protective facilities.

(5) No improvement shall be passed over, under, or through the walls, levees, improved channels or floodways, nor shall any excavation or construction be permitted within the limits of the project right-of-way, nor shall any change be made in any feature of the works without prior determination by the District Engineer of the Department of the Army or his authorized representative that such improvement, excavation, construction, or alteration will not adversely affect the functioning of the protective facilities. Such improvements or alterations as may be found to be desirable and permissible under the above determination shall be constructed in accordance with standard engineering practice. Advice regarding the effect of proposed improvements or alterations on the functioning of the project and information concerning methods of construction acceptable under standard engineering practice shall be obtained from the District Engineer or, if otherwise obtained, shall be submitted for his approval. Drawings or prints showing such improvements or alterations as finally constructed shall be furnished the District Engineer after completion of the work.

(6) It shall be the duty of the Superintendent to submit a semiannual report to the District Engineer covering inspection, maintenance, and operation of the protective works.

(7) The District Engineer or his authorized representatives shall have access at all times to all portions of the protective works.

(8) Maintenance measures or repairs which the District Engineer deems necessary shall be promptly taken or made.

(9) Appropriate measures shall be taken by local authorities to insure that the activities of all local organizations operating public or private facilities connected with the protective works are coordinated with those of the Superintendent's organization during flood periods.

(10) The Department of the Army will furnish local interests with an Operation and Maintenance Manual for each completed project, or separate useful part thereof, to assist them in carrying out their obligations under this part.

(b) Levees - (1) Maintenance. The Superintendent shall provide at all times such maintenance as may be required to insure serviceability of the structures in time of flood. Measures shall be taken to promote the growth of sod, exterminate burrowing animals, and to provide for routine mowing of the grass and weeds, removal of wild growth and drift deposits, and repair of damage caused by erosion or other forces. Where practicable, measures shall be taken to retard bank erosion by planting of willows or other suitable growth on areas riverward of the levees. Periodic inspections shall be made by the Superintendent to insure that the above maintenance measures are being effectively carried out and, further, to be certain that:

(i) No unusual settlement, sloughing, or material loss of grade or levee cross section has taken place;

(ii) No caving has occurred on either the land side or the river side of the levee which might affect the stability of the levee section;

(iii) No seepage, saturated areas, or sand boils are occurring;

(iv) Toe drainage systems and pressure relief wells are in good working condition, and that such facilities are not becoming clogged;

(v) Drains through the levees and gates on said drains are in good working condition;

(vi) No revetment work or riprap has been displaced, washed out, or removed;

(vii) No action is being taken, such as burning grass and weeds during inappropriate seasons, which will retard or destroy the growth of sod;

(viii) Access roads to and on the levee are being properly maintained;

(ix) Cattle guards and gates are in good condition;

(x) Crown of levee is shaped so as to drain readily, and roadway thereon, if any, is well shaped and maintained;

(xi) There is no unauthorized grazing or vehicular traffic on the levees;

(xii) Encroachments are not being made on the levee right-of-way which might endanger the structure or hinder its proper and efficient functioning during times of emergency.

Such inspections shall be made immediately prior to the beginning of the flood season; immediately following each major high water period, and otherwise at intervals not exceeding 90 days, and such intermediate times as may be necessary to insure the best possible care of the levee.

Immediate steps will be taken to correct dangerous conditions disclosed by such inspections. Regular maintenance repair measures shall be accomplished during the appropriate season as scheduled by the Superintendent.

(2) Operation. During flood periods the levee shall be patrolled continuously to locate possible sand boils or unusual wetness of the landward slope and to be certain that:

(i) There are no indications of slides or sloughs developing;

(ii) Wave wash or scouring action is not occurring;

(iii) No low reaches of levee exist which may be overtopped;

(iv) No other conditions exist which might endanger the structure.

Appropriate advance measures wil be taken to insure the availability of adequate labor and materials to meet all contingencies. Immediate steps will be taken to control any condition which endangers the levee and to repair the damaged section.

(c) Flood Walls - (1) Maintenance. Periodic inspections shall be made by the Superintendent to be certain that:

(i) No seepage, saturated areas, or sand boils are occurring;

(ii) No undue settlement has occurred which affects the stability of the wall or its watertightness.

(iii) No trees exist, the roots of which might extend under the wall and offer accelerated seepage paths;

(iv) The concrete has not undergone cracking, chipping, or breaking to an extent which might affect the stability of the wall or its watertightness;

(v) There are no encroachments upon the right-of-way which might endanger the structure or hinder its functioning in time of flood;

(vi) Care is being exercised to prevent accumulation of trash and debris adjacent to walls, and to insure that no fires are being built near them;

(vii) No bank caving conditions exists riverward of the wall which might endanger its stability;

(viii) Toe drainage systems and pressure relief wells are in good working condition, and that such facilities are not becoming clogged.

Such inspections shall be made immediately prior to the beginning of the flood season, immediately following each major high water period, and otherwise at intervals not exceeding 90 days. Measures to eliminate encroachments and effect repairs found necessary by such inspections shall be undertaken immediately. All repairs shall be accomplished by methods acceptable in standard engineering practice.

(2) Operation. Continuous patrol of the wall shall be maintained during flood periods to locate possible leakage at monolith joints or seepage underneath the wall. Floating plant or boats will not be allowed to lie against or tie up to the wall. Should it become necessary during a flood emergency to pass anchor cables over the wall, adequate measures shall be taken to protect the concrete and construction joints. Immediate steps shall be taken to correct any condition which endangers the stability of the wall.

(d) Drainage Structures - (1) Maintenance. Adequate measures shall be taken to insure that inlet and outlet channels are kept open and that trash, drift, or debris is not allowed to accumulate near drainage structures. Flap gates and manually operated gates and valves on drainage structures shall be examined, oiled, and trial operated at least once every 90 days. Where drainage structures are provided with stop log or other emergency closures, the condition of the equipment and its housing shall be

inspected regularly and a trial installation of the emergency closure shall be made at least once each year. Periodic inspections shall be made by the Superintendent to be certain that:

(i) Pipes, gates, operating mechanism, riprap, and headwalls are in good condition;

(ii) Inlet and outlet channels are open;

(iii) Care is being exercised to prevent the accumulation of trash and debris near the structures and that no fires are being built near bituminous coated pipes;

(iv) Erosion is not occurring adjacent to the structure which might endanger its watertightness or stability.

Immediate steps will be taken to repair damage, replace missing or broken parts, or remedy adverse conditions disclosed by such inspections.

(2) Operation. Whenever high water conditions impend, all gates will be inspected a short time before water reaches the invert of the pipe and any object which might prevent closure of the gates shall be removed. Automatic gates shall be closely observed until it has been ascertained that they are securely closed. Manually operated gates and valves shall be closed as necessary to prevent inflow of flood water. All drainage structures in levees shall be inspected frequently during floods to ascertain whether seepage is taking place along the lines of their contact with the embankment. Immediate steps shall be taken to correct any adverse condition.

(e) Closure Structures - (1) Maintenance. Closure structures for traffic openings shall be inspected by the Superintendent every 90 days to be certain that:

(i) No parts are missing;

(ii) Metal parts are adequately covered with paint;

(iii) All movable parts are in satisfactory working order;

(iv) Proper closure can be made promptly when necessary;

(v) Sufficient materials are on hand for the erection of sandbag closures and that the location of such materials will be readily accessible in times of emergency.

Tools and parts shall not be removed for other use. Trial erections of one or more closure structures shall be made once each year, alternating the structures chosen so that each gate will be erected at least once in each 3-year period. Trial erection of all closure structures shall be made whenever a change is made in key operating personnel. Where railroad operation makes trial erection of a closure structure infeasible, rigorous inspection and drill of operating personnel may be substituted therefor. Trial erection of sandbag closures is not required. Closure materials will be carefully checked prior to and following flood periods, and damaged or missing parts shall be repaired or replaced immediately.

(2) Operation. Erection of each movable closure shall be started in sufficient time to permit completion before flood waters reach the top of the structure sill. Information regarding the proper method of erecting each individual closure structure, together with an estimate of the time required by an experienced crew to complete its erection, will be given in the Operation and Maintenance Manual which will be furnished local interests upon completion of the project. Closure structures will be inspected frequently during flood periods to ascertain that no undue leakage is occurring and that drains provided to care for ordinary leakage are functioning properly. Boats or floating plant shall not be allowed to tie up to closure structures or to discharge passengers or cargo over them.

(f) Pumping Plants - (1) Maintenance. Pumping plants shall be inspected by the Superintendent at intervals not to exceed 30 days during flood seasons and 90 days during off-flood seasons to insure that all equipment is in order for instant use. At regular intervals, proper measures shall be taken to provide for cleaning plant, buildings, and equipment, repainting as necessary, and lubricating all machinery. Adequate supplies of lubricants for all types of machines, fuel for gasoline or diesel powered equipment, and flashlights or lanterns for emergency lighting shall be kept on hand at all times. Telephone service shall be maintained at pumping plants. All equipment, including switchgear, transformers, motors, pumps, valves, and gates shall be trial operated and checked at least once every 90 days. Megger tests of all insulation shall be made whenever wiring has been subjected to undue dampness and otherwise at intervals not to exceed one year. A record shall be kept showing the results of such tests. Wiring disclosed to be in an unsatisfactory condition by such tests shall be brought to a satisfactory condition or shall be promptly replaced. Diesel and gasoline engines shall be started at such intervals and allowed to run for such length of time as may be necessary to insure their serviceability in times of emergency. Only skilled electricians and mechanics shall be employed on tests and repairs. Operating personnel for the plant shall be present during tests. Any equipment removed from the station for repair or replacement shall be returned or replaced as soon as practicable and shall be trial operated after reinstallation. Repairs requiring removal of equipment from the plant shall be made during off-flood seasons insofar as practicable.

(2) Operation. Competent operators shall be on duty at pumping plants whenever it appears that necessity for pump operation is imminent. The operator shall thoroughly inspect, trial operate, and place in readiness all plant equipment. The operator shall be familiar with the equipment manufacturers' instructions and drawings and with the "Operating Instructions" for each station. The equipment shall be operated in accordance with the above-mentioned "Operating Instructions" and care shall be exercised that proper lubrication is being supplied all equipment, and that no overheating, undue vibration or noise is occurring. Immediately upon final recession of flood waters, the pumping station shall be thoroughly cleaned, pump house sumps flushed, and equipment thoroughly inspected, oiled and greased. A record or log of pumping plant operation shall be kept for each station, a copy of which shall be furnished the District Engineer following each flood.

(g) Channels and Floodways - (1) Maintenance. Periodic inspections of improved channels and floodways shall be made by the Superintendent to be certain that:

(i) The channel or floodway is clear of debris, weeds, and wild growth.

(ii) The channel or floodway is not being restricted by the depositing of waste materials, building of unauthorized structures, or other encroachments;

(iii) The capacity of the channel or floodway is not being reduced by the formation of shoals;

(iv) Banks are not being damaged by rain or wave wash, and that no sloughing of banks has occurred;

(v) Riprap sections and deflection dikes and walls are in good condition;

(vi) Approach and egress channels adjacent to the improved channel or floodway are sufficiently clear of obstructions and debris to permit proper functioning of the project works.

Such inspections shall be made prior to the beginning of the flood season and otherwise at intervals not to exceed 90 days. Immediate steps will be taken to remedy any adverse conditions disclosed by such inspections. Measures will be taken by the Superintendent to promote the growth of grass on bank slopes and earth deflection dikes. The Superintendent shall provide for periodic repair and cleaning of debris basins, check dams, and related structures as may be necessary.

(2) Operation. Both banks of the channel shall be patrolled during periods of high water, and measures shall be taken to protect those reaches being attacked by the current or by wave wash. Appropriate measures shall be taken to prevent the formation of jams of ice or debris. Large objects which become lodged against the bank shall be removed. The improved channel or floodway shall be thoroughly inspected immediately following each major high water period. As soon as practicable thereafter, all snags and other debris shall be removed and all damage to banks, riprap, deflection dikes and walls, drainage outlets, or other flood control structures repaired.

(h) Miscellaneous Facilities - (1) Maintenance. Miscellaneous structures and facilities constructed as a part of the protective works and other structures and facilities which function as a part of, or affect the efficient functioning of, the protective works shall be periodically inspected by the Superintendent and appropriate maintenance measures taken. Damaged or unserviceable parts shall be repaired or replaced without delay. Areas used for ponding in connection with pumping plants or for temporary storage of interior runoff during flood periods shall not be allowed to become filled with silt, debris, or dumped material. The Superintendent shall take proper steps to prevent restriction of bridge openings and, where practicable, shall provide for temporary raising during floods of bridges which restrict channel capacities during high flows.

(2) Operation. Miscellaneous facilities shall be operated to prevent or reduce flooding during periods of high water. Those facilities constructed as a part of the protective works shall not be used for purposes other than flood protection without approval of the District Engineer unless designed therefor.

(Sect. 3, 49 Stat. 1571, as amended; 33 U.S.C. 701c) [9 F.R. 9999, Aug. 17, 1944; 9 F.R. 10203, Aug. 22, 1944]

Pursuant to ordinance adopted by the board of commissioners of the City of Paducah on May 2, 1938, the City of Paducah, acting by and through its Mayor and City Clerk, duly authorized by vote of the board of commissioners in said ordinance, does hereby agree: (a) To furnish and pay 60 percentum of the cost of all lands, easements, and rights of way necessary for the construction of flood protection works, as shown on Drawings Nos. 934-12.1/2 to 16 incl. dated _____, prepared by the United States Engineer Office, Louisville, Kentucky, and a copy of which drawings are attached hereto and made a part hereof. The lands, easements and rights of way as included therein shall include those needed for the sites of structures, for borrow pits and spoil disposal areas, for access roads, and all rights in, upon, through or over private property, which are needed by the United States in connection with the work of improvement. Detailed property surveys and title searches necessary to acquire the land or interests therein will be performed by the City, and abstracts of title or other necessary supporting title papers furnished by the City. (b) That the City will assume 60 per centum of the cost of relocating and reconstructing highways, bridges, buildings, railroad lines, and any other structures, facilities or properties, as may be required to prosecute the work of improvement. (c) That the said City of Paducah will hold and save the United States, its officers, and employees free from all claims for damages and all liabilities due to the construction work and will maintain and operate without expense to the United States all completed flood control structures in accordance with regulations prescribed by the Secretary of War.

IN WITNESS WHEREOF the said City of Paducah has caused this instrument to be executed in its name and on its behalf and its corporate seal to be affixed hereto by City Clerk, thereunto duly authorized, this 17th day of May, 1938.

ATTEST:

Rudy Stewart
City Clerk

CITY OF PADUCAH

By Edgar T. Washburn
Mayor

(SEAL)

INSTALLATION OF PRESSURE PIPE OR CONDUIT OVER, UNDER, OR THROUGH LEVEES

No new installations of pressure pipes or conduits through levees will be permitted.

(NOTE: THIS SAMPLE SPECIFICATION IS SUBJECT TO CHANGE. WRITE LOUISVILLE ENGINEER DISTRICT FOR LATEST SPECIFICATIONS WHEN NEEDED)

SPECIFICATIONS FOR INSTALLATION OF PRESSURE PIPE LINE OR CONDUIT OVER LEVEES
(August 1970)

1. Pressure pipe or conduit shall be placed over the levee and shall be buried in the levee embankment so that there is a minimum covering of 18 inches of earth over the top of the pipe. If so desired, the pipe or conduit may be laid on the surface of the embankment and fill placed over the line to provide a minimum cover of 18 inches and a top width of fill not less than 5 feet greater than the pipe diameter with side slopes not steeper than 1 on 5.

2. When placing pipe lines over the levee, excavation for the pipe shall be to the bottom of the pipe only and the trench shall be shaped so that the bottom 1/3 of the pipe will be bearing on original or well compacted material. After the pipe is installed, the trench shall be backfilled, the fill being placed in approximate 4-inch layers with each layer compacted by means of hand or mechanical tampers, or otherwise compacted in an approved manner, to a density equal to that of the adjacent levee embankment. Fill material shall be equally as impervious as the adjacent levee embankment.

3. The new earth surface over the levee and across the landside and riverside berms shall be seeded or sodded with clean, well developed turf. Sodding shall be done in accordance with instructions contained in the Operations and Maintenance Manual applicable to the project or sound engineering practice, and all sod on slopes shall be pegged into place with stakes 12" long by 3/4x1" at 3' intervals measured traverse and parallel to levee centerline.

4. Joints in pipes over the levee at both shoulders of the crown and at both toes shall be made by means of flexible couplings (Dresser or equal). Tension ties across joints may be required for pipes 12" or more in diameter and pipes carrying pressure in excess of 25 p.s.i.

5. Where a pipe crosses the levee with the pressure source landward of the levee, a valve should be located landward of the landside toe or, in some cases, both here and riverward of the riverside toe. Where the pressure source is riverward of the levee, the option is to locate a valve either riverward of the riverside toe or on the crown of the levee, or both. Valves should be placed in a manhole or in a valve box. In the latter case, surround the box, at the surface, with a concrete slab with a minimum of 24" diameter x 4" thickness.

6. In the event a pipe line or conduit carrying fluids over the levee breaks and the escaping fluid infiltrates the earth levee so as to reduce

the compaction or destroy the protective vegetation, the applicant responsible for the pipe line or conduit shall remove and replace the affected portion of the levee embankment and replace the protective vegetation covering with new sod.

7. In the event a pipe line becomes defective and is abandoned, the entire pipe should be removed and the disturbed area recompacted and sodded.

8. During flood emergencies full cooperation shall be given the Local Operating Agency, and it reserves the right to take any action necessary to prevent water from flowing through the pipe lines or conduit into the protected area.

9. The applicant responsible for the pipe line or conduit shall be responsible for and shall repair any damage to the levee or any part of the flood protection works which is caused by the installation, repair, and maintenance of the pipe line or conduit.

10. A request including plans showing the type of construction and location of pipe lines or conduit shall be submitted to the Local Operating Agency for its approval prior to commencement of any construction operations. The Local Operating Agency shall submit the proposed permit and plans to the Corps of Engineers for approval before the issuance of the permit. No construction work shall be started until a permit has been issued by the Local Operating Agency and approved by the District Engineer of the Corps of Engineers. Ample time must be allowed for review of the proposed permit and plans. Five copies of the proposed permit, including pertinent papers and plans, must be submitted for review and approval.

11. These specifications represent the minimum requirements acceptable by the Federal Government. Additional requirements may be made or specified by the Local Operating Agency.

(NOTE: THIS SAMPLE SPECIFICATION IS SUBJECT TO CHANGE. WRITE LOUISVILLE ENGINEER DISTRICT FOR LATEST SPECIFICATIONS WHEN NEEDED)

SPECIFICATIONS FOR INSTALLATION OF DRAINAGE PIPE OR SEWERS 36" OR LESS IN DIAMETER THROUGH OR UNDER COMPLETED LEVEES
(August 1970)

1. All pipe 36 inches or less in diameter shall be cast iron or bituminous-coated corrugated metal pipe, or vitrified clay or precast concrete pipe encased in reinforced concrete. Neither corrugated metal nor concrete pipe shall be used for sewers carrying sanitary sewage. The strength of the pipe and/or encasement shall be determined by the individual installation and loading conditions. Bedding criteria shall be Marston method for projection bedding condition.

2. Excavation for pipe shall be to the flow line of the pipe only and the trench shall be shaped so that the bottom 1/3 of the pipe will be bearing on original or well compacted material. Excavations shall be adequately shored as required. Should any excavation occur below the elevation of the pipe bed, it shall be backfilled in layers not exceeding 4 inches in depth and thoroughly compacted by hand or mechanical tampers, or otherwise compacted in an approved manner, before pipe is placed. After pipe has been installed, tamping or other approved compaction shall be continued in the above specified manner until at least 24 inches of cover has been placed over the pipe. The backfill material shall be compacted so that the density will be equal to that of the surrounding levee embankment or foundation. Backfill material shall be equally as impervious as the adjacent levee or foundation material.

3. Concrete headwalls shall be placed on both ends of the pipe, except where the new pipe connects to an existing pipe, in which case a suitable concrete junction block shall be substituted for the affected headwall.

4. Riprap, if required, shall be placed adjacent to each headwall and extend approximately 10 feet outward from the outermost end of the headwall structure, and to each side on the slopes of the ditch or embankment to an elevation not less than 1 foot below the top of the headwall. Riprap shall be hand placed 12 inches deep on a bed of well graded gravel 6 inches deep, or may be a minimum of 18 inches of dumped 150# stone.

5. Pipe with less than 30 inches of cover beyond the toes of the levee shall have concrete or bituminous-coated corrugated metal seep rings installed as required for each individual case so as to increase the line of percolation at least 20 percent.

6. After the completion of all excavation and backfill, the surrounding area shall be restored to its original condition, including sodding or seeding. All restored areas shall also be fertilized and limed.

7. The pipe crossing shall be gated to prevent backflow through the levee. The basic gate installation on the crossing shall consist of a sluice gate installed in a gatewell on the riverside of the levee midway between the toe and centerline. Unless unusual conditions prevent it, the gatewell shall extend above levee surface to place top slab even with top of levee. Sluice gate operator, of rising stem type, shall be placed on top of slab, shall be provided with a stem cover tube, and shall have a gate position indicator. If other similar pipe crossings on the project are equipped with flap gates, a flap gate with bronze bushings and seat ring shall also be installed at the riverward end of the pipe. When local conditions and existing equipment warrant, deviation from the above provisions will be considered.

8. In the event a drainage line or sewer crossing under or through the levee breaks and the escaping fluid reduces the compaction of the levee embankment and destroys the protective vegetation, the applicant shall remove and replace such portion of the damaged drainage line or sewer crossing, levee embankment, and protective vegetation as may be necessary.

9. During flood emergencies full cooperation shall be given the Local Operating Agency by the applicant; however, the Local Operating Agency reserves the right to take any action necessary to prevent water from flowing through the drainage pipe or sewer into the protected area.

10. A request including plans showing the type of construction and location of drainage lines or sewers shall be submitted to the Local Operating Agency for its approval prior to commencement of any construction operations. The Local Operating Agency shall submit the proposed permit and plans to the Corps of Engineers for approval before the issuance of the permit. No construction work shall be started until a permit has been issued by the Local Operating Agency and approved by the District Engineer of the Corps of Engineers. Ample time must be allowed for review of the proposed permit and plans. Five copies of the proposed permit, including pertinent papers and plans, must be submitted for review and approval.

11. When a new gravity pipe line is to be installed through the levee the owner of the line shall furnish, with his design plan and request for permit, information as to the elevation of water (based on river gage readings) at which closure must be made to prevent damage to protected areas. This will be added to the operating sequence schedule herein as a revision to this manual.

12. These specifications represent the minimum requirements acceptable by the Federal Government. Additional requirements may be made or specified by the Local Operating Agency.

(NOTE: THIS SAMPLE SPECIFICATION IS SUBJECT TO CHANGE. WRITE LOUISVILLE ENGINEER DISTRICT FOR LATEST SPECIFICATIONS WHEN NEEDED)

SPECIFICATIONS FOR INSTALLATION OF DRAINAGE PIPE OR SEWERS LARGER THAN 36" IN DIAMETER THROUGH OR UNDER COMPLETED LEVEES

(August 1970)

1. All pipe larger than 36 inches in diameter shall be bituminous-coated corrugated metal pipe encased in reinforced concrete, monolithic concrete, or cast iron. Neither corrugated metal nor concrete pipe shall be used for sewers carrying sanitary sewage. The strength of the pipe and/or encasement shall be determined by the individual installation and loading conditions and must have flexible joints, consisting of rubber water stops and collar. Bedding criteria shall be Marston method for projection bedding condition.

2. Excavation for pipe shall be to the flow line of the pipe only and the trench shall be shaped so that the bottom 1/3 of the pipe will be bearing on original or well compacted material. Excavations shall be adequately shored as required. Should any excavation occur below the elevation of the pipe bed, it shall be backfilled in layers not exceeding 4 inches in depth and thoroughly compacted by hand or mechanical tampers, or otherwise compacted in an approved manner before pipe is placed. After pipe has been installed, tamping or other approved compaction shall be continued in the above specified manner until at least one pipe diameter or 48 inches of cover has been placed over the pipe. The backfill material shall be compacted so that the density will be equal to that of the surrounding levee embankment or foundation. Backfill material shall be equally as impervious as the adjacent levee or foundation material.

3. Concrete headwalls shall be placed on both ends of the pipe, except where the new pipe connects to an existing pipe, in which case a suitable concrete junction block shall be substituted for the affected headwall.

4. Riprap, if required, shall be placed adjacent to each headwall and extend approximately 10 feet outward from the outermost end of the headwall structure, and to each side on the slopes of the ditch or embankment to an elevation not less than 1 foot below the top of the headwall. Riprap shall be hand placed 12 inches deep on a bed of well graded gravel 6 inches deep, or may be a minimum of 18 inches of dumped 150# stone.

5. Pipe with less than 30 inches of cover beyond the toes of the levee shall have concrete or bituminous-coated corrugated metal seep rings installed as required for each individual case so as to increase the line of percolation at least 20 percent.

6. After the completion of all excavation and backfill, the surrounding area shall be restored to its original condition, including sodding or seeding. All restored areas shall also be fertilized and limed.

7. The pipe crossing shall be gated to prevent backflow through the levee. The basic gate installation on the crossing shall consist of a sluice gate installed in a gatewell on the riverside of the levee midway between the toe and centerline. Unless unusual conditions prevent it, the gatewell shall extend above levee surface to place top slab even with top of levee. Sluice gate operator, of rising stem type, shall be placed on top of slab, shall be provided with a stem cover tube, and shall have a gate position indicator. To expedite closing, on sluice gate 42" through 54", an electrical outlet shall be provided on the top of gate well to permit use of a portable electric operator. Permittee shall either provide the Levee Authority with a portable operator or, if they already have one, with a chuck to adapt it to the gate operator. For sluice gate 60" and larger, sluice gate operator shall have an integral electric motor device (limitorque type). If other similar pipe crossings on the project are equipped with flap gates, a flap gate with bronze bushings and seat ring shall also be installed at the riverward end of the pipe. When local conditions and existing equipment warrant, deviation from the above provisions will be considered.

8. In the event a drainage line or sewer crossing carrying fluids under or through the levee breaks and the escaping fluid reduces the compaction of the levee embankment and destroys the protective vegetation, the applicant shall remove and replace such portion of the damaged drainage line or sewer crossing, levee embankment, and protective vegetation as may be necessary.

9. During flood emergencies full cooperation shall be given the Local Operating Agency by the applicant; however, the Local Operating Agency reserves the right to take any action necessary to prevent water from flowing through the drainage pipe or sewer into the protected area.

10. A request including plans showing the type of construction and location of drainage lines or sewers shall be submitted to the Local Operating Agency for its approval prior to commencement of any construction operations. The Local Operating Agency shall submit the proposed permit and plans to the Corps of Engineers for approval before the issuance of the permit. No construction work shall be started until a permit has been issued by the Local Operating Agency and approved by the District Engineer of the Corps of Engineers. Ample time must be allowed for review of the proposed permit and plans. Five copies of the proposed permit, including pertinent papers and plans, must be submitted for review and approval.

11. When a new gravity pipe line is to be installed through the levee the owner of the line shall furnish, with his design plan and request for permit, information as to the elevation of water (based on river gage readings) at which closure must be made to prevent damage to protected areas. This will be added to the operating sequence schedule herein as a revision to this manual.

12. These specifications represent the minimum requirements acceptable by the Federal Government. Additional requirements may be made or specified by the Local Operating Agency.

PERMIT

_____
(Name of Operating Commission, City or State)

_____
(Location)

Permission is hereby given to:

_____
(Name of Firm or Individual) (Address)

TO: (Describe in these spaces the proposal, including kind and type of construction purpose intended, location by stationing. Indicate passageway provided by means of gates, etc. Use separate sheets if necessary, identifying each by reference herein.)

_____

_____

_____

_____

Provided That:

Upon termination or expiration of this permit (whether by voluntary relinquishment by the permittee, by revocation by the permitter or otherwise) the permittee shall remove all structures, improvements, or appurtenances which may have been erected or constructed under this permit, and shall repair or replace any portion of the flood protection structure or right-of-way which may have been damaged by his operations (including grading and seeding, or sodding, if necessary), to the satisfaction of the permitter.

The structure or operation for which this permit is issued shall be maintained by the permittee in such manner as shall not injure or damage the flood protection structure, or interfere with its operation and maintenance in accordance with regulations of the Secretary of the Army.

The structure or operation covered by this permit may be damaged, removed or destroyed by the permitter in time of flood emergency if such action is determined by the permitter to be necessary in order to preserve life or property or prevent damage or impairment to the use or safety of the flood protection structure, and the permitter shall not be liable to the permittee for such damage or destruction.

Unless otherwise specifically provided herein, this permit may be cancelled at any time by the permitter upon 10 days written notice mailed to the address shown above. During such 10 day period, (or such other period as may be provided herein), the permittee will be permitted to remove any property or improvements installed under this permit, and to repair or replace any damage to the flood protection right-of-way or structures resulting from his use or operations. At the end of such period, the permitter shall have the right to possess and dispose of any such property or improvements remaining upon its right-of-way, and may proceed to repair or replace any such damage, and the permittee herein shall be liable to the permitter for the full cost of such repairs or replacements.

The construction, installation and maintenance of the structure or structures covered by this permit shall be subject to inspection by representatives of the permitter and the United States at all reasonable times.

In the event the work covered by this permit consists of or includes major construction, the cost of inspection thereof by the permitter and/or the United States shall be paid by the applicant.

Permittee agrees that it will not use the area or facilities covered by this permit, or permit such area to be used, for any purpose other than is specifically covered by this permit.
(Use these spaces for special conditions applicable to this permit.)

_____

_____

_____

THIS PERMIT SHALL NOT BE VALID UNTIL APPROVED BY THE DISTRICT ENGINEER, CORPS OF ENGINEERS, U. S. ARMY, OR HIS AUTHORIZED REPRESENTATIVE.

_____ _____ _____
Signature on behalf of local interest (Title) (Date)
Approved:

Terms of this
permit are hereby accepted

_____ _____
Signature (Permittee) (Date)

Approved:

_____ _____
District Engineer (Date)
Louisville District
Corps of Engineers

By: _____

ORL FORM 803
18 August 1971

Operations

PADUCAH, KENTUCKY

FLOOD PROTECTION PROJECT

Name and Location of Project	=	Paducah, Kentucky
Name of River	=	Ohio
Type of Protection	=	Earth Levee and Concrete Wall
Reference Gage	=	U.S.G.S. Automatic Gaging Station Foot of Jefferson Street Paducah, Kentucky
Elevation of Zero of Gage	=	286.26 (U.S.E.D. datum) (U.S.G.S. Survey Adj.)
Beginning of Operation Gage	=	20.0 feet
Stage top of Levee	=	63.8 feet

Crest Stages of Major Floods and Dates

1884	1913	1937	1943	1945	1950	1951	1964
54.2	54.3	60.6	46.0	50.3	53.3	42.8	49.3

RIVER STAGE FORECASTS

* Prepared by National Weather Service, NOAA, Cairo, Illinois

* Telephone Number: (618) 734-0216

PUMPING PLANT OPERATIONS REPORT

PROJECT _____ DATE _____

PUMPING PLANT NO. _____ SHIFT _____

WEATHER _____ RIVER STAGE WHEN PLANT IS PUT IN OPERATION _____

PUMP NO.	START		STOP		PUMPING TIME	VOLTS	AMPS.	TIME OILED	TIME GREASED	AUTO-MATIC	MAN-UAL
	TIME	GAGE READING	TIME	GAGE READING							

(See Reverse Side for Remarks)

PUMP NO.	START		STOP		PUMPING TIME	VOLTS	AMPS.	TIME OILED	TIME GREASED	AUTO-MATIC	MANUAL
	TIME	GAGE READING	TIME	GAGE READING							

REMARKS: _____

_____

_____

_____

_____

_____
Operator's Signature

_____
Supervisor's Signature

NOTES:

1. Readings shall be taken when starting or stopping a pump and at the beginning of each shift.
2. Note any unusual occurrence in remarks.

INSPECTION REPORT FORMS

FLOOD PROTECTION WORKS - PADUCAH, KENTUCKY

1. Forms similar to the sample inspection report forms contained herein are to be used in submitting reports to the District Engineer covering inspection, maintenance and operation of the protective works. All information desired and all remarks shall be given precisely and accurately. Additional sheets and sketches should be added where necessary to clearly convey the submitted information.

2. Inspection of the features comprising the protection system shall be made as indicated below and as may otherwise be required by regulations.

3. Inspections of the pumping plants shall be made monthly from December to May, inclusive, and in July and October. Each item of pumping equipment shall be trial-operated during inspections in October, January, April, and July.

4. Inspection of the remainder of the works (levees, floodwalls, drainage structures, closure structures, and other miscellaneous facilities) shall be made in October, January, April, and July.

5. Inspection should be made at the beginning of the months designated above.

6. Semiannual reports covering inspection, maintenance and operation of the protection works shall be submitted in October and April. These reports shall include all logs of operation and dated copies of all inspection checklists made during the period covered by the reports. See paragraphs 3-11 and 3-12 of this manual.

INSPECTION REPORT

FLOOD PROTECTION WORKS - PADUCAH, KENTUCKY

SUMMARY OF LEVEE, FLOOD WALL AND DRAINAGE STRUCTURES

1. Date of this inspection report _____
2. Date of last inspection report _____
3. Levee:
   a. Unusual occurrences or remarks concerning levee inspection _____
   _____
   _____
   b. The following repairs have been revealed as necessary by the levee inspection (inclose rough plan of anticipated repairs or explain) _____
   _____
   _____
4. Flood Wall:
   a. Unusual occurrences or remarks concerning flood wall inspection ___
   _____
   _____
   b. The following repairs have been revealed as necessary by the flood wall inspection (inclose rough plan of anticipated repairs or explain)
   _____
   _____
5. Drainage Structures:
   a. Unusual occurrences or remarks concerning drainage structures inspection _____
   _____
   b. The following repairs have been revealed as necessary by the drainage structures inspection (inclose rough plan of anticipated repairs or explain) _____
   _____
6. At what date (state specific date) will the local operating agency perform the above repairs? _____
7. Remarks and explanations _____
8. Number of additional sheets _____

Signed _____
Superintendent of Flood Protection Works, Paducah, Kentucky.

Note: Where additional space is required for any item listed above use the reverse side of this sheet or additional sheets.

INSPECTION REPORT AND CHECK LIST

FLOOD PROTECTION WORKS - LEVEE

PROJECT _____

THIS INSPECTION COVERS STATION * _____ TO * _____

	Location, Station	Condition	Type of Maintenance Required
1. Settlement or loss of grade.			
2. Bank caving (either side of levee).			
3. Rain, wave or current wash.			
4. Seepage, sloughing, saturated areas or sandboils.			
5. Have these areas (4) been marked on the ground?			
6. Low spots, ponding areas.			
7. Crown of levee			
8. Riprap			
9. Crib Walls			
10. Acess roads and road ramps, surfacing			
11. Grass or sod on crown, slopes and berms.			
12. Weeds or undesirable vegetation.			

* Insert name of street, gate number, railroad or other descriptive levee landmark.

LEVEE

	Location, Station	Condition	Type of Maintenance Required
13. Accumulation of drifts, trash, or debris			
14. Damage due to fire			
15. Damage due to rodents			
16. Damage due to livestock			
17. Trespassing on right-of-way (encroachment, excavation, dumping or construction)			
18. Miscellaneous (describe)			

19. Unusual occurrences, remarks, or explanation concerning levee inspection _____

20. The following necessary repairs have been revealed by the levee inspection. (Inclose rough plan of anticipated repairs or explain.) _____

21. Date of last inspection _____

22. Date of this inspection _____

Signed _____
Superintendent of Flood Protection Works.

INSPECTION CHECK LIST

FLOOD PROTECTION WORKS

CONCRETE FLOOD WALL

Sheet 1 of 2 Sheets

	Location, Station	Condition	Type of Maintenance Required
1. Settlement			
2. Bank Caving			
3. Seepage, saturated areas or sandboils			
4. Have these areas (3) been marked on the ground?			
5. Grass or sod on berm			
6. Accumulation of drift, trash or debris			
7. Bituminous monolith joints			
8. Concrete at joints			

OVL Form 124
15 Feb. 1950

Engrg.

CONCRETE FLOOD WALL Sheet 2 of 2 Sheets

	Location, Station	Condition	Type of Maintenance Required
9. Concrete, wall (cracking, spalling or breaking)			
10. Evidence of fires being built near wall			
11. Tresspassing on right-of-way (encroachment, excavation, dumping or construction.)			
12. Miscellaneous (describe)			

No. of additional sheets _____

13. Date of last Inspection _____

14. Date of This Inspection _____

15. Inspector _____

INSPECTION CHECK LIST

FLOOD PROTECTION WORKS - PADUCAH, KENTUCKY

DRAINAGE STRUCTURES

	Condition	Maintenance Required
A. Gravity discharge pipes, silting and headwall.		
1. Sta. 157/63-A		
2. Sta. 151/25-A		
3. Sta. 147/25-A		
4. Sta. 130/00-A		
5. Sta. 111/67-A		
6. Sta. 84/00-A		
7. Sta. 175/40-B		
8. Sta. 128/61-B		
9. Sta. 80/00-B		
10. Sta. 19/11-B		
11. Sta. 7/54-B		
12. Sta. 3/91-B		
13. Sta. 291/75-C		
14. Sta. 254/06-C		
15. Sta. 244/65-C		
16. Sta. 244/17-C		
17. Sta. 223/57-C		
18. Sta. 217/35-C		
19. Sta. 200/55-C		
20. Sta. 199/80-C		
21. Sta. 176/90-C		
22. Sta. 172/08-C		
23. Sta. 176/47-C		
24. Sta. 150/05-C		
25. Sta. 92/70-C		
26. Sta. 51/28-C		
27. Sta. 32/38-C		
28. Sta 32/12-C		

	Condition	Lubrication	Maintenance Required
B. Flap Gates:			
1. Sta. 200+35-A			
2. Sta. 157+63-A			
3. Sta. 151+25-A			
4. Sta. 147+25-A			
5. Sta. 130+00-A			
6. Sta. 130+00-A			
7. Sta. 111+67-A			
8. Sta. 175+40-B			
9. Sta. 80+00-B			
10. Left bank Island Creek, Yeiser St. Sewer			
11. Sta. 74+40-B1			

	Condition	Lubrication	Maintenance Required
B. Flap Gates: (Continued)			
12. Sta. 69+86-B1			
13. Sta. 57+98-B1			
14. Sta. 28+52-B1			
15. Sta. 19+11-B			
16. Sta. 7+54-B			
17. Sta. 3+91-B			
18. Sta. 108+58-B2			
19. Sta. 115+27-B2			
20. Sta. 119+37-B2			
21. Sta. 123+61-B2			
22. Sta. 128+61-B2			
23. Sta. 150+38-B2			
24. Manhole at Bridge & Locust Streets			
25. Sta. 291+75-C			
26. Sta. 254+06-C			
27. Sta. 244+65-C			
28. Sta. 244+50-C			
29. Sta. 224+17-C			
30. Sta. 223+57-C			
31. Sta. 217+35-C (north gate)			
32. Sta. 217+35-C (south gate)			
* 33. Sta. 206+95-C			
34. Sta. 200+55-C			
35. Sta. 199+80-C			
36. Sta. 176+90-C			
37. Sta. 176+47-C			
38. Sta. 172+08-C			
39. Sta. 150+05-C			
* 40. Sta. 125+95-C			
41. Sta. 92+70-C (north gate)			
42. Sta. 92+70-C (south gate)			
43. Sta. 51+28-C			
C. Sluice Gates:			
1. Pine St. Diversion Sewer (shear gate)			
2. M.H. No. 23-B2, Sta. 66+27-A			
3. M.H. No. 24-B2, Sta. 66+17-A			
4. Sta. 187+34-A			
5. M.H. No. 20-B2, Sta. 161+66-B			
6. M.H. No. 21-B2, Sta. 161+66-B			
7. M.H. No. 16-B2, Sta. 150+60-B			
8. M.H. No. 15-A, Sta. 149+72-B2			
9. M.H. No. 15-B2, Sta. 149+69-B			
10. M.H. No. 13-P, Sta. 145+92-B			
11. M.H. No. 14-B2, Sta. 145+92-B			
12. M.H. No. 12-P, Sta. 145+61-B			
13. M.H. No. 13-B2, Sta. 145+61-B			
14. M.H. No. 25-B2, Sta. 135+00-B			
15. M.H. No. 12-B2, Sta. 131+73-B		(Closed Permanently)	
16. M.H. No. 1-P, 2nd & Jefferson Sts.			
17. M.H. No. 2-P, 2nd & Jefferson Sts.			
18. M.H. No. 11-B2, Sta. 128+61-B			
19. M.H. No. 3-P, 2nd St. & Broadway			
20. M.H. NO. 4-P, 2nd St. & Broadway			

	Condition	Lubrication	Maintenance Required
C. Sluice Gates: (Continued)			
21. M.H. No. 8-B2, Sta. 123+61-B			
22. M.H. No. 5-P, 2nd St. & Kentucky Ave.			
23. M.H. No. 6-P, 2nd St. & Kentucky Ave.			
24. M.H. No. 7-B2, Sta. 119+45-B			
25. M.H. No. 7-P, 2nd & Washington Sts.			
26. M.H. No. 8-P, 2nd & Washington Sts.			
27. M.H. No. 6-B2, Sta. 115+26-B			
28. M.H. No. 6-A, Sta. 115+06-B2			
29. M.H. No. 3-B2, Sta. 108+58-B (54" gate)			
30. M.H. No. 3-B2, Sta. 108+58-B (north 36" gate)			
31. M.H. No. 3-B2, Sta. 108+58-B (south 36" gate)			
32. M.H. No. 2-B2, Sta. 99+70-B			
33. M.H. No. 1-B2, Sta. 90+36-B			
34. M.H. No. 14-P, Sta. 90+36-B			
35. M.H. No. 6-B1, Sta. 74+40-B			
36. M.H. No. 5-B1, Sta. 69+86-B			
37. M.H. No. 4-B1, Sta. 57+98-B			
38. M.H. No. 2-B1, Sta. 28+49-B			
39. M.H. No. 1-B1, Sta. 26+87-B			
40. Sta. 32+38-C (north gate)			
41. Sta. 32+38-C (center gate)			
42. Sta. 32+38-C (south gate)			
43. Sta. 32+12-C (north gate)			
44. Sta. 32+12-C (south gate)			
45. Sta. 219+80-C			

	Condition	Maintenance Required
D. Gate Valves:		
1. M.H. No. 6-B2, Sta 115+26-B		
2. Sta. 80+00-B		

	Location	Condition	Maintenance Required
E. Condition of pipes, manholes and inlets:			
1. Pine St. Diversion Sewer			
2. 2nd St. Interceptor			
3. Yeiser St. Diversion Sewer			
4. Sta. 291+79-C, discharge pipe for pump			
5. Other sewers and drains			

F. Date of last inspection _____

G. Date of this inspection _____

H. Inspector _____

INSPECTION CHECK LIST

FLOOD PROTECTION WORKS - PADUCAH, KENTUCKY

CLOSURE STRUCTURES

Location _____

1. ABUTMENTS:

   a. Concrete _____

   b. Gate recess _____

   c. Guard rail and chains _____

   d. Hook bolts _____

2. SILL:

   a. Road surface _____

   b. Gate recess _____

   c. Anchor recess _____

3. VAULT:

   a. Doors, louvers and lock _____

   b. Floor _____

   c. Walls _____

   d. Roof _____

   e. Hook and chain assembly _____

   f. Gate erection diagram _____

INSPECTION REPORT

FLOOD PROTECTION WORKS - PADUCAH, KENTUCKY

SUMMARY OF GATE CLOSURES

1. Date of this inspection _____

2. Date of last inspection _____

Approx. Station	Type Closure	Date inspection since last report	Date last parts inventory	Date last erected
140/46-A	Railroad			
2/87-B	Service			
3/21-B	Service			
4/30-B	Railroad			
5/35-B	Railroad			
9/44-B	Roadway			
10/40-B	Roadway			
15/32-B	Service			
25/15-B	Railroad			
26/90-B	Roadway			
29/80-B	Railroad			
31/01-B	Roadway			
31/51-B	Railroad			
36/85-B	Roadway			
51/87-B	Roadway			
54/38-B	Roadway			
62/84-B	Railroad			
*69/64-B	Roadway			
71/75-B	Railroad			
73/31-B	Service			
75/85-B	Railroad			
79/27-B	Service			
83/92-B	Railroad			
90/39-B	Roadway			
91/96-B	Roadway			
93/57-B	Roadway			
94/64-B	Roadway			
98/89-B	Roadway			
103/64-B	Roadway			
106/10-B	Roadway			
108/53-B	Roadway			
114/99-B	Roadway			
119/63-B	Roadway			
119/93-B	Service			
123/50-B	Service			
123/80-B	Roadway			
124/10-B	Service			
128/20-B	Railroad			
132/41-B	Roadway			
135/23-B	Railroad			
137/93-B	Service			

Approx. Station	Type Closure	Date inspection since last report	Date last parts inventory	Date last erected
138+23-B	Roadway			
138+54-B	Service			
145+74-B	Roadway			
149+57-B	Service			
149+87-B	Roadway			
150+18-B	Service			
156+96-B	Service			
157+26-B	Roadway			
157+57-B	Service			
161+53-B	Roadway			
166+49-B	Roadway			
170+04-B	Railroad			
104+96-C	Railroad			

3. Unusual occurrences or remarks concerning inspections, inventories or erections of the gate closure and storage vaults _____

4. Has the regular erection personnel been changed? (If changes have been made submit revised list of personnel).

5. The following necessary repairs have been revealed by the inspections. (Inclose rough plan of expected repairs or explain). _____

6. At what date (state specific date) will the operating agency perform the above repairs? _____

7. Remarks and explanations _____

Signed _____
Superintendent of Flood Protection Works

INSPECTION REPORT
FLOOD PROTECTION WORKS - PADUCAH, KY.
CLOSURE STORAGE VAULTS

CLOSURES

ITEM	STA. 1+00/6+-8			STA. 8+50-8 STA. 9+35-8			STA. 9+44-8 STA. 10+40-8			STA. 25+15-8			STA. 25+90-8			STA. 29+80-8 STA. 31+21-8 STA. 34+85-8			STA. 31+51-8 STA. 71+75-8 STA. 62+84-8 STA. 75+85-8		
	SIZE OR MARK	NO. REQ'D.	OR NAMO	SIZE OR MARK	* NO. REQ'D.	OR NAMO	SIZE OR MARK	* NO. REQ'D.	OR NAMO	SIZE OR MARK	NO. REQ'D.	OR NAMO	SIZE OR MARK	NO. REQ'D.	OR NAMO	SIZE OR MARK	* NO. REQ'D.	OR NAMO	SIZE OR MARK	* NO. REQ'D.	OR NAMO
Anchor Shoe Plug	SP	1	-	SP	1	-	-	-	-	SP	1	-	SP	1	-	-	-	-	SP	1	-
Bracing Angle (Diagonal)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bracing Angle (Horizontal)	-	-	-	-	-	-	-	-	-	-	-	-	3/8" X 3-1/4"	1	-	-	-	-	3/8" X 3-1/4"	1	-
Cotter Pin	5/8" X 5-1/4"	1	-	3/8" X 7-1/4"	1	-	-	-	-	3/8" X 5-1/4"	1	-	-	-	-	-	-	-	-	-	-
Cotter Pin	-	-	-	-	-	-	-	-	-	-	-	-	12"-0"	1	-	-	1	-	12"-0"	1	-
Ladder	15'-0"	1	-	16'-0"	1	-	16'-0"	1	-	13'-0"	1	-	2-1/4" X 5-3/8" (MT 6)	1	-	-	-	-	2-1/4" X 5-3/8" (MT 6)	1	-
Pin	2" X 4-7/8" (MT4)	1	-	2-1/4" X 5-7/8" (MT4)	1	-	-	-	-	2-1/4" X 5-3/8" (MT6)	1	-	-	-	-	-	-	-	-	-	-
Pin	-	-	-	-	-	-	-	-	-	-	-	-	10"-8" (8" WF @ 19#) TP 19	8	-	12"-10" (10" WF @ 25#) TP 1	3	-	9"-10" (9" WF @ 17#) TP 1	6	-
Purlin	10"-8" (8" WF @ 21#)	6	-	8"-2" (8" WF @ 17#)	8	-	12"-10" (10" WF @ 25#) TP18	4	-	8"-10" (8" WF @ 17#) TP1	4	-	1/2" X 1-1/2"	16	-	-	-	-	1/2" X 1-1/2"	16	-
Purlin; Nuts, Bolts & Washers, Sets	1/2" X 1-1/2"	16	-	1/2" X 1-1/2"	20	-	-	-	-	1/2" X 1-1/2"	20	-	-	-	-	3"	6	-	-	-	-
Purlin Plug	-	-	-	-	-	-	8"	4	-	-	-	-	10'-0" (ST 10)	2	-	11'-6" (ST 10)	2	-	9'-6" (ST 10)	3	-
Sealing Timber (Abutment)	10'-6" (ST 31)	2	-	12'-0" (ST 25)	2	-	12'-0" (ST 18)	2	-	12'-0" (ST 18)	2	-	-	-	-	-	-	-	-	-	-
Sealing Timber (Abutment)	10'-6" (ST 32)	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sealing Timber; Connector Links	(CL) with 2-5/8" X 8" Bolts	4	-	-	-	-	-	-	-	-	-	-	7'-6"	3	-	4'-6"	2	-	8'-6"	2	-
Sealing Timber (Sill Trench) Units	7'-3"	3	-	9'-9"	7	-	7'-6"	2	-	8'-8"	2	-	6'-3"	4	-	3'-3"	4	-	1'-3"	6	-
Sealing Timber; Wedges, Sets of 2	32"	6	-	1'-3"	8	-	1'-7"	6	-	2'-3"	6	-	1/4" X 5" X 13'-0"	2	-	1/4" X 6" X 12'-6"	2	-	1/4" X 6" X 12'-6"	2	-
Seal Strip	1/4" X 6" X 21'-6"	2	-	1/4" X 5" X 15'-0"	2	-	1/4" X 5" X 15'-0"	2	-	1/4" X 6" X 15'-0"	2	-	3'-0" X 12'-10" (CS 25)	8	-	4'-6" X 12'-10" (CS 26)	8	-	4'-6" X 12'-6" (CS 27)	8	-
Sheeting Panel	5'-3" X 23'-4" (CS 22)	5	-	3'-2-3/8" X 12'-2" (CS 22)	6	-	5'-6" X 12'-10" (CS 23)	6	-	5'-6" X 12'-10" (CS 24)	5	-	18'-6"	1	-	8'-6"	1	-	12'-10"	1	-
Stiffener Chain; with 2 Turnbuckles	18'-6"	2	-	12'-6"	1	-	6'-8"	1	-	12'-6"	1	-	10'-3-3/16" (AS 5)	1	-	-	-	-	8'-5-3/16" (AS 9)	1	-
Strut	7'-11-15/16" (AS 7)	1	-	7'-6-3/16" (AS 6)	2	-	-	-	-	8'-5-3/16" (AS 9)	2	-	3/4" X 5-1/2"	1	-	-	-	-	3/4" X 5-1/2"	1	-
Strut; Nuts, Bolts & Washers, Sets	3/4" X 1-1/2"	1	-	3/4" X 1-1/2"	2	-	-	-	-	3/4" X 3-1/2"	2	-	CT 29	1	-	-	-	-	CT 29	1	-
Truss	CT 22	1	-	CT 27	1	-	-	-	-	CT 29	1	-	C 2	1	-	-	-	-	C 2	1	-
Truss Shoe	C 2	1	-	C 2	1	-	-	-	-	C 2	1	-	2" X 8" X 11'-0"	8	-	2" X 8" X 15'-6"	8	-	2" X 8" X 9'-6"	8	-
Walkway Planking	2" X 10" X 21'-6"	2	-	2" X 8" X 8'-6"	8	-	2" X 8" X 10'-6"	4	-	2" X 8" X 9'-6"	8	-	-	-	-	-	-	-	-	-	-
Walkway Planking	2" X 12" X 21'-6"	2	-	-	-	-	-	-	-	-	-	-	9'-10-5/8" (WE 28)	2	-	11'-9-3/4" (WE 37)	1	-	8'-0-3/8" (WE 29)	2	-
Walkway Frame	11'-0" (WE 18)	5	-	7'-4-7/8" (WE 28)	2	-	11'-9-3/4" (WE 29)	1	-	7'-10-1/8" (WE 29)	2	-	-	-	-	-	-	-	-	-	-
Walkway Frame	11'-0" (WE 19)	1	-	-	-	-	-	-	-	-	-	-	1/2" X 1-1/8"	4	-	-	-	-	1/2" X 1-1/8"	4	-
Walkway Frame; Nuts & Bolts, Sets	1/2" X 1-1/8"	4	-	1/2" X 1-1/8"	4	-	-	-	-	1/2" X 1-1/8"	4	-									

* No. Req'd. Each Sta.

* No. Req'd. Each Sta.

* No. Req'd. Each Sta.

* No. Req'd. Each Sta.
** [AS 9] Sta. 31+51-8, 71+75-8, 75+85-8.
(AS 11) Sta. 62+84-8

INSPECTION REPORT

FLOOD PROTECTION WORKS PADUCAH, KY.

CLOSURE STORAGE VAULTS

CLOSURES

ITEM	STA. 54/87-9 STA. 94/38-8			STA. 49/64-8			STA. 82/92			STA. 90/39-8 STA. 109/84-8			STA. 91/86-7 STA. 154/49 3			STA. 93/67-8			STA. 94/64-8		
	SIZE OR MARK	NO. REQ'D.	ON HAND	SIZE OR MARK	* NO. REQ'D.	ON HAND	SIZE OR MARK	NO. REQ'D.	ON HAND	SIZE OR MARK	* NO. REQ'D.	ON HAND	SIZE OR MARK	* NO. REQ'D.	ON HAND	SIZE OR MARK	NO. REQ'D.	ON HAND	SIZE OR MARK	NO. REQ'D.	ON HAND
Anchor Shoe Plug	"	"	"	"	"	"	5#	3		5#	1		"	"	"	5#	3		5#	3	
Bracing Angle [Diagonal]	"	"	"	"	"	"	5'-6-1/2" (4#0 27)"	2	"	"	"	"	"	"	"	5'-4" (4#0 21)"	2		5'-3" (4#0 21)"	2	
Bracing Angle [Horizontal]	"	"	"	"	"	"	8'-6-3/8" (4#0 27)"*	4	"	"	"	"	"	"	"	5'8" X 3-1/8"	2		5'8" X 3-1/8"	2	
Cotter Pin	1/8" X 2"	2		"	"	"	7/8" X 3-1/8"	3		7/8" X 3-1/8"	1		"	"	"	"	"	"	"	"	"
Cotter Pin	3/8" X 3"	3		"	"	"	"	1	"	"	"	"	"	"	"	"	1		"	1	
Ladder	8'-0"	1		13'-0"	1		18'-0"	1		15'-0"	1		18'-0"			16'-0"	1		18'-0"	1	
Pin	1-1/8" X 5-7/16" (MT 1)	1		"	"	"	2-1/8" X 1-7/8" (MT 6)	3		2-1/8" X 5-7/8" (MT 6)	1		"	"	"	2-1/8" X 5-3/8" (MT 5)	2		2-1/8" X 5-3/8" (MT 6)	1	
Pin	2" X 4-3/16" (MT 3)	4		"	"	"	"	1	"	"	"	"	"	"	"	"	"	"	"	"	"
Purlin	6"-0-7/8" [5" WF @ 16#] TP 20	3		12'-10"[10" WF @ 22#] TP 22	2		8'-1[6-1/8" [8" WF @ 17#] TP 22	19		8'-10"[8" WF @ 17#] TP 1	8		12'-10"[12" WF @ 25#]TP 8	8		9'-3-7/8" [8" WF @ 18#] TP 3	12		7'-3-7/8" [8" WF @ 17#] TP 4	12	
Purlin; Nuts, Bolts & Washer, Sets	1/2" X 1-1/2"	12		"	"	"	1'3" X 1-1/2"	56		1/2" X 1-1/2"	20		"	"	"	1/2" X 1-1/2"	36		1/2" X 1-1/2"	36	
Purlin Plug	"	"	"	5"	8		"	"	"	"	"	"	14"-0" (ST 10)	2		"	"	"	"	"	"
Sealing Timber [Abutment]	6"-8" (ST 19)	2		8"-0" (ST 10)	2		12'-0" (ST 19)	3		11'-6" (ST 10)	2		"	"	"	14'-0" (ST 10)	2		14'-0" (ST 10)	2	
Sealing Timber [Abutment]	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
Sealing Timber; Connector Link	"	"	"	"	"	"	"	"	"	"	"	"	6"-6"	2		5'-0"	5		7'-0"	5	
Sealing Timber [Sill Trench] Brts	8'-8"	2		6"-4"	2		11'-4"	3		8'-5"	2		1'-3"	4		1'-3"	8		1'-3"	8	
Sealing Timber; wedges, Sets of 2	1'-3"	4		1'-3"	5		1'-3"	8		1'-3"	4		1/8" X 6" X 14"-0"	2		1/8" X 5" X 17'-6"	2		1/8" X 6" X 17'-6"	2	
Seal Strip	1/4" X 6" X 8'-0"	2		1/8" X 6" X 9'-6"	2		1/4" X 6" X 15'-0"	2		1/4" X 6" X 14'-0"	2		5'-4" X 15'-10" [CS 7]	4		3'-0" X 17'-4" [CS 3]	10		3'-0" X 17'-4" [CS 3]	8	
Sheeting Pans	8'-4" X 7'-10" [CS 29]	3		4'-4" X 9'-4" [CS 29]	4		5'-1-1/8" X 15'-4" [CS 30]	12		8'-4" X 19'-10" [CS 23]	5		8'-6"	1		22'-6"	1		16'-6"	1	
Stiffener Chain; with 2 Turnbuckles	12'-10"	1		8'-6"	1		39'-6"	1		12'-10"	1		"	"	"	"	"	"	"	"	"
Strut	5'-7-3/8" (AS 10)	1		"	"	"	"	"	"	8'-5-3/16" (AS 9)	2		"	"	"	"	"	"	"	"	"
Strut; Nuts, Bolts & Washers, Sets	1/2" X 1-1/2"	1		"	"	"	"	"	"	3/4" X 1-1/2"	2		"	"	"	"	"	"	"	"	"
Truss	CT 36 & CT 37 *	2		"	"	"	CT 39	7		CT 34	1		"	"	"	CT 8	2		CT 9	1	
Truss Shoe	Link Plate (LMT)	2		"	"	"	C 2	3		C 2	1		2" X 9" X 15"-0"	6		C 2	2		C 2	2	
Walkway Planking	"	"	"	"	"	"	2" X 8" X 9'-4"	5		2" X 8" X 9'-6"	8		"	"	"	1" X 8" X 10'-8"	8		2" X 8" X 8'-9"	29	
Walkway Planking	"	"	"	"	"	"	2" X 8" X 8'-11"	5		"	"	"	11'-9-3/8" (WE 37)	1		2" X 8" X 8'-6"	4		2" X 8" X 9'-6"	9	
Walkway Frame	"	"	"	"	"	"	8'-3-11-16" (WE 7)	2		8'-0-7/8" (WE 29)	2		"	"	"	8'-8-15/16" (WE 1)	4		8'-8-15/16" (WE 1)	8	
Walkway Frame	"	"	"	"	"	"	6'-0-7/8" (WE 31)	2		"	"	"	"	"	"	8'-5-7/8" (WE 49)	2		8'-2-1/8" (WE 32)	2	
Walkway Frame, Nuts & Bolts, Sets	"	"	"	"	"	"	1/2" X 1-1/8"	12		1/2" X 1-1/8"	8		"	"	"	1/2" X 1-1/8"	8		1/2" X 1-1/8"	28	

* CT 36 for Sta. 54/87-9
CT 37 for Sta. 94/38-8

* add; 15-7/8" X 1-1/2" Nuts, Bolts & Washers, Sets
** add; 16-3/8" X 1-7/8" Nuts, Bolts & Washers, Sets

* No. Req'd. Each Sta.

* add; 8-3/8" X 1-1/2" Nuts, Bolts & Washers, Sets
**add; 8-3/8" X 1-1/2" Nuts, Bolts & Washers, Sets

* add; 8-3/8" X 1-1/2" Nuts, Bolts & Washers, Sets
**add; 8-3/8" X 1-3/4" Nuts, Bolts & Washers, Sets

INSPECTION REPORT

FLOOD PROTECTION WORKS - PADUCAH, KY.

CLOSURE STORAGE VAULT

CLOSURES

ITEM	STA. 98459-B STA. 103563-B			STA. 104210-B			STA. 114759-B			STA. 116492-B STA. 123480-B			STA. 129420-B			STA. 132481-B			STA. 135623-B		
	SIZE OR MARK	NO. REQ'D.	ON HAND	SIZE OR MARK	NO. REQ'D.	ON HAND	SIZE OR MARK	NO. REQ'D.	ON HAND	SIZE OR MARK	NO. REQ'D.	ON HAND	SIZE OR MARK	NO. REQ'D.	ON HAND	SIZE OR MARK	NO. REQ'D.	ON HAND	SIZE OR MARK	NO. REQ'D.	ON HAND
Anchor Show Plug	SP	1		SP	1		SP	4		SP	2		SP	2		SP	1		SP	7	
Bracing Angle (Diagonal)	-	-	-	-	-	-	12'-3-9/16" (APD 1)	4		12'-4-1/8" (APD 2)	2		9'-9-13/16" (APD 2)	2		-	-	-	10'-10-3/16" (APD 6)	4	
Bracing Angle (Horizontal)	-	-	-	-	-		8'-11-1/16" (APH 1)	4		9'-3" (APH 2)	2		7'-3" (APD 2)	2		-	-	-	8'-2-5/8" (APH 4)	4	
Center Pin	3/8" X 3-1/4"	1		3/4" X 3-1/4"	1		5'-8" X 7-1/4"	4		3'-9" X 3-1/4"	2		3'4" X 3-1/4"	2		3'4" X 3-1/4"	1		5'4" X 3-1/4"	5	
Center Pin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ladder	18'-0"	1		14'-0"	1		18'-0"	1		18'-0"	1		18'-0"	1		14'-0"	1		18'-0"	1	
Pin	2-1/4" X 5-3/8" (PF 6)	1		2-1/4" X 5-3/8" (PF 6)	1		2-1/4" X 7-1/4" (PF 6)	4		2-1/4" X 5-3/8" (PF 6)	2		2-1/4" X 5-3/8" (PF 6)	2		2-1/4" X 5-3/8" (PF 6)	1		2-1/4" X 5-3/8" (PF 6)	3	
Pin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Purlin	41'-10" (24" WF @ 174) TP 1	8		33'-4" (24" WF @ 174) TP 25	7		8'-11-1/8" (24" WF @ 174) TP 3	29		9'-3-7/8" (24" WF @ 194) TP 7	12		7'-3-3/8" (24" WF @ 174) TP 9	12		8'-10" (24" WF @ 174) TP 1	8		8'-7-1/8" (24" WF @ 174) TP 5	14	
Purlin; Cuts, Bolts & washers, Sets	1/2" X 1-1/2"	20		1/2" X 1-1/2"	16		1/2" X 1-1/2"	108		1/2" X 1-1/2"	26		1/2" X 1-1/2"	36		1/2" X 1-1/2"	20		1/2" X 1-1/2"	54	
Purlin Plug	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sealing Timber (Abutment)	18'-0" (ST 18)	2		18'-0" (ST 18)	2		14'-9" (ST 18)	2		14'-0" (ST 18)	1		18'-0" (ST 18)	2		18'-0" (ST 18)	2		16'-8" (ST 18)	2	
Sealing Timber (Abutment)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sealing Timber; Connector Lines	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sealing Timber (Sill Trench) Bolts	8"-0"	2		7'-0"	4		7'-4"	8		9"-0"	3		7'-0"	2		8"-0"	2		11'-0"	3	
Sealing Timber; wedges, Sets of 2	8"-3"	8		1'-3"	8		1'-3"	5		1'-3"	2		1'-3"	8		1'-3"	8		1'-3"	8	
Seal Strip	3/8" X 6" X 17'-6"	2		3/8" X 6" X 17'-6"	2		3/8" X 6" X 17'-6"	2		5/8" X 8" X 17'-6"	2		1/8" X 6" X 17'-6"	2		1'-4" X 17'-4" (CS 1)	8		8'-3" X 17'-4" (CS 3)	12	
Sheeting Panel	6'-8" X 17'-4" (CS 1)	6		5'-8" X 12'-10" (CS 26)	8		7'-10" X 17'-8" (CS 2)	13		7'-0" X 17'-4" (CS 3)	10		3'-0" X 17'-4" (CS 1)	8		4'-4" X 17'-4" (CS 1)	5		8'-3" X 17'-4" (CS 3)	1	
Stiffener Plate; with 2 Turnbuckles	12"-10"	1		14'-6"	1		55'-6"	1		22'-6"	1		16'-6"	1		12'-10"	1		28'-6"	1	
Strut	6'-2-9/16" (AS 1)	2		3'7-3-7/16" (AS 1)	1		-	-	-	-	-	-	-	-	-	8'-3-3/16" (AS 9)	2		-	-	-
Strut; Nuts, Bolts & washer, Sets	3/4" X 1-1/2"	2		3/4" X 1-1/2"	1		-	-	-	-	-	-	-	-	-	3/4" X 1-1/2"	2		-	-	-
Truss	6" 16	1		6" 23	1		6" 32	4		6" 32	2		6" 15	2		6" 16	1		6" 17	3	
Truss Shoe	C 2	1		C 2	1		C 2	6		C 2	2		C 2	2		C 2	1		C 2	2	
Walkway Planking	2" X 8" X 9'-6"	6		2" X 6" X 8'-3"	8		2" X 8" X 8'-3"	20		2" X 8" X 8'-7"	4		2" X 6" X 6'-2"	4		2" X 6" X 9'-5"	8		2" X 6" X 7'-10"	9	
Walkway Planking	-	-	-	-	-	-	2" X 8" X 8'-4"	8		2" X 8" X 18'-3"	8		2" X 6" X 8'-3"	8		-	-	-	2" X 6" X 9'-0"	8	
Walkway Frame	8'-0-3/8" (WE 29)	2		9'-10-3/8" (WE 30)	2		9'-3-9/16" (WE 1)	5		8'-8-15/16" (WE 2)	1		6'-6-15/16" (WE 3)	1		8'-0-5/8" (WE 29)	1		8'-8-11/16" (WE 4)	2	
Walkway Frame	-	-	-	-	-	-	8'-7-1/4" (WE 30)	2		8'-5-7/8" (WE 30)	2		6'-5-7/8" (WE 30)	2		-	-	-	7'-9-3/8" (WE 35)	2	
Walkway Frame; Nuts & Bolts, Sets	1/2" X 1-1/4"	8		1/2" X 1-1/4"	8		1/2" X 1-1/4"	24		1/2" X 1-1/4"	8		1/2" X 1-1/4"	8		1/2" X 1-1/4"	8		1/2" X 1-1/4"	12	

* No. Req'd. Each Station

* No. Req'd. Each Station

INSPECTION REPORT
FLOOD PROTECTION WORKS – PADUCAH, KY.
CLOSURE STORAGE VAULTS

CLOSURES

ITEM	STA. 138423-B STA. 145474-B STA. 149187-B SIZE OR MARK	*NO. REQ'D.	ON HAND	STA. 157425-B SIZE OR MARK	NO. REQ'D.	ON HAND	STA. 161453-B SIZE OR MARK	NO. REQ'D.	ON HAND	STA. 170484-B SIZE OR MARK	NO. REQ'D.	ON HAND	STA. 184495-C SIZE OR MARK	NO. REQ'D.	ON HAND
Anchor Shoe Plug	SP	4		SP	4		SP	9		SP	4		SP	1	
Bracing Angle (Diagonal)	10'-10-9/16" (ABD 5)**	4		9'-5-11/16" (ABD 7)	4		11'-1-3/4" (ABD 8)	10		9'-8-5/16" (ABD 9)	4		"	-	-
Bracing Angle (Horizontal)	8'-8-3/4" (ABH 3)	4		8'-8-3/4" (ABH 7)	4		8'-9-1/2" (ABH 8)	10		8'-8-3/4" (ABH 9)	4		"	-	-
Cotter Pin	3/8" X 3-1/4"	4		3/8" X 3-1/4"	6		3/0" X 3-1/4"	9		3/8" X 3-1/4"	4		3/8" X 3-1/4"	1	
Cotter Pin	"	-	-	"	-	-	"	-	-	"	-	-	"	-	-
Ladder	18'-0"	1		16'-0"	1		18'-0"	1		15'-0"	1		11'-0"	1	
Pin	2-1/4" X 5-3/8" (PT 6)	4		2-1/4" X 5-3/8" (PT 6)	4		2-1/4" X 5-3/8" (PT 6)	9		2-1/4" X 5-3/8" (PT 6)	4		2-1/4" X 5-3/8" (PT 6)	1	
Pin	"	-	-	"	-	-	"	-	-	"	-	-	"	-	-
Purlin	8'-9-1/8" (8" WF @ 17#) TP 6	20		8'-9-1/8" (8" WF @ 17#) TP 6	20		8'-9-7/8" (8" WF @ 17#) TP 7	20		8'-9-1/8" (8" WF @ 17#) TP 6	20		10'-8" (10" WF @ 21#) TP 9	8	
Purlin; Nuts Bolts & washers, Sets	1/2" X 1-1/2"	72		1/2" X 1-1/2"	72		1/2" X 1-1/2"	162		1/2" X 1-1/2"	72		1/2" X 1-1/2"	8	
Purlin Plug	"	-	-	"	-	-	"	-	-	"	-	-	"	-	-
Sealing Timber (Abutment)	18'-0" (ST 10)	2		12'-0" (ST 10)	2		15'-0" (ST 10)	2		12'-0" (ST 10)	2		8'-6" (ST 11)	6	
Sealing Timber (Abutment)	"	-	-	"	-	-	"	-	-	"	-	-	6'-6" (ST 12)	6	
Sealing Timber; Connector Link	"	-	-	"	-	-	"	-	-	"	-	-	(CL) with 2-5/8" X 8" Bolts	6	
Sealing Timber (Silt Trench) Units	7'-0"	6		7'-0"	6		9'-0"	9		7'-0"	6		7'-0"	3	
Sealing Timber; Wedges, Sets of 2	1'-3"	8		1'-3"	8		1'-3"	8		1'-3"	8		12"	6	
Seal Strip	1/8" X 6" X 17'-6"	2		1/8" X 6" X 17'-6"	2		1/8" X 6" X 17'-0"	2		1/8" X 6" X 15'-0"	2		1/8" X 6" X 11'-0"	2	
Sheeting Panel	5'-3" X 17'-8" (CS 4)	9		5'-3" X 17'-1" (CS 5)	9		5'-3" X 16'-10" (CS 5)	17		5'-3" X 15'-1" (CS 8)	9		5'-3" X 11'-1" (CS 9)	6	
Stiffener Chain; With 2 Turnbuckles	37'-6"	1		37'-6"	1		39'-6"	1		37'-6"	1		16'-6"	1	
Strut	"	-	-	"	-	-	"	-	-	"	-	-	10'-2-13/16" (AS 2)	1	
Strut; Nuts, Bolts & Washers, Sets	"	-	-	"	-	-	"	-	-	"	-	-	3/8" X 1-1/2"	1	
Truss	CT 18, CT 19 & CT 20 ***	1		CT 31	4		CT 21	9		CT 32	4		CT 2	1	
Truss Shoe	C 2	1		C 2	4		C 2	9		C 2	4		C 2	1	
Walkway Planking	2" X 8" X 8'-0"	12		2" X 8" X 8'-0"	12		2" X 8" X 8'-1"	32		2" X 8" X 8'-0"	12		2" X 12" X 11'-0"	6	
Walkway Planking	2" X 8" X 9'-6"	8		2" X 8" X 9'-6"	8		2" X 8" X 9'-6"	8		2" X 8" X 9'-6"	8		"	-	-
Walkway Frame	8'-2-11/16" (WB 5)	3		8'-2-11/16" (WB 5)	3		8'-5-7/16" (WB 6)	8		8'-2-11/16" (WB 5)	3		10'-0-7/8" (WE 16)	1	
Walkway Frame	7'-11-3/4" (WE 36)	2		7'-11-3/4" (WE 36)	2		8'-8-5/8" (WE 29)	2		7'-11-3/4" (WE 36)	2		10'-0-7/8" (WE 17)	1	
Walkway Frame, Nuts & Bolts, Sets	1/2" X 1-1/4"	16		1/2" X 1-1/4"	16		1/2" X 1-1/4"	36		1/2" X 1-1/4"	16		1/2" X 1-1/4"	4	

* No. Req'd. Each Sta.

**10'-6-15/16" (ABD 6)
Sta. 145474-B

***CT 18 for Sta. 138423-B
CT 19 for Sta. 145474-B
CT 20 for Sta. 149187-B

INSPECTION REPORT

FLOOD PROTECTION WORKS - PADUCAH, KENTUCKY

SUMMARY OF PUMPING PLANTS

1. Date of this inspection report: _____

2. Date of last inspection report: _____

3.

Pumping Plants:	Dates of inspections since last report	Dates of pump operations since last report	Dates of Operation Logs since last report
No. 1 - Noble Park	_____	_____	_____
No. 2 - Sixth Street	_____	_____	_____
No. 3 - Park Avenue	_____	_____	_____
No. 4 - Clay Street	_____	_____	_____
No. 5 - Harrison St.	_____	_____	_____
No. 6 - Clark Street	_____	_____	_____
No. 7 - Tennessee St.	_____	_____	_____
No. 8 - Norton Street	_____	_____	_____
No. 9 - Husbands St.	_____	_____	_____
No. 10- George Street	_____	_____	_____
No. 11- Island Creek	_____	_____	_____
No. 12- Southeast of Paducah	_____	_____	_____
* No. 13- Sta. 291+75C	_____	_____	_____

4. Condition of Ponding Areas:

At Pumping Plant No. 1 _____

At Pumping Plant No. 11 _____

At Pumping Plant No. 12 _____

* At Pumping Plant No. 13 _____

5. Unusual occurrences, or remarks concerning trial operations and inspection during period covered by this report: _____

_____

_____

_____

_____

6. Has the list of key operating personnel been changed? If changes have been made submit revised list.

7. This inspection revealed the following necessary repairs. (Explain, or inclose rough plan of anticipated repairs). _____

_____

_____

8. State specific date when the local operating agency will perform the above repairs: _____

9. Remarks and explanations: _____

_____

10. No. of additional sheets: _____

Signed _____
Superintendent of Flood Protection
Works, Paducah, Kentucky

INSPECTION CHECK LIST

FLOOD PROTECTION WORKS - PADUCAH, KENTUCKY

PUMPING PLANT

1. Access road _____
2. Pumping Plant:
   a. Doors and locks _____
   b. Floor, walls, roof _____
   c. Fire Extinguisher _____
   d. Sump, ladders, paint _____
   e. Operating instructions _____
   f. Operation log forms available _____
3. Fire hazards _____
4. Grating and manhole covers _____
5. Discharge pipes _____
6. Substation and power lines _____
7. Air relief valves _____
8. Crane _____
9. Trash rack _____
10. Sluice gates _____
11. Dresser couplings _____
    a. Leaks _____
12. Wiring system:
    a. Lamps, fuses, switches _____
    b. Conduit, wire and cable, receptacles _____
    c. Sump pump _____
13. Lubrication system:
    a. Motor and pump No. 1 - General _____
       (1). Lubricator _____
    b. Motor and pump No. 2 - General _____
       (1). Lubricator _____
    c. Motor and pump No. 3 - General _____
       (1). Lubricator _____
    d. Motor and pump No. 4 - General _____
       (1). Lubricator _____
    e. Motor and pump No. 5 - General _____
       (1). Lubricator _____
    f. Motor and pump No. 6 - General _____
       (1). Lubricator _____
14. Switchgear:
    a. Control breaker, motor breakers Nos. 1,2,3,4,5 & 6 _____
    b. Control panel and protective devices _____
    c. Main disconnect switch _____
15. Motors Nos. 1,2,3,4,5 & 6 _____
16. Pumps:
    a. Pump No. 1 - General _____
       (1). Bowl, impeller, bearings _____
    b. Pump No. 2 - General _____
       (1). Bowl, impeller, bearings _____
    c. Pump No. 3 - General _____
       (1). Bowl, impeller, bearings _____

d. Pump No. 4 - General _____
(1). Bowl, impeller, bearings _____
e. Pump No. 5 - General _____
(1). Bowl, impeller, bearings _____
f. Pump No. 6 - General _____
(1). Bowl, impeller, bearings _____
g. Sump pump _____
h. Tool List _____

Plant #1 - 1 Williams #38A Open end wrench _____
1 Williams #25A Open end wrench _____
1 Williams #731 Open end wrench _____
1 Williams #474 Spanner wrench _____
1 Stuffing Box Tool C-3039-M _____

Plant #2 - 1 Williams #468 Spanner wrench _____
1 Williams #38A Open end wrench _____
1 Williams #25A Open end wrench _____
1 Williams #731 Open end wrench _____
1 Williams #508 Set Screw wrench _____
1 Stuffing Box Tool for E-4794 (C-3039-M) _____
1 Stuffing Box Tool for E-4782-3 (C-3040) _____
1 Stuffing Box Tool for E-4784-5 (C-3040) _____
1 Stuffing Box Tool for E-4892 (C-3039) (B-6605) _____
2 Williams #730 Open end wrenches _____
1 Williams #461 Spanner wrench _____
2 Williams #735 Double head wrench _____
1 Impeller Nut wrench for E-4892 (B-6648) _____
1 Williams #SD-1232 Socket Wrench _____
1 Williams #B-30 Handle for socket wrench _____
1 7" Spanner Wrench _____
1 Williams #13A Open end wrench _____
1 Williams #709 Open end wrench _____
1 Williams #702 Open end wrench _____
1 Shaft nut wrench (C-3260) for E-4782-3 _____
1 Handle and socket wrench 3-1/2" deep-opening 1-5/16" for 1" cap screws _____

Plant #3 - 1 Williams #38A Open end wrench _____
1 Williams #725A Double head engineers wrench _____
1 Williams #458 Spanner wrench _____
1 Williams #736A Open end wrench _____
2 Williams #730 Open end wrench _____
1 Williams #461 Spanner wrench _____
2 Williams #735 Double head wrench _____
1 Allen key 1/8 across flats _____
1 Face spanner for E-4895 (B6747) _____
1 Stuffing Box Tools for E-4803-4 (E-5266) _____
1 Stuffing Box Tools for E-4895 (B-6758) _____

Plant #4 - 1 Williams #731 Open end wrench _____
1 Williams #474 Spanner wrench _____
1 Williams #735 Double head wrench _____
1 Williams #40A Double head wrench _____
1 Impeller nut wrench for E-4887-8 (E-5322) _____
1 Allen hex key - 3/16 across flats _____

Plant #5 - 1 Williams #468 Spanner wrench _____
1 Williams #38A Open end wrench _____
1 Williams #25A Open end wrench _____
1 Williams #731 Open end wrench _____
1 Williams #39A Double head Engineers wrench _____
1 Williams #732 Double head wrench _____
2 Williams #730 Open end wrench _____
1 Williams #461 Spanner wrench _____
2 Williams #735 Double head wrench _____
1 Williams #709 Open end wrench _____
1 Allen hex key - 3/32" across flats _____
1 Allen hex key - 1/8" across flats _____
1 Impeller nut wrench for E-4891 (B-6848) _____
1 Stuffing Box Tool for E-4792-3 (C-3039-M) _____
1 Stuffing Box Tool for E-4801 (C-3039) _____
1 Stuffing Box Tool for #-4891 (C-3039) (B-6605) _____

Plant #6 - 1 Williams #468 Spanner wrench _____
1 Williams #38A Open end wrench _____
1 Williams #25A Open end wrench _____
1 Williams #731 Open end wrench _____
1 Williams #474 Spanner wrench _____
1 Williams #508 Set screw wrench _____
2 Williams #730 Open end wrenches _____
2 Williams #735 Double head wrenches _____
1 Williams #458 Spanner wrench _____
1 Williams #DB-1216 Socket wrench _____
1 Williams #B30 Handle for socket wrench _____
1 Williams #704 Open end wrench _____
1 Williams #8A Open end wrench _____
1 Allen set screw key - 1/8" across floats _____
1 Face spanner for E-4894 (B6747) _____
1 Stuffing Box Tool for E-4797 (C-3039-M) _____
1 Stuffing Box Tool for E-4789-90-91 (C-3040) _____
1 Stuffing Box Tool for E-4894 (B-6758) _____

Plant #7 - 1 Williams #38A Open end wrench _____
1 Williams #25A Open end wrench _____
1 Williams #731 Open end wrench _____
1 Williams #474 Spanner wrench _____
1 Williams #725A Double head Engineers wrench _____
1 Williams #736A Open end wrench _____
1 Williams #730 Open end wrench _____
1 Williams #461 Spanner wrench _____
2 Williams #735 Double head wrench _____
1 Williams #709 Open end wrench _____
1 Allen key - 3/32" across flats _____
1 Allen key - 1/8" across flats _____
1 B-6747 - Face spanner wrench _____
1 E-5322 - Impeller nut wrench for E-4893 _____
1 Stuffing Box Tool for E-4798 (C-3039-M) _____
1 Stuffing Box Tool for #-4802 (C-5266) _____
1 Stuffing Box Tool for #-4893 (C-3039) (B-6605) _____

Plant #8 - 1 Williams #731 Open end wrench _____
1 Williams #730 Open end wrench _____
1 Williams #37A Double head wrench _____
1 Williams #472 Adj. hook spanner _____
1 Allen Key - 1/8" across flats _____
1 "T" wrench for 7/8" impeller nut-- 1-1/4 across flats _____

Plant #9 - 1 Williams #725A Double head engineers wrench _____
1 Williams #732 Double head engineers wrench _____
1 Williams #462 Pin spanner wrench _____
1 Williams #40A Double head wrench _____
1 Williams #729 Double head wrench _____
1 Williams #733 Double head wrench _____
1 Williams #37A Double head wrench _____
1 Impeller nut wrench E-5322 _____
1 Stuffing Box Tool B-6605-A _____

Plant #10 - 1 Williams #725A Double head wrench _____
1 Williams #730 Open end wrench _____
1 Williams #37A Double head wrench _____
1 Williams #474 Adj. hook spanner _____
1 Face spanner #B-6747 _____
1 Allen Key 1/8 across flats _____

Island Creek - 1 Williams #468 Spanner wrench _____
1 Williams #38A Open end wrench _____
1 Williams #508 Set screw wrench _____
1 Stuffing Box Tool (C-3040) _____
1 Williams #BD 1216 socket wrench _____
1 Williams #B-30 handle for socket wrench _____
1 Williams #704 Open end wrench _____

Plant #12 - 1 Williams #39A Double head wrench _____
1 Williams #725A Double head wrench _____
1 Williams #508 Set screw wrench _____
1 Stuffing Box Tool #3039 _____
1 Williams #705 Single head wrench _____
1 Williams #462 Pin spanner wrench _____

17. Equipment or parts in need of repair or replacement _____

18. Moisture conditions in pumping plant _____
19. Weather conditions and temperature _____
20. Remarks and explanation _____
21. Date of last inspection _____
22. Dates of pump operations since last inspection (trial and flood) _____

23. Were pumps operated during this inspection _____
24. Date of this inspection _____
25. Inspector _____

LIST OF CORPS OF ENGINEERS DRAWINGS

FLOOD PROTECTION WORKS - PADUCAH, KENTUCKY

"As Built" construction drawings prepared by the Corps of Engineers, plans, specifications, bulletins and instructions prepared by the equipment manufacturers are listed in this appendix. A complete set of prints has been delivered to the City of Paducah and constitutes a part of the Operation and Maintenance Manual. The original drawings prepared by the Corps of Engineers are on file at the District Office, Louisville, Kentucky.

Drawing Nos.	Title or Subject
Levees - General	
933-12.3/9	Typical sections
934-12.2/6 (Sect. A)	Typical sections
934-12.2/7 (Sect. C)	Typical sections
935-12.2/17	Typical sections
934-12.2/17.1 (Sect. A)	Ramps
934-12.2/37 (Sect. C)	Ramps
934-C1/2	Ramps
Levee - Section A	
934-12.2/1 (Sect. A)	General plan
2 - 3 - 4.1 & 5 (Sect. A)	Plan and profile
934-C1/1	Plan and profile
Levee - Section B-2	
935-12.2/1	General plan
9 - 10 & 11	Plan and profile
Levee - Section B-1	
933-12.3/1	General plan
3	Plan and profile
934-1[illegible].5/2	Plan and profile
Levee - Section C	
934-12.2/1 (Sect. C)	General plan
2 - 3 - 4 - 5 - 6 & 7 (Sect. C)	Plan and profile
Concrete Wall - Section B-2	
935-12.2/1	General plan
2 - 3 - 4 - 5 - 6 - 7 - 8 & 9	Plan and profile
934-A2/2	Plan and profile
935-12.2/22	Typical sections

Drawing Nos.	Title or Subject
Concrete Wall - Section B-1	
933-12.3/1	General plan
2 - 3 - 4 - 5 - 6 - 7 - 8 & 9	Plan and profile
934-12.5/2	Plan and profile
Closure Structures - General	
933-12.3/19	Service opening bulkhead & frame details
935-12.2/26	Service opening bulkhead & frame details
96 - 97 - 99 - 102 - 103 - 104 - 105 - 106 - 107 - 108 & 109	Closure parts
933-12.3/98 & 99	Closure parts
934-C1/3	Closure parts
Closure Structure - Section A	
934-12.2/25 (Sect. A)	Sta. 190+46 & storage vault
Closure Structures - Section B-2	
934-12.3/90	Sta. 90+39
934-A2/3	Sta. 91+96 & storage vault
5	Sta. 93+57 & Sta. 94+64
935-12.2/59	Sta. 98+89, Sta. 108+53 & storage vaults
48	Sta. 103+64 & storage vault
62	Sta. 106+10 & storage vault
64	Sta. 114+99 & storage vault
67	Sta. 119+63 & Sta. 123+80
70	Sta. 128+20 & storage vault
72	Sta. 132+41 & storage vault
75	Sta. 135+23 & storage vault
80	Sta. 138+23 & storage vault
78	Sta. 145+74
81	Sta. 149+87 & storage vault
84	Sta. 157+26 & storage vault
87	Sta. 161+53
89	Sta. 166+49 & storage vault
92	Sta. 170+04 & storage vault
69	Storage vaults
934-12.3/93 & 94	Storage vaults
Closure Structures - Section B-1	
933-12.3/69	Sta. 4+50, Sta. 5+35 & storage vaults
72	Sta. 9+44, Sta. 10+40 & storage vaults
75	Sta. 25+15
79	Sta. 26+90
81	Sta. 29+80, Sta. 31+01, Sta. 36+85 & storage vaults

Drawing Nos.	Title or Subject
	Closure Structures - Section B-1 (Continued)
933-12.3/84	Sta. 31+51, Sta. 71+75, Sta. 75+85 & storage vaults
87	Sta. 51+87, Sta. 54+38 & storage vaults
89	Sta. 62+84 & storage vault
94	Sta. 67+73 & Sta. 69+64
96	Sta. 83+92 & storage vault
77 & 92	Storage vaults
	Closure Structure - Section C
934-12.2/31.1 (Sect. C)	Sta. 104+96 & storage vault
	Drainage Structures - Section A
934-12.2/7 (Sect. A)	Drainage structure, Sta. 84+00
8 (Sect. A)	Drainage structure, Sta. 111+67
10 (Sect. A)	Drainage structure, Sta. 130+00
11 (Sect. A)	Drainage structure, Sta. 147+25
12 (Sect. A)	Drainage structure, Sta. 151+25
13 (Sect. A)	Drainage structure, Sta. 157+63
934-19.2/13.1	Drainage structure, 10th & Pine Sts.
934-12.3/14	Discharge headwall, Sta. 159+40
30	Discharge headwall, Sta. 66+90
935-12.2/121.1	Sewer at Sta. 66+27
122.1	Manhole No. 23-B2
123.1	Manhole No. 24-B2
934-12.2/6 (Sect. A)	Catch basins
17.1 (Sect. A)	Drainage at ramps
934-19.2/13.1	Drainage at ramps, catch basins
	Drainage Structures - Section B-2
935-12.2/124	Drainage structure, Sta. 175+40
112	Manhole No. 1
113	Manhole Nos. 2, 8, 12, 15 & 25
114	Manhole No. 3
116	Manhole No. 21 & miscellaneous manholes
117	Manhole Nos. 6 & 16
118	Manhole Nos. 7 & 11
119	Manhole Nos. 13 & 14
120.1	Manhole No. 20
934-A1/1	Manhole Nos. 12-P & 13-P
2	Manhole No. 14-P
934-18.3/3	Manhole No. 16
935-12.2/110	Catch basins
934-A2/6	Catch basins

Drawing Nos.	Title or Subject
	Drainage Structures - Section B-1
933-12.3/112	Drainage Structures, Sta. 3/91 & Sta. 7/54
110	Drainage structures, Sta. 19/11
934-19.2/10	Drainage structures, Sta. 19/11
933-12.3/101	Drainage structures, Sta. 80/00; catch basins
102 & 103	Catch basins
104	Manhole No. 1
105	Manhole No. 2
107	Manhole No. 4
108	Manhole No. 5
109	Manhole No. 6
106	Miscellaneous manholes
934-18.3/3	Miscellaneous manholes
934-19.2/11	Yeiser St. diversion sewer
	Drainage Structures - Section C
934-12.8/30 - 31 & 32	Drainage structure, Sta. 32/38
934-CM/1 & 2	Drainage structure, Sta. 32/38
934-19.2/3	Drainage structure, Sta. 32/38 & Sta. 32/12
6 & 7	Drainage structure, Sta. 217/35
934-12.2/24 (Sect. C)	Drainage structure, Sta. 217/35
11 & 13 (Sect. C)	Drainage structure, Sta. 32/12
14 (Sect. C)	Drainage structure, Sta. 51/28
15 (Sect. C)	Drainage structure, Sta. 92/70
17 (Sect. C)	Drainage structure, Sta. 150/05
18 (Sect. C)	Drainage structure, Sta. 172/08
19 (Sect. C)	Drainage structure, Sta. 176/47
20 (Sect. C)	Drainage structure, Sta. 176/90
22 (Sect. C)	Drainage structure, Sta. 199/80
23 (Sect. C)	Drainage structure, Sta. 200/55
25 (Sect. C)	Drainage structure, Sta. 223/57
26 (Sect. C)	Drainage structure, Sta. 224/17
27 (Sect. C)	Drainage structure, Sta. 244/65
28 (Sect. C)	Drainage structure, Sta. 254/06
29 (Sect. C)	Drainage structure, Sta. 291/75
35 (Sect. C)	Culvert, Sta. 0/90
37 (Sect. C)	Drainage at ramps
934-12.3/83	Discharge headwall, Sta. 175/20
934-19.2/8	Portable pumping facilities at Sta. 291/75
* 9.1	Manhole at Bridge & Locust Sts.
13.1	Pine St. Div. Sewer
14	Dehumid. Equip.
933-12.5/1	Loc. Plan
2	M.H. 3-A & 4-A
3	M.H. 6-A & 7-A
4	M.H. 15-A & 16-A
5	M.H. 2-A & 8-A
6	M.H. 5-A

Drawing Nos.	Title or Subject
	Second St. Interceptor
934-12.8/21	General plan
22	Manhole details
934-12.3/96 - 97 & 98	Plan and profile
100	Manhole Nos. 1 & 2
101	Manhole Nos. 3 & 4
102	Manhole Nos. 5 & 6
103	Manhole Nos. 7 & 8
104	Manhole No. 9
105	Manhole No. 10
106	Manhole No. 11
	Pumping Plants
934-12.3/1	General plan, P.P. Nos. 1, 2, 3, 5, 6, 7 & 12
934-12.7/1	General plan, P.P. Nos. 4, 8 & 9
10	General plan, P.P. No. 10
934-12.5/1	General plan, P.P. No. 11
934-12.3/2 - 3 - 4 & 14	Details, Pumping Plant No. 1
934-12.8/2	Details, Pumping Plant No. 1
934-12.3/15 - 16 - 17 - 18 & 30	Details, Pumping Plant No. 2
934-12.8/4 & 5	Details, Pumping Plant No. 2
934-12.3/32 - 33 & 34	Details, Pumping Plant No. 3
934-12.8/7	Details, Pumping Plant No. 3
934-12.7/2 - 3 & 4	Details, Pumping Plant No. 4
934-12.3/41 - 42 - 43 & 44	Details, Pumping Plant No. 5
934-12.8/9 & 10	Details, Pumping Plant No. 5
934-12.3/49 - 50 - 51 - 52 & 62	Details, Pumping Plant No. 6
934-12.8/12 & 13	Details, Pumping Plant No. 6
934-12.3/64 - 65 - 66 - 67 & 68	Details, Pumping Plant No. 7
934-12.8/ 15 & 16	Details, Pumping Plant No. 7
934-12.7/13	Details, Pumping Plant No. 8
14 - 15 & 16	Details, Pumping Plant No. 9
934-18.3/4	Details, Pumping Plant No. 9
934-12.7/25	Details, Pumping Plant No. 10
934-12.5/3 - 4 - 6 - 7 - 8 - 17 - 18 - 24 & 26	Details, Pumping Plant No. 11
934-12.8/24 & 25	Details, Pumping Plant No. 11
934-12.3/75 - 76 - 77 & 83	Details, Pumping Plant No. 12
934-12.8/18 & 19	Details, Pumping Plant No. 12
934-12.3/10	Substations, P.P. Nos. 1, 5 & 6
12	Substations, P.P. Nos. 1, 2, 5 & 6
28	Substations, P.P. No. 2
39	Substations, P.P. Nos. 3, 7 & 12
934-12.5/26 & 28	Substations, P.P. No. 11
934-12.7/12	Substations, P.P. Nos. 4 & 9
26	Substations, P.P. Nos. 8 & 10
934-12.3/9	Wiring diagrams, P.P. Nos. 1, 5, 6 & 7
27	Wiring diagrams, P.P. No. 2
38	Wiring diagrams, P.P. Nos. 3 & 12

Drawing Nos.	Title or Subject
	Pumping Plants (Continued)
934-12.7/10	Wiring diagrams, P.P. Nos. 4 & 9
934-12.8/27	Wiring diagrams, P.P. No. 11
33 & 34	Wiring diagrams, P.P. Nos. 1, 5, 6 & 7
36 - 37 & 38	Wiring diagrams, P.P. No. 2
41	Wiring diagrams, P.P. Nos. 3 & 12
43	Wiring diagrams, P.P. Nos. 5 & 7
45	Wiring diagrams, P.P. No. 6
934-12.3/13	Lighting & power systems, P.P. No. 1
934-12.8/3	Lighting & power systems, P.P. No. 1
934-12.3/29	Lighting & power systems, P.P. No. 2
934-12.8/6 & 35	Lighting & power systems, P.P. No. 2
934-12.3/40	Lighting & power systems, P.P. No. 3
934-12.8/8 & 40	Lighting & power systems, P.P. No. 3
934-12.7/11	Lighting & power systems, P.P. No. 4
934-12.3/47	Lighting & power systems, P.P. No. 5
934-12.8/11 & 42	Lighting & power systems, P.P. No. 5
934-12.3/61	Lighting & power systems, P.P. No. 6
934-12.8/14 & 44	Lighting & power systems, P.P. No. 6
934-12.3/74	Lighting & power systems, P.P. No. 7
934-12.8/17 & 46	Lighting & power systems, P.P. No. 7
934-12.7/24	Lighting & power systems, P.P. No. 9
934-12.5/32	Lighting & power systems, P.P. No. 11
934-12.8/29	Lighting & power systems, P.P. No. 11
934-12.3/82	Lighting & power systems, P.P. No. 12
*1 thru 8	Black & Veatch, P.P. No. 1

MANUFACTURERS' PLANS, SPECIFICATIONS, BULLETINS AND INSTRUCTIONS

PUMPING PLANT NO. 1

Manufacturer	Drawing No.	Title or Subject
Economy Pumps, Inc. Hamilton, Ohio	AB-6597-2	Data Sheet
	AD-1727-1	Assembly Drawing
	AC-2953-2	Installation Outline
Westinghouse Elect.&Mfg.Co. East Pittsburgh, Pa.	3-C-8954	Motor Outline
	12-A-4600	Switchgear Assembly
	12-A-4683	Wiring Diagram

PUMPING PLANT NO. 2

Economy Pumps, Inc. Hamilton, Ohio	AB-6597-2	Data Sheet
	AD-1727-1	Assembly Drawing
	AB-6552-1	Installation Outline Unit 1
	AC-2953-2	Installation Outline Units 2, 3, 4, 5 & 6
Westinghouse Elect.&Mfg.Co. East Pittsburgh, Pa.	3-B-9975	Motor Outline Unit 1
	6-C-3797	Motor Outline Unit 2
	6-C-3750	Motor Outline Units 3 & 4
	5-C-9394	Motor Outline Units 5 & 6
	12-A-4715	Switchgear Assembly
	12-A-3425	Wiring Diagram

PUMPING PLANT NO. 3

Economy Pumps, Inc. Hamilton, Ohio	AB-6597-2	Data Sheet
	AD-1727-1	Assembly Drawing
	AC-2953-2	Installation Outline Units 1&2
	AB-6552-1	Installation Outline Unit 3
Westinghouse Elect.&Mfg.Co. East Pittsburgh, Pa.	12-B-2650	Motor Outline Unit 1
	3-B-9975	Motor Outline Units 2 & 3
	3-C-1484	Wiring Diagram

PUMPING PLANT NO. 4

Economy Pumps, Inc. Hamilton, Ohio	AB-6597-2	Data Sheet
	AC-2151	Assembly Drawing
	AC-2986	Installation Outline
Westinghouse Elect.&Mfg.Co. East Pittsburgh, Pa.	3-B-7575	Motor Outline

PUMPING PLANT NO.1

Fairbanks Morse Co.	Fig. 6300	Installation & Operating Instr.
Farval Corp.		Engr. & Operating Instr.

PUMPING PLANT NO. 5

Manufacturer	Drawing No.	Title or Subject
Economy Pumps, Inc. Hamilton, Ohio	AB-6597-2	Data Sheet
	AD-1727-1	Assembly Drawing
	AC-2953-2	Installation Outline Units 1, 2 & 3
	AB-6552-1	Installation Outline Unit 4
Westinghouse Elect.&Mfg. Co. East Pittsburgh, Pa.	6-C-3801	Motor Outline Units 1 & 2
	5-C-8530	Motor Outline Unit 3
	95-B-681	Motor Outline Unit 4
	12-A-4601	Switchgear Assembly
	12-A-4684	Wiring Diagram

PUMPING PLANT NO. 6

Economy Pumps, Inc. Hamilton, Ohio	AB-6597-2	Data Sheet
	AD-1727-1	Assembly Drawing
	AC-2953-2	Installation Outline Units 1, 2, 3 & 4
	AB-6552-1	Installation Outline Unit 5
Westinghouse Elect.&Mfg. Co. East Pittsburgh, Pa.	7-C-1291	Motor Outline Units 1, 3 & 4
	3-C-8954	Motor Outline Unit 2
	3-B-9975	Motor Outline Unit 5
	12-A-4602	Switchgear Assembly
	12-A-4681	Wiring Diagram

PUMPING PLANT NO. 7

Economy Pumps, Inc. Hamilton, Ohio	AB-6597-2	Data Sheet
	AD-1727-1	Assembly Drawing
	AC-2953-2	Installation Outline Units 1 & 2
	AB-6552-1	Installation Outline Unit 3
Westinghouse Elect.&Mfg. Co. East Pittsburgh, Pa.	3-C-8954	Motor Outline Unit 1
	3-B-9975	Motor Outline Unit 2
	95-B-681	Motor Outline Unit 3
	12-A-4603	Switchgear Assembly
	3-C-1482	Wiring Diagram
	12-A-4682	Wiring Diagram

PUMPING PLANT NO. 8

Economy Pumps, Inc. Hamilton, Ohio	AB-6597-2	Data Sheet
	AD-1661	Assembly Drawing
	AC-2981-1	Installation Outline
Westinghouse Elect.&Mfg. Co. East Pittsburgh, Pa.	Dim.Sheet 3100 Page 209 Sub 3	Motor Outline
	B-7347	Wiring Diagram

PUMPING PLANT NO. 9

Manufacturer	Drawing No.	Title or Subject
Economy Pumps, Inc. Hamilton, Ohio	AB-6597-2	Data Sheet
	AC-2985-1	Installation Outline
Westinghouse Elect.&Mfg. Co. East Pittsburgh, Pa.	Dim.Sheet 3830 Page 160 Sub 4	Motor Outline

PUMPING PLANT NO. 10

Economy Pumps, Inc. Hamilton, Ohio	AB-6597-2	Data Sheet
	AD-1747-1	Installation Outline
Westinghouse Elect.&Mfg. Co. East Pittsburgh, Pa.	3-B-7575	Motor Outline
	B-7346	Wiring Diagram

PUMPING PLANT NO. 11

Economy Pumps, Inc. Hamilton, Ohio	AB-6597-2	Data Sheet
	AD-1727-1	Assembly Drawing
	AC-2953-2	Installation Outline
Farval Corp.		Engr. & Operating Instr.
Westinghouse Elect.&Mfg. Co. East Pittsburgh, Pa.	6-C-3109	Motor Outline
	21-A-3906	Switchgear Assembly
	19-A-4966	Wiring Diagram

PUMPING PLANT NO. 12

Economy Pumps, Inc. Hamilton, Ohio	AB-6597-2	Data Sheet
	AD-1724-1	Assembly Drawing
	AC-2953-2	Installation Outline
Westinghouse Elect.&Mfg. Co. East Pittsburgh, Pa.	Dim.Sheet 3830 Cat. Page 160 Sub 4	Motor Outline
	3-C-1483	Wiring Diagram

SLUICE GATES

Armco Drainage & Metal Products, Inc. Hardesty Division Denver, Colo.	2-0166	Pumping Plant No. 2 - 96"
	3346	Pumping Plant No. 3 - 36"
	3372	Pumping Plant No. 5 - 60"
	2-0169	Pumping Plant No. 6 - 84"
	3374	Pumping Plant No. 7 - 54"
	2-0237	Manhole Nos. 1,2,5,6,7&8 - 18"
	3352	Manhole Nos. 3 & 4 - 24"
	2-0239	Sta. 32+38.1 60"

MISCELLANEOUS

Manufacturer	Drawing No.	Title or Subject
Economy Pumps, Inc. Hamilton, Ohio	S-1252 S-1243 AB-6593-2	Grease Line Layout, General Oil Line Layout, General Shaft Bearing & Coupling Details
Westinghouse Elect.&Mfg. Co. East Pittsburgh, Pa.	21-A-6292	Motor Assembly & Instructions, General
Philadelphia Gear Works Philadelphia, Pa.	C-75620 3830-2 L-3401	Gate Hoist, Twin Screen Motors, Westinghouse Bulletin Lubrication, Madison-Kipp Bulletin Motor & Switchgear, Maintenance, Renewal Parts List, Westinghouse Limitorque Valve Control, Engineer Manual

PRESSURE LINES THROUGH OR OVER LEVEE OR WALL
Private Lines Installed by Permit

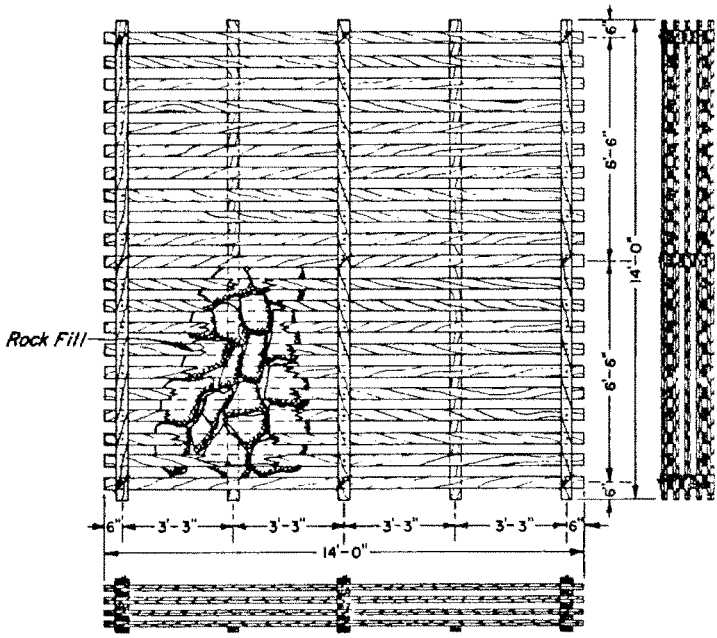
Owner	Type	Usage	Size	Valve Location	Line Location
Gulf Ref. Co.	A	Gasoline	5-3"		52+25-B1
Gulf Ref. Co.	T	Gasoline	4-6" 1-4" 3-2"		55+52-B1
Gulf Ref. Co.	T	Gasoline	1-6"		55+52-B1
Paducah Water Works	HT	Water	8"	R/S & L/S TOE	149+20-C
Paducah Water Works	HT	Water	8"	R/S & L/S TOE	200+00-C
Paducah Water Works	HT	Water	10"	R/S & L/S TOE	224+50-C
Paducah Water Works	HT	Water	10"	R/S & L/S TOE	215+25-C
Ky. Utilities Co.	HT	Gas	6"	L/S TOE	141+74.43-C
Paducah Water Works	HT	Water	12"	50' R/S & L/S	144+00-A
The Texas Co.	T	Gasoline	6"	R/S & L/S WALL	169+83.86-B2
Western Kentucky Gas Co., Inc.	HT	Natural Gas	2"	L/S TOE	220+12-C
Western Kentucky Gas Co., Inc.	HT	Natural Gas	8"	L/S TOE & R/S Borrow Pit	141+54-C
Walker Boat Yard	HT	Water	1-1/2"		97+88.25-B2
*Texas, Inc.	T	Gasoline	8"		170+04.36-B2
*Weston Ky. Gas Co.	HT	Gas	6"	R/S & L/S TOE	76+74-A
*Kommodere Kessel's Pizza Boat Dock	HT	Water	1-1/2"		124+00-B
*Paducah Water Works	HT	Water	8"		187+97-A
*Paducah Water Works	HT	Water	6"	R/S & L/S TOE	29+60-C

T - Straight through levee or wall

A - Aerial

HT - Humped through levee or wall

CORPS OF ENGINEERS U. S. ARMY



Note:

Cribs constructed of double thickness of 1"X4"X14'-0" lumber.
Nail all intersections with 1-20d nail.
Each intersection of walls securely fastened by loop of No. 9 wire tightly twisted.

BILL OF MATERIAL FOR ONE CRIB 14'-0"
LUMBER
130 pieces 1"X4"X14'-0"
WIRE
30' No. 9 Wire
NAILS
13 lbs.-20d Nails

OHIO RIVER BASIN

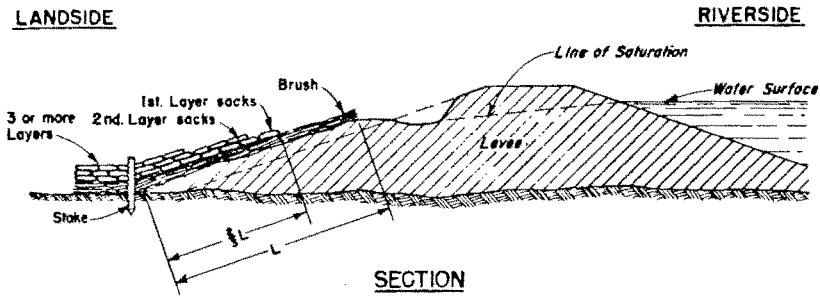
HIGH WATER MAINTENANCE
CAVING BANK PROTECTION

ROCK FILLED CRIB

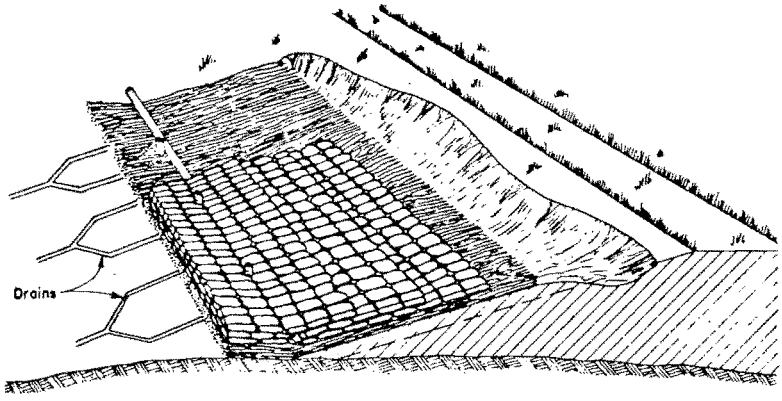
LOUISVILLE DISTRICT, LOUISVILLE, KY.

PLATE I

CORPS OF ENGINEERS U. S. ARMY



SECTION



Note:

Cut V-Shaped drains no deeper than necessary and not more than 6" deep. Sandbags should be only ⅔ full.

OHIO RIVER BASIN

HIGH WATER MAINTENANCE

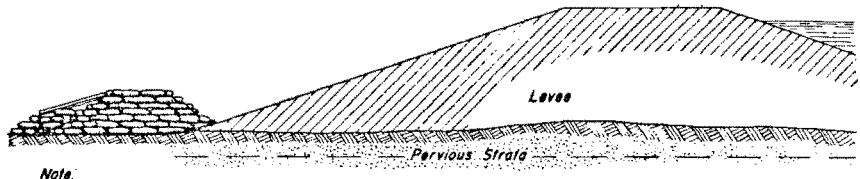
SLOUGHING

SANDBAG & BRUSH MAT

LOUISVILLE DISTRICT, LOUISVILLE, KY.

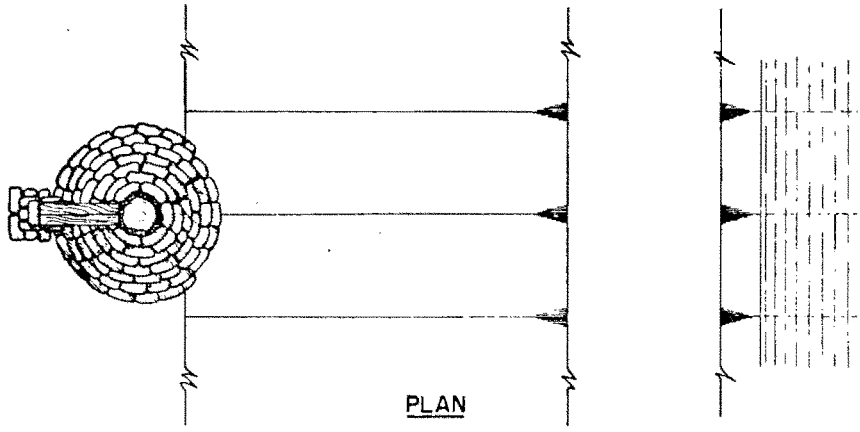
PLATE 2

CORPS OF ENGINEERS U. S. ARMY



ELEVATION

Note:
Bottom width to be no less than 1½ times height.
Be sure to clear sand discharge.
Tie into levee if boil is near toe.



PLAN

Note:
Do not sack boil which does not put out material and whose flow is small.
Prepare base of sack ring by clearing debris, sod, loose sand or other objectionable material and scarify base.
Tamp sand bags into place.
Height of sack loop or ring should be only sufficient to create enough head to slow down flow through boil so that no more material is displaced and boil runs clear.
Never attempt to completely stop flow through boil.
Carry off water by omitting one sack in top layer or construct a "V"-shaped drain of boards or sheet metal.

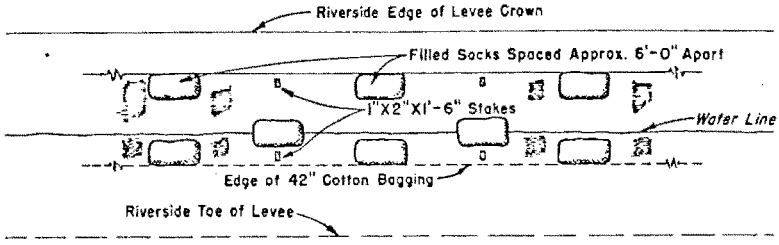
OHIO RIVER BASIN

HIGH WATER MAINTENANCE
SAND BOIL

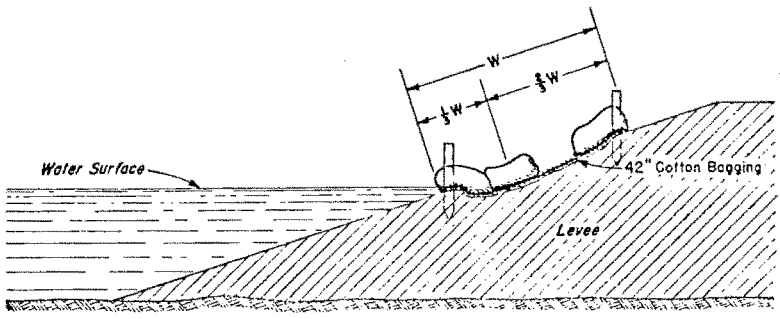
SACKED EARTH RING

LOUISVILLE DISTRICT, LOUISVILLE, KY.

PLATE 3



PLAN



SECTION

BILL OF MATERIAL TO CONSTRUCT 180 FEET OF PROTECTION		
LUMBER	BAGGING	SANDBAGS
60-1"X2"X1'-6" Stakes (Sharpened)	One roll regular (jute) Cotton Bagging 42"X180'-0"	90-Filled sacks

* ***Note:***

Plastic sheeting or burlap may be substituted for cotton bagging.

OHIO RIVER BASIN

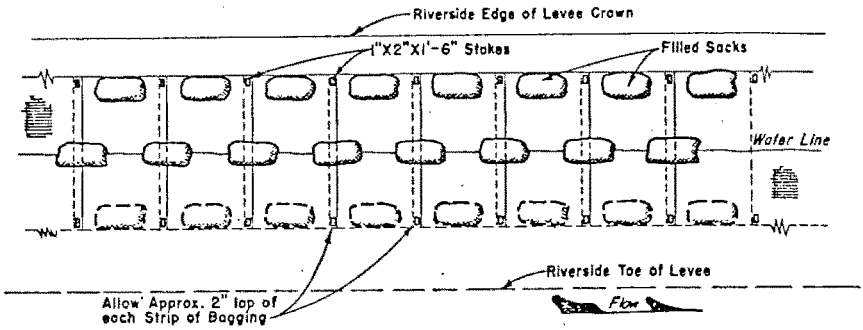
HIGH WATER MAINTENANCE
WAVE WASH PROTECTION

SANDBAG &
COTTON BAGGING-NO 1

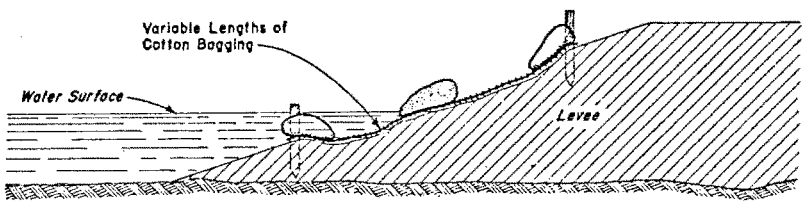
LOUISVILLE DISTRICT, LOUISVILLE, KY.

* R 1981

PLATE 4



PLAN



SECTION

Note:

Lay lengths as required of Cotton Bagging approximately parallel with levee slope and across damaged section.

Lap strips with current to prevent lifting.

Weight top and edges of bagging with filled socks as shown above.

The filled socks should be wired or tied to each strip before laying in place.

Stake the corners of each strip above water surface.

* *Plastic sheeting or burlap may be substituted for cotton bagging.*

BILL OF MATERIAL FOR 100 LINEAR FEET OF LEVEE
LUMBER
120 pieces 1"X2"X1'-6" (Sharpened)
SANDBAGS
180 Filled Socks Cotton Bagging as Required

OHIO RIVER BASIN

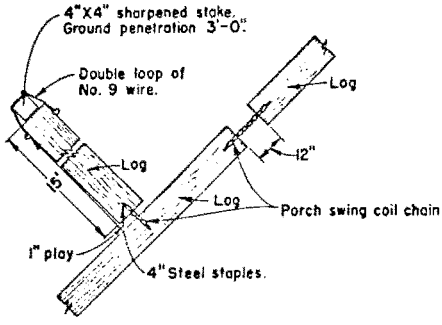
HIGH WATER MAINTENANCE
WAVE WASH PROTECTION

SANDBAG & COTTON BAGGING-NO 2

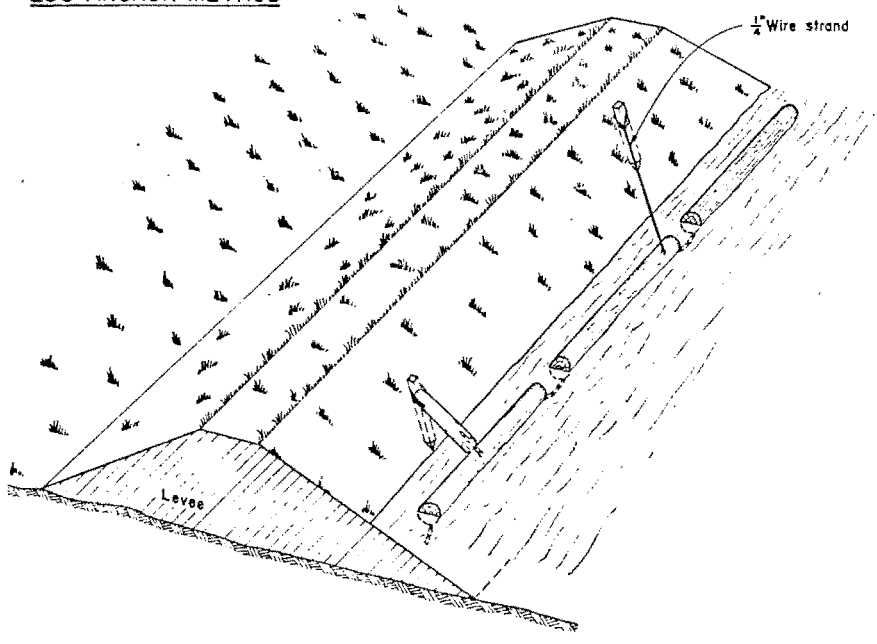
LOUISVILLE DISTRICT, LOUISVILLE, KY.

* R 1981

PLATE 5



LOG ANCHOR METHOD



Note:

Do not drive steel staples all the way in.

Staples should protrude sufficiently to allow enough play for rotation of logs.

Substitute 3 doubled loops of No. 9 wire if porch swing coil chain is not available.

Anchor logs spaced a maximum of 50' apart.

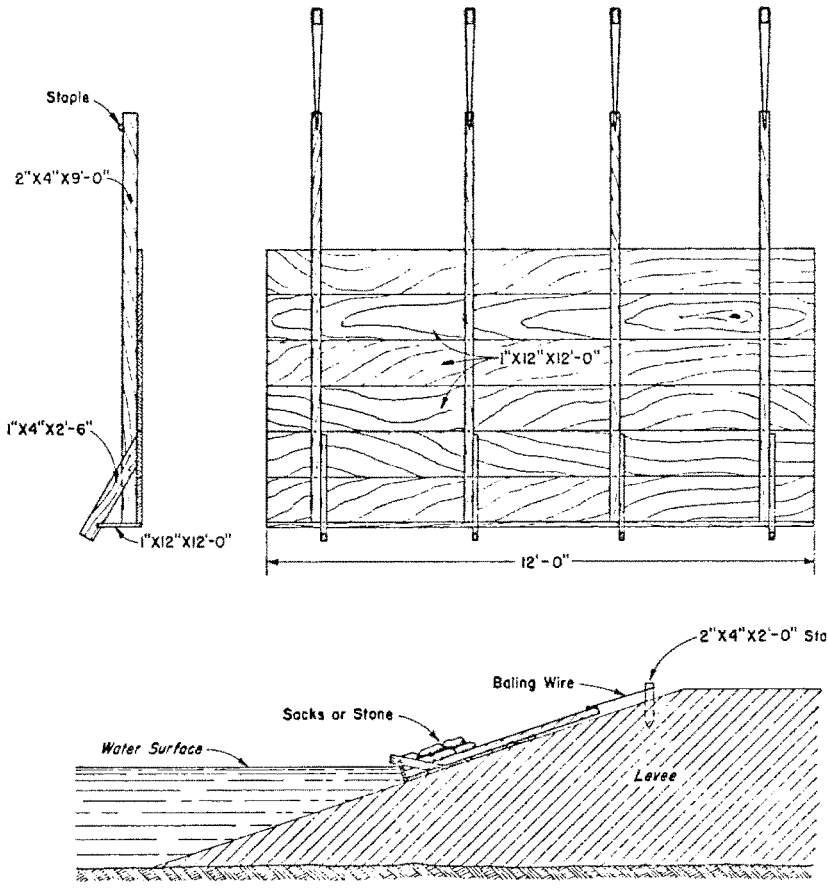
OHIO RIVER BASIN

HIGH WATER MAINTENANCE
WAVE WASH PROTECTION

LOG BOOM

LOUISVILLE DISTRICT, LOUISVILLE, KY.

PLATE 6



BILL OF MATERIAL FOR 100 LINEAR FEET OF LEVEE
LUMBER
56 pieces 1"X12"X12'-0" 36 pieces 1"X4"X2'-6" 36 pieces 2"X4"X9'-0" * 36 pieces 2"X4"X2'-6" * (Sharpened)
NAILS
5 lbs. 8d nails
WIRE
200' baling wire
STAPLES
1 lb. 2" staples

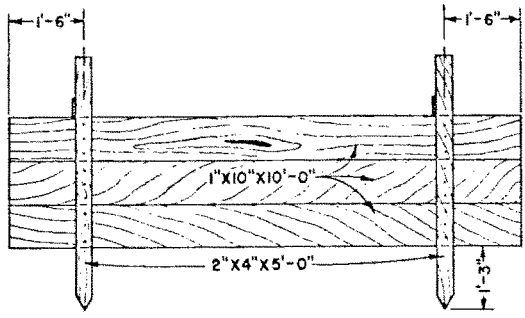
OHIO RIVER BASIN

HIGH WATER MAINTENANCE
WAVE WASH PROTECTION

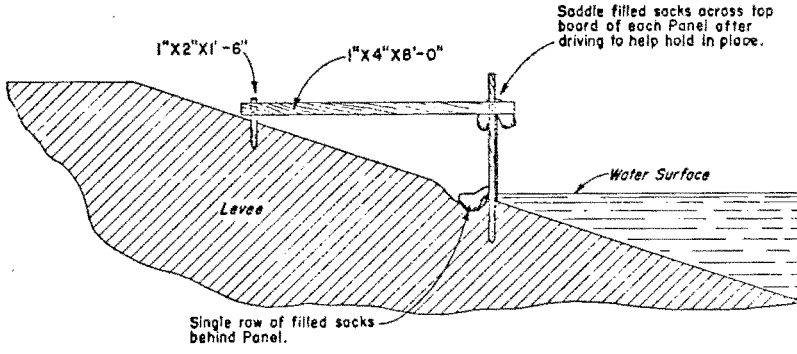
MOVABLE PANEL

LOUISVILLE DISTRICT, LOUISVILLE, KY.

PLATE 7



ELEVATION



SECTION

BILL OF MATERIAL FOR 100 LINEAR FEET OF LEVEE
LUMBER
30 pieces 1"X10"X10'-0" * 20 pieces 2"X4"X5'-0" 20 pieces 1"X4"X8'-0" * 20 pieces 1"X2"X1'-3" * (Sharpened)
NAILS
3 lbs. 8d nails
SANDBAGS
150 Filled Sacks

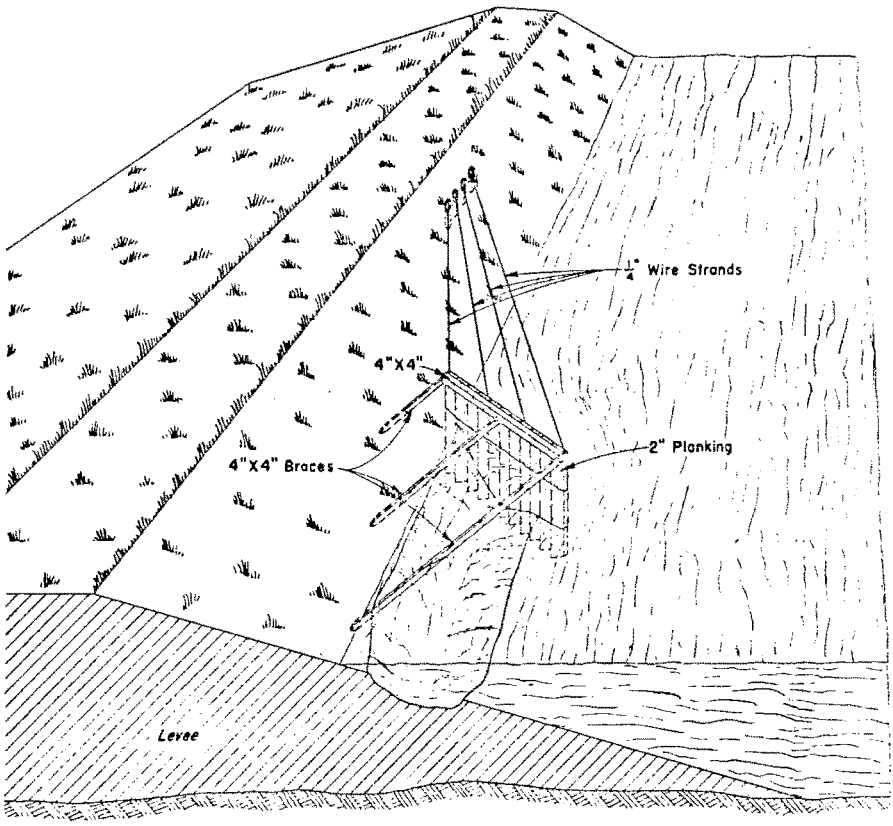
OHIO RIVER BASIN

HIGH WATER MAINTENANCE
WAVE WASH PROTECTION

PORTABLE BOARD PANEL

LOUISVILLE DISTRICT, LOUISVILLE, KY.

PLATE 8



Note:
Place tied sandbags on both sides of wall at base.

OHIO RIVER BASIN

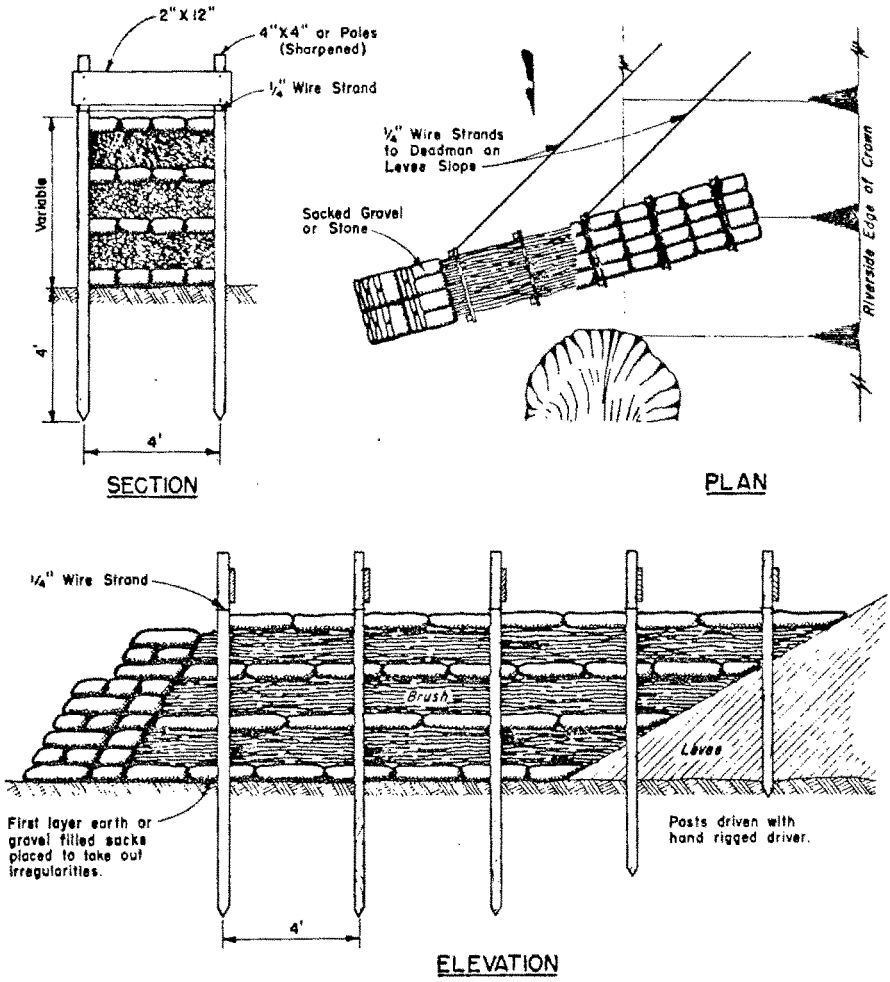
HIGH WATER MAINTENANCE
CURRENT SCOUR PROTECTION

BOARD DEFLECTION WALL

LOUISVILLE DISTRICT, LOUISVILLE, KY.

PLATE 9

CORPS OF ENGINEERS U. S. ARMY



Note:

Brush should be rammed tightly in place, each layer approximately one foot thick.

Dike should extend above anticipated high water.

OHIO RIVER BASIN

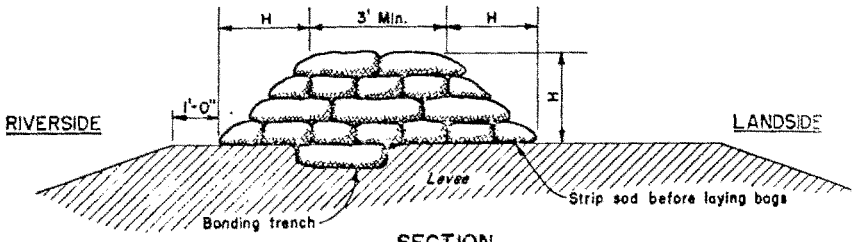
HIGH WATER MAINTENANCE
CURRENT SCOUR PROTECTION

BRUSH DEFLECTION DIKE

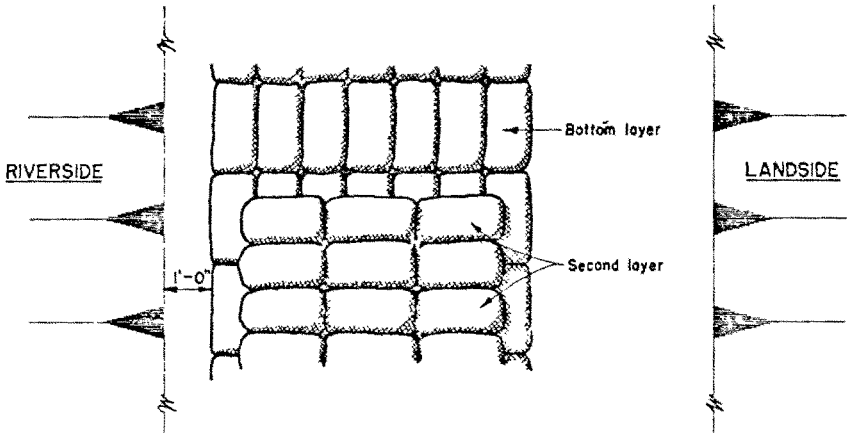
LOUISVILLE DISTRICT, LOUISVILLE, KY.

PLATE 10

CORPS OF ENGINEERS U. S. ARMY



SECTION



PLAN

Note:

Alternate direction of bags with bottom layer lengthwise of levee, next layer crosswise, etc.

Lap unfilled portion under the bag.

Tying or sewing sacks not necessary.

Tamp thoroughly in place.

Bags should be approximately 2/3 full of clay, silt or sand.

BAGS REQUIRED FOR 100 LINEAR FEET OF LEVEE	
HEIGHT ABOVE LEVEE	BAGS REQUIRED
1 FT.	1300*
2 FT.	3100*
3 FT.	5500*

OHIO RIVER BASIN

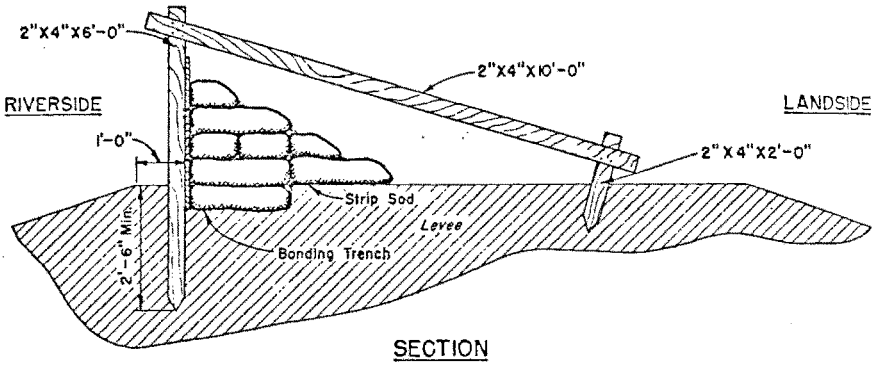
HIGH WATER MAINTENANCE OVER TOPPING

SANDBAG TOPPING

LOUISVILLE DISTRICT, LOUISVILLE, KY.

* R 1981

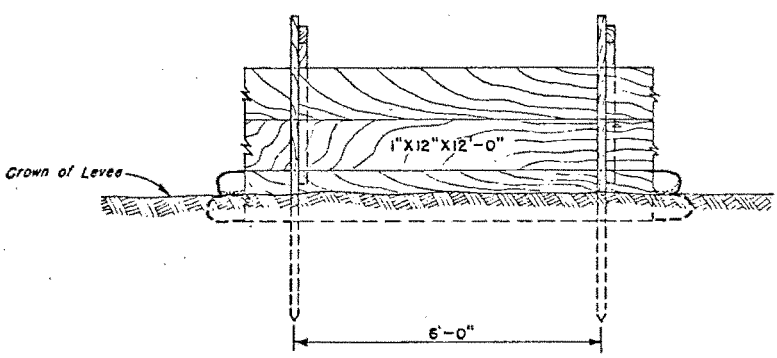
PLATE 11



SECTION

* Note:

Earth fill may be substituted for sacked earth in times of emergency.



RIVERSIDE ELEVATION

BILL OF MATERIAL FOR 100 LINEAR FEET OF LEVEE
LUMBER
25 pieces 1"X12"X12' 17 pieces 2"X4"X10' + 17 pieces 2"X4"X6' + 17 pieces 2"X4"X2' + (Sharpened)
NAILS
1 lb. 8d nails 2 lbs. 16d nails
SANDBAGS
1100 bags

OHIO RIVER BASIN

HIGH WATER MAINTENANCE

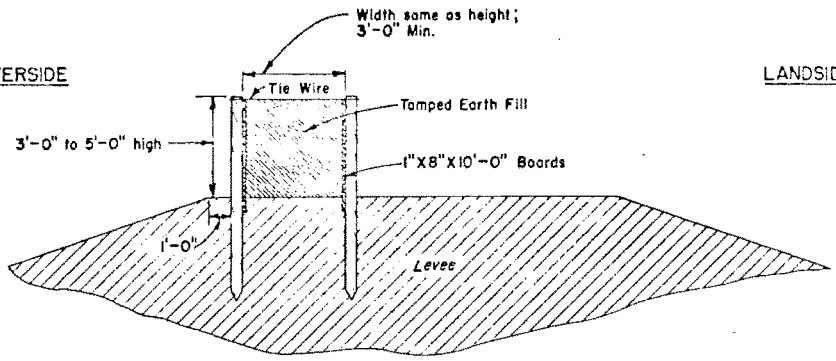
OVER TOPPING

LUMBER AND SACK TOPPING

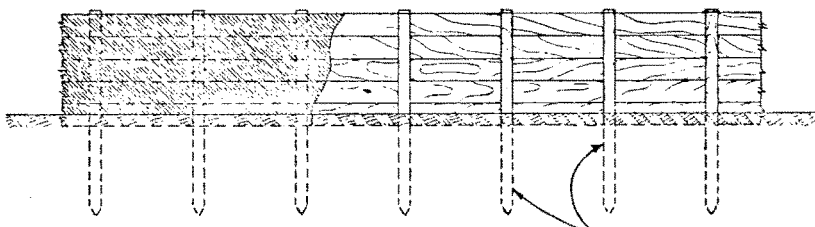
LOUISVILLE DISTRICT, LOUISVILLE, KY.

* R 1981

PLATE 12



SECTION



RIVERSIDE ELEVATION

4"X4" posts spaced approximately 3' apart and driven 2' to 3' into ground.

BILL OF MATERIAL FOR 100 LINEAR FEET OF LEVEE		
3 FT. HIGH	4 FT. HIGH	5 FT. HIGH
66 pieces 4"X4"X6'-0" posts (Sharpened) 100 pieces 1"X8"X10'-0" 7½ lbs. – 8d nails 400' No. 9 wire	66 pieces 4"X4"X7'-0" posts (Sharpened) 140 pieces 1"X8"X10'-0" 9½ lbs. – 8d nails 400' No. 9 wire	66 pieces 4"X4"X8'-0" posts (Sharpened) 180 pieces 1"X8"X10'-0" 11½ lbs. – 8d nails 400' No. 9 wire

OHIO RIVER BASIN

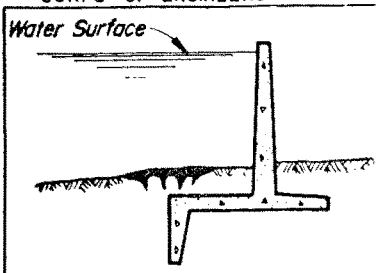
HIGH WATER MAINTENANCE
OVER TOPPING

MUD BOX TOPPING

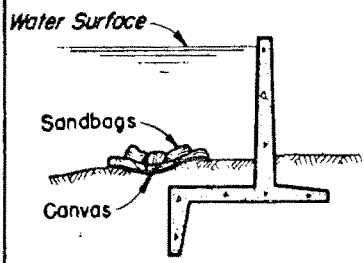
LOUISVILLE DISTRICT, LOUISVILLE, KY.

PLATE 13

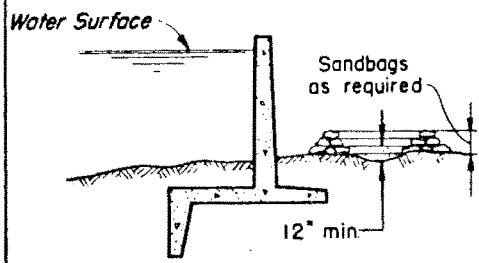
CORPS OF ENGINEERS U. S. ARMY



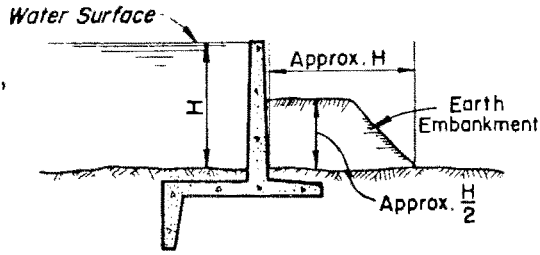
(A.) Small leaks sealed with cinders, coal dust, etc.



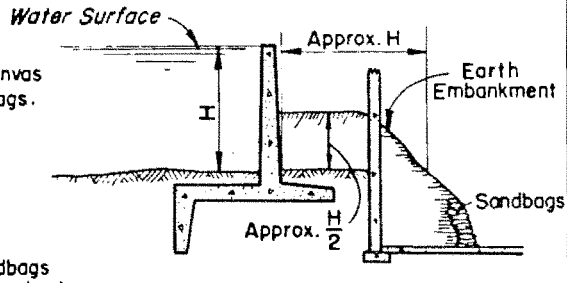
(B.) Larger holes covered with canvas sunk and weighted by sandbags.



(C.) Landside boils ringed with sandbags as required. Boil area within ring to be covered with 12" min. pervious material (Bank-run gravel, etc.)



(D.) Wall stabilized by earth embankment (Preferably sand or sand and gravel)



(E.) Wall stabilization when close to deep basement.

NOTE: Struts should not be used except against base or immediately above.

OHIO RIVER BASIN

FLOOD WALL

SEEPAGE & STABILIZATION CORRECTIVE MEASURES

LOUISVILLE DISTRICT LOUISVILLE, KY.

PLATE 14

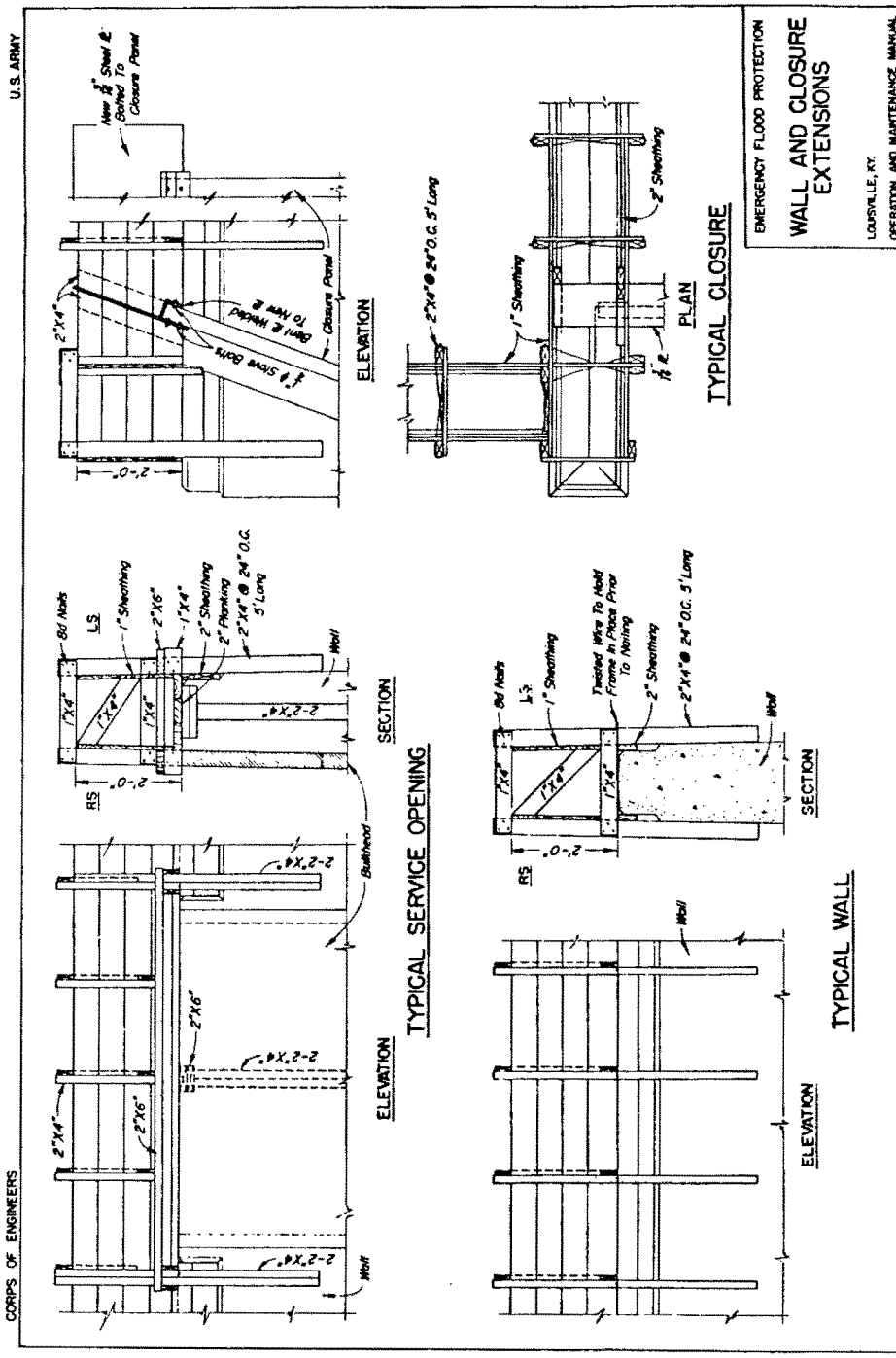
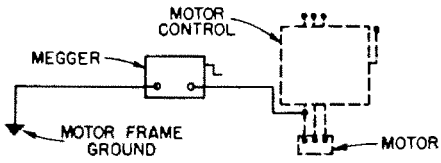

U.S. ARMY
CORPS OF ENGINEERS
EMERGENCY FLOOD PROTECTION
WALL AND CLOSURE EXTENSIONS
LOUISVILLE, KY.
OPERATION AND MAINTENANCE MANUAL
TYPICAL CLOSURE
PLAN
ELEVATION
SECTION
TYPICAL SERVICE OPENING
TYPICAL WALL
Closure Panel
Bent & Welded To New ℞
Bulkhead
Wall
Twisted Wire To Hold Frame In Place Prior To Nailing
2"X4" @ 24" O.C. 5' Long
2" Sheathing
1" Sheathing
2" Planking
8d Nails
LS
RS

PLATE 15

CORPS OF ENGINEERS U.S. ARMY



WIRING DIAGRAM
INSULATION RESISTANCE

FLOOD PROTECTION

MOTOR WINDING
INSULATION RESISTANCE-TEMPERATURE CURVE

SCALES AS SHOWN

LOUISVILLE, KY.

PADUCAH, KENTUCKY
PUMPING PLANTS
NO. 1, 3 & 4

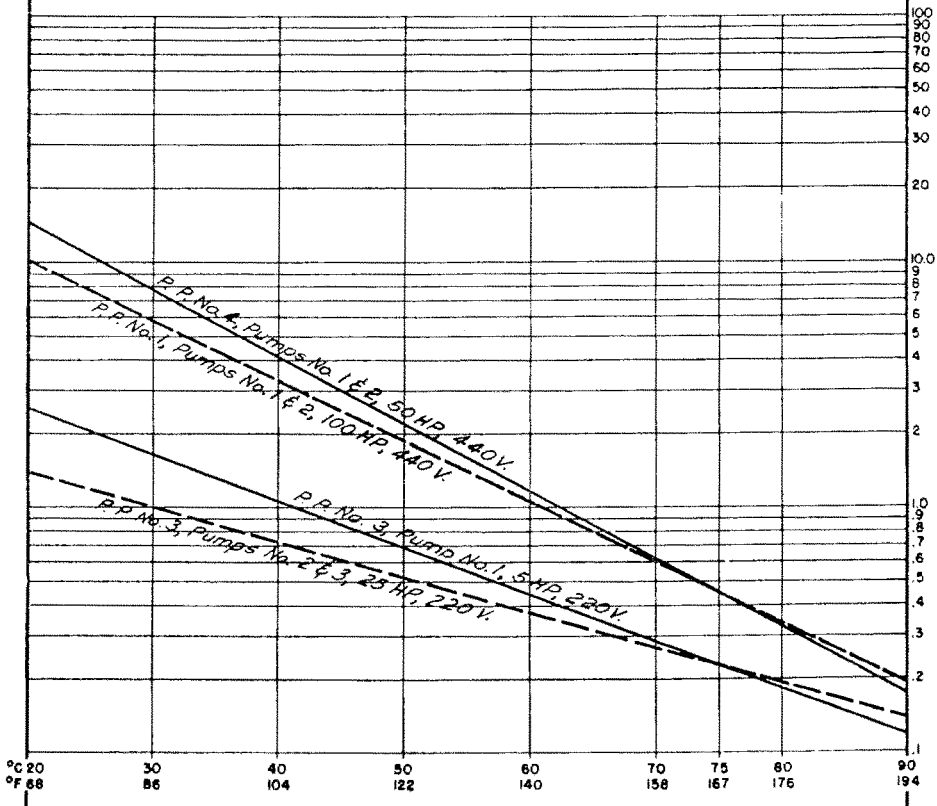
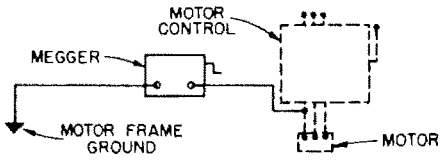


PLATE 16

CORPS OF ENGINEERS U.S. ARMY



WIRING DIAGRAM
INSULATION RESISTANCE

FLOOD PROTECTION

MOTOR WINDING
INSULATION RESISTANCE-TEMPERATURE CURVE

SCALES AS SHOWN

LOUISVILLE, KY.

PADUCAH, KENTUCKY

PUMPING PLANT NO. 2

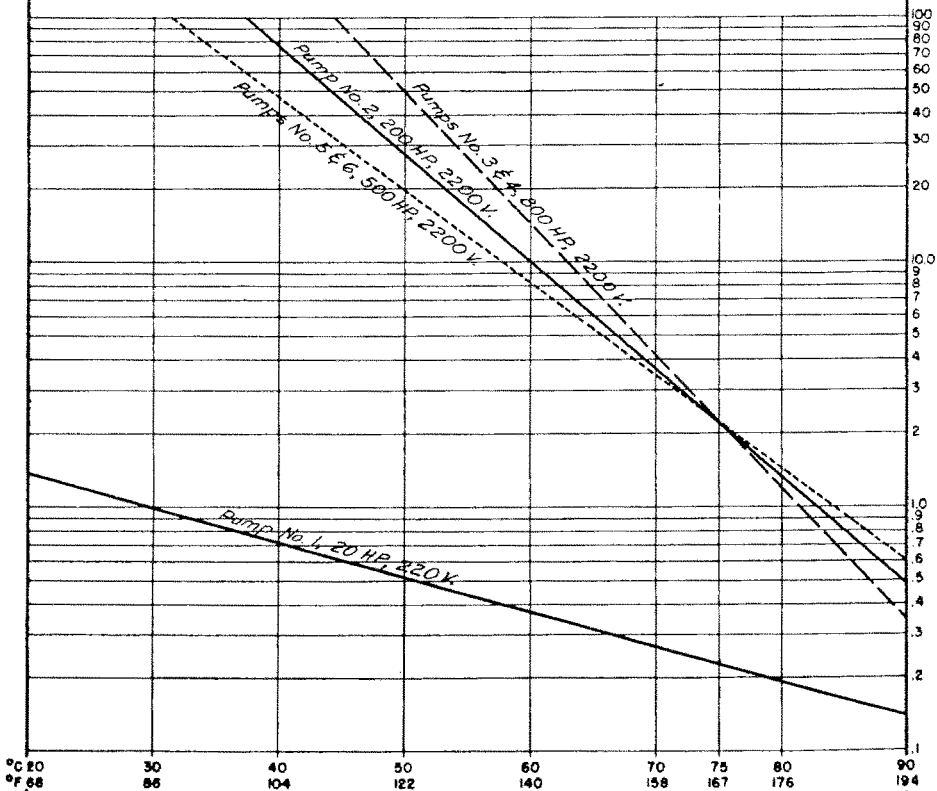
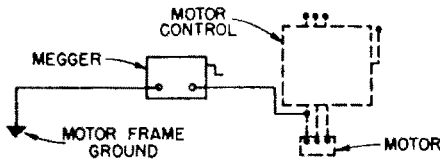


PLATE 17

CORPS OF ENGINEERS U.S. ARMY



WIRING DIAGRAM
INSULATION RESISTANCE

FLOOD PROTECTION

MOTOR WINDING
INSULATION RESISTANCE-TEMPERATURE CURVE

SCALES AS SHOWN

LOUISVILLE, KY.

PADUCAH, KENTUCKY

PUMPING PLANT NO. 5

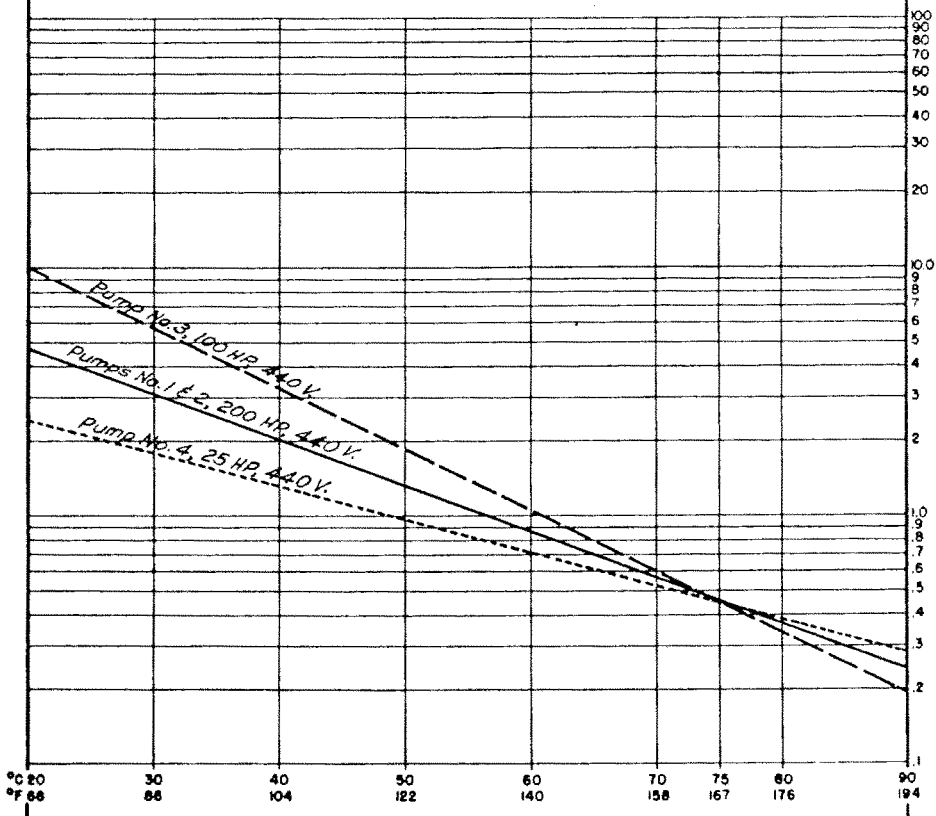
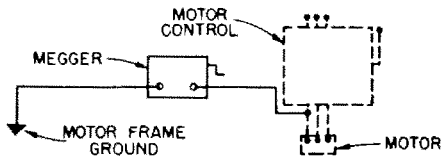


PLATE 18

CORPS OF ENGINEERS U.S. ARMY



WIRING DIAGRAM
INSULATION RESISTANCE

FLOOD PROTECTION

MOTOR WINDING
INSULATION RESISTANCE-
TEMPERATURE CURVE

SCALES AS SHOWN

LOUISVILLE, KY.

PADUCAH, KENTUCKY

PUMPING PLANT NO. 6

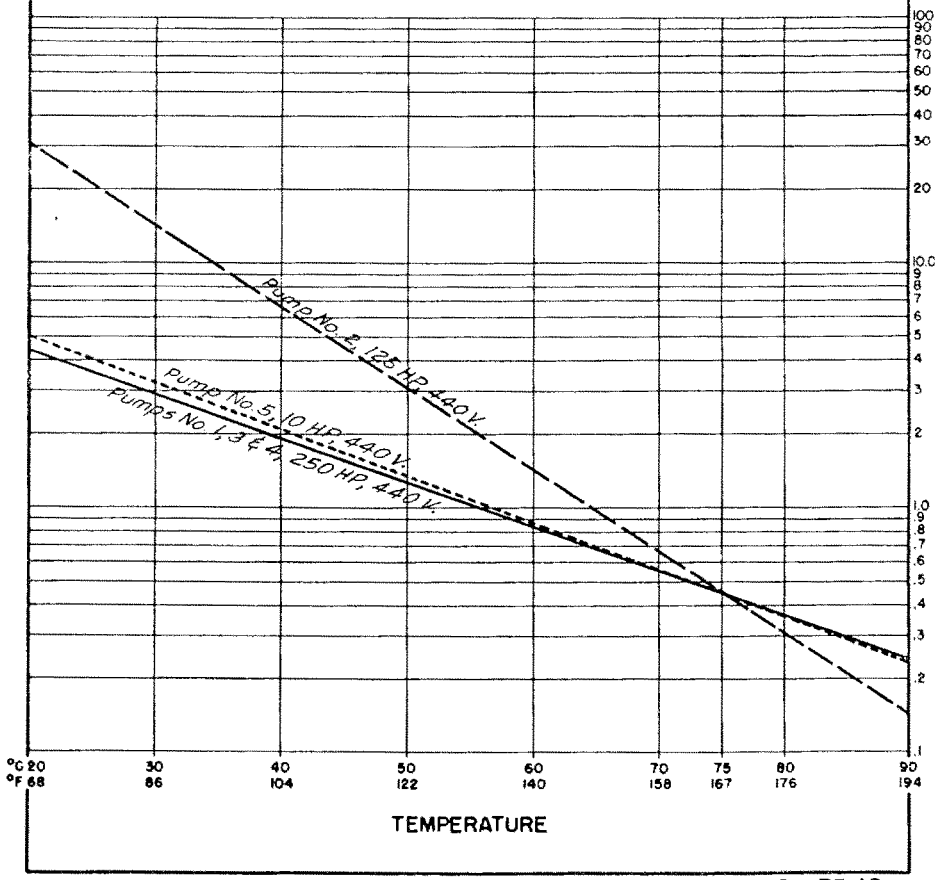
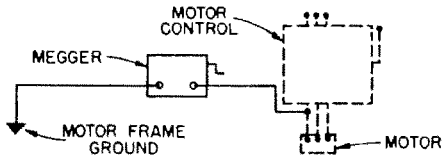


PLATE 19

CORPS OF ENGINEERS U.S. ARMY



WIRING DIAGRAM
INSULATION RESISTANCE

FLOOD PROTECTION

MOTOR WINDING
INSULATION RESISTANCE-TEMPERATURE CURVE

SCALES AS SHOWN

LOUISVILLE, KY.

PADUCAH, KENTUCKY

PUMPING PLANTS
NO. 7, 8 & 9

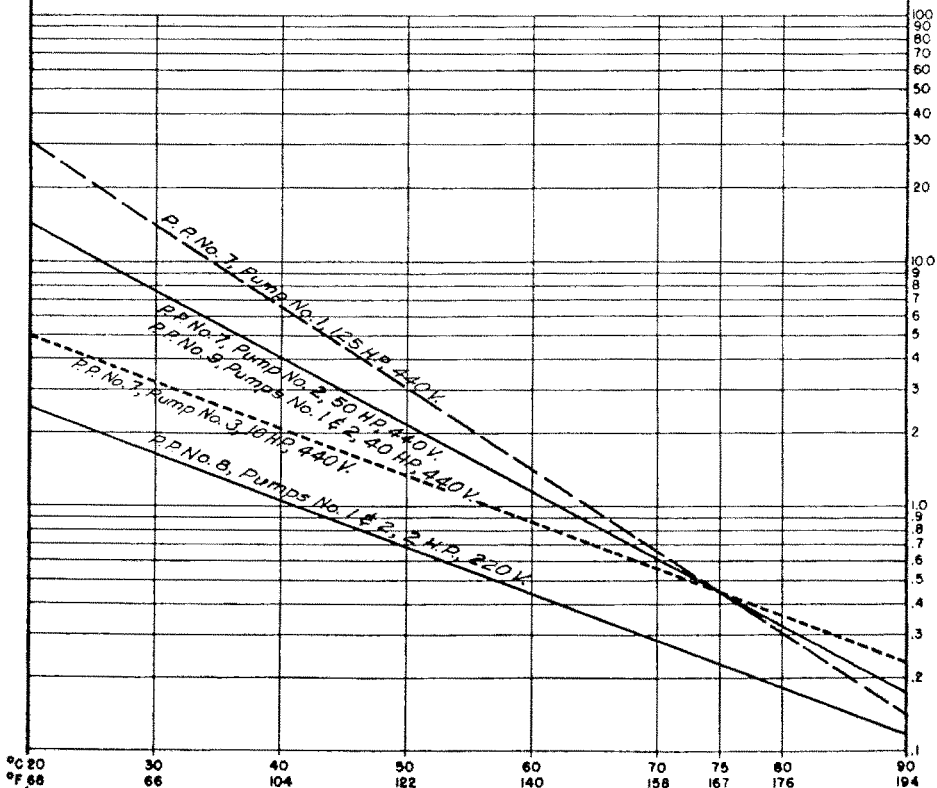
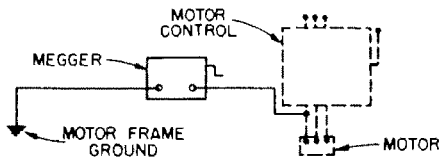


PLATE 20

CORPS OF ENGINEERS U.S. ARMY



WIRING DIAGRAM
INSULATION RESISTANCE

FLOOD PROTECTION

MOTOR WINDING
INSULATION RESISTANCE-TEMPERATURE CURVE

SCALES AS SHOWN

LOUISVILLE, KY.

PADUCAH, KENTUCKY

PUMPING PLANTS
NO. 10, 11 & 12

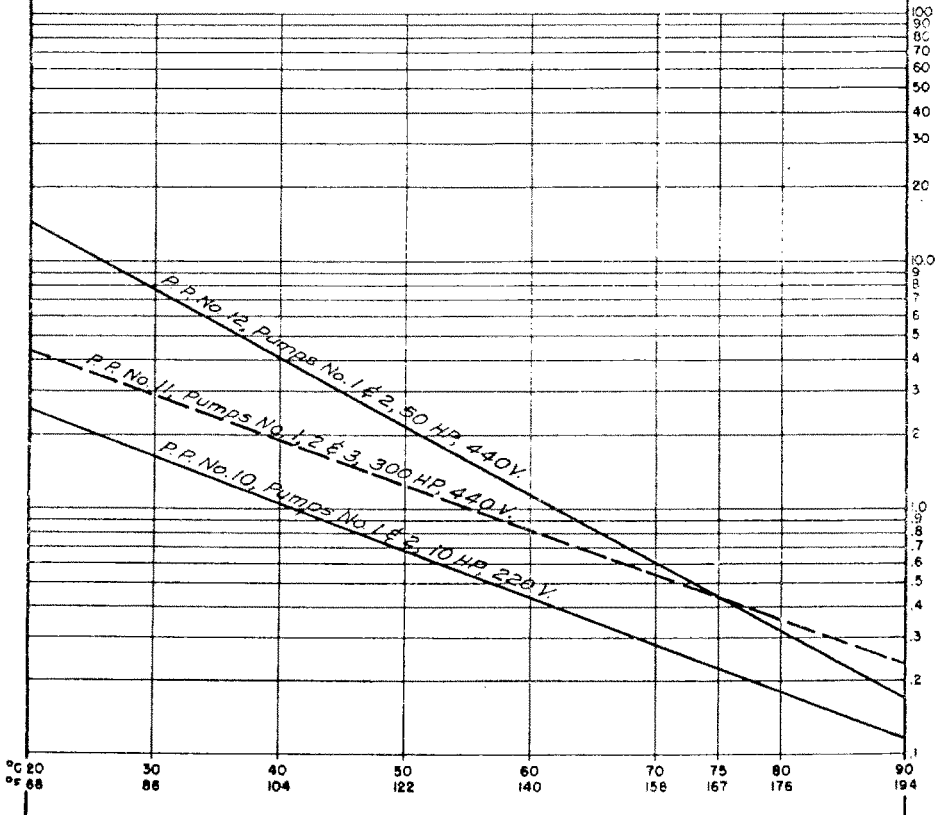


PLATE 21

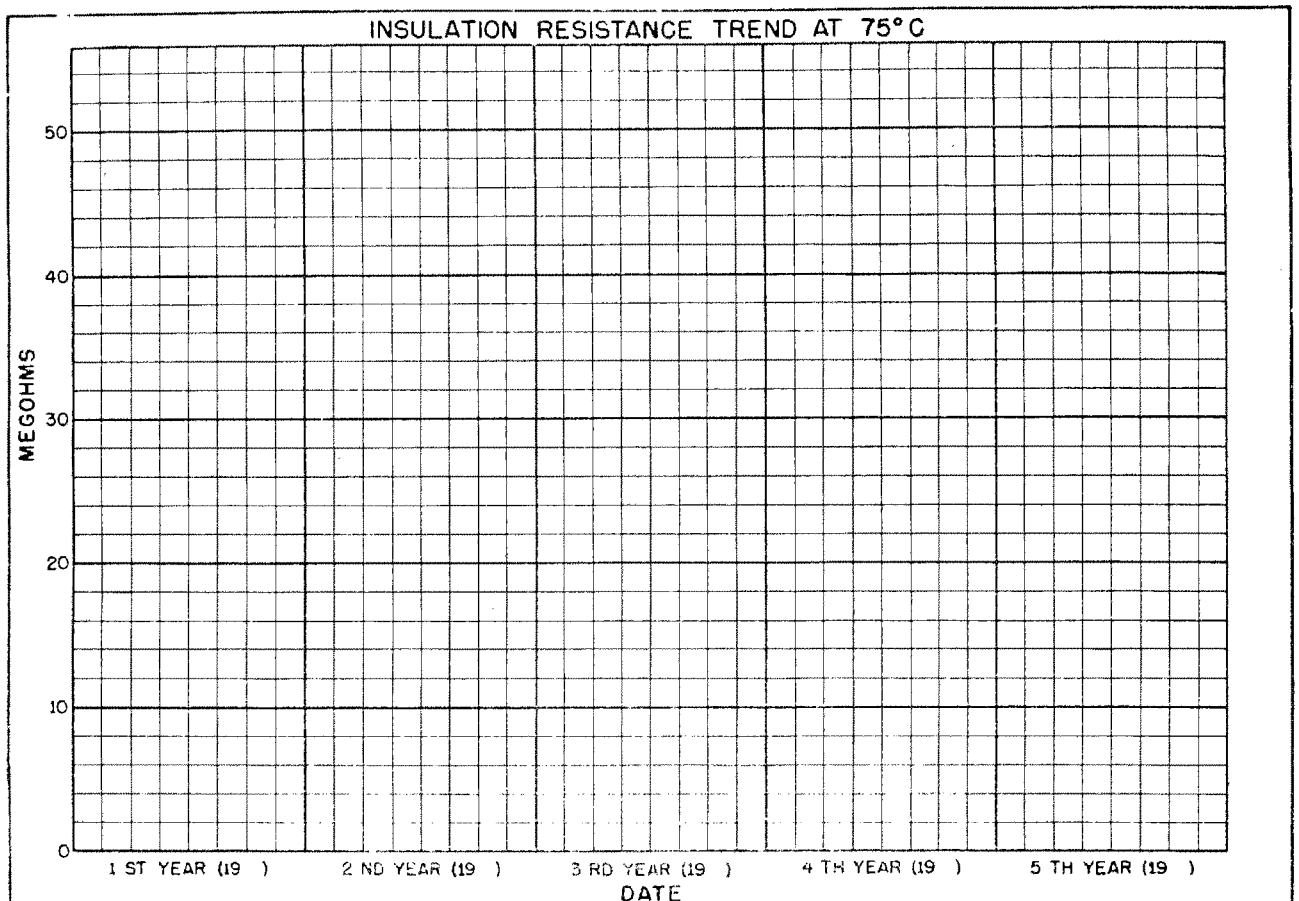
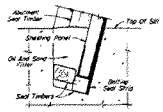
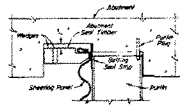

INSULATION RESISTANCE TREND AT 75°C
MEGOHMS
50
40
30
20
10
0
1 ST YEAR (19)
2 ND YEAR (19)
3 RD YEAR (19)
4 TH YEAR (19)
5 TH YEAR (19)
DATE

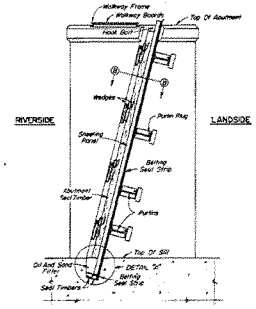
PLATE 22



DETAIL "A"



SECTION B-B



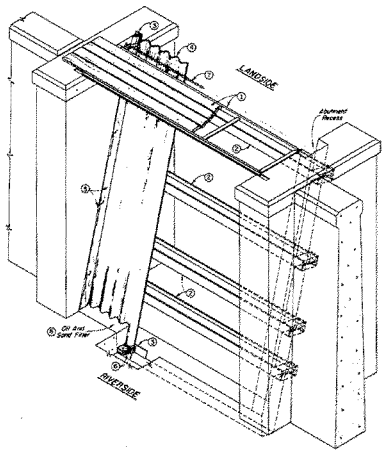
SECTION - ELEVATION

ORDER OF ERECTION

CLEAN OFF CONCRETE SILL, REMOVE BRICK AND SAND FROM SILL SEAL TRENCH.

1. PLACE WALKWAY FRAME AND BOARDS (SEE SECTION-ELEVATION).
2. PLACE PURLINS, BEGINNING AT BOTTOM, AND FIX WITH ATTACHED PINS.
3. LAY 5/8"X6" BOLTING SEAL STRIPS IN ABUTMENT RECESSES (SEE SECTION-ELEVATION). PLACE BOLTING SEAL STRIP IN SILL SEAL TRENCH (SEE DETAIL "A").
4. ERECT SHEETING PANELS AS SHOWN (SEE SECTION-ELEVATION). SET FIRST PANEL WITH LOOPED END 1' FROM CONCRETE IN ABUTMENT RECESS (SEE SECTION B-B). LOOPED END OF SECOND PANEL IS TO SLIP OVER PROJECTING LEG OF FIRST PANEL. REPEAT ASSEMBLY TO OPPOSITE ABUTMENT.
5. SET SIDE SEAL TIMBERS IN PLACE IN ABUTMENT RECESSES AND FIX WITH WEDGES (SEE SECTION ELEVATION).
6. SET BOTTOM SEAL TIMBERS AND WEDGE IN PLACE (SEE DETAIL "A"). PLACE OIL AND SAND FILLER IN SILL SEAL TRENCH.
7. INSTALL STIFFENER CHAIN ASSEMBLY. OBTAIN TENSION WITH TURNBUCKLES AND LOCK WITH JAM NUTS IN ORDER TO FACILITATE PLACEMENT OF SHEETING DURING WINDY WEATHER. STIFFENER CHAIN ASSEMBLY MAY BE INSTALLED BEFORE SHEETING IS ERECTED

NOTE: Before erecting gate, advise appropriate Railroad and Highway Patrol or Police officials to erect barricades, stopping wheeled traffic through gate opening.



CLOSURE DATA

ERECTION STAGE	LOCATION	
	CLOSURE	STORAGE VAULT
① 49.5 FEET	STA. 166+49-B TO TEXAS OIL CO	LANDSIDE STA. 166+40-B
① 49.5 FEET	STA. 8+98-B TO WEST KY. COAL CO.	LANDSIDE STA. 8+98-B
② 54.0 FEET	STA. 10+40-B TO THREE RIVERS OIL CO	LANDSIDE STA. 10+48-B
② 54.0 FEET	STA. 9+44-B TO PADUCAH COOPERAGE WORKS	LANDSIDE STA. 10+46-B
③ 52.5 FEET	STA. 36+95-B 325' EAST OF ISLAND CREEK	LANDSIDE STA. 36+40-B
	STA. 31+01-B TO BARGE ASSEMBLY WKS	LANDSIDE STA. 30+33-B
③ 52.5 FEET	STA. 29+80-B TO WEST KY. COAL CO.	LANDSIDE STA. 30+33-B
④ 55.0 FEET	STA. 69+64-B TO FOWLER WOLF BOILER WORKS	LANDSIDE STA. 69+51-B

OHIO RIVER BASIN

FLOOD PROTECTION - PADUCAH, KENTUCKY

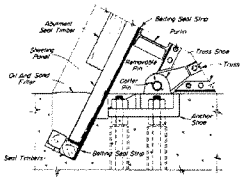
TYPICAL MOVABLE CLOSURE
(WITHOUT TRUSSES)

ORDER OF ERECTION

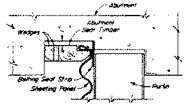
NOT TO SCALE

LOUISVILLE, KY. 1952

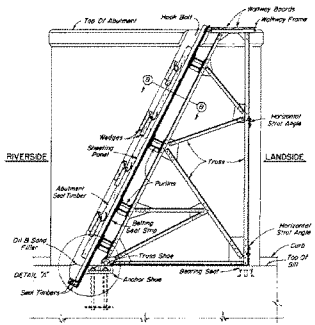
OPERATION AND MAINTENANCE MANUAL



DETAIL "A"



SECTION B-B



SECTION - ELEVATION

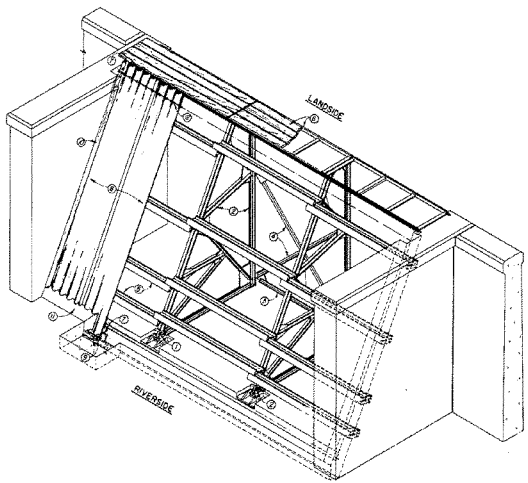
ORDER OF ERECTION

FOR RAILROAD CLOSURES: REMOVE SECTIONS OF RAIL, BALLAST AND CLEAN OFF CONCRETE BASE, REMOVE BRICK AND SAND FROM SILL SEAL TRENCH

FOR HIGHWAY CLOSURES: CLEAN OFF CONCRETE SILL, REMOVE BRICK AND SAND FROM SILL SEAL TRENCH

1. REMOVE CAST IRON PLUGS FROM FIXED ANCHOR SHOES IN TRUSS ANCHOR RECESSES AND INSERT TRUSS SHOES (SEE DETAIL "A")
2. SET TRUSSES IN PLACE AND CONNECT TO TRUSS SHOES WITH REMOVABLE PINS AND FIX WITH COTTER PINS (SEE DETAIL "A")
3. BOLT HORIZONTAL STRUT ANGLES TO TRUSSES.
4. BOLT DIAGONAL STRUT ANGLES TO TRUSSES.
5. PLACE PURLINS BEGINNING AT BOTTOM AND BOLT TO TRUSSES.
6. PLACE WALKWAY FRAME SECTIONS AND BOLT TOGETHER AND TO TRUSSES. PLACE WALKWAY FLOOR BOARDS (SEE SECTION-ELEVATION)
7. LAY BELTING SEAL STRIPS IN ABUTMENT RECESSES. INSERT SILL SEAL TRENCH SEAL STRIP (SEE DETAIL "A")
8. ERECT SHEETING PANELS, SETTING FIRST PANEL WITH LOOPED END 1 INCH FROM CONCRETE IN ABUTMENT RECESS. LOOPED END OF SECOND PANEL IS TO SLIP OVER PROJECTING LEG OF FIRST PANEL. REPEAT ASSEMBLY TO OPPOSITE ABUTMENT (SEE SECTION B-B)
9. SET SILL SEAL TRENCH SEAL TIMBERS AND WEDGE IN PLACE (SEE DETAIL "A")
10. SET SIDE SEAL TIMBERS IN ABUTMENT RECESSES AND FIX WITH WEDGES (SEE SECTION-ELEVATION)
11. PLACE OIL AND SAND FILLER IN SILL SEAL TRENCH (SEE DETAIL "A")
12. INSTALL STIFFENER CHAIN ASSEMBLY. OBTAIN TENSION WITH TURN BUCKLES AND LOCK WITH JAM NUTS. IN ORDER TO FACILITATE PLACEMENT OF SHEETING DURING WINDY WEATHER, STIFFENER CHAIN ASSEMBLY MAY BE INSTALLED BEFORE SHEETING IS ERECTED. WEDGE UNDER STIFFENER CHAIN AS REQUIRED TO PREVENT MOVEMENT OF THE PANELS DUE TO WIND PRIOR TO WATER LOADING.

NOTE: Before erecting gate, advise appropriate Railroad and Highway Patrol or Police officials to erect barricades, stopping wheeled traffic through gate opening.



CLOSURE DATA

ERECTION STAGE	LOCATION	
	CLOSURE	STORAGE VAULT
① 49.5 FEET	STA. 161+53-B 5th ST @ PARK AVE	LANDSIDE STA. 162+03-B
	STA. 149+87-B CLAY ST	RIVERSIDE STA. 149+48-B
	STA. 145+74-B HARRISON ST	RIVERSIDE NEAR PUMPING PLANT
	STA. 138+73-B 2nd ST	RIVERSIDE STA. 137+85
	STA. 135+23-B I.C.R.R. SPUR	LANDSIDE WEST ABUTMENT
	STA. 132+41-B MONROE ST	LANDSIDE STA. 132+51-B
	STA. 128+20-B I.C.R.R.	LANDSIDE WEST ABUTMENT
	STA. 123+80-B BROADWAY	RIVERSIDE STA. 124+24-B
	STA. 119+83-B KENTUCKY AVE.	RIVERSIDE STA. 120+08-B
	STA. 114+99-B WASHINGTON ST	RIVERSIDE NORTH ABUTMENT
	STA. 108+53-B CLARK ST	LANDSIDE STA. 109+63-B
	STA. 99+89-B JACKSON ST	LANDSIDE STA. 98+99-B
	STA. 94+64-B OHIO ST	LANDSIDE STA. 94+76-B
① 49.5 FEET	STA. 93+57-B TO WEST KY COAL CO.	LANDSIDE STA. 94+76-B
② 51.0 FEET	STA. 172+04-B I.C.R.R.	LANDSIDE WEST ABUTMENT
	STA. 157+26-B 4th ST	LANDSIDE STA. 156+88-B
	STA. 151+92-B N.C.& ST. L.R.R.	RIVERSIDE STA. 153+28-B
	STA. 23+15-B I.C.R.R.	LANDSIDE STA. 26+22-B
	STA. 4+35-B I.C.R.R. SPUR	RIVERSIDE STA. 4+00-B
	STA. 4+50-B I.C.R.R. SPUR	RIVERSIDE STA. 4+00-B

ERECTION STAGE	LOCATION	
	CLOSURE	STORAGE VAULT
⑤ 52.5 FEET	STA. 103+64-B ADAMS ST	LANDSIDE STA. 103+74-B
	STA. 90+39-B TENNESSEE ST	LANDSIDE STA. 90+29-B
③ 52.5 FEET	STA. 142+46-A I.C.R.R. MAIN LINE	LANDSIDE SOUTH ABUTMENT
④ 53.5 FEET	STA. 106+10-B TO LANDSTAFF OKIM LBR CO.	LANDSIDE STA. 105+22-B
	STA. 75+85-B N.C.& ST. L.R.R.	RIVERSIDE EAST ABUTMENT
	STA. 71+75-B N.C.& ST. L.R.R. SPUR	RIVERSIDE EAST ABUTMENT
	STA. 62+34-B N.C.& ST. L.R.R. SPUR	RIVERSIDE WEST ABUTMENT
	STA. 5+93-B I.C.R.R. SPUR	RIVERSIDE EAST ABUTMENT
④ 53.5 FEET	STA. 26+90-B NEAR CLEMENTS ST	LANDSIDE STA. 26+35-B
⑤ 55.0 FEET	STA. 104+56-C N.C.& ST. L.R.R. MAIN LINE	LANDSIDE WEST ABUTMENT
	STA. 54+38-B ELIZABETH ST	LANDSIDE SOUTH ABUTMENT
⑤ 55.0 FEET	STA. 5+87-B TO GULF REFINING CO.	LANDSIDE SOUTH ABUTMENT

OHIO RIVER BASIN

FLOOD PROTECTION - PADUCAH, KENTUCKY

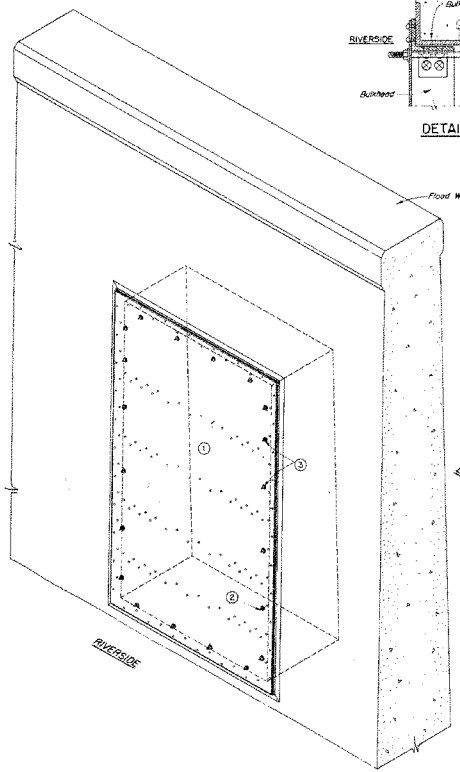
TYPICAL MOVABLE CLOSURE
(WITH TRUSSES)

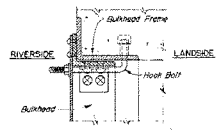
ORDER OF ERECTION

NOT TO SCALE

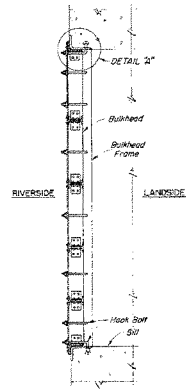
LOUISVILLE, KY 1952

OPERATION AND MAINTENANCE MANUAL





DETAIL "A"



SECTION – ELEVATION

ORDER OF ERECTION

CLEAN OFF SILL AND REMOVE DIRT FROM HOOK BOLT HOLES IN BULKHEAD FRAME.

1. PLACE BULKHEAD AGAINST BULKHEAD FRAME ON RIVERSIDE OF SERVICE OPENING (SEE SECTION-ELEVATION).
2. INSERT HOOK BOLTS, ATTACH WASHERS AND NUTS (SEE DETAIL "A").
3. TIGHTEN NUTS EVENLY AROUND BULKHEAD.

SERVICE OPENING DATA

ERECTION STAGE	LOCATION	
	SERVICE OPENING	STORAGE VAULT
1 49.5 FEET	STA. 150+18-B CLAY ST.	RIVERSIDE STA. 149+49-B
	STA. 149+57-B CLAY ST.	RIVERSIDE STA. 149+49-B
	STA. 136+54-B 2nd ST.	RIVERSIDE STA. 137+86-B
	STA. 137+93-B 2nd ST.	RIVERSIDE STA. 137+86-B
	STA. 124+10-B BROADWAY	RIVERSIDE STA. 124+25-B
	STA. 123+50-B BROADWAY	RIVERSIDE STA. 124+25-B
1 49.5 FEET	STA. 119+93-B KENTUCKY AVE.	RIVERSIDE STA. 120+08-B
2 51.0 FEET	STA. 157+57-B 4th ST.	LANDSIDE STA. 156+88-B
	STA. 156+96-B 4th ST.	LANDSIDE STA. 156+88-B
2 51.0 FEET	STA. 154+32-B TO THREE RIVERS OIL CO.	LANDSIDE STA. 154+49-B
4 53.5 FEET	STA. 3+21-B 125' EAST OF I.C.R.R. SPUR	RIVERSIDE STA. 4+00-B
4 53.5 FEET	STA. 2+67-B 160' EAST OF I.C.R.R. SPUR	RIVERSIDE STA. 4+00-B
5 55.0 FEET	STA. 79+27-B TO SOU. TEXTILE MACH. CO.	RIVERSIDE STA. 75+94-B
5 55.0 FEET	STA. 73+31-B TO PHILLIPS PETROLEUM CO.	RIVERSIDE STA. 71+86-B

OHIO RIVER BASIN

FLOOD PROTECTION – PADUCAH, KY.

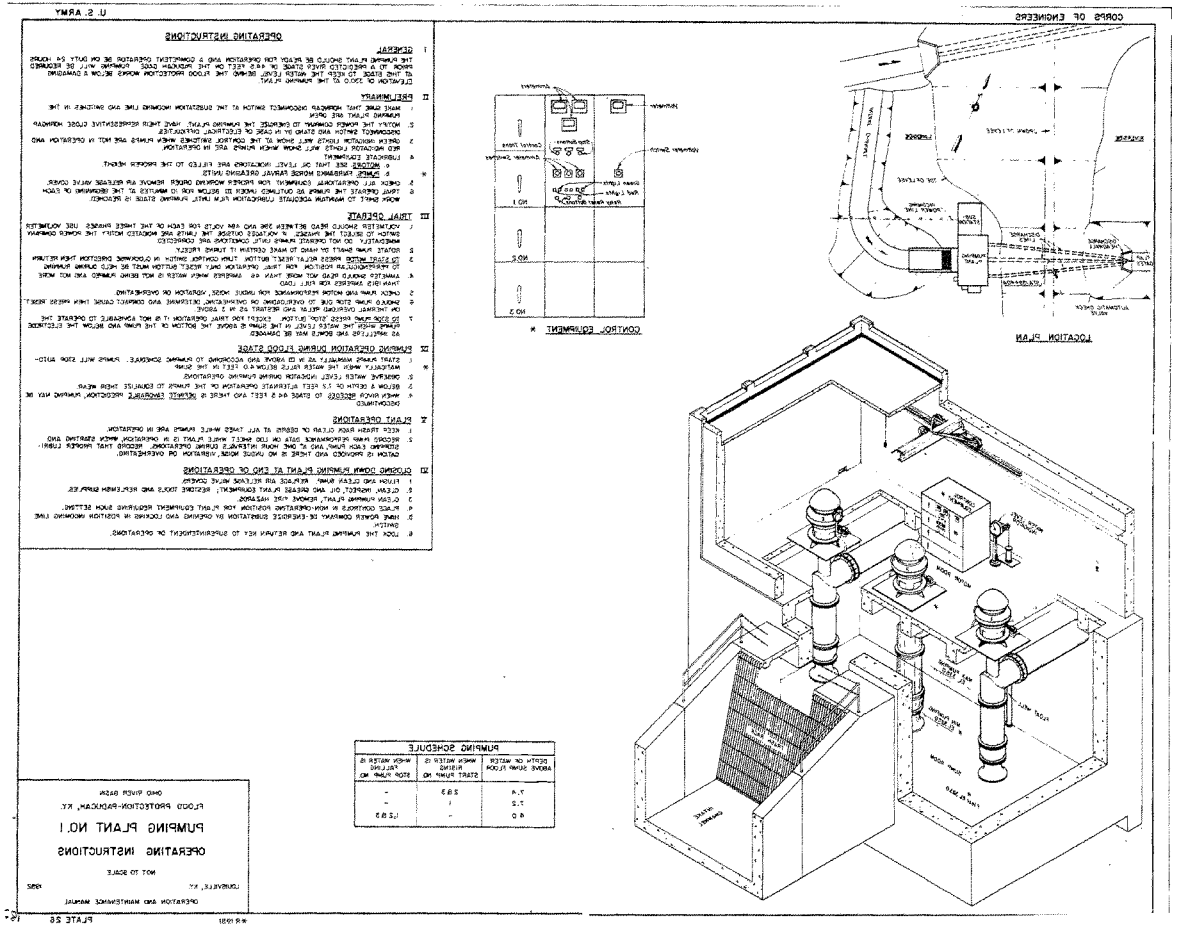
TYPICAL SERVICE OPENING

ORDER OF ERECTION

NOT TO SCALE

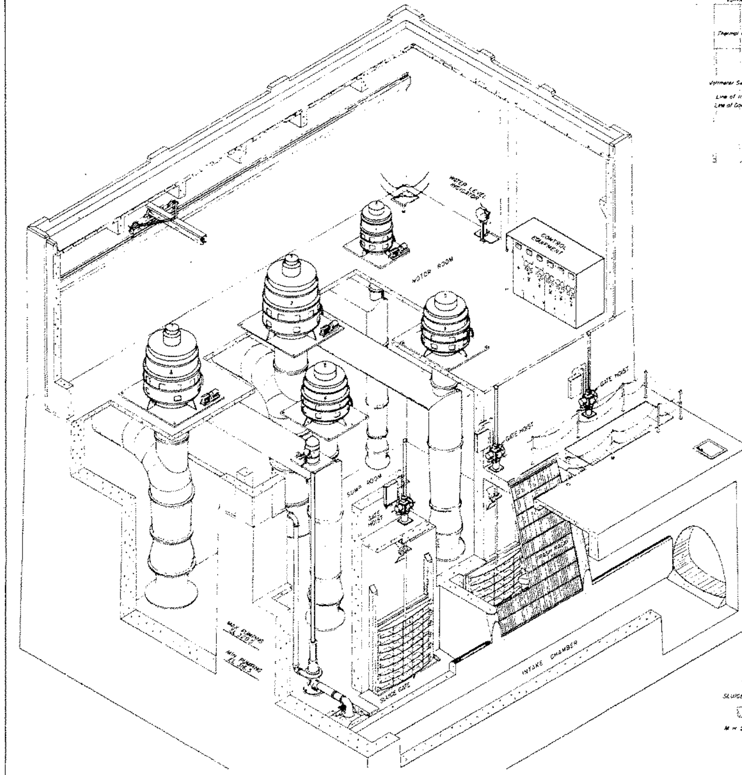
LOUISVILLE, KY. 1952

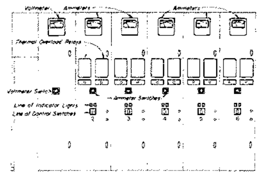
OPERATION AND MAINTENANCE MANUAL


U. S. ARMY
CORPS OF ENGINEERS
OPERATING INSTRUCTIONS
I GENERAL
II PRELIMINARY
III TRIAL OPERATE
IV PUMPING OPERATION DURING FLOOD STAGE
V PLANT OPERATIONS
VI CLOSING DOWN PUMPING PLANT AT END OF OPERATIONS
CONTROL EQUIPMENT
LOCATION PLAN
PUMPING SCHEDULE
OHIO RIVER BASIN
FLOOD PROTECTION-PADUCAH, KY.
PUMPING PLANT NO. 1
OPERATING INSTRUCTIONS
NOT TO SCALE
LOUISVILLE, KY.
1952
OPERATION AND MAINTENANCE MANUAL
PLATE 26

CORPS OF ENGINEERS

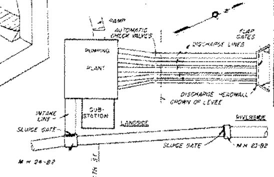
U. S. ARMY





CONTROL EQUIPMENT

PUMPING SCHEDULE				
PLANT WATER LEVEL INDICATOR GAGE READING	WHEN WATER IS RISING		WHEN WATER IS FALLING	
	START PUMP	STOP PUMP	START PUMP	STOP PUMP
155	1&2	-	-	-
150	6	-	-	-
145	5	-	-	-
140	4	5	-	-
135	3	6	-	-
130	6	-	-	-
125	5	2	-	-
120	2	-	-	-
110	-	-	-	1&2
105	-	-	-	6
100	-	-	-	5
95	-	-	5	4
90	-	-	6	3
85	-	-	-	[illegible]
80	-	-	2	[illegible]
30	-	-	1	2
20	-	-	-	-
10	-	-	-	-



LOCATION PLAN

OPERATING INSTRUCTIONS

I. GENERAL:

THE PUMPING PLANT SHOULD BE READY FOR OPERATION WITH A COMPETENT OPERATOR ON DUTY 24 HOURS PRIOR TO PREDICTED RIVER STAGE OF 32.5 FEET ON THE PADUCAH GAGE.

II. PRELIMINARY:

1. ALL SWITCHES ARE IN THE "OFF" POSITIONS, ESPECIALLY THE HORNGAP DISCONNECT SWITCH AT THE SUBSTATION.
2. NOTIFY THE POWER COMPANY TO ENERGIZE THE PUMPING PLANT. HAVE THEIR REPRESENTATIVE CLOSE THE FUSED CUTOUTS AND STAND BY IN CASE OF IMMEDIATE ELECTRICAL DIFFICULTY.
3. THE GREEN INDICATOR LIGHTS WILL SHOW AT THE CONTROL SWITCHES WHEN PUMP MOTORS ARE NOT IN OPERATION AND RED LIGHTS WILL SHOW WHEN PUMP MOTORS ARE RUNNING.
4. TRASH RACKS AND SUMP SHOULD BE CLEAR OF DEBRIS AND THE TRASH RACKS SECURELY IN PLACE.
5. LUBRICATE EQUIPMENT.
   A. MOTORS. CHECK THAT OIL LEVEL INDICATORS ARE FILLED TO THE PROPER HEIGHT.
   B. PUMPS. ALLOW APPROXIMATELY ONE PINT OF OIL TO FLOW INTO EACH PUMP. REFILL OILERS. OPERATE OILERS BY HAND WHEN MOTORS ARE NOT OPERATING. GREASE LOWER PUMP BEARING ALEMITE FITTING ON PUMP BASE.
6. CHECK ALL OPERATION EQUIPMENT FOR PROPER WORKING ORDER.
7. TRIAL OPERATE PUMPS AS OUTLINED UNDER III BELOW FOR ABOUT 10 MINUTES AT THE BEGINNING OF EACH WORK SHIFT TO MAINTAIN ADEQUATE LUBRICATION UNTIL PUMPING STAGE IS REACHED.
8. REMOVE BLIND FLANGES FROM AIR RELEASE VALVES.
9. UNLOCK SYPHON BREAKER VALVES.

III. TRIAL OPERATION:

1. VOLTMETER SHOULD READ BETWEEN 2300 AND 2400 VOLTS FOR EACH OF THE THREE PHASES. USE VOLTMETER SWITCH TO SELECT THE PHASES. NOTIFY POWER COMPANY IF VOLTAGES ARE NOT WITHIN LIMITS. DO NOT OPERATE THE PUMPS UNTIL CONDITIONS ARE CORRECTED.
2. TURN PUMP SHAFT BY HAND TO MAKE SURE IT IS FREE.
3. TO START MOTOR TURN CONTROL SWITCH TO "MANUAL".
4. * AMMETER SHOULD NOT READ MORE THAN THE RATED AMPERAGE PER TERMINAL ON EACH INDIVIDUAL MOTOR SEE TABLE 1 COLUMN 6
5. CHECK PUMP AND MOTOR PERFORMANCE FOR UNDUE NOISE, VIBRATION OR OVERHEATING.
6. SHOULD PUMP STOP DUE TO OVERHEATING, DETERMINE AND CORRECT CAUSE. IF PUMP STOPS REPEATEDLY, DETERMINE AND CORRECT CAUSE. RE-START MOTORS AS IN 3. ABOVE.
7. STOP MOTOR BY RETURNING SWITCH TO CENTER OR "OFF" POSITION. EXCEPT FOR TRIAL OPERATION, IT IS NOT ADVISABLE TO OPERATE THE PUMPS WHEN THE WATER LEVEL IN THE SUMP IS BELOW THE ELECTRODES AS IMPELLERS AND BOWLS MAY BE DAMAGED.
8. TO OPERATE SUMP SLUICE GATES OPEN DOORS TO EACH HOIST UNIT, TURN BREAKER HANDLE TO "ON" POSITION, PUSH APPROPRIATE BUTTON FOR "UP" OR "DOWN" TRAVEL. INDICATOR LIGHTS WILL SHOW WHEN GATE IS FULLY OPEN OR CLOSED AND MECHANICAL INDICATOR WILL SHOW GATE AT ANY POINT OF TRAVEL.

IV. PUMPING OPERATION DURING FLOOD STAGE:

1. WHEN RIVER STAGE REACHES ABOUT 34.0 FEET OPEN SLUICE GATE IN MANHOLE 24-82 THEN SEPARATELY RAISE EACH MOTOR-OPERATED SLUICE GATE TO PUMP SUMP.
2. SET PUMP CONTROLS FOR AUTOMATIC OPERATION AND START PUMPING.
3. CLOSE SLUICE GATE IN MANHOLE 23-82.

V. PLANT OPERATION:

1. KEEP TRASH RACKS CLEAR OF DEBRIS WITH THE RAKE WHILE PUMPS ARE OPERATING.
2. WHEN THE RIVER STAGE DROPS TO ABOUT 34.0 FEET AND CONTINUED LOWERING IS PREDICTED OPEN GATE IN MANHOLE 23-82 AND PLACE PUMP CONTROLS IN "OFF" POSITION.
3. CLOSE SLUICE GATE IN MANHOLE 24-82.
4. RECORD PLANT PERFORMANCE DATA ON LOG SHEET WHILE PLANT IS IN OPERATION, WHEN STARTING AND STOPPING EACH PUMP AND AT THE BEGINNING OF EACH SHIFT. OBSERVE THAT PROPER LUBRICATION IS PROVIDED AND THERE IS NO UNDUE VIBRATION, NOISE OR OVERHEATING.

VI. CLOSING DOWN PUMPING PLANT AT END OF OPERATIONS:

1. LOWER MOTOR-OPERATED SLUICE GATES. CLOSE GATE IN MANHOLE 24-82. OPEN SLUICE GATE IN MANHOLE 23-82.
2. FLUSH AND CLEAN INTAKE CHAMBER AND SUMP.
3. CLEAN, INSPECT, OIL AND GREASE PLANT EQUIPMENT; RESTORE TOOLS AND REPLENISH SUPPLIES.
4. CLEAN PUMPING PLANT; REMOVE FIRE HAZARDS.
5. OPEN ALL SWITCHES. NOTIFY POWER COMPANY TO OPEN HORNGAP DISCONNECT SWITCH AT SUBSTATION, LOCK INTO POSITION AND SO DE-ENERGIZE PLANT.
6. LOCK THE PUMPING PLANT AND RETURN KEY TO SUPERINTENDENT OF OPERATIONS.

OHIO RIVER BASIN

FLOOD PROTECTION - PADUCAH, KY

PUMPING PLANT NO. 2

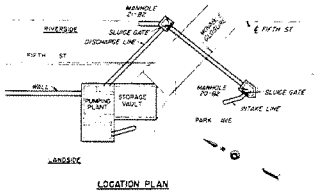
OPERATING INSTRUCTIONS

NOT TO SCALE

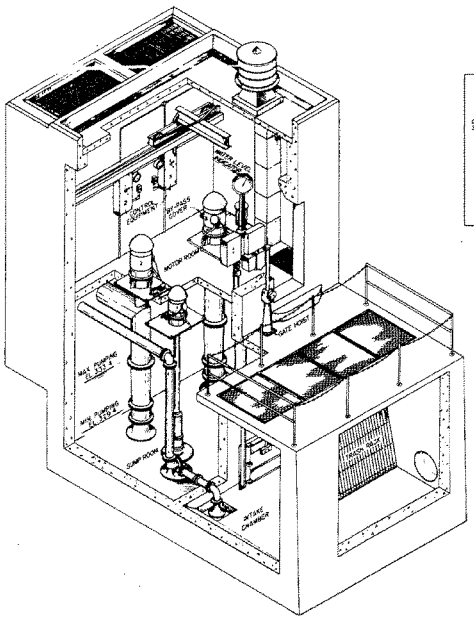
LOUISVILLE, KY 1952

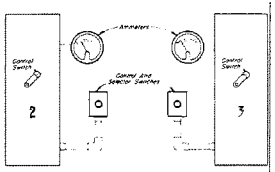
OPERATION AND MAINTENANCE MANUAL 183

K.R. 1981



LOCATION PLAN





CONTROL EQUIPMENT

PUMPING SCHEDULE		
PLANT WATER LEVEL INDICATOR GAGE READING	WHEN WATER IS RISING START PUMP NO	WHEN WATER IS FALLING STOP PUMP NO
7.9	2	-
7.5	-	-
3.2	-	2
2.8	-	-
2.5	3	-
1.0	-	3

OPERATING INSTRUCTIONS

I. GENERAL:

THE PUMPING PLANT SHOULD BE READY FOR OPERATION WITH A COMPETENT OPERATOR ON DUTY 24 HOURS PRIOR TO PREDICTED RIVER STAGE OF 44.4 FEET ON THE PADUCAH GAGE.

II. PRELIMINARY:

1. ALL SWITCHES ARE TO BE IN THE OPEN POSITION, ESPECIALLY THE FUSED CUTOUTS ON THE INCOMING POWER LINE.
2. NOTIFY THE POWER COMPANY TO ENERGIZE THE PUMPING PLANT. HAVE THEIR REPRESENTATIVE CLOSE THE FUSED CUTOUTS AND STAND BY IN CASE OF IMMEDIATE ELECTRICAL DIFFICULTY.
3. TRASH RACKS AND SUMP SHOULD BE CLEAR OF DEBRIS AND THE TRASH RACKS SECURELY IN PLACE.
4. LUBRICATE EQUIPMENT.
   A. MOTORS. CHECK THAT OIL LEVEL INDICATORS ARE FILLED TO THE PROPER HEIGHT.
   B. PUMPS. ALLOW APPROXIMATELY ONE PINT OF OIL TO FLOW INTO EACH PUMP. REFILL OILERS. CRANK OILERS BY HAND IF MOTORS ARE NOT OPERATING. GREASE LOWER BEARING IN PUMPS. ALEMITE FITTING ON PUMP BASE.
5. CHECK ALL OPERATION EQUIPMENT FOR PROPER WORKING ORDER AND ADJUSTMENT.
6. TRIAL OPERATE PUMPS AS OUTLINED UNDER III BELOW FOR ABOUT 10 MINUTES AT THE BEGINNING OF EACH WORK SHIFT TO MAINTAIN ADEQUATE LUBRICATION UNTIL PUMPING STAGE IS REACHED.

III. TRIAL OPERATION:

1. VOLTMETER SHOULD READ BETWEEN 200 AND 240 VOLTS FOR EACH OF THE THREE PHASES. USE VOLTMETER SWITCH TO SELECT THE PHASES. NOTIFY POWER COMPANY IF VOLTAGES ARE NOT WITHIN LIMITS. DO NOT OPERATE THE PUMPS UNTIL CONDITIONS ARE CORRECTED.
2. TURN PUMP SHAFT BY HAND TO MAKE SURE IT IS FREE.
3. START MOTOR BY PUSHING CONTROL LEVER RAPIDLY TO "ON". TURN ROTARY SELECTOR SWITCH TO "RUN" OR "AUTOMATIC".
4. * AMMETER SHOULD NOT READ MORE THAN THE RATED AMPERAGE PER TERMINAL ON EACH INDIVIDUAL MOTOR. SEE TABLE 5 COLUMN 10
5. CHECK PUMP AND MOTOR PERFORMANCE FOR UNDUE NOISE, VIBRATION OR OVERHEATING.
6. SHOULD PUMP STOP DUE TO OVERHEATING, PUSH RESET BUTTON AND RESTART. IF PUMP STOPS REPEATEDLY OR DOES NOT START, DETERMINE AND CORRECT CAUSE. RE-START MOTORS AS IN 3. ABOVE.
7. STOP MOTOR BY TURNING SELECTOR SWITCH TO THE "OFF" POSITION. EXCEPT FOR TRIAL OPERATION, IT IS NOT ADVISABLE TO OPERATE THE PUMPS WHEN THE WATER LEVEL IN THE SUMP IS BELOW THE ELECTRODES AS IMPELLERS AND BOWLS MAY BE DAMAGED.

IV. PUMPING OPERATION DURING FLOOD STAGE:

1. WHEN RIVER STAGE REACHES ABOUT 45.9 FEET OPEN SLUICE GATE IN MANHOLE 20-B2 THEN OPEN SLUICE GATE TO PUMP SUMP.
2. CLOSE SLUICE GATE IN MANHOLE 21-B2.
3. SET PUMP CONTROLS, IN TURN, FOR AUTOMATIC OPERATION.

V. PLANT OPERATION:

1. KEEP TRASH RACKS CLEAR OF DEBRIS WITH THE RAKE WHILE PUMPS ARE OPERATING.
2. WHEN THE RIVER STAGE DROPS TO ABOUT 45.9 FEET AND CONTINUES LOWERING IS PREDICTED OPEN GATE IN MANHOLE 21-B2 AND PLACE PUMP CONTROLS IN "OFF" POSITION.
3. RECORD PLANT PERFORMANCE DATA ON LOG SHEET WHILE PLANT IS IN OPERATION, WHEN STARTING AND STOPPING EACH PUMP AND AT THE BEGINNING OF EACH SHIFT. OBSERVE THAT PROPER LUBRICATION IS PROVIDED AND THERE IS NO UNDUE VIBRATION, NOISE OR OVERHEATING.

VI. CLOSING DOWN PUMPING PLANT AT END OF OPERATIONS:

1. SEE THAT GATE IN MANHOLE 21-B2 IS OPEN.
2. CLOSE SLUICE GATE IN MANHOLE 20-B2.
3. FLUSH AND CLEAN INTAKE CHAMBER AND SUMP.
4. CLOSE SLUICE GATE TO PUMP SUMP.
5. CLEAN, INSPECT, OIL AND GREASE PLANT EQUIPMENT: RESTORE TOOLS AND REPLENISH SUPPLIES.
6. CLEAN PUMPING PLANT: REMOVE FIRE HAZARDS.
7. OPEN ALL SWITCHES. NOTIFY POWER COMPANY TO OPEN HORNGAP DISCONNECT SWITCH AT SUBSTATION, LOCK INTO POSITION AND SO DE-ENERGIZE PLANT.
8. LOCK THE PUMPING PLANT AND RETURN KEY TO SUPERINTENDENT OF OPERATIONS.

OHIO RIVER BASIN
FLOOD PROTECTION - PADUCAH, KY.

PUMPING PLANT NO. 3

OPERATING INSTRUCTIONS

NOT TO SCALE

LOUISVILLE, KY. 1952

OPERATION AND MAINTENANCE MANUAL

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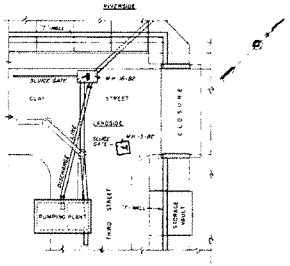
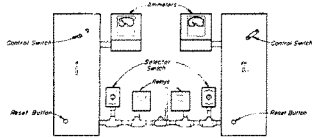
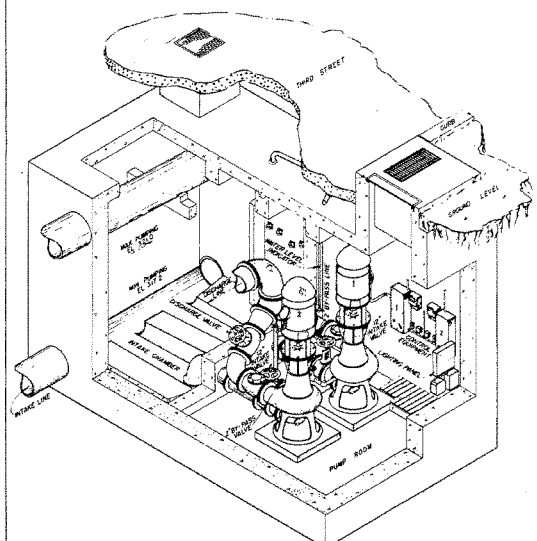
PLATE 28



LOCATION PLAN



CONTROL EQUIPMENT



PUMPING SCHEDULE		
PLANT WATER LEVEL INDICATOR GAGE READING	WHEN WATER IS RISING START PUMP NO.	WHEN WATER IS FALLING STOP PUMP NO.
36	4	-
34	1	-
24	-	2
20	-	1

OPERATING INSTRUCTIONS

I. GENERAL:

THE PUMPING PLANT SHOULD BE READY FOR OPERATION WITH A COMPETENT OPERATOR ON DUTY 24 HOURS PRIOR TO PREDICTED RIVER STAGE OF 32.7 FEET ON THE PADUCAH GAGE.

II. PRELIMINARY:

1. ALL SWITCHES ARE TO BE IN THE OPEN POSITION, ESPECIALLY THE FUSED CUTOUTS ON THE INCOMING POWER LINE.
2. NOTIFY THE POWER COMPANY TO ENERGIZE THE PUMPING PLANT. HAVE THEIR REPRESENTATIVE CLOSE THE FUSED CUTOUTS AND STAND BY IN CASE OF IMMEDIATE ELECTRICAL DIFFICULTY.
3. CLOSE LINE POLE SWITCH.
4. TURN ON VENTILATING FAN AND LIGHT SWITCH. SUMP SHOULD BE CLEAR OF DEBRIS.
5. PROVIDE FRESH GREASE FOR THE PUMP BEARINGS BY ADDING GREASE AT THE ALEMITE FITTINGS. LUBRICATE EVERY EIGHT HOURS OF OPERATION.
6. CHECK ALL OPERATION EQUIPMENT FOR PROPER WORKING ORDER AND ADJUSTMENT.
7. TRIAL OPERATE PUMPS AS OUTLINED UNDER III BELOW FOR ABOUT 10 MINUTES AT THE BEGINNING OF EACH WORK SHIFT TO MAINTAIN ADEQUATE LUBRICATION UNTIL PUMPING STAGE IS REACHED.

III. TRIAL OPERATION:

1. TURN PUMP SHAFT BY HAND TO MAKE SURE IT IS FREE.
2. START MOTOR BY PUSHING CONTROL LEVER RAPIDLY TO "ON". TURN ROTARY SELECTOR SWITCH TO "RUN" OR "AUTOMATIC".
3. AMMETER SHOULD READ NOT MORE THAN 27.2 AMPS WHEN WATER IS NOT BEING PUMPED AND NOT MORE THAN 78.0 AMPS UNDER FULL LOAD.
4. CHECK PUMP AND MOTOR PERFORMANCE FOR UNDUE NOISE, VIBRATION OR OVERHEATING.
5. SHOULD PUMP STOP DUE TO OVERHEATING, PUSH RESET BUTTON AND RESTART. IF PUMP STOPS REPEATEDLY, OR DOES NOT START DETERMINE AND CORRECT CAUSE. RE-START MOTORS AS IN 2, ABOVE.
6. STOP MOTOR BY TURNING THE SELECTOR SWITCH TO THE "OFF" POSITION. EXCEPT FOR TRIAL OPERATION, IT IS NOT ADVISABLE TO OPERATE THE PUMPS WHEN THE WATER LEVEL IN THE SUMP IS BELOW THE ELECTRODES AS VOLUTES AND SEALS MAY BE DAMAGED.

IV. PUMPING OPERATION DURING FLOOD STAGE:

1. WHEN RIVER STAGE REACHES ABOUT 34.2 FEET OPEN 12 INCH INTAKE AND DISCHARGE LINE GATE VALVES IN PUMP CHAMBER.
2. MAKE SURE 2" BYPASS VALVES ARE CLOSED BEFORE PUMPING.
3. START PUMPS.
4. CLOSE SLUICE GATE IN MH 16-82 AND INSPECT PRESSURE PLATE.
5. AT A RIVER STAGE OF 45.7 CLOSE SLUICE GATE IN MH 25-82.

V. PLANT OPERATION:

1. OPEN SLUICE GATE IN MH 25-82 AT A RIVER STAGE OF 42.7. WHEN THE RIVER STAGE DROPS TO ABOUT 34.2 FEET AND CONTINUED LOWERING IS PREDICTED OPEN GATE IN MANHOLE 16-82 AND PLACE PUMP CONTROLS IN "OFF" POSITION.
2. RECORD PLANT PERFORMANCE DATA ON LOG SHEET WHILE PLANT IS IN OPERATION, WHEN STARTING AND STOPPING EACH PUMP AND AT THE BEGINNING OF EACH SHIFT. OBSERVE THAT PROPER LUBRICATION IS PROVIDED AND THERE IS NO UNDUE VIBRATION, NOISE OR OVERHEATING.

VI. CLOSING DOWN PUMPING PLANT AT END OF OPERATIONS:

1. SEE THAT GATE IN MANHOLE 16-82 IS OPEN.
2. FLUSH AND CLEAN INTAKE CHAMBER AND SUMP.
3. DRAIN PUMPS BY OPENING 2-INCH BY-PASS VALVES.
4. CLEAN, INSPECT, OIL AND GREASE PLANT EQUIPMENT: RESTORE TOOLS AND REPLENISH SUPPLIES.
5. CLEAN PUMPING PLANT: REMOVE FIRE HAZARDS.
6. NOTIFY POWER COMPANY TO OPEN FUSED CUTOUTS AT SUBSTATION, LOCK INTO POSITION AND SO DE-ENERGIZE PLANT.
7. OPEN LINE POLE SWITCH.
8. START DEHUMIDIFIER, TURN OFF LIGHTS FROM TOP OF LADDER
9. LOCK THE PUMPING PLANT AND RETURN KEY TO SUPERINTENDENT OF OPERATIONS.

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OHIO RIVER BASIN
FLOOD PROTECTION - PADUCAH, KY.

PUMPING PLANT NO. 4

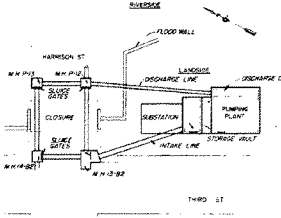
OPERATING INSTRUCTIONS

NOT TO SCALE

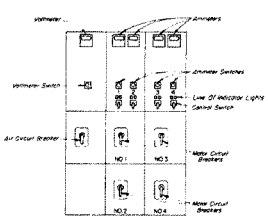
LOUISVILLE, KY. 1952

OPERATION AND MAINTENANCE MANUAL

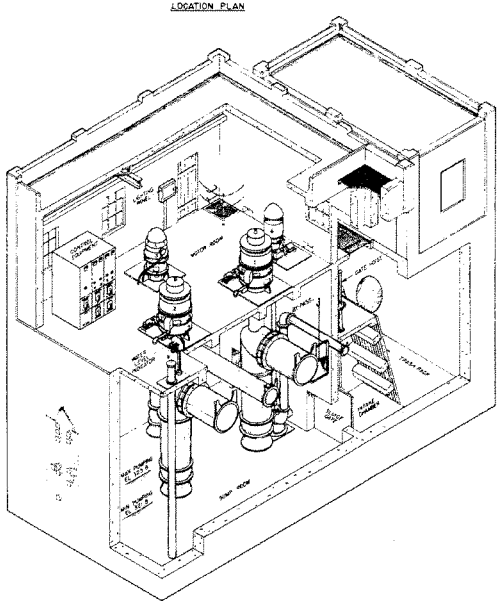
PLATE 29



LOCATION PLAN



CONTROL EQUIPMENT



PUMPING SCHEDULE				
PLANT WATER LEVEL INDICATOR GAGE READING	WHEN WATER IS RISING		WHEN WATER IS FALLING	
	START PUMP	STOP PUMP	START PUMP	STOP PUMP
10.3	1	-	-	-
9.9	2	3	-	-
9.5	3	-	-	-
9.1	2	3	-	-
8.7	3	-	-	-
5.8	-	-	-	3
5.4	-	-	3	2
5.0	4	-	-	3
4.6	-	-	3	1
4.0	-	-	-	3
1.5	-	-	-	4

OPERATING INSTRUCTIONS

I. GENERAL:

THE PUMPING PLANT SHOULD BE READY FOR OPERATION WITH A COMPETENT OPERATOR ON DUTY 24 HOURS PRIOR TO PREDICTED RIVER STAGE OF 37.5 FEET ON THE PADUCAH GAGE.

II. PRELIMINARY:

1. ALL SWITCHES ARE TO BE IN THE OPEN POSITION, ESPECIALLY THE FUSED CUTOUTS ON THE INCOMING POWER LINE. GREEN INDICATORS WILL SHOW ON CONTROL PANELS WHEN BREAKERS ARE OPEN. RED INDICATORS WILL SHOW WHEN BREAKERS ARE CLOSED.
2. NOTIFY THE POWER COMPANY TO ENERGIZE THE PUMPING PLANT. HAVE THEIR REPRESENTATIVE CLOSE THE FUSED CUTOUTS AND STAND BY IN CASE OF IMMEDIATE ELECTRICAL DIFFICULTY.
3. TRASH RACKS AND SUMP SHOULD BE CLEAR OF DEBRIS AND THE TRASH RACKS SECURELY IN PLACE.
4. LUBRICATE EQUIPMENT.
   A. MOTORS. CHECK THAT OIL LEVEL INDICATORS ARE FILLED TO THE PROPER HEIGHT.
   B. PUMPS. ALLOW APPROXIMATELY ONE PINT OF OIL TO FLOW INTO EACH PUMP. REFILL OILERS. OPERATE OILERS BY HAND.
5. CHECK ALL OPERATION EQUIPMENT FOR PROPER WORKING ORDER AND ADJUSTMENT.
6. GREASE EDITON PUMP BEARINGS. ALEMITE FITTING ON PUMP BASE.
7. TRIAL OPERATE PUMPS AS OUTLINED UNDER III BELOW FOR ABOUT 10 MINUTES AT THE BEGINNING OF EACH WORK SHIFT TO MAINTAIN ADEQUATE LUBRICATION UNTIL PUMPING STAGE IS REACHED.

III. TRIAL OPERATION:

1. VOLTMETER SHOULD READ BETWEEN 390 AND 480 VOLTS FOR EACH OF THE THREE PHASES. USE VOLTMETER SWITCH TO SELECT THE PHASES. NOTIFY POWER COMPANY IF VOLTAGES ARE NOT WITHIN LIMITS. DO NOT OPERATE THE PUMPS UNTIL CONDITIONS ARE CORRECTED.
2. TURN EACH PUMP SHAFT BY HAND TO MAKE SURE IT IS FREE.
3. START MOTOR BY TURNING CONTROL KNOB TO "MANUAL" POSITION.
4. AMMETER SHOULD NOT READ MORE THAN THE RATED AMPERAGE PER TERMINAL ON EACH INDIVIDUAL MOTOR SEE TABLE 3 COLUMN 10
5. CHECK PUMP AND MOTOR PERFORMANCE FOR UNUSUAL NOISE, VIBRATION OR OVERHEATING.
6. SHOULD PUMP STOP DUE TO OVERHEATING, DETERMINE AND CORRECT CAUSE. IF PUMP STOPS REPEATEDLY, DETERMINE AND CORRECT CAUSE. RE-START MOTORS AS IN 3 ABOVE.
7. STOP MOTOR BY TURNING CONTROL KNOB TO "OFF" POSITION. EXCEPT FOR TRIAL OPERATION, IT IS NOT ADVISABLE TO OPERATE THE PUMPS WHEN THE WATER LEVEL IN THE SUMP IS BELOW THE ELECTRODES AS IMPELLERS AND BOWLS MAY BE DAMAGED.

IV. PUMPING OPERATION DURING FLOOD STAGE:

1. WHEN RIVER STAGE REACHES ABOUT 39.8 FEET OPEN SLUICE GATES IN MANHOLES 13-B2 and 14-B2.
2. OPEN SLUICE GATES TO PUMP SUMP.
3. SET PUMP CONTROLS FOR AUTOMATIC OPERATION.
4. CLOSE SLUICE GATES IN MANHOLES 12-P and 13-P.
5. WHEN RIVER STAGE REACHES 48.5 CLOSE SLUICE GATE IN MANHOLE 15-B2, LOCATED AT 3RD AND CLAY STREETS.

V. PLANT OPERATION:

1. KEEP TRASH RACKS CLEAR OF DEBRIS WITH THE RAKE WHILE PUMPS ARE OPERATING.
2. WHEN THE RIVER STAGE DROPS TO ABOUT 48.0 FEET AND CONTINUED LOWERING IS PREDICTED OPEN SLUICE GATE IN MANHOLE 15-B2.
3. WHEN RIVER STAGE DROPS TO ABOUT 39.5 FEET OPEN SLUICE GATES IN MANHOLES 12-P and 13-P.
4. PLACE PUMP CONTROLS IN "OFF" POSITION.
5. RECORD PLANT PERFORMANCE DATA ON LOG SHEET WHILE PLANT IS IN OPERATION. WHEN STARTING AND STOPPING EACH PUMP AND AT THE BEGINNING OF EACH SHIFT. OBSERVE THAT PROPER LUBRICATION IS PROVIDED AND THERE IS NO UNUSUAL VIBRATION, NOISE OR OVERHEATING.

VI. CLOSING DOWN PUMPING PLANT AT END OF OPERATIONS:

1. SEE THAT SLUICE GATES IN MANHOLES 12-P and 13-P ARE OPEN AND CLOSE GATES IN MANHOLES 13-B2 AND 14-B2.
2. FLUSH AND CLEAN INTAKE CHAMBER AND SUMP.
2A. CLOSE SLUICE GATES TO PUMP SUMP.
3. CLEAN, INSPECT, OIL AND GREASE PLANT EQUIPMENT; RESTORE TOOLS AND REPLENISH SUPPLIES.
4. CLEAN PUMPING PLANT; REMOVE FIRE HAZARDS.
5. OPEN ALL SWITCHES, NOTIFY POWER COMPANY TO OPEN HOOKUP DISCONNECT SWITCH AT SUBSTATION. LOCK INTO POSITION AND DO RE-ENERGIZE PLANT.
6. LOCK THE PUMPING PLANT AND RETURN KEY TO SUPERINTENDENT OF OPERATIONS.

K R 1961

OHIO RIVER BASIN
FLOOD PROTECTION - PADUCAH, KY.

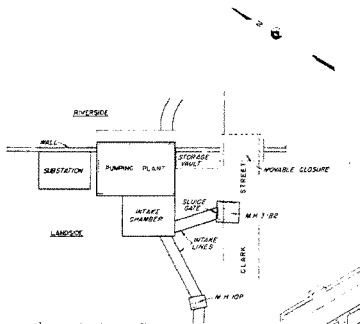
PUMPING PLANT NO. 5
OPERATING INSTRUCTIONS

NOT TO SCALE

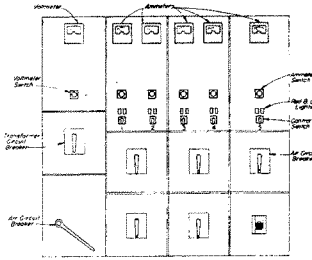
LOUISVILLE, KY. 1952

OPERATION AND MAINTENANCE MANUAL

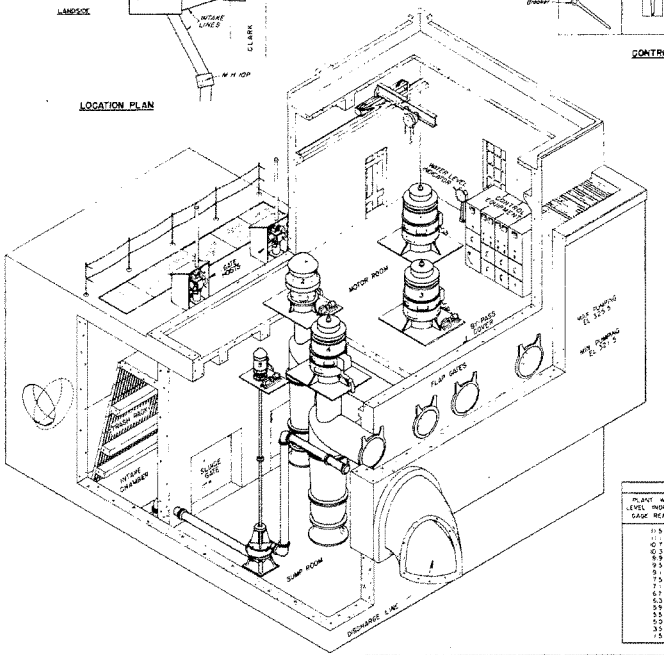
PLATE 30



LOCATION PLAN



CONTROL EQUIPMENT



OPERATING INSTRUCTIONS

I. GENERAL:
THE PUMPING PLANT SHOULD BE READY FOR OPERATION WITH A COMPETENT OPERATOR ON DUTY 24 HOURS PRIOR TO PREDICTED RIVER STAGE OF 37.0 FEET ON THE PADUCAH GAGE.

II. PRELIMINARY:
1. ALL SWITCHES ARE TO BE IN THE OPEN POSITION, ESPECIALLY THE FUSED CUTOUTS ON THE INCOMING POWER LINE.
2. NOTIFY THE POWER COMPANY TO ENERGIZE THE PUMPING PLANT. HAVE THEIR REPRESENTATIVE CLOSE THE FUSED CUTOUTS AND STAND BY IN CASE OF IMMEDIATE ELECTRICAL DIFFICULTY.
3. TRASH RACKS AND SUMP SHOULD BE CLEAR OF DEBRIS AND THE TRASH RACKS SECURELY IN PLACE.
4. LUBRICATE EQUIPMENT:
   A. MOTORS: CHECK THAT OIL LEVEL INDICATORS ARE FILLED TO THE PROPER HEIGHT.
   B. PUMPS: ALLOW APPROXIMATELY ONE PINT OF OIL TO FLOW INTO EACH PUMP. REFILL OILERS. CRANK OILERS BY HAND WHEN MOTOR IS NOT OPERATING.
5. CHECK ALL OPERATION EQUIPMENT FOR PROPER WORKING ORDER AND RE-ADJUSTMENT.
6. GREASE BOTTOM PUMP BEARINGS. A GREASE FITTING ON PUMP BASE.
7. TRIAL OPERATE PUMPS AS OUTLINED UNDER III BELOW FOR ABOUT 10 MINUTES AT THE BEGINNING OF EACH WORK SHIFT TO MAINTAIN ADEQUATE LUBRICATION UNTIL PUMPING STAGE IS REACHED.

III. TRIAL OPERATION:
1. VOLTMETER SHOULD READ BETWEEN 4.00 AND 4.80 VOLTS. FOR EACH OF THE THREE PHASES. USE VOLTMETER SWITCH TO SELECT THE PHASES. NOTIFY POWER COMPANY IF VOLTAGES ARE NOT WITHIN LIMITS. DO NOT OPERATE THE PUMPS UNTIL CONDITIONS ARE CORRECTED.
2. TURN PUMP SHAFT BY HAND TO MAKE SURE IT IS FREE.
3. CLOSE INCOMING LINE SWITCH.
4. START MOTOR. TURN CONTROL KNOB TO "MANUAL" POSITION.
5. AMMETER SHOULD NOT READ MORE THAN THE RATED AMPERAGE PER TERMINAL ON EACH INDIVIDUAL MOTOR. SEE TABLE 3 COLUMN 10.
6. CHECK PUMP AND MOTOR PERFORMANCE FOR UNDUE NOISE, VIBRATION OR OVERHEATING.
7. SHOULD PUMP STOP DUE TO OVERHEATING, DETERMINE AND CORRECT CAUSE. IF PUMP STOPS REPEATEDLY, DETERMINE AND CORRECT CAUSE. RE-START MOTORS AS IN 3. ABOVE.
8. STOP MOTOR BY TURNING SWITCH TO "OFF" POSITION. EXCEPT FOR TRIAL OPERATION, IT IS NOT ADVISABLE TO OPERATE THE PUMPS WHEN THE WATER LEVEL IN THE SUMP IS BELOW THE ELECTRODES AS ARCING, EMS AND SONICS MAY BE DAMAGED.

IV. PUMPING OPERATION DURING FLOOD STAGE:
1. WHEN RIVER STAGE REACHES ABOUT 38.5 FEET:-
   A. OPEN SEPERATELY EACH MOTOR OPERATED SLUICE GATE TO SUMP PUMP.
   B. OPEN SINGLE SLUICE GATE IN NORTH WALL OF MANHOLE 3-82.
   C. PREPARE FOR OPERATION OF INTERCEPTOR SEWER - SEE BELOW!
   D. SET UP PUMP CONTROLS FOR AUTOMATIC OPERATION.
   E. CLOSE THE TWO SLUICE GATES IN EAST WALL OF MANHOLE 3-82.
2. WHEN RIVER STAGE REACHES ABOUT 45.2 FEET CLOSE SLUICE GATE IN MANHOLE 2-82.

V. PLANT OPERATION:
KEEP TRASH RACKS CLEAR OF DEBRIS WITH THE RAKE WHILE PUMPS ARE OPERATING.
1. WHEN THE RIVER STAGE DROPS TO ABOUT 45.2 FEET AND CONTINUED LOWERING IS PREDICTED OPEN SLUICE GATE IN MANHOLE 2-82.
2. WHEN THE RIVER STAGE DROPS TO ABOUT 38.5 FEET AND CONTINUED LOWERING IS PREDICTED OPEN THE TWO SLUICE GATES IN EAST WALL OF MANHOLE 3-82.
3. PLACE PUMP CONTROLS IN "OFF" POSITION.
4. RECORD PLANT PERFORMANCE DATA ON LOG SHEET WHILE PLANT IS IN OPERATION. WHEN STARTING AND STOPPING EACH PUMP AND AT THE BEGINNING OF EACH SHIFT. OBSERVE THAT PROPER LUBRICATION IS PROVIDED AND THERE IS NO UNDUE VIBRATION, NOISE OR OVERHEATING.

VI. CLOSING DOWN PUMPING PLANT AT END OF OPERATIONS:
1. SEE THAT SLUICE GATES IN EAST WALL MANHOLE 3-82 ARE OPEN AND CLOSE GATE IN NORTH WALL.
2. FLUSH AND CLEAN INTAKE CHAMBER AND SUMP.
3. CLOSE PUMP SUMP GATES.
4. CLEAN, INSPECT, OIL AND GREASE PLANT EQUIPMENT; RESTORE TOOLS AND REPLENISH SUPPLIES.
5. CLEAN PUMPING PLANT; REMOVE FIRE HAZARDS.
6. OPEN ALL SWITCHES, NOTIFY POWER COMPANY TO OPEN HORNGAP DISCONNECT SWITCH AT SUBSTATION, LOCK INTO POSITION AND SO DE-ENERGIZE PLANT.
7. LOCK THE PUMPING PLANT AND RETURN KEY TO SUPERINTENDENT OF OPERATIONS.

OPERATING INSTRUCTIONS
2ND STREET INTERCEPTING SEWER

1. PUMPING PLANT NO 6 SHOULD BE READY FOR OPERATION.
2. SLUICE GATES IN THE MANHOLES IN SECOND STREET OPENING TO INTERCEPTOR SHOULD BE OPENED BEFORE CLOSING THE GATES IN THE MANHOLES IN FIRST STREET CUTTING OFF FLOW TO RIVER.
3. DURING FALLING RIVER STAGE THE POSITIONS OF THE GATES SHOULD BE REVERSED FROM THOSE IN TABLE BELOW AS THE STAGES ARE REACHED. GATES IN FIRST STREET SHOULD BE OPENED BEFORE CLOSING GATES IN SECOND STREET.

CITY SEWER LOCATION	RIVER STAGE ELEVATION IN FEET	RIVER STAGE CORRESPONDING RIVER STAGE IN FEET	SLUICE GATE OPERATION OPEN MANHOLES IN SECOND ST	SLUICE GATE OPERATION CLOSE MANHOLES IN FIRST ST
JEFFERSON STREET	327.4	40.9	3-P & 2-S	11-82
BROADWAY	330.4	43.9	5-P & 4-P	8-82
KENTUCKY AVENUE	325.9	39.4	5-P & 6-P	7-82
WASHINGTON STREET	325.9	39.4	7-P & 6-P	6-82
WASHINGTON STREET	321.3	45.0		6-82 (18" GATE VALVE)

PUMPING SCHEDULE

PLANT WATER LEVEL INDICATOR GAGE READING	WHEN WATER IS RISING START PUMP	WHEN WATER IS RISING STOP PUMP	WHEN WATER IS FALLING START PUMP	WHEN WATER IS FALLING STOP PUMP
11.5	2	-	-	-
10	4	2	-	-
10.5	3	2	-	-
9.5	3	-	-	-
9.0	2	2	-	-
7.5	-	-	-	-
7.0	-	-	2	2
6.5	-	-	-	2
5.5	-	-	2	2
5.0	-	-	-	2
4.5	2	-	-	2
4.0	-	-	-	2

W.R. (95)

DHO RIVER BASIN
FLOOD PROTECTION - PADUCAH, KY.

PUMPING PLANT NO. 6

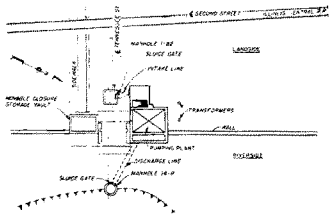
OPERATING INSTRUCTIONS

NOT TO SCALE

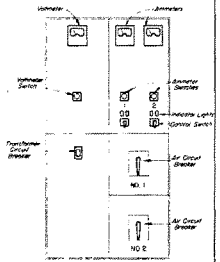
LOUISVILLE, KY. 1952

OPERATION AND MAINTENANCE MANUAL

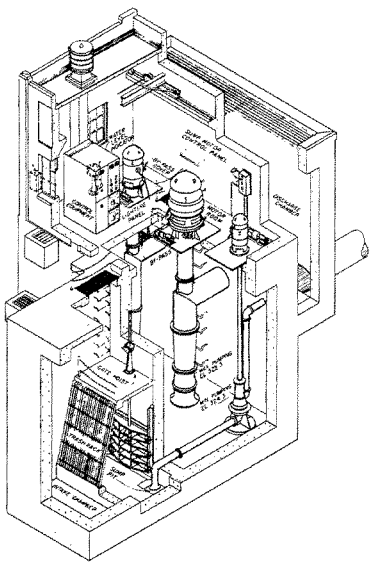
PLATE 31



LOCATION PLAN



CONTROL EQUIPMENT



PUMPING SCHEDULE				
PLANT WATER LEVEL INDICATOR GAGE READING	WHEN WATER IS RISING		WHEN WATER IS FALLING	
	START PUMP	STOP PUMP	START PUMP	STOP PUMP
9.2	2	–	–	–
8.8	1	2	–	–
8.4	2	–	–	1
4.2	–	–	–	2
3.3	–	–	2	1
2.9	3	–	–	2
0.9	–	–	–	3

OPERATING INSTRUCTIONS

I. **GENERAL:**

THE PUMPING PLANT SHOULD BE READY FOR OPERATION WITH A COMPETENT OPERATOR ON DUTY 24 HOURS PRIOR TO PREDICTED RIVER STAGE OF 39.3 FEET ON THE PADUCAH GAGE.

II. **PRELIMINARY**

1. ALL SWITCHES ARE TO BE IN THE OPEN POSITION, ESPECIALLY THE FUSED CUTOUTS ON THE INCOMING POWER LINE. GREEN INDICATORS WILL SHOW AT CONTROL PANELS WHEN BREAKERS ARE OPEN. RED INDICATORS WILL SHOW WHEN BREAKERS ARE CLOSED.
2. NOTIFY THE POWER COMPANY TO ENERGIZE THE PUMPING PLANT. HAVE THEIR REPRESENTATIVE CLOSE THE FUSED CUTOUTS AND STAND BY IN CASE OF IMMEDIATE ELECTRICAL DIFFICULTY.
3. TRASH RACKS AND SUMP SHOULD BE CLEAR OF DEBRIS AND THE TRASH RACKS SECURELY IN PLACE.
4. LUBRICATE EQUIPMENT.
   A. MOTORS. CHECK THAT OIL LEVEL INDICATORS ARE FILLED TO THE PROPER HEIGHT.
   B. PUMPS. ALLOW APPROXIMATELY ONE PINT OF OIL TO FLOW INTO EACH PUMP. REFILL OILERS. GREASE LOWER PUMP BEARINGS. ALEMITE FITTING ON PUMP BASE.
5. CHECK ALL OPERATION EQUIPMENT FOR PROPER WORKING ORDER AND ADJUSTMENT.
6. TRIAL OPERATE PUMPS AS OUTLINED UNDER III BELOW FOR ABOUT 10 MINUTES AT THE BEGINNING OF EACH WORK SHIFT TO MAINTAIN ADEQUATE LUBRICATION UNTIL PUMPING STAGE IS REACHED.

III. **TRIAL OPERATION:**

* 1. VOLTMETER SHOULD READ BETWEEN 396 AND 404 VOLTS FOR EACH OF THE THREE PHASES. USE VOLTMETER SWITCH TO SELECT THE PHASES. NOTIFY POWER COMPANY IF VOLTAGES ARE NOT WITHIN LIMITS. DO NOT OPERATE THE PUMPS UNTIL CONDITIONS ARE CORRECTED.
2. TURN PUMP SHAFT BY HAND TO MAKE SURE IT IS FREE.
3. START MOTOR BY SETTING CONTROL SWITCH AT "MANUAL".
* 4. AMMETER SHOULD NOT READ MORE THAN THE RATED AMPERAGE PER TERMINAL ON EACH INDIVIDUAL MOTOR. SEE TABLE 6 COLUMN 10.
5. CHECK PUMP AND MOTOR PERFORMANCE FOR UNDUE NOISE, VIBRATION OR OVERHEATING.
6. SHOULD PUMP STOP DUE TO OVERHEATING, DETERMINE AND CORRECT CAUSE. IF PUMP STOPS REPEATEDLY, DETERMINE AND CORRECT CAUSE. RE-START MOTORS AS IN 3, ABOVE.
7. STOP MOTOR BY RETURNING CONTROL SWITCH TO "OFF" POSITION. EXCEPT FOR TRIAL OPERATION, IT IS NOT ADVISABLE TO OPERATE THE PUMPS WHEN THE WATER LEVEL IN THE SUMP IS BELOW THE ELECTRODES AS IMPELLERS AND BOWLS MAY BE DAMAGED.

IV. **PUMPING OPERATION DURING FLOOD STAGE:**

1. WHEN RIVER STAGE REACHES ABOUT 41.5 FEET OPEN SLUICE GATES IN MANHOLE 1-B2 AND TO SUMP PUMP.
2. SET PUMPS FOR AUTOMATIC OPERATION.
3. CLOSE SLUICE GATE IN MANHOLE 14-P

V. **PLANT OPERATION:**

1. KEEP TRASH RACKS CLEAR OF DEBRIS WITH THE RAKE WHILE PUMPS ARE OPERATING.
2. WHEN THE RIVER STAGE DROPS TO ABOUT 41.5 FEET AND CONTINUED LOWERING IS PREDICTED OPEN SLUICE GATE IN MANHOLE 14-P AND PLACE PUMP CONTROLS IN "OFF" POSITION.
3. RECORD PLANT PERFORMANCE DATA ON LOG SHEET WHILE PLANT IS IN OPERATION, WHEN STARTING AND STOPPING EACH PUMP AND AT THE BEGINNING OF EACH SHIFT. OBSERVE THAT PROPER LUBRICATION IS PROVIDED AND THERE IS NO UNDUE VIBRATION, NOISE OR OVERHEATING.

VI. **CLOSING DOWN PUMPING PLANT AT END OF OPERATIONS:**

1. SEE THAT SLUICE GATE IN MANHOLE 14-P IS OPEN AND CLOSE GATE IN MANHOLE 1-B2.
2. FLUSH AND CLEAN INTAKE CHAMBER AND SUMP.
3. CLOSE PUMP SUMP GATE.
4. CLEAN, INSPECT, OIL AND GREASE PLANT EQUIPMENT: RESTORE TOOLS AND REPLENISH SUPPLIES.
5. CLEAN PUMPING PLANT: REMOVE FIRE HAZARDS.
6. OPEN ALL SWITCHES. NOTIFY POWER COMPANY TO OPEN HORNGAP DISCONNECT SWITCH AT SUBSTATION, LOCK INTO POSITION AND SO DE-ENERGIZE PLANT.
7. LOCK THE PUMPING PLANT AND RETURN KEY TO SUPERINTENDENT OF OPERATIONS.

H R 1981

OHIO RIVER BASIN
FLOOD PROTECTION - PADUCAH, KY.

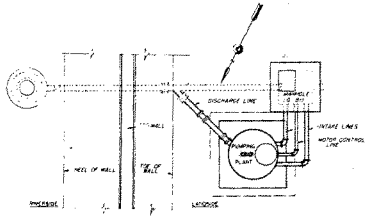
PUMPING PLANT NO. 7

OPERATING INSTRUCTIONS

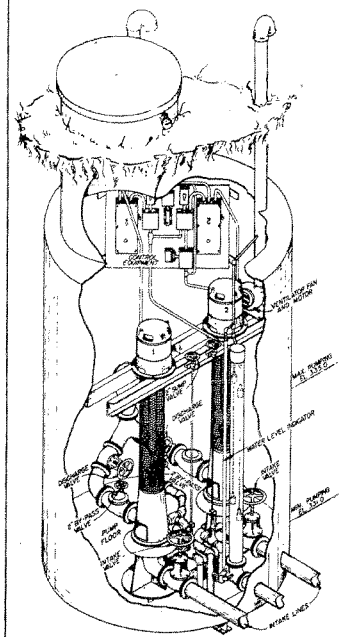
NOT TO SCALE

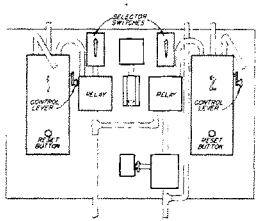
LOUISVILLE, KY. 1952

OPERATION AND MAINTENANCE MANUAL



LOCATION PLAN





CONTROL EQUIPMENT

PUMPING SCHEDULE		
PLANT WATER LEVEL INDICATOR GAGE READING	WHEN WATER IS RISING START PUMP NO	WHEN WATER IS FALLING STOP PUMP NO
6.0	2	-
7.2	1	-
10.4	-	1
10.8	-	2

OPERATING INSTRUCTIONS

I. GENERAL:

THE PUMPING PLANT SHOULD BE READY FOR OPERATION WITH A COMPETENT OPERATOR ON DUTY 24 HOURS PRIOR TO PREDICTED RIVER STAGE OF 46.0 FEET ON THE PADUCAH GAGE.

II. PRELIMINARY:

1. ALL SWITCHES ARE TO BE IN THE OPEN POSITION, ESPECIALLY THE FUSED CUTOUTS ON THE INCOMING POWER LINE.
2. NOTIFY THE POWER COMPANY TO ENERGIZE THE PUMPING PLANT. HAVE THEIR REPRESENTATIVE CLOSE THE LINE SWITCH ON POLE AND STAND BY IN CASE OF IMMEDIATE ELECTRICAL DIFFICULTY.
3. TURN ON VENTILATING FAN AND LIGHT SWITCH. SUMP SHOULD BE CLEAN OF DEBRIS.
4. PROVIDE FRESH GREASE FOR THE PUMP BEARINGS BY ADDING GREASE AT THE ALEMITE FITTINGS. LUBRICATE EVERY EIGHT HOURS OF OPERATION.
5. CHECK ALL OPERATION EQUIPMENT FOR PROPER WORKING ORDER AND ADJUSTMENT.
6. TRIAL OPERATE PUMPS AS OUTLINED UNDER III BELOW FOR ABOUT 10 MINUTES AT THE BEGINNING OF EACH WORK SHIFT TO MAINTAIN ADEQUATE LUBRICATION UNTIL PUMPING STAGE IS REACHED.

III. TRIAL OPERATION:

1. TURN PUMP SHAFT BY HAND TO MAKE SURE IT IS FREE.
2. START MOTOR BY PUSHING CONTROL LEVER RAPIDLY TO "ON". TURN ROTARY SELECTOR SWITCH TO "HAND" OR "AUTOMATIC".
3. CHECK PUMP AND MOTOR PERFORMANCE FOR UNDUE NOISE, VIBRATION OR OVERHEATING.
4. SHOULD PUMP STOP DUE TO OVERHEATING, PUSH RESET BUTTON AND RESTART. IF PUMP STOPS REPEATEDLY OR DOES NOT START, DETERMINE AND CORRECT CAUSE.
5. STOP MOTOR BY TURNING THE SELECTOR SWITCH TO THE "OFF" POSITION. EXCEPT FOR TRIAL OPERATION, IT IS NOT ADVISABLE TO OPERATE THE PUMPS WHEN THE WATER LEVEL IN THE SUMP IS BELOW THE ELECTRODES AS IMPELLERS AND BOWLS MAY BE DAMAGED.

IV. PUMPING OPERATION DURING FLOOD STAGE:

1. WHEN RIVER STAGE REACHES ABOUT 47.5 FEET OPEN THE 4-INCH INTAKE AND DISCHARGE LINE GATE VALVES IN THE PUMP CHAMBER.
2. MAKE SURE BY-PASS VALVES ARE CLOSED BEFORE OPERATING.
3. SET PUMP CONTROLS FOR AUTOMATIC OPERATION.
4. CLOSE THE SLUICE GATE IN INTAKE WELL, MANHOLE 6-B1.

V. PLANT OPERATION:

1. WHEN THE RIVER STAGE DROPS TO ABOUT 47.5 FEET AND CONTINUED LOWERING IS PREDICTED OPEN GATE IN INTAKE WELL AND PLACE PUMP CONTROLS IN "OFF" POSITION.
2. RECORD PLANT PERFORMANCE DATA ON LOG SHEET WHILE PLANT IS IN OPERATION, WHEN STARTING AND STOPPING EACH PUMP AND AT THE BEGINNING OF EACH SHIFT. OBSERVE THAT PROPER LUBRICATION IS PROVIDED AND THERE IS NO UNDUE VIBRATION, NOISE OR OVERHEATING.

VI. CLOSING DOWN PUMPING PLANT AT END OF OPERATIONS:

1. SEE THAT GATE IN INTAKE WELL MANHOLE 6-B1 IS OPEN.
2. FLUSH PUMP CHAMBER WALLS AND UNWATER CHAMBER.
3. ALLOW PUMPS TO DRAIN BY OPENING 1-1/2 INCH BY-PASS VALVES.
4. CLOSE ALL GATE VALVES.
5. REMOVE CLEAN OUT HAND HOLE COVERS AND CLEAN INSIDE OF PUMP. REPLACE COVERS SECURELY.
6. CLEAN, INSPECT, OIL AND GREASE PLANT EQUIPMENT: RESTORE TOOLS AND REPLENISH SUPPLIES.
7. CLEAN PUMPING PLANT: REMOVE FIRE HAZARDS.
8. OPEN ALL SWITCHES. LEAVE EXHAUST FAN SWITCH "ON", NOTIFY POWER COMPANY TO OPEN SWITCH ON POLE, LOCK INTO POSITION AND SO DE-ENERGIZE PLANT.
9. LOCK THE PUMPING PLANT AND RETURN KEY TO SUPERINTENDENT OF OPERATIONS.

OHIO RIVER BASIN
FLOOD PROTECTION - PADUCAH, KY.

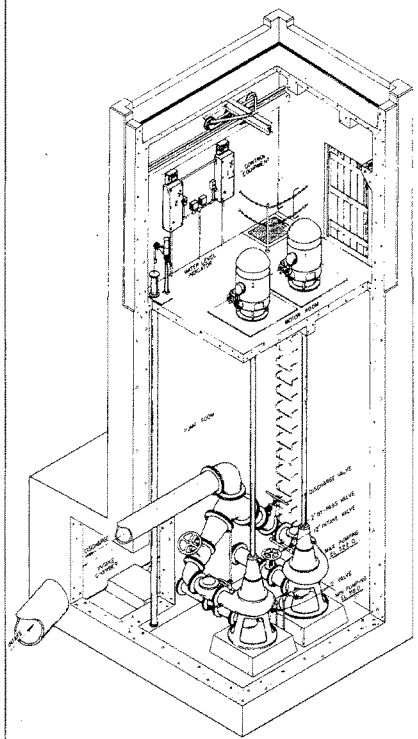
PUMPING PLANT NO. 8

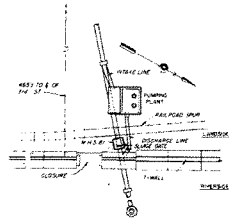
OPERATING INSTRUCTIONS

NOT TO SCALE

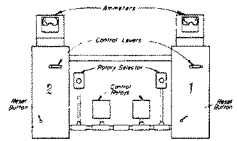
LOUISVILLE, KY. 1952

OPERATION AND MAINTENANCE MANUAL





LOCATION PLAN



CONTROL EQUIPMENT

PUMPING SCHEDULE		
PLANT WATER LEVEL INDICATOR GAGE READING	WHEN WATER IS RISING START PUMP NO.	WHEN WATER IS FALLING STOP PUMP NO.
21.9	1	-
21.5	2	-
24.7	-	2
25.1	-	1

OPERATING INSTRUCTIONS

I. GENERAL:

THE PUMPING PLANT SHOULD BE READY FOR OPERATION WITH A COMPETENT OPERATOR ON DUTY 24 HOURS PRIOR TO PREDICTED RIVER STAGE OF 33 FEET ON THE PADUCAH GAGE.

II. PRELIMINARY:

1. ALL SWITCHES ARE TO BE IN THE OPEN POSITION, ESPECIALLY THE FUSED CUTOUTS ON THE INCOMING POWER LINE.
2. NOTIFY THE POWER COMPANY TO ENERGIZE THE PUMPING PLANT. HAVE THEIR REPRESENTATIVE CLOSE THE FUSED CUTOUTS AND STAND BY IN CASE OF IMMEDIATE ELECTRICAL DIFFICULTY.
3. SUMP SHOULD BE CLEAR OF DEBRIS AND THE HAND HOLE COVERS SECURELY IN PLACE.
4. ALLOW APPROXIMATELY 1 PINT OF OIL TO FLOW INTO PUMP BEARINGS. OPERATE OILERS BY HAND.
5. GREASE LOWER PUMP BEARINGS. ALEMITE FITTING ON PUMP BASE.
6. CHECK ALL OPERATION EQUIPMENT FOR PROPER WORKING ORDER AND ADJUSTMENT.
7. TRIAL OPERATE PUMPS AS OUTLINED UNDER III BELOW FOR ABOUT 10 MINUTES AT THE BEGINNING OF EACH WORK SHIFT TO MAINTAIN ADEQUATE LUBRICATION UNTIL PUMPING STAGE IS REACHED.

III. TRIAL OPERATION:

1. TURN PUMP SHAFT BY HAND TO MAKE SURE IT IS FREE.
2. START MOTOR BY PUSHING CONTROL LEVER TO "ON". TURN ROTARY SELECTOR SWITCH TO "RUN" OR "AUTOMATIC".
3. AMMETER SHOULD READ NOT MORE THAN 20.6 AMPS WHEN WATER IS NOT BEING PUMPED AND NOT MORE THAN 47.65 AMPS UNDER FULL LOAD.
4. CHECK PUMP AND MOTOR PERFORMANCE FOR UNDUE NOISE, VIBRATION OR OVERHEATING.
5. SHOULD PUMP STOP DUE TO OVERHEATING, PUSH RESET BUTTON AND RESTART. IF PUMP STOPS REPEATEDLY OR DOES NOT START, DETERMINE AND CORRECT CAUSE. RE-START MOTORS AS IN 2. ABOVE.
6. STOP MOTOR BY TURNING SELECTOR SWITCH TO THE "OFF" POSITION. EXCEPT FOR TRIAL OPERATION, IT IS NOT ADVISABLE TO OPERATE THE PUMPS WHEN THE WATER LEVEL IN THE SUMP IS BELOW THE ELECTRODES AS IMPELLERS AND BOWLS MAY BE DAMAGED.

IV. PUMPING OPERATION DURING FLOOD STAGE:

1. WHEN RIVER STAGE REACHES ABOUT 34.5 FEET OPEN THE 12-INCH INTAKE AND DISCHARGE LINE GATE VALVES IN THE PUMP CHAMBER.
2. SET PUMP CONTROLS FOR "AUTOMATIC" OPERATION.
3. CLOSE SLUICE GATE IN MANHOLE S-81.
4. MAKE SURE BY-PASS VALVES ARE CLOSED BEFORE PUMPING.

V. PLANT OPERATION:

1. WHEN THE RIVER STAGE DROPS TO ABOUT 34.5 FEET AND CONTINUED LOWERING IS PREDICTED OPEN GATE IN MANHOLE S-81 AND PLACE PUMP CONTROLS IN "OFF" POSITION.
2. RECORD PLANT PERFORMANCE DATA ON LOG SHEET WHILE PLANT IS IN OPERATION, WHEN STARTING AND STOPPING EACH PUMP AND AT THE BEGINNING OF EACH SHIFT. OBSERVE THAT PROPER LUBRICATION IS PROVIDED AND THERE IS NO UNDUE VIBRATION, NOISE OR OVERHEATING.

VI. CLOSING DOWN PUMPING PLANT AT END OF OPERATIONS:

1. SEE THAT GATE IN MANHOLE S-81 IS OPEN.
2. FLUSH AND CLEAN CHAMBER WALLS AND UNWATER CHAMBER.
3. ALLOW PUMPS TO DRAIN BY OPENING 2-INCH BY-PASS GATE VALVES.
4. CLEAN, INSPECT, OIL AND GREASE PLANT EQUIPMENT: RESTORE TOOLS AND REPLENISH SUPPLIES.
5. CLOSE ALL GATE VALVES, REMOVE HAND HOLE COVERS AND CLEAN INSIDE OF PUMPS. REPLACE COVERS SECURELY.
6. OPEN ALL SWITCHES, NOTIFY POWER COMPANY TO OPEN DISCONNECT SWITCH AT SUBSTATION, LOCK INTO POSITION AND SO DE-ENERGIZE PLANT.
7. LOCK THE PUMPING PLANT AND RETURN KEY TO SUPERINTENDENT OF OPERATIONS.

OHIO RIVER BASIN
FLOOD PROTECTION - PADUCAH, KY.

PUMPING PLANT NO. 9

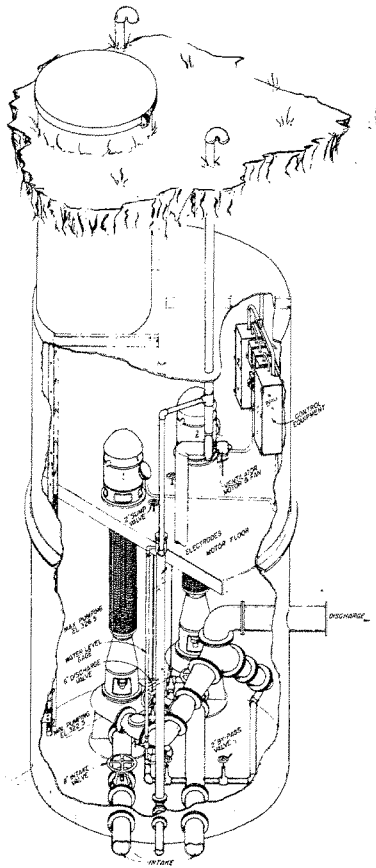
OPERATING INSTRUCTIONS

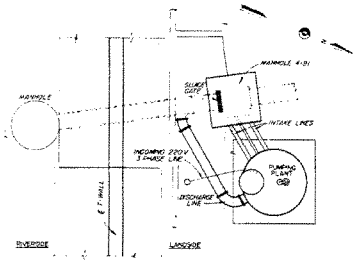
NOT TO SCALE

LOUISVILLE, KY 1952

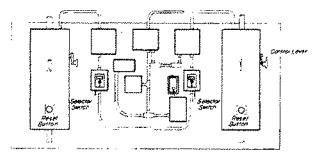
OPERATION AND MAINTENANCE MANUAL

PLATE 34





LOCATION PLAN



CONTROL EQUIPMENT

PUMPING SCHEDULE		
PLANT WATER LEVEL INDICATOR GAGE READING	WHEN WATER IS RISING START PUMP NO.	WHEN WATER IS FALLING STOP PUMP NO.
11.9	2	-
11.5	1	-
8.5	-	2
7.9	-	1

OPERATING INSTRUCTIONS

I. GENERAL:

* THE PUMPING PLANT SHOULD BE READY FOR OPERATION WITH A COMPETENT OPERATOR ON DUTY 24 HOURS PRIOR TO PREDICTED RIVER STAGE OF 54.5 FEET ON THE PADUCAH GAGE.

II. PRELIMINARY:

1. ALL SWITCHES ARE TO BE IN THE OPEN POSITION, ESPECIALLY THE FUSED CUTOUTS ON THE INCOMING POWER LINE.
2. NOTIFY THE POWER COMPANY TO ENERGIZE THE PUMPING PLANT. HAVE THEIR REPRESENTATIVE CLOSE THE FUSED CUTOUTS AND STAND BY IN CASE OF IMMEDIATE ELECTRICAL DIFFICULTY.
3. CLOSE LINE POLE SWITCH.
4. TURN ON VENTILATING FAN AND LIGHT SWITCH.
5. PROVIDE FRESH GREASE FOR THE PUMP BEARING BY ADDING GREASE AT THE ALEMITE FITTINGS. LUBRICATE EVERY EIGHT HOURS OF OPERATION.
6. CHECK ALL OPERATION EQUIPMENT FOR PROPER WORKING ORDER AND ADJUSTMENT.
7. TRIAL OPERATE PUMPS AS OUTLINED UNDER III BELOW FOR ABOUT 10 MINUTES AT THE BEGINNING OF EACH WORK SHIFT TO MAINTAIN ADEQUATE LUBRICATION UNTIL PUMPING STAGE IS REACHED.

III. TRIAL OPERATION:

1. TURN PUMP SHAFT BY HAND TO MAKE SURE IT IS FREE.
2. START MOTOR BY PUSHING CONTROL LEVER RAPIDLY TO "ON" THEN TURN ROTARY SELECTOR SWITCH TO "HAND" OR "AUTOMATIC".
3. CHECK PUMP AND MOTOR PERFORMANCE FOR UNDUE NOISE, VIBRATION OR OVERHEATING.
4. SHOULD PUMP STOP DUE TO OVERHEATING, DETERMINE AND CORRECT CAUSE. IF PUMP STOPS REPEATEDLY, DETERMINE AND CORRECT CAUSE. RE-START MOTORS AS IN 3. ABOVE.
5. STOP MOTOR BY TURNING THE SELECTOR SWITCHES TO THE "OFF" POSITION. EXCEPT FOR TRIAL OPERATION, IT IS NOT ADVISABLE TO OPERATE THE PUMPS WHEN THE WATER LEVEL IN THE SUMP IS BELOW THE ELECTRODES AS IMPELLERS AND SEALS MAY BE DAMAGED.

IV. PUMPING OPERATION DURING FLOOD STAGE:

1. WHEN GAGE INSIDE ISLAND CREEK REACHES 38 FEET, CLOSE CHAIN CONTROLLED FLAP GATE IN THE MANHOLE AT LOCUST AND BRIDGE STREETS.
2. OPEN 8-INCH INTAKE AND 5-INCH DISCHARGE LINE GATE VALVES IN PUMP CHAMBER.
3. MAKE SURE BY-PASS VALVES ARE CLOSED BEFORE OPERATING.
4. SET PUMPS FOR "AUTOMATIC" OPERATION.
5. CLOSE SLUICE GATE IN INTAKE WELL, MANHOLE 4-B1.

* 6. WHEN RIVER STAGE REACHES 45 FEET CLOSE SLUICE GATE IN MANHOLE 2-B1, ON MEYERS BETWEEN CLEMENT & WOODWARD STREETS

* 7. WHEN RIVER STAGE REACHES 53 FEET CLOSE SLUICE GATE IN MANHOLE 1-B1, ON MEYERS BETWEEN CLEMENT & WOODWARD STREETS

V. PLANT OPERATION:

1. WHEN THE RIVER STAGE DROPS TO ABOUT 47 FEET AND CONTINUED LOWERING IS PREDICTED OPEN SLUICE GATE IN MANHOLE 1-B1.
2. WHEN THE RIVER STAGE DROPS TO ABOUT 42 AND CONTINUED LOWERING IS PREDICTED OPEN SLUICE GATE IN MANHOLE 2-B1.
3. WHEN THE RIVER STAGE DROPS TO ABOUT 39 FEET AND CONTINUED LOWERING IS PREDICTED OPEN GATE IN MANHOLE 4-B1.
4. PLACE PUMP CONTROLS IN "OFF" POSITION.
5. RECORD PLANT PERFORMANCE DATA ON LOG SHEET WHILE PLANT IS IN OPERATION, WHEN STARTING AND STOPPING EACH PUMP AND AT THE BEGINNING OF EACH SHIFT. OBSERVE THAT PROPER LUBRICATION IS PROVIDED AND THERE IS NO UNDUE VIBRATION, NOISE OR OVERHEATING.

VI. CLOSING DOWN PUMPING PLANT AT END OF OPERATIONS:

1. SEE THAT SLUICE GATES UNDER V ABOVE ARE OPEN.
2. OPEN CHAIN CONTROLLED FLAP GATE.
3. ALLOW PUMPS TO DRAIN BY OPENING 2-INCH BY-PASS GATE VALVES.
4. CLOSE ALL GATE VALVES.
5. REMOVE CLEAN OUT HAND HOLE COVERS AND CLEAN INSIDE OF PUMPS. REPLACE COVERS SECURELY.
6. CLEAN, INSPECT, OIL AND GREASE PLANT EQUIPMENT; RESTORE TOOLS AND REPLENISH SUPPLIES.
7. CLEAN PUMPING PLANT; REMOVE FIRE HAZARDS.
8. OPEN ALL SWITCHES, NOTIFY POWER COMPANY TO OPEN HOOKUP DISCONNECT SWITCH AT SUBSTATION, LOCK INTO POSITION AND SO DE-ENERGIZE PLANT.
9. LOCK THE PUMPING PLANT AND RETURN KEY TO SUPERINTENDENT OF OPERATIONS.

H R (198)

OHIO RIVER BASIN
FLOOD PROTECTION - PADUCAH, KY.

PUMPING PLANT NO. 10

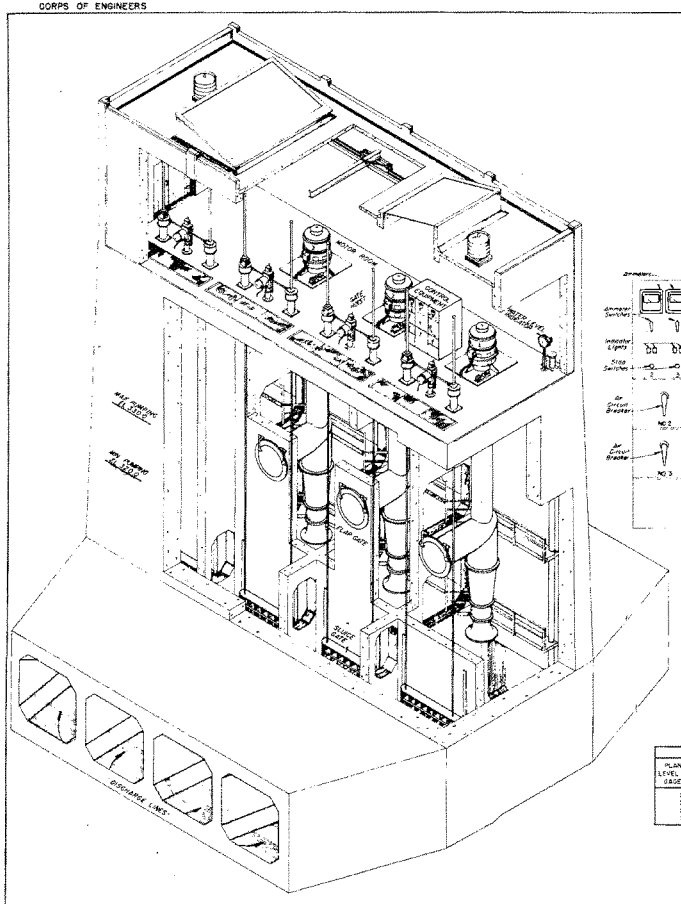
OPERATING INSTRUCTIONS

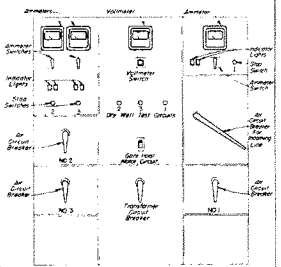
NOT TO SCALE

LOUISVILLE, KY 1952

OPERATION AND MAINTENANCE MANUAL

PLATE 35





CONTROL EQUIPMENT

PUMPING SCHEDULE		
PLANT WATER LEVEL INDICATOR GAGE READING	WHEN WATER IS RISING START PUMP NO.	WHEN WATER IS FALLING STOP PUMP NO.
24.6	3	-
24.4	2	-
24.2	1	-
24.0	-	1,2&3

OPERATING INSTRUCTIONS

I. GENERAL:

THE PUMPING PLANT SHOULD BE READY FOR OPERATION WITH A COMPETENT OPERATOR ON DUTY 24 HOURS PRIOR TO PREDICTED RIVER STAGE OF 33.0 FEET ON THE PROJECT GAGE.

II. PRELIMINARY:

1. ALL SWITCHES ARE TO BE IN THE OPEN POSITION, ESPECIALLY THE FUSED CUTOUTS ON THE INCOMING POWER LINE. INDICATOR WILL SHOW GREEN WHEN BREAKER IS OPEN AND RED WHEN BREAKER IS CLOSED.
2. NOTIFY THE POWER COMPANY TO ENERGIZE THE PUMPING PLANT. HAVE THEIR REPRESENTATIVE CLOSE THE FUSED CUTOUTS AND STAND BY IN CASE OF IMMEDIATE ELECTRICAL DIFFICULTY.
3. CLOSE MAIN CIRCUIT BREAKER IN PLANT. CAUTION: RAISE HANDLE HIGH AND PUSH DOWN RAPIDLY INTO POSITION.
4. TRASH RACKS AND SUMP SHOULD BE CLEAR OF DEBRIS AND THE TRASH RACKS SECURELY IN PLACE.
5. LUBRICATE EQUIPMENT.
   A. MOTORS. CHECK THAT OIL LEVEL INDICATORS ARE FILLED TO THE PROPER HEIGHT.
   B. PUMPS. ALLOW APPROXIMATELY ONE PINT OF OIL TO FLOW INTO EACH PUMP. REFILL OILERS. CHARGE PULLEYS BY HAND WHEN MOTORS ARE NOT OPERATING NO. 2 PUMP HAS FAYOUL BREAKER
   C. GREASE LOWER PUMP BEARINGS. ALEMITE FITTING ON PUMP BASE PLATES.
6. CHECK ALL OPERATION EQUIPMENT FOR PROPER WORKING ORDER AND ADJUSTMENT.
7. TRIAL OPERATE PUMPS AS OUTLINED UNDER III BELOW FOR ABOUT 30 MINUTES AT THE BEGINNING OF EACH WORK SHIFT TO MAINTAIN ADEQUATE LUBRICATION UNTIL PUMPING STAGE IS REACHED.

III. TRIAL OPERATION:

1. VOLTMETER SHOULD READ BETWEEN 400 AND 480 VOLTS FOR EACH OF THE THREE PHASES. USE VOLTMETER SWITCH TO SELECT THE PHASES. NOTIFY POWER COMPANY IF VOLTAGES ARE NOT WITHIN LIMITS. DO NOT OPERATE THE PUMPS UNTIL CONDITIONS ARE CORRECTED.
2. TURN PUMP SHAFT BY HAND TO MAKE SURE IT IS FREE.
3. START MOTOR FOR DRY OPERATION ONLY BY MAKING SOMEONE HOLD IN "DRY WELL TEST" BUTTON. PULL CIRCUIT BREAKER HANDLE RAPIDLY INTO LOCKED POSITION. FOR WET OPERATION PULL CIRCUIT BREAKER ONLY.
4. AMMETER SHOULD READ NOT MORE THAN 175 AMPS WHEN WATER IS NOT BEING PUMPED AND NOT MORE THAN 450 AMPS UNDER FULL LOAD.
5. CHECK PUMP AND MOTOR PERFORMANCE FOR UNDUE NOISE, VIBRATION OR OVERHEATING.
6. SHOULD PUMP STOP DUE TO OVERHEATING, DETERMINE AND CORRECT CAUSE. IF PUMP STOPS REPEATEDLY, DETERMINE AND CORRECT CAUSE. RE-START MOTORS AS IN 3. ABOVE.
7. STOP MOTOR IN DRY OPERATION BY RELEASING "DRY WELL TEST" BUTTON. STOP MOTOR IN WET OPERATION BY PUSHING IN RED "STOP" BUTTON. EXCEPT FOR TRIAL OPERATION, IT IS NOT ADVISABLE TO OPERATE THE PUMPS WHEN THE WATER LEVEL IN THE SUMP IS BELOW THE ELEVATION OF IMPELLERS AND BOWLS MAY BE DAMAGED.
8. TO OPERATE SUMP SLUICE GATES SEE THAT SWITCHES ON HOIST PANELS ARE "OFF". CLOSE SUMP SWITCH ON THE MAIN CONTROL PANEL. PUSH THE SWITCH ON EACH HOIST MOTOR CONTROL PANEL TO THE "ON" POSITION. CAUTION: OPERATE EACH GATE SEPARATELY.

IV. PUMPING OPERATION DURING FLOOD STAGE:

NOTE: SHUT OFF PUMPS AND OPEN PLANT SLUICE GATES AT ANY TIME WATER IN SUMP IS 5 INCHES OR MORE ABOVE RIVER, IN ORDER TO EQUALIZE.

1. WHEN RIVER STAGE REACHES ABOUT 33.0 FEET CLOSE EACH PUMPING PLANT SLUICE GATE INTO POSITION SEPARATELY.
2. START PUMPS SEPARATELY IN ACCORDANCE WITH THE "PUMPING SCHEDULE".
3. THE 5 SLUICE GATES AT ABOUT STA. 32+25 SHOULD BE CLOSED WHEN CLOSED RIVER BREAKS OVER INTO THE LOCAL AREA PROTECTED BY THIS STRUCTURE ABOUT STAGE 43.5 FEET.

V. PLANT OPERATION:

1. WHEN WATER IN SUMP REACHES A DEPTH OF 24 FEET PLACE PUMP CONTROLS IN "AUTO" POSITION.
2. RECORD PLANT PERFORMANCE DATA ON LOG SHEET WHILE PLANT IS IN OPERATION. OPEN STOPCOCKS AND STOPPING EACH PUMP AND AT THE BEGINNING OF EACH SHIFT. OBSERVE THAT PROPER LUBRICATION IS PROVIDED AND THERE IS NO UNDUE VIBRATION, NOISE OR OVERHEATING.

VI. CLOSING DOWN PUMPING PLANT AT END OF OPERATIONS:

1. OPEN ALL SLUICE GATES.
2. FLUSH AND CLEAN INTAKE CHAMBER AND SUMP.
3. CLEAN, INSPECT, OIL AND GREASE PLANT EQUIPMENT; RESTORE TOOLS AND REPLENISH SUPPLIES.
4. CLEAR PUMPING PLANT; REMOVE FIRE HAZARDS.
5. OPEN ALL SWITCHES. NOTIFY POWER COMPANY TO OPEN HORNRAY DISCONNECT SWITCH AT SUBSTATION. LOCK INTO POSITION AND DO DE-ENERGIZE PLANT.
6. LOCK THE PUMPING PLANT AND RETURN KEY TO SUPERINTENDENT OF OPERATIONS.

NOTE: WATER BEHIND LEVEE AT STA. 32+93 TO 40+00 AGAINST LEVEE. SLUICE GATES HERSEY CAN BE OPENED AT A RIVER STAGE BELOW 45.5 FEET AND WATER MUST BE PUMPED THROUGH PUMPING PLANT HOWEVER. IF SLUICE GATES ARE LEFT CLOSED UNTIL A FLOOD FALL IS PREDICTED IN RIVER, THE WATER WILL DRAIN BY GRAVITY WHEN ISLAND CREEK GATES ARE OPENED.

OHIO RIVER BASIN
FLOOD PROTECTION - PADUCAH, KY.

ISLAND CREEK PUMPING PLANT
OPERATING INSTRUCTIONS

NOT TO SCALE

LOUISVILLE, KY. 1952

OPERATION AND MAINTENANCE MANUAL

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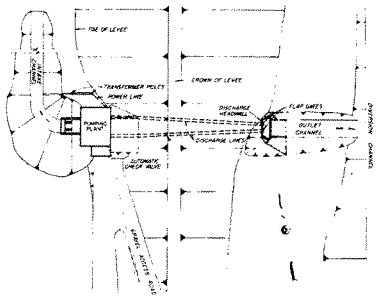
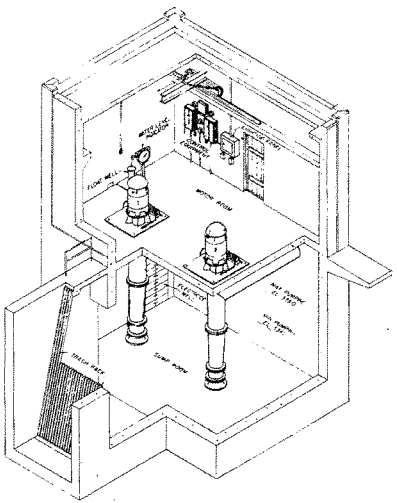
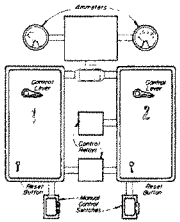


LOCATION PLAN





CONTROL EQUIPMENT

PUMPING SCHEDULE		
PLANT WATER LEVEL INDICATOR GAGE READING	WHEN WATER IS RISING START PUMP NO.	WHEN WATER IS FALLING STOP PUMP NO.
5.9	2	-
5.7	1	-
5.5	-	1&2

OPERATING INSTRUCTIONS

THE PUMPING PLANT SHOULD BE READY FOR OPERATION WITH A COMPETENT OPERATOR ON DUTY 24 HOURS PRIOR TO PREDICTED RIVER STAGE OF 46.5 FEET ON THE PADUCAH GAGE.

I. GENERAL:

1. ALL SWITCHES ARE TO BE IN THE OPEN POSITION, ESPECIALLY THE FUSED CUTOUTS ON THE INCOMING POWER LINE.
2. NOTIFY THE POWER COMPANY TO ENERGIZE THE PUMPING PLANT. HAVE THEIR REPRESENTATIVE CLOSE THE FUSED CUTOUTS AND STAND BY IN CASE OF IMMEDIATE ELECTRICAL DIFFICULTY.
3. TRASH RACKS AND SUMP SHOULD BE CLEAR OF DEBRIS AND THE TRASH RACKS SECURELY IN PLACE.
4. LUBRICATE EQUIPMENT.
   A. MOTORS. CHECK THAT OIL LEVEL INDICATORS ARE FILLED TO THE PROPER HEIGHT.
   B. PUMPS. ALLOW APPROXIMATELY ONE PINT OF OIL TO FLOW INTO EACH PUMP. REFILL OILERS. CRANK OILERS BY HAND.
   C. GREASE LOWER PUMP BEARINGS. ALEMITE FITTING ON PUMP BASE PLATE.
5. CHECK ALL OPERATION EQUIPMENT FOR PROPER WORKING ORDER AND ADJUSTMENT.
6. TRIAL OPERATE PUMPS AS OUTLINED UNDER III BELOW FOR ABOUT 10 MINUTES AT THE BEGINNING OF EACH WORK SHIFT TO MAINTAIN ADEQUATE LUBRICATION UNTIL PUMPING STAGE IS REACHED.
7. REMOVE BLANKS FROM AIR RELEASE VALVES AND UNLOCK SYPHON BREAKER COVERS.

II. PRELIMINARY:

1. TURN PUMP SHAFT BY HAND TO MAKE SURE IT IS FREE.
2. START MOTOR BY MOVING CONTROL SWITCH LEVER UPWARDS SHARPLY TO "ON" POSITION. PUSH IN RELAY BUTTON AND HOLD UNTIL MOTOR RUNS SMOOTHLY.
3. AMMETER SHOULD READ NOT MORE THAN 490 AMPS WHEN WATER IS NOT BEING PUMPED AND NOT MORE THAN 87.5 AMPS UNDER FULL LOAD.
4. CHECK PUMP AND MOTOR PERFORMANCE FOR UNDUE NOISE, VIBRATION OR OVERHEATING.
5. SHOULD PUMP STOP DUE TO OVERHEATING, DETERMINE AND CORRECT CAUSE. IF PUMP STOPS REPEATEDLY, DETERMINE AND CORRECT CAUSE. RE-START MOTORS AS IN 3. ABOVE.
6. STOP MOTOR BY PUSHING ROCKER SWITCH TO OFF POSITION. EXCEPT FOR TRIAL OPERATION, IT IS NOT ADVISABLE TO OPERATE THE PUMPS WHEN THE WATER LEVEL IN THE SUMP IS BELOW THE ELECTRODES AS IMPELLERS AND BOWLS MAY BE DAMAGED.

III. TRIAL OPERATION:

1. WHEN THE WATER LEVEL IN THE SUMP REACHES ABOUT 5.9 FEET START PUMPS MANUALLY AT INTERVALS OF 30 SECONDS. AS THE WATER LEVEL DROPS THE PUMPS WILL STOP AUTOMATICALLY UPON REACHING CUTOFF LEVELS. WARNING: AFTER CONTINUED IMMERSION ELECTRODES FAIL TO CUT OUT AS WATER RECEDES.
2. FOR OPERATION OVER LONG PERIODS WHEN WATER IN SUMP IS LESS THAN 5.7 FEET ALTERNATE PUMPS TO EQUALIZE WEAR.

IV. PUMPING OPERATION DURING FLOOD STAGE:

1. KEEP TRASH RACKS CLEAR OF DEBRIS WITH THE RAKE WHILE PUMPS ARE OPERATING.
2. WHEN THE RIVER STAGE DROPS TO ABOUT 51.5 FEET AND CONTINUED LOWERING IS PREDICTED TO 46.5 WITHOUT ADDITIONAL RAIN PLACE PUMP CONTROLS IN "OFF" POSITION.
3. RECORD PLANT PERFORMANCE DATA ON LOG SHEET WHILE PLANT IS IN OPERATION. WHEN STARTING AND STOPPING EACH PUMP AND AT THE BEGINNING OF EACH SHIFT. OBSERVE THAT PROPER LUBRICATION IS PROVIDED AND THERE IS NO UNDUE VIBRATION, NOISE OR OVERHEATING.

V. PLANT OPERATION:

1. FLUSH AND CLEAN INTAKE CHAMBER AND SUMP.
2. CLEAN, INSPECT, OIL AND GREASE PLANT EQUIPMENT: RESTORE TOOLS AND REPLENISH SUPPLIES.
3. CLEAN PUMPING PLANT: REMOVE FIRE HAZARDS.

3A. REPLACE BLANK ON AIR RELEASE VALVES. LOCK SYPHON BREAKER COVERS IN PLACE.

4. OPEN ALL SWITCHES. NOTIFY POWER COMPANY TO OPEN HORNGAP DISCONNECT SWITCH AT SUBSTATION, LOCK INTO POSITION AND SO DE-ENERGIZE PLANT.
5. LOCK THE PUMPING PLANT AND RETURN KEY TO SUPERINTENDENT OF OPERATIONS.

OHIO RIVER BASIN
FLOOD PROTECTION-PADUCAH, KY.

PUMPING PLANT NO.12

OPERATING INSTRUCTIONS

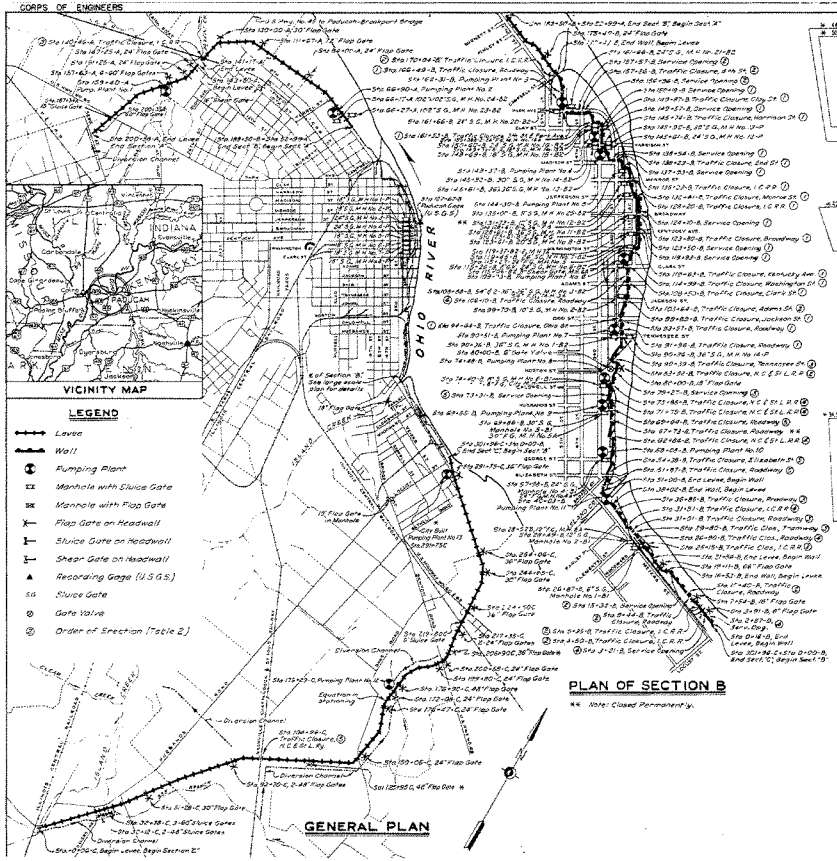
NOT TO SCALE

LOUISVILLE, KY 1952

OPERATION AND MAINTENANCE MANUAL

CORPS OF ENGINEERS

U. S. ARMY



PLAN OF SECTION B

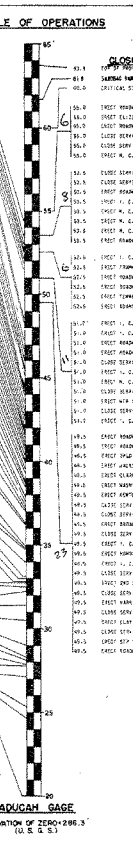
** Note: Closed Permanently.

PUMPING PLANTS AND DRAINAGE STRUCTURES

INSPECT 24" FLAP GATE, STA. 27+45.5	54.3
INSPECT 24" FLAP GATE, STA. 28+64.0	53.0
CLOSE 24" GATE ABOVE, STA. 63+30.0	53.0
INSPECT 24" FLAP GATE, STA. 109+60.0	52.0
INSPECT 24" FLAP GATE, STA. 117+47.0	52.0
INSPECT 24" FLAP GATE, STA. 137+24.0	52.0
INSPECT 24" FLAP GATE, STA. 140+24.0	51.0
INSPECT 24" FLAP GATE, STA. 209+50.0	50.0
INSPECT 48" SLUICE GATE, M.H. NO. 4-B4, STA. 28+40.0	48.0
CLOSE 24" SLUICE GATE, STA. 137+24.0	50.0
PROPOSE PUMPING PLANT NO. 12, STA. 137+24.0	45.0
INSPECT 24" FLAP GATE, STA. 147+21.0	46.0
PROPOSE PUMPING PLANT NO. 4, STA. 7+40.0	45.0
INSPECT 24" FLAP GATE, STA. 15+05.0	45.0
CLOSE 24" SLUICE GATES, STA. 29+10.0	45.0
CLOSE 24" SLUICE GATE, STA. 29+18.0	45.0
CLOSE 48" SLUICE GATE, M.H. NO. 5A, STA. 135+55.0	45.0
* 5.5 SPRUCE PUMPING PLANT NO. 13	
PROPOSE PUMPING PLANT NO. 1, STA. 15+40.0	44.5
PROPOSE PUMPING PLANT NO. 3, STA. 15+30.0	44.5
INSPECT 24" SLUICE GATE, M.H. NO. 5A, STA. 15+05.0	44.0
INSPECT 24" SLUICE GATE, M.H. NO. 5-B2, STA. 15+05.0	43.0
INSPECT 24" FLAP GATE, STA. 17+24.0	43.0
INSPECT 24" SLUICE GATE, M.H. NO. 5-B2, STA. 17+24.0	43.0
INSPECT 24" SLUICE GATE, M.H. NO. 2A, STA. 28+53.0	43.0
INSPECT 24"-48" FLAP GATES, STA. 101+78.0	43.0
INSPECT 24" SLUICE GATE, M.H. NO. 6-B3, STA. 7+40.0	41.0
INSPECT 24" SLUICE GATE, M.H. NO. 8-B2, STA. 12+45.0	41.0
CLOSE 24" SLUICE GATE, M.H. NO. 4A, STA. 148+72.0	41.0
INSPECT 24" FLAP GATE, STA. 24+31.0	41.0
INSPECT 48" SLUICE GATE, M.H. NO. 10-B2, STA. 140+64.0	41.0
CLOSE 24" SLUICE GATE, STA. 27+60.0	40.0
INSPECT 24" FLAP GATE, M.H. NO. 10, STA. 123+43.0	40.0
INSPECT 48" SLUICE GATE, M.H. NO. 10-B2, STA. 123+43.0	40.0
INSPECT 48" FLAP GATE, M.H. NO. 10-B2, STA. 127+72.0	40.0
INSPECT 24" SLUICE GATE, STA. 21+55.0	39.0
INSPECT 24" FLAP GATE, STA. 30+30.0	39.0
INSPECT 24" FLAP GATE, STA. 30+30.0	39.0
INSPECT 18" FLAP GATE, STA. 30+30.0	39.0
INSPECT 24" FLAP GATE, M.H. NO. 6, STA. 11+27.0	38.5
INSPECT 24" SLUICE GATE, M.H. NO. 2-B2, STA. 15+20.0	38.0
INSPECT 20" FLAP GATE, STA. 26+55.0	37.0
INSPECT 20" FLAP GATE, STA. 28+55.0	37.0
INSPECT 20" SLUICE GATE, M.H. NO. 10-B2, STA. 145+40.0	37.0
* 36.5 PROPOSE PUMPING PLANT NO. 5, STA. 12+25.0	
PROPOSE PUMPING PLANT NO. 5, STA. 14+55.0	37.0
INSPECT 36" SLUICE GATE, M.H. NO. 14-F, STA. 90+34.0	37.0
INSPECT 36" SLUICE GATE, M.H. NO. 14-B2, STA. 90+34.0	37.0
PROPOSE PUMPING PLANT NO. 6, STA. 107+22.0	37.0
CLOSE 24" FLAP GATE, VIRGINIA STREET CONVERSION DEMOLISH AT ISLAND CREEK	
ISLAND CREEK	37.0
INSPECT 30" x 24" SLUICE GATE, M.H. NO. 19-B1, STA. 144+44.0	34.0
INSPECT 48" SLUICE GATE, M.H. NO. 1A, STA. 14+20.5	35.0
INSPECT 24" FLAP GATE, M.H. NO. 7A, STA. 17+27.0	34.0
INSPECT 24" SLUICE GATE, M.H. NO. 12-F, STA. 18+45.0	34.0
INSPECT 24" FLAP GATE, STA. 17+24.0	34.0
INSPECT 24" SLUICE GATE, M.H. NO. 7-B2, STA. 17+24.0	34.0
INSPECT 48" FLAP GATES, STA. 15+45.0	34.0
PROPOSE PUMPING PLANT NO. 2, STA. 8+40.0	32.0
INSPECT 24" FLAP GATE, STA. 7+44.0	32.0
PROPOSE PUMPING PLANT NO. 11, STA. 14+72.0	32.0
PROPOSE PUMPING PLANT NO. 9, STA. 20+55.0	32.0
PROPOSE PUMPING PLANT NO. 8, STA. 21+55.0	32.0
PROPOSE PUMPING PLANT NO. 7, STA. 14+27.0	32.0
INSPECT 24" FLAP GATE, STA. 23+45.0	32.0
INSPECT 24" AND 5-24" x 36" SLUICE GATES, M.H. NO. 2-B2, STA. 15+45.0	32.0
INSPECT 2-48" SLUICE GATES AND HOISTS, STA. 20+20.0	31.5
INSPECT 2-48" SLUICE GATES AND HOISTS, STA. 20+20.0	31.0
INSPECT 24" FLAP GATE, M.H. NO. 3A, STA. 18+04.0	30.0
INSPECT 48" SLUICE GATE, M.H. NO. 2A-B2, STA. 15+45.0	30.0
INSPECT 24" FLAP GATE, STA. 15+45.0	30.0
INSPECT 20" FLAP GATE, STA. 29+37.0	29.0
INSPECT 30" FLAP GATE, M.H. NO. 5A, STA. 15+55.0	29.0
INSPECT 24" FLAP GATE, M.H. NO. 4A, STA. 17+55.0	29.0
INSPECT 24" SLUICE GATE, M.H. NO. 3A-B2, STA. 17+55.0	29.0
INSPECT 30" SLUICE GATE, M.H. NO. 6-B2, STA. 12+55.0	27.0
INSPECT 24" FLAP GATE, STA. 12+55.0	27.0
INSPECT 24" SLUICE GATE, M.H. NO. 4-B2, STA. 12+55.0	27.0
INSPECT 102" x 102" SLUICE GATE, M.H. NO. 2A-B2, STA. 69+17.0	26.5
INSPECT 102" SLUICE GATE, M.H. NO. 2A-B2, STA. 69+17.0	26.0
INSPECT 102" FLAP GATE, STA. 12+12.0	26.0

* SEE PLATE 31 FOR OPERATING INSTRUCTIONS FOR 2ND STREET INTERCEPTER SEWER

SCHEDULE OF OPERATIONS



NOTE: GAGE READING INDICATES RIVER STAGE AT WHICH OPERATION SHOULD BE COMPLETED.

CLOSURES AND SERVICE OPENINGS

93.1	FLOOD PROTECTION
81.8	SAFEGUARD PUMPS-SEE TABLE 2 **
60.0	CRITICAL STAGE
56.0	CREST BROADWAY CLOSURE, STA. 9+47-B
56.0	CREST ELIZABETH ST. CLOSURE, STA. 144+58-B
65.0	CREST BROADWAY CLOSURE, STA. 64+06-B
55.0	CLOSE SERVICE OPENINGS, STA. 73+41-B
55.0	CLOSE SERV. EX OPENING, STA. 79+17-B
55.0	CREST N. C. & ST. L. R.R. CLOSURE, STA. 106+94-C
53.5	CLOSE SERVICE OPENING, STA. 3+87-B
53.5	CLOSE SERVICE OPENING, STA. 3+21-B
50.0	CREST BROADWAY CLOSURE, STA. 35+90-B
53.5	CREST N. C. & N.R. CLOSURE, STA. 21+55-B
53.5	CREST N. C. & ST. L. R.R. CLOSURE, STA. 62+84-B
53.5	CREST N. C. & ST. L. R.R. CLOSURE, STA. 79+85-B
53.5	CREST BROADWAY CLOSURE, STA. 18+40-B
53.5	CREST I. C. R.R. CLOSURE, STA. 143+45-A
53.5	CREST FRANKLIN CLOSURE, STA. 29+83-B
53.5	CREST BROADWAY CLOSURE, STA. 31+51-B
53.5	CREST BROADWAY CLOSURE, STA. 38+95-B
53.5	CREST TENNESSEE ST. CLOSURE, STA. 30+30-B
53.5	CREST ADAMS ST. CLOSURE, STA. 102+54-B
51.5	CREST I. C. R.R. CLOSURE, STA. 44+5-B
51.0	CREST I. C. R.R. CLOSURE, STA. 5+55-B
51.0	CREST BROADWAY CLOSURE, STA. 6+44-F
51.0	CREST BROADWAY CLOSURE, STA. 10+40-B
51.0	CLOSE SERVICE OPENINGS, STA. 15+52-B
51.0	CREST N. C. & R.R. CLOSURE, STA. 35+45-B
51.0	CREST N. C. & ST. L. R.R. CLOSURE, STA. 83+92-B
51.0	CLOSE SERVICE OPENING, STA. 15+45-B
51.0	CREST 14TH ST. CLOSURE, STA. 15+23-B
51.0	CLOSE SERVICE OPENING, STA. 15+53-B
51.0	CREST I. C. R.R. CLOSURE, STA. 17+74-B
49.5	CREST BROADWAY CLOSURE, STA. 91+96-B
49.5	CREST BROADWAY CLOSURE, STA. 93+57-B
49.5	CREST SHAW ST. CLOSURE, STA. 94+64-B
49.5	CREST JACKSON ST. CLOSURE, STA. 98+03-B
49.5	CREST CLARK ST. CLOSURE, STA. 108+53-B
49.5	CREST WASHINGTON ST. CLOSURE, STA. 114+99-B
49.5	CREST KENTUCKY AVE. CLOSURE, STA. 118+83-B
49.5	CLOSE SERVICE OPENING, STA. 17+93-B
49.5	CLOSE SERVICE OPENING, STA. 123+58-B
49.5	CREST BROADWAY CLOSURE, STA. 123+89-B
49.5	CLOSE SERVICE OPENING, STA. 124+15-B
49.5	CREST I. C. R.R. CLOSURE, STA. 129+20-B
49.5	CREST HOPKINS ST. CLOSURE, STA. 132+11-B
49.5	CREST I. C. R.R. CLOSURE, STA. 134+22-B
49.5	CLOSE SERVICE OPENING, STA. 137+83-B
49.5	CREST 2ND ST. CLOSURE, STA. 138+23-B
49.5	CLOSE SERVICE OPENING, STA. 139+54-B
49.5	CREST HARRISON ST. CLOSURE, STA. 140+75-B
49.5	CLOSE SERVICE OPENING, STA. 140+17-B
49.5	CREST FLAT ST. CLOSURE, STA. 140+87-B
49.5	CLOSE SERVICE OPENING, STA. 141+34-B
49.5	CREST 5TH ST. & PARK AVE. CLOSURE, STA. 141+53-B
49.5	CREST KIRKMAN CLOSURE, STA. 146+48-B

OHIO RIVER BASIN

FLOOD PROTECTION - PADUCAH, KY.

GENERAL PLAN

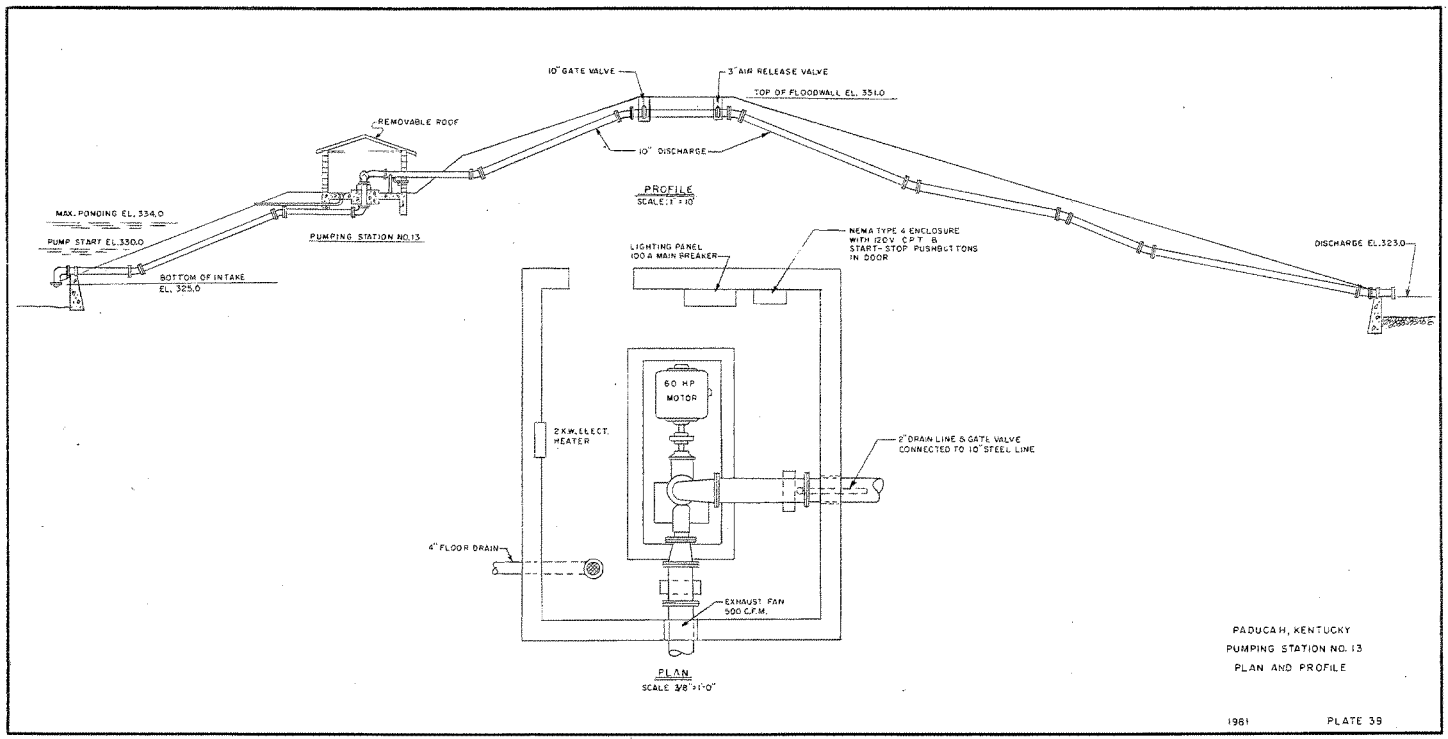
SCHEDULE OF OPERATIONS

NOT TO SCALE

LOUISVILLE, KY. 1962

OPERATION AND MAINTENANCE MANUAL

* R 1981


10" GATE VALVE
3" AIR RELEASE VALVE
TOP OF FLOODWALL EL. 351.0
REMOVABLE ROOF
10" DISCHARGE
PROFILE
SCALE: 1" = 10'
MAX. PONDING EL. 334.0
PUMP START EL. 330.0
PUMPING STATION NO. 13
BOTTOM OF INTAKE
EL. 325.0
DISCHARGE EL. 323.0
LIGHTING PANEL
100 A MAIN BREAKER
NEMA TYPE 4 ENCLOSURE
WITH 120V CPT &
START-STOP PUSHBUTTONS
IN DOOR
60 HP
MOTOR
2 K.W. ELECT.
HEATER
2" DRAIN LINE & GATE VALVE
CONNECTED TO 10" STEEL LINE
4" FLOOR DRAIN
EXHAUST FAN
500 C.F.M.
PLAN
SCALE 3/8" = 1'-0"
PADUCAH, KENTUCKY
PUMPING STATION NO. 13
PLAN AND PROFILE
1981
PLATE 39

MEMORANDUM OF UNDERSTANDING
BETWEEN
THE DEPARTMENT OF THE ARMY
AND THE
CITY OF PADUCAH, KENTUCKY
FOR WORK PROVIDED OR PERFORMED
PRIOR TO EXECUTION OF
A
PROJECT PARTNERSHIP AGREEMENT
FOR
PADUCAH, KENTUCKY
LOCAL FLOOD PROTECTION PROJECT

THIS MEMORANDUM OF UNDERSTANDING (hereinafter the "MOU") is entered into this 17th day of November, 2008 by and between the Department of the Army (hereinafter the "Government"), represented by the U.S. Army Engineer, Louisville District (hereinafter the "District Engineer") and the City of Paducah, Kentucky (hereinafter the "Non-Federal Interest"), represented by the Mayor.

WITNESSETH, THAT:

WHEREAS, Section 221(a) of the Flood Control Act of 1970, as amended by Section 2003 of the Water Resources Development Act of 2007, provides that a cost sharing partnership agreement may provide credit for the value of materials or services provided before the execution of such cost sharing partnership agreement if the Secretary and the non-Federal interest enter into an agreement under which the non-Federal interest shall carry out such work and only work carried out following the execution of such agreement shall be eligible for credit;

WHEREAS, the Non-Federal Interest understands and acknowledges that any credit for eligible in-kind contributions will be afforded only toward the required non-Federal contribution of funds (i.e. cash contribution) under the Project Partnership Agreement for the project or separable element of the project except such credit will not be afforded toward the non-Federal requirement to provide in cash 5 percent of the costs allocated to structural flood damage reduction; and

WHEREAS, by letter dated October 02, 2008, the Non-Federal Interest stated its intent to perform certain work (hereinafter the "Proposed Work", as defined in Paragraph 1 of this MOU) prior to the execution of the Project Partnership Agreement for the Paducah, Kentucky Local Flood Protection Project at Ohio River Mile 934.4 in Paducah, Kentucky.

NOW, THEREFORE, the Government and the Non-Federal Interest agree as follows:

1. The Non-Federal Interest shall provide or perform the Proposed Work in accordance

with the terms and conditions of this MOU. The Proposed Work shall consist of the reconstruction of existing drainage structures, including corrugated metal pipes, at the Paducah, Kentucky Local Flood Protection Project, as generally described in the Ohio River, Paducah, Kentucky Section 905(b) Analysis dated May 2000, and the above-referenced letter from the Non-Federal Interest.

2. The Non-Federal Interest shall develop all necessary engineering plans and specifications for the Proposed Work.

3. The Non-Federal Interest shall complete all necessary environmental coordination and obtain all applicable Federal, State, and local permits required for the performance of the Proposed Work.

4. The Non-Federal Interest shall comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policy Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 C.F.R. Part 24, in acquiring lands, easements, and rights-of-way required for construction and subsequent operation and maintenance of the Proposed Work, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

5. Nothing in this MOU creates any duty, obligation, or responsibility for the Government. Any activity undertaken by the Non-Federal Interest for the implementation of the Proposed Work is solely at the Non-Federal Interest's own risk and responsibility.

6. The Non-Federal Interest shall keep books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to this MOU to the extent and in such detail as will properly reflect total costs for the Proposed Work and the Non-Federal Interest shall make such evidence available for inspection and audit by authorized representatives of the Government.

7. The Non-Federal Interest understands that any costs incurred for the clean-up of hazardous material regulated by the Comprehensive Environmental Response, Compensation, and Liability Act (hereinafter "CERCLA"; 42 U.S.C. Sections 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way required for the Proposed Work are a Non-Federal Interest responsibility and that no credit shall be afforded for such clean-up costs. In addition, the Non-Federal Interest understands that as between the Government and the Non-Federal Interest, the Non-Federal Interest shall be considered the operator of the Proposed Work for the purposes of CERCLA liability. To the maximum extent practicable, the Non-Federal Interest shall operate, maintain, repair, replace, and rehabilitate the Proposed Work in a manner that will not cause liability to arise under CERCLA.

8. The parties to this MOU shall each act in an independent capacity in the performance of their respective functions under this MOU, and neither party is to be considered the officer, agent, or employee of the other.

9. The Non-Federal Interest understands that to be eligible for credit for the costs of the Proposed Work:

a. The Government must make a determination that the Proposed Work is integral to the project;

b. The Proposed Work shall be subject to a review or on-site inspection, as applicable, and certification by the Government that the work was accomplished in a satisfactory manner and in accordance with applicable Federal laws, regulations, and policies;

c. The costs for the Proposed Work that may be eligible for credit shall be subject to an audit by the Government to determine the reasonableness, allocability, and allowability of such costs;

d. The costs incurred for the Proposed Work are not subject to interest charges, nor are they subject to adjustment to reflect changes in price levels between the time the Proposed Work is completed and the time that credit may be afforded;

e. The Non-Federal Interest shall not use Federal program funds (either funds or grants provided by a Federal agency as well as any non-Federal matching share or contribution that was required by such Federal agency for such program or grant) for the Proposed Work unless the Federal agency providing the Federal portion of such funds verifies in writing that expenditure of such funds for such purpose is expressly authorized by Federal law;

f. Only the costs of the Proposed Work that do not exceed the Government's estimate of the cost of such work if the work been accomplished by the Government may be eligible for credit;

g. Any contract awarded for the Proposed Work shall include provisions consistent with all applicable Federal laws and regulations and the Non-Federal Interest shall comply with all applicable Federal and State laws and regulations, including, but not limited to Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army";

h. The Non-Federal Interest must comply with applicable Federal labor laws covering non-Federal construction, including but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.*), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c)); and

i. Crediting for the costs of the Proposed Work may be withheld, in whole or in part, as a result of the Non-Federal Interest's failure to comply with the terms of this MOU.

10. If the parties agree to enter into a Project Partnership Agreement for the Paducah, Kentucky Local Flood Protection Project at Ohio River Mile 934.4 in Paducah, Kentucky, then the Project Partnership Agreement will contain provisions regarding affording credit for costs of the Proposed Work, if the Secretary determines that the Proposed Work is integral to the project.

11. Execution of this MOU shall not be interpreted as a Federal assurance regarding later approval of any project; shall not commit the United States to any type of reimbursement or credit for the Proposed Work; does not alter any process to be followed by the Government in making a determination to execute a future Project Partnership Agreement; nor does it provide any assurance that any future agreement will ever be executed for the project, the Proposed Work, or any portion of the project. Further, this MOU shall not be interpreted to signify any Federal participation in or commitment to the project or the Proposed Work. Finally, this MOU shall not be construed as committing the Government to assume any responsibility placed upon the Non-Federal Interest or any other non-Federal entity or as preventing the Government from modifying the project that could result in the Proposed Work performed by the Non-Federal Interest no longer being an integral part of the design of the project.

IN WITNESS WHEREOF, the parties hereto have executed this MOU, which shall become effective upon the date it is signed by the District Engineer.

DEPARTMENT OF THE ARMY

BY: _____
Keith A. Landry
Colonel, Corps of Engineers
District Commander

DATE: 11/17/08

CITY OF PADUCAH, KENTUCKY

BY: _____
William F. Paxton
Mayor
City of Paducah

DATE: 11/17/08

CERTIFICATE OF AUTHORITY

I, W. David Denton, do hereby certify that I am the principal legal officer of the City of Paducah, Kentucky, that the City of Paducah, Kentucky is a legally constituted public body with full authority and legal capability to perform the terms of the MOU between the Department of the Army and the City of Paducah, Kentucky, in connection with the Proposed Work to be provided or performed prior to execution of a Project Partnership Agreement for the Paducah, Kentucky Local Flood Protection Project at Ohio River Mile 934.4 in Paducah, Kentucky, and that the persons who have executed this MOU on behalf of the City of Paducah, Kentucky have acted within their statutory authority.

IN WITNESS WHEREOF, I have made and executed this certification this 17 day of November 2008

BY: _____
W. David Denton
City Attorney,
City of Paducah, Kentucky

ADOPTED

MUNICIPAL ORDER NO. 1418

A MUNICIPAL ORDER AUTHORIZING THE MAYOR TO EXECUTE A MEMORANDUM OF UNDERSTANDING BETWEEN THE DEPARTMENT OF THE ARMY AND THE CITY OF PADUCAH FOR WORK PROVIDED OR PERFORMED PRIOR TO EXECUTION OF A PROJECT PARTNERSHIP AGREEMENT FOR THE CITY'S LOCAL FLOOD PROTECTION PROJECT

BE IT ORDERED BY THE CITY OF PADUCAH, KENTUCKY:

SECTION 1. That the City of Paducah hereby authorizes the Mayor to execute a Memorandum of Understanding between the Department of the Army, represented by the U.S. Army Engineer, Louisville District and the City of Paducah for work provided or performed prior to execution of a Project Partnership Agreement for Paducah Kentucky Local Flood Protection Project contingent upon the Assistant Secretary of the Army Civil Works approving an "Exception to Policy for Paducah".

SECTION 2. This Order shall be in full force and effect from and after the date of its adoption.

Mayor

ATTEST:

Tammara S. Brock, City Clerk

Adopted by the Board of Commissioners, November 11, 2008
Recorded by Tammara S. Brock, City Clerk, November 11, 2008
\mo\MOU-Local Flood Protection Project

CERTIFICATION

I hereby certify that the above is a true and correct copy of an Ordinance adopted by the City of Paducah, KY on November 11, 2008.

Tammara S. Brock, City Clerk

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
P. O. BOX 59
LOUISVILLE, KENTUCKY 40201-0059

RECEIVED
NOV 2 0 2008
ENGINEERING
DEPARTMENT

November 18, 2008

Civil Project Management Branch

Mr. Rick Murphy, P.E.
City Engineer
City of Paducah
300 South 5th Street
Paducah, Kentucky 42002-2267

Dear Mr. Murphy:

Enclosed are two executed copies of the November 17, 2008 Memorandum of Understanding between the Department of the Army and City of Paducah, Kentucky.

Please contact me at (502) 315-6783 if you have any questions regarding this agreement.

Sincerely,

Michael Q. Holley

Michael Q. Holley, P.E.
Project Manager

Tammy: This Information Is To Be Received & Filed For Our Carugated Metal Pipe Rehab. Project w/ The Floodwall.

Thxs
Rick

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

NOV 14 2008

MEMORANDUM FOR THE DEPUTY COMMANDING GENERAL FOR CIVIL WORKS AND EMERGENCY OPERATIONS

SUBJECT: Paducah, Kentucky, Flood Damage Reduction Project, Request for Exception to Policy on Timing of Execution of In-Kind Memorandum of Understanding (MOU).

This is in response to the Great Lakes and Ohio River Division Regional Integration Team's (LRD-RIT) November 3, 2008 request for approval of a one-time only waiver of Corps policy on the timing of execution of an In-Kind MOU as set forth in Engineering Circular 1165-2-208, paragraph 4.a. (1), to allow execution of an In-Kind MOU with the city of Paducah, Kentucky prior to completion of the feasibility study. The In-Kind MOU would allow the city to perform necessary pipe repair work and preserve the right to request credit for this work at some point in the future.

The work to be completed by the city of Paducah consists of reconstruction of existing drainage structures, including deteriorated corrugated metal pipes, to restore the functional integrity of the Paducah Local Flood Protection Project. This work is as described in the Ohio River, Paducah, KY Section 905(b) report dated May 2000 and the letter from the city of Paducah to the Louisville District Commander dated October 2, 2008. The city of Paducah intends to initiate and complete this repair work before the next flood season for life/safety reasons. The city of Paducah's latest cost estimate for the pipe repairs is approximately $3 million.

The Corps has determined that the new drainage pipes will not have to be removed with a future project. The Corps has determined that the proposed reconstruction of drainage structures would meet engineering standards and requirements of the likely project that could be recommended in the Feasibility Study. Further, the Corps has determined that the items of work included in the reconstruction ((including the pipes) are those items beyond normal project O&M. The local sponsor has consistently and adequately performed all expected work with respect to the project's O&M manual.

Based upon the information in the November 3, 2008 LRD-RIT request, I have determined that a one-time exception to the policy on the timing requirements contained in EC 1165-2-208, paragraph 4.a.(1) to allow execution of an In-Kind MOU with the city of Paducah prior to completion of the feasibility study is warranted. For purposes of the Feasibility Study, the work accomplished by the non-Federal sponsor will not be considered as part of the Without Project Condition. ER 1165-2-29 in reference to Section 104 credit states that "all costs for non-Federal work incorporated in the recommended plan shall be included in the project first cost and will therefore be subject to cost sharing. Related benefits will be included in the project's economic evaluation". This same policy applies to the Paducah Feasibility Study.

Printed on Recycled Paper

Execution of an In-Kind MOU with the city of Paducah does not grant or guarantee a credit to the city of Paducah. Rather, this waiver allows the city to perform the work as described and preserve the right to request credit for this work at some point in the future. The amount of credit that the city would be eligible for will be based upon completion of the Corps of Engineers Feasibility Study which will document that the work performed by the city is integral to the project. The final credit determination will be in accordance with Paragraph 6 of EC 1165-2-208.

John Paul Woodley, Jr.

John Paul Woodley, Jr.
Assistant Secretary of the Army
(Civil Works)

US Army Corps of Engineers

27 September 2008

Subject: Paducah, Kentucky – LFPP – Pipe Rehabilitation Memorandum

This memorandum documents the progression of the seamless collaborative process undertaken by an informal partnership between the City of Paducah and the Louisville District regarding rehabilitation of deteriorated corrugated metal pipes (CMP's) within the Flood Damage Reduction Project in the City of Paducah.

Guidance that requires inspecting the condition of pipes that penetrate levee/floodwall systems comes from the Inspection of Completed Works (ICW) "Inspection Checklist", page 3 of 4, under the heading of "Levee Embankments" (this guidance is still in draft form but will soon replace Appendix B in EP 500-1-1) and states: "Condition of pipes has been verified using television camera video taping or visual inspection methods within the past five years, and the report for every pipe is available for review by the inspector." Many of the corrugated metal pipes in Paducah had visible perforations and displayed advance corrosion, and the project received an "Unacceptable" rating from the Louisville District in the Annual Inspection Report dated 24 September 2007.

A detailed process for the inspection, condition assessment, engineering review, design of repairs and quality assurance review of the repair process was then developed and agreed upon by a strong team of qualified technical evaluators. The team consisted of a partnership of the City Engineer for the City of Paducah, Rick Murphy, P.E.; the Project Engineer, Jason Peterson, P.E. of Florence &Hutcheson, Inc. Consulting Engineers (F&H); the Louisville District's Levee Safety Geotechnical Engineer, Christina M. Neutz, P.E.; the Louisville District's Levee Safety Structural Engineer, Terry M. Sullivan, P.E; Section Chief, Hydraulic Section, Richard Pruitt, P.E.; and Hydraulic Engineer, Ron Holmberg, P.E.

In the Fall of 2007, the City of Paducah embarked on a process to video inspect all 65 of the drainage pipes that were noted on "As Built" drawings passing through the line of protection of the entire levee/floodwall system. The City retained F&H of Paducah, KY to spearhead the technical preparation of a contract to have all of the pipes inspected and also have their condition evaluated. Hydromax USA was given a contract by the City of Paducah to video inspect all of the drainage pipes that penetrate the levee/floodwall system. Between the dates of November 26 and December 7 of 2007, 60 of the project's pipes were video inspected by technicians from Hydromax. It was noted on the summary report provided by F&H that five pipes previously listed by the Corps in the "Ohio River, Paducah, Kentucky, Flood Damage Reduction, 905(b), (WRDA 1996) Analysis" Report dated May 2000 could not be found in the locations noted on the "As Built" plans, and

this was confirmed by F&H with concurrence by the City Engineer, Rick Murphy. A Final Inspection Report was received by the City of Paducah and F&H on 17 December 2008 from Hydromax. A copy of the summary of the field inspection data sheets is attached as Enclosure 1.

After receiving the Final Inspection Report from Hydromax USA, F&H began the process of performing a Condition Assessment of all 60 pipes. On 6 March 2008, a conference call was held between R. Murphy, J. Peterson, R. Pruitt, C. Neutz, D. Frank and T. Sullivan. The purpose of the call was to discuss USACE criteria for pipe rehabilitation. F&H proposed the following pipe selection criteria:

- All corrugated metal pipes (CMP's) should be rehabilitated; this was due to both the age of the pipes (greater than 60 years) and the latest Corps guidance in EM 1110-2-2902, which allows CMP's for rural levees only, but even then only when the risk of substantial property damage and loss of life is low.
- All other pipes receiving a PACP coding or condition assessment grade of 4 or 5 for structural condition should be rehabilitated.

During the 6 March conference call, F&H also provided a list of approximately 13 other criteria for selection of pipe materials and rehabilitation methods. Some of these items included the pipes' structural capacity to support both dead and live loading was also discussed, and it was agreed that pipe rehabilitation methods should be employed that do not count on the existing pipe to support any of the live or dead load. Discussion of the application of USACE guidance memoranda EM 1110-2-1913 and EM 1110-2-2902 to design for structural loading was discussed in detail. F&H subsequently prepared structural calculations in spreadsheet format which were reviewed and approved by Louisville District personnel. The technical documentation of the structural analyses can be provided upon request.

Other items included in the 6 March conference call were related to hydraulic issues. For example, R. Pruitt pointed out that any loss of the existing pipe's capacity was not acceptable, as this would result in an increase in water levels on the protected side of the levee. Based on this information, a study was made by F&H of the hydraulic capacity of all of the pipes in the project and considerations were given for the following:

- inlet control;
- outlet control - channel lining that may be required to protect for higher flows as a result of pipe rehabilitation
- smoothness of the existing pipe versus the proposed rehabilitated pipe wall smoothness;

Additionally, Louisville District H&H personnel had discussions with Jason Peterson of F&H and Rick Murphy, Paducah City Engineer, regarding historical interior drainage issues. There is only one location where interior drainage conditions could possibly warrant an increase in the capacity of a gravity outlet. This location is at Station 157+63 where there are six existing 5-foot diameter culverts through the line of protection. There is a low probability that additional capacity would ever be needed, but this will have to be confirmed by an analysis of the watershed during the upcoming Feasibility Study on this

project. However, if the analysis were to conclude that additional capacity is required, this would be accomplished by adding a pipe rather than removing and replacing a newly sliplined pipe. It should be noted that the proposed slip lining efforts will not decrease the capacity of the gravity outlets at this location, nor at any of the other pipes being sliplined in this contract. Additional supporting documentation on the hydraulic analyses of the pipes in this contract with respect to the pre- and post-flow conditions have been technically reviewed and approved by Richard Pruitt, P.E. and Ron Holmberg, P.E., Hydraulic Engineers for the Louisville District. The technical documentation of the hydraulic analyses can be provided upon request.

On March 26, 2008 Jason Peterson of F&H and R. Murphy met with personnel at the Louisville District (Mike Holley, Ron Elliott, David Lasoski, Carmen Williams, Matt Whelan, C. Neutz, D. Frank, R. Pruitt, R. Holmberg and T. Sullivan) to discuss progress on the field inspections, review condition assessment progress, and discuss preliminarily which pipes needed to be included for rehabilitation. F&H also discussed the PACP coding system, and the preliminary list of design criteria. A discussion of hydraulic capacity requirements also occurred. The Louisville District agreed with the previously proposed list of design criteria.

On May 28-29, 2008, the City of Paducah and F&H jointly hosted a series of pipe rehabilitation vendor presentations at the Louisville District Office. Vendors engaged in the field of pipe rehabilitation responded to a "Request for Presentation" issued on 13 May 2008. Eight different suppliers of sliplining materials and installers of these systems presented their products, procedures and experience, and were available to answer any questions from the Louisville District's personnel in attendance. This provided the Louisville District with an excellent opportunity to see a wide range of different methods using a wide variety of different materials for trenchless pipe rehabilitation. A copy of the "Request for Presentation" which included a list of the project data and site conditions and topics of discussion along with a "Vendor Presentation Schedule" is attached as Enclosure 2. It is noted that nine Louisville District personnel attended all or part of these two days of presentations (C. Neutz, D. Frank, Chris Alvey, R. Pruitt, R. Holmberg, T. Sullivan, C. Williams, Neil Cash and Morgan Stuart).

It was clear from this series of presentations that several of the more "popular" methods for trenchless pipe rehabilitation would not be appropriate for the particular application of a pipe passing under a levee or floodwall. It was agreed by the technical evaluators that any method of pipe repair that did not include pressurized grouting of the annulus between the host pipe and the liner pipe would not be an acceptable method of repair. This is because any voids that may have developed outside of the host pipe as a result of piping and erosion could only be filled by pressure grouting. There is no currently accepted method that can accurately determine whether or not voids exist on the outside of an existing buried pipe. The video recorded by Hydromax clearly showed numerous openings/perforations in the walls of some of the inspected corrugated metal pipes, and it was conservatively assumed by the technical evaluators that there would be some voids adjacent to those perforations.

During June and July of 2008, F&H performed engineering analyses and prepared the contract documents for a Request for Proposals package to rehabilitate all 37 of the project's CMP pipes. The Louisville District technical reviewers, C. Neutz, R. Pruitt, R. Holmberg and T. Sullivan, were consulted on numerous occasions through phone calls and/or email correspondence. The Louisville District and F&H together developed a list of four acceptable methods for pipe rehabilitation. It should be noted that not all methods were approved for every pipe. The four methods are:

- Method A: Segmental sliplining with solid-wall high density polyethylene (HDPE) pipe and non-structural grout. The new liner pipe is the structural element.
- Method B: Segmental sliplining with glass-reinforced plastic pipe and non-structural grout. The new liner pipe is the structural element.
- Method C: Sliplining with machine operated, spiral-wound polyvinylchloride (PVC) liner and non-structural grout. The new liner PVC strip is the structural element.
- Method D: Sliplining with man-entry, spiral-wound polyvinylchloride (PVC) liner with structural grout. The PVC strip is a non-structural liner only.

During the month of August, 2008, Louisville District personnel (C. Neutz, D. Frank, R. Pruitt, R. Holmberg and T. Sullivan) reviewed draft contract documents prepared by F&H. Review comments from R. Holmberg, T. Sullivan and C. Neutz were emailed to J. Peterson on 12 August 2008. On 21 August 2008, a conference call was held between R. Murphy, J. Peterson, R. Pruitt, C. Neutz, and T. Sullivan to evaluate and reach consensus on resolution to all of the USACE review comments.

On 6 September 2008, the City of Paducah formally issued the "Request for Proposals" for the pipe rehabilitation. The final version of the contract documents for the Paducah Floodwall Pipe Rehabilitation had been technically reviewed and approved by representatives of the Louisville District. The package consisted of:

- A set of 25 drawings outlining the locations of the pipes to be rehabilitated, a summary of the requirements for pipe rehabilitation, and the details for the inlet and outlet controls.
- A "Project Manual" consisting of the technical specifications for the work.

The City of Paducah and F&H jointly hosted a Pre-Bid Meeting at the City of Paducah City Hall on 17 September 2008. This was attended by C. Neutz and T. Sullivan of the Louisville District. Approximately 15 contractors and suppliers were in attendance. This pre-bid meeting also included a site visit to three of the more unique pipe rehabilitation locations so that questions could be raised and answered. Plain communication ground rules were provided to all of the attendees and it was made clear that if a general contractor did not attend the pre-bid meeting then his/her proposal would not be accepted. A copy of the Pre-Bid Meeting Minutes is attached as Enclosure 3.

In summary the pipes specified by the City of Paducah to replace the existing deteriorated pipes, and the four different methods of installation permitted by the construction contract, meet current USACE engineering standards and specifications. Further these

same engineering standards and specifications most likely will be the required standards used during the evaluation of these pipes during the pending feasibility study. It should again be noted that the proposed sliplining of the CMP's for the Paducah project will not decrease the hydraulic capacity of any of the existing gravity outlets.

As a final note, the Louisville District is now utilizing the collaborative process and standards described in detail above for the Ohio River Shoreline Projects at Jeffersonville and New Albany, Indiana. A contract will be awarded on the Jeffersonville project by 30 September 2008 for the rehabilitation of deteriorated CMP's. Additionally, the Louisville District will encourage sponsors at other projects, such as Covington, Kentucky and Cincinnati, Ohio, to utilize the same process on their pipe inspections, evaluations, and restoration.

Christina M. Neutz, P.E.
Geotechnical Engineer
Levee Safety Section
U. S. Army Corps of Engineers
Louisville District

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:

AUG 16 2005

CECW-PB

MEMORANDUM FOR COMMANDERS, MAJOR SUBORDINATE COMMANDS

SUBJECT: Reconstruction of U.S. Army Corps of Engineers Structural Flood Damage Reduction Projects for which Non-Federal Interests are Responsible for Operation, Maintenance, Repair, Rehabilitation and Replacement

1. Purpose. This memorandum provides policy guidance on reconstruction of Corps structural flood damage reduction projects for which non-Federal interests are responsible for operation, maintenance, repair, rehabilitation and replacement (OMRR&R).

2. Background. Pursuant to Section 3 of the Flood Control Act of 1936 and Section 103 of the Water Resources Development Act of 1986 (WRDA 86), non-Federal interests are required to pay 100 percent of the costs of OMRR&R of structural flood damage reduction projects. As projects age, it is recognized that the projects may not perform as intended due to long term degradation of features which have exceeded their expected service life. The term "reconstruction" applies to the measures to address the long-term degradation of project features, which have exceeded their expected service life. There are several ongoing feasibility level studies examining reconstruction of such projects.

3. Policy. This policy is applicable to Federally constructed structural flood damage reduction projects and separable elements for which non-Federal interests are responsible for OMRR&R. It does not apply to Corps activities pursuant to Public Law 84-99.

a. Authority. There is no general authority for reconstruction of projects for which non-Federal interests are responsible for OMRR&R. This lack of authority, however, does not apply to measures addressing design and construction deficiencies, which will continue to be addressed pursuant to existing project authority. Except for those specific features on which it is determined that a design or construction deficiency is involved, Congressional authorization is required to undertake reconstruction.

b. Study Authority. The authority to conduct feasibility studies examining the reconstruction of structural flood damage reduction projects and separable elements constructed by the Corps is Section 216 of the Flood Control Act of 1970 (Public Law 91-611) which states:

"The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply,

and related purposes, when found advisable due to significantly changed physical or economic conditions, and to report thereon to Congress with recommendations of the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest."

Feasibility studies may also be conducted in response to specific study resolutions.

c. Adequate Non-Federal Maintenance. In general, a Federal project or separable element will only be eligible for reconstruction when the non-Federal sponsor has adequately maintained the project or separable element by accomplishing the items provided for in the operation and maintenance manual and the Code of Federal Regulations (33 CFR 208.10 - Local flood protection works; maintenance and operation of structures and facilities) and by addressing operation and maintenance deficiencies noted in any inspection. Where a non-Federal sponsor has not adequately maintained a project, it may still be eligible for reconstruction but the non-Federal sponsor will be responsible for 100 percent of the costs of bringing the project to a fully maintained condition in accordance with the operation and maintenance manual for the project and the Code of Federal Regulations. In other words, the cost of any items recommended in a reconstruction project report that are the result of deficient maintenance will be at 100 percent non-Federal expense.

d. Design Deficiencies. Design or construction deficiencies will continue to be addressed according to ER 1165-2-119 and under the guidance presented in the annual budget EC under the original/existing project authority. Cost sharing and financing of deficiency corrections at structural flood damage reduction projects for which non-Federal interests are responsible for OMRR&R, will reflect the concepts of WRDA 86, as amended, unless the Assistant Secretary of the Army (Civil Works) grants an exception for a project implemented under pre-WRDA 1986 cost sharing or Congress directs otherwise.

e. Definition of Reconstruction. Cost shared reconstruction will be defined by elimination. Reconstruction excludes design or construction deficiencies. Further, reconstruction is limited to addressing impediments that prevent a project from performing as authorized after all maintenance, as required by the project operation and maintenance manual and the Code of Federal Regulations, has been accomplished and any deficiencies resulting from a lack of maintenance have been addressed. Reconstruction will consist of addressing the major performance deficiencies caused by a long-term degradation of the foundation, construction materials, and engineering systems that have exceeded their expected service lives and the resulting inability of the project to perform its authorized project functions. In addressing reconstruction needs, the latest design standards and efficiency improvements should be incorporated into the project.

f. Implementation Process. Reconstruction feasibility studies will be pursued under the two-phase preauthorization study process described in Chapter 4 of ER 1105-2-100. Because Corps interest in the existing structural flood damage reduction project is already established, the reconnaissance phase will concentrate on the need for and rationale for reconstruction (over and above any deficiency correction and performance of deficient maintenance) and the level of interest and support from the non-Federal sponsor. After certification of the 905 (b) report for consistency with policy, preparation of the Project Management Plan and negotiation and execution of the Feasibility Cost Sharing Agreement will take place. The cost shared feasibility study will follow the same procedures as described in Appendix H of ER 1105-2-100 leading to a Chief's Report, ASA(CW) and OMB review and transmittal to Congress for authorization.

g. Study Scope. Depending on the interest of the non-Federal sponsor, the feasibility study may be limited to examination of the reconstruction of the existing project with no change in its scope or function. Under this limited objective, evaluation would be limited to individual project features, (closure structures, pumping stations, gravity drains, relief wells, etc.) to establish the justification of reconstruction based on a comparison between the with and without reconstruction condition. Features considered for reconstruction should be evaluated as to their incremental justification in a manner similar to that used for major rehabilitation at federally maintained projects in accordance with Chapter 3 of EP 1130-2-500. The analysis should first determine whether there are any design or construction deficiencies or insufficient maintenance of the existing project. The analysis should then address the probability of a feature not performing, physical and fiscal consequences of that failure to perform, and consideration of the actions that would be taken after the failure occurred and how that would affect the likelihood of failure in the future. For levee and floodwall projects, the with and without reconstruction analysis should include consideration of both exterior and interior flooding. Reconstruction studies may also include a combination of reconstruction of an existing project with extension or expansion of flood damage reduction (change in scope or level of protection). These studies would be identical in scope to any other flood damage reduction feasibility study and include a full range of alternatives and economic evaluation to identify the plan that maximizes net benefits as well as compliance with all environmental laws and regulations. In both instances (limited and expanded scope), the report should address operation and maintenance and design deficiencies and recommend combined actions subject to the appropriate cost sharing.

h. Ecosystem Restoration. In accordance with the Chief of Engineer's Environmental Operating Principles, any project reconstruction study will include an evaluation of the environmental sustainability of the existing project. The question to be addressed in the evaluation is whether the reconstruction and continued operation and maintenance of the structural flood protection project are compatible with a healthy, diverse, and sustainable condition in the affected aquatic and riparian ecosystem. Modification of the project to add

ecosystem restoration measures would require specific authorization and should be considered in cooperation with the non-Federal sponsor and subject to cost-sharing in accordance with Section 103 of WRDA 86, as amended.

i. Cost Sharing. Costs for reconstruction will be shared in accordance with the provisions of Section 103 of WRDA 86, as amended. A non-Federal sponsor commitment to cost share will be a condition for undertaking a reconstruction project. Measures to address maintenance deficiencies may be included in a reconstruction project but will be at 100 percent non-Federal cost. The non-Federal sponsor must commit to operate, maintain, repair, rehabilitate and replace the completed reconstructed project in accordance with the provisions of Section 103 of WRDA 86, as amended.

4. Permanent Guidance. The guidance in this PGL will be incorporated into permanent guidance as it is updated.

FOR THE COMMANDER:

DON T. RILEY
Major General, USA
Director of Civil Works

OHIO RIVER, PADUCAH, KENTUCKY

Flood Damage Reduction

Section 905(b) (WRDA 1996) Analysis

May 2000

U.S. ARMY CORPS OF ENGINEERS
LOUISVILLE DISTRICT
600 Dr. Martin Luther King, Jr. Place
Louisville, KY 40202-2230

TABLE OF CONTENTS

1 STUDY AUTHORITY 3

2 STUDY PURPOSE 3

3 PROJECT LOCATION / CONGRESSIONAL DISTRICT 4

4 DISCUSSION OF PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS 4

5 PLAN FORMULATION 5

5.a Identified Problems 5

5.a.1 Existing Conditions 5

5.a.2 Expected Future Conditions 6

5.a.3 Problems and Opportunities 6

5.b Alternative Plans 7

5.c Preliminary Evaluation of Alternatives 8

6 FEDERAL INTEREST 11

7 PRELIMINARY FINANCIAL ANALYSIS 11

8 SUMMARY OF FEASIBILITY STUDY ASSUMPTIONS 11

9 FEASIBILITY PHASE MILESTONES 12

10 FEASIBILITY PHASE COST ESTIMATE 12

11 RECOMMENDATIONS 12

12 POTENTIAL ISSUES EFFECTING INITIATION OF FEASIBILITY PHASE 12

13 VIEWS OF OTHER RESOURCE AGENCIES 13

14 PROJECT AREA MAP 14

1. STUDY AUTHORITY

This study was initiated pursuant to the provision of funds in the Energy & Water Development Appropriations Act, 1994 (P.L 103-206). The study was completed under the current Ohio River Mainstem Study authority adopted May 16, 1955, by the Committee on Public Works of The United States Senate.

> "Resolved by the Committee on Public Works of the United States Senate, that the Board of Engineers for Rivers and Harbors created under Section 3 of the Rivers and Harbor Act, approved June 13, 1902, be, and is hereby requested to review the reports on the Ohio River published in House Document No. 306, Seventy-fourth Congress, First Session, House Committee on Flood Control Document No. 1, Seventy-fifth Congress, First Session, and related reports, with a view to determining whether any modifications in the present comprehensive plan for flood control and other purposes in the Ohio River basin is advisable at this time."

A subsequent resolution aimed principally at navigation interests, but also referencing other purposes, was adopted by the U.S. House of Representatives Committee on Public Works and Transportation 11 March 1982:

> "Resolved by the Committee on Public Works of the United States Senate, that the Board of Engineers for Rivers and Harbors created under Section 3 of the Rivers and Harbor Act, approved June 13, 1902, be, and is hereby requested to review the reports on the Ohio River published in House Document No. 492, 60th Congress, First Session, and House Document No. 306, Seventy-fourth Congress, First Session, and other pertinent reports, with a view to determine whether any modifications in the authorized plan for modern barge navigation and other purposes on the Ohio River is advisable at this time with particular emphasis on need for improvement or replacement of Emsworth Locks and Dam, Ohio River Mile 13.3; Montgomery Island Locks and Dam, Ohio River Mile 31.7; and other locations where obsolete or inadequate facilities impede the orderly flow of commerce."

2. STUDY PURPOSE

The primary purpose of this study is to: assess the conditions of the existing flood damage reduction project in Paducah, Kentucky that protects against flooding from the Ohio River; determine the repair, rehabilitation, and/or replacement measures required, if any, to address the systems capacity to provide its original degree of protection in order to ensure its ability to deliver the full benefits expected by Congress at the time of authorization; determine an approximate cost for these measures; and evaluate the potential Federal interest in cost sharing the above measures.

3. PROJECT LOCATION / CONGRESSIONAL DISTRICT

3.a Paducah, Kentucky is located in the northwestern part of the state in McCracken County, along the left bank of the Ohio River 934.4 miles below Pittsburgh, Pennsylvania. Please refer to Figure 6 (Page 17) for a project area map. Paducah has a population of approximately 27,256 (1990 census).

3.b The study area is located in the following Congressional District:
KY 1st – Congressman Edward Whitfield.

4. DISCUSSION OF PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

Paducah Flood Damage Reduction Project - The existing project was authorized by the Flood Control Act of 1937.

Ohio River Mainstem Systems Study (ORMSS) –The scope includes a systems study covering the entire Ohio River Main Stem. The output will be a detailed review of the overall Operations, Maintenance, and Major Rehabilitation needs and costs of the entire Main Stem navigation system. This broad system review will assure the best and most prudent recommendations for maximizing system performance. This study will be complete in 2002. An Interim Feasibility report on J.T. Myers and Greenup L&D's will be complete by early 2000.

Ohio River Main Stem Ecosystem Restoration Feasibility Study – The primary purpose of this study is the development of restoration plans for sites identified by individual states as part of the ORMSS. The main objective is to restore, enhance and protect terrestrial, wetland and aquatic habitats in the Ohio River Corridor. There are currently 5 potential projects listed that are located within the reach of the Paducah Flood Damage Reduction Project. This study will be complete in September of 2000.

SE Illinois Shoreline 905(b) Analysis (1997) – This analysis assessed the conditions of five existing flood damage reduction projects in Southeastern Illinois; these projects are located in the communities of Brookport, Golconda, Harrisburg, Reevesville/Cache River, and Rosiclare, Illinois. A supplement to this analysis will be prepared by early 2000.

OLMSTED Locks & Dam: A navigation project in Pulaski County, Illinois will consist of new twin 1200' lock chambers with a navigable pass dam. Plans and specifications have been prepared for the project, and construction is underway. During high flows, the navigation pass will be down and Olmsted L&D Project will have a negligible effect on the river. The current contract for the lock is forecasted to be completed June 2001. The Dam construction (contract not yet awarded) is scheduled to be completed in 2008.

Lock and Dam 52 & 53 – These L&D's are currently active and operating; however, these 2 existing low lift locks will be replaced by Olmsted Locks & Dam in 2008.

5. PLAN FORMULATION

5.a Identified Problems

5.a.1 Existing Conditions

The Paducah Local Protection Project consists of approximately 48,700 feet (9.2 miles) of earth levee, 15,870 feet (3 miles) of concrete flood wall, 13 pump stations, 55 closure and service openings, 8 ramps, 5 diversion channels and other necessary appurtenances. The top elevation of the protective works is at elevation 350.06 msl. The project affords protection to the City of Paducah against Ohio River floods equal to the maximum on record, elevation 346.8 in January-February 1937, with a freeboard of three feet. The construction of this project started in August 1939 and was completed in January 1950 for a total project cost of $ 5,398,028 (FY99 dollars). The project was assigned to local interests in July 1949 and has been locally operated and consistently well maintained the last 50 years. Some of the major components are nearing the end of their useful design lives. During the March 1997 flood event, as detailed in annual Paducah Flood Protection Project report (1997), there have been documented problems concerning the integrity of the flood protection system which raise questions regarding the systems ability to provide its originally intended level of protection. The original plans assumed a 50-year design life for most major system components, and at the turn of the century this useful life will be nearly exhausted.

5.a.2 Expected Future Conditions

Little change from existing conditions is expected for the study area in the near future. If no action is taken, the City of Paducah will persevere with a protection system that has obsolete and deteriorated components. During the March 1997 flood event, 3 corrugated metal pipes (CMP's) collapsed and were temporarily repaired. Other Local flood reduction projects along the Ohio River (Indiana and Southeast Illinois) have experienced multiple CMP collapses as well. It is projected that other CMP's may collapse during the next flood event. Most major electrical components are original equipment (over 50 years old) and replacement parts are extremely rare. Possible failure of this obsolete equipment poses a serious threat to the reliability of the flood damage reduction project. Completion of the Olmsted Locks and Dam Project in 2008 will have little to no affect upon Paducah, KY. No other significant changes in the conditions of the study area are anticipated for the foreseeable future.

5.a.3 Problems and Opportunities

The objective of this reconnaissance-level study is to investigate the condition of the existing flood damage reduction project at Paducah, Kentucky. Alternatives were constrained by the fact that reconstruction policy excludes any work on items that are considered to be normal operation and maintenance (O&M) responsibilities. The current definition of reconstruction is documented in memorandum, CECW-PC, 7 Sep 1999,

subject: Ohio River Southeastern Illinois, Section 905(b) Analysis – Supplemental Guidance. This definition states that reconstruction is work needed to correct a deficiency in a project that prevents it from performing as authorized after all maintenance, required by the project operation and maintenance manual and Section 208.10 of the Code of Federal Regulations, Local Flood Protection Works; Maintenance and Operation of Structures and Facilities, and any actions identified from project inspections have been accomplished. Recommendations for measures required for repair, rehabilitation, and/or replacement were prepared for deficiencies that prevent the project from performing as originally authorized. Items considered to be O&M responsibility were noted but not included in the cost estimate. All recommended items, both reconstruction and maintenance, can be found separately in Appendix A.

In March of 1997, major regional flooding occurred in the Ohio River Basin. For most of the basin, this flooding was the worst in over thirty years. Subsequent to this flooding event, an annual government field inspection was performed and noted that the overall condition of maintenance of the project is in good shape. Prior to initiation of field inspections by personnel from both Louisville District Engineering Division and Parsons Harland Bartholomew & Associates, Inc, a review was conducted of the annual inspection reports prepared by the Louisville District Emergency Operations Division. The scope of this study includes field Structural, Electrical, Civil and Geotechnical, and Mechanical evaluations/inspections of the floodwalls, closure structures, corrugated metal pipes (CMPs), and levees and all necessary appurtenances. Parsons Harland Bartholomew & Associates, Inc. performed the Structural Evaluation of the existing structural elements. Recommendations resulting from these detailed field investigations clearly identify the need for reconstruction of some major project features. Repair, rehabilitation, or replacement of some project components was deemed necessary because the components were nearing the end of their useful design lives of 50 years. Corrugated metal drainage pipes and pump switchgear are prime examples. Reconstruction of these components is costly, but vital, since the components are critical to the viability of the project. Three CMP's collapsed as a result of the March 1997 flood event. These pipes were temporarily repaired (pipes were excavated and encased with concrete grout). These temporary fixes resulted in unexpected O&M costs of over $19,000. Slip lining the existing CMP's is a feasible restoration and is the requested action by the local sponsor. Switch gear and other electrical equipment, which is integral to the pump system operation, even though adequately maintained has become obsolete; some pumps revealed detrimental vibrations and/or malfunctions that necessitate repair, rehabilitation, or replacement. Operable switchgear, pumps, and pipes are crucial to the intended operation of the levee system and its ability to provide the authorized level of protection.

As a result of the correspondence during this study, an additional potential project was acknowledged. The City of Paducah's Department of Planning & Community Development has long range plans of developing park-like areas adjacent to the floodwall/levee system. During a meeting on 3AUG99, CELRL-PD personnel described potential Corps assistance of Ecosystem Restoration and Protection under authority of the Section 1135 (Water Resources Development Act of 1986) and assistance of Clearing

and Snagging under authority of Section 208 (Flood Control Act of 1954). In the course of this meeting, it was determined that the potential sponsor should formulate and finalize an overall plan and then contact CELRL-PD for assistance.

As a result of the correspondence during this study, an additional potential project was acknowledged. The City of Paducah is interested in a Waterfront Development Master Plan. Draft Appropriations language was scripted for this potential project and submitted to the City of Paducah.

5.b Alternative Plans

5.b.1 Alternative 1: No Action. The No Action alternative assumes that local interests will continue to perform items of normal local operation and maintenance as they have since 1949. These typical items include repair of animal burrows in levees, removal of vegetation from levees and riprap, applying sealer protection to existing concrete surfaces, continued dependable operation during flood events, and other regularly scheduled operation and maintenance items. This No Action alternative assumes a continued deterioration of existing drainage structures and pump stations. If no action is taken to bring the existing system into compliance with its originally intended protection level, the next major flood event could cause numerous collapses of CMP's which would not allow control of interior flooding. If just one pipe collapses, then rapid settlement of the levee could lower the probable failure point of the levee system. Should a breach in any portion of the levee system occur, over 27,000 lives would be at risk and abundant damages would amass.

5.b.2 Alternative 2: Reconstruction. Items of work to be included in the reconstruction alternative are those items that are beyond normal O&M. Major reconstruction items were identified during Engineering Division's Paducah Team site investigations and in the team's professional judgement, the items appear to be a result of unrealistic performance expectations rather than deficient maintenance. Annual reports from both the Corps and Paducah Floodwall teams were reviewed for content relating to proper O&M throughout the history of the LFPP. The local sponsor has consistently and adequately performed all expected work with respect to the project's O&M manual. The following is a concise list of items determined to require reconstruction : (a) slip line all corrugated metal pipes either by traditional or cured in-place methods; (c) electrically upgrade 8 pump stations; (d) install motor on one sluice gate (e) rebuild pumps as necessary. The complete list of reconstruction items is listed in the Appendix A.

CIVIL ITEMS

- There are 38 gravity outlet pipes ranging in size from 8-inches to 84-inches in diameter that were evaluated. The pipes are corrugated metal and it appears that a bituminous coating had been applied to a majority of the pipes. Continued deterioration of the pipes would likely lead to their collapse. If the pipes collapse, the immediate result would be a reduction in the level of protection that is being provided. This reduction could range from a lowering of the levee protection

proportional to the size of the pipe that collapsed to a complete loss of protection. Recommendations are to replace all corrugated metal pipes (CMP's) that are 24" diameter or less by the cured in-place slip lining method; and replace all CMP's that are larger than 24" diameter by the traditional slip lining method.

ELECTRICAL ITEMS

- Eight of the existing project's 12 pump stations' electrical equipment are obsolete and are recommended to be upgraded. The equipment in pump stations #3, #4, #5, #6, #7, #9, #10 and #12 is all original and replacement parts are extremely rare.

MECHANICAL ITEMS

- After recording vibration displacement measurements and audio and visual observations, it was determined that a number of pumps are fatigued and require repair, rehabilitation, and or replacement.

The engineering inspections found that significant items of work beyond the scope of normal routine operation & maintenance are required in order to maintain project integrity. The major problems discovered include aging, deteriorating, and collapsing CMPs and aging pump station equipment - pumps, motors, and electrical switchgear. Our expert engineering opinion is that the reliability of the current system is sub par due to outdated electrical equipment, maintained but fatigued mechanical equipment, and CMPs which have already past their useful design life and which appear to be in good condition but have collapsed nonetheless. The CMPs and essential mechanical and electrical equipment have been in service fifty (50) years and have since obtained maximum expected benefits.

5.c Preliminary Evaluation of Alternatives

5.c.1 Benefits

Under the No Action alternative there would be no additional Corps' costs; however, there would be the high probability of eventual failure or unsatisfactory performance of one or more of the existing projects. Such an incident would most likely incur Federal costs for recovery efforts and inevitably damage the Corps' great reputation. In 1961 an elevation-damage curve was estimated for the Paducah Flood Damage Reduction Project. This curve was used to estimate existing project benefits and uses river stages at the USGS Paducah gage. A stage-frequency curve for the Paducah gage was integrated with the elevation-damage curve indexed to 1999 values. Using the HEC-FDA software, an estimate was made of the Expected Annual Damages (EAD) under the No Action alternative. The Paducah Flood Damage Reduction Project provides protection against a flood equal to the 1937 flood plus three feet of freeboard. This is equal to a stage 63.6 feet on the USGS Paducah gage. The No Action alternative with levee height of 63.6 was used in the HEC-FDA software to measure the expected annual benefits. Environmental

benefits associated with continued protection of industrial facilities have not been determined.

Alternative 1 – No Action
This alternative would incur no additional Corps' costs though there is a greater probability of eventual failure or unsatisfactory performance of the existing flood protection project. During the recent March 1997 flood on the Ohio River, three CMP's collapsed and tons of stone were eroded away. Paducah incurred significant emergency flood fighting costs in order to prevent massive flood damages. Should any portion of the levee system fail, a full failure of the entire system is very probable. Given this circumstance, it is very possible that the existing flood protection works would result in Expected Annual Damages (EAD) of over $ 1,856,000.

Alternative 2 – Reconstruction
It is recommended that all actions identified in Alternative 2 be addressed under the original project authority. By repairing, replacing, and/or rehabilitating deteriorating items to their original authorization parameters this alternative would ensure that the existing project would continue to provide a 1% chance event protection to the City of Paducah, KY and thereby eliminate the predicted EADs of over $ 1,856,000.

5.c.2 Costs

Updated MCACES format cost estimates for the recommended Alternative 2 reconstruction work were prepared for each of the following inspected categories: Structural, Civil, Electrical, and Mechanical. Table 5-1 (below) summarizes the reconstruction costs. Federal participation in reconstruction will be cost-shared in accordance with Section 103 of the Water Resources Development Act of 1986, as amended (i.e., minimum of 35 percent non-Federal). These costs include ONLY items determined by mature engineering judgement to be beyond the scope of normal O&M activities

Table 5-1 - Reconstruction Costs of Recommended Alterative 2

Reconstruction Category	Sponsor Costs	Federal Costs	Construction Costs
Structural	$31,850	$59,150	$91,000
Civil	$462,700	$859,300	$1,322,000
Electrical	$148,400	$275,600	$424,000
Mechanical	$429,800	$798,200	$1,228,000
Total	$1,072,750	$1,992,250	$3,065,000
Total w/Contigency			**$3,678,000.00**

5.c.3 Economic Evaluation of Alternative 2

Table 5-2 (page 10) summarizes the estimated cost of construction, costs for Planning, Engineering & Design and costs for Supervision & Administration (S&A) during construction. All work is expected to be performed within the existing project lands, and acquisition of additional real estate is not anticipated in this cost estimate. The sum of these costs was utilized to determine the Benefit-to-Cost Ratio that – by law - must be greater than or equal to 1.0 in order to be economically feasible.

Table 5-2 - Project Costs

ECONOMIC ANALYSIS ($1000'S)	
Construction Cost	$3,678
Plng, Engr, Design (25%)	$920
S&A (8%)	$294
TOTAL FIRST COST (FY99)	**$4,892**
Interest During Construction	$180
TOTAL PROJECT COST (FY99)	**$5,072**
Average Annual Costs	$362
Expected Annual Benefits	$1,856
Benefit-to-Cost Ratio	5.13
Net Benefits (FY99)	$1,494

The annualized cost calculations only include the reconstruction portion of the project reconstruction costs. O&M items were not considered in the calculation of net benefits. The BCR for this reconstruction project ranges from 1.0 to 6.0.

6. FEDERAL INTEREST

6.a Determination of Interest

This project is a flood damage reduction project that is high priority for the Administration. There is federal interest in ensuring that the original constructed project continues to deliver the full benefits intended by Congress at the time of authorization. As aging infrastructure vital for the general public welfare, the protection of life and industry, the City of Paducah requires federal intervention to ensure that it continues to provide its intended level of protection as originally authorized. The proposed alternative involving reconstruction of the existing flood damage reduction project is consistent with Federal objectives and has the support of the local sponsor. All reconstruction items (see Appendix A) are in accordance with policy as defined in memorandum, CECW-PC, 7 Sep 1999, subject: Ohio River, Southeastern Illinois, Section 905(b) Analysis – Supplemental Guidance. This reconnaissance report serves as the basis for budgeting for future project activity. The preliminary economic analysis indicates that flood damage prevention benefits outweigh the costs of project reconstruction. Accordingly, this study concludes that a reconstruction project covering all items previously identified as in excess of normal local operation and maintenance requirements is justified. As such, the project would be eligible for the receipt of federal funding to reconstruct the project to its original level of protection in order to assure that it continues to provide the benefits for which it was originally designed.

6.b Environmental Review

A review of the environmental considerations for the project indicate that an Environmental Assessment should result in a Finding of No Significant Impact since all recommended actions are on an existing project footprint and no known additional impacts are predicted.

7. PRELIMINARY FINANCIAL ANALYSIS

The City of Paducah has the legal capability to enter into a binding contract with the Government. The City of Paducah will indicate by a letter of intent that they understand the cost sharing responsibilities affiliated with the recommended reconstruction and are willing to enter into a Planning, Engineering & Design Cost Sharing Agreement. The sponsor's letter of intent was received on December 7, 1999.

8. SUMMARY OF FEASIBILITY STUDY ASSUMPTIONS

See Section 12, page 12.

9. FEASIBILITY PHASE MILESTONES

See Section 12, page 12.

10. FEASIBILITY PHASE COST ESTIMATE

See Section 12, page 12.

11. RECOMMENDATIONS

Having considered the social, economic, environmental, and engineering aspects of reconstructing the existing flood damage reduction project in Paducah, KY, I believe there is a federal interest in reconstruction of the existing Paducah Flood Damage Reduction Project. There are sufficient indications that reconstruction of the existing project can be formulated, which accrue benefits sufficient to exceed costs. Accordingly, I recommend that reconstruction of the Paducah Flood Damage Reduction Project, as described in this report, be implemented with such modifications as in the discretion of the Chief of Engineers may be advisable and in accordance with existing cost sharing and financing requirements. The total first cost of the project, based on FY 99 price levels, is estimated at $ 4,892,000 (See Table 5-2, page 10).

It is recommend that this Section 905(b) Analysis be approved as the basis for entering into planning, engineering, and design for reconstruction. As delineated in EC 11-2-177, 31 Mar 99, planning, engineering, and design for reconstruction will be funded from Operation and Maintenance, General (O&M) funds allocated for inspection of completed works. The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for implementation funding. However, prior to transmittal to Congress, the local sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

12. POTENTIAL ISSUES EFFECTING INITIATION OF FEASIBILITY PHASE

There is no need for a feasibility study for this project. We recommend that this document serve as the decision document and basis for budgeting to continue project activities per the guidance contained in EC 11-2-177, paragraph B-2.4a. Preliminary discussions with the local sponsor indicate no issues which would preclude their signing of Planning, Engineering & Design Cost Sharing Agreements and, ultimately, a Project Cooperation Agreement for project reconstruction efforts.

13. VIEWS OF OTHER RESOURCE AGENCIES

Views of other resource agencies are unknown at this time.

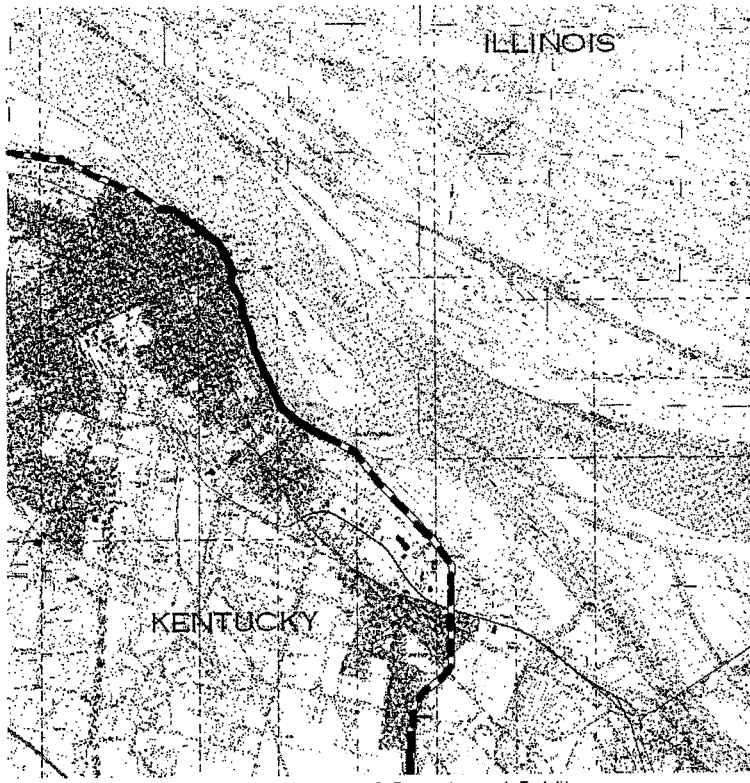
14. PROJECT AREA MAP:

A project area map is attached.

____/s/_____
Robert E. Slockbower
Colonel, Corps of Engineers
Commander and District Engineer

Date:_____

PADUCAH, KENTUCKY

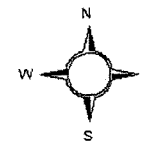


0.5 0 0.5 1 1.5 Miles

Legend

Levee

Floodwall



US Army Corps of Engineers
Louisville District

Section 905(b) Analysis
Ohio River, Paducah, Kentucky

Figure 6

HQUSACE COMMENT # 1

The report does not provide sufficient information to support the determination that the proposed work is consistent with reconstruction policy. Reconstruction is defined as work needed to correct a deficiency in a project that prevents it from performing as authorized after all maintenance, required by the project operation and maintenance manual and Title 33, Section 208.10 of the Code of Federal Regulations, Local Flood Protection Works; Maintenance and Operation of Structures and Facilities, and any actions identified from project inspections have been accomplished. There is no discussion of what is required by the project O&M manual or 33 CFR 208.10 that would provide a basis for concluding that the proposed work is reconstruction. I prepared the attached comparison to 33 CFR 208.10 and it is my assessment that vast majority of the proposed work is required maintenance.

There is no indication that the proposed work is to correct major structural deficiencies in the project caused by design or construction deficiency, minimization of the original design, unanticipated conditions, or changes in foundation conditions. Perhaps upgrading the old electrical gear at the pumping plants qualifies as reconstruction/major rehabilitation because these old components can no longer be serviced. On the other hand, 33 CFR 208.10 (h)(1) calls for repair or replacement of damaged or unserviceable parts that affect the efficient functioning of the project. Adding a motor to a sluice gate sounds like an efficiency improvement that could be part of a reconstruction project.

CELRL RESPONSE # 1

According to a MEMORANDUM FOR COMMANDERS, MAJOR SUBORDINATE COMMANDS with subject: Policy Guidance Letter (PGL) No. 50, Reconstruction of U.S. Army Corps of Engineers Flood Damage Reduction Projects Turned Over to Non-Federal Interests for Operation and Maintenance, dated 05NOV1999, the definition of reconstruction is as follows:

Reconstruction will exclude a design or construction deficiency. Design or construction deficiencies will continue to be addressed according to ER 1165-2-119. Also, reconstruction is only addressing the impediments preventing a project from performing as authorized after all maintenance , as required by the project operation and maintenance manual and the Code of Federal Regulations, has been accomplished and any deficiencies resulting from a lack of maintenance have been addressed. Reconstruction will consist of addressing the major project deficiencies caused by a long term degradation of the foundation, construction materials and engineering systems beyond their expected service lives and the resulting inability of the project to perm its authorized project functions. In addressing reconstruction needs, the latest design standards and efficiency improvements can be incorporated into the project as long as the scope, function and purpose of the project are not changed. It is recognized that the distinctions between maintenance and reconstruction are not precise and sometimes will rely heavily on professional judgements.

Also please reference MEMORANDUM FOR Commander, Great Lakes and Ohio River Division ATTN: CELRD-ET-P with subject: Ohio River, Southeastern Illinois, Section 905(b) Analysis – Supplemental Guidance, dated 07SEP1999, further interpretation of this newly revised reconstruction definition includes the following:

Reconstruction is defined as work needed to correct a deficiency in a project that prevents it from performing as authorized after all maintenance, required by the project operation and maintenance manual and Section 208.120 of the Code of Federal Regulations, Local Flood Protection Works; Maintenance and Operation of Structures and Facilities, and any actions identified from project inspection have been accomplished. Reconstruction will generally consist of addressing the major structural deficiencies of a project caused by design or changes in foundation conditions. Reconstruction also includes the kinds of major rehabilitation items being addressed at Corps-maintained projects primarily from the deterioration of the ability of materials and components of a project to perform (e.g., deteriorating concrete). In addressing reconstruction needs, current design standards and efficiency improvements can be incorporated into the project as long as the scope, function, and purpose of the project is not changed. Federal participation in reconstruction will be cost-shared in accordance with section 103 of the Water Resources Development Act of 1986, as amended (i.e., minimum of 35 percent non-Federal). Corrections of deficiencies resulting from inadequate maintenance may be included in the reconstruction project, but are not eligible for cost sharing.

The following is a summary of the two interpretations:

- Reconstruction is defined as work needed to correct in a project that prevents it from performing as authorized, after all maintenance, required by the project operation and maintenance manual and Section 208.120 of the Code of Federal Regulations, Local Flood Protection Works; Maintenance and Operation of Structures and Facilities, and after any actions identified from project inspection have been accomplished.

According to the Paducah, Kentukcy Local Protection Project O&M Manual which references Section 208.10 of Title 33 Code of Federal Regulations, the following are local responsibilities and guidance:

- Structures and facilities constructed by the United States for local flood protection shall be continuously maintained in such a manner and operated at such times and for such periods as may be necessary to obtain the maximum benefits. It is the professional engineering opinion of CELRL that this project has reached its threshold of obtaining benefits. It would be both dangerous and costly to risk not reconstructing major system components. Failure of one CMP could potentially cause collapse of the entire flood protection project.
- Maintenance measures or repairs which the District Engineer deems necessary shall be promptly taken or made. Over the past 50 years, the City of Paducah, Kentucky has honorably made any and all corrections as noted on annual Corps Inspection Survey Reports.
- Pipes, gates, operating mechanisms, riprap, and headwalls are in good condition. The key word here is "*good*" condition. It is extremely difficult - if not impossible -

to predict the exact condition of the 50 year old CMPs. One minute section of pipe, if overlooked, could collapse at any given time. Engineering analysis shows that 50 years is the approximate useful lifespan of similar corrugated metal pipes.

- Reconstruction will consist of addressing the major project deficiencies caused by a long term degradation of the foundation, construction materials and engineering systems beyond their expected service lives and the resulting inability of the project to provide its authorized project functions.

- Reconstruction will generally consist of addressing the major structural deficiencies of a project caused by design or changes in foundation conditions.

- Reconstruction also includes the kinds of major rehabilitation items being addressed at Corps-maintained projects primarily from the deterioration of the ability of materials and components of a project to perform (e.g., deteriorating concrete).

- It is recognized that the distinctions between maintenance and reconstruction are not precise and sometimes will rely heavily on professional judgements.

HQUSACE COMMENT # 2

There is no explanation of the basis for the estimate of the benefits attributable to reconstruction. Since reconstruction is related to project performance, there should be an analysis of expected project performance without and with reconstruction. Performance should be described in terms of the probability that the project will perform satisfactorily under certain flood events.

CELRL RESPONSE # 2

Expected project performance without reconstruction is complete system failure and potential loss of lives. Under the No Action alternative there would be no additional Corps' costs; however, there would be the high probability of eventual failure or unsatisfactory performance of one or more of the existing projects. Such an incident would most likely incur Federal costs for recovery efforts and inevitably damage the Corps' great reputation. The damages expected yearly should the local flood damage reduction project fail is approximately $ 2,000,000.

Expected project performance with reconstruction items is at least another 50 years full protection to the City of Padcuah, KY against the flood of record (1937 event). By repairing, replacing, and/or rehabilitating deteriorating items to their original authorization parameters this alternative would ensure that the existing project would continue to provide a 1% chance event protection to the City of Paducah, KY and thereby eliminate the predicted EADs of nearly $ 2,000,000.

HQUSACE COMMENT # 3

3. There is no sponsor letter of intent. This is needed before HQ can approve the 905b.

CELRL RESPONSE # 3

The letter of intent was received in December 1999, as faxed to HQ/DIV accordingly. An electronic copy of the letter of intent is attached below.

CITY OF PADUCAH
300 South 5th Street
P.O. Box 2267
Paducah, KY 42002-2267
TDD 1-800-247-2510

December 7, 1999

Colonel Robert E. Slockbower
District Engineer
U.S Army Corps of Engineers
Louisville District
Post Office Box 59
Louisville, KY 40201-0059

Dear Colonel,

The City of Paducah, designated hereafter as "the Sponsor", is interested in obtaining the Corps of Engineers assistance in rehabilitating our existing flood protection facility along the Ohio and Tennessee Rivers.

We are aware of the cost sharing requirements associated with project reconstruction efforts in partnership with the Corps of Engineers. If the current reconnaissance study evaluating the conditions of the flood protection facility for the City of Paducah results in an authorization of one or more Corps restoration projects, preparation of the appropriate specifications and plan formulation will be undertaken. We understand this phase to be Preconstruction Engineering and Design (PED). We also understand, time necessity depending on the complexity of the project, is conducted and managed by the Corps, and those costs associated with PED are shared at the same percentage as the construction. Near the end of this design phase, the Corps and sponsor will execute a Project Cooperation Agreement which commits both to proceeding with construction of the project according to the cost sharing distribution as described in the reconnaissance study.

I am aware that this letter constitutes an expression of intent and not a contractual obligation and that the sponsor or the corps may opt to discontinue the project development process before entering into agreement to reconstruct the project. Should you have any questions regarding this letter of intent please direct your call to Mr. Rick Murphy, P.E., City Engineer at (270) 444-8511.

Sincerely,

Albert Jones

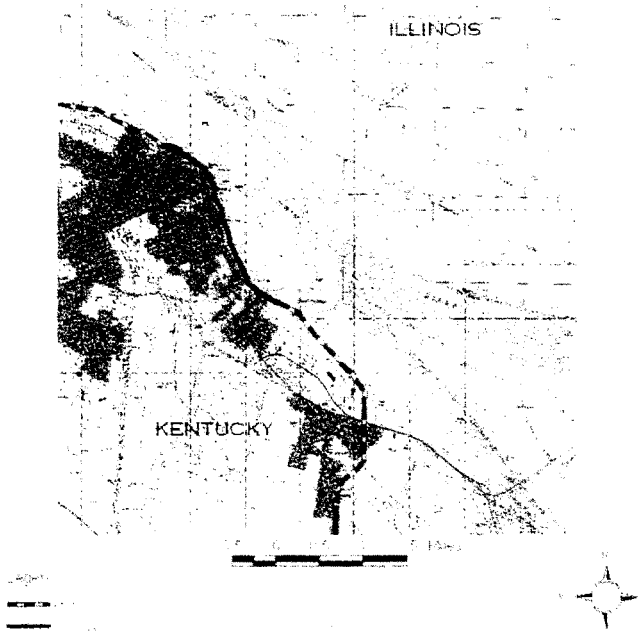
Albert Jones, Mayor
City of Paducah

AJ/kjl

Ohio River
Paducah, Kentucky

Analysis

PADUCAH, KENTUCKY



U.S. Army Corps of Engineers
Louisville District
600 Dr. Martin Luther King, Jr. Place
Louisville, KY 40202-2230

Exhibit 1

Table of Contents

1. Flood Damage Reduction
   May 2000 Analysis 905 B

2. Study - Structural, Electrical, Civil and Geotechnical and Mechanical

3. Hydraulic Analysis
   Levee and Drainage Structures

4. Civil and Geotechnical Evaluation Appendix B

5. Mechanical Evaluation - Appendix D

6. Pump Stations Evaluation

7. Recommendations - Appendix A

8. HQ Memorandum Guidance

U.S. Army Corps of Engineers
Louisville District
600 Dr. Martin Luther King, Jr. Place
Louisville, KY 40202-2230

Exhibit 2

OHIO RIVER, PADUCAH, KENTUCKY
Flood Damage Reduction
Section 905(b) (WRDA 1996) Analysis

Engineering Appedices

Volume 1 of 2

U.S. ARMY CORPS OF ENGINEERS
LOUISVILLE DISTRICT

Appendix A
Recommendations

OHIO RIVER, PADUCAH, KENTUCKY
Flood Damage Reduction
Section 905(b) (WRDA 1996) Analysis

U.S. ARMY CORPS OF ENGINEERS
LOUISVILLE DISTRICT

RECONSTRUCTION ITEMS:

STRUCTURAL (Evaluated by Parsons Harland Bartholomew & Associates, Inc.)

- The floodwall and most of the accompanying structures are in good condition. There is no evidence to suggest any structural failures exist, which would compromise the integrity of the floodwall.

- Rip rap should be installed at gated outlets station locations 7+54 B, 19+11 B and 80+09 B to prevent future bank erosion and possible damage to these structures.

CIVIL

Section A

- Repair slight depressed area on riverside slope just downstream from Pump Station #2, approximately 60 feet in length, located about 25 feet off the levee crown.

- Repair small sink in the landside toe area, just upstream from Pump Station #2.

- Repair small depression across the levee crown and side slopes at approximate Station 96+00-A, approximate 4 inch depth.

- Repair small sink at the landside toe area, approximate Station 113+00-A (near Highway 45), approximately 3 feet deep.

- Repair low area in the levee crown on the north side of the abandoned railroad closure adjacent to Perkins Creek, approximately 30 feet in length, Station 140+46-A.

- Add stone protection to the outlet area at Pump Station #1, Station 159+40-A.

- Repair two washouts in the outlet area of the drainage structure at Station 157+63-A.
  Dimensions: (1) 8' x 20' x 5' D
  (2) 5' x 4' x 2' D

- Add riprap protection to the inlet and outlet areas for at least the following locations Station 200+35-A and Station 147+25-A.

Section B

- Repair depression at landside toe of the levee, approximate Station 172+40-B.
- Repair small depression in the embankment crown and landside slope in the approximate area of Boyd Street and North Sixth Street, approximate 8" depth.
- Repair small depression at the landside toe area near residence fenceline, approximate area of Boyd Street and North Sixth Street.
- Repair small eroded area on the riverside embankment face just downstream and adjacent to new stone placement, approximate Station 19+11-B, approximate 30 foot length and 10 foot width.
- Repair eroded area at approximate high water elevation along the top of the headwall for the 66 inch CMP, approximate Station 19+11-B, approximate 250 foot length and 50 foot width.
- Repair low area in levee crown at access ramp at the end of Main Street.
- Add riprap protection to the inlet and outlet areas for at least the following location Station 19+11-B.

Section C

- Repair undercutting and erosion around and beneath the grouted riprap at the drainage structure outlet area, Station 291+75-C.
- Repair low area in levee crown, approximate Station 219+00-C (approx. 115 feet upstream from railroad tracks), approximate 10 foot length, 5 foot width, and 6 inch depth.
- Repair loss of turf along levee crown between Cook Street and Georgia Street.
- Repair low area in levee crown and sideslopes where settlement occurred following the installation of a 36 inch drain line, approximately Station 206+00-C (90 feet from the centerline of Georgia Street) approximate 6 inch depth.
- Repair low area on riverside of levee embankment, approximately Station 203+00-C, approximate 5 foot length and 2 foot width.
- Repair loss of turf and four-wheeler damage to levee embankment crown and sideslopes, approximate Station 110+00-C, approximate 6 inch depth.

- Remove tree growth encroaching to within 15 feet of the landside levee toe, approximately between Stations 105+00-C and 150+00-C, approximate 10 foot width needs to be removed along this length.

- Repair loss of turf along levee crown approximately between Stations 105+00-C and 150+00-C.

- Add stone protection to the outlet area of the drainage structure located at approximately Station 112+00-C.

- Repair handrails on railroad closure at Station 104+96-C. Handrails are rusted and loose.

- Repair low area in levee crown, approximately Station 103+80, approximate 8 foot length, 4 foot width and 6 inch depth.

- Repair loss of turf along levee crown from approximate Station 93+00-C to where I-24 crosses the protection.

- Repair small eroded area on the landside levee slope just upstream from the I-24 embankment, approximate 20 foot length and 4 foot width.

- Seed and straw in an effort to maintain turf cover on the levee crown and sideslopes upstream from the I-24 embankment.

- Add stone protection to the outlet area of the drainage structure located at Station 51+28-C.

- Repair two potholes in the levee crown located approximately 150 feet upstream from Lydon Road (approximate Station 40+00-C).

- Add riprap protection to the inlet and outlet areas for at least the following locations Station 291+75-C, Station 254+06-C, Station 244+65-C, Station 224+50-C, Station 217+35-C, Station 200+55-C, Station 199+80-C, Station 157+63-C, Station 150+05-C, Station 111+67-C, Station 92+70-C, approximate Station 112+00, Station 51+28-C, Station 32+38-C and Station 32+12-C.

- Repair small depression at the landside levee toe in the area of the Husbands Road crossing (approximate Station 0+25-C).

- Refurbish all CMP's larger than 24" by slip lining. Refurbish all CMP's 24" diameter or less by the cured in-place method. See tables below for summary.

Pipes to be Slip-Lined

STATION	QUANTITY	DIAMETER	LENGTH (EA.)
157+63-A	3	60"	159'
130+00-A	1	30"	134'
111+67-A	1	72"	197'
19+11-B	1	66"	157'
291+75-C	1	36"	175'
254+06-C	1	36"	168'
244+65-C	1	30"	135'
176+90-C	1	48"	112'
149+00-C	1	84"	124'
92+70-C	2	48"	100'
51+28-C	1	30"	136'
32+38-C	3	60"	113'
32+12-C	2	48"	184'

Pipes to be Cured-In-Place

STATION	QUANTITY	DIAMETER	LENGTH (EA.)
187+34-A	1	15"	78'
151+25-A	1	24"	86'
147+25-A	1	24"	77'
84+00-A	1	24"	194'
175+40-B	1	24"	175'
80+00-B	1	18"	44'
7+54-B	1	18"	55'
3+91-B	1	8"	36'
3+68-B	1	8"	78'
224+17-C	1	24"	44'
223+57-C	1	24"	43'
217+35-C	2	24"	47'
200+55-C	1	24"	49'
199+80-C	1	24"	54'
176+47-C	1	24"	53'
172+08-C	1	24"	107'
169+59-C	1	24"	30'
150+05-C	1	24"	57'

ELECTRICAL

- Pump Station # 1: Study the possibility of raising operating elevations of the pump station because of the motors running above the full load current while sump elevation is low.

- Pump Station #2: Replace Pump No. 1 starter, rated 240 volts, 3 phase, NEMA size 3, with HAND-OFF-AUTO switch, circuit breaker and ammeter. Replace Pump No. 6 indicating run light.

- Pump Station #3: Replace Pump No. 1 NEMA size 1, No. 2 & No. 3 NEMA size 3 starters with 400 amps, 230 volts, 3 phase motor control center with: main circuit breaker and voltmeter; starters with H-O-A switch, circuit breaker and ammeter; 5 kVA dry type transformer; 100 amps, 120/240 volts, single phase panel. Replace 230 volts, 3 phase service drop, motor conductors, hps lighting and receptacles.

- Pump Station #4: Replace Pumps No. 1 & No. 2 starters rated 440 volts, 3 phase, 50 hp with H-O-A switch, circuit breaker and ammeter; underground 440 volts and 120/240 volt service entrance conductors; motor conductors; 50 amps, 120/240 volts, single phase panel with main circuit breaker; 480 volts main circuit breaker at pole.

- Pump Station #5: Replace 480 volts, 3 phase motor control center with new MCC with: 800 amps main circuit breaker and voltmeter; 2 starters rated 200 hp, 1 starter 100 hp, 1 starter 25 hp, and all with H-O-A switch, circuit breaker and ammeter; 5 kVA dry type transformer; 100 amps, 120/240 volts single phase panel. Replace 480 volts, 3 phase service drop, motor conductors, hps lighting and receptacles.

- Pump Station #6: Replace 480 volts, 3 phase motor control center with new MCC with: 1200 amps main circuit breaker and voltmeter; 3 starters rated 250 hp, 1 starter 125 hp, 1 starter 10 hp, and all with H-O-A switch, circuit breaker and ammeter; 5 kVA dry type transformer; 100 amps, 120/240 volts single phase panel. Replace 480 volts, 3 phase service drop, motor conductors, hps lighting and receptacles.

- Pump Station #7: Replace 480 volts, 3 phase motor control center with new MCC with: 600 amps main circuit breaker and voltmeter; 1 starter rated 125 hp, 1 starter 50 hp, 1 starter 10 hp, and all with H-O-A switch, circuit breaker and ammeter; 5 kVA dry type transformer; 100 amps, 120/240 volts single phase panel. Replace 480 volts, 3 phase service drop, motor conductors, hps lighting and receptacles.

- Pump Station #9: Replace Pumps No. 1 & No. 2 starters rated 440 volts, 3 phase, 50 hp with H-O-A switch, circuit breaker and ammeter; overhead 440 volts and 120/240 volt service entrance conductors; motor conductors; 100 amps, 120/240 volts, single phase panel with main circuit breaker; 200 amps, 480 volts main circuit breaker with voltmeter.

- Pump Station #10: Replace Pumps No. 1 & No. 2 starters rated 220 volts, 3 phase, 15 hp with H-O-A switch, circuit breaker and ammeter; underground 220 volt service entrance conductors; motor conductors; 50 amps, 120/240 volts, single phase panel with main circuit breaker; .75 kVA transformer; 480 volts main circuit breaker at pole.

- Pump Station #12: Replace Pumps No. 1 & No. 2 starters rated 440 volts, 3 phase, 50 hp with H-O-A switch, circuit breaker and ammeter; overhead 440 volts and 120/240 volt service entrance conductors; motor conductors; 50 amps, 120/240 volts, single phase panel with main circuit breaker; 200 amps, 480 volts main circuit breaker with voltmeter.

- Sluice Gate #2: Recommend permanately installing a motor on the sluice gate for the opening and closing of the gate. Motor should be installed on a platform above flood stage.

MECHANICAL

Pump Station #1; Noble Park:

Pump Identification	Displacement (mils)	Pump Velocity (rpm)	Severity of Operation*	Rebuild Required
1	1.7	703	Good	Yes, See Note 1
2	2.56	703	Fair	Yes
3	3.6	703	Fair	Yes

- Pumps that are in the good range or better with regular maintenance should provide many years of reliable operation. Pumps that are below the good range are required to be rebuilt with all new rotating elements which include the shaft, enclosure tube, bearings and couplings. Pumps that are being rebuilt will also require impellers to be dynamically rebalanced and new Dresser type couplings installed on the discharge piping.

Note 1: Pump needs to be rebuilt due to the fact that there was a knocking noise. The noise indicates a possible wear or failure problem at the impeller or diffuser bearing locations. All three pumps were observed to have this problem. I am recommending the installation of a vortex suppressor at this pump station, due to the type of inflow conditions at the sump entrance. My experience has shown that by installing a suppressor, we can reduce the amount of cavitation and wear damage that is currently be shown on this three pumps.

Pump Station #2; Sixth Street: All discharge piping requires replacement located within the sump, due to heavy corrosion. Replace pressure piping from discharge elbow to the first dresser coupling located outside the sump wall in the levee. Also, replace discharge piping at the outlet headwall to a point approximately 10 feet back from the headwall. The heavily corroded air vent from sump to outside, vent on north and south sides of the sump need to be replaced

Pump Identification	Displacement (mils)	Pump Velocity (rpm)	Severity of Operation*	Rebuild Required
1 (Sump Type)	N/A	880	N/A	No
2	0.9	706	Very Good	No; See Note 1
3	8.6	355	Fair	Yes
4	8.6	355	Fair	Yes
5	8.6	443	Slightly Rough	Yes, See Note 2
6	No Measurements	443	N/A	No; See Note 3
7	3.4	1200	Slightly Rough	Yes

- Pumps that are in the good range or better with regular maintenance should provide many years of reliable operation. Pumps that are below the good range are required to be rebuilt with all new rotating elements which include the shaft, enclosure tube, bearings and couplings. Pumps that are being rebuilt will also require impellers to be dynamically rebalanced and new Dresser type couplings installed on the discharge piping.

Note 1: Impeller has been damaged requires that a new impeller be installed.

Note 2: Impeller needs to have nicks on edges repaired.

Note 3: Measurements for vibration were not taken, pump ran smooth in the sump.

Pump Station #3; Park Avenue: Station superstructure is in good condition, except that hoist needs to be repaired The pumps and discharge piping within the sump required sandblasting and repainting. Painting of pump components will be accomplished using Corps of Engineers Formula C-200 (Coal tar epoxy). The supports and grating for the top of the discharge well are heavily deteriorated and require replacement.

Pump Station #5; Harrison Street: The supports and grating for the top of the discharge well are heavily deteriorated and require replacement

Pump Identification	Displacement (mils)	Pump Velocity (rpm)	Severity of Operation*	Rebuild Required
1	2.4	694	Fair	Yes
2	7.0	694	Slightly Rough	Yes
3	2.4	870	Fair	Yes, See Note 1
4 (Sump)	0.12	710	Extreme Smooth	No

- Pumps that are in the good range or better with regular maintenance should provide many years of reliable operation. Pumps that are below the good range are required to be rebuilt with all new rotating elements, which include the shaft, enclosure tube, bearings and couplings. Pumps that are being rebuilt will also require impellers to be dynamically rebalanced and new Dresser type couplings installed on the discharge piping. Existing couplings are currently leaking and corroding.

Note 1: Impeller has been damaged requires that a new impeller be installed.

Pump Station #6; Clark Street: Level indicator requires adjustment, investigation indicated being 1.5 feet off. The pumps and discharge piping within the sump require sandblasting and repainting. Painting of pump components will be accomplished using Corps of Engineers Formula C-200 (Coal tar epoxy). The supports and grating for the top of the discharge well are heavily deteriorated and require replacement

Pump Identification	Displacement (mils)	Pump Velocity (rpm)	Severity of Operation*	Rebuild Required
1	2.17	501	Good	No, See Note 1
2	10.0	700	Slightly Rough	Yes
3	5.8	501	Fair	Yes
4	9.6	501	Slightly Rough	Yes
5 (Sump)	0.05	875	Extremely Smooth	No

- Pumps that are in the good range or better with regular maintenance should provide many years of reliable operation. Pumps that are below the good range are required to be rebuilt with all new rotating elements which include the shaft, enclosure tube, bearings and couplings. Pumps that are being rebuilt will also require impellers to be dynamically rebalanced and new Dresser type couplings installed on the discharge piping.

Note 1: Pump #1 requires a new Dresser type coupling be installed on the discharge pipe in the sump.

Pump Station #7; Tennessee Street: The pumps and discharge piping within the sump require sandblasting and repainting. Painting of pump components will be accomplished using Corps of Engineers Formula C-200 (Coal tar epoxy). The discharge well has a crack located near the ladder in the well, recommend that crack be pressure grouted. Also, the supports and grating for the top of the discharge well are heavily deteriorated and require replacement.

Pump Station #11; Island Creek: Station superstructure is in good condition, except for a clutch problem in the hoist that requires repair. Pump #1 has a water lubricating system.

Pump Station #12: Pumps are started and shutdown manually at 4.25 feet and 3.5 feet, respectively. Stop elevation is currently lower than required by the Corps of Engineers Operation and Maintenance Manual. Superintendent informed us that the pumps are being operated at lower elevations to prevent residential flood damages in the area of ponding.

Pump Identification	Displacement (mils)	Pump Velocity (rpm)	Severity of Operation*	Rebuild Required
1	6.8	880	Slightly Rough	Yes
2	7.4	880	Slightly Rough	Yes

- Pumps that are in the good range or better with regular maintenance should provide many years of reliable operation. Pumps that are below the good range are required to be rebuilt with all new rotating elements, which include the shaft, enclosure tube, bearings and couplings. Pumps that are being rebuilt will also require impellers to be dynamically rebalanced and new Dresser type couplings installed on the discharge piping.

Manholes that were inspected during site visit: Inspections where made of all confined space entries in manholes (see table for manholes gated outlets in this appendix) that have gated outlets and visual inspections made of all headwalls that contain flapgates. The following is a list of locations and new equipment to be installed at each structure:

1. 20-inch flapgate at MH # 8-A, Sta. 123+61-B2.
2. 24-inch flapgate at MH # 7-A, Sta. 119+37-B2.
3. 8-inch gate valve at MH # 6-B2, Sta. 115+26-B.
4. Two – 36-inch by 36-inch sluice gates at MH # 3-B2, Sta. 108+58-B.
5. 54-inch sluice gate at MH # 3-A, Sta. 108+58-B2.
6. 30-inch flapgate at MH # 5-A, Sta. 69+86-B1.
7. 24-inch flapgate at MH # 4-A, Sta. 57+98-B1.
8. New seat for 60-inch flapgate frame only at Sta. 200+35-A.
9. New ladder rungs for MH at Sta. 187+34-A.
10. 24-inch flapgate at Sta. 84+00-A.
11. New structural covering and supports for MH 24-B2 at Sta. 66+17-A.
12. New ladder rungs for MH 15-A at Sta. 149+72-B2, gate does not seal due to concrete poured into channel flow during conversion from sanitary to storm sewer manhole.
13. New ladder rungs for MH 12-P at Sta. 145+61-B.
14. New ladder rungs for MH 1-P at Second and Jefferson Streets.
15. New ladder rungs for North location MH 2-P at Second and Jefferson Streets.
16. 30-inch flapgate at Sta. 244+65-C.
17. Two – 48-inch flap Sta. 92+70-C.
18. Replace the seats and bushings for three – 30-inch at Sta. 32+38-C.
19. Replace the seats and bushings for two – 48-inch at Sta. 32+12-C.
20. Two – 60-inch flapgates at discharge outlet headwall for pump station # 2.
21. Two – 48-inch flapgates at discharge outlet headwall for pump station # 2.
22. 30-inch flapgate at discharge outlet headwall for pump station # 2.
23. 12-inch flapgate at discharge outlet headwall for pump station # 2.

Manholes that require the replacement of walkway and operating grating and supports, due to deterioation:

1. Manhole # 16-B2, Sta. 150+62-B.
2. Manhole # 13-P, Sta. 145+92-B.
3. Manhole # 14-B2, Sta. 145+92-B.
4. Manhole # 12-P, Sta. 145+61-B.
5. Manhole # 11-B2, Sta. 128+61-B.
6. Manhole # 7-B2, Sta. 119+45-B.
7. Manhole # 3-B2, Sta. 108+58-B.
8. Manhole # 14-P, Sta. 90+36-B.
9. Manhole # 1-B2, Sta. 90+36-B.
10. Manhole # 5-B1, Sta. 69+86-B.
11. Manhole # 4-B1, Sta. 57+98-B.

MAINTENANCE ITEMS:

STRUCTURAL (Parsons Harland Bartholomew & Associates, Inc.)

- The construction joint sealant for the length of the wall and for the accompanying structures is cracking and not continuous. The joint sealant should be replaced for the length of the wall.

- Minor cracking and concrete deterioration is scattered throughout the floodwall system. In the pump stations this deterioration is usually due to poor roof drainage and the interaction between steel doorframes and windows. The floodwalls show problems at the floodgates where there is collision damage or around the sill angles of service openings. In no case does this minor deterioration threaten the integrity of the floodwall system; however, preventive measures should be taken to prevent further crack growth. At nearly all of the service openings, the sill angles have peeling paint and rust. These angles should be cleaned and painted to prevent deterioration.

- The riprap placed along the earthen levee is in need of maintenance repair to reshape the slopes and to remove vegetation in several areas. The areas identified for maintenance riprap repair are at Section 170+47 B, Station 21+86 B, Station 38+02 B and at Station 170+47 B.

CIVIL AND GEOTECHNICAL:

- Maintenance: Repair minor rutting in the levee crown, approximate 6 inch depth, approximate Station 98+00-A.

- Maintenance: Repair minor rutting in levee crown at Pump Station #1, Station 159+40-A.

- Maintenance: Replace missing riverside staff gauge at Station 19+11-B.

- Maintenance: Repair post holes in landside levee embankment, just upstream from Main Street.

- Maintenance: Repair minor rutting in the levee crown, approximate 6 inch depth, approximate Station 270+00.

- Maintenance: Repair animal burrows in levee crown and landside upper sideslopes in the area just downstream from Pump Station #12.

- Maintenance: Repair animal burrows in levee embankment located just downstream from Oaks Road.

- Maintenance: Repair rutting in the levee crown, approximate Station 38+00-C, approximate 6 inch depth.

Appendix B
Civil and Geotechnical Evaluation

OHIO RIVER, PADUCAH, KENTUCKY
Flood Damage Reduction
Section 905(b) (WRDA 1996) Analysis

U.S. ARMY CORPS OF ENGINEERS
LOUISVILLE DISTRICT

Civil and Geotechnical Evaluation

Summary

March 29 through March 31, 1999, the following CELRL Engineering Division personnel inspected the levee embankment and corrugated metal pipe (CMP) and reinforced concrete pipe (RCP) drainage structures of the Paducah Flood Protection Project: Jenni Smith of the Geotech and Dam Safety Section, Ron Holmberg of the Hydrology and Hydraulic Design Section, and Mike Witcher of the Cost Engineering Section. Mr. Harold Newton and Mr. Bill Ballard of the Paducah floodwall maintenance department accompanied the inspection team.

The civil and geotechnical portion of the inspection of the Paducah Flood Protection Project consisted of walking the entire 48,700 feet of earthen levee and inspecting the majority of the approximate 34 CMP and RCP drainage structures. The protection system is divided into three sections. Section A curves around the western side of Paducah and is approximately 14,760 feet of earthen levee. Section B runs along the northern edge of the city itself and consists mainly of concrete floodwall (approximately 13,300 feet) and 3750 feet of levee. Section C runs along the eastern side of town and is approximately 31,370 feet of earthen embankment. The general overall condition of the levee embankment is very good. The levee system has been well maintained and has no major problem areas that would be considered a critical threat to the protection system. The majority of the CMP drainage structures throughout the project are those originally placed during the project construction. All in all, they are operable but showing deteriorated conditions.

Evaluation

Levee Embankment:

Section A: The levee was generally in good condition in this area. Minor rutting along the crown of the levee, small depressions, and minor erosion around grouted riprap were noted.

Section B: The levee embankment appeared to be in good shape. A few small depressions and erosion areas as well as an area needing additional drainage were observed.

Section C: The levee embankment was in good shape and generally appeared to be well maintained. Several items such as minor rutting at the crown of the levee, small areas experiencing a loss of vegetative growth, animal burrows, open post holes, and encroaching tree growth were observed during the field inspections.

Drainage Structures: The drainage structures observed during the field inspections were in the same general condition throughout the project sections, the majority of which are those originally placed during project construction. All of the CMP's inspected were rusted even though preventative measures such as bituminous coating and some metal plates at the inlet and outlet areas had been placed along the interior of the pipe in the low-flow zone. Each CMP observed had little to no bituminous coating remaining in the low-flow area of the pipe. Each metal plate placed in this low-flow area was observed to be completely rusted. The RCP's observed appeared to be in good condition. It should be noted that, for this level of evaluation, these drainage structures were inspected without the aid of cameras or other means to observe the structural condition of the pipes at points other than the inlet and outlet locations. A few of the pipes were large enough to walk through and inspect, but this was an exception rather than the norm. A general observation was made during the field inspection that the amount of riprap protection around the inlet and outlet structures was typically lacking throughout the length of the project.

Recommendations

Section A

1. Repair slight depressed area on riverside slope just downstream from Pump Station #2, approximately 60 feet in length, located about 25 feet off the levee crown. See Photo #15, attached.

2. Repair small sink in the landside toe area, just upstream from Pump Station #2. See Photo #16, attached.

3. Repair small depression across the levee crown and side slopes at approximate Station 96+00-A, approximate 4 inch depth. See Photo #24, attached.

4. Repair small sink at the landside toe area, approximate Station 113+00-A (near Highway 45), approximately 3 feet deep. See Photos #31 and #32, attached.

5. Repair low area in the levee crown on the north side of the abandoned railroad closure adjacent to Perkins Creek, approximately 30 feet in length, Station 140+46-A. See Photo #41, attached.

6. Add stone protection to the outlet area at Pump Station #1, Station 159+40-A. See Photos #48 and #49.

7. Repair two washouts in the outlet area of the drainage structure at Station 157+63-A.
   Dimensions: (1) 8' x 20' x 5' D
   (2) 5' x 4' x 2' D

8. Add riprap protection to the inlet and outlet areas for at least the following locations Station 200+35-A and Station 147+25-A.

Section B

9. Repair depression at landside toe of the levee, approximate Station 172+40-B.

10. Repair small depression in the embankment crown and landside slope in the approximate area of Boyd Street and North Sixth Street, approximate 8" depth.

11. Repair small depression at the landside toe area near residence fenceline, approximate area of Boyd Street and North Sixth Street.

12. Repair small eroded area on the riverside embankment face just downstream and adjacent to new stone placement, approximate Station 19+11-B, approximate 30 foot length and 10 foot width. See Photo 63, attached.

13. Repair eroded area at approximate high water elevation along the top of the headwall for the 66 inch CMP, approximate Station 19+11-B, approximate 250 foot length and 50 foot width.

14. Repair low area in levee crown at access ramp at the end of Main Street. See Photo 71, attached.

15. Add riprap protection to the inlet and outlet areas for at least the following location Station 19+11-B.

Section C

16. Repair undercutting and erosion around and beneath the grouted riprap at the drainage structure outlet area, Station 291+75-C.

17. Repair low area in levee crown, approximate Station 219+00-C (approx. 115 feet upstream from railroad tracks), approximate 10 foot length, 5 foot width, and 6 inch depth. See Photo 81, attached.

18. Repair loss of turf along levee crown between Cook Street and Georgia Street. See Photos 84 and 85, attached.

19. Repair low area in levee crown and sideslopes where settlement occurred following the installation of a 36 inch drain line, approximately Station 206+00-C (90 feet from the centerline of Georgia Street) approximate 6 inch depth. See Photos 86 and 87, attached.

20. Repair low area on riverside of levee embankment, approximately Station 203+00-C, approximate 5 foot length and 2 foot width. See Photo 90, attached.

21. Repair loss of turf and four-wheeler damage to levee embankment crown and sideslopes, approximate Station 110+00-C, approximate 6 inch depth.

22. Remove tree growth encroaching to within 15 feet of the landside levee toe, approximately between Stations 105+00-C and 150+00-C, approximate 10 foot width needs to be removed along this length. See Photo 119, attached.

23. Repair loss of turf along levee crown approximately between Stations 105+00-C and 150+00-C.

24. Add stone protection to the outlet area of the drainage structure located at approximately Station 112+00-C. See Photo 122, attached.

25. Repair handrails on railroad closure at Station 104+96-C. Handrails are rusted and loose. See Photos 124 and 125, attached.

26. Repair low area in levee crown, approximately Station 103+80, approximate 8 foot length, 4 foot width and 6 inch depth. See Photo 123, attached.

27. Repair loss of turf along levee crown from approximate Station 93+00-C to where I-24 crosses the protection.

28. Repair small eroded area on the landside levee slope just upstream from the I-24 embankment, approximate 20 foot length and 4 foot width. See Photo 129, attached.

29. Seed and straw in an effort to maintain turf cover on the levee crown and sideslopes upstream from the I-24 embankment.

30. Add stone protection to the outlet area of the drainage structure located at Station 51+28-C. See Photo 133, attached.

31. Repair two potholes in the levee crown located approximately 150 feet upstream from Lydon Road (approximate Station 40+00-C). See Photo 134, attached.

32. Add riprap protection to the inlet and outlet areas for at least the following locations Station 291+75-C, Station 254+06-C, Station 244+65-C, Station 224+50-C, Station 217+35-C, Station 200+55-C, Station 199+80-C, Station 157+63-C, Station 150+05-C, Station 111+67-C, Station 92+70-C, approximate Station 112+00, Station 51+28-C, Station 32+38-C and Station 32+12-C.

33. Repair small depression at the landside levee toe in the area of the Husbands Road crossing (approximate Station 0+25-C).

34. Refurbish all CMP's larger than 24" by slip lining. Refurbish all CMP's 24" diameter or less by the cured in-place method. See tables below for summary.

Pipes to be Slip-Lined

STATION	QUANTITY	DIAMETER	LENGTH (EA.)
157+63-A	3	60"	159'
130+00-A	1	30"	134'
111+67-A	1	72"	197'
19+11-B	1	66"	157'
291+75-C	1	36"	175'
254+06-C	1	36"	168'
244+65-C	1	30"	135'
176+90-C	1	48"	112'
149+00-C	1	84"	124'
92+70-C	2	48"	100'
51+28-C	1	30"	136'
32+38-C	3	60"	113'
32+12-C	2	48"	184'

Pipes to be Cured-In-Place

STATION	QUANTITY	DIAMETER	LENGTH (EA.)
187+34-A	1	15"	78'
151+25-A	1	24"	86'
147+25-A	1	24"	77'
84+00-A	1	24"	194'
175+40-B	1	24"	175'
80+00-B	1	18"	44'
7+54-B	1	18"	55'
3+91-B	1	8"	36'
3+68-B	1	8"	78'
224+17-C	1	24"	44'
223+57-C	1	24"	43'
217+35-C	2	24"	47'
200+55-C	1	24"	49'
199+80-C	1	24"	54'
176+47-C	1	24"	53'
172+08-C	1	24"	107'
169+59-C	1	24"	30'
150+05-C	1	24"	57'

Pipe info by: Mark Burt
Checked by: Jenni Smith

Maintenance

The following items were noted during the subject field inspection as items considered to be maintenance issues and therefore are **not** included as part of the recommended repairs listed or as part of the cost estimate for this report.

1. Maintenance: Repair minor rutting in the levee crown, approximate 6 inch depth, approximate Station 98+00-A. See Photo #25, attached.

2. Maintenance: Repair minor rutting in levee crown at Pump Station #1, Station 159+40-A.

3. Maintenance: Replace missing riverside staff gauge at Station 19+11-B.

4. Maintenance: Repair post holes in landside levee embankment, just upstream from Main Street.

5. Maintenance: Repair minor rutting in the levee crown, approximate 6 inch depth, approximate Station 270+00.

6. Maintenance: Repair animal burrows in levee crown and landside upper sideslopes in the area just downstream from Pump Station #12.

7. Maintenance: Repair animal burrows in levee embankment located just downstream from Oaks Road.

8. Maintenance: Repair rutting in the levee crown, approximate Station 38+00-C, approximate 6 inch depth. See Photo 135, attached.

Conclusion

The overall condition of the levee embankment of the Paducah, Kentucky flood protection system is very good. The repair items noted for the levee embankment are generally minor in nature and do not pose a serious threat to the design level of protection. However, the slip-lining and cured in-place repairs recommended for all CMP's in the project is critical to continuing the design level of protection for the Paducah flood protection system. In the event of a collapse failure of a drain line, the levee embankment at the failure location is in jeopardy of losing material in the defective zone. This is especially significant because a failure of this type during a flood event could result in a breach of the protection. Minor tree clearing should be considered typical at each drainage structure location in order to have adequate room for the needed repairs.

HYDRAULIC ANALYSIS
LEVEE AND DRAINAGE STRUCTURES
PADUCAH, KENTUCKY

Introduction:

Paducah is located on the Ohio River between river miles 938 and 932 just below the confluence of the Ohio and Tennessee Rivers. The drainage area at Paducah is approximately 202,800 square miles of which the Tennessee River contributes 40,330 square miles. The levee was built to an elevation comparable to the 1937 Flood with freeboard and therefore the levee of protection is not a concern in the analysis. The analysis of the levee focused on the condition of the levee and the numerous gravity outlets that go through the levee.

Levee Condition (Earth Embankment Only):

The entire levee was inspected and while there were minor problems identified, which are discussed in the Geotechnical analysis, no problems were encountered that would impact the hydraulic performance of the project.

Gravity Outlet Pipes:

There were 38 gravity outlet pipes ranging from 8-inches to 84-inches in diameter that were evaluated. The pipes were corrugated metal and it appeared that a bituminous coating had been applied to a majority of the pipes. This coating would have served two basic functions when it was in place: it would have provided a lower roughness coefficient for the pipe, and it would have protected the metal pipe from the water and any corrosive elements that were contained in the water.
However, in inspecting the pipes it was evident that only a fraction of the coating is still inplace on the pipes and even that was highly fractured and provide little if any protection to the pipes.

Each of the inlet and outlet ends of the pipes were inspected as closely as possible. However, there were a few pipes that were partially submerged and could not be accessed for a close inspection. From this inspection it was evident that there is deterioration of the existing pipes at the inlet and outlet ends for a high percentage of the pipes. While it was not possible to visually inspect the entire length of each pipe, it is reasonable to expect that any deterioration evident at either the inlet or outlet would exist throughout the pipe.

Continued deterioration of the pipes would likely lead to its collapse. If a pipe did collapse the immediate result would be a reduction in the level of protection that is being provided. This reduction could range from a lowering of the levee's level of protection proportional to the size of the pipe that collapsed to a complete loss of protection. In addition, if the levee were to remain intact and the voids created by the pipe failure were filled with the levee embankment material, there is the potential for interior flooding to occur due to the inability of the rainfall runoff to flow out of the interior area.

Hydraulic Recommendation:

Given the age of these pipes, and the evidence of some degree of deterioration in the majority of the pipes it is our recommendation that the pipes be replaced or slip lined by either the traditional method or the cured-inplace method. Given that replacement of the majority of the pipes would be extremely expensive given the size of the levee, it is reasonable to expect that either traditional or cured-inplace methods will be used. If the traditional slip lining method is used, it is estimated that the inside diameter of the pipe will decrease approximately 6-inches, while the cured-inplace method will only result in a nominal decrease in the inside diameter.

If the cured-inplace method were used, the flow capacity of the pipes would increase. With the nominal change in the diameter of the pipe and the reduction in the roughness coefficient, the flow capacity of the pipes would increase. When using the traditional slip lining method, the 6-inch loss in the inside diameter can result in a significant decrease in the flow capacity of those pipes with a diameter of 24-inches or less. While the reduction in the roughness coefficient does tend to offset the loss of flow area, it does not have enough impact for these smaller pipes. However, for those 30-inch pipes the loss in capacity is less than 10% and traditional slip lining would be acceptable. For those pipes with a diameter of 36-inches or more,

the flow capacity would increase due to the change in the roughness coefficient. The following table contains the recommended method of slip lining the pipe.

TABLE #1
RECOMMENDED REPAIR METHOD

EXISTING PIPE DIAMETER	REPAIR METHOD
8-inch	Cured inplace or Replacement
15-inch	Cured-inplace or Replacement
18-inch	Cured-inplace or Replacement
24-inch	Cured-inplace or Replacement
30-inch	Traditional Slip Lining
36-inch	Traditional Slip Lining
48-inch	Traditional Slip Lining
60-inch	Traditional Slip Lining
66-inch	Traditional Slip Lining
72-inch	Traditional Slip Lining
84-inch	Traditional Slip Lining

CALCULATIONS FOR SLIP LINING PIPES

PIPE SIZE (INCHES)	AREA (Square Feet)	WETTED PERIMETER (ft.)	HYDRAULIC RADIUS (ft.)	AREA * HYD. RAD^2/3
15	1.23	3.93	0.31	0.57
18	1.77	4.71	0.38	0.92
24	3.14	6.28	0.50	1.98
30	4.91	7.85	0.63	3.59
36	7.07	9.42	0.75	5.83
42	9.62	11.00	0.88	8.80
48	12.57	12.57	1.00	12.57
54	15.90	14.14	1.13	17.20
60	19.64	15.71	1.25	22.78
66	23.76	17.28	1.38	29.38
72	28.27	18.85	1.50	37.05
12	0.79	3.14	0.25	0.31
84	38.48	21.99	1.75	55.89

BASED ON JUST FULL CAPACITY

Pipe size Reduction	From	To	Percent Change in Capacity
	18-inch	12-inch	
	54.83	30.79	-0.44
	24-inch	18-inch	
	117.95	91.28	-0.23
	30-inch	24-inch	
	213.96	196.68	-0.09
	36-inch	30-inch	
	347.47	356.61	0.03
	48-inch	42-inch	
	749.17	874.13	0.17

Old pipe is assumed to have a mannings n-value of 0.025

Slip lined pipe is assumed to have a mannings n-value of 0.015

CALCULATIONS BY: R. Holmberg CALCULATIONS CHECKED BY: George McCollum

Civil and Geotechnical Evaluation

Summary

March 29 through March 31, 1999, the following CELRL Engineering Division personnel inspected the levee embankment and corrugated metal pipe (CMP) and reinforced concrete pipe (RCP) drainage structures of the Paducah Flood Protection Project: Jenni Smith of the Geotech and Dam Safety Section, Ron Holmberg of the Hydrology and Hydraulic Design Section, and Mike Witcher of the Cost Engineering Section. Mr. Harold Newton and Mr. Bill Ballard of the Paducah floodwall maintenance department accompanied the inspection team.

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Evaluation

Levee Embankment:

Section A: The levee was generally in good condition in this area. Minor rutting along the crown of the levee, small depressions, and minor erosion around grouted riprap were noted.

Section B: The levee embankment appeared to be in good shape. A few small depressions and erosion areas as well as an area needing additional drainage were observed.

Section C: The levee embankment was in good shape and generally appeared to be well maintained. Several items such as minor rutting at the crown of the levee, small areas experiencing a loss of vegetative growth, animal burrows, open post holes, and encroaching tree growth were observed during the field inspections.

Drainage Structures: The drainage structures observed during the field inspections were in the same general condition throughout the project sections, the majority of which are those originally placed during project construction. All of the CMP's inspected were rusted even though preventative measures such as bituminous coating and some metal plates at the inlet and outlet areas had been placed along the interior of the pipe in the low-flow zone. Each CMP observed had little to no bituminous coating remaining in the low-flow area of the pipe. Each metal plate placed in this low-flow area was observed to be completely rusted. The RCP's observed appeared to be in good condition. It should be noted that, for this level of evaluation, these drainage structures were inspected without the aid of cameras or other means to observe the structural condition of the pipes at points other than the inlet and outlet locations. A few of the pipes were large enough to walk through and inspect, but this was an exception rather than the norm. A general observation was made during the field inspection that the amount of riprap protection around the inlet and outlet structures was typically lacking throughout the length of the project.

Recommendations

Section A

1. Repair slight depressed area on riverside slope just downstream from Pump Station #2, approximately 60 feet in length, located about 25 feet off the levee crown. See Photo #15, attached.

2. Repair small sink in the landside toe area, just upstream from Pump Station #2. See Photo #16, attached.

3. Repair small depression across the levee crown and side slopes at approximate Station 96+00-A, approximate 4 inch depth. See Photo #24, attached.

4. Repair small sink at the landside toe area, approximate Station 113+00-A (near Highway 45), approximately 3 feet deep. See Photos #31 and #32, attached.

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6. Add stone protection to the outlet area at Pump Station #1, Station 159+40-A. See Photos #48 and #49.

7. Repair minor rutting in levee crown at Pump Station #1, Station 159+40-A.

8. Repair two washouts in the outlet area of the drainage structure at Station 157+63-A.
   Dimensions: (1) 8' x 20' x 5' D
   (2) 5' x 4' x 2' D

9. Add riprap protection to the inlet and outlet areas for at least the following locations Station 200+35-A and Station 147+25-A.

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10. Repair depression at landside toe of the levee, approximate Station 172+40-B.

11. Repair small depression in the embankment crown and landside slope in the approximate area of Boyd Street and North Sixth Street, approximate 8" depth.

12. Repair small depression at the landside toe area near residence fenceline, approximate area of Boyd Street and North Sixth Street.

13. Repair small eroded area on the riverside embankment face just downstream and adjacent to new stone placement, approximate Station 19+11-B, approximate 30 foot length and 10 foot width. See Photo 63, attached.

14. Repair eroded area at approximate high water elevation along the top of the headwall for the 66 inch CMP, approximate Station 19+11-B, approximate 250 foot length and 50 foot width.

15. Repair low area in levee crown at access ramp at the end of Main Street. See Photo 71, attached.

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Section C

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20. Repair low area in levee crown and sideslopes where settlement occurred following the installation of a 36 inch drain line, approximately Station 206+00-C (90 feet from the centerline of Georgia Street) approximate 6 inch depth. See Photos 86 and 87, attached.

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34. Repair small depression at the landside levee toe in the area of the Husbands Road crossing (approximate Station 0+25-C).

35. Replace all CMP's 24" diameter or less by the cured in-place method. Replace all CMP's larger than 24" by slip lining.

Maintenance

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Hydraulic Recommendation:

Given the age of these pipes and the evidence of some degree of deterioration in the majority of the pipes it is our recommendation that the pipes be replaced or slip lined by either the traditional method or the cured-inplace method. Given that replacement of the majority of the pipes would be extremely expensive given the size of the levee, it is reasonable to expect that either traditional or cured-inplace methods will be used. If the traditional slip lining method is used, it is estimated that the inside diameter of the pipe will decrease approximately 6-inches, while the cured-inplace method will only result in a nominal decrease in the inside diameter.

If the cured-inplace method were used, the impact on flow capacity would actual be positive. With the nominal change in the diameter of the pipe and the reduction in the roughness coefficient, the flow capacity of the pipes would increase. When using the traditional slip lining method, the 6-inch loss in the inside diameter can result in a significant decrease in the flow capacity of those pipes with a diameter of 24-inches or less. While the reduction in the roughness coefficient does tend to offset the loss of flow area, it does not have enough impact for these smaller pipes. However, for those 30-inch pipes the loss in capacity is less than 10% and traditional slip lining would be acceptable. For those pipes with a diameter of 36-inches

or more, the flow capacity would increase due to the change in the roughness coefficient. The following table contains the recommended method of slip lining the pipe.

TABLE #1
RECOMMENDED REPAIR METHOD

EXISTING PIPE DIAMETER	REPAIR METHOD
8-inch	Cured inplace or Replacement
15-inch	Cured-inplace or Replacement
18-inch	Cured-inplace or Replacement
24-inch	Cured-inplace or Replacement
30-inch	Traditional Slip Lining
36-inch	Traditional Slip Lining
48-inch	Traditional Slip Lining
60-inch	Traditional Slip Lining
66-inch	Traditional Slip Lining
72-inch	Traditional Slip Lining
84-inch	Traditional Slip Lining

MB/jc

Paducah, KY : CMP lengths to be slip-Lined

	Diameter	Length
Section A		
sta. 187 + 34-A	15"	78'
157 + 63-A	3@ 60"	159' ea.
151 + 25-A	24"	86'
147 + 25-A	24"	77'
130 + 00-A	30"	134'
111 + 67-A	72"	197'
84 + 00-A	24"	194'
Section B		
sta. 175 + 40-B	24"	175'
80 + 00-B	18"	44'
19 + 11-B	66"	157'
7 + 54-B	18"	55'
3 + 91-B	8"	36'
3 + 68-B	8"	78'
Section C		
Sta. 291 + 75-C	36"	175'
254 + 06-C	36"	168'
244 + 65-C	30"	135'
217 + 35-C	2 @ 24"	47' ea.
200 + 55-C	24"	49'
199 + 80-C	24"	54'
176 + 90-C	48"	112'
172 + 08-C	24"	107'
169 + 59-C	24"	30'
150 + 05-C	24"	57'
92 + 70-C	2 @ 48"	100' ea.
51 + 28-C	30"	136'
32 + 38-C	3 @ 60"	113' ea.
32 + 12-C	2 @ 48"	184'
149 + 00-C	84"	124'
176 + 47-C	24"	53'
223 + 57-C	24"	43'
224 + 17-C	24"	44'

Indicates those pipes to be cured in-place c

PIPE SIZE (INCHES)	AREA (Square Feet)	WETTED PERIMETER (ft.)	HYDRAULIC RADIUS (ft.)	AREA * HYD. RAD^2/3
15	1.23	3.93	0.31	0.57
18	1.77	4.71	0.38	0.92
24	3.14	6.28	0.50	1.98
30	4.91	7.85	0.63	3.59
36	7.07	9.42	0.75	5.83
42	9.62	11.00	0.88	8.80
48	12.57	12.57	1.00	12.57
54	15.90	14.14	1.13	17.20
60	19.64	15.71	1.25	22.78
66	23.76	17.28	1.38	29.38
72	28.27	18.85	1.50	37.05
12	0.79	3.14	0.25	0.31
84	38.48	21.99	1.75	55.89

BASED ON JUST FULL CAPACITY

Pipe size Reduction	From	To	Percent Change in Capacity
	18-inch	12-inch	
	54.83	30.79	-0.44
	24-inch	18-inch	
	117.95	91.28	-0.23
	30-inch	24-inch	
	213.96	196.68	-0.09
	36-inch	30-inch	
	347.47	356.61	0.03
	48-inch	42-inch	
	749.17	874.13	0.17

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 200+35-A

Description Location: on diversion ditch

Diameter: 60" Wall thickness: RCP

Approximate Installation Date: original

1. Condition Assessment:

   a. Access/right-of-Way: accessible at outlet

   b. Material & Condition: RCP, appears fine – difficult to tell without walking

   c. Alignment: OK

   d. Settlement: none visible

   e. Separation: none visible

   f. Outlet Drainage/Riprap: needs stone

   g. Flap: appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 159+40-A

Description Location: 3 – 60" pipes at pump station #1

Diameter: 60" Wall thickness: CMP's

Approximate Installation Date: original

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1. Condition Assessment:

   a. Access/right-of-Way: fully accessible

   b. Material & Condition: CMP, rusted, plate gone from low flow area & bituminous coating gone, pipe rusted completely through at inlet invert

   c. Alignment: straight

   d. Settlement: none visible although possible local "bulges" seen in alignment

   e. Separation: slight separation from concrete

   f. Outlet Drainage/Riprap: grouted riprap past concrete apron

   g. Flap: appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith/ R. Holmberg Date: 3-30-99

City: Paducah, KY Station: 147+25-A

Description Location: station 147 + 25-A

Diameter: 24" Wall thickness: CMP

Approximate Installation Date: original

1. Condition Assessment:

   a. Access/right-of-Way: fully accessible, minor tree clearing needed for slip lining

   b. Material & Condition: CMP, rusted in areas, metal plate at low flow area rusted through, bituminous coating gone

   c. Alignment: OK

   d. Settlement: none visible

   e. Separation: none visible

   f. Outlet Drainage/Riprap: stone 1 course thickness

   g. Flap: appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-29-99

City: Paducah, KY Station: 130+00-A

Diameter: 30" Wall thickness: CMP

Approximate Installation Date: original

1. Condition Assessment:

a. Access/right-of-Way: minor tree clearing on riverside to slip-line

b. Material & Condition: CMP, metal plate in low-flow area rusted

c. Alignment: straight

d. Settlement: none visible

e. Separation: none visible

f. Outlet Drainage/Riprap:

g. Flap: appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-29-99

City: Paducah, KY Station: 111+67-A

Diameter: 72" Wall thickness: CMP

Approximate Installation Date: original

1. Condition Assessment:

a. Access/right-of-Way: minor tree clearing on each end for slip-line

b. Material & Condition: CMP, bituminous coating gone from low-flow area, rusty in places

c. Alignment: straight

d. Settlement: none visible

e. Separation: none visible

f. Outlet Drainage/Riprap:

g. Flap: appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 19+11-B

Description Location: through small levee leg

Diameter: 66" Wall thickness: CMP

Approximate Installation Date: original

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1. Condition Assessment:

   a. Access/right-of-Way: accessible

   b. Material & Condition: CMP, appears suitable, no bituminous liner or low-flow plate

   c. Alignment: OK

   d. Settlement: none visible

   e. Separation: none visible

   f. Outlet Drainage/Riprap: could use additional riprap at outlet

   g. Flap: appears in good condition – first gate to be closed, lowest invert

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 176-90-C

Diameter: 48" Wall thickness: CMP

Approximate Installation Date: Original

1. Condition Assessment:

a. Access/right-of-Way: residence on landside, tree clearing needed on riverside levee for slip lining

b. Material & Condition: CMP, partial bituminous coating left at low-flow area, rusty in places, no coating on sides

c. Alignment: straight

d. Settlement: none visible

e. Separation: none visible

f. Outlet Drainage/Riprap: hand-placed stone in good shape

g. Flap: appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 200+55-C

Diameter: 24" Wall thickness: CMP

Approximate Installation Date: Original

1. Condition Assessment:

a. Access/right-of-Way: adjacent to road embankment minor tree clearing to slip-side on riverside, utility pole on land side levee, residence too.

b. Material & Condition: CMP, rusted entirely through at outlet area, bottom of pipe missing at inlet ≈ 3' length (rust)

c. Alignment: straight

d. Settlement: none visible

e. Separation: none visible

f. Outlet Drainage/Riprap: additional stone needed to prevent erosion of embankment

g. Flap: appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 199+80-C

Diameter: 24" Wall thickness: CMP

Approximate Installation Date: Original

1. Condition Assessment:

a. Access/right-of-Way: adjacent to road embankment (Benton), telephone pole on land side levee & business, although open area

b. Material & Condition: CMP, bituminous coating gone from low flow area, spot rusting

c. Alignment: straight

d. Settlement: none visible

e. Separation: none, newer grout around newer gate

f. Outlet Drainage/Riprap: some stone needed- all original stone washed out

g. Flap: newer flapgate

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 217+35-C

Diameter: (2) - 24" Wall thickness: CMP

Approximate Installation Date: Original

1. Condition Assessment:

a. Access/right-of-Way: adjacent to railroad embankment minor tree clearing to slip-line, mobile home residence is adjacent.

b. Material & Condition: CMP, partial bituminous coating out of low flow area of pipe, but not below

c. Alignment: straight

d. Settlement: none visible

e. Separation: slight at inlet headwall in invert area

f. Outlet Drainage/Riprap: none – wingwalls okay

g. Flap: appear operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 224+50-C

Diameter: 36" Wall thickness: RCP

Approximate Installation Date: Original

1. Condition Assessment:

   a. Access/right-of-Way: roadway embankment, telephone poles adjacent

   b. Material & Condition: RCP, appears good condition

   c. Alignment: not straight

   d. Settlement: none visible

   e. Separation: none visible

   f. Outlet Drainage/Riprap: could use stone protection just past concrete side by headwall

   g. Flap: appear operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 291+75-C

Diameter: 36" Wall thickness: CMP

Approximate Installation Date: Original

1. Condition Assessment:

a. Access/right-of-Way: clear

b. Material & Condition: CMP, rusted through in areas at outlet

c. Alignment: straight

d. Settlement: none visible

e. Separation: none visible

f. Outlet Drainage/Riprap: could use some additional riprap at outlet

g. Flap: appears operable

* could use some stone around outlet of urban development pump station #13 discharge – erosion & undermining of grouted store.

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 244+65-C

Diameter: 30" Wall thickness: CMP

Approximate Installation Date: Original

1. Condition Assessment:

a. Access/right-of-Way: minor tree clearing may be needed to slip-lining

b. Material & Condition: CMP, bituminous coating gone, pipe appears rusty

c. Alignment: straight

d. Settlement: none visible

e. Separation: none visible

f. Outlet Drainage/Riprap: slight erosion around each end of headwall, hand-placed stone in fairly good condition.

g. Flap: appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 254+06-C

Diameter: 36" Wall thickness: CMP

Approximate Installation Date: Original

1. Condition Assessment:

a. Access/right-of-Way: minor tree clearing may be necessary to slip-line pipe

b. Material & Condition: CMP, bituminous coating gone, appears rusty

c. Alignment: straight

d. Settlement: none visible

e. Separation: none visible

f. Outlet Drainage/Riprap: could use some stone at outlet location

g. Flap: newer, lighter gate, appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 111+67-C

Diameter: 72" Wall thickness: CMP

Approximate Installation Date: Original

1. Condition Assessment:

a. Access/right-of-Way: clear on river side, minor tree clearing needed on land side ditch area

b. Material & Condition: CMP, no bituminous coating remains, appears rusty

c. Alignment: straight

d. Settlement: none visible

e. Separation: none visible

f. Outlet Drainage/Riprap: needs additional stone protection

g. Flap: appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 32+12-C

Diameter: (2) - 48" Wall thickness: CMP

Approximate Installation Date: Original

1. Condition Assessment:

a. Access/right-of-Way: (same as 3- 60")

b. Material & Condition: CMP, difficult to tell, over ½ full of water, rusty areas, small amount of bituminous coating remains at top of pipe.

c. Alignment: straight

d. Settlement: none visible

e. Separation: none visible

f. Outlet Drainage/Riprap: (same as 3- 60")

g. Sluice gate: appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 32+38-C

Diameter: (3) - 60" Wall thickness: CMP

Approximate Installation Date: Original

1. Condition Assessment:

a. Access/right-of-Way: minor tree clearing either side to slip line, road embankment on land side (Husbands Rd.)

b. Material & Condition: CMP, ≈ 2' standing water, rusty in areas showing, partial bituminous coating remains in upper pipe

c. Alignment: straight

d. Settlement: none visible

e. Separation: possible slight separation from gate structure

f. Outlet Drainage/Riprap: none visible (above water), stone needed on slopes & bottom outlet area

g. Sluice gate: appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-31-99

City: Paducah, KY Station: 51+28-C

Diameter: 30" Wall thickness: CMP

Approximate Installation Date: Original

1. Condition Assessment:

a. Access/right-of-Way: clear either end

b. Material & Condition: CMP, rusted through in spots, partial bituminous coating remains in low flow area

c. Alignment: straight

d. Settlement: none visible

e. Separation: possible slight separation from gate structure

f. Outlet Drainage/Riprap: hand-placed stone in good shape (at base)- need additional stone for failing outlet slopes

g. Flap: appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 92+70-C

Diameter: (2) - 48" Wall thickness: CMP

Approximate Installation Date: Original

1. Condition Assessment:

a. Access/right-of-Way: accessible, minor tree clearing on land side & river side for slip lining, open field both sides

b. Material & Condition: CMP, partially under water, loss of bituminous coating in low flow area

c. Alignment: straight

d. Settlement: none visible

e. Separation: none visible

f. Outlet Drainage/Riprap: stone needed at outlet slopes

g. Flap: appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: ≈112+00 - C (2100' DS from RR x-ing)

Diameter: 48" Wall thickness: CMP

Approximate Installation Date: newer pipe placement

1. Condition Assessment:

a. Access/right-of-Way: accessible, minor tree clearing on each end to slip-line

b. Material & Condition: CMP, pipe appears to be in good shape although no bituminous coating

c. Alignment: straight

d. Settlement: none visible

e. Separation: none visible

f. Outlet Drainage/Riprap: slopes need to be laid back & stone placed, undercut below sill by ≈ 2' H, 1' V, repair needed

g. Flap: appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 150+05-C

Diameter: 24" Wall thickness: CMP

Approximate Installation Date: original

1. Condition Assessment:

*a. Access/right-of-Way: minor tree clearing on each end to slip-line, adjacent to Oaks Rd embankment

b. Material & Condition: CMP, partial bituminous coating remains, rusty in areas

c. Alignment: straight

d. Settlement: none visible

e. Separation: none visible

f. Outlet Drainage/Riprap: minor stone placement needed, some large stone is in channel just downstream

g. Flap: appears operable

* would have to slip line from river side to road alignment (curve at land side & utility pole)

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 176+47-C

Diameter: 24" Wall thickness: CMP

Approximate Installation Date: original

1. Condition Assessment:

   a. Access/right-of-Way: little to no tree clearing needed on river side, none on land side, residence w/ junk car yard behind it, room on land side

   b. Material & Condition: CMP, appears to be in fairly good condition w/ some bituminous coating remaining

   c. Alignment: straight

   d. Settlement: none visible

   e. Separation: none visible

   f. Outlet Drainage/Riprap: new stone placed

   g. Flap: appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-30-99

City: Paducah, KY Station: 172+08-C

Diameter: 24" Wall thickness: CMP

Approximate Installation Date: original

1. Condition Assessment:

   a. Access/right-of-Way: minor tree clearing on riverside to slip-line, same on land side – field area although might be part of residence

   b. Material & Condition: CMP, bituminous coating gone, rusty in areas

   c. Alignment: straight

   d. Settlement: none visible

   e. Separation: none visible

   f. Outlet Drainage/Riprap: stone in place

   g. Flap: appears operable

CMP PIPE – CIVIL EVALUATION

Evaluator: J. Smith, R. Holmberg, & M. Witcher Date: 3-29-99

City: Paducah, KY Station: 157+63-C

Diameter: 60"-(6) Wall thickness: CMP

Approximate Installation Date: original

1. Condition Assessment:

   a. Access/right-of-Way: minor tree clearing needed at riverside & land side to slip-line

   b. Material & Condition: CMP, no bituminous liners on low flow are, rusty in areas, possibly clear through at outlet

   c. Alignment: straight

   d. Settlement: none visible

   e. Separation: none visible

   f. Outlet Drainage/Riprap: could use more protection stone

   g. Flap: appears operable

Paducah, Kentucky
Section 905 (b)

Photo #1
Small Sink Hole

Paducah, Kentucky
Section 905 (b)

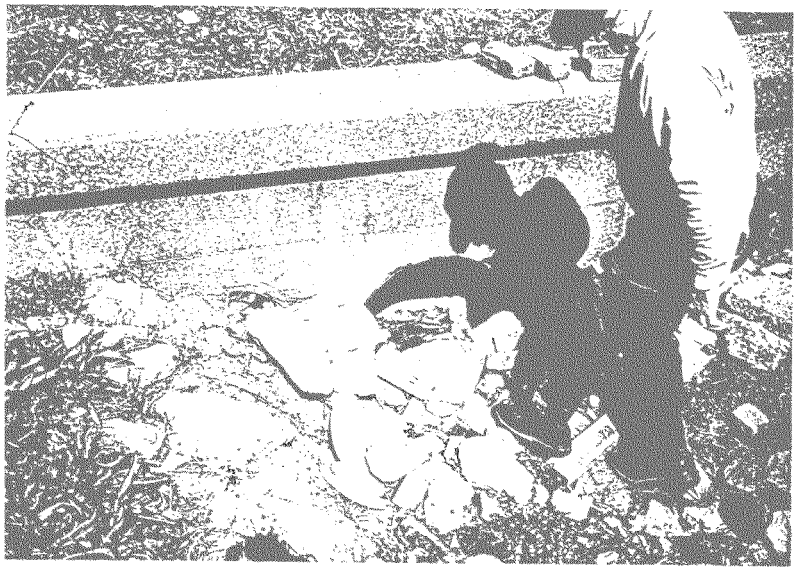

Photo #3
24" CMP Pipe STA. 175 + 40, Section B

Photo #4
24" CMP Pipe STA. 175 + 40, Section B

Paducah, Kentucky
Section 905 (b)

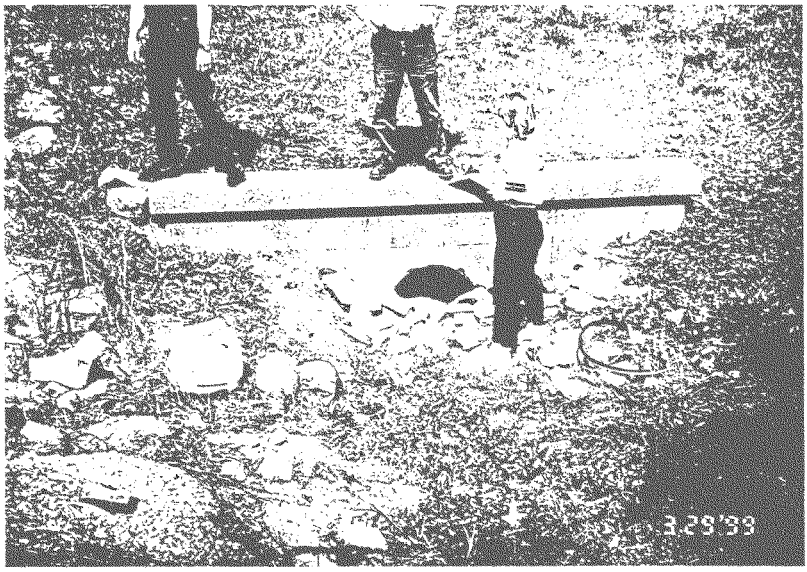

Photo #5
24" CMP Pipe STA. 175 + 40, Section B

Photo #6
Gatewell and Manholes to river, STA 175 + 40, Section B

Paducah, Kentucky
Section 905 (b)

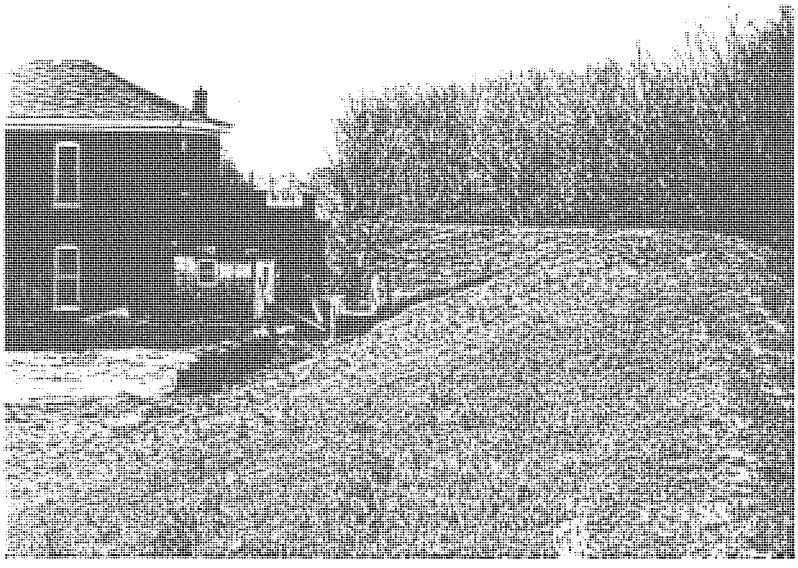

Photo #7

House at the land side toe of slope- adjacent to levee, section B.

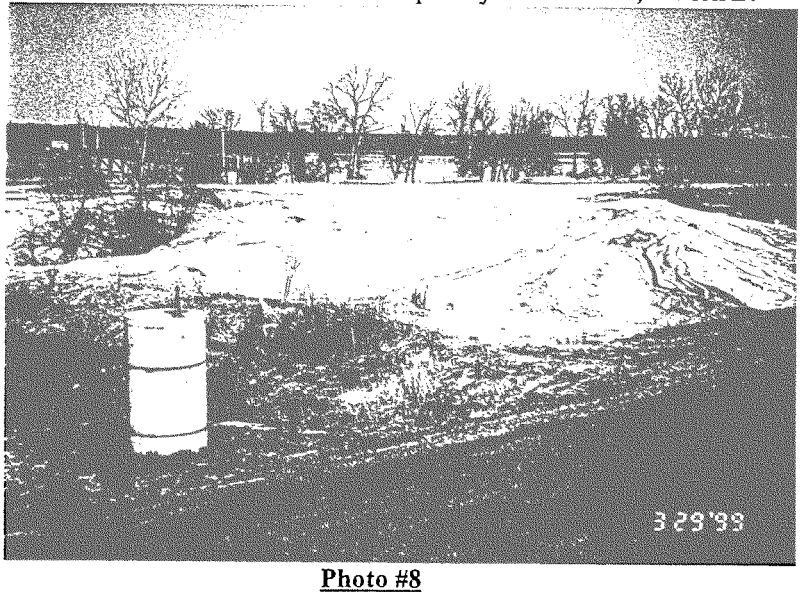

Photo #8

Riverside levee side slope at Federal Materials concrete, section B. Notice ponding water at the toe area.

Paducah, Kentucky
Section 905 (b)

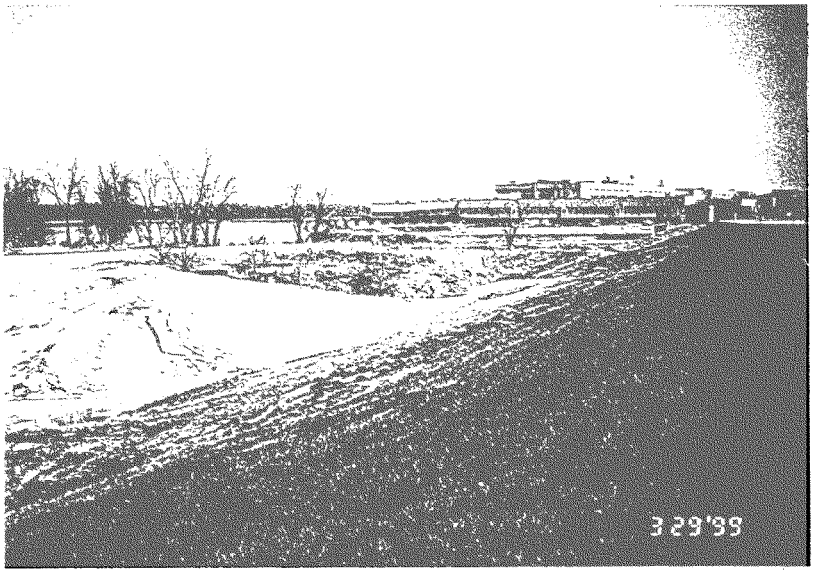

Photo #9

Riverside side slope, also showing part of the crown at Federal Materials concrete, section B.

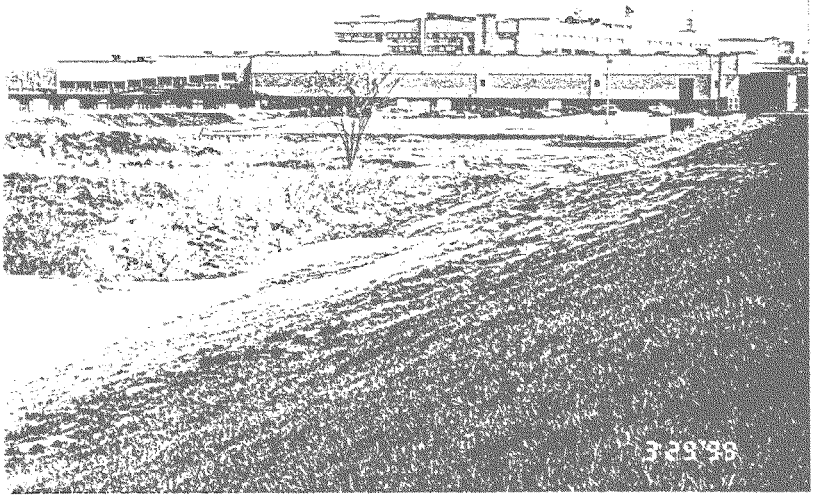

Photo #10

Riverside levee toe at Federal Materials concrete, section B. Notice ponding water at the toe area.

Paducah, Kentucky
Section 905 (b)

Photo #11
Small depression in levee crown, approximate 6" depth, section B.

Photo #12
Small depression in levee crown approximate 6" depth, section B.

Paducah, Kentucky
Section 905 (b)

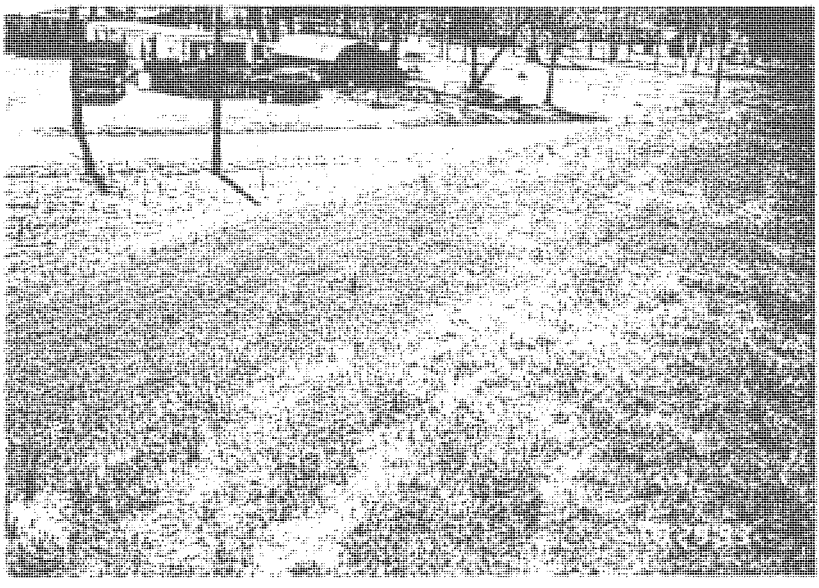

Photo #13
Part of crown and landside of levee side slope, section B.

Photo #14
Riverside levee slope just upstream from pump station #2, section A.

Paducah, Kentucky
Section 905 (b)

Photo #15

Slight depressed area on riverside of levee, 2' deep x 60' x 20'

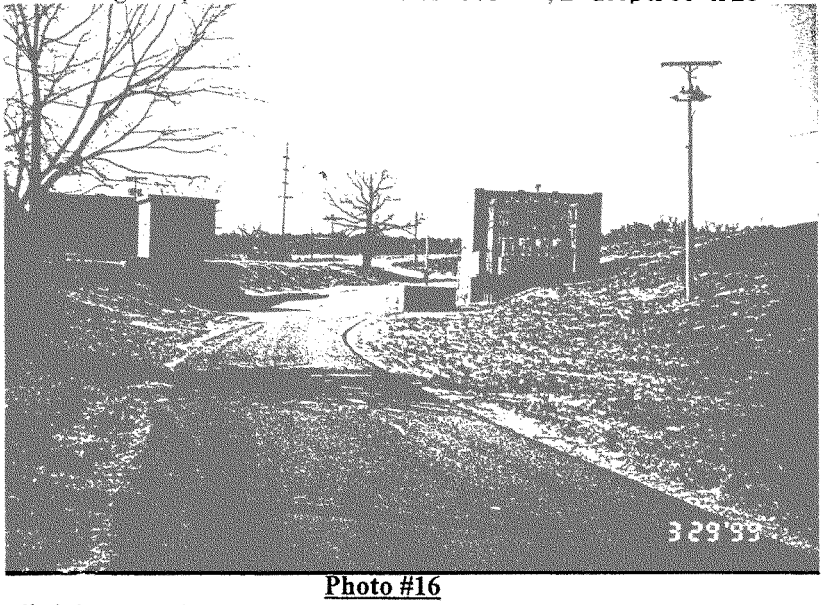

Photo #16

Small sink at landside toe of levee, 475' from Pump Station #2 across from fire training area

Paducah, Kentucky
Section 905 (b)

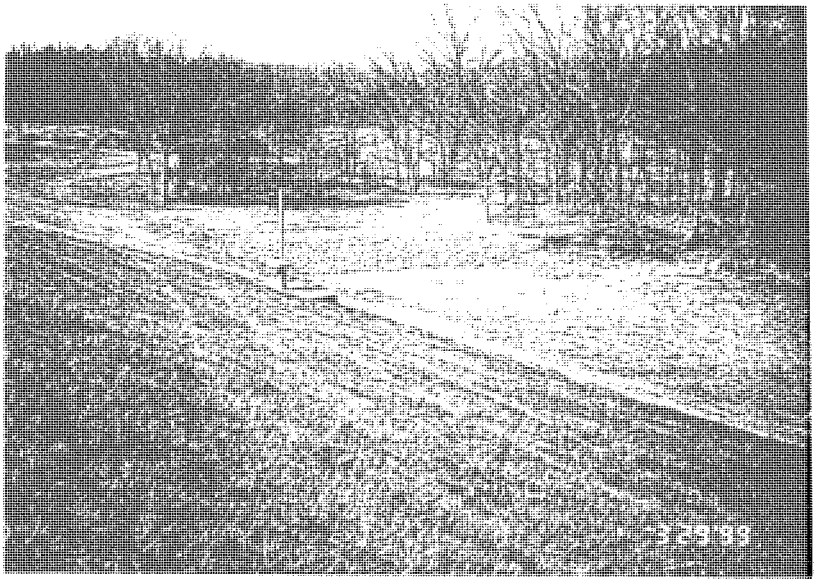

Photo #17
Outlet area at Pump Station #2, station 66 + 90, section A.

Photo #18
Outlet area at Pump Station #2, station 66 +90, section A.

Paducah, Kentucky
Section 905 (b)

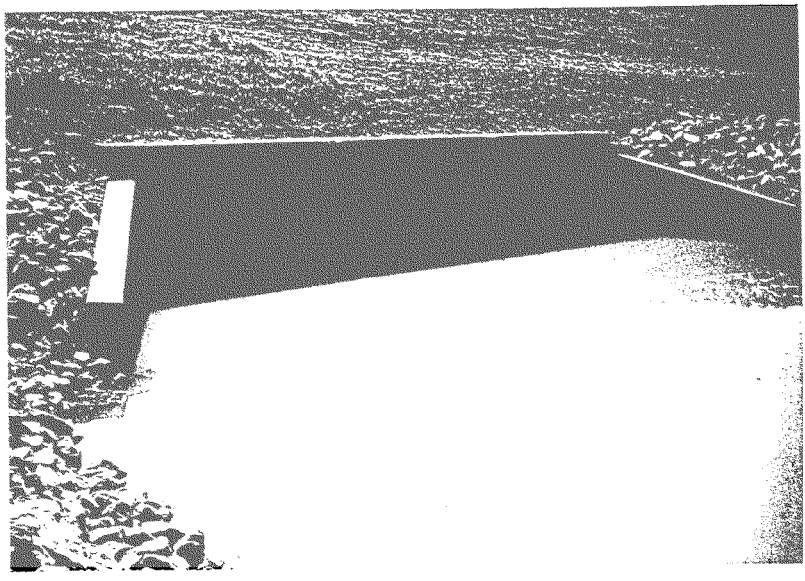

Photo #19
Flap gates at Pump Station #2 outlet.

Photo #20
Concrete pipe and small inlet storm drainage and sewer treatment with washed out area, section A.

Paducah, Kentucky
Section 905 (b)

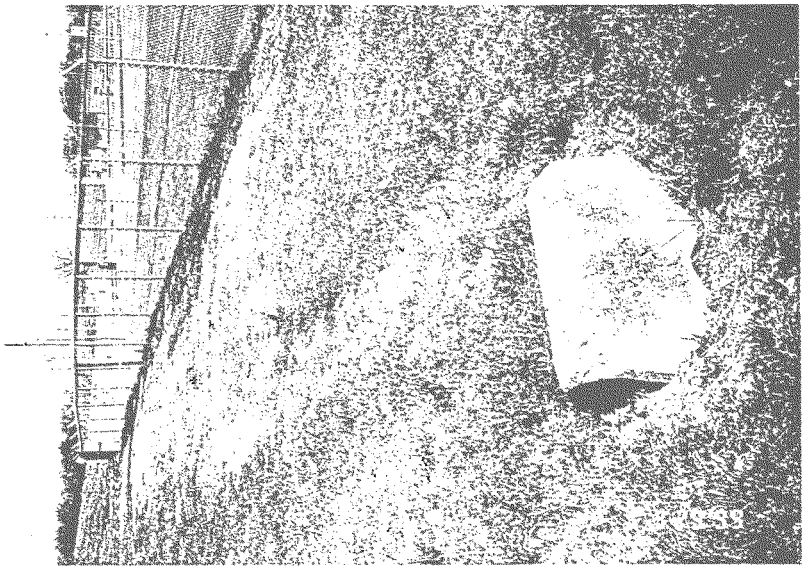

Photo #21
Toe drain landside of levee at sewage treatment plant, section A.

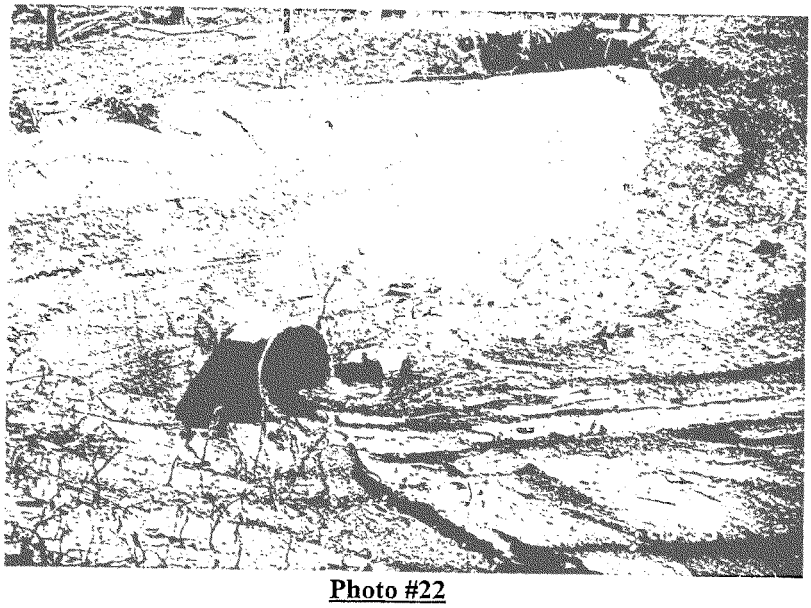

Photo #22
24″ CMP at Station 84 + 00, section A.

Paducah, Kentucky
Section 905 (b)

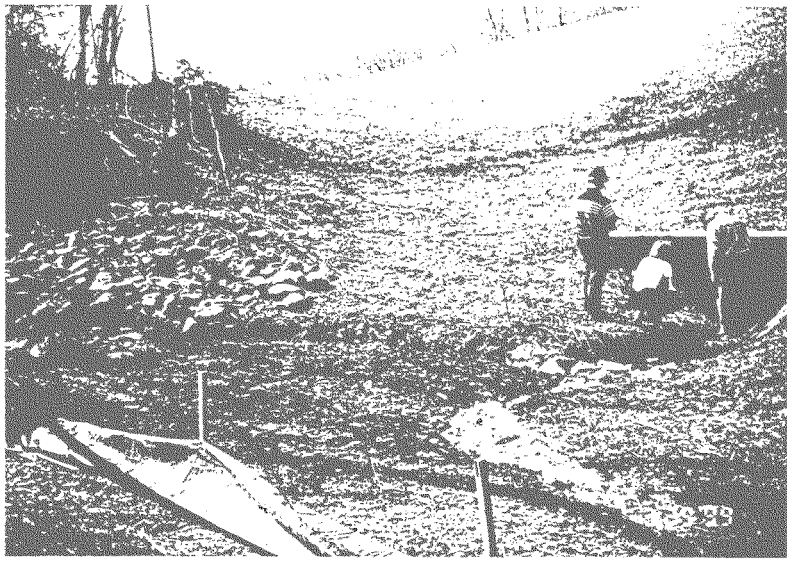

Photo #23
CMP landside of levee, section A.

Photo #24
Small depression at levee crown and sideslopes, approximate 4″depth, approximate station 96 + 00, section A.

Paducah, Kentucky
Section 905 (b)

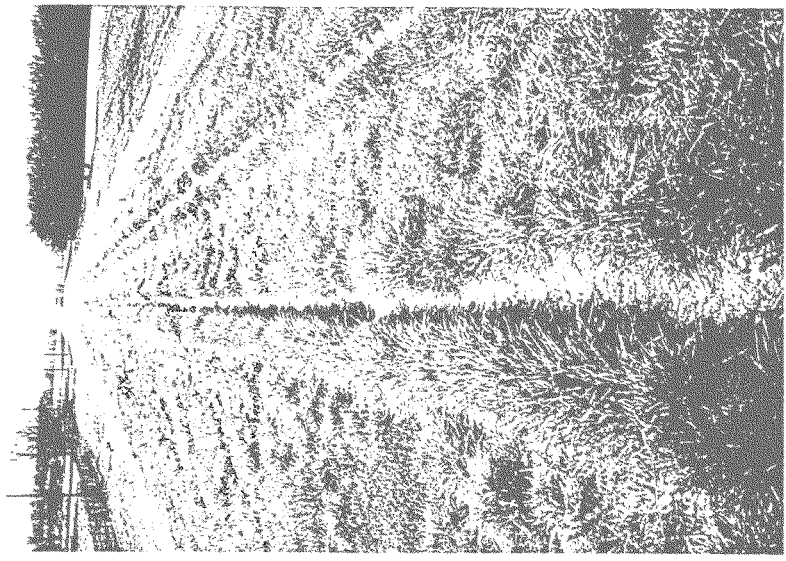

Photo #25
Tire rutting in the levee crown, approximate station 98 + 00, section A.

Photo #26
Small depression (approx. 6″ depth) in a 5' x 7' area in landside levee embankment, section A.

Paducah, Kentucky
Section 905 (b)

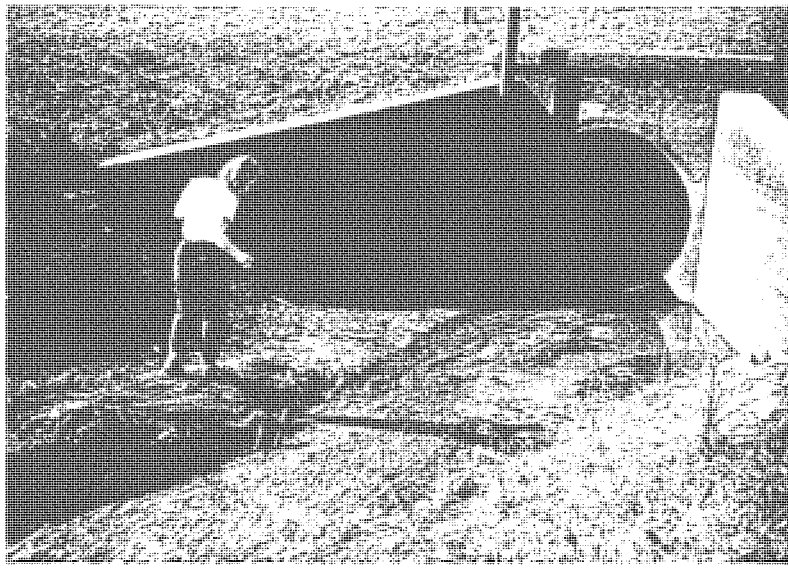

Photo #27
Landside of 72″ CMP, station 111 + 67, section A.

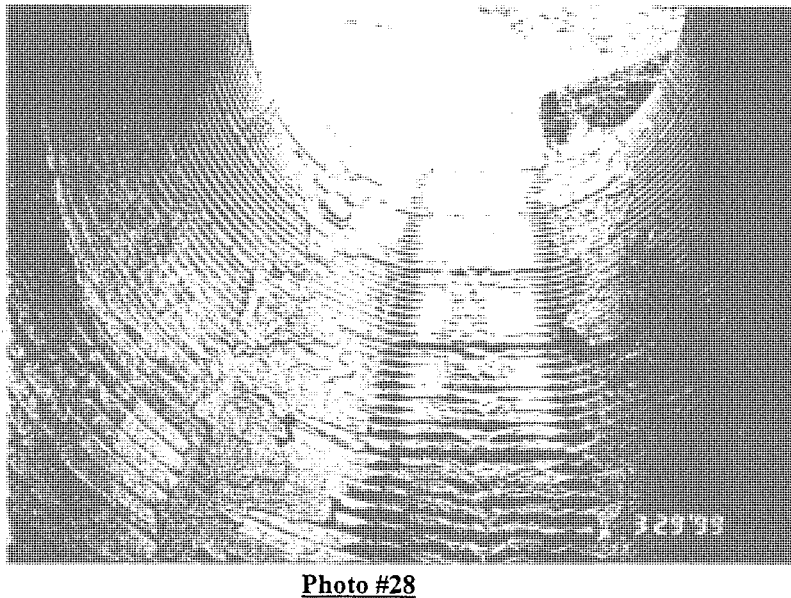

Photo #28
Inside the landside of 72" CMP at station 111 + 67, section A. Notice loss of bituminous coating in low-flow area of pipe.

Paducah, Kentucky
Section 905 (b)

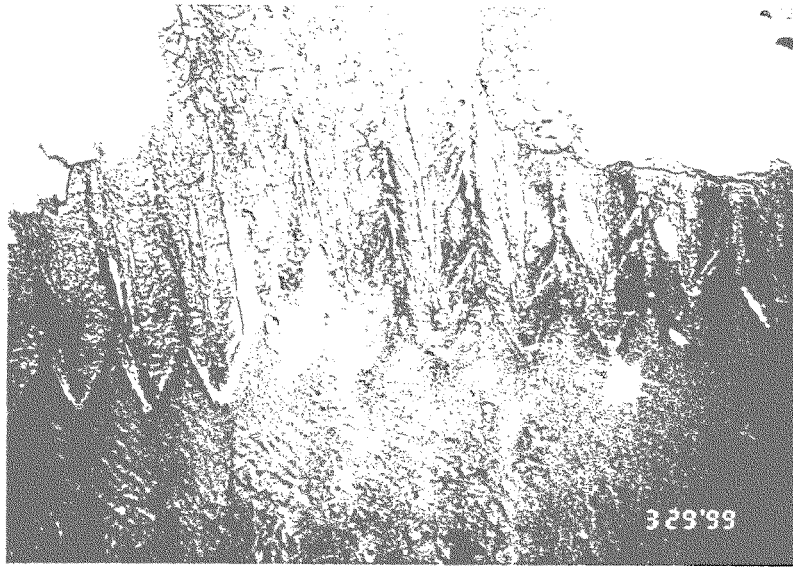

Photo #29
Rusted flow line of 72″ CMP at station 111 + 67-A.

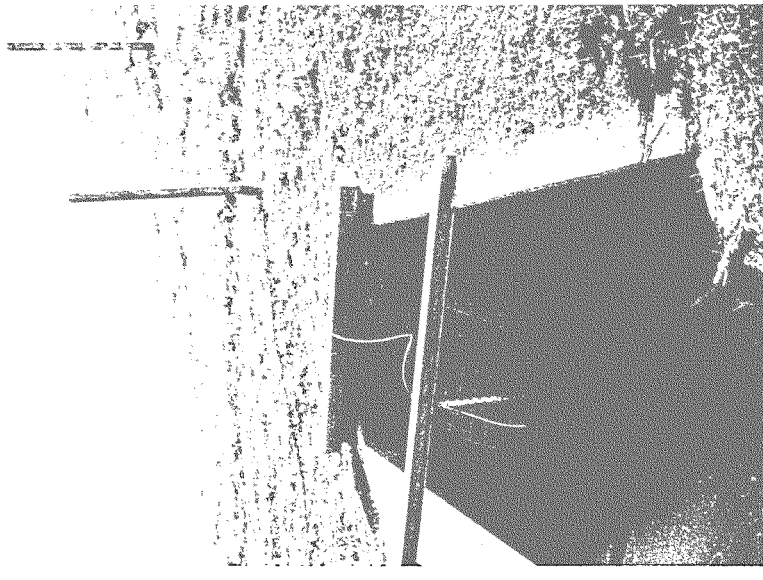

Photo #30
Flap gate of 72" CMP at river outlet, station 111 + 67, section A.

Paducah, Kentucky
Section 905 (b)

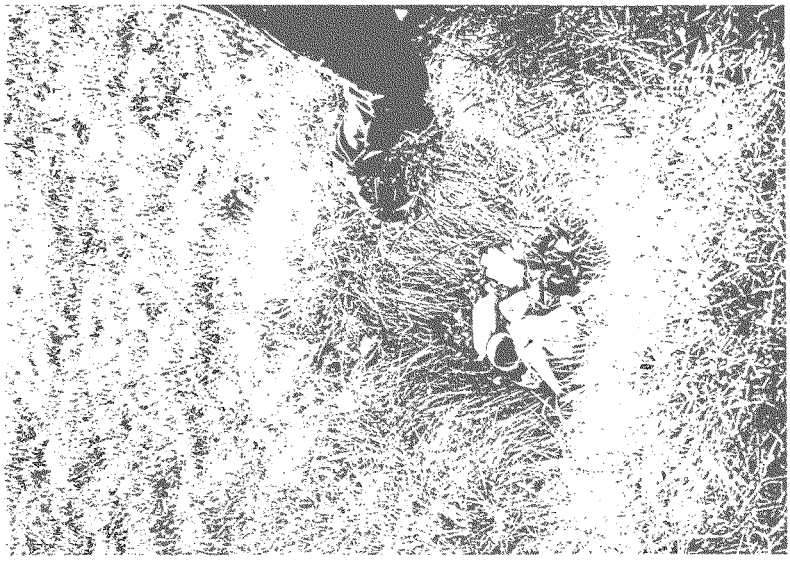

Photo #31

Small sink hole at road ramp landside toe of levee near Hwy 45 crossing, approximate station 113 + 00, section A.

Photo #32

Small sink hole at road ramp landside toe of levee near Hwy 45 crossing, approximate station 113 + 00, section A.

Paducah, Kentucky
Section 905 (b)

Photo #33

Small sink hole at landside levee toe near Hwy. 45 crossing, approximate station 113 +20, section A.

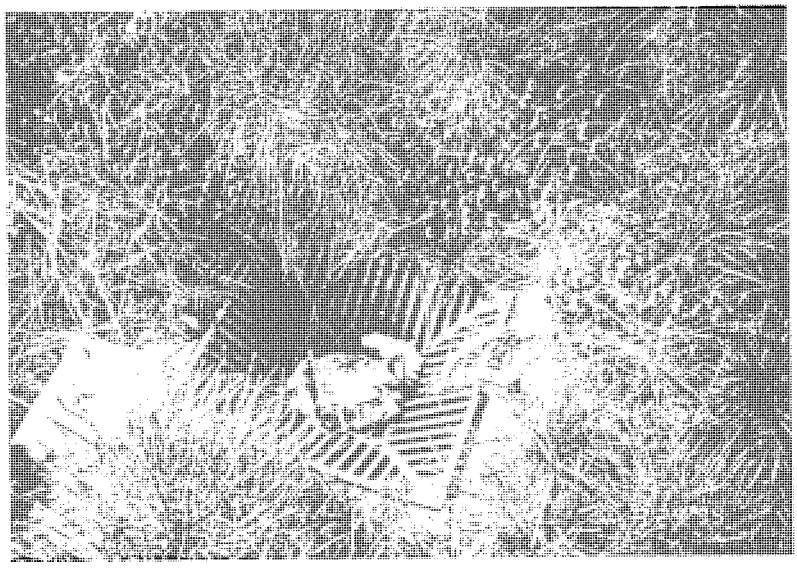

Photo #34

Catch basin at south corner of Hwy 45 crossing of the protection, section A.

Paducah, Kentucky
Section 905 (b)

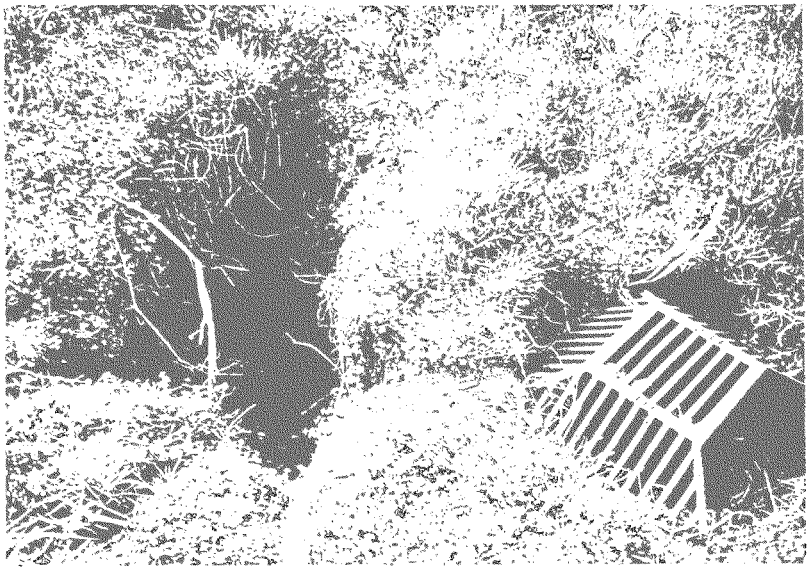

Photo #35
Sink hole and broken pipe at catch basin landside of levee, westside of Hwy 45 crossing, section A.

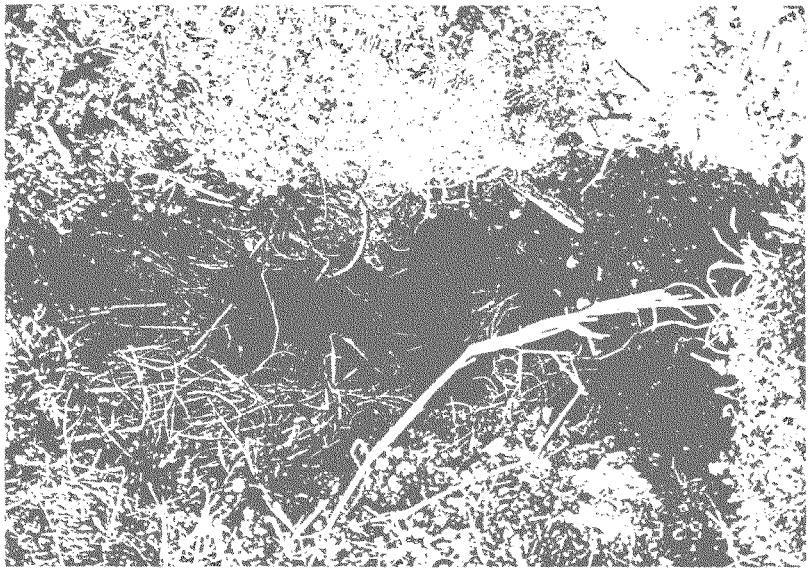

Photo #36
Sink hole, section A.

Paducah, Kentucky
Section 905 (b)

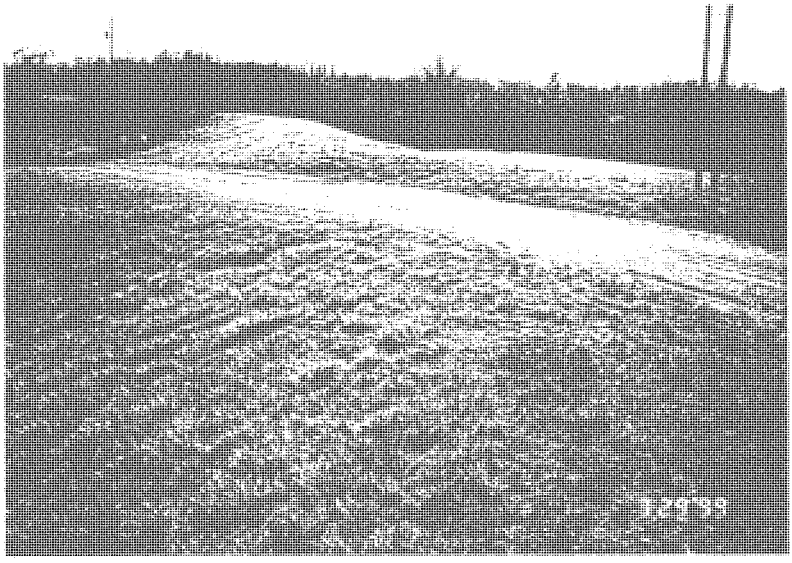

Photo #37

Farm field access gravel road ramp crossing the protection at 250' west of Hwy 45 crossing, section A.

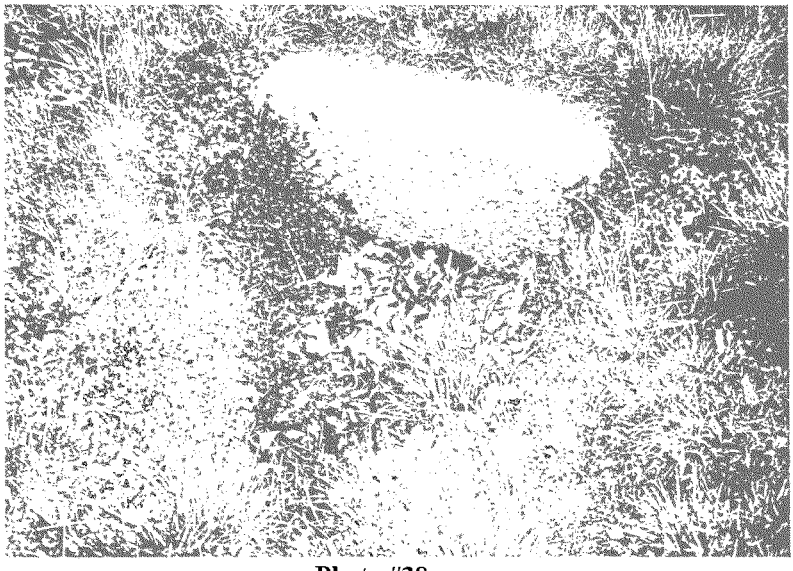

Photo #38

Filled in toe drain outlet, landside of the levee approximate station 132 + 00, section A.

Paducah, Kentucky
Section 905 (b)

Photo #39
Abandoned railroad closure at station 140 + 46, section A.

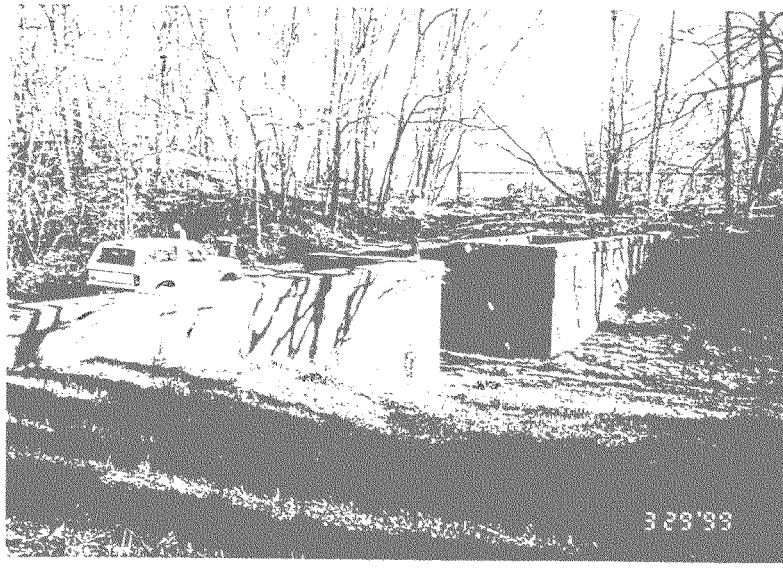

Photo #40
Abandoned railroad closure at station 140 + 46, section A.

Paducah, Kentucky
Section 905 (b)

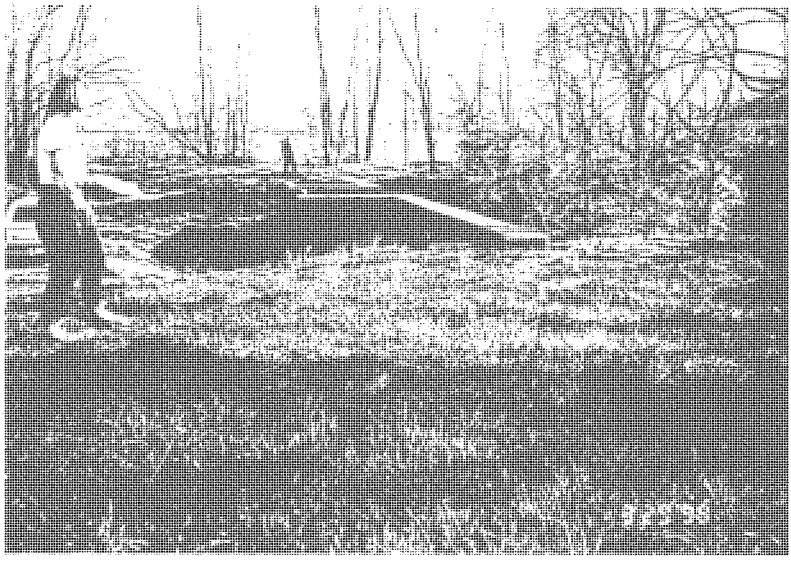

Photo #41
Abandon railroad closure at station 140 + 46, section A. Notice low area of embankment crown at north end of the closure structure.

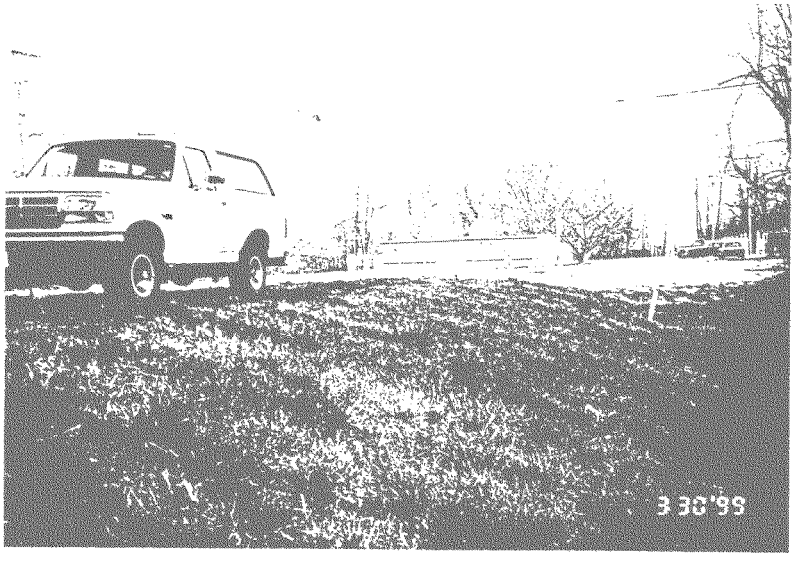

Photo #42
Cario Road crossing, approximately station 144 + 00, section A.

Paducah, Kentucky
Section 905 (b)

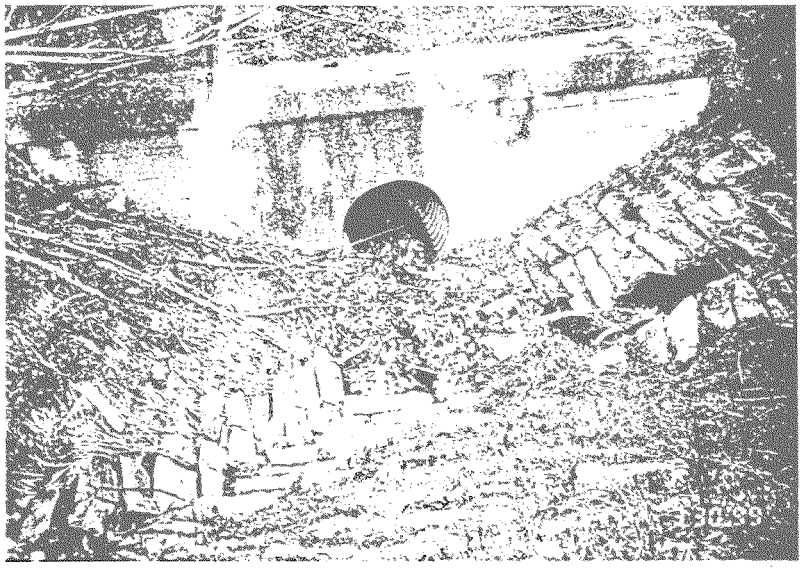

Photo #43

24″ CMP inlet on the landside of the levee, station 147 + 25, section A.

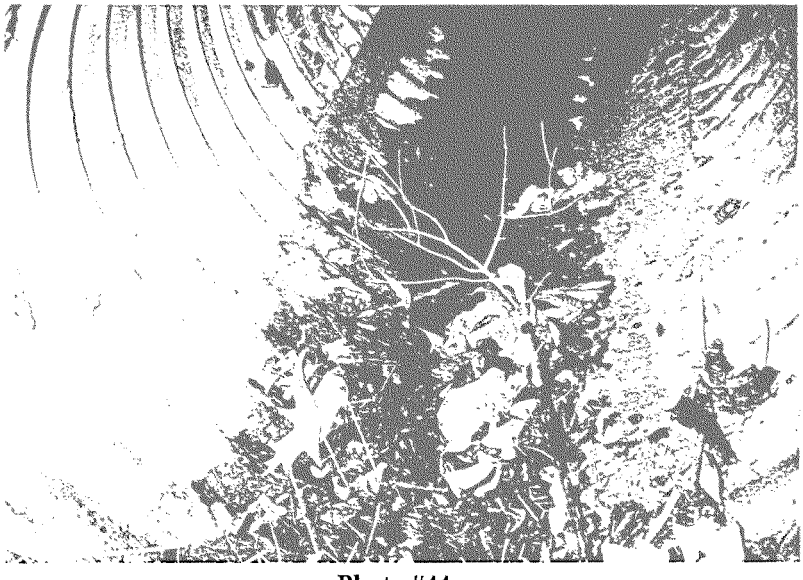

Photo #44

24″ CMP inlet on the landside of the levee, station 147 + 25, section A. Notice metal plate in low-flow area has rusted away.

Paducah, Kentucky
Section 905 (b)

Photo #45

24″ CMP inlet on the landside of the levee at STA 151 + 25, section A. Notice the bituminous coating has worn off.

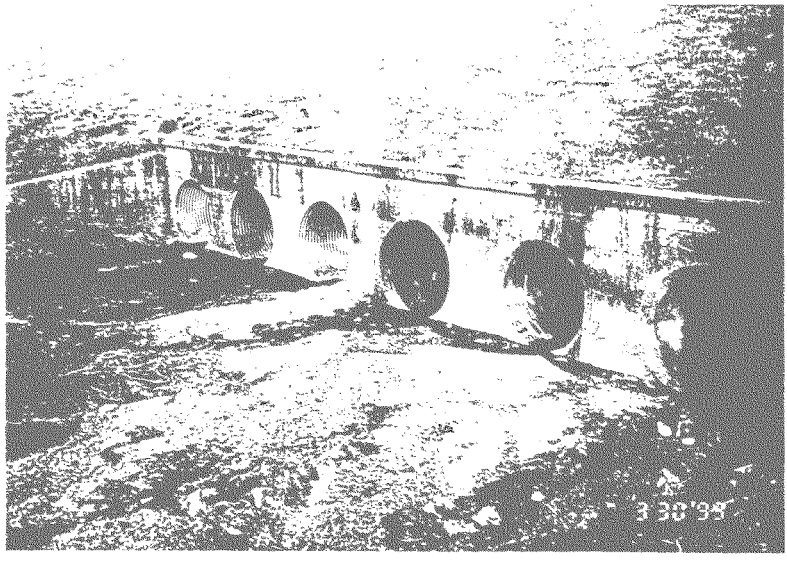

Photo #46

Perkins Creek inlet (6) 60" CMP landside of levee at STA 157 + 63, section A.

Paducah, Kentucky
Section 905 (b)

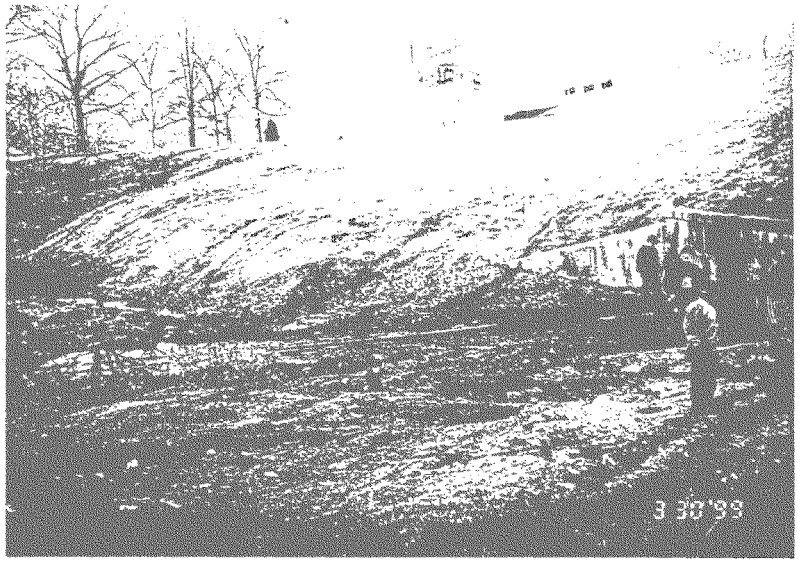

Photo #47
Landside inlet at Pump Station #1, station 159 + 40, section A.

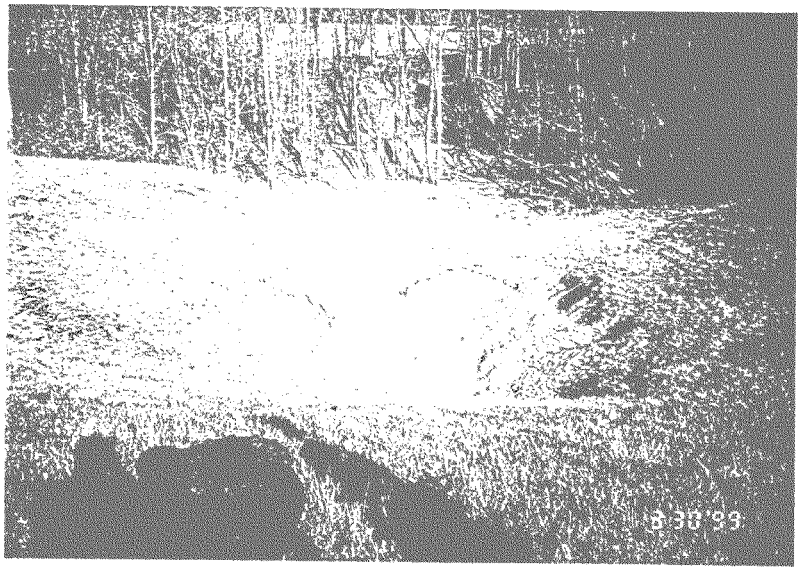

Photo #48
Wash out just beyond the riprap protection at Pump Station #1, section A.

Paducah, Kentucky
Section 905 (b)

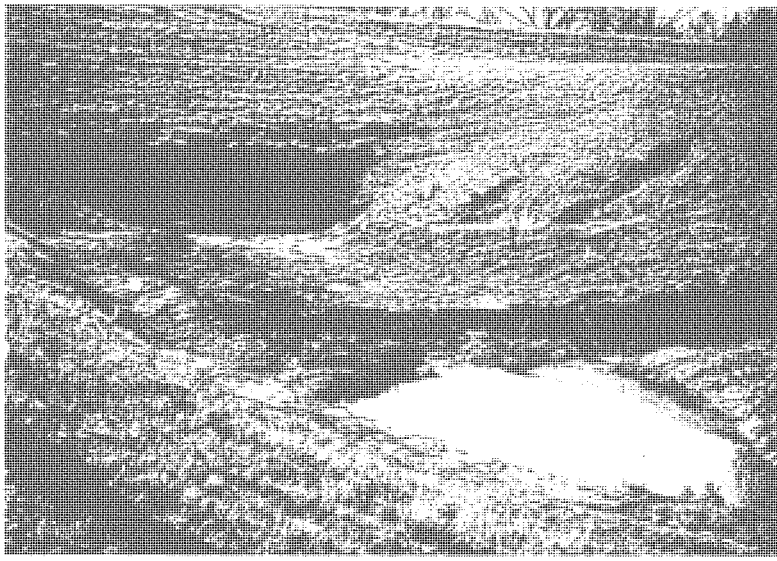

Photo #49

Wash out just beyond the riprap protection at Pump Station #1, section A.

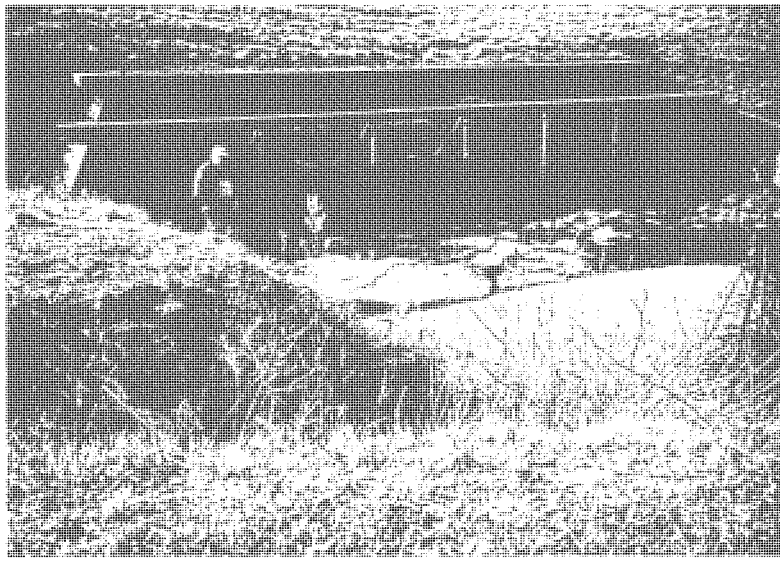

Photo #50

Riverside outlet of (6) 60" CMP's at station 157 + 63, section A. Location of two washed out areas.

Paducah, Kentucky
Section 905 (b)

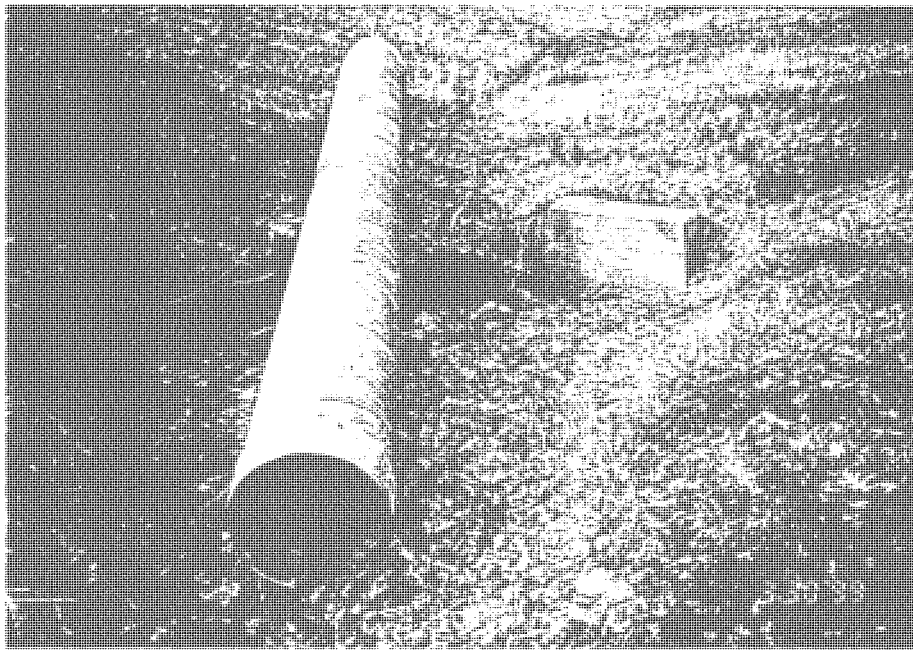

Photo #52

Toe drain at the landside of the levee at Noble Park between the ball fields.

Paducah, Kentucky
Section 905 (b)

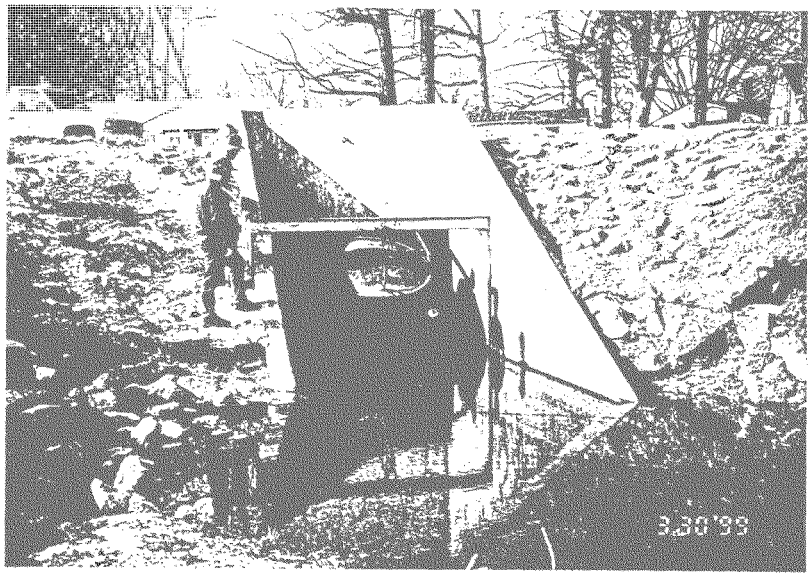

Photo #53
Riverside outlet of concrete pipe under 32nd street at end of levee, section A.

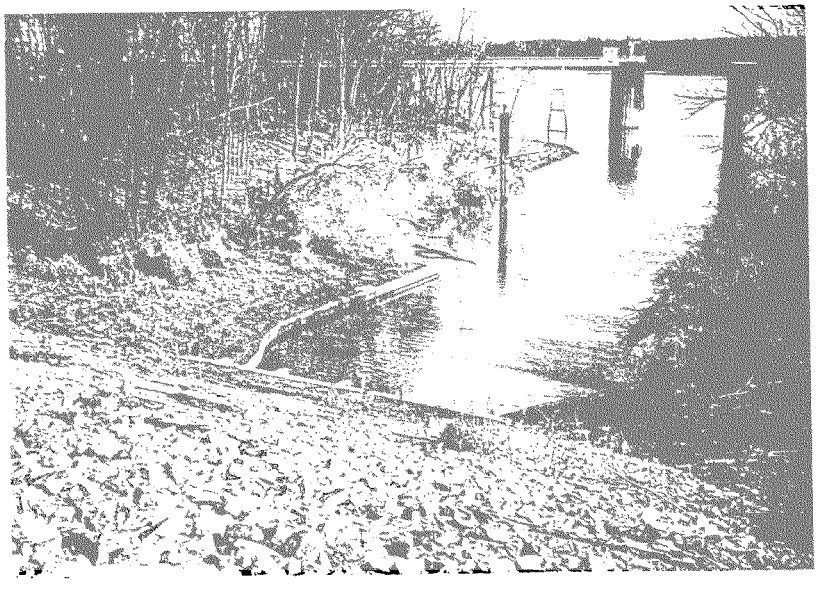

Photo #54
Island creek outlet at Pump Station #11, station 40 + 03, section B.

Paducah, Kentucky
Section 905 (b)

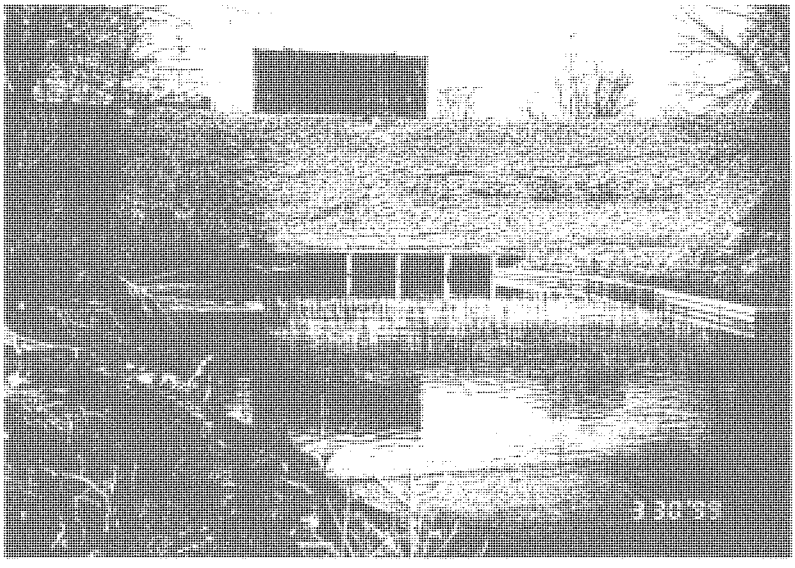

Photo #55
Landside inlet at Island Creek Pump Station #11, station 40 + 03, section B.

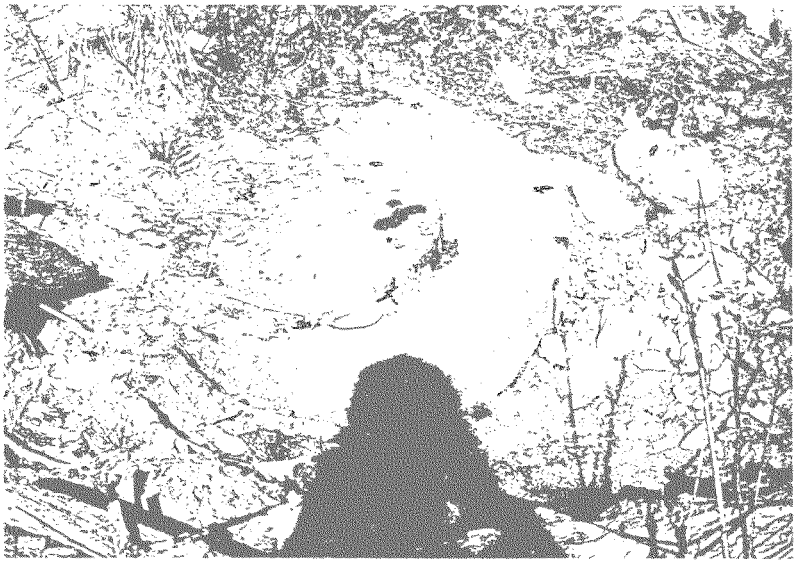

Photo #56
Sanitary manhole cover open, section B.

Paducah, Kentucky
Section 905 (b)

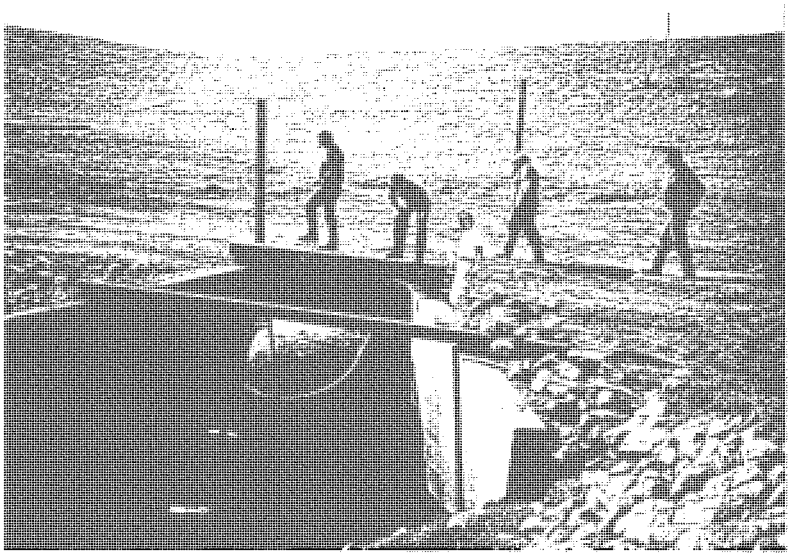

Photo #57
66″ outlet at Woodard Street Station 19 + 11, section B.

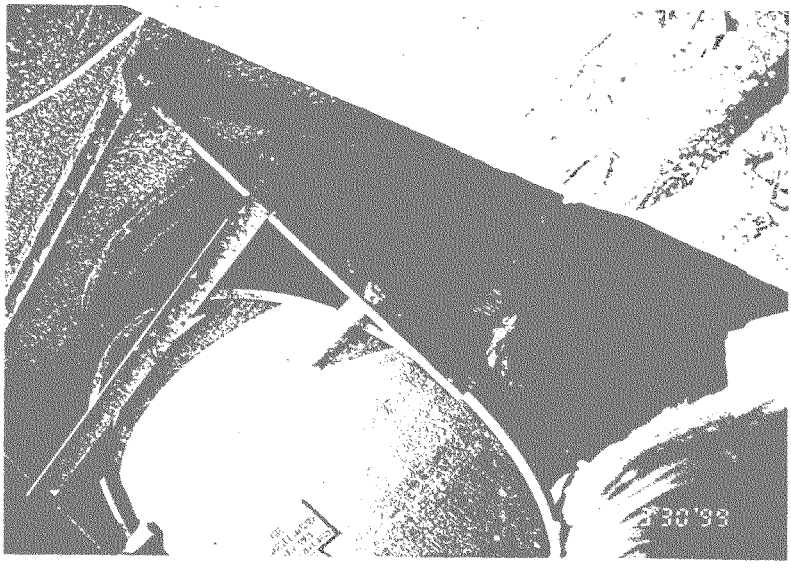

Photo #58
66″ outlet at Woodard Street Station 19 + 11, section B.

Paducah, Kentucky
Section 905 (b)

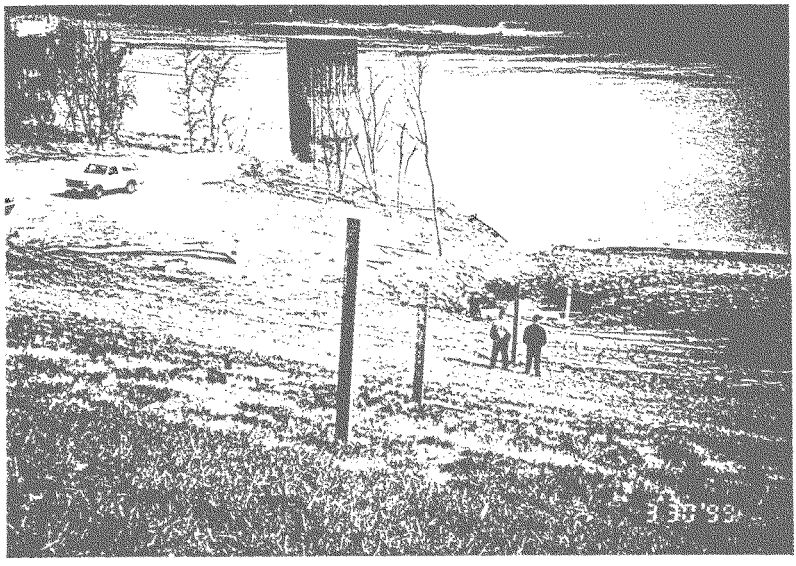

Photo #59
View of Ohio River from levee crown outlet area and Station 19 + 11, section B.

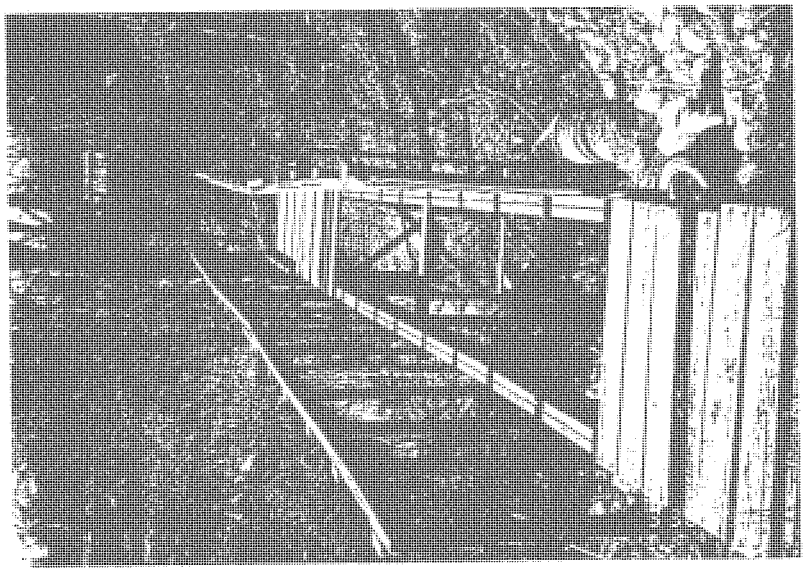

Photo #60
Landside inlet area, Station 19 + 11, section B.

Paducah, Kentucky
Section 905 (b)

Photo #61
Landside inlet area, Station 19 + 11, section B.

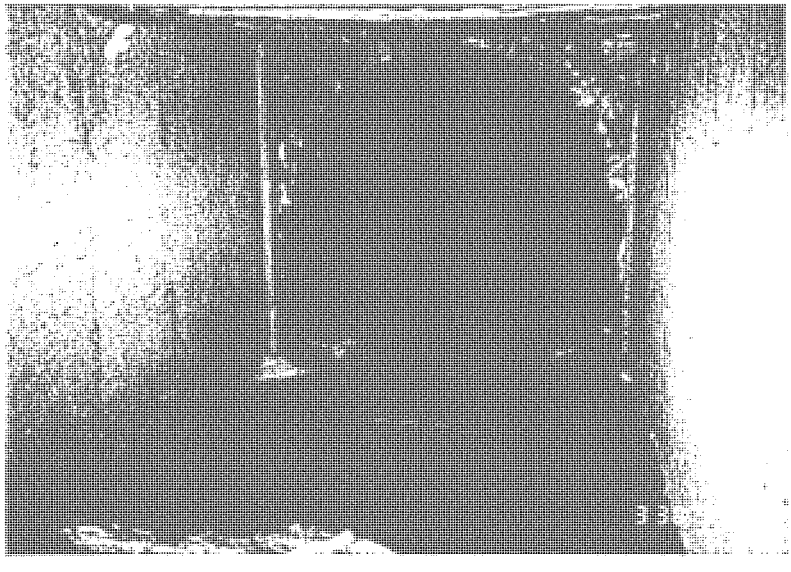

Photo #62
Inlet into 66″ CMP at Station 19 + 11, section B.

Paducah, Kentucky
Section 905 (b)

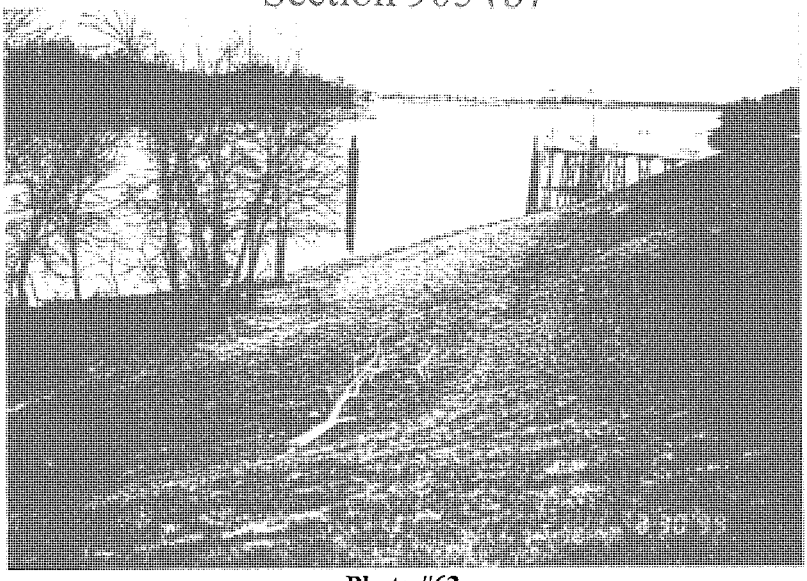

Photo #63

Small eroded area on riverside embankment face, approximate Station 19 + 11, section B.

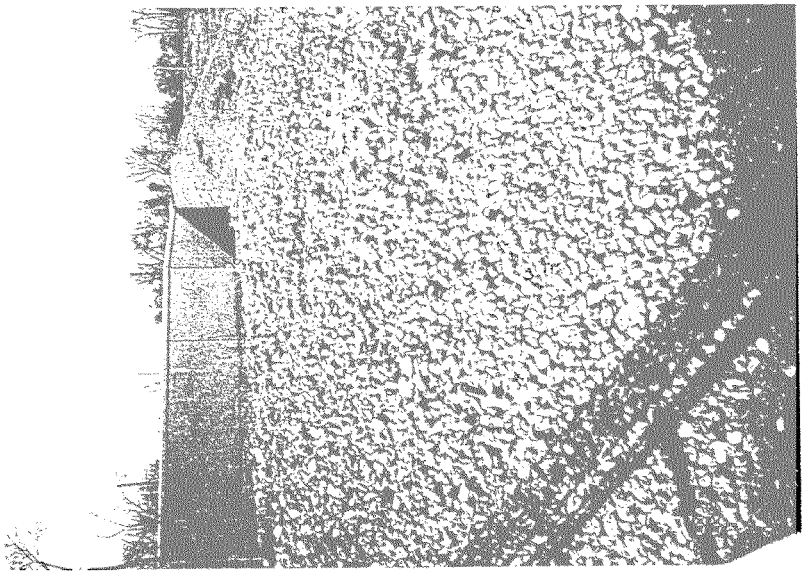

Photo #64

Recently placed riprap (1998) for protection of the concrete flood, approximate Station 16 + 53, section B.

Paducah, Kentucky
Section 905 (b)

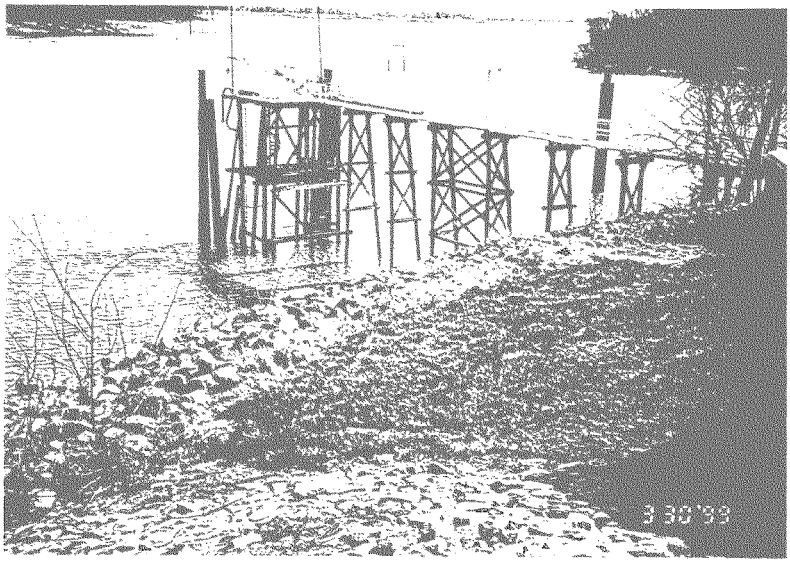

Photo #65

Recently placed riprap (1998) for protection of the concrete flood, approximate Station 16 + 53, section B.

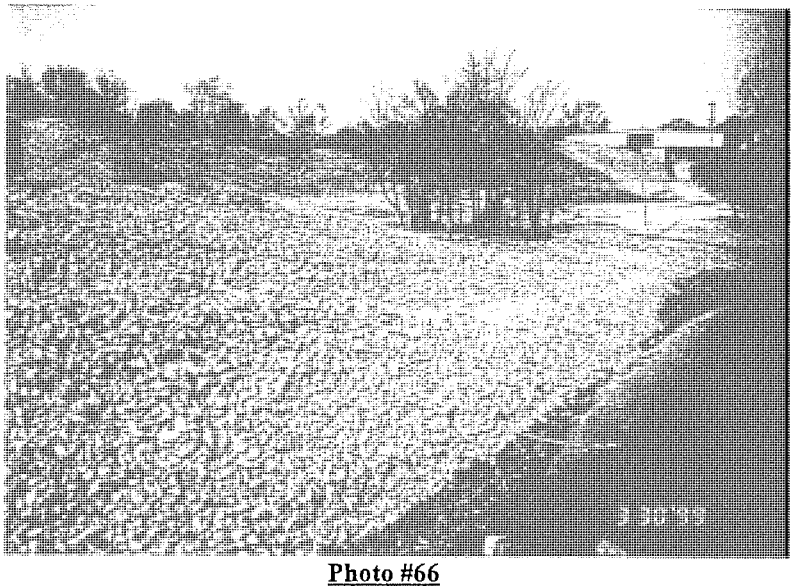

Photo #66

Recently placed riprap (1998) for protection of the concrete flood, approximate Station 16 + 53, section B.

Paducah, Kentucky
Section 905 (b)

Photo #67
Landside inlet of 36" CMP at Station 291 + 75, section C.

Photo #68
Landside inlet of 36" CMP at Station 291 + 75, section C.

Paducah, Kentucky
Section 905 (b)

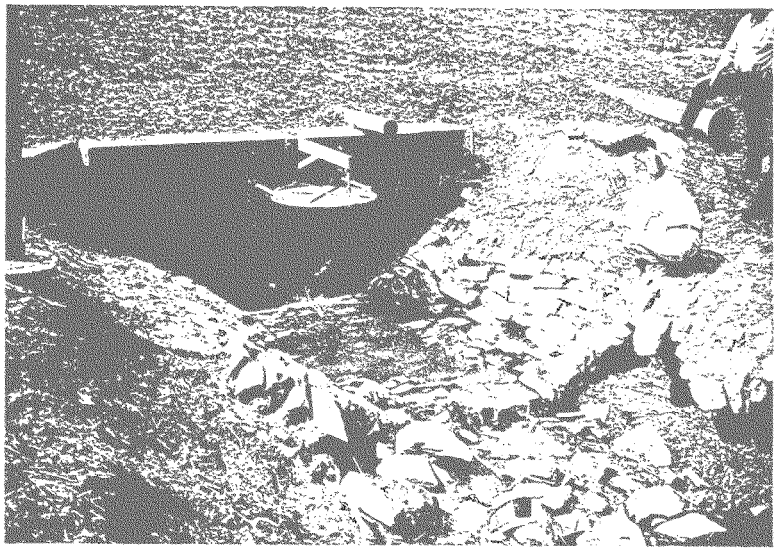

Photo #69
36″ CMP riverside outlet, at Station 291 + 75, section C.

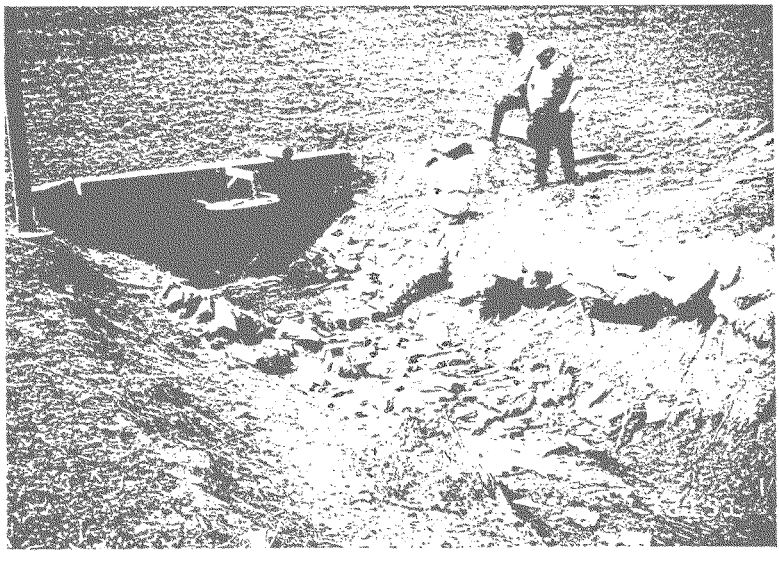

Photo #70
Undercutting and erosion beneath riprap at outlet area, Station 291 + 75, section C.

Paducah, Kentucky
Section 905 (b)

Photo #71

Low area in levee crown at access ramp at the end of Main Street, Section C.

Photo #72

Notice the Kudzu growth on both sides of the levee. Looking along levee crown, Section C.

Paducah, Kentucky
Section 905 (b)

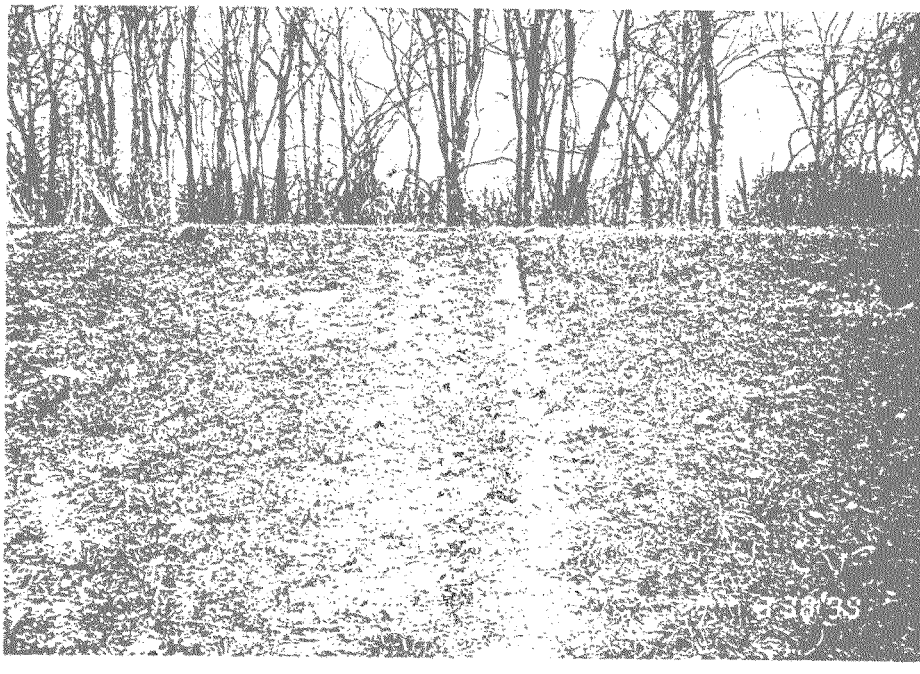

Photo #74
Bike track rutt in landside sideslope of the levee, Section C.

Paducah, Kentucky
Section 905 (b)

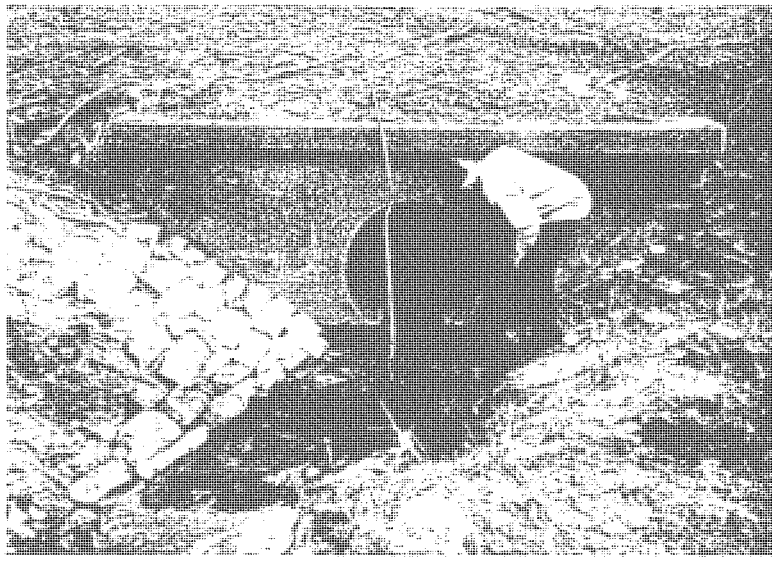

Photo #75
36" CMP landside at Station 254 + 06, Section C.

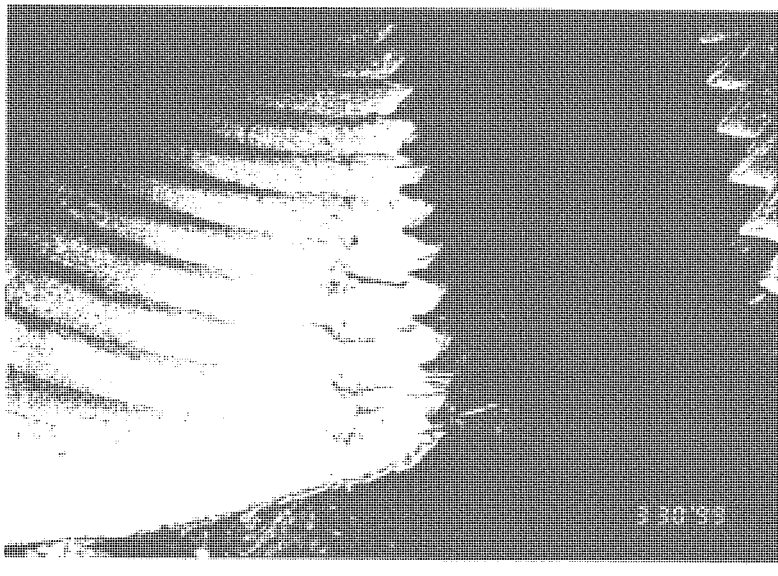

Photo #76
Inlet of 36" CMP at Station 254 + 06, Section C.

Paducah, Kentucky
Section 905 (b)

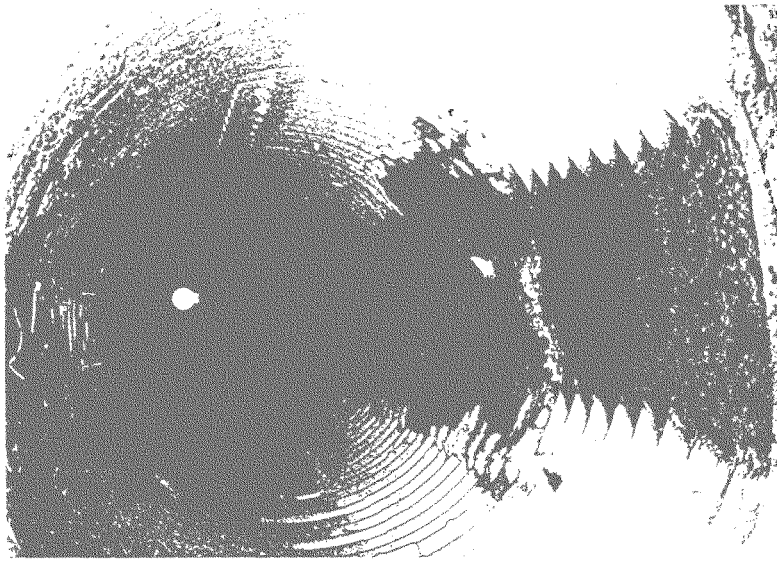

Photo #77
Looking through 36" CMP, Station 254 + 06, Section C.

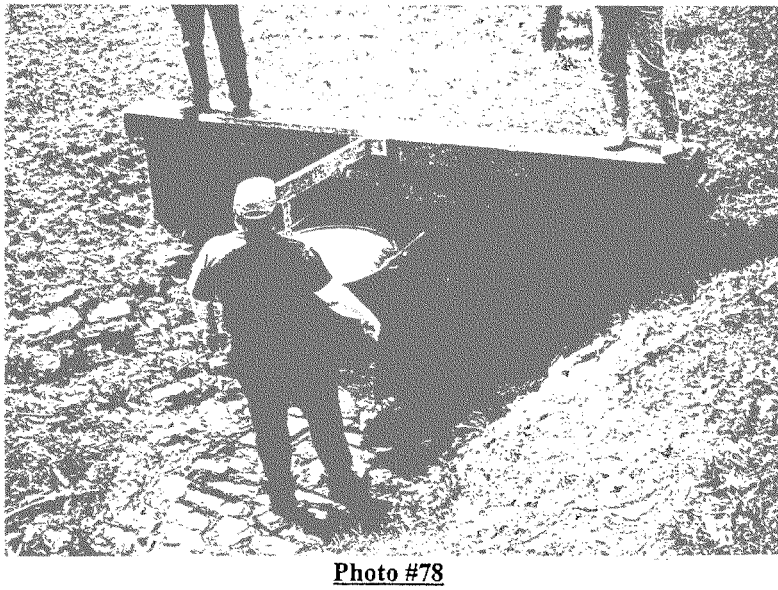

Photo #78
Riverside outlet of 30" CMP at Station 244 + 65, Section C.

Paducah, Kentucky
Section 905 (b)

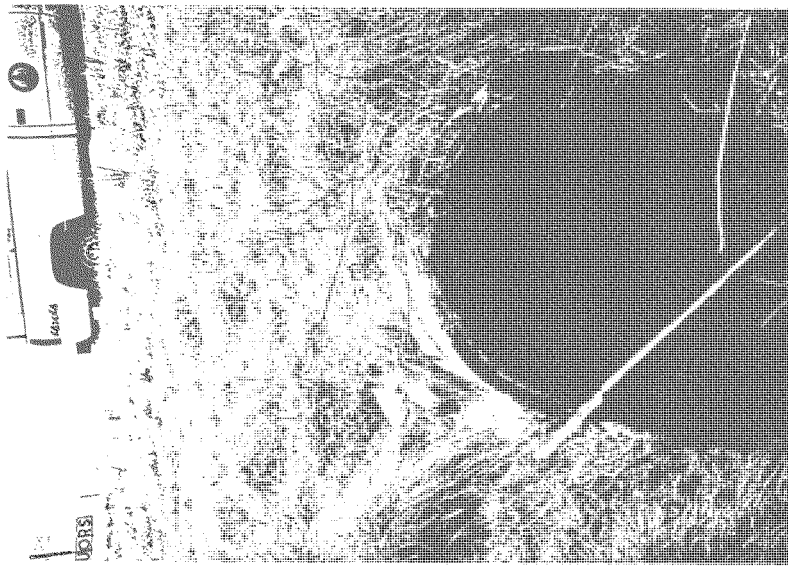

Photo #79
Landside inlet 36" RCP at Hwy 60 & 62 Station 224 + 50, Section C.

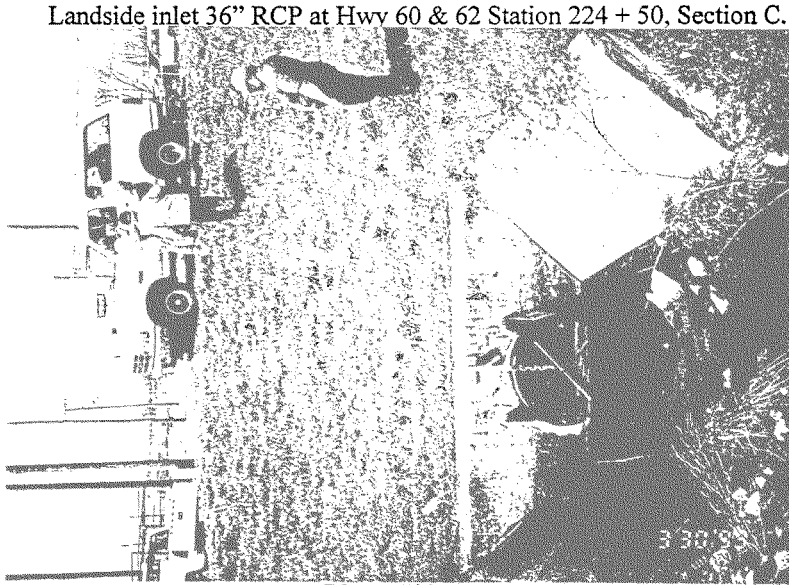

Photo #80
Riverside outlet of 36" RCP at Hwy 60 & 62, Station 224 + 50, Section C.

Paducah, Kentucky
Section 905 (b)

Photo #81
Approximate 4" low area in levee crown approximate, Station 219 + 00,, Section C.

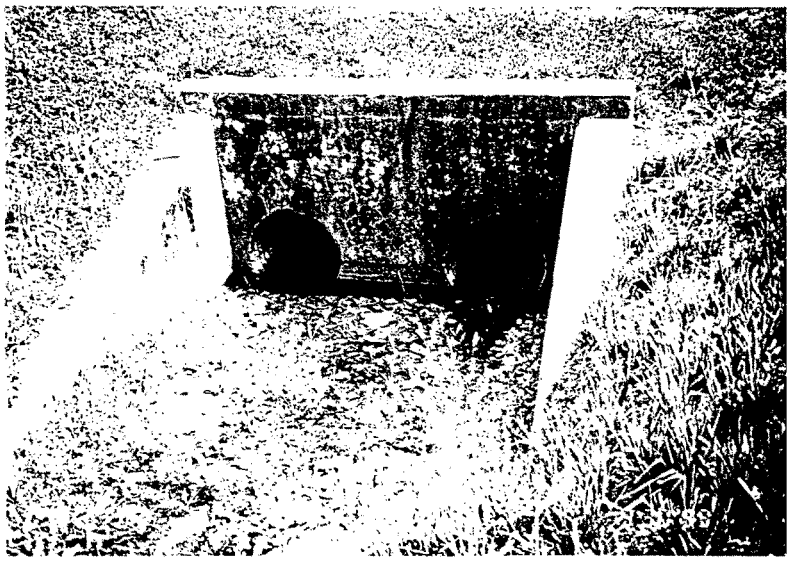

Photo #82
Landside inlet of (2) 24" CMP's at Station 217 + 35, Section C.

Paducah, Kentucky
Section 905 (b)

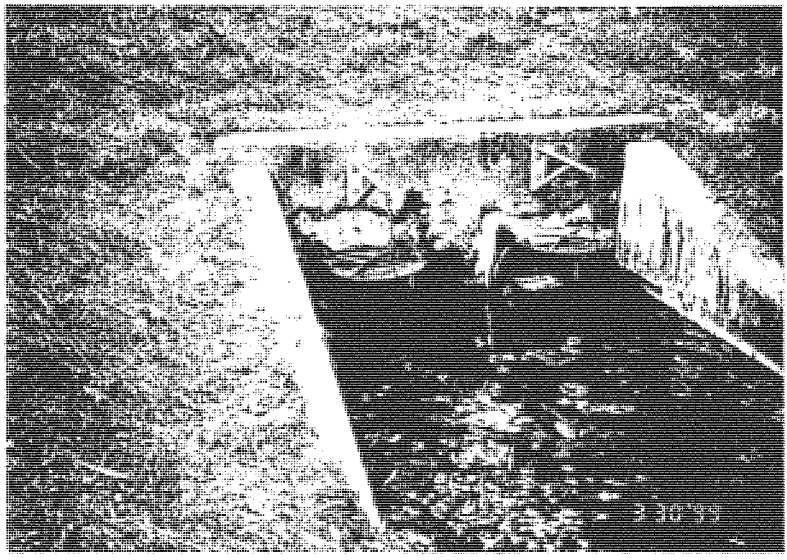

Photo #83

Riverside outlet of (2) 24" CMP's, Station 217 + 35, Section C.

Photo #84

Top of levee looking toward Georgia Street crossing from Alabama Street, Section C. Notice loss of turf along crown.

Paducah, Kentucky
Section 905 (b)

Photo #85

Top of levee looking toward Cook Street crossing from Alabama Street, Section C. Notice loss of turf along crown.

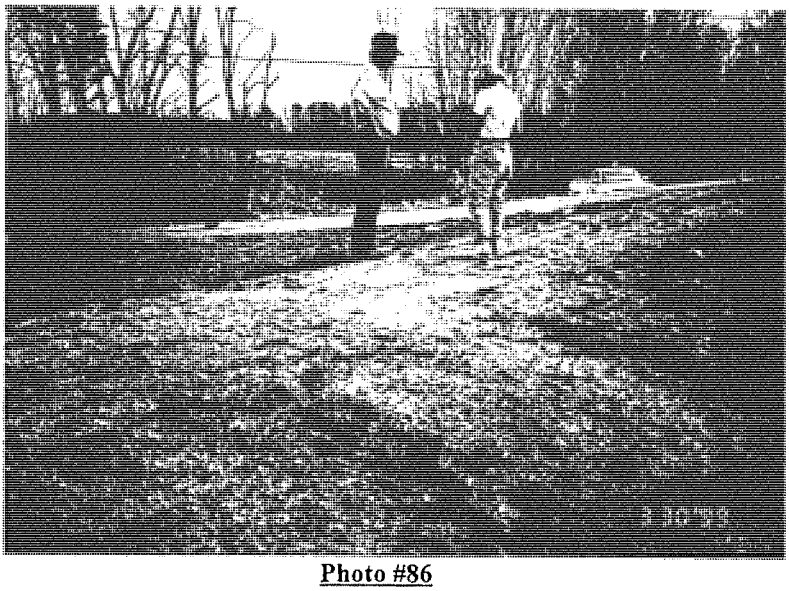

Photo #86

Low area in levee crown and sideslopes, approximate Station 206 + 00, settlement following installation of new 36" drain through protection, Section C.

Paducah, Kentucky
Section 905 (b)

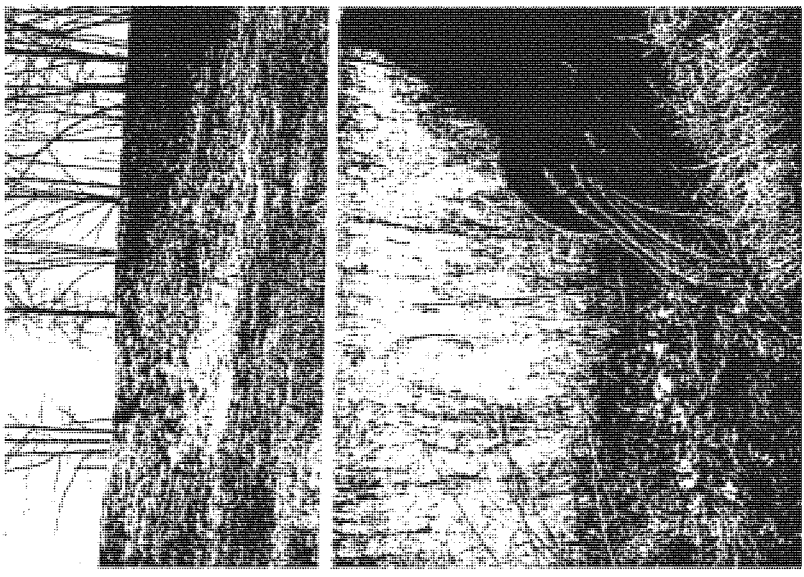

Photo #87
Landside inlet of new 36" CMP at Georgia Street crossing, Section C.

Photo #88
Landside inlet of new 36" CMP at Georgia Street crossing, Section C.

Paducah, Kentucky
Section 905 (b)

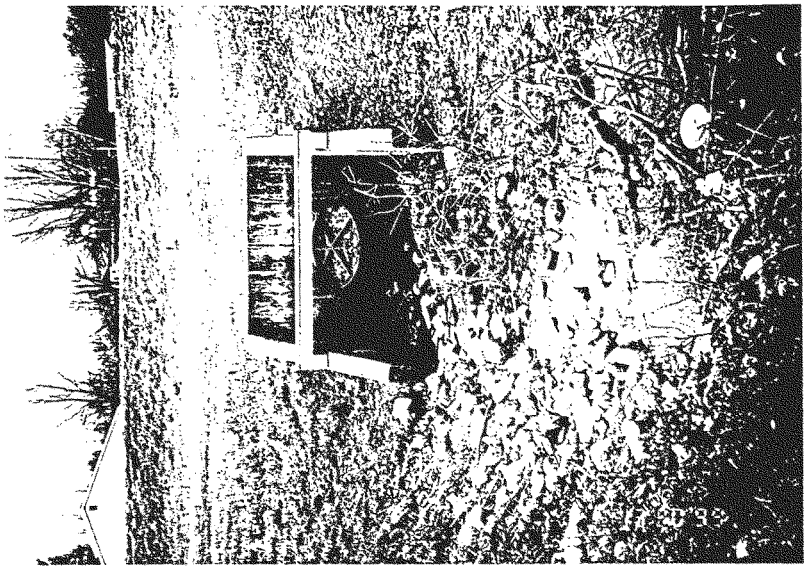

Photo #89
Riverside outlet 36" CMP at approximate Station 205 + 00, Section C.
(pipe placed in mid-1980's)

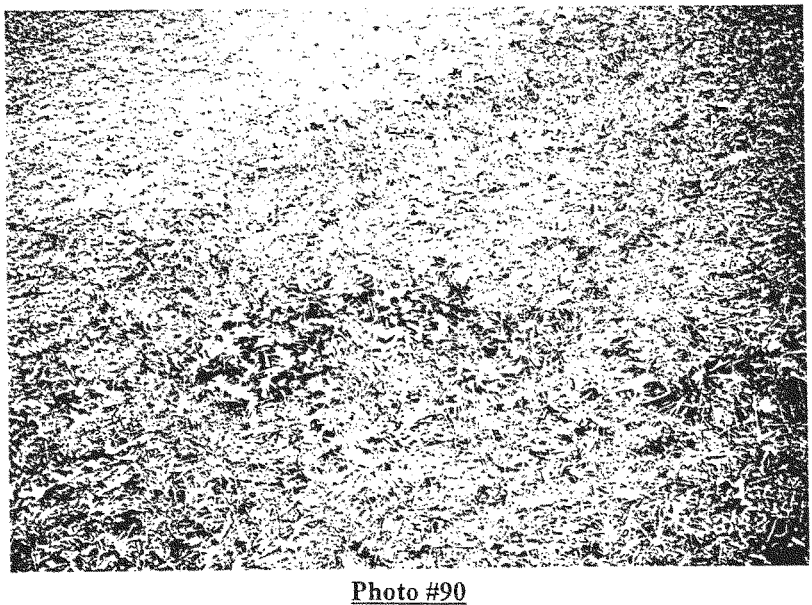

Photo #90
Low area on riverside slope of levee, approximate Station 203 + 00, Section C.

Paducah, Kentucky
Section 905 (b)

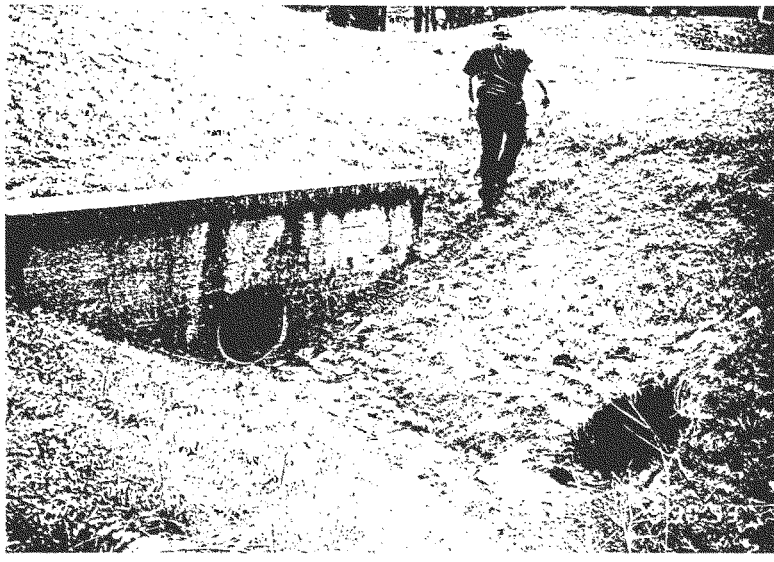

Photo #91

Landside inlet of 24" CMP, Section C. Station 200 + 55, north side of Benton Road crossing, Section C.

Photo #92

Riverside outlet of 24" CMP, with Station 200 + 55, north side of Benton Road crossing, Section C.

Paducah, Kentucky
Section 905 (b)

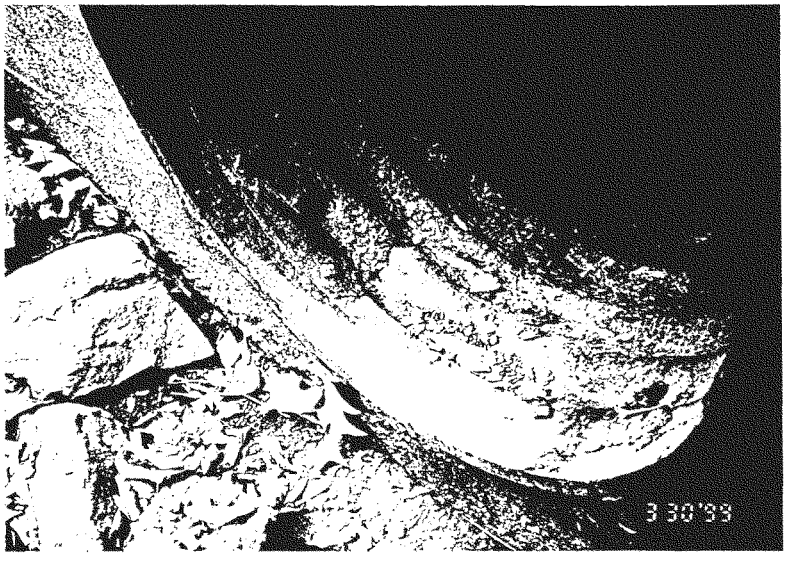

Photo #93

24″ RCP outlet, Station 200 + 55, Section C. Notice bituminous coating is gone from low flow area of pipe.

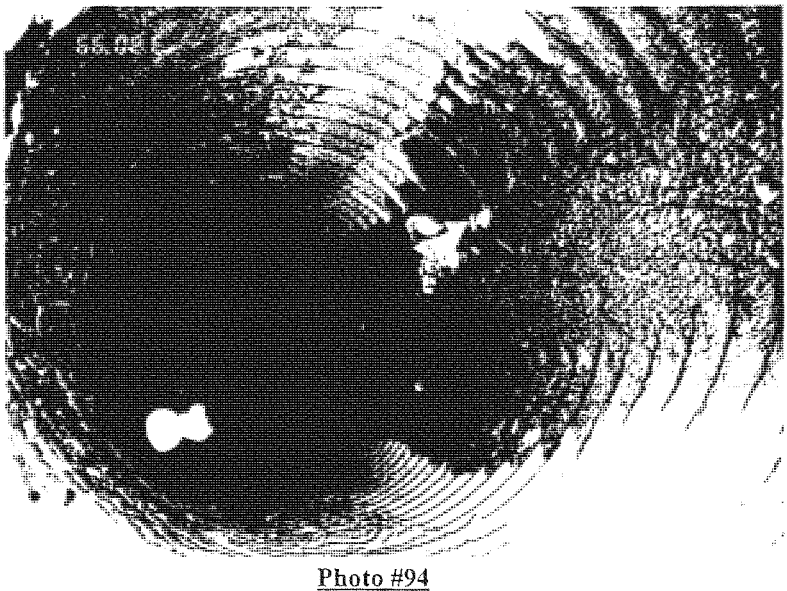

Photo #94

Looking through 24" CMP inlet on landside, Station 199 + 80, on the south side of the Benton Road crossing, Section C.

Paducah, Kentucky
Section 905 (b)

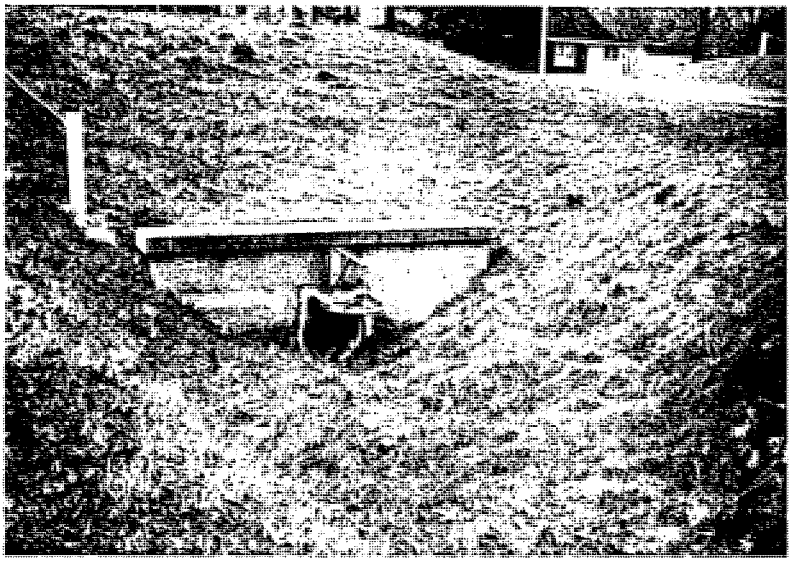

Photo #95

Riverside outlet of 24" CMP, Station 199 + 80 on the south side of the Benton Road crossing, Section C.

Photo #96

Landside inlet of 48" CMP, adjacent Pump Station #12, Station 176 + 90, Section C.

Paducah, Kentucky
Section 905 (b)

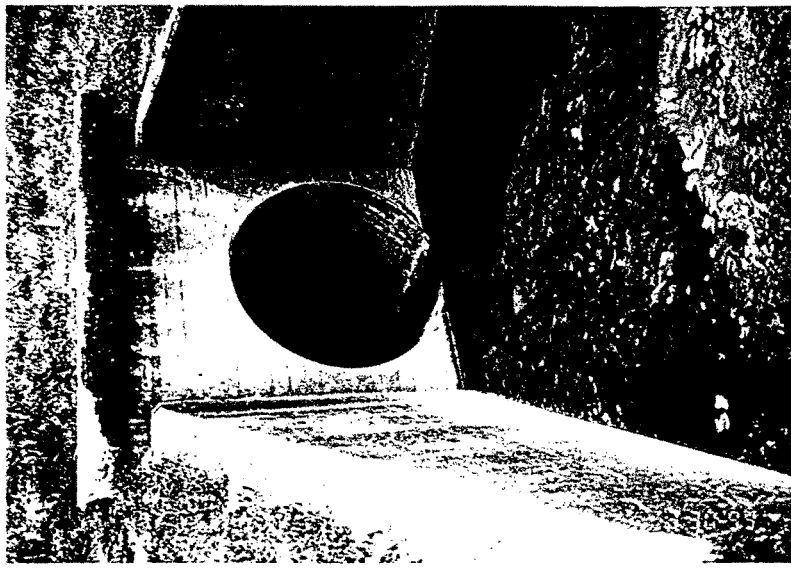

Photo #97

Landside inlet 48" CMP at Station 176 + 90, Section C. Notice some bituminous coating remains in the low-flow area.

Photo #98

Riverside outlet of 48" CMP at Station 176 + 90 near Pump Station #12, Section C.

Paducah, Kentucky
Section 905 (b)

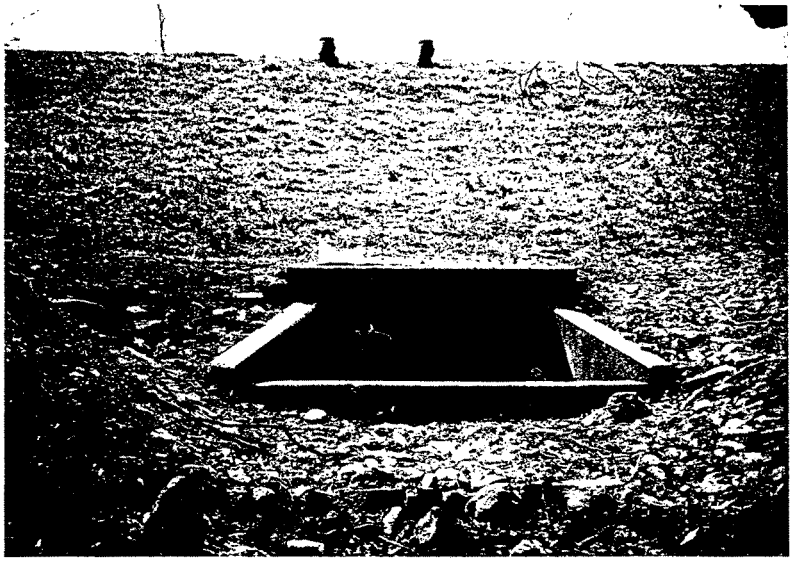

Photo #99
Twin 24" CMP discharge pipes at Pump Station #12, Station 175 + 20, Section C.

Photo #100
Vent on air relief valve at Pump Station #12, Station 175 + 20, Section C.

Paducah, Kentucky
Section 905 (b)

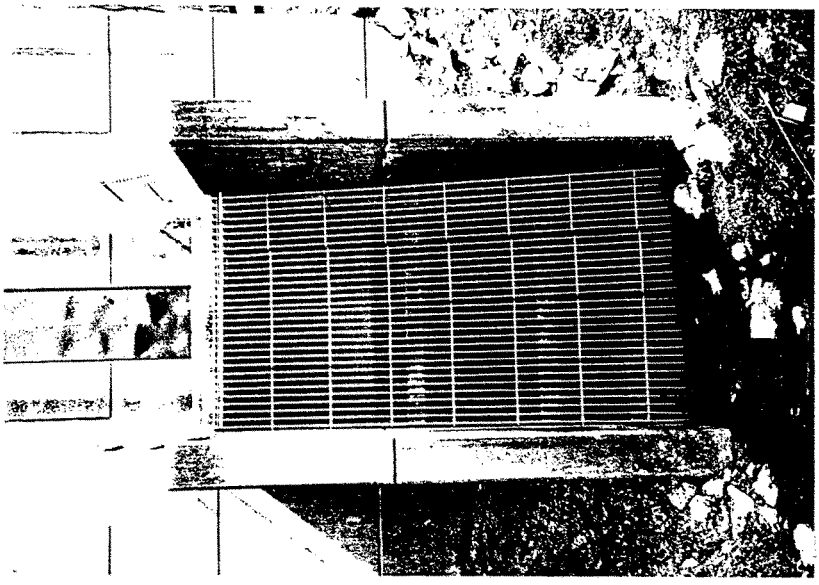

Photo #101
Trash rack on intake at Pump Station #12, Station 175 + 20, Section C.

Photo #102
Landside inlet of 24" CMP and toe drain outlet, Station 172 + 08, Section C.

Paducah, Kentucky
Section 905 (b)

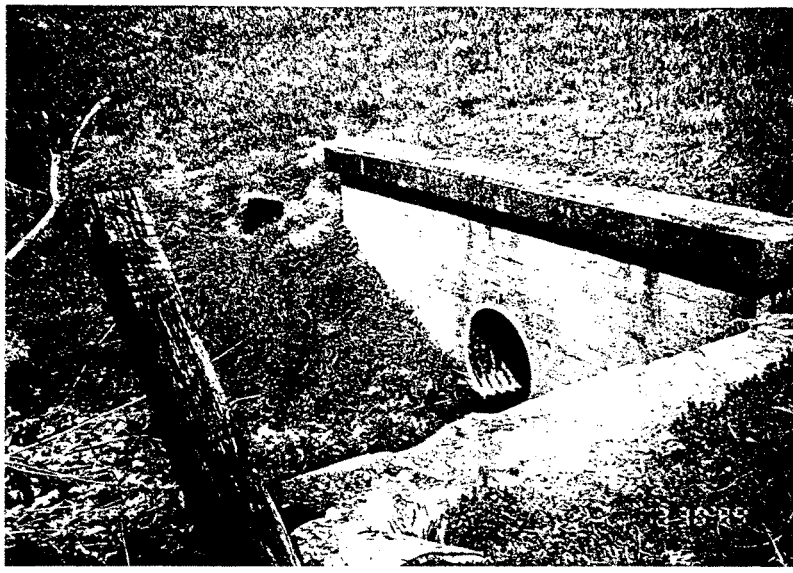

Photo #103
Landside inlet of 24" CMP and toe drain outlet, Station 172 + 08, Section C.

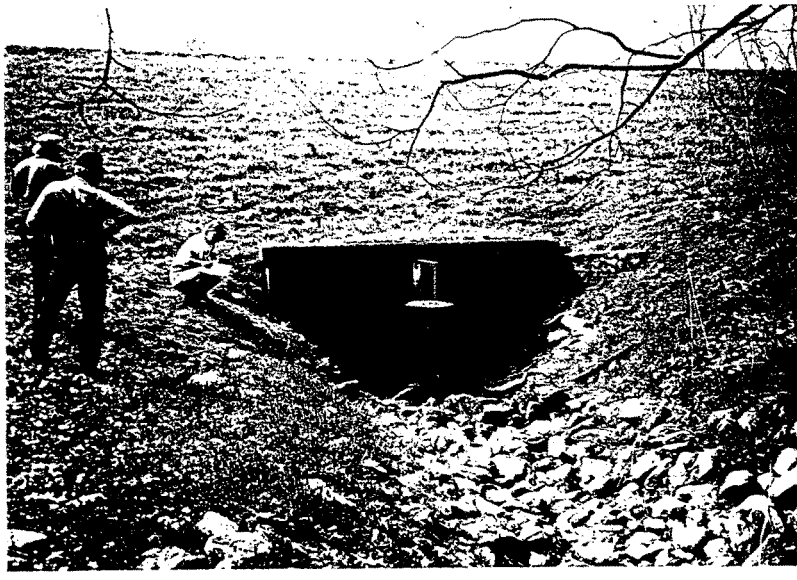

Photo #104
Riverside outlet of 24" CMP Station 172 + 08, Section C.

Paducah, Kentucky
Section 905 (b)

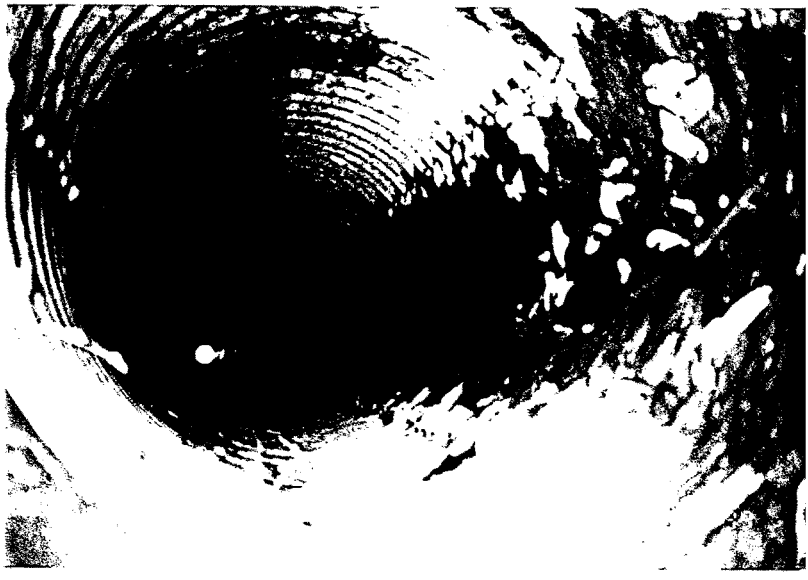

Photo #105
Looking through outlet into 24" CMP, Station 172 + 08, Section C.

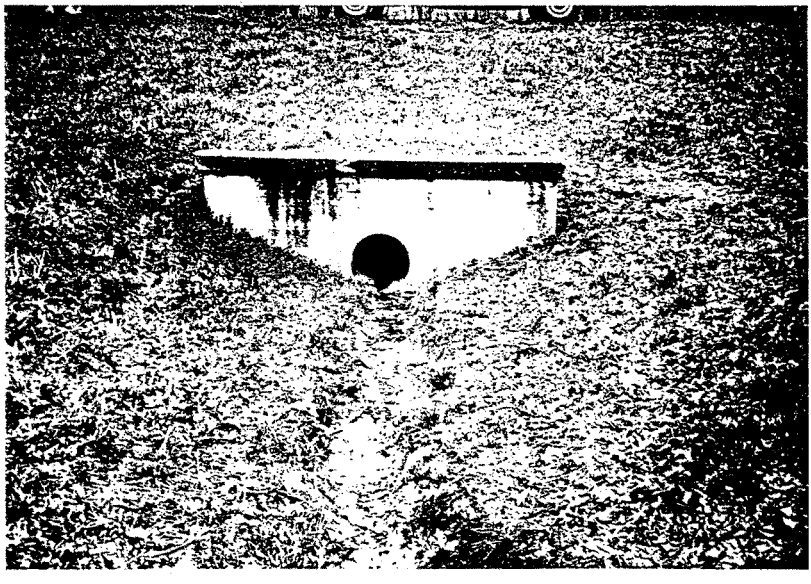

Photo #106
Landside inlet of 24" CMP at Station 176 + 47, Section C.

Paducah, Kentucky
Section 905 (b)

Photo #107
Landside inlet of 24" CMP at Station 176 + 47, Section C.

Photo #108
Riverside outlet of 24" CMP at Station 176 + 47, Section C.

Paducah, Kentucky
Section 905 (b)

Photo #109

Looking north along levee crown, approximate Station 163 + 00, Section C. Notice loss of turf along levee crown.

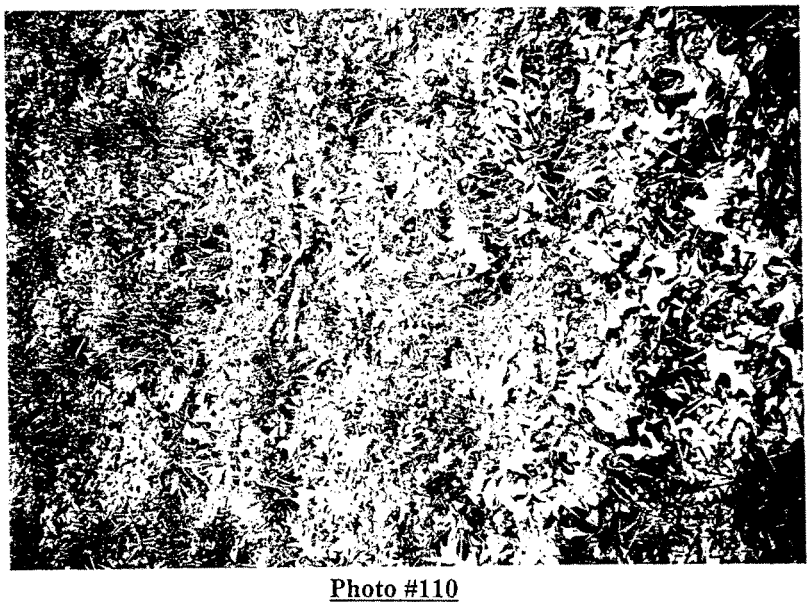

Photo #110

Small holes in land side of levee slope near old Oak tree fallen

Paducah, Kentucky
Section 905 (b)

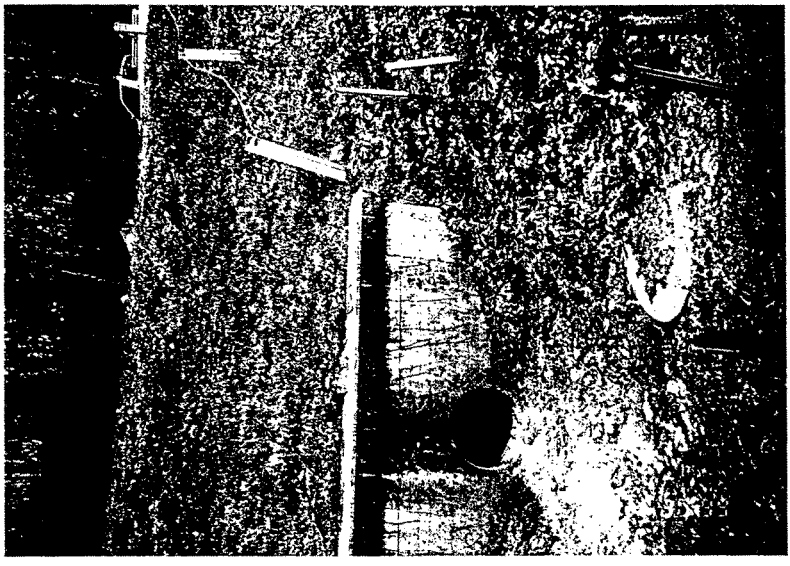

Photo #111

Landside inlet of 24" CMP on the north side of the Oaks Road crossing, Station 150 + 05, Section C.

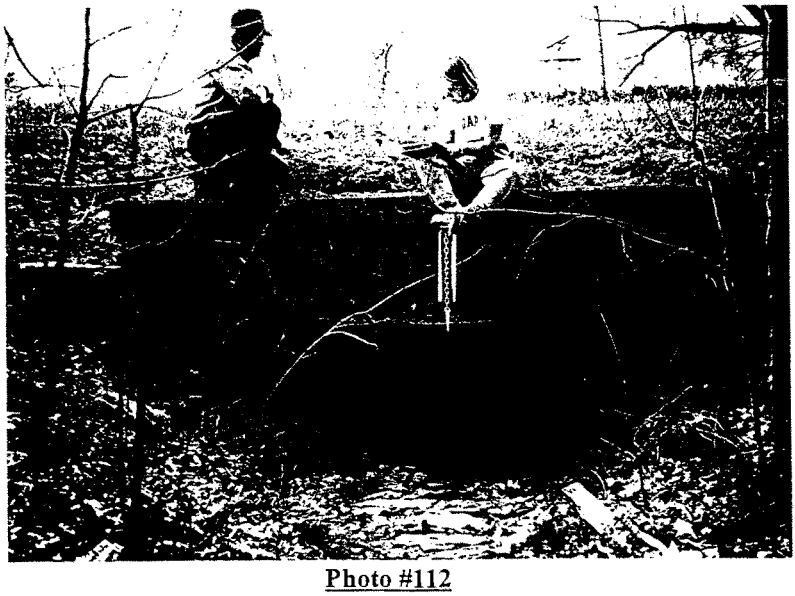

Photo #112

Riverside outlet of 24" CMP at Station 150 + 05 on the north side of the Oaks Road crossing, Section C.

Paducah, Kentucky
Section 905 (b)

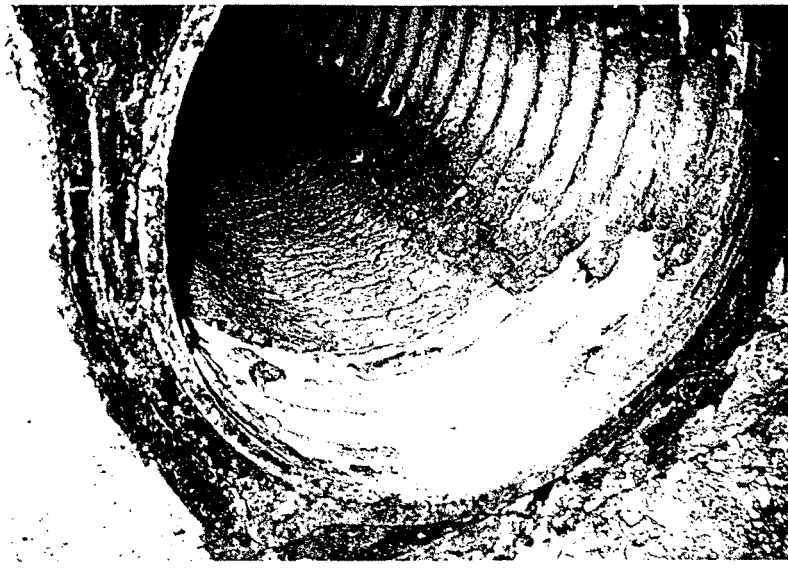

Photo #113

Riverside outlet of 24" CMP at Station 150 + 05 on the north side of the Oaks Road crossing, Section C.

Photo #114

Sluice gate for diversion channel outlet Oaks Road, approximately 100'+ South of the levee protection system, Section C.

Paducah, Kentucky
Section 905 (b)

Photo #115

Sluice gate for diversion channel outlet Oaks Road, approximately 100'+ South of the levee protection system, Section C.

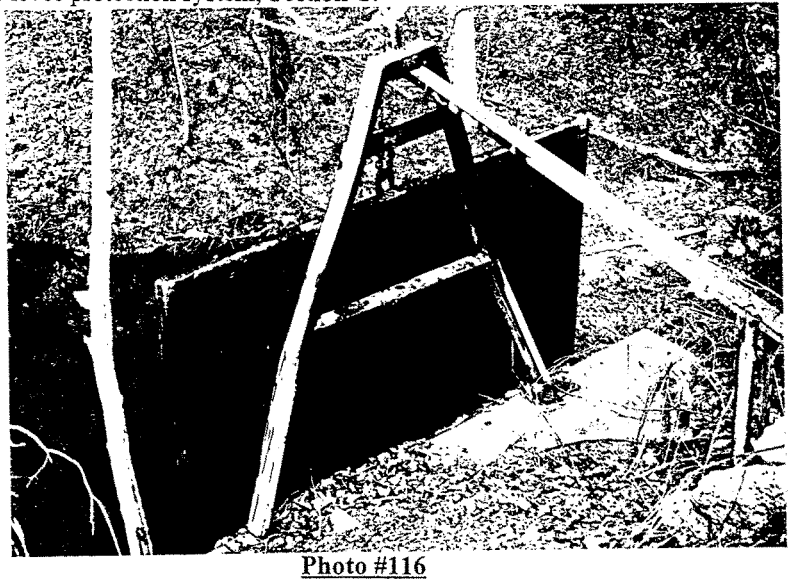

Photo #116

Sluice gate for diversion channel outlet Oaks Road, approximately 100'+ South of the levee protection system, Section C.

Paducah, Kentucky
Section 905 (b)

Photo #117

Inlet 72" CMP on South side of Oaks road, 100' East of the levee Diversion channel inlet beneath Oaks Road, approximately 100' south of the levee protection system, Section C.

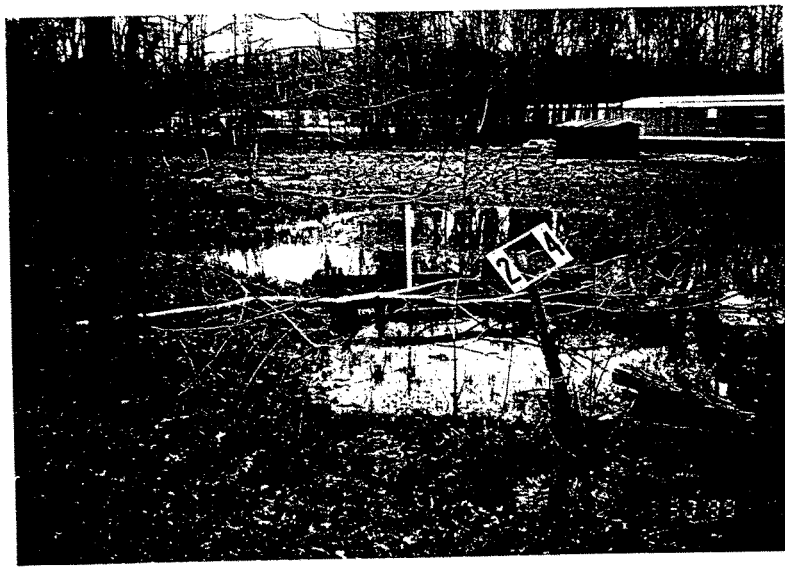

Photo #118

Gas line in low area on the landside of the levee, Section C.

Paducah, Kentucky
Section 905 (b)

Photo #119
Looking southwest along treeline at the toe of the levee embankment, Section C.

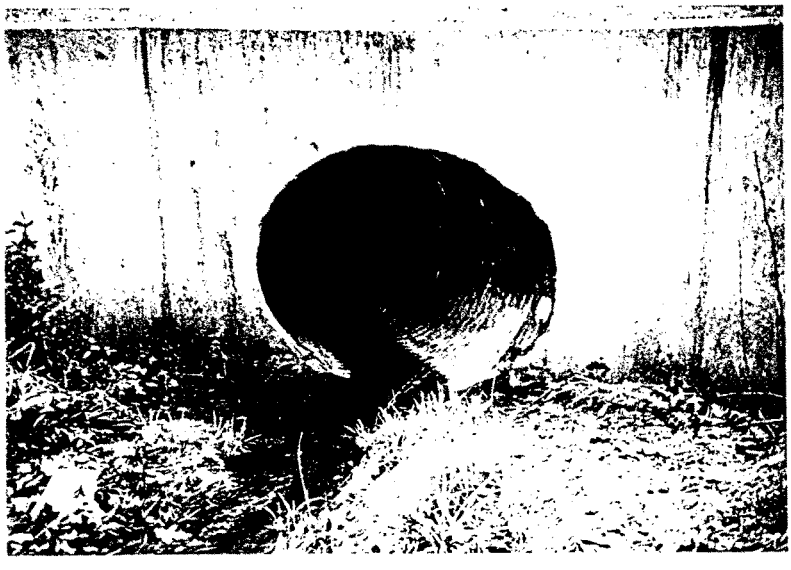

Photo #120
Landside inlet of 48" CMP at approximate Station 112 + 00, this is a newer pipe placement.

Paducah, Kentucky
Section 905 (b)

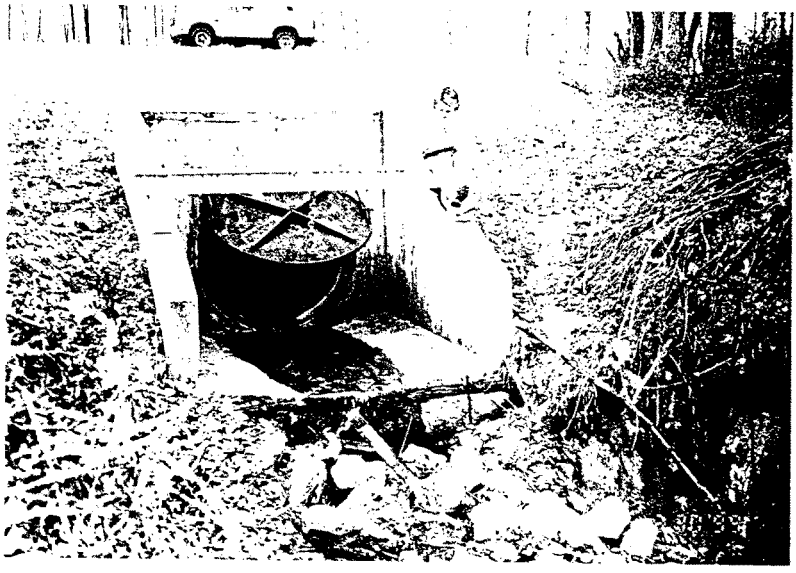

Photo #121

Riverside outlet of 48" CMP at approximate Station 112 + 00, Section C. This is a newer pipe placement.

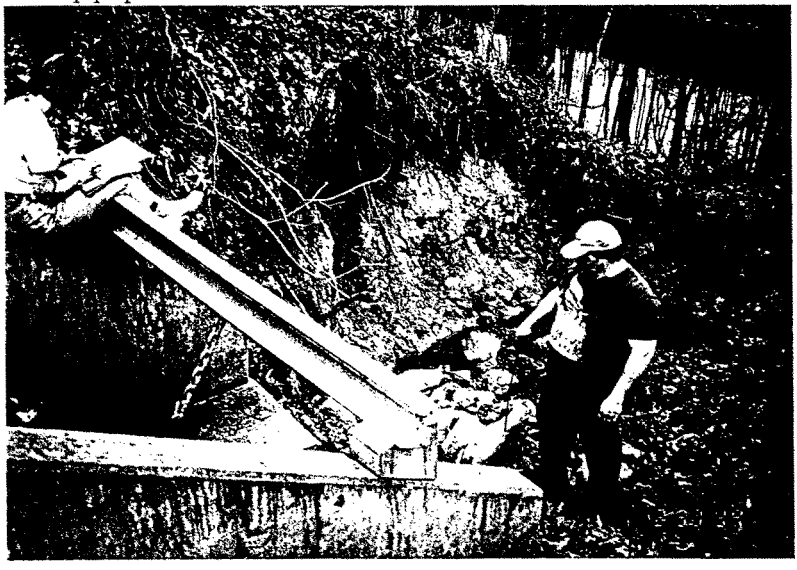

Photo #122

Riverside outlet of 48" CMP at approximate Station 112 + 00, Section C. This is a newer pipe placement. (Notice bank erosion at outlet area)

Paducah, Kentucky
Section 905 (b)

Photo #123

Approximate 6″ Deep pothole in levee crown at Station approximate 103 + 80.
Approximate 6″, Section C.

Paducah, Kentucky
Section 905 (b)

Photo #124
Abandoned railroad closure at Station 104 + 96, Section C.

Photo #125
Abandoned railroad closure at Station 104 + 96, Section C.

Paducah, Kentucky
Section 905 (b)

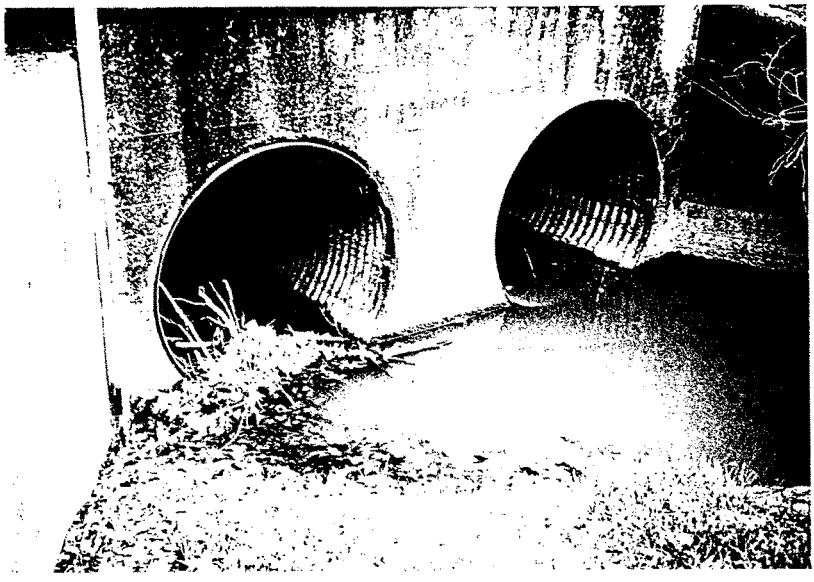

Photo #126
Landside inlet of twin 48" CMP's at Station 92 + 70, Section C.

Photo #127
Riverside outlet of twin 48" CMP's at Station 92 + 70, Section C.

Paducah, Kentucky
Section 905 (b)

Photo #128

Outlet channel at Station 92 + 70, Section C, drainage away from outlet structure appears to be negative thus ponding in this area.

Photo #129

Small eroded area on the landside levee slope just upstream from the I-24 embankment, Section C.

Paducah, Kentucky
Section 905 (b)

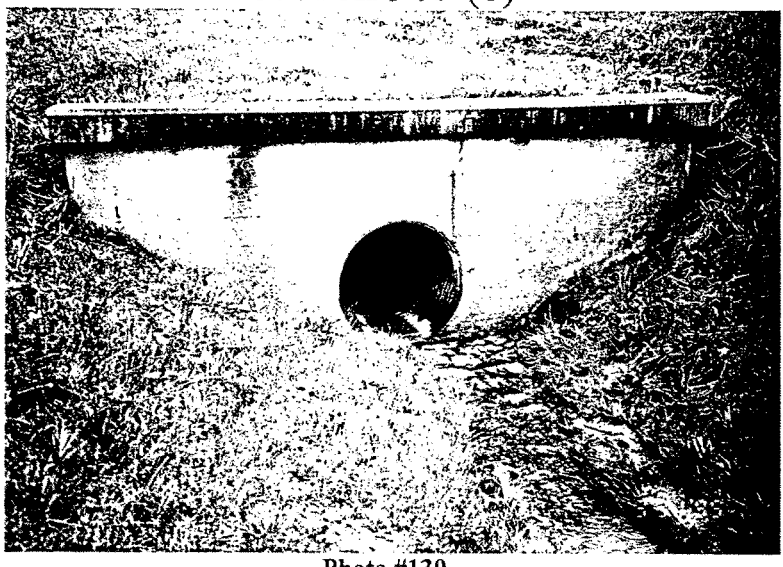

Photo #130
Landside inlet of 30" CMP at Station 51 + 28, Section C.

Photo #131
Landside inlet of 30" CMP at Station 51 + 28, Section C.
(Notice loss of bituminous coating in low-flow area)

Paducah, Kentucky
Section 905 (b)

Photo #132
Looking through 30″ RCP inlet at Station 51 + 28, Section C.
(Notice loss of bituminous coating)

Photo #133
Riverside outlet of 30" CMP at Station 51 + 28, Section C. Notice bank erosion at outlet area.

Paducah, Kentucky
Section 905 (b)

Photo #134
Two potholes in the levee crown at approximate Station 40 + 00, Section C.
(Approximate 150' south of Lydon Road crossing)

Photo #135
Rutting in the levee crown at approximate Station 38 + 00, Section C.

Paducah, Kentucky
Section 905 (b)

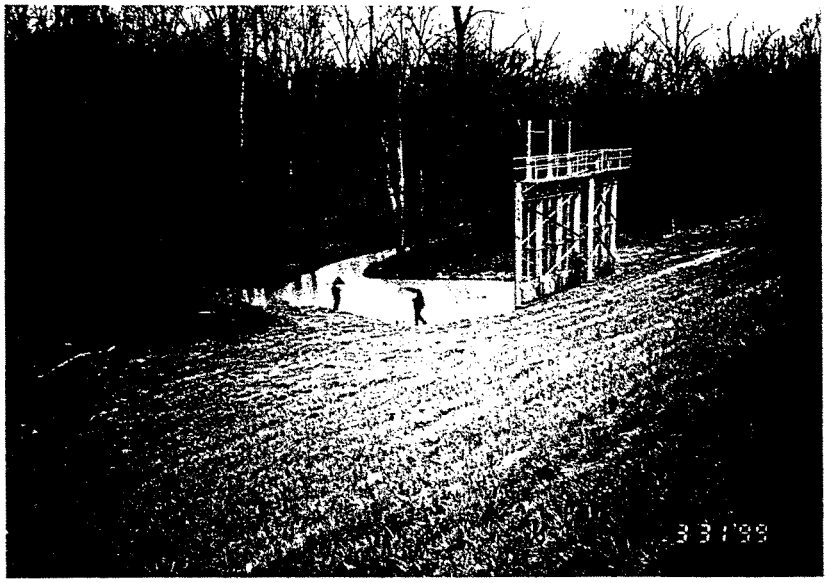

Photo #136

Sluice gates at outlet on riverside at Station 32 + 38 (3-60″ RCP's) and Station 32 + 12 (2- 48″ RCP's), Section C.

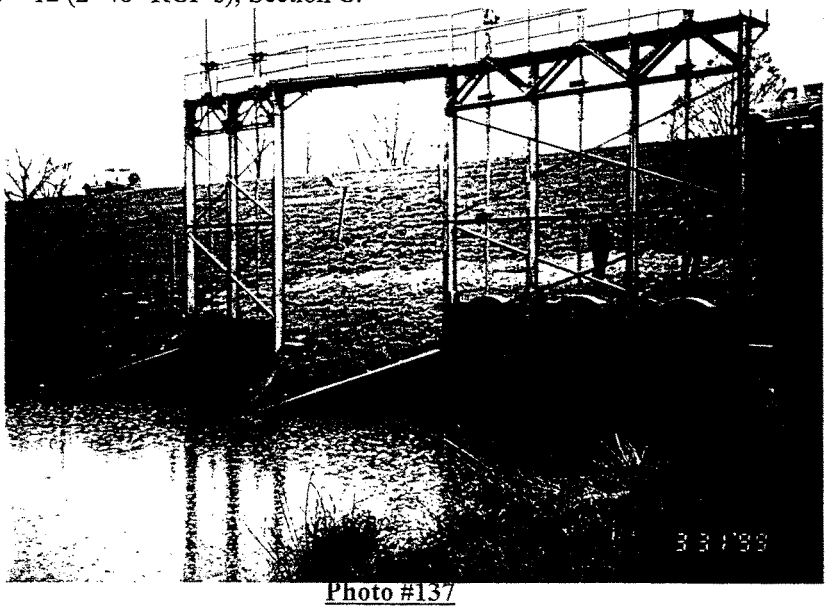

Photo #137

Sluice gates at outlet on riverside at Station 32 + 38 (3-60″ RCP's) and Station 32 + 12 (2- 48″ RCP's), Section C.

Paducah, Kentucky
Section 905 (b)

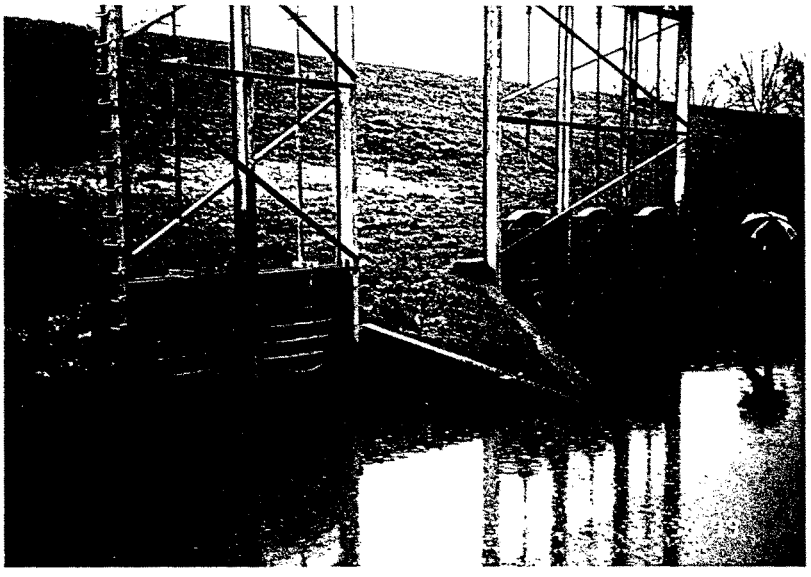

Photo #138

Sluice gates at outlet on riverside at Station 32 + 38 (3-60″ RCP's) and Station 32 + 12 (2- 48″ RCP's), Section C.

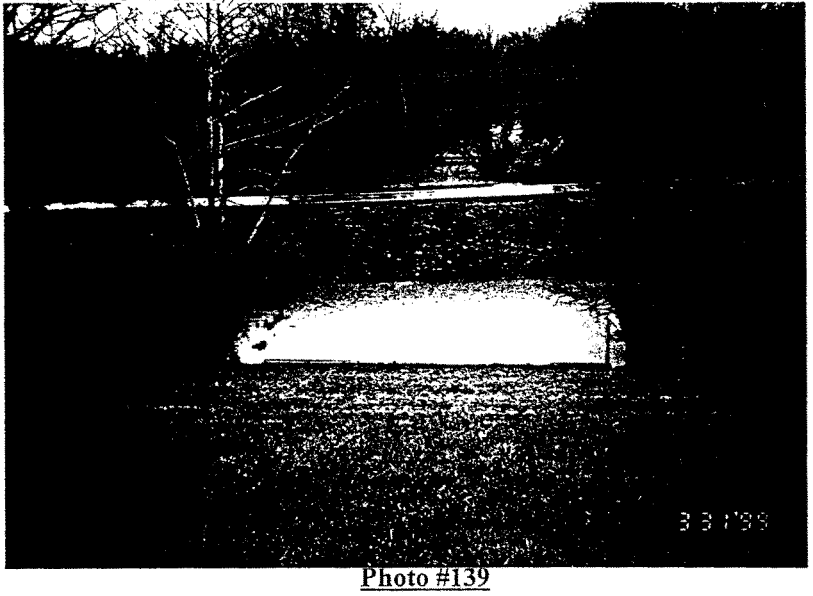

Photo #139

Landside inlet for Station 32 + 38 (3- 60″ RCP's) and Station 32 + 12 (2- 48″ RCP's), Section C.

Paducah, Kentucky
Section 905 (b)

Photo #140

Landside inlet for Station 32 + 38 (3- 60″ RCP's) and Station 32 + 12 (2- 48″ RCP's), Section C.

Appendix C
Electrical Evaluation

OHIO RIVER, PADUCAH, KENTUCKY
Flood Damage Reduction
Section 905(b) (WRDA 1996) Analysis

U.S. ARMY CORPS OF ENGINEERS
LOUISVILLE DISTRICT

Pump Station Electrical Evaluation

Summary

March 29 and 30, 1999, Tina Beavin and Ben Finn, CELRLED-DE inspected the thirteen pump stations in the Paducah Flood Protection Project. Gary Thompson, Floodwall Superintendent, accompanied them.

In general, the pump stations are in good condition, very well maintained and capable of many more years of service. Pump Station #11 has been totally upgraded, i.e. new motor control center, lights, automatic lubrication system, vibration monitors, programmable logic controllers, motor conductors and service entrance conductors. Pump Station #1 has been upgraded except for the programmable logic controller, automatic lubrication system and vibration monitors. Pump Station #2 has also been upgraded except for the automatic lubrication system and vibration monitors. All level sensors were in good operating condition and well maintained. Although parts for the sensors are obsolete, Gary Thompson stated that parts can be made and the sensors are easily maintained. Pump Station #2 & #11 have position transmitters installed on the existing level sensors that work in conjunction with the programmable logic controllers. The goal of the local flood authority is to totally automate the pump stations. They're currently researching monitoring systems and hope to soon have Pump Station #11 set up and in use as a test station.

Sluice Gate #2 is designed to be closed by hand crank. It is very labor intensive to operate and the gate is required to be closed several times per year. Currently, Floodwall personnel carry a 200 pound portable motor from Pump Station #2 over the levy to the gate. Safety is the main concern since the levy is usually wet when the gate is required to be closed. This method of closing the gate is also labor intensive.

Evaluation

Pump Station #1: Station is in excellent condition due to the electrical upgrade in 1996. Automatic lubrication system, vibration monitors, and programmable logic controllers are budgeted for installation in 2001. All motors ran well, however, Gary Thompson stated that all three motors operate above its full load current during a flood event. Once the level of the sump reaches a certain point, the amperage of the motors decrease.

Pump Station #2: Station is in excellent condition due to the electrical upgrade in 1996. Automatic lubrication system, vibration monitors are budgeted for installation in 2002. All equipment is new except for Pump No. 1 starter, which is the original starter. Pump No. 6 indicating run light is out. All motors ran well.

Pump Station #3: Station is well maintained, but all original equipment remains. No voltmeter was present. All motors ran well.

Pump Station #4: Station is in a concrete manhole. All original equipment is still being used, but station is well maintained. No voltmeter was present. All motors ran well.

Pump Station #5: Station is well maintained, but all original equipment remains.
Electrical upgrade is scheduled for summer of 1999. All motors ran well.

Pump Station #6: Station is well maintained, but all original equipment remains.
Electrical upgrade is scheduled for summer of 1999. All motors ran well.

Pump Station #7: Station is well maintained, but all original equipment remains. Starter for pump no. 2 would not immediately disengage when switched to OFF. Electrical upgrade is scheduled for 2000-01. All motors ran well.

Pump Station #8: Station is in concrete manhole. All original equipment is still being used, but station is well maintained. All motors ran well.

Pump Station #9: Station is well maintained, but all original equipment remains. Station was in operation two weeks prior to inspection and no problems were noted. No voltmeter was present. All motors ran well.

Pump Station #10: Station is in concrete manhole. All original equipment is still being used, but station is well maintained. Station has excess moisture, but there were no signs of corrosion. No ammeter or voltmeter was present. All motors ran well.

Pump Station #11: Station is in excellent condition due to recent electrical upgrade. All motors ran well.

Pump Station #12: Station is well maintained, but all original equipment remains. No voltmeter was present. All motors ran well.

Pump Station #13: Station is in good condition and well maintained. No meters were present. Motor ran well.

Recommendations

Pump Station # 1: Study the possibility of raising operating elevations of the pump station because of the motors running above the full load current while sump elevation is low.

Pump Station #2: Replace Pump No. 1 starter, rated 240 volts, 3 phase, NEMA size 3, with HAND-OFF-AUTO switch, circuit breaker and ammeter. Replace Pump No. 6 indicating run light.

Pump Station #3: Replace Pump No. 1 NEMA size 1, No. 2 & No. 3 NEMA size 3 starters with 400 amps, 230 volts, 3 phase motor control center with: main circuit breaker and voltmeter; starters with H-O-A switch, circuit breaker and ammeter; 5 kVA dry type transformer; 100 amps, 120/240 volts, single phase panel. Replace 230 volts, 3 phase service drop, motor conductors, hps lighting and receptacles.

Pump Station #4: Replace Pumps No. 1 & No. 2 starters rated 440 volts, 3 phase, 50 hp with H-O-A switch, circuit breaker and ammeter; underground 440 volts and 120/240 volt service entrance conductors; motor conductors; 50 amps, 120/240 volts, single phase panel with main circuit breaker; 480 volts main circuit breaker at pole.

Pump Station #5: Replace 480 volts, 3 phase motor control center with new MCC with: 800 amps main circuit breaker and voltmeter; 2 starters rated 200 hp, 1 starter 100 hp, 1 starter 25 hp, and all with H-O-A switch, circuit breaker and ammeter; 5 kVA dry type transformer; 100 amps, 120/240 volts single phase panel. Replace 480 volts, 3 phase service drop, motor conductors, hps lighting and receptacles.

Pump Station #6: Replace 480 volts, 3 phase motor control center with new MCC with: 1200 amps main circuit breaker and voltmeter; 3 starters rated 250 hp, 1 starter 125 hp, 1 starter 10 hp, and all with H-O-A switch, circuit breaker and ammeter; 5 kVA dry type transformer; 100 amps, 120/240 volts single phase panel. Replace 480 volts, 3 phase service drop, motor conductors, hps lighting and receptacles.

Pump Station #7: Replace 480 volts, 3 phase motor control center with new MCC with: 600 amps main circuit breaker and voltmeter; 1 starter rated 125 hp, 1 starter 50 hp, 1 starter 10 hp, and all with H-O-A switch, circuit breaker and ammeter; 5 kVA dry type transformer; 100 amps, 120/240 volts single phase panel. Replace 480 volts, 3 phase service drop, motor conductors, hps lighting and receptacles.

Pump Station #8: No work recommended.

Pump Station #9: Replace Pumps No. 1 & No. 2 starters rated 440 volts, 3 phase, 50 hp with H-O-A switch, circuit breaker and ammeter; overhead 440 volts and 120/240 volt service entrance conductors; motor

conductors; 100 amps, 120/240 volts, single phase panel with main circuit breaker; 200 amps, 480 volts main circuit breaker with voltmeter.

Pump Station #10: Replace Pumps No. 1 & No. 2 starters rated 220 volts, 3 phase, 15 hp with H-O-A switch, circuit breaker and ammeter; underground 220 volt service entrance conductors; motor conductors; 50 amps, 120/240 volts, single phase panel with main circuit breaker; .75 kVA transformer; 480 volts main circuit breaker at pole.

Pump Station #11: No work recommended.

Pump Station #12: Replace Pumps No. 1 & No. 2 starters rated 440 volts, 3 phase, 50 hp with H-O-A switch, circuit breaker and ammeter; overhead 440 volts and 120/240 volt service entrance conductors; motor conductors; 50 amps, 120/240 volts, single phase panel with main circuit breaker; 200 amps, 480 volts main circuit breaker with voltmeter.

Pump Station #13: No work recommended.

Sluice Gate #2: Recommend permanately installing a motor on the sluice gate for the opening and closing of the gate. Motor should be installed on a platform above flood stage.

Conclusion

Pump Stations #1, #2, & #11 are in excellent condition because of the recent electrical upgrades and are capable of being in operation several more years. Pump Stations # 5, #6, & #7 are scheduled for electrical upgrades over the next 3 years. The remaining Pump Stations, #3, #4, #8, #9, #10, #12 & #13 have not been planned or budgeted for an electrical upgrade. It is recommended to electrically upgrade Pump Stations #3, #4, #5, #6, #7, #9, #10 & #12. It is not recommended to upgrade Pump Stations #8 and #13. Pump Station #8 is seldom used, running once every ten years and parts from upgraded stations that are salvaged and saved can be used as spare parts for this station. Pump Station #13 was built in the late sixties and has no obsolete parts, therefore it is capable of being in operation several more years. It is also recommended to install a motor on Sluice Gate #2 due to the safety issues of the current method of operation.

PUMP STATION – ELECTRICAL EVALUATION
STATION DATA

Paducah, Kentucky **Noble Park Pump Station - #1**

Evaluator: Tina Beavin & Ben Finn . Date: 30 March 1999.

Switchgear

a. Nameplate Data: 480 volts, 3 phase, 3 wire, 60 hz, 800 amps

b. Manufacturer: Westinghouse.

c. Condition: Good, installed 1996.

d. Comments: Hand-Off-Automatic switch and start/stop pushbutton for each pump (1,2,3). Controlled by electrode level system, which works well.

e. Voltmeters: None.

f. Ammeters: 0-400 amps for each pump, and in good condition

g. Indicating Lights:.

Building

	Condition	NEC Compliance
Panel Board	100 amps, good	yes
Lights	HPS, good	yes
Receptacles	good	yes
Conduit	good	yes
Wiring	good	yes

Comments: Electrical service upgrade in 1996 – included new transformers, 3-167kVA and new service entrance conductors. Switchgear and motor conductors replaced in 1996. Pumps replaced and one added in the mid 1950's. Separate feed for the 120/240 volt service. Automatic lubrication, PLC operation and vibration monitors budgeted to be installed in 2001.

All 3 motors run above the full load current during flood event. Larger motors and variable frequency drives were suggested but are cost prohibitive. Station goes into operation at 42' and amperage of motors drop off once the sump level reaches 45'. Could change operating elevations. This is not a major problem, has been occurring since 1954 when station was upgraded and station operates only about 10 hours per year.

Overall station is in good condition and all systems operate well.

PUMP STATION – ELECTRICAL EVALUATION
PUMP DATA

Paducah, Kentucky **Noble Park Pump Station - #1**

Evaluator: Tina Beavin & Ben Finn . Date: 30 March 1999

Pump No. 1 Nameplate Data: 150 hp, 440 volts, 703 rpm, 191.5 FLA

a. Amperage Reading : 50 amps . Voltage Reading: none .

b. Electrical Connections: new .

Pump No. 2 Nameplate Data : 150 hp, 440 volts, 703 rpm, 191.5 FLA

a. Amperage Reading : 50 amps . Voltage Reading: none .

b. Electrical Connections: new .

Pump No. 3 Nameplate Data: 150 hp, 440 volts, 703 rpm, 191.5 FLA

a. Amperage Reading: 50 amps . Voltage Reading: none .

b. Electrical Connections: new .

PUMP STATION – ELECTRICAL EVALUATION
STATION DATA

Paducah, Kentucky **Sixth Street Pump Station - #2**

Evaluator: Tina Beavin & Ben Finn. Date: 30 March 1999

Switchgear

a. Nameplate Data: 1200 amps, 2400 volts, 60 hz, 3 phase for Pumps 2-6.

b. Manufacturer: Cutler Hammer Ampsgard Medium Voltage Controller.

c. Condition: Good, installed 1996.

d. Comments: Hand-Off-Automatic switch and start/stop pushbutton control provided for each pump starter. Westinghouse IQ 1000II electronic monitors on each 2300 volts starter. All is Y2K compliant.

e. Voltmeters: LED Function display.

f. Ammeters: LED Function display.

g. Indicating Lights: Green – OFF, Red-RUN, Pump #6 run light out.

Building

a.

	Condition	NEC Compliance
Panel Board	150 amps main, - new.	yes.
Lights	HPS-good.	yes.
Receptacles	good.	yes.
Conduit	good.	yes.
Wiring	good.	yes.

b. Transformers: 225 kVA, 2300 volts-pri, 277/480 volts-sec, for Pump #7. 45 kVA, 480 volts-pri, 120/208 volts-sec for Sump Pump #1 receptacles and lighting. Transformers installed in 1996.

c. Starter: Sump Pump #1, original starter, Westinghouse, 230 volts, NEMA size 3, H-O-A switch.

d. Variable Frequency Drive: ABB Drives, 480 volts, 140 amps, 3 phase for Pump #7 waste water treatment pump, good condition, installed in 1996.

Comments: Medium voltage starters, PLC, motor conductors, service entrance conductors, panelboard, transformers, VFD, installed in 1996. Auto lube and vibration monitors are scheduled to be installed in 2001-02. Position transmitter installed on existing electrode level system is in good condition and operates well. Station has by-pass capability (manual start) if PLC is not operating. Station is served by a 833 kVA transformer. Station is in excellent condition.

PUMP STATION – ELECTRICAL EVALUATION
PUMP DATA

Paducah, Kentucky **Sixth Street Pump Station -#2**

Evaluator: Tina Beavin & Ben Finn. Date: 30 March 1999

Pump No. 1 Nameplate Data: 20 hp, 220 volts, 3 phase, 880 rpm, 53 FLA.

a. Amperage Reading no meter. Voltage Reading no meter.

b. Electrical Connections: good.

Pump No. 2 Nameplate Data: 200 hp, 2300 volts, 760 rpm, 51.9 FLA.

a. Amperage Reading 48 amps. Voltage Reading 2300 volts.

b. Electrical Connections: good.

Pump No. 3 Nameplate Data: 800 hp, 2300 volts, 355 rpm, 196.2 FLA.

a. Amperage Reading 84 amps. Voltage Reading 2300 volts.

b. Electrical Connections: good.

Pump No. 4 Nameplate Data: 800 hp, 2300 volts, 355 rpm, 196.2 FLA.

a. Amperage Reading 82 amps. Voltage Reading 2300 volts.

b. Electrical Connections: good.

Pump No. 5 Nameplate Data: 500 hp, 2300 volts, 443 rpm, 124.4 FLA.

a. Amperage Reading 90 amps. Voltage Reading 2300 volts.

b. Electrical Connections: good.

Pump No. 6 Nameplate Data: 500 hp, 2300 volts, 443 rpm, 124.4 FLA.

a. Amperage Reading 48 amps. Voltage Reading 2300 volts.

b. Electrical Connections: good.

Pump No. 7 Nameplate Data: 100 hp, 480 volts, 1100 rpm, 122 FLA.

a. Amperage Reading 120 amps Voltage Reading 460 volts.

b. Electrical Connections: good.

PUMP STATION – ELECTRICAL EVALUATION
STATION DATA

Paducah, Kentucky **Park Avenue Pump Station - #3**

Evaluator: Tina Beavin & Ben Finn Date: 30 March 1999

Starters

a. Nameplate Data: Pump 1- NEMA size 1 starter, 220 volts, 35 amps circuit breaker; Pumps 2 & 3 – NEMA size 3 starter, 220 volts, 100 amps circuit breaker.

b. Manufacturer: Westinghouse

c. Condition: good, original equipment

d. Comments:

e. Voltmeters: None

f. Ammeters: 0-70 amps (2), 0-25 amps (1)

g. Indicating Lights: None

Building

	Condition	NEC Compliance
Panel Board	100 amps –good	yes
Lights	HPS - good	yes
Receptacles.	good	yes
Conduit	good	yes
Wiring	good	yes

Comments: : Main disconnect located outside of station. Overhead service entrance for 3 phase, 230 volt system for the pumps. Separate 120/240 volt service for lights and receptacles. All original equipment, and all maintained well. Each starter has a H-O-A switch. Electrode type level system operates well.

PUMP STATION – ELECTRICAL EVALUATION
PUMP DATA

Paducah, Kentucky **Park Avenue Pump Station - #3**

Evaluator: Tina Beavin & Ben Finn. Date: 30 March 1999.

Pump No. 1 Nameplate Data: 5 hp, 220 volts, 3 phase, 60 Hz, 14.2 FLA, 880 rpm.

a. Amperage Reading: 11 amps. Voltage Reading: no meter.

b. Electrical Connections: good.

Pump No. 2 Nameplate Data: 25 hp, 220 volts, 3 phase, 60 Hz, 68 FLA, 880 rpm.

a. Amperage Reading 28 amps. Voltage Reading no meter.

b. Electrical Connections: good.

Pump No. 3 Nameplate Data: 25 hp, 220 volts, 3 phase, 60 Hz, 68 FLA, 880 rpm.

a. Amperage Reading 26 amps. Voltage Reading no meter.

b. Electrical Connections: good.

PUMP STATION – ELECTRICAL EVALUATION
STATION DATA

Paducah, Kentucky **Clay Street Pump Station - #4**

Evaluator: Tina Beavin & Ben Finn . Date: 30 March 1999 .

Starters

a. Nameplate Data: Pumps 1 & 2 – 440 volts, rated for 50 hp, 3 phase .

b. Manufacturer: General Electric .

c. Condition: Good .

d. Comments: .

e. Voltmeters: None .

f. Ammeters: 0-100 amps .

g. Indicating Lights: None .

Building

	Condition	NEC Compliance
Panel Board	50 amps -good	yes
Lights	HPS – fair	yes
Receptacles	good	yes
Conduit	good	yes
Wiring	good	yes

Comments: Pump Station is in concrete manhole. Clean and no excess moisture present. All equipment is original. Main disconnect is located on the service pole. Two services, 480 volts for pumps and 120/240 for lights and receptacles. Each starter has H-O-A switch. Electrode type level sensor system operates well. .

PUMP STATION – ELECTRICAL EVALUATION
PUMP DATA

Paducah, Kentucky **Clay Street Pump Station - #4**

Evaluator: Tina Beavin & Ben Finn . Date: 30 March 1999

Pump No. 1 Nameplate Data: 50 hp, 440 volts, 3 phase, 60 Hz, 885 rpm .

a. Amperage Reading : 48 amps . Voltage Reading: .

b. Electrical Connections: good .

Pump No. 2 Nameplate Data: 50 hp, 440 volts, 3 phase, 60 Hz , 885 rpm .

a. Amperage Reading 48 amps . Voltage Reading .

b. Electrical Connections: good .

PUMP STATION – ELECTRICAL EVALUATION
STATION DATA

Paducah, Kentucky **Harrison Street Pump Station - #5**

Evaluator: Tina Beavin & Ben Finn Date: 30 March 1999

Switchgear

a. Nameplate Data: 3 phase, 480 volts

b. Manufacturer: Westinghouse

c. Condition: good, original

d. Comments: 4 motor starters

e. Voltmeters: 0-600 volts, good condition

f. Ammeters: 2 each – 0-300 amps, 1 each – 0-150 amps, 1 each 0-50 amps, all in good condition

g. Indicating Lights: each pump, red running/ green ready - good condition

Building

	Condition	NEC Compliance
Panel Board	100 amps, new	yes
Lights	hps, good	yes
Receptacles	good	yes
Conduit	good	yes
Wiring	good	yes

Comments: Overhead service from a 3-167kVA, transformer bank. 120 volt service is separate. All original equipment and well maintained. Electrical upgrade/modernization is scheduled for later this year. Upgrade includes motor control center, lubricators, vibration monitors, PLC, motor conductors, service conductors. 120 volt service will be provided through step down transformer in MCC.

PUMP STATION – ELECTRICAL EVALUATION
PUMP DATA

Paducah, Kentucky **Harrison Street Pump Station - #5**

Evaluator: Tina Beavin & Ben Finn. Date: 30 March 1999.

Pump No. 1 Nameplate Data: 200 hp, 440 volts, 240 FLA, 60 Hz, 694 rpm.

a. Amperage Reading 75 amps Voltage Reading 490 volts.

b. Electrical Connections: All connections good.

Pump No. 2 Nameplate Data: : 200 hp, 440 volts, 240 FLA, 60 Hz, 694 rpm.

a. Amperage Reading 75 amps Voltage Reading 490 volts.

b. Electrical Connections: All connections good.

Pump No. 3 Nameplate Data: 100 hp, 440 volts, 116 FLA, 60 Hz, 870 rpm.

a. Amperage Reading 35 amps Voltage Reading 490 volts.

b. Electrical Connections: All connections good.

Pump No. 4 Nameplate Data: 25 hp, 440 volts, 34 FLA, 60 Hz, 710 rpm.

a. Amperage Reading 25 amps Voltage Reading 490 volts.

b. Electrical Connections: All connections good.

PUMP STATION – ELECTRICAL EVALUATION
STATION DATA

Paducah, Kentucky **Clark Street Pump Station - #6**

Evaluator: Tina Beavin & Ben Finn . Date: 29 March 1999 .

Switchgear

a. Nameplate Data: 480 volts, 3 phase .

b. Manufacturer: Westinghouse .

c. Condition: good – original equipment .

d. Comments: 5 motor starters and circuit breakers .

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e. Voltmeters: 0 – 600 volts, good condition .

f. Ammeters: good condition .

g. Indicating Lights: motor circuits – on/off, good condition .

Building

	Condition	NEC Compliance
Panel Board	60 amps, good	yes
Lights	hps, good	yes
Receptacles	good	yes
Conduit	good	yes
Wiring	good	yes

Comments: Underground 480 volt service from 500 kVA transformer, separate 120 volt service. Level Control maintained well. 5 kVA transformer for control circuit for pumps in good condition. Station upgrade/ modernization due in summer of 1999. Includes new motor control center, automatic lubricators, vibration monitors, PLCs, service entrance and motor conductors. 120 volt service will come from step down transformer in MCC.

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PUMP STATION – ELECTRICAL EVALUATION
PUMP DATA

Paducah, Kentucky **Clark Street Pump Station - #6**

Evaluator: Tina Beavin & Ben Finn. Date: 29 March 1999

Pump No. 1 Nameplate Data: 250 hp, 440 volts, 3 phase, 60 Hz 323 FLA, 501 rpm.

a. Amperage Reading : 140 amps. Voltage Reading: 490 volts.

b. Electrical Connections: good.

Pump No. 2 Nameplate Data: 125 hp, 440 volts, 3 phase, 60 Hz, 151 FLA, 700 rpm.

a. Amperage Reading 130 amps Voltage Reading 490 volts.

b. Electrical Connections: good.

Pump No. 3 Nameplate Data: 250 hp, 440 volts, 3 phase, 60 Hz, 323 FLA, 501 rpm.

a. Amperage Reading 150 amps. Voltage Reading 490 volts.

b. Electrical Connections: good.

Pump No. 4 Nameplate Data: 250 hp, 440 volts, 3 phase, 60 Hz, 323 FLA, 501 rpm.

a. Amperage Reading 140 amps. Voltage Reading 490 volts.

b. Electrical Connections: good.

Pump No. 5 Nameplate Data: 10 hp, 440 volts, 3 phase, 14.4 FLA, 60 Hz, 875 rpm.

a. Amperage Reading 17 amps. Voltage Reading 490 volts.

b. Electrical Connections: good.

PUMP STATION – ELECTRICAL EVALUATION
STATION DATA

Paducah, Kentucky **Tennessee Street Pump Station - #7**

Evaluator: Tina Beavin & Ben Finn Date: 29 March 1999

Switchgear

a. Nameplate Data: 480 volts, 600 amps

b. Manufacturer: Westinghouse

c. Condition: good – original equipment

d. Comments: Motor starter and circuit breaker for 2 pumps, 1 pump has separate starter. H-O-A for pump # 2 would not disengage pump.

e. Voltmeters: 0-600

f. Ammeters: 0-100

g. Indicating Lights: motor circuits – running (red) / ready (green), good condition

Building

	Condition	NEC Compliance
Panel Board	100 amps, good	yes
Lights	HPS, good	yes
Receptacles	good	yes
Conduit	good	yes
Wiring	good	yes

Comments: Overhead 480 volt service from 3-75 kVA transformer bank, separate 120 volt service. Level control well maintained. 5 kVA transformer for control circuit for pumps in good condition. Station upgrade/modernization due in 2000-01. Includes new motor control center, automatic lubricators, vibration monitors, PLC, service entrance and motor conductors. 120 volt service will come from step down transformer in MCC and all 3 motor starters will be fed from MCC.

PUMP STATION – ELECTRICAL EVALUATION
PUMP DATA

Paducah, Kentucky **Tennessee Street Pump Station - #7**

Evaluator: Tina Beavin & Ben Finn . Date: 29 March 1999

Pump No. 1 Nameplate Data: 440 volts, 125 hp, 3 phase, 60 Hz, 700 rpm, 151 FLA .

a. Amperage Reading : 115 amps . Voltage Reading: 490 volts .

b. Electrical Connections: good .

Pump No. 2 Nameplate Data: : 440 volts, 50 hp, 3 phase, 60 Hz, 1170 rpm, 70 FLA .

a. Amperage Reading : 30 amps Voltage Reading: 490 volts .

b. Electrical Connections: good .

Pump No. 2 Nameplate Data: 440 volts, 10 hp, 3 phase, 60 Hz, 705 rpm, 17.4 FLA .

a. Amperage Reading : ammeter out of order . Voltage Reading: .

b. Electrical Connections: good .

PUMP STATION – ELECTRICAL EVALUATION
STATION DATA

Paducah, Kentucky **Near Norton Street Pump Station - #8**

Evaluator: Tina Beavin & Ben Finn. Date: 29 March 1999

Starters

a. Nameplate Data: Pumps 1 & 2 - 220 volts, 3 phase, rated for 2 hp.

b. Manufacturer: Square D.

c. Condition: good - original.

d. Comments: Starters have H-O-A switch and liquid level control.

g. Voltmeters: none.

h. Ammeters: none.

g. Indicating Lights: none.

Building

	Condition	NEC Compliance
Panel Board	good	yes
Lights	good	yes
Receptacles	good	yes
Conduit	good	yes
Wiring	good	yes

Comments: Pump station is in concrete manhole. Clean and no excess moisture present. All equipment is original. Main 60 amps disconnect switch is located on nearby service pole. Station is in use only once every ten years.

PUMP STATION – ELECTRICAL EVALUATION
PUMP DATA

Paducah, Kentucky **Near Norton Street Pump Station -#8**

Evaluator: Tina Beavin & Ben Finn. Date: 30 March 1999

Pump No. 1 Nameplate Data: 220 volts, 2 hp, single phase, 1150 rpm, 3.4 FLA.

a. Amperage Reading _____. Voltage Reading _____.

b. Electrical Connections: good.

Pump No. 2 Nameplate Data: 220 volts, 2 hp, single phase, 1150 rpm, 3.4 FLA.

a. Amperage Reading _____. Voltage Reading _____.

b. Electrical Connections: good.

PUMP STATION – ELECTRICAL EVALUATION
STATION DATA

Paducah, Kentucky **Near Husbands Street Pump Station - #9**

Evaluator: Tina Beavin & Ben Finn. Date: 30 March 1999

Starters

a. Nameplate Data: Pumps 1 & 2 - 440 volts, rated for 50 hp, 3 phase.

b. Manufacturer: General Electric.

c. Condition: good – original.

d. Comments: H-O-A switch for each pump.

g. Voltmeters: none.

h. Ammeters: 0-100.

g. Indicating Lights: none.

Building

	Condition	NEC Compliance
Panel Board	100 amps, good	yes
Lights	HPS, good	yes
Receptacles	good	yes
Conduit	good	yes
Wiring	good	yes

Comments: All original equipment and in good condition. 480 volts feed is overhead from a 3-25 kVA transformer bank. Level control system works well. Service was upgraded recently. Station had been in operation two weeks prior to the inspection and no problems were noted.

PUMP STATION – ELECTRICAL EVALUATION
PUMP DATA

Paducah, Kentucky **Near Husbands Street Pump Station - #9**

Evaluator: Tina Beavin & Ben Finn. Date: 30 March 1999

Pump No. 1 Nameplate Data: 440 volts, 40 hp, 3 phase, 870 rpm, 47.8 FLA.

a. Amperage Reading : 10 amps. Voltage Reading: .

b. Electrical Connections: good.

Pump No. 2 Nameplate Data: 440 volts, 40 hp, 3 phase, 870 rpm, 47.8 FLA.

a. Amperage Reading 10 amps. Voltage Reading .

b. Electrical Connections: good.

PUMP STATION – ELECTRICAL EVALUATION
STATION DATA

Paducah, Kentucky **Near George Street Pump Station - #10**

Evaluator: Tina Beavin & Ben Finn Date: 30 March 1999

Starters

a. Nameplate Data: Pumps 1 & 2 – 220 volts, rated 15 hp

b. Manufacturer: Square D

c. Condition: good – original equipment

d. Comments:

g. Voltmeters: None

h. Ammeters: None

g. Indicating Lights: None

Building

	Condition	NEC Compliance
Panel Board	50 amps -good	yes
Lights	HPS - fair	yes
Receptacles	good	yes
Conduit	good	yes
Wiring	good	yes

Comments: Pump station is in a concrete manhole. All equipment is original and in good condition. There is excess moisture but no signs of corrosion yet. Station main disconnect is located on nearby pole. Small transformer, .75 kVA, serves lights and receptacles. Each starter has a H-O-A switch. Electrode type level sensor operates well. Alarm/high water lights installed in recent years. Pumps ran well, no meters so could not take readings.

PUMP STATION – ELECTRICAL EVALUATION
PUMP DATA

Paducah, Kentucky **Near George Street Pump Station - #10**

Evaluator: Tina Beavin & Ben Finn. Date: 30 March 1999.

Pump No. 1 Nameplate Data: 10 hp, 3 phase, 220 volts, 875 rpm, 28.8 FLA.

a. Amperage Reading :_____. Voltage Reading:_____.

b. Electrical Connections: _____.

c. Controls:_____.

Pump No. 2 Nameplate Data: 10 hp, 3 phase, 220 volts, 875 rpm, 28.8 FLA.

a. Amperage Reading _____ Voltage Reading _____.

b. Electrical Connections: _____.

c. Controls:_____.

PUMP STATION – ELECTRICAL EVALUATION
STATION DATA

Paducah, Kentucky **Island Creek Pump Station - #11**

Evaluator: Tina Beavin & Ben Finn Date: 29 March 1999

Switchgear

a. Nameplate Data: 480 volts, 2000 amps, 3 wire, 3 phase

b. Manufacturer: Cutler Hammer/ Westinghouse Advantage MCC

c. Condition: new

d. Comments: Pump starting by PLC.

i. Voltmeters: 0-600

j. Ammeters: 0-600 (one for each pump)

g. Indicating Lights: all good condition

Building

	Condition	NEC Compliance
Panel Board	new	yes
Lights	new	yes
Receptacles	good	yes
Conduit	good	yes
Wiring	good	yes

Comments: Pump station upgraded/modernization included new motor control center, lights, PLC, auto lube, service entrance and motor conductors, vibration monitors, dry type transformer for 120/208 volt loads. Level sensor works well, new transmitter added to existing gauge. Working towards total automatic operation of station – will be a test station for remaining pump stations.

PUMP STATION – ELECTRICAL EVALUATION
PUMP DATA

Paducah, Kentucky **Island Creek Pump Station - #11**

Evaluator: Tina Beavin & Ben Finn . Date: 29 March 1999

Pump No. 1 Nameplate Data: 300 hp, 460 v, 3 phase, 391 rpm, 421 FLA .

a. Amperage Reading 150-175 amps . Voltage Reading 490 volts .

b. Electrical Connections: good .

Pump No. 2 Nameplate Data: 300 hp, 460 v, 3 phase, 584 rpm, 374 FLA .

a. Amperage Reading 150-175 amps . Voltage Reading 490 volts .

b. Electrical Connections: good .

Pump No. 3 Nameplate Data: 300 hp, 460 v, 3 phase, 584 rpm, 374 FLA .

a. Amperage Reading 150-175 amps . Voltage Reading 490 volts .

b. Electrical Connections: good .

Pump No. 4 Nameplate Data: 300 hp, 440 v, 3 phase, 584 rpm, 374 FLA .

a. Amperage Reading . Voltage Reading .

b. Electrical Connections: good .

c. Comments: Additional pump added in 1998. Pump could not be operated without water.

PUMP STATION – ELECTRICAL EVALUATION
STATION DATA

Paducah, Kentucky **Southeast of Paducah Pump Station - #12**

Evaluator: Tina Beavin & Ben Finn Date: 29 March 1999

Starters

a. Nameplate Data: Pumps 1 & 2 – 480 volts, 80 amps, 3 phase

b. Manufacturer: Westinghouse

c. Condition: good – original

d. Comments:

i. Voltmeters: None

j. Ammeters: 0 – 100 amps

g. Indicating Lights: none

Building

	Condition	NEC Compliance
Panel Board	50 amps – good	yes
Lights	good	yes
Receptacles	good	yes
Conduit	good	yes
Wiring	good	yes

Comments: Two services, 480 volts for pumps and 120/240 volts for lights and receptacles. New service transformers installed two years ago. No main disconnect in station. Original tape type level sensor operates trouble free. All equipment in station is original and in good condition.

PUMP STATION – ELECTRICAL EVALUATION
PUMP DATA

Paducah, Kentucky **Southeast of Paducah Pump Station - #12**

Evaluator: Tina Beavin & Ben Finn. Date: 29 March 1999

Pump No. 1 Nameplate Data: 440 volts, 50 hp, 3 phase, 885 rpm, 75 FLA.

a. Amperage Reading : 50 amps. Voltage Reading: .

b. Electrical Connections: good.

Pump No. 2 Nameplate Data: 440 volts, 50 hp, 3 phase, 885 rpm, 75 FLA.

a. Amperage Reading 45 amps. Voltage Reading .

b. Electrical Connections: good.

PUMP STATION – ELECTRICAL EVALUATION
STATION DATA

Paducah, Kentucky **Urban Renewal Pump Station - #13**

Evaluator: Tina Beavin & Ben Finn. Date: 29 March 1999

Starters

a. Nameplate Data: Pumps 1 – 460 volts, 3 phase , size 4, fused at 125 amps.

b. Manufacturer: Furnas.

c. Condition: good – original.

d. Comments: Starter with stop/start button.

k. Voltmeters: none.

l. Ammeters: none.

g. Indicating Lights: none.

Building

	Condition	NEC Compliance
Panel Board	200 amps – good	yes
Lights	good	yes
Receptacles	good	yes
Conduit	good	yes
Wiring	good	yes

Comments: This station was built in 1968. All equipment , panels lights, exhaust fan, unit heater, conduit, wiring, thermostats are in good condition. Two separate services, one for the pump and the other for the 120 volt loads.

PUMP STATION – ELECTRICAL EVALUATION
PUMP DATA

Paducah, Kentucky **Urban Renewal Pump Station - #13**

Evaluator: Tina Beavin & Ben Finn. Date: 29 March 1999

Pump No. 1 Nameplate Data: 460 volts, 50 hp, 3 phase.

a. Amperage Reading : 50 amps. Voltage Reading: .

b. Electrical Connections: good.

Appendix D
Mechanical Evaluation

OHIO RIVER, PADUCAH, KENTUCKY
Flood Damage Reduction
Section 905(b) (WRDA 1996) Analysis

U.S. ARMY CORPS OF ENGINEERS
LOUISVILLE DISTRICT

Pump Station Mechanical Evaluation

Summary

June 28 thru July 1, 1999, Mark Robertson, CELRLED-DM inspected the thirteen pump stations and manholes (confined space entries) in the Paducah Flood Protection Project. Gary Thompson, Floodwall Superintendent, Wayne Ryan and Harold Newton, Floodwall Operators accompanied him.

In general, the pump stations superstructures are in good condition, while the substructures (sump wells) were in a state of disrepair. Superstructures were very well maintained and capable of many more years of service. The substructures need to be maintained by cleaning of the areas after high water events, thus eliminating some of the repair work that is required for this study.

Evaluation and Recommendations

Pump Station #1; Noble Park: Station superstructure is in good condition, except that hoist needs to be repaired. Lubrication system is a manual Farval grease type and is in good condition for all three pumps in the station. Pumps are started manually when water level is at 5 feet and shutdown is automatic between 3 and 5 feet using mercury float bulbs, no problems have been encountered with the control system. The pumps where painted in 1995 and appear to be in good condition. Photo # 26 shows the discharge flapgates on the headwall, note the good condition of the outlet. Vibration displacement measurements where taken on all three pumps using peak to peak technique (mils vs rpm, see vibration displacement and velocity severity chart for general horizontal rotating machinery; IRD Mechanalysis, Inc. in the Mechanical Appendix). The following table gives the field measurements that where taken during operation of the equipment:

Pump Identification	Displacement (mils)	Pump Velocity (rpm)	Severity of Operation*	Rebuild Required
1	1.7	703	Good	Yes, See Note 1
2	2.56	703	Fair	Yes
3	3.6	703	Fair	Yes

- Pumps that are in the good range are better with regular maintenance should provide many years of reliable operation. Pumps that are below the good range are required to be rebuilt with all new rotating elements which include the shaft, enclosure tube, bearings and couplings. Pumps that are being rebuilt will also require impellers to be dynamically rebalanced and new Dresser type couplings installed on the discharge piping.

Note 1: Pump needs to be rebuilt due to the fact that there was a knocking noise. The noise indicates a possible wear or failure problem at the impeller or diffuser bearing locations. All three pumps were observed to have this problem. I am recommending the installation of a vortex suppressor at this pump station, due to the type of inflow conditions at the sump entrance, see photo # 22 and 23. My experience has shown that by installing a suppressor, we can reduce the amount of cavitation and wear damage that is currently be shown on this three pumps.

Pump Station #2; Sixth Street: Station superstructure is in good condition. Lubrication system is a manual Farval type for six pumps and oil lubrication for pump #7 only, systems are in good condition throughout the station. Pumps are started manually and shutdown is automatic using mercury float bulbs, no problems have been encountered with the control system. All discharge piping requires replacement located within the sump, due to heavy corrosion, see photos # 30, 31. Replace pressure piping from discharge elbow to the first dresser coupling located outside the sump wall in the levee. Also, replace discharge piping at the outlet headwall to a point approximately 10 feet back from the headwall. Pipe replacement is not necessary for pump #7 (20-inch pipe), since it was installed in 1996. The pipeline that had collapsed next to the 20-inch line was replaced at the headwall during installation of the 20-inch line. Photo # 32 shows heavily corroded air vent from sump to outside, vent on north and south sides of the sump need to be replaced. Photo #33 shows the 102-inch sluice gate operator on the side of the levee, see electrical report which has indicated that this is a safety problem, since a heavy motor operated device has to be brought to this location to operate the gate. Vibration displacement measurements where taken on all three pumps using peak to peak technique (mils vs rpm, see vibration displacement and velocity severity chart for general

horizontal rotating machinery; IRD Mechanalysis, Inc. at the end of this Appendix). The following table gives the field measurements that where taken during operation of the equipment:

Pump Identification	Displacement (mils)	Pump Velocity (rpm)	Severity of Operation*	Rebuild Required
1 (Sump Type)	N/A	880	N/A	No
2	0.9	706	Very Good	No; See Note 1
3	8.6	355	Fair	Yes
4	8.6	355	Fair	Yes
5	8.6	443	Slightly Rough	Yes, See Note 2
6	No Measurements	443	N/A	No; See Note 3
7	3.4	1200	Slightly Rough	Yes

- Pumps that are in the good range are better with regular maintenance should provide many years of reliable operation. Pumps that are below the good range are required to be rebuilt with all new rotating elements which include the shaft, enclosure tube, bearings and couplings. Pumps that are being rebuilt will also require impellers to be dynamically rebalanced and new Dresser type couplings installed on the discharge piping.

Note 1: Impeller has been damaged, see photo # 24, requires that a new impeller be installed.

Note 2: Impeller needs to have nicks on edges repaired, see photo # 25.

Note 3: Measurements for vibration were not taken, pump ran smooth in the sump.

Pump Station #3; Park Avenue: Station superstructure is in good condition, except that hoist needs to be repaired. Lubrication system is a manual Farval type and is in good condition for all three pumps in the station. Pumps are started and shutdown manually when water level is at 8 feet and 3 feet respectively. The pumps and discharge piping within the sump required sandblasting and repainting, see photos # 28 and 29. Painting of pump components will be accomplished using Corps of Engineers Formula C-200 (Coal tar epoxy). Vibration displacement measurements where not taken at this location since all three pumps operated without any noticeable vibration problems. The supports and grating for the top of the discharge well are heavily deteriorated and require replacement.

Pump Station #4; North 3rd St. & Executive Blvd.: Station is a underground dry will type with no superstructure. Sump structure was in excellent condition, see photo # 18. Lubrication system is a manual grease type and is in good condition. Pumps are started and shutdown automatically with electrodes. The pumps and discharge piping located within the dry well are in good condition. Vibration displacement measurements where not taken at this location since both pumps operated without any noticeable vibration problems.

Pump Station #5; Harrison Street: Station superstructure is in good condition. Lubrication system is a manual grease type for tail bearing and automatic oil for line shaft bearings, system is in good condition for all four pumps in the station. Pumps are started and shutdown manually. The supports and grating for the top of the discharge well are heavily deteriorated and require replacement. Vibration displacement measurements where taken on all three pumps using peak to peak technique (mils vs rpm, see vibration displacement and velocity severity chart for general horizontal rotating machinery; IRD Mechanalysis, Inc. in the Mechanical Appendix). The following table gives the field measurements that where taken during operation of the equipment:

Pump Identification	Displacement (mils)	Pump Velocity (rpm)	Severity of Operation*	Rebuild Required
1	2.4	694	Fair	Yes
2	7.0	694	Slightly Rough	Yes
3	2.4	870	Fair	Yes, See Note 1
4 (Sump)	0.12	710	Extreme Smooth	No

- Pumps that are in the good range are better with regular maintenance should provide many years of reliable operation. Pumps that are below the good range are required to be rebuilt with all new rotating elements, which

include the shaft, enclosure tube, bearings and couplings. Pumps that are being rebuilt will also require impellers to be dynamically rebalanced and new Dresser type couplings installed on the discharge piping. Existing couplings are currently leaking and corroding, see photos # 16.

Note 1: Impeller has been damaged, see photo # 15 , requires that a new impeller be installed.

Pump Station #6; Clark Street: Station superstructure is in good condition. Lubrication system is a manual grease type for tail bearing and automatic oil for lineshaft bearings are in good condition for all five pumps in the station. Pumps are started and shutdown manually when water level is at 8 feet and shutdown is at 3 feet, respectively. Level indicator requires adjustment, investigation indicated being 1.5 feet off. The pumps and discharge piping within the sump require sandblasting and repainting, see photo # 17, 19, 20 and 21. Painting of pump components will be accomplished using Corps of Engineers Formula C-200 (Coal tar epoxy). The supports and grating for the top of the discharge well are heavily deteriorated and require replacement. Vibration displacement measurements where taken on all three pumps using peak to peak technique (mils vs rpm, see vibration displacement and velocity severity chart for general horizontal rotating machinery; IRD Mechanalysis, Inc. in the Mechanical Appendix). The following table gives the field measurements that where taken during operation of the equipment:

Pump Identification	Displacement (mils)	Pump Velocity (rpm)	Severity of Operation*	Rebuild Required
1	2.17	501	Good	No, See Note 1
2	10.0	700	Slightly Rough	Yes
3	5.8	501	Fair	Yes
4	9.6	501	Slightly Rough	Yes
5 (Sump)	0.05	875	Extremely Smooth	No

- Pumps that are in the good range are better with regular maintenance should provide many years of reliable operation. Pumps that are below the good range are required to be rebuilt with all new rotating elements which include the shaft, enclosure tube, bearings and couplings. Pumps that are being rebuilt will also require impellers to be dynamically rebalanced and new Dresser type couplings installed on the discharge piping.

Note 1: Pump #1 requires a new Dresser type coupling be installed on the discharge pipe in the sump.

Pump Station #7; Tennessee Street: Station superstructure is in good condition. Lubrication system is a manual grease type for tail bearing and automatic oil for lineshaft bearings are in good condition for all three pumps in the station. Pumps are started and shutdown manually. The pumps and discharge piping within the sump require sandblasting and repainting, see photos # 4, 6, 8, 9, 10, 11 and 12. Painting of pump components will be accomplished using Corps of Engineers Formula C-200 (Coal tar epoxy). Vibration displacement measurements where not taken at this location since all pumps operated without any noticeable vibration problems. The discharge well has a crack (see photo # 13) located near the ladder in the well, recommend that crack be pressure grouted. Also, the supports and grating for the top of the discharge well are heavily deteriorated and require replacement, see photo #14.

Pump Station #8; Norton Street: Station is a underground dry will type with no superstructure. Sump structure was in good condition, see photo # 5. Lubrication system is a manual grease type and is in good condition. Pumps are started and shutdown automatically with electrodes. The pumps and discharge piping located within the dry well are in good condition. Vibration displacement measurements where not taken at this location since both pumps operated without any noticeable vibration problems.

Pump Station #9; Husbands Street: Station is a underground dry will type with no superstructure. Sump structure was in good condition. Lubrication system is automatic oil for lineshaft bearings and manual grease type for tail bearing and is in good condition. Pumps are started manually. The pumps and discharge piping located within the dry well are in good condition. Vibration displacement measurements where not taken at this location since both pumps operated without any noticeable vibration problems.

Pump Station #10; George Street: Station is a underground dry will type with no superstructure. Sump structure was in good condition. Lubrication system is a manual grease type and is in good condition. Pumps are started and shutdown automatically with electrodes. The pumps and discharge piping located within the dry well are in good condition. Vibration displacement measurements where not taken at this location since both pumps operated without any noticeable vibration problems.

Pump Station #11; Island Creek: Station superstructure is in good condition, except for a clutch problem in the hoist that requires repair. Automatic grease lubrication system for pumps 2 thru 4 were found to be in good condition. Pump #1 has a water lubricating system. Pump #1 was installed in Nov. 1998, manufacturer has indicated that the pumps shall not be run in a dry condition, therefore during this investigation the pump was not operated. Superintendent informed me they're where no problems encountered when it was last operated. Pumps are started and shutdown manually. Vibration displacement measurements where taken on all three pumps using peak to peak technique (mils vs rpm, see vibration displacement and velocity severity chart for general horizontal rotating machinery; IRD Mechanalysis, Inc. in the Mechanical Appendix). The following table gives the field measurements that where taken during operation of the equipment:

Pump Identification	Displacement (mils)	Pump Velocity (rpm)	Severity of Operation*	Rebuild Required
1	N/A	590	N/A	No
2	0.54	600	Smooth	No
3	0.18	600	Very Smooth	No
4	0.18	600	Very Smooth	No

- Pumps that are in the good range are better with regular maintenance should provide many years of reliable operation. Pumps that are below the good range are required to be rebuilt with all new rotating elements, which include the shaft, enclosure tube, bearings and couplings. Pumps that are being rebuilt will also require impellers to be dynamically rebalanced and new Dresser type couplings installed on the discharge piping.

Pump Station #12: Station superstructure is in good condition. Lubrication system is a manual grease type for tail bearing and automatic oil for lineshaft bearings are in good condition for both pumps in the station. Pumps are started and shutdown manually at 4.25 feet and 3.5 feet, respectively. Stop elevation is currently lower than required by the Corps of Engineers Operation and Maintenance Manual. Superitendent informed us that the pumps are being operated at lower elevations to prevent residential flood damages in the area of ponding. Photo # 7 shows inside of suction bowl and impeller, both are in good condition. Vibration displacement measurements where taken on all three pumps using peak to peak technique (mils vs rpm, see vibration displacement and velocity severity chart for general horizontal rotating machinery; IRD Mechanalysis, Inc. in the Mechanical Appendix). The following table gives the field measurements that where taken during operation of the equipment:

Pump Identification	Displacement (mils)	Pump Velocity (rpm)	Severity of Operation*	Rebuild Required
1	6.8	880	Slightly Rough	Yes
2	7.4	880	Slightly Rough	Yes

- Pumps that are in the good range are better with regular maintenance should provide many years of reliable operation. Pumps that are below the good range are required to be rebuilt with all new rotating elements, which include the shaft, enclosure tube, bearings and couplings. Pumps that are being rebuilt will also require impellers to be dynamically rebalanced and new Dresser type couplings installed on the discharge piping.

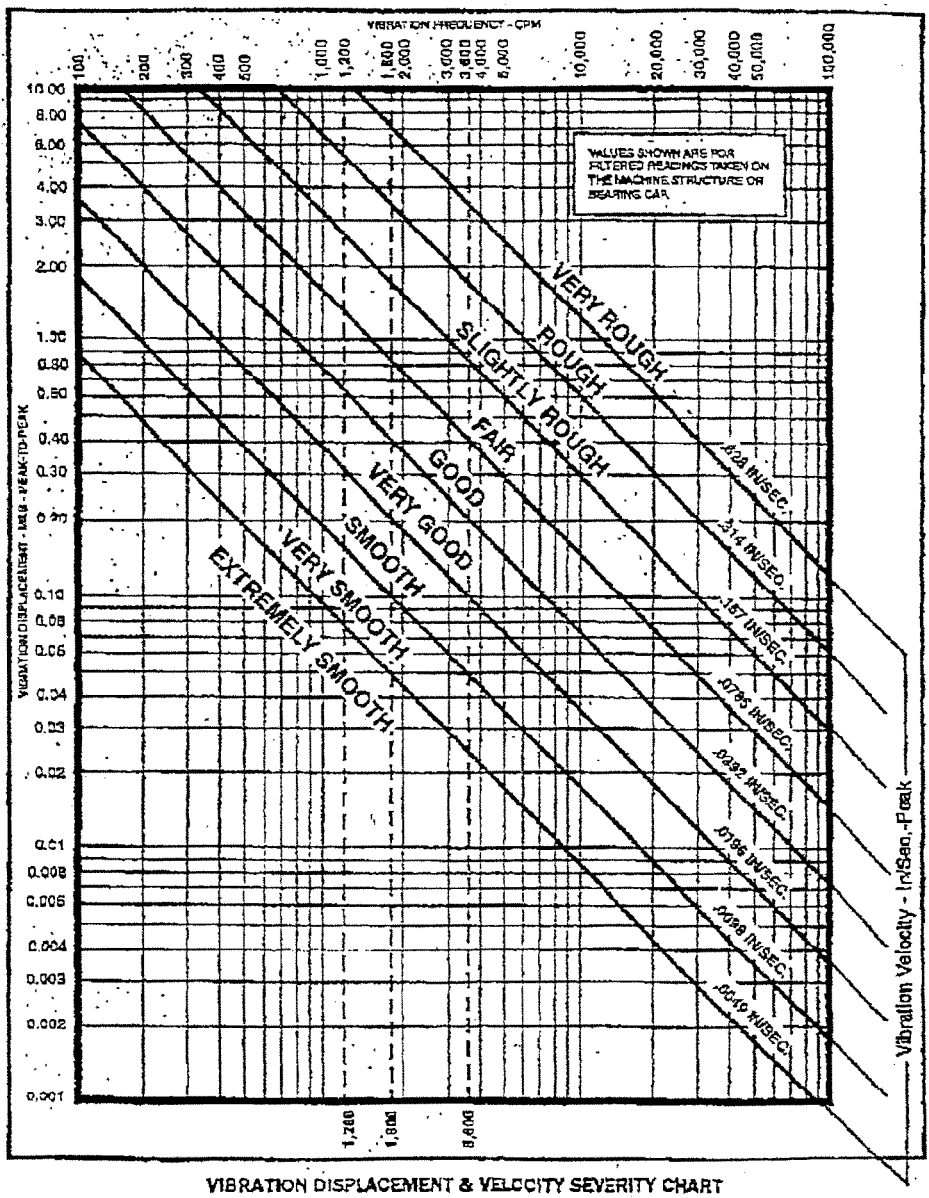
Pump Station #13: Station superstructure is in good condition. Lubrication system is a manual grease type for tail bearing and automatic oil for lineshaft bearings, system is in good condition. Pumps are started and shutdown manually. Vibration displacement measurements where not taken at this location since pump could not be operated due to pump having ceramic type seals.

Manholes that were inspected during site visit: Inspections where made of all confined space entries in manholes (see table for manholes gated outlets in this appendix) that have gated outlets and visual inspections made of all headwalls that contain flapgates. The following is a list of locations and new equipment to be installed at each structure:

1. 20-inch flapgate at MH # 8-A, Sta. 123+61-B2.
2. 24-inch flapgate at MH # 7-A, Sta. 119+37-B2.
3. 8-inch gate valve at MH # 6-B2, Sta. 115+26-B.
4. Two – 36-inch by 36-inch sluice gates at MH # 3-B2, Sta. 108+58-B.
5. 54-inch sluice gate at MH # 3-A, Sta. 108+58-B2, see photo # 36.
6. 30-inch flapgate at MH # 5-A, Sta. 69+86-B1.
7. 24-inch flapgate at MH # 4-A, Sta. 57+98-B1.
8. New seat for 60-inch flapgate frame only at Sta. 200+35-A.
9. New ladder rungs for MH at Sta. 187+34-A.
10. 24-inch flapgate at Sta. 84+00-A.
11. New structural covering and supports for MH 24-B2 at Sta. 66+17-A, see photos # 27 and 37.
12. New ladder rungs for MH 15-A at Sta. 149+72-B2, gate does not seal due to concrete poured into channel flow during conversion from sanitary to storm sewer manhole, see photo # 38.
13. New ladder rungs for MH 12-P at Sta. 145+61-B, see photo # 35.
14. New ladder rungs for MH 1-P at Second and Jefferson Streets.
15. New ladder rungs for North location MH 2-P at Second and Jefferson Streets.
16. 30-inch flapgate at Sta. 244+65-C.
17. Two – 48-inch flap Sta. 92+70-C.
18. Replace the seats and bushings for three – 30-inch at Sta. 32+38-C.
19. Replace the seats and bushings for two – 48-inch at Sta. 32+12-C.
20. Two – 60-inch flapgates at discharge outlet headwall for pump station # 2, see photo # 34.
21. Two – 48-inch flapgates at discharge outlet headwall for pump station # 2, see photo # 34.
22. 30-inch flapgate at discharge outlet headwall for pump station # 2, see photo # 34.
23. 12-inch flapgate at discharge outlet headwall for pump station # 2, see photo # 34.

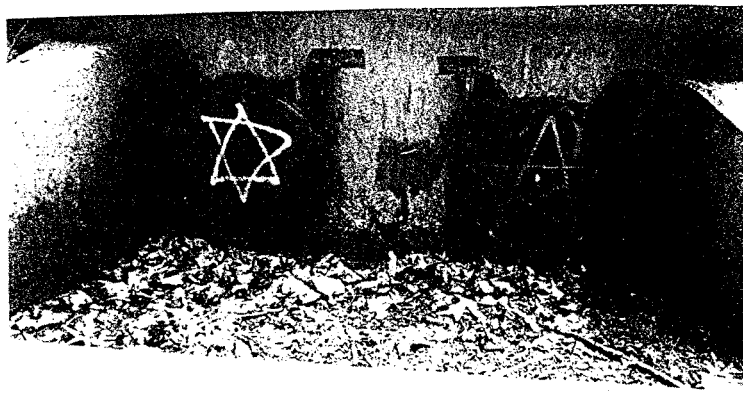
Manholes that require the replacement of walkway and operating grating and supports, due to deterioation:

1. Manhole # 16-B2, Sta. 150+62-B.
2. Manhole # 13-P, Sta. 145+92-B.
3. Manhole # 14-B2, Sta. 145+92-B.
4. Manhole # 12-P, Sta. 145+61-B, see photo # 35.
5. Manhole # 11-B2, Sta. 128+61-B.
6. Manhole # 7-B2, Sta. 119+45-B.
7. Manhole # 3-B2, Sta. 108+58-B.
8. Manhole # 14-P, Sta. 90+36-B.
9. Manhole # 1-B2, Sta. 90+36-B.
10. Manhole # 5-B1, Sta. 69+86-B.
11. Manhole # 4-B1, Sta. 57+98-B.



VIBRATION DISPLACEMENT & VELOCITY SEVERITY CHART
FOR GENERAL HORIZONTAL ROTATING MACHINERY
(Source: IRD Mechanalysis, Inc. Columbus, Ohio)
FIGURE 20

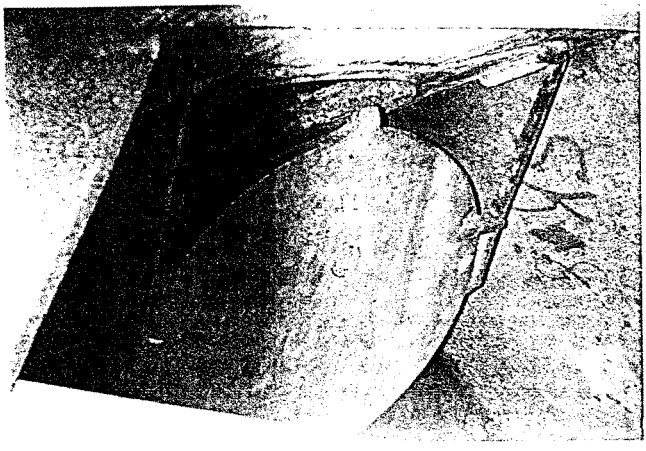
Paducah Reconnaissance Report



#1

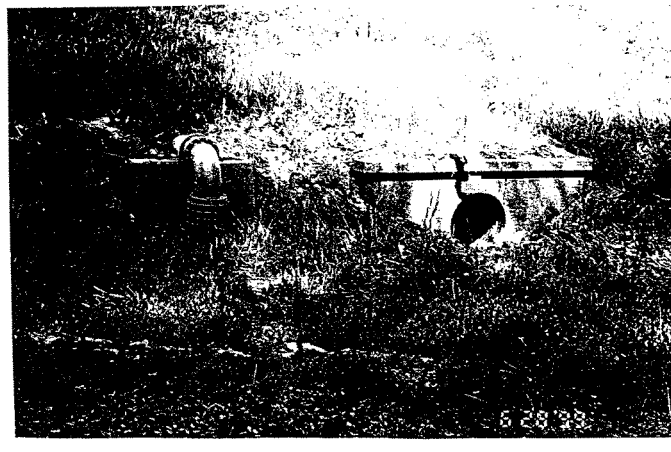
Pump Station #12

Discharge flapgates



#2

48" Flapgate
STA. 176+90



#3

Pump Station #13

Intake.

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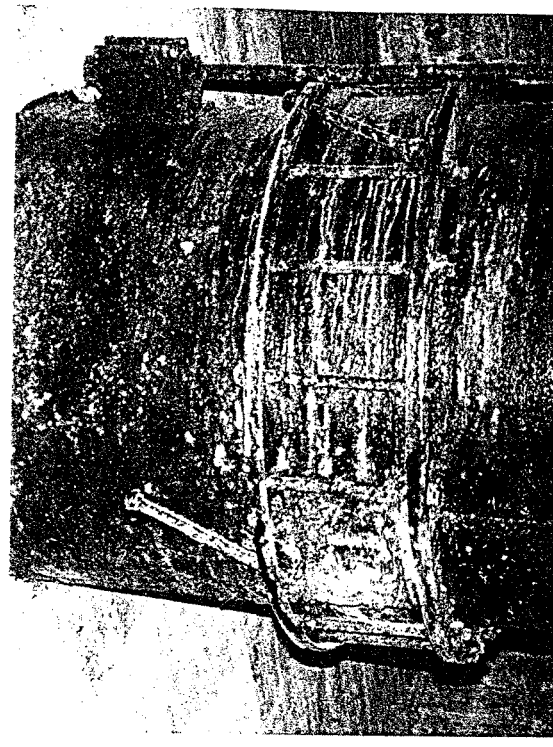


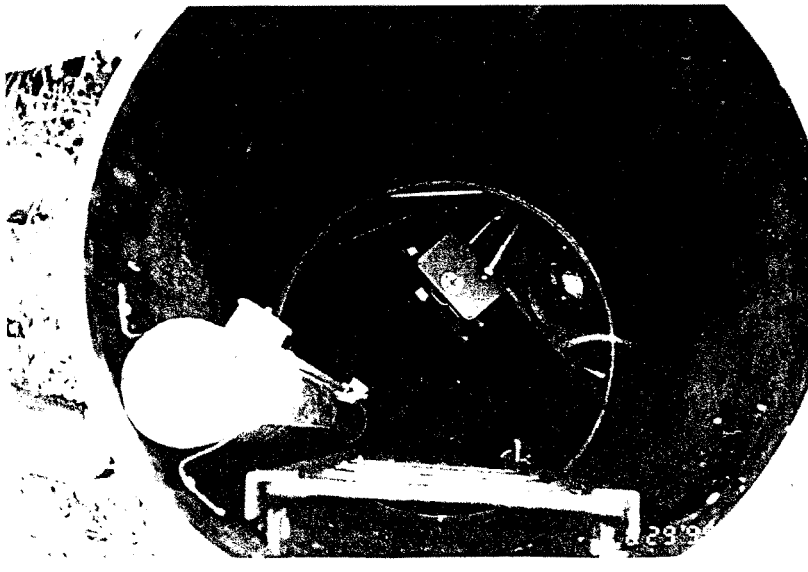
#4

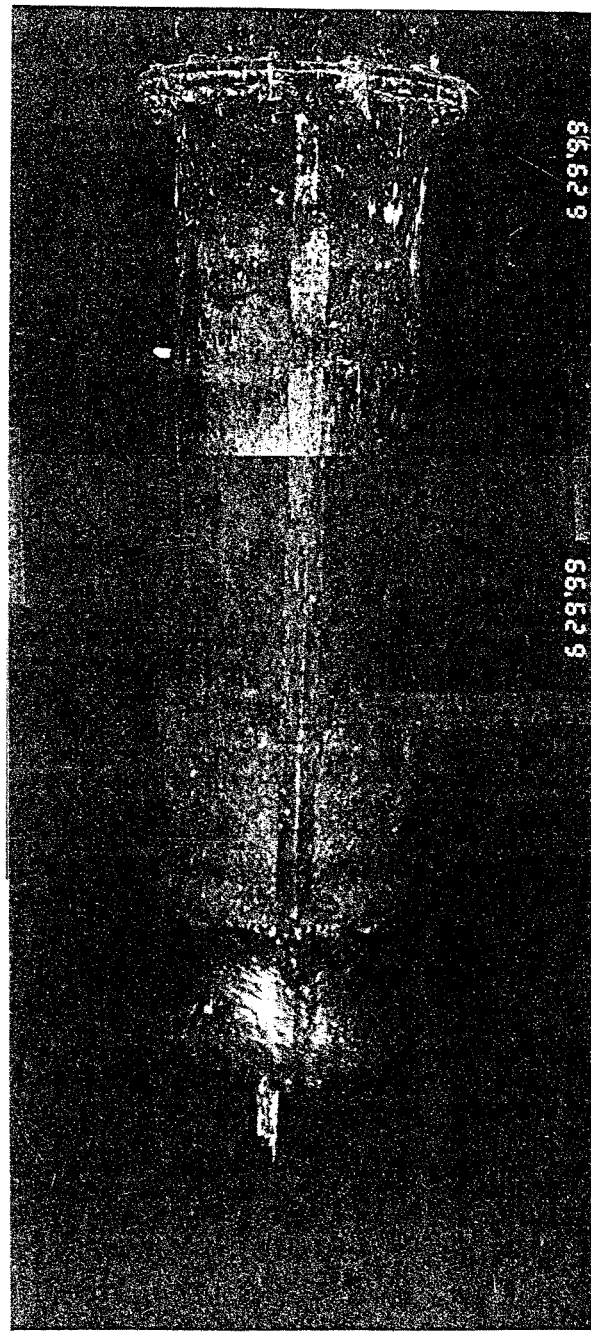
Pump Station #7
Pump #1

Note, rusted coupling.

#5

Pump Station #8
Inside of storm water lift station.





#6

Pump Station #7
Pump #2

Note, corrosion on pump body.

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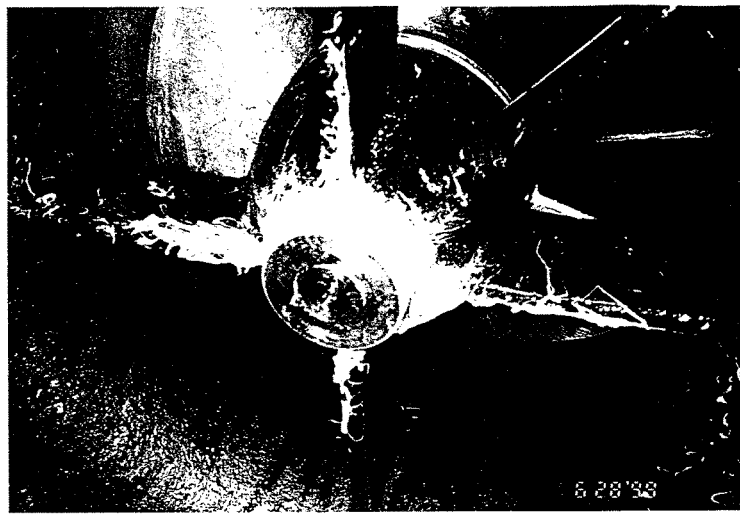
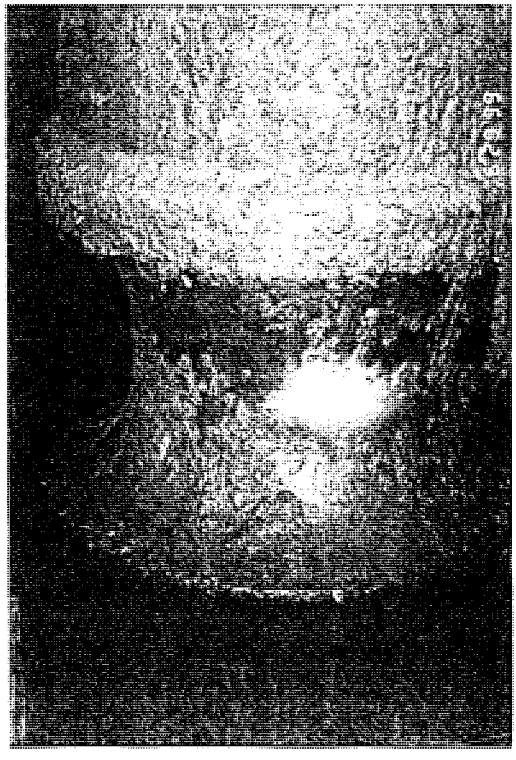


#7

Pump Station #12
Pump #1

Intake
showing inside
of suction
bowl & impeller.

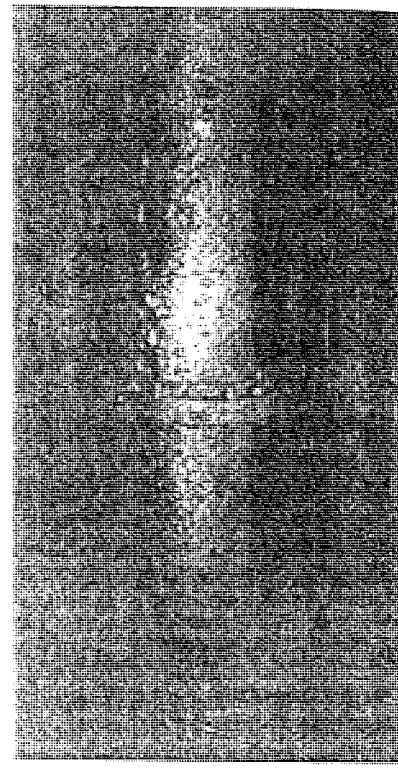


#8

Pump Station #7
Pump #1

Corrosion on intake bowl.

#9
Pump Station #7
Sump Pump



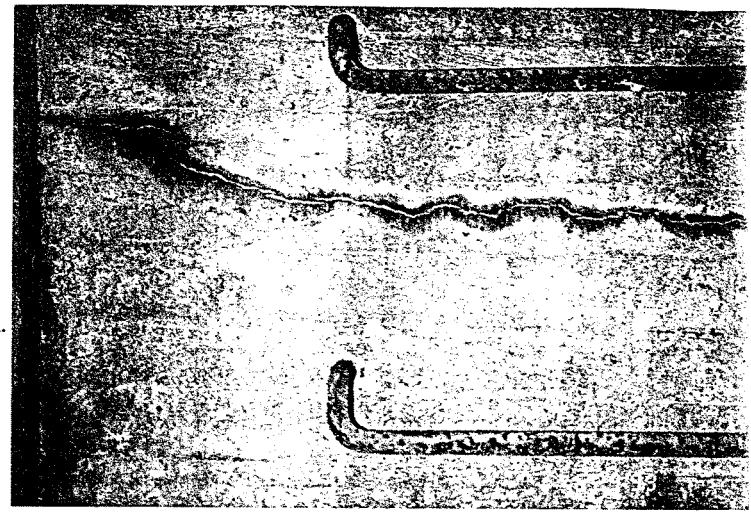
#10
Pump Station #7
Sump Pump discharge line.

#11

Pump Station #7

Pump #1
Baseplate

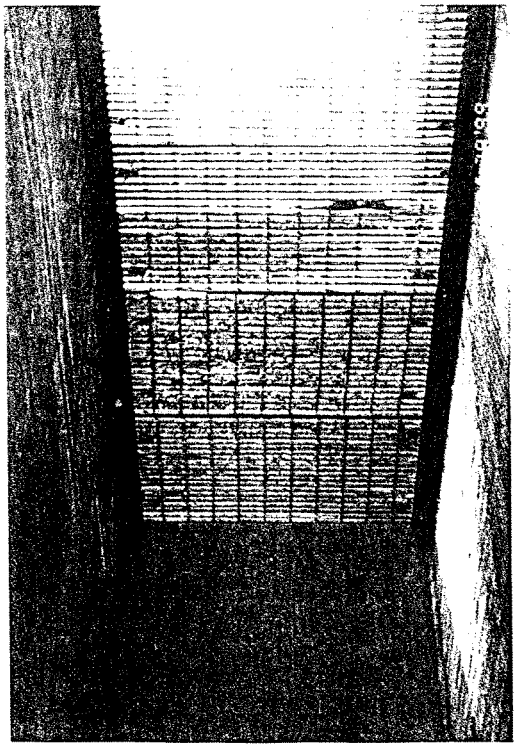
#12
Pump Station #7
Sluice gate to discharge well.



#13

Pump Station #7
Discharge well

Note, Crack on wall.



#14

Pump Station #7
Discharge Well
Looking up at
grating from bottom
of well.

Note, rusted grating.

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#15

Pump Station #5
Pump #3

Note, bent impeller.

#16

Pump Station #5
Pump #5

Dresser coupling
Leaking & rusted.

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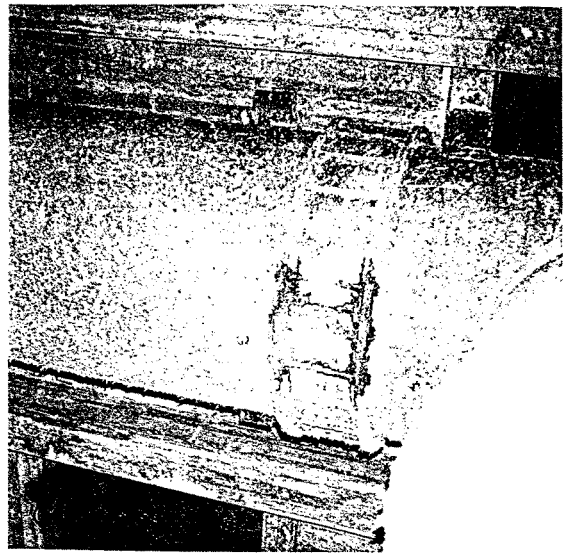


#17

Pump Station #6
Pump #1

Dresser coupling rusted.

#18

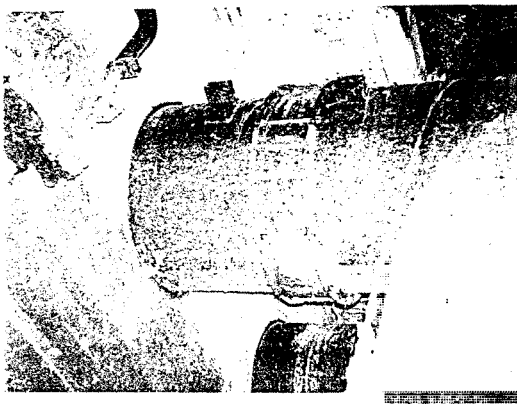
Pump Station #4
Pump #2

Paducah Reconnaissance Report

#19

Pump Station #6
Pump #2

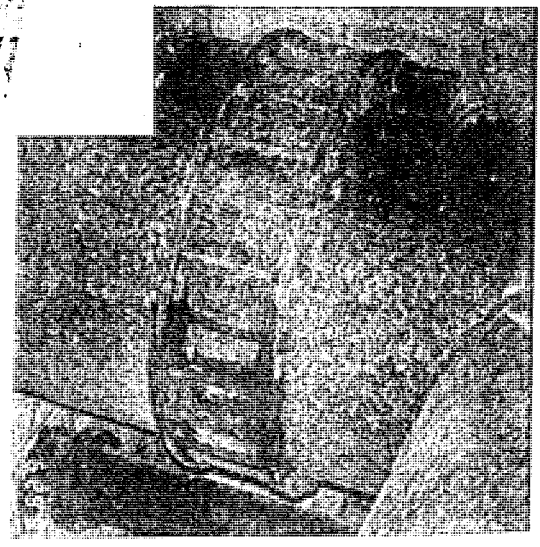
Dresser coupling rusted & leaking.



#20

Pump Station #6
Pump #3

Dresser coupling rusted.



#21

Pump Station #6
Pump #4

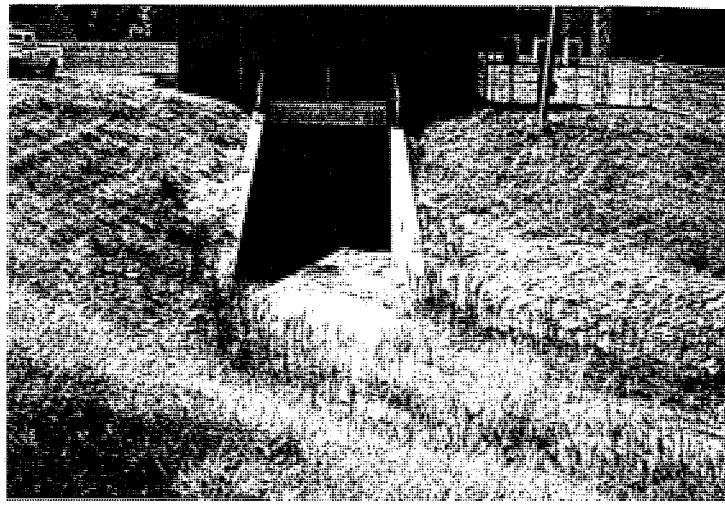
Dresser coupling rusted.

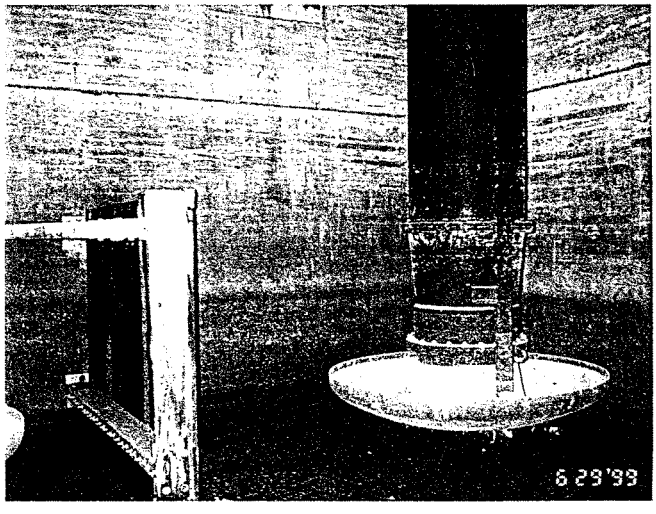
Paducah Reconnaissance Report

#22

Pump Station #1

Intake.





#23

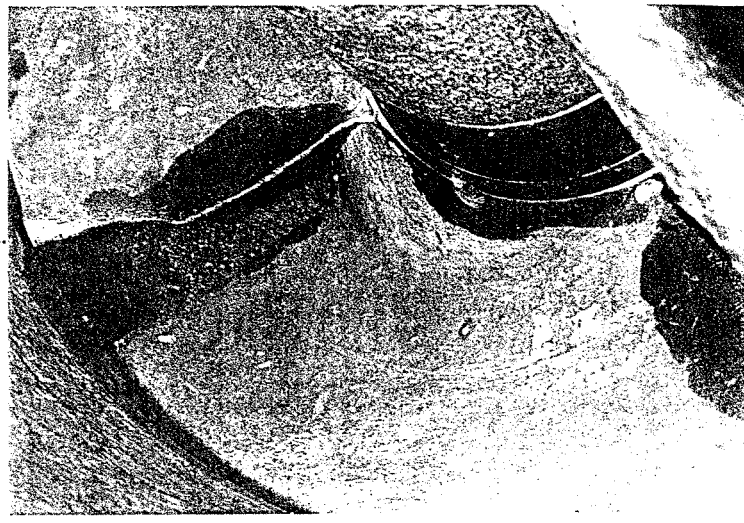
Pump Station #1
Pump #3

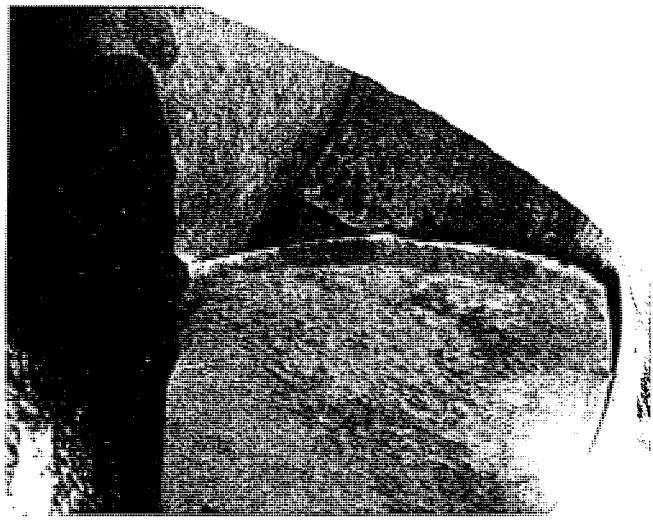
Divider wall
Between pump 2&3

Paducah Reconnaissance Report

#24

Pump Station #2
Pump #2
Impeller damage..



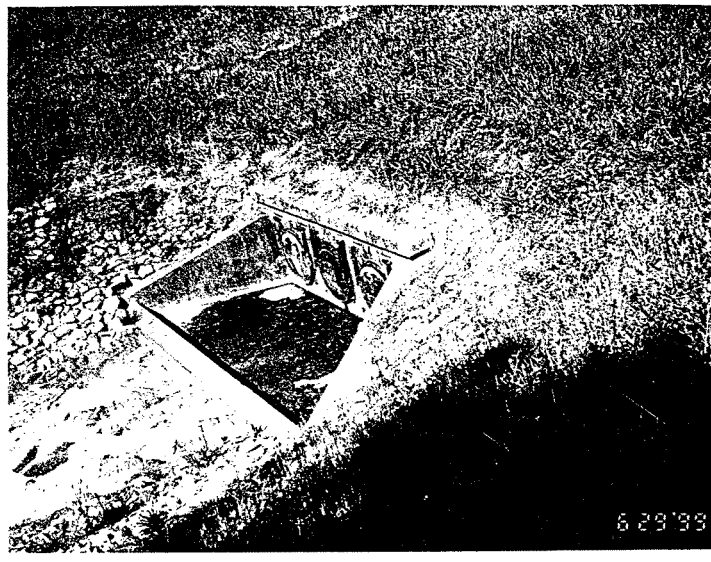


#25

Pump Station #2
Pump #5

Impeller nicks
on edges.

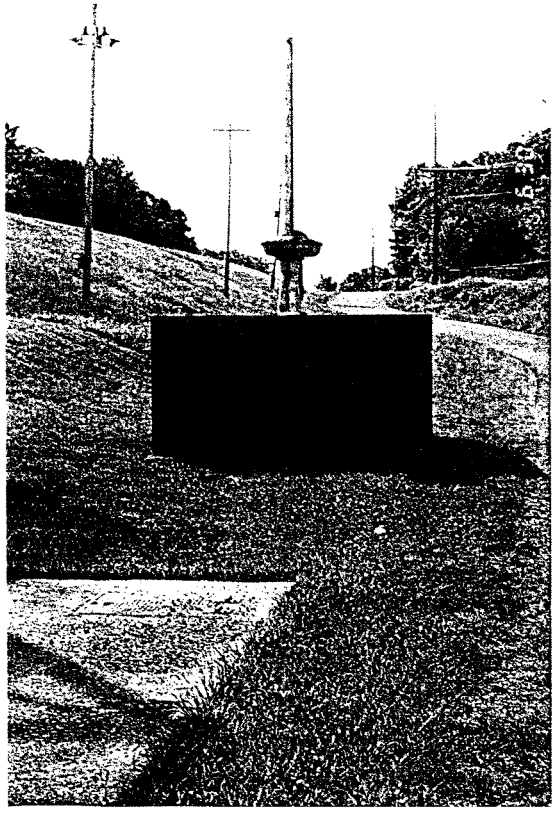
Paducah Reconnaissance Report



#26

Pump Station #1

Flapgate at headwall.



#27

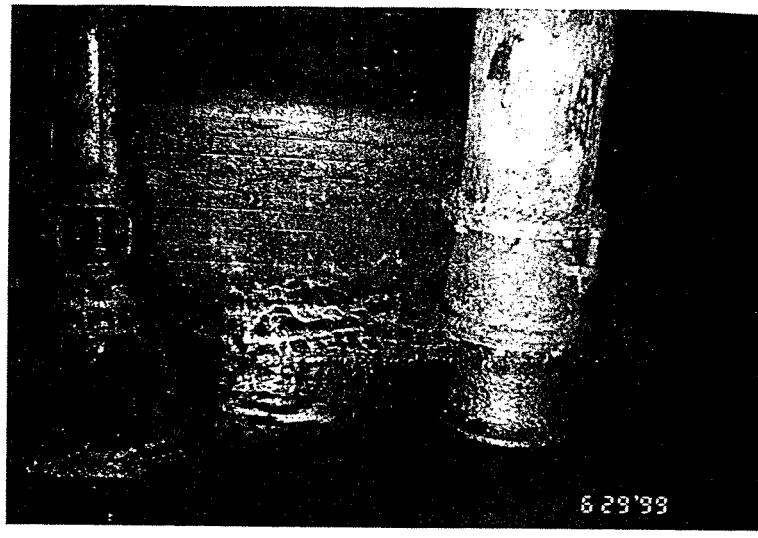
Manual sluice gate operator on MH #24-B2 Near Pump Station 2

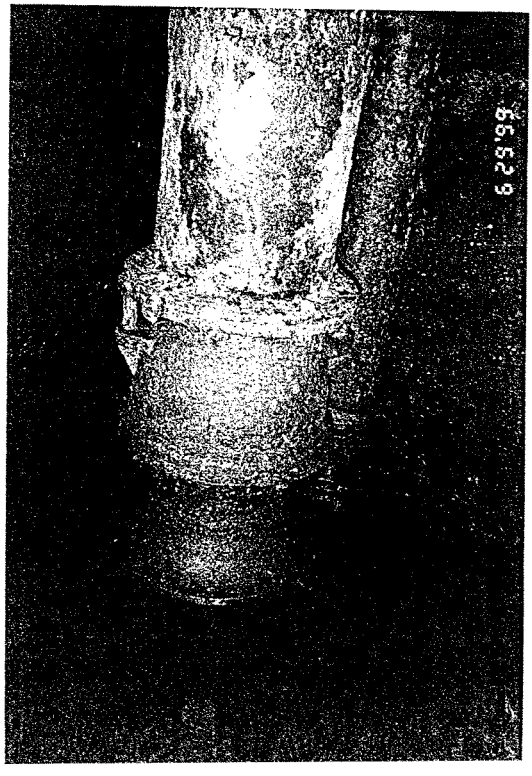
Top structural heavily corroded.

#28

Pump Station #3

Sump





#29

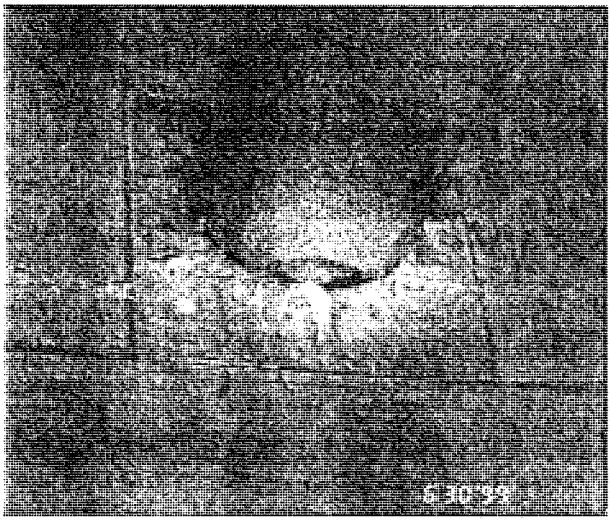
Pump Station #3

Sump

Paducah Reconnaissance Report

#30

Pump Station #2
Pump #6
Dresser & pipe



#31

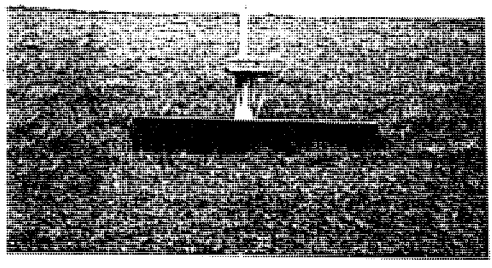
Pump Station #2

Leakage at wall

#32

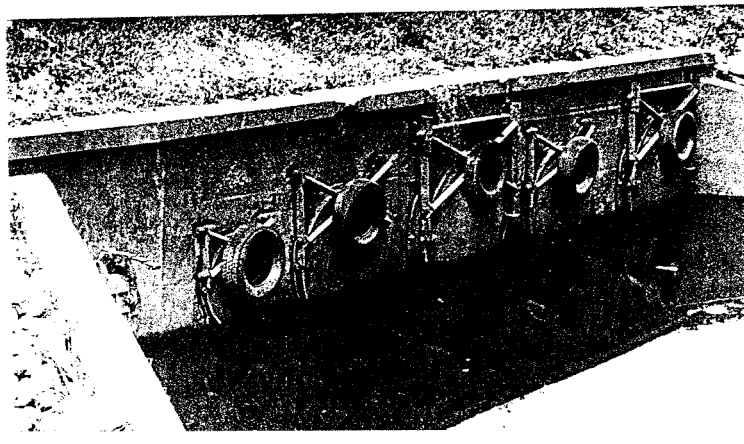
Pump Station #2

Air vent
heavily corroded.



#33

102" Sluice gate &
operator on riverside
near pump
station #2.



#34

Pump Station #2

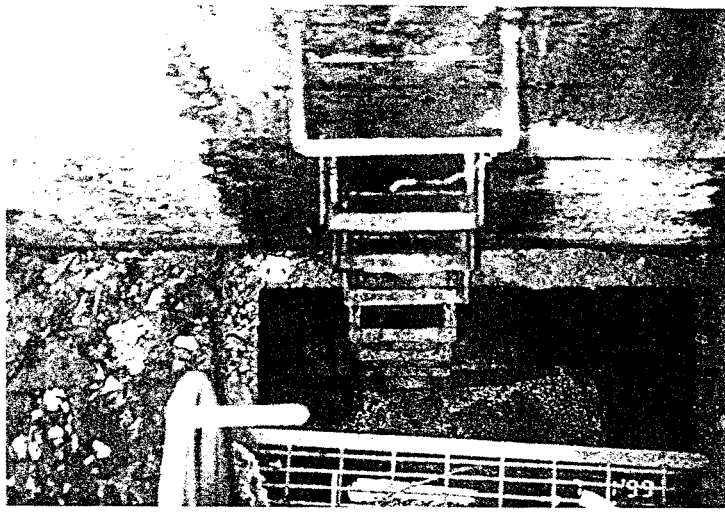
Flap gates

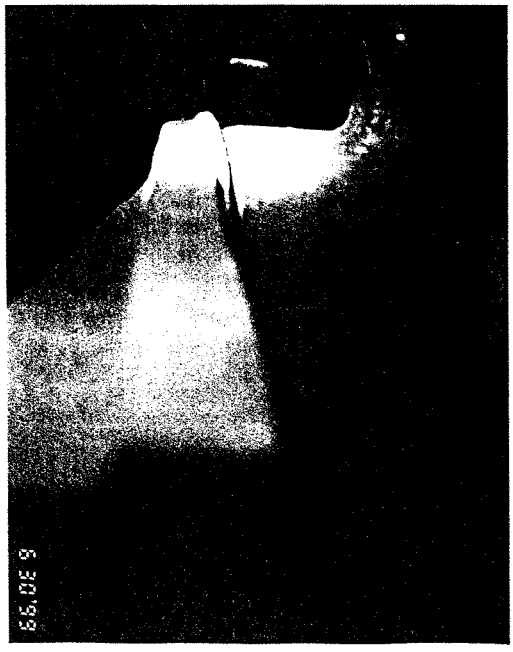
Paducah Reconnaissance Report

#35

Man hole 12-P

Note, missing ladder rung & fix needed on top rung.





#36

Man hole #3A
53" flap gate

Note, gap between Frame and gate seat

Paducah Reconnaissance Report

#37

Man hole 24-B2

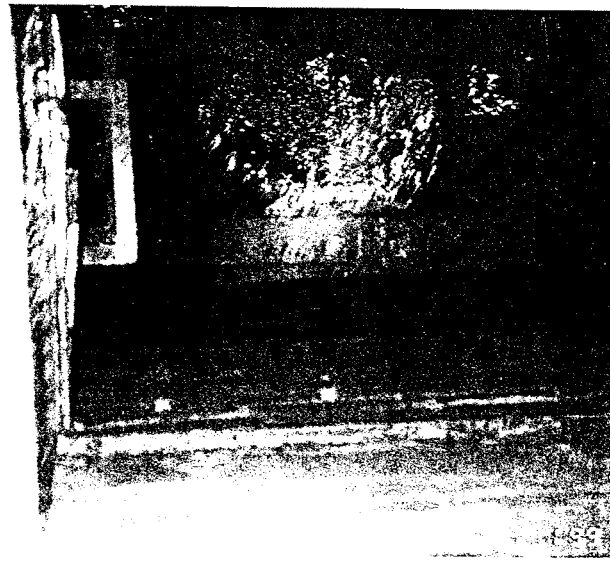
Note, deteoriated beam in center of plate support at top of gatewell.

#38

Ladder needs to be inserted to access man hole #15-A

Note, sluice gate does not seal due to concrete poured in channel when converted

Man hole raised Approx. 4 to 5 feet.



PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 1 (Noble Park)

Pump No. 1, Pumps painted in 1995, good condition.

1. Physical and Operational Observation:

   a. Flap gates: N/A

   b. Relief valves/siphon breakers: Good condition

   c. Pump lubrication systems: Farval Manual Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Knock during coast down, Check Impeller Clearance, if clearance OK, bearing could be worn, bowl in good condition, impeller in good condition. Vibration displacement readings were taken at the impeller bowl during operation – 1.7 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Start Manually at 5 ft in the sump and shutdown is automatic at 3-5 ft using mercury floats.

   b. Coast time: Specified: None Given

      Tested: 1 min-35 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): 1954

3. Nameplate data:

   a. Manufacturer: Fairbanks Morse

   b. Model: FM 30

   c. Serial numbers: PR6704

   d. gpm: 22,000 Head: 20.5

   e. rpm: 703 HP: 150

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 1 (Noble Park)

Pump No. 2, Pump painted in 1995, good condition.

1. Physical and Operational Observation:

   a. Flap gates: N/A

   b. Relief valves/siphon breakers: Good condition

   c. Pump lubrication systems: Farval Manual Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Medium knock during coast down, Check Impeller Clearance, if clearance OK, bearing could be worn, bowl in good condition, impeller in good condition. Vibration displacement readings were taken at the impeller bowl during operation – 2.56 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Start Manually at 5 ft in the sump and shutdown is automatic at 3-5 ft using mercury floats.

   b. Coast time: Specified: None Given

      Tested: 58 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): Addition in 1954

3. Nameplate data:

   a. Manufacturer: Fairbanks Morse

   b. Model: FM 30

   c. Serial numbers: PR6705

   d. gpm: 22,000 Head: 20.5

   e. rpm: 703 HP: 150

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 1 (Noble Park)

Pump No. 3, Pumps painted in 1995, good condition.

1. Physical and Operational Observation:

   a. Flap gates: N/A

   b. Relief valves/siphon breakers: Good condition

   c. Pump lubrication systems: Farval Manual Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Slight knock during coast down, Check Impeller Clearance, if clearance OK, bearing could be worn, bowl in good condition, impeller in good condition. Vibration displacement readings were taken at the impeller bowl during operation – 3.6 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Start Manually at 5 ft in the sump and shutdown is automatic at 3-5 ft using mercury floats.

   b. Coast time: Specified: None Given

      Tested: 1 min-3 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): 1954

3. Nameplate data:

   a. Manufacturer: Fairbanks Morse

   b. Model: FM 30

   c. Serial numbers: PR6706

   d. gpm: 22,000 Head: 20.5

   e. rpm: 703 HP: 150

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 30 June 1999

City: Paducah, KY Pump Station No. 2 (Sixth Street)

Pump No. 7

1. Physical and Operational Observation:

   a. Flap gates: Good Condition

   b. Relief valves/siphon breakers: Good condition

   c. Pump lubrication systems: Oil Lubrication only, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Bowl in good condition, Impeller in good condition, Bearings OK, shafts OK. Vibration displacement readings were taken at the impeller bowl during operation – 3.4 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Start Manually at 9 ft in the sump and shutdown is automatic at 5 ft using mercury floats.

   b. Coast time: Specified: None Given

      Tested: 33 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): Installed in 1996

3. Nameplate data:

   a. Manufacturer: WDM Pumps, Memphis, TN

   b. Model: Impeller 20 VAF-1; 20KLD/1

   c. Serial numbers: 950435971; 95-469-1

   d. gpm: 8,600 Head: 32.5

   e. rpm: 1200 HP: 100

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 30 June 1999

City: Paducah, KY Pump Station No. 2 (Sixth Street)

Pump No. 1

1. Physical and Operational Observation:

   a. Flap gates: Seat Needs to be replaced on headwall, replace pins and bushings to lever arms; Original seat appears to welded in place, instead of screwed to the frame.

   b. Relief valves/siphon breakers: OK

   c. Pump lubrication systems: Manual Farvall Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Not exposed for visible inspeciton, sump pump.

2. Operation and Maintenance:

   a. Starting sequence: Starts automatically at 3 ft in the sump using mercury floats.

   b. Coast time: Specified: None Given

      Tested: 8 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy (Sump)

   b. Model: SSV – 8

   c. Serial numbers: E-4892

   d. gpm: 1500 Head: 26.7

   e. rpm: 880 HP: 20

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 30 June 1999

City: Paducah, KY Pump Station No. 2 (Sixth Street)

Pump No. 2

1. Physical and Operational Observation:

   a. Flap gates: Seat Needs to be replaced on headwall, replace pins and bushings to lever arms; Original seat appears to welded in place, instead of screwed to the frame.

   b. Relief valves/siphon breakers: OK

   c. Pump lubrication systems: Manual Farvall Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impeller, nicks on edges and bent or missing part (requires replacement); Bearings, OK; Shafts, OK. Vibration displacement readings were taken at the impeller bowl during operation – 0.9 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Start Manually at 9 ft in the sump and shutdown is automatic at 5 ft using mercury floats.

   b. Coast time: Specified: None Given

      Tested: 1 min – 50 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): Motor shaft in 1993

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SAFV – 26 x 30

   c. Serial numbers: E-4794

   d. gpm: 18,500 Head: 26.7

   e. rpm: 706 HP: 200

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 30 June 1999

City: Paducah, KY Pump Station No. 2 (Sixth Street)

Pump No. 3

1. Physical and Operational Observation:

   a. Flap gates: Flap gate had a crack which was repaired by welding. Seat Needs to be replaced on headwall, replace pins and bushings to lever arms; Original seat appears to welded in place, instead of screwed to the frame. Recommend that the flap gate and frame be replaced.

   b. Relief valves/siphon breakers: OK

   c. Pump lubrication systems: Manual Farvall Grease, good condition

   e. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impeller, nicks on edges; Bearings, OK; Shafts, OK. Vibration displacement readings were taken at the impeller bowl during operation – 8.6 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Start Manually at 13.5 ft in the sump and shutdown is automatic at 8 ft using mercury floats.

   b. Coast time: Specified: None Given

      Tested: 19 min – 16 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SAFV – 54 x 60

   c. Serial numbers: E-4782

   d. gpm: 90,000 Head: 26.7

   e. rpm: 355 HP: 800

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 30 June 1999

City: Paducah, KY Pump Station No. 2 (Sixth Street)

Pump No. 4

1. Physical and Operational Observation:

   a. Flap gates: Seat Needs to be replaced on headwall, replace pins and bushings to lever arms; Original seat appears to welded in place, instead of screwed to the frame.

   b. Relief valves/siphon breakers: OK

   c. Pump lubrication systems: Manual Farvall Grease, good condition

   f. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impeller, OK; Bearings, OK; Shafts; OK. Vibration displacement readings were taken at the impeller bowl during operation – 8.6 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Start Manually at 13.5 ft in the sump and shutdown is automatic at 8 ft using mercury floats.

   b. Coast time: Specified: None Given

      Tested: 16 min – 24 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SAFV – 54 x 60

   c. Serial numbers: E-4783

   d. gpm: 90,000 Head: 26.7

   e. rpm: 355 HP: 800

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 30 June 1999

City: Paducah, KY Pump Station No. 2 (Sixth Street)

Pump No. 5

1. Physical and Operational Observation:

   a. Flap gates: Seat Needs to be replaced on headwall, replace pins and bushings to lever arms; Original seat appears to welded in place, instead of screwed to the frame.

   b. Relief valves/siphon breakers: OK

   c. Pump lubrication systems: Manual Farvall Grease, good condition

   g. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impeller, nicks on edges; Bearings, OK; Shafts, OK. Vibration displacement readings were taken at the impeller bowl during operation – 8.6 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Start Manually at 12.5 ft in the sump and shutdown is automatic at 6 ft using mercury floats.

   b. Coast time: Specified: None Given

      Tested: 14 min – 34 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SAFV – 42 x 48

   c. Serial numbers: E-4784

   d. gpm: 50,000 Head: 26.7

   e. rpm: 443 HP: 500

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 30 June 1999

City: Paducah, KY Pump Station No. 2 (Sixth Street)

Pump No. 6

1. Physical and Operational Observation:

   a. Flap gates: Seat Needs to be replaced on headwall, replace pins and bushings to lever arms; Original seat appears to welded in place, instead of screwed to the frame.

   b. Relief valves/siphon breakers: OK

   c. Pump lubrication systems: Manual Farvall Grease, good condition

   h. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impeller, OK; Bearings, OK; Shafts, OK. Shaft has a slight wobble above the baseplate at coupling. Pump ran smooth in sump with no vibration.

2. Operation and Maintenance:

   a. Starting sequence: Start Manually at 12.5 ft in the sump and shutdown is automatic at 6 ft using mercury floats.

   b. Coast time: Specified: None Given

      Tested: 18 min – 52 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SAFV – 42 x 48

   c. Serial numbers: E-4785

   d. gpm: 50,000 Head: 26.7

   e. rpm: 443 HP: 500

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 3 (Park Avenue)

Pump No. 1; Clean and repaint pumps and piping in the sump.

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Manual Farvall Grease, good condition

   i. Pumps (bowls, impellers, bearings, shafts): Not exposed, sump pump type.

2. Operation and Maintenance:

   a. Starting sequence: Start and Stop Manually at 8 ft in the sump and 3 ft respectively.

   b. Coast time: Specified: None Given

      Tested: 5 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy (Sump)

   b. Model: SSV – 6

   c. Serial numbers: E-4895

   d. gpm: 600 Head: 18.7

   e. rpm: 870 HP: 5

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 3 (Park Avenue)

Pump No. 2; Clean and repaint pumps and piping in the sump.

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Manual Farvall Grease, good condition

   j. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impeller, OK; Bearings, OK; Shafts, OK.

2. Operation and Maintenance:

   a. Starting sequence: Start and Stop Manually at 8 ft in the sump and 3 ft respectively.

   b. Coast time: Specified: None Given

      Tested: 50 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SAFV – 16 x 18

   c. Serial numbers: E-4803

   d. gpm: 4,400 Head: 13.8

   e. rpm: 880 HP: 25

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 3 (Park Avenue)

Pump No. 3; Clean and repaint pumps and piping in the sump.

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Manual Farvall Grease, good condition

   k. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impeller, OK; Bearings, OK; Shafts, OK.

2. Operation and Maintenance:

   a. Starting sequence: Start and Stop Manually at 8 ft in the sump and 3 ft respectively.

   b. Coast time: Specified: None Given

      Tested: 48 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SAFV – 16 x 18

   c. Serial numbers: E-4804

   d. gpm: 4,400 Head: 13.8

   e. rpm: 880 HP: 25

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 4 (N. 3rd St. & Exec. Blvd.)

Pump No. 1

1. Physical and Operational Observation:

   a. Flap gates: N/A

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Manual Grease

   l. Pumps (bowls, impellers, bearings, shafts): Not exposed, sump pump type, underground dry well.

2. Operation and Maintenance:

   a. Starting sequence: Electrode Start - Stop

   b. Coast time: Specified: None Given

      Tested: 37 sec

   c. Pump rehabilitated (year): Lower Bearing replaced (20 yrs ago).

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy (Sump)

   b. Model: SSV – 10 x 12

   c. Serial numbers: E-4888

   d. gpm: 4,500 Head: 19.6

   e. rpm: 885 HP: 50

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 4 (N. 3rd St. & Exec. Blvd.)

Pump No. 2

1. Physical and Operational Observation:

   a. Flap gates: N/A

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Manual Grease

   d. Pumps (bowls, impellers, bearings, shafts): Not exposed, sump pump type, underground dry well.

2. Operation and Maintenance:

   a. Starting sequence: Electrode Start - Stop

   b. Coast time: Specified: None Given

      Tested: 25 sec

   c. Pump rehabilitated (year): Lower Bearing and Shaft (15 yrs ago).

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy (Sump)

   b. Model: SSV – 10 x 12

   c. Serial numbers: E-4887

   d. gpm: 4,500 Head: 19.6

   e. rpm: 885 HP: 50

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 5 (Harrison St.)

Pump No. 1; Clean and repaint pumps (Corps of Engineers Paint Formula C-200) and piping in the sump.

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Auto Oil, Tail Bearing Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impeller, OK; Bearings, OK; Shafts, OK. Vibration displacement readings were taken at the impeller bowl during operation – 2.4 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Start and Stop Manually

   b. Coast time: Specified: None Given

      Tested: 3 min - 20 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SAFV – 26 x 36

   c. Serial numbers: E-4793

   d. gpm: 20,000 Head: 21.4

   e. rpm: 694 HP: 200

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 5 (Harrison St.)

Pump No. 2; Clean and repaint pumps (Corps of Engineers Paint Formula C-200) and piping in the sump.

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Auto Oil, Tail Bearing Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impeller, OK; Bearings, OK; Shafts, OK. Vibration displacement readings were taken at the impeller bowl during operation – 7.0 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Start and Stop Manually

   b. Coast time: Specified: None Given

      Tested: 3 min - 13 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SAFV – 26 x 36

   c. Serial numbers: E-4792

   d. gpm: 20,000 Head: 21.4

   e. rpm: 694 HP: 200

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 5 (Harrison St.)

Pump No. 3; Clean and repaint pumps (Corps of Engineers Paint Formula C-200) and piping in the sump.

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Auto Oil, Tail Bearing Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impeller, bent (needs to be replaced); Bearings, OK; Shafts, OK. Vibration displacement readings were taken at the impeller bowl during operation – 2.4 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Start and Stop Manually

   b. Coast time: Specified: None Given

      Tested: 1 min - 11 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SAFV – 18 x 24

   c. Serial numbers: E-4801

   d. gpm: 9,500 Head: 21.4

   e. rpm: 870 HP: 100

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 5 (Harrison St.)

Pump No. 4; Clean and repaint pumps (Corps of Engineers Paint Formula C-200) and piping in the sump.

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Auto Oil, Manual Grease Tail Bearing

   d. Pumps (bowls, impellers, bearings, shafts): Not exposed, sump pump type, underground dry well. Vibration displacement readings were taken at the impeller bowl during operation – 0.12 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Manual Start and Stop

   b. Coast time: Specified: None Given

      Tested: 9 sec

   c. Pump rehabilitated (year): N/A.

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy (Sump)

   b. Model: SSV – 8

   c. Serial numbers: E-4891

   d. gpm: 2,200 Head: 21.4

   e. rpm: 710 HP: 25

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 6 (Clark St.)

Pump No. 1; Clean and repaint pumps (Corps of Engineers Paint Formula C-200) and piping in the sump.

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Auto Oil, Tail Bearing Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impeller, OK; Bearings, OK; Shafts, OK. Shakes during shutdown. Vibration displacement readings were taken at the impeller bowl during operation – 2.17 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Start and Stop Manually at 8 ft in the sump and 3 ft respectively.

   b. Coast time: Specified: None Given

      Tested: 4 min - 17 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SAFV – 30 x 42

   c. Serial numbers: E-4790

   d. gpm: 31,100 Head: 22.1

   e. rpm: 501 HP: 250

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 6 (Clark St.)

Pump No. 2; Clean and repaint pumps (Corps of Engineers Paint Formula C-200) and piping in the sump.

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Auto Oil, Tail Bearing Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impeller, OK; Bearings, OK; Shafts, OK. Wobbles while running. Vibration displacement readings were taken at the impeller bowl during operation – 10.0 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Start and Stop Manually at 8 ft in the sump and 3 ft respectively.

   b. Coast time: Specified: None Given

      Tested: 1 min - 25 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SAFV – 26 x 36

   c. Serial numbers: E-4797

   d. gpm: 15,600 Head: 22.1

   e. rpm: 700 HP: 125

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 6 (Clark St.)

Pump No. 3; Clean and repaint pumps (Corps of Engineers Paint Formula C-200) and piping in the sump.

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Auto Oil, Tail Bearing Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impeller, OK; Bearings, OK; Shafts, OK. Wobbles while running. Vibration displacement readings were taken at the impeller bowl during operation – 5.8 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Start and Stop Manually at 8 ft in the sump and 4 ft respectively.

   b. Coast time: Specified: None Given

      Tested: 4 min - 10 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SAFV – 30 x 42

   c. Serial numbers: E-4791

   d. gpm: 31,100 Head: 22.1

   e. rpm: 501 HP: 250

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 6 (Clark St.)

Pump No. 4; Clean and repaint pumps (Corps of Engineers Paint Formula C-200) and piping in the sump.

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Auto Oil, Tail Bearing Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impeller, OK; Bearings, OK; Shafts, OK. Wobbles while running. Vibration displacement readings were taken at the impeller bowl during operation – 9.6 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Start and Stop Manually at 8 ft in the sump and 4 ft respectively.

   b. Coast time: Specified: None Given

      Tested: 3 min - 35 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SAFV – 30 x 42

   c. Serial numbers: E-4789

   d. gpm: 31,100 Head: 22.1

   e. rpm: 501 HP: 250

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 6 (Clark St.)

Pump No. 5; Clean and repaint pumps (Corps of Engineers Paint Formula C-200) and piping in the sump.

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Auto Oil, Manual Grease Tail Bearing

   d. Pumps (bowls, impellers, bearings, shafts): Not exposed, sump pump type. Vibration displacement readings were taken at the impeller bowl during operation – 0.048 mils (peak to peak).

2. Operation and Maintenance:

   a. Starting sequence: Manual Start and Stop

   b. Coast time: Specified: None Given

      Tested: 8 sec

   c. Pump rehabilitated (year): N/A.

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy (Sump)

   b. Model: SSV – 6

   c. Serial numbers: E-4894

   d. gpm: 1,000 Head: 22.1

   e. rpm: 875 HP: 10

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 7 (Tennessee St.)

Pump No. 1; Clean and repaint pumps (Corps of Engineers Paint Formula C-200) and piping in the sump.

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Auto Oil, Tail Bearing Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Extreme Rust on Diffuser and Impeller Bowls and Suction Bell; Impeller, OK; Bearings, OK; Shafts, OK.

2. Operation and Maintenance:

   a. Starting sequence: Start and Stop Manual Operation.

   b. Coast time: Specified: None Given

      Tested: 3 min - 30 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SAFV – 26 x 30

   c. Serial numbers: E-4798

   d. gpm: 15,000 Head: 19.6

   e. rpm: 700 HP: 125

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 7 (Tennessee St.)

Pump No. 2; Clean and repaint pumps (Corps of Engineers Paint Formula C-200) and piping in the sump.

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Auto Oil, Tail Bearing Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Extreme Rust on Diffuser and Impeller Bowls and Suction Bell; Impeller, OK; Bearings, OK; Shafts, OK.

2. Operation and Maintenance:

   a. Starting sequence: Start and Stop Manual Operation.

   b. Coast time: Specified: None Given

      Tested: 23 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SAFV – 16 x 21

   c. Serial numbers: E-4802

   d. gpm: 7,000 Head: 19.6

   e. rpm: 1170 HP: 50

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 7 (Tennessee St.)

Pump No. 3; Clean and repaint pumps (Corps of Engineers Paint Formula C-200) and piping in the sump.

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Auto Oil, Tail Bearing Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Not Exposed, Extreme Rust on sump pump and piping. Bearings, OK; Shafts, OK.

2. Operation and Maintenance:

   a. Starting sequence: Start and Stop Manual Operation.

   b. Coast time: Specified: None Given

      Tested: 5 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy (Sump)

   b. Model: SSV – 8 x 10

   c. Serial numbers: E-4893

   d. gpm: 1,300 Head: 19.6

   e. rpm: 705 HP: 10

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 8 (Norton St.)

Pump No. 1

1. Physical and Operational Observation:

   a. Flap gates: 8-Inch Bronze, OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Manual Grease

   d. Pumps (bowls, impellers, bearings, shafts): Not exposed, sump pump type, underground dry well.

2. Operation and Maintenance:

   a. Starting sequence: Electrode Start - Stop

   b. Coast time: Specified: None Given

      Tested: 2 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy (Sump)

   b. Model: SSV – 3

   c. Serial numbers: E-4898

   d. gpm: 300 Head: 7.6

   e. rpm: 1150 HP: 2

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 8 (Norton St.)

Pump No. 2

1. Physical and Operational Observation:

   a. Flap gates: One flap gate for pumps 1 & 2, OK

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Manual Grease

   d. Pumps (bowls, impellers, bearings, shafts): Not exposed, sump pump type, underground dry well.

2. Operation and Maintenance:

   a. Starting sequence: Electrode Start - Stop

   b. Coast time: Specified: None Given

      Tested: 2 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy (Sump)

   b. Model: SSV – 3

   c. Serial numbers: E-4899

   d. gpm: 300 Head: 7.6

   e. rpm: 1150 HP: 2

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 9 (Husbands St.)

Pump No. 1

1. Physical and Operational Observation:

   a. Flap gates: N/A

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Auto Oil, Tail Bearing Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Not Exposed, Sump pump type; underground dry well. Bearings, OK; Shafts, OK.

2. Operation and Maintenance:

   a. Starting sequence: Manual Start Operation.

   b. Coast time: Specified: None Given

      Tested: 53 sec

   c. Pump rehabilitated (year): Pump Bearing Replace (1997)

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SSV – 10

   c. Serial numbers: E-4889

   d. gpm: 3,900 Head: 21.5

   e. rpm: 870 HP: 40 – 46

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 9 (Husbands St.)

Pump No. 2

1. Physical and Operational Observation:

   a. Flap gates: N/A

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Auto Oil, Tail Bearing Grease, good condition

   d. Pumps (bowls, impellers, bearings, shafts): Not Exposed, Sump pump type; underground dry well. Bearings, OK; Shafts, OK.

2. Operation and Maintenance:

   a. Starting sequence: Manual Start Operation.

   b. Coast time: Specified: None Given

      Tested: 47 sec

   c. Pump rehabilitated (year): Line Bearing Replace (1989)

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SSV – 10

   c. Serial numbers: E-4890

   d. gpm: 3,900 Head: 21.5

   e. rpm: 870 HP: 40 – 46

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 10 (George St.)

Pump No. 1

1. Physical and Operational Observation:

   a. Flap gates: N/A

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Manual Grease

   d. Pumps (bowls, impellers, bearings, shafts): Not Exposed, Sump pump type; underground dry well. Bearings, OK; Shafts, OK.

2. Operation and Maintenance:

   a. Starting sequence: Electrode Start Operation.

   b. Coast time: Specified: None Given

      Tested: 9 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SSV – 6 x 8

   c. Serial numbers: E-4897

   d. gpm: 1,200 Head: 11.7

   e. rpm: 875 HP: 10

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah, KY Pump Station No. 10 (George St.)

Pump No. 2

1. Physical and Operational Observation:

   a. Flap gates: N/A

   b. Relief valves/siphon breakers: N/A

   c. Pump lubrication systems: Manual Grease

   d. Pumps (bowls, impellers, bearings, shafts): Not Exposed, Sump pump type; underground dry well. Bearings, OK; Shafts, OK.

2. Operation and Maintenance:

   a. Starting sequence: Electrode Start Operation.

   b. Coast time: Specified: None Given

      Tested: 10 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model: SSV – 6 x 8

   c. Serial numbers: E-4896

   d. gpm: 1,200 Head: 11.7

   e. rpm: 875 HP: 10

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 28 June 1999

City: Paducah, KY Pump Station No. 11 (Island Creek)

Pump No. 1; New Installed in November 1998

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: OK

   c. Pump lubrication systems: Water Lubricated Bearings

   d. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impellers, OK; Bearings, OK; Shafts, OK.

2. Operation and Maintenance:

   a. Starting sequence: Manufacturer has indicated that the pump can not be run in the dry condition, due to water lubricated bearings, No current problems during operation procedures during last event.

   b. Coast time: Specified: None Given

      Tested: N/A

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Cascade

   b. Model: 36 MF

   c. Serial numbers: L5272

   d. gpm: 33,000 Head: 26.7

   e. rpm: 590 HP: 300

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 28 June 1999

City: Paducah, KY Pump Station No. 11 (Island Creek)

Pump No. 2

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: OK

   c. Pump lubrication systems: Automatic Greasing

   d. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impellers, OK; Bearings, OK; Shafts, OK. Vibration displacement readings were taken at the motor – 1.15 mils (peak to peak), impeller bowl 0.54 mils and motor stand – 0.34 mils during pump operation.

2. Operation and Maintenance:

   a. Starting sequence: Operation.

   b. Coast time: Specified: None Given

      Tested: 1 min - 2 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model:

   c. Serial numbers: E47-86

   d. gpm: 33,000 Head: 28.0

   e. rpm: 600 HP: 300

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 28 June 1999

City: Paducah, KY Pump Station No. 11 (Island Creek)

Pump No. 3

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: OK

   c. Pump lubrication systems: Automatic Greasing

   d. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impellers, OK; Bearings, OK; Shafts, OK. Vibration displacement readings were taken at the motor – 0.178 mils (peak to peak), impeller bowl 0.18 mils and motor stand – 0.048 mils during pump operation.

2. Operation and Maintenance:

   a. Starting sequence: Operation.

   b. Coast time: Specified: None Given

      Tested: 52 sec

   c. Pump rehabilitated (year): 1965

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model:

   c. Serial numbers: E47-87

   d. gpm: 33,000 Head: 28.0

   e. rpm: 600 HP: 300

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 28 June 1999

City: Paducah, KY Pump Station No. 11 (Island Creek)

Pump No. 4

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: OK

   c. Pump lubrication systems: Automatic Greasing

   d. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impellers, OK; Bearings, OK; Shafts, OK. Vibration displacement readings were taken at the motor – 0.11 mils (peak to peak), impeller bowl 0.18 mils and motor stand – 0.036 mils during pump operation.

2. Operation and Maintenance:

   a. Starting sequence: Operation.

   b. Coast time: Specified: None Given

      Tested: 45 sec

   c. Pump rehabilitated (year): All of the diffuser vanes were found cracked, repairs were made by drilling and pinning in 1990.

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model:

   c. Serial numbers: E47-88

   d. gpm: 33,000 Head: 28.0

   e. rpm: 600 HP: 300

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 28 June 1999

City: Paducah, KY Pump Station No. 12

Pump No. 1

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: OK, Gate on Levee, OK

   c. Pump lubrication systems: Automatic Oil and Manual Tail Bearing Grease

   d. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impellers, OK; Bearings, OK; Shafts, OK. Vibration displacement readings were taken at the motor – 0.62 mils (peak to peak), impeller bowl 6.8 mils and motor stand – 0.078 mils during pump operation.

2. Operation and Maintenance:

   a. Starting sequence: Start and Stop Manually at 4.25 ft in the sump and 3.5 ft respectively. Stop elevation is lower than required by Corps of Engineers Operation and Maintenance Manual. Verify if pump column can be extended. Operation is at a lower elevation to prevent residential flood damage in the area of ponding.

   b. Coast time: Specified: None Given

      Tested: 1 min - 45 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model:

   c. Serial numbers: E47-98

   d. gpm: 9,700 Head: 14.0

   e. rpm: 880 HP: 50

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 28 June 1999

City: Paducah, KY Pump Station No. 12

Pump No. 2

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: OK, Gate on Levee, OK

   c. Pump lubrication systems: Automatic Oil and Manual Tail Bearing Grease

   d. Pumps (bowls, impellers, bearings, shafts): Bowls, OK; Impellers, OK; Bearings, OK; Shafts, OK. Vibration displacement readings were taken at the motor – 0.42 mils (peak to peak), impeller bowl 7.4 mils and motor stand – 0.058 mils during pump operation.

2. Operation and Maintenance:

   a. Starting sequence: Start and Stop Manually at 4.25 ft in the sump and 3.5 ft respectively. Stop elevation is lower than required by Corps of Engineers Operation and Maintenance Manual. Verify if pump column can be extended. Operation is at a lower elevation to prevent residential flood damage in the area of ponding.

   b. Coast time: Specified: None Given

      Tested: 1 min - 30 sec

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Economy

   b. Model:

   c. Serial numbers: E47-99

   d. gpm: 9,700 Head: 14.0

   e. rpm: 880 HP: 50

PUMP DATA – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 28 June 1999

City: Paducah, KY Pump Station No. 13

Pump No. 1; Did not operate pumps due to ceramic seals in the pump.

1. Physical and Operational Observation:

   a. Flap gates: OK

   b. Relief valves/siphon breakers: OK, Gate on Levee, OK

   c. Pump lubrication systems: Automatic Oil and Manual Tail Bearing Grease

   d. Pumps (bowls, impellers, bearings, shafts): Not Exposed.

2. Operation and Maintenance:

   a. Starting sequence: Start and Stop Manually at ft in the sump and ft respectively.

   b. Coast time: Specified: None Given

      Tested: N/A

   c. Pump rehabilitated (year): N/A

   d. Pump replaced (year): N/A

3. Nameplate data:

   a. Manufacturer: Crown

   b. Model: P08 - 60

   c. Serial numbers: 192469

   d. gpm: _____ Head:

   e. rpm: 1760 HP: 60

PUMP STATION – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah Pump Station No. 1 (Noble Park)

Number of Pumps: 3

1. Local Representatives on Evaluation:

Name	Title
Gary Thompson	Floodwall Superintendent
Wayne Ryan	Floodwall Operator
Harold Newton	Floodwall Operator

2. Physical and Operational Observation:

   a. Cranes/winches: 3-Ton Chain Hoist and Trolley Has Been Sprung (Operable but not very smooth)

   b. Trash racks: Sandblasted and Painted in 1994, good condition (Auto trash cleaning needed if possible)

   c. Float switches: Mercury Floats for Control of Stop only; Level Indicator, OK

   d. Sluice gates: N/A

3. Ventilation: Gravity Sump Only

4. Pressure piping: OK

5. Access Covers: OK

PUMP STATION – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 30 June 1999

City: Paducah Pump Station No.2 (Sixth Street)

Number of Pumps: 7; Discharge Pipe and Dresser Couplings required to be replaced, Pumps need to be cleaned and repainted

1. Local Representatives on Evaluation:

Name	Title
Gary Thompson	Floodwall Superintendent
Wayne Ryan	Floodwall Operator
Harold Newton	Floodwall Operator

2. Physical and Operational Observation:

   a. Cranes/winches: 12-Ton Chain Hoist and Trolley, OK

   b. Trash racks: New in 1998

   c. Float switches: OK, Transmits data to PLC to dictate stops on pumps 2 thru 7

   d. Sluice gates: Operational but not used, left open all the time

3. Ventilation: Gravity Sump Only

4. Pressure piping: Needs to be replaced in sump and possible in Levee, Pump #2 piping collapsed near flapgate headwall in 1997, approx. 10 feet replace during the construction of pump #7.

5. Access Covers: OK

PUMP STATION – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah Pump Station No.3 (Park Avenue)

Number of Pumps: 3; Pumps need to be cleaned and repainted

1. Local Representatives on Evaluation:

Name	Title
Gary Thompson	Floodwall Superintendent
Wayne Ryan	Floodwall Operator
Harold Newton	Floodwall Operator

2. Physical and Operational Observation:

   a. Cranes/winches: 1-Ton Chain Hoist and Trolley, OK

   b. Trash racks: New in 1998

   c. Float switches: OK

   d. Sluice gates: Operational but not used, left open all the time

3. Ventilation: Gravity Sump Only

4. Pressure piping: OK

5. Access Covers: OK

PUMP STATION – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah Pump Station No.4 (N. 3rd St. & Exec. Blvd.)

Number of Pumps: 2

1. Local Representatives on Evaluation:

Name	Title
Gary Thompson	Floodwall Superintendent
Wayne Ryan	Floodwall Operator
Harold Newton	Floodwall Operator

2. Physical and Operational Observation:

   a. Cranes/winches: N/A

   b. Trash racks: N/A

   c. Float switches: N/A, Sight glass tube

   d. Sluice gates: N/A

3. Ventilation: Automatic Fan

4. Pressure piping: OK

5. Access Covers: OK

PUMP STATION – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah Pump Station No.5 (Harrison Street)

Number of Pumps: 4; Pumps and piping need to be cleaned and repainted

1. Local Representatives on Evaluation:

Name	Title
Gary Thompson	Floodwall Superintendent
Wayne Ryan	Floodwall Operator
Harold Newton	Floodwall Operator

2. Physical and Operational Observation:

   a. Cranes/winches: 3-Ton Chain Hoist and Trolley, OK

   b. Trash racks: New in 1998

   c. Float switches: OK

   d. Sluice gates: Operational but not used, left open all the time

3. Ventilation: Gravity Sump Only

4. Pressure piping: OK, Dresser coupling leaking on pump #1, recommend it be replaced

5. Access Covers: OK

PUMP STATION – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah Pump Station No.6 (Clark Street)

Number of Pumps: 5; Pumps and piping need to be cleaned and repainted

1. Local Representatives on Evaluation:

Name	Title
Gary Thompson	Floodwall Superintendent
Wayne Ryan	Floodwall Operator
Harold Newton	Floodwall Operator

2. Physical and Operational Observation:

   a. Cranes/winches: 6-Ton Chain Hoist and Trolley, OK

   b. Trash racks: New in 1999

   c. Float switches: Indicator is off 1.5 feet, needs to be adjusted or repaired

   d. Sluice gates: Operational but not used, left open all the time, see photo indicating rust of embeded metal seals

3. Ventilation: Sump Only

4. Pressure piping: Needs to be repainted within the sump, Dresser Couplings leaking on pumps #1 thru #4, couplings need to be replaced

5. Access Covers: OK

PUMP STATION – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah Pump Station No.7 (Tennessee Street)

Number of Pumps: 3; Pumps and piping need to be cleaned and repainted

1. Local Representatives on Evaluation:

Name	Title
Gary Thompson	Floodwall Superintendent
Wayne Ryan	Floodwall Operator
Harold Newton	Floodwall Operator

2. Physical and Operational Observation:

   a. Cranes/winches: 3-Ton Chain Hoist and Trolley, OK

   b. Trash racks: Replace new in 1998

   c. Float switches: OK

   d. Sluice gates: Operational but not used, left open all the time

3. Ventilation: Gravity Sump Only

4. Pressure piping: OK;Dresser couplings leaking on pumps #1 and #2, recommend they be replaced

5. Access Covers: OK; replace the grating and channels on discharge wet well, heavily rusted

PUMP STATION – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah Pump Station No.8 (Norton Street)

Number of Pumps: 2

1. Local Representatives on Evaluation:

Name	Title
Gary Thompson	Floodwall Superintendent
Wayne Ryan	Floodwall Operator
Harold Newton	Floodwall Operator

2. Physical and Operational Observation:

   a. Cranes/winches: N/A

   b. Trash racks: N/A

   c. Float switches: N/A

   d. Sluice gates: OK

3. Ventilation: OK, underground vent for dry well

4. Pressure piping: OK; Gate Valve, OK

5. Access Covers: OK

PUMP STATION – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah Pump Station No.9 (Husbands Street)

Number of Pumps: 2

1. Local Representatives on Evaluation:

Name	Title
Gary Thompson	Floodwall Superintendent
Wayne Ryan	Floodwall Operator
Harold Newton	Floodwall Operator

2. Physical and Operational Observation:

   a. Cranes/winches: 1-Ton Chain Hoist, OK

   b. Trash racks: N/A

   c. Float switches: OK

   d. Sluice gates: Operational but not used, left open all the time

3. Ventilation: Sump Only

4. Pressure piping: OK; Gate Valve, OK

5. Access Covers: OK

PUMP STATION – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 29 June 1999

City: Paducah Pump Station No. 10 (George Street)

Number of Pumps: 2

1. Local Representatives on Evaluation:

Name	Title
Gary Thompson	Floodwall Superintendent
Wayne Ryan	Floodwall Operator
Harold Newton	Floodwall Operator

2. Physical and Operational Observation:

   a. Cranes/winches: N/A

   b. Trash racks: N/A

   c. Float switches: OK, Electrode Start

   d. Sluice gates: N/A

3. Ventilation: Excellent ducted mechanical fan for dry well

4. Pressure piping: OK; Gate Valve, OK

5. Access Covers: OK

PUMP STATION – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 28 June 1999

City: Paducah Pump Station No. 11 (Island Creek)

Number of Pumps: 4

1. Local Representatives on Evaluation:

Name	Title
Gary Thompson	Floodwall Superintendent
Wayne Ryan	Floodwall Operator
Harold Newton	Floodwall Operator

2. Physical and Operational Observation:

   a. Cranes/winches: Clutch Problems on Hoist

   b. Trash racks: N/A

   c. Float switches: Replaced in 1998

   d. Sluice gates: OK

3. Ventilation: N/A

4. Pressure piping: OK

5. Access Covers: OK

PUMP STATION – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 28 June 1999

City: Paducah Pump Station No. 12

Number of Pumps: 2

1. Local Representatives on Evaluation:

Name	Title
Gary Thompson	Floodwall Superintendent
Wayne Ryan	Floodwall Operator
Harold Newton	Floodwall Operator

2. Physical and Operational Observation:

   a. Cranes/winches: OK

   b. Trash racks: OK, (Good Shape)

   c. Float switches: OK

   d. Sluice gates: N/A

3. Ventilation: N/A

4. Pressure piping: OK

5. Access Covers: OK

PUMP STATION – MECHANICAL EVALUATION

Evaluator: Mark Robertson Date: 28 June 1999

City: Paducah Pump Station No.13

Number of Pumps: 1

1. Local Representatives on Evaluation:

Name	Title
Gary Thompson	Floodwall Superintendent
Wayne Ryan	Floodwall Operator
Harold Newton	Floodwall Operator

2. Physical and Operational Observation:

   a. Cranes/winches: N/A, Roof is Removable

   b. Trash racks: N/A

   c. Float switches: N/A

   d. Sluice gates: N/A

3. Ventilation: OK, (Mechanical Fan and Louver Operational)

4. Pressure piping: OK

5. Access Covers: N/A

MANHOLES WITH GATED OUTLETS

MH NO.	LOCATION	DESCRIPTION	OPERATE	REMARKS
8-A	Sta. 123+61-B2	20" Flap Gate	OK	Leaks, Install New
3-P	2nd & Broadway	24" Sluice Gate	OK	
4-P	2nd & Broadway	24" Sluice Gate	OK	
7-B2	Sta. 119+45-B	24" Sluice Gate	OK	
7-A	Sta. 119+37-B2	24" Flap Gate	OK	
5-P	2nd & Kentucky	18" Sluice Gate	OK	
6-P	2nd & Kentucky	18" Sluice Gate	OK	
5	Sta. 115+27-B2	24" Flap Gate	OK	
6-B2	Sta. 115+26-B	8" Gate Valve	OK	Leaks, Install New
6-B2	Sta. 115+26-B	24" Sluice Gate	OK	
6-A	Sta. 115+06-B2	8" Shear Gate	OK	
7-P	2nd & Washington	18" Sluice Gate	OK	
8-P	2nd & Washington	18" Sluice Gate	OK	
3-B2	Sta. 108+58-B	2-36x36 Sluice	OK	Leaks, Install New
3-B2	Sta. 108+58-B	54" Sluice Gate	OK	
3-A	Sta. 108+58-B2	54" Sluice Gate	OK	Leaks, Install New
14-P	Sta. 90+36-B	36" Sluice Gate	OK	
1-B2	Sta. 90+36-B	36" Sluice Gate	OK	
	Sta. 80+00-B	18" Flap Gate	OK	New in 1995
6-B1	Sta. 74+40-B	8" Sluice Gate	OK	
City	Sta. 74+40-B1	8" Flap Gate	OK	Remove Silt
5-B1	Sta. 69+86-B	30" Sluice Gate	OK	
5-A	Sta. 69+86-B1	30" Flap Gate	OK	Leaks, Install New
4-B1	Sta. 57+98-B	24" Sluice Gate	OK	
4-A	Sta. 57+98-B1	24" Flap Gate	OK	Leaks, Install New
Yeiser	Diversion Sewer	18" Flap Gate	OK	
	Sta. 200+35-A	60" Flap Gate	OK	See Note 1
	Sta. 187+34-A	15" Sluice Gate	OK	See Note 2
	Sta. 157+63-A	6-60" Flap Gate	OK	
	Sta. 151+25-A	24" Flap Gate	OK	
	Sta. 147+25-A	24" Flap Gate	OK	
	Sta. 130+00-A	30" Flap Gate	OK	
	Sta. 11+67-A	72" Flap Gate	OK	
	Pine St Headwall	16" Shear Gate	OK	
	Sta. 84+00-A	24" Flap Gate	OK	Install New
23-B2	Sta. 66+27-A	102" Sluice	OK	
24-B2	Sta. 66+17-A	102x102 Sluice	OK	See Note 3
ICRR	Sta. 175+40-B	24" Flap Gate	OK	
ICRR	Sta. 175+40-B	24" Sluice Gate	OK	
20-B2	Sta. 161+66-B	24" Sluice Gate	OK	
21-B2	Sta. 161+66-B	24" Sluice Gate	OK	
16-B2	Sta. 150+60-B	24" Sluice Gate	OK	
16-A	Sta. 150+38-B2	24" Flap Gate	N/A	See Note 4
15-A	Sta. 149+72-B2	18" Sluice Gate	OK	
13-P	Sta. 145+92-B	30" Sluice Gate	OK	
14-B2	Sta. 145+92-B	30" Sluice Gate	OK	
12-P	Sta. 145+61-B	24" Sluice Gate	OK	See Note 2

MH NO.	LOCATION	DESCRIPTION	OPERATE	REMARKS
13-B2	Sta. 145+61-B	36" Sluice Gate	OK	
11-B2	Sta. 128+61-B	36" Sluice Gate	OK	
	Sta. 128+61-B2	36" Flap Gate	OK	
1-P	2nd & Jefferson	18" Sluice Gate	OK	See Note 2
2-P	2nd & Jefferson	18" Sluice Gate	OK	See Note 5
8-B2	Sta. 123+61-B	20" Sluice Gate	OK	
2-B1	Sta. 28+49-B	12" Sluice Gate	OK	
2-A	Sta. 28+52-B1	12" Flap Gate	OK	
	Sta. 19+11-B	66" Flap Gate	OK	
	Sta. 7+54-B	18" Flap Gate	OK	New in 1995
	Sta. 291+75-C	36" Flap Gate	OK	New in 1998
	Sta. 254+06-C	36" Flap Gate	OK	New in 1998
	Sta. 244+65-C	30 Flap Gate	OK	Install New
	Sta. 224+50-C	36" Flap Gate	OK	New in 1996
	Sta. 219+80-C	8" Sluice Gate	OK	
	Sta. 217+35-C	2-24" Flap Gate	OK	New in 1996
	Sta. 206+90-C	36" Flap Gate	OK	New in 1980
	Sta. 200+55-C	24" Flap Gate	OK	
	Sta. 199+80-C	24" Flap Gate	OK	New in 1995
	Sta. 176+90-C	48" Flap Gate	OK	
	Sta. 176+47-C	24" Flap Gate	OK	
	Sta. 172+08-C	24" Flap Gate	OK	
	Sta. 150+05-C	24" Flap Gate	OK	
	Sta. 125+95-C	48" Flap Gate	OK	New in 1980
	Sta. 92+70-C	2-48" Flap Gate	OK	
	Sta. 51+28-C	30" Flap Gate	OK	New in 1996
	Sta. 32+38-C	3-30" Sluice	OK	See Note 6
	Sta. 32+12-C	2-48" Sluice	OK	See Note 6

Notes:

1. **Install new seat on gate frame.**
2. **Install new ladder rungs.**
3. **Install new structural support and cover.**
4. **Manhole # 16-A is located under the Executive Inn Parking Lot (location is not known).**
5. **Install new ladder rungs in the north manhole at 2nd and Jefferson.**
6. **Install new seats on gate frame, provide new bushings and adjust wedges as required to seal sluice gates.**

Appendix E
Engineering Cost Estimate

OHIO RIVER, PADUCAH, KENTUCKY
Flood Damage Reduction
Section 905(b) (WRDA 1996) Analysis

U.S. ARMY CORPS OF ENGINEERS
LOUISVILLE DISTRICT

PADUCAH FLOOD PROTECTION UPGRADE
SECTION 905(b) - RECONNAISSANCE
REPORT FOR PADUCAH, KENTUCKY

Designed By: USA COE, LOUISVILLE DISTRICT
Estimated By: M.WITCHER, B.NICHOLSON, T.LAMB

Prepared By:

Preparation Date: 09/01/99
Effective Date of Pricing: 09/01/99
Est Construction Time: 540 Days

Sales Tax: 6.00%

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SCOPE OF WORK

THIS PROJECT CONSISTS OF THE UPGRADE OF THE EXISTING FLOOD PROTECTION PROJECT FOR THE CITY OF PADUCAH, KENTUCKY, ALONG THE LOWER OHIO RIVER BETWEEN 932 RIVER MILE AND 938 RIVER MILE. THIS WORK TO INCLUDE: 1)THE MAJOR UPGADE OF BOTH ELECTRICAL AND MECHANICAL ITEMS OF ALL 13 PUMP STATIONS; 2)THE REPAIR/REPLACEMENT OF MISCELLANEOUS ITEMS ALONG THE LEVEE.

THE STRUCTURAL EVALUATION OF THE PUMP STATIONS AND THE FLOODWALL PORTION PREPARED BY AN INDEPENDENT A/E FIRM IS INCLUDED HERE IN THE TOTAL COSTS. THE STRUCTURAL AND FLOODWALL DETAILS ARE IN A SEPARATE APPENDIX

SUMMARY REPORTS SUMMARY PAGE

PROJECT INDIRECT SUMMARY - Assembly.....1

DETAILED ESTIMATE DETAIL PAGE

001. PRIME CONTRACTOR.....1
02. PADUCAH LEVEE UPGRADE
02. PADUCAH LEVEE UPGRADE.....3
03. PADUCAH FLOODWALL UPGRADE
03. FLOODWALL UPGRADE.....13
10. PADUCAH PUMP PLANT ELEC UPGRADE
010. PADUCAH PUMP PLANT ELEC UPGRADE.....14
15. PADUCAH PUMP PLANT MECH UPGRADE
AA. Manhole Grating.....49
BB. Vortex Supressor in PS 1.....50
CC. Pump Station Grating.....51
DD. Pump Repair.....52
FF. Pipe Repair.....53

No Backup Reports...

* * * END TABLE OF CONTENTS * * *

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
02 PADUCAH LEVEE UPGRADE									
02. 02 PADUCAH LEVEE UPGRADE									
02. 02.002 PADUCAH LEVEE UPGRADE									
02. 02.002.001 LEVEE UPGRADE - SECTION A									
02. 02.002.001.001 Repair of Depression/Sink Hole	197.90	SY	2,998	227	97	244	41	3,606	18.22
02. 02.002.001.002 Slip Lining of Existing Pipes	1.00	EA	224,750	16,993	7,252	7,470	2,924	259,389	259388.92
02. 02.002.001.003 Cure-in-Place Pipe Lining, 24"&<	1.00	EA	87,450	6,612	2,822	2,907	1,138	100,928	100927.97
02. 02.002.001.005 Stone Protection	200.00	CY	8,308	628	268	676	113	9,993	49.97
02. 02.002.001.007 Replace Drainage Control Device	1.00	EA	33,942	2,566	1,095	2,764	460	40,828	40827.94
TOTAL LEVEE UPGRADE - SECTION A	1.00	EA	357,448	27,026	11,534	14,061	4,675	414,744	414743.52
02. 02.002.002 LEVEE UPGRADE - SECTION B									
02. 02.002.002.001 Repair of Depression/Sink Hole	47.30	SY	742	56	24	60	10	893	18.87
02. 02.002.002.002 Slip Lining of Existing Pipes	1.00	EA	53,380	4,036	1,722	1,774	694	61,607	61607.03
02. 02.002.002.003 Cure-in-Place Pipe Lining, 24"&<	1.00	EA	70,530	5,333	2,276	2,344	918	81,400	81400.22
02. 02.002.002.005 Stone Protection	695.00	CY	28,869	2,183	932	2,351	391	34,726	49.97
02. 02.002.002.007 Replace Drainage Control Device	1.00	EA	55,159	4,171	1,780	4,492	748	66,349	66349.23
TOTAL LEVEE UPGRADE - SECTION B	1.00	EA	208,681	15,778	6,734	11,021	2,761	244,975	244974.88
02. 02.002.003 LEVEE UPGRADE - SECTION C									
02. 02.002.003.001 Repair of Depression/Sink Hole	262.30	SY	4,232	320	137	345	57	5,090	19.41
02. 02.002.003.002 Slip Lining of Existing Pipes	1.00	EA	341,167	25,795	11,009	11,339	4,438	393,748	393748.34
02. 02.002.003.003 Cure-in-Place Pipe Lining, 24"&<	1.00	EA	111,510	8,431	3,598	3,706	1,451	128,696	128696.14
02. 02.002.003.004 Tree Clearing, Minor	1.00	EA	206	16	7	17	3	247	247.32
02. 02.002.003.005 Stone Protection	112.00	CY	4,652	352	150	379	63	5,596	49.97
02. 02.002.003.006 Vegetative Cover	2117.00	SY	4,335	328	140	353	59	5,214	2.46
02. 02.002.003.007 Replace Drainage Control Device	1.00	EA	102,510	7,751	3,308	8,347	1,390	123,306	123305.76
TOTAL LEVEE UPGRADE - SECTION C	1.00	EA	568,611	42,992	18,348	24,486	7,461	661,898	661897.84
TOTAL PADUCAH LEVEE UPGRADE	1.00	EA	1,134,740	85,796	36,616	49,568	14,897	1,321,616	1321616
TOTAL PADUCAH LEVEE UPGRADE	1.00	EA	1,134,740	85,796	36,616	49,568	14,897	1,321,616	1321616
TOTAL PADUCAH LEVEE UPGRADE	1.00	EA	1,134,740	85,796	36,616	49,568	14,897	1,321,616	1321616
03 PADUCAH FLOODWALL UPGRADE									
03. 03 FLOODWALL UPGRADE									

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
03. 03. 03 Paducah Floodwall Upgrade									
03. 03. 03. 03 Paducah Floodwall Upgrade									
03. 03. 03. 03.003 Paducah Floodwall Upgrade									
03. 03. 03. 03.003.01 Paducah Floodwall Upgrade	1.00	EA	91,369	0	0	0	0	91,369	91369.00
TOTAL Paducah Floodwall Upgrade	1.00	EA	91,369	0	0	0	0	91,369	91369.00
TOTAL Paducah Floodwall Upgrade	1.00	EA	91,369	0	0	0	0	91,369	91369.00
TOTAL Paducah Floodwall Upgrade	1.00	EA	91,369	0	0	0	0	91,369	91369.00
TOTAL FLOODWALL UPGRADE	1.00	EA	91,369	0	0	0	0	91,369	91369.00
TOTAL PADUCAH FLOODWALL UPGRADE	1.00	EA	91,369	0	0	0	0	91,369	91369.00
10 PADUCAH PUMP PLANT ELEC UPGRADE									
10.010 PADUCAH PUMP PLANT ELEC UPGRADE									
10.010.010 PADUCAH PUMP PLANT ELEC UPGRADE									
10.010.010.010 PADUCAH PUMP PLANT ELEC UPGRADE									
10.010.010.010.001 PUMP PLANT #1 - ELEC UPGRADE									
10.010.010.010.002 PUMP PLANT #2 - ELEC UPGRADE									
10.010.010.010.002.01 MTR CONTR CENTER - ELEC UPGRADE	1.00	EA	2,731	207	88	91	36	3,152	3152.44
10.010.010.010.002.02 Removal	1.00	EA	110	8	4	4	1	127	127.13
TOTAL PUMP PLANT #2 - ELEC UPGRADE	1.00	EA	2,842	215	92	94	37	3,280	3279.56
10.010.010.010.003 PUMP PLANT #3 - ELEC UPGRADE									
10.010.010.010.003.01 INTERIOR - ELEC UPGRADE	1.00	EA	3,518	266	114	117	46	4,060	4060.08
10.010.010.010.003.02 MTR CONTR CENTER - ELEC UPGRADE	1.00	EA	13,770	1,041	444	458	179	15,892	15892.22
10.010.010.010.003.03 PUMP MOTOR CONDUCTORS - UPGRADE	1.00	EA	1,969	149	64	65	26	2,272	2272.42
10.010.010.010.003.04 LGT & RECPT ELECTRICAL - UPGRADE	1.00	EA	3,224	244	104	107	42	3,721	3720.63
10.010.010.010.003.05 SERVICE ENTRANCE - UPGRADE	1.00	EA	6,930	524	224	230	90	7,998	7997.55
10.010.010.010.003.06 SITE ELECTRICAL - UPGRADE	1.00	EA	4,397	332	142	146	57	5,074	5074.44
10.010.010.010.003.07 Removal	1.00	EA	2,800	212	90	93	36	3,231	3231.28
TOTAL PUMP PLANT #3 - ELEC UPGRADE	1.00	EA	36,607	2,768	1,181	1,217	476	42,249	42248.62

		QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
10.010.010.010.004	PUMP PLANT #4 - ELEC UPGRADE									
10.010.010.010.004.01	MTR CONTR CENTER - ELEC UPGRADE	1.00	EA	7,420	561	239	247	97	8,564	8563.90
10.010.010.010.004.02	INTERIOR - ELEC UPGRADE	1.00	EA	991	75	32	33	13	1,143	1143.38
10.010.010.010.004.03	PUMP MOTOR CONDUCTORS - UPGRADE	1.00	EA	1,506	114	49	50	20	1,738	1738.00
10.010.010.010.004.04	440V Underground Secondary Serv	1.00	EA	2,313	175	75	77	30	2,669	2669.41
10.010.010.010.004.05	120/240V Underground Service	1.00	EA	1,316	100	42	44	17	1,519	1519.28
	TOTAL PUMP PLANT #4 - ELEC UPGRADE	1.00	EA	13,546	1,024	437	450	176	15,634	15633.97
10.010.010.010.005	PUMP PLANT #5 - ELEC UPGRADE									
10.010.010.010.005.01	INTERIOR - ELEC UPGRADE	1.00	EA	3,518	266	114	117	46	4,060	4060.08
10.010.010.010.005.02	MTR CONTR CENTER - ELEC UPGRADE	1.00	EA	31,012	2,345	1,001	1,031	403	35,792	35792.18
10.010.010.010.005.03	PUMP MOTOR CONDUCTORS - UPGRADE	1.00	EA	5,762	436	186	192	75	6,650	6650.00
10.010.010.010.005.04	LGT & RECPT ELECTRICAL - UPGRADE	1.00	EA	4,298	325	139	143	56	4,961	4960.84
10.010.010.010.005.05	SERVICE ENTRANCE - UPGRADE	1.00	EA	11,917	901	385	396	155	13,754	13753.83
10.010.010.010.005.06	SITE ELECTRICAL - UPGRADE	1.00	EA	7,024	531	227	233	91	8,106	8106.01
10.010.010.010.005.07	Removal	1.00	EA	4,333	328	140	144	56	5,001	5000.53
	TOTAL PUMP PLANT #5 - ELEC UPGRADE	1.00	EA	67,864	5,131	2,190	2,256	883	78,323	78323.47
10.010.010.010.006	PUMP PLANT #6 - ELEC UPGRADE									
10.010.010.010.006.01	INTERIOR - ELEC UPGRADE	1.00	EA	3,518	266	114	117	46	4,060	4060.08
10.010.010.010.006.02	MTR CONTR CENTER - ELEC UPGRADE	1.00	EA	68,945	5,213	2,225	2,291	897	79,571	79570.60
10.010.010.010.006.03	PUMP MOTOR CONDUCTORS - UPGRADE	1.00	EA	13,277	1,004	428	441	173	15,323	15322.82
10.010.010.010.006.04	LGT & RECPT ELECTRICAL - UPGRADE	1.00	EA	5,373	406	173	179	70	6,201	6201.05
10.010.010.010.006.05	SERVICE ENTRANCE - UPGRADE	1.00	EA	15,894	1,202	513	528	207	18,344	18343.60
10.010.010.010.006.06	SITE ELECTRICAL - UPGRADE	1.00	EA	14,047	1,062	453	467	183	16,212	16212.02
10.010.010.010.006.07	Removal	1.00	EA	7,744	586	250	257	101	8,938	8938.05
	TOTAL PUMP PLANT #6 - ELEC UPGRADE	1.00	EA	128,798	9,738	4,156	4,281	1,675	148,648	148648.22
10.010.010.010.007	PUMP PLANT #7 - ELEC UPGRADE									
10.010.010.010.007.01	INTERIOR - ELEC UPGRADE	1.00	EA	3,518	266	114	117	46	4,060	4060.08
10.010.010.010.007.02	MTR CONTR CENTER - ELEC UPGRADE	1.00	EA	21,615	1,634	697	718	281	24,947	24946.86
10.010.010.010.007.03	PUMP MOTOR CONDUCTORS - UPGRADE	1.00	EA	2,436	184	79	81	32	2,812	2811.54
10.010.010.010.007.04	LGT & RECPT ELECTRICAL - UPGRADE	1.00	EA	3,224	244	104	107	42	3,721	3720.63
10.010.010.010.007.05	SERVICE ENTRANCE - UPGRADE	1.00	EA	8,347	631	269	277	109	9,633	9633.05
10.010.010.010.007.06	SITE ELECTRICAL - UPGRADE	1.00	EA	7,024	531	227	233	91	8,106	8106.01
10.010.010.010.007.07	Removal	1.00	EA	3,626	274	117	121	47	4,185	4184.77
	TOTAL PUMP PLANT #7 - ELEC UPGRADE	1.00	EA	49,789	3,765	1,607	1,655	648	57,463	57462.94
10.010.010.010.008	PUMP PLANT #8 - ELEC UPGRADE									

		QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
10.010.010.010.009	PUMP PLANT #9 - ELEC UPGRADE									
10.010.010.010.009.01	INTERIOR - ELEC UPGRADE	1.00	EA	1,660	125	54	55	22	1,915	1915.41
10.010.010.010.009.02	MTR CONTR CENTER - ELEC UPGRADE	1.00	EA	8,506	643	274	283	111	9,817	9816.94
10.010.010.010.009.03	PUMP MOTOR CONDUCTORS - UPGRADE	1.00	EA	1,423	108	46	47	19	1,642	1642.17
10.010.010.010.009.04	SERVICE ENTRANCE - UPGRADE	1.00	EA	2,944	223	95	98	38	3,398	3398.27
10.010.010.010.009.05	SITE ELECTRICAL - UPGRADE	1.00	EA	4,162	315	134	138	54	4,803	4803.47
10.010.010.010.009.06	Removal	1.00	EA	1,781	135	57	59	23	2,055	2055.30
	TOTAL PUMP PLANT #9 - ELEC UPGRADE	1.00	EA	20,476	1,548	661	681	266	23,632	23631.56
10.010.010.010.010	PUMP PLANT #10 - ELEC UPGRADE									
10.010.010.010.010.01	MTR CONTR CENTER - ELEC UPGRADE	1.00	EA	5,474	414	177	182	71	6,318	6317.72
10.010.010.010.010.02	INTERIOR - ELEC UPGRADE	1.00	EA	991	75	32	33	13	1,143	1143.38
10.010.010.010.010.03	PUMP MOTOR CONDUCTORS - UPGRADE	1.00	EA	3,728	282	120	124	48	4,302	4302.31
10.010.010.010.010.04	440V Underground Secondary Serv	1.00	EA	2,306	174	74	77	30	2,662	2661.56
10.010.010.010.010.05	120/240V Underground Service	1.00	EA	607	46	20	20	8	700	700.30
10.010.010.010.010.06	480 V WP Dry Transformer	1.00	EA	3,990	302	129	133	52	4,604	4604.41
	TOTAL PUMP PLANT #10 - ELEC UPGRADE	1.00	EA	17,095	1,293	552	568	222	19,730	19729.69
10.010.010.010.011	PUMP PLANT #11 - ELEC UPGRADE									
10.010.010.010.012	PUMP PLANT #12 - ELEC UPGRADE									
10.010.010.010.012.01	INTERIOR - ELEC UPGRADE	1.00	EA	1,660	125	54	55	22	1,915	1915.41
10.010.010.010.012.02	MTR CONTR CENTER - ELEC UPGRADE	1.00	EA	8,506	643	274	283	111	9,817	9816.94
10.010.010.010.012.03	PUMP MOTOR CONDUCTORS - UPGRADE	1.00	EA	1,745	132	56	58	23	2,014	2013.57
10.010.010.010.012.04	SERVICE ENTRANCE - UPGRADE	1.00	EA	4,266	323	138	142	55	4,924	4923.91
10.010.010.010.012.05	SITE ELECTRICAL - UPGRADE	1.00	EA	4,162	315	134	138	54	4,803	4803.47
10.010.010.010.012.06	Removal	1.00	EA	1,781	135	57	59	23	2,055	2055.30
	TOTAL PUMP PLANT #12 - ELEC UPGRADE	1.00	EA	22,120	1,672	714	735	288	25,529	25528.61
10.010.010.010.013	PUMP PLANT #13 - ELEC UPGRADE									
10.010.010.010.014	SLUICE GATE #2 - ELEC UPGRADE									
10.010.010.010.014.01	GATE #2 - MOTOR OPERATOR	1.00	EA	7,838	593	253	261	102	9,046	9046.16
	TOTAL SLUICE GATE #2 - ELEC UPGRADE	1.00	EA	7,838	593	253	261	102	9,046	9046.16
	TOTAL PADUCAH PUMP PLANT ELEC UPGRADE	1.00	EA	366,974	27,746	11,842	12,197	4,774	423,533	423532.79
	TOTAL PADUCAH PUMP PLANT ELEC UPGRADE	1.00	EA	366,974	27,746	11,842	12,197	4,774	423,533	423532.79

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
TOTAL PADUCAH PUMP PLANT ELEC UPGRADE	1.00	EA	366,974	27,746	11,842	12,197	4,774	423,533	423532.79
TOTAL PADUCAH PUMP PLANT ELEC UPGRADE	1.00	EA	366,974	27,746	11,842	12,197	4,774	423,533	423532.79
15 PADUCAH PUMP PLANT MECH UPGRADE									
15. AA Manhole Grating	12.00	EA	28,486	2,154	919	947	371	32,876	2739.65
15. BB Vortex Supressor in PS 1	12.00	EA	28,109	2,125	907	934	366	32,441	2703.40
15. CC Pump Station Grating	1.00	EA	17,375	1,314	561	577	226	20,052	20052.40
15. DD Pump Repair	1.00	EA	749,806	56,692	24,195	24,921	9,754	865,367	865367.20
15. FF Pipe Repair	1.00	EA	239,879	18,137	7,740	7,973	3,121	276,850	276850.00
TOTAL PADUCAH PUMP PLANT MECH UPGRADE	1.00	EA	1,063,654	80,422	34,322	35,352	13,837	1,227,586	1227586
TOTAL PADUCAH FLOOD PROTECTION UPGRADE	1.00	EA	2,656,736	193,964	82,780	97,116	33,507	3,064,104	3064104
CONTINGENCIES								743,184	
TOTAL INCL OWNER COSTS								3,807,288	

0.001. PRIME CONTRACTOR			QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
0.001. PRIME CONTRACTOR													
0.001. 0. Overhead Items - AA													
MIL	<01910 1201 >	General Superintendent (P.M.) OTHER DUTIES INCLUDE QUALITY CONTROL OFFICIER AND SAFETY OFFICIER.	18.00	MON	N/A	0.00	0.00 0	0.00 0	0.00 0	5618.00 101,124	0.00 0	5618.00 101,124	5618.00
MIL	<01910 2103 >	Adminstrative Clerk USED ONLY PART TIME.	9.00	MON	N/A	0.00	0.00 0	0.00 0	0.00 0	2756.00 24,804	0.00 0	2756.00 24,804	2756.00
USR	<01910 43011>	Surveyor and Crew	40.00	HR	N/A	0.00	0.00 0	180.00 7,200	8.00 320	8.48 339	0.00 0	196.48 7,859	196.48
USR	<01924 3003 >	Telephone Costs	18.00	MOS		0.00	0.00 0	0.00 0	0.00 0	127.20 2,290	0.00 0	127.20 2,290	127.20
USR	<01932 1000 >	Mob/DeMob Equipment THIS MAY INCLUDE AN EXTRA MOB AND DEMOB.	1.00	LS		0.00	40.00 40	20.00 20	0.00 0	10600.00 10,600	0.00 0	10620.00 10,620	10620.00
AF	<01941 3112 >	Temp Office Trailer 32' X 8' w/o Hookup	18.00	MO	N/A	0.00	0.00 0	0.00 0	0.00 0	231.49 4,167	0.00 0	231.49 4,167	231.49
AF	<01941 3115 >	Temp Const Office Air Conditioner	18.00	MO	N/A	0.00	0.00 0	0.00 0	0.00 0	43.57 784	0.00 0	43.57 784	43.57
AF	<01941 3121 >	Temp Const Stor. Van 16 X 8	18.00	MO	N/A	0.00	0.00 0	0.00 0	0.00 0	102.12 1,838	0.00 0	102.12 1,838	102.12
AF	<01941 5001 >	Toilet Portable Chemical	72.00	MO	N/A	0.00	0.00 0	0.00 0	0.00 0	106.00 7,632	0.00 0	106.00 7,632	106.00
AF	<01942 4201 >	Temporary Construction Sign	60.00	SF	N/A	0.00	0.00 0	0.00 0	0.00 0	11.44 686	0.00 0	11.44 686	11.44
AF	<01943 1001 >	Temporary Construction/Heat, 12 Hr Day	1000.00	CSF	N/A	0.00	0.00 0	0.00 0	0.00 0	1.06 1,060	0.00 0	1.06 1,060	1.06
AF	<01943 1003 >	Temp Const Lighting w/Service Min	100.00	CSF	EELEC	10.00	0.33 33	10.10 1,010	0.00 0	1.97 197	0.00 0	12.07 1,207	12.07
AF	<01943 1005 >	Temp Power/Lighting/Month Ave	30.00	CSF	N/A	0.00	0.00 0	0.00 0	0.00 0	74.20 2,226	0.00 0	74.20 2,226	74.20
HTW	<01951 1201 >	Co2 Extinguisher (5#)	2.00	EA	N/A	0.00	0.00 0	0.00 0	0.00 0	92.16 184	0.00 0	92.16 184	92.16
HTW	<01953 1115 >	8" x 10", Color, Each	100.00	EA	N/A	0.00	0.00 0	0.00 0	0.00 0	5.29 529	0.00 0	5.29 529	5.29

0.001. PRIME CONTRACTOR			QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
HTW	<01953 1116 >	35 mm Slides, Ectachrome, 24 Ct.					0.00	0.00	0.00	10.48	0.00	10.48	
		Includes Film	100.00	EA	N/A	0.00	0	0	0	1,048	0	1,048	10.48
AF	<01954 6132 >	Pickup Truck Mileage Charge					0.00	0.00	0.00	0.42	0.00	0.42	
			10000	MI	N/A	0.00	0	0	0	4,240	0	4,240	0.42
AF	<01720 1001 >	Site Debris Clean-Up & Removal					6.40	205.47	82.19	0.00	0.00	287.66	
			20.00	AC	COETF	0.63	128	4,109	1,644	0	0	5,753	287.66
USR	<01915 29999>	Janitoral Cleaning					0.00	0.00	0.00	106.00	0.00	106.00	
			18.00	MOS	COETF	0.63	0	0	0	1,908	0	1,908	106.00
USR	<01915 29999>	Office Equipment for Corps pers.					6.40	164.89	83.12	530.00	0.00	778.00	
		INCLUDES DESK, CHAIR, FILE CABINET, COPIER, FAX MACHINE, REFRIGATOR, AND DRINKING WATER	18.00	MOS	COETF	0.63	115	2,968	1,496	9,540	0	14,004	778.00
		TOTAL Overhead Items - AA					316	15,307	3,460	175,197	0	193,964	

0.001.020. PIPE SLIPLINER SUBCONTRACTOR
NO OVERHEAD AND PROFIT COSTS SHOWN, ARE INCLUDED IN HIS UNIT COSTS QUOTED.

0.001.021. PIPE CURED-IN-PLACE LINER SUB
NO OVERHEAD AND PROFIT COSTS SHOWN, COSTS ARE INCLUDED IN THE UNIT COSTS QUOTED.

02. 02. PADUCAH LEVEE UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
02. PADUCAH LEVEE UPGRADE THIS WORK CONSISTS OF REPAIRS TO THE EXISTING STORM DRAINAGE SYSTEMS. IT INVOLVES THE SLIPLINING OR CURED-IN-PLACE PIPE REPAIR METHODS TO APPROXIMATELY 4,100 LF OF CMP DRAINAGE PIPES VARIOUS SIZES FROM 8 TO 84 INCHES IN DIAMETER THRU/UNDER THE EXISTING LEVEE. ALSO THE MINOR REPAIR OF DEPRESSIONS AND/OR GROUNDHOG OR SMALL SINK HOLES IN THE LEVEE EMBANKMENT AND SLOPE AT VARIOUS LOCATIONS. AND SOME MISC. CLEARING. 02. 02. PADUCAH LEVEE UPGRADE										
02. 02.002.001. LEVEE UPGRADE - SECTION A										
02. 02.002.001.001. Repair of Depression/Sink Hole THIS ITEM IS FOR THE REPAIR OF LOW AREAS, SPOTS, RUTTING, SMALL SINK HOLES, AND ERODED AREAS IN THE CROWN OR EMBANKMENT OF THE LEVEE AT 6 DIFFERENT LOCATIONS AND RANGING/VARIES IN SIZE OF AREA FROM 3 SF TO 1,200 SF AND 0.10 CY TO 22.0 CY OF FILL.										
MIL AA <02820 3002 > Furn & Pl Imported Topsoil, 6"Dp					0.13	4.54	2.58	21.65	0.00	28.77	
	31.50	CY	CODLA	11.50	4	143	81	682	0	906	28.77
MIL AA <02820 2002 > Spread Topsoil by Hand					0.79	23.16	0.00	15.46	0.00	38.62	
From Stockpile	31.50	CY	ULABA	1.64	25	730	0	487	0	1,216	38.62
MIL AA <02212 3102 > Compact Bfill, by Hand w/Vib Pl					0.12	3.59	0.09	0.00	0.00	3.67	
6"(15cm) Lift	31.50	CY	CLACC	24.50	4	113	3	0	0	116	3.67
MIL AA <02820 2003 > Top Dress by Hand					0.00	0.06	0.00	0.08	0.00	0.14	
	1780.00	SF	ULABA	605.50	4	112	0	138	0	250	0.14
L MIL AA <02810 2001 > Seeding by Hand, 50#/MSY					0.01	0.16	0.00	17.12	0.00	17.28	
	19.80	CSY	ULABA	242.25	0	3	0	339	0	342	17.28
AF AA <02810 4001 > 35 Lb/1000 SF Fertilizer,					0.02	0.79	0.90	0.64	0.00	2.33	
Spread by Machine	17.80	MSF	COFWK	75.00	0	14	16	11	0	41	2.33
USR AA <02830 29999> Mulch, Pine Straw					0.00	0.04	0.00	0.03	0.00	0.07	
	1780.00	SF	ULABA	1000.00	4	69	0	57	0	126	0.07
TOTAL Repair of Depression/Sink Hole	197.90	SY			41	1,184	100	1,713	0	2,998	15.15
02. 02.002.001.002. Slip Lining of Existing Pipes											
USR SL <02465 99999> PIPE SLIPLINER, 30 INCH					0.00	0.00	0.00	0.00	92.00	92.00	
QUOTE RECEIVECD FROM BOWEN ENGINEERING, 8/99 INCLUDES MATERIAL(HOBAS PIPE LINER) INSTALLATION, SOME LIGHT CLEANING EXISTING PIPE, GROUTING AND RESTORATION. BASED ON 20 FT LENGTHS. SLIPLINE PIPE I.D. 24	134.00	LF		0.00	0	0	0	0	12,328	12,328	92.00

02. 02. PADUCAH LEVEE UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
INCHES AT $92/LF.											
USR SL <02465 99999> PIPE SLIPLINER, 60 INCH					0.00	0.00	0.00	0.00	276.00	276.00	
QUOTE RECEIVECD FROM BOWEN ENGINEERING, 8/99 FOR SLIPLINE PIPE I.D. 54 INCH AT $276/LF. INCLUDES MATERIAL (USING HOBAS PIPE LINER), INSTALLATION, SOME LIGHT CLEANING EXISTING PIPE, GROUTING AND RESTORATION. BASED ON 20 FT LENGTHS.	477.00	LF		0.00	0	0	0	0	131,652	131,652	276.00
USR SL <02465 99999> PIPE SLIPLINER, 72 INCH					0.00	0.00	0.00	0.00	410.00	410.00	
QUOTE RECEIVECD FROM BOWEN ENGINEERING, 8/99 INCLUDES MATERIAL(HOBAS PIPE LINER) INSTALLATION, SOME LIGHT CLEANING EXISTING PIPE, GROUTING AND RESTORATION. BASED ON 20 FT LENGTHS. SLIPLINE PIPE I.D. 66 INCHES AT $410/LF.	197.00	LF		0.00	0	0	0	0	80,770	80,770	410.00
TOTAL Slip Lining of Existing Pipes	1.00	EA			0	0	0	0	224,750	224,750	224750.00
02. 02.002.001.003. Cure-in-Place Pipe Lining, 24"&<											
USR S2 <02465 99999> PIPE LINER, CIPP METHOD, 15 INCH					0.00	0.00	0.00	0.00	160.00	160.00	
UNIT COSTS PRORATED FROM 24 INCH UNIT COSTS AT $210/LF. QUOTE FROM REYNOLDS INCORP. INLINER FOR CIPP (CURED-IN-PLACE PIPE) LINER, INCLUDES LIGHT CLEANING.	78.00	LF		0.00	0	0	0	0	12,480	12,480	160.00
USR S2 <02465 99999> PIPE LINER, CIPP METHOD, 24 INCH					0.00	0.00	0.00	0.00	210.00	210.00	
QUOTE RECEIVED FROM REYNOLDS INCORP. INLINER, 11/98 FOR 24" CIPP (CURED-IN-PLACE METHOD) PIPE LINER AT $210/LF.	357.00	LF		0.00	0	0	0	0	74,970	74,970	210.00
TOTAL Cure-in-Place Pipe Lining, 24"&<	1.00	EA			0	0	0	0	87,450	87,450	87450.00
02. 02.002.001.005. Stone Protection											
MIL AA <02261 1001 > Rip Rap, 3/8 CY to 1/4 CY Pcs					0.51	16.13	6.18	19.23	0.00	41.54	
Random, Dumped from Truck	200.00	CY	CODEX	9.75	102	3,226	1,236	3,846	0	8,308	41.54
TOTAL Stone Protection	200.00	CY			102	3,226	1,236	3,846	0	8,308	41.54

02. 02. PADUCAH LEVEE UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
02. 02.002.001.007. Replace Drainage Control Device											
CIV AA <05651 1403 > 30" Dia (76cm) Alum Flap Gates AT PUMP STA #2	1.00	EA	SIWSE	0.38	9.33 9	420.39 420	85.74 86	1019.72 1,020	0.00 0	1525.85 1,526	1525.85
CIV AA <05651 1402 > 24" Dia (61cm) Alum Flap Gates AT STA. 84+00-A.	1.00	EA	SIWSE	0.44	8.00 8	360.33 360	73.49 73	786.52 787	0.00 0	1220.34 1,220	1220.34
L MIL AA <05521 3001 > 20"(51cm)Wide Vert Steel Ladder Primed. THIS ITEM FOR REPLACEMENT OF MANHOLE LADDER RUNGS AT STA. 187+34-A. REVISED PRODUCTION RATE FROM 10.625 VLF/HR TO 3.0 VLF/HR.	10.00	VLF	SIWSC	3.00	1.35 13	62.19 622	1.66 17	23.24 232	0.00 0	87.09 871	87.09
USR AA <05651 14999> 60" Dia Alum Flap Gate Seat THIS ITEM IS FOR REPLACING OF FLAP GATE SEAT AT STA 200+35-A. REVISED MATERIAL UNIT COSTS FROM $6,002/EA TO $1,500/EA AND PRODUCTION RATE FROM 0.0875/HR TO 0.25/HR.	1.00	EA	SIWSE	0.25	14.00 14	630.59 631	128.61 129	1590.00 1,590	0.00 0	2349.20 2,349	2349.20
MIL AA <05120 1302 > 30-65 LB/LF THIS ITEM PART OF REPLACEMENT OF STRUCTURAL TOP AT STA. 66+17A.	0.50	TON	SIWSM	1.13	7.11 4	315.63 158	61.17 31	1945.10 973	0.00 0	2321.91 1,161	2321.91
MIL AA <05521 3001 > 20"(51cm)Wide Vert Steel Ladder Primed THIS ITEM IS PART OF REPLACEMENT OF STRUCTURAL TOP AT STA. 66+17A	15.00	VLF	SIWSC	10.63	0.38 6	17.56 263	0.47 7	23.23 348	0.00 0	41.26 619	41.26
MIL AA <05530 2204 > 1-1/4"x3/16"Galv Steel Grating Welded Steel,9.1 #/SF(2 Oz /SF) THIS ITEM IS PART OF REPLACEMENT OF STRUCTURAL TOP AT STA. 66+17A.	100.00	SF	SIWSC	75.00	0.05 5	2.49 249	0.07 7	6.01 601	0.00 0	8.57 857	8.57
CIV AA <05651 1401 > 18" Dia (46cm) Alum Flap Gates THIS ITEM FOR 12 INCH FLAP GATE AT PUMP STA #2.	1.00	EA	SIWSE	0.50	7.00 7	315.29 315	64.31 64	585.12 585	0.00 0	964.72 965	964.72
CIV AA <05651 1406 > 48" Dia (122cm) Alum Flap Gates FOR PUMP STA #2.	2.00	EA	SIWSE	0.19	18.67 37	840.78 1,682	171.49 343	2643.64 5,287	0.00 0	3655.91 7,312	3655.91
CIV AA <05651 1408 > 60" Dia (152cm) Alum Flap Gates FOR PUMP STA #2.	2.00	EA	SIWSE	0.09	40.00 80	1801.67 3,603	367.47 735	6362.12 12,724	0.00 0	8531.26 17,063	8531.26
TOTAL Replace Drainage Control Device	1.00	EA			183	8,304	1,491	24,147	0	33,942	33942.27

02. 02. PADUCAH LEVEE UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL LEVEE UPGRADE - SECTION A	1.00	EA			326	12,714	2,827	29,706	312,200	357,448	357447.54
02. 02.002.002. LEVEE UPGRADE - SECTION B											
02. 02.002.002.001. Repair of Depression/Sink Hole THIS ITEM IS FOR THE REPAIR OF LOW AREAS, SPOTS, RUTTING, SMALL SINK HOLES, AND ERODED AREAS IN THE CROWN OR EMBANKMENT OF THE LEVEE AT 4 DIFFERENT LOCATIONS AND RANGING/VARIES IN SIZE OF AREA FROM 3 SF TO 300 SF AND 0.10 CY TO 6.0 CY OF FILL.											
MIL AA <02820 3002 > Furn & Pl Imported Topsoil, 6"Dp					0.13	4.54	2.58	21.65	0.00	28.77	
	8.90	CY	CODLA	11.50	1	40	23	193	0	256	28.77
MIL AA <02820 2002 > Spread Topsoil by Hand From Stockpile					0.79	23.16	0.00	15.46	0.00	38.62	
	8.90	CY	ULABA	1.64	7	206	0	138	0	344	38.62
MIL AA <02212 3102 > Compact Bfill, by Hand w/Vib Pl 6"(15cm) Lift					0.12	3.59	0.09	0.00	0.00	3.67	
	8.90	CY	CLACC	24.50	1	32	1	0	0	33	3.67
MIL AA <02820 2003 > Top Dress by Hand					0.00	0.06	0.00	0.08	0.00	0.14	
	427.00	SF	ULABA	605.50	1	27	0	33	0	60	0.14
L MIL AA <02810 2001 > Seeding by Hand, 50#/MSY					0.01	0.16	0.00	17.12	0.00	17.28	
	0.50	CSY	ULABA	242.25	0	0	0	9	0	9	17.28
AF AA <02810 4001 > 35 Lb/1000 SF Fertilizer, Spread by Machine					0.02	0.79	0.90	0.64	0.00	2.33	
	4.70	MSF	COFWK	75.00	0	4	4	3	0	11	2.33
USR AA <02830 29999> Mulch, Pine Straw					0.00	0.04	0.00	0.03	0.00	0.07	
	427.00	SF	ULABA	1000.00	1	17	0	14	0	30	0.07
TOTAL Repair of Depression/Sink Hole	47.30	SY			11	326	28	388	0	742	15.69
02. 02.002.002.002. Slip Lining of Existing Pipes											
USR SL <02465 99999> PIPE SLIPLINER, 66 INCH QUOTE RECEIVECD FROM BOWEN ENGINEERING, 8/99 (THIS SIZE PIPE WAS PRORATED FROM OTHER SIZE PIPES QUOTED). INCLUDES MATERIAL, INSTALLATION, SOME LIGHT CLEANING EXISTING PIPE, GROUTING AND RESTORATION. BASED ON 20 FT LENGTHS					0.00	0.00	0.00	0.00	340.00	340.00	
	157.00	LF		0.00	0	0	0	0	53,380	53,380	340.00
TOTAL Slip Lining of Existing Pipes	1.00	EA			0	0	0	0	53,380	53,380	53380.00

02. 02. PADUCAH LEVEE UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
02. 02.002.002.003. Cure-in-Place Pipe Lining, 24"&<											
USR S2 <02465 99999> PIPE LINER, CIPP METHOD, 8 INCH					0.00	0.00	0.00	0.00	140.00	140.00	
UNIT COSTS PRORATED FROM 24 INCH UNIT COSTS AT $210/LF. QUOTE FROM REYNOLDS INCORP. INLINER FOR CIPP (CURED-IN-PLACE PIPE) LINER, INCLUDES LIGHT CLEANING. IT IS UNKNOWN AT THIS TIME, IF THIS SMALL A LINER CAN BE INSTALLED IN A 8 INCH PIPE, DO TO EQUIPMENT SIZE. ASSUMING IT CAN AND AM PRORATING THE COSTS.	114.00	LF		0.00	0	0	0	0	15,960	15,960	140.00
USR S2 <02465 99999> PIPE LINER, CIPP METHOD, 18 INCH					0.00	0.00	0.00	0.00	180.00	180.00	
UNIT COSTS PRORATED FROM 24 INCH UNIT COSTS AT $210/LF. QUOTE FROM REYNOLDS INCORP. INLINER FOR CIPP (CURED-IN-PLACE PIPE) LINER, INCLUDES LIGHT CLEANING.	99.00	LF		0.00	0	0	0	0	17,820	17,820	180.00
USR S2 <02465 99999> PIPE LINER, CIPP METHOD, 24 INCH					0.00	0.00	0.00	0.00	210.00	210.00	
QUOTE RECEIVED FROM REYNOLDS INCORP. INLINER, 11/98 FOR 24" CIPP (CURED-IN-PLACE METHOD) PIPE LINER AT $210/LF.	175.00	LF		0.00	0	0	0	0	36,750	36,750	210.00
TOTAL Cure-in-Place Pipe Lining, 24"&<	1.00	EA			0	0	0	0	70,530	70,530	70530.00
02. 02.002.002.005. Stone Protection											
MIL AA <02261 1001 > Rip Rap, 3/8 CY to 1/4 CY Pcs					0.51	16.13	6.18	19.23	0.00	41.54	
Random, Dumped from Truck	695.00	CY	CODEX	9.75	354	11,210	4,295	13,364	0	28,869	41.54
TOTAL Stone Protection	695.00	CY			354	11,210	4,295	13,364	0	28,869	41.54
02. 02.002.002.007. Replace Drainage Control Device											
L MIL AA <02555 3003 > 8"(21cm) Cast Iron Gate Valve					17.60	603.28	102.89	828.09	0.00	1534.26	
Includes Box. AT STA 115+26-B	1.00	EA	XXPLA	0.31	18	603	103	828	0	1,534	1534.26
CIV AA <05651 1401 > 18" Dia (46cm) Alum Flap Gates					7.00	315.29	64.31	585.12	0.00	964.72	
THIS ITEM IS FOR 20 INCH FLAP GATE AT STA 123+61-B2.	1.00	EA	SIWSE	0.50	7	315	64	585	0	965	964.72

02. 02. PADUCAH LEVEE UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
CIV AA <05651 1402 > 24" Dia (61cm) Alum Flap Gates					8.00	360.33	73.49	786.52	0.00	1220.34	
AT STA. 57+98-B1 AND STA. 119+37-B2.	2.00	EA	SIWSE	0.44	16	721	147	1,573	0	2,441	1220.34
CIV AA <05651 1403 > 30" Dia (76cm) Alum Flap Gates					9.33	420.39	85.74	1019.72	0.00	1525.85	
AT STA. 69+86-B1.	1.00	EA	SIWSE	0.38	9	420	86	1,020	0	1,526	1525.85
CIV AA <05651 1104 > 36"x 36"Heavy Duty Sluice Gates					35.00	1576.46	321.54	9759.99	0.00	11657.99	
Self Contained w/Crank Oper Gate AT STA. 108+58-B.	2.00	EA	SIWSE	0.10	70	3,153	643	19,520	0	23,316	11657.99
CIV AA <05651 1107 > 54"x 54"Heavy Duty Sluice Gates					84.75	3817.10	778.54	19911.33	0.00	24506.97	
Self Contained w/Crank Oper Gate AT STA 108+58-B2.	1.00	EA	SIWSE	0.04	85	3,817	779	19,911	0	24,507	24506.97
L MIL AA <05521 3001 > 20"(51cm)Wide Vert Steel Ladder					1.35	62.19	1.67	23.24	0.00	87.09	
Primed. THIS ITEM FOR REPLACEMENT OF MANHOLE LADDER RUNGS AT STA. 145+61-B. REVISED PRODUCTION RATE FROM 10.625 VLF/HR TO 3.0 VLF/HR.	10.00	VLF	SIWSC	3.00	13	622	17	232	0	871	87.09
TOTAL Replace Drainage Control Device	1.00	EA			218	9,652	1,838	43,670	0	55,159	55159.38
TOTAL LEVEE UPGRADE - SECTION B	1.00	EA			584	21,188	6,161	57,422	123,910	208,681	208680.70
02. 02.002.003. LEVEE UPGRADE - SECTION C											
02. 02.002.003.001. Repair of Depression/Sink Hole THIS ITEM IS FOR THE REPAIR OF LOW AREAS, SPOTS, RUTTING, SMALL SINK HOLES, AND ERODED AREAS IN THE CROWN OR EMBANKMENT OF THE LEVEE AT 11 DIFFERENT LOCATIONS AND RANGING/VARIES IN SIZE OF AREA FROM 3 SF TO 1,750 SF AND 0.10 CY TO 32.0 CY OF FILL.											
MIL AA <02820 3002 > Furn & Pl Imported Topsoil, 6"Dp					0.13	4.54	2.58	21.65	0.00	28.77	
	45.40	CY	CODLA	11.50	6	206	117	983	0	1,306	28.77
MIL AA <02820 2002 > Spread Topsoil by Hand					0.79	23.16	0.00	15.46	0.00	38.62	
From Stockpile	45.40	CY	ULABA	1.64	36	1,051	0	702	0	1,753	38.62
MIL AA <02212 3102 > Compact Bfill, by Hand w/Vib Pl					0.12	3.59	0.09	0.00	0.00	3.67	
6"(15cm) Lift	45.40	CY	CLACC	24.50	6	163	4	0	0	167	3.67
MIL AA <02820 2003 > Top Dress by Hand					0.00	0.06	0.00	0.08	0.00	0.14	
	2360.00	SF	ULABA	605.50	5	149	0	183	0	331	0.14
L MIL AA <02810 2001 > Seeding by Hand, 50#/MSY					0.01	0.16	0.00	17.12	0.00	17.28	
	26.20	CSY	ULABA	242.25	0	4	0	449	0	453	17.28

02. 02. PADUCAH LEVEE UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
AF AA <02810 4001 > 35 Lb/1000 SF Fertilizer,					0.02	0.79	0.90	0.64	0.00	2.33	
Spread by Machine	23.60	MSF	COFWK	75.00	1	19	21	15	0	55	2.33
USR AA <02830 29999> Mulch, Pine Straw					0.00	0.04	0.00	0.03	0.00	0.07	
	2360.00	SF	ULABA	1000.00	5	92	0	75	0	167	0.07
TOTAL Repair of Depression/Sink Hole	262.30	SY			58	1,684	142	2,406	0	4,232	16.13
02. 02.002.003.002. Slip Lining of Existing Pipes											
USR SL <02465 99999> PIPE SLIPLINER, 30 INCH					0.00	0.00	0.00	0.00	92.00	92.00	
QUOTE RECEIVECD FROM BOWEN ENGINEERING, 8/99 INCLUDES MATERIAL(HOBAS PIPE LINER) INSTALLATION, SOME LIGHT CLEANING EXISTING PIPE, GROUTING AND RESTORATION. BASED ON 20 FT LENGTHS. SLIPLINE PIPE I.D. 24 INCHES AT $92/LF.	271.00	LF		0.00	0	0	0	0	24,932	24,932	92.00
USR SL <02465 99999> PIPE SLIPLINER, 36 INCH					0.00	0.00	0.00	0.00	117.00	117.00	
QUOTE RECEIVECD FROM BOWEN ENGINEERING, 8/99 INCLUDES MATERIAL(HOBAS PIPE LINER) INSTALLATION, SOME LIGHT CLEANING EXISTING PIPE, GROUTING AND RESTORATION. BASED ON 20 FT LENGTHS. SLIPLINE PIPE I.D. 30 INCHES AT $92/LF.	343.00	LF		0.00	0	0	0	0	40,131	40,131	117.00
USR SL <02465 99999> PIPE SLIPLINER, 48 INCH					0.00	0.00	0.00	0.00	180.00	180.00	
QUOTE RECEIVECD FROM BOWEN ENGINEERING, 8/99 INCLUDES MATERIAL(HOBAS PIPE LINER) INSTALLATION, SOME LIGHT CLEANING EXISTING PIPE, GROUTING AND RESTORATION. BASED ON 20 FT LENGTHS. SLIPLINE PIPE I.D. 42 INCHES AT $92/LF.	680.00	LF		0.00	0	0	0	0	122,400	122,400	180.00
USR SL <02465 99999> PIPE SLIPLINER, 60 INCH					0.00	0.00	0.00	0.00	276.00	276.00	
QUOTE RECEIVECD FROM BOWEN ENGINEERING, 8/99 FOR SLIPLINE PIPE I.D. 54 INCH AT $276/LF. INCLUDES MATERIAL (USING HOBAS PIPE LINER), INSTALLATION, SOME LIGHT CLEANING EXISTING PIPE, GROUTING AND RESTORATION. BASED ON 20 FT LENGTHS.	339.00	LF		0.00	0	0	0	0	93,564	93,564	276.00

02. 02. PADUCAH LEVEE UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR SL <02465 99999> PIPE SLIPLINER, 84 INCH					0.00	0.00	0.00	0.00	485.00	485.00	
QUOTE RECEIVECD FROM BOWEN ENGINEERING, 8/99 INCLUDES MATERIAL(HOBAS PIPE LINER) INSTALLATION, SOME LIGHT CLEANING EXISTING PIPE, GROUTING AND RESTORATION. BASED ON 20 FT LENGTHS. SLIPLINE PIPE I.D. 78 INCHES AT $485/LF.	124.00	LF		0.00	0	0	0	0	60,140	60,140	485.00
TOTAL Slip Lining of Existing Pipes	1.00	EA			0	0	0	0	341,167	341,167	341167.00
02. 02.002.003.003. Cure-in-Place Pipe Lining, 24"&<											
USR S2 <02465 99999> PIPE LINER, CIPP METHOD, 24 INCH					0.00	0.00	0.00	0.00	210.00	210.00	
QUOTE RECEIVED FROM REYNOLDS INCORP. INLINER, 11/98 FOR 24" CIPP (CURED-IN-PLACE METHOD) PIPE LINER AT $210/LF.	531.00	LF		0.00	0	0	0	0	111,510	111,510	210.00
TOTAL Cure-in-Place Pipe Lining, 24"&<	1.00	EA			0	0	0	0	111,510	111,510	111510.00
02. 02.002.003.004. Tree Clearing, Minor											
AF AA <02102 1131 > Wet Clearing - Heavy - w/o Grub					20.55	632.74	395.29	0.00	0.00	1028.03	
D7LGP	0.20	ACR	COMCI	0.44	4	127	79	0	0	206	1028.03
TOTAL Tree Clearing, Minor	1.00	EA			4	127	79	0	0	206	205.61
02. 02.002.003.005. Stone Protection											
MIL AA <02261 1001 > Rip Rap, 3/8 CY to 1/4 CY Pcs					0.51	16.13	6.18	19.23	0.00	41.54	
Random, Dumped from Truck	112.00	CY	CODEX	9.75	57	1,807	692	2,154	0	4,652	41.54
TOTAL Stone Protection	112.00	CY			57	1,807	692	2,154	0	4,652	41.54
02. 02.002.003.006. Vegetative Cover											
THIS ITEM IS FOR THE SEEDING, FERTILIZING, MULCH OF AREAS NEEDING VEGETATIVE COVER. CONSISTING OF SIX DIFFERENT LOCATIONS AND SIZE OF AREA VARIES FROM 6 TO 1167 SY.											
MIL AA <02820 2003 > Top Dress by Hand					0.00	0.06	0.00	0.07	0.00	0.13	
	19051	SF	ULABA	605.50	38	1,143	0	1,414	0	2,557	0.13
L MIL AA <02810 2001 > Seeding by Hand, 50#/MSY					0.01	0.16	0.00	17.12	0.00	17.28	
	21.17	CSY	ULABA	242.25	0	3	0	362	0	366	17.28

02. 02. PADUCAH LEVEE UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
AF AA <02810 4001 > 35 Lb/1000 SF Fertilizer, Spread by Machine					0.02	0.79	0.90	0.64	0.00	2.33	
	19.05	MSF	COFWK	75.00	0	15	17	12	0	44	2.33
USR AA <02830 29999> Mulch, Straw					0.00	0.04	0.00	0.03	0.00	0.07	
	19052	SF	ULABA	1000.00	46	762	0	606	0	1,368	0.07
TOTAL Vegetative Cover	2117.00	SY			84	1,923	17	2,394	0	4,335	2.05
02. 02.002.003.007. Replace Drainage Control Device											
CIV AA <05651 1403 > 30" Dia (76cm) Alum Flap Gates AT STA 244+65-C.					9.33	420.39	85.74	1019.72	0.00	1525.85	
	1.00	EA	SIWSE	0.38	9	420	86	1,020	0	1,526	1525.85
CIV AA <05651 1406 > 48" Dia (122cm) Alum Flap Gates FOR STA 92+70-C.					18.67	840.78	171.49	2643.64	0.00	3655.91	
	2.00	EA	SIWSE	0.19	37	1,682	343	5,287	0	7,312	3655.91
USR AA <05651 14999> 30" Dia Alum Flap Gate Seat THIS ITEM IS FOR REPLACING OF FLAP GATE SEATS AND/OR BUSHINGS ON 3-30" SLUICE GATES AT STA 32+38-C. REVISED MATERIAL UNIT COSTS FROM $962/EA TO $500/EA AND PRODUCTION RATE FROM 0.375/HR TO 0.50/HR.					7.00	315.30	64.31	530.00	0.00	909.60	
	3.00	EA	SIWSE	0.50	21	946	193	1,590	0	2,729	909.60
USR AA <05651 14999> 48" Dia Alum Flap Gate Seat THIS ITEM IS FOR REPLACING OF FLAP GATE SEATS AND/OR BUSHINGS ON 2-48" SLUICE GATES AT STA 32+12-C. REVISED MATERIAL UNIT COSTS FROM $2,494/EA TO $1,200/EA AND PRODUCTION RATE FROM 0.1875/HR TO 0.50/HR.					7.00	315.30	64.31	1272.00	0.00	1651.61	
	2.00	EA	SIWSE	0.50	14	631	129	2,544	0	3,303	1651.61
MIL AA <02411 1001 > Shoring for 15'(5M) Exc, 22 PSF Steel Sheeting, Pull and Salvage					16.84	598.30	357.98	768.50	0.00	1724.78	
	10.00	TON	CPIDV	0.48	168	5,983	3,580	7,685	0	17,248	1724.78
MIL AA <09910 2131 > Paint Exposed Dkg, 1 Coat Spray					0.01	0.45	0.00	0.06	0.00	0.52	
	100.00	SF	APTRA	93.75	1	45	0	6	0	52	0.52
MIL AA <09910 2132 > Paint Steel Joists, 1 Coat Spray					1.33	45.25	0.00	80.26	0.00	125.51	
	0.40	TON	APTRA	0.94	1	18	0	32	0	50	125.51
MIL AA <09910 2133 > Paint Steel Columns,1 Coat Spray					10.00	339.38	0.00	59.80	0.00	399.17	
	0.80	TON	APTRA	0.13	8	272	0	48	0	319	399.17
MIL AA <09910 2142 > Sandblasting-Commercial Blast					0.02	0.74	0.14	0.06	0.00	0.94	
	1000.00	SF	CODBA	90.00	20	740	140	64	0	944	0.94

02. 02. PADUCAH LEVEE UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
B MIL AA <02520 2121 > CIP Concrete Headwall, 60" Pipe					200.00	6431.98	0.00	1590.00	0.00	8021.98	
30 Degree Skewed Wingwall	2.00	EA	ALABM	0.03	400	12,864	0	3,180	0	16,044	8021.98
THIS ITEM FOR 84 INCH HEADWALLS AT OAKS ROAD ON RIVERSIDE DIVERSION CHANNEL. REVISED UNIT COSTS FROM $4867.50/EA TO $8000/EA, BY REVISING MATERIAL COSTS FROM $847.51/EA TO $1500/EA AND PRODUCTION RATE FROM 0.048 EA/HR TO 0.030 EA/HR.											
CIV AA <05651 1113 > 84"x 84"Heavy Duty Sluice Gates					280.00	12611.69	2572.30	37799.98	0.00	52983.97	
Self Contained w/Crank Oper Gat	1.00	EA	SIWSE	0.01	280	12,612	2,572	37,800	0	52,984	52983.97
e THIS ITEM FOR 84 INCH CMP CULVERT AT OAKS ROAD ON RIVERSIDE DIVERSION CHANNEL.											
TOTAL Replace Drainage Control Device	1.00	EA			960	36,212	7,042	59,256	0	102,510	102510.14
TOTAL LEVEE UPGRADE - SECTION C	1.00	EA			1,163	41,752	7,973	66,209	452,677	568,611	568611.44
TOTAL PADUCAH LEVEE UPGRADE	1.00	EA			2,073	75,654	16,962	153,337	888,787	1,134,740	1134740
TOTAL PADUCAH LEVEE UPGRADE	1.00	EA			2,073	75,654	16,962	153,337	888,787	1,134,740	1134740

03. 03. FLOODWALL UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
03. PADUCAH FLOODWALL UPGRADE											
03. 03. FLOODWALL UPGRADE											
03. 03. 03. 03. Paducah Floodwall Upgrade											
03. 03. 03. 03.003. Paducah Floodwall Upgrade											
03. 03. 03. 03.003.01. Paducah Floodwall Upgrade THE COSTS INCLUDED HERE WERE PROVIDED BY AN A/E FIRM, PARSONS HARLAND BARTHOLOMEW, AND ASSOC, INC, ST. LOUIS, MO. FOR THE STRUCTURAL ANALYSIS, AND ARE INCLUDED AS A SEPERATE ITEM IN THE REPORT. TOTAL ALSO INCLUDES OVERHEAD, PROFIT, AND CONTINGENCY.											
TOTAL Paducah Floodwall Upgrade	1.00	EA			0	0	0	0	91,369	91,369	91369.00
TOTAL Paducah Floodwall Upgrade	1.00	EA			0	0	0	0	91,369	91,369	91369.00
TOTAL Paducah Floodwall Upgrade	1.00	EA			0	0	0	0	91,369	91,369	91369.00
TOTAL FLOODWALL UPGRADE	1.00	EA			0	0	0	0	91,369	91,369	91369.00
TOTAL PADUCAH FLOODWALL UPGRADE	1.00	EA			0	0	0	0	91,369	91,369	91369.00

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
10. PADUCAH PUMP PLANT ELEC UPGRADE											
10.010. PADUCAH PUMP PLANT ELEC UPGRADE											
10.010.010.010. PADUCAH PUMP PLANT ELEC UPGRADE											
10.010.010.010.001. PUMP PLANT #1 - ELEC UPGRADE											
NO ELECTRICAL REQUIRED AT PUMP PLANT NO. 1.											
TOTAL PUMP PLANT #1 - ELEC UPGRADE	1.00	EA			0	0	0	0	0	0	0.00
10.010.010.010.002. PUMP PLANT #2 - ELEC UPGRADE											
10.010.010.010.002.01. MTR CONTR CENTER - ELEC UPGRADE											
M MIL EL <16922 1103 > Circuit Brkr Comb Starter,Size 3					5.75	181.75	0.83	1259.28	0.00	1441.86	
Class I Type A	1.00	EA	EELEB	0.44	6	229	1	1,586	0	1,816	1815.71
CIV EL <16923 1011 > Control Circuit Fuse And Holder					0.25	7.91	0.00	12.20	0.00	20.11	
Small Dim, Dual Element Time Del	1.00	EA	EELEA	5.00	0	10	0	15	0	25	25.32
MIL EL <16923 2001 > Ctrl Device,2 Un Push Button Sta					0.42	13.18	0.06	35.59	0.00	48.82	
Cover Mtd	1.00	EA	EELEB	6.00	0	17	0	45	0	61	61.48
MIL EL <16923 2004 > Ctrl Device,Hand-Off-Auto Sw					1.37	43.20	0.20	73.81	0.00	117.21	
Cover Mtd w/Pilot Light	1.00	EA	EELEB	1.83	1	54	0	93	0	148	147.60
MIL EL <16923 3003 > Extra Interlocks,Class I,Type C					0.26	8.24	0.04	44.63	0.00	52.90	
Per Contact	1.00	EA	EELEB	9.60	0	10	0	56	0	67	66.62
CIV EL <16923 6001 > Start/Stop Indicating Light					0.50	15.81	0.00	58.58	0.00	74.39	
	3.00	EA	EELEA	2.50	2	60	0	221	0	281	93.67
M USR EL <16923 2005 > PANEL MTD AMP METER					0.00	0.00	0.00	201.40	0.00	201.40	
	1.00	EA	N/A	0.00	0	0	0	254	0	254	253.62
M USR EL <16923 2004 > Amp Meter Selector Switch					0.00	0.00	0.00	63.60	0.00	63.60	
	1.00	EA	N/A	0.00	0	0	0	80	0	80	80.09
TOTAL MTR CONTR CENTER - ELEC UPGRADE	1.00	EA			10	380	1	2,350	0	2,731	2731.46
10.010.010.010.002.02. Removal											
USR EL <16990 2203 > Pump Station Electrical Removal					3.00	87.47	0.00	0.00	0.00	87.47	
	1.00	EA	EELEG	2.00	3	110	0	0	0	110	110.15
TOTAL Removal	1.00	EA			3	110	0	0	0	110	110.15

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL PUMP PLANT #2 - ELEC UPGRADE	1.00	EA			13	490	1	2,350	0	2,842	2841.61
10.010.010.010.003. PUMP PLANT #3 - ELEC UPGRADE											
10.010.010.010.003.01. INTERIOR - ELEC UPGRADE											
MIL EL <16330 1105 > 15KVA,480V-120/240V Xformer,Dry					7.51	236.99	7.04	619.75	0.00	863.77	
1Ph,60Hz,Dry	1.00	EA	EELEE	0.55	8	298	9	780	0	1,088	1087.73
MIL EL <16330 1401 > Transformer Mounting Bracket					4.00	117.18	0.61	87.40	0.00	205.18	
	1.00	EA	EELEF	1.17	4	148	1	110	0	258	258.38
MIL EL <16111 1121 > RGS 1" Conduit w/Coupling					0.08	2.28	0.01	1.46	0.00	3.75	
	40.00	LF	EELEF	60.00	3	115	1	74	0	189	4.73
MIL EL <16111 1122 > RGS 1" Elbow					0.49	14.22	0.07	8.22	0.00	22.51	
	3.00	EA	EELEF	9.60	1	54	0	31	0	85	28.34
MIL EL <16111 1123 > RGS 1" Bushing Set w/Locknuts					0.39	11.38	0.06	0.84	0.00	12.27	
	2.00	EA	EELEF	12.00	1	29	0	2	0	31	15.45
MIL EL <16120 1501 > #8 AWG Cable-Type THW					9.71	284.41	1.47	239.16	0.00	525.04	
	0.12	MLF	EELEF	0.48	1	43	0	36	0	79	661.17
MIL EL <16121 1201 > #8 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	4.00	EA	EELEB	6.90	1	58	0	21	0	79	19.79
MIL EL <16451 1203 > #8 AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.74	
	0.05	MLF	EELEC	0.47	0	12	0	10	0	22	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	2.00	EA	EELEB	2.85	2	70	0	1	0	71	35.60
MIL EL <16471 2206 > 100A,120/240V,3W-1Ph Panelboard					12.08	381.95	1.74	444.89	0.00	828.58	
Main Brkr,Assemb	1.00	EA	EELEB	0.21	12	481	2	560	0	1,043	1043.42
MIL EL <16111 1131 > RGS 1-1/4"Conduit w/Coupling					0.10	2.84	0.02	1.87	0.00	4.73	
	10.00	LF	EELEF	48.00	1	36	0	24	0	60	5.95
MIL EL <16111 1132 > RGS 1-1/4" Elbow					0.59	17.17	0.09	11.87	0.00	29.13	
	2.00	EA	EELEF	7.95	1	43	0	30	0	73	36.68
MIL EL <16111 1133 > RGS 1-1/4"Bush Set w/Locknuts					0.49	14.22	0.07	1.11	0.00	15.41	
	2.00	EA	EELEF	9.60	1	36	0	3	0	39	19.40
MIL EL <16111 1134 > RGS 1-1/4" Type LB 2 Hub					1.24	36.40	0.19	21.89	0.00	58.48	
	2.00	EA	EELEF	3.75	2	92	0	55	0	147	73.64
MIL EL <16120 1706 > No 4-Type THWN Feeder for XFMR					11.30	330.95	1.71	531.97	0.00	864.63	
	0.05	MLF	EELEF	0.41	1	21	0	33	0	54	1088.81

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
MIL EL <16121 1201 > #8 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	6.00	EA	EELEB	6.90	2	87	0	32	0	119	19.79
MIL EL <16451 1203 > #8 AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.75	
	0.02	MLF	EELEC	0.47	0	5	0	4	0	9	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	2.00	EA	EELEB	2.85	2	70	0	1	0	.71	35.60
TOTAL INTERIOR - ELEC UPGRADE	1.00	EA			44	1,695	15	1,808	0	3,518	3517.90
10.010.010.010.003.02. MTR CONTR CENTER - ELEC UPGRADE											
M MIL EL <16922 1101 > Circuit Brkr Comb Starter,Size 1					3.86	122.01	0.56	719.74	0.00	842.31	
Class I Type A	1.00	EA	EELEB	0.65	4	154	1	906	0	1,061	1060.70
M MIL EL <16922 1103 > Circuit Brkr Comb Starter,Size 3					5.75	181.75	0.83	1259.28	0.00	1441.86	
Class I Type A	2.00	EA	EELEB	0.44	12	458	2	3,172	0	3,631	1815.71
AF EL <16922 3401 > Structure Combination Of					10.53	332.90	1.52	941.87	0.00	1276.29	
Starters To 72" High	3.00	EA	EELEB	0.24	32	1,258	6	3,558	0	4,822	1607.21
CIV EL <16923 1011 > Control Circuit Fuse And Holder					0.25	7.91	0.00	12.20	0.00	20.11	
Small Dim, Dual Element Time Del	4.00	EA	EELEA	5.00	1	40	0	61	0	101	25.32
MIL EL <16923 2001 > Ctrl Device,2 Un Push Button Sta					0.42	13.18	0.06	35.59	0.00	48.82	
Cover Mtd	3.00	EA	EELEB	6.00	1	50	0	134	0	184	61.48
MIL EL <16923 2004 > Ctrl Device,Hand-Off-Auto Sw					1.37	43.20	0.20	73.81	0.00	117.21	
Cover Mtd w/Pilot Light	3.00	EA	EELEB	1.83	4	163	1	279	0	443	147.60
MIL EL <16923 3003 > Extra Interlocks,Class I,Type C					0.26	8.24	0.04	44.63	0.00	52.90	
Per Contact	3.00	EA	EELEB	9.60	1	31	0	169	0	200	66.62
CIV EL <16923 6001 > Start/Stop Indicating Light					0.50	15.81	0.00	58.58	0.00	74.39	
	3.00	EA	EELEA	2.50	2	60	0	221	0	281	93.67
M USR EL <16923 2005 > Starter MTD AMP METER					0.00	0.00	0.00	201.40	0.00	201.40	
	3.00	EA	N/A	0.00	0	0	0	761	0	761	253.62
M USR EL <16923 2004 > Amp Meter Selector Switch					0.00	0.00	0.00	63.60	0.00	63.60	
	3.00	EA	N/A	0.00	0	0	0	240	0	240	80.09
MIL EL <16471 1304 > XFMR CIRCUIT BREAKER 2P 240V					1.77	55.95	0.26	30.21	0.00	86.42	
	1.00	EA	EELEB	1.41	2	70	0	38	0	109	108.83
M USR EL <16930 1111 > PANEL MTD VOLTMETER					0.00	0.00	0.00	1012.30	0.00	1012.30	
	1.00	EA	N/A	0.00	0	0	0	1,275	0	1,275	1274.77

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
M USR EL <16923 2004 > Voltmeter Selector Switch					0.00	0.00	0.00	525.76	0.00	525.76	
	1.00	EA	N/A	0.00	0	0	0	662	0	662	662.08
TOTAL MTR CONTR CENTER - ELEC UPGRADE	1.00	EA			57	2,283	10	11,477	0	13,770	13769.97
10.010.010.010.003.03. PUMP MOTOR CONDUCTORS - UPGRADE											
MIL EL <16120 1301 > #10 AWG Type USE MTR Feeder Ckt					15.53	455.05	2.36	259.05	0.00	716.46	
	0.15	MLF	EELEF	0.30	2	86	0	49	0	135	902.23
MIL EL <16120 1304 > #4 AWG Type USE MTR Feeder Ckt					15.53	455.05	2.36	579.68	0.00	1037.09	
	0.30	MLF	EELEF	0.30	5	172	1	219	0	392	1305.99
MIL EL <16121 1201 > #10 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	6.00	EA	EELEB	6.90	2	87	0	32	0	119	19.79
MIL EL <16121 1203 > #4 AWG Compr Lug					0.42	13.18	0.06	4.63	0.00	17.86	
	12.00	EA	EELEB	6.00	5	199	1	70	0	270	22.50
M MIL EL <16151 2009 > AC Mtr 3PH,230V Motor/Eqpt,Conn, Term & Rot Tstg					2.25	71.23	0.33	41.34	0.00	112.90	
	1.00	EA	EELEB	1.11	2	90	0	52	0	142	142.17
M MIL EL <16151 2014 > AC Mtr 3PH,230V Motor/Eqpt,Conn, Term & Rot Tstg					4.17	131.77	0.60	118.72	0.00	251.09	
	2.00	EA	EELEB	0.60	8	332	2	299	0	632	316.19
MIL EL <16451 1203 > 8AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.75	
	0.15	MLF	EELEC	0.47	1	35	0	30	0	65	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	6.00	EA	EELEB	2.85	5	210	1	3	0	214	35.60
TOTAL PUMP MOTOR CONDUCTORS - UPGRADE	1.00	EA			31	1,209	6	754	0	1,969	1968.96
10.010.010.010.003.04. LGT & RECPT ELECTRICAL - UPGRADE											
MIL EL <16140 1101 > Duplex Rcpt, 120 V, 20 Amp,Exp Exposed Devices - Complete					0.42	13.18	0.06	10.07	0.00	23.31	
	6.00	EA	EELEB	6.00	3	100	0	76	0	176	29.35
L MIL EL <16510 3021 > HID Ind Low Bay Pendant Fxtr Type 302a, Metal Halide Lamp					2.00	58.59	0.30	301.78	0.00	360.67	
	6.00	EA	EELEF	2.33	12	443	2	2,280	0	2,725	454.19
B MIL EL <16510 3021 > Removed Low Bay Pendant Fxtr					1.00	29.30	0.15	0.00	0.00	29.45	
	6.00	EA	EELEF	4.66	6	221	1	0	0	223	37.09
M MIL EL <16140 1101 > Remove Duplex Rcpt, 120V					0.42	13.18	0.06	0.00	0.00	13.24	
	6.00	EA	EELEB	6.00	3	100	0	0	0	100	16.67

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL LGT & RECPT ELECTRICAL - UPGRADE	1.00	EA			23	863	4	2,356	0	3,224	3223.78
10.010.010.010.003.05. SERVICE ENTRANCE - UPGRADE											
MIL EL <16111 4111 > 3"RGS Conduit w/Coupling					0.19	5.69	0.03	6.34	0.00	12.06	
	50.00	LF	EELEF	24.00	10	358	2	399	0	759	15.18
M MIL EL <16111 4112 > 3"RGS Elbow w/two couplings					2.07	60.67	0.31	63.98	0.00	124.97	
	4.00	EA	EELEF	2.25	8	306	2	322	0	629	157.37
MIL EL <16111 4113 > 3"RGS Bushing Set w/Locknuts					0.86	25.28	0.13	9.92	0.00	35.33	
	2.00	EA	EELEF	5.40	2	64	0	25	0	89	44.49
MIL EL <16111 4115 > 3"RGS Two Hub Conduit Body					2.00	63.25	0.29	103.41	0.00	166.95	
	4.00	EA	EELEB	1.25	8	319	1	521	0	841	210.24
MIL EL <16120 1511 > 250 MCM-Type THW					33.05	968.19	5.01	2980.11	0.00	3953.31	
	0.36	MLF	EELEF	0.14	12	439	2	1,351	0	1,792	4978.33
MIL EL <16121 1108 > 250 MCM Compr Conn					1.67	52.71	0.24	9.60	0.00	62.55	
	8.00	EA	EELEB	1.50	13	531	2	97	0	630	78.77
MIL EL <16121 1208 > 250 MCM Compr Lug					1.04	32.94	0.15	7.38	0.00	40.48	
	24.00	EA	EELEB	2.40	25	996	5	223	0	1,223	50.97
L MIL EL <16451 1206 > #2 AWG Insltd Gnd Conductor					0.01	0.34	0.00	396.12	0.00	396.46	
	0.11	MLF	EELEC	254.90	0	0	0	55	0	55	499.25
MIL EL <16454 1101 > #2-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	4.00	EA	EELEB	2.85	4	140	1	2	0	142	35.60
MIL EL <16120 9145 > Svce Entrance Thrd Weatherhead					2.50	79.06	0.36	225.54	0.00	304.96	
	2.00	EA	EELEB	1.00	5	199	1	568	0	768	384.03
TOTAL SERVICE ENTRANCE - UPGRADE	1.00	EA			86	3,350	16	3,563	0	6,930	6929.56
10.010.010.010.003.06. SITE ELECTRICAL - UPGRADE											
AF EL <16120 6201 > Neutral Support Conductor					121.95	3595.22	739.06	1272.00	0.00	5606.28	
	0.20	MLF	EELEJ	0.04	24	905	186	320	0	1,412	7059.88
MIL EL <16120 7217 > Service Drop Conductor					39.89	1168.62	174.36	2607.45	0.00	3950.43	
	0.60	MLF	EELEK	0.18	24	883	132	1,970	0	2,985	4974.70
TOTAL SITE ELECTRICAL - UPGRADE	1.00	EA			48	1,788	318	2,290	0	4,397	4396.79

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
10.010.010.010.003.07. Removal											
USR EL <16990 2203 > Pump Station Electrical Removal					76.25	2223.31	0.00	0.00	0.00	2223.31	
	1.00	EA	EELEG	0.08	76	2,800	0	0	0	2,800	2799.77
TOTAL Removal	1.00	EA			76	2,800	0	0	0	2,800	2799.77
TOTAL PUMP PLANT #3 - ELEC UPGRADE	1.00	EA			366	13,989	369	22,248	0	36,607	36606.72
10.010.010.010.004. PUMP PLANT #4 - ELEC UPGRADE											
10.010.010.010.004.01. MTR CONTR CENTER - ELEC UPGRADE											
MIL EL <16155 3144 > Comb Str,Sz 3,NEMA 4 w/Crk Brkr Non-Reversing,240-600V,3P					11.11	351.39	1.60	1940.43	0.00	2293.42	
	2.00	EA	EELEB	0.23	22	885	4	4,887	0	5,776	2888.05
CIV EL <16923 1011 > Control Circuit Fuse And Holder Small Dim, Dual Element Time Del					0.25	7.91	0.00	12.20	0.00	20.11	
	2.00	EA	EELEA	5.00	1	20	0	31	0	51	25.32
MIL EL <16923 2001 > Ctrl Device,2 Un Push Button Sta Cover Mtd					0.42	13.18	0.06	35.59	0.00	48.82	
	2.00	EA	EELEB	6.00	1	33	0	90	0	123	61.48
MIL EL <16923 2004 > Ctrl Device,Hand-Off-Auto Sw Cover Mtd w/Pilot Light					1.37	43.20	0.20	73.81	0.00	117.21	
	2.00	EA	EELEB	1.83	3	109	0	186	0	295	147.60
MIL EL <16923 3003 > Extra Interlocks,Class I,Type C Per Contact					0.26	8.24	0.04	44.63	0.00	52.90	
	2.00	EA	EELEB	9.60	1	21	0	112	0	133	66.62
CIV EL <16923 6001 > Start/Stop Indicating Light					0.50	15.81	0.00	58.58	0.00	74.39	
	4.00	EA	EELEA	2.50	2	80	0	295	0	375	93.67
M USR EL <16923 2005 > Starter MTD AMP METER					0.00	0.00	0.00	201.40	0.00	201.40	
	2.00	EA	N/A	0.00	0	0	0	507	0	507	253.62
M USR EL <16923 2004 > Amp Meter Selector Switch					0.00	0.00	0.00	63.60	0.00	63.60	
	2.00	EA	N/A	0.00	0	0	0	160	0	160	80.09
TOTAL MTR CONTR CENTER - ELEC UPGRADE	1.00	EA			29	1,147	5	6,268	0	7,420	7420.27
10.010.010.010.004.02. INTERIOR - ELEC UPGRADE											
MIL EL <16111 1121 > RGS 1" Conduit w/Coupling					0.08	2.28	0.01	1.46	0.00	3.75	
	20.00	LF	EELEF	60.00	2	57	0	37	0	95	4.73
MIL EL <16111 1122 > RGS 1" Elbow					0.49	14.22	0.07	8.22	0.00	22.51	
	3.00	EA	EELEF	9.60	1	54	0	31	0	85	28.34
MIL EL <16111 1123 > RGS 1" Bushing Set w/Locknuts					0.39	11.38	0.06	0.84	0.00	12.27	
	2.00	EA	EELEF	12.00	1	29	0	2	0	31	15.45

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
MIL EL <16120 1502 > #6 AWG Cable-Type THW					11.64	340.86	1.76	335.61	0.00	678.23	
	0.06	MLF	EELEF	0.40	1	26	0	25	0	51	854.08
MIL EL <16121 1201 > #6 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	3.00	EA	EELEB	6.90	1	43	0	16	0	59	19.79
MIL EL <16121 1101 > #6 AWG Compr Conn					0.52	16.47	0.08	3.42	0.00	19.97	
	3.00	EA	EELEB	4.80	2	62	0	13	0	75	25.15
MIL EL <16451 1203 > #8 AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.75	
	0.05	MLF	EELEC	0.47	0	12	0	10	0	22	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	2.00	EA	EELEB	2.85	2	70	0	1	0	71	35.60
MIL EL <16471 2202 > Panelboard,120/240V,3W,1Ph - 50A Main Brkr,Assemb	1.00	EA	EELEB	0.41	6.08	192.37	0.88	204.85	0.00	398.10	
					6	242	1	258	0	501	501.31
TOTAL INTERIOR - ELEC UPGRADE	1.00	EA			15	595	3	393	0	991	990.69
10.010.010.010.004.03. PUMP MOTOR CONDUCTORS - UPGRADE											
MIL EL <16120 1304 > #4 AWG Type USE MTR Feeder Ckt					15.53	455.05	2.36	579.68	0.00	1037.09	
	0.30	MLF	EELEF	0.30	5	172	1	219	0	392	1305.99
MIL EL <16121 1203 > #4 AWG Compr Lug					0.42	13.18	0.06	4.63	0.00	17.86	
	12.00	EA	EELEB	6.00	5	199	1	70	0	270	22.50
M MIL EL <16151 3016 > 50 HP AC Motor Three Ph, 460 V Motor/Eqpt,Conn,Term & Rot Tstg	2.00	EA	EELEB	0.81	3.09	97.61	0.45	168.54	0.00	266.60	
					6	246	1	424	0	671	335.72
MIL EL <16451 1203 > 8AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.75	
	0.07	MLF	EELEC	0.47	0	16	0	14	0	30	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	4.00	EA	EELEB	2.85	4	140	1	2	0	142	35.60
TOTAL PUMP MOTOR CONDUCTORS - UPGRADE	1.00	EA			20	773	4	730	0	1,506	1505.91
10.010.010.010.004.04. 440V Underground Secondary Serv											
MIL EL <16120 1304 > #4 AWG Cable-Type USE					15.53	455.05	2.36	579.69	0.00	1037.09	
	0.68	MLF	EELEF	0.30	11	390	2	496	0	888	1305.99
MIL EL <16121 1102 > #4 AWG Compr Conn,Tape Wrapped					0.52	16.47	0.08	4.09	0.00	20.64	
	3.00	EA	EELEB	4.80	2	62	0	15	0	78	25.99

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
MIL EL <16121 1303 > #4 AWG Split Bolt Conn,Wrapped					0.73	22.92	0.11	3.64	0.00	26.66	
	3.00	EA	EELEB	3.45	2	87	0	14	0	101	33.58
MIL EL <16121 1202 > #4 AWG Compr Lugs,1Hole,Wrapped					0.36	11.46	0.05	4.00	0.00	15.51	
	9.00	EA	EELEB	6.90	3	130	1	45	0	176	19.53
MIL EL <16170 2124 > 480V F HD Disc Sw, 200A NEMA 3R					9.26	292.83	1.34	391.98	0.00	686.15	
	1.00	EA	EELEB	0.27	9	369	2	494	0	864	864.05
MIL EL <16451 1203 > 8AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.75	
	0.23	MLF	EELEC	0.47	2	53	0	46	0	100	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	3.00	EA	EELEB	2.85	3	105	0	2	0	107	35.60
TOTAL 440V Underground Secondary Serv	1.00	EA			31	1,195	5	1,112	0	2,313	2312.93
10.010.010.010.004.05. 120/240V Underground Service											
MIL EL <16120 1303 > #6 AWG Cable-Type USE					15.53	455.05	2.36	381.17	0.00	838.58	
Underground Feeder & Branch Ckts	0.68	MLF	EELEF	0.30	11	390	2	326	0	718	1056.00
MIL EL <16121 1101 > #6 AWG Compr Conn,Tape Wrapped					0.52	16.47	0.08	3.42	0.00	19.97	
Low Voltage - To 600 Volts	3.00	EA	EELEB	4.80	2	62	0	13	0	75	25.15
MIL EL <16121 1302 > #6 AWG Split Bolt Conn,Wrapped					0.72	22.92	0.10	3.01	0.00	26.03	
Low Voltage - To 600 Volts	3.00	EA	EELEB	3.45	2	87	0	11	0	98	32.78
MIL EL <16121 1201 > #6 AWG Compr Lugs,1Hole,Wrapped					0.36	11.46	0.05	4.21	0.00	15.72	
Low Voltage - To 600 Volts	9.00	EA	EELEB	6.90	3	130	1	48	0	178	19.79
MIL EL <16451 1203 > 8AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.75	
	0.23	MLF	EELEC	0.47	2	53	0	46	0	100	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	3.00	EA	EELEB	2.85	3	105	0	2	0	107	35.60
B MIL EL <16170 2112 > Reconn 240V Disc Sw,60A NEMA 3R					1.00	31.63	0.14	0.00	0.00	31.77	
	1.00	EA	EELEB	2.50	1	40	0	0	0	40	40.01
TOTAL 120/240V Underground Service	1.00	EA			23	866	4	446	0	1,316	1316.40
TOTAL PUMP PLANT #4 - ELEC UPGRADE	1.00	EA			118	4,576	20	8,950	0	13,546	13546.20

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
10.010.010.010.005. PUMP PLANT #5 - ELEC UPGRADE											
10.010.010.010.005.01. INTERIOR - ELEC UPGRADE											
MIL EL <16330 1105 > 15KVA,480V-120/240V Xformer,Dry 1Ph,60Hz,Dry	1.00	EA	EELEE	0.55	7.51	236.99	7.04	619.75	0.00	863.77	
					8	298	9	780	0	1,088	1087.73
MIL EL <16330 1401 > Transformer Mounting Bracket	1.00	EA	EELEF	1.17	4.00	117.18	0.61	87.40	0.00	205.18	
					4	148	1	110	0	258	258.38
MIL EL <16111 1121 > RGS 1" Conduit w/Coupling	40.00	LF	EELEF	60.00	0.08	2.28	0.01	1.46	0.00	3.75	
					3	115	1	74	0	189	4.73
MIL EL <16111 1122 > RGS 1" Elbow	3.00	EA	EELEF	9.60	0.49	14.22	0.07	8.22	0.00	22.51	
					1	54	0	31	0	85	28.34
MIL EL <16111 1123 > RGS 1" Bushing Set w/Locknuts	2.00	EA	EELEF	12.00	0.39	11.38	0.06	0.84	0.00	12.27	
					1	29	0	2	0	31	15.45
MIL EL <16120 1501 > #8 AWG Cable-Type THW	0.12	MLF	EELEF	0.48	9.71	284.41	1.47	239.16	0.00	525.04	
					1	43	0	36	0	79	661.17
MIL EL <16121 1201 > #8 AWG Compr Lug	4.00	EA	EELEB	6.90	0.36	11.46	0.05	4.21	0.00	15.72	
					1	58	0	21	0	79	19.79
MIL EL <16451 1203 > #8 AWG Insltd Gnd Conductor	0.05	MLF	EELEC	0.47	6.99	183.49	0.00	160.26	0.00	343.74	
					0	12	0	10	0	22	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug	2.00	EA	EELEB	2.85	0.88	27.74	0.13	0.40	0.00	28.27	
					2	70	0	1	0	71	35.60
MIL EL <16471 2206 > 100A,120/240V,3W-1Ph Panelboard Main Brkr,Assemb	1.00	EA	EELEB	0.21	12.08	381.95	1.74	444.89	0.00	828.58	
					12	481	2	560	0	1,043	1043.42
MIL EL <16111 1131 > RGS 1-1/4"Conduit w/Coupling	10.00	LF	EELEF	48.00	0.10	2.84	0.02	1.87	0.00	4.73	
					1	36	0	24	0	60	5.95
MIL EL <16111 1132 > RGS 1-1/4" Elbow	2.00	EA	EELEF	7.95	0.59	17.17	0.09	11.87	0.00	29.13	
					1	43	0	30	0	73	36.68
MIL EL <16111 1133 > RGS 1-1/4"Bush Set w/Locknuts	2.00	EA	EELEF	9.60	0.49	14.22	0.07	1.11	0.00	15.41	
					1	36	0	3	0	39	19.40
MIL EL <16111 1134 > RGS 1-1/4" Type LB 2 Hub	2.00	EA	EELEF	3.75	1.24	36.40	0.19	21.89	0.00	58.48	
					2	92	0	55	0	147	73.64
MIL EL <16120 1706 > No 4-Type THWN Feeder for XFMR	0.05	MLF	EELEF	0.41	11.30	330.95	1.71	531.97	0.00	864.63	
					1	21	0	33	0	54	1088.81
MIL EL <16121 1201 > #8 AWG Compr Lug	6.00	EA	EELEB	6.90	0.36	11.46	0.05	4.21	0.00	15.72	
					2	87	0	32	0	119	19.79

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
MIL EL <16451 1203 > #8 AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.75	
	0.02	MLF	EELEC	0.47	0	5	0	4	0	9	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	2.00	EA	EELEB	2.85	2	70	0	1	0	71	35.60
TOTAL INTERIOR - ELEC UPGRADE	1.00	EA			44	1,695	15	1,808	0	3,518	3517.90
10.010.010.010.005.02. MTR CONTR CENTER - ELEC UPGRADE											
M MIL EL <16921 1005 > Inc Sec MCC,AirCktBrkr, 800A					21.93	693.54	3.17	2371.22	0.00	3067.93	
30000 Amp IC,3-Pole,w/Struc Incl	1.00	EA	EELEB	0.11	22	873	4	2,986	0	3,863	3863.38
M USR EL <16930 1111 > PANEL MTD VOLTMETER					0.00	0.00	0.00	1012.30	0.00	1012.30	
	1.00	EA	N/A	0.00	0	0	0	1,275	0	1,275	1274.77
M USR EL <16923 2004 > Voltmeter Selector Switch					0.00	0.00	0.00	525.76	0.00	525.76	
	1.00	EA	N/A	0.00	0	0	0	662	0	662	662.08
AF EL <16922 3401 > Structure Combination Of					10.53	332.90	1.52	941.87	0.00	1276.29	
Starters To 72" High	4.00	EA	EELEB	0.24	42	1,677	8	4,744	0	6,429	1607.21
M MIL EL <16922 1102 > Circuit Brkr Comb Starter,Size 2					4.27	135.15	0.62	834.22	0.00	969.99	
Class I Type A	1.00	EA	EELEB	0.59	4	170	1	1,051	0	1,221	1221.49
M MIL EL <16922 1104 > Circuit Brkr Comb Starter,Size 4					7.58	239.58	1.09	2142.26	0.00	2382.93	
Class I Type A	1.00	EA	EELEB	0.33	8	302	1	2,698	0	3,001	3000.78
M MIL EL <16922 1105 > Circuit Brkr Comb Starter,Size 5					9.47	299.48	1.37	4224.10	0.00	4524.95	
Class I Type A	2.00	EA	EELEB	0.26	19	754	3	10,639	0	11,396	5698.18
CIV EL <16923 6001 > Start/Stop Indicating Light					0.50	15.81	0.00	58.58	0.00	74.39	
	4.00	EA	EELEA	2.50	2	80	0	295	0	375	93.67
MIL EL <16923 3003 > Extra Interlocks,Class I,Type C					0.26	8.24	0.04	44.63	0.00	52.90	
Per Contact	4.00	EA	EELEB	9.60	1	41	0	225	0	266	66.62
MIL EL <16923 2004 > Ctrl Device,Hand-Off-Auto Sw					1.37	43.20	0.20	73.81	0.00	117.21	
Cover Mtd w/Pilot Light	4.00	EA	EELEB	1.83	5	218	1	372	0	590	147.60
MIL EL <16923 2001 > Ctrl Device,2 Un Push Button Sta					0.42	13.18	0.06	35.59	0.00	48.82	
Cover Mtd	4.00	EA	EELEB	6.00	2	66	0	179	0	246	61.48
CIV EL <16923 1011 > Control Circuit Fuse And Holder					0.25	7.91	0.00	12.20	0.00	20.11	
Small Dim, Dual Element Time Del	4.00	EA	EELEA	5.00	1	40	0	61	0	101	25.32
M USR EL <16923 2005 > Starter MTD AMP METER					0.00	0.00	0.00	201.40	0.00	201.40	
	4.00	EA	N/A	0.00	0	0	0	1,014	0	1,014	253.62

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
M USR EL <16923 2004 > Amp Meter Selector Switch					0.00	0.00	0.00	63.60	0.00	63.60	
	4.00	EA	N/A	0.00	0	0	0	320	0	320	80.09
MIL EL <16471 1704 > 2P,480V,100A, XFMR Ckt Bkr					1.88	59.36	0.27	139.82	0.00	199.45	
	1.00	EA	EELEB	1.33	2	75	0	176	0	251	251.17
TOTAL MTR CONTR CENTER - ELEC UPGRADE	1.00	EA			108	4,296	19	26,697	0	31,012	31012.48
10.010.010.010.005.03. PUMP MOTOR CONDUCTORS - UPGRADE											
MIL EL <16120 1302 > #8 AWG Type USE Mtr Feeder					15.53	455.05	2.36	365.23	0.00	822.64	
	0.15	MLF	EELEF	0.30	2	86	0	69	0	155	1035.94
MIL EL <16120 1307 > #1/0 AWG Type USE Mtr Feeder					17.07	500.06	2.59	1429.56	0.00	1932.21	
	0.15	MLF	EELEF	0.27	3	94	0	270	0	365	2433.19
L MIL EL <16120 1314 > 350 MCM Type USE Mtr Feeder					26.80	785.02	4.06	4382.90	0.00	5171.98	
	0.30	MLF	EELEF	0.17	8	297	2	1,656	0	1,954	6512.97
MIL EL <16451 1202 > #10 AWG Insltd Cu Gnd Conductor					6.02	158.01	0.00	113.66	0.00	271.67	
	0.05	MLF	EELEC	0.54	0	10	0	7	0	17	342.11
MIL EL <16451 1204 > #6 AWG Insltd Cu Gnd Conductor					8.67	227.53	0.00	167.25	0.00	394.78	
	0.06	MLF	EELEC	0.38	1	17	0	13	0	30	497.13
MIL EL <16451 1205 > #4 AWG Insltd Cu Gnd Conductor					10.32	270.87	0.00	254.36	0.00	525.23	
	0.10	MLF	EELEC	0.32	1	34	0	32	0	66	661.41
MIL EL <16121 1201 > #10 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	2.00	EA	EELEB	6.90	1	29	0	11	0	40	19.79
MIL EL <16454 1101 > #6-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	2.00	EA	EELEB	2.85	2	70	0	1	0	71	35.60
MIL EL <16121 1203 > #4 AWG Compr Lug					0.42	13.18	0.06	4.63	0.00	17.86	
	4.00	EA	EELEB	6.00	2	66	0	23	0	90	22.50
M MIL EL <16151 3013 > 25 HP AC Motor Three Ph, 460 V Motor/Eqpt,Conn,Term & Rot Tstg					2.31	73.21	0.33	104.94	0.00	178.48	
	1.00	EA	EELEB	1.08	2	92	0	132	0	225	224.76
M MIL EL <16151 3019 > 100 HP AC Motor Three Ph, 460 V Motor/Eqpt,Conn,Term & Rot Tstg					5.21	164.71	0.75	299.98	0.00	465.44	
	1.00	EA	EELEB	0.48	5	207	1	378	0	586	586.12
M MIL EL <16151 3023 > 200 HP AC Motor Three Ph, 460 V Motor/Eqpt,Conn,Term & Rot Tstg					10.42	329.43	1.50	527.88	0.00	858.81	
	2.00	EA	EELEB	0.24	21	830	4	1,329	0	2,163	1081.48
TOTAL PUMP MOTOR CONDUCTORS - UPGRADE	1.00	EA			47	1,833	8	3,921	0	5,762	5761.95

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
10.010.010.010.005.04. LGT & RECPT ELECTRICAL - UPGRADE											
MIL EL <16140 1101 > Duplex Rcpt, 120 V, 20 Amp,Exp					0.42	13.18	0.06	10.07	0.00	23.31	
Exposed Devices - Complete	8.00	EA	EELEB	6.00	3	133	1	101	0	235	29.35
L MIL EL <16510 3021 > HID Ind Low Bay Pendant Fxtr					2.00	58.59	0.30	301.78	0.00	360.67	
Type 302a, Metal Halide Lamp	8.00	EA	EELEF	2.33	16	590	3	3,040	0	3,633	454.19
B MIL EL <16510 3021 > Removed Low Bay Pendant Fxtr					1.00	29.30	0.15	0.00	0.00	29.45	
	8.00	EA	EELEF	4.66	8	295	2	0	0	297	37.09
M MIL EL <16140 1101 > Remove Duplex Rcpt, 120V					0.42	13.18	0.06	0.00	0.00	13.24	
	8.00	EA	EELEB	6.00	3	133	1	0	0	133	16.67
TOTAL LGT & RECPT ELECTRICAL - UPGRADE	1.00	EA			31	1,151	6	3,142	0	4,298	4298.37
10.010.010.010.005.05. SERVICE ENTRANCE - UPGRADE											
MIL EL <16111 4111 > 3"RGS Conduit w/Coupling					0.19	5.69	0.03	6.34	0.00	12.06	
	75.00	LF	EELEF	24.00	15	537	3	599	0	1,139	15.18
M MIL EL <16111 4112 > 3"RGS Elbow w/two couplings					2.07	60.67	0.31	63.98	0.00	124.97	
	6.00	EA	EELEF	2.25	12	458	2	483	0	944	157.37
MIL EL <16111 4113 > 3"RGS Bushing Set w/Locknuts					0.86	25.28	0.13	9.92	0.00	35.33	
	3.00	EA	EELEF	5.40	3	96	0	37	0	133	44.49
MIL EL <16111 4115 > 3"RGS Two Hub Conduit Body					2.00	63.25	0.29	103.41	0.00	166.95	
	6.00	EA	EELEB	1.25	12	478	2	781	0	1,261	210.24
MIL EL <16120 1513 > 350 MCM-Type THW					38.83	1137.63	5.89	4063.08	0.00	5206.60	
600V Cu,Sgl Strd,Pl in Cnd,12'Hg	0.54	MLF	EELEF	0.12	21	774	4	2,763	0	3,541	6556.56
MIL EL <16121 1111 > 350 MCM Compr Conn,Tape Wrapped					1.85	58.57	0.27	10.85	0.00	69.69	
Low Voltage - To 600 Volts	12.00	EA	EELEB	1.35	22	885	4	164	0	1,053	87.76
MIL EL <16121 1211 > 350 MCM Compr Lugs,1Hole,Wrapped					1.28	40.55	0.19	8.94	0.00	49.68	
Low Voltage - To 600 Volts	36.00	EA	EELEB	1.95	46	1,838	9	405	0	2,252	62.56
MIL EL <16451 1208 > 1/0AWG,Insulated Stranded Cu 1/c					16.67	437.55	0.00	627.31	0.00	1064.86	
Laid in Trench,w/o Trnhg & Bfill	0.11	MLF	EELEC	0.20	2	61	0	87	0	148	1340.95
MIL EL <16454 1102 > #1/0-AWG Cadweld Splice/Lug					1.04	32.94	0.15	5.83	0.00	38.92	
	6.00	EA	EELEB	2.40	6	249	1	44	0	294	49.01
MIL EL <16120 9145 > Svce Entrance Thrd Weatherhead					2.50	79.06	0.36	225.54	0.00	304.96	
	3.00	EA	EELEB	1.00	8	299	1	852	0	1,152	384.03
TOTAL SERVICE ENTRANCE - UPGRADE	1.00	EA			146	5,674	27	6,216	0	11,917	11917.14

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
10.010.010.010.005.06. SITE ELECTRICAL - UPGRADE											
MIL EL <16413 4403 > 4 Spool Secondary Rack					1.77	52.27	10.75	20.62	0.00	83.64	
	2.00	EA	EELEJ	2.82	4	132	27	52	0	211	105.32
MIL EL <16120 9137 > #4/0 AWG Al QuadPX ASCR w/Neu Ca					234.74	6920.37	1422.61	3408.73	0.00	11751.71	
Svce Drp Strd Ca,600V w/WeatHd	0.40	MLF	EELEJ	0.02	94	3,486	717	1,717	0	5,919	14798.69
MIL EL <16413 4301 > Neutral Clevis					0.52	15.35	3.16	5.30	0.00	23.81	
	2.00	EA	EELEJ	9.60	1	39	8	13	0	60	29.98
B MIL EL <16121 1308 > 3PH Sec Ckt Tap @ Pole Mtd Xfmr					8.00	252.21	1.16	77.55	0.00	330.92	
	2.00	EA	EELEB	0.31	16	635	3	195	0	833	416.72
TOTAL SITE ELECTRICAL - UPGRADE	1.00	EA			114	4,291	755	1,978	0	7,024	7023.53
10.010.010.010.005.07. Removal											
USR EL <16990 2203 > Pump Station Electrical Removal					118.00	3440.66	0.00	0.00	0.00	3440.66	
	1.00	EA	EELEG	0.05	118	4,333	0	0	0	4,333	4332.75
TOTAL Removal	1.00	EA			118	4,333	0	0	0	4,333	4332.75
TOTAL PUMP PLANT #5 - ELEC UPGRADE	1.00	EA			609	23,273	830	43,761	0	67,864	67864.11
10.010.010.010.006. PUMP PLANT #6 - ELEC UPGRADE											
10.010.010.010.006.01. INTERIOR - ELEC UPGRADE											
MIL EL <16330 1105 > 15KVA,480V-120/240V Xformer,Dry					7.51	236.99	7.04	619.75	0.00	863.77	
1Ph,60Hz,Dry	1.00	EA	EELEE	0.55	8	298	9	780	0	1,088	1087.73
MIL EL <16330 1401 > Transformer Mounting Bracket					4.00	117.18	0.61	87.40	0.00	205.18	
	1.00	EA	EELEF	1.17	4	148	1	110	0	258	258.38
MIL EL <16111 1121 > RGS 1" Conduit w/Coupling					0.08	2.28	0.01	1.46	0.00	3.75	
	40.00	LF	EELEF	60.00	3	115	1	74	0	189	4.73
MIL EL <16111 1122 > RGS 1" Elbow					0.49	14.22	0.07	8.22	0.00	22.51	
	3.00	EA	EELEF	9.60	1	54	0	31	0	85	28.34
MIL EL <16111 1123 > RGS 1" Bushing Set w/Locknuts					0.39	11.38	0.06	0.84	0.00	12.27	
	2.00	EA	EELEF	12.00	1	29	0	2	0	31	15.45
MIL EL <16120 1501 > #8 AWG Cable-Type THW					9.71	284.41	1.47	239.16	0.00	525.04	
	0.12	MLF	EELEF	0.48	1	43	0	36	0	79	661.17
MIL EL <16121 1201 > #8 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	4.00	EA	EELEB	6.90	1	58	0	21	0	79	19.79

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
MIL EL <16451 1203 > #8 AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.74	
	0.05	MLF	EELEC	0.47	0	12	0	10	0	22	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	2.00	EA	EELEB	2.85	2	70	0	1	0	71	35.60
MIL EL <16471 2206 > 100A,120/240V,3W-1Ph Panelboard					12.08	381.95	1.74	444.89	0.00	828.58	
Main Brkr,Assemb	1.00	EA	EELEB	0.21	12	481	2	560	0	1,043	1043.42
MIL EL <16111 1131 > RGS 1-1/4"Conduit w/Coupling					0.10	2.84	0.02	1.87	0.00	4.73	
	10.00	LF	EELEF	48.00	1	36	0	24	0	60	5.95
MIL EL <16111 1132 > RGS 1-1/4" Elbow					0.59	17.17	0.09	11.87	0.00	29.13	
	2.00	EA	EELEF	7.95	1	43	0	30	0	73	36.68
MIL EL <16111 1133 > RGS 1-1/4"Bush Set w/Locknuts					0.49	14.22	0.07	1.11	0.00	15.41	
	2.00	EA	EELEF	9.60	1	36	0	3	0	39	19.40
MIL EL <16111 1134 > RGS 1-1/4" Type LB 2 Hub					1.24	36.40	0.19	21.89	0.00	58.48	
	2.00	EA	EELEF	3.75	2	92	0	55	0	147	73.64
MIL EL <16120 1706 > No 4-Type THWN Feeder for XFMR					11.30	330.95	1.71	531.97	0.00	864.63	
	0.05	MLF	EELEF	0.41	1	21	0	33	0	54	1088.81
MIL EL <16121 1201 > #8 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	6.00	EA	EELEB	6.90	2	87	0	32	0	119	19.79
MIL EL <16451 1203 > #8 AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.75	
	0.02	MLF	EELEC	0.47	0	5	0	4	0	9	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	2.00	EA	EELEB	2.85	2	70	0	1	0	71	35.60
TOTAL INTERIOR - ELEC UPGRADE	1.00	EA			44	1,695	15	1,808	0	3,518	3517.90
10.010.010.010.006.02. MTR CONTR CENTER - ELEC UPGRADE											
M MIL EL <16921 1005 > Inc Sec MCC,AirCktBrkr, 1200A					21.93	693.54	3.17	16811.60	0.00	17508.31	
30000 Amp IC,3-Pole,w/Struc Incl	1.00	EA	EELEB	0.11	22	873	4	21,171	0	22,048	22047.86
M USR EL <16930 1111 > PANEL MTD VOLTMETER					0.00	0.00	0.00	1012.30	0.00	1012.30	
	1.00	EA	N/A	0.00	0	0	0	1,275	0	1,275	1274.77
M USR EL <16923 2004 > Voltmeter Selector Switch					0.00	0.00	0.00	525.76	0.00	525.76	
	1.00	EA	N/A	0.00	0	0	0	662	0	662	662.08
AF EL <16922 3401 > Structure Combination Of					10.53	332.90	1.52	941.87	0.00	1276.29	
Starters To 72" High	4.00	EA	EELEB	0.24	42	1,677	8	4,744	0	6,429	1607.21

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
M MIL EL <16922 1101 > Circuit Brkr Comb Starter,Size 1					3.86	122.01	0.56	719.74	0.00	842.31	
Class I Type A	1.00	EA	EELEB	0.65	4	154	1	906	0	1,061	1060.70
M MIL EL <16922 1105 > Circuit Brkr Comb Starter,Size 5					9.47	299.48	1.37	4224.10	0.00	4524.95	
Class I Type A	1.00	EA	EELEB	0.26	9	377	2	5,319	0	5,698	5698.18
B MIL EL <16922 1105 > Circuit Brkr Comb Starter,Size 6					13.31	420.92	1.93	6956.78	0.00	7379.63	
Class I Type A	3.00	EA	EELEB	0.19	40	1,590	7	26,282	0	27,879	9293.02
CIV EL <16923 6001 > Start/Stop Indicating Light					0.50	15.81	0.00	58.58	0.00	74.39	
	5.00	EA	EELEA	2.50	3	100	0	369	0	468	93.67
MIL EL <16923 3003 > Extra Interlocks,Class I,Type C					0.26	8.24	0.04	44.63	0.00	52.90	
Per Contact	5.00	EA	EELEB	9.60	1	52	0	281	0	333	66.62
MIL EL <16923 2004 > Ctrl Device,Hand-Off-Auto Sw					1.37	43.20	0.20	73.81	0.00	117.21	
Cover Mtd w/Pilot Light	5.00	EA	EELEB	1.83	7	272	1	465	0	738	147.60
MIL EL <16923 2001 > Ctrl Device,2 Un Push Button Sta					0.42	13.18	0.06	35.59	0.00	48.82	
Cover Mtd	5.00	EA	EELEB	6.00	2	83	0	224	0	307	61.48
CIV EL <16923 1011 > Control Circuit Fuse And Holder					0.25	7.91	0.00	12.20	0.00	20.11	
Small Dim, Dual Element Time Del	5.00	EA	EELEA	5.00	1	50	0	77	0	127	25.32
M USR EL <16923 2005 > Starter MTD AMP METER					0.00	0.00	0.00	201.40	0.00	201.40	
	5.00	EA	N/A	0.00	0	0	0	1,268	0	1,268	253.62
M USR EL <16923 2004 > Amp Meter Selector Switch					0.00	0.00	0.00	63.60	0.00	63.60	
	5.00	EA	N/A	0.00	0	0	0	400	0	400	80.09
MIL EL <16471 1704 > 2P,480V,100A, XFMR Ckt Bkr					1.88	59.36	0.27	139.82	0.00	199.45	
	1.00	EA	EELEB	1.33	2	75	0	176	0	251	251.17
TOTAL MTR CONTR CENTER - ELEC UPGRADE	1.00	EA			133	5,302	24	63,619	0	68,945	68944.71
10.010.010.010.006.03. PUMP MOTOR CONDUCTORS - UPGRADE											
MIL EL <16120 1301 > #10 AWG Cable-Type USE					15.53	455.05	2.36	259.05	0.00	716.46	
Underground Feeder & Branch Ckts	0.15	MLF	EELEF	0.30	2	86	0	49	0	135	902.23
MIL EL <16120 1308 > #2/0 AWG Cable-Type USE					17.07	500.06	2.59	1743.98	0.00	2246.63	
Underground Feeder & Branch Ckts	0.15	MLF	EELEF	0.27	3	94	0	329	0	424	2829.13
L MIL EL <16120 1315 > 400 MCM-Type USE					28.21	826.36	4.28	5103.13	0.00	5933.77	
Underground Feeder & Branch Ckts	0.45	MLF	EELEF	0.17	13	468	2	2,892	0	3,363	7472.27
MIL EL <16451 1202 > #10 AWG Insltd Cu Gnd Conductor					6.02	158.01	0.00	113.66	0.00	271.67	
	0.05	MLF	EELEC	0.54	0	10	0	7	0	17	342.11

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
MIL EL <16451 1204 > #6 AWG Insltd Cu Gnd Conductor					8.67	227.53	0.00	167.25	0.00	394.78	
	0.06	MLF	EELEC	0.38	1	17	0	13	0	30	497.13
L MIL EL <16451 1206 > 3AWG Insltd Gnd Cu Conductor					0.01	0.33	0.00	396.12	0.00	396.45	
Laid in Trench,w/o Trnhg & Bfill	0.15	MLF	EELEC	254.90	0	0	0	75	0	75	499.24
MIL EL <16121 1201 > #10 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	2.00	EA	EELEB	6.90	1	29	0	11	0	40	19.79
MIL EL <16454 1101 > #6-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	2.00	EA	EELEB	2.85	2	70	0	1	0	71	35.60
MIL EL <16121 1203 > #3 AWG Compr Lug					0.42	13.18	0.06	4.63	0.00	17.86	
	4.00	EA	EELEB	6.00	2	66	0	23	0	90	22.50
MIL EL <16151 3009 > 10 HP AC Motor Three Ph, 460 V					1.98	62.75	0.29	410.75	0.00	473.79	
Motor/Eqpt,Conn,Term & Rot Tstg	1.00	EA	EELEB	1.26	2	79	0	517	0	597	596.63
MIL EL <16151 3021 > 125 HP AC Motor Three Ph, 460 V					5.95	188.25	0.86	3465.24	0.00	3654.35	
Motor/Eqpt,Conn,Term & Rot Tstg	1.00	EA	EELEB	0.42	6	237	1	4,364	0	4,602	4601.84
B MIL EL <16151 3023 > 250 HP AC Motor Three Ph, 460 V					14.26	450.83	2.05	561.80	0.00	1014.68	
Motor/Eqpt,Conn,Term & Rot Tstg	3.00	EA	EELEB	0.18	43	1,703	8	2,122	0	3,833	1277.77
TOTAL PUMP MOTOR CONDUCTORS - UPGRADE	1.00	EA			73	2,860	13	10,403	0	13,277	13276.60
10.010.010.010.006.04. LGT & RECPT ELECTRICAL - UPGRADE											
MIL EL <16140 1101 > Duplex Rcpt, 120 V, 20 Amp,Exp					0.42	13.18	0.06	10.07	0.00	23.31	
Exposed Devices - Complete	10.00	EA	EELEB	6.00	4	166	1	127	0	294	29.35
L MIL EL <16510 3021 > HID Ind Low Bay Pendant Fxtr					2.00	58.59	0.30	301.78	0.00	360.67	
Type 302a, Metal Halide Lamp	10.00	EA	EELEF	2.33	20	738	4	3,800	0	4,542	454.19
B MIL EL <16510 3021 > Removed Low Bay Pendant Fxtr					1.00	29.30	0.15	0.00	0.00	29.45	
	10.00	EA	EELEF	4.66	10	369	2	0	0	371	37.09
M MIL EL <16140 1101 > Remove Duplex Rcpt, 120V					0.42	13.18	0.06	0.00	0.00	13.24	
	10.00	EA	EELEB	6.00	4	166	1	0	0	167	16.67
TOTAL LGT & RECPT ELECTRICAL - UPGRADE	1.00	EA			38	1,439	7	3,927	0	5,373	5372.96
10.010.010.010.006.05. SERVICE ENTRANCE - UPGRADE											
MIL EL <16111 4111 > 3"RGS Conduit w/Coupling					0.19	5.69	0.03	6.34	0.00	12.06	
	100.00	LF	EELEF	24.00	19	716	4	798	0	1,518	15.18

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
M MIL EL <16111 4112 > 3"RGS Elbow w/two couplings					2.07	60.67	0.31	63.98	0.00	124.97	
	8.00	EA	EELEF	2.25	17	611	3	645	0	1,259	157.37
MIL EL <16111 4113 > 3"RGS Bushing Set w/Locknuts					0.86	25.28	0.13	9.92	0.00	35.33	
	4.00	EA	EELEF	5.40	3	127	1	50	0	178	44.49
MIL EL <16111 4115 > 3"RGS Two Hub Conduit Body					2.00	63.25	0.29	103.41	0.00	166.95	
	8.00	EA	EELEB	1.25	16	637	3	1,042	0	1,682	210.24
MIL EL <16120 1513 > 350 MCM-Type THW					38.83	1137.63	5.89	4063.08	0.00	5206.60	
600V Cu,Sgl Strd,Pl in Cnd,12'Hg	0.72	MLF	EELEF	0.12	28	1,031	5	3,684	0	4,721	6556.56
MIL EL <16121 1111 > 350 MCM Compr Conn,Tape Wrapped					1.85	58.57	0.27	10.85	0.00	69.69	
Low Voltage - To 600 Volts	16.00	EA	EELEB	1.35	30	1,180	5	219	0	1,404	87.76
MIL EL <16121 1211 > 350 MCM Compr Lugs,1Hole,Wrapped					1.28	40.55	0.19	8.94	0.00	49.68	
Low Voltage - To 600 Volts	48.00	EA	EELEB	1.95	61	2,451	11	540	0	3,003	62.56
MIL EL <16451 1208 > 1/0AWG,Insulated Stranded Cu 1/c					16.67	437.55	0.00	627.31	0.00	1064.86	
Laid in Trench,w/o Trnhg & Bfill	0.15	MLF	EELEC	0.20	3	83	0	118	0	201	1340.95
MIL EL <16454 1102 > #1/0-AWG Cadweld Splice/Lug					1.04	32.94	0.15	5.83	0.00	38.92	
	8.00	EA	EELEB	2.40	8	332	2	59	0	392	49.01
MIL EL <16120 9145 > Svce Entrance Thrd Weatherhead					2.50	79.06	0.36	225.54	0.00	304.96	
	4.00	EA	EELEB	1.00	10	398	2	1,136	0	1,536	384.03
TOTAL SERVICE ENTRANCE - UPGRADE	1.00	EA			195	7,567	36	8,291	0	15,894	15893.98
10.010.010.010.006.06. SITE ELECTRICAL - UPGRADE											
MIL EL <16413 4403 > 4 Spool Secondary Rack					1.77	52.27	10.75	20.62	0.00	83.64	
	4.00	EA	EELEJ	2.82	7	263	54	104	0	421	105.32
MIL EL <16120 9137 > #4/0 AWG Al QuadPX ASCR w/Neu Ca					234.74	6920.37	1422.61	3408.73	0.00	11751.71	
Svce Drp Strd Ca,600V w/WeatHd	0.80	MLF	EELEJ	0.02	188	6,972	1,433	3,434	0	11,839	14798.69
MIL EL <16413 4301 > Neutral Clevis					0.52	15.35	3.16	5.30	0.00	23.81	
	4.00	EA	EELEJ	9.60	2	77	16	27	0	120	29.98
B MIL EL <16121 1308 > 3PH Sec Ckt Tap @ Pole Mtd Xfmr					8.00	252.21	1.16	77.55	0.00	330.92	
	4.00	EA	EELEB	0.31	32	1,270	6	391	0	1,667	416.72
TOTAL SITE ELECTRICAL - UPGRADE	1.00	EA			229	8,583	1,509	3,955	0	14,047	14047.06

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
10.010.010.010.006.07. Removal											
USR EL <16990 2203 > Pump Station Electrical Removal					210.92	6149.91	0.00	0.00	0.00	6149.91	
	1.00	EA	EELEG	0.03	211	7,744	0	0	0	7,744	7744.46
TOTAL Removal	1.00	EA			211	7,744	0	0	0	7,744	7744.46
TOTAL PUMP PLANT #6 - ELEC UPGRADE	1.00	EA			924	35,190	1,605	92,003	0	128,798	128797.67
10.010.010.010.007. PUMP PLANT #7 - ELEC UPGRADE											
10.010.010.010.007.01. INTERIOR - ELEC UPGRADE											
MIL EL <16330 1105 > 15KVA,480V-120/240V Xformer,Dry 1Ph,60Hz,Dry					7.51	236.99	7.04	619.75	0.00	863.77	
	1.00	EA	EELEE	0.55	8	298	9	780	0	1,088	1087.73
MIL EL <16330 1401 > Transformer Mounting Bracket					4.00	117.18	0.61	87.40	0.00	205.18	
	1.00	EA	EELEF	1.17	4	148	1	110	0	258	258.38
MIL EL <16111 1121 > RGS 1" Conduit w/Coupling					0.08	2.28	0.01	1.46	0.00	3.75	
	40.00	LF	EELEF	60.00	3	115	1	74	0	189	4.73
MIL EL <16111 1122 > RGS 1" Elbow					0.49	14.22	0.07	8.22	0.00	22.51	
	3.00	EA	EELEF	9.60	1	54	0	31	0	85	28.34
MIL EL <16111 1123 > RGS 1" Bushing Set w/Locknuts					0.39	11.38	0.06	0.84	0.00	12.27	
	2.00	EA	EELEF	12.00	1	29	0	2	0	31	15.45
MIL EL <16120 1501 > #8 AWG Cable-Type THW					9.71	284.41	1.47	239.16	0.00	525.04	
	0.12	MLF	EELEF	0.48	1	43	0	36	0	79	661.17
MIL EL <16121 1201 > #8 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	4.00	EA	EELEB	6.90	1	58	0	21	0	79	19.79
MIL EL <16451 1203 > #8 AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.74	
	0.05	MLF	EELEC	0.47	0	12	0	10	0	22	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	2.00	EA	EELEB	2.85	2	70	0	1	0	71	35.60
MIL EL <16471 2206 > 100A,120/240V,3W-1Ph Panelboard Main Brkr,Assemb					12.08	381.95	1.74	444.89	0.00	828.58	
	1.00	EA	EELEB	0.21	12	481	2	560	0	1,043	1043.42
MIL EL <16111 1131 > RGS 1-1/4"Conduit w/Coupling					0.10	2.84	0.02	1.87	0.00	4.73	
	10.00	LF	EELEF	48.00	1	36	0	24	0	60	5.95
MIL EL <16111 1132 > RGS 1-1/4" Elbow					0.59	17.17	0.09	11.87	0.00	29.13	
	2.00	EA	EELEF	7.95	1	43	0	30	0	73	36.68

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
MIL EL <16111 1133 > RGS 1-1/4"Bush Set w/Locknuts					0.49	14.22	0.07	1.11	0.00	15.41	
	2.00	EA	EELEF	9.60	1	36	0	3	0	39	19.40
MIL EL <16111 1134 > RGS 1-1/4" Type LB 2 Hub					1.24	36.40	0.19	21.89	0.00	58.48	
	2.00	EA	EELEF	3.75	2	92	0	55	0	147	73.64
MIL EL <16120 1706 > No 4-Type THWN Feeder for XFMR					11.30	330.95	1.71	531.97	0.00	864.63	
	0.05	MLF	EELEF	0.41	1	21	0	33	0	54	1088.81
MIL EL <16121 1201 > #8 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	6.00	EA	EELEB	6.90	2	87	0	32	0	119	19.79
MIL EL <16451 1203 > #8 AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.75	
	0.02	MLF	EELEC	0.47	0	5	0	4	0	9	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	2.00	EA	EELEB	2.85	2	70	0	1	0	71	35.60
TOTAL INTERIOR - ELEC UPGRADE	1.00	EA			44	1,695	15	1,808	0	3,518	3517.90
10.010.010.010.007.02. MTR CONTR CENTER - ELEC UPGRADE											
M MIL EL <16921 1005 > Inc Sec MCC,AirCktBrkr, 600A 30000 Amp IC,3-Pole,w/Struc Incl	1.00	EA	EELEB	0.11	21.93	693.54	3.17	2371.22	0.00	3067.93	
					22	873	4	2,986	0	3,863	3863.38
M USR EL <16930 1111 > PANEL MTD VOLTMETER					0.00	0.00	0.00	1012.30	0.00	1012.30	
	1.00	EA	N/A	0.00	0	0	0	1,275	0	1,275	1274.77
M USR EL <16923 2004 > Voltmeter Selector Switch					0.00	0.00	0.00	525.76	0.00	525.76	
	1.00	EA	N/A	0.00	0	0	0	662	0	662	662.08
AF EL <16922 3401 > Structure Combination Of Starters To 72" High					10.53	332.90	1.52	941.87	0.00	1276.29	
	3.00	EA	EELEB	0.24	32	1,258	6	3,558	0	4,822	1607.21
M MIL EL <16922 1101 > Circuit Brkr Comb Starter,Size 1 Class I Type A					3.86	122.01	0.56	719.74	0.00	842.31	
	1.00	EA	EELEB	0.65	4	154	1	906	0	1,061	1060.70
M MIL EL <16922 1103 > Circuit Brkr Comb Starter,Size 3 Class I Type A					5.75	181.75	0.83	1245.50	0.00	1428.08	
	1.00	EA	EELEB	0.44	6	229	1	1,568	0	1,798	1798.35
M MIL EL <16922 1105 > Circuit Brkr Comb Starter,Size 5 Class I Type A					9.47	299.48	1.37	4224.10	0.00	4524.95	
	1.00	EA	EELEB	0.26	9	377	2	5,319	0	5,698	5698.18
CIV EL <16923 6001 > Start/Stop Indicating Light					0.50	15.81	0.00	58.58	0.00	74.39	
	3.00	EA	EELEA	2.50	2	60	0	221	0	281	93.67
MIL EL <16923 3003 > Extra Interlocks,Class I,Type C Per Contact					0.26	8.24	0.04	44.63	0.00	52.90	
	3.00	EA	EELEB	9.60	1	31	0	169	0	200	66.62

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
MIL EL <16923 2004 > Ctrl Device,Hand-Off-Auto Sw					1.37	43.20	0.20	73.81	0.00	117.21	
Cover Mtd w/Pilot Light	3.00	EA	EELEB	1.83	4	163	1	279	0	443	147.60
MIL EL <16923 2001 > Ctrl Device,2 Un Push Button Sta					0.42	13.18	0.06	35.58	0.00	48.82	
Cover Mtd	3.00	EA	EELEB	6.00	1	50	0	134	0	184	61.48
CIV EL <16923 1011 > Control Circuit Fuse And Holder					0.25	7.91	0.00	12.20	0.00	20.11	
Small Dim, Dual Element Time Del	3.00	EA	EELEA	5.00	1	30	0	46	0	76	25.32
M USR EL <16923 2005 > Starter MTD AMP METER					0.00	0.00	0.00	201.40	0.00	201.40	
	3.00	EA	N/A	0.00	0	0	0	761	0	761	253.62
M USR EL <16923 2004 > Amp Meter Selector Switch					0.00	0.00	0.00	63.60	0.00	63.60	
	3.00	EA	N/A	0.00	0	0	0	240	0	240	80.09
MIL EL <16471 1704 > 2P,480V,100A, XFMR Ckt Bkr					1.88	59.36	0.27	139.82	0.00	199.45	
	1.00	EA	EELEB	1.33	2	75	0	176	0	251	251.17
TOTAL MTR CONTR CENTER - ELEC UPGRADE	1.00	EA			83	3,299	15	18,302	0	21,615	21615.44
10.010.010.010.007.03. PUMP MOTOR CONDUCTORS - UPGRADE											
MIL EL <16120 1301 > #10 AWG Type USE Mtr Feeder					15.53	455.05	2.36	259.05	0.00	716.46	
Underground Feeder & Branch Ckts	0.15	MLF	EELEF	0.30	2	86	0	49	0	135	902.23
MIL EL <16120 1308 > #2/0 AWG Type USE Mtr Feeder					17.07	500.06	2.59	1743.98	0.00	2246.63	
Underground Feeder & Branch Ckts	0.18	MLF	EELEF	0.27	3	113	1	395	0	509	2829.13
MIL EL <16120 1304 > #4 AWG Type USE Mtr Feeder					15.53	455.05	2.36	579.68	0.00	1037.09	
Underground Feeder & Branch Ckts	0.21	MLF	EELEF	0.30	3	120	1	153	0	274	1305.99
MIL EL <16451 1202 > #10 AWG Insltd Cu Gnd Conductor					6.02	158.01	0.00	113.66	0.00	271.67	
	0.05	MLF	EELEC	0.54	0	10	0	7	0	17	342.11
MIL EL <16451 1204 > #6 AWG Insltd Cu Gnd Conductor					8.67	227.53	0.00	167.25	0.00	394.78	
	0.06	MLF	EELEC	0.38	1	17	0	13	0	30	497.13
MIL EL <16451 1203 > #8 AWG Insltd Gnd Cu Conductor					6.99	183.49	0.00	160.25	0.00	343.74	
	0.07	MLF	EELEC	0.47	0	16	0	14	0	30	432.87
MIL EL <16454 1101 > #8-#1 AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	6.00	EA	EELEB	2.85	5	210	1	3	0	214	35.60
MIL EL <16121 1201 > #10 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	2.00	EA	EELEB	6.90	1	29	0	11	0	40	19.79
MIL EL <16121 1203 > #8 AWG Compr Lug					0.42	13.18	0.06	4.63	0.00	17.87	
	2.00	EA	EELEB	6.00	1	33	0	12	0	45	22.50

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
M MIL EL <16151 3009 > 10 HP AC Motor Three Ph, 460 V					1.98	62.75	0.29	41.34	0.00	104.38	
Motor/Eqpt,Conn,Term & Rot Tstg	1.00	EA	EELEB	1.26	2	79	0	52	0	131	131.44
M MIL EL <16151 3016 > 50 HP AC Motor Three Ph, 460 V					3.09	97.61	0.45	168.54	0.00	266.60	
Motor/Eqpt,Conn,Term & Rot Tstg	1.00	EA	EELEB	0.81	3	123	1	212	0	336	335.72
M MIL EL <16151 3021 > 125 HP AC Motor Three Ph, 460 V					5.95	188.25	0.86	346.62	0.00	535.73	
Motor/Eqpt,Conn,Term & Rot Tstg	1.00	EA	EELEB	0.42	6	237	1	436	0	675	674.63
TOTAL PUMP MOTOR CONDUCTORS - UPGRADE	1.00	EA			28	1,074	5	1,358	0	2,436	2436.09
10.010.010.010.007.04. LGT & RECPT ELECTRICAL - UPGRADE											
MIL EL <16140 1101 > Duplex Rcpt, 120 V, 20 Amp,Exp					0.42	13.18	0.06	10.07	0.00	23.31	
Exposed Devices - Complete	6.00	EA	EELEB	6.00	3	100	0	76	0	176	29.35
L MIL EL <16510 3021 > HID Ind Low Bay Pendant Fxtr					2.00	58.59	0.30	301.78	0.00	360.67	
Type 302a, Metal Halide Lamp	6.00	EA	EELEF	2.33	12	443	2	2,280	0	2,725	454.19
B MIL EL <16510 3021 > Removed Low Bay Pendant Fxtr					1.00	29.30	0.15	0.00	0.00	29.45	
	6.00	EA	EELEF	4.66	6	221	1	0	0	223	37.09
M MIL EL <16140 1101 > Remove Duplex Rcpt, 120V					0.42	13.18	0.06	0.00	0.00	13.24	
	6.00	EA	EELEB	6.00	3	100	0	0	0	100	16.67
TOTAL LGT & RECPT ELECTRICAL - UPGRADE	1.00	EA			23	863	4	2,356	0	3,224	3223.77
10.010.010.010.007.05. SERVICE ENTRANCE - UPGRADE											
MIL EL <16111 4111 > 3"RGS Conduit w/Coupling					0.19	5.69	0.03	6.34	0.00	12.06	
	75.00	LF	EELEF	24.00	15	537	3	599	0	1,139	15.18
M MIL EL <16111 4112 > 3"RGS Elbow w/two couplings					2.07	60.67	0.31	63.98	0.00	124.97	
	4.00	EA	EELEF	2.25	8	306	2	322	0	629	157.37
MIL EL <16111 4113 > 3"RGS Bushing Set w/Locknuts					0.86	25.28	0.13	9.92	0.00	35.33	
	2.00	EA	EELEF	5.40	2	64	0	25	0	89	44.49
MIL EL <16111 4115 > 3"RGS Two Hub Conduit Body					2.00	63.25	0.29	103.41	0.00	166.95	
	4.00	EA	EELEB	1.25	8	319	1	521	0	841	210.24
MIL EL <16120 1513 > 350 MCM-Type THW					38.83	1137.63	5.89	4063.08	0.00	5206.60	
600V Cu,Sgl Strd,Pl in Cnd,12'Hg	0.36	MLF	EELEF	0.12	14	516	3	1,842	0	2,360	6556.56
MIL EL <16121 1111 > 350 MCM Compr Conn,Tape Wrapped					1.85	58.57	0.27	10.85	0.00	69.69	
Low Voltage - To 600 Volts	8.00	EA	EELEB	1.35	15	590	3	109	0	702	87.76

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
MIL EL <16121 1211 > 350 MCM Compr Lugs,1Hole,Wrapped					1.28	40.55	0.19	8.94	0.00	49.68	
Low Voltage - To 600 Volts	24.00	EA	EELEB	1.95	31	1,226	6	270	0	1,501	62.56
MIL EL <16451 1208 > 1/0AWG,Insulated Stranded Cu 1/c					16.67	437.55	0.00	627.31	0.00	1064.86	
Laid in Trench,w/o Trnhg & Bfill	0.09	MLF	EELEC	0.20	2	50	0	71	0	121	1340.95
MIL EL <16454 1102 > #1/0-AWG Cadweld Splice/Lug					1.04	32.94	0.15	5.83	0.00	38.92	
	4.00	EA	EELEB	2.40	4	166	1	29	0	196	49.01
MIL EL <16120 9145 > Svce Entrance Thrd Weatherhead					2.50	79.06	0.36	225.54	0.00	304.96	
	2.00	EA	EELEB	1.00	5	199	1	568	0	768	384.03
TOTAL SERVICE ENTRANCE - UPGRADE	1.00	EA			103	3,971	19	4,357	0	8,347	8346.65
10.010.010.010.007.06. SITE ELECTRICAL - UPGRADE											
MIL EL <16413 4403 > 4 Spool Secondary Rack					1.77	52.27	10.75	20.62	0.00	83.64	
	2.00	EA	EELEJ	2.82	4	132	27	52	0	211	105.32
MIL EL <16120 9137 > #4/0 AWG Al QuadPX ASCR w/Neu Ca					234.74	6920.37	1422.61	3408.73	0.00	11751.71	
Svce Drp Strd Ca,600V w/WeatHd	0.40	MLF	EELEJ	0.02	94	3,486	717	1,717	0	5,919	14798.69
MIL EL <16413 4301 > Neutral Clevis					0.52	15.35	3.16	5.30	0.00	23.81	
	2.00	EA	EELEJ	9.60	1	39	8	13	0	60	29.98
B MIL EL <16121 1308 > 3PH Sec Ckt Tap @ Pole Mtd Xfmr					8.00	252.21	1.16	77.55	0.00	330.92	
	2.00	EA	EELEB	0.31	16	635	3	195	0	833	416.72
TOTAL SITE ELECTRICAL - UPGRADE	1.00	EA			114	4,291	755	1,978	0	7,024	7023.53
10.010.010.010.007.07. Removal											
USR EL <16990 2203 > Pump Station Electrical Removal					98.75	2879.37	0.00	0.00	0.00	2879.37	
	1.00	EA	EELEG	0.06	99	3,626	0	0	0	3,626	3625.93
TOTAL Removal	1.00	EA			99	3,626	0	0	0	3,626	3625.93
TOTAL PUMP PLANT #7 - ELEC UPGRADE	1.00	EA			494	18,819	813	30,157	0	49,789	49789.31
10.010.010.010.008. PUMP PLANT #8 - ELEC UPGRADE											
NO ELECTRICAL WORKED REQUIRED FOR PUMP PLANT NO. 8.											
TOTAL PUMP PLANT #8 - ELEC UPGRADE	1.00	EA			0	0	0	0	0	0	0.00

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
10.010.010.010.009. PUMP PLANT #9 - ELEC UPGRADE											
10.010.010.010.009.01. INTERIOR - ELEC UPGRADE											
MIL EL <16471 2206 > 100A,120/240V,3W-1Ph Panelboard					12.08	381.95	1.74	444.89	0.00	828.58	
Main Brkr,Assemb	1.00	EA	EELEB	0.21	12	481	2	560	0	1,043	1043.42
MIL EL <16111 1131 > RGS 1-1/4"Conduit w/Coupling					0.10	2.84	0.02	1.87	0.00	4.73	
	10.00	LF	EELEF	48.00	1	36	0	24	0	60	5.95
MIL EL <16111 1132 > RGS 1-1/4" Elbow					0.59	17.17	0.09	11.87	0.00	29.13	
	2.00	EA	EELEF	7.95	1	43	0	30	0	73	36.68
MIL EL <16111 1133 > RGS 1-1/4"Bush Set w/Locknuts					0.49	14.22	0.07	1.11	0.00	15.41	
	2.00	EA	EELEF	9.60	1	36	0	3	0	39	19.40
MIL EL <16111 1134 > RGS 1-1/4" Type LB 2 Hub					1.24	36.40	0.19	21.89	0.00	58.48	
	2.00	EA	EELEF	3.75	2	92	0	55	0	147	73.64
MIL EL <16120 1705 > No 6-Type THWN					9.56	280.03	1.45	341.57	0.00	623.05	
	0.05	MLF	EELEF	0.49	0	18	0	22	0	39	784.60
MIL EL <16121 1201 > #6 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	9.00	EA	EELEB	6.90	3	130	1	48	0	178	19.79
MIL EL <16451 1203 > #8 AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.75	
	0.02	MLF	EELEC	0.47	0	5	0	4	0	9	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	2.00	EA	EELEB	2.85	2	70	0	1	0	71	35.60
TOTAL INTERIOR - ELEC UPGRADE	1.00	EA			23	910	4	746	0	1,660	1659.63
10.010.010.010.009.02. MTR CONTR CENTER - ELEC UPGRADE											
M MIL EL <16921 1002 > Inc Sec MCC,AirCktBkr,3P, 200 A					9.69	306.45	1.40	895.70	0.00	1203.55	
	1.00	EA	EELEB	0.26	10	386	2	1,128	0	1,516	1515.61
M USR EL <16930 1111 > PANEL MTD VOLTMETER					0.00	0.00	0.00	1012.30	0.00	1012.30	
	1.00	EA	N/A	0.00	0	0	0	1,275	0	1,275	1274.77
M USR EL <16923 2004 > Voltmeter Selector Switch					0.00	0.00	0.00	525.76	0.00	525.76	
	1.00	EA	N/A	0.00	0	0	0	662	0	662	662.08
M MIL EL <16922 1103 > Circuit Brkr Comb Starter,Size 3					5.75	181.75	0.83	1245.50	0.00	1428.08	
Class I Type A	2.00	EA	EELEB	0.44	12	458	2	3,137	0	3,597	1798.35
CIV EL <16923 6001 > Start/Stop Indicating Light					0.50	15.81	0.00	58.58	0.00	74.39	
	2.00	EA	EELEA	2.50	1	40	0	148	0	187	93.67

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
MIL EL <16923 3003 > Extra Interlocks,Class I,Type C					0.26	8.24	0.04	44.63	0.00	52.90	
Per Contact	2.00	EA	EELEB	9.60	1	21	0	112	0	133	66.62
MIL EL <16923 2004 > Ctrl Device,Hand-Off-Auto Sw					1.37	43.20	0.20	73.81	0.00	117.21	
Cover Mtd w/Pilot Light	2.00	EA	EELEB	1.83	3	109	0	186	0	295	147.60
MIL EL <16923 2001 > Ctrl Device,2 Un Push Button Sta					0.42	13.18	0.06	35.59	0.00	48.82	
Cover Mtd	2.00	EA	EELEB	6.00	1	33	0	90	0	123	61.48
CIV EL <16923 1011 > Control Circuit Fuse And Holder					0.25	7.91	0.00	12.20	0.00	20.11	
Small Dim, Dual Element Time Del	2.00	EA	EELEA	5.00	1	20	0	31	0	51	25.32
M USR EL <16923 2005 > Starter MTD AMP METER					0.00	0.00	0.00	201.40	0.00	201.40	
	2.00	EA	N/A	0.00	0	0	0	507	0	507	253.62
M USR EL <16923 2004 > Amp Meter Selector Switch					0.00	0.00	0.00	63.60	0.00	63.60	
	2.00	EA	N/A	0.00	0	0	0	160	0	160	80.09
TOTAL MTR CONTR CENTER - ELEC UPGRADE	1.00	EA			27	1,066	5	7,435	0	8,506	8505.98
10.010.010.010.009.03. PUMP MOTOR CONDUCTORS - UPGRADE											
MIL EL <16120 1303 > #6 AWG Cable-Type USE					15.53	455.05	2.36	381.17	0.00	838.58	
Underground Feeder & Branch Ckts	0.42	MLF	EELEF	0.30	7	241	1	202	0	444	1056.00
MIL EL <16451 1202 > #10 AWG Insltd Cu Gnd Conductor					6.02	158.01	0.00	113.66	0.00	271.67	
	0.09	MLF	EELEC	0.54	1	18	0	13	0	31	342.11
MIL EL <16121 1201 > #10 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	2.00	EA	EELEB	6.90	1	29	0	11	0	40	19.79
MIL EL <16121 1201 > #6 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	12.00	EA	EELEB	6.90	4	173	1	64	0	238	19.79
M MIL EL <16151 3016 > 50 HP AC Motor Three Ph, 460 V					3.09	97.61	0.45	168.54	0.00	266.60	
Motor/Eqpt,Conn,Term & Rot Tstg	2.00	EA	EELEB	0.81	6	246	1	424	0	671	335.72
TOTAL PUMP MOTOR CONDUCTORS - UPGRADE	1.00	EA			18	706	3	713	0	1,423	1422.87
10.010.010.010.009.04. SERVICE ENTRANCE - UPGRADE											
MIL EL <16111 1141 > RGS 1-1/2"Conduit 480V					0.12	3.41	0.02	2.34	0.00	5.77	
	35.00	LF	EELEF	40.05	4	150	1	103	0	254	7.27
MIL EL <16111 1142 > RGS 1-1/2" Elbow 480V					0.72	21.17	0.11	14.17	0.00	35.45	
	2.00	EA	EELEF	6.45	1	53	0	36	0	89	44.64

10.010. PADUCAH PUMP PLANT ELEC UPGRADE		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
MIL EL <16111 1143 > RGS 1-1/2"Bush w/LNs	480V					0.59	17.17	0.09	1.59	0.00	18.85	
		2.00	EA	EELEF	7.95	1	43	0	4	0	47	23.74
MIL EL <16111 1144 > RGS 1-1/2" Type LB 2 Hub	480V					1.73	50.56	0.26	23.84	0.00	74.66	
		2.00	EA	EELEF	2.70	3	127	1	60	0	188	94.02
MIL EL <16120 1504 > #2 AWG Type THW	480V					17.45	511.29	2.65	822.76	0.00	1336.70	
		0.17	MLF	EELEF	0.27	3	109	1	176	0	286	1683.28
MIL EL <16121 1103 > #2 AWG Compr Conn	480V					0.57	18.18	0.08	4.96	0.00	23.22	
		8.00	EA	EELEB	4.35	5	183	1	50	0	234	29.24
MIL EL <16121 1203 > #2 AWG Compr Lug	480V					0.42	13.18	0.06	4.62	0.00	17.86	
		12.00	EA	EELEB	6.00	5	199	1	70	0	270	22.49
MIL EL <16451 1203 > 8AWG,Insul Gnd Conductor	480V					6.99	183.49	0.00	160.25	0.00	343.74	
		0.05	MLF	EELEC	0.47	0	12	0	10	0	22	432.87
MIL EL <16454 1101 > #8-1AWG Cadweld Lug	480V					0.88	27.74	0.13	0.40	0.00	28.27	
		2.00	EA	EELEB	2.85	2	70	0	1	0	71	35.60
MIL EL <16120 9142 > Svce Entrance Weatherhead	480V					0.85	25.09	5.16	22.26	0.00	52.51	
		1.00	EA	EELEJ	5.88	1	32	6	28	0	66	66.12
MIL EL <16111 1131 > RGS 1-1/4"Conduit	240V					0.10	2.84	0.01	1.87	0.00	4.72	
		35.00	LF	EELEF	48.00	4	125	0	82	0	208	5.94
MIL EL <16111 1132 > RGS 1-1/4" Elbow	240V					0.59	17.17	0.09	11.87	0.00	29.13	
		2.00	EA	EELEF	7.95	1	43	0	30	0	73	36.69
MIL EL <16111 1133 > RGS 1-1/4"Bushing w/LNs	240V					0.49	14.22	0.07	1.11	0.00	15.40	
		2.00	EA	EELEF	9.60	1	36	0	3	0	39	19.40
MIL EL <16111 1134 > RGS 1-1/4" Type LB 2 Hub	240V					1.24	36.40	0.19	21.89	0.00	58.48	
		2.00	EA	EELEF	3.75	2	92	0	55	0	147	73.64
MIL EL <16120 1504 > #2 AWG Type THW	240V					17.45	511.29	2.65	822.76	0.00	1336.70	
		0.17	MLF	EELEF	0.27	3	109	1	176	0	286	1683.28
MIL EL <16121 1103 > #2 AWG Compr Conn	240V					0.57	18.18	0.08	4.96	0.00	23.22	
		8.00	EA	EELEB	4.35	5	183	1	50	0	234	29.24
MIL EL <16121 1203 > #2 AWG Compr Lug	240V					0.42	13.18	0.06	4.62	0.00	17.86	
		12.00	EA	EELEB	6.00	5	199	1	70	0	270	22.49
MIL EL <16451 1203 > 8AWG,Insul Gnd Conductor	240V					6.99	183.49	0.00	160.25	0.00	343.74	
		0.05	MLF	EELEC	0.47	0	12	0	10	0	22	432.87
MIL EL <16454 1101 > #8-1AWG Cadweld Lug	240V					0.88	27.74	0.13	0.40	0.00	28.27	
		2.00	EA	EELEB	2.85	2	70	0	1	0	71	35.60

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
MIL EL <16120 9142 > Svce Entrance Weatherhead 240V					0.85	25.09	5.16	22.26	0.00	52.51	
	1.00	EA	EELEJ	5.88	1	32	6	28	0	66	66.12
TOTAL SERVICE ENTRANCE - UPGRADE	1.00	EA			49	1,880	22	1,043	0	2,944	2944.47
10.010.010.010.009.05. SITE ELECTRICAL - UPGRADE											
MIL EL <16120 9133 > #2 AWG Al QuadPX ASCR w/Neu Ca					128.87	3799.07	780.97	1197.52	0.00	5777.56	
	0.20	MLF	EELEJ	0.04	26	957	197	302	0	1,455	7275.57
B MIL EL <16121 1308 > 3PH Sec Ckt Tap @ Pole Mtd Xfmr					8.00	252.21	1.16	77.55	0.00	330.92	
	1.00	EA	EELEB	0.31	8	318	1	98	0	417	416.72
B MIL EL <16121 1308 > 3PH Service Entrance Connection					8.00	252.21	1.16	77.55	0.00	330.92	
	1.00	EA	EELEB	0.31	8	318	1	98	0	417	416.72
MIL EL <16413 4301 > Neutral Support					0.52	15.35	3.16	5.30	0.00	23.81	
	2.00	EA	EELEJ	9.60	1	39	8	13	0	60	29.98
MIL EL <16120 9123 > #2 AWG Al TriPX ASCR w/Neu Cable					100.00	2948.08	606.03	881.39	0.00	4435.50	
	0.20	MLF	EELEJ	0.05	20	742	153	222	0	1,117	5585.54
B MIL EL <16121 1308 > 1PH Sec Ckt Tap @ Pole					8.00	252.21	1.16	77.55	0.00	330.92	
	1.00	EA	EELEB	0.31	8	318	1	98	0	417	416.72
B MIL EL <16121 1308 > 1PH Service Entrance Connection					5.00	157.64	0.73	16.09	0.00	174.46	
	1.00	EA	EELEB	0.50	5	199	1	20	0	220	219.69
MIL EL <16413 4301 > Neutral Clevis					0.52	15.35	3.16	5.30	0.00	23.81	
	2.00	EA	EELEJ	9.60	1	39	8	13	0	60	29.98
TOTAL SITE ELECTRICAL - UPGRADE	1.00	EA			77	2,928	371	864	0	4,162	4162.01
10.010.010.010.009.06. Removal											
USR EL <16990 2203 > Pump Station Electrical Removal					48.50	1414.17	0.00	0.00	0.00	1414.17	
	1.00	EA	EELEG	0.12	49	1,781	0	0	0	1,781	1780.84
TOTAL Removal	1.00	EA			49	1,781	0	0	0	1,781	1780.84
TOTAL PUMP PLANT #9 - ELEC UPGRADE	1.00	EA			243	9,271	404	10,801	0	20,476	20475.79

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
10.010.010.010.010. PUMP PLANT #10 - ELEC UPGRADE											
10.010.010.010.010.01. MTR CONTR CENTER - ELEC UPGRADE											
MIL EL <16155 3143 > Comb Str,Sz 2,NEMA 4 w/Crk Brkr					9.26	292.83	1.34	1226.49	0.00	1520.66	
Non-Reversing,240-600V,3P	2.00	EA	EELEB	0.27	19	738	3	3,089	0	3,830	1914.94
CIV EL <16923 1011 > Control Circuit Fuse And Holder					0.25	7.91	0.00	12.20	0.00	20.11	
Small Dim, Dual Element Time Del	2.00	EA	EELEA	5.00	1	20	0	31	0	51	25.32
MIL EL <16923 2001 > Ctrl Device,2 Un Push Button Sta					0.42	13.18	0.06	35.59	0.00	48.82	
Cover Mtd	2.00	EA	EELEB	6.00	1	33	0	90	0	123	61.48
MIL EL <16923 2004 > Ctrl Device,Hand-Off-Auto Sw					1.37	43.20	0.20	73.81	0.00	117.21	
Cover Mtd w/Pilot Light	2.00	EA	EELEB	1.83	3	109	0	186	0	295	147.60
MIL EL <16923 3003 > Extra Interlocks,Class I,Type C					0.26	8.24	0.04	44.63	0.00	52.90	
Per Contact	2.00	EA	EELEB	9.60	1	21	0	112	0	133	66.62
CIV EL <16923 6001 > Start/Stop Indicating Light					0.50	15.81	0.00	58.58	0.00	74.39	
	4.00	EA	EELEA	2.50	2	80	0	295	0	375	93.67
M USR EL <16923 2005 > Starter MTD AMP METER					0.00	0.00	0.00	201.40	0.00	201.40	
	2.00	EA	N/A	0.00	0	0	0	507	0	507	253.62
M USR EL <16923 2004 > Amp Meter Selector Switch					0.00	0.00	0.00	63.60	0.00	63.60	
	2.00	EA	N/A	0.00	0	0	0	160	0	160	80.09
TOTAL MTR CONTR CENTER - ELEC UPGRADE	1.00	EA			25	1,000	4	4,470	0	5,474	5474.05
10.010.010.010.010.02. INTERIOR - ELEC UPGRADE											
MIL EL <16111 1121 > RGS 1" Conduit w/Coupling					0.08	2.28	0.01	1.46	0.00	3.75	
	20.00	LF	EELEF	60.00	2	57	0	37	0	95	4.73
MIL EL <16111 1122 > RGS 1" Elbow					0.49	14.22	0.07	8.22	0.00	22.51	
	3.00	EA	EELEF	9.60	1	54	0	31	0	85	28.34
MIL EL <16111 1123 > RGS 1" Bushing Set w/Locknuts					0.39	11.38	0.06	0.84	0.00	12.27	
	2.00	EA	EELEF	12.00	1	29	0	2	0	31	15.45
MIL EL <16120 1502 > #6 AWG Cable-Type THW					11.64	340.86	1.76	335.61	0.00	678.23	
	0.06	MLF	EELEF	0.40	1	26	0	25	0	51	854.08
MIL EL <16121 1201 > #6 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	3.00	EA	EELEB	6.90	1	43	0	16	0	59	19.79
MIL EL <16121 1101 > #6 AWG Compr Conn					0.52	16.47	0.08	3.42	0.00	19.97	
	3.00	EA	EELEB	4.80	2	62	0	13	0	75	25.15

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
MIL EL <16451 1203 > #8 AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.75	
	0.05	MLF	EELEC	0.47	0	12	0	10	0	22	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	2.00	EA	EELEB	2.85	2	70	0	1	0	71	35.60
MIL EL <16471 2202 > Panelboard,120/240V,3W,1Ph - 50A Main Brkr,Assemb					6.08	192.37	0.88	204.85	0.00	398.10	
	1.00	EA	EELEB	0.41	6	242	1	258	0	501	501.31
TOTAL INTERIOR - ELEC UPGRADE	1.00	EA			15	595	3	393	0	991	990.69
10.010.010.010.010.03. PUMP MOTOR CONDUCTORS - UPGRADE											
MIL EL <16120 1303 > #6 AWG Type USE MTR Feeder Ckt					15.53	455.05	2.36	381.17	0.00	838.58	
	0.30	MLF	EELEF	0.30	5	172	1	144	0	317	1056.00
MIL EL <16121 1203 > #6 AWG Compr Lug					0.42	13.18	0.06	4.63	0.00	17.86	
	12.00	EA	EELEB	6.00	5	199	1	70	0	270	22.50
MIL EL <16151 3011 > 15 HP AC Motor Three Ph, 460 V Motor/Eqpt,Conn,Term & Rot Tstg					2.03	64.28	0.29	1114.01	0.00	1178.58	
	2.00	EA	EELEB	1.23	4	162	1	2,806	0	2,968	1484.16
MIL EL <16451 1203 > 8AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.75	
	0.07	MLF	EELEC	0.47	0	16	0	14	0	30	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	4.00	EA	EELEB	2.85	4	140	1	2	0	142	35.60
TOTAL PUMP MOTOR CONDUCTORS - UPGRADE	1.00	EA			18	689	3	3,036	0	3,728	3727.78
10.010.010.010.010.04. 440V Underground Secondary Serv											
MIL EL <16120 1303 > #6 AWG Cable-Type USE					15.53	455.05	2.36	381.17	0.00	838.58	
	0.68	MLF	EELEF	0.30	11	390	2	326	0	718	1056.00
MIL EL <16121 1101 > #6 AWG Compr Conn					0.52	16.47	0.08	3.42	0.00	19.97	
	3.00	EA	EELEB	4.80	2	62	0	13	0	75	25.15
MIL EL <16121 1302 > #6 AWG Split Bolt Conn					0.72	22.92	0.10	3.01	0.00	26.03	
	3.00	EA	EELEB	3.45	2	87	0	11	0	98	32.78
MIL EL <16121 1201 > #6 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	9.00	EA	EELEB	6.90	3	130	1	48	0	178	19.79
L CIV EL <16182 1105 > 3P,480V,70A Ckt Breaker NEMA 3R					2.82	89.09	0.40	679.86	0.00	769.35	
	1.00	EA	EELEB	0.89	3	112	1	856	0	969	968.83

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
L MIL EL <16451 1203 > 8AWG Insltd Gnd Conductor					15.00	393.81	0.00	160.25	0.00	554.06	
	0.23	MLF	EELEC	0.22	3	114	0	46	0	160	697.72
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	3.00	EA	EELEB	2.85	3	105	0	2	0	107	35.60
TOTAL 440V Underground Secondary Serv	1.00	EA			26	999	4	1,302	0	2,306	2306.14
10.010.010.010.010.05. 120/240V Underground Service											
MIL EL <16120 1303 > #6 AWG Cable-Type USE Underground Feeder & Branch Ckts	0.09	MLF	EELEF	0.30	15.53	455.05	2.36	381.17	0.00	838.58	
					1	52	0	43	0	95	1056.00
MIL EL <16121 1101 > #6 AWG Compr Conn,Tape Wrapped Low Voltage - To 600 Volts					0.52	16.47	0.08	3.42	0.00	19.97	
	3.00	EA	EELEB	4.80	2	62	0	13	0	75	25.15
MIL EL <16121 1302 > #6 AWG Split Bolt Conn,Wrapped Low Voltage - To 600 Volts					0.72	22.92	0.10	3.01	0.00	26.03	
	3.00	EA	EELEB	3.45	2	87	0	11	0	98	32.78
MIL EL <16121 1201 > #6 AWG Compr Lugs,1Hole,Wrapped Low Voltage - To 600 Volts					0.36	11.46	0.05	4.21	0.00	15.72	
	9.00	EA	EELEB	6.90	3	130	1	48	0	178	19.79
MIL EL <16451 1203 > 8AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.75	
	0.03	MLF	EELEC	0.47	0	7	0	6	0	13	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	3.00	EA	EELEB	2.85	3	105	0	2	0	107	35.60
B MIL EL <16170 2112 > Reconn 240V Disc Sw,60A NEMA 3R					1.00	31.63	0.14	0.00	0.00	31.77	
	1.00	EA	EELEB	2.50	1	40	0	0	0	40	40.01
TOTAL 120/240V Underground Service	1.00	EA			12	482	2	123	0	607	606.78
10.010.010.010.010.06. 480 V WP Dry Transformer											
M MIL EL <16330 1201 > .75KVA,240x480V-120/240V Xformer 1Ph,60Hz, WP Dry Type					4.00	126.31	3.75	192.92	0.00	322.98	
	1.00	EA	EELEE	1.03	4	159	5	243	0	407	406.72
M MIL EL <16330 2403 > 45 KVA,480 X 208y/120V,Xfrmr 3Ph,60Hz, WP Dry Type					15.02	474.23	14.08	2077.60	0.00	2565.91	
	1.00	EA	EELEE	0.27	15	597	18	2,616	0	3,231	3231.20
MIL EL <16330 2701 > Mounting Bracket For Transformer					4.00	117.18	0.61	161.43	0.00	279.22	
	1.00	EA	EELEF	1.17	4	148	1	203	0	352	351.61
TOTAL 480 V WP Dry Transformer	1.00	EA			23	904	23	3,063	0	3,990	3989.53

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL PUMP PLANT #10 - ELEC UPGRADE	1.00	EA			120	4,668	40	12,387	0	17,095	17094.97
10.010.010.010.011. PUMP PLANT #11 - ELEC UPGRADE											
NO ELECTRICAL WORKED REQUIRED FOR PUMP PLANT NO. 11.											
TOTAL PUMP PLANT #11 - ELEC UPGRADE	1.00	EA			0	0	0	0	0	0	0.00
10.010.010.010.012. PUMP PLANT #12 - ELEC UPGRADE											
10.010.010.010.012.01. INTERIOR - ELEC UPGRADE											
MIL EL <16471 2206 > 100A,120/240V,3W-1Ph Panelboard					12.08	381.95	1.74	444.89	0.00	828.58	
Main Brkr,Assemb	1.00	EA	EELEB	0.21	12	481	2	560	0	1,043	1043.42
MIL EL <16111 1131 > RGS 1-1/4"Conduit w/Coupling					0.10	2.84	0.02	1.87	0.00	4.73	
	10.00	LF	EELEF	48.00	1	36	0	24	0	60	5.95
MIL EL <16111 1132 > RGS 1-1/4" Elbow					0.59	17.17	0.09	11.87	0.00	29.13	
	2.00	EA	EELEF	7.95	1	43	0	30	0	73	36.68
MIL EL <16111 1133 > RGS 1-1/4"Bush Set w/Locknuts					0.49	14.22	0.07	1.11	0.00	15.41	
	2.00	EA	EELEF	9.60	1	36	0	3	0	39	19.40
MIL EL <16111 1134 > RGS 1-1/4" Type LB 2 Hub					1.24	36.40	0.19	21.89	0.00	58.48	
	2.00	EA	EELEF	3.75	2	92	0	55	0	147	73.64
MIL EL <16120 1705 > No 6-Type THWN					9.56	280.03	1.45	341.57	0.00	623.05	
	0.05	MLF	EELEF	0.49	0	18	0	22	0	39	784.60
MIL EL <16121 1201 > #6 AWG Compr Lug					0.36	11.46	0.05	4.21	0.00	15.72	
	9.00	EA	EELEB	6.90	3	130	1	48	0	178	19.79
MIL EL <16451 1203 > #8 AWG Insltd Gnd Conductor					6.99	183.49	0.00	160.26	0.00	343.75	
	0.02	MLF	EELEC	0.47	0	5	0	4	0	9	432.87
MIL EL <16454 1101 > #8-AWG Cadweld Lug					0.88	27.74	0.13	0.40	0.00	28.27	
	2.00	EA	EELEB	2.85	2	70	0	1	0	71	35.60
TOTAL INTERIOR - ELEC UPGRADE	1.00	EA			23	910	4	746	0	1,660	1659.63
10.010.010.010.012.02. MTR CONTR CENTER - ELEC UPGRADE											
M MIL EL <16921 1002 > Inc Sec MCC,AirCktBkr,3P, 200 A					9.69	306.45	1.40	895.70	0.00	1203.55	
	1.00	EA	EELEB	0.26	10	386	2	1,128	0	1,516	1515.61
M USR EL <16930 1111 > PANEL MTD VOLTMETER					0.00	0.00	0.00	1012.30	0.00	1012.30	
	1.00	EA	N/A	0.00	0	0	0	1,275	0	1,275	1274.77

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
M USR EL <16923 2004 > Voltmeter Selector Switch					0.00	0.00	0.00	525.76	0.00	525.76	
	1.00	EA	N/A	0.00	0	0	0	662	0	662	662.08
M MIL EL <16922 1103 > Circuit Brkr Comb Starter,Size 3					5.75	181.75	0.83	1245.50	0.00	1428.08	
Class I Type A	2.00	EA	EELEB	0.44	12	458	2	3,137	0	3,597	1798.35
CIV EL <16923 6001 > Start/Stop Indicating Light					0.50	15.81	0.00	58.58	0.00	74.39	
	2.00	EA	EELEA	2.50	1	40	0	148	0	187	93.67
MIL EL <16923 3003 > Extra Interlocks,Class I,Type C					0.26	8.24	0.04	44.63	0.00	52.90	
Per Contact	2.00	EA	EELEB	9.60	1	21	0	112	0	133	66.62
MIL EL <16923 2004 > Ctrl Device,Hand-Off-Auto Sw					1.37	43.20	0.20	73.81	0.00	117.21	
Cover Mtd w/Pilot Light	2.00	EA	EELEB	1.83	3	109	0	186	0	295	147.60
MIL EL <16923 2001 > Ctrl Device,2 Un Push Button Sta					0.42	13.18	0.06	35.59	0.00	48.82	
Cover Mtd	2.00	EA	EELEB	6.00	1	33	0	90	0	123	61.48
CIV EL <16923 1011 > Control Circuit Fuse And Holder					0.25	7.91	0.00	12.20	0.00	20.11	
Small Dim, Dual Element Time Del	2.00	EA	EELEA	5.00	1	20	0	31	0	51	25.32
M USR EL <16923 2005 > Starter MTD AMP METER					0.00	0.00	0.00	201.40	0.00	201.40	
	2.00	EA	N/A	0.00	0	0	0	507	0	507	253.62
M USR EL <16923 2004 > Amp Meter Selector Switch					0.00	0.00	0.00	63.60	0.00	63.60	
	2.00	EA	N/A	0.00	0	0	0	160	0	160	80.09
TOTAL MTR CONTR CENTER - ELEC UPGRADE	1.00	EA			27	1,066	5	7,435	0	8,506	8505.98
10.010.010.010.012.03. PUMP MOTOR CONDUCTORS - UPGRADE											
MIL EL <16120 1305 > #2 AWG Cable-Type USE					15.53	455.05	2.36	902.73	0.00	1360.14	
Underground Feeder & Branch Ckts	0.42	MLF	EELEF	0.30	7	241	1	477	0	719	1712.79
MIL EL <16451 1203 > 8AWG,Insulated Stranded Cu 1/c					6.99	183.49	0.00	160.25	0.00	343.74	
Laid in Trench,w/o Trnhg & Bfill	0.09	MLF	EELEC	0.47	1	21	0	18	0	39	432.87
MIL EL <16121 1203 > #2 AWG Compr Lugs,1Hole,Wrapped					0.42	13.18	0.06	4.62	0.00	17.86	
Low Voltage - To 600 Volts	2.00	EA	EELEB	6.00	1	33	0	12	0	45	22.49
MIL EL <16121 1203 > #2 AWG Compr Lugs,1Hole,Wrapped					0.42	13.18	0.06	4.62	0.00	17.86	
Low Voltage - To 600 Volts	12.00	EA	EELEB	6.00	5	199	1	70	0	270	22.49
M MIL EL <16151 3016 > 50 HP AC Motor Three Ph, 460 V					3.09	97.61	0.45	168.54	0.00	266.60	
Motor/Eqpt,Conn,Term & Rot Tstg	2.00	EA	EELEB	0.81	6	246	1	424	0	671	335.72
TOTAL PUMP MOTOR CONDUCTORS - UPGRADE	1.00	EA			19	740	3	1,002	0	1,745	1744.68

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
10.010.010.010.012.04. SERVICE ENTRANCE - UPGRADE											
MIL EL <16111 4101 > 2-1/2"RGS Conduit w/Coupling					0.16	4.55	0.02	5.11	0.00	9.68	
Service & Feeder Conduit,10' Hgt	35.00	LF	EELEF	30.00	6	201	1	225	0	427	12.19
MIL EL <16111 4102 > 2-1/2"RGS Elbow					1.48	43.34	0.22	34.40	0.00	77.96	
Service & Feeder Conduit,10' Hgt	2.00	EA	EELEF	3.15	3	109	1	87	0	196	98.17
MIL EL <16111 4103 > 2-1/2"RGS Bushing Set w/Locknuts					0.78	22.75	0.12	8.16	0.00	31.03	
Service & Feeder Conduit,10' Hgt	2.00	EA	EELEF	6.00	2	57	0	21	0	78	39.08
MIL EL <16111 4105 > 2 1/2"RGS Two Hub Conduit Body					1.60	50.60	0.23	79.96	0.00	130.79	
Service & Feeder Conduit,10' Hgt	2.00	EA	EELEB	1.56	3	127	1	201	0	329	164.70
MIL EL <16120 1508 > #3/0 AWG Cable-Type THW					27.25	798.34	4.13	2043.45	0.00	2845.92	
600V Cu,Sgl Strd,Pl in Cnd,12'Hg	0.17	MLF	EELEF	0.17	5	171	1	437	0	609	3583.81
MIL EL <16121 1106 > #3/0 AWG Compr Conn,Tape Wrapped					1.04	32.94	0.15	7.95	0.00	41.04	
Low Voltage - To 600 Volts	8.00	EA	EELEB	2.40	8	332	2	80	0	413	51.68
MIL EL <16121 1206 > #3/0 AWG Compr Lugs,1Hole,Wrappe					0.72	22.92	0.10	5.58	0.00	28.60	
Low Voltage - To 600 Volts	12.00	EA	EELEB	3.45	9	346	2	84	0	432	36.01
MIL EL <16451 1205 > 4AWG,Insulated Stranded Cu 1/c					10.32	270.87	0.00	254.36	0.00	525.23	
Laid in Trench,w/o Trnhg & Bfill	0.05	MLF	EELEC	0.32	1	17	0	16	0	33	661.41
MIL EL <16454 1101 > #8-1AWG Cadweld Splice Or Lug					0.88	27.74	0.13	0.40	0.00	28.27	
Ground Conductor Bonding	2.00	EA	EELEB	2.85	2	70	0	1	0	71	35.60
MIL EL <16120 9144 > 2 1/2"WeatHd For #3/0 Thru #4/0					1.48	43.68	8.98	154.22	0.00	206.88	
Svce Entrance Thrd Weatherhead	1.00	EA	EELEJ	3.38	1	55	11	194	0	261	260.52
MIL EL <16111 1131 > RGS 1-1/4"Conduit 240V					0.10	2.84	0.01	1.87	0.00	4.72	
	35.00	LF	EELEF	48.00	4	125	0	82	0	208	5.94
MIL EL <16111 1132 > RGS 1-1/4" Elbow 240V					0.59	17.17	0.09	11.87	0.00	29.13	
	2.00	EA	EELEF	7.95	1	43	0	30	0	73	36.69
MIL EL <16111 1133 > RGS 1-1/4"Bushing w/LNs 240V					0.49	14.22	0.07	1.11	0.00	15.40	
	2.00	EA	EELEF	9.60	1	36	0	3	0	39	19.40
MIL EL <16111 1134 > RGS 1-1/4" Type LB 2 Hub 240V					1.24	36.40	0.19	21.89	0.00	58.48	
	2.00	EA	EELEF	3.75	2	92	0	55	0	147	73.64
MIL EL <16120 1504 > #2 AWG Type THW 240V					17.45	511.29	2.65	822.76	0.00	1336.70	
	0.17	MLF	EELEF	0.27	3	109	1	176	0	286	1683.28
MIL EL <16121 1103 > #2 AWG Compr Conn 240V					0.57	18.18	0.08	4.96	0.00	23.22	
	8.00	EA	EELEB	4.35	5	183	1	50	0	234	29.24

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
MIL EL <16121 1203 > #2 AWG Compr Lug 240V					0.42	13.18	0.06	4.62	0.00	17.86	
	12.00	EA	EELEB	6.00	5	199	1	70	0	270	22.49
MIL EL <16451 1203 > 8AWG,Insul Gnd Conductor 240V					6.99	183.49	0.00	160.25	0.00	343.74	
	0.05	MLF	EELEC	0.47	0	12	0	10	0	22	432.87
MIL EL <16454 1101 > #8-1AWG Cadweld Lug 240V					0.88	27.74	0.13	0.40	0.00	28.27	
	2.00	EA	EELEB	2.85	2	70	0	1	0	71	35.60
MIL EL <16120 9142 > Svce Entrance Weatherhead 240V					0.85	25.09	5.16	22.26	0.00	52.51	
	1.00	EA	EELEJ	5.88	1	32	6	28	0	66	66.12
TOTAL SERVICE ENTRANCE - UPGRADE	1.00	EA			62	2,386	28	1,852	0	4,266	4266.37
10.010.010.010.012.05. SITE ELECTRICAL - UPGRADE											
MIL EL <16120 9133 > #2 AWG Al QuadPX ASCR w/Neu Ca					128.87	3799.07	780.97	1197.52	0.00	5777.56	
	0.20	MLF	EELEJ	0.04	26	957	197	302	0	1,455	7275.57
B MIL EL <16121 1308 > 3PH Sec Ckt Tap @ Pole Mtd Xfmr					8.00	252.21	1.16	77.55	0.00	330.92	
	1.00	EA	EELEB	0.31	8	318	1	98	0	417	416.72
B MIL EL <16121 1308 > 3PH Service Entrance Connection					8.00	252.21	1.16	77.55	0.00	330.92	
	1.00	EA	EELEB	0.31	8	318	1	98	0	417	416.72
MIL EL <16413 4301 > Neutral Support					0.52	15.35	3.16	5.30	0.00	23.81	
	2.00	EA	EELEJ	9.60	1	39	8	13	0	60	29.98
MIL EL <16120 9123 > #2 AWG Al TriPX ASCR w/Neu Cable					100.00	2948.08	606.03	881.39	0.00	4435.50	
	0.20	MLF	EELEJ	0.05	20	742	153	222	0	1,117	5585.54
B MIL EL <16121 1308 > 1PH Sec Ckt Tap @ Pole					8.00	252.21	1.16	77.55	0.00	330.92	
	1.00	EA	EELEB	0.31	8	318	1	98	0	417	416.72
B MIL EL <16121 1308 > 1PH Service Entrance Connection					5.00	157.64	0.73	16.09	0.00	174.46	
	1.00	EA	EELEB	0.50	5	199	1	20	0	220	219.69
MIL EL <16413 4301 > Neutral Clevis					0.52	15.35	3.16	5.30	0.00	23.81	
	2.00	EA	EELEJ	9.60	1	39	8	13	0	60	29.98
TOTAL SITE ELECTRICAL - UPGRADE	1.00	EA			77	2,928	371	864	0	4,162	4162.01
10.010.010.010.012.06. Removal											
USR EL <16990 2203 > Pump Station Electrical Removal					48.50	1414.17	0.00	0.00	0.00	1414.17	
	1.00	EA	EELEG	0.12	49	1,781	0	0	0	1,781	1780.84

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL Removal	1.00	EA			49	1,781	0	0	0	1,781	1780.84
TOTAL PUMP PLANT #12 - ELEC UPGRADE	1.00	EA			257	9,810	411	11,898	0	22,120	22119.50
10.010.010.010.013. PUMP PLANT #13 - ELEC UPGRADE											
NO ELECTRICAL WORKED REQUIRED FOR PUMP PLANT NO. 13.											
TOTAL PUMP PLANT #13 - ELEC UPGRADE	1.00	EA			0	0	0	0	0	0	0.00
10.010.010.010.014. SLUICE GATE #2 - ELEC UPGRADE											
10.010.010.010.014.01. GATE #2 - MOTOR OPERATOR											
MIL EL <16111 1111 > RGS 3/4" Conduit w/Coupling					0.06	1.85	0.01	1.03	0.00	2.89	
Mtd Exposed on Flat Wall,10' Hgt	50.00	LF	EELEF	73.80	3	116	1	65	0	182	3.64
MIL EL <16111 1112 > RGS 3/4" Elbow					0.39	11.38	0.06	5.56	0.00	16.99	
Mtd Exposed on Flat Wall,10' Hgt	3.00	EA	EELEF	12.00	1	43	0	21	0	64	21.40
MIL EL <16111 1113 > RGS 3/4" Bushing Set w/Locknuts					0.34	9.89	0.05	0.50	0.00	10.45	
Mtd Exposed on Flat Wall,10' Hgt	1.00	EA	EELEF	13.80	0	12	0	1	0	13	13.15
MIL EL <16111 1114 > RGS 3/4" Type LL Or LR 2 Hub					0.78	22.75	0.12	10.31	0.00	33.18	
Mtd Exposed on Flat Wall,10' Hgt	4.00	EA	EELEF	6.00	3	115	1	52	0	167	41.78
MIL EL <16120 1301 > #10 AWG Cable-Type USE					15.53	455.05	2.36	259.05	0.00	716.46	
Underground Feeder & Branch Ckts	0.20	MLF	EELEF	0.30	3	115	1	65	0	180	902.22
M MIL EL <16151 2007 > 5 HP AC Motor Three Ph, 230 V					1.94	61.29	0.28	26.50	0.00	88.07	
Motor/Eqpt,Conn,Term & Rot Tstg	1.00	EA	EELEB	1.29	2	77	0	33	0	111	110.90
MIL EL <16152 1007 > 5 HP Motor Mounting					3.09	97.61	0.45	0.00	0.00	98.05	
	1.00	EA	EELEB	0.81	3	123	1	0	0	123	123.48
M MIL EL <16155 4122 > Comb Str,Sz 1,NEMA 3R w/Ckt Bkr					8.33	263.54	1.20	869.20	0.00	1133.94	
Reversing,240V,3P	1.00	EA	EELEB	0.30	8	332	2	1,095	0	1,428	1427.95
MIL EL <16170 2111 > 240V NEMA 3R HD Disc Sw,30A, 3P					3.70	117.13	0.54	57.11	0.00	174.78	
	1.00	EA	EELEB	0.68	4	147	1	72	0	220	220.09
B MIL EL <16471 1306 > Panelboard Motor Ckt Hookup					2.00	63.35	0.29	0.00	0.00	63.64	
	1.00	EA	EELEB	1.25	2	80	0	0	0	80	80.14
B USR EL <16152 1007 > Sluice Gate Operator for Gate #2					16.00	471.43	2.43	3710.00	0.00	4183.86	
	1.00	EA	EELEF	0.29	16	594	3	4,672	0	5,269	5268.65

10.010. PADUCAH PUMP PLANT ELEC UPGRADE	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL GATE #2 - MOTOR OPERATOR	1.00	EA			46	1,754	9	6,075	0	7,838	7838.13
TOTAL SLUICE GATE #2 - ELEC UPGRADE	1.00	EA			46	1,754	9	6,075	0	7,838	7838.13
TOTAL PADUCAH PUMP PLANT ELEC UPGRADE	1.00	EA			3,189	121,841	4,502	240,631	0	366,974	366974.03
TOTAL PADUCAH PUMP PLANT ELEC UPGRADE	1.00	EA			3,189	121,841	4,502	240,631	0	366,974	366974.03
TOTAL PADUCAH PUMP PLANT ELEC UPGRADE	1.00	EA			3,189	121,841	4,502	240,631	0	366,974	366974.03

15. AA. Manhole Grating	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15. PADUCAH PUMP PLANT MECH UPGRADE											
15. AA. Manhole Grating											
M CIV ME <05501 4003 > 1/2"x7"SS L Concrete Anchor					0.54	15.79	0.00	3.01	0.00	18.80	
Incl Drilling,Matl,Installation	144.00	EA	USKCD	4.63	78	2,969	0	566	0	3,535	24.55
CIV ME <05501 5001 > 3/4"x9-1/2"(24.1cm)Chemical Anch					0.63	18.25	0.00	4.56	0.00	22.81	
w/Rod & Epoxy Cartridge	144.00	EA	USKCD	4.00	90	3,432	0	858	0	4,290	29.79
MIL ME <05530 2203 > 1-1/4"x 1/8"Galv Steel Grating					0.04	1.99	0.05	5.70	0.00	7.75	
Welded Steel,6.3 #/SF(2 Oz /SF)	180.00	SF	SIWSC	93.75	8	468	13	1,340	0	1,821	10.12
MIL ME <05530 3001 > Add Strt Cutting Wld Stl Grating					0.00	0.00	0.00	1.17	0.00	1.17	
Include in Matl Costs Per LF	96.00	LF	N/A	0.00	0	0	0	147	0	147	1.53
MIL ME <05530 3003 > Add Strt Banding Wld Stl Grating					0.00	0.00	0.00	1.68	0.00	1.68	
Include in Matl Costs Per LF	192.00	LF	N/A	0.00	0	0	0	421	0	421	2.19
L CIV ME <05560 1001 > Torch Cutting,Bolts 1/2"Th					0.06	2.80	0.08	0.02	0.00	2.90	
	144.00	EA	SIWSC	66.67	9	527	15	4	0	546	3.79
USR ME <05560 3001 > Drilling 1/2" Hole in Concrete					0.00	4.23	0.14	0.00	0.00	4.37	
	144.00	EA		0.00	0	795	26	0	0	822	5.71
MIL ME <15094 9019 > 3"x3"x3/8" Angle Iron SS					0.32	10.66	0.53	17.68	0.00	28.87	
	192.00	LF	MSPFZ	7.14	61	2,673	133	4,433	0	7,239	37.70
M MIL ME <05120 1201 > Demo Steel Grate and Suport					20.00	967.20	0.00	0.00	0.00	967.20	
	1.20	TON	SIWSB	0.13	24	1,516	0	0	0	1,516	1263.03
MIL ME < > CRANE,HYD,S/P,RT,4WD, 9T/44'BOOM					0.00	0.00	21.73	0.00	0.00	21.73	
	96.00	HR	C75BD002	0.00	0	0	2,724	0	0	2,724	28.38
MIL ME < > Outside Equip. Op. Heavy					1.00	43.28	0.00	0.00	0.00	43.28	
	96.00	HR	X-EQOPRHVY	0.00	96	5,426	0	0	0	5,426	56.52
TOTAL Manhole Grating	12.00	EA			366	17,805	2,911	7,769	0	28,486	2373.80

15. BB. Vortex Supressor in PS 1	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15. BB. Vortex Supressor in PS 1											
M MIL ME <05120 2401 > Misc Galv Shapes, Steel Feild					50.00	2417.99	0.00	1425.73	0.00	3843.72	
A-36 Structural Steel	1.92	TON	SIWSB	0.05	96	6,062	0	3,575	0	9,637	5019.35
B MIL ME <05120 2402 > Misc Galv Shapes, Steel Bar Shop					7.10	343.08	0.00	2327.87	0.00	2670.95	
A-36 Structural Steel	3.26	TON	SIWSB	0.35	23	1,461	0	9,910	0	11,370	3487.87
L CIV ME <05120 2731 > 3/16"Horz Fillet Welds,Welded Up					0.04	2.12	0.08	0.14	0.00	2.34	
Based on Std Oper Factor of 50% for Shop Execution	726.00	LF	SIWWA	26.69	29	2,010	76	131	0	2,216	3.05
M CIV ME <05501 4004 > 3/4"x5-3/4"(14.6cm)L Conc Anchor					0.56	16.22	0.00	2.10	0.00	18.32	
Incl Drilling,Matl,Installation	64.00	EA	USKCD	4.50	36	1,356	0	175	0	1,531	23.92
CIV ME <05501 5001 > 3/4"x9-1/2"(24.1cm)Chemical Anch					0.63	18.25	0.00	4.56	0.00	22.81	
w/Rod & Epoxy Cartridge	64.00	EA	USKCD	4.00	40	1,525	0	381	0	1,906	29.79
B CIV ME <05504 1007 > 3/4" Dia x 4"Long Hex Bolts Galv					0.03	1.40	0.00	1.46	0.00	2.86	
A325 HS Strl Bolt w/Hvy Hex Nut Shop Installed	120.00	EA	SIWSA	43.18	4	219	0	229	0	449	3.74
USR ME <05560 3001 > Drilling 1/2" Hole in Concrete					0.00	4.23	0.14	0.00	0.00	4.37	
	64.00	EA		0.00	0	354	12	0	0	365	5.71
USR ME <05560 3005 > Drilling 1/2" Hole in Steel Shop					0.00	1.33	0.15	0.00	0.00	1.48	
	120.00	EA		0.00	0	208	24	0	0	232	1.93
CIV ME <09940 1162 > Zinc Rich Epoxy Paint, B-303b					0.00	0.00	0.00	0.18	0.00	0.18	
Per Avg 1 Mil Thickness	300.00	SF	N/A	0.00	0	0	0	71	0	71	0.24
CIV ME <09940 1224 > NearWhite Blast-Tight Mill Scale					0.02	0.75	0.11	0.29	0.00	1.15	
Little Rust 6.9 #/SF=896 #/HR	200.00	SF	APTSD	130.00	5	196	29	75	0	300	1.50
CIV ME <09940 1316 > Paint,Strl Steel,Spray Med Size					0.00	0.12	0.00	0.00	0.00	0.12	
One Coat-Application Only	200.00	SF	APTSA	350.00	1	31	0	0	0	31	0.16
TOTAL Vortex Supressor in PS 1	12.00	EA			233	13,422	140	14,546	0	28,109	2342.38

15. CC. Pump Station Grating	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15. CC. Pump Station Grating											
M CIV ME <05501 4003 > 1/2"x7"SS L Concrete Anchor					0.54	15.79	0.00	3.01	0.00	18.80	
Incl Drilling,Matl,Installation	72.00	EA	USKCD	4.63	39	1,485	0	283	0	1,768	24.55
CIV ME <05501 5001 > 3/4"x9-1/2"(24.1cm)Chemical Anch					0.63	18.25	0.00	4.56	0.00	22.81	
w/Rod & Epoxy Cartridge	72.00	EA	USKCD	4.00	45	1,716	0	429	0	2,145	29.79
MIL ME <05530 2203 > 1-1/4"x 1/8"Galv Steel Grating					0.04	1.99	0.05	5.70	0.00	7.75	
Welded Steel,6.3 #/SF(2 Oz /SF)	665.00	SF	SIWSC	93.75	29	1,728	47	4,952	0	6,727	10.12
MIL ME <05530 3001 > Add Strt Cutting Wld Stl Grating					0.00	0.00	0.00	1.17	0.00	1.17	
Include in Matl Costs Per LF	120.00	LF	N/A	0.00	0	0	0	184	0	184	1.53
MIL ME <05530 3003 > Add Strt Banding Wld Stl Grating					0.00	0.00	0.00	1.68	0.00	1.68	
Include in Matl Costs Per LF	276.00	LF	N/A	0.00	0	0	0	606	0	606	2.19
L CIV ME <05560 1001 > Torch Cutting,Bolts 1/2"Th					0.06	2.80	0.08	0.02	0.00	2.90	
	72.00	EA	SIWSC	66.67	4	263	8	2	0	273	3.79
USR ME <05560 3001 > Drilling 1/2" Hole in Concrete					0.00	4.23	0.14	0.00	0.00	4.37	
	72.00	EA		0.00	0	398	13	0	0	411	5.71
MIL ME <15094 9019 > 3"x3"x3/8" Angle Iron SS					0.32	10.66	0.53	17.68	0.00	28.87	
	16.00	LF	MSPFZ	7.14	5	223	11	369	0	603	37.70
M MIL ME <05120 1201 > Demo Steel Grate and Suport					20.00	967.20	0.00	0.00	0.00	967.20	
	1.00	TON	SIWSB	0.13	20	1,263	0	0	0	1,263	1263.03
MIL ME < > CRANE,HYD,S/P,RT,4WD, 9T/44'BOOM					0.00	0.00	21.73	0.00	0.00	21.73	
	40.00	HR	C75BD002	0.00	0	0	1,135	0	0	1,135	28.38
MIL ME < > Outside Equip. Op. Heavy					1.00	43.28	0.00	0.00	0.00	43.28	
	40.00	HR	X-EQOPRHVY	0.00	40	2,261	0	0	0	2,261	56.52
TOTAL Pump Station Grating	1.00	EA			182	9,336	1,214	6,825	0	17,375	17374.59

15. DD. Pump Repair	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15. DD. Pump Repair Based on Design conditions of replacing shafts and bearings in 7 pumps.											
USR ME <05651 00001> Machine Pump Shafts Small Pumps					0.00	6122.00	0.00	5303.18	0.00	11425.18	
Assume new shafts from stainless steel and require new drawings to be preped	12.00	EA		0.00	0	95,933	0	83,102	0	179,036	14919.65
USR ME <05651 00002> Rebuild Bearing Sets Small Pumps					0.00	4377.00	650.00	1436.30	0.00	6463.30	
Assume new bearings and the inplace assembly and test of new ssytem	12.00	EA		0.00	0	68,589	10,186	22,507	0	101,282	8440.15
MIL ME < > CRANE,HYD,S/P,RT,4WD, 9T/44'BOOM					0.00	0.00	21.73	0.00	0.00	21.73	
	150.00	HR	C75BD002	0.00	0	0	4,256	0	0	4,256	28.38
MIL ME < > Outside Equip. Op. Heavy					1.00	43.28	0.00	0.00	0.00	43.28	
	150.00	HR	X-EQOPRHVY	0.00	150	8,478	0	0	0	8,478	56.52
MIL ME <14302 1014 > Indus Hoists,HD30,000# Capacity,					11.46	408.31	0.00	5748.54	0.00	6156.85	
(13608Kg)	1.00	EA	ESELB	0.36	11	533	0	7,507	0	8,040	8039.97
USR ME <05651 00002> Machine Pump Shafts Large Pumps					0.00	12103.00	0.00	9880.26	0.00	21983.26	
	3.00	EA		0.00	0	47,414	0	38,707	0	86,121	28707.00
USR ME <05651 00004> Rebuild Bearing Sets Large Pumps					0.00	8303.00	950.00	4569.66	0.00	13822.66	
	3.00	EA		0.00	0	32,528	3,722	17,902	0	54,151	18050.42
USR ME <05651 00006> New Cast Impellers Large Pumps					0.00	5321.00	750.00	23778.98	0.00	29849.98	
	2.00	EA		0.00	0	13,897	1,959	62,104	0	77,960	38979.81
USR ME <05651 00008> Balance and Refinish Impellers					0.00	8633.00	650.00	2483.58	0.00	11766.58	
	15.00	EA		0.00	0	169,102	12,732	48,648	0	230,482	15365.47
TOTAL Pump Repair	1.00	EA			161	436,474	32,855	280,477	0	749,806	749805.66

15. FF. Pipe Repair	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
15. FF. Pipe Repair											
B MIL ME <02221 1503 > Trench,1-1/2 CY Hyd Exc and Plae					0.11	5.61	4.84	23.32	0.00	33.77	
136 CY/Hr (104M3)/Hr Cost is for excaavting around pipes in place and backfilling with clay around new placement.	30.00	CY	CODES	12.36	3	220	190	914	0	1,323	44.10
MIL ME <02221 2304 > Trench, Hand Exc, Heavy Clay					2.08	60.70	0.00	0.00	0.00	60.70	
2'-6' Dp, Piled Only	12.00	CY	ULABA	0.63	25	951	0	0	0	951	79.26
AF ME <02227 3001 > Compaction by Vibratory Plate					0.08	2.24	0.13	0.00	0.00	2.37	
8" Lifts	30.00	CY	CLACE	16.25	2	88	5	0	0	93	3.10
MIL ME <02231 2101 > Soil Density Test,Nuclear Method					1.25	36.50	0.00	0.00	0.00	36.50	
ASTM D2922-71	4.00	EA	USKCB	2.00	5	191	0	0	0	191	47.67
MIL ME <02231 2301 > Moisture Density, Rel of Soils					2.50	73.01	0.00	0.00	0.00	73.01	
ASTM D1557-70	4.00	EA	USKCA	0.50	10	381	0	0	0	381	95.34
CIV ME <02456 1201 > 12"(31cm) Dia Uncoat Steel Pipe					0.42	15.21	4.92	22.58	0.00	42.71	
5/16" Wall Thickness, PE, Welded	50.00	LF	XXPLC	26.25	21	993	321	1,475	0	2,789	55.77
CIV ME <02456 1214 > 30"(76cm) Dia Uncoat Steel Pipe					0.73	26.62	8.61	89.01	0.00	124.24	
7/16" Wall Thickness, PE, Welded	50.00	LF	XXPLC	15.00	37	1,738	562	5,812	0	8,112	162.23
CIV ME <02456 1222 > 48"(122cm) Dia Uncoat Steel Pipe					1.10	39.92	12.91	188.03	0.00	240.86	
7/16" Wall Thickness, PE, Welded	100.00	LF	XXPLC	10.00	110	5,214	1,686	24,554	0	31,453	314.53
CIV ME <02456 1226 > 60"(152cm) Dia Uncoat Steel Pipe					1.47	53.23	17.21	242.45	0.00	312.90	
1/2" Wall Thickness, PE, Welded	100.00	LF	XXPLC	7.50	147	6,951	2,248	31,661	0	40,860	408.60
CIV ME <02456 1304 > 60"(152cm) Dia Uncoat Steel Pipe					1.47	53.23	17.21	301.80	0.00	372.24	
5/8" Wall Thickness, PE, Welded	100.00	LF	XXPLC	7.50	147	6,951	2,248	39,410	0	48,609	486.09
CIV ME <02456 5007 > 12"(31cm) Dia Dresser Coupling					3.75	125.82	16.08	339.95	0.00	481.84	
For Plain End Welded Steel Pipe	2.00	EA	XXPLB	2.00	8	329	42	888	0	1,258	629.22
CIV ME <02456 5012 > 20"(51cm) Dia Dresser Coupling					5.00	167.76	21.44	471.34	0.00	660.54	
For Plain End Welded Steel Pipe	3.00	EA	XXPLB	1.50	15	657	84	1,847	0	2,588	862.57
CIV ME <02456 5015 > 30"(76cm) Dia Dresser Coupling					6.00	201.31	25.72	857.92	0.00	1084.95	
For Plain End Welded Steel Pipe	6.00	EA	XXPLB	1.25	36	1,577	202	6,722	0	8,501	1416.79
CIV ME <02456 5016 > 36"(91cm) Dia Dresser Coupling					6.00	201.31	25.72	1032.55	0.00	1259.58	
For Plain End Welded Steel Pipe	3.00	EA	XXPLB	1.25	18	789	101	4,045	0	4,935	1644.84
CIV ME <02456 5017 > 42"(106cm) Dia Dresser Coupling					7.50	251.64	32.15	1219.05	0.00	1502.85	
For Plain End Welded Steel Pipe	3.00	EA	XXPLB	1.00	23	986	126	4,776	0	5,888	1962.50

15. FF. Pipe Repair	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
CIV ME <02456 5018 > 48"(122cm) Dia Dresser Coupling					7.50	251.64	32.15	1415.73	0.00	1699.52	
For Plain End Welded Steel Pipe	4.00	EA	XXPLB	1.00	30	1,314	168	7,395	0	8,877	2219.33
CIV ME <02456 5021 > 60"(152cm) Dia Dresser Coupling					10.00	335.52	42.87	1685.32	0.00	2063.71	
For Plain End Welded Steel Pipe	4.00	EA	XXPLB	0.75	40	1,753	224	8,803	0	10,780	2694.90
CIV ME <09940 1163 > Coal Tar Base Paint, Mil-C-18480					0.00	0.00	0.00	0.18	0.00	0.18	
Per Avg 1 Mil Thickness	9000.00	SF	N/A	0.00	0	0	0	2,118	0	2,118	0.24
CIV ME <09940 1161 > Coal Tar Epoxy Paint, C-200a					0.00	0.00	0.00	0.15	0.00	0.15	
Per Avg 1 Mil Thickness	18000	SF	N/A	0.00	0	0	0	3,488	0	3,488	0.19
CIV ME <09940 1214 > Metal Prep Work,Pressure Washing					0.00	0.08	0.00	0.00	0.00	0.08	
2800-6000 SF/Day	9000.00	SF	APTSA	550.00	18	917	0	0	0	917	0.10
CIV ME <09940 1226 > Near White Blast-Badly Pitted					0.04	1.22	0.18	0.46	0.00	1.86	
Rust Nodules 11.3 #/SF=904 #/HR	9000.00	SF	APTSD	80.00	360	14,338	2,115	5,357	0	21,811	2.42
MIL ME < > CRANE,HYD,S/P,RT,4WD, 9T/44'BOOM					0.00	0.00	21.73	0.00	0.00	21.73	
	400.00	HR	C75BD002	0.00	0	0	11,351	0	0	11,351	28.38
MIL ME < > Outside Equip. Op. Heavy					1.00	43.28	0.00	0.00	0.00	43.28	
	400.00	HR	X-EQOPRHVY	0.00	400	22,607	0	0	0	22,607	56.52
TOTAL Pipe Repair	1.00	EA			1,454	68,944	21,671	149,264	0	239,879	239879.32
TOTAL PADUCAH PUMP PLANT MECH UPGRADE	1.00	EA			2,396	545,982	58,791	458,881	0	1,063,654	1063654
TOTAL PADUCAH FLOOD PROTECTION UPGRADE	1.00	EA			7,658	743,476	80,255	852,849	980,156	2,656,736	2656736

** PROJECT SETTINGS **

ESTIMATE TYPE : K-Crews with Reprice Key

SALES TAX : 6.00%

DATE OF ESCALATION SCHEDULE : 09/01/99

PROJECT DIRECT COST COLUMNS

Col Type	H	L	E	M	U
Rep Width	8	9	9	9	8
Title	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER

PROJECT INDIRECT COST COLUMNS

Col Type	O	U	P	B	X
Rep Width	12	12	12	12	0
Title	OVERHEAD	HOME OFC	PROFIT	BOND	(Unused)

PROJECT OWNER COST COLUMNS

Col Type	E	C	U	X	X
Rep Width	12	12	12	0	0
Title	ESCALATN	CONTINGN	SIOH	(Unused)	(Unused)

PROJECT BREAKDOWN

PROJECT ID	Length	Trail Sep	Level Title	2nd View Order
Level 1 ID :	2	.	Scope	1
Level 2 ID :	3	.	Facility	2
Level 3 ID :	3	.	System	3
Level 4 ID :	3	.	Subsystm	0
Level 5 ID :	3	.	Assm Cat	0
Level 6 ID :	2	.	Assembly	0

Owner Cost Level : 2

** PROJECT SETTINGS **

2ND VIEW COLUMNS

Quantity Column Width : 10

Col Type	X	X	X	X	X
Rep Width	0	0	0	0	0
Title	(Unused)	(Unused)	(Unused)	(Unused)	(Unused)
Shadow	X	X	X	X	X

DETAIL REPORT FORMATTING

PAGE OPTIONS
Page Break Levels : 2
Table of Contents Levels : 2

		0	1	2	3	4	5	6	7
ROW OPTIONS	Print Titles at Levels :		Y	Y	N	Y	Y	Y	
	Print Totals at Levels :		Y	Y	N	Y	Y	Y	
	Print Notes at Levels :	Y	Y	Y	Y	Y	Y	Y	Y
	Print Unit Cost Row :	Y							
	Print Page Footer :	Y							
	Show Cost Codes :	Y							
COLUMNS OPTIONS	Print Crew Id :	Y							
	Crew Output :	Y							
	Unit Cost :	Y							
UPB TITLES	No. of Levels to Print :	0							
	Bracket Titles With :	N	N						
	Include titles Notes :	N							

** PROJECT SETTINGS **

OTHER REPORT FORMATTING

COLUMN TITLES FOR SUMMARY REPORTS

Column 1 OVERHEAD : OVERHEAD
Column 2 HOME OFC : HOME OFC
Column 3 PROFIT : PROFIT
Column 4 BOND : BOND
Column 5 (Unused) : (Unused)

Column 1 ESCALATN : OTHER
Column 2 CONTINGN : CONTINGENCIES
Column 3 SIOH : OWN FURN
Column 4 (Unused) :
Column 5 (Unused) : SIOH

STANDARD COLUMN WIDTHS

Quantity Columns : 10
Total cost Columns : 12
Unit Cost Columns : 10

SUMMARY FEATURES

Round Totals Column : N-None
Contingency Notes : No
Show Project Totals : Yes

SPECIAL REPORT FORMATTING OPTIONS

First Alternate ID : (None)
Show Markup at Level : 0
Display Indirect/Owner Markup as : A - Unit Costs Only
CSI Sort at Level : (None)

1204

** PROJECT SETTINGS **

REPORT SELECTION

Project Settings : Y Profit Guidelines : Y
Contractor Settings : N
Link Listing : N Measurement Units : U.S.

	REPORT FORMAT TYPE			FOR LEVEL (S)						
	Direct	Indirect	Owner	0	1	2	3	4	5	6
Detail :	Y									
Project :	N	Y	N		N	N	N	N	N	Y
Contractor :	N	N		N	N	N	N	N	N	N
Division :	N	N	N	N	N	N	N	N	N	N
System :	N	N	N	N	N	N	N	N	N	N
2nd View :	N									
Crew :	N			N	N	N	N	N	N	N
Labor :	N									
Equipment :	N									
Prime Labor Cost Level :	N									

** OWNER, OVERTIME, AND ADJUSTMENTS SETTINGS **

		AMOUNT	PERCENT	*ESCALATN DATE* BEGIN	END	*ESCALATN INDEX* BEGIN	END
02. 02 PADUCAH LEVEE UPGRADE							
	OTHER	P	0.00				
	CONTINGENCIES	P	25.00				
	OWN FURN	P	0.00				
03. 03 FLOODWALL UPGRADE							
	OTHER	P	0.00				
	CONTINGENCIES	P	0.00				
	OWN FURN	P	0.00				
10.010 PADUCAH PUMP PLANT ELEC UPGRADE							
	OTHER	P	0.00				
	CONTINGENCIES	P	25.00				
	OWN FURN	P	0.00				
15. AA Manhole Grating							
	OTHER	P	0.00				
	CONTINGENCIES	P	25.00				
	OWN FURN	P	0.00				
15. BB Vortex Supressor in PS 1							
	OTHER	P	0.00				
	CONTINGENCIES	P	25.00				
	OWN FURN	P	0.00				
15. CC Pump Station Grating							
	OTHER	P	0.00				
	CONTINGENCIES	P	25.00				
	OWN FURN	P	0.00				
15. DD Pump Repair							
	OTHER	P	0.00				
	CONTINGENCIES	P	25.00				
	OWN FURN	P	0.00				
15. FF Pipe Repair							
	OTHER	P	0.00				
	CONTINGENCIES	P	25.00				
	OWN FURN	P	0.00				

Reconnaissance Level Structural Evaluation Condition Analysis of the Flood Protection System

Volume 2

City of Paducah, Kentucky

Submitted By:
Parsons Harland Bartholomew & Associates, Inc.

US Army Corps of Engineers
Louisville District
September 1999

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TABLE OF CONTENTS

Page

Table of Contents i

List of Figures ii

1.0 INTRODUCTION 1

2.0 PURPOSE OF STUDY 1

3.0 PROJECT LOCATION 2

4.0 FIELD INSPECTION CONDITION ANALYSIS 4

4.1 Floodwall Segments 4

4.2 Closure Structures 8

4.3 Storage Vaults for Closure Structures 22

4.4 Pump Stations 26

4.5 Earthen Levees 29

4.6 Gated Outlets 31

5.0 RECOMMENDATIONS 33

6.0 PROJECT COSTS 35

7.0 CONCLUSION 35

Appendix A Construction Cost Estimates A-1

Appendix B Site Photographs B-1

Appendix C Field Evaluation Forms C-1

LIST OF FIGURES

Page

Figure 1 Location Map 2

Figure 2 Flood Protection System Alignment 3

STRUCTURAL EVALUATION - CONDITION ANALYSIS

Paducah, Kentucky Flood Protection System

1.0 Introduction

The Paducah Flood Protection System was constructed approximately 50 years ago after several major floods severely damaged the City of Paducah. The Flood Protection System is comprised of approximately ten miles of earthen levee, three miles of concrete floodwall and thirteen pump stations. This flood protection system is currently maintained and operated by City personnel.

Between May 5 and May 11, 1999, a reconnaissance level field inspection was performed to develop a structural evaluation and condition analysis of the components of the Paducah, Kentucky Flood Protection System. A visual and tactile inspection was performed to determine the structural soundness of the floodwall/levee and the accompanying structures. The Paducah Flood Protection System is comprised of concrete floodwalls, closure structures, storage vaults for closure structures, pump stations, earthen levees and gated outlets. Approximately three miles of the flood protection system was inspected for this report. This segment of the flood protection system is identified as Section B.

This report summarizes the condition of the flood protection system by individual sections of the wall between the closure gates and significant service openings. The report also summarizes the condition of the pump stations located along the floodwall/levee system, the earthen levee sections between floodwall sections and the gated outlets.

The photographs in Appendix B should be viewed in conjunction with a reading of this report to further clarify the findings of this inspection.

2.0 Purpose of Study

The purpose of this study is to evaluate the condition of the various components of the flood protection system and to develop recommendations for repair, rehabilitation, or replacement of the flood protection system facilities. Cost estimates for recommended non-maintenance repairs are included in this report.

3.0 Project Location

Paducah, Kentucky is located in the northwestern part of the state, along the southern/western bank of the Ohio River. Section B on the flood protection system extends from approximately River Mile 932.5 to River Mile 935.5. Paducah has a population of approximately 27,300 and is located in McCracken County.

See Figures 1 and 2

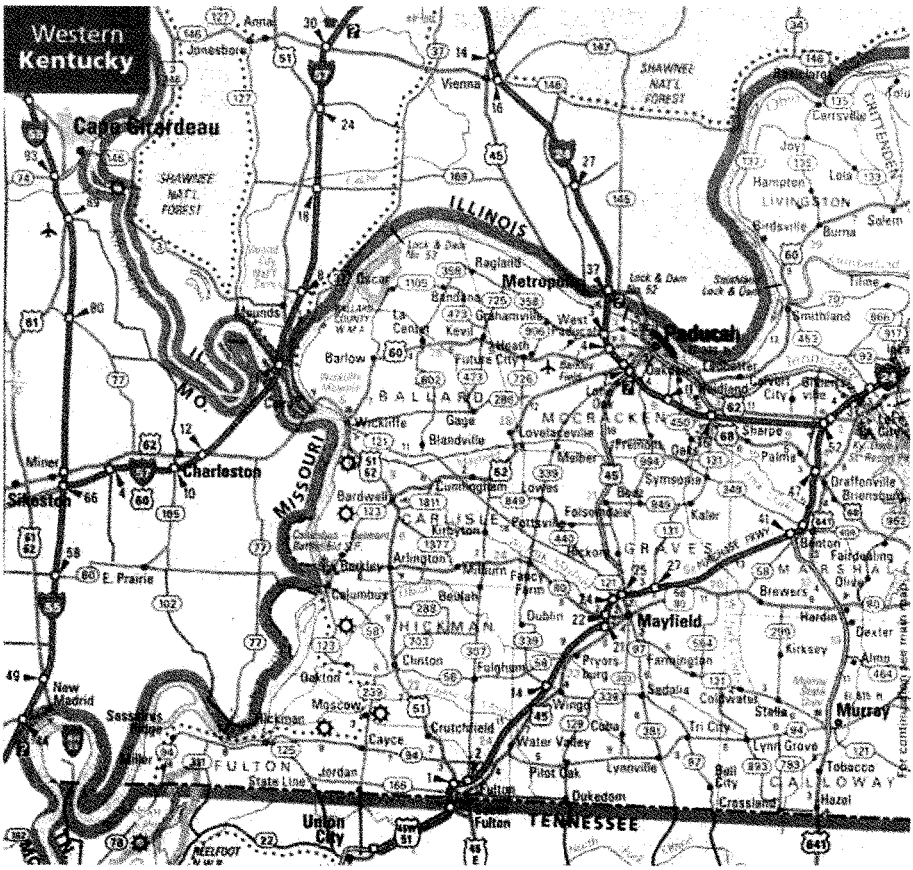

Figure 1

Figure 2

4.0 Field Inspection Condition Analysis

4.1 Floodwall Segments.

A field team of two structural engineers inspected both sides of the floodwall for the entire length of Section B. The objective of the inspection was to identify existing structural damages or maintenance repairs that would need to be addressed so that the floodwall can protect the City for another 50 years. The floodwall inspection findings are divided into segments between closure structures or major service openings and are as follows:

Floodwall Sta. 0+18 to 2+87:

Some sealant missing in construction joints. Existing sealant is old and cracking. There is no apparent horizontal, vertical or rotational movement of the wall. There is no significant deterioration of the wall that would compromise the integrity of the structure. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the wall. The floodwall appears to be in good repair.

Floodwall Sta. 2+87 to 5+34:

Some sealant missing in construction joints. Existing sealant is old and cracking. There is no apparent horizontal, vertical or rotational movement of the wall. There is no significant deterioration of the wall that would compromise the integrity of the structure. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the wall. A portion of this wall (Sta. 3+20 to 4+00) was originally cast against a brick structure. The brick structure has since been removed, but there are 1" diameter anchor holes approximately 8" deep, spaced about 2.5' on center and 1.5' from the ground line. The floodwall appears to be in good repair.

Floodwall Sta. 5+34 to 9+44:

Some sealant missing in construction joints. Existing sealant is old and cracking. There is no apparent horizontal, vertical or rotational movement of the wall. There is no significant deterioration of the wall that would compromise the integrity of the structure. The wall right-of-way appears to be clear of any

permanent structures or growth that would hinder access to the wall or compromise the integrity of the wall. The floodwall appears to be in good repair.

Floodwall Sta. 9+44 to 10+40:

Some sealant missing in construction joints. Existing sealant is old and cracking. There is no apparent horizontal or vertical movement of the wall. There is no significant deterioration of the wall that would compromise the integrity of the structure. A section of wall at station 10+20 appears to have rotated 1 ½" towards the river. This same section of wall shows some minor cracking at the ground line. This section of wall has been rubbed with a grout finish. Conversations with Gary Thompson, Paducah City Floodwall Superintendent, indicate that repairs were made to that section of wall, and that it was then rubbed with the grout finish. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the wall. The floodwall appears to be in good repair.

Floodwall Sta. 10+40 to 16+53:

Some sealant missing in construction joints. Existing sealant is old and cracking. There is no apparent horizontal or vertical movement of the wall. There is no significant deterioration of the wall that would compromise the integrity of the structure. There are various rotational movements from station 10+40 to 16+53. These movements are minor, equal to or less than 1", but visible. The wall has rubbed with the grout finish, indicating that repairs have been made to wall in the past. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the wall. The floodwall appears to be in good repair.

Floodwall Sta. 21+86 to 26+90:

Some sealant missing in construction joints. Existing sealant is old and cracking. There is no apparent horizontal, vertical or rotational movement of the wall. There is one section of wall at station 21+86 that has rotated approximately 2 ½" towards the river. This section has some minor cracking at the ground line and has been rubbed with the grout finish indicating past repairs. There is no significant deterioration of the wall that would

compromise the integrity of the structure. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the wall. The floodwall appears to be in good repair.

Floodwall Sta. 26+90 to 31+01:

Some sealant missing in construction joints. Existing sealant is old and cracking. There is no apparent horizontal, vertical or rotational movement of the wall. There is no significant deterioration of the wall that would compromise the integrity of the structure. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the wall. The floodwall appears to be in good repair.

Floodwall Sta. 31+01 to 38+02:

Some sealant missing in construction joints. Existing sealant is old and cracking. There is no apparent horizontal, vertical or rotational movement of the wall. There is no significant deterioration of the wall that would compromise the integrity of the structure. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the wall. The floodwall appears to be in good repair.

Floodwall Sta. 51+00 to 71+74:

Some sealant missing in construction joints. Existing sealant is old and cracking. There is no apparent horizontal, vertical or rotational movement of the wall. There is no significant deterioration of the wall that would compromise the integrity of the structure. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the wall. The floodwall appears to be in good repair.

Floodwall Sta. 71+74 to 83+92:

Some sealant missing in construction joints. Existing sealant is old and cracking. There is no apparent horizontal, vertical or rotational movement of the wall. There is no significant deterioration of the wall that would compromise the integrity of the

structure. The wall right-of-way appears to be clear of any permanent that would hinder access to the wall or compromise the integrity of the wall. There is some moderately heavy growth at station 72+00, near Closure Structure No. 15. The floodwall appears to be in good repair.

Floodwall Sta. 83+92 to 108+53:

Some sealant missing in construction joints. Existing sealant is old and cracking. There is no apparent horizontal, vertical or rotational movement of the wall. There are some sections that have been rubbed with a grout finish, indicating past repairs, but no visible movement. There is no significant deterioration of the wall that would compromise the integrity of the structure. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the wall. There are various fences on the landside of the wall. The floodwall appears to be in good repair.

Floodwall Sta. 108+53 to 128+19:

Some sealant missing in construction joints. Existing sealant is old and cracking. There is no apparent horizontal, vertical or rotational movement of the wall. There is no significant deterioration of the wall that would compromise the integrity of the structure. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the wall. The floodwall appears to be in good repair.

Floodwall Sta. 128+19 to 149+87:

Some sealant missing in construction joints. Existing sealant is old and cracking. There is no apparent horizontal, vertical or rotational movement of the wall. There is no significant deterioration of the wall that would compromise the integrity of the structure. There are minor pop-outs with exposed reinforcing (see pictures). The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the wall. The floodwall appears to be in good repair.

Floodwall Sta. 149+87 to 170+38:

Some sealant missing in construction joints. Existing sealant is old and cracking. There is no apparent horizontal, vertical or rotational movement of the wall. Some minor separation at station 151+20 was observed. There is no significant deterioration of the wall that would compromise the integrity of the structure. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the wall. The floodwall appears to be in good repair.

4.2 Closure Structures

The structural engineers also inspected each of the closure structures to determine if any deficiencies exist. Items checked included the condition of the walls around the opening, the condition of the sills and troughs and the accessibility of the adjacent right-of-way on each side of the structure. Each structure is identified by number and flood protection system stationing.

Closure Structure No. 1-A (Sta. 2+87):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The paint on the sill angles is peeling, and the angles are rusting. The opening is in fair condition.

Closure Structure No. 1-B (Sta. 3+21):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The paint on the sill angles is peeling, and the angles are rusting. There is some pitting on the angles. The landside sill is covered with silt, and

there is debris around the opening. The opening is in fair condition.

Closure Structure No. 2 (Sta. 4+49):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are covered with silt, and there is standing water and debris around the opening. The condition of the seal trough and the sills is unknown. The opening is in fair condition.

Closure Structure No. 3 (Sta. 5+34):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are covered with silt and debris, and the condition of the seal trough and sills is unknown. The opening is in fair condition.

Closure Structure No. 4 (Sta. 9+44):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are covered with silt. The condition of the seal trough and the sills is unknown. The opening is in fair condition.

Closure Structure No. 4-A (Sta. 10+40):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the

wall or compromise the integrity of the opening. The sills have some debris and sand, and the seal trough is covered with a steel plate. The opening is in fair condition.

Closure Structure No. 4-B (Sta. 15+32):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are free of debris, and the embedded angles are painted and in good condition. The opening is in good condition.

Closure Structure No. 5 (Sta. 25+15):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills and the seal trough are covered with gravel and their condition is unknown. There is some minor patching of collision damage on the landside face of the opening. The patches are cracking and need to be repaired. The opening is in good condition.

Closure Structure No. 6 (Sta. 26+90):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills and the seal trough are partially covered with gravel and their condition appears to be good. The opening is in good condition.

Closure Structure No. 7 (Sta. 29+80):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the

opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills and the seal trough are covered with silt and their condition is unknown. The opening is in good condition.

Closure Structure No. 8 (Sta. 31+01):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills and the seal trough are covered with silt and their condition is unknown. The opening is in good condition.

Closure Structure No. 9 (Sta. 31+51):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills and the seal trough are covered with silt/gravel and their condition is unknown. The opening is in good condition.

Closure Structure No. 10 (Sta. 36+84):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills and the seal trough are covered with gravel and their condition is unknown. The opening is in good condition.

Closure Structure No. 11 (Sta. 51+87):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the

opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition, and the seal trough is filled in with bricks. The opening is in good condition.

Closure Structure No. 12 (Sta. 54+37):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition, and the seal trough is filled in with bricks. The opening is in good condition.

Closure Structure No. 13 (Sta. 62+84):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are covered with gravel and their condition is unknown. The opening is in good condition.

Closure Structure No. 14 (Sta. 69+64):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. There is some minor collision damage that has been patched and needs to be repaired again. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are covered with asphalt and their condition is unknown. The opening is in good condition.

Closure Structure No. 15 (Sta. 71+74):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant

deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are covered with silt and their condition is unknown. There is standing water around the opening and some heavy vegetation on the landside face of the floodwall. The opening is in fair condition.

Closure Structure No. 15-A (Sta. 73+31):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sill angles in fair condition, but need cleaning and painting. The opening is in good condition.

Closure Structure No. 16 (Sta. 75+85):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are covered with gravel and their condition is unknown. The opening is in good condition.

Closure Structure No. 16-A (Sta. 79+27):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sill angles are clean and painted. The opening is in good condition.

Closure Structure No. 17 (Sta. 83+92):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are covered with gravel and their condition is unknown. The opening is in good condition.

Closure Structure No. 18 (Sta. 90+41):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition, and the seal trough is filled with silt and debris. The opening is in good condition.

Closure Structure No. 19 (Sta. 91+96):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are covered with silt/sand and their condition is unknown. The opening is in good condition.

Closure Structure No. 20 (Sta. 93+57):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are covered with silt and their condition is unknown. The seal trough is filled with sand and bricks. The opening is in good condition.

Closure Structure No. 21 (Sta. 94+63):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are covered with silt and their condition is unknown. The opening is in good condition.

Closure Structure No. 22 (Sta. 98+88):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition. The seal trough is filled with sand and bricks. The opening is in good condition.

Closure Structure No. 23 (Sta. 103+63):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition. The seal trough is filled with silt. The opening is in good condition.

Closure Structure No. 24 (Sta. 106+10):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills and seal trough are covered with asphalt, and their condition is unknown. The opening is in good condition.

Closure Structure No. 25 (Sta. 108+53):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills and seal trough are covered with gravel and their condition is unknown. The opening is in good condition.

Closure Structure No. 26 (Sta. 114+98):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition. The seal trough is covered with a steel plate. The opening is in good condition.

Closure Structure No. 27 (Sta. 119+62):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition. The seal trough is covered with a steel plate. The opening is in good condition.

Closure Structure No. 27-A (Sta. 119+93):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in fair condition. The sill angles need cleaning and painting. The opening is in good condition.

Closure Structure No. 27-B (Sta. 123+50):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in fair condition. The sill angles need cleaning and painting. The opening is in good condition.

Closure Structure No. 28 (Sta. 123+80):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition. The seal trough is covered with a steel plate. The opening is in good condition.

Closure Structure No. 28-A (Sta. 124+10):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in fair condition. The sill angles need cleaning and painting. The opening is in good condition.

New Closure Structure between Structure Nos. 28 & 29 (Sta. 126+00±):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. There is some minor cracking at the base of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition. The opening is in good condition.

Closure Structure No. 29 (Sta. 128+19):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition. The seal trough is covered with a steel plate. The opening is in good condition.

Closure Structure No. 30 (Sta. 132+40):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition. There is some minor wearing of the sill edges. The seal trough is filled with bricks. The opening is in fair condition.

Closure Structure No. 31 (Sta. 135+22):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are covered with silt and there is standing water in the opening. The sill condition is unknown. The opening is in fair condition.

Closure Structure No. 31-A (Sta. 137+93):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in fair condition. The sill angles need cleaning and painting. The opening is in fair condition.

Closure Structure No. 32 (Sta. 138+22):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. There is some minor cracking at the base of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition. The seal trough is covered with a steel plate. The opening is in good condition.

Closure Structure No. 32-A (Sta. 138+54):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in fair condition. The sill angles need cleaning and painting. There is asphalt built up around the opening, which will hinder the closure of the opening. The opening is in fair condition.

Closure Structure No. 33 (Sta. 145+74):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. There is some minor cracking at the base of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition. The seal trough is covered with a steel plate. The opening is in good condition.

Closure Structure No. 33-A (Sta. 149+57):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no critical deterioration of the wall that would compromise the integrity of the opening. There is some minor cracking and leaching at the sill angles. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the

integrity of the opening. The sills are in fair condition. The sill angles need cleaning and painting. The opening is in fair condition.

Closure Structure No. 34 (Sta. 149+87):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. There is some minor cracking at the base of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition. The seal trough is covered with a steel plate. The opening is in good condition.

Closure Structure No. 34-A (Sta. 150+18):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in fair condition. The sill angles need cleaning and painting. The opening is in good condition.

Closure Structure No. 34-B (Sta. 156+96):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no critical deterioration of the wall that would compromise the integrity of the opening. There is some concrete deterioration at the sill angles. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in fair condition. The sill angles need cleaning and painting. The opening is in fair condition.

Closure Structure No. 35 (Sta. 157+26):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the

opening. There is some minor cracking at the base of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition. The seal trough is covered with a steel plate. The opening is in good condition.

Closure Structure No. 35-A (Sta. 157+57):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no critical deterioration of the wall that would compromise the integrity of the opening. There is some concrete deterioration at the sill angles. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in fair condition. The sill angles need cleaning and painting. The opening is in fair condition.

Closure Structure No. 36 (Sta. 161+53):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition. The seal trough is covered with a steel plate. The opening is in good condition.

Closure Structure No. 37 (Sta. 166+48):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills are in good condition. The seal trough is filled with gravel and silt. The opening is in good condition.

Closure Structure No. 38 (Sta. 170+04):

There is no apparent horizontal, vertical or rotational movement of the wall around the opening. There is no significant deterioration of the wall that would compromise the integrity of the opening. The wall right-of-way appears to be clear of any permanent structures or growth that would hinder access to the wall or compromise the integrity of the opening. The sills and seal trough are covered with silt/gravel and their condition is unknown. The opening is in good condition.

4.3 Storage Vaults for Closure Structures

Storage vaults are located adjacent to or near each closure structure for the storing of the gates and materials for the closure structures. The concrete walls and ceiling of each vault was inspected for cracking and leaching. The storage vaults are identified by the closure structure(s) that they serve and by flood protection system stationing.

Storage Vault for Closure Structure Nos. 1-A, 1-B, 2 & 3(Sta. 4+49):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings. There are large water puddles in the vault. These puddles appear to be caused by drainage under the doorway.

Storage Vault for Closure Structure No. 5 (Sta. 25+15):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 6 (Sta. 26+90):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure Nos. 7 & 8 (Sta. 29+80):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 9 (Sta. 31+51):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 10 (Sta. 36+84):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 11 (Sta. 51+87):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 12 (Sta. 54+37):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 13 (Sta. 62+84):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings. There are some puddles of water on the floor of the vault. There is gravel built up around the door outside of the vault. This condition is funneling water into the vault.

Storage Vault for Closure Structure No. 14 (Sta. 69+64):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 15 (Sta. 71+74):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings. There are some puddles of water on the floor of the vault, due to drainage under the doorway.

Storage Vault for Closure Structure No. 16 (Sta. 75+85):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 17 (Sta. 83+92):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 18 (Sta. 90+41):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 19 (Sta. 91+96):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure Nos. 20 & 21 (Sta. 94+63):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 22 (Sta. 98+88):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 23 (Sta. 103+63):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 24 (Sta. 106+10):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 25 (Sta. 108+53):

The concrete enclosure is in good structural condition. There is some minor cracking in the walls. There is no leaching to indicate drainage problems on the roof of the vault.
Storage Vault for Closure Structure No. 26 (Sta. 114+98):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 27 (Sta. 119+62):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 28 (Sta. 123+80):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 29 (Sta. 128+19):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 30 (Sta. 132+40):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 31 (Sta. 135+22):

The concrete enclosure is in good structural condition. There is some minor cracking in the interior walls of the vault. There is no observable leaching to indicate drainage problems on the roof of the vault.

Storage Vault for Closure Structure No. 32 (Sta. 138+22):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 33 (Sta. 145+74):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 34 (Sta. 149+87):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 35 (Sta. 157+26):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 36 (Sta. 161+53):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

Storage Vault for Closure Structure No. 37 (Sta. 166+48):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings. There is some water seepage under the doorway.

Storage Vault for Closure Structure No. 38 (Sta. 170+04):

The concrete enclosure is in good structural condition. No leaching or cracking was noted in the walls or ceilings.

4.4 Pump Stations

The exterior features of the pump stations along with the interior spaces not considered, "confined space areas", were inspected by the structural engineers. Items typically inspected on the pump stations were the interior and exterior wall surfaces, the ceiling, the floor and the equipment pads. Each pump station is identified by a number and flood protection system stationing.

Pump Station No. 1 (Sta. 159+40-A):

The structure is a concrete vault type structure with a flat roof drained by scuppers. There is some water staining of the exterior walls. At the construction joints the sealant is cracked and brittle. There are some minor cracks and pop-outs on the exterior face of the walls. There is some cracking on the interior face of the walls, usually next to a metal frame cast into the concrete, such as a window or door. At the ceiling there is leaching and cracking at the corners and along the wall. This would indicate some drainage and sealant problems on the roof. The floor of the station is fairly clean and absent of signs of standing water or drainage problems. The pump pads are well painted and maintained. The exterior trash rack is fairly clean, but needs

painting. The concrete channel walls around the exterior trash rack show signs of some cracking and abrasion.

Pump Station No. 2 (Sta. 66+90-A):

The structure is a concrete vault type structure with a flat roof drained by scuppers. There is some water staining of the exterior walls. There are some minor patches on the exterior face of the walls. There is some cracking on the interior face of the walls, usually next to a metal frame cast into the concrete, such as a window or door. At the ceiling there is leaching and cracking at the corners and along the wall. This would indicate some drainage and sealant problems on the roof. The floor of the station is fairly clean and absent of signs of standing water or drainage problems. The pump pads are well painted and maintained.

Pump Station No. 3 (Sta. 162+31-B):

The structure is a concrete vault type structure with a flat roof drained by scuppers. The skylight is a constant maintenance problem. There is some water staining of the exterior walls. At the construction joints the sealant is cracked and brittle. There are some minor patches on the exterior face of the walls. At the ceiling there is leaching and cracking at the corners and along the wall. This would indicate some drainage and sealant problems on the roof. The floor of the station is fairly clean and absent of signs of standing water or drainage problems. The pump pads fairly well maintained, but have places where paint is peeling.

Pump Station No. 4 (Sta. 149+37-B):

The structure is a concrete vault type structure, which is completely underground. The floor of the station is water stained, and the paint is peeling. There is evidence that water stands occasionally in the floor of the station. The pump pads show some rust and peeling paint.

Pump Station No. 5 (Sta. 144+30-B):

The structure is a concrete vault type structure with a flat roof drained by scuppers. The exterior walls are in good condition. At the ceiling there is leaching and cracking at the corners and along the wall. This would indicate some drainage and sealant

problems on the roof. The floor of the station is fairly clean and absent of signs of standing water or drainage problems. The pump pads are well painted and maintained.

Pump Station No. 6 (Sta. 109+03-B):

The structure is a concrete vault type structure with a flat roof drained by scuppers. There are some rust stains on the exterior walls. There is some cracking on the interior face of the walls, usually next to a metal frame cast into the concrete, such as a window or door. At the ceiling there is leaching and cracking at the corners and along the wall. This would indicate some drainage and sealant problems on the roof. The floor of the station is fairly clean, but there are of signs of a drainage problem next to the duct going to the ceiling. The pump pads are fairly well painted and maintained but there is some peeling paint on the pads.

Pump Station No. 7 (Sta. 90+51-B):

The structure is a concrete vault type structure with a flat roof drained by scuppers. At the construction joints the sealant is cracked and brittle. There is some cracking on the interior face of the walls, usually next to a metal frame cast into the concrete, such as a window or door. The floor of the station is fairly clean and absent of signs of standing water or drainage problems. The pump pads are fairly well painted and maintained, but there is some peeling paint on the pads. The exterior trash rack is fairly clean, but needs painting.

Pump Station No. 8 (Sta. 74+40-B):

Pump Station No. 8 is a below grade structure that is considered "confined space". This station was not inspected by the Parsons team.

Pump Station No. 9 (Sta. 69+85-B):

The structure is a concrete vault type structure with a flat roof drained by scuppers. There are some minor patches on the exterior face of the walls. The floor of the station is fairly clean and absent of signs of standing water or drainage problems. The pump pads are well painted and maintained.

Pump Station No. 10 (Sta. 58+08-B):

Pump Station No. 10 is a below grade structure that is considered "confined space". This station was not inspected by the Parsons team.

Pump Station No. 11 (Sta. 40+03-B):

The structure is a concrete vault type structure with a flat roof drained by scuppers. At the construction joints the sealant is cracked and brittle. There is some cracking on the interior face of the walls, usually next to a metal frame cast into the concrete, such as a window or door. The floor of the station is fairly clean and absent of signs of standing water or drainage problems. The pump pads are fairly well painted and maintained.

Pump Station No. 12 (Sta. 175+20-C):

The structure is a concrete vault type structure with a flat roof drained by scuppers. There is some cracking of the exterior walls, but overall the walls are in good condition. There is some cracking on the interior face of the walls, usually next to a metal frame cast into the concrete, such as a window or door. The floor of the station is fairly clean and absent of signs of standing water or drainage problems. The pump pads are fairly well painted and maintained. The exterior trash rack is fairly clean, but needs painting.

Pump Station No. 13 (Sta. Unknown-C):

The structure is a concrete masonry block building with timber rafters and asphalt shingles. The paint on the timber rafters is blistering and peeling on the exterior. The concrete masonry walls are good condition. The machine pads show some peeling paint and some rust, but they are in generally good condition. The trash rack on the exterior intake pipe is fairly clear but is in generally good condition.

4.5 Earthen Levees

A team of two civil engineers inspected the earthen levee segments that connect the floodwall segments and the floodwall to the major levee system for Section B. The earthen levees

were inspected to determine if all slopes were stable, if the riprap bank protection was in good condition and to check if any holes or openings had developed along the levee embankments. The earthen levee segments are identified by the flood protection system stationing.

Sta. 0+00 to Sta. 0+18

The earthen levee for this segment is in good condition and well vegetated. No areas of erosion or instability were found in the earthen embankment. The riverside embankment is protected with riprap that extends to the toe of slope in front of the floodwall. The riprap is in generally good condition but some of the stones have been loosened and displaced and some vegetation is beginning to develop between stones.

Sta. 16+53 to Sta. 21+86

The earthen levee for this segment is in good condition and is well vegetated. No areas of instability were found. Erosion is occurring along the toe of the slope on the riverside embankment in areas where no rip rap or gravel surface is present. This especially occurs in the area of the gated outlet at station 19+11. This erosion appears to be occurring above normal pool elevation when the river elevation is high.

At Station 16+53, the riverside embankment is protected with riprap that extends from the toe of slope in front of the floodwall to a distance of approximately 60 feet past the end of the floodwall. The riprap in this location is in very good condition and still tightly packed. No vegetation is growing within this rip rap protection.

At Station 21+86, the riverside embankment is protected with riprap that extends from the toe of slope in front of the floodwall to a distance of approximately 50 feet past the beginning of the floodwall. The riprap in this location is in generally good condition. Some of the stones have been loosened and displaced with some vegetation developing within this rip rap protection.

Sta. 38+02 to Sta. 51+00

The earthen levee for this segment is in good condition with a gravel roadway on top that provides access to the Pump Station No. 11 at station 40+03. No areas of erosion or instability were found. The levee is well vegetated.

The entire length of the riverside embankment for this segment of the earthen levee is protected with riprap. The riprap extends from the top of the embankment to the river's edge and to the toe of slope in front of the floodwalls. The riprap in this location is in generally good condition. At Station 38+02, the riprap stone in this location appears to have been dumped and roughly placed with equipment, which created a very uneven surface. The remaining part of the riprap was more uniformly placed and has a more even surface. Vegetation is growing within this rip rap protection in several areas.

Sta. 170+47

The earthen levee for this segment is in good condition and well vegetated. No areas of erosion or instability were found in the earthen embankment. The riverside embankment is protected with riprap that extends to the toe of slope in front of the floodwall. The riprap is in generally good condition but some of the stones have been loosened and displaced and some vegetation is beginning to develop between stones.

4.6 Gated Outlets

A team of two civil engineers also inspected the gated outlets that were accessible and not in "confined spaces". Items inspected included the flap gate, concrete headwalls and the adjacent riverbank. The gated outlets are identified by the flood protection system stationing.

Gated Outlet - Sta. 7+54-B

The gated outlet at this location is for an 18-inch diameter pipe. A 7'-6" wide x 4' high x 1'-6" deep concrete headwall is located at the end of this pipe. This headwall is in good condition with no visible cracking or deterioration.

A flap gated is attached to the end of this pipe to prevent floodwaters from entering the pipe at high river elevations. The flap gate is a Neenah model "Nach" and is good functioning condition.

The pipe discharges into an earthen ditch approximately 51 feet from the floodwall. Silt has accumulated in the ditch at the pipe discharge point to a depth of approximately 4"-6". This silt deposit prevented the flap gate from being able to open fully during normal operating conditions. The earthen ditch has little to

no vegetative cover and is eroding downstream of the discharge point. There is no rip rap protection of any kind for this structure.

Gated Outlet – Sta. 19+11

The gated outlet at this location is for a 66-inch diameter pipe. A concrete headwall with wingwalls is located at the discharge point. The headwall is 10'-6" wide x 8'-6" high x 1'-10" deep. The wingwalls are 14'-10" long and are at approximately a 45 degree angle to the headwall. The headwall and wingwalls are in good condition with no visible cracking or problem areas.

The flap gate is in good condition. The flap gate is fitted with a cable operated opening mechanism. The cable extends from the flap gate to the top of the levee.

The pipe discharges into the Ohio River approximately 125 feet from the top of the levee. The headwall and gated outlet is set back slightly from the main river edge at normal pool stage but is directly connected by a drainage ditch. Riprap is in place along both wingwalls for bank protection. The riprap is in good condition along the south side and in fair condition along the north side. No riprap is in place behind the headwall where erosion has occurred. This erosion appears to be caused to a small degree by runoff from the levee slope but primarily from wave action when the river level is up.

At the time of the inspection, the gated outlet was partially submerged, so it was not possible to determine what the existing ditch bottom materials might be.

Gated Outlet – Sta. 80+09

The gated outlet at this location is for an 18-inch steel pipe. The 18-inch pipe discharges into a 5 foot square concrete structure, which has a 15-inch vitrified clay pipe that exits out the bottom of the concrete structure. We were unable to determine if the 15-inch connects to the nearby manhole or discharges into the river directly. No discharge pipe was visible between the concrete structure and the river.

It appeared that a new flap gate had been installed in the recent past. The new flap gate was a Neenah Model 5050-0022, which was in very good condition and operated freely.

The concrete structure was in generally good condition. There

was however severe erosion under the structure on the riverside and the incoming pipe was partially exposed at the landside of the structure.

The gated outlet is located approximately 52'-6" from the floodwall.

Gated Outlet – Sta. 128+61

The gated outlet at this location is for a 36-inch CMP. . A concrete headwall with wingwalls is located at the discharge point. The headwall is 8'-6" wide x 4'-0" high x 1'-6" deep. The wingwalls are 2'-6" long and are at approximately a 45 degree angle to the headwall. The headwall and wingwalls are in good condition with no visible cracking or problem areas.

The flap gate is in good condition and operated freely. The flap gate is a Brown & Brown Model M36 90-805.

The pipe discharges into the Ohio River approximately 111 feet from the floodwall. The headwall and gated outlet is set back from the main river edge at normal pool stage. Riprap is in place from the roadway at the top of bank to the river's edge for bank protection. The riprap is in good condition.

5.0 Recommendations

The floodwall and most of the accompanying structures are in good condition. There is no evidence to suggest any structural failures exist, which would compromise the integrity of the floodwall. The construction joint sealant for the length of the wall and for the accompanying structures is cracking and not continuous. The joint sealant should be replaced for the length of the wall. There are sections of the wall that appear to have rotated out of plumb, but according to the floodwall superintendent of the city of Paducah, the wall has been in that state since very soon after construction. Field observations seem to confirm this statement.

None of the rotational movements are serious enough to prevent a good seal at the construction joints. Minor cracking and concrete deterioration is scattered throughout the floodwall system. In the pump stations this deterioration is usually due to poor roof drainage and the interaction between steel doorframes and windows. The floodwalls show problems at the floodgates where there is collision damage or around the sill angles of

service openings. In no case does this minor deterioration threaten the integrity of the floodwall system, however preventive measures should be taken to prevent further crack growth. At nearly all of the service openings, the sill angles have peeling paint and rust. These angles should be cleaned and painted to prevent deterioration.

Closure Structures: The following closure structures sills were covered with water, silt and debris and the condition of the seal trough and sills were unknown.

Station 4+49	Station 71+74
Station 5+34	Station 73+31
Station 9+44	Station 75+85
Station 10+40	Station 83+92
Station 25+15	Station 90+41
Station 26+90	Station 91+96
Station 29+80	Station 93+57
Station 31+01	Station 94+63
Station 31+51	Station 106+10
Station 36+84	Station 108+53
Station 62+84	Station 135+22
Station 69+64	Station 170+04

Clearing, cleaning and inspection of these closures need to be scheduled in the near future.

All of the items for the concrete floodwall mentioned in the above paragraphs, are maintenance issues and do not undermine the integrity and functionality of floodwall system.

This report recommends that rip rap be installed at three of the gated outlets to prevent future bank erosion and possible damage to these structures. Bank erosion appears to have occurred at these structures due to wave action at high river levels and poorly vegetated banks. Gated outlets at station 7+54 B, 19+11 B and 80+09 B have been identified for the rip rap bank protection. The photographs in Appendix B show the erosion that has and is occurring at these structures.

The riprap placed along the earthen levee is in need of maintenance repair to reshape the slopes and to remove vegetation in several areas. The areas identified for maintenance riprap repair are at Station 0+18B, Station 21+86 B, Station

38+02 B and at Station 170+47 B. None of these conditions are threatening the integrity of the flood protection system at this time but they need to be addressed in the maintenance program to prevent future damages.

6.0 Project Costs.

Cost estimates have been prepared for the recommended repairs that are not identified as maintenance repairs. These repairs all relate to placing rip rap at outlet structures to stabilize the embankments and better protect the structures. The cost estimates are included in Appendix A.

7.0 Conclusion

The quality of the initial construction of the flood protection system appears to have been very good and the system has been well maintained by the City over the last 50 years. Overall, the components of the Paducah Flood Protection System are in good to very good condition. The City has maintained the various structures and facilities and performed minor repairs as necessary.

If the maintenance items described in Section 6.0 are performed and a scheduled inspection program and repair of these items is maintained in the future, this flood protection system can remain functional for another 50 years.

Appendix A
Paducah Floodwall Protection System Cost Estimates

PADUCAH, KENTUCKY
FLOOD PROTECTION SYSTEM
U.S. CORPS OF ENGINEERS
LOUISVILLE DISTRICT
LOUISVILLE, KY

Designed By: EDWARD M. SWEET
Estimated By: TODD D. WILLIAMS

Prepared By: TODD D. WILLIAMS

Preparation Date: 08/11/99
Effective Date of Pricing: 08/11/99

Sales Tax: 6.00%

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Fri 27 Aug 1999 U.S. Army Corps of Engineers TIME 12:47:16
Eff. Date 08/11/99 PROJECT PADUCA: PADUCAH, KENTUCKY - FLOOD PROTECTION SYSTEM
TEST REPORTS SETTINGS PAGE 1

** CONTRACTOR SETTINGS **

		AMOUNT	PCT	PCT S	RISK	DIFF	SIZE	PERIOD	INVEST	ASSIST	SUBCON
AA PRIME CONTRACTOR`											
PRIME CONTRACTOR'S FIELD OVERHEAD	P		2.00								
PRIME'S HOME OFFICE EXPENSE	P		2.00								
PRIME CONTRACTOR'S PROFIT	C		8.70		0.030	0.120	0.120	0.060	0.060	0.060	0.120
PRIME CONTRACTOR'S BOND	C			(Class: A)							

Fri 27 Aug 1999
Eff. Date 08/11/99
DETAILED ESTIMATE

U.S. Army Corps of Engineers
PROJECT PADUCA: PADUCAH, KENTUCKY - FLOOD PROTECTION SYSTEM
TEST REPORTS
1000. PADUCAH, KENTUCKY

TIME 12:47:16
DETAIL PAGE 1

STORM SEWERS	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
GATED OUTFALL @ STATION 7+54									
MOBILIZATION					0.00	0.00	0.00	1500.00	1500.00
	1.00	EA		0.00	0	0	0	1,500	1,500
EXCAVATE AND LOAD-WH,BH 1.5CY					12.07	1.22	0.00	0.00	13.29
	130.00	CY	CODEF	30.00	1,569	159	0	0	1,728
Haul, 8 CY(61M3) Trk, 6 Mi(10Km) 40 MPH (60 Km/Hr), 2.1 Cycles/Hr 2.1 Cycles/Hr					9.94	2.08	0.00	0.00	12.03
	130.00	CY	CDETB	16.38	1,293	271	0	0	1,563
Rip Rap, 10# to 200# Pieces Random, Dumped from Truck					11.38	1.62	25.84	0.00	38.85
	130.00	CY	CDETF	32.00	1,480	211	3,360	0	5,050
Erosion Control,12 Mil Vinyl Mat 3 Dimensional, Nylon Geomatrix					1.07	0.05	5.19	0.00	6.32
	200.00	SY	ULABK	64.38	214	11	1,039	0	1,264
Erosion Control, Slope Stakes Required 3' to 5' Intervals					0.00	0.00	0.33	0.00	0.33
	240.00	EA	N/A	0.00	0	0	79	0	79
PROTECTION AND RESTORATION					0.00	0.00	0.00	1500.00	1500.00
	1.00	EA		0.00	0	0	0	1,500	1,500
TOTAL GATED OUTFALL @ STATION 7+54					4,555	652	4,477	3,000	12,684

LABOR ID: KNOX96 EQUIP ID: RG295A Currency in DOLLARS CREW ID: NAT95A UPB ID: NAT95A

STORM SEWERS	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
GATED OUTFALL @ STATION 19+11									
MOBILIZATION					0.00	0.00	0.00	2000.00	2000.00
	1.00	EA		0.00	0	0	0	2,000	2,000
EXCAVATE AND LOAD-WH,BH 1.5CY					12.07	1.22	0.00	0.00	13.29
	450.00	CY	CCDEF	30.00	5,430	551	0	0	5,981
Haul, 8 CY(61M3) Trk, 6 Mi(10Km) 40 MPH (60 Km/Hr), 2.1 Cycles/Hr 2.1 Cycles/Hr					9.94	2.08	0.00	0.00	12.03
	450.00	CY	CDETB	16.38	4,475	936	0	0	5,411
Rip Rap, 10# to 200# Pieces Random, Dumped from Truck					11.38	1.62	25.84	0.00	38.85
	450.00	CY	CDETF	32.00	5,122	731	11,629	0	17,482
Erosion Control,12 Mil Vinyl Mat 3 Dimensional, Nylon Geomatrix					1.07	0.05	5.19	0.00	6.32
	670.00	SY	ULABK	64.38	717	36	3,480	0	4,234
Erosion Control, Slope Stakes Required 3' to 5' Intervals					0.00	0.00	0.33	0.00	0.33
	804.00	EA	N/A	0.00	0	0	264	0	264
PROTECTION AND RESTORATION					0.00	0.00	0.00	2500.00	2500.00
	1.00	EA		0.00	0	0	0	2,500	2,500
TOTAL GATED OUTFALL @ STATION 19+11					15,744	2,254	15,373	4,500	37,872

STORM SEWERS	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
GATED OUTFALL @ STATION 80+09									
MOBILIZATION					0.00	0.00	0.00	1500.00	1500.00
	1.00	EA		0.00	0	0	0	1,500	1,500
EXCAVATE AND LOAD-WH,BH 1.5CY					12.07	1.22	0.00	0.00	13.29
	130.00	CY	CODEF	30.00	1,569	159	0	0	1,728
Haul, 8 CY(6IM3) Trk, 6 Mi(10Km) 40 MPH (60 Km/Hr), 2.1 Cycles/Hr 2.1 Cycles/Hr					9.94	2.08	0.00	0.00	12.03
	90.00	CY	COETB	16.38	895	187	0	0	1,082
Rip Rap, 10# to 200# Pieces Random, Dumped from Truck					11.38	1.62	25.84	0.00	38.85
	90.00	CY	COETF	32.00	1,024	146	2,326	0	3,496
Erosion Control,12 Mil Vinyl Mat 3 Dimensional, Nylon Geomatrix					1.07	0.05	5.19	0.00	6.32
	140.00	SY	ULABK	64.38	150	8	727	0	885
Erosion Control, Slope Stakes Required 3' to 5' Intervals					0.00	0.00	0.33	0.00	0.33
	168.00	EA	N/A	0.00	0	0	55	0	55
PROTECTION AND RESTORATION					0.00	0.00	0.00	1000.00	1000.00
	1.00	EA		0.00	0	0	0	1,000	1,000
TOTAL GATED OUTFALL @ STATION 80+09					3,638	500	3,108	2,500	9,746
TOTAL PADUCAH, KENTUCKY					23,937	3,406	22,959	10,000	60,302

Fri 27 Aug 1999 U.S. Army Corps of Engineers TIME 12:47:16
Eff. Date 08/11/99 PROJECT PADUCA: PADUCAH, KENTUCKY - FLOOD PROTECTION SYSTEM
TEST REPORTS SUMMARY PAGE 1
** PROJECT OWNER SUMMARY - ELEMENT (Rounded to 10's) **

	QUANTITY	UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT COST
1000 PADUCAH, KENTUCKY							
1000_01 STORM SEWERS							
1000_01.01 OUTFALLS							
1000_01.01.01 GATED OUTFALL @ STATION 7+54	1.00	EA	14,560	2,910	1,750	19,220	19218.77
1000_01.01.02 GATED OUTFALL @ STATION 19+11	1.00	EA	43,470	8,690	5,220	57,380	57383.22
1000_01.01.03 GATED OUTFALL @ STATION 80+09	1.00	EA	11,190	2,240	1,340	14,770	14767.52
TOTAL OUTFALLS	1.00	EA	69,220	13,840	8,310	91,370	91369.52
TOTAL STORM SEWERS	1.00	EA	69,220	13,840	8,310	91,370	91369.52
TOTAL PADUCAH, KENTUCKY	1.00	EA	69,220	13,840	8,310	91,370	91369.52
TOTAL PADUCAH, KENTUCKY	1.00	EA	69,220	13,840	8,310	91,370	91369.52

LABOR ID: KNOX96 EQUIP ID: RG295A Currency in DOLLARS CREW ID: NAT95A UPB ID: NAT95A

Fri 27 Aug 1999 U.S. Army Corps of Engineers TIME 12:47:16
Eff. Date 08/11/99 PROJECT PADUCA: PADUCAH, KENTUCKY - FLOOD PROTECTION SYSTEM
TEST REPORTS SUMMARY PAGE 2
** PROJECT INDIRECT SUMMARY - ELEMENT (Rounded to 10's) **

	QUANTITY UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
1000 PADUCAH, KENTUCKY								
1000_01 STORM SEWERS								
1000_01.01 OUTFALLS								
1000_01.01.01 GATED OUTFALL @ STATION	1.00 EA	12,680	250	260	1,150	220	14,560	14559.67
1000_01.01.02 GATED OUTFALL @ STATION	1.00 EA	37,870	760	770	3,430	640	43,470	43472.14
1000_01.01.03 GATED OUTFALL @ STATION	1.00 EA	9,750	190	200	880	170	11,190	11187.52
TOTAL OUTFALLS	1.00 EA	60,300	1,210	1,230	5,460	1,020	69,220	69219.33
TOTAL STORM SEWERS	1.00 EA	60,300	1,210	1,230	5,460	1,020	69,220	69219.33
TOTAL PADUCAH, KENTUCKY	1.00 EA	60,300	1,210	1,230	5,460	1,020	69,220	69219.33
TOTAL PADUCAH, KENTUCKY	1.00 EA	60,300	1,210	1,230	5,460	1,020	69,220	69219.33
CONTINGENCY							13,840	
SUBTOTAL							83,060	
ESCALATION							8,310	
TOTAL INCL OWNER COSTS							91,370	

LABOR ID: KNOX96 EQUIP ID: RG295A Currency in DOLLARS CREW ID: NAT95A UPB ID: NAT95A

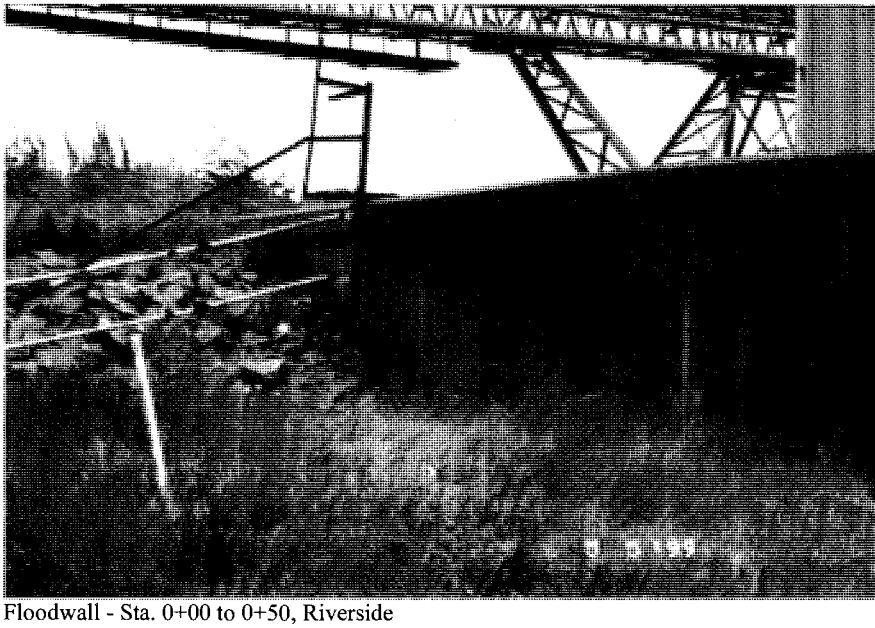
Fri 27 Aug 1999 U.S. Army Corps of Engineers TIME 12:47:16
Eff. Date 08/11/99 PROJECT PADUCA: PADUCAH, KENTUCKY - FLOOD PROTECTION SYSTEM
TEST REPORTS SUMMARY PAGE 3
** PROJECT DIRECT SUMMARY - ELEMENT (Rounded to 10's) **

	QUANTITY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
1000 PADUCAH, KENTUCKY								
1000_01 STORM SEWERS								
1000_01.01 OUTFALLS								
1000_01.01.01 GATED OUTFALL @ STATION 7+54	1.00	EA	4,560	650	4,480	3,000	12,680	12683.98
1000_01.01.02 GATED OUTFALL @ STATION 19+11	1.00	EA	15,740	2,250	15,370	4,500	37,870	37871.72
1000_01.01.03 GATED OUTFALL @ STATION 80+09	1.00	EA	3,640	500	3,110	2,500	9,750	9746.26
TOTAL OUTFALLS	1.00	EA	23,940	3,410	22,960	10,000	60,300	60301.97
TOTAL STORM SEWERS	1.00	EA	23,940	3,410	22,960	10,000	60,300	60301.97
TOTAL PADUCAH, KENTUCKY	1.00	EA	23,940	3,410	22,960	10,000	60,300	60301.97
TOTAL PADUCAH, KENTUCKY	1.00	EA	23,940	3,410	22,960	10,000	60,300	60301.97
PRIME CONTRACTOR'S FIELD OVERHEAD							1,210	
SUBTOTAL							61,510	
PRIME'S HOME OFFICE EXPENSE							1,230	
SUBTOTAL							62,740	
PRIME CONTRACTOR'S PROFIT							5,460	
SUBTOTAL							68,200	
PRIME CONTRACTOR'S BOND							1,020	
TOTAL INCL INDIRECTS							69,220	
CONTINGENCY							13,840	
SUBTOTAL							83,060	
ESCALATION							8,310	
TOTAL INCL OWNER COSTS							91,370	

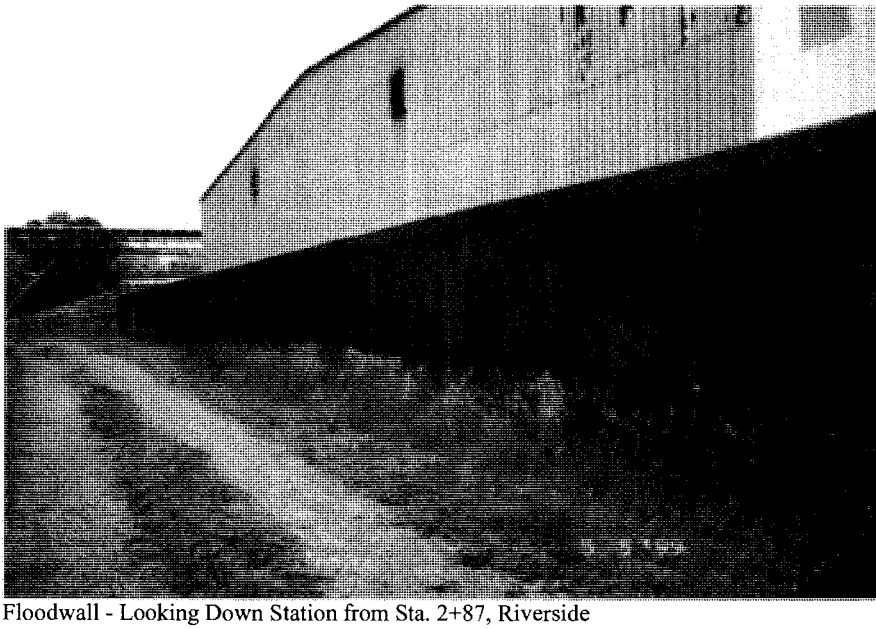
Appendix B
Paducah Floodwall Protection System Floodwall Photographs

May 5 – 11, 1999

Paducah Floodwall Inspection



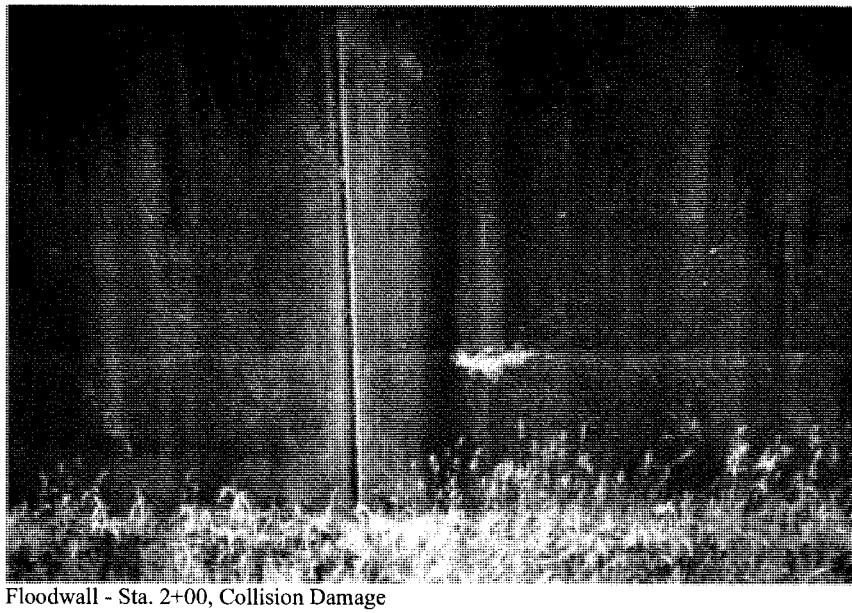
Floodwall - Sta. 0+00 to 0+50, Riverside



Floodwall - Looking Down Station from Sta. 2+87, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection

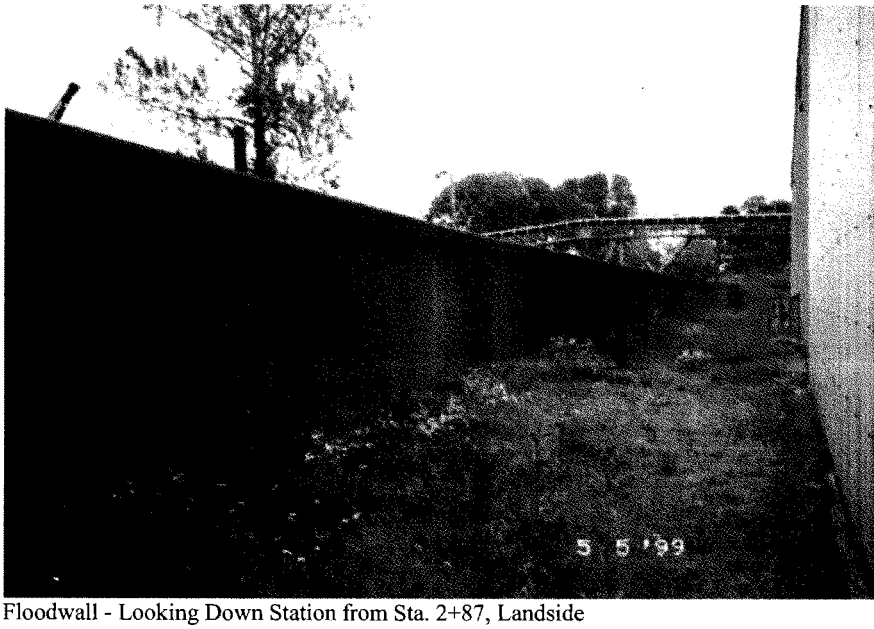


Floodwall - Sta. 2+00, Collision Damage

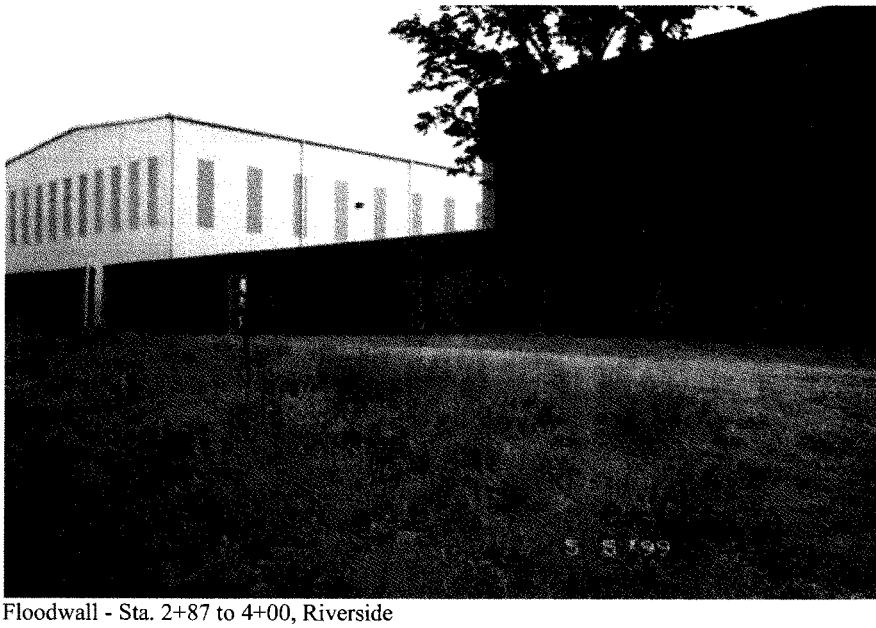
Floodwall - Sta. 2+60, Sealant Missing (Typical)

May 5 – 11, 1999

Paducah Floodwall Inspection



Floodwall - Looking Down Station from Sta. 2+87, Landside

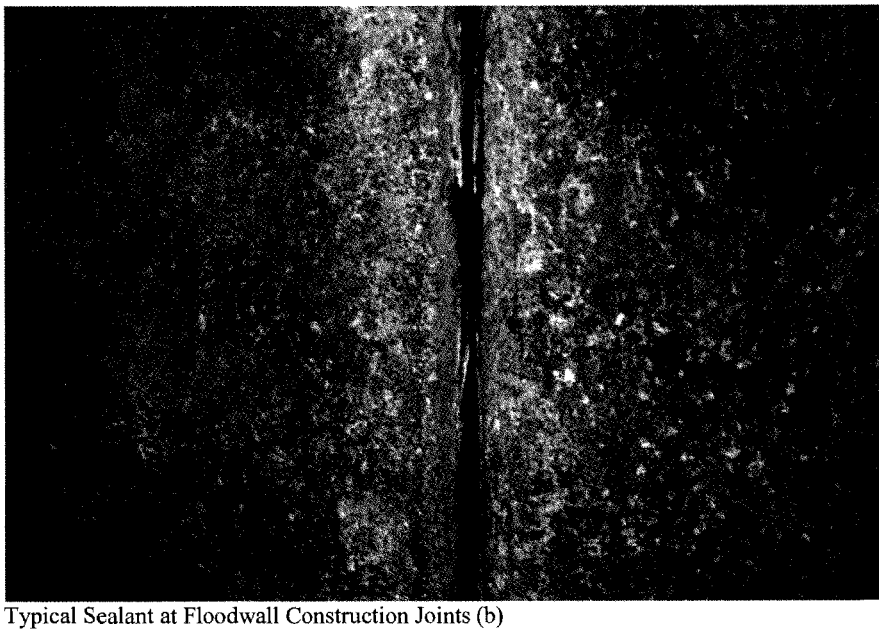


Floodwall - Sta. 2+87 to 4+00, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection

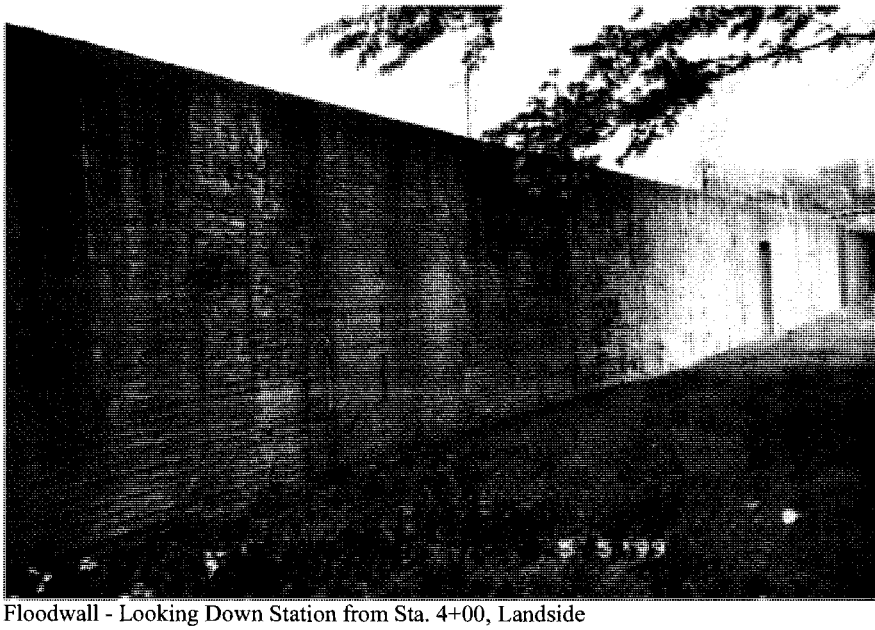
Typical Sealant at Floodwall Construction Joints (a)



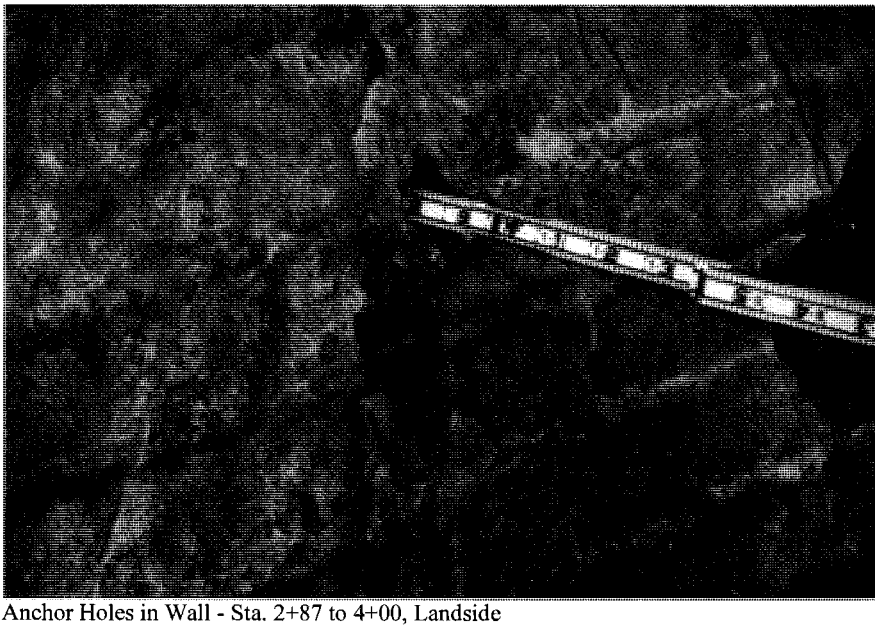
Typical Sealant at Floodwall Construction Joints (b)

May 5 – 11, 1999

Paducah Floodwall Inspection



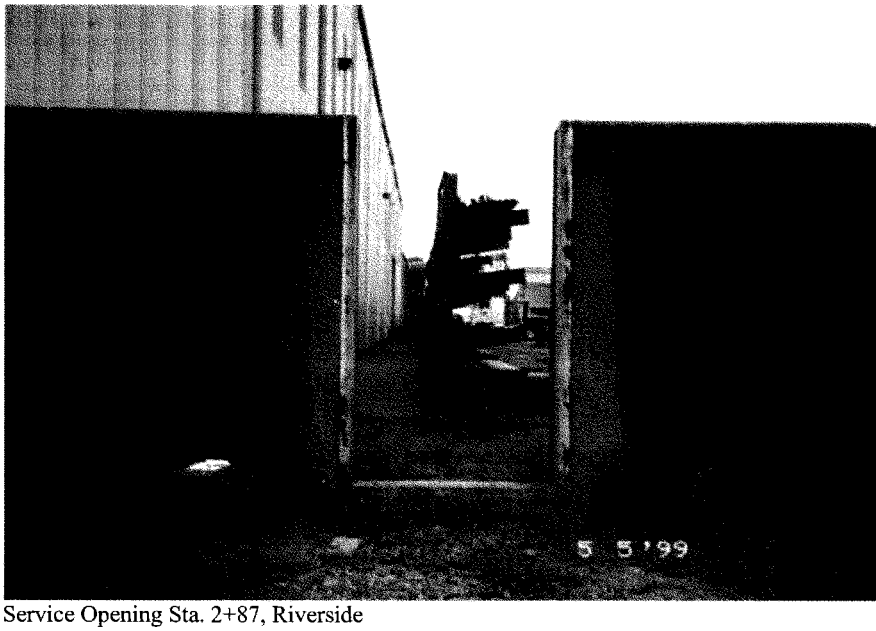
Floodwall - Looking Down Station from Sta. 4+00, Landside



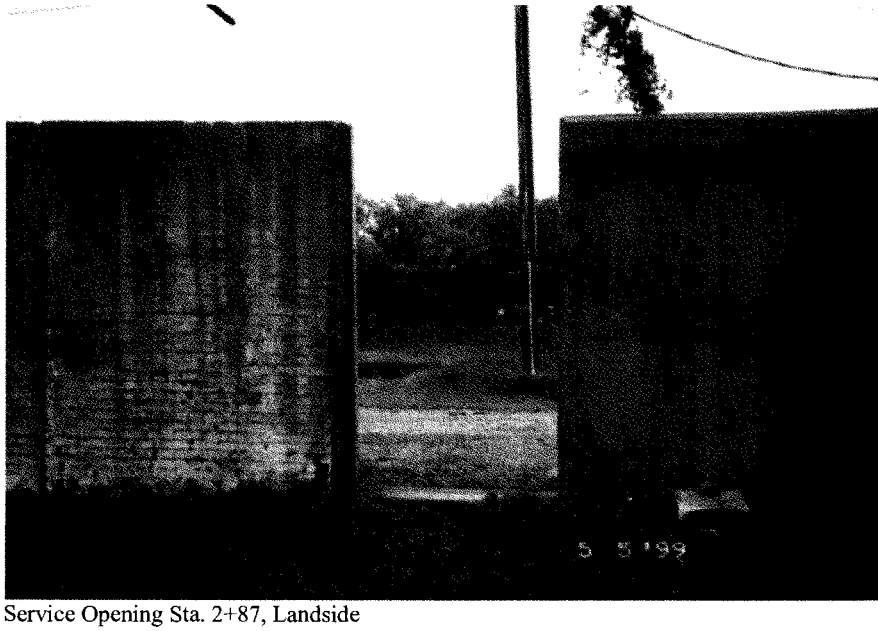
Anchor Holes in Wall - Sta. 2+87 to 4+00, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



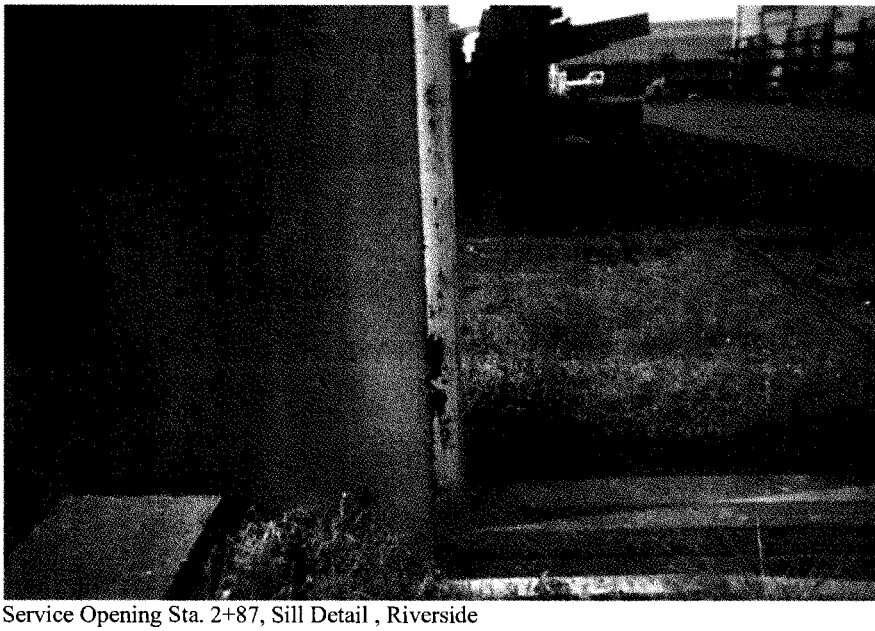
Service Opening Sta. 2+87, Riverside



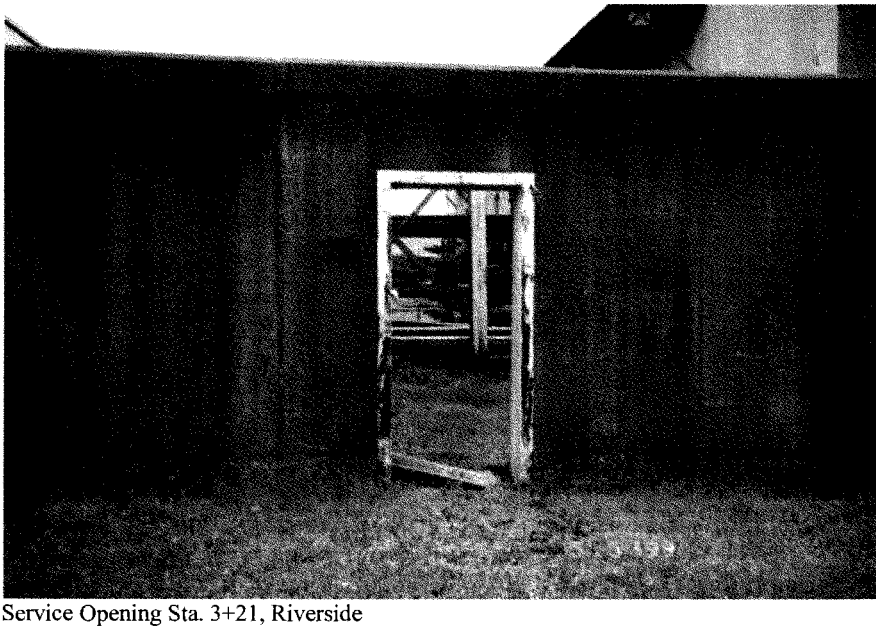
Service Opening Sta. 2+87, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



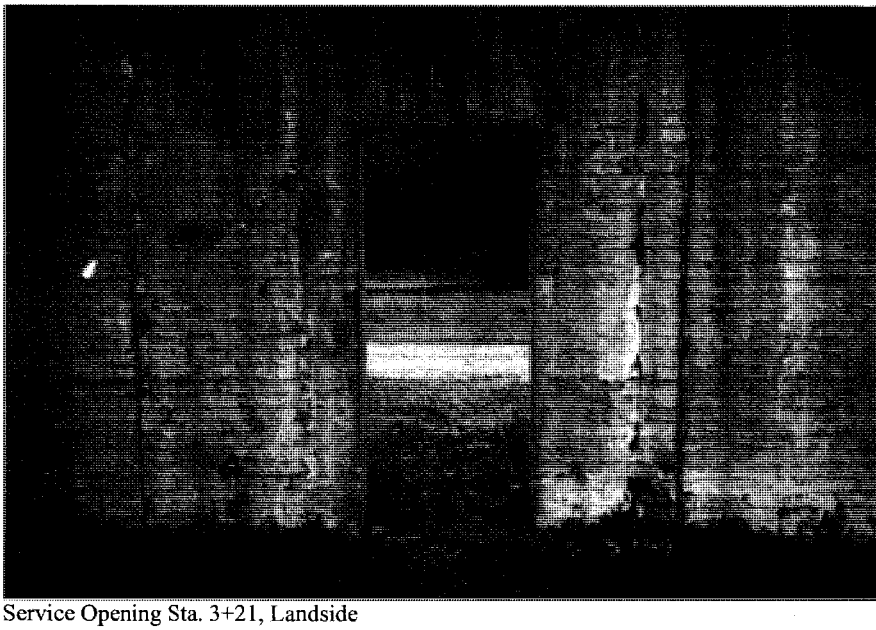
Service Opening Sta. 2+87, Sill Detail , Riverside



Service Opening Sta. 3+21, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection

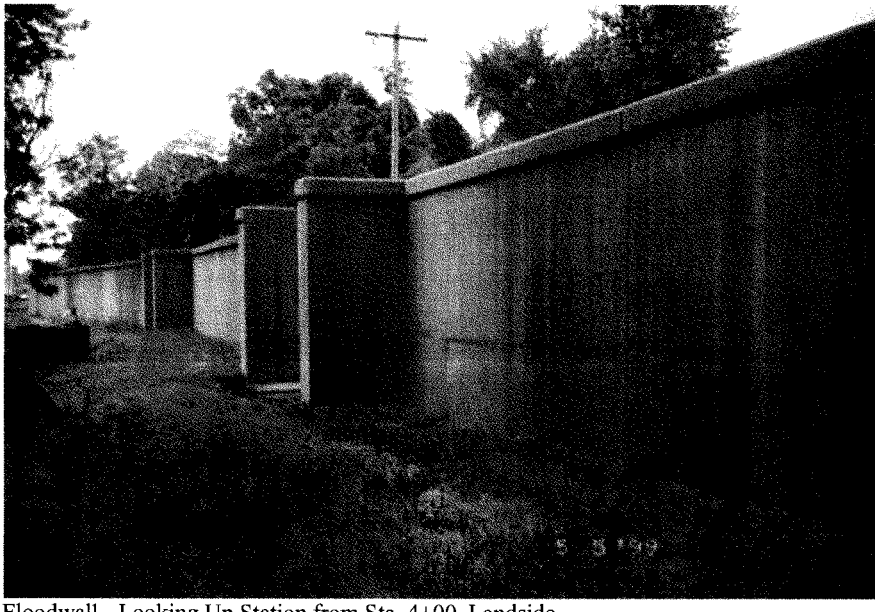


Service Opening Sta. 3+21, Landside

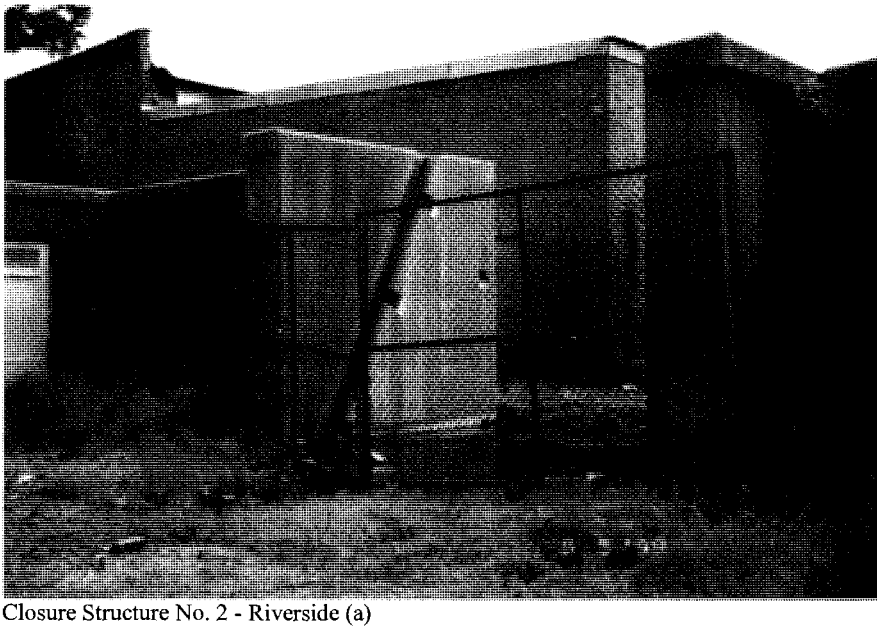
Service Opening Sta. 3+21, Detail of Sill, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



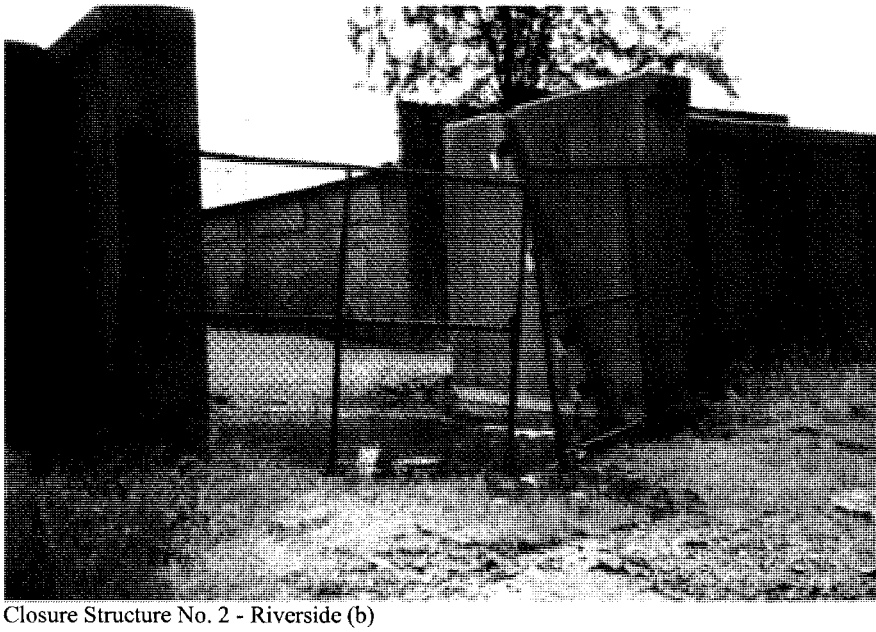
Floodwall - Looking Up Station from Sta. 4+00, Landside



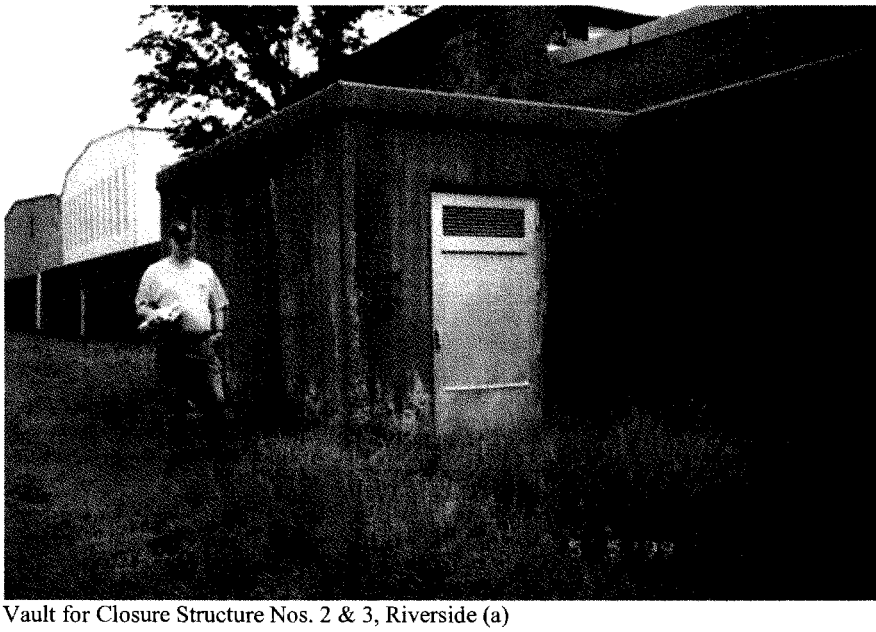
Closure Structure No. 2 - Riverside (a)

May 5 – 11, 1999

Paducah Floodwall Inspection



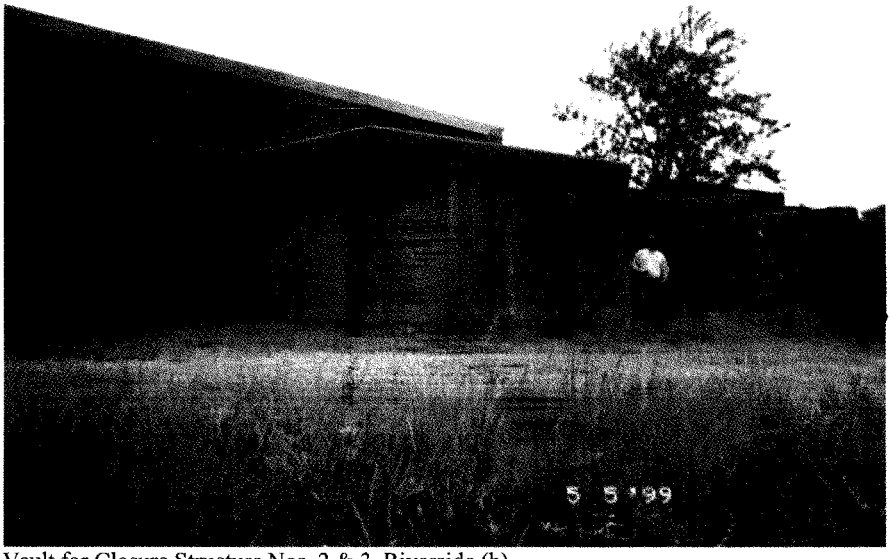
Closure Structure No. 2 - Riverside (b)



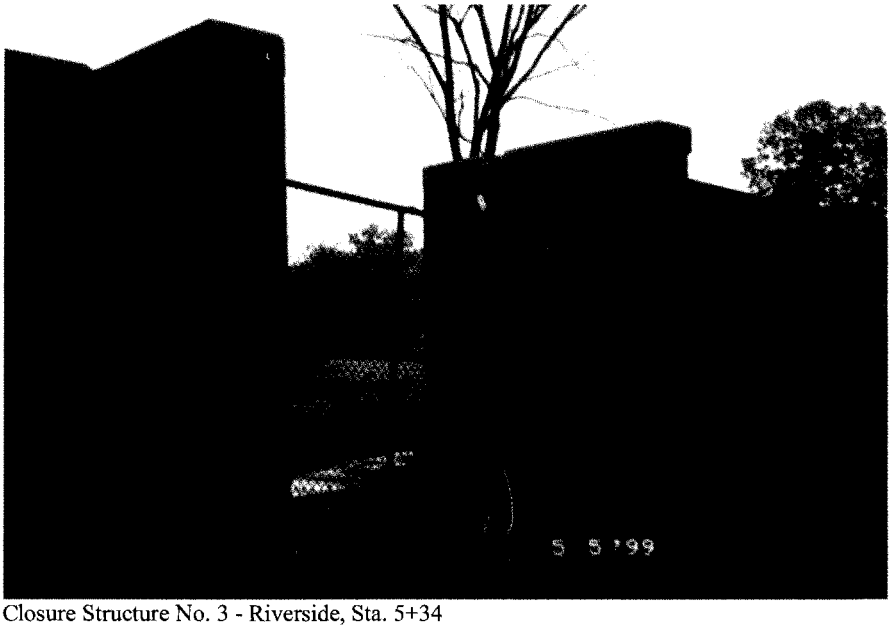
Vault for Closure Structure Nos. 2 & 3, Riverside (a)

May 5 – 11, 1999

Paducah Floodwall Inspection



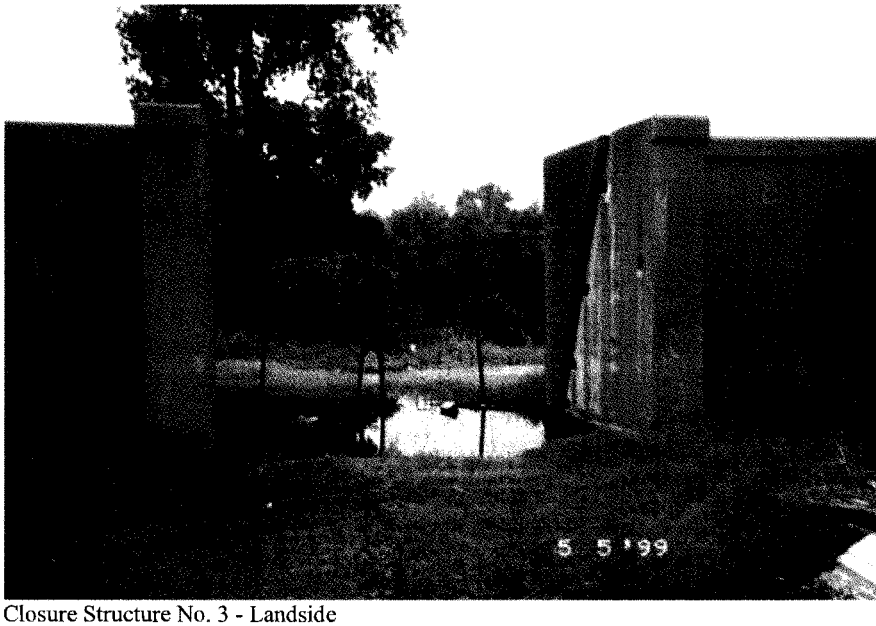
Vault for Closure Structure Nos. 2 & 3, Riverside (b)



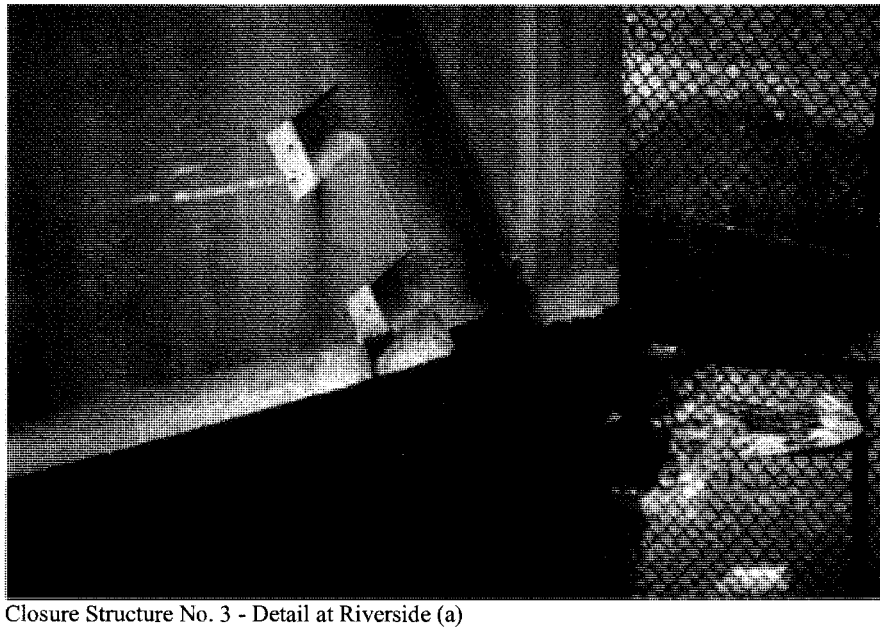
Closure Structure No. 3 - Riverside, Sta. 5+34

May 5 – 11, 1999

Paducah Floodwall Inspection



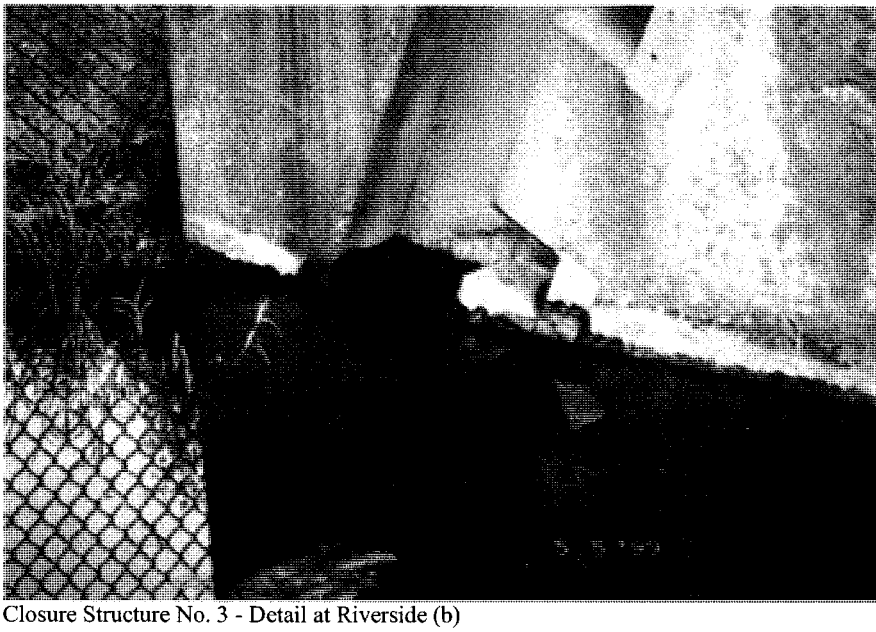
Closure Structure No. 3 - Landside



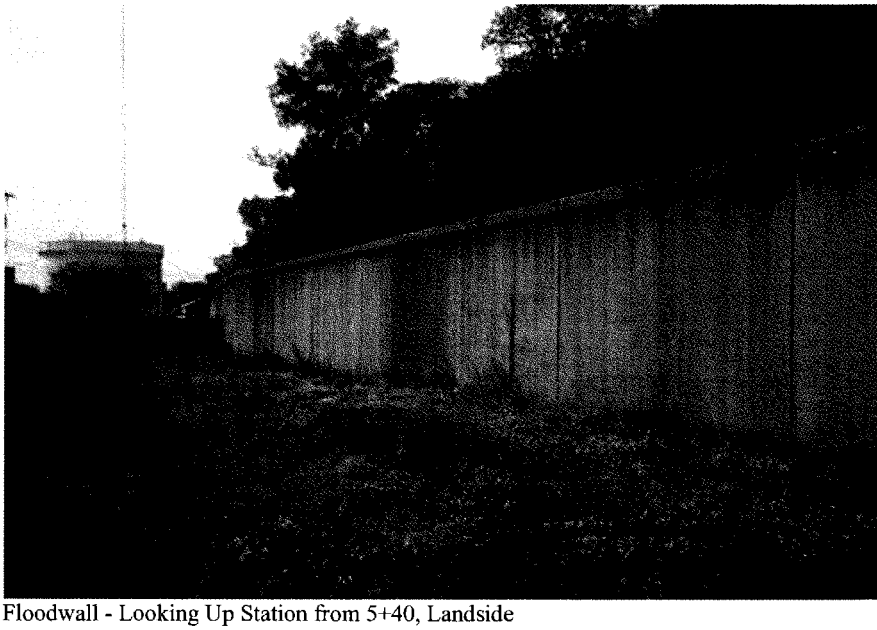
Closure Structure No. 3 - Detail at Riverside (a)

May 5 – 11, 1999

Paducah Floodwall Inspection



Closure Structure No. 3 - Detail at Riverside (b)

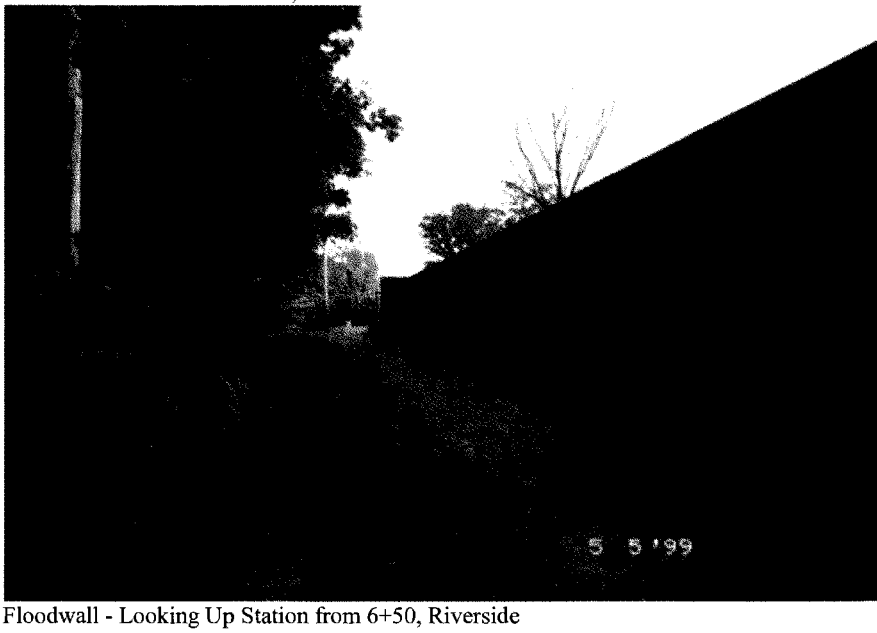


Floodwall - Looking Up Station from 5+40, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection

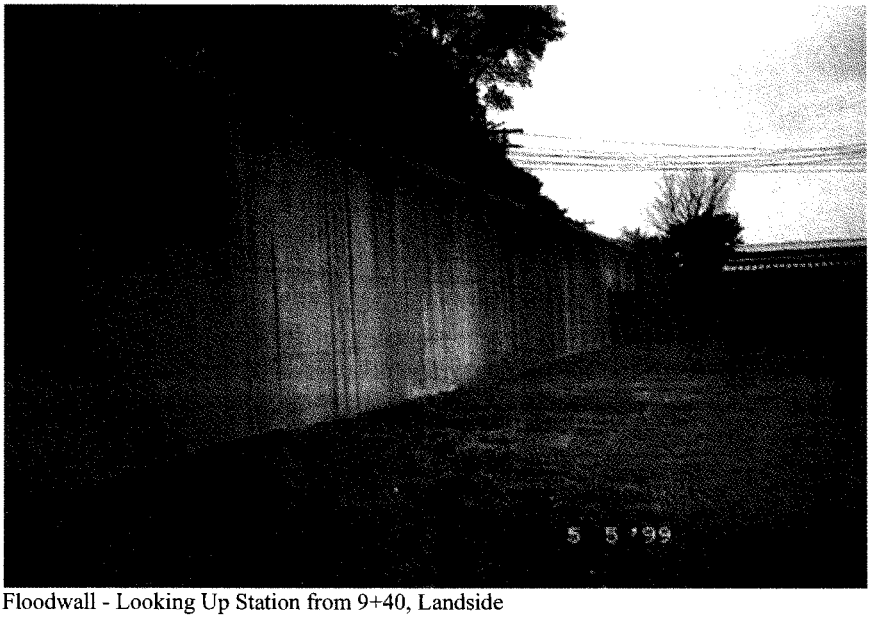
Floodwall - Sta. 5+40 to 6+50, Riverside



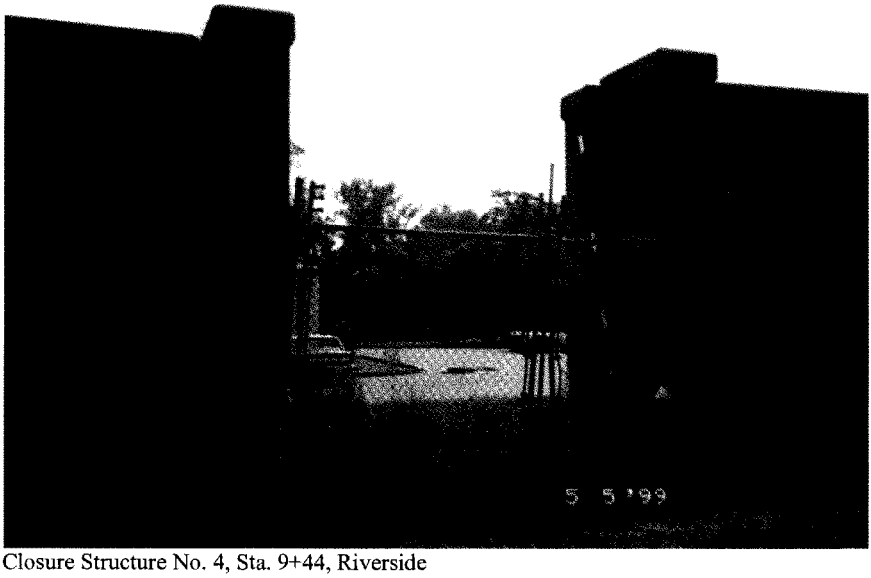
Floodwall - Looking Up Station from 6+50, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



Floodwall - Looking Up Station from 9+40, Landside

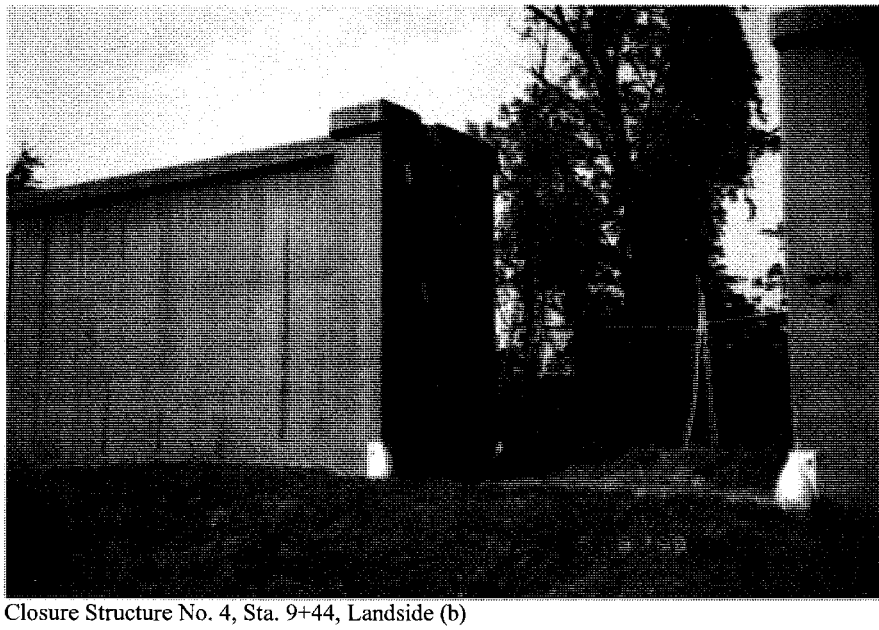


Closure Structure No. 4, Sta. 9+44, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection

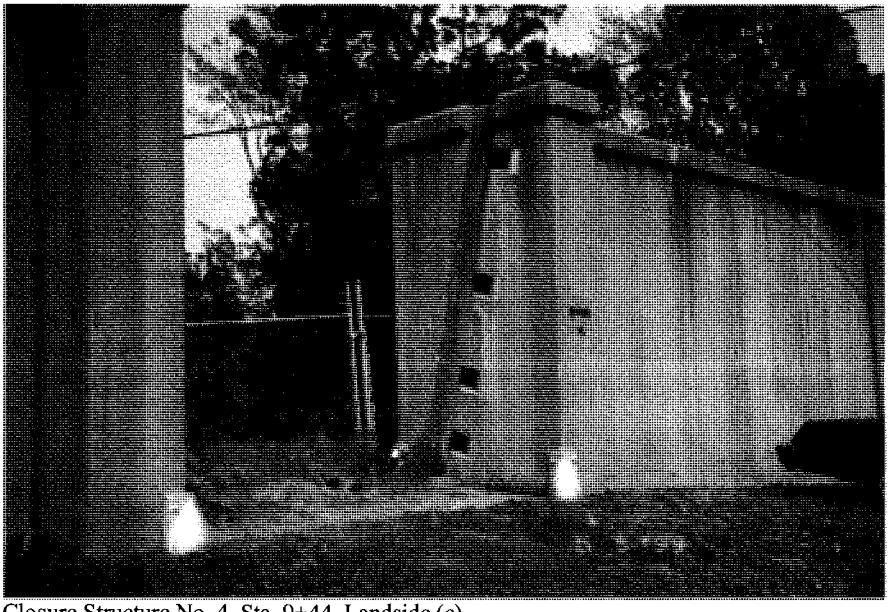
Closure Structure No. 4, Sta. 9+44, Landside (a)



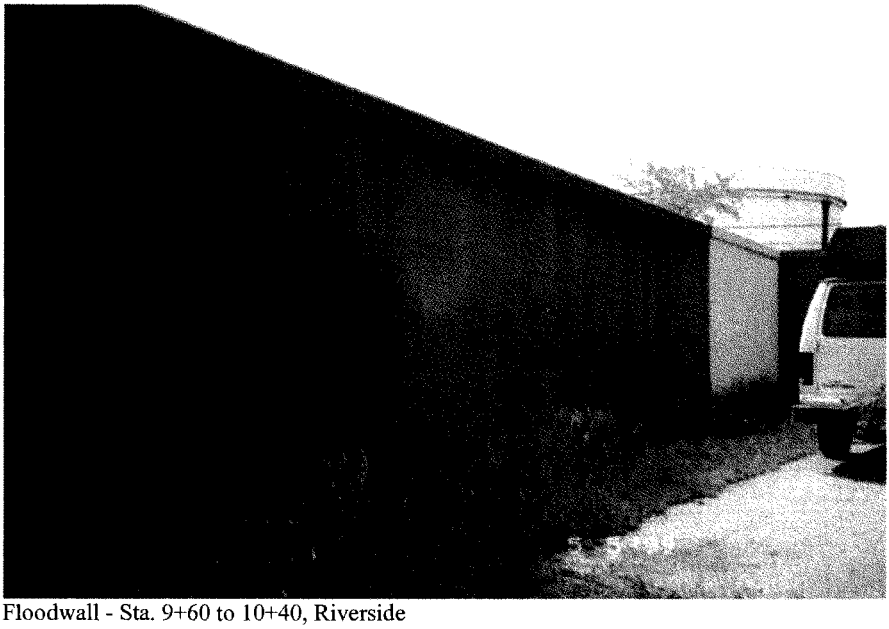
Closure Structure No. 4, Sta. 9+44, Landside (b)

May 5 – 11, 1999

Paducah Floodwall Inspection



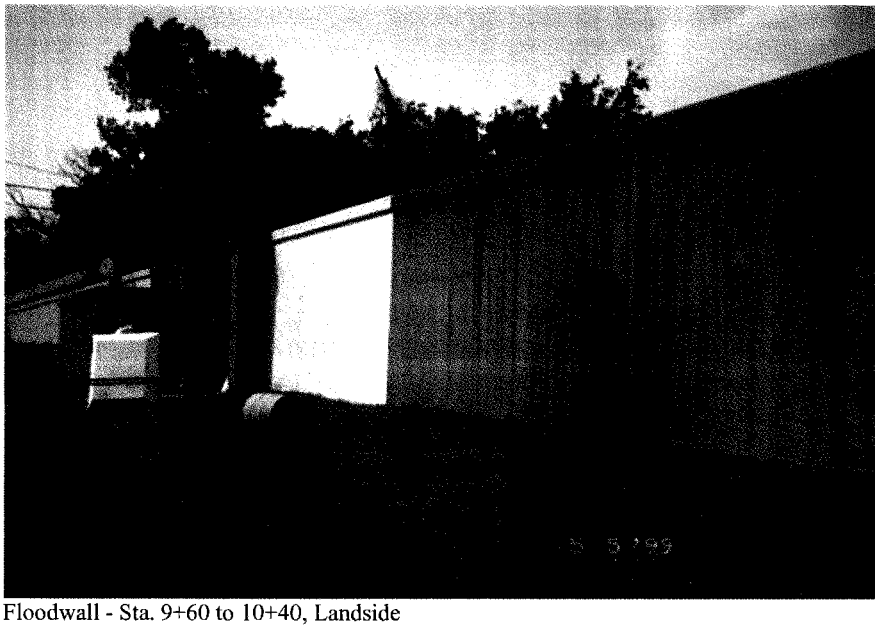
Closure Structure No. 4, Sta. 9+44, Landside (c)



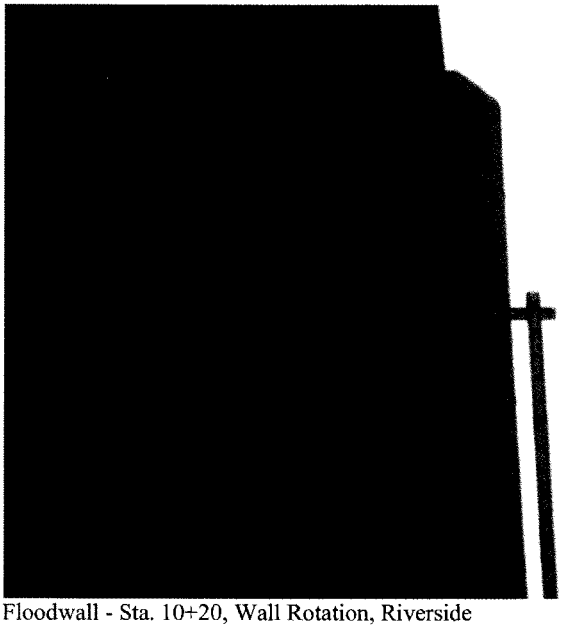
Floodwall - Sta. 9+60 to 10+40, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



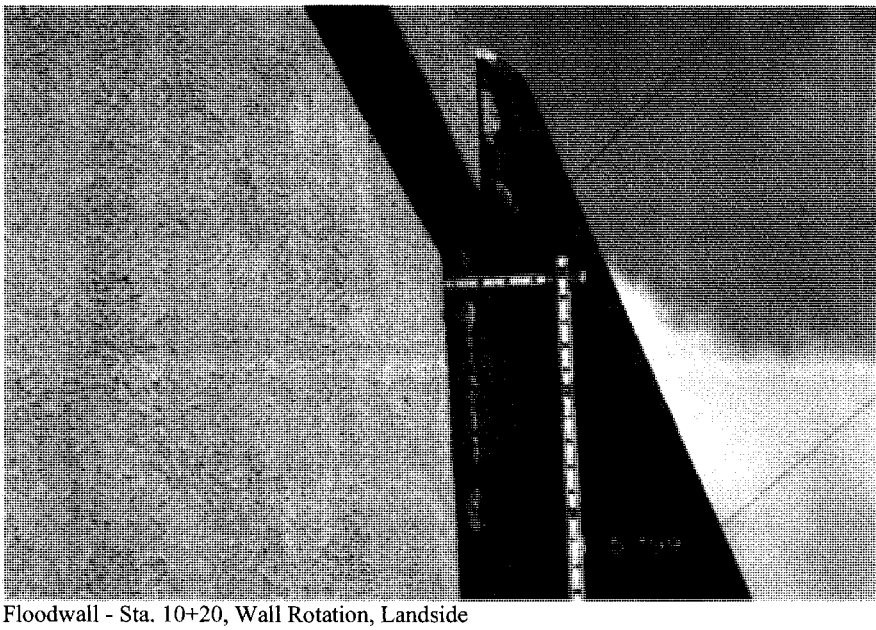
Floodwall - Sta. 9+60 to 10+40, Landside



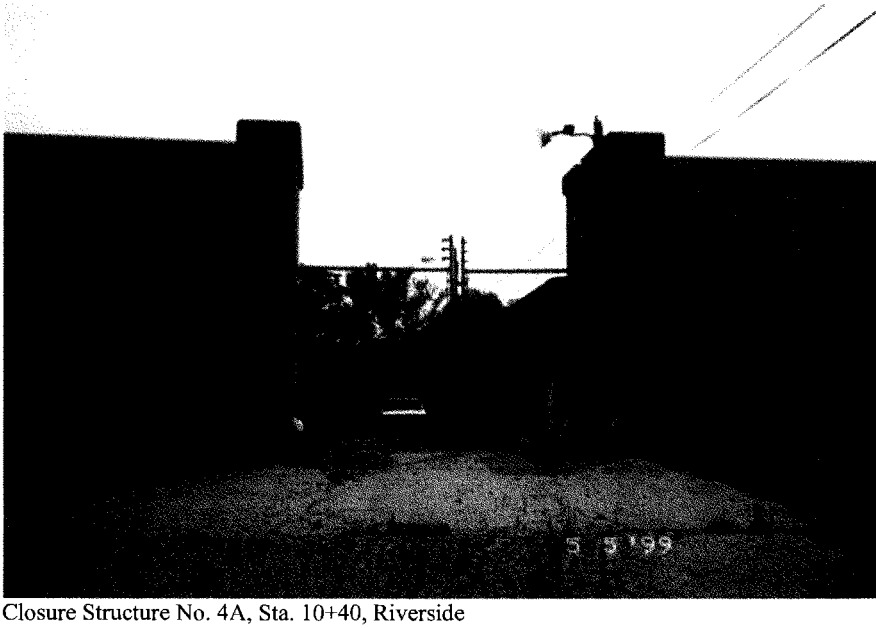
Floodwall - Sta. 10+20, Wall Rotation, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



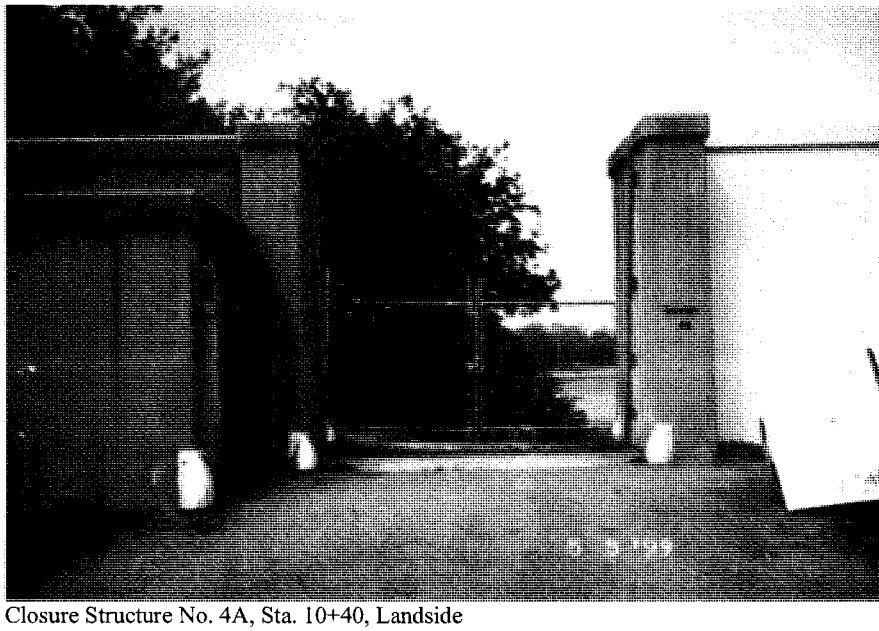
Floodwall - Sta. 10+20, Wall Rotation, Landside



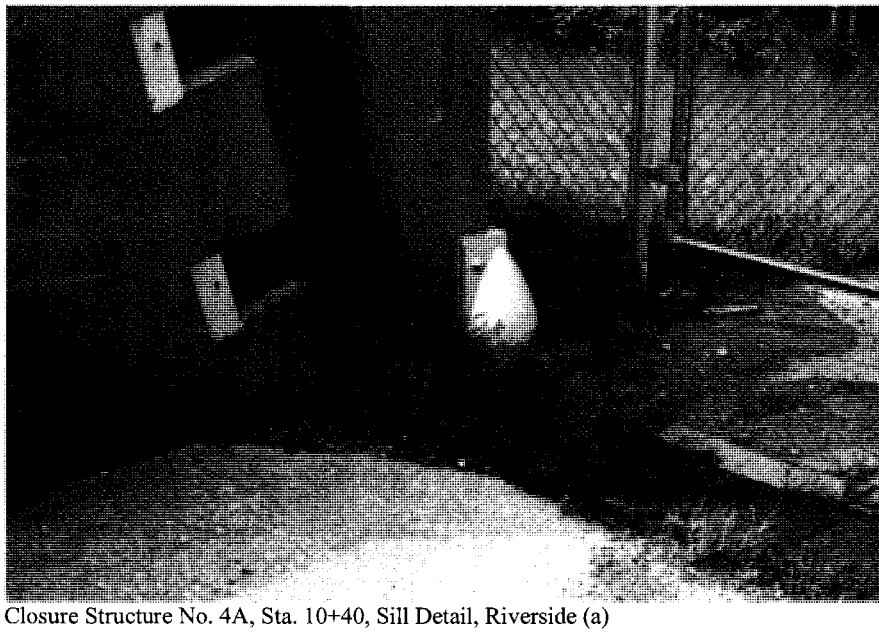
Closure Structure No. 4A, Sta. 10+40, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



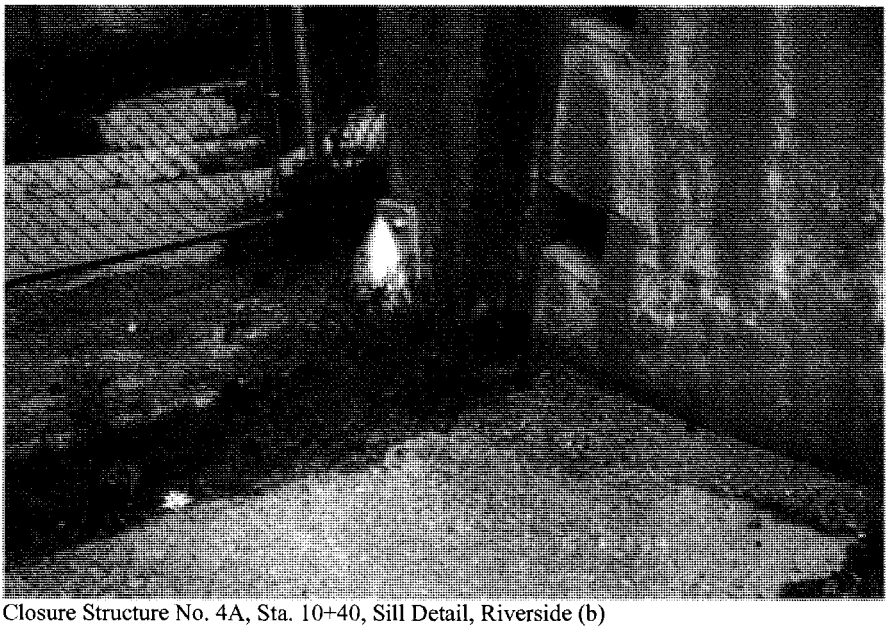
Closure Structure No. 4A, Sta. 10+40, Landside



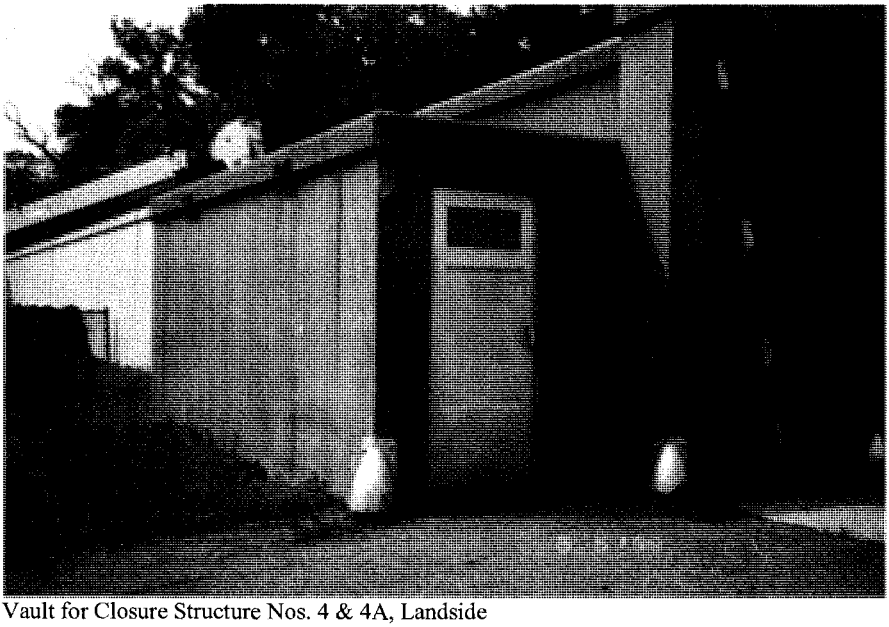
Closure Structure No. 4A, Sta. 10+40, Sill Detail, Riverside (a)

May 5 – 11, 1999

Paducah Floodwall Inspection



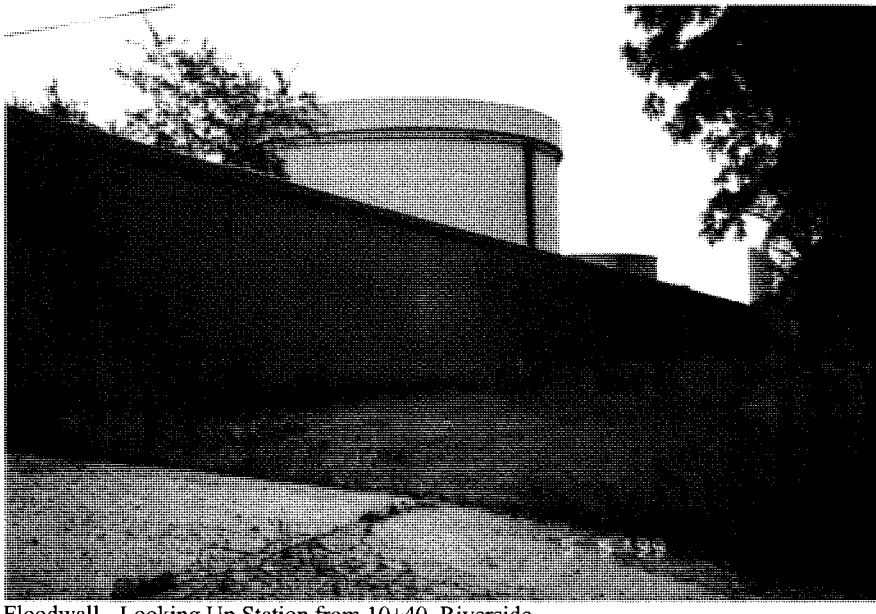
Closure Structure No. 4A, Sta. 10+40, Sill Detail, Riverside (b)



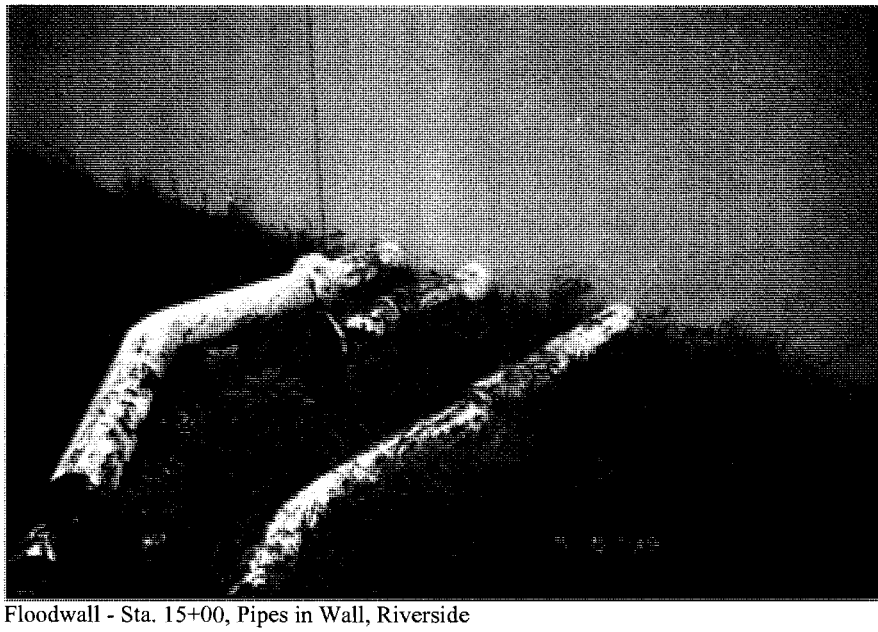
Vault for Closure Structure Nos. 4 & 4A, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



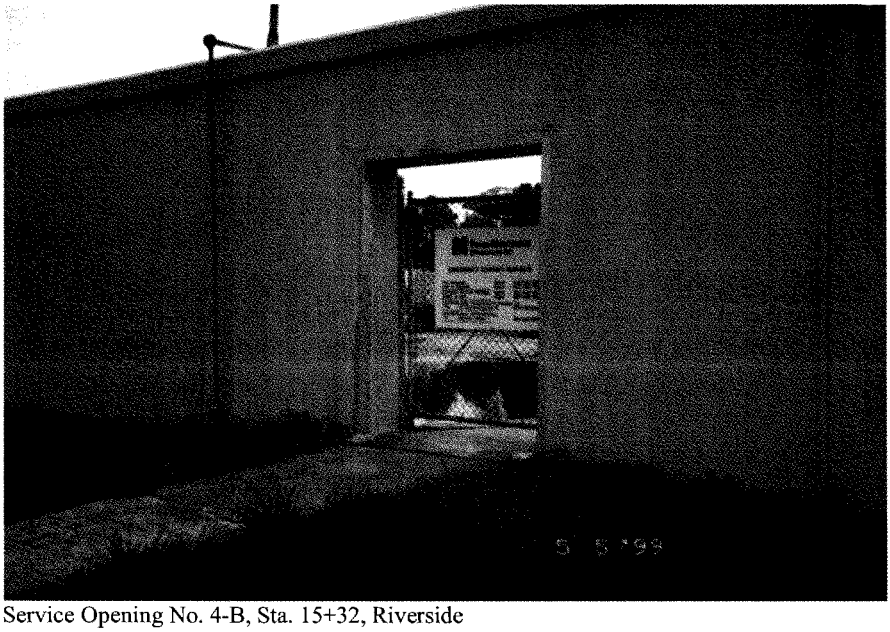
Floodwall - Looking Up Station from 10+40, Riverside



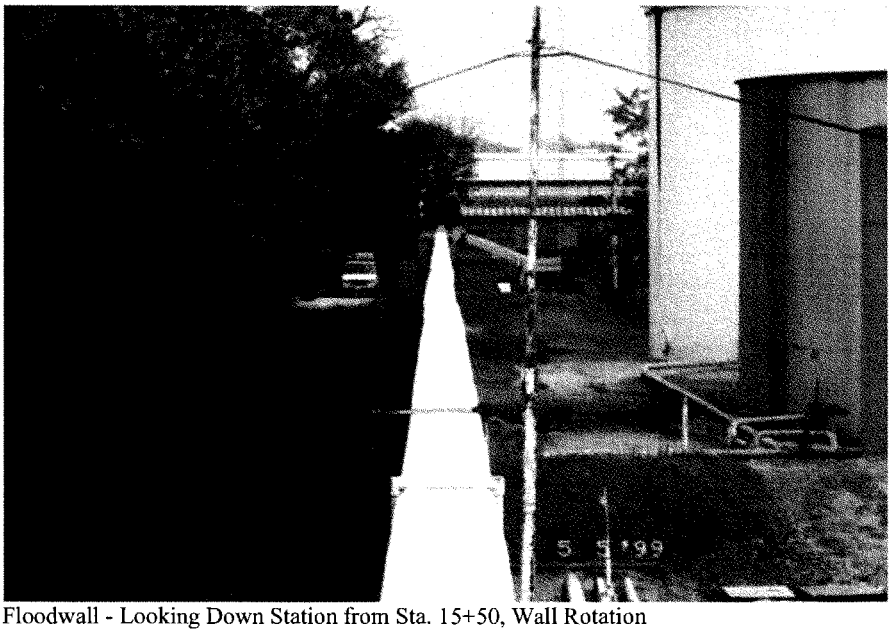
Floodwall - Sta. 15+00, Pipes in Wall, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



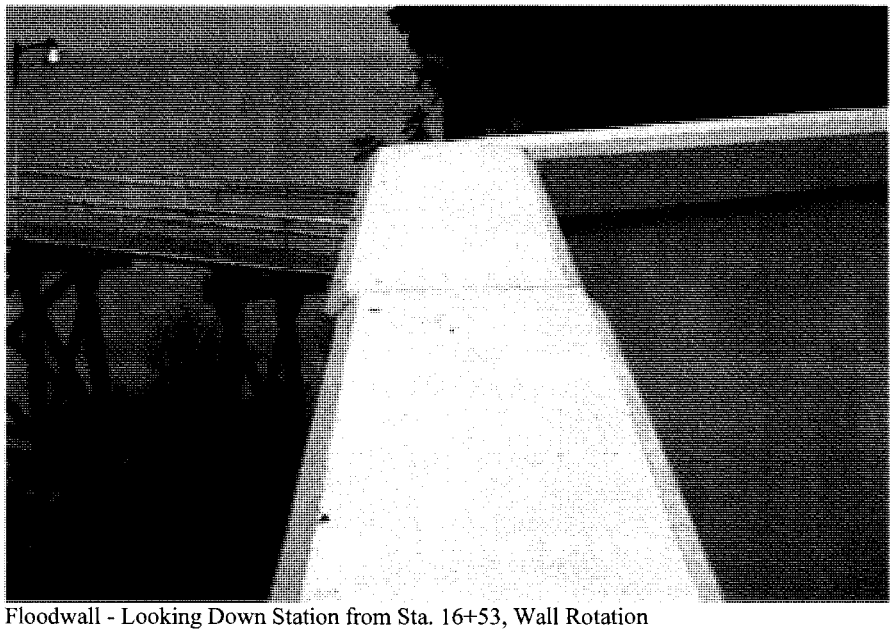
Service Opening No. 4-B, Sta. 15+32, Riverside



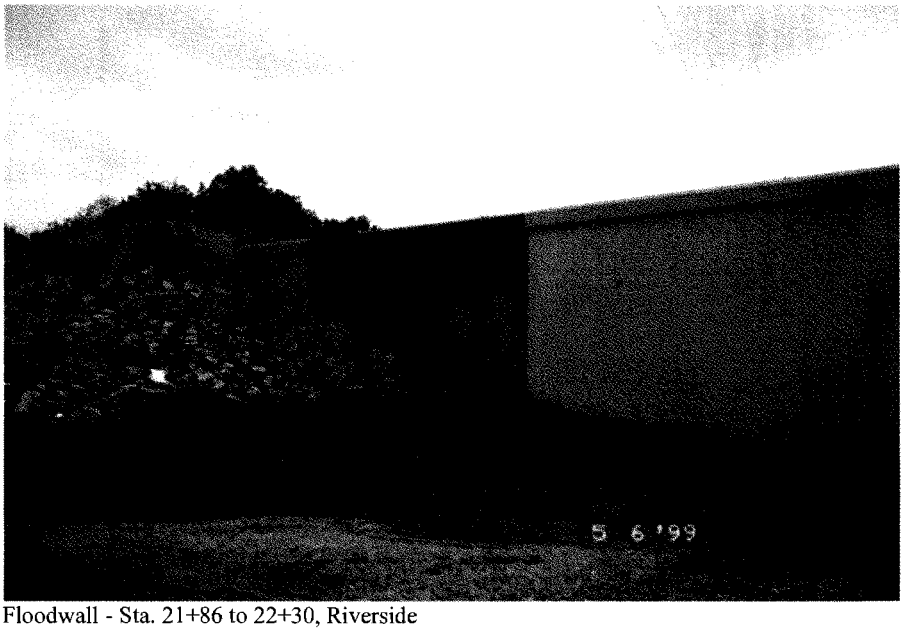
Floodwall - Looking Down Station from Sta. 15+50, Wall Rotation

May 5 – 11, 1999

Paducah Floodwall Inspection



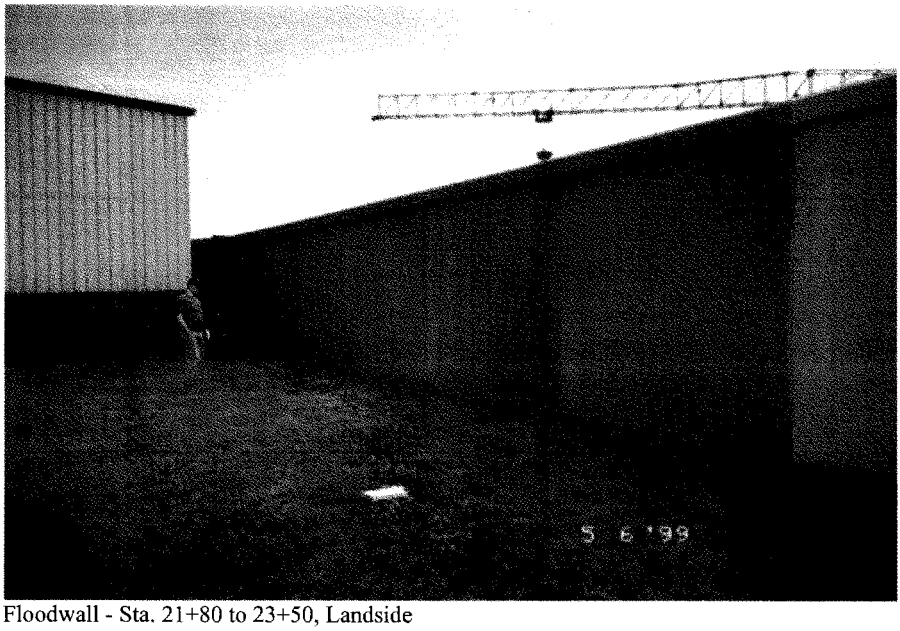
Floodwall - Looking Down Station from Sta. 16+53, Wall Rotation



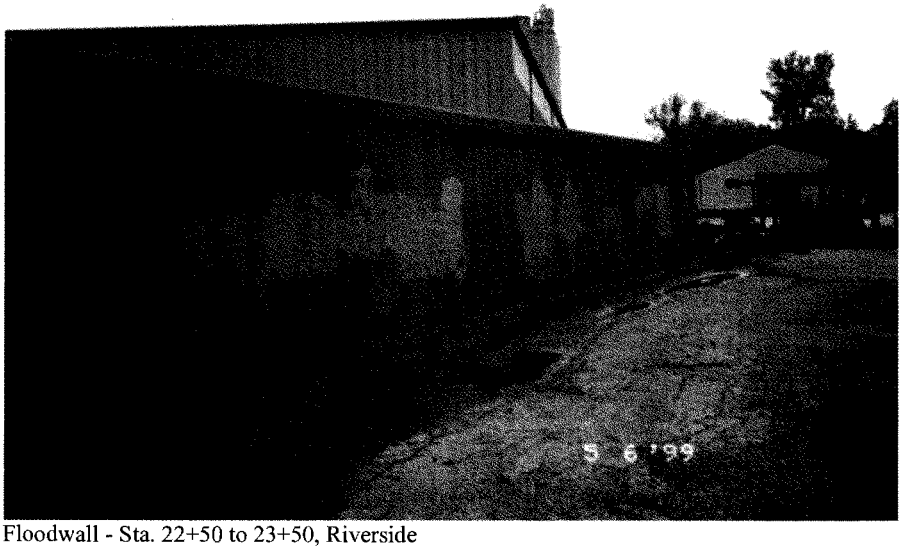
Floodwall - Sta. 21+86 to 22+30, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



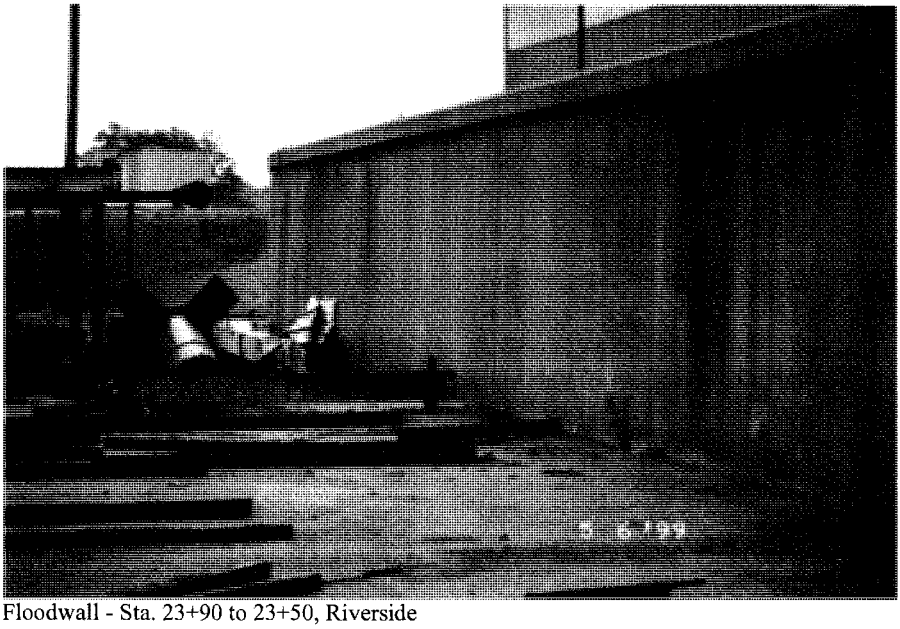
Floodwall - Sta. 21+80 to 23+50, Landside



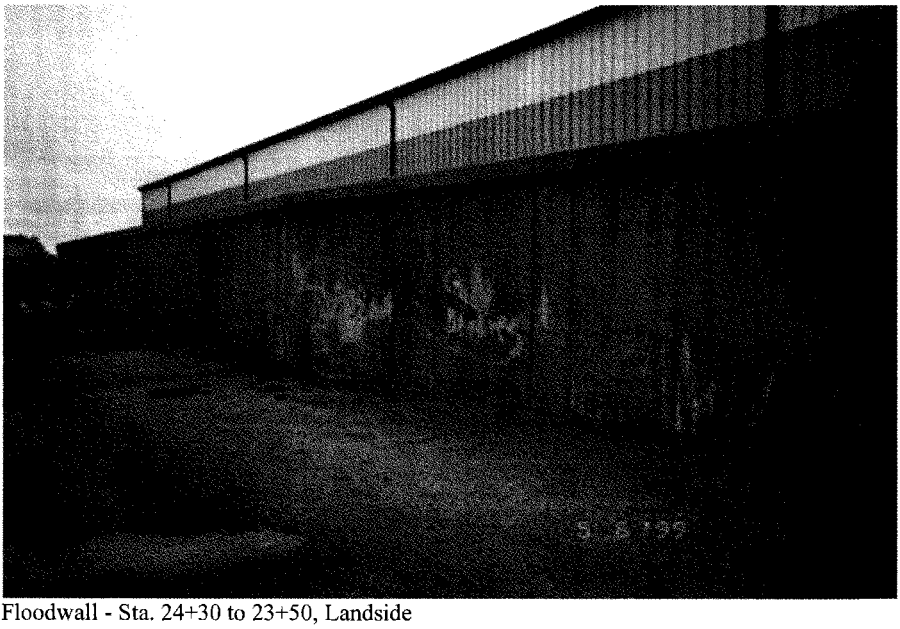
Floodwall - Sta. 22+50 to 23+50, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



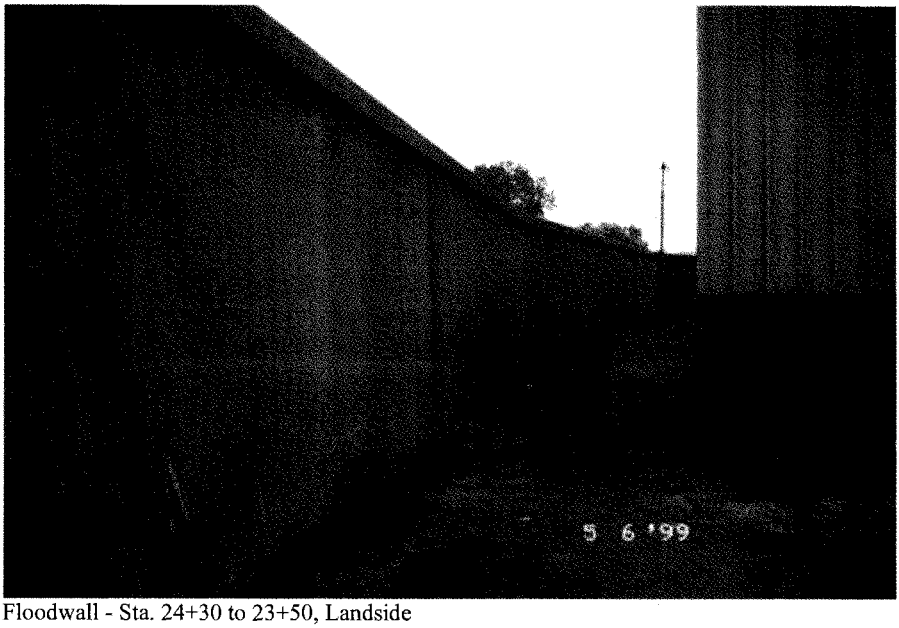
Floodwall - Sta. 23+90 to 23+50, Riverside



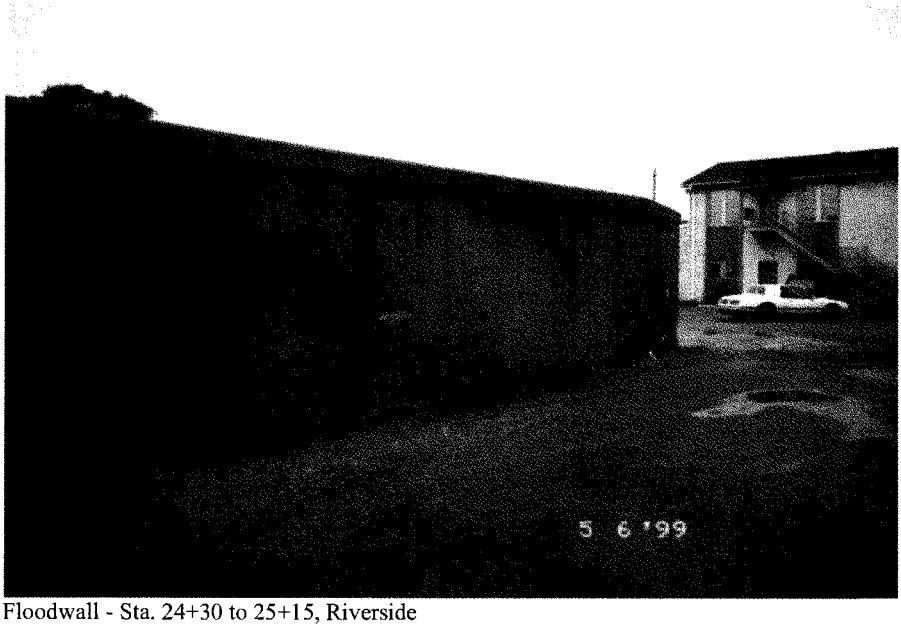
Floodwall - Sta. 24+30 to 23+50, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



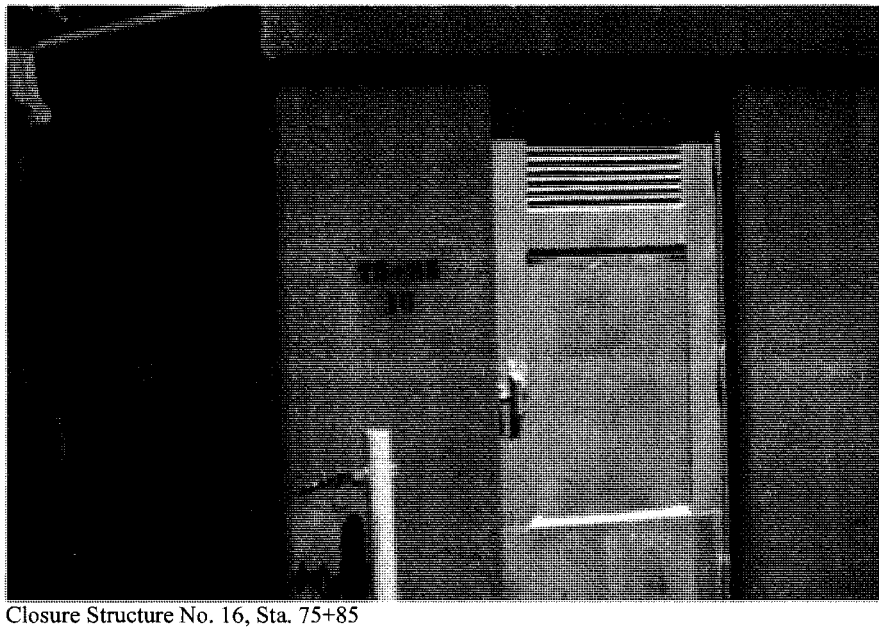
Floodwall - Sta. 24+30 to 23+50, Landside



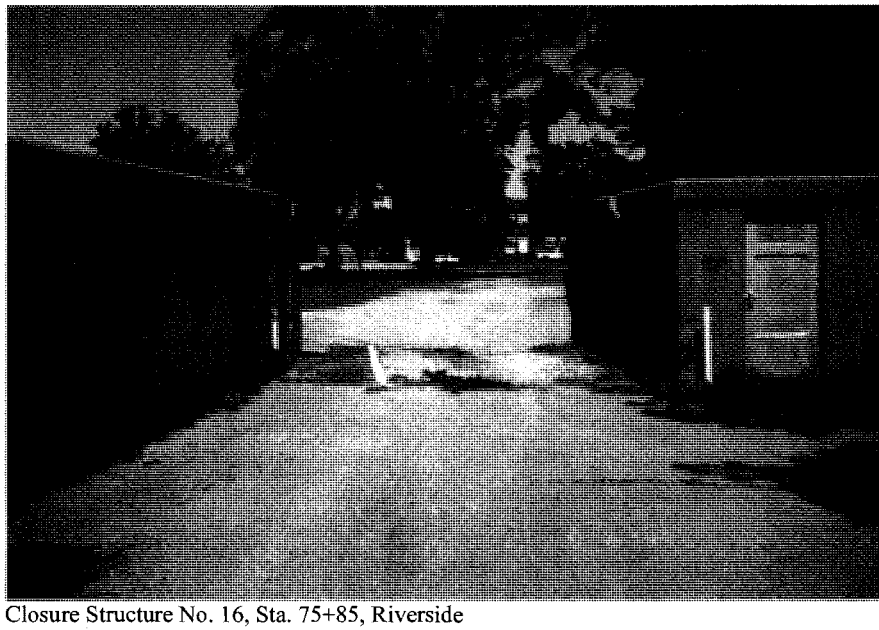
Floodwall - Sta. 24+30 to 25+15, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



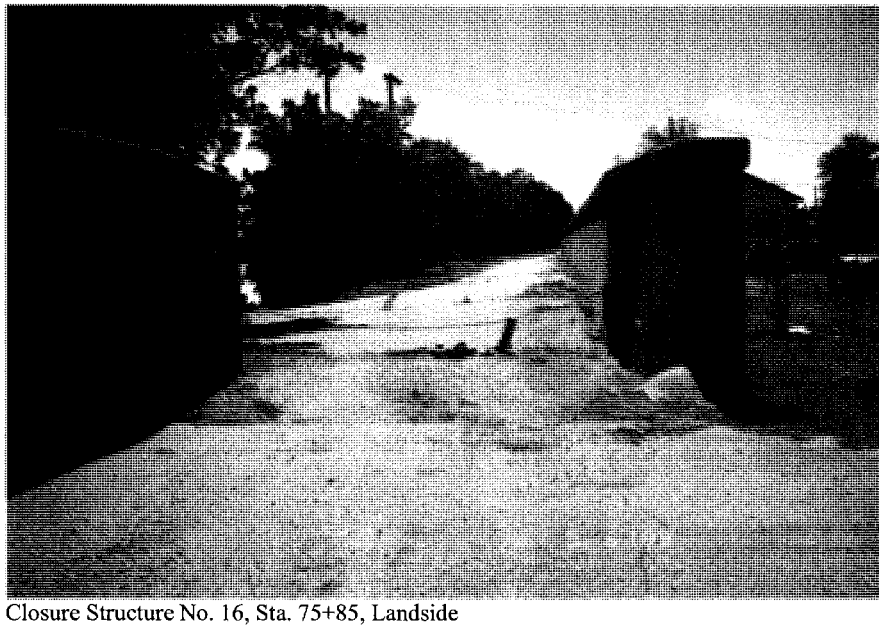
Closure Structure No. 16, Sta. 75+85



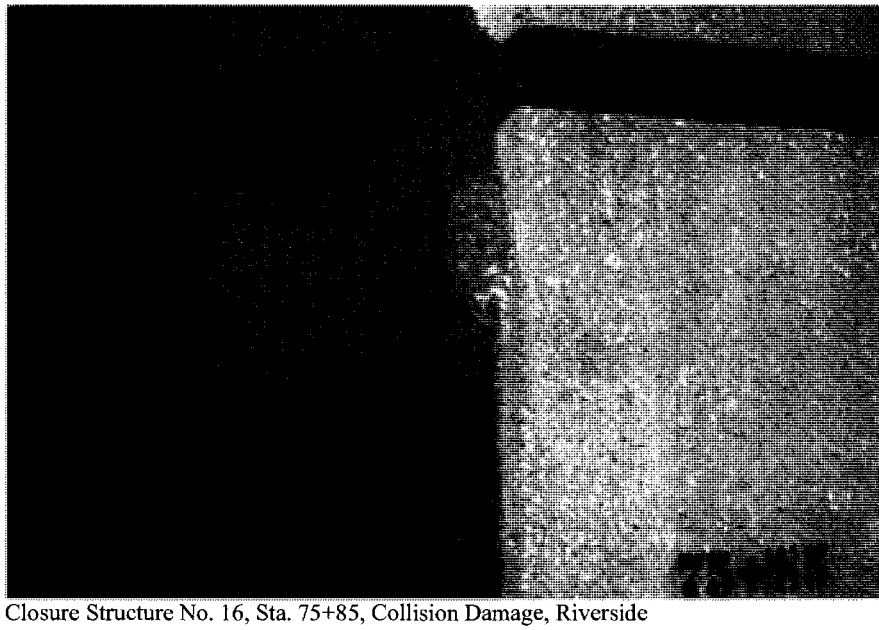
Closure Structure No. 16, Sta. 75+85, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



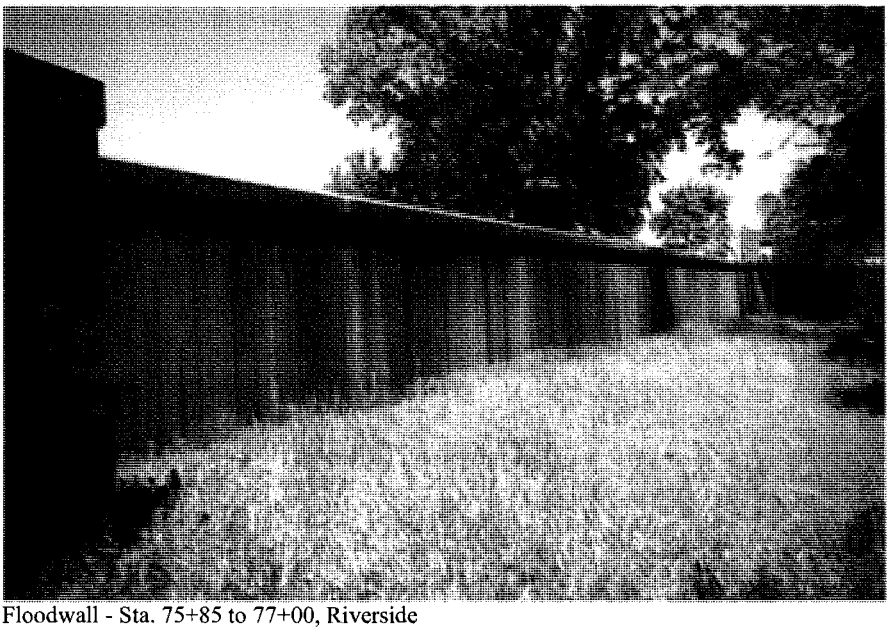
Closure Structure No. 16, Sta. 75+85, Landside



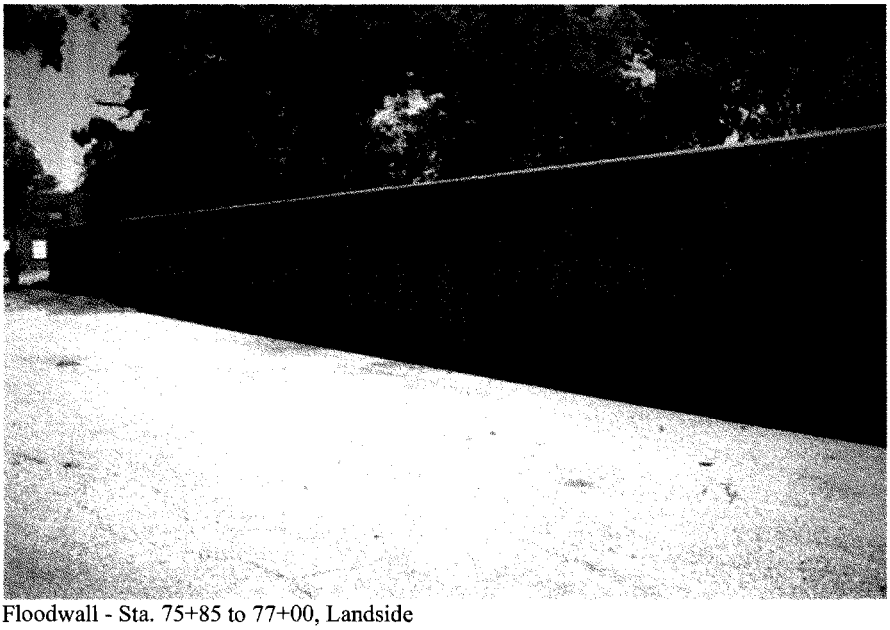
Closure Structure No. 16, Sta. 75+85, Collision Damage, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



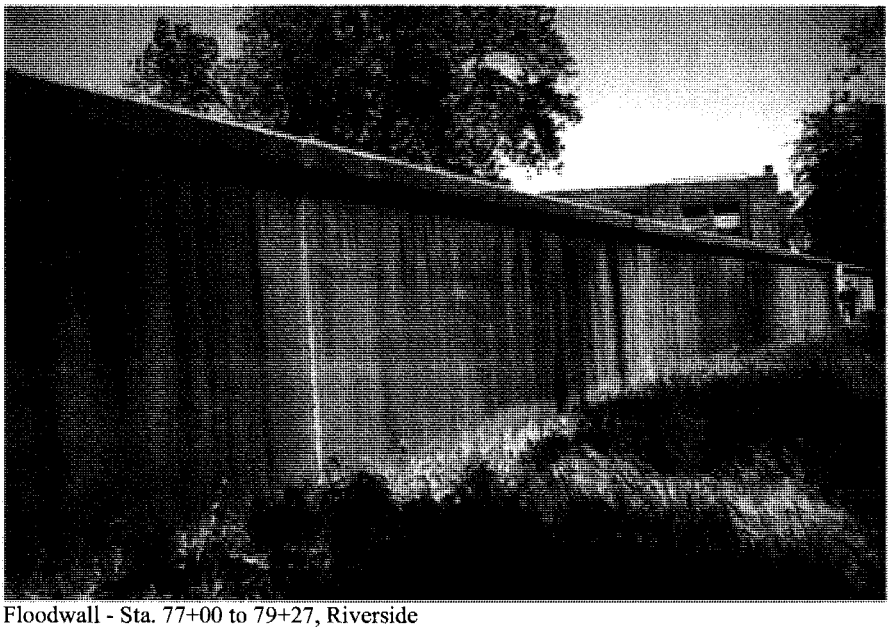
Floodwall - Sta. 75+85 to 77+00, Riverside



Floodwall - Sta. 75+85 to 77+00, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection

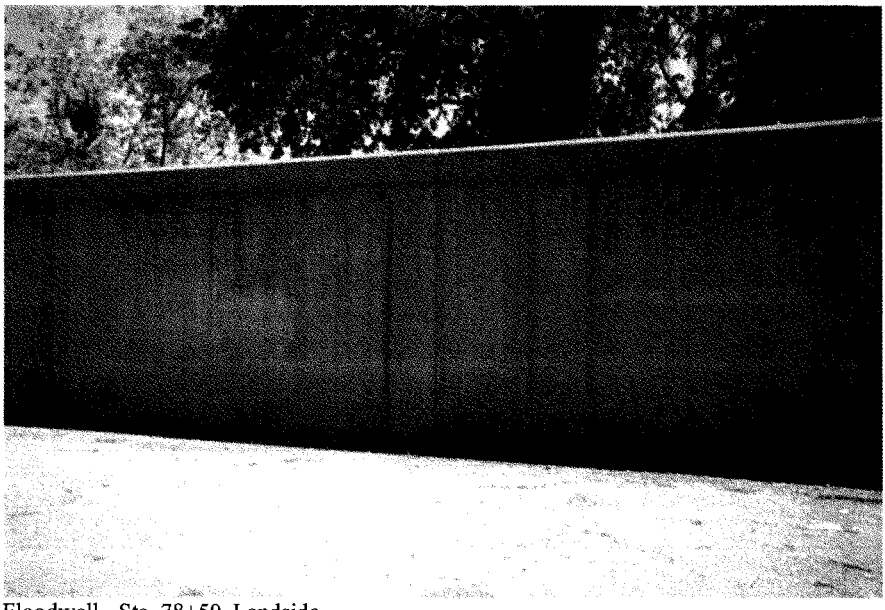


Floodwall - Sta. 77+00 to 79+27, Riverside

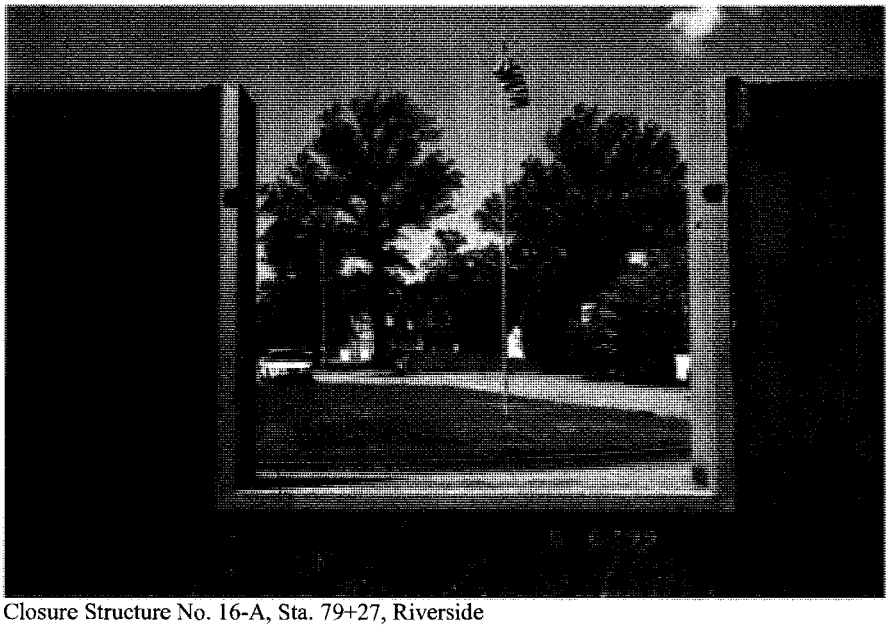
Floodwall - Sta. 77+00 to 79+27, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



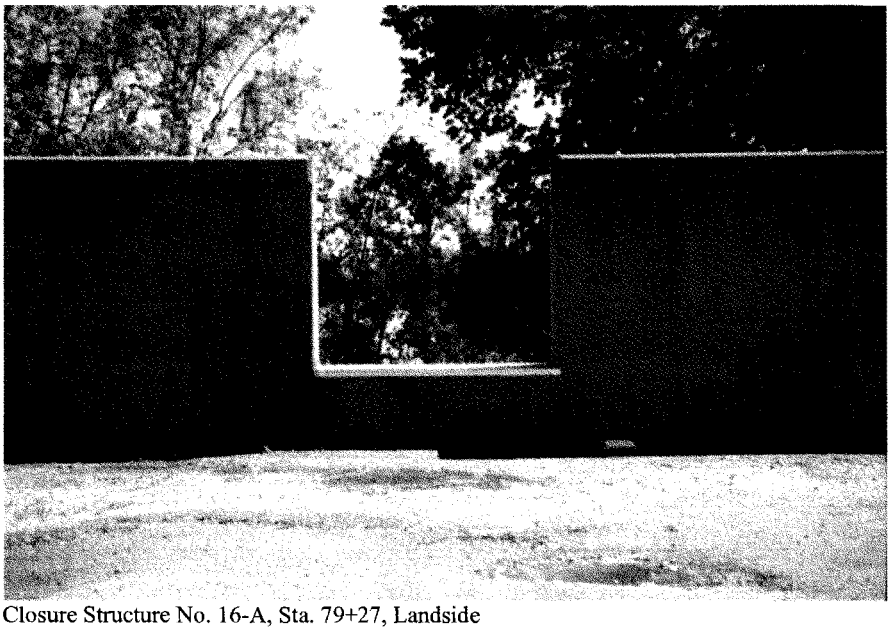
Floodwall - Sta. 78+50, Landside



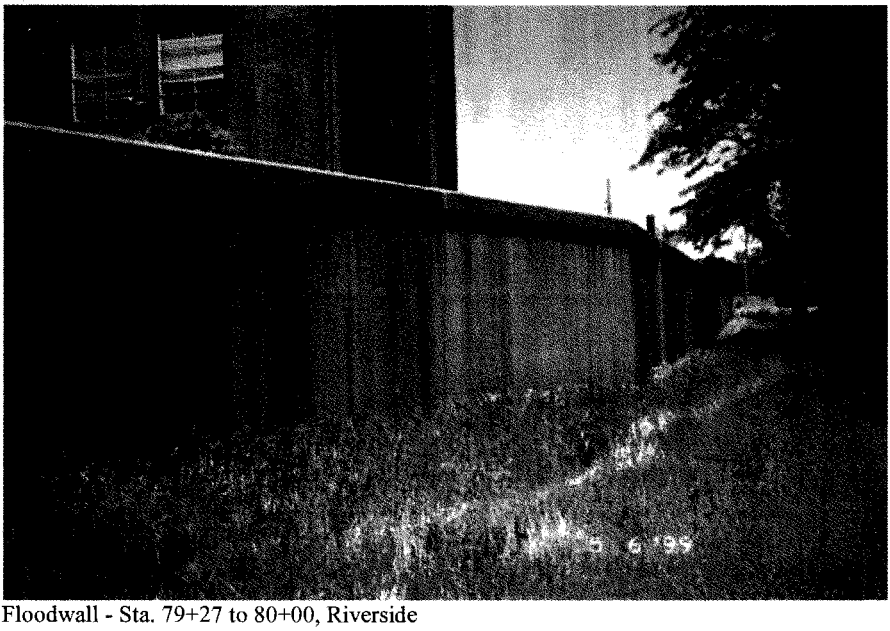
Closure Structure No. 16-A, Sta. 79+27, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



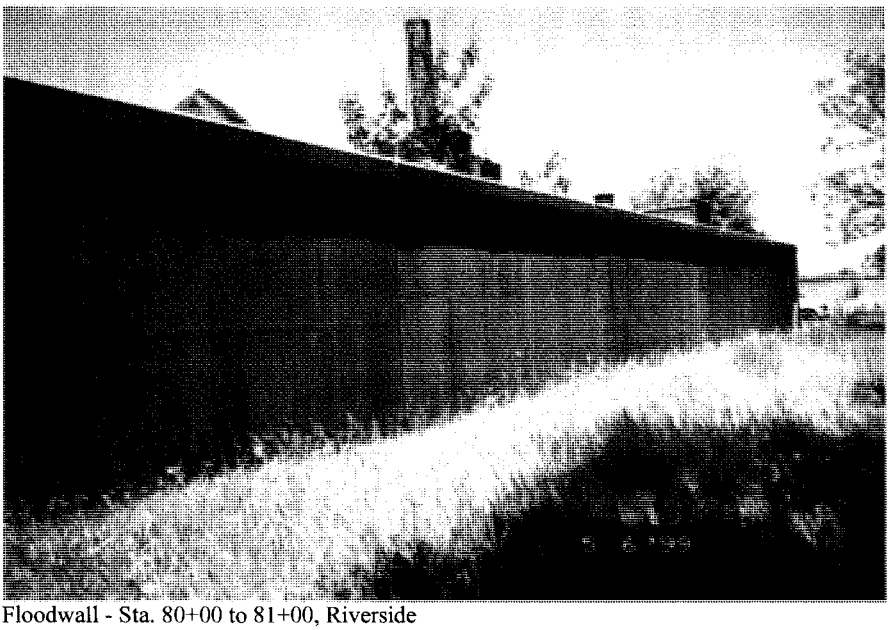
Closure Structure No. 16-A, Sta. 79+27, Landside



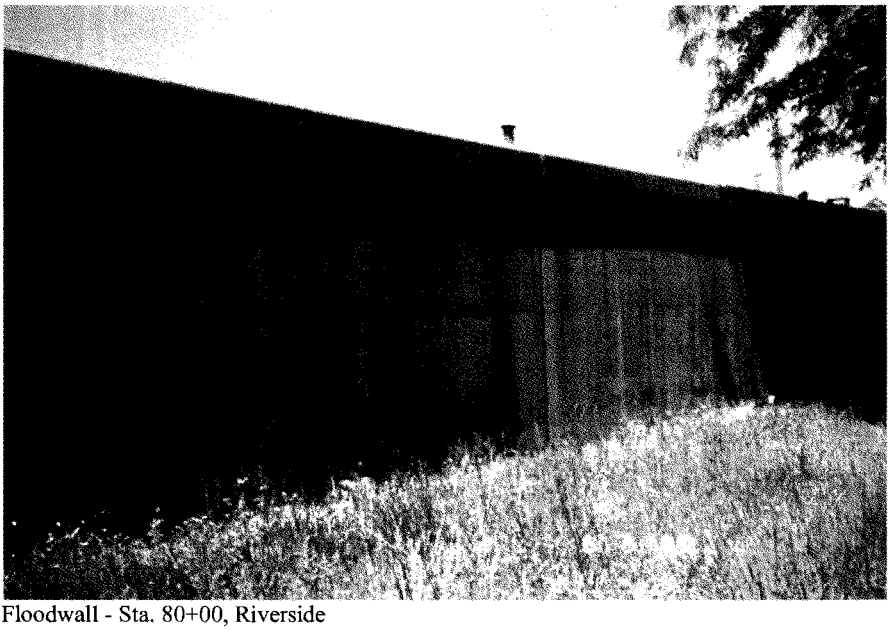
Floodwall - Sta. 79+27 to 80+00, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



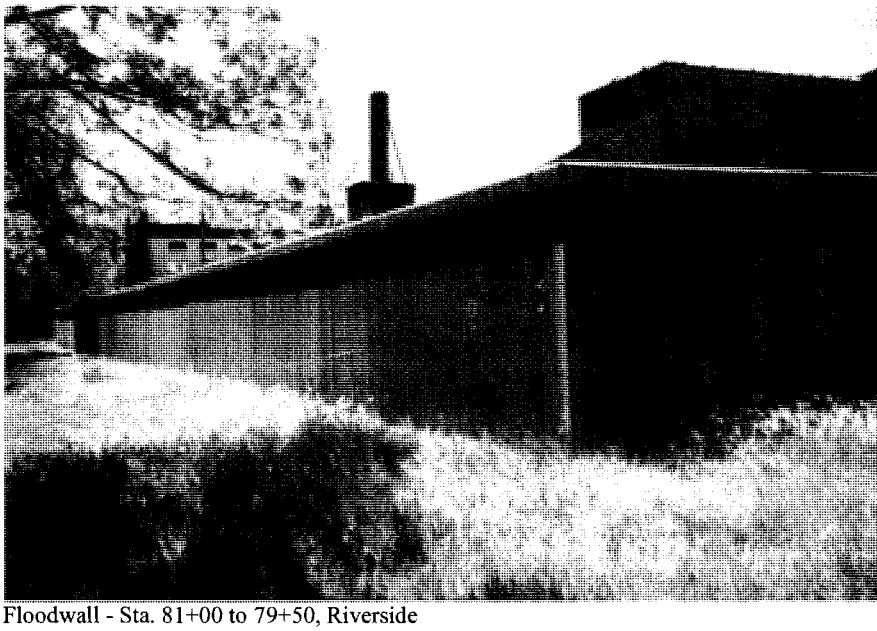
Floodwall - Sta. 80+00 to 81+00, Riverside



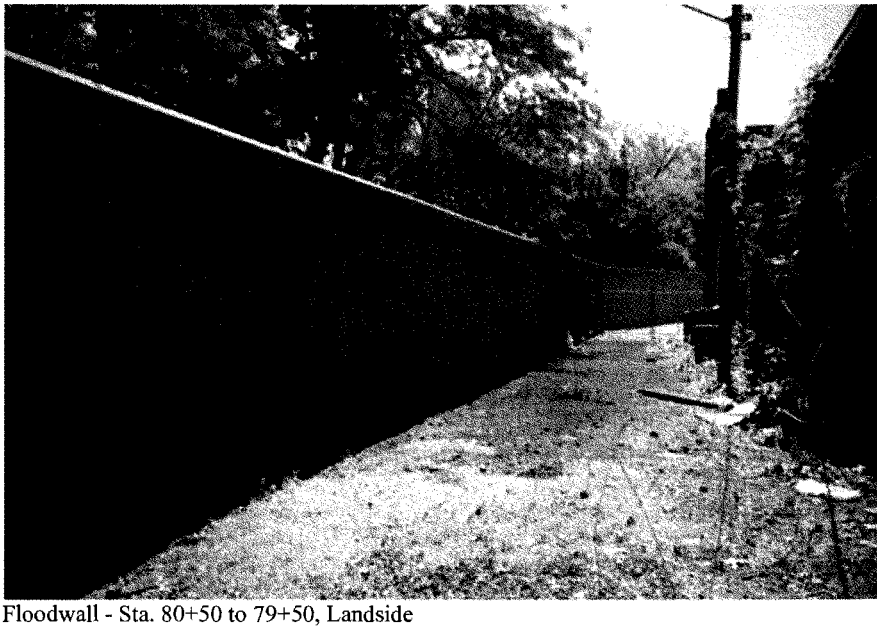
Floodwall - Sta. 80+00, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



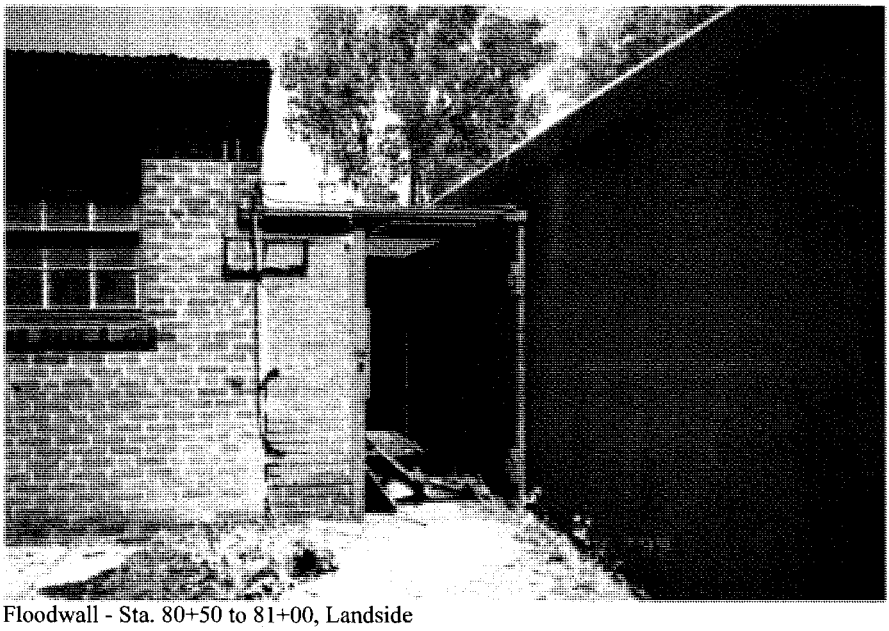
Floodwall - Sta. 81+00 to 79+50, Riverside



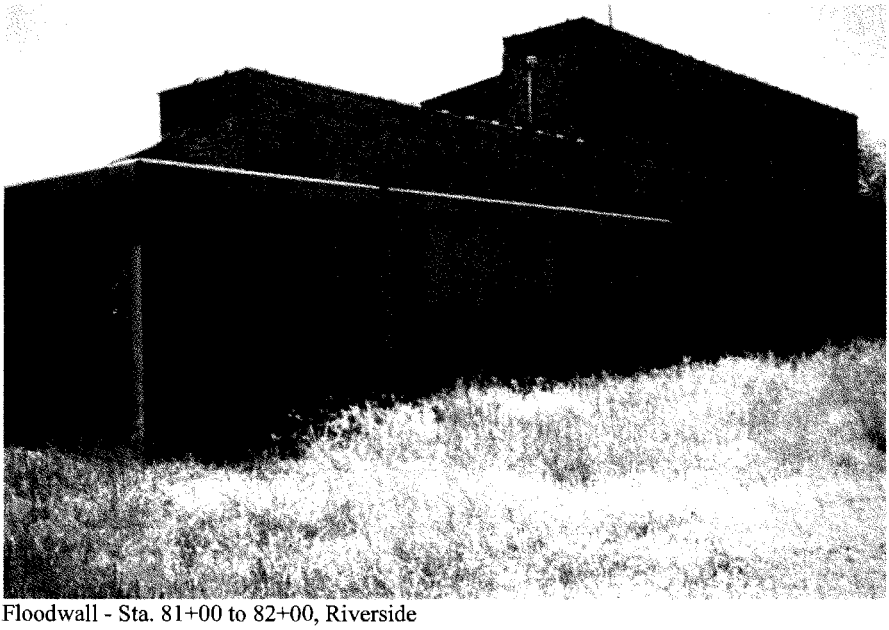
Floodwall - Sta. 80+50 to 79+50, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



Floodwall - Sta. 80+50 to 81+00, Landside

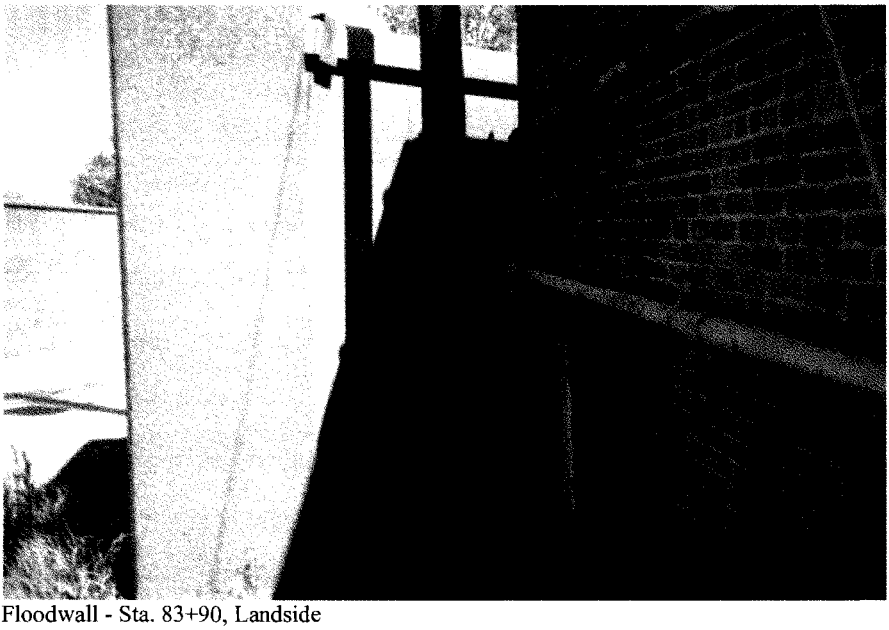


Floodwall - Sta. 81+00 to 82+00, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection

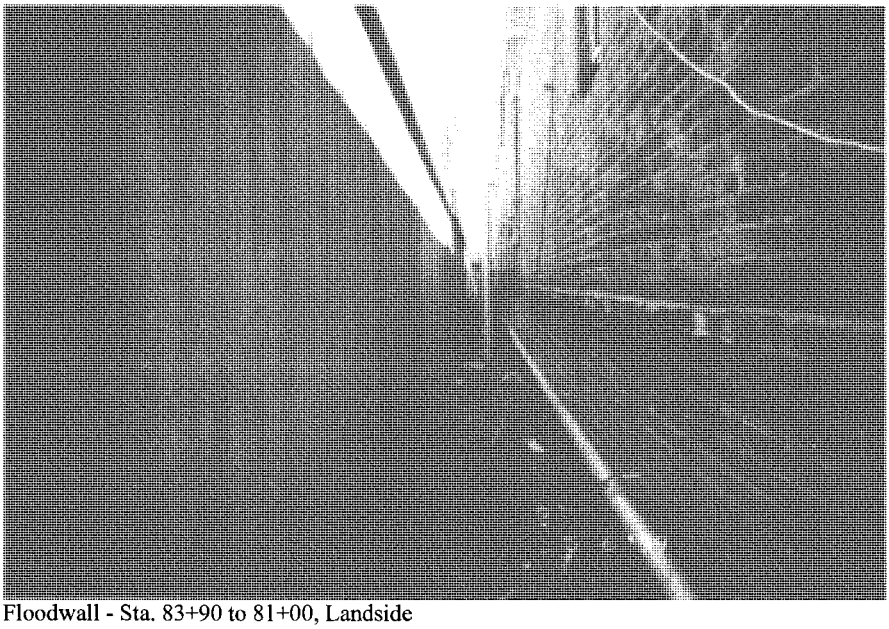
Floodwall - Sta. 81+50 to 83+92, Riverside



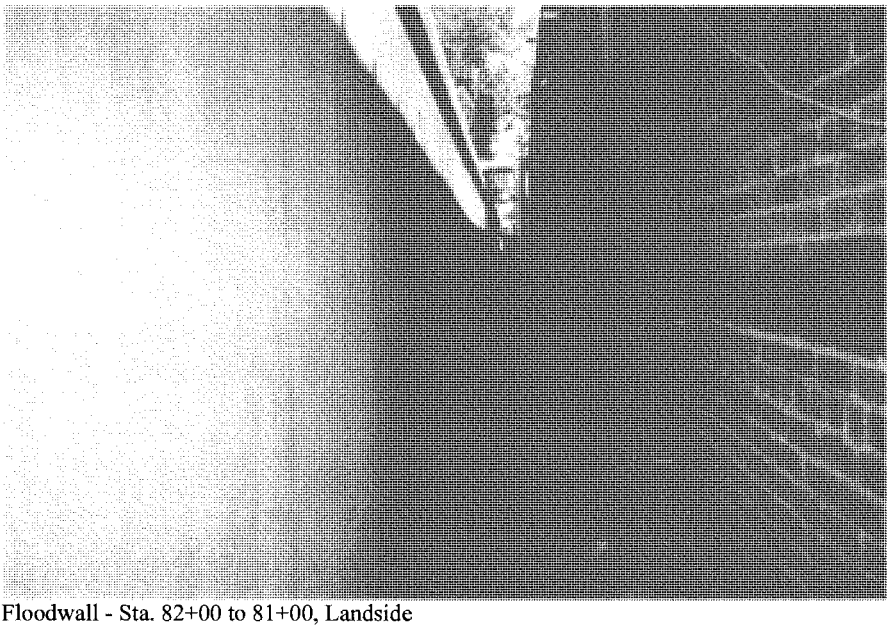
Floodwall - Sta. 83+90, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



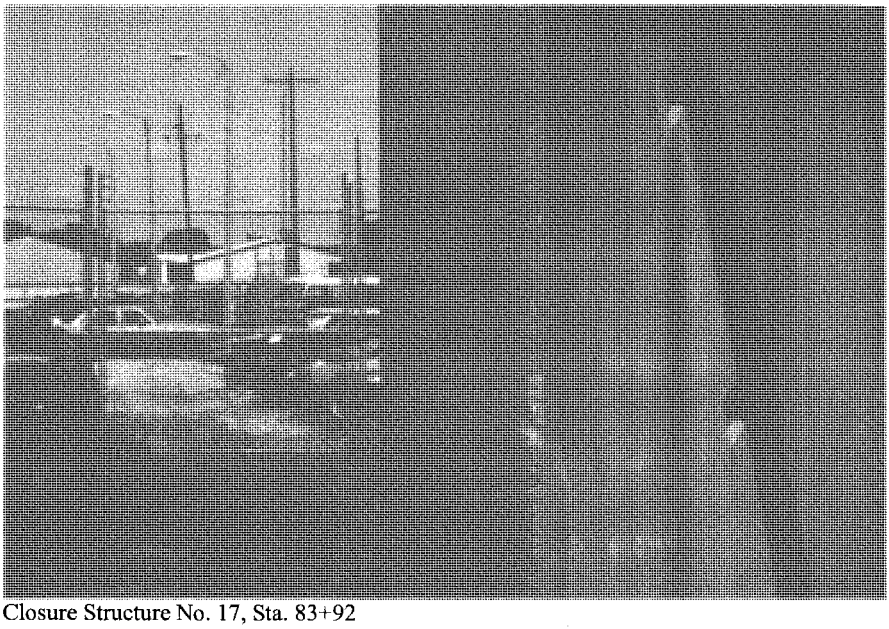
Floodwall - Sta. 83+90 to 81+00, Landside



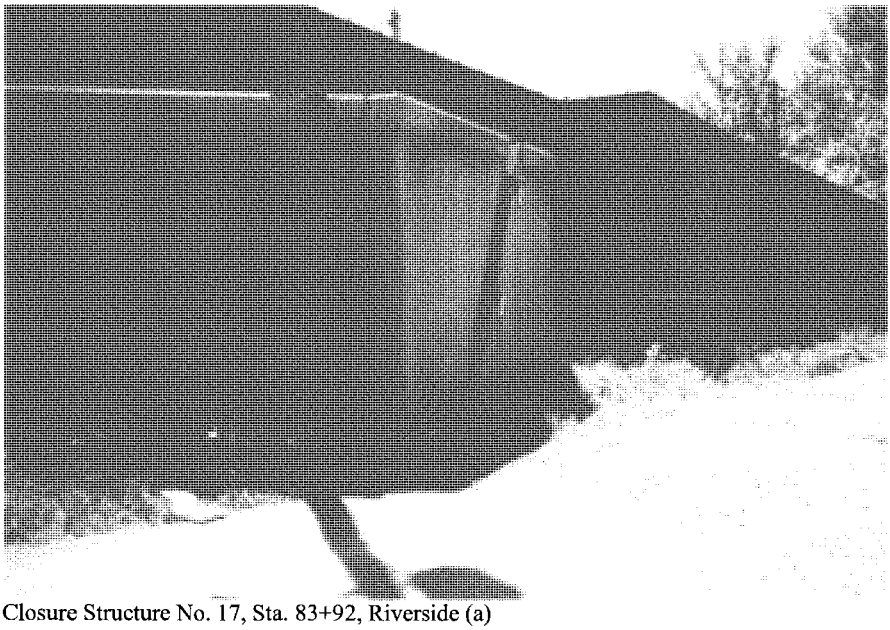
Floodwall - Sta. 82+00 to 81+00, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



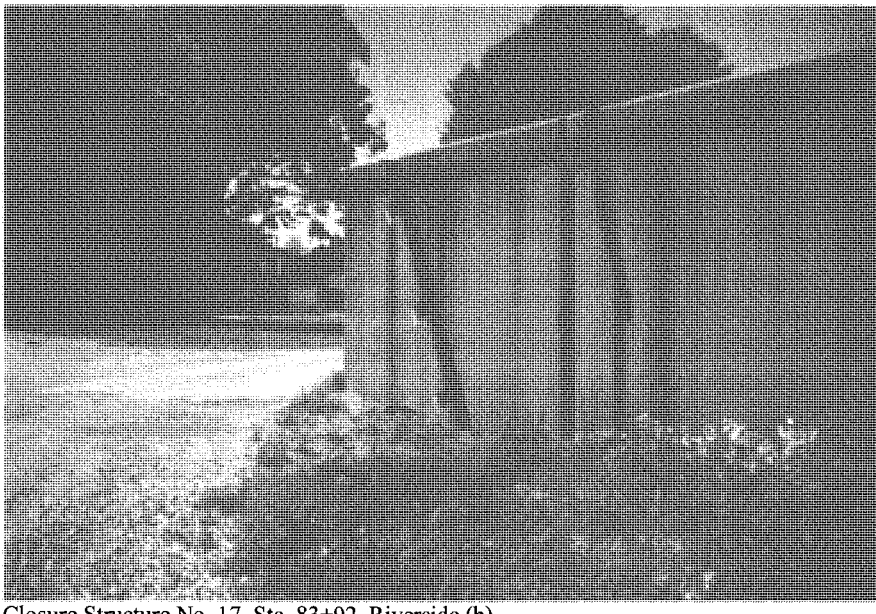
Closure Structure No. 17, Sta. 83+92



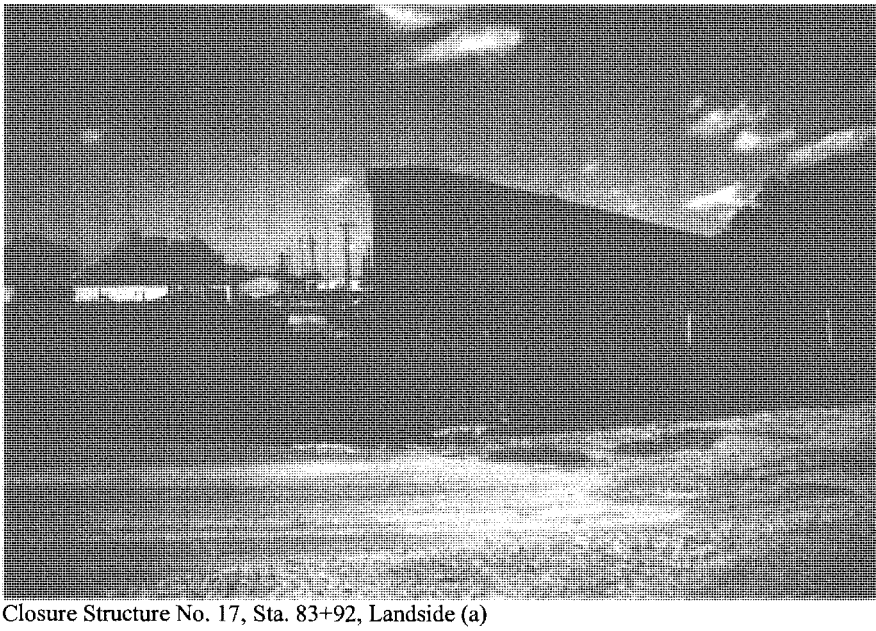
Closure Structure No. 17, Sta. 83+92, Riverside (a)

May 5 – 11, 1999

Paducah Floodwall Inspection



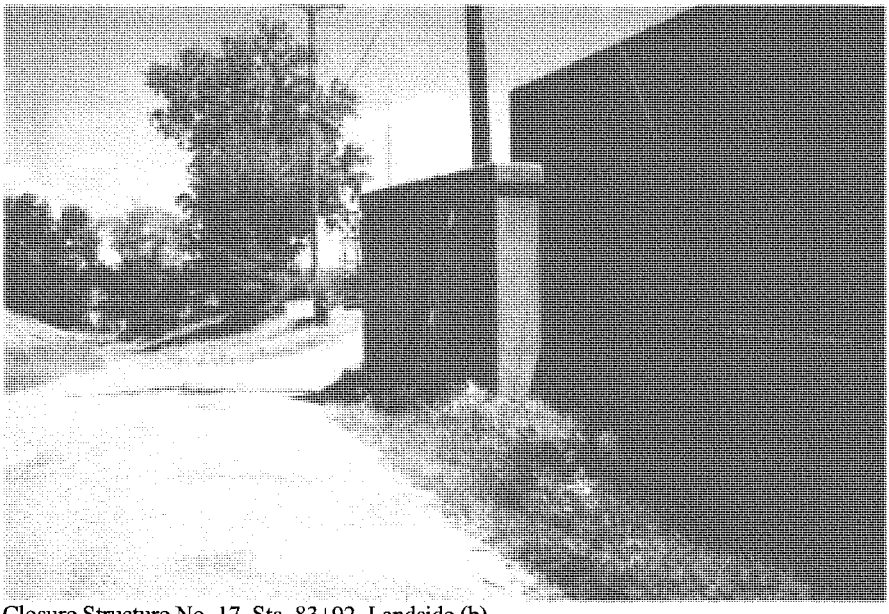
Closure Structure No. 17, Sta. 83+92, Riverside (b)



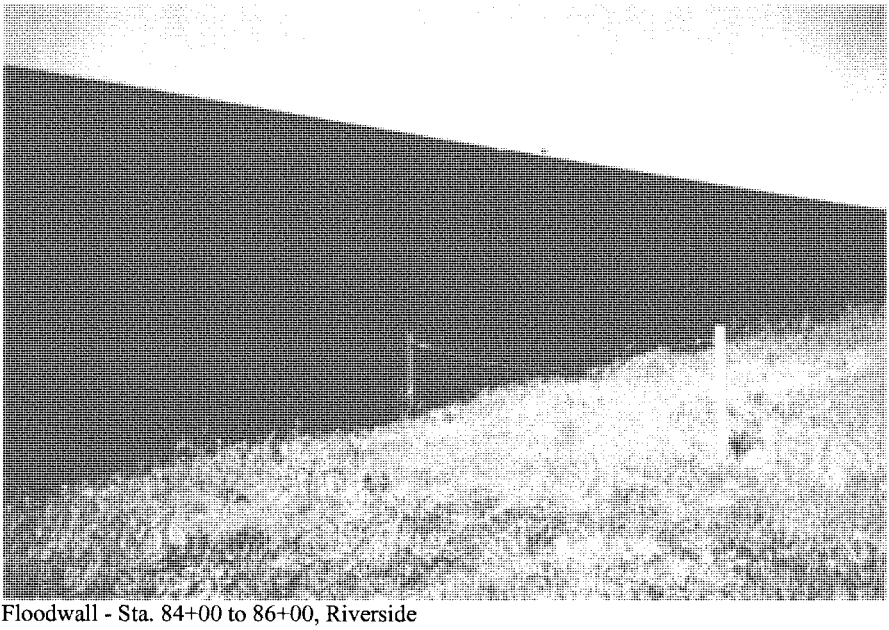
Closure Structure No. 17, Sta. 83+92, Landside (a)

May 5 – 11, 1999

Paducah Floodwall Inspection



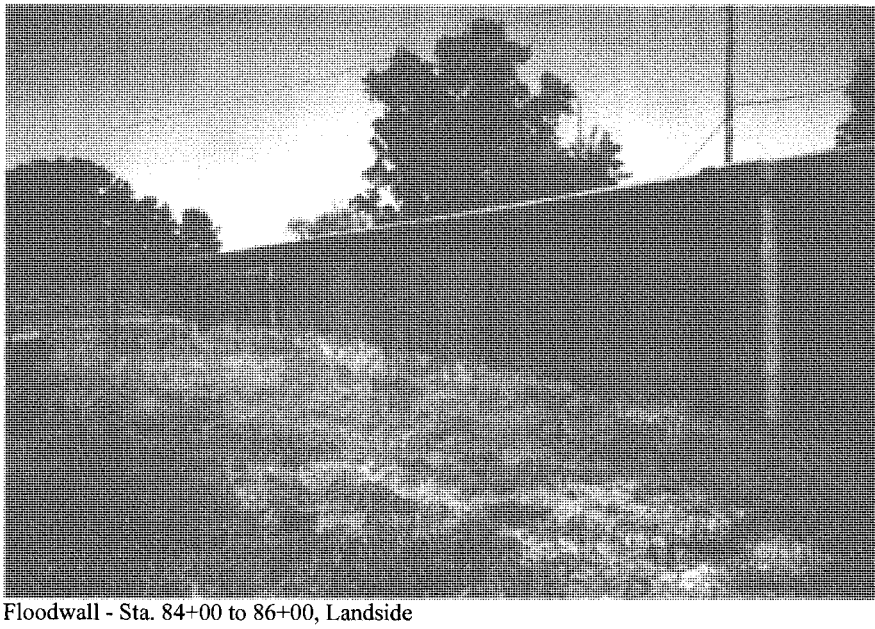
Closure Structure No. 17, Sta. 83+92, Landside (b)



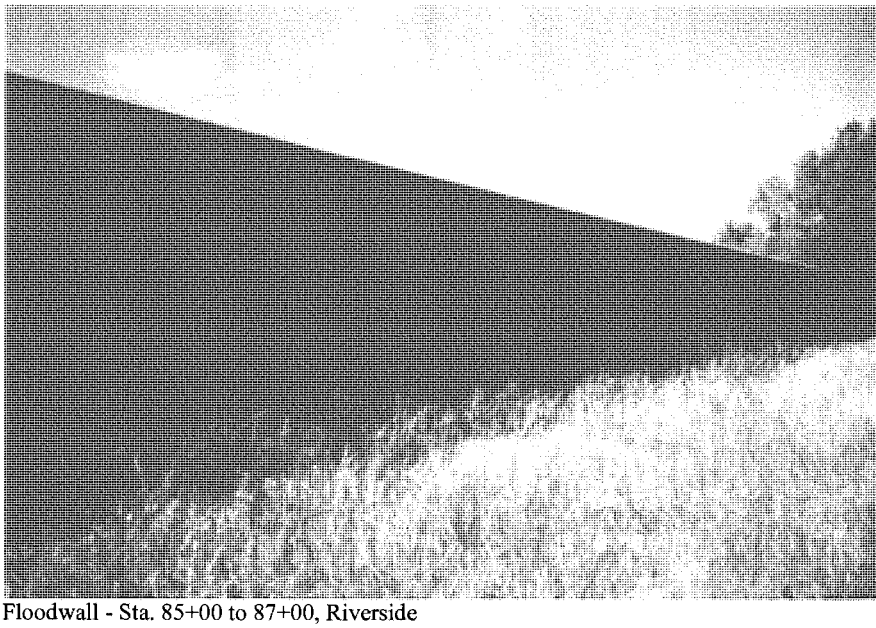
Floodwall - Sta. 84+00 to 86+00, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



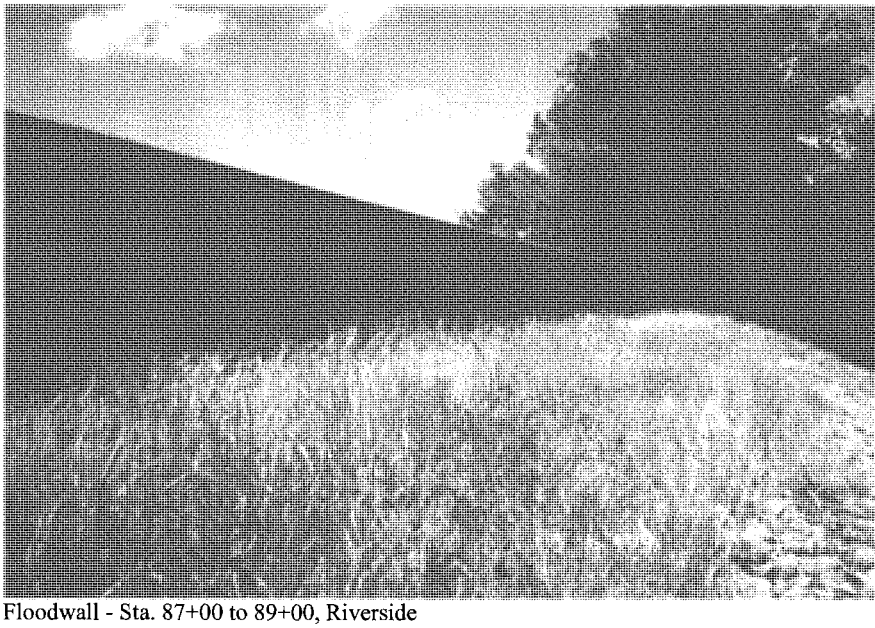
Floodwall - Sta. 84+00 to 86+00, Landside



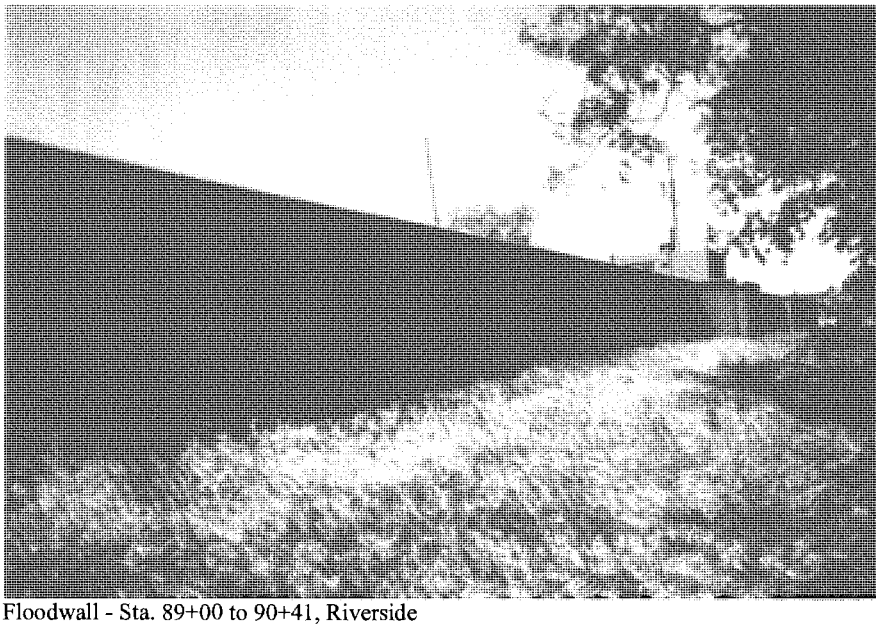
Floodwall - Sta. 85+00 to 87+00, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



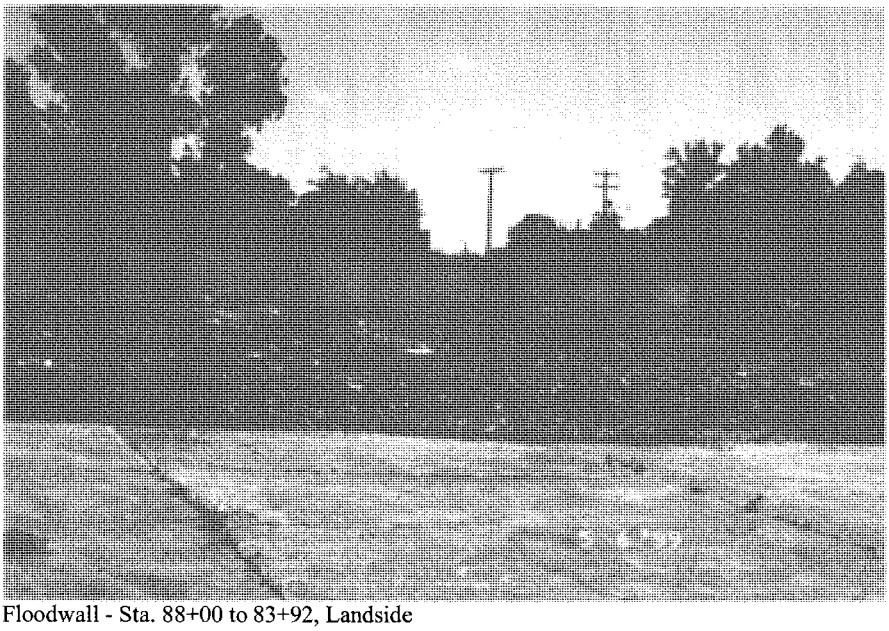
Floodwall - Sta. 87+00 to 89+00, Riverside



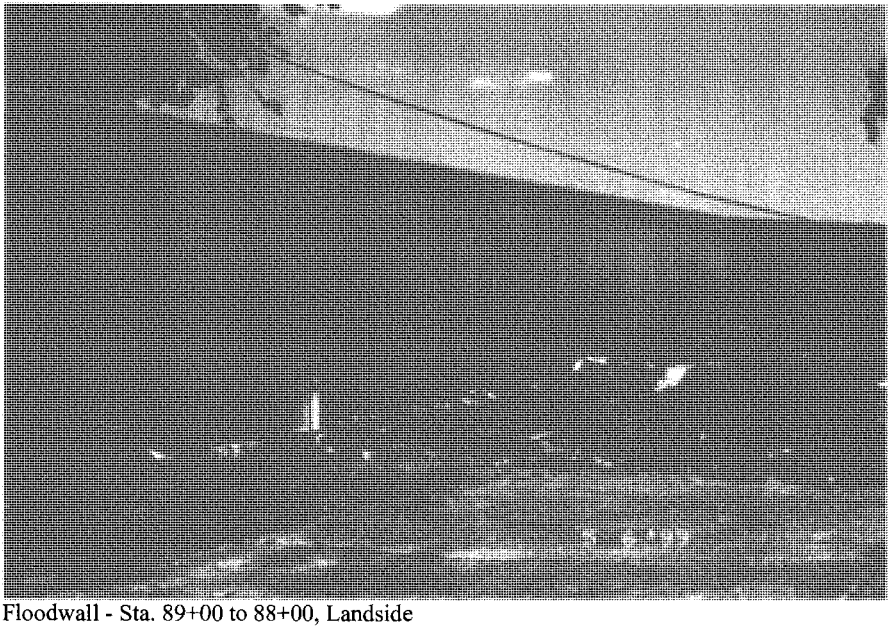
Floodwall - Sta. 89+00 to 90+41, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



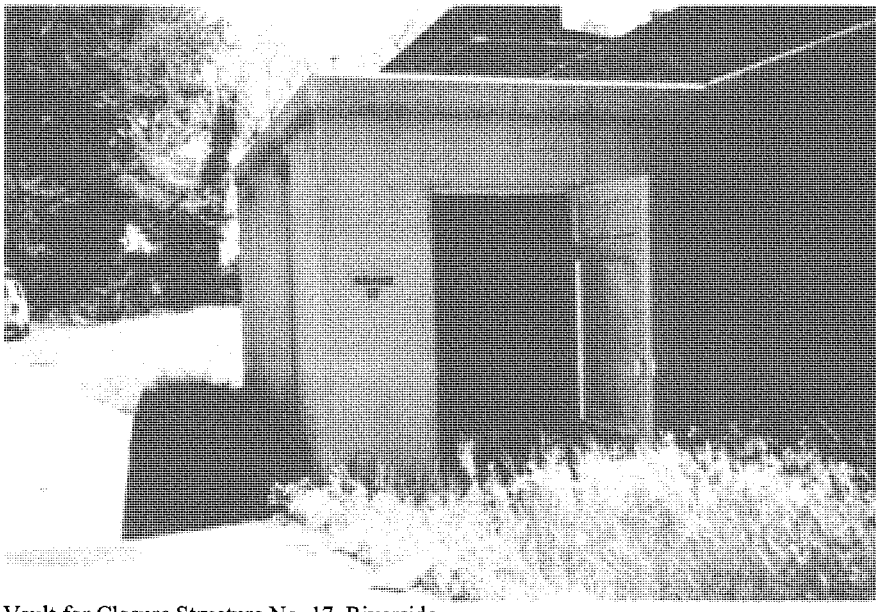
Floodwall - Sta. 88+00 to 83+92, Landside



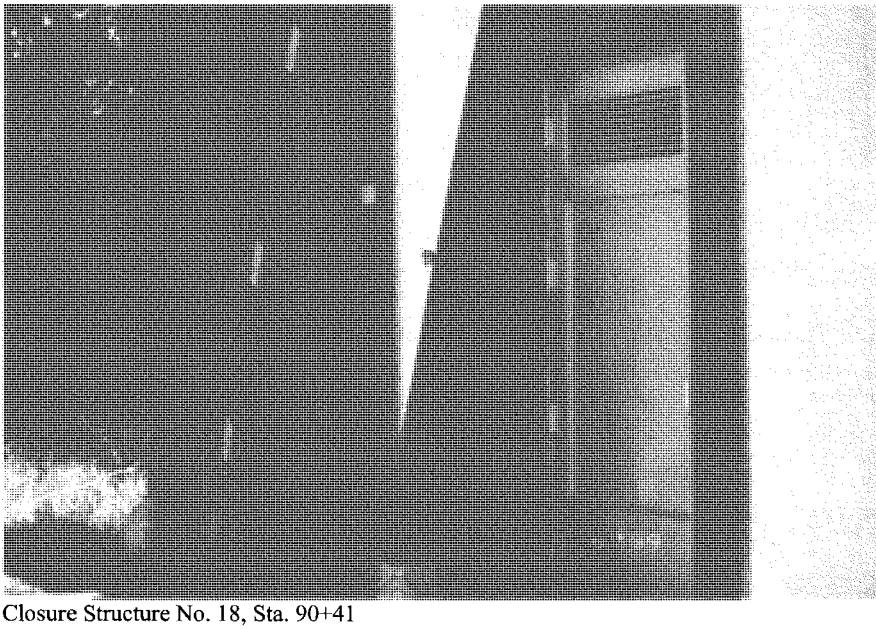
Floodwall - Sta. 89+00 to 88+00, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



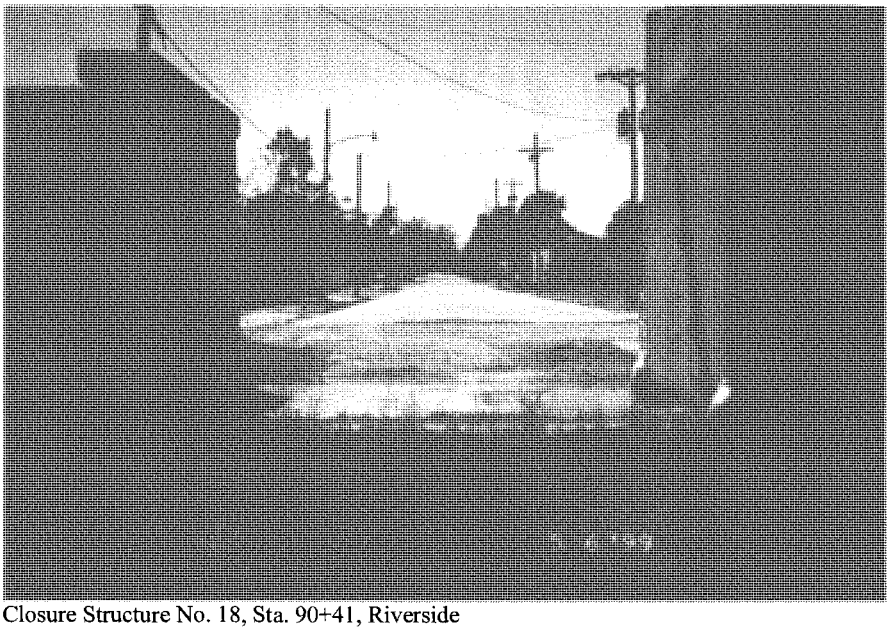
Vault for Closure Structure No. 17, Riverside



Closure Structure No. 18, Sta. 90+41

May 5 – 11, 1999

Paducah Floodwall Inspection

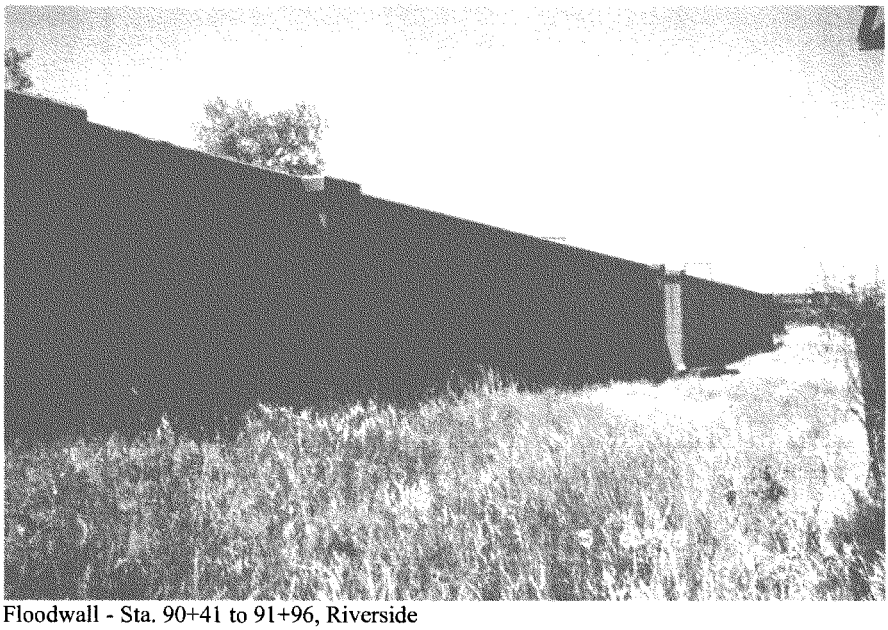


Closure Structure No. 18, Sta. 90+41, Riverside

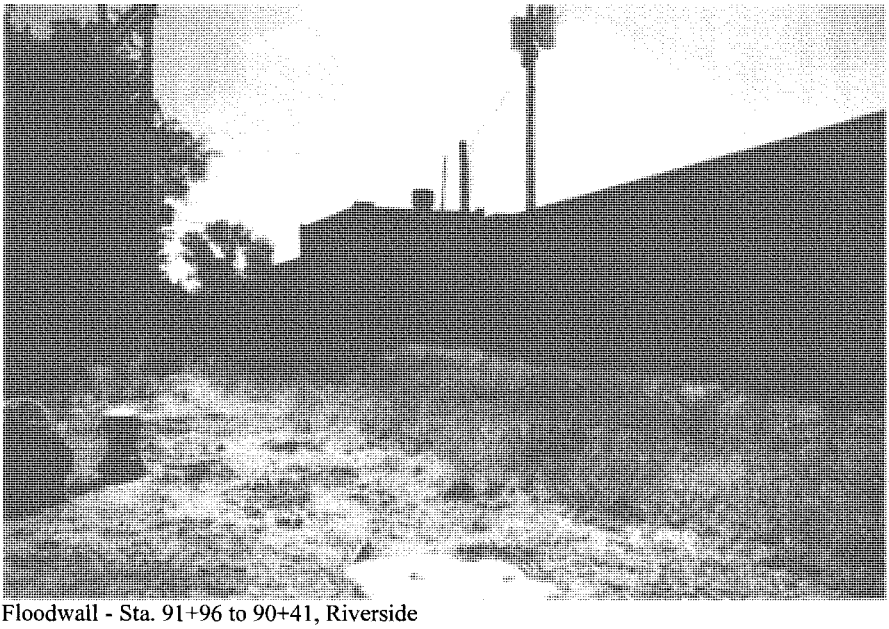
Closure Structure No. 18, Sta. 90+41, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



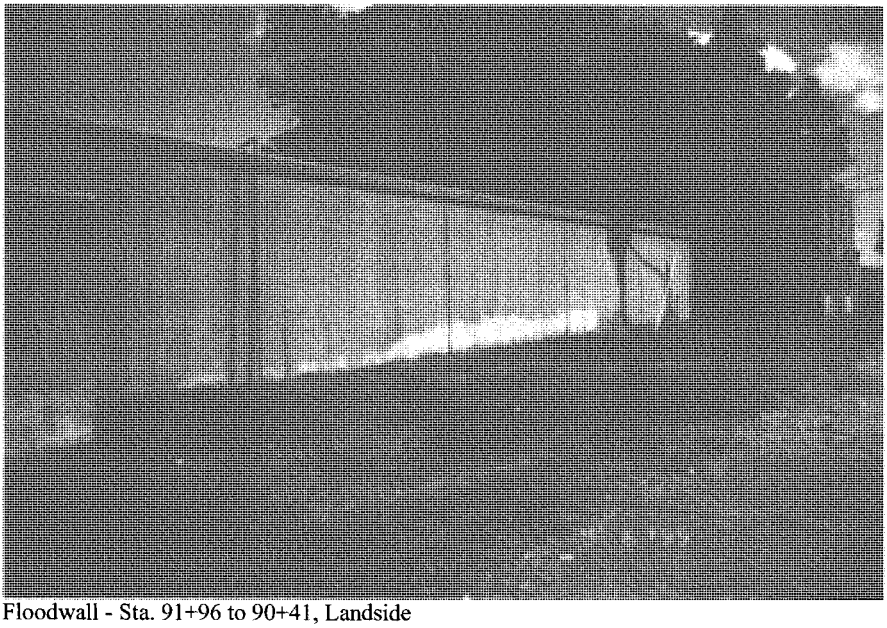
Floodwall - Sta. 90+41 to 91+96, Riverside



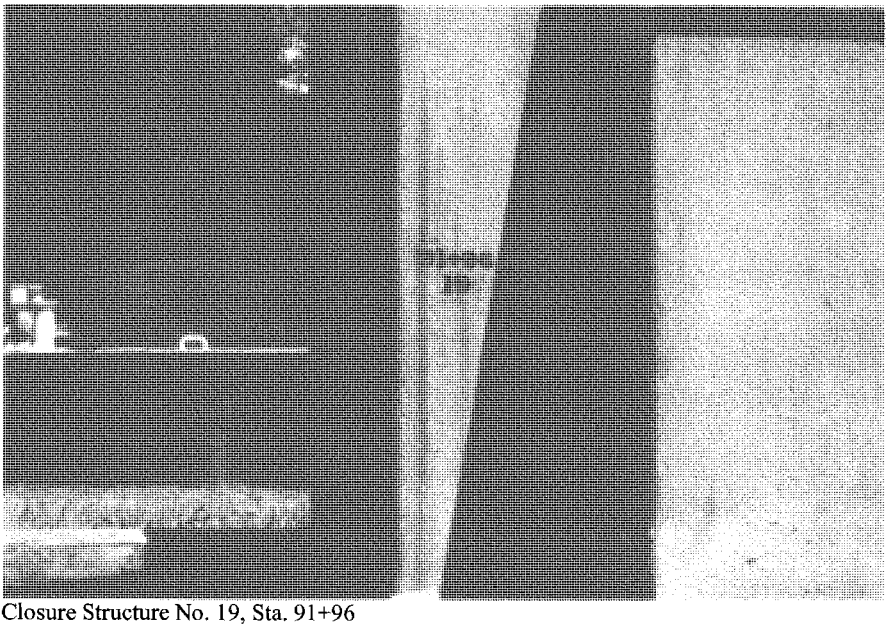
Floodwall - Sta. 91+96 to 90+41, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



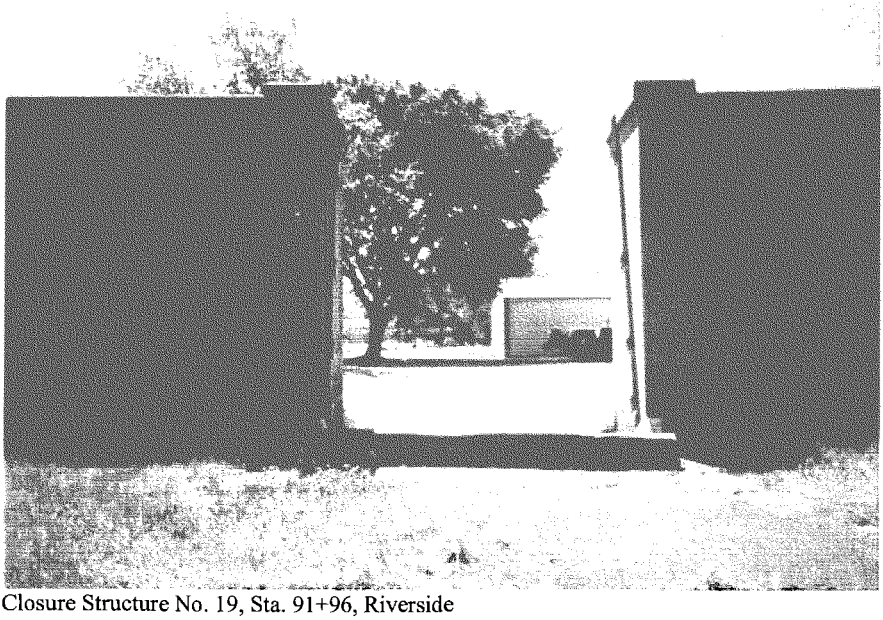
Floodwall - Sta. 91+96 to 90+41, Landside



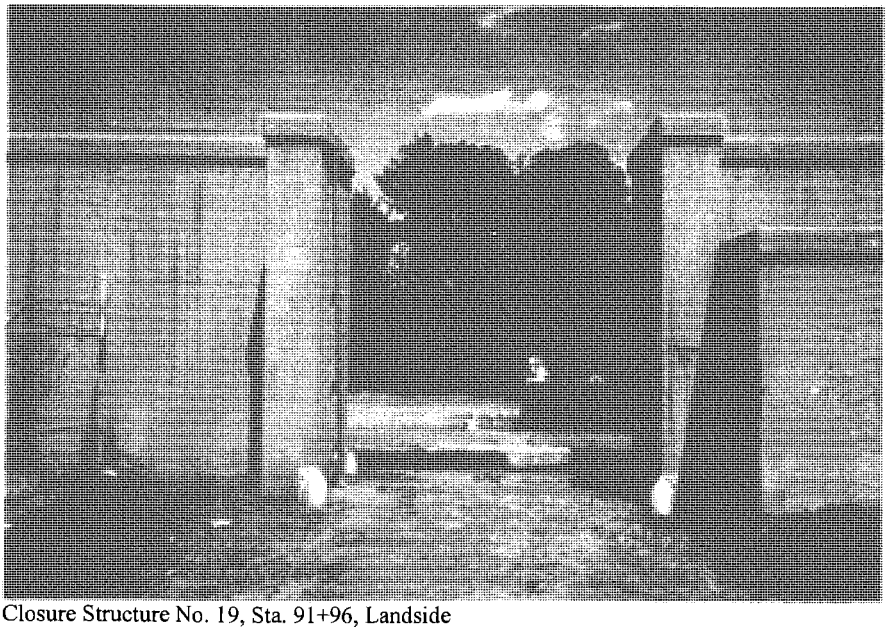
Closure Structure No. 19, Sta. 91+96

May 5 – 11, 1999

Paducah Floodwall Inspection



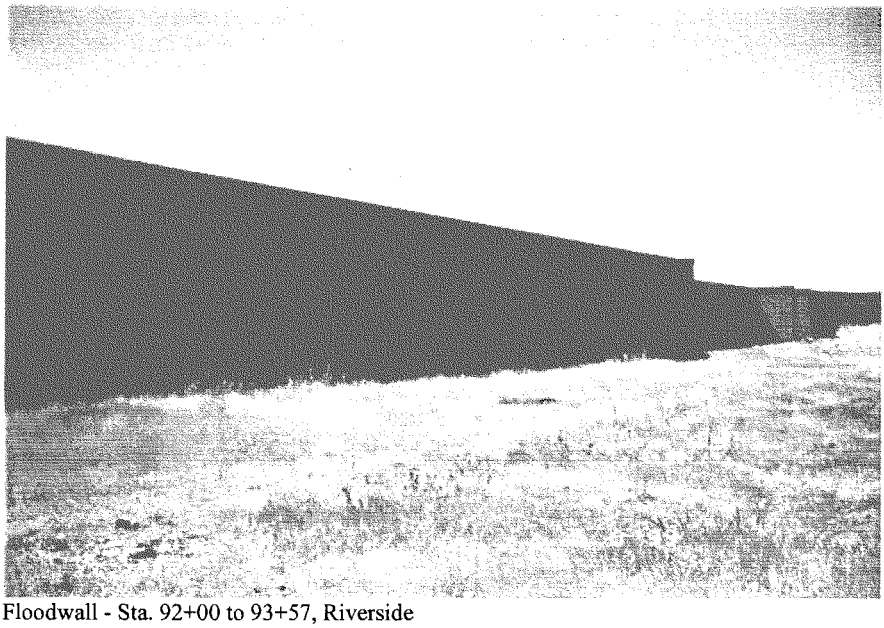
Closure Structure No. 19, Sta. 91+96, Riverside



Closure Structure No. 19, Sta. 91+96, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection

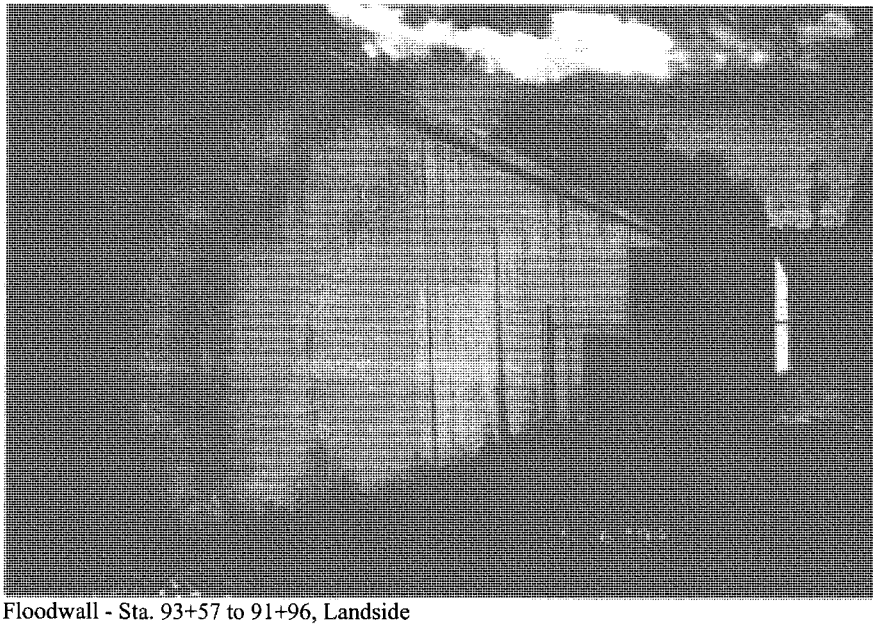


Floodwall - Sta. 92+00 to 93+57, Riverside

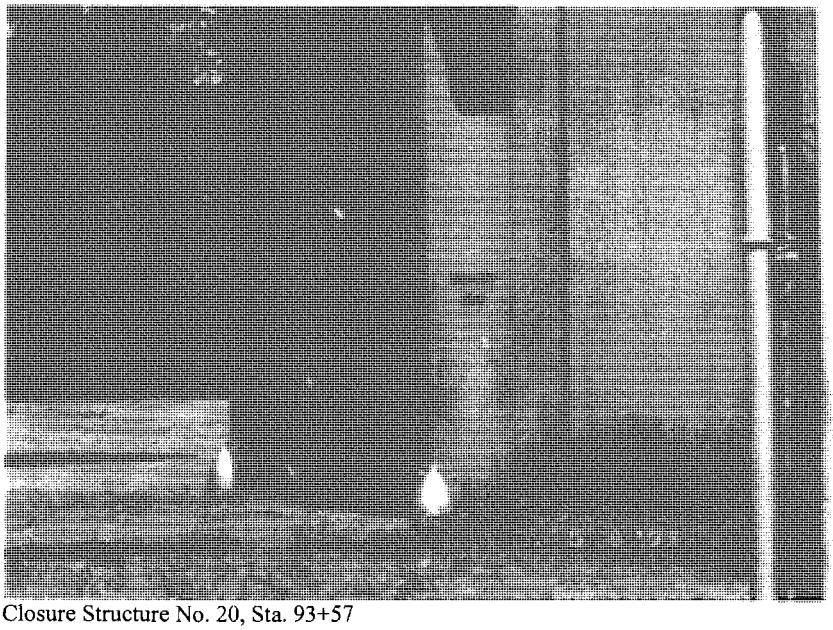
Floodwall - Sta. 92+00, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



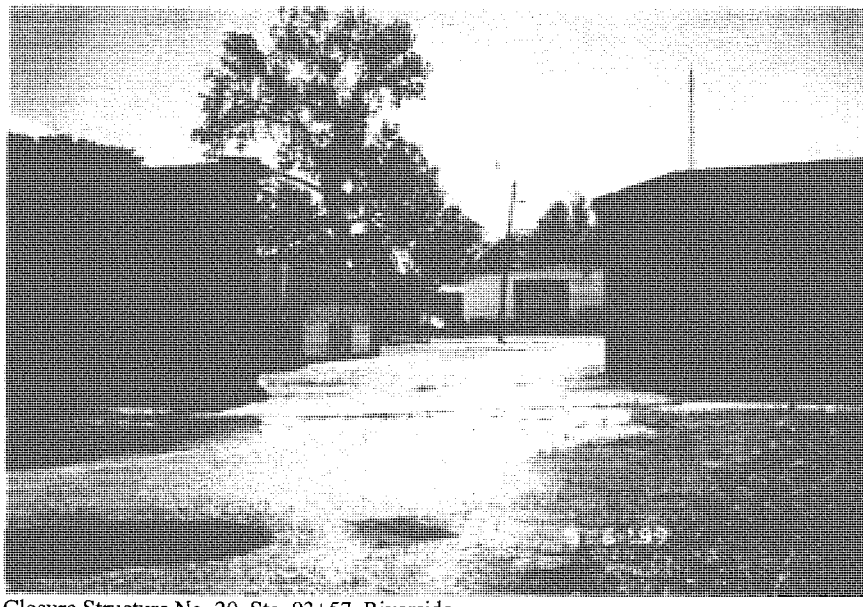
Floodwall - Sta. 93+57 to 91+96, Landside



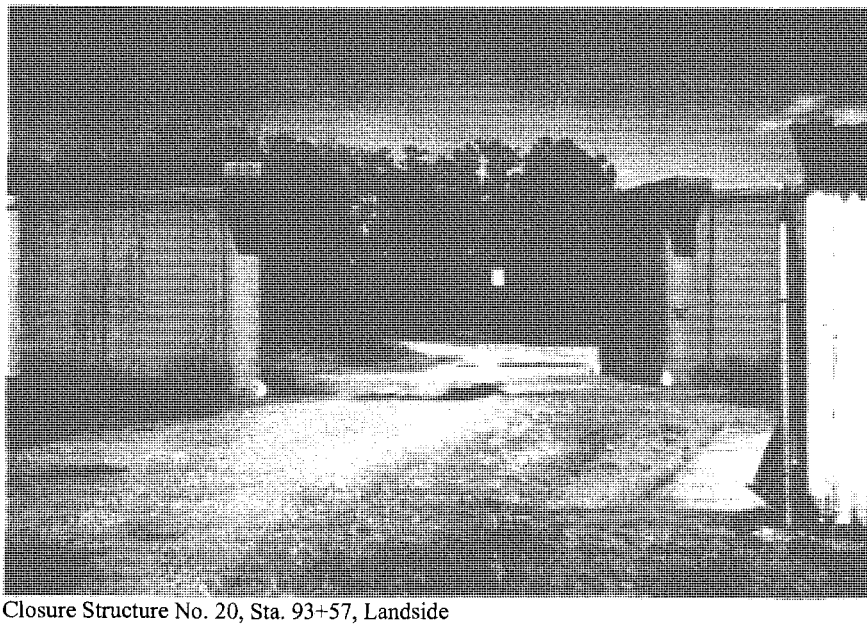
Closure Structure No. 20, Sta. 93+57

May 5 – 11, 1999

Paducah Floodwall Inspection



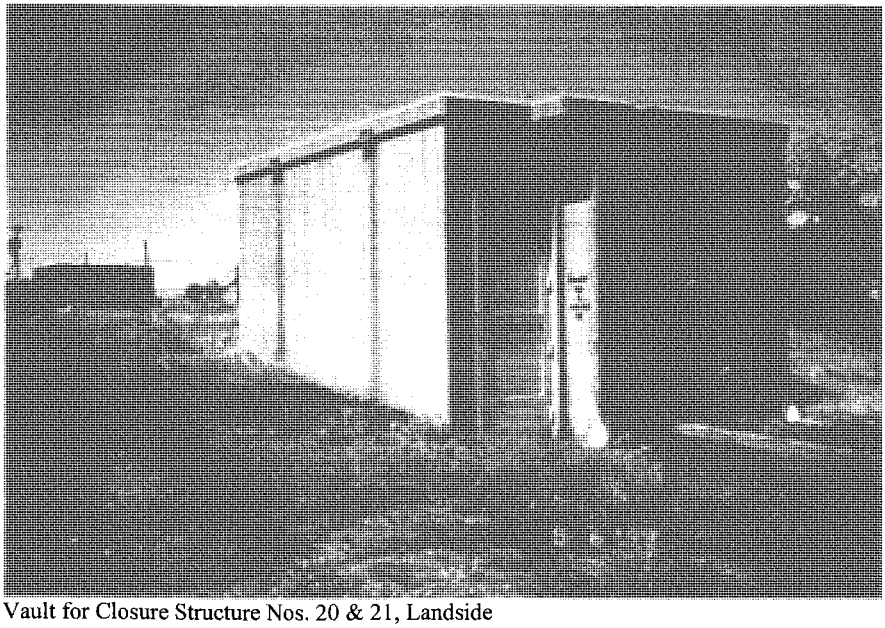
Closure Structure No. 20, Sta. 93+57, Riverside



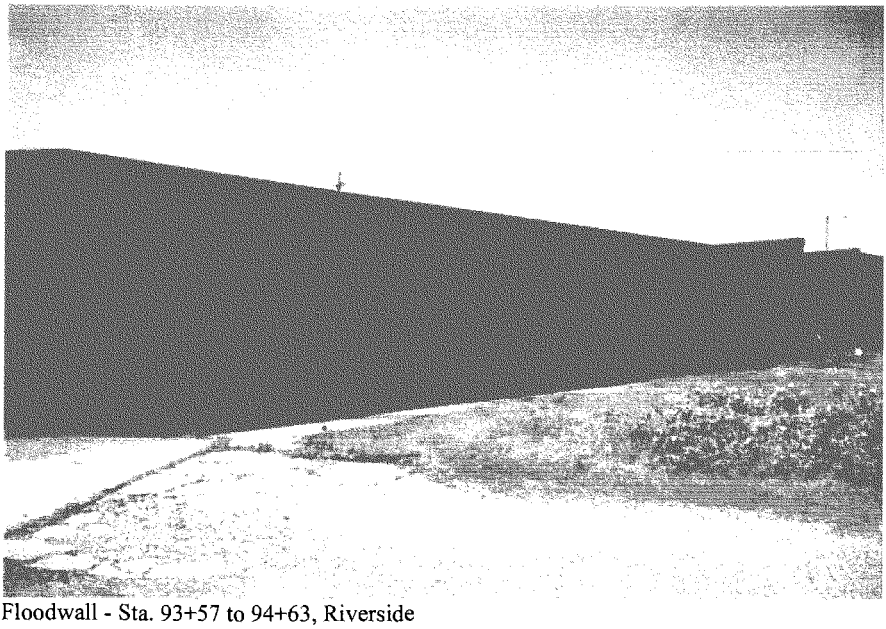
Closure Structure No. 20, Sta. 93+57, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



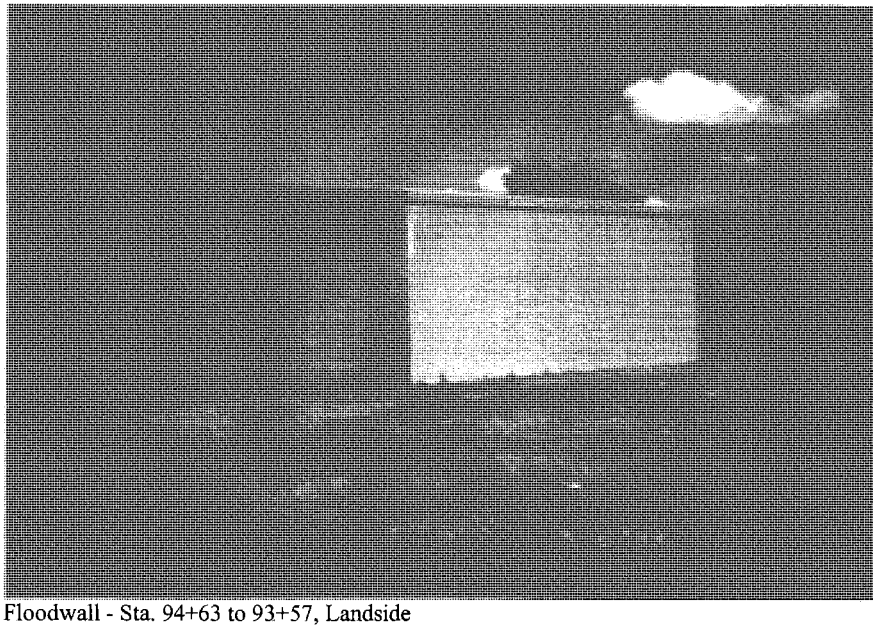
Vault for Closure Structure Nos. 20 & 21, Landside



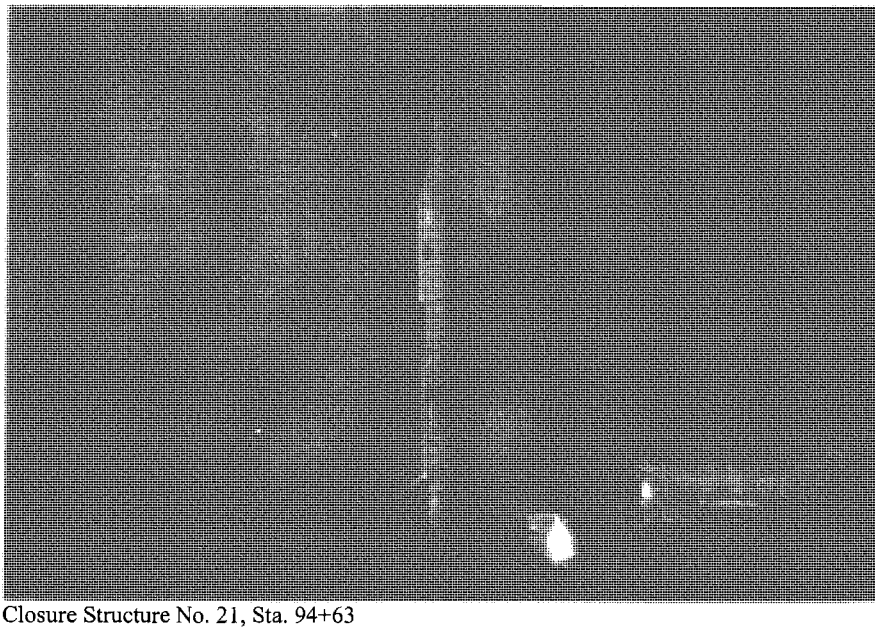
Floodwall - Sta. 93+57 to 94+63, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



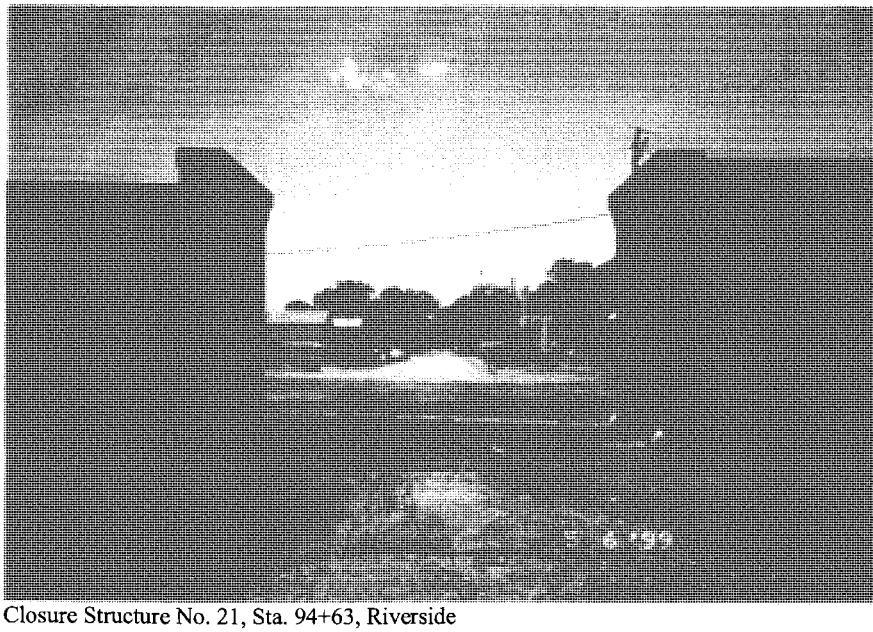
Floodwall - Sta. 94+63 to 93+57, Landside



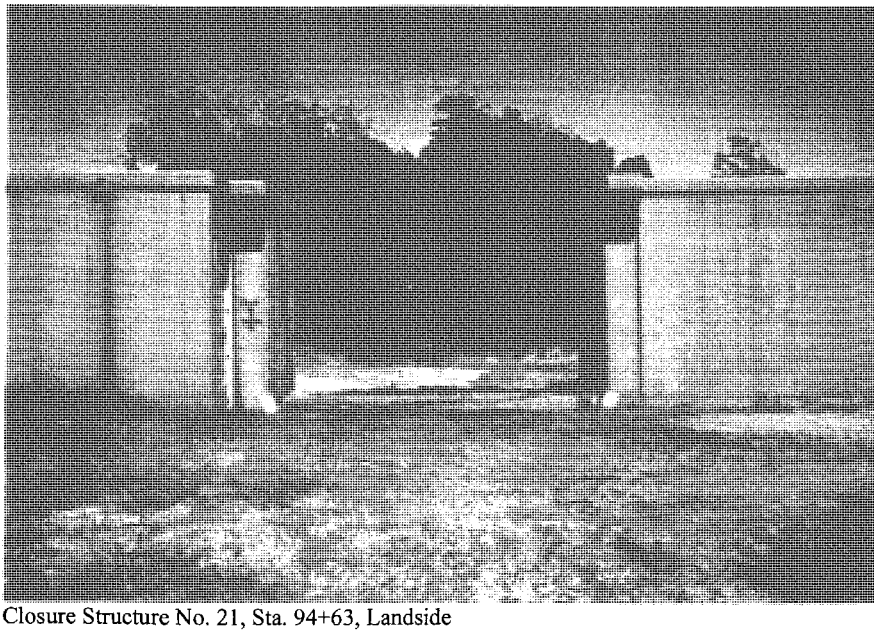
Closure Structure No. 21, Sta. 94+63

May 5 – 11, 1999

Paducah Floodwall Inspection



Closure Structure No. 21, Sta. 94+63, Riverside

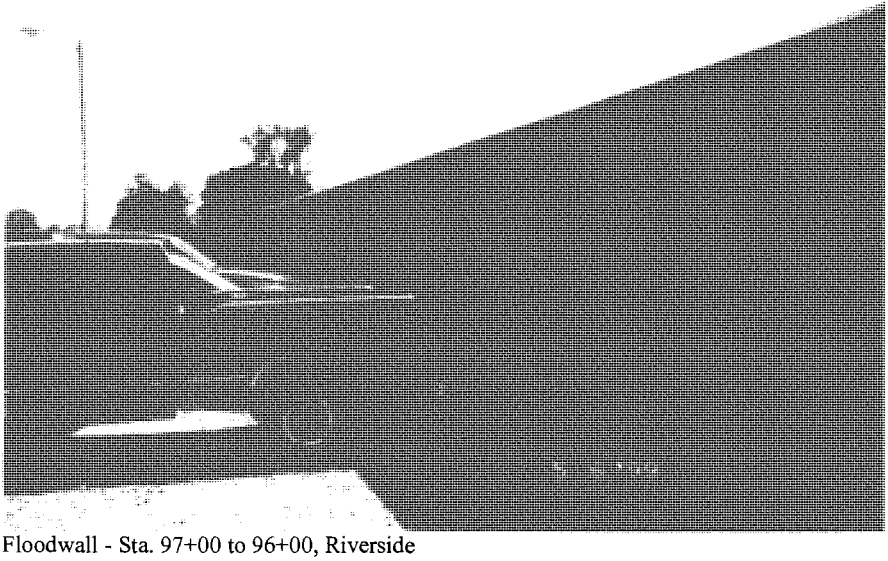


Closure Structure No. 21, Sta. 94+63, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection

Floodwall - Sta. 94+63 to 96+50, Landside



Floodwall - Sta. 97+00 to 96+00, Riverside

May 5 – 11, 1999

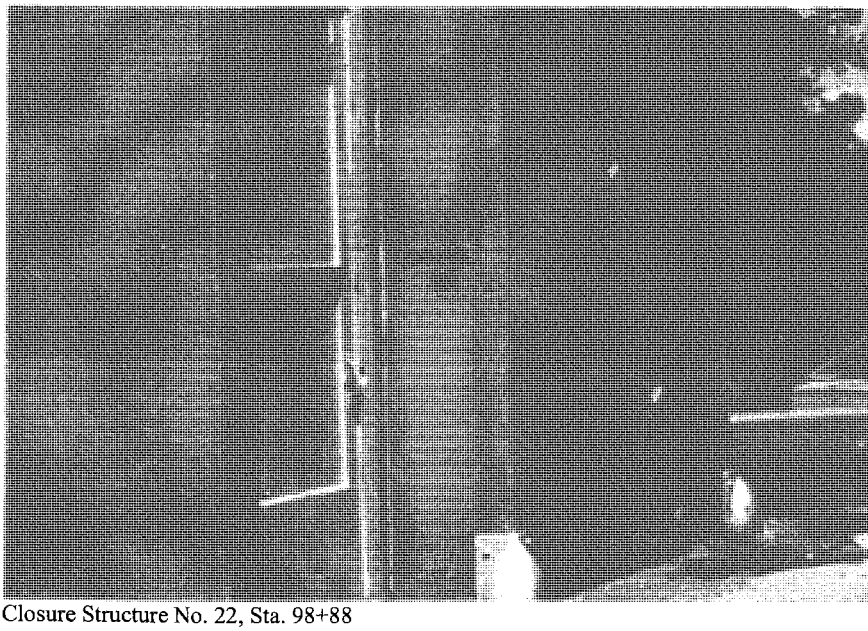
Paducah Floodwall Inspection

Floodwall - Sta. 97+00 to 98+88, Landside

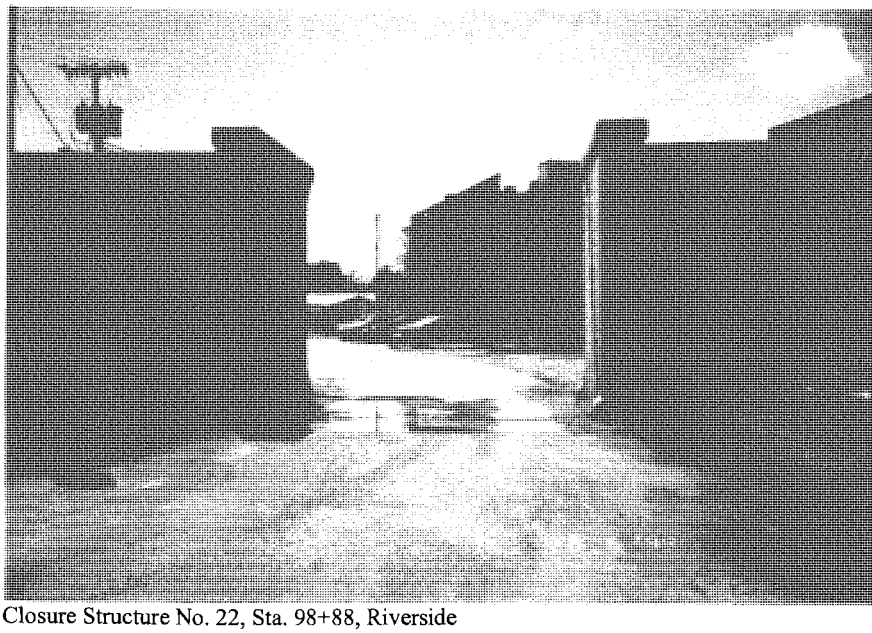
Top of Floodwall, Sta. 97+00 to 98+88

May 5 – 11, 1999

Paducah Floodwall Inspection



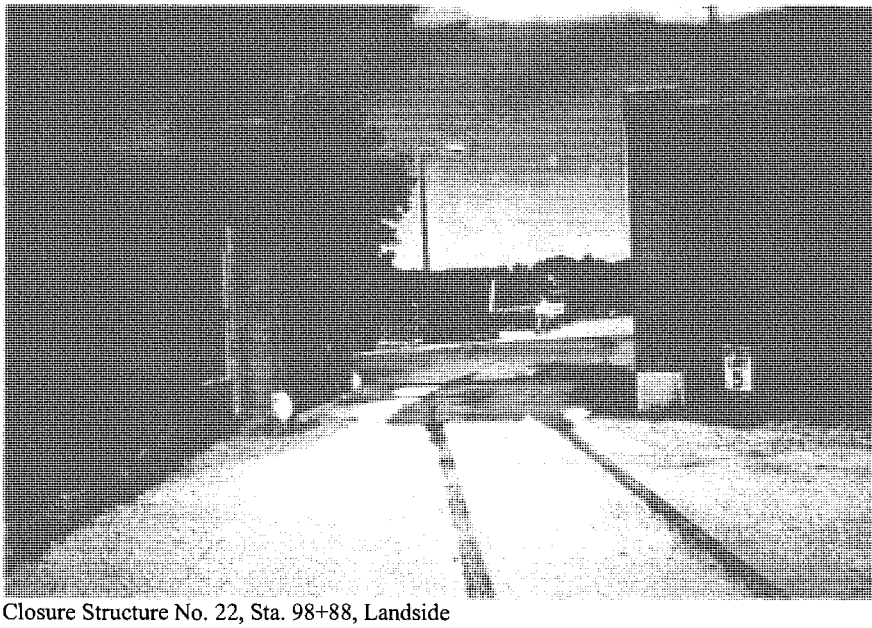
Closure Structure No. 22, Sta. 98+88



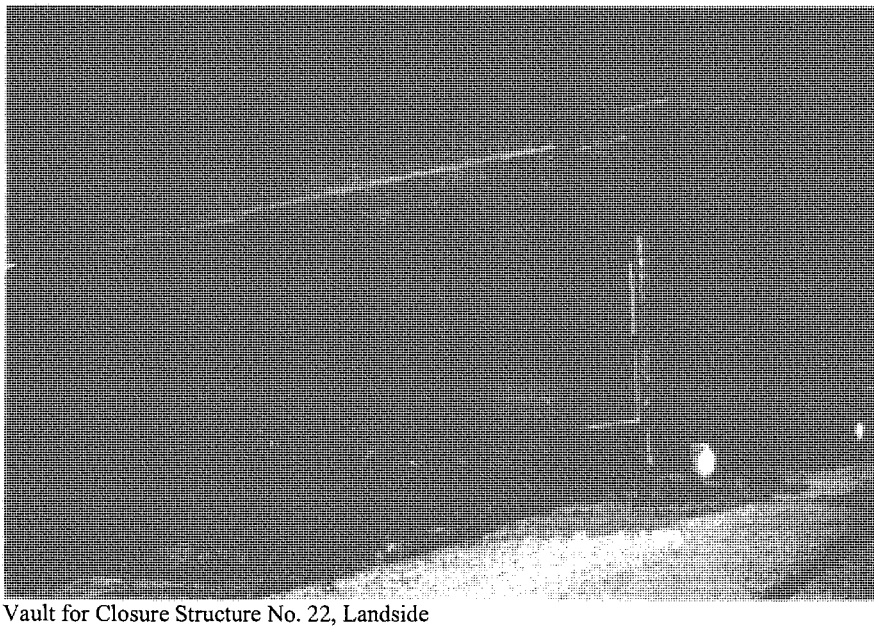
Closure Structure No. 22, Sta. 98+88, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



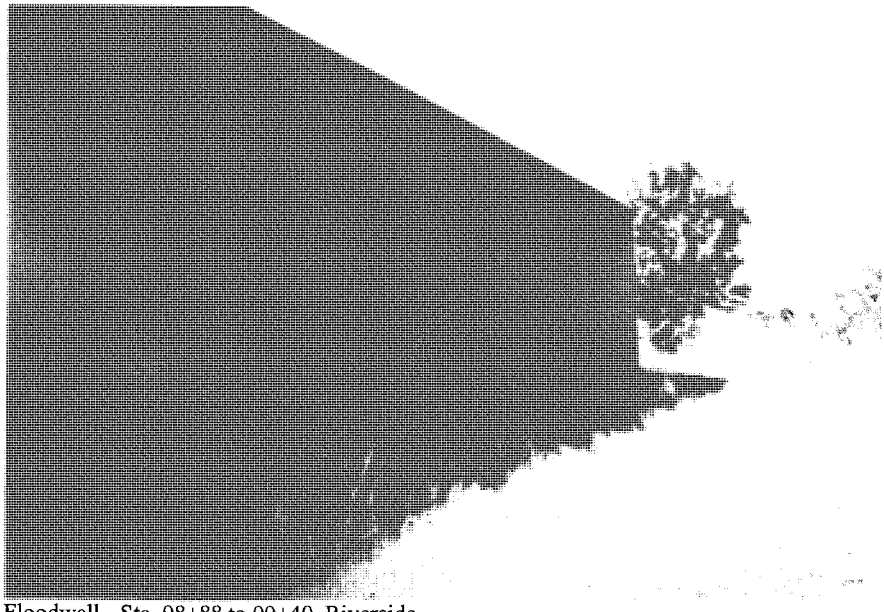
Closure Structure No. 22, Sta. 98+88, Landside



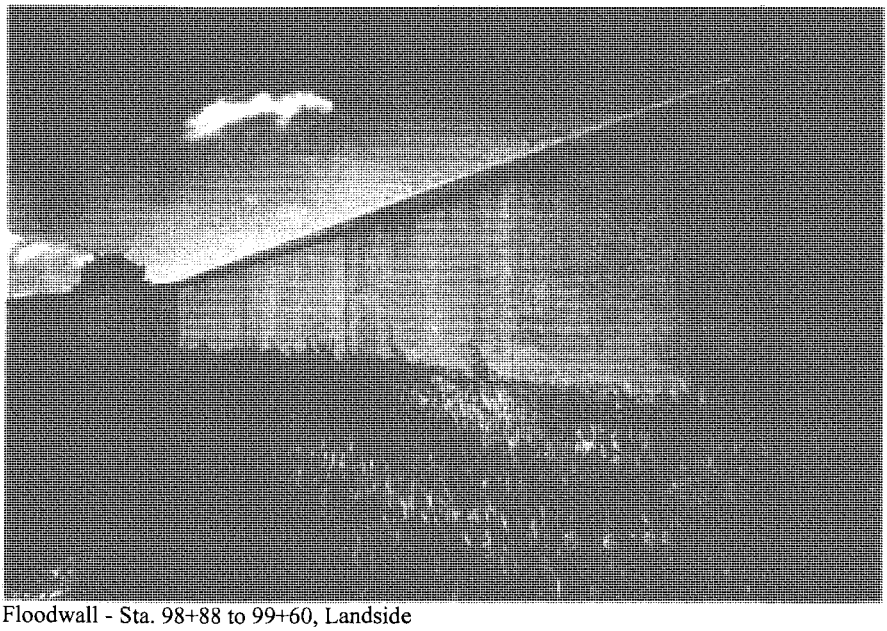
Vault for Closure Structure No. 22, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



Floodwall - Sta. 98+88 to 99+40, Riverside

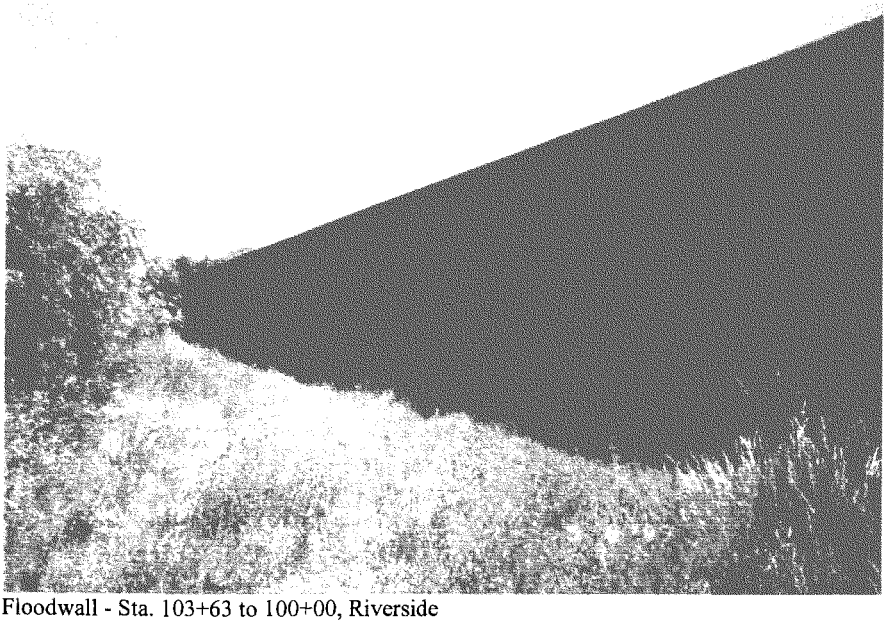


Floodwall - Sta. 98+88 to 99+60, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection

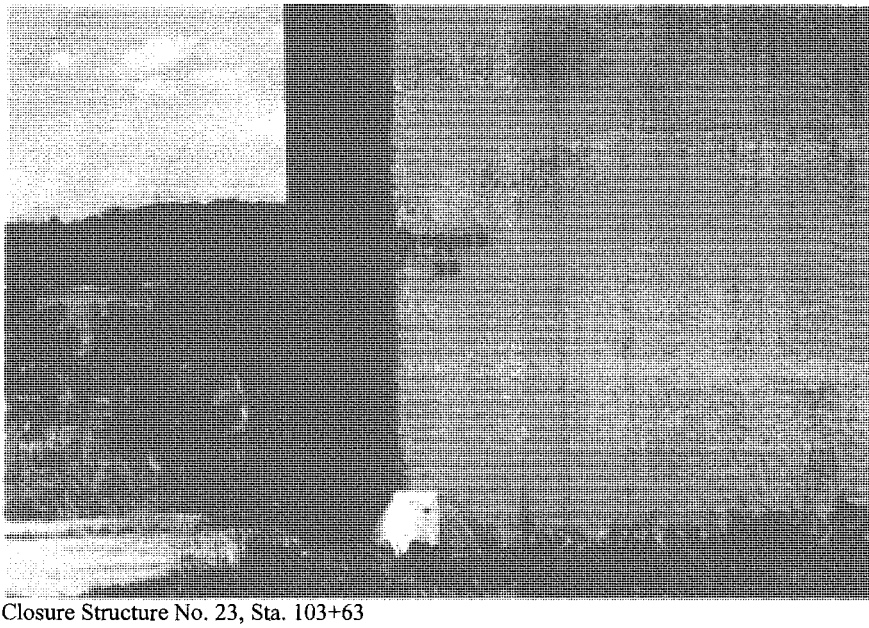
Floodwall - Sta. 99+60 to 103+63, Landside



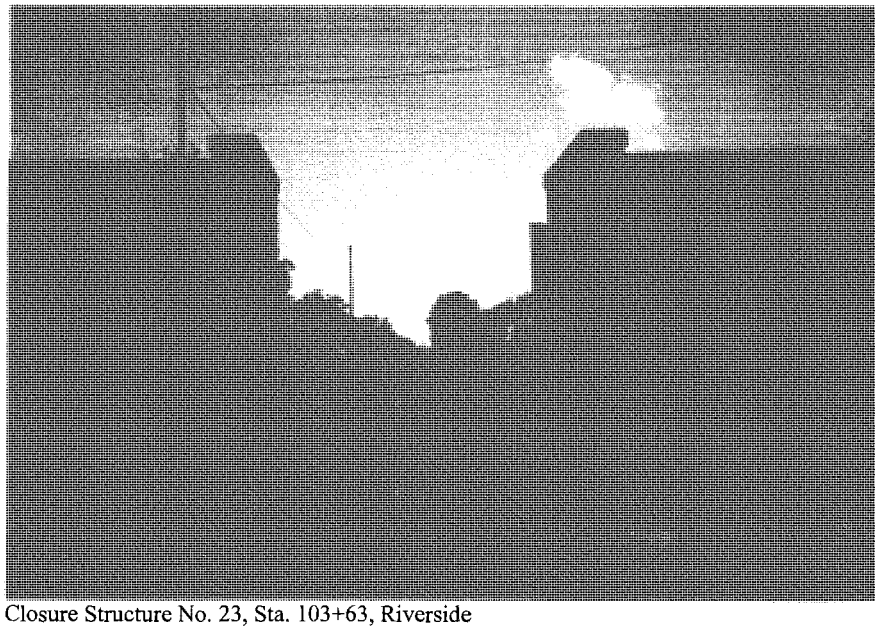
Floodwall - Sta. 103+63 to 100+00, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



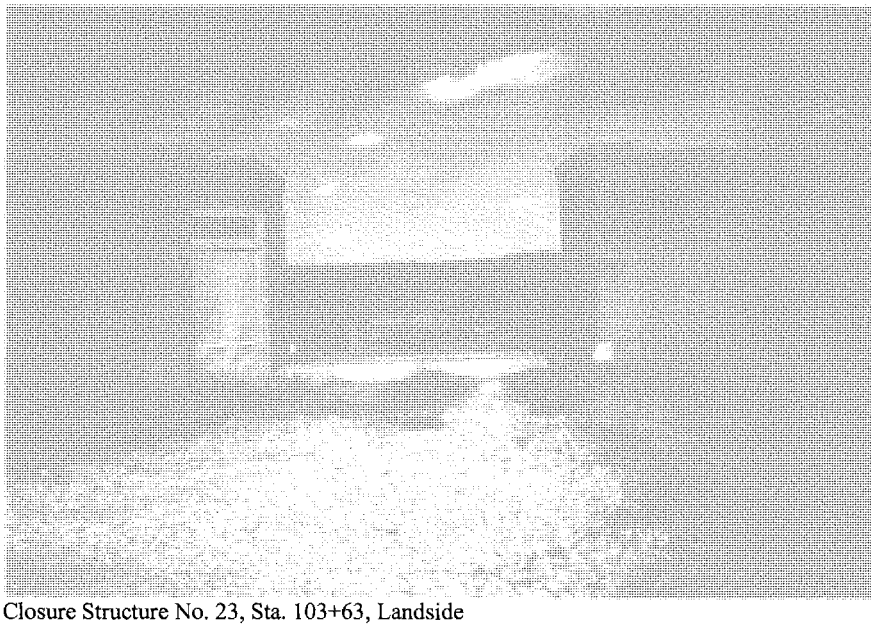
Closure Structure No. 23, Sta. 103+63



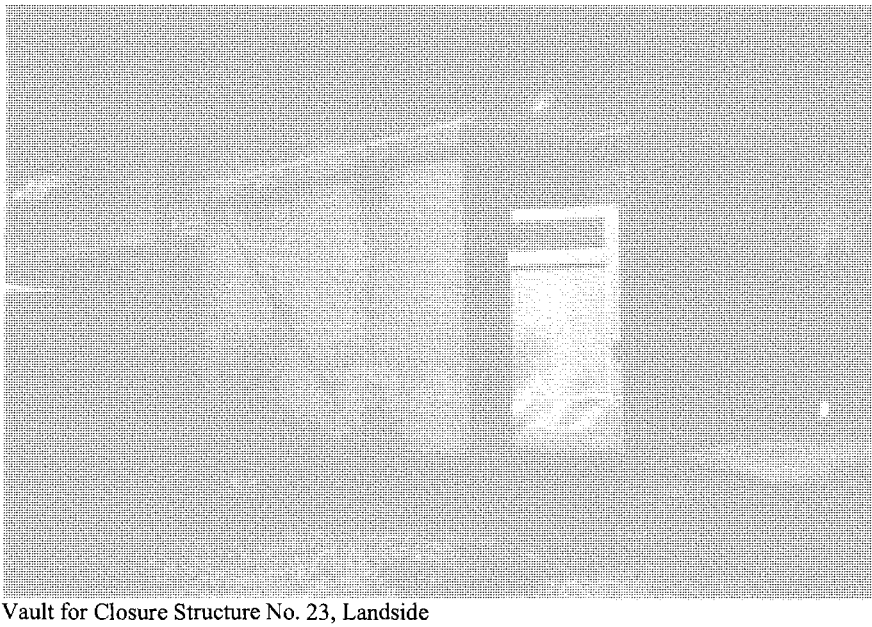
Closure Structure No. 23, Sta. 103+63, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



Closure Structure No. 23, Sta. 103+63, Landside

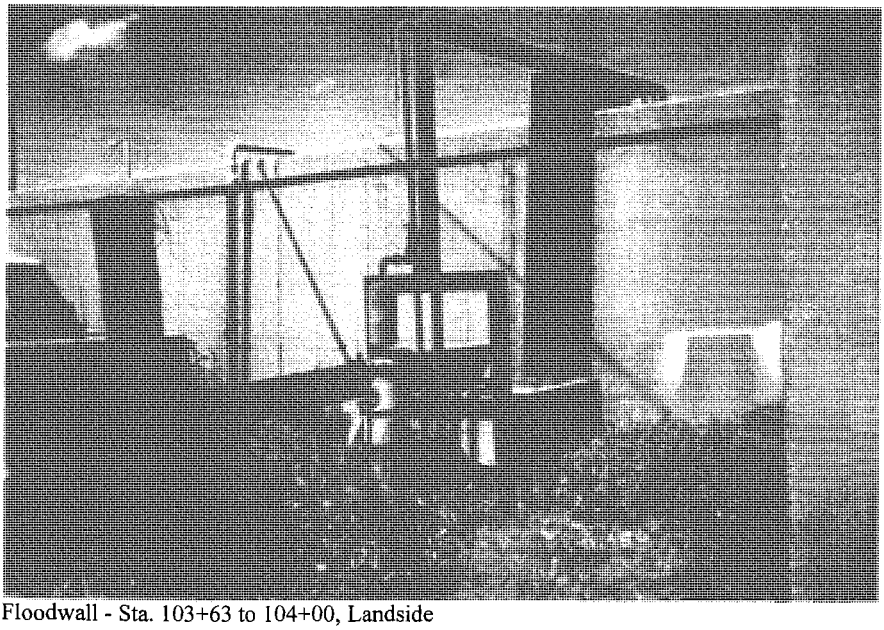


Vault for Closure Structure No. 23, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection

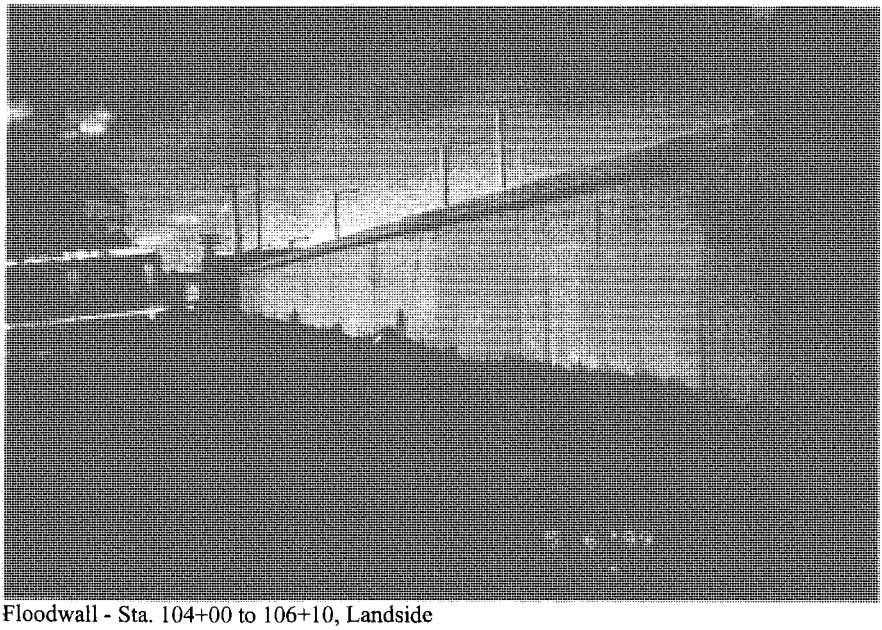
Floodwall - Sta. 103+63 to 104+50, Riverside



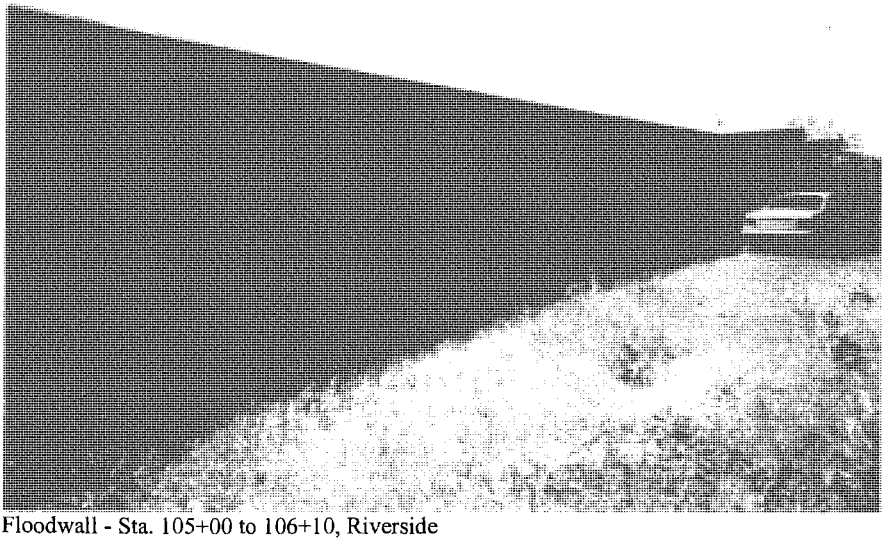
Floodwall - Sta. 103+63 to 104+00, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



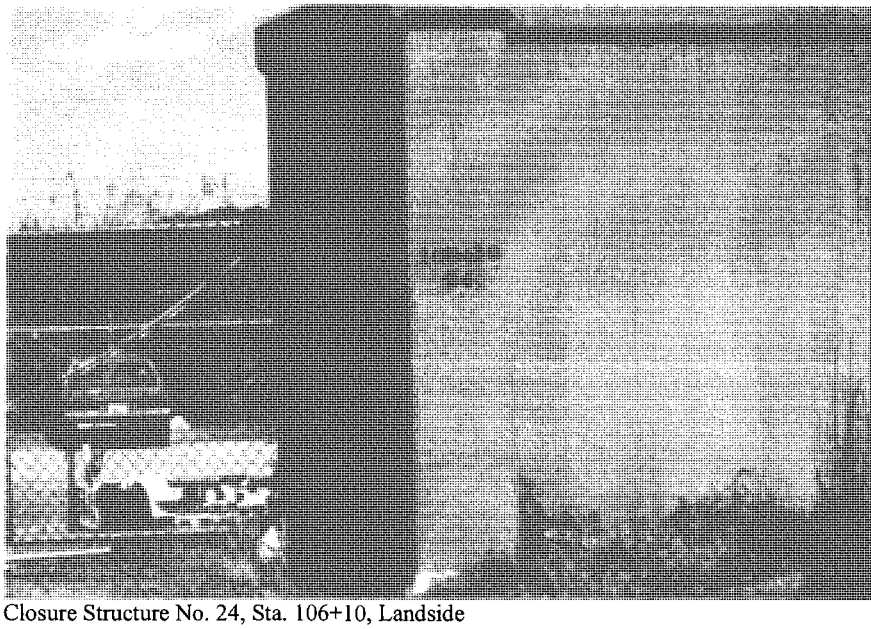
Floodwall - Sta. 104+00 to 106+10, Landside



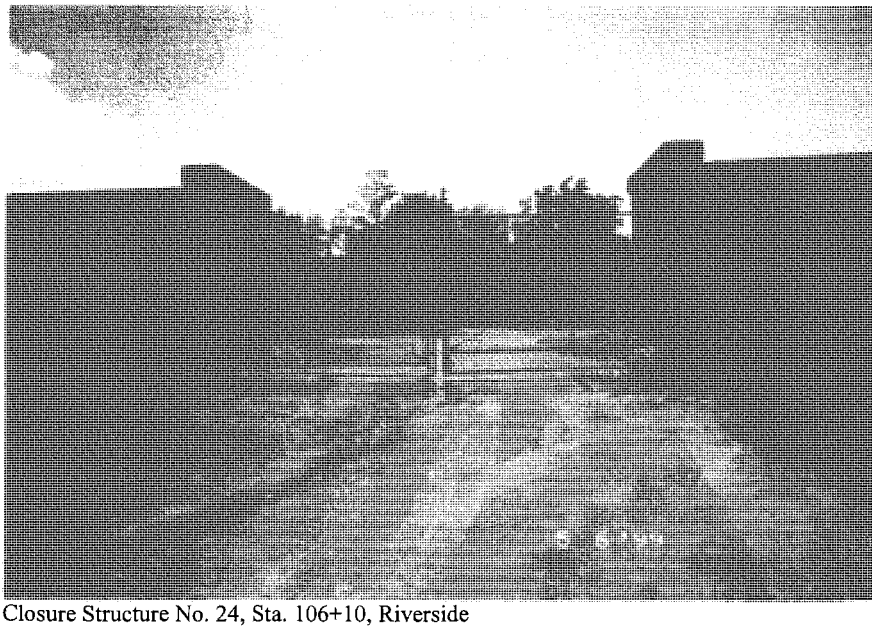
Floodwall - Sta. 105+00 to 106+10, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



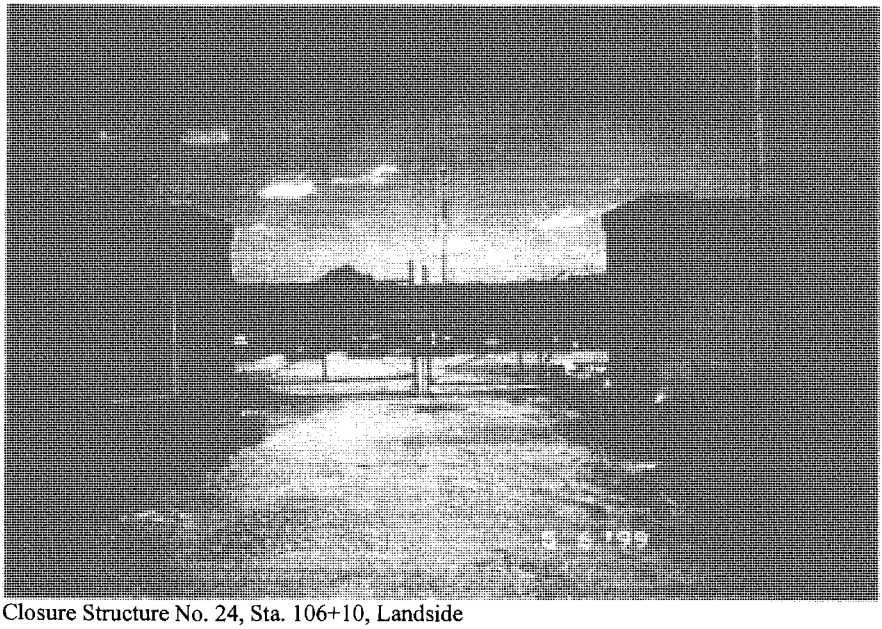
Closure Structure No. 24, Sta. 106+10, Landside



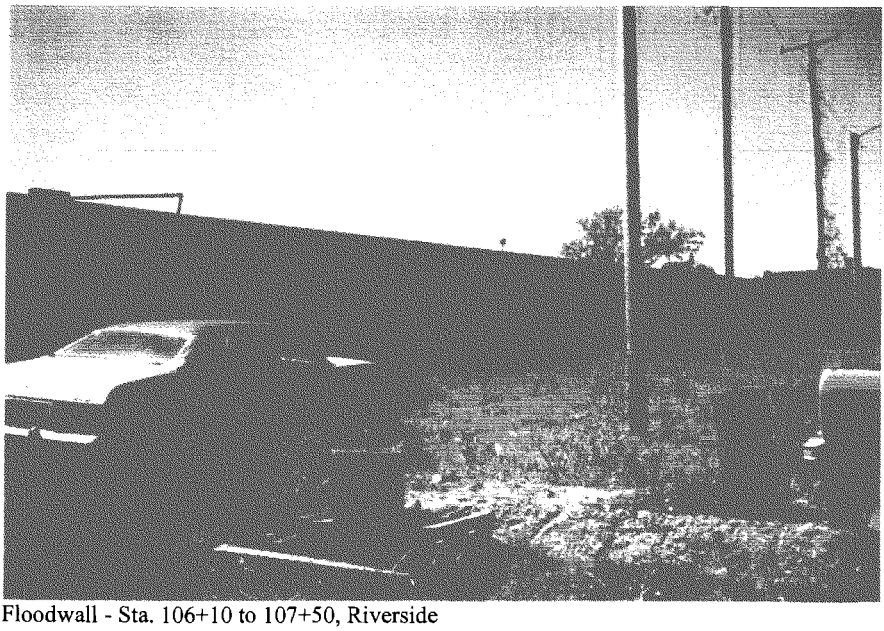
Closure Structure No. 24, Sta. 106+10, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



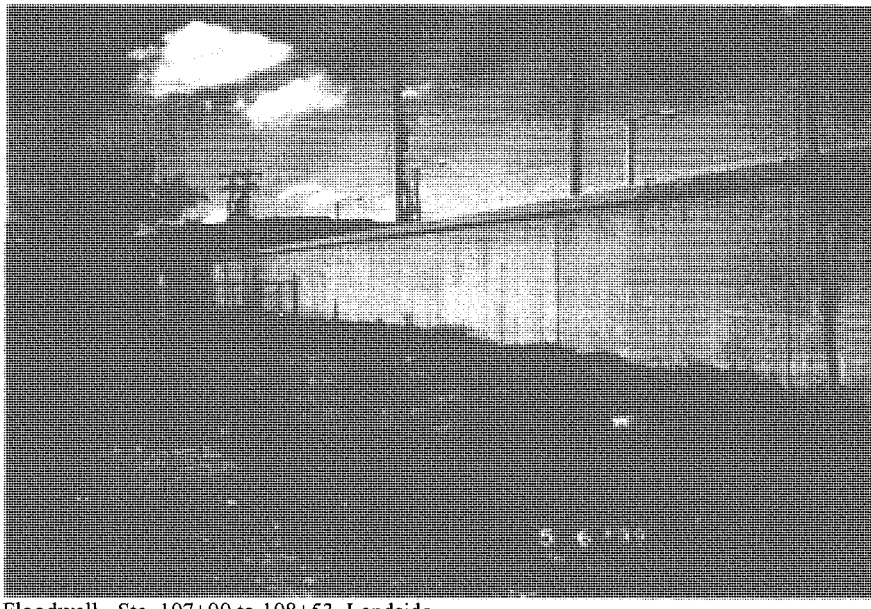
Closure Structure No. 24, Sta. 106+10, Landside



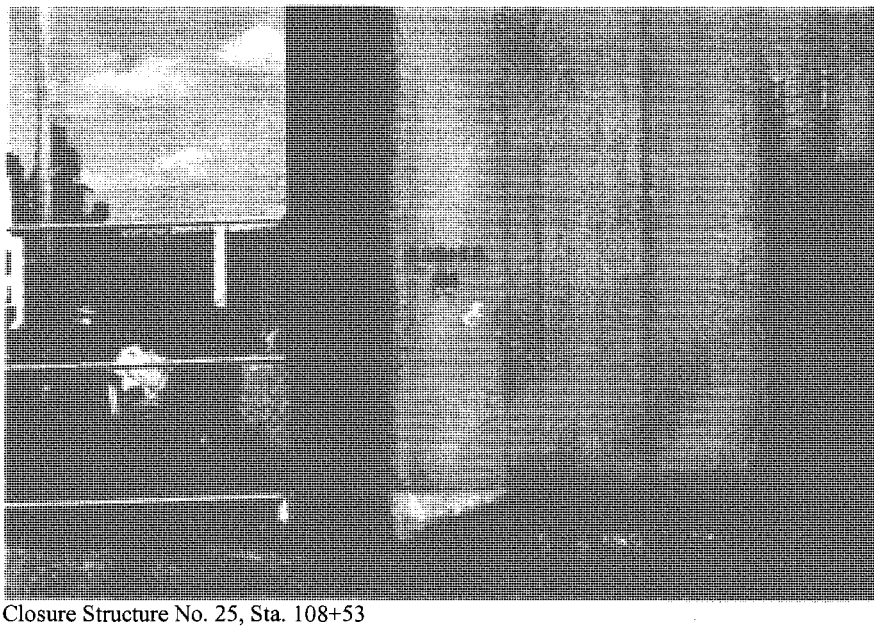
Floodwall - Sta. 106+10 to 107+50, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



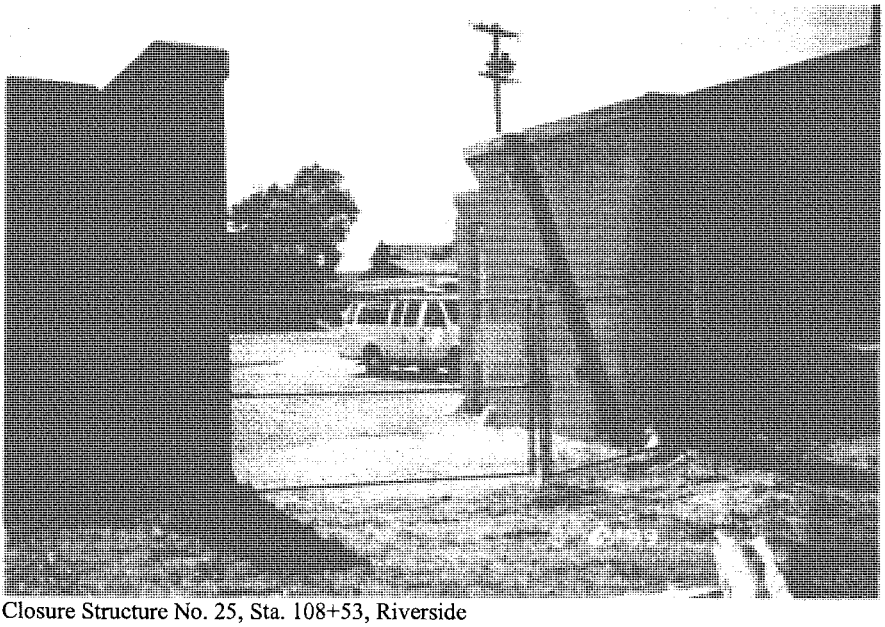
Floodwall - Sta. 107+00 to 108+53, Landside



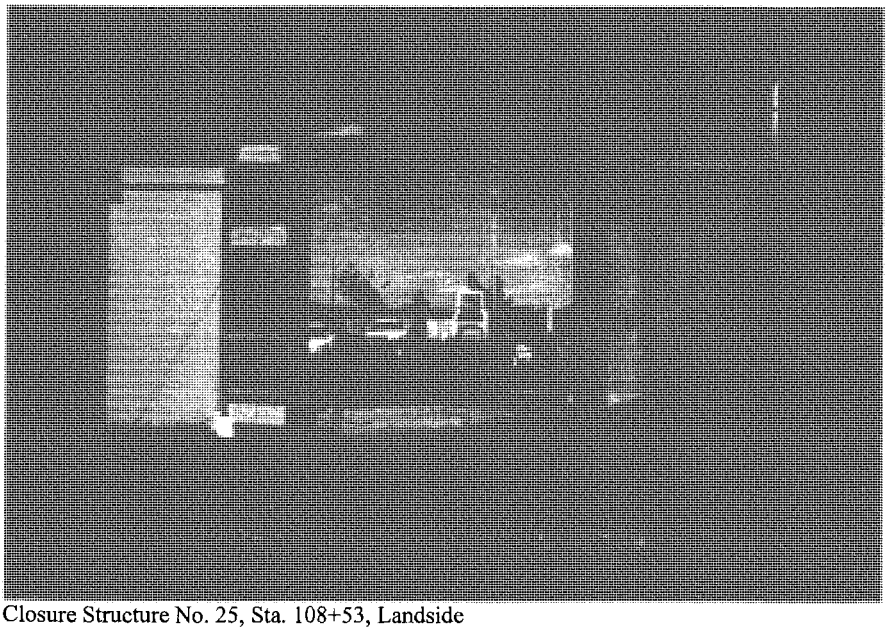
Closure Structure No. 25, Sta. 108+53

May 5 – 11, 1999

Paducah Floodwall Inspection



Closure Structure No. 25, Sta. 108+53, Riverside

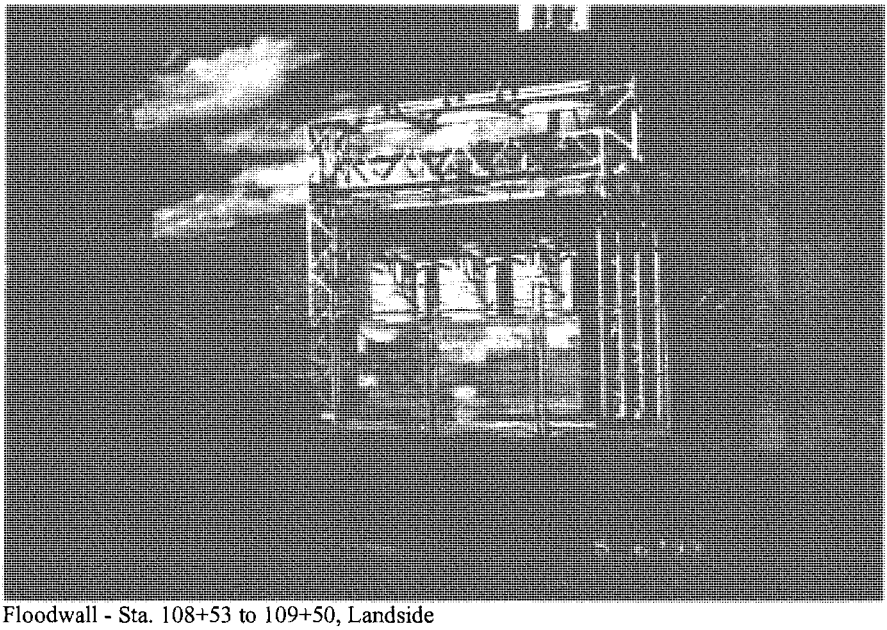


Closure Structure No. 25, Sta. 108+53, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection

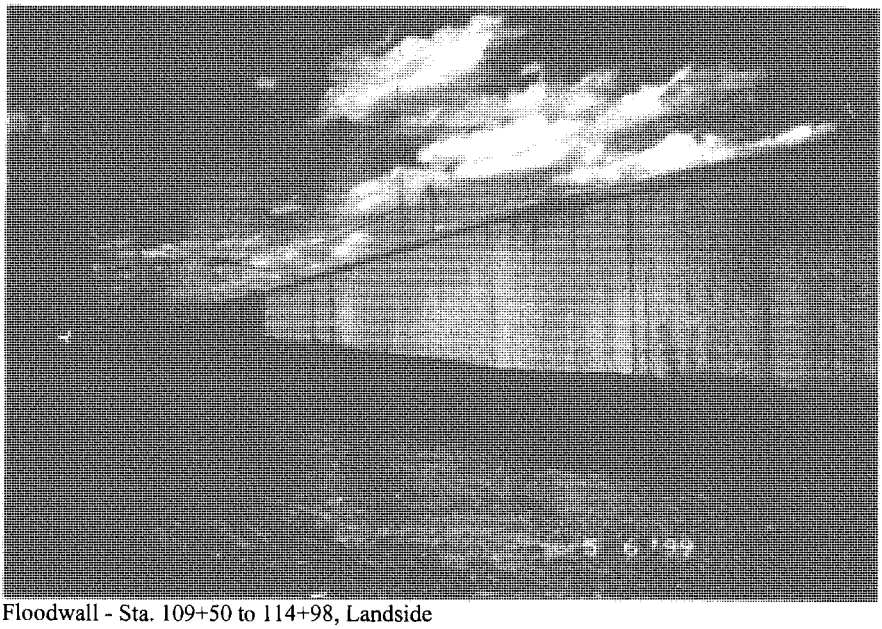
Floodwall - Sta. 108+53 to 109+50, Riverside



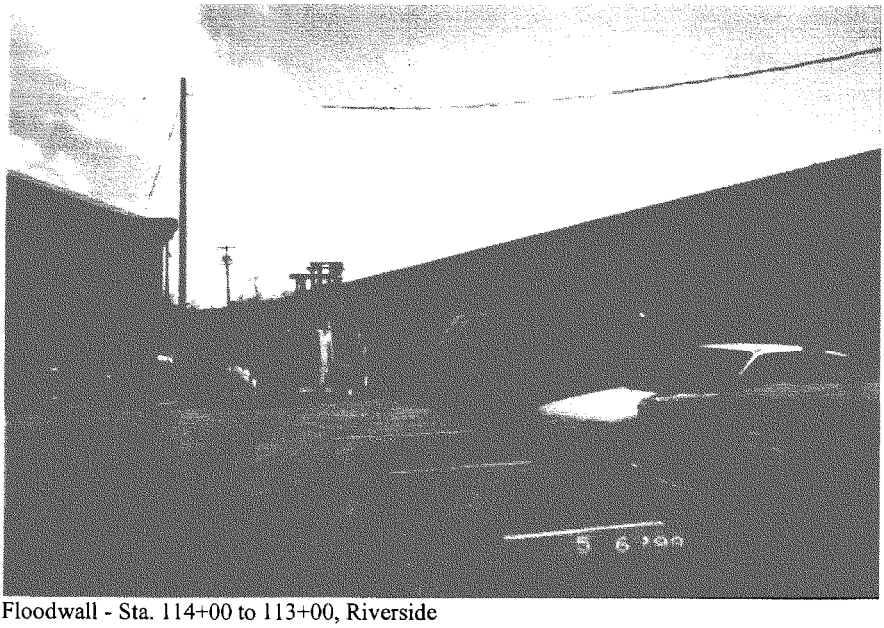
Floodwall - Sta. 108+53 to 109+50, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



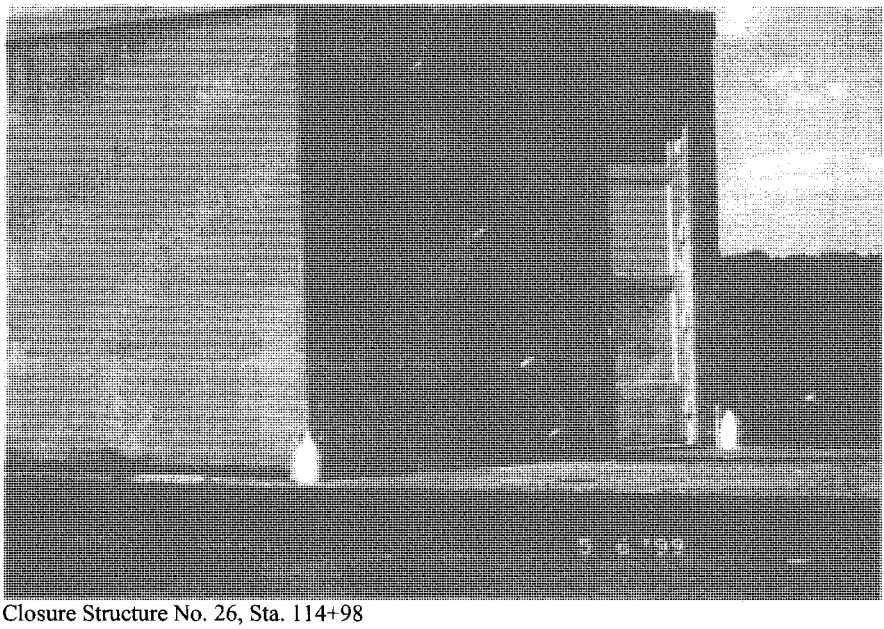
Floodwall - Sta. 109+50 to 114+98, Landside



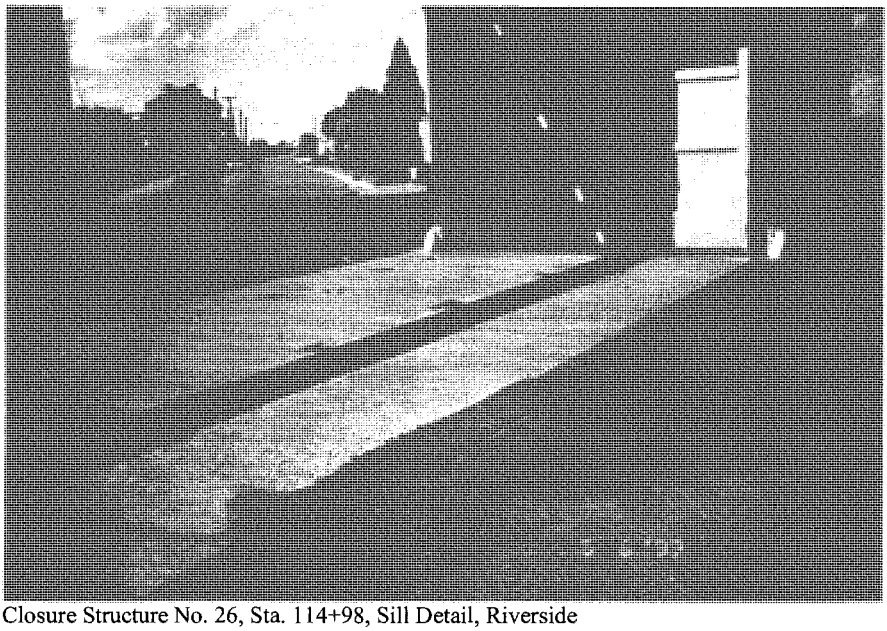
Floodwall - Sta. 114+00 to 113+00, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



Closure Structure No. 26, Sta. 114+98

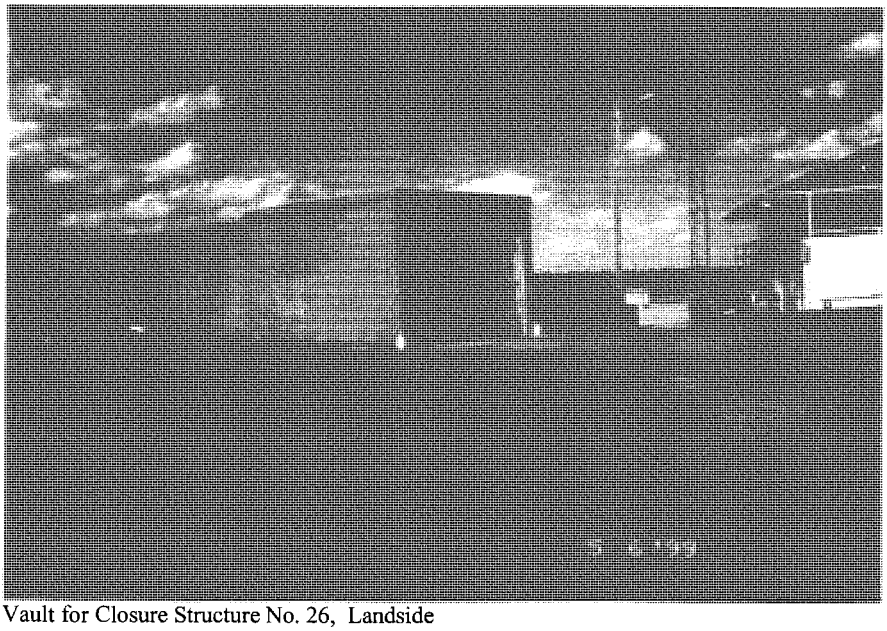


Closure Structure No. 26, Sta. 114+98, Sill Detail, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection

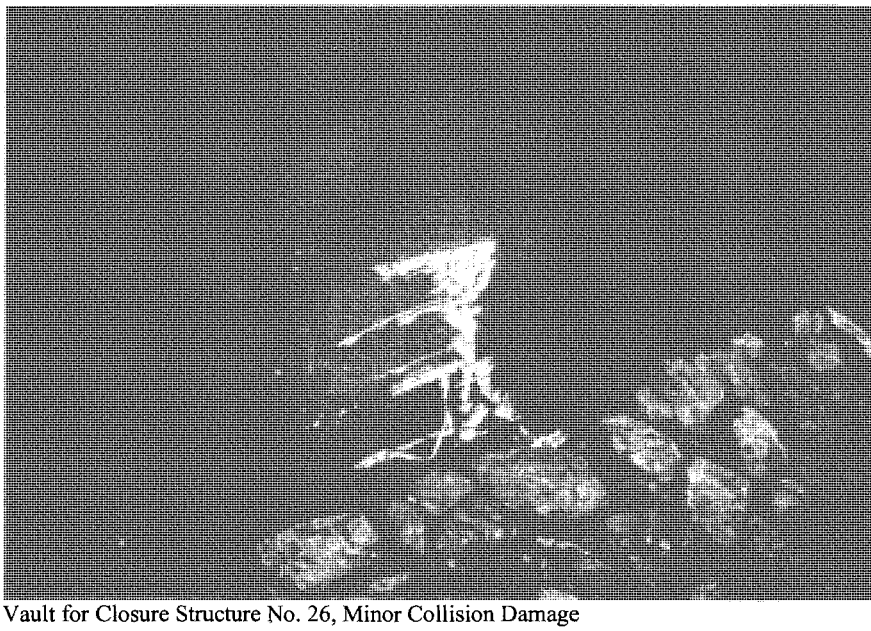
Closure Structure No. 26, Sta. 114+98, Landside



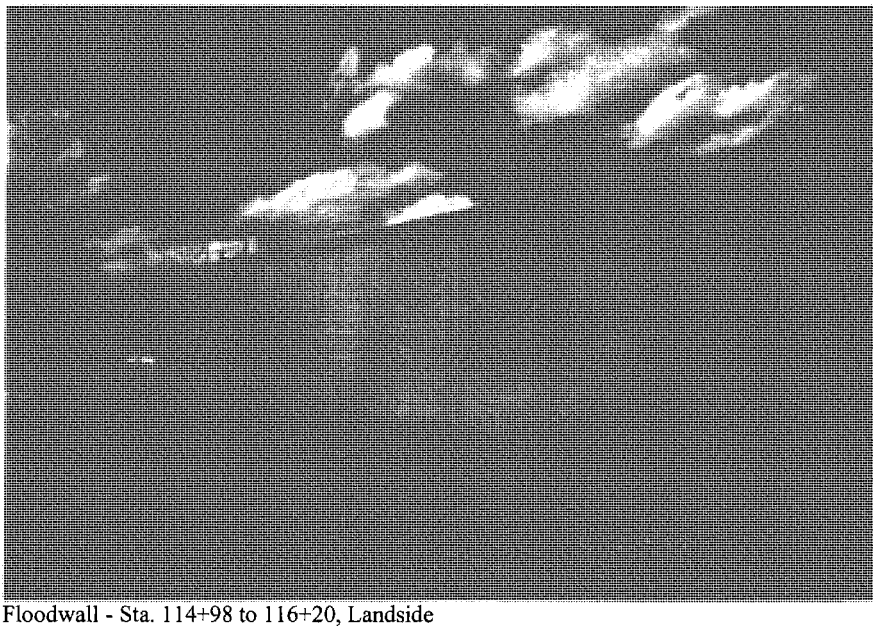
Vault for Closure Structure No. 26, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



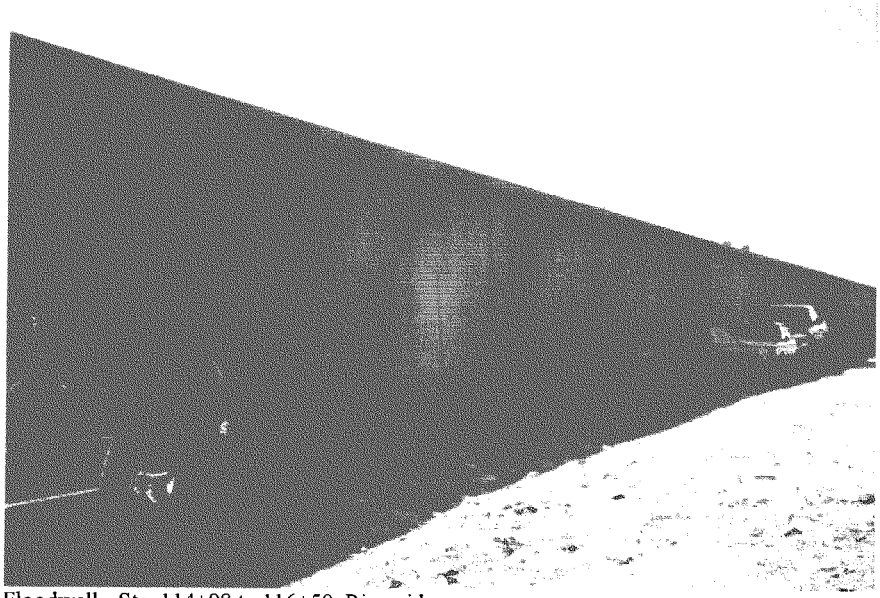
Vault for Closure Structure No. 26, Minor Collision Damage



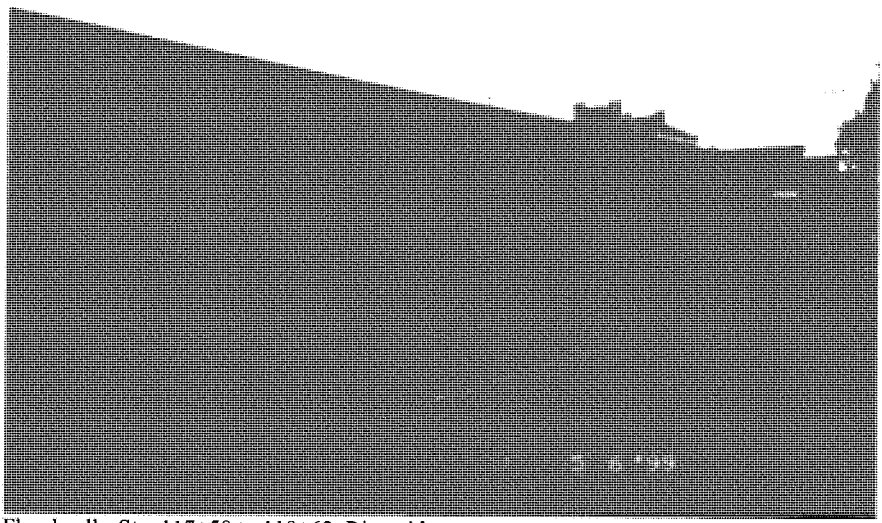
Floodwall - Sta. 114+98 to 116+20, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



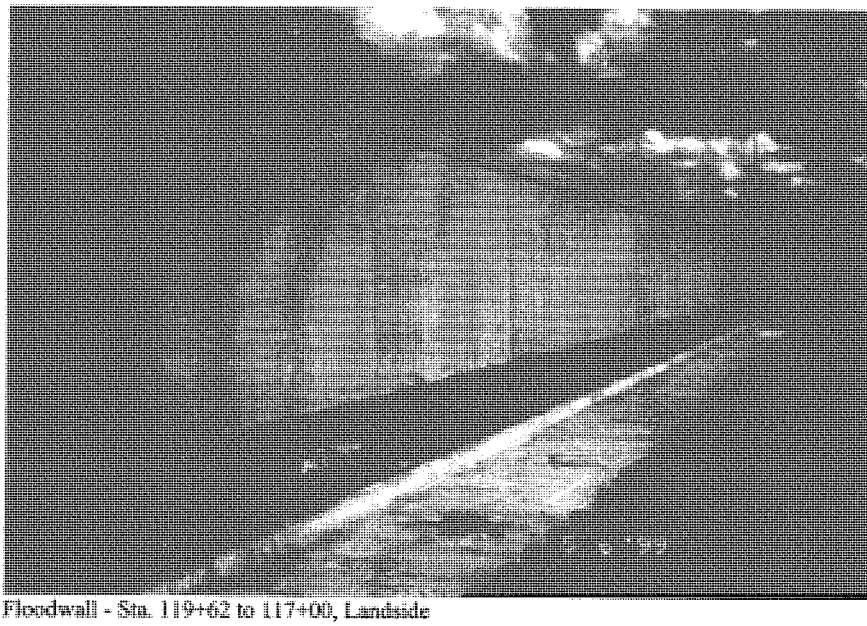
Floodwall - Sta. 114+98 to 116+50, Riverside



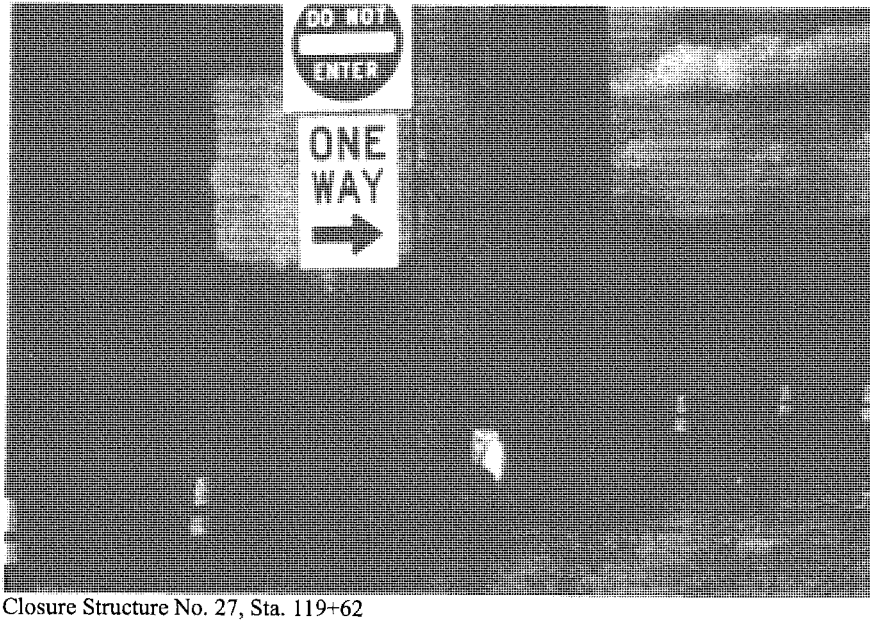
Floodwall - Sta. 117+50 to 119+62, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



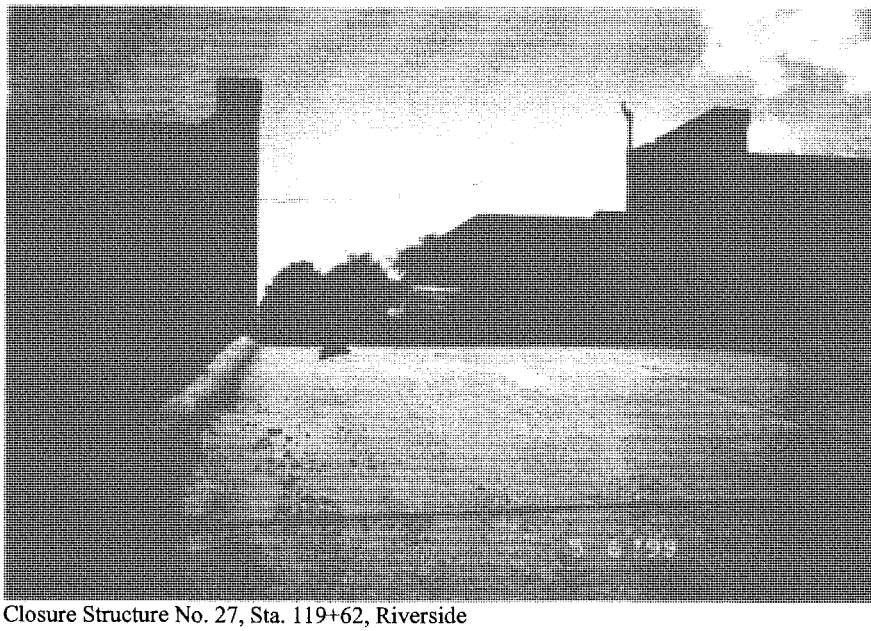
Floodwall - Sta. 119+62 to 117+00, Landside



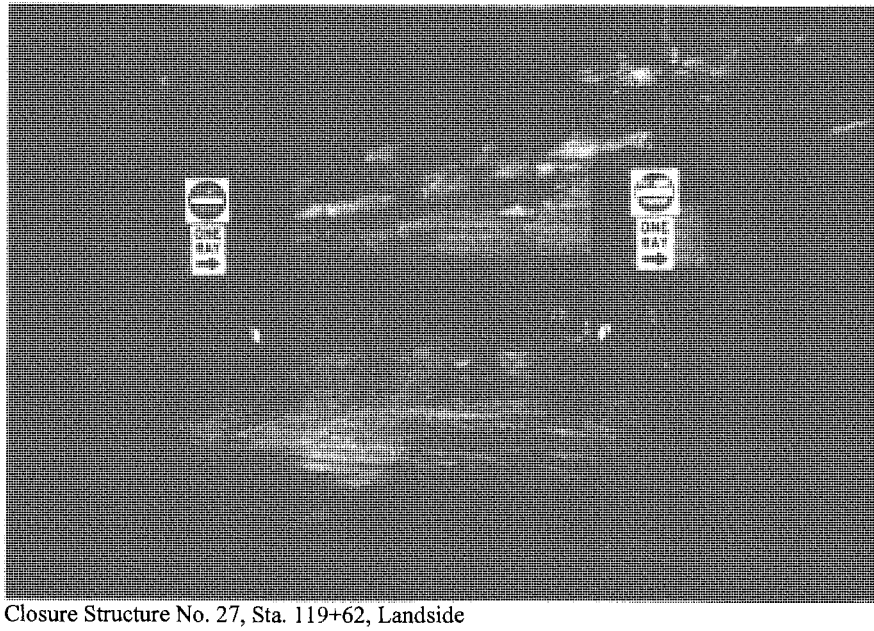
Closure Structure No. 27, Sta. 119+62

May 5 – 11, 1999

Paducah Floodwall Inspection



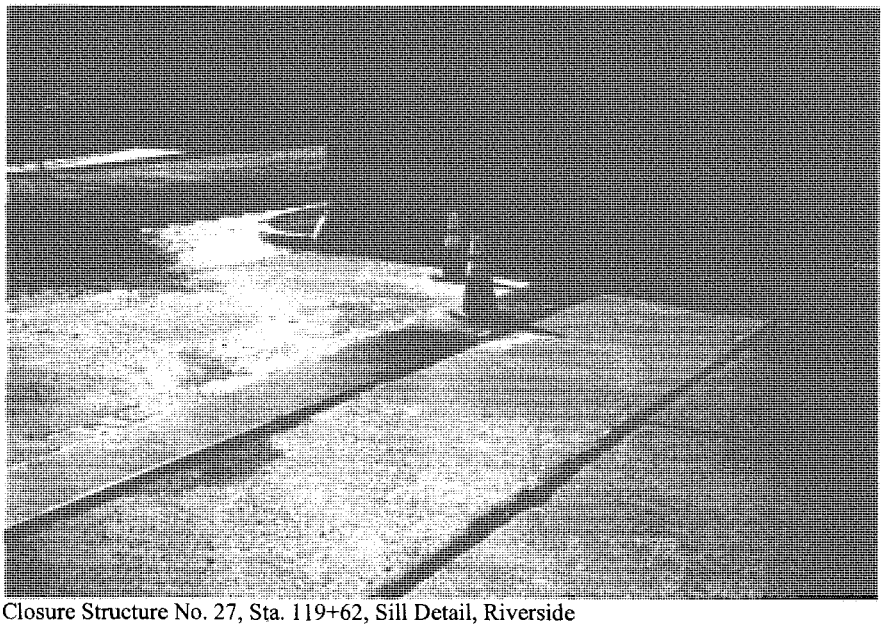
Closure Structure No. 27, Sta. 119+62, Riverside



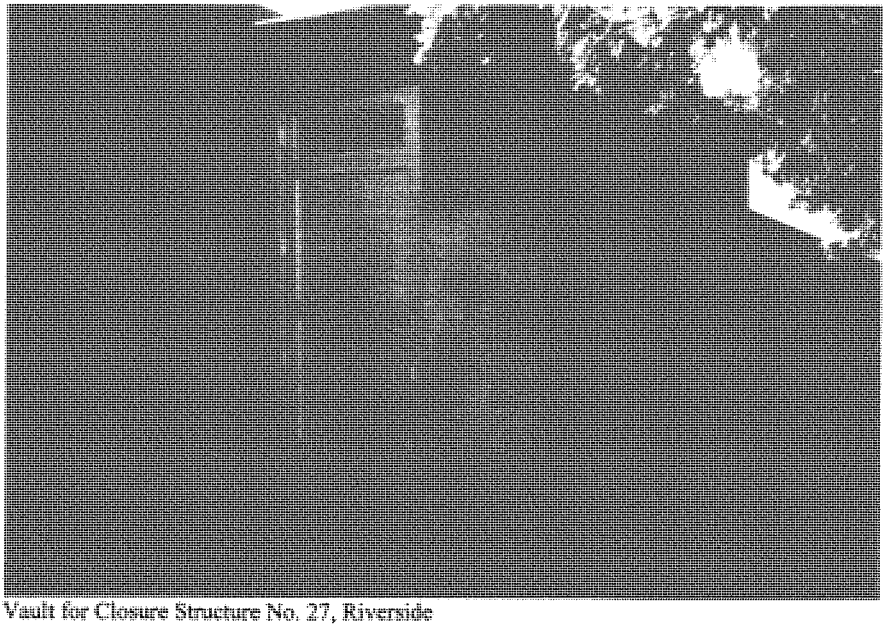
Closure Structure No. 27, Sta. 119+62, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



Closure Structure No. 27, Sta. 119+62, Sill Detail, Riverside

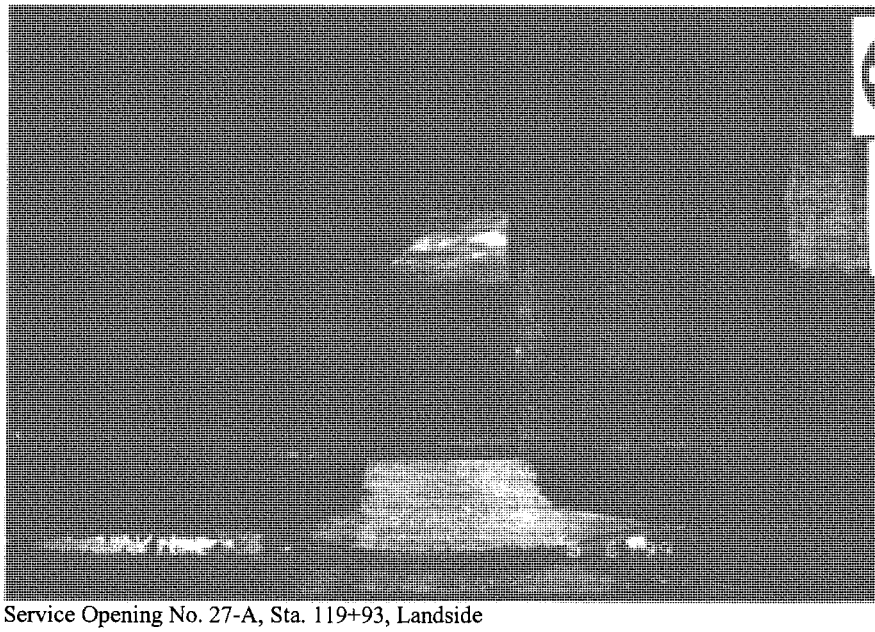


Vault for Closure Structure No. 27, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection

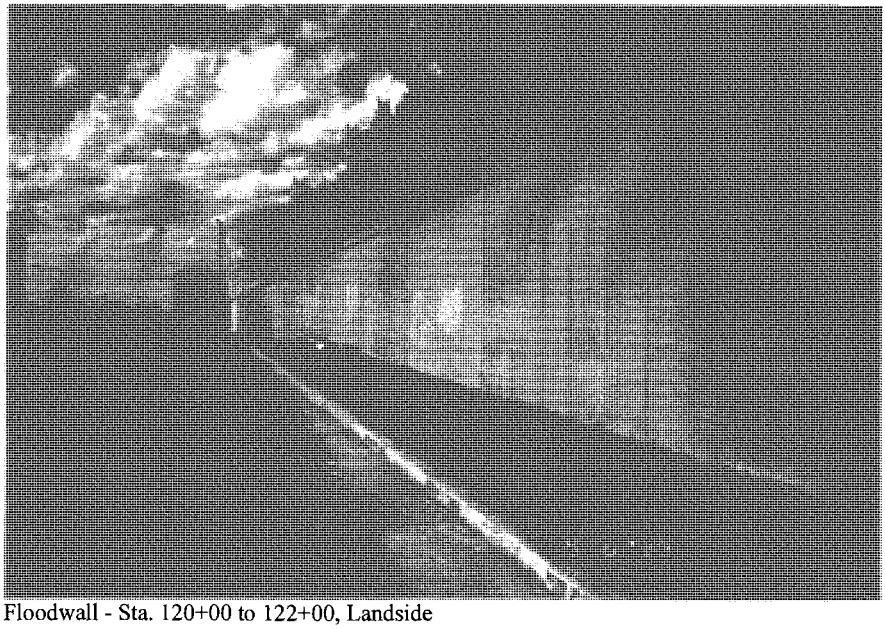
Service Opening No. 27-A, Sta. 119+93, Riverside



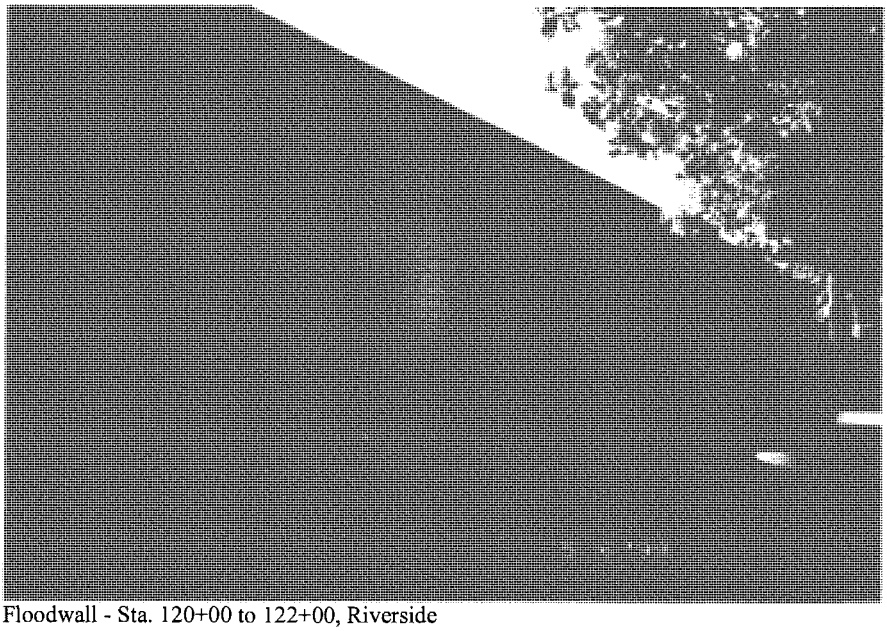
Service Opening No. 27-A, Sta. 119+93, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



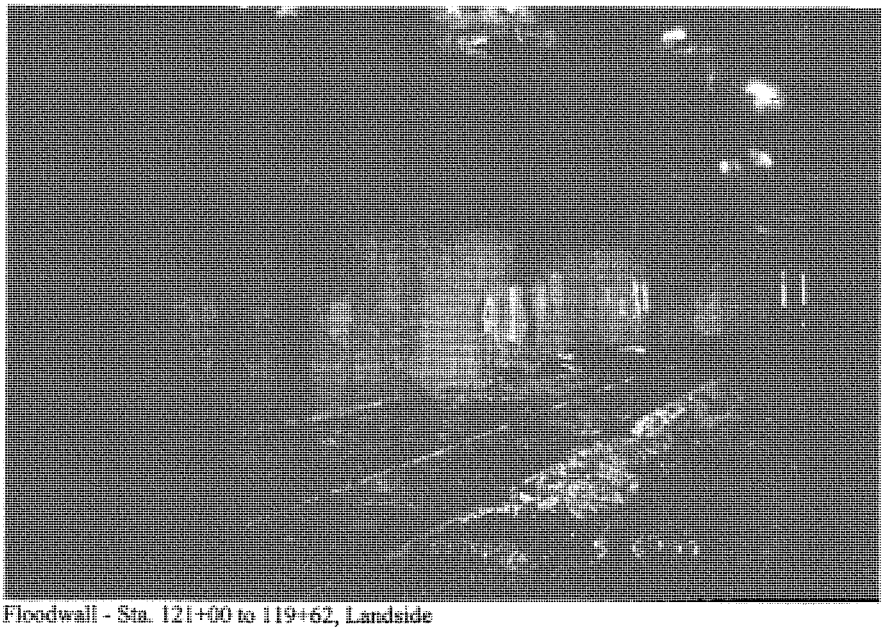
Floodwall - Sta. 120+00 to 122+00, Landside



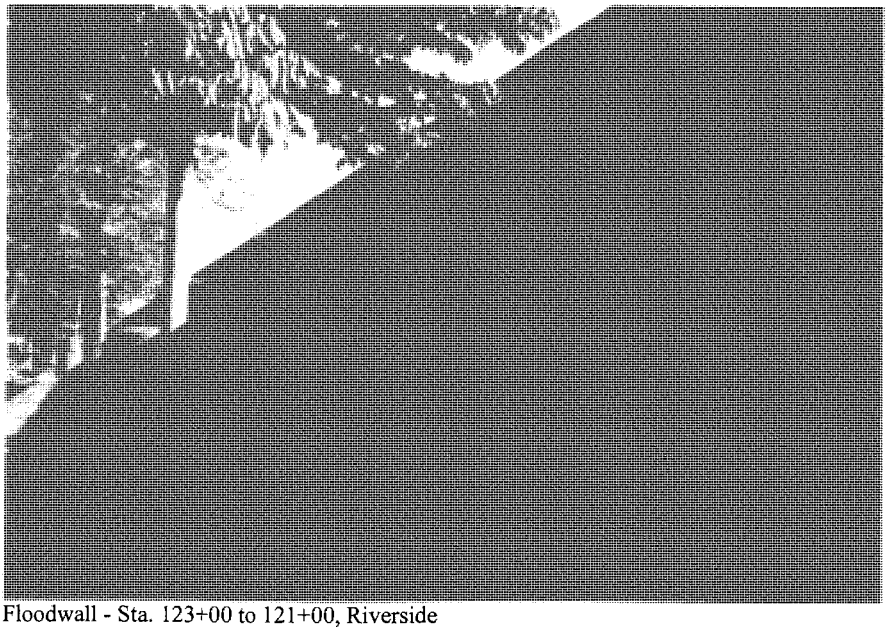
Floodwall - Sta. 120+00 to 122+00, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



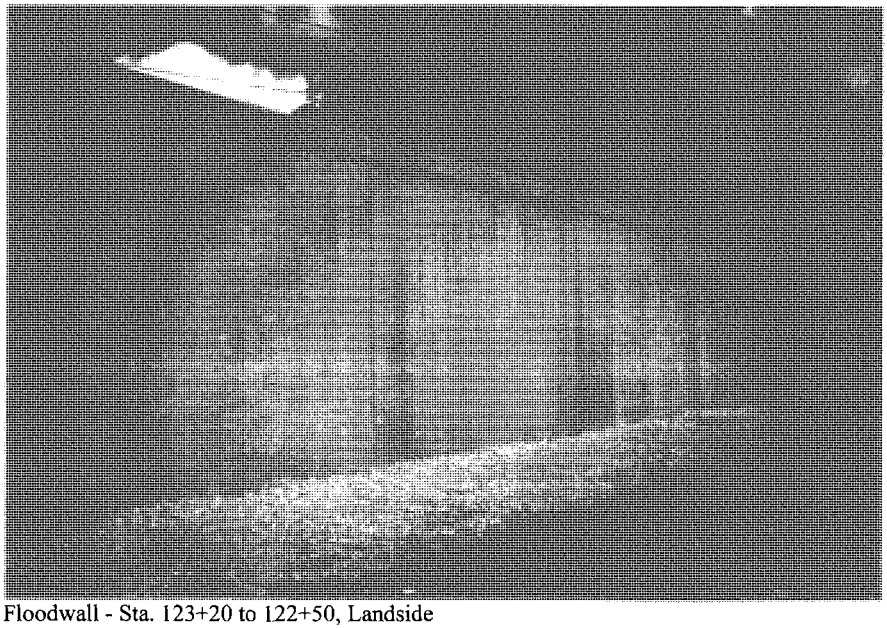
Floodwall - Sta. 121+00 to 119+62, Landside



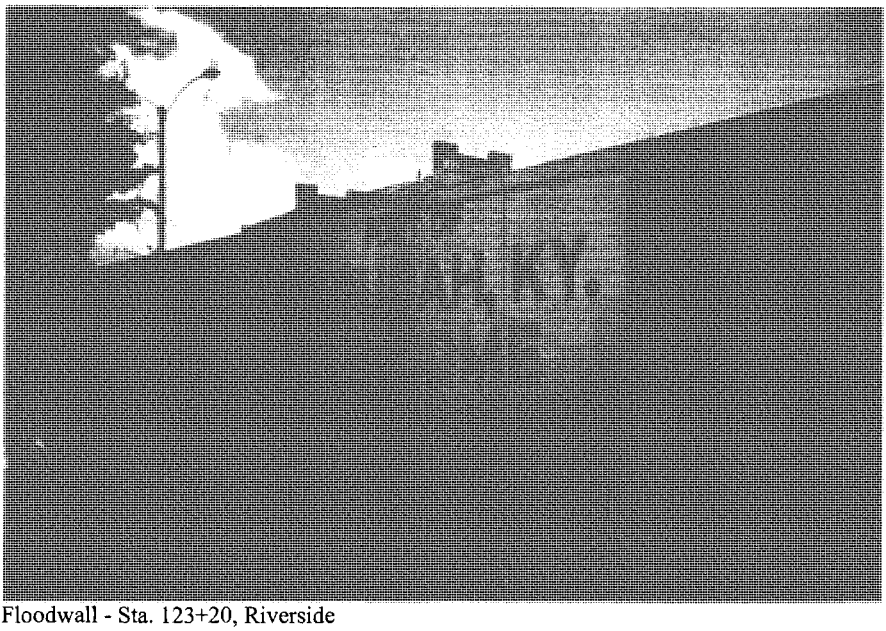
Floodwall - Sta. 123+00 to 121+00, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



Floodwall - Sta. 123+20 to 122+50, Landside

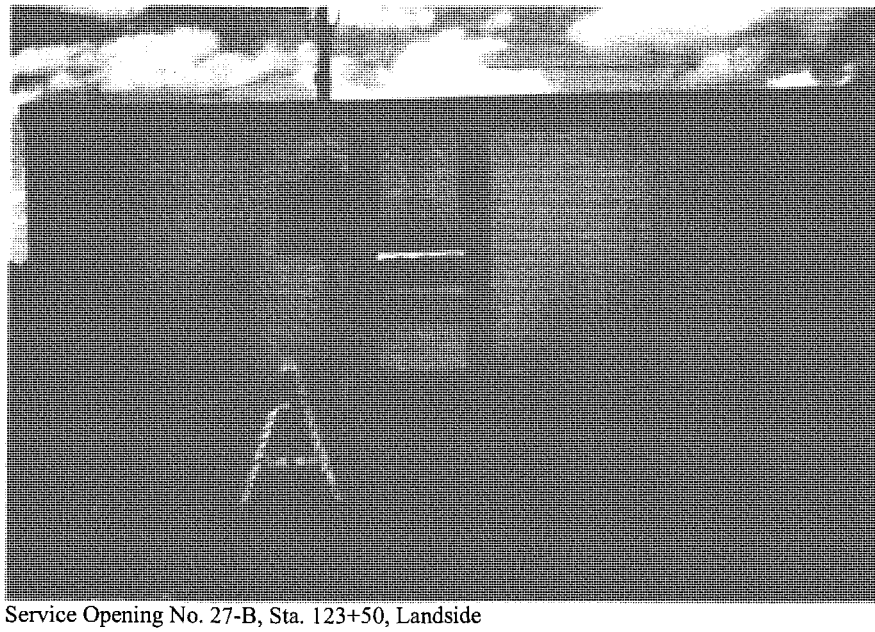


Floodwall - Sta. 123+20, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection

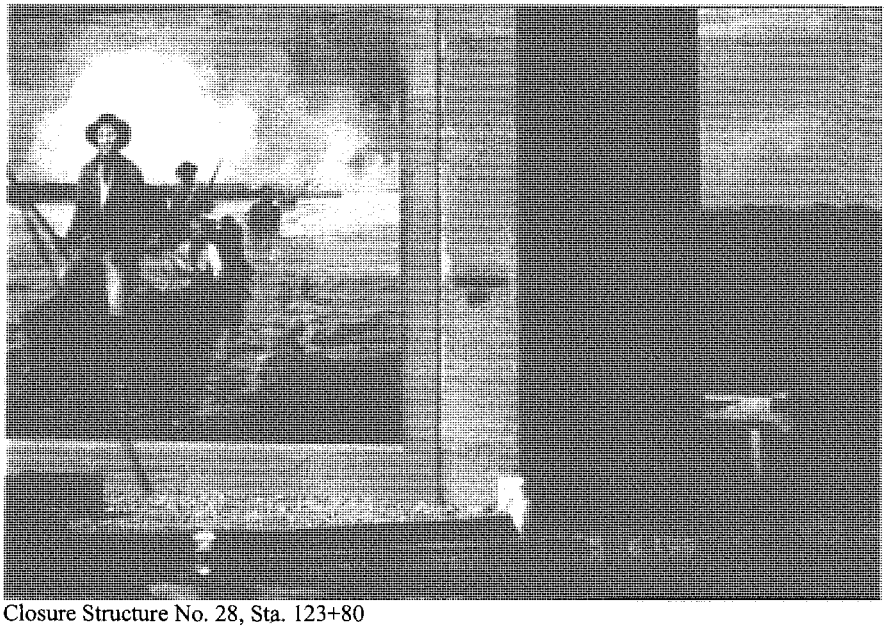
Service Opening No. 27-B, Sta. 123+50, Riverside



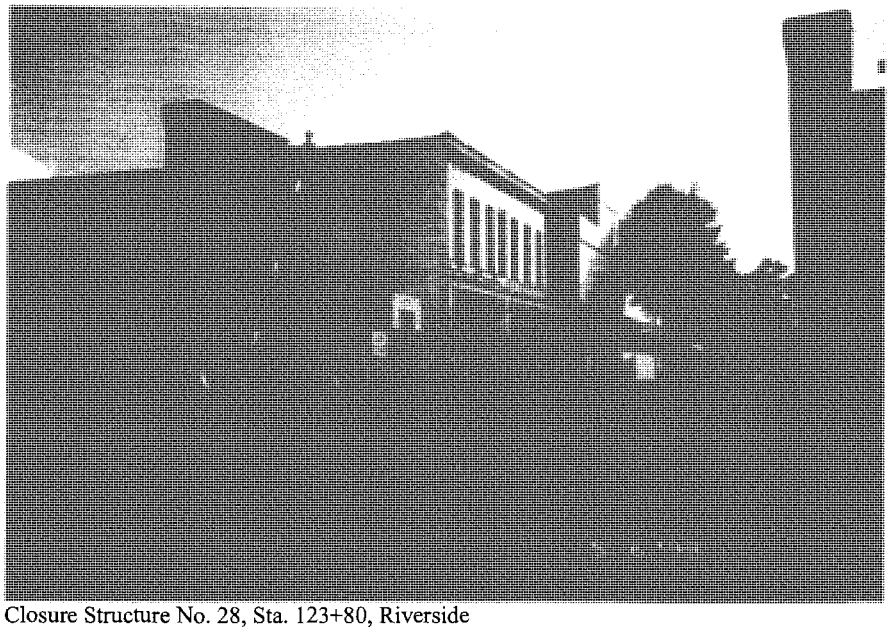
Service Opening No. 27-B, Sta. 123+50, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



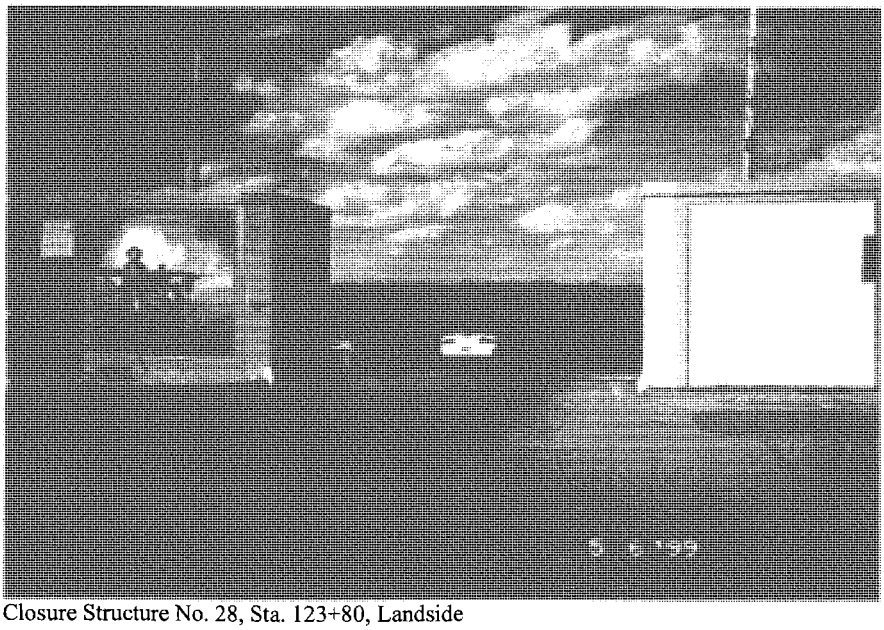
Closure Structure No. 28, Sta. 123+80



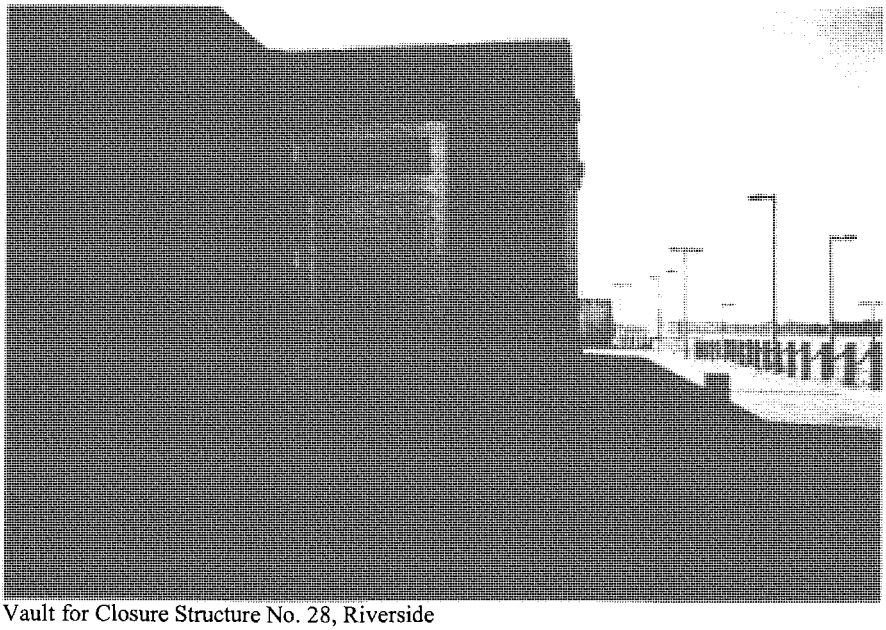
Closure Structure No. 28, Sta. 123+80, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection



Closure Structure No. 28, Sta. 123+80, Landside

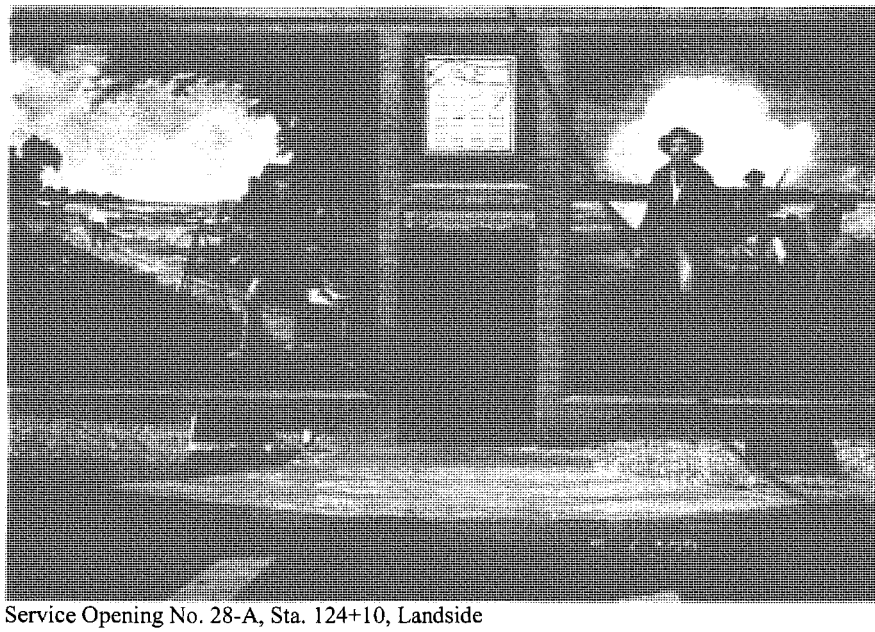


Vault for Closure Structure No. 28, Riverside

May 5 – 11, 1999

Paducah Floodwall Inspection

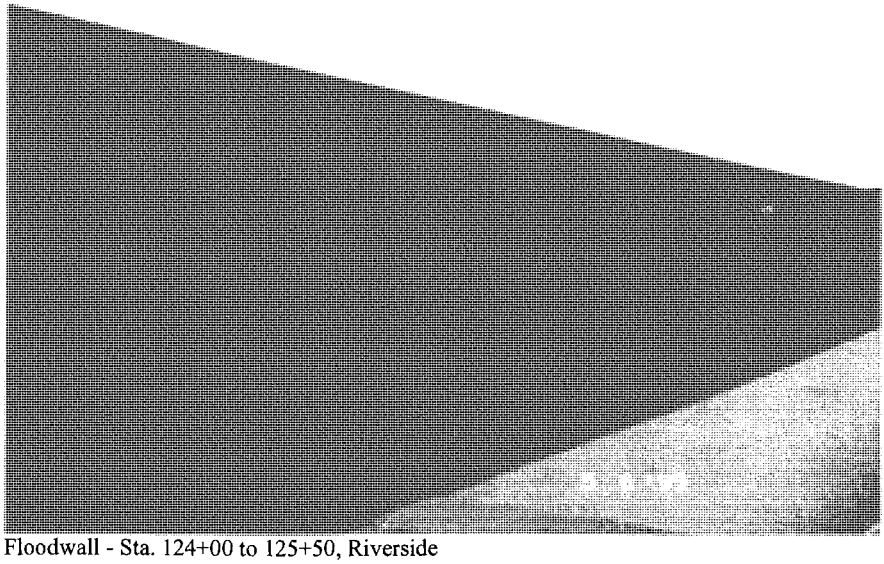
Service Opening No. 28-A, Sta. 124+10, Riverside



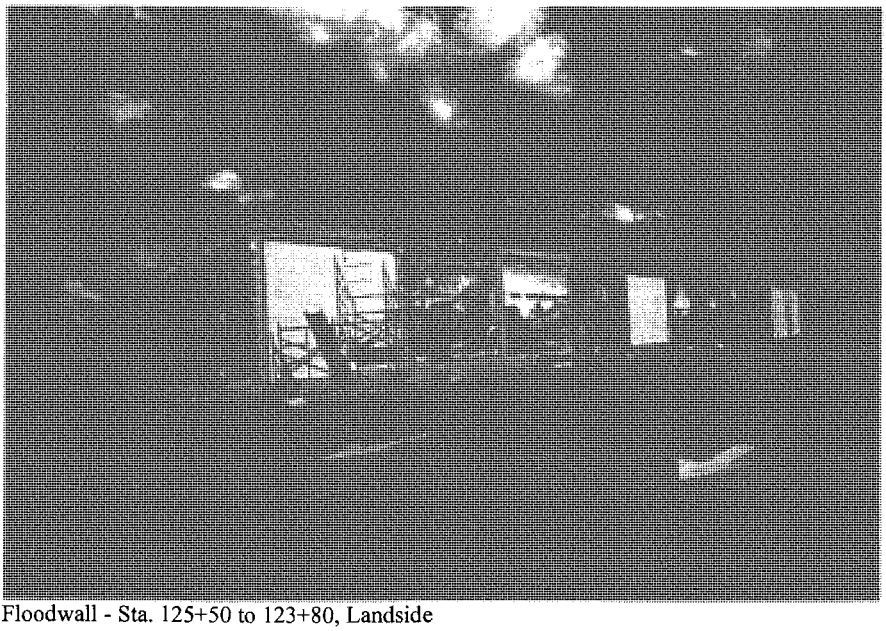
Service Opening No. 28-A, Sta. 124+10, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



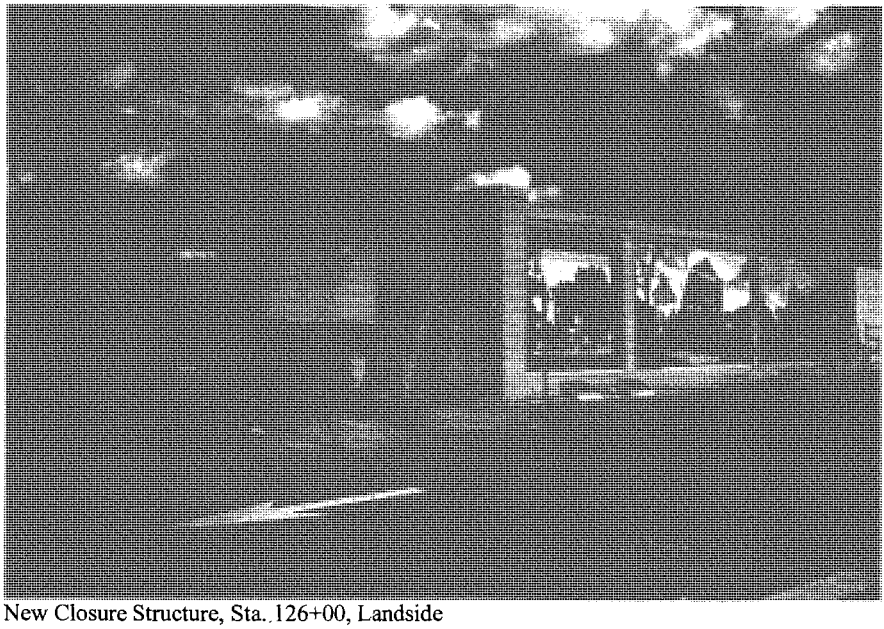
Floodwall - Sta. 124+00 to 125+50, Riverside



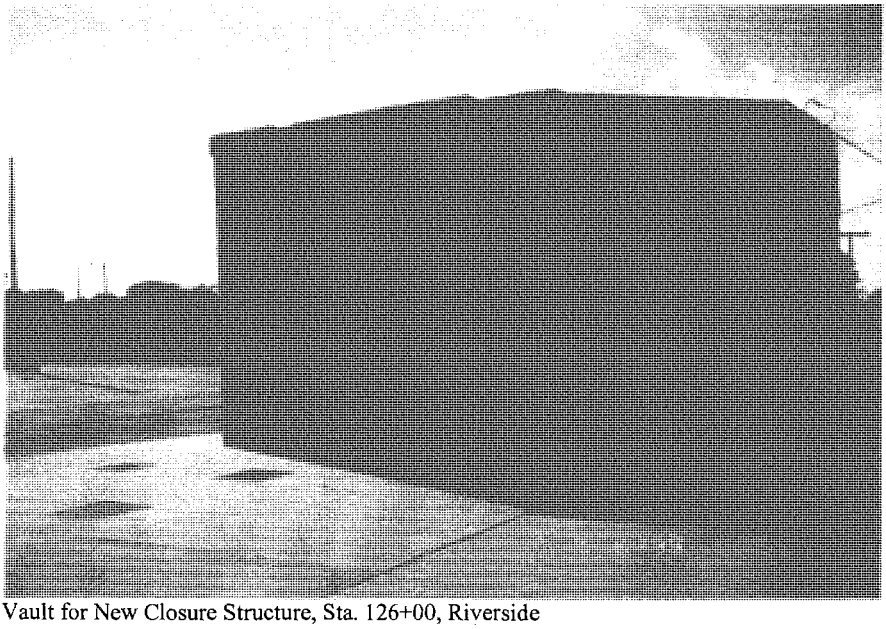
Floodwall - Sta. 125+50 to 123+80, Landside

May 5 – 11, 1999

Paducah Floodwall Inspection



New Closure Structure, Sta. 126+00, Landside

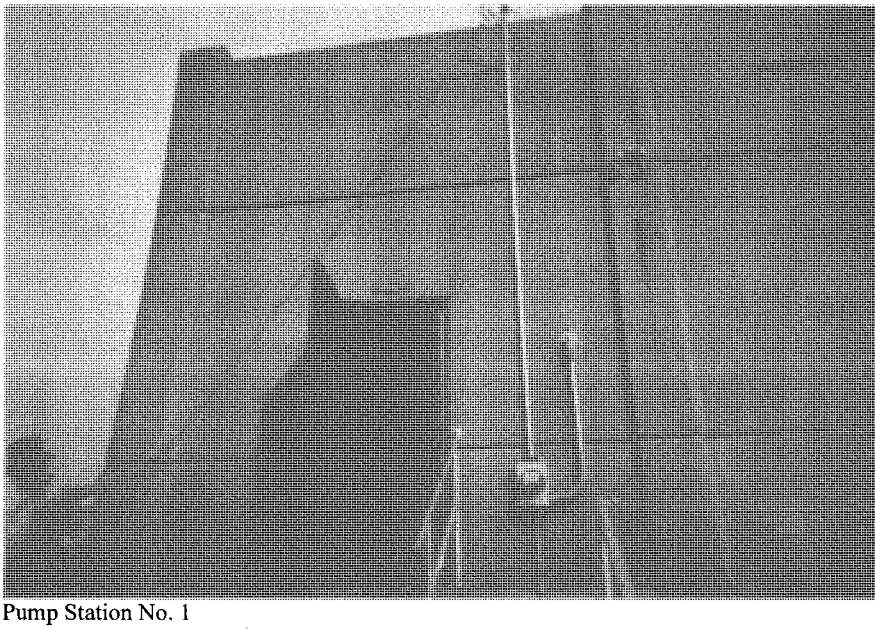


Vault for New Closure Structure, Sta. 126+00, Riverside

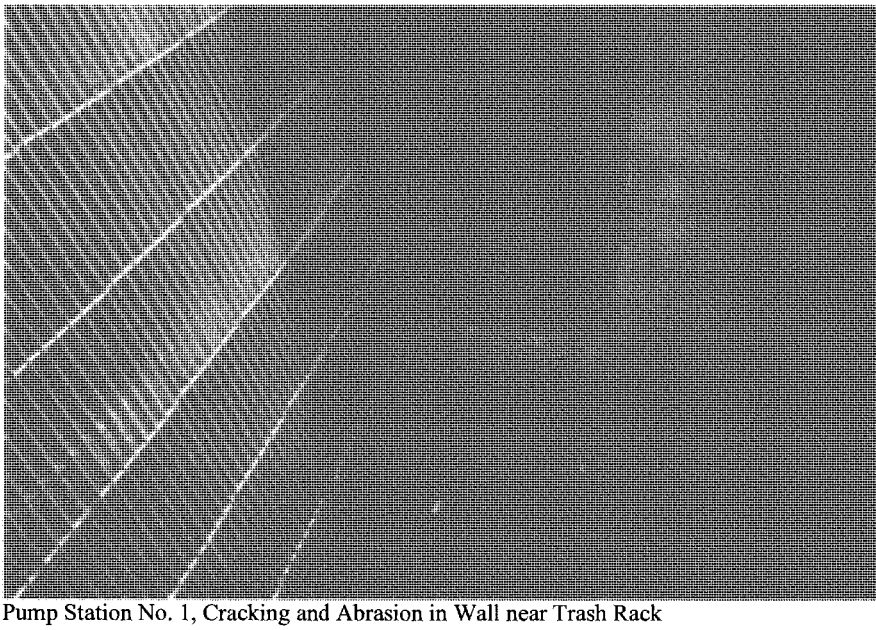
Appendix B
Paducah Floodwall Protection System Pump Station Photographs

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



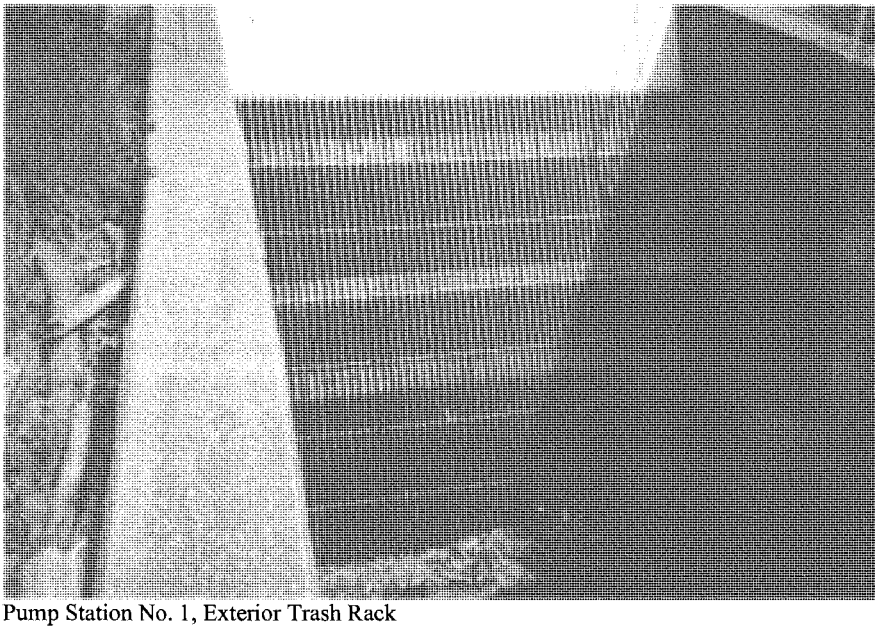
Pump Station No. 1



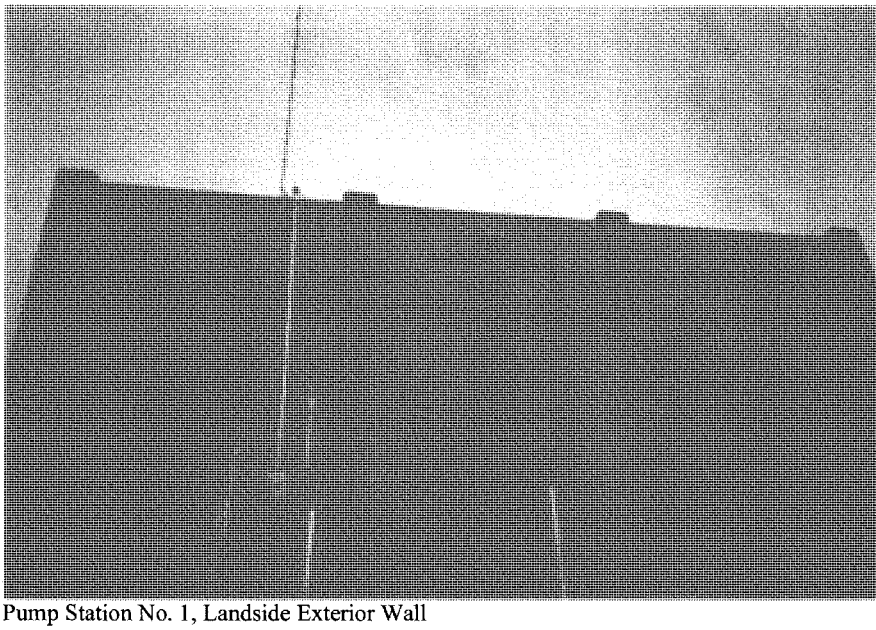
Pump Station No. 1, Cracking and Abrasion in Wall near Trash Rack

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



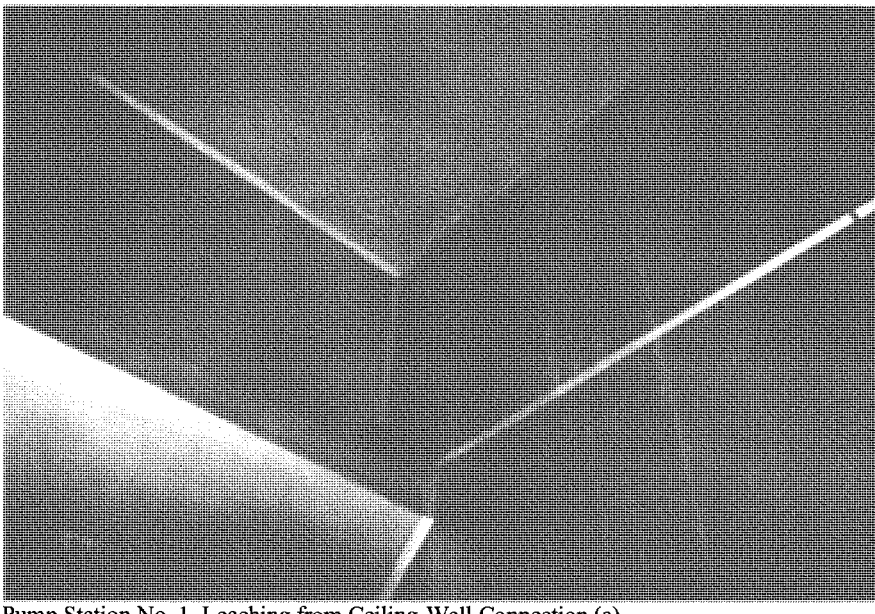
Pump Station No. 1, Exterior Trash Rack



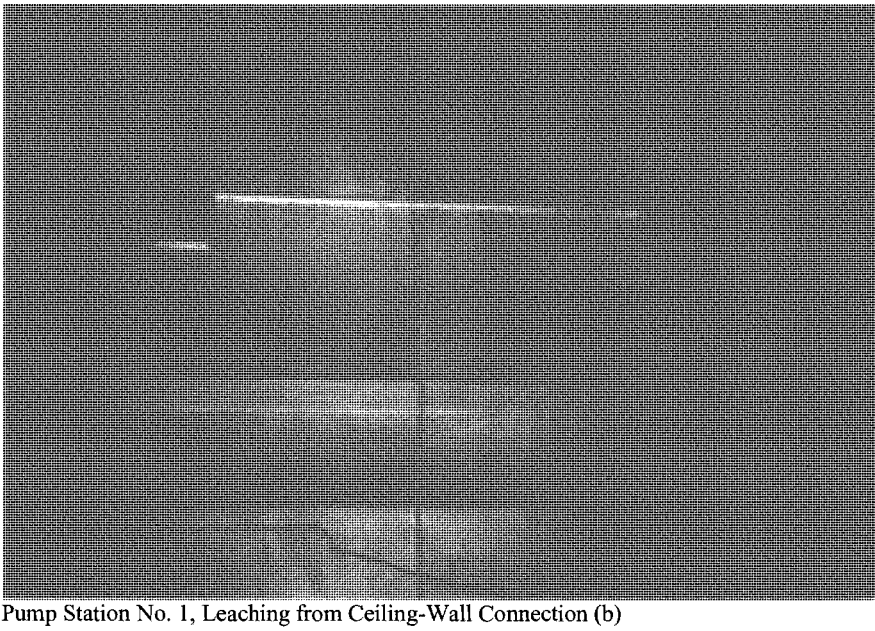
Pump Station No. 1, Landside Exterior Wall

May 5 – 11, 1999

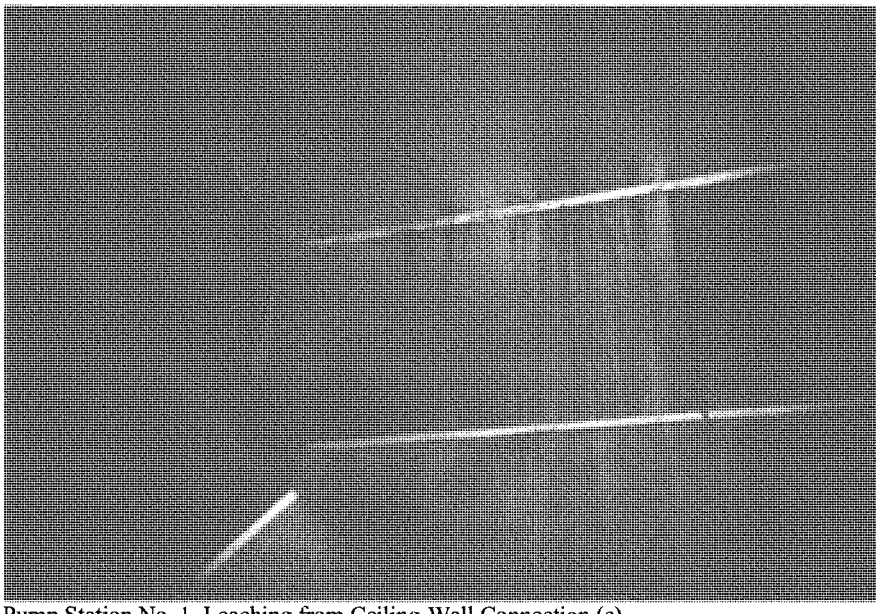
Paducah Floodwall Inspection: Pump Stations



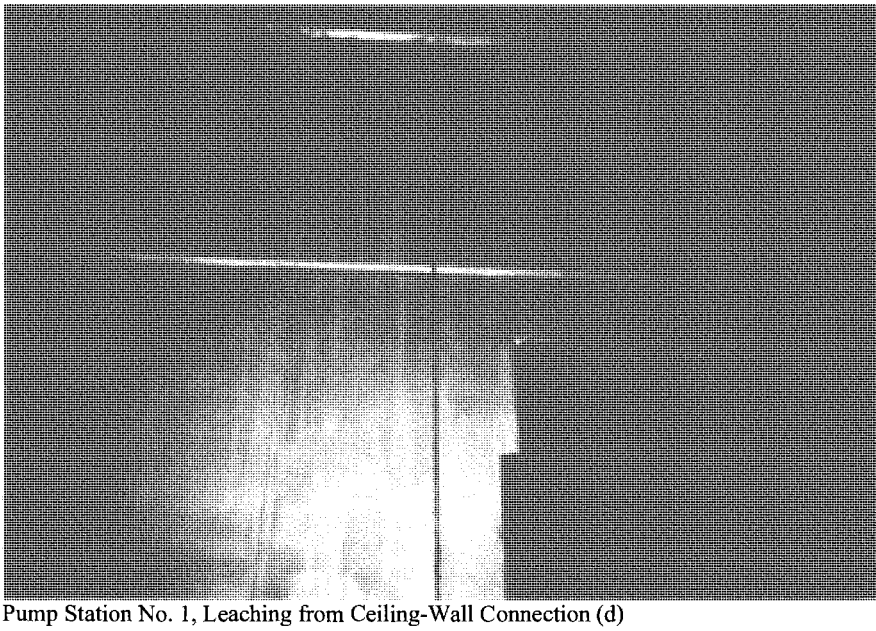
Pump Station No. 1, Leaching from Ceiling-Wall Connection (a)



Pump Station No. 1, Leaching from Ceiling-Wall Connection (b)



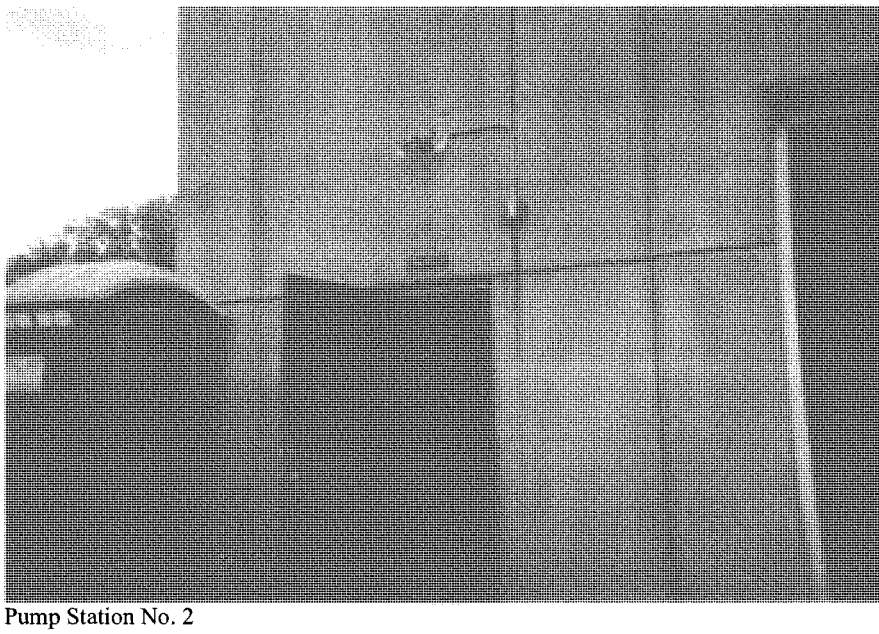
Pump Station No. 1, Leaching from Ceiling-Wall Connection (c)



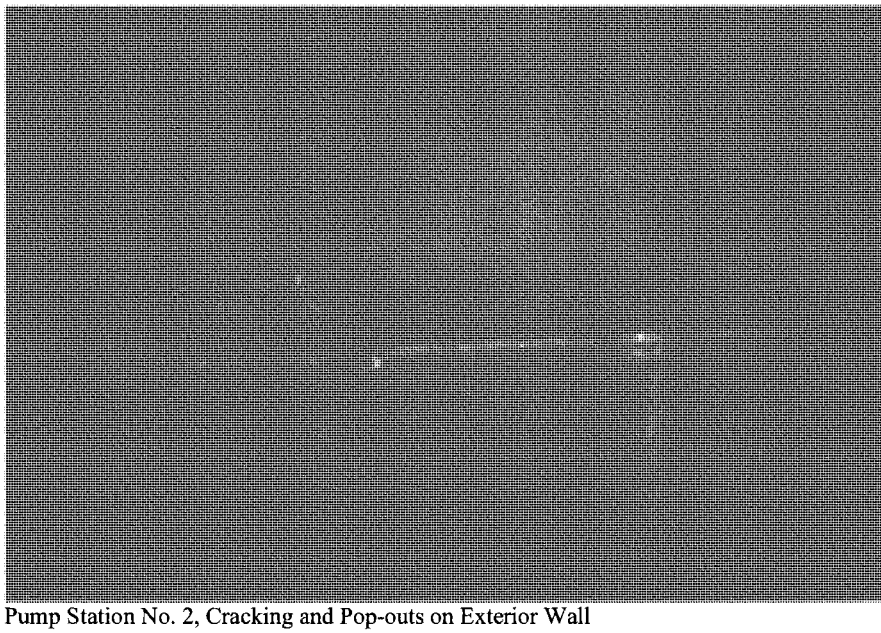
Pump Station No. 1, Leaching from Ceiling-Wall Connection (d)

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



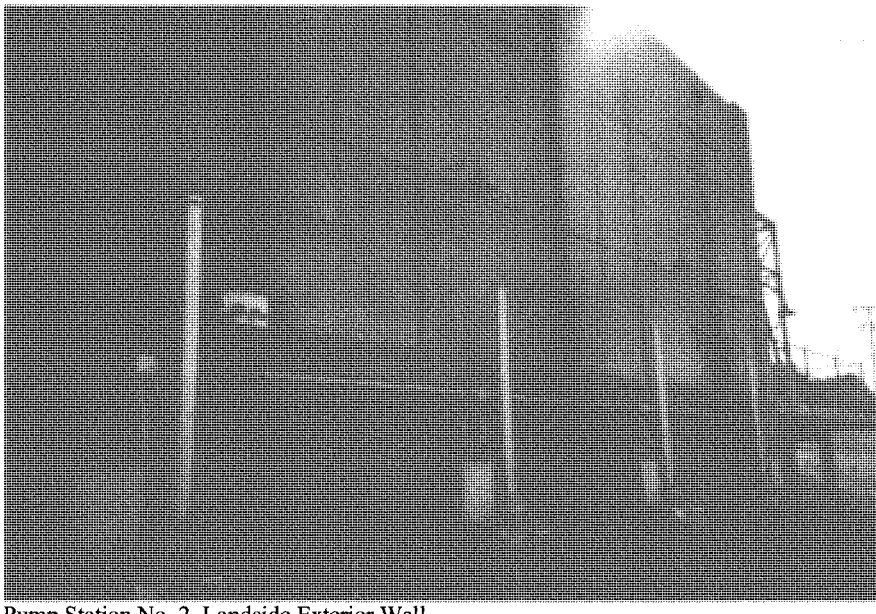
Pump Station No. 2



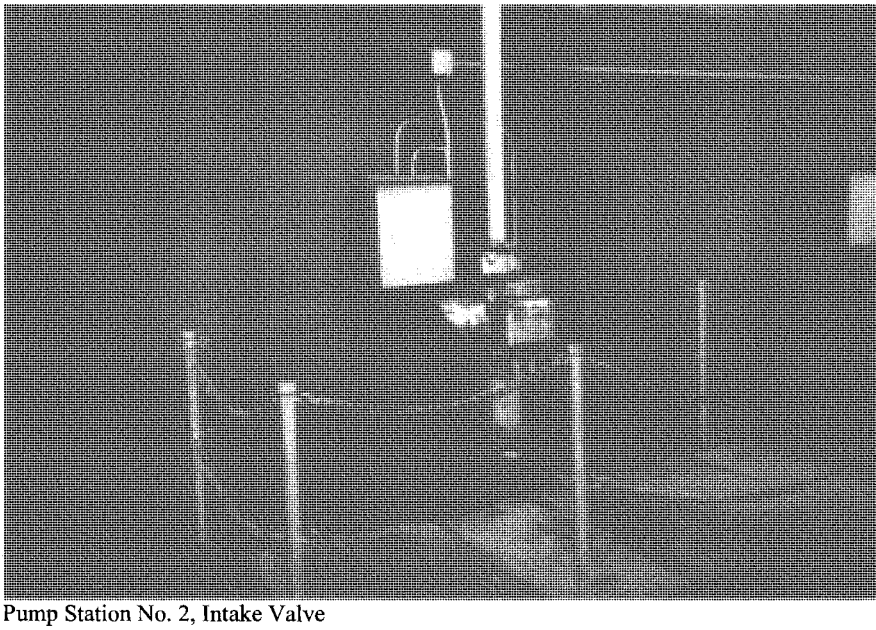
Pump Station No. 2, Cracking and Pop-outs on Exterior Wall

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



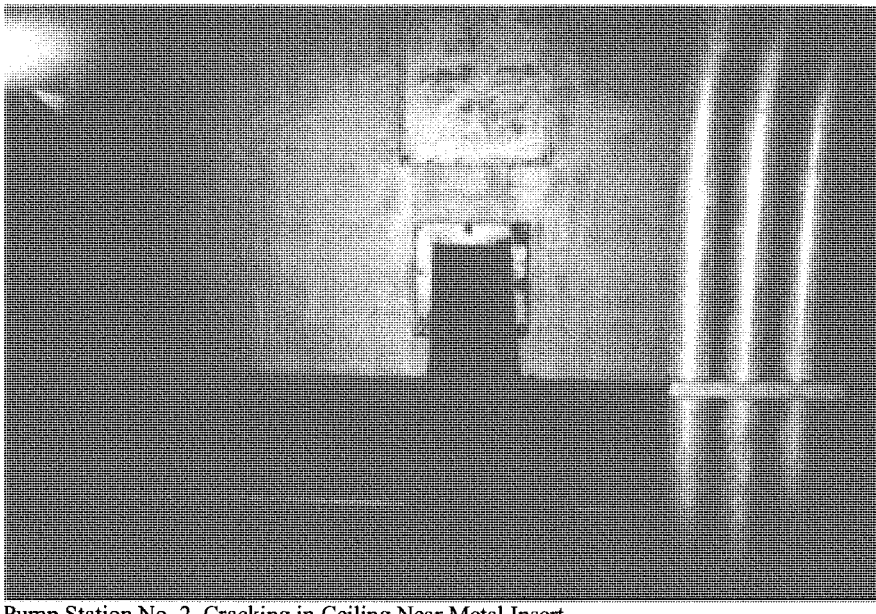
Pump Station No. 2, Landside Exterior Wall



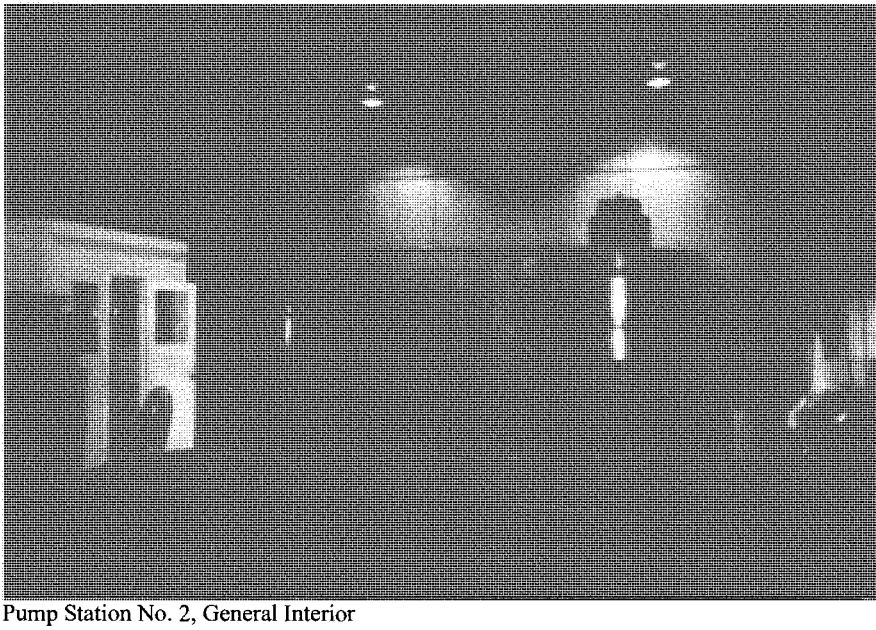
Pump Station No. 2, Intake Valve

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations

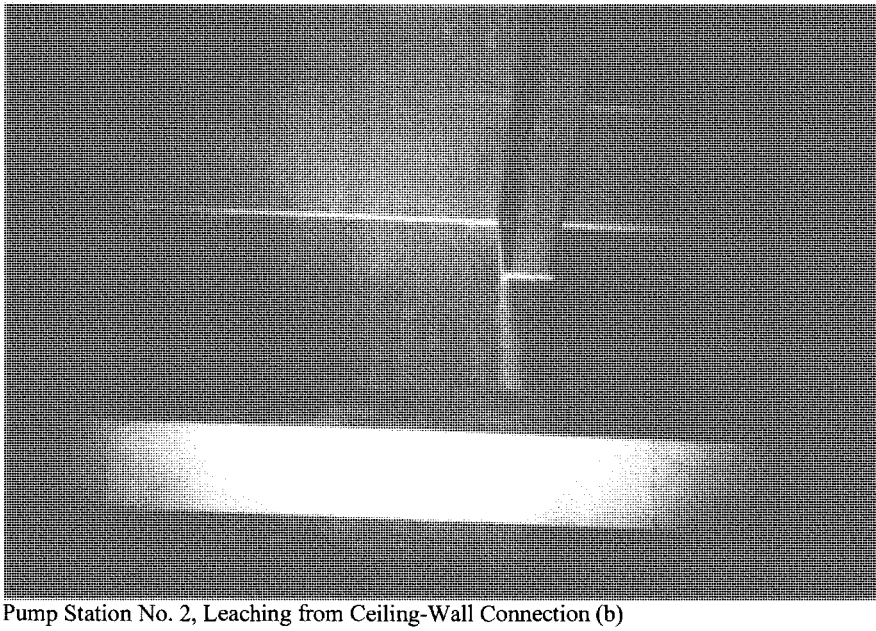


Pump Station No. 2, Cracking in Ceiling Near Metal Insert



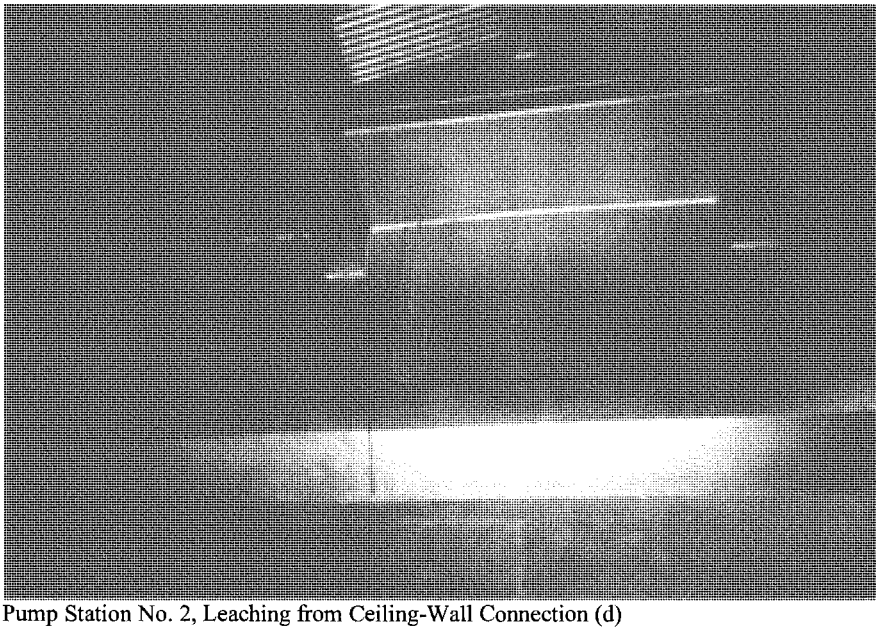
Pump Station No. 2, General Interior

Pump Station No. 2, Leaching from Ceiling-Wall Connection (a)



Pump Station No. 2, Leaching from Ceiling-Wall Connection (b)

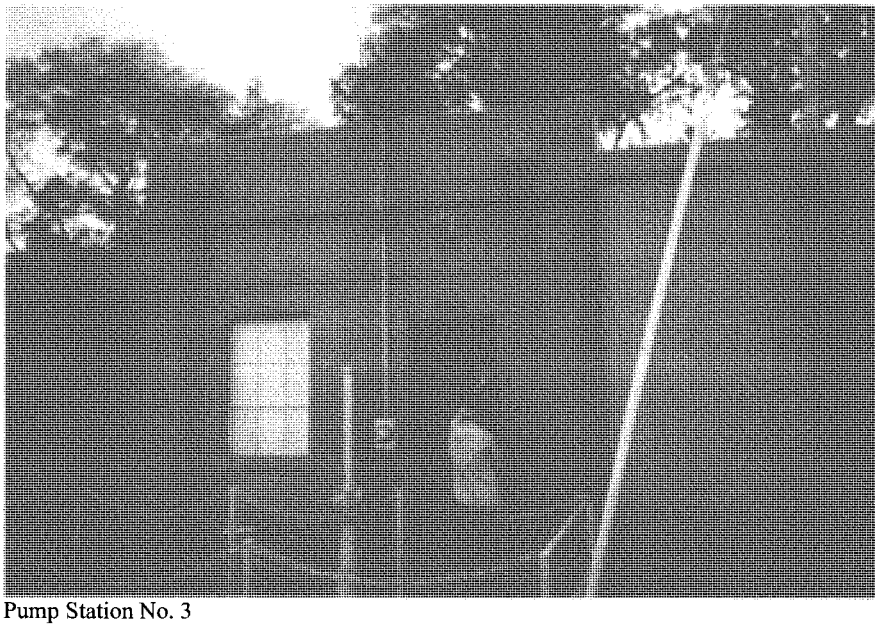
Pump Station No. 2, Leaching from Ceiling Wall Connection (c)



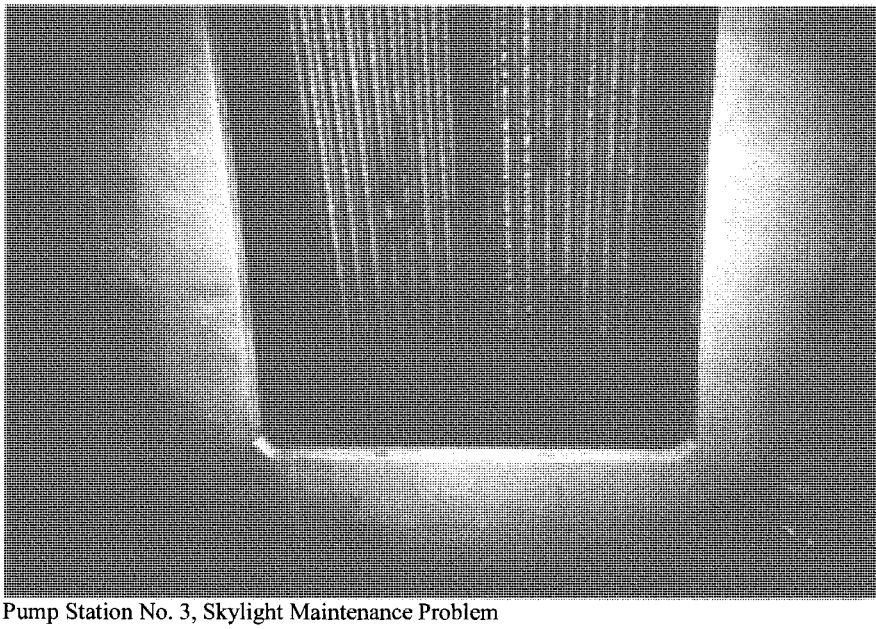
Pump Station No. 2, Leaching from Ceiling-Wall Connection (d)

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



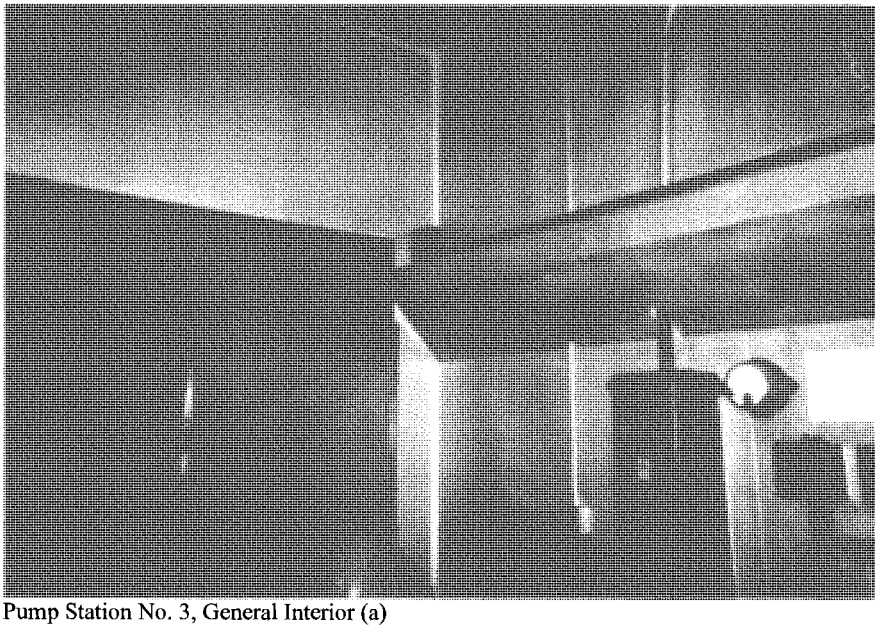
Pump Station No. 3



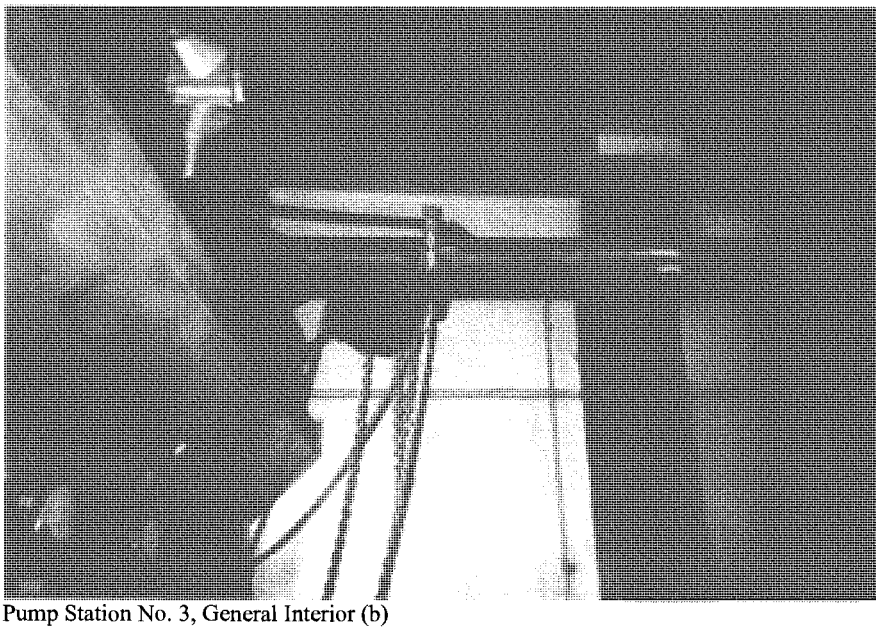
Pump Station No. 3, Skylight Maintenance Problem

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



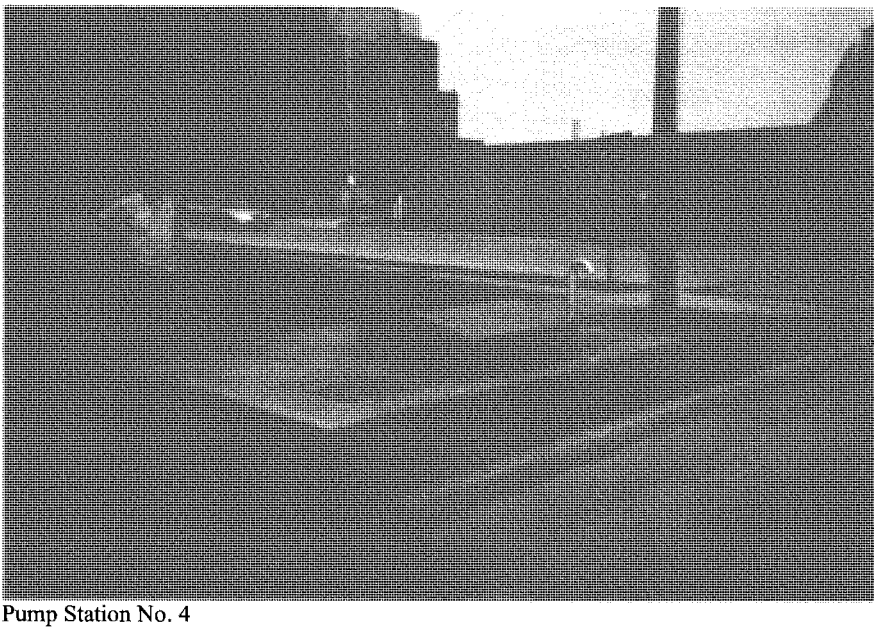
Pump Station No. 3, General Interior (a)



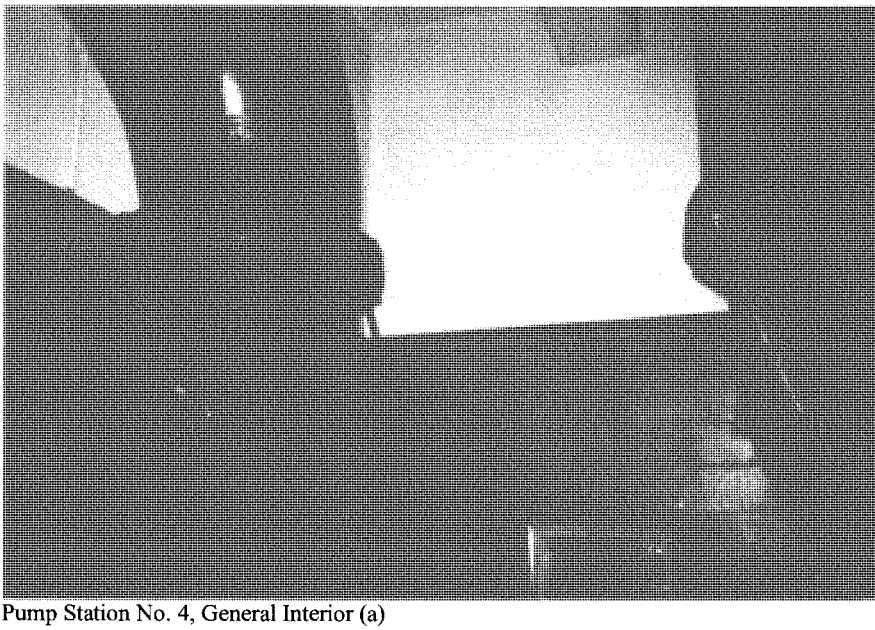
Pump Station No. 3, General Interior (b)

May 5 – 11, 1999

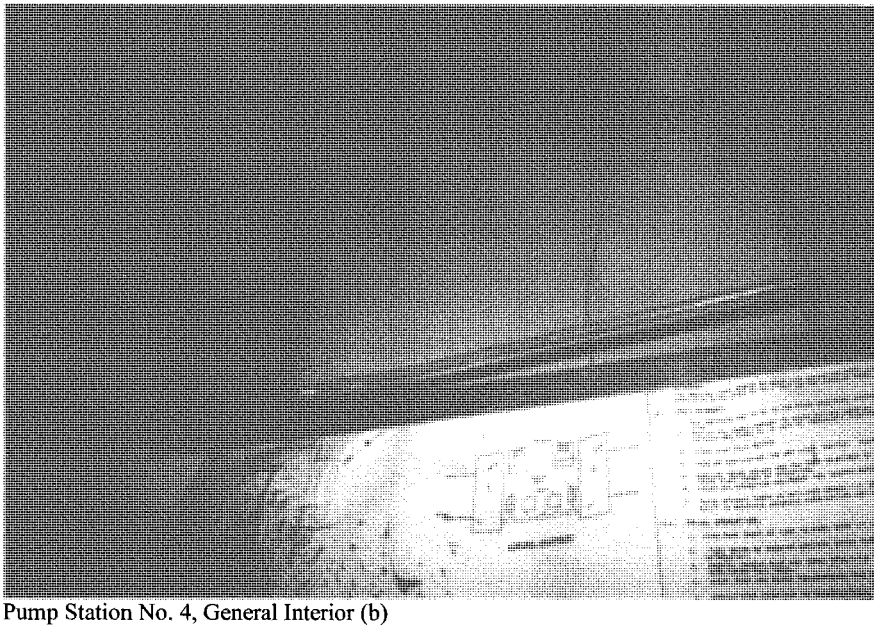
Paducah Floodwall Inspection: Pump Stations



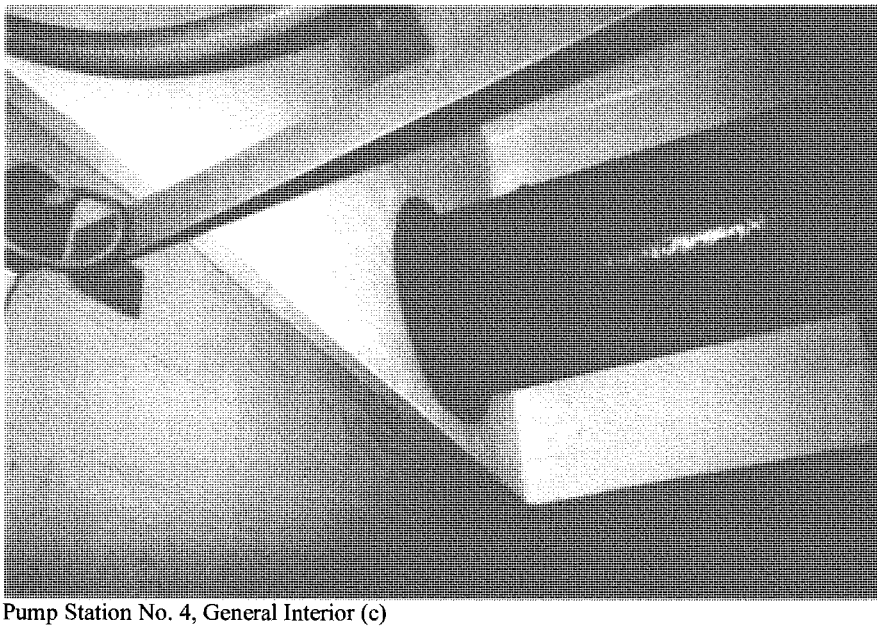
Pump Station No. 4



Pump Station No. 4, General Interior (a)

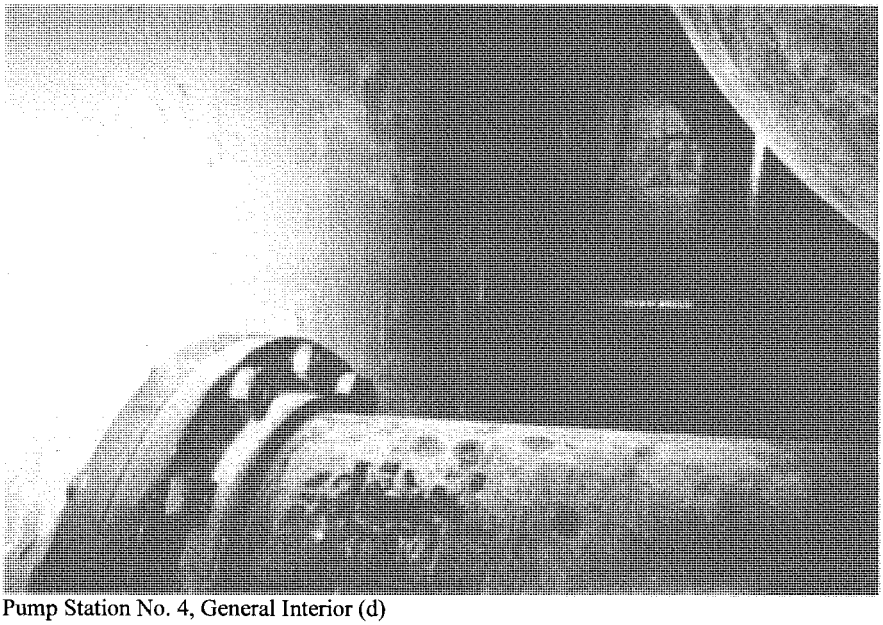


Pump Station No. 4, General Interior (b)

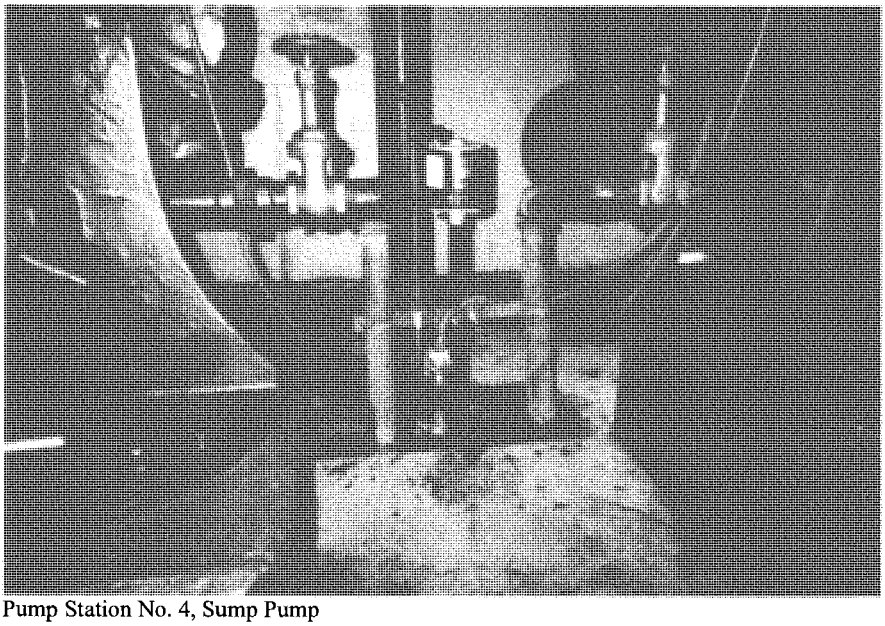


Pump Station No. 4, General Interior (c)

Paducah Floodwall Inspection: Pump Stations



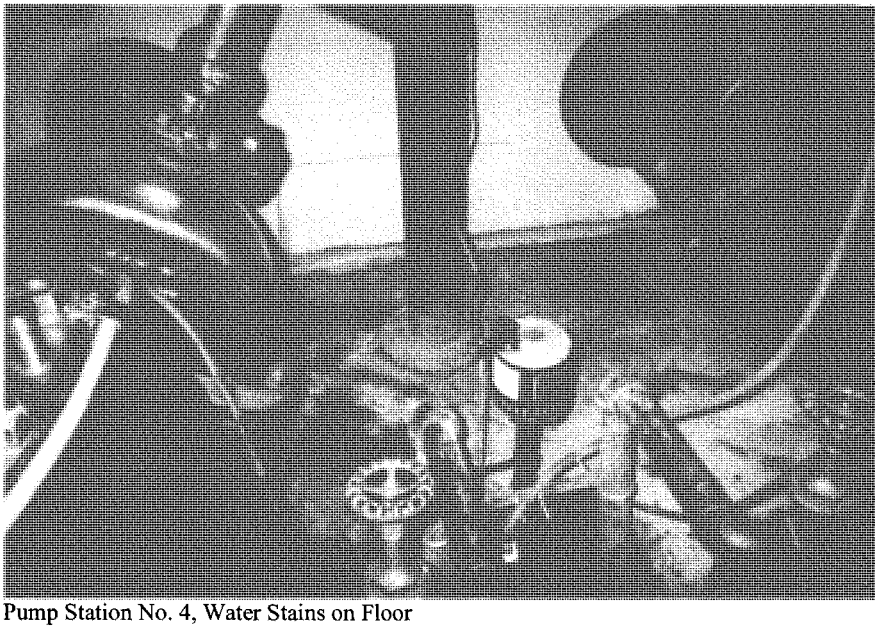
Pump Station No. 4, General Interior (d)



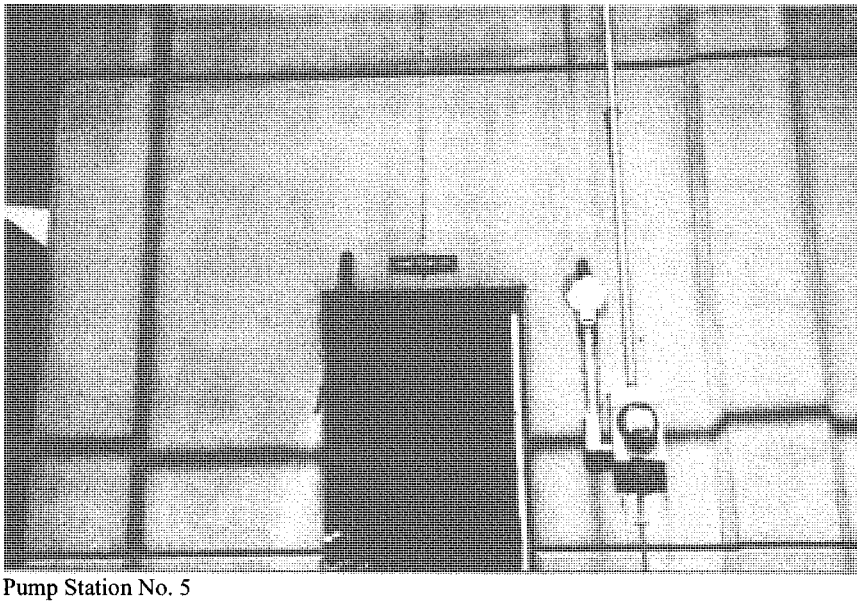
Pump Station No. 4, Sump Pump

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



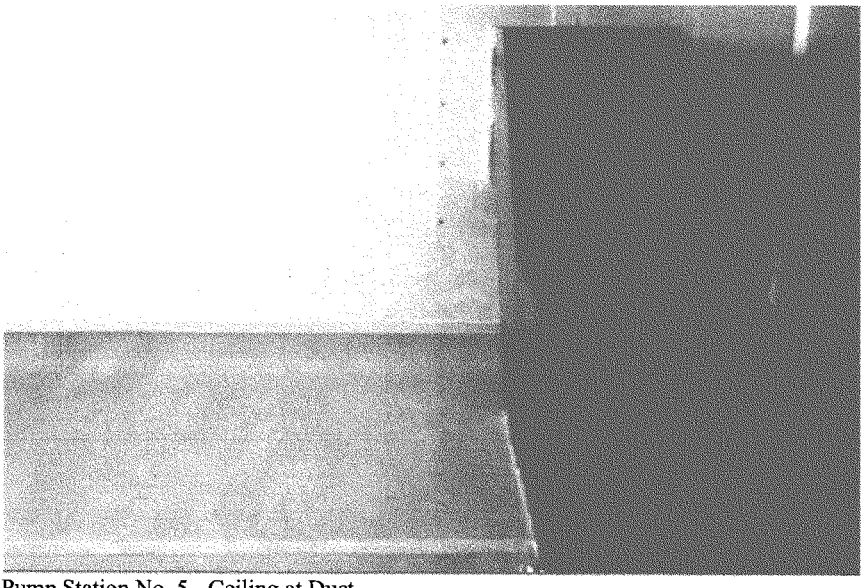
Pump Station No. 4, Water Stains on Floor



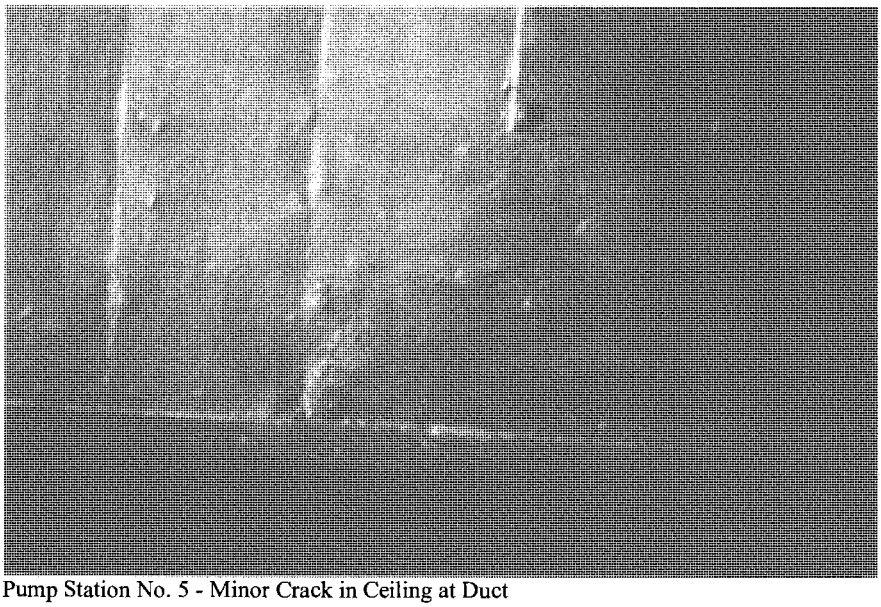
Pump Station No. 5

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



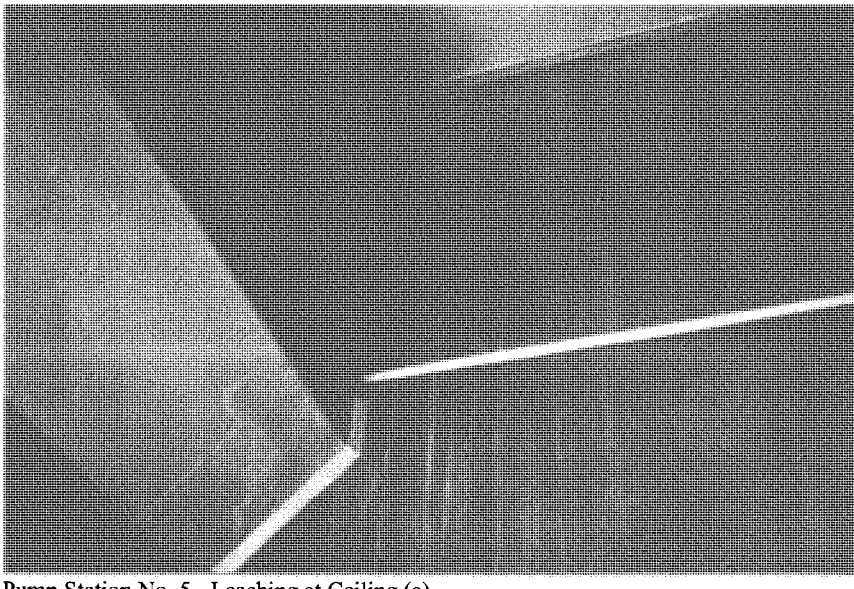
Pump Station No. 5 - Ceiling at Duct



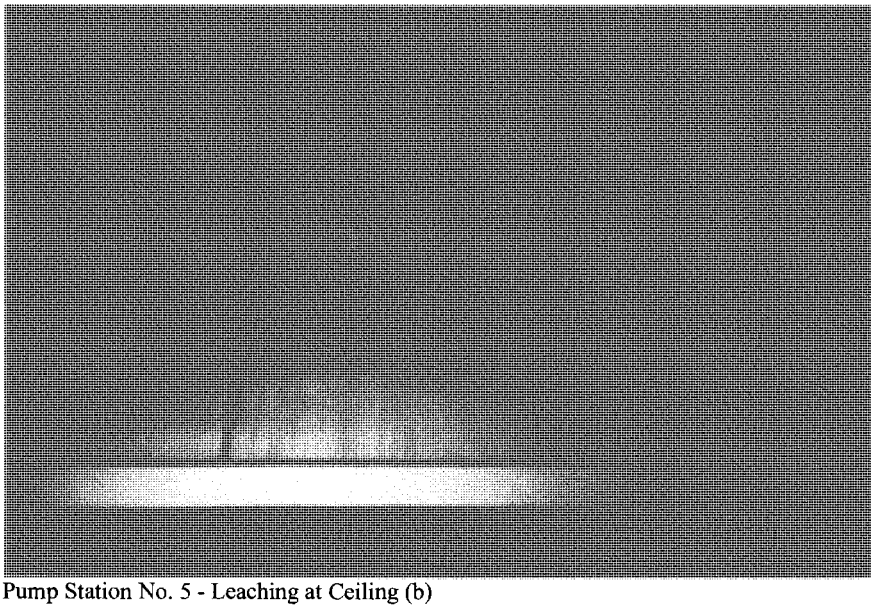
Pump Station No. 5 - Minor Crack in Ceiling at Duct

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



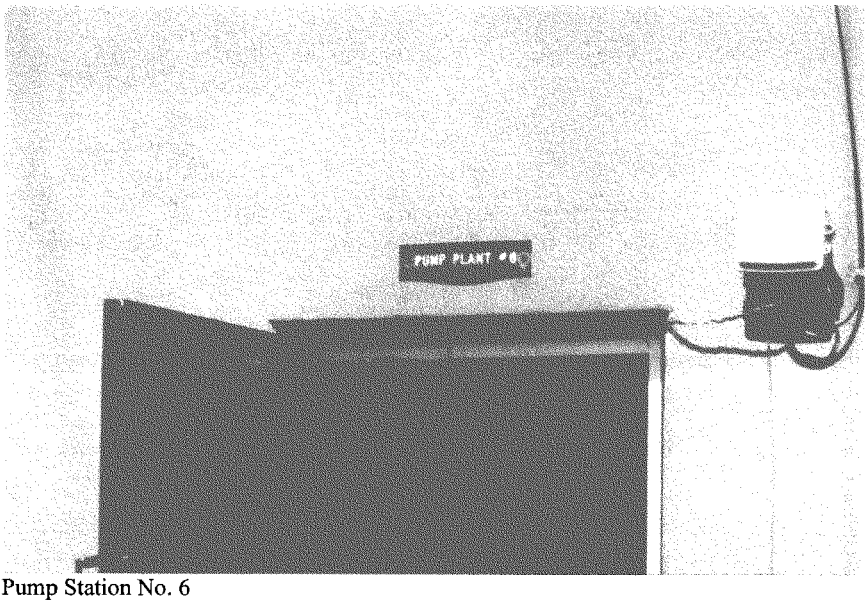
Pump Station No. 5 - Leaching at Ceiling (a)



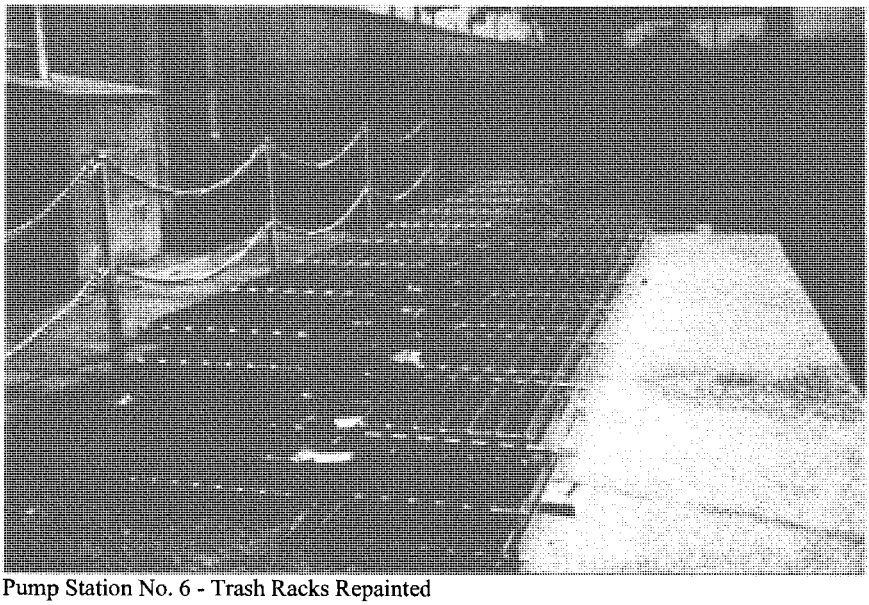
Pump Station No. 5 - Leaching at Ceiling (b)

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations

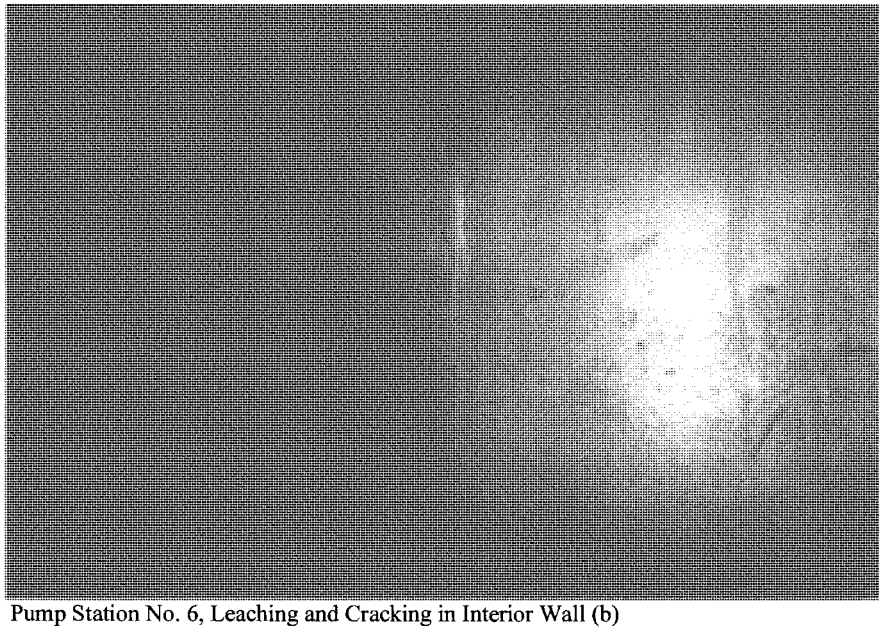


Pump Station No. 6

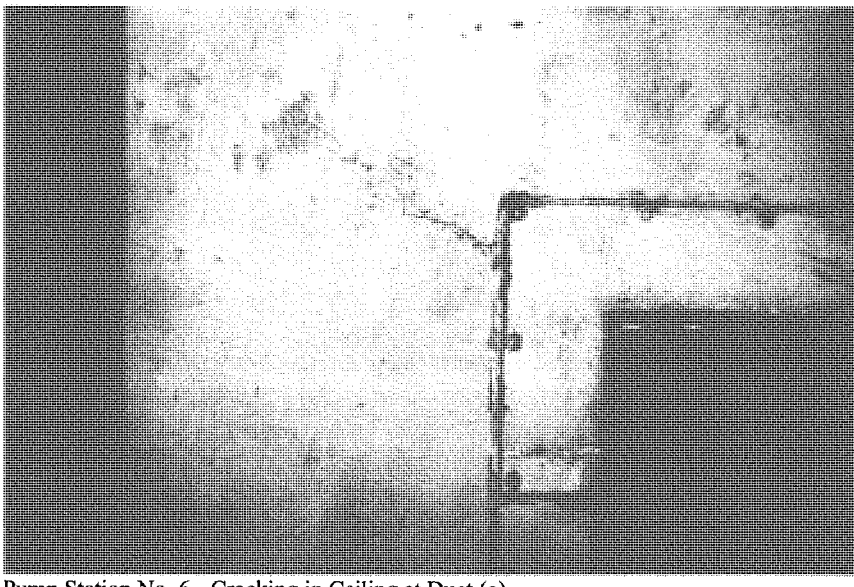


Pump Station No. 6 - Trash Racks Repainted

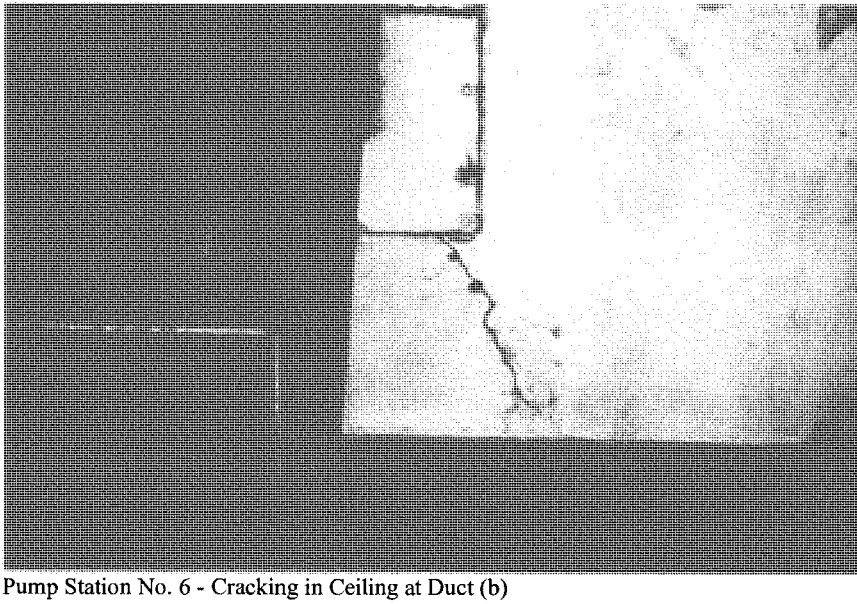
Pump Station No. 6, Leaching and Cracking in Interior Wall (a)



Pump Station No. 6, Leaching and Cracking in Interior Wall (b)



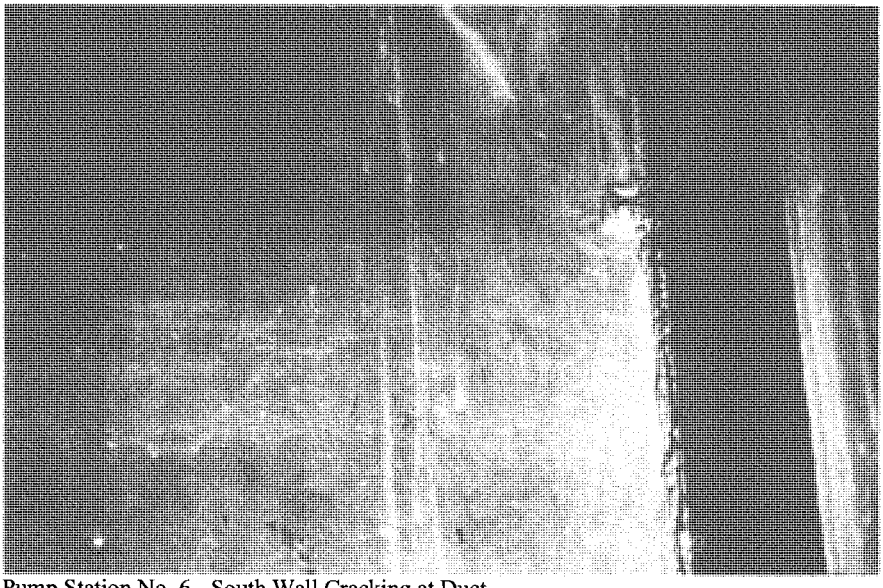
Pump Station No. 6 - Cracking in Ceiling at Duct (a)



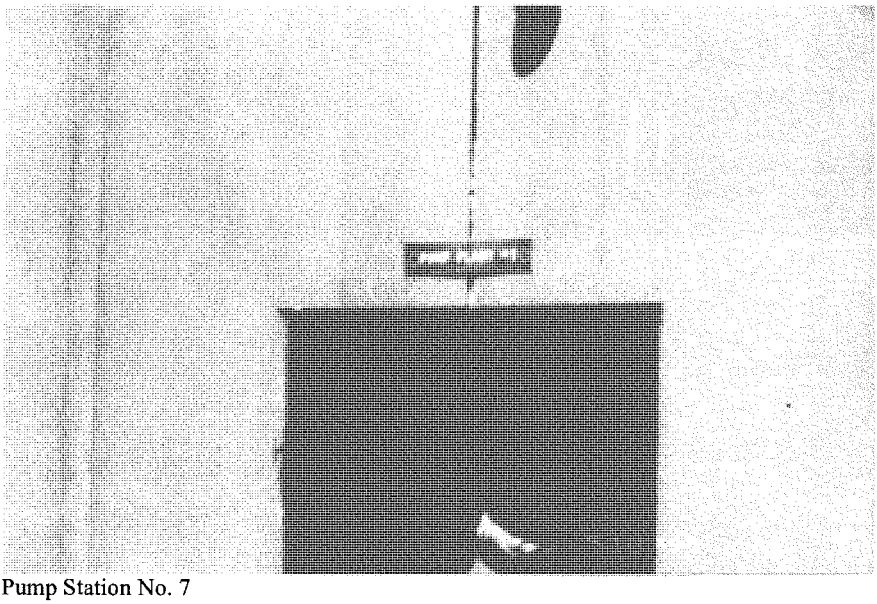
Pump Station No. 6 - Cracking in Ceiling at Duct (b)

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



Pump Station No. 6 - South Wall Cracking at Duct

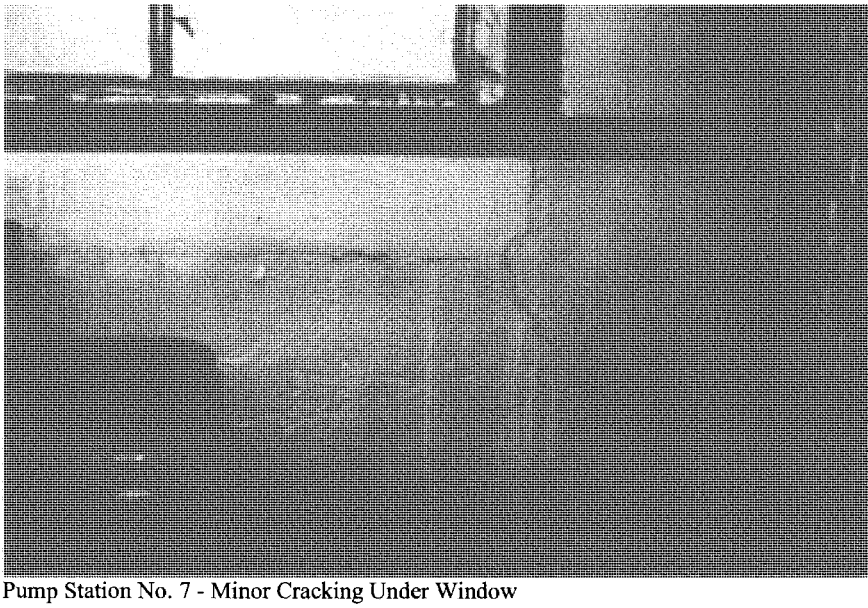


Pump Station No. 7

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations

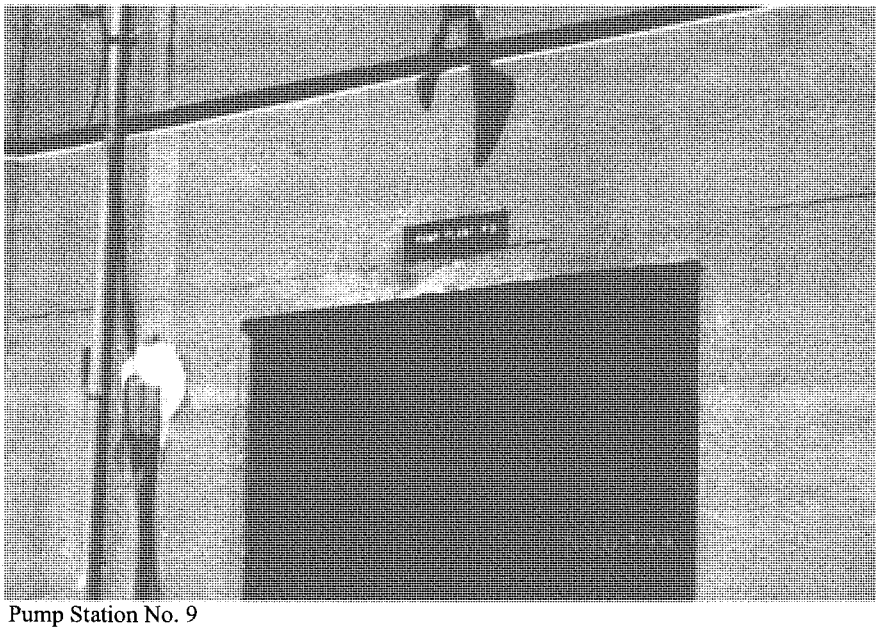
Pump Station No. 7 - General Interior



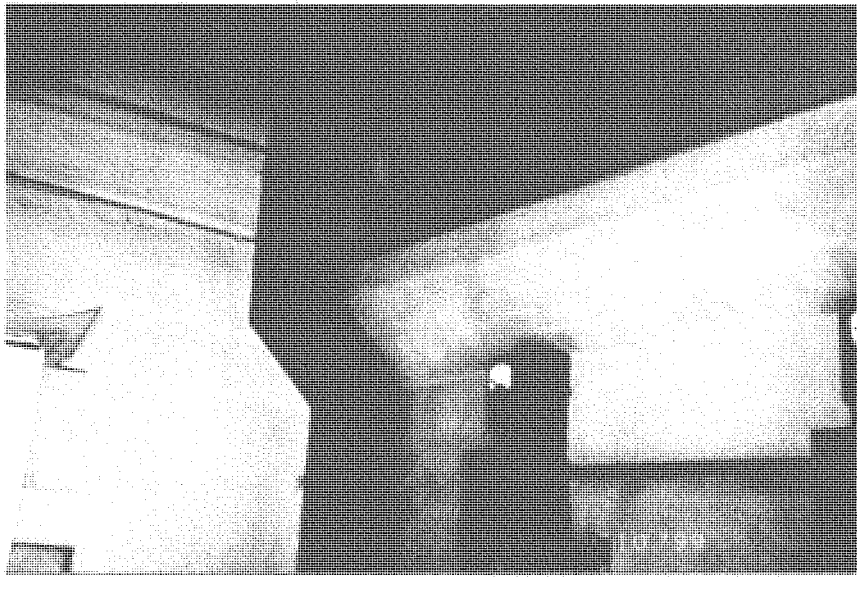
Pump Station No. 7 - Minor Cracking Under Window

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



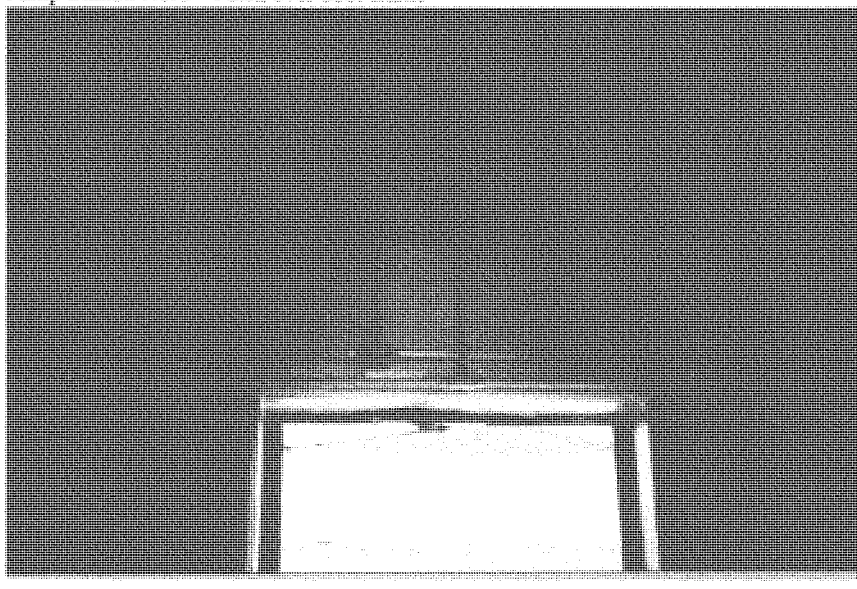
Pump Station No. 9
Pump Station No. 9 - General Interior

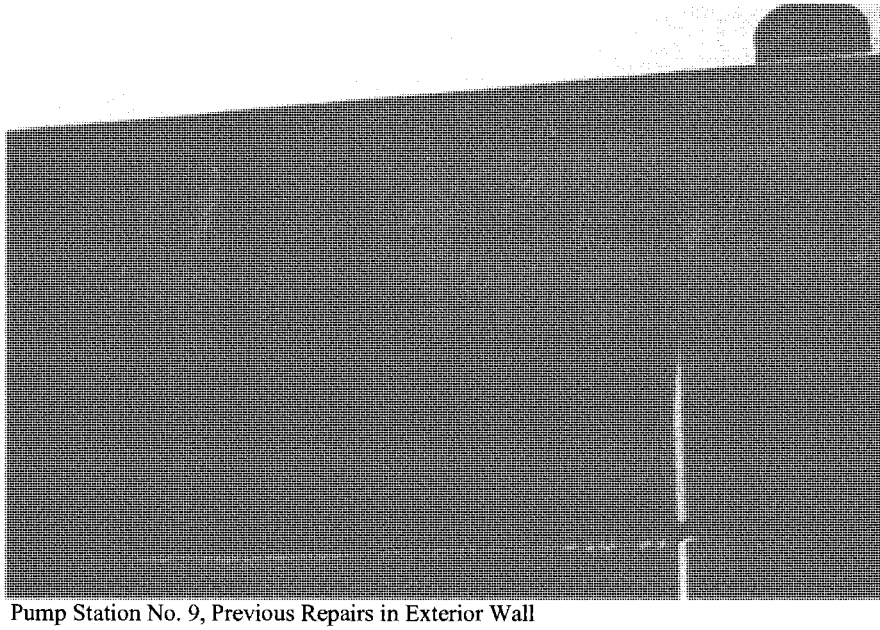


May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations

Pump Station No. 9 - Patch over door frame

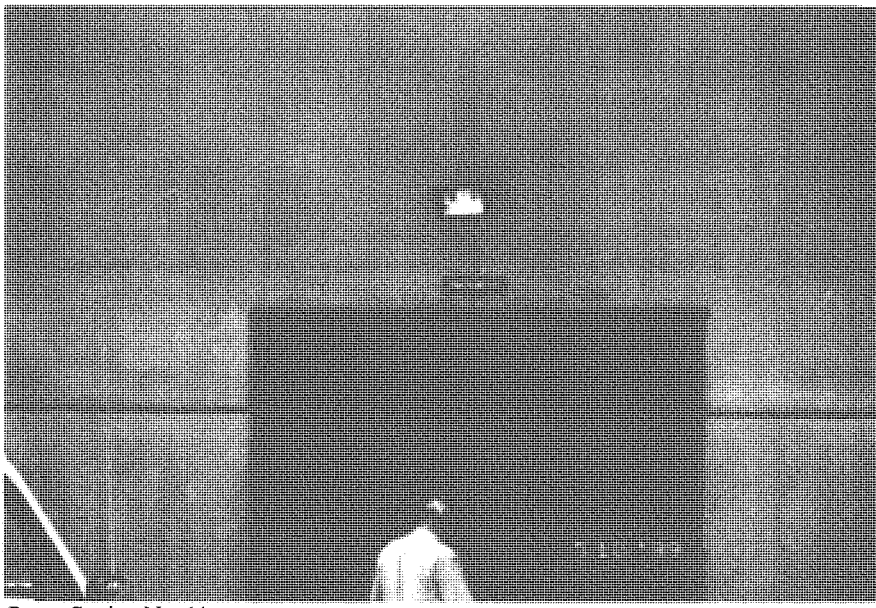




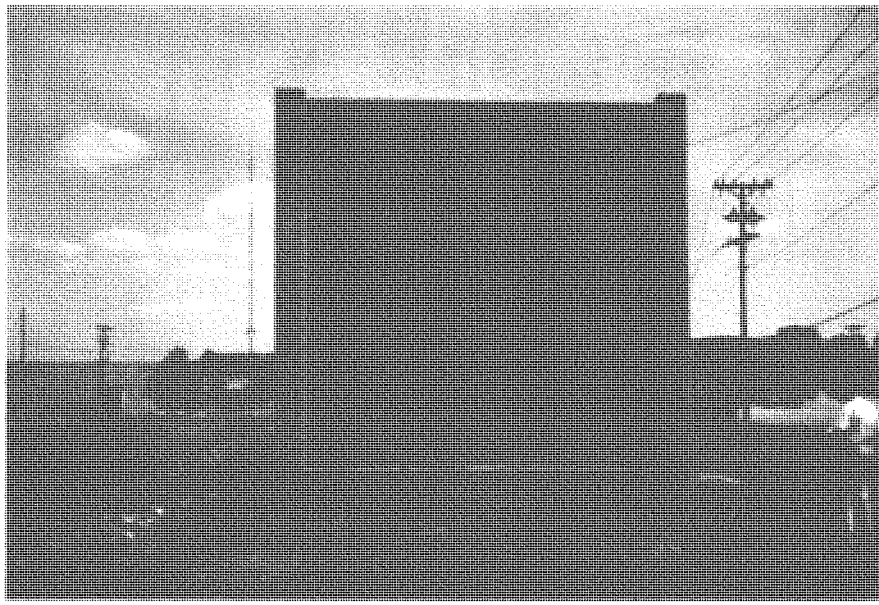
Pump Station No. 9, Previous Repairs in Exterior Wall

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



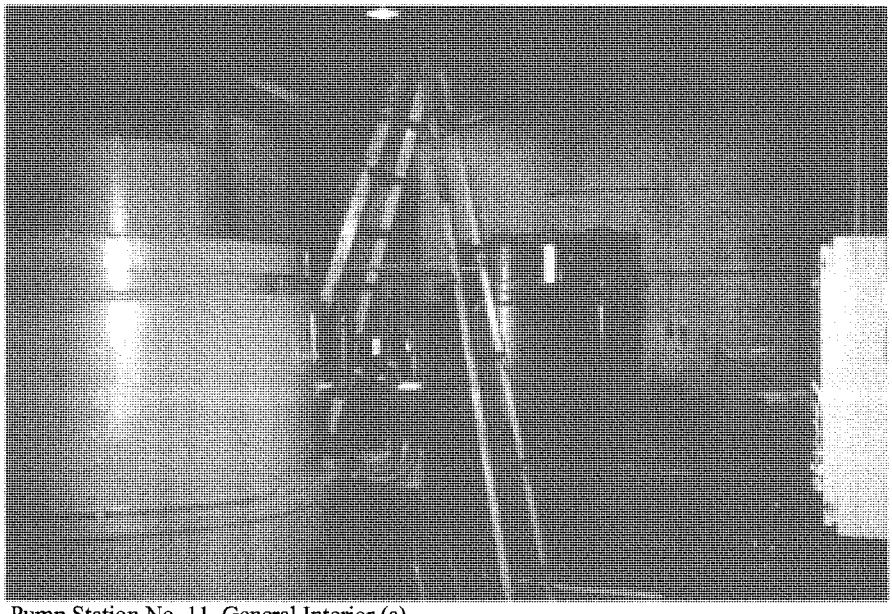
Pump Station No. 11



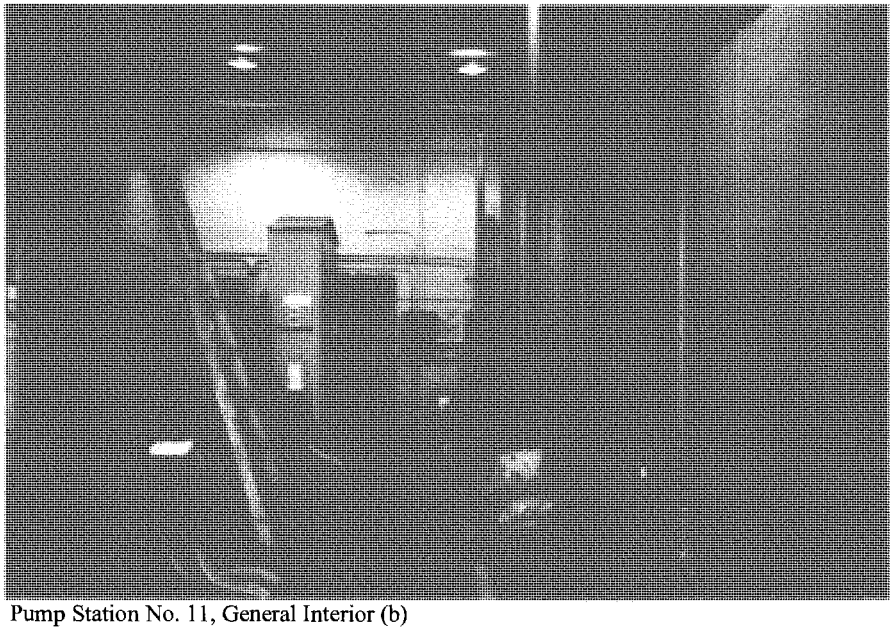
Pump Station No. 11, Exterior Wall

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



Pump Station No. 11, General Interior (a)

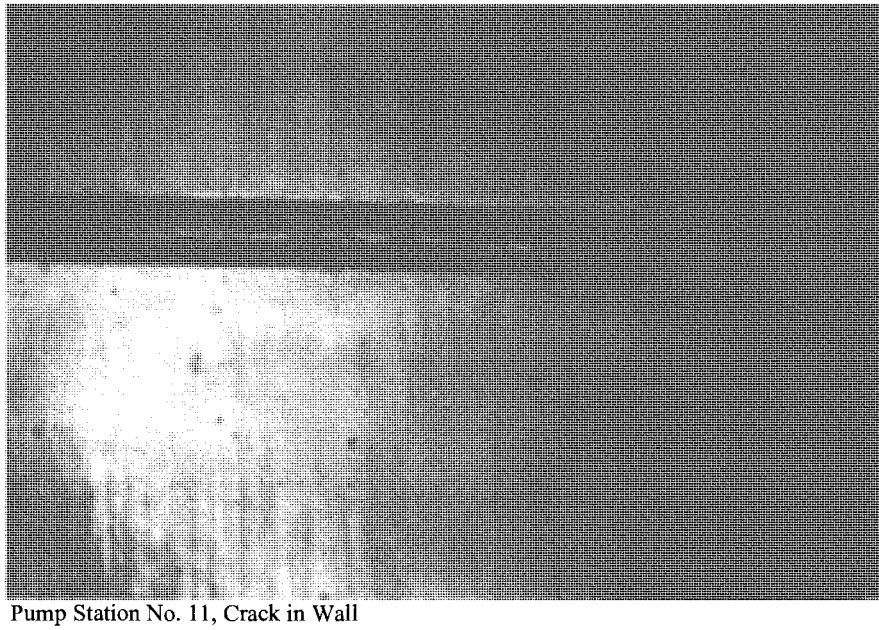


Pump Station No. 11, General Interior (b)

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations

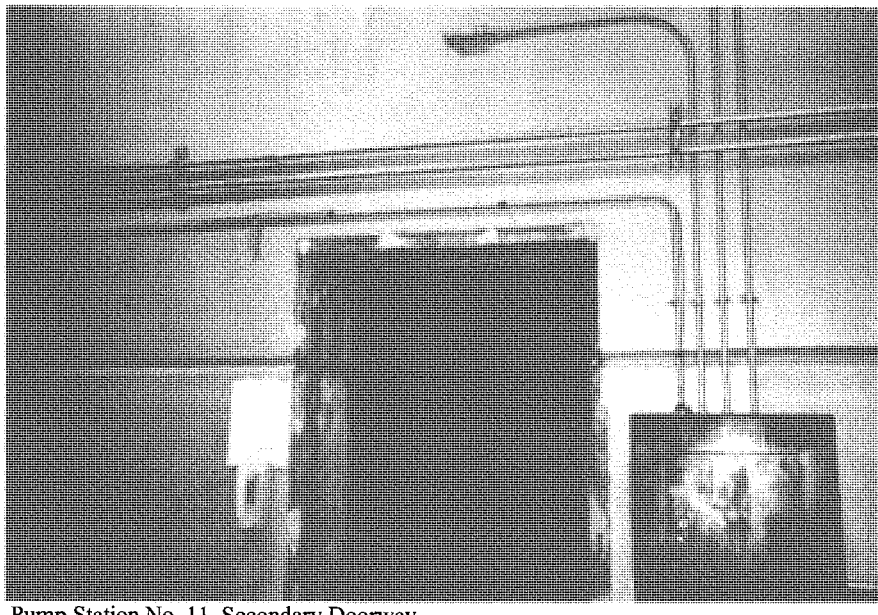
Pump Station No. 11, Crack in Riverside Wall



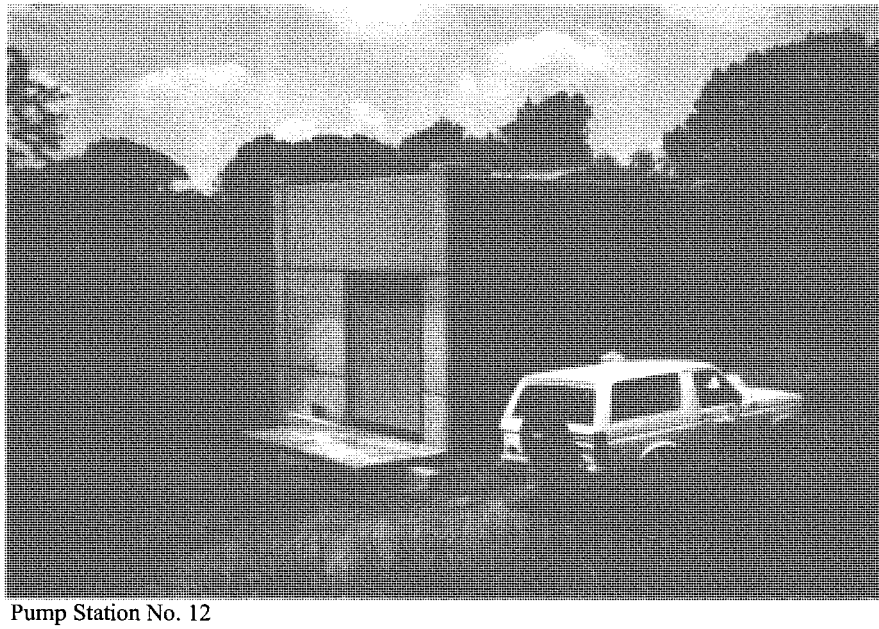
Pump Station No. 11, Crack in Wall

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



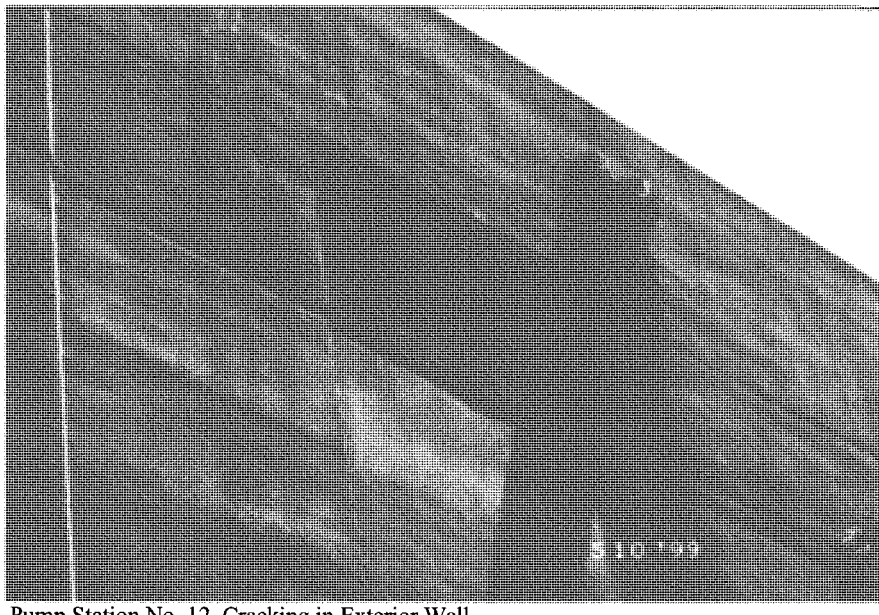
Pump Station No. 11, Secondary Doorway



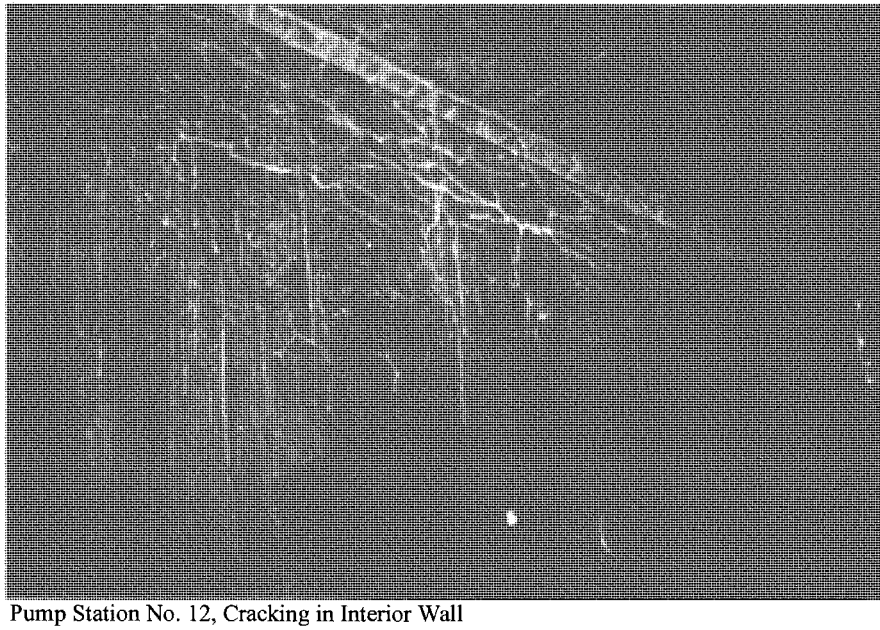
Pump Station No. 12

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



Pump Station No. 12, Cracking in Exterior Wall

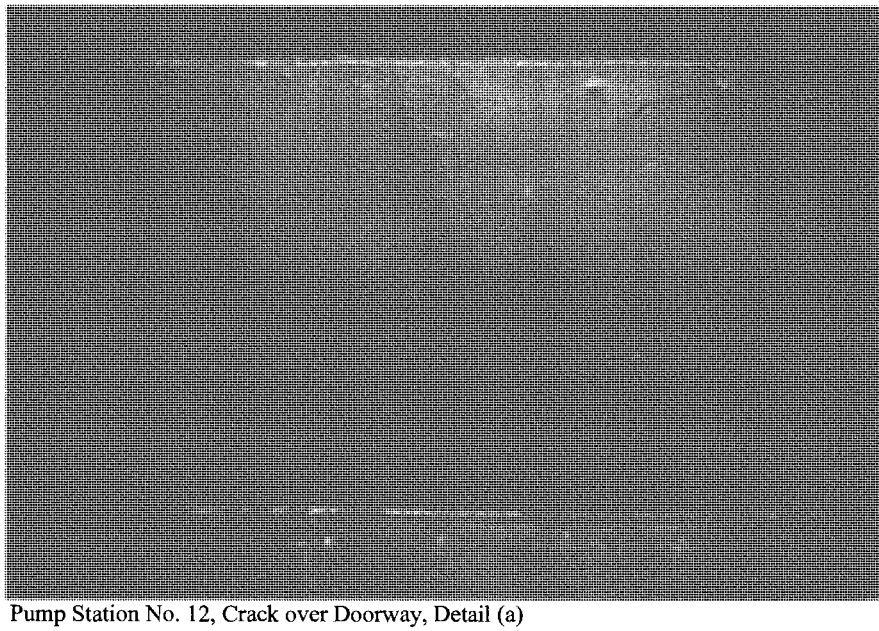


Pump Station No. 12, Cracking in Interior Wall

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations

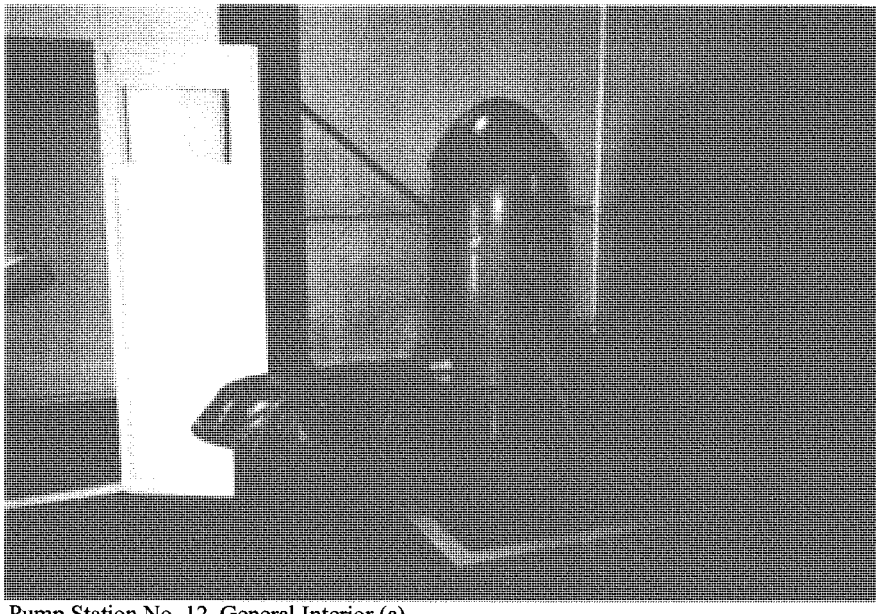
Pump Station No. 12, Crack over Doorway



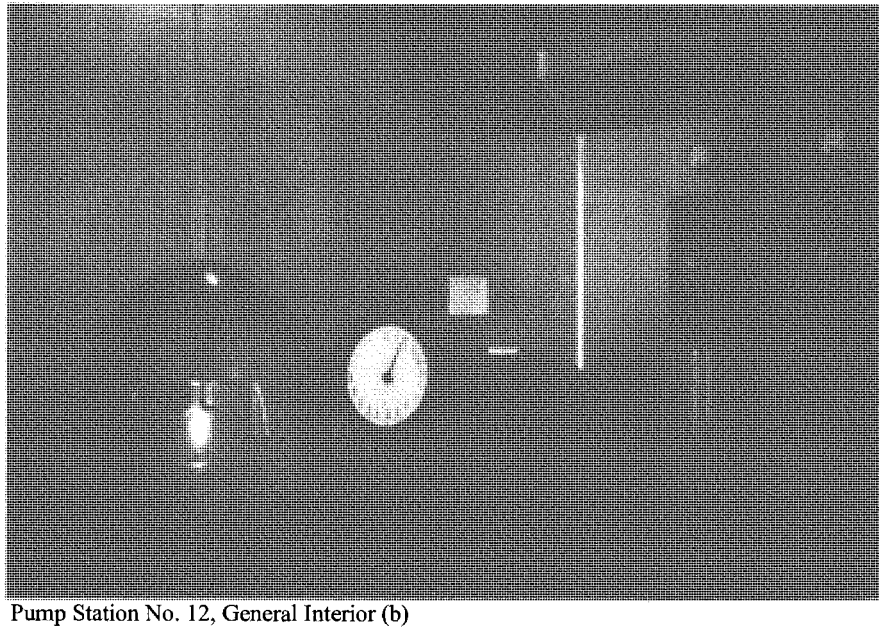
Pump Station No. 12, Crack over Doorway, Detail (a)

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



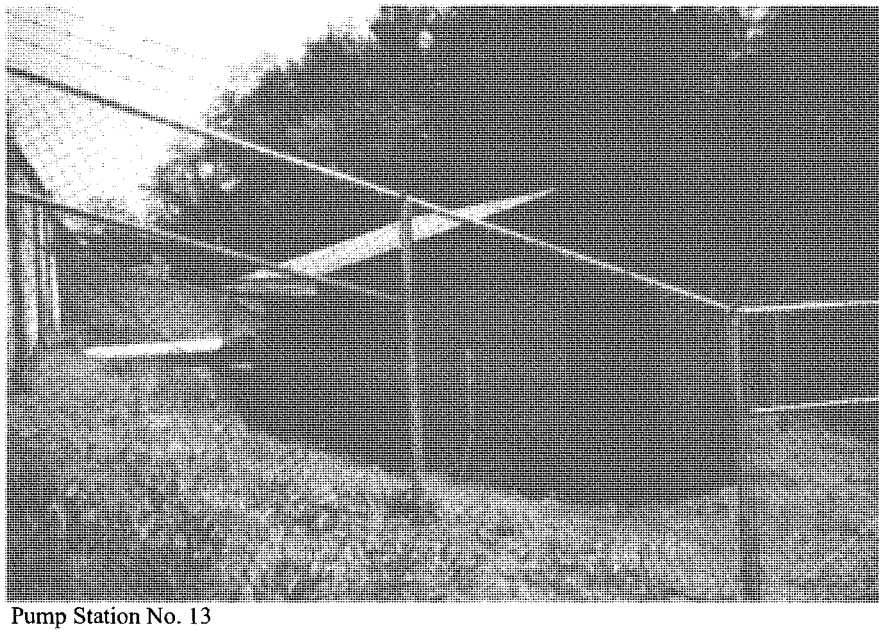
Pump Station No. 12, General Interior (a)



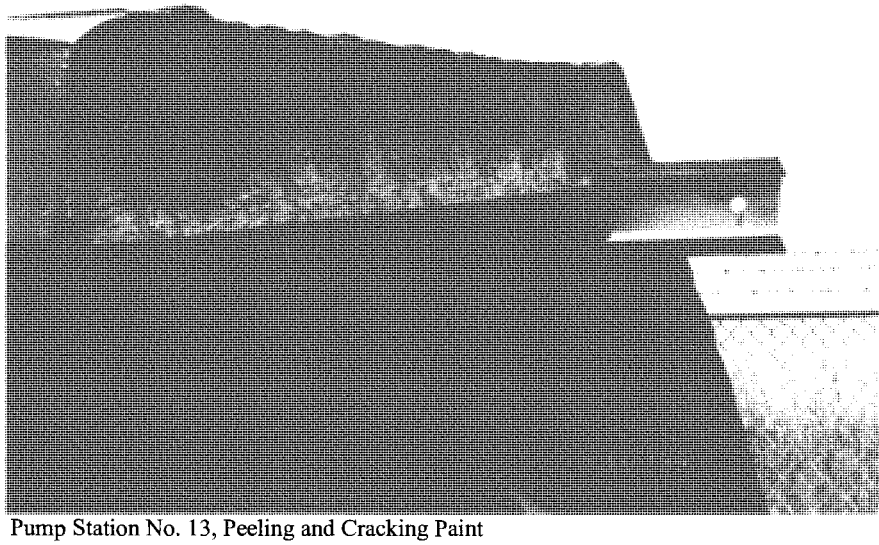
Pump Station No. 12, General Interior (b)

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations

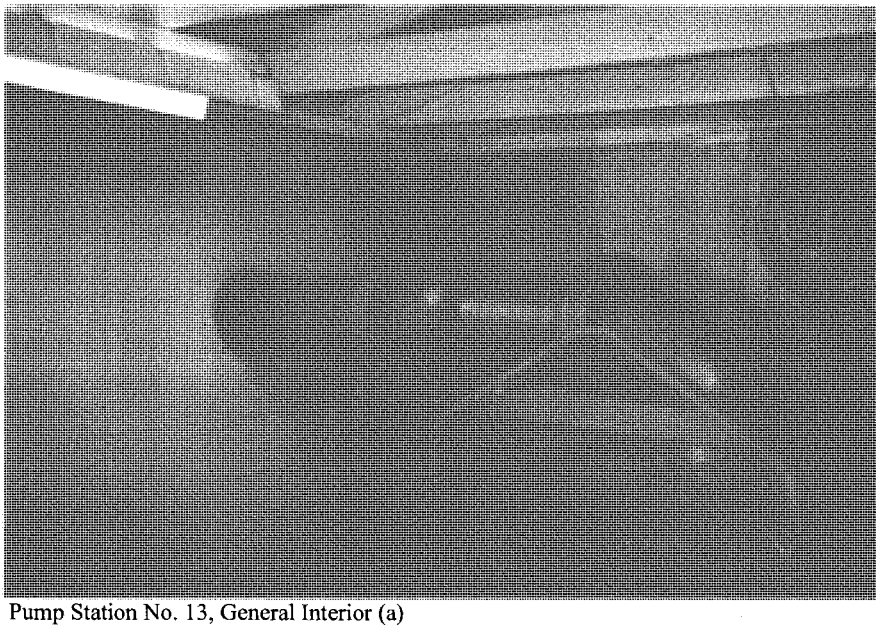


Pump Station No. 13

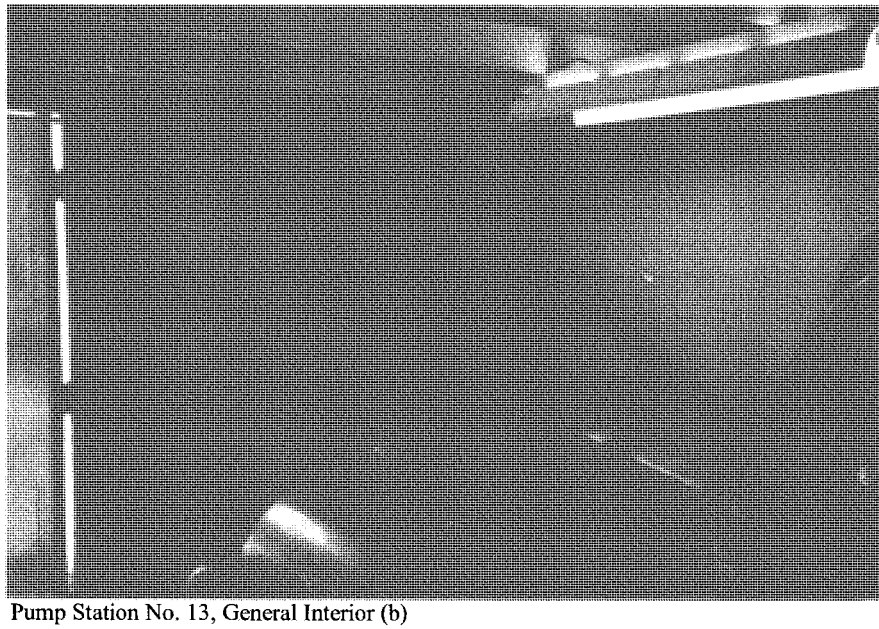


Pump Station No. 13, Peeling and Cracking Paint

Paducah Floodwall Inspection: Pump Stations



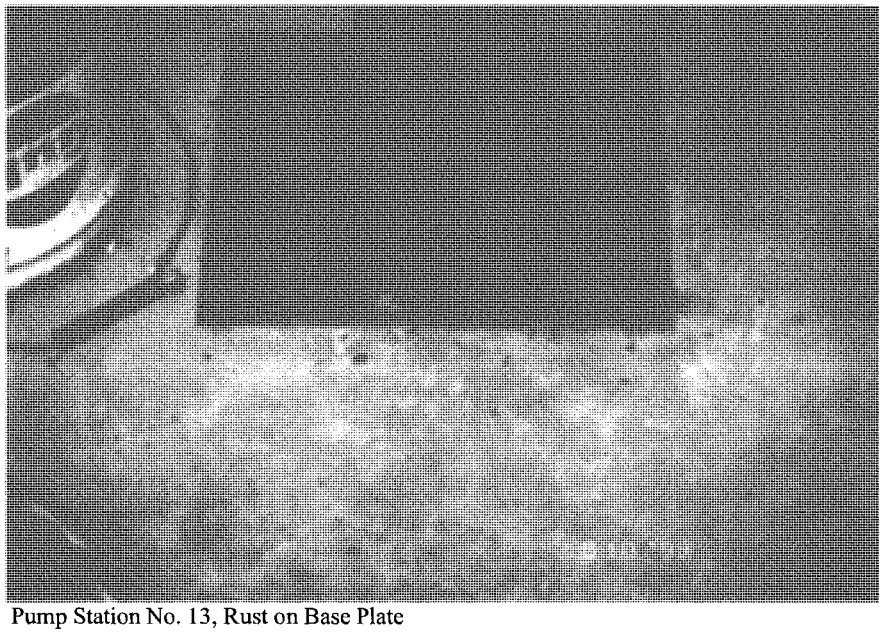
Pump Station No. 13, General Interior (a)



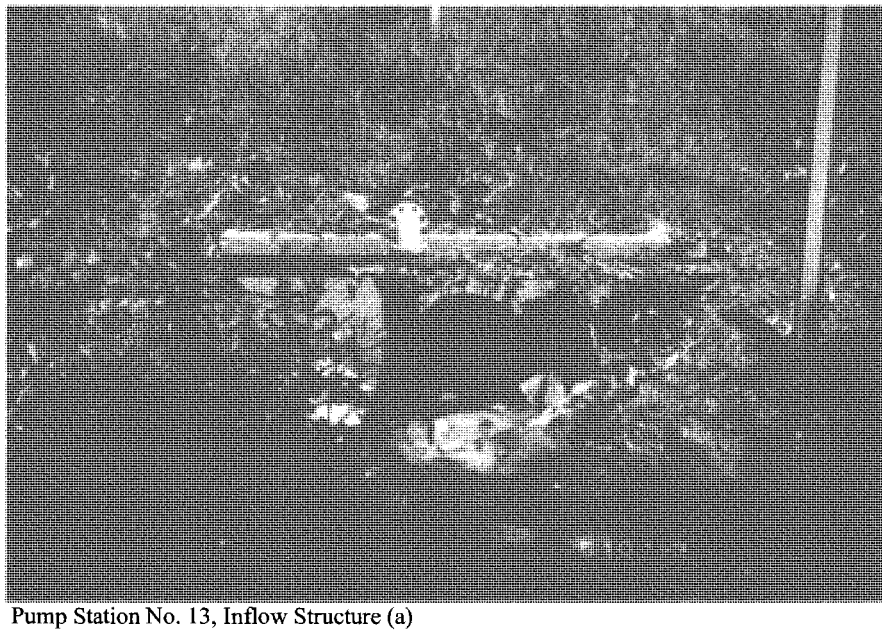
Pump Station No. 13, General Interior (b)

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations



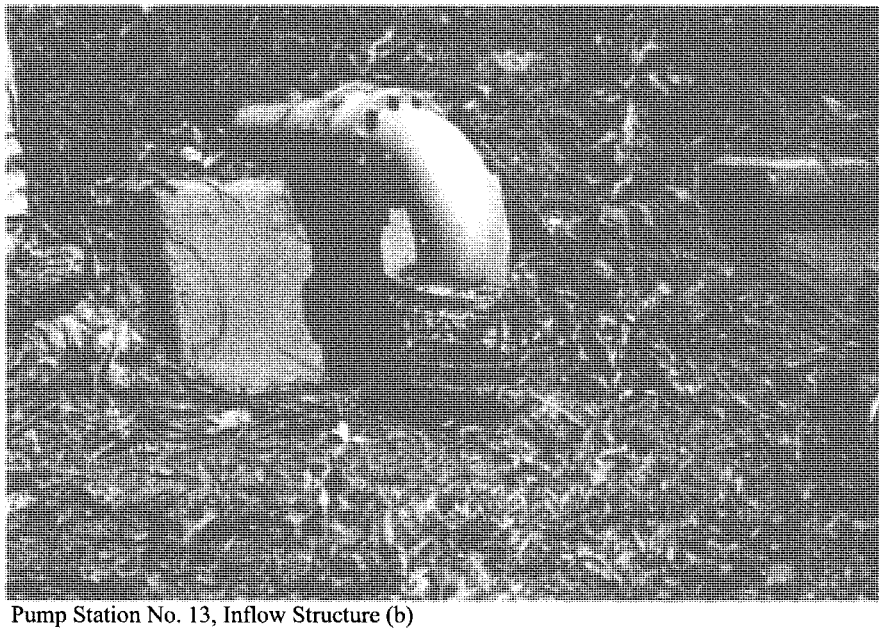
Pump Station No. 13, Rust on Base Plate



Pump Station No. 13, Inflow Structure (a)

May 5 – 11, 1999

Paducah Floodwall Inspection: Pump Stations

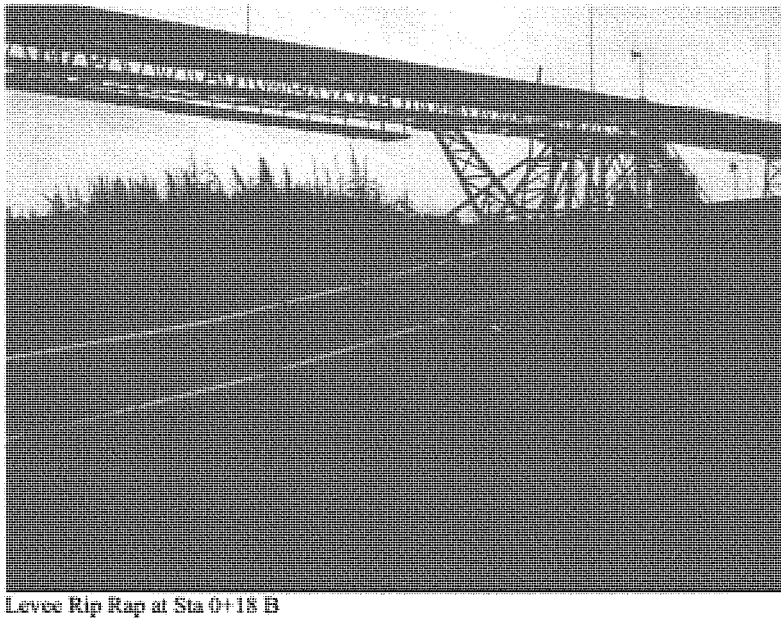


Pump Station No. 13, Inflow Structure (b)

Appendix B
Paducah Floodwall Protection System
Earthen Levee Photographs

May 5, 1999

Paducah Floodwall Inspection – Earthen Levee

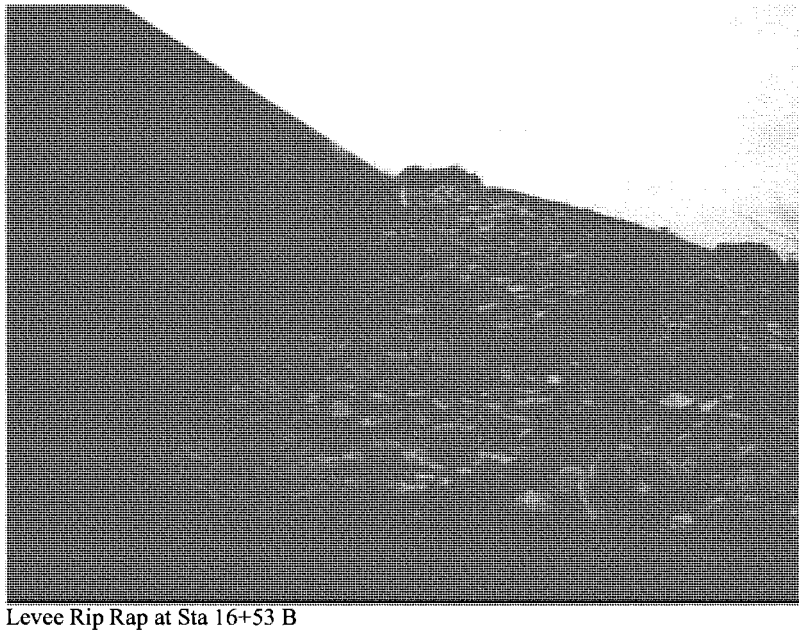


Levee Rip Rap at Sta 0+18 B

Levee Sta 16+53 to Sta 21+68 B

May 5, 1999

Paducah Floodwall Inspection – Earthen Levee

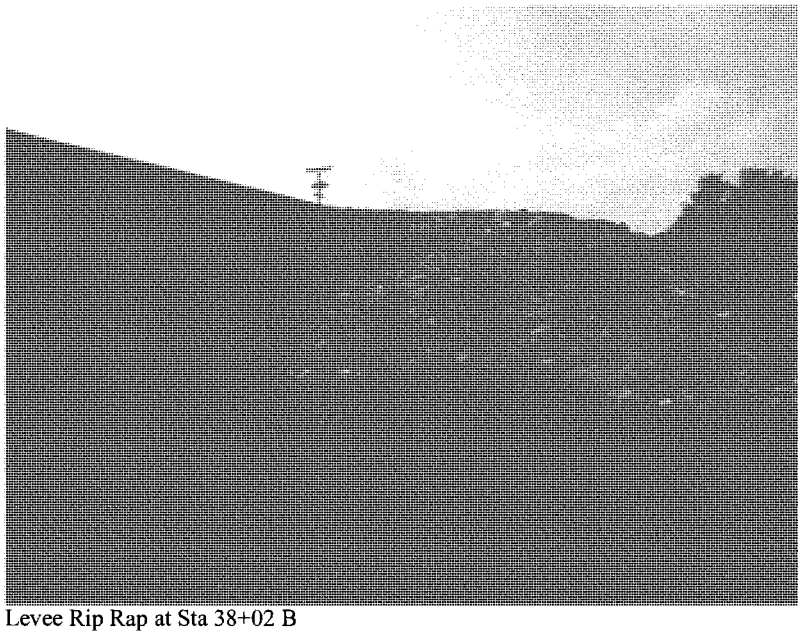


Levee Rip Rap at Sta 16+53 B

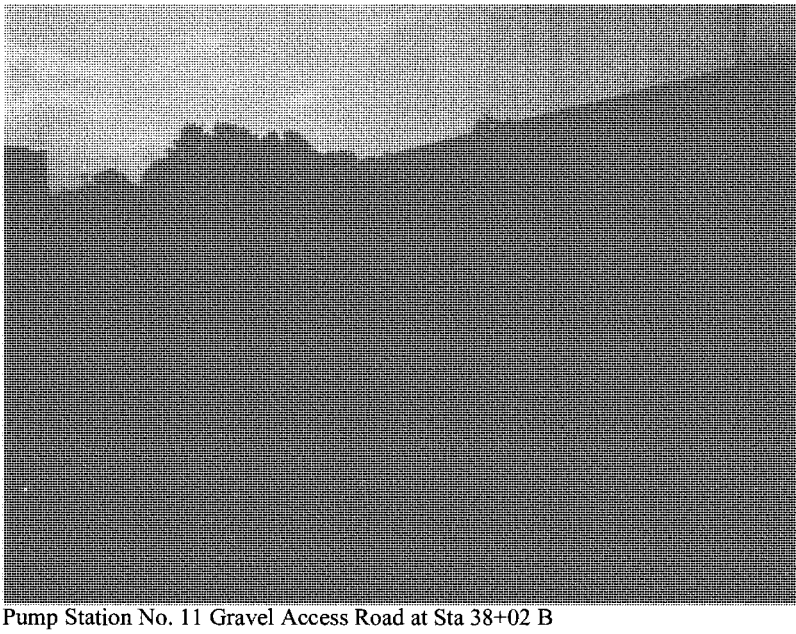
Levee Rip Rap at Sta 21+86 B

May 5, 1999

Paducah Floodwall Inspection – Earthen Levee



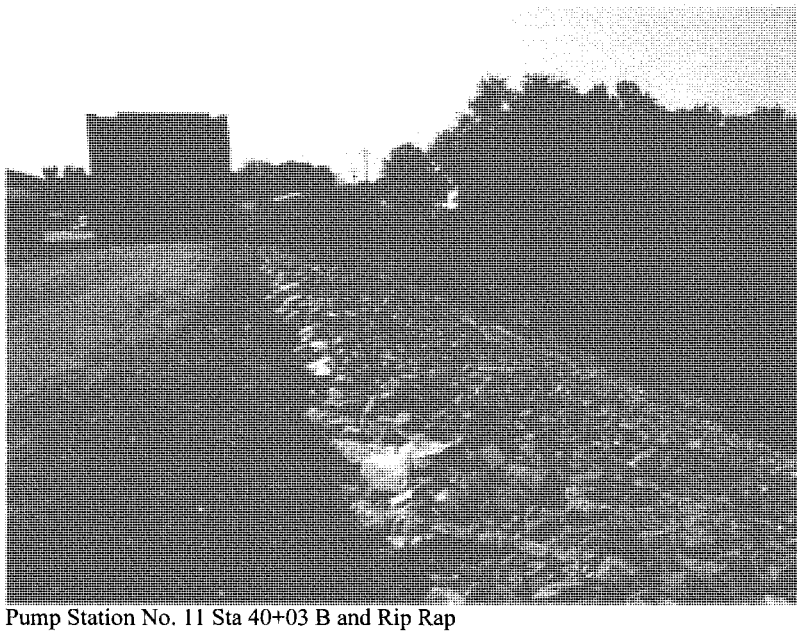
Levee Rip Rap at Sta 38+02 B



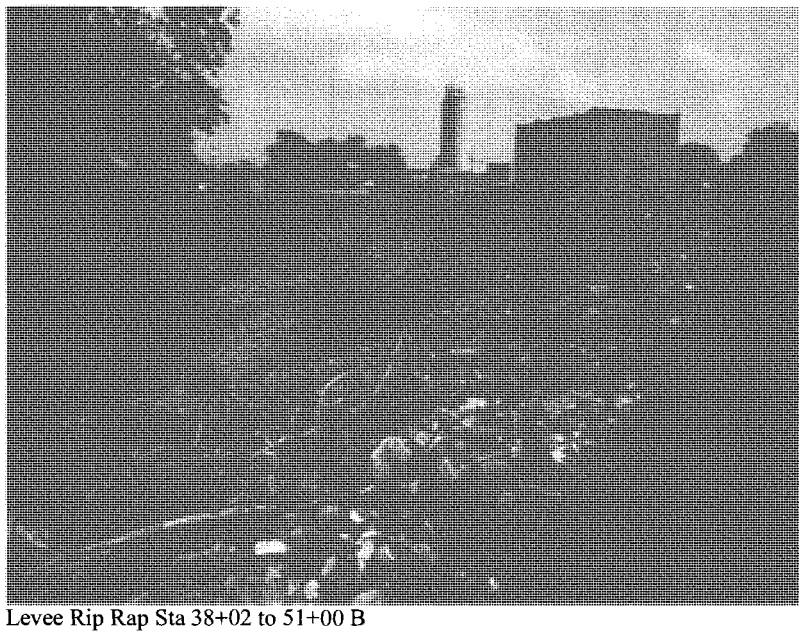
Pump Station No. 11 Gravel Access Road at Sta 38+02 B

May 5, 1999

Paducah Floodwall Inspection – Earthen Levee



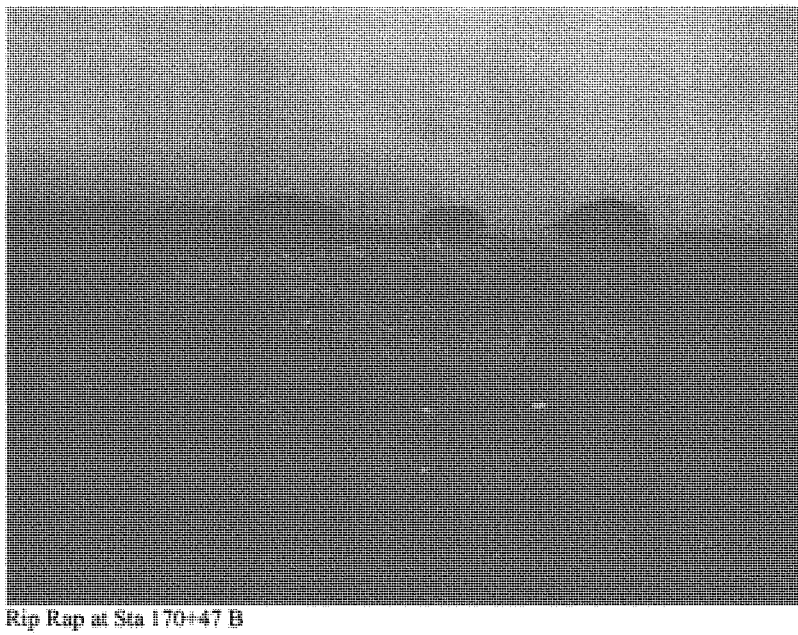
Pump Station No. 11 Sta 40+03 B and Rip Rap



Levee Rip Rap Sta 38+02 to 51+00 B

May 5, 1999

Paducah Floodwall Inspection – Earthen Levee



Rip Rap at Sta 170+47 B

Appendix B
Paducah Floodwall Protection System Gated Outlet Photographs

May 5, 1999

Paducah Floodwall Inspection – Gated Outlets

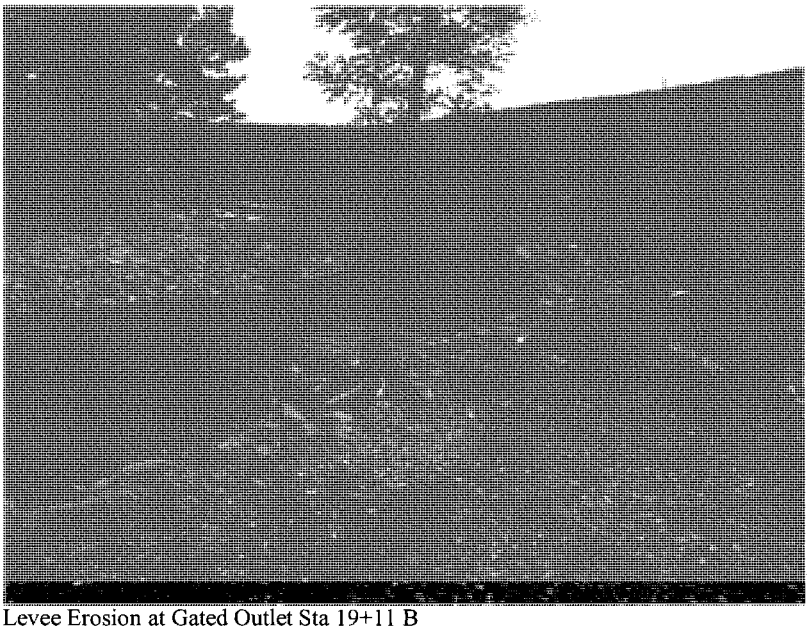
Gated Outlet Sta 7+54 B

Gated Outlet and Headwall Sta 7+54 B

May 5, 1999

Paducah Floodwall Inspection – Gated Outlets

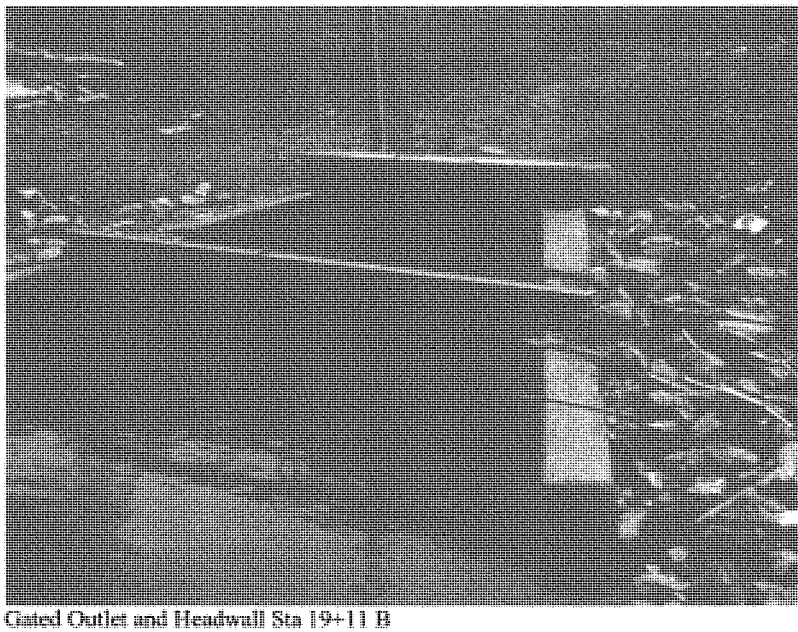
Ditch Downstream of Gated Outlet Sta 7+54 B



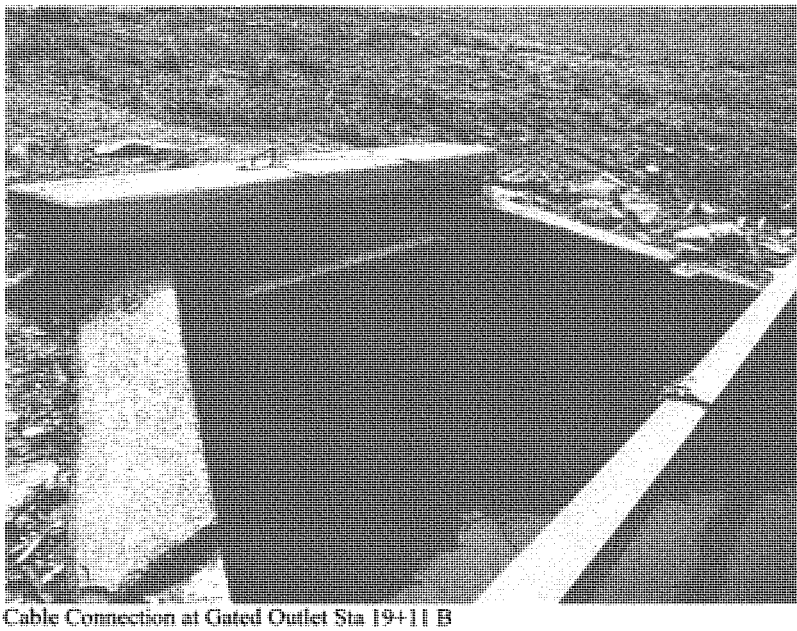
Levee Erosion at Gated Outlet Sta 19+11 B

May 5, 1999

Paducah Floodwall Inspection – Gated Outlets



Gated Outlet and Headwall Sta 19+11 B

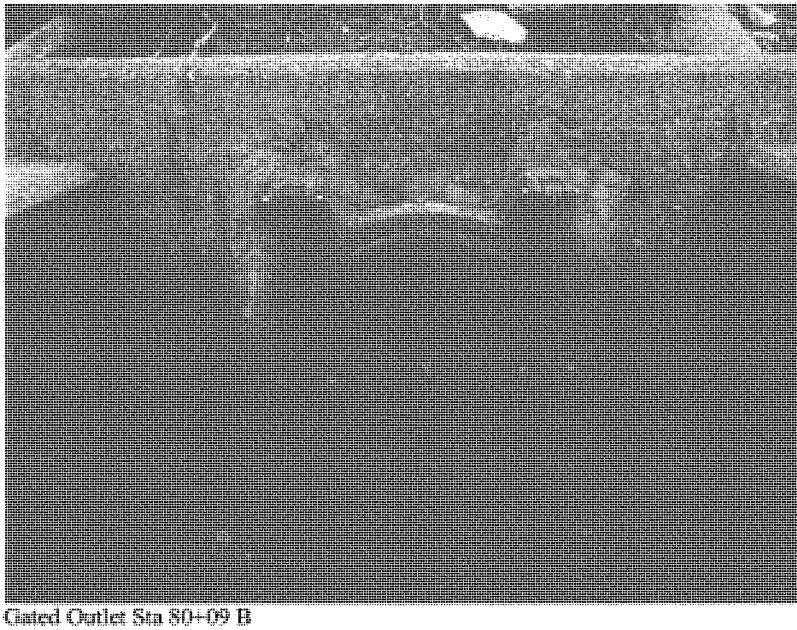


Cable Connection at Gated Outlet Sta 19+11 B

May 5, 1999

Paducah Floodwall Inspection – Gated Outlets

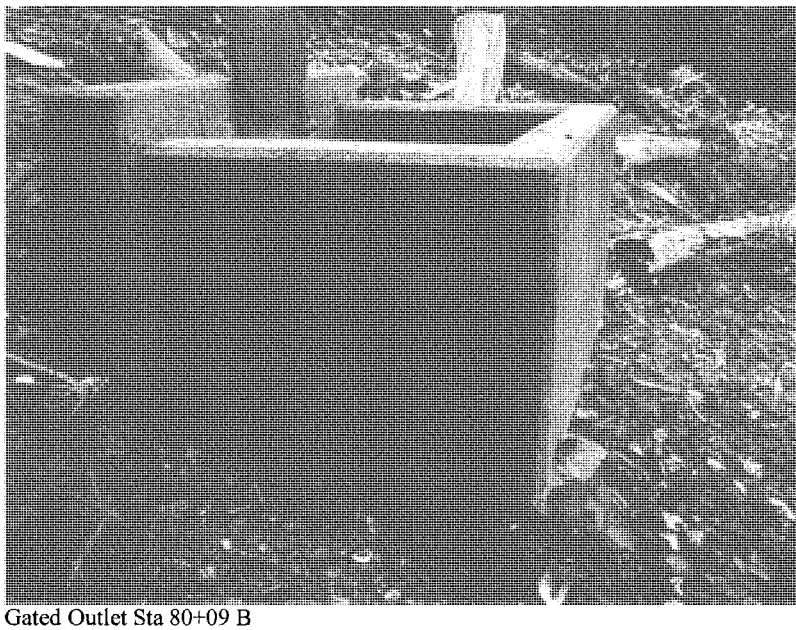
Gated Outlet at Sta 80+09 B



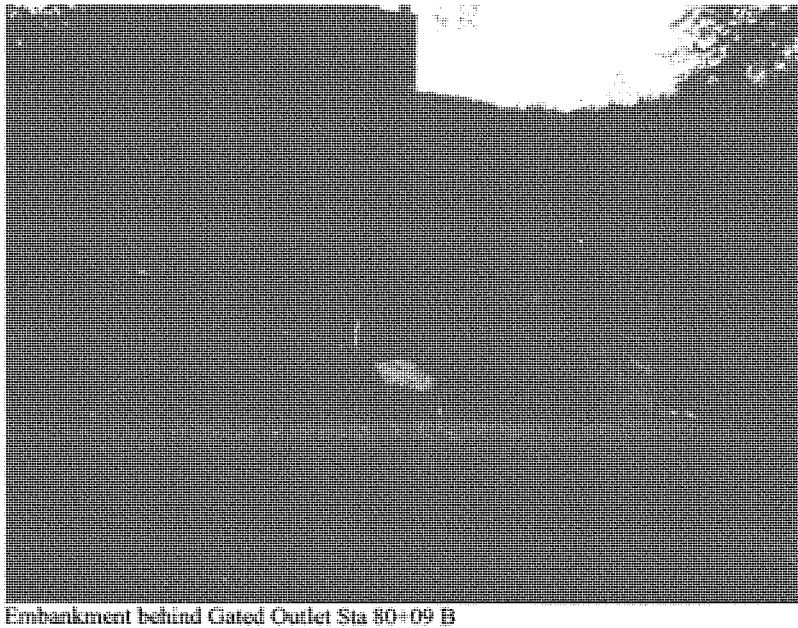
Gated Outlet Sta 80+09 B

May 5, 1999

Paducah Floodwall Inspection – Gated Outlets



Gated Outlet Sta 80+09 B



Embankment behind Gated Outlet Sta 80+09 B

May 5, 1999

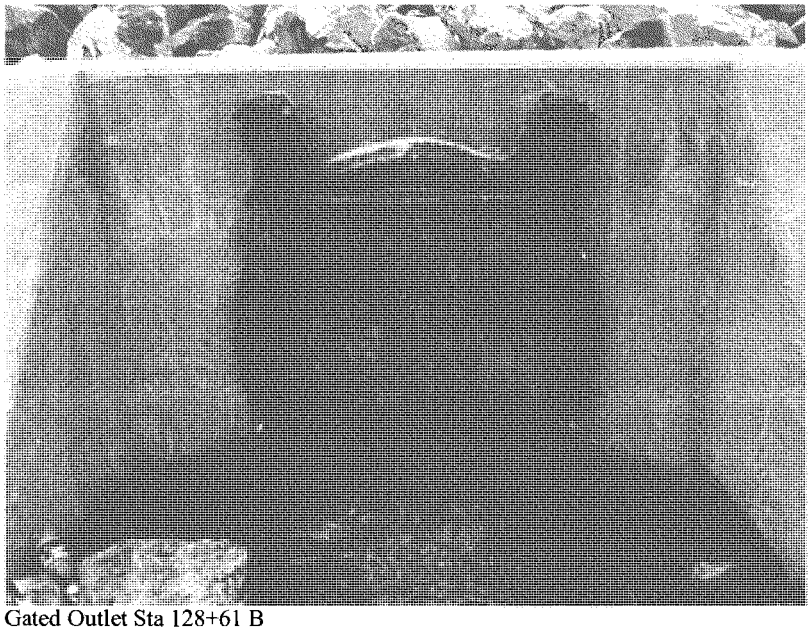
Paducah Floodwall Inspection – Gated Outlets

Exposed Pipe at Foundation at Gated Outlet Sta 80+09 B

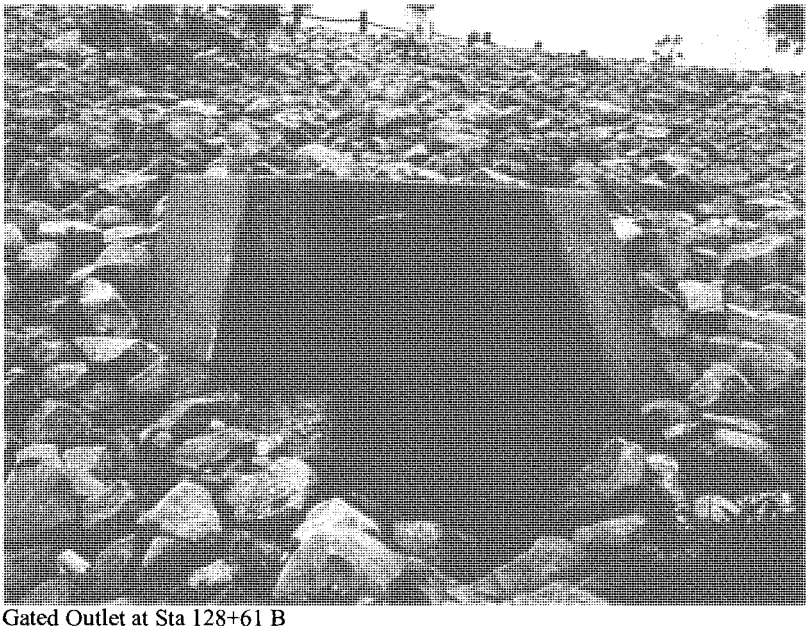
Embankment Condition at Gated Outlet Sta 80+09 B

May 5, 1999

Paducah Floodwall Inspection – Gated Outlets



Gated Outlet Sta 128+61 B

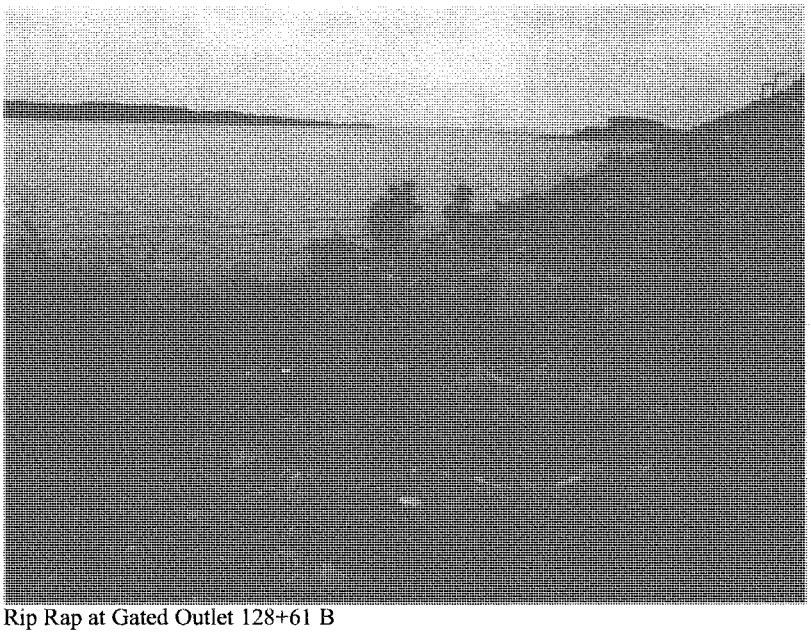


Gated Outlet at Sta 128+61 B

May 5, 1999

Paducah Floodwall Inspection – Gated Outlets

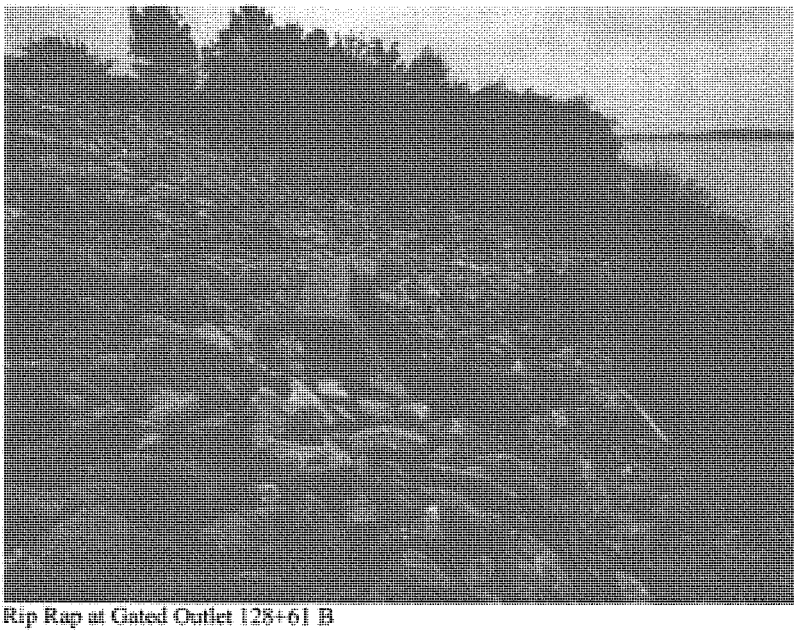
Rip Rap Downstream of Gated Outlet Sta 128+61 B



Rip Rap at Gated Outlet 128+61 B

May 5, 1999

Paducah Floodwall Inspection – Gated Outlets



Rip Rap at Gated Outlet 128+61 B

Appendix C
Paducah Floodwall Protection System Evaluation Forms

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: B. CAGLE Date: 5/5/97

City: PADUCAH, KY Station 0+18 to 2+87

Descriptive Location: INLAND SIDE

1. Construction Joints (comment as necessary): SOME SELANT MISSING IN SOME VERT. JOINTS - SELANT OLD & BRITTLE

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.

   NONE APPARENT

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.

   NONE

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?

   NO

5. General Condition and Other Remarks:

   WALL APPEARS TO BE IN GOOD REPAIR

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: ICE Date: 5/5/99

City: PADUCAH, KY Station 0+18 to 2+87

Descriptive Location: riverside

1. Construction Joints (comment as necessary):
   Sealant cracked, not continuous, infrequently missing

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.
   N/A

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.
   OK

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?
   No

5. General Condition and Other Remarks:

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: B. CAGLE Date: 5/5/99

City: PADUCAH KY Station 2+87 to 5+34

Descriptive Location: INLAND SIDE

1. Construction Joints (comment as necessary): SELANT BRITTLE
SOME VERT. JOINTS MISSING SELANT

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.
NONE APPARENT

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.
MINOR SURFACE VARIATIONS WHERE WALL WAS CAST AGAINST OLD BRICK WALL, BRICK WALL REMOVED - OLD BLDG. STA 2+87 — 4+00

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?
NO

5. General Condition and Other Remarks:
WALL ORIGINALLY CAST AGAINST BRICK BUILDING BLDG HAS BEEN REMOVED 1" DIA HOLES ~8" DEEP, 2.5' OC, 1.5' ABOVE GRND STA 3+20-4+00, INLAND SIDE

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: ICE Date: 5/5/99

City: PADUCAH KY. Station 3+87 to 4+49 5+39

Descriptive Location: DS

1. Construction Joints (comment as necessary):
   TYP. CRACKING, NOT CONTINUOUS, MISSING INFREQUENTLY, (USUALLY MISSING @ GROUND LINE)

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.
   N/A

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.
   GOOD

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?
   N/A

5. General Condition and Other Remarks:
   VAULT (TOP OF FTG. EXPOSED PARTIAL)

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: B. CAGLE Date: 5/5/99

City: PADUCAH, KY Station 5+34 to 9+44

Descriptive Location: INLAND SIDE

1. Construction Joints (comment as necessary): SEALANT BRITTLE SMALL SECTIONS MISSING

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.

   NONE APPARENT

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.

   NONE

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?

   NO

5. General Condition and Other Remarks:

   GOOD

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: ICE Date: 5/5/99

City: PADUCAH KY Station 5+34 to 9+44

Descriptive Location: DS (RIVERSIDE)

1. Construction Joints (comment as necessary):
   TYP. CRACKING, NOT CONTINUOUS

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.
   N/A

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.
   GOOD

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?
   GOOD

5. General Condition and Other Remarks:

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: B. Cragle Date: 5/5/99

City: Paducah, KY Station 9+44 to 10+40

Descriptive Location: Inland Side

1. Construction Joints (comment as necessary): Sealant Brittle, Some Missing

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.

   Section Down Station of Gate @ 10+40 (4A) Appears To Have Rotated Towards River, 1.5" @ Top

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.

   Minor Cracking @ Base, Section Has Been "Pushed" W Grout In Recent Years

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?

   No

5. General Condition and Other Remarks:

   As Noted Above.

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: ICE Date: 5/5/99

City: PADUCAH KY Station 9+44 to 10+40

Descriptive Location: RIVERSIDE DS

1. Construction Joints (comment as necessary):
   TYP. CRACKED, NOT CONTINUOUS

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.
   10+20± – 10+40 SECTION OF WALL ROTATED 1½" ± @ TOP

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?

5. General Condition and Other Remarks:

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: B. Cagle Date: 5/5/99

City: Paducah, KY Station 10+40 to 16+53 End Conc Section, Begin Earth Section

Descriptive Location: Inland & River Side

1. Construction Joints (comment as necessary): Sealant Brittle
Some Missing

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.

Yes, Various Sections Rotated Minor But Visible Amounts
Corner Section Downstation of Earth Levee
Moved 0.04' Toward River

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.

Wall Has Been Rubbed w/Grout From Station 10+40 – Begin Levee
(Painted By City of Paducah Per Gary
Thompson, Floodwall Superintendent)

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?

Earth Fuel Containment Berms Butt Against
Wall @ 2 Locations Landside

5. General Condition and Other Remarks:

Product Piping Penetration @ Sta
40' SOE 6'x8' Opening.

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: B. Cagle Date: 5/6/99

City: Paducah, KY Station 21+86 Begin Wall to Gate 26+90

Descriptive Location: Both Sides

1. Construction Joints (comment as necessary): Sealant Brittle
   Small Sections of Sealant Missing

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.

   One Section Minor Rotation Towards River 2.5"
   Section Has Been Rubbed W/Grout First Full Section
   Beyond Toe of Earth Berm

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.

   Minor Cracking in Above Section

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?

   No

5. General Condition and Other Remarks:

   Good

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: B. Cagle Date: 5/6/99

City: Paducah, KY Station Gate 6 26+90 to Gate 8 31+01

Descriptive Location: Both Sides

1. Construction Joints (comment as necessary): Sealant Brittle
   Small Sections Missing

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.

   None

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.

   No Problems Apparent

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?

   No

5. General Condition and Other Remarks:

   Good

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: B. Cagle Date: 5/6/99

City: Paducah, KY Station Gate 8 31+01 to End Wall, Beg Lever 38+02

Descriptive Location: Both Sides

1. Construction Joints (comment as necessary): Sealant Brittle
   Small Sections Missing

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.

   None Apparent

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.

   Good Cond'n

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?

   No

5. General Condition and Other Remarks:

   Good

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: B CAGLE Date: 5/6/99

City: PADUCAH, KY Station 51+00 (ENDLEVEE, BTG WALL) to 71+74 (GATE 15)

Descriptive Location: BOTH SIDES

1. Construction Joints (comment as necessary): SELANT BRITTLE PERIODIC MISSING SELANT

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.

   NONE APPARENT

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.

   16' 4" STA 54+37

   GOOD CONDITION

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?

   CONC FUEL TANK CONTAINMENT WALL BUTTS AGAINST WALL B/T GATE 11 - STA 51+87 & GATE 12 STA 54+37 INLAND SIDE

5. General Condition and Other Remarks:

   GOOD

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: B Cagle Date: 5-6-99

City: Paducah, KY Station Gate 15 71+74 to Gate 17 83+92

Descriptive Location: Both Sides

1. Construction Joints (comment as necessary): Sealant Brittle
   Small Sections Missing

8' 7' Tall
79+27

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.

   None Noted

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.

   OK

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?

   Small Vegetation On Inland Side 71+74 - 72+00
   Fence For Plumbing Supplies 71+74 - 72+20 Inland
   Paducah River Fuel Service Fence Inland Sta. 75+85 To Sta 83+92

5. General Condition and Other Remarks:

   Good

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: B. Cagle Date: 5-6-99

City: Paducah, KY Station Gate 17 83+92 to Gate 25 108+53

Descriptive Location: Both Sides

1. Construction Joints (comment as necessary): Sealant Brittle Missing In Small Segments

93+57 26'

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.

94+63 20'

None

98+83 16'-4"

103+63 16'-4"

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.

Good

R.S. Sta. Pump House

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?

Landside Fence @ BA's Automotive B/T Sta 83+92 To Sta 90+41

Riverside Fenceroad B/T 103+63 to 108+53 @ Ingram Barge Lines

106+10 20'

5. General Condition and Other Remarks:

1 Section B/T 93+57 & 94+63 Grout Rubbed

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: B. Crace Date: 5-6-99

City: Paducah, KY Station Gate 25 108+53 to Gate 29 128+19

Descriptive Location: Both Sides

1. Construction Joints (comment as necessary): Sealant Brittle Small Lengths Missing

2 x 10'
~~122½~~
113
122
121
110½
465½

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.

None Observed

20'

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.

Good

39
12) 466
36
106
8

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?

No North Fence @ Zingram Barge Lines

5. General Condition and Other Remarks:

2½" Piping Penetration @ Sta 113+50

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: B. Cagle Date: 5-7-99

City: Paducah, KY Station Gate 29 128+14 to Gate 34 149+87

Descriptive Location: Both Sides

1. Construction Joints (comment as necessary): Grant Brittle Small Sections Missing

67
3
211

13823
165
13668

155'

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.

None Observed

77
3
231
9' 2"

Top Wall to Secondary Levee Effective Joint

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.

Spalled Area Landside Sta 136+70± Where Forming Timber Cast Into Wall, Spall & Joint Rebar Exposed Landside Sta 149+05

28
3
84

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?

Fence B/T Sta 140+50 & Sta 142+64 Landside

138+23
231
140+54
210
6"

5. General Condition and Other Remarks:

Good

CONCRETE FLOODWALL – STRUCTURAL EVALUATION

Evaluator: B. Cagle Date: 5-7-99

City: Paducah, KY Station Gate 34 149+87 to Endwall, Beg Levee 170+38

Descriptive Location: Both Sides

1. Construction Joints (comment as necessary): Sealant Brittle
   Small Sections Missing

2. Horizontal, Vertical or Rotational movement of wall visible? If so, note station, amount, and possible effect on structural stability.
   Str 150+90 – 151+20 Corner Section Has Separated
   @ C.J. Slightly

3. Comment on strucutral integrity (cracking, spalling, efflorescence, etc.) of wall where necessary.
   Good Cond'n

4. Access: Does vegetation growth or other obstructions hinder access to or stability of flood wall?
   Landside Fence Str 162+50 — 170+00
   Oil Distribution Depot

5. General Condition and Other Remarks:
   Good

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: R.C. ENGSTROM Date: 5/5/99

City: PADUCAH, KY Closure Structure No.: 1-A

Closure Structure Location: STA. 2+87

Approximate Plan Dimensions: 9 x 5

---

1. Closure Vault:
   a. Concrete Enclosure: _____

   b. Door: Proper closure? _____

      Proper seal? _____

2. Closure Gate:
   a. Walls: Movement Visible? NO

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: FAIR - SURFACE RUST

   c. Downstream Sill: Condition: FAIR - SURFACE RUST
      PAINT PEELING

   d. Gate Opening: Measured: 5 ft. 0 in (Bottom)
      5 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? N/A

   f. General Condition and Other Remarks:
      FAIR

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/5/99

City: PADUCAH, KY Closure Structure No.: I-B

Closure Structure Location: STA 3+21

Approximate Plan Dimensions: _____

---

1. Closure Vault:
   a. Concrete Enclosure: _____

   b. Door: Proper closure? _____

      Proper seal? _____

2. Closure Gate:
   a. Walls: Movement Visible? NO

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: COVERED BY SILT

   c. Downstream Sill: Condition: LIGHT PITTING, RUST

   d. Gate Opening: Measured: 3 ft. 0 in (Bottom)
      3 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      LIGHT DEBRIS, SILT COVER SILL

   f. General Condition and Other Remarks:
      FAIR

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/5/99

City: PADUCAH, KY Closure Structure No.: 2

Closure Structure Location: 4+49

Approximate Plan Dimensions: 15' WIDE

---

1. Closure Vault:
   a. Concrete Enclosure: GOOD, SOME WATER PUDDLES IN VAULT

   b. Door: Proper closure? GOOD

      Proper seal? N/A, WATER COMING UNDER DOOR

2. Closure Gate:
   a. Walls: Movement Visible? NO

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: FAIR

   c. Downstream Sill: Condition: FAIR

   d. Gate Opening: Measured: 15 ft. 0 in (Bottom)
      15 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      LIGHT DEBRIS

   f. General Condition and Other Remarks: FAIR
      STANDING WATER @ GATE

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I. C. ENGSTROM Date: 5/5/99

City: PADUCAH, KY Closure Structure No.: 3

Closure Structure Location: STA 5+34

Approximate Plan Dimensions: _____

---

1. Closure Vault:
   a. Concrete Enclosure: (SEE VAULT @ 4+49)

   b. Door: Proper closure? _____

      Proper seal? _____

2. Closure Gate:
   a. Walls: Movement Visible? ND

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: SILTED

   c. Downstream Sill: Condition: SILT & DEBRIS

   d. Gate Opening: Measured: 15 ft. 0 in (Bottom)
      15 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? _____
      SOME SILT & DEBRIS

   f. General Condition and Other Remarks: _____
      FAIR. SILLS COVERED - CONDITION UNKNOWN

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I. C. ENGSTROM Date: 5/5/99

City: PADUCAH, KY Closure Structure No.: 4

Closure Structure Location: GATE 9+44

Approximate Plan Dimensions: _____

---

1. Closure Vault:
   a. Concrete Enclosure: (SEE VAULT @ 10+40)

   b. Door: Proper closure? _____

      Proper seal? _____

2. Closure Gate:
   a. Walls: Movement Visible? NO

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: FAIR

   c. Downstream Sill: Condition: POOR (DEBRIS)

   d. Gate Opening: Measured: 12 ft. 0 in (Bottom)
      12 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? _____
      DEBRIS ON DS SILL

   f. General Condition and Other Remarks: _____
      FAIR

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I. C. ENGSTROM Date: 5/5/99

City: PADUCAH, KY Closure Structure No.: 4A

Closure Structure Location: 10+40

Approximate Plan Dimensions:

---

1. Closure Vault: 10+40
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? NO SEAL

2. Closure Gate:
   a. Walls: Movement Visible? NO

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: FAIR

   d. Gate Opening: Measured: 12 ft. 0 in (Bottom)
      12 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?

      DEBRIS @ DS SILL

   f. General Condition and Other Remarks:

      GOOD

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I. C. ENGSTROM Date: 5/5/99

City: PADUCAH, KY. Closure Structure No.: 4-B

Closure Structure Location: GATE SOUTH OF LEVEE (15+32)

Approximate Plan Dimensions: 6x8

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1. Closure Vault:
   a. Concrete Enclosure: _____

   b. Door: Proper closure? _____

      Proper seal? _____

2. Closure Gate:
   a. Walls: Movement Visible? NO

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 6 ft. 0 in (Bottom)
      6 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      NO

   f. General Condition and Other Remarks:
      GOOD

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I. C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 5

Closure Structure Location: 25+15

Approximate Plan Dimensions: _____

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1. Closure Vault: 25+15
   a. Concrete Enclosure: GOOD CONDITION

   b. Door: Proper closure? YES

      Proper seal? NO SEAL

2. Closure Gate:
   a. Walls: Movement Visible? NO

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD SOME PATCHING + COLLISION DAMAGE (MINOR)

   b. Upstream Sill: Condition: UNKNOWN
      COVERED W/ GRAVEL

   c. Downstream Sill: Condition: UNKNOWN
      COVERED W/ GRAVEL

   d. Gate Opening: Measured: 16 ft. 3 in (Bottom) ±
      16 ft. 3 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      NO

   f. General Condition and Other Remarks:
      GOOD

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I. C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 6

Closure Structure Location: 26+90

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? YES

      Proper seal? NO SEAL

2. Closure Gate:
   a. Walls: Movement Visible? NO

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD
      GRAVEL COVERS SILL

   d. Gate Opening: Measured: 20 ft. 0 in (Bottom)
      20 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      NO

   f. General Condition and Other Remarks:
      GOOD

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: H.C. ENGSTROM Date: 5/6/99

City: PADUCAH KY Closure Structure No.: 7

Closure Structure Location: 29+80

Approximate Plan Dimensions: _____

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1. Closure Vault: 29+80 + 31+01
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? NO

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: COVERED W/ SILT

   c. Downstream Sill: Condition: COVERED W/ SILT

   d. Gate Opening: Measured: 12 ft. 0 in (Bottom)
      12 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?

      BOLLARDS W/ CHAIN @ US OPENING

   f. General Condition and Other Remarks:

      GOOD, SILL CONDITION UNKNOWN

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I. C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 8

Closure Structure Location: 31+01

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: (SEE 29+80 FOR VAULT)

   b. Door: Proper closure? _____

      Proper seal? _____

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: CLOGGED W/ SILT

   c. Downstream Sill: Condition: CLOGGED W/ SILT

   d. Gate Opening: Measured: 12 ft. 0 in (Bottom)
      12 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? _____
      BOLLARD'S W/ CHAIN

   f. General Condition and Other Remarks: _____
      GOOD, SILL CONDITION UNKNOWN

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 9

Closure Structure Location: 31+51

Approximate Plan Dimensions:

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1. Closure Vault: 31+51
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? YES

      Proper seal? NO

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: COVERED W/ GRAVEL / SILT

   c. Downstream Sill: Condition: COVERED W/ GRAVEL / SILT

   d. Gate Opening: Measured: 16 ft. 6 in (Bottom)
      16 ft. 6 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      GATE @ DS (NOT ~~[illegible]~~ A PROBLEM)

   f. General Condition and Other Remarks:
      GOOD, SILL CONDITION UNKNOWN

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 10

Closure Structure Location: 36+84

Approximate Plan Dimensions: _____

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1. Closure Vault: 36+84
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? YES

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? NO

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: COVERED W/ GRAVEL

   c. Downstream Sill: Condition: COVERED W/ GRAVEL

   d. Gate Opening: Measured: 12 ft. 0 in (Bottom)
      12 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? NO

   f. General Condition and Other Remarks:
      GOOD, SILL CONDITION UNKNOWN

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 11

Closure Structure Location: 51+87

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? YES

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD, SOME CHIPPING N. SIDE OF GATE (MINOR)

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 16 ft. 4 in (Bottom)
      16 ft. 4 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      FENCE @ DS, BRICKS/GRAVEL IN SEAL TROUGH

   f. General Condition and Other Remarks:
      GOOD

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I. C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 12

Closure Structure Location: 54+37

Approximate Plan Dimensions: _____

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1. Closure Vault: 54+37
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 16 ft. 4 in (Bottom)
      16 ft. 4 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? N/A

   f. General Condition and Other Remarks: GOOD
      BRICKS IN SEAL TROUGH, SOME GRAVEL

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 13

Closure Structure Location: 62+84

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

      WATER SEEPAGE

      GRAVEL BUILT UP AROUND DOOR ← FUNNEL WATER INTO VAULT

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)

      GOOD

      MINOR SCRAPES / POPOUTS

   b. Upstream Sill: Condition: UNKNOWN

      COVERED W/ GRAVEL

   c. Downstream Sill: Condition: UNKNOWN

      COVERED W/ GRAVEL

   d. Gate Opening: Measured: 16 ft. 4 in (Bottom)

      16 ft. 4 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?

      FENCE @ US

   f. General Condition and Other Remarks:

      GOOD, SILL CONDITION UNKNOWN

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: L.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 14

Closure Structure Location: 69+64

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

      BROKEN SCUPPER @ VAULT

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)

      MINOR COLLISION DAMAGE, GOOD CONDITION

   b. Upstream Sill: Condition: UNKNOWN

      COVERED WITH ASPHALT

   c. Downstream Sill: Condition: UNKNOWN

      COVERED W/ ASPHALT

   d. Gate Opening: Measured: 12 ft. 0 in (Bottom)

      12 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?

      NO

   f. General Condition and Other Remarks:

      GOOD, SILL CONDITION UNKNOWN

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 15

Closure Structure Location: 71+74

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

      WATER SEEPAGE @ DOOR

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: UNKNOWN
      COVERED W/ SILT

   c. Downstream Sill: Condition: UNKNOWN
      COVERED W/ SILT

   d. Gate Opening: Measured: 16 ft. 4 in (Bottom)
      ____ ft. ____ in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? _____
      SOME TREES @ GATE, DEBRIS @ GATE

   f. General Condition and Other Remarks: _____
      FAIR, SILL CONDITION UNKNOWN

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH KY Closure Structure No.: 15-A

Closure Structure Location: 73+31

Approximate Plan Dimensions: 8X5 OPENING

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1. Closure Vault:
   a. Concrete Enclosure: _____

   b. Door: Proper closure? _____

      Proper seal? _____

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD
      NEEDS PAINTING

   c. Downstream Sill: Condition: GOOD
      NEEDS PAINTING

   d. Gate Opening: Measured: 8 ft. 0 in (Bottom)
      8 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? _____
      N/A

   f. General Condition and Other Remarks: _____
      GOOD

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 16

Closure Structure Location: 75+55

Approximate Plan Dimensions:

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? YES

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: UNKNOWN
      COVERED BY GRAVEL

   c. Downstream Sill: Condition: UNKNOWN
      COVERED BY GRAVEL

   d. Gate Opening: Measured: 16 ft. 4 in (Bottom)
      16 ft. 4 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A

   f. General Condition and Other Remarks:
      GOOD, SILL CONDITION UNKNOWN

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 16-A

Closure Structure Location: 79+27

Approximate Plan Dimensions: 8 x 7

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1. Closure Vault:
   a. Concrete Enclosure: _____

   b. Door: Proper closure? _____

      Proper seal? _____

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 8 ft. 0 in (Bottom)
      8 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? _____
      N/A

   f. General Condition and Other Remarks: _____
      GOOD

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: J. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 17

Closure Structure Location: 83+92

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: UNKNOWN
      COVERED BY GRAVEL

   c. Downstream Sill: Condition: UNKNOWN
      COVERED BY GRAVEL

   d. Gate Opening: Measured: 33 ft. 4 in (Bottom)
      33 ft. 4 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A SOME DEBRIS

   f. General Condition and Other Remarks:
      GOOD, SILL CONDITION UNKNOWN

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 18

Closure Structure Location: 90+41

Approximate Plan Dimensions: _____

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1. Closure Vault: 90+41
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 16 ft. 4 in (Bottom)
      16 ft. 4 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A

   f. General Condition and Other Remarks: GOOD
      Vegetation / Silt in seal trough

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 19

Closure Structure Location: 91+96

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: UNKNOWN
      COVERED BY SILT / SAND

   c. Downstream Sill: Condition: UNKNOWN
      COVERED BY SILT / SAND

   d. Gate Opening: Measured: 12 ft. 0 in (Bottom)
      12 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A

   f. General Condition and Other Remarks:
      GOOD, SILL CONDITION UNKNOWN

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 20

Closure Structure Location: 92+57

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: (SEE 94+63 for VAULT)

   b. Door: Proper closure? _____

      Proper seal? _____

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: UNKNOWN
      COVERED BY SILT

   c. Downstream Sill: Condition: UNKNOWN
      COVERED BY SILT

   d. Gate Opening: Measured: 26 ft. 0 in (Bottom)
      26 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? _____
      N/A

   f. General Condition and Other Remarks: _____
      GOOD, SILL CONDITION UNKNOWN
      BRICKS / SAND IN SEAL TROUGH

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: L.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: ~~94+63~~ 21

Closure Structure Location: 94+63

Approximate Plan Dimensions:

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: UNKNOWN
      COVERED BY SILT

   c. Downstream Sill: Condition: UNKNOWN
      COVERED BY SILT

   d. Gate Opening: Measured: 20 ft. 0 in (Bottom)
      20 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? NO
      (SOME DEBRIS)

   f. General Condition and Other Remarks:
      GOOD, SILL CONDITION UNKNOWN

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 22

Closure Structure Location: 95+88

Approximate Plan Dimensions:

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 16 ft. 4 in (Bottom)
      16 ft. 4 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A

   f. General Condition and Other Remarks:
      GOOD
      BRICKS IN SEAL TROUGH

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 23

Closure Structure Location: 103+63

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 16 ft. 4 in (Bottom)
      16 ft. 4 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A

   f. General Condition and Other Remarks:
      GOOD
      SILT IN SEAL TROUGH

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. EUGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 24

Closure Structure Location: 1D6H10

Approximate Plan Dimensions:

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD, DOES NOT OPEN COMPLETELY

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: UNKNOWN
      COVERED BY ASPHALT

   c. Downstream Sill: Condition: UNKNOWN
      COVERED BY ASPHALT

   d. Gate Opening: Measured: 20 ft. 0 in (Bottom)
      20 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A FENCE OS (RIVERSIDE)

   f. General Condition and Other Remarks:
      GOOD, SILL CONDITION UNKNOWN

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH KY Closure Structure No.: 25

Closure Structure Location: 1051 53

Approximate Plan Dimensions:

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1. Closure Vault:
   a. Concrete Enclosure: GOOD (MINOR CRACKS IN WALLS)

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD (HALF PAINTED W/ TEXTURE FINISH)

   b. Upstream Sill: Condition: UNKNOWN
      COVERED BY GRAVEL

   c. Downstream Sill: Condition: UNKNOWN
      COVERED BY GRAVEL

   d. Gate Opening: Measured: 16 ft. 4 in (Bottom)
      ____ ft. ____ in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A FENCE OS

   f. General Condition and Other Remarks:
      GOOD, SILL CONDITION UNKNOWN

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 36

Closure Structure Location: 114+93

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 60 ft. 0 in (Bottom)
      60 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A

   f. General Condition and Other Remarks:
      GOOD
      STEEL PLATE OVER SEAL TROUGH

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: L.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 27

Closure Structure Location: 119+62

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 26 ft. 0 in (Bottom)
      26 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A

   f. General Condition and Other Remarks:
      GOOD
      STEEL PLATE OVER SEAL TROUGH

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 27-A

Closure Structure Location: 119+93 (APPROX.)

Approximate Plan Dimensions: 4 x 7

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1. Closure Vault:
   a. Concrete Enclosure: _____

   b. Door: Proper closure? _____

      Proper seal? _____

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: FAIR RUST ON SILL
      NEEDS PAINT

   d. Gate Opening: Measured: 4 ft. 0 in (Bottom)
      4 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? _____
      N/A

   f. General Condition and Other Remarks: _____
      GOOD

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 27-B

Closure Structure Location: 125+50 (APPROX.)

Approximate Plan Dimensions: 4 x 7

---

1. Closure Vault:
   a. Concrete Enclosure: _____

   b. Door: Proper closure? _____

      Proper seal? _____

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: FAIR NEEDS PAINT

   d. Gate Opening: Measured: 4 ft. 0 in (Bottom)
      4 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? _____
      N/A

   f. General Condition and Other Remarks: _____
      GOOD

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: L.C. ENGSTROM Date: 5/6/99

City: PADUCAH KY Closure Structure No.: 28

Closure Structure Location: 1234 80

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 36 ft. 0 in (Bottom)
      26 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A

   f. General Condition and Other Remarks:
      GOOD
      STEEL PLATE @ SEAL TROUGH

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: L.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: _____

Closure Structure Location: 124+00 (APPROX.)

Approximate Plan Dimensions: 4x7

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1. Closure Vault:
   a. Concrete Enclosure: _____

   b. Door: Proper closure? _____

      Proper seal? _____

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: FAIR NEEDS PAINT

   d. Gate Opening: Measured: 4 ft. 0 in (Bottom)
      4 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? _____
      N/A

   f. General Condition and Other Remarks: _____
      GOOD

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.:

Closure Structure Location: NEW OPENINGS DOWNTOWN PADUCAH

Approximate Plan Dimensions:

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      MINOR CRACKING AT BASE OF WALL

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 56 ft. 10 in (Bottom)
      56 ft. 10 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A

   f. General Condition and Other Remarks:
      GOOD

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: K. ENGSTROM Date: 5/7/99

City: PADUCAH, KY Closure Structure No.: 32

Closure Structure Location: 189+22

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD, MINOR HAIRLINE CRACKING @ BASE

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 41 ft. 0 in (Bottom)
      41 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A

   f. General Condition and Other Remarks:
      GOOD

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/6/99

City: PADUCAH, KY Closure Structure No.: 29

Closure Structure Location: 128+19

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 20 ft. 0 in (Bottom)
      20 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A

   f. General Condition and Other Remarks:
      GOOD
      STEEL PLATE @ SEAL TROUGH

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: L.C. ENGSTROM Date: 5/7/99

City: PADUCAH, KY Closure Structure No.: 30

Closure Structure Location: 132+40

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: FAIR
      MINOR WEARING

   c. Downstream Sill: Condition: FAIR
      MINOR WEARING

   d. Gate Opening: Measured: 16 ft. 4 in (Bottom)
      16 ft. 4 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A

   f. General Condition and Other Remarks:
      FAIR
      BRICKS IN SEAL TROUGH

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: L.C. ENGSTROM Date: 5/7/99

City: PADUCAH, KY Closure Structure No.: 31

Closure Structure Location: 135+22

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD
   MINOR HAIRLINE CRACKS (INT. WALLS)

   b. Door: Proper closure? GOOD

   Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

   Structural Integrity (cracking, spalling, efflorescence, etc.)
   GOOD

   b. Upstream Sill: Condition: UNKNOWN
   COVERED W/ SILT (HAND NO WATER)

   c. Downstream Sill: Condition: UNKNOWN
   COVERED W/ SILT STANDING WATER

   d. Gate Opening: Measured: 32 ft. 0 in (Bottom)
   32 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
   N/A

   f. General Condition and Other Remarks:
   GOOD, SILL CONDITION UNKNOWN

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/7/99

City: PADUCAH, KY Closure Structure No.: _____

Closure Structure Location: SERVICE GATES @ BOTH SIDES OF CLOSURE STRUCTURE NO. 32

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: _____

   b. Door: Proper closure? _____

      Proper seal? _____

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: RUST, NEEDS PAINT
      FAIR

   d. Gate Opening: Measured: 4 ft. 0 in (Bottom)
      4 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? _____

      N/A 138+70 - ASPHALT PARTIALLY COVERING SILL

   f. General Condition and Other Remarks: _____
      GOOD TO FAIR

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/7/99

City: PADUCAH, KY Closure Structure No.: 33

Closure Structure Location: 145+74

Approximate Plan Dimensions:

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD, HAIRLINE CRACKING @ US + DS

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 41 ft. 0 in (Bottom)
      41 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?

      N/A

   f. General Condition and Other Remarks:
      GOOD
      STEEL PL @ SEAL TROUGH

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/7/99

City: PADUCAH, KY Closure Structure No.: 24

Closure Structure Location: 149+87

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD w/ MINOR HAIRLINE CRACKING US + DS

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 41 ft. 0 in (Bottom)
      41 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A

   f. General Condition and Other Remarks:
      GOOD
      STEEL ⊕ @ SEAL TROUGH

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/7/99

City: PADUCAH, KY Closure Structure No.:

Closure Structure Location: 149+40 & 150+40 (APPROX.)

Approximate Plan Dimensions: SERVICE GATES @ 149+37
7×4

1. Closure Vault:
   a. Concrete Enclosure:

   b. Door: Proper closure?

      Proper seal?

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      FAIR, EFF. @ SILL L'S

   b. Upstream Sill: Condition: FAIR

   c. Downstream Sill: Condition: FAIR, NEEDS PAINT

   d. Gate Opening: Measured: 4 ft. 0 in (Bottom)
      4 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A

   f. General Condition and Other Remarks:
      FAIR

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/7/99

City: PADUCAH KY Closure Structure No.: 35

Closure Structure Location: 157+26

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD, minor hairline cracking

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 41 ft. 0 in (Bottom)
      41 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A

   f. General Condition and Other Remarks:
      GOOD

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: L.C. ENGSTROM Date: 5/7/99

City: PADUCAH, KY Closure Structure No.:

Closure Structure Location: SERVICE GATES @ 157+26 (156+80, 157+30) (APPROX.) [CLOSURE STRUCTURE NO. 35]

Approximate Plan Dimensions: 7x4

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1. Closure Vault:
   a. Concrete Enclosure:

   b. Door: Proper closure?

      Proper seal?

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      FAIR, POCKETS AT L'S, EFF @ DS SILL,

   b. Upstream Sill: Condition: FAIR

   c. Downstream Sill: Condition: FAIR
      NEEDS PAINT

   d. Gate Opening: Measured: 4 ft. 0 in (Bottom)
      4 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure?
      N/A

   f. General Condition and Other Remarks:
      FAIR

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/7/99

City: PADUCAH, KY Closure Structure No.: 36

Closure Structure Location: 161+53

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 33 ft. 0 in (Bottom)
      83 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? N/A

   f. General Condition and Other Remarks:
      GOOD
      STEEL R @ SEAL TROUGH

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: L.C. ENGSTROM Date: 3/7/99

City: PADUCAH, KY Closure Structure No.: 37

Closure Structure Location: 166+46

Approximate Plan Dimensions: _____

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1. Closure Vault:
   a. Concrete Enclosure: GOOD
   SOME WATER SEEPAGE @ DOOR

   b. Door: Proper closure? GOOD
   Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A
   Structural Integrity (cracking, spalling, efflorescence, etc.)
   GOOD

   b. Upstream Sill: Condition: GOOD

   c. Downstream Sill: Condition: GOOD

   d. Gate Opening: Measured: 12 ft. 6 in (Bottom)
   12 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? _____
   N/A FENCE @ U.S.

   f. General Condition and Other Remarks: _____
   GOOD
   STANDING WATER
   SEAL TRUNCH NOT COVERED SOME GRAVEL/SILT IN PLACE

CLOSURE STRUCTURE – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5/7/99

City: PADUCAH, KY Closure Structure No.: 33

Closure Structure Location: 170+04

Approximate Plan Dimensions:

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1. Closure Vault:
   a. Concrete Enclosure: GOOD

   b. Door: Proper closure? GOOD

      Proper seal? N/A

2. Closure Gate:
   a. Walls: Movement Visible? N/A

      Structural Integrity (cracking, spalling, efflorescence, etc.)
      GOOD

   b. Upstream Sill: Condition: UNKNOWN
      COVERED BY SILT / GRAVEL

   c. Downstream Sill: Condition: UNKNOWN
      COVERED BY SILT / GRAVEL

   d. Gate Opening: Measured: 41 ft. 0 in (Bottom)
      41 ft. 0 in (Top)

   e. Access: Does vegetation growth or other obstructions hinder access to closure structure? N/A SOME DEBRIS

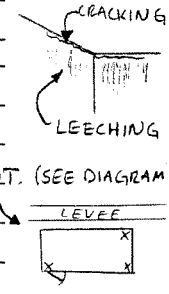
   f. General Condition and Other Remarks:
      GOOD, SILL CONDITION UNKNOWN

PUMP STATION – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5-11-99

City: PADUCAH, KY Pump Station No. 1 (STA 159+40-A)

1. Superstructure:
   a. Roof type and condition: FLAT CONCRETE WITH SCUPPERS -- GOOD COND.
   b. Exterior type and condition: CONCRETE, SOME WATER STAINING, CRACKING SEALANT, & MINOR SPALLING
   c. Interior type and condition: CONCRETE, HAIRLINE CRACKS ON WALLS, CRACKING & LEECHING AT CEILING-WALL JOINT. (SEE DIAGRAM (AT 3 LOCATIONS))
   d. Lintel beams: GOOD
   e. General: GOOD



2. Foundation Observation:
   a. Machine Pads & Anchor Bolts: GOOD
   b. Pump Floor: CLEAN - GOOD
   c. Wet well: N/A
   d. Discharge well: N/A
   e. Trash rack: CLEAN, SOME CRACKING IN CONCRETE ON WALLS BESIDE RACK OTHERWISE - GOOD COND.
3. Site:
   a. Access/right-of-way: GOOD
   b. Settlement: N/A
   c. Drainage: N/A
   d. Outfall structures: N/A

PUMP STATION – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5-11-99

City: PADUCAH, KY Pump Station No. 2 (STA 66+90 A)

1. Superstructure:
   a. Roof type and condition: FLAT CONCRETE WITH SCUPPERS -- GOOD COND.
   b. Exterior type and condition: CONCRETE. SOME RUST & WATER STAINS, MINOR CONCRETE PATCHING. OTHERWISE - GOOD COND.
   c. Interior type and condition: CONCRETE. LEECHING AT CEILING-WALL JOINT.
   d. Lintel beams: GOOD
   e. General: GOOD

2. Foundation Observation:
   a. Machine Pads & Anchor Bolts: GOOD
   b. Pump Floor: GOOD
   c. Wet well: N/A
   d. Discharge well: N/A
   e. Trash rack: N/A

3. Site:
   a. Access/right-of-way: GOOD
   b. Settlement: N/A
   c. Drainage: N/A
   d. Outfall structures: N/A

PUMP STATION – STRUCTURAL EVALUATION

Evaluator: L.C. ENGSTROM Date: 5-11-99

City: PADUCAH, KY Pump Station No. 3 (STA - 162+31 - B)

1. Superstructure:
   a. Roof type and condition: FLAT CONCRETE WITH SCUPPERS SKYLIGHT CONSTANT MAINTENANCE PROBLEM. OTHERWISE GOOD.
   b. Exterior type and condition: CONCRETE WITH SOME MINOR PATCHING, CRACKING SEALANT. OTHERWISE - GOOD.
   c. Interior type and condition: CONCRETE - GOOD.
   d. Lintel beams: GOOD.
   e. General: GOOD

2. Foundation Observation:
   a. Machine Pads & Anchor Bolts: SOME PAINT PEELING. OTHERWISE - GOOD.
   b. Pump Floor: GOOD
   c. Wet well: N/A
   d. Discharge well: N/A
   e. Trash rack: N/A

3. Site:
   a. Access/right-of-way: GOOD
   b. Settlement: N/A
   c. Drainage: N/A
   d. Outfall structures: N/A

PUMP STATION – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5-11-99

City: PADUCAH, KY Pump Station No. 4 (STA 149+37-B)

1. Superstructure:
   a. Roof type and condition: N/A (UNDERGROUND)
   b. Exterior type and condition: N/A
   c. Interior type and condition: CONCRETE - GOOD.
   d. Lintel beams: N/A
   e. General: GOOD

2. Foundation Observation:
   a. Machine Pads & Anchor Bolts: SLIGHT RUST AROUND BASEPLATES - OTHERWISE, GOOD.
   b. Pump Floor: SOME WATER COLLECTED IN PLACES OTHERWISE - GOOD.
   c. Wet well: N/A
   d. Discharge well: N/A
   e. Trash rack: N/A

3. Site:
   a. Access/right-of-way: GOOD
   b. Settlement: N/A
   c. Drainage: N/A
   d. Outfall structures: N/A

PUMP STATION – STRUCTURAL EVALUATION

Evaluator: L.C. ENGSTROM Date: 5-10-99

City: PADUCAH, KY Pump Station No. 5 (STA 144+30-B)

1. Superstructure:
   a. Roof type and condition: FLAT CONCRETE WITH SCUPPERS – GOOD COND.
   b. Exterior type and condition: CONCRETE - GOOD COND.
   c. Interior type and condition: CONCRETE. SOME LEECHING AT CEILING – WALL JOINT (NORTH & WEST WALLS) – OTHERWISE - GOOD
   d. Lintel beams: GOOD
   e. General: GOOD

2. Foundation Observation:
   a. Machine Pads & Anchor Bolts: GOOD
   b. Pump Floor: GOOD
   c. Wet well: N/A
   d. Discharge well: N/A
   e. Trash rack: N/A

3. Site:
   a. Access/right-of-way: GOOD
   b. Settlement: N/A
   c. Drainage: N/A
   d. Outfall structures: N/A

PUMP STATION – STRUCTURAL EVALUATION

Evaluator: L.C. ENGSTROM Date: 5-10-99

City: PADUCAH, KY Pump Station No. 6 (STA 109+03 - B)

1. Superstructure:
   a. Roof type and condition: FLAT CONCRETE WITH SCUPPERS - GOOD COND.
   b. Exterior type and condition: CONCRETE WITH SOME RUST STAINS. OTHERWISE - GOOD.
   c. Interior type and condition: CONCRETE. SOME CRACKING ON WALL & CEILING NEAR DUCTWORK HAIRLINE CRACKS & LEECHING ON NORTH WALL - OTHERWISE GOOD.
   d. Lintel beams: GOOD
   e. General: GOOD

2. Foundation Observation:
   a. Machine Pads & Anchor Bolts: SOME PAINT PEELING - OTHERWISE - GOOD
   b. Pump Floor: SOME WATER POOLING UP NEAR DUCTWORK. OTHERWISE - GOOD
   c. Wet well: N/A
   d. Discharge well: N/A
   e. Trash rack: N/A -- HOWEVER, SCHEDULED TO BE REPLACED

3. Site:
   a. Access/right-of-way: GOOD
   b. Settlement: N/A
   c. Drainage: N/A
   d. Outfall structures: N/A

PUMP STATION – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5-10-99

City: PADUCAH, KY Pump Station No. 7 (STA 90+51-B)

1. Superstructure:
   a. Roof type and condition: FLAT CONCRETE WITH SCUPPERS - GOOD COND.
   b. Exterior type and condition: CONCRETE - SOME CRACKED SEALANT - OTHERWISE - GOOD
   c. Interior type and condition: CONCRETE WITH MINOR CRACKING AROUND WINDOW (NORTH FACE)
   d. Lintel beams: GOOD
   e. General: GOOD

2. Foundation Observation:
   a. Machine Pads & Anchor Bolts: SOME PAINT PEELING OTHERWISE - GOOD
   b. Pump Floor: GOOD
   c. Wet well: N/A
   d. Discharge well: N/A
   e. Trash rack: N/A

3. Site:
   a. Access/right-of-way: GOOD
   b. Settlement: N/A
   c. Drainage: N/A
   d. Outfall structures: N/A

PUMP STATION – STRUCTURAL EVALUATION

Evaluator: L.C. ENGSTROM Date: 5-10-99

City: PADUCAH, KY Pump Station No. 9 (STA 69+85-B)

1. Superstructure:
   a. Roof type and condition: FLAT CONCRETE WITH SCUPPER - GOOD COND.
   b. Exterior type and condition: CONCRETE WITH MINOR PATCHING - GOOD COND.
   c. Interior type and condition: CONCRETE - GOOD
   d. Lintel beams: GOOD
   e. General: GOOD

2. Foundation Observation:
   a. Machine Pads & Anchor Bolts: GOOD
   b. Pump Floor: GOOD
   c. Wet well: N/A
   d. Discharge well: N/A
   e. Trash rack: N/A

3. Site:
   a. Access/right-of-way: GOOD
   b. Settlement: N/A
   c. Drainage: N/A
   d. Outfall structures: N/A

PUMP STATION – STRUCTURAL EVALUATION

Evaluator: L.C. ENGSTROM Date: 5-10-99

City: PADUCAH, KY Pump Station No. 11 (STA 40+03-B)

1. Superstructure:
   a. Roof type and condition: FLAT CONCRETE WITH SCUPPERS – GOOD COND.
   b. Exterior type and condition: CONCRETE – GOOD COND.
   c. Interior type and condition: CONCRETE WITH MINOR CRACKS, CRACKING SEALANT BETWEEN PANELS. OTHERWISE - GOOD
   d. Lintel beams: GOOD
   e. General: GOOD

2. Foundation Observation:
   a. Machine Pads & Anchor Bolts: GOOD
   b. Pump Floor: GOOD
   c. Wet well: N/A
   d. Discharge well: N/A
   e. Trash rack: N/A

3. Site:
   a. Access/right-of-way: GOOD
   b. Settlement: N/A
   c. Drainage: N/A
   d. Outfall structures: N/A

PUMP STATION – STRUCTURAL EVALUATION

Evaluator: I.C. ENGSTROM Date: 5-10-99

City: PADUCAH, KY Pump Station No. 12 (STA 175+20-C)

1. Superstructure:
   a. Roof type and condition: FLAT CONCRETE WITH SCUPPERS (SOME CHIPPED) -- GOOD COND.
   b. Exterior type and condition: CONCRETE, SOME MINOR HAIRLINE CRACKING & LEECHING (LANDSIDE) - OTHERWISE - GOOD
   c. Interior type and condition: CONCRETE WITH MINOR CRACKING AROUND DOORFRAMES - OTHERWISE - GOOD.
   d. Lintel beams: SOME CRACKING - OTHERWISE, GOOD.
   e. General: GOOD

2. Foundation Observation:
   a. Machine Pads & Anchor Bolts: GOOD
   b. Pump Floor: GOOD
   c. Wet well: N/A
   d. Discharge well: N/A
   e. Trash rack: FAIR

3. Site:
   a. Access/right-of-way: GOOD
   b. Settlement: N/A
   c. Drainage: GOOD
   d. Outfall structures: N/A

PUMP STATION – STRUCTURAL EVALUATION

Evaluator: L.C. ENGSTROM Date: 5-10-99

City: PADUCAH, KY Pump Station No. 13

1. Superstructure:
   a. Roof type and condition: PEAKED ROOF WITH SHINGLES. DUE FOR REPLACEMENT. OTHERWISE, GOOD.
   b. Exterior type and condition: CONCRETE MASONRY UNITS - GOOD
   c. Interior type and condition: CONCRETE MASONRY UNITS - GOOD
   d. Lintel beams: N/A
   e. General: GOOD

2. Foundation Observation:
   a. Machine Pads & Anchor Bolts: SURFACE RUST, NEEDS PAINT. FAIR CONDITION
   b. Pump Floor: GOOD
   c. Wet well: N/A
   d. Discharge well: N/A
   e. Trash rack: FAIRLY CLEAR, SOME DEBRIS

3. Site:
   a. Access/right-of-way: GOOD
   b. Settlement: N/A
   c. Drainage: N/A
   d. Outfall structures: N/A

CMP PIPE – CIVIL EVALUATION

Evaluator: E Sweet, T. Williams Date: 5/5/99

City: Paducah, Kentucky Station: 7+54 B

Description Location: 51 Feet from Floodwall

Diameter: 18-inch Wall thickness:

Approximate Installation Date:

1. Local Representative and Maintenance Program:

   a. Name Title

2. Local Maintenance Report:

3. Condition Assessment:

   a. Access/right-of-Way: Gravel Road at Top of Bank

   b. Material & Condition: Concrete Headwall with Steel Flap Gate - Both items are in good condition

   c. Alignment: Perpendicular to Floodwall

   d. Settlement: None

   e. Separation: None

   f. Outlet Drainage/Riprap: No Riprap, Erosion of slopes, Sparse Vegetation

   g. Flap/Sluice Gate: Neenah "MACH" Flap Gate in Good Condition. Operates freely except for sediment blocking bottom 1/3 of gate

Headwall 7'-6" wide x 4'-0" High x 1'-6" Deep

CMP PIPE – CIVIL EVALUATION

Evaluator: E Sweet, T. Williams Date: 5/5/99

City: Paducah, Kentucky Station: 19+11 B

Description Location: 125 feet from top of levee

Diameter: 66-inch Wall thickness:

Approximate Installation Date:

1. Local Representative and Maintenance Program:

   a. Name Title

2. Local Maintenance Report:

3. Condition Assessment:

   a. Access/right-of-Way: Gravel road extends to gated outlet

   b. Material & Condition: Concrete Headwall with Steel Flap Gate- Both items are in good to very good condition

   c. Alignment: Skewed to levee

   d. Settlement: None

   e. Separation: None

   f. Outlet Drainage/Riprap: Riprap located on both sides, no riprap on top where erosion is occurring, bottom material unknown because it was under water

   g. Flap/Sluice Gate:

Flap gate was in good condition, operates freely. Flapgate has cable attachment for opening. Cable extends to top of levee.

Headwall 10'-6" wide x 8'-6" High x 1'-10" Deep
Wingwalls 14'-10" Long x 1'-3" wide at 45°

CMP PIPE – CIVIL EVALUATION

Evaluator: E Sweet, T Williams Date: 5/5/99

City: Paducah, Kentucky Station: 80+09

Description Location: 52 feet from Floodwall

Diameter: 18-inch Wall thickness:

Approximate Installation Date:

1. Local Representative and Maintenance Program:

   a. Name Title

2. Local Maintenance Report:

3. Condition Assessment:

   a. Access/right-of-Way: Grass access road at top of Bank

   b. Material & Condition: Concrete Box around outlet, steel flap gate, 15" VCP outfall pipe through bottom of box Both in good condition

   c. Alignment: Perpendicular to Floodwall

   d. Settlement: None. Erosion around box is severe

   e. Separation: None.

   f. Outlet Drainage/Riprap: No riprap. Sparsely vegetated Serious/damaging erosion occurring around box

   g. Flap/Sluice Gate: Recently installed Neenah steel flap gate Model 5050-0022 in very good condition "MACH" type, gate operates freely

Box is 5' wide x 5' Long x 3' High

CMP PIPE – CIVIL EVALUATION

Evaluator: E Sweet, T Williams Date: 5/5/99

City: Paducah, Kentucky Station: 128+61

Description Location: 111 feet from Floodwall

Diameter: 36-inch Wall thickness:

Approximate Installation Date:

1. Local Representative and Maintenance Program:

   a. Name Title

2. Local Maintenance Report:

3. Condition Assessment:

   a. Access/right-of-Way: Asphalt road at top of Bank

   b. Material & Condition: Concrete Headwall with steel Flap Gate. Both items in very good condition

   c. Alignment: Perpindicular to Floodwall

   d. Settlement: None

   e. Separation: None

   f. Outlet Drainage/Riprap: Riprap all around outlet that is in good condition

   g. Flap/Sluice Gate: Brown & Brown Model M 36 90-805 steel flap gate in very good condition. Gate operates freely

Headwall 8'-6" wide x 4'-0" High x 1'-6" Deep
Wingwalls 2'-6" Long x 1'-6" wide

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
WASHINGTON DC 20314-1000

CECW-LRD

JUN 11 2009

MEMORANDUM FOR COMMANDER, GREAT LAKES AND OHIO RIVER DIVISION

SUBJECT: Implementation Guidance for Section 5077 of the Water Resources Development Act of 2007 (WRDA 2007) - Paducah, Kentucky.

1. Section 5077 of WRDA 2007 authorizes the Secretary of the Army to complete a feasibility report for rehabilitation of the project for flood damage reduction at Paducah, Kentucky, authorized by section 4 of the Flood Control Act of 1938 (P.L. 75-761) and may carry out the project at a total cost of $3,000,000 if the Secretary determines that the project is feasible. A copy of Section 5077 is enclosed for information.

2. This study may be undertaken in accordance with existing budgetary policy and procedures. At such time that funds are provided, the Louisville District should negotiate and execute a Feasibility Cost Sharing Agreement with the non-Federal sponsor to initiate the feasibility study for the project consistent with the CECW-PB Memorandum dated 16 August 2005, Subject: Reconstruction of U.S. Army Corps of Engineers Structural Flood Damage Reduction Projects for which Non-Federal Interests are Responsible for Operations, Maintenance, Repair, Rehabilitation and Replacement. If the feasibility phase does not recommend a feasible project, no additional design or construction work shall be undertaken unless funds are specifically appropriated for such work. If a feasible project is recommended and approved, the project may be considered for implementation in accordance with current policy and budgetary guidance. However, if the total project cost of the recommended project exceeds $3M, additional authority will be required before a Project Partnership Agreement (PPA) can be executed and construction can be initiated.

3. In accordance with the In-Kind Memorandum of Understanding (MOU) executed between the non-Federal Sponsor and the Federal Government on November 11, 2008, Engineering Circular No. 1165-2-208, and the ASA(CW) memorandum dated November 14, 2008, Subject: Paducah, Kentucky, Flood Damage Reduction Project, Request for Exception to Policy on Timing of Execution of In-Kind Memorandum of Understanding (MOU), work completed prior to completion of the feasibility study may be eligible for credit toward the non-Federal sponsor's share of total project costs pursuant to the PPA. The feasibility report shall include the appropriate information to make the determination if the design and construction work performed pursuant to the In-Kind MOU is integral to the project. The integral determination will be reviewed and approved by the Secretary as part of the decision document review and

CECW-LRD
SUBJECT: Implementation Guidance for Section 5077 of the Water Resources Development Act of 2007 (WRDA 2007) - Paducah, Kentucky

approval process. The actual value of the eligible design and construction work and amount of credit afforded will be determined in accordance with the terms and conditions of the PPA for the project.

FOR THE COMMANDER:

Encl

MICHAEL G. ENSCH
Chief, Regional Integration Team
Great Lakes and Ohio River Division
Civil Works Directorate

WATER RESOURCES DEVELOPMENT ACT OF 2007

SEC. 5077. PADUKAH, KENTUCKY.

The Secretary shall complete a feasibility report for rehabilitation of the project for flood damage reduction, Paducah, Kentucky, authorized by section 4 of the Flood Control Act of June 28, 1938 (52 Stat. 1217), and, if the Secretary determines that the project is feasible, the Secretary may carry out the project at a total cost of $3,000,000.

CECW-PG 10 October 2003

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Economic Guidance Memorandum (EGM) 04-01, Generic Depth-Damage Relationships for Residential Structures with Basements.

1. Purpose. The purpose of this memorandum is to release, and provide guidance for the use of, generic depth-damage curves for use in U.S. Army Corps of Engineers flood damage reduction studies.

2. Background. Proper planning and evaluation of flood damage reduction projects require knowledge of actual damage caused to various types of properties. The primary purpose of the Flood Damage Data Collection Program is to meet that requirement by providing Corps district offices with standardized relationships for estimating flood damage and other costs of flooding, based on actual losses from flood events. Under this program, data have been collected from major flooding that occurred in various parts of the United States from 1996 through 2001. Damage data collected are based on comprehensive accounting of losses from flood victims' records. The generic functions developed and provided in this EGM represent a substantive improvement over other generalized depth-damage functions such as the Flood Insurance Administration (FIA) Rate Reviews.

3. Results. Generic damage functions are attached for one-story homes with basement, two or more story homes with basement, and split-level homes with basement. Generic damage functions for similar structures without basements were published in 2000 and are included as enclosure 1 for ready reference.

a. Regression analysis was used to create the damage functions. While several independent variables, such as flood duration and flood warning lead-time, were examined in building the models, the models that were most efficient in explaining the percent damage to structure and contents were quadratic and cubic forms with depth as the only independent variable.

b. Content damage was modeled with the dependent variable being content damage as a percentage of structure value. This differs from the previous technique of first developing content valuations and then content damage relationships as a function of content valuations. The generic content damage models are statistically significant and their use eliminates the need to establish content-to-structure ratios through surveys.

c. While the data collected include information on all aspects of National Economic Development (NED) losses, only results and recommendations related to the structure and content damages for homes with basements are included in this EGM.

Direct costs for cleanup expenses, unpaid hours for cleanup and repair, emergency damage prevention actions, and other flood-related costs are not included in these damage functions. Information on other residential flood costs, beyond those included in these damage functions will found the summary report, discussed in paragraph 5. These costs should be developed using site-specific historical information.

4. Application. The following paragraphs provide information on the application of the generic curves within the HEC-FDA damage calculation program.

a. The economic section of HEC-FDA divides the quantification of flood damages into a direct method and an indirect method. The direct method allows the user to directly enter a stage-damage relationship for any structure. This approach is commonly used for large or unique properties such as industrial or pubic buildings. The indirect method quantifies the stage-damage relationship for a group of structures that have significant commonality. Typically damage to residential structures is calculated using the indirect method. The procedures described in the following paragraphs apply only when using the indirect method to determine the stage-damage relationship.

b. The traditional approach to quantifying damage to contents by the indirect method relies on three pieces of information: 1) structure value; 2) content-to-structure value ratio; and 3) the content depth-damage relationship. The content-to-structure value ratio and content depth-damage relationship are unique to the structure occupancy type to which a structure is assigned. The content depth-damage relationship provides the estimate of content flood damage as a percentage of content value. Thus, to calculate a content stage-damage function for an individual structure, the structure value for an individual structure is first multiplied by the content-to-structure value ratio to provide an estimate of the content value. This content value is then multiplied by each percent damage value of the content depth-damage relationship.

c. The new content depth-damage functions provided herein are different from those used by the Corps in the past in one important aspect. The new functions calculate content damage as a percent of structure value rather than content value. Using these functions within HEC-FDA requires care in specifying a content-to-structure value ratio. To understand the requirements for using the new content depth-damage functions requires a basic understanding of how HEC-FDA calculates content damage.

(1). To calculate damages by the indirect method, each structure must be assigned to a structure occupancy type. For each structure occupancy type a content-to-structure value ratio and content depth-damage relationship are defined. These data for calculating content damage within HEC-FDA is entered on the "Study Structure Occupancy Type" screen. As long as a content value is not entered for a structure in the Structure Inventory Data, HEC-FDA calculates the content stage-damage by first calculating content using the structure value multiplied by the content-to-structure value ratio.

In some instances, however, analysts develop unique estimates of content values for a structure, which are entered for the individual structure on the Structure Inventory Data screen. For each structure that has a content value entered, calculating a content value by using the content-to-structure value ratio is ignored and the user entered content value is used to calculate content damage.

(2). The new content depth-damage functions do not require this intermediate step of calculating content values. Therefore, the content-to-structure value ratio for each structure occupancy type using the new content depth-damage relationships must be set to one hundred percent (100). This forces the content depth-damage function to be multiplied by the structure value as required. Also, the "Error Associated with Content/Structure Value" on the "Study Structure Occupancy Type" screen should be left blank. This implies that the error in content-to-structure value ratio is part of the new content depth-damage relationship.

(3). Because entering a content value on the Structure Inventory Data window overrides the content-to-structure value ratio, the new content depth-damage relationships should not be used for structures that have separately entered content values.

(4). Questions concerning the use of the generic curves within the HEC-FDA model can be addressed to Dr. David Moser, Institute of Water Resources (IWR), (703) 428-8066.

5. Report. A report summarizing the data collection effort and analyses performed to derive these curves will shortly be available on the IWR website. More information may be obtained by contacting the program's principal investigator, Stuart Davis, (703) 428-7086.

6. Waiver to Policy. These curves are developed for nation-wide applicability in flood damage reduction studies. When using these curves, the requirement to develop site-specific depth-damage curves contained in ER 1105-2-100, E-19q.(2) is waived. Additionally, the requirement to develop content valuations and content-to-structure ratios based on site-specific or comparable floodplain information, ER 1005-2-100, E-19q.(1)(a), is also waived. Note these waivers currently apply only to single-family homes with and without basements for which generic curves have been published, and not other categories of flood inundation damages for which no generic curves exist. Feasibility reports must state the generic curves are being used in the flood damage analysis for residential structures with and/or without basements. Use of these curves is optional and analysts should always endeavor to use the best available information to accurately quantify the damages and benefits in inundation reduction studies.

CECW-PG
SUBJECT: Economic Guidance Memorandum (EGM) 04-01, Generic Depth-Damage Relationships

7. Point of Contact. Administrators of the Flood Damage Data Collection Program continue to collect and analyze flood-related damages to both residential and commercial properties. The HQUSACE program monitor is Lillian Almodovar, (202) 761-4233, who can address any questions concerning the program.

FOR THE COMMANDER:

/s/
WILLIAM R. DAWSON, P.E.
Chief, Planning and Policy Division
Directorate of Civil Works

Encl

CECW-PG
SUBJECT: Economic Guidance Memorandum (EGM) 04-01, Generic Depth-Damage Relationships

DISTRIBUTION:
North Atlantic Division, ATTN: CENAD-ET-P
South Atlantic Division, ATTN: CESAD-ET-P
Great Lakes/Ohio River Division: ATTN: CELRD-E-P
Northwestern Division, ATTN: CENWD-PNP-ET-P
Pacific Ocean Division, ATTN: CEPOD-ET-E
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Southwestern Division, ATTN: CESWD-ET-P
Mississippi Valley Division: ATTN: CEMVD-PM

DAMAGE FUNCTIONS FOR SINGLE FAMILY RESIDENTIAL STRUCTURES WITH BASEMENTS

Structure Depth-Damage

Table 1 Structure One Story, With Basement		
Depth	Mean of Damage	Standard Deviation of Damage
-8	0%	0
-7	0.7%	1.34
-6	0.8%	1.06
-5	2.4%	0.94
-4	5.2%	0.91
-3	9.0%	0.88
-2	13.8%	0.85
-1	19.4%	0.83
0	25.5%	0.85
1	32.0%	0.96
2	38.7%	1.14
3	45.5%	1.37
4	52.2%	1.63
5	58.6%	1.89
6	64.5%	2.14
7	69.8%	2.35
8	74.2%	2.52
9	77.7%	2.66
10	80.1%	2.77
11	81.1%	2.88
12	81.1%	2.88
13	81.1%	2.88
14	81.1%	2.88
15	81.1%	2.88
16	81.1%	2.88

Table 2 Structure Two or More Stories, With Basement		
Depth	Mean of Damage	Standard Deviation of Damage
-8	1.7%	2.70
-7	1.7%	2.70
-6	1.9%	2.11
-5	2.9%	1.80
-4	4.7%	1.66
-3	7.2%	1.56
-2	10.2%	1.47
-1	13.9%	1.37
0	17.9%	1.32
1	22.3%	1.35
2	27.0%	1.50
3	31.9%	1.75
4	36.9%	2.04
5	41.9%	2.34
6	46.9%	2.63
7	51.8%	2.89
8	56.4%	3.13
9	60.8%	3.38
10	64.8%	3.71
11	68.4%	4.22
12	71.4%	5.02
13	73.7%	6.19
14	75.4%	7.79
15	76.4%	9.84
16	76.4%	12.36

Table 3 Structure Split Level, With Basement		
Depth	Mean of Damage	Standard Deviation of Damage
-8		
-7		
-6	2.5%	1.8%
-5	3.1%	1.6%
-4	4.7%	1.5%
-3	7.2%	1.6%
-2	10.4%	1.6%
-1	14.2%	1.6%
0	18.5%	1.6%
1	23.2%	1.7%
2	28.2%	1.9%
3	33.4%	2.1%
4	38.6%	2.4%
5	43.8%	2.6%
6	48.8%	2.9%
7	53.5%	3.2%
8	57.8%	3.4%
9	61.6%	3.6%
10	64.8%	3.9%
11	67.2%	4.2%
12	68.8%	4.8%
13	69.3%	5.7%
14	69.3%	5.7%
15	69.3%	5.7%
16	69.3%	5.7%

Content Depth-Damage

Table 4 Content One Story, With Basement		
Depth	Mean of Damage	Standard Deviation of Damage
-8	0.1%	1.60
-7	0.8%	1.16
-6	2.1%	0.92
-5	3.7%	0.81
-4	5.7%	0.78
-3	8.0%	0.76
-2	10.5%	0.74
-1	13.2%	0.72
0	16.0%	0.74
1	18.9%	0.83
2	21.8%	0.98
3	24.7%	1.17
4	27.4%	1.39
5	30.0%	1.60
6	32.4%	1.81
7	34.5%	1.99
8	36.3%	2.13
9	37.7%	2.25
10	38.6%	2.35
11	39.1%	2.45
12	39.1%	2.45
13	39.1%	2.45
14	39.1%	2.45
15	39.1%	2.45
16	39.1%	2.45

Table 5 Content Two or More Stories-With Basement		
Depth	Mean of Damage	Standard Deviation of Damage
-8	0%	0
-7	1.0%	2.27
-6	2.3%	1.76
-5	3.7%	1.49
-4	5.2%	1.37
-3	6.8%	1.29
-2	8.4%	1.21
-1	10.1%	1.13
0	11.9%	1.09
1	13.8%	1.11
2	15.7%	1.23
3	17.7%	1.43
4	19.8%	1.67
5	22.0%	1.92
6	24.3%	2.15
7	26.7%	2.36
8	29.1%	2.56
9	31.7%	2.76
10	34.4%	3.04
11	37.2%	3.46
12	40.0%	4.12
13	43.0%	5.08
14	46.1%	6.39
15	49.3%	8.08
16	52.6%	10.15

Table 6 Content Split-Level-With Basement		
Depth	Mean of Damage	Standard Deviation of Damage
-8	0.6%	2.09
-7	0.7%	1.49
-6	1.4%	1.14
-5	2.4%	1.01
-4	3.8%	1.00
-3	5.4%	1.02
-2	7.3%	1.03
-1	9.4%	1.04
0	11.6%	1.06
1	13.8%	1.12
2	16.1%	1.23
3	18.2%	1.38
4	20.2%	1.57
5	22.1%	1.76
6	23.6%	1.95
7	24.9%	2.13
8	25.8%	2.28
9	26.3%	2.44
10	26.3%	2.44
11	26.3%	2.44
12	26.3%	2.44
13	26.3%	2.44
14	26.3%	2.44
15	26.3%	2.44
16	26.3%	2.44

ENCLOSURE
DAMAGE FUNCTIONS
FOR SINGLE FAMILY RESIDENTIAL

STRUCTURES WITHOUT BASEMENTS

Structure One Story, No Basement		
Depth	**Mean of Damage**	**Standard Deviation of Damage**
-2	0%	0%
-1	2.5%	2.7%
0	13.4%	2.0%
1	23.3%	1.6%
2	32.1%	1.6%
3	40.1%	1.8%
4	47.1%	1.9%
5	53.2%	2.0%
6	58.6%	2.1%
7	63.2%	2.2%
8	67.2%	2.3%
9	70.5%	2.4%
10	73.2%	2.7%
11	75.4%	3.0%
12	77.2%	3.3%
13	78.5%	3.7%
14	79.5%	4.1%
15	80.2%	4.5%
16	80.7%	4.9%

Structure Two or More Stories-No Basement		
Depth	**Mean of Damage**	**Standard Deviation of Damage**
-2	0%	0%
-1	3.0%	4.1%
0	9.3%	3.4%
1	15.2%	3.0%
2	20.9%	2.8%
3	26.3%	2.9%
4	31.4%	3.2%
5	36.2%	3.4%
6	40.7%	3.7%
7	44.9%	3.9%
8	48.8%	4.0%
9	52.4%	4.1%
10	55.7%	4.2%
11	58.7%	4.2%
12	61.4%	4.2%
13	63.8%	4.2%
14	65.9%	4.3%
15	67.7%	4.6%
16	69.2%	5.0%

Structure Split-Level-No Basement		
Depth	**Mean of Damage**	**Standard Deviation of Damage**
-2	0%	0%
-1	6.4%	2.9%
0	7.2%	2.1%
1	9.4%	1.9%
2	12.9%	1.9%
3	17.4%	2.0%
4	22.8%	2.2%
5	28.9%	2.4%
6	35.5%	2.7%
7	42.3%	3.2%
8	49.2%	3.8%
9	56.1%	4.5%
10	62.6%	5.3%
11	68.6%	6.0%
12	73.9%	6.7%
13	78.4%	7.4%
14	81.7%	7.9%
15	83.8%	8.3%
16	84.4%	8.7%

Content One Story, No Basement		
Depth	**Mean of Damage**	**Standard Deviation of Damage**
-2	0%	0%
-1	2.4%	2.1%
0	8.1%	1.5%
1	13.3%	1.2%
2	17.9%	1.2%
3	22.0%	1.4%
4	25.7%	1.5%
5	28.8%	1.6%
6	31.5%	1.6%
7	33.8%	1.7%
8	35.7%	1.8%
9	37.2%	1.9%
10	38.4%	2.1%
11	39.2%	2.3%
12	39.7%	2.6%
13	40.0%	2.9%
14	40.0%	3.2%
15	40.0%	3.5%
16	40.0%	3.8%

Content Two or More Stories-No Basement		
Depth	**Mean of Damage**	**Standard Deviation of Damage**
-2	0%	0%
-1	1.0%	3.5%
0	5.0%	2.9%
1	8.7%	2.6%
2	12.2%	2.5%
3	15.5%	2.5%
4	18.5%	2.7%
5	21.3%	3.0%
6	23.9%	3.2%
7	26.3%	3.3%
8	28.4%	3.4%
9	30.3%	3.5%
10	32.0%	3.5%
11	33.4%	3.5%
12	34.7%	3.5%
13	35.6%	3.5%
14	36.4%	3.6%
15	36.9%	3.8%
16	37.2%	4.2%

Content Split-Level-No Basement		
Depth	**Mean of Damage**	**Standard Deviation of Damage**
-2	0%	0%
-1	2.2%	2.2%
0	2.9%	1.5%
1	4.7%	1.2%
2	7.5%	1.3%
3	11.1%	1.4%
4	15.3%	1.5%
5	20.1%	1.6%
6	25.2%	1.8%
7	30.5%	2.1%
8	35.7%	2.5%
9	40.9%	3.0%
10	45.8%	3.5%
11	50.2%	4.1%
12	54.1%	4.6%
13	57.2%	5.0%
14	59.4%	5.4%
15	60.5%	5.7%
16	60.5%	6.0%

CITY OF PADUCAH
300 South 5th Street
P. O. Box 2267
Paducah, KY 42002-2267
www.paducahky.gov

Rick Murphy, P.E.
City Engineer

Phone: (270) 444-8511
Fax: (270) 444-8689

September 7, 2006

Mr. Steve Rager, Chief Emergency Management and Security Branch
U.S. Army Corp of Engineers
Louisville District
P.O. Box 59
Louisville, KY. 40201

RE: Abandonment of Pump Plant #8

Dear Mr. Rager:

The City of Paducah has completed the abandonment of pump plant #8 left of approximate station 74 + 40 Section "B" in accordance with my June 29, 2006 correspondence to Mr. Dan Frank and your letter of no objection dated July 24, 2006 with the exceptions described herein.

- The gravity line from the wetwell (manhole No. 6 on Corps 1940 Plans) at pump plant #8 to the river will be maintained. The Corps plans of 1940 indicate this line was a V.C. sewer pipe to be upgraded at the time to a C.I.P. from manhole No. 6 to the riverside manhole.
- The City caused approximately forty feet of the V. C. P. gravity discharge line to be replaced with 10" C.I.P. from the existing riverside manhole to its point of discharge on the riverbank.
- A pre-cast headwall and riprap was constructed at the point of discharge of the 10" C.I.P. and the slopes stabilized with riprap around the headwall.
- The gravity discharge line can be sealed from a rising river via the existing flap gate in the existing riverside manhole and the existing sluice gate inside the wetwell.
- In the event of a flood occurrence this discharge line will be operated in the same manner as if the station remained. However, the wetwell (manhole No. 6) will be pumped by a portable pump into the adjacent storm sewer system.

The purpose for maintaining the gravity discharge from the wetwell (manhole No. 6) to the river allows for ground water collected by the toe drain to the gravity flow to the river during non-flood events.

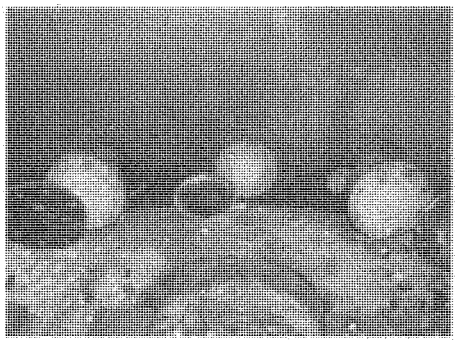
Please find attached various photos and red marked plans (as-built to the original design) illustrating pump plant #8's abandonment. In the event you have any questions, please contact me at 270-444-8511.

Sincerely,

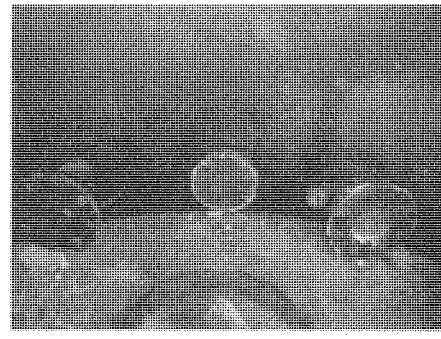
Rick Murphy, P.E.
City Engineer

RM/my

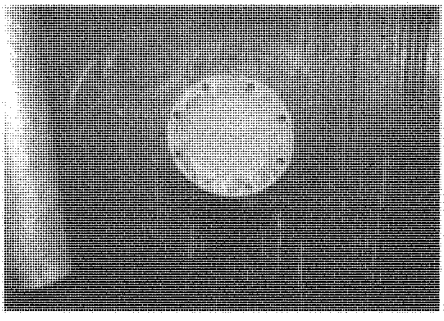
C: Dan Frank, OP-E
Kenny Brannon, Floodwall Superintendent



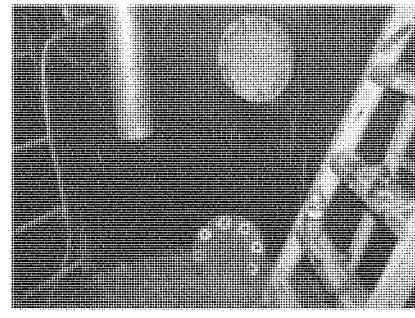
Intakes sealed with concrete.



Cover plates on intakes from wetwell with sealant between the plate and flange.



Discharge pipe sealed with concrete.



Discharge pipe to river sealed with concrete.

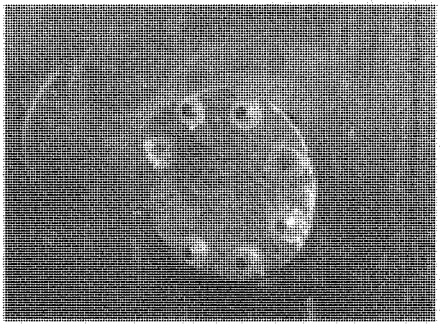


Plate placed on discharge pipe.

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT LOUISVILLE
CORPS OF ENGINEERS
P. O. BOX 59
LOUISVILLE, KENTUCKY 40201-0059

http://www.lrl.usace.army.mil/

July 24, 2006

Operations Division
Emergency Management and
Security Branch

Mr. Rick Murphy, P.E.
City Engineer
City of Paducah
300 South 5th Street
P.O. Box 2267
Paducah, Kentucky 42002-2267

Dear Mr. Murphy:

We have reviewed the technical information submitted for the proposed modifications for abandoning Pumping Station No. 8 at Station 74+48 on Section B-1 of the Paducah Local Flood Protection Project.

We have no objections to the proposed work in regards to the Paducah Local Flood Protection Project providing the following efforts are accomplished during project construction:

The abandoned discharge pipe under the floodwall will be permanently sealed with grout for a distance of at least 10 feet from the centerline of the floodwall on each side of the floodwall.

A copy of As-Built drawings need to be provided to this office, ATTN: CELRL-OP-E (Dan Frank) upon project completion.

I am forwarding a copy of this letter to Mr. Kenny Brannon, Superintendent, Paducah Local Flood Protection Project.

Sincerely,

Steven W. Rager
Chief, Emergency Management
and Security Branch

RECEIVED
JUL 2 4 2006
ENGINEERING
DEPARTMENT

US Army Corps of Engineers
Louisville District

EOC Message

From the CELRL-OP-E Emergency Operations Center
Emergency Management Branch
Operations Division
P. O. Box 59 (OP-E)
Louisville, Kentucky 40201-0059
Phone: (502) 315-6912
FAX: (502) 315-6918

Date: 24 JUL 06 From: Steve Rager
No. of pages (including cover sheet): ____

Please Deliver to: (at FAX: [270] 444 - 8689)
Name: Rick Murphy Office: ____

Comments / Message:

Rick:

- Here is a copy of a letter that was sent To Congressman Whitfield. IT discusses the cost share issue on the repairs.

- Also here is an advance copy of the "letter of no objection" for your work at pumping station #8

- We will be sending a letter to the city officially accepting your plan of action for the repair of the CMT. That letter with requested information should be today.

Thanks Steve

If you do not receive all pages, please call: (502) 315-6911

CITY OF PADUCAH

Rick Murphy, P.E.
City Engineer

300 South 5th Street
P. O. Box 2267
Paducah, KY 42002-2267
www.paducahky.gov

Phone: (270) 444-8511
Fax: (270) 444-8689

June 29, 2006

Mr. Dan Frank
U.S. Army District Louisville
Corp of Engineers
P.O. Box 59
Louisville, KY. 40201-0059

RE: Paducah Flood Protection Project Pump Plant No. 8 at Station 74 + 48 on Section B-1

Dear Dan:

Ingram Barge Company is currently constructing their inland waterways headquarters in the City of Paducah directly adjacent to the above referenced pump plant as discussed in your recent visit. Ingram's development plan currently requires the pump plant to be abandoned in place. I have reviewed Ingram's request and do not foresee any potential flood exposures to the City due to abandonment of the pump plant. My research of the plant's operation history is as follows:

- Over the last twenty-two years the pump plant has been engaged four times of which operations were insignificant.
- This pump plant serves the approximate 600 linear feet of 8" toe drain from approximately Section B-1 station 74 + 00 +/- to station 80 + 00 +/-.
- The accounts of floodwall operators yield the infrequent utilization of the pump plant.

The City of Paducah's actions to abandon and provide an alternate discharge point for Pump Plant no. 8's wet well will be as follows:

- All useable equipment will be salvaged from the station.
- All pipes leading to and from the pump plant will be permanently disconnected and sealed using blind flanges or by sealing all pipes with grout or concrete pumped throughout. This procedure will be carefully inspected for all discharge lines traversing under the floodwall to the river.
- Upon recovering useable equipment and permanently sealing all pipes, the pump plant will be backfilled with sand and the plant riser will be cut below the proposed site grade.

- The pump plant's wet well will be maintained in order to place a small pump to remove any toe drain discharge during flood events. The discharge from the small pump will be released to the Ingram site storm drainage system of which is conveyed to Pump Plant No. 9.
- Monitoring and pumping of Pump Plant No. 8 wet well will continue to be a part of the City of Paducah's flood protection maintenance and operations procedure.

As the U. S. Army Corps of Engineers provides inspection and consulting services to the City of Paducah's flood protection project, I am formally requesting the Corps consider our abandonment plan, offer additional guidance, and support our desire to abandon the station as described herein.

This project is moving along rapidly, therefore your prompt attention to this request is appreciated.

Sincerely,

Rick Murphy, P. E.
City Engineer

RBM:mly

C: Mayor Paxton, City of Paducah
Jim Zumwalt, City of Paducah
Kenny Brannon, City of Paducah
Pete Ciaramitaro, Ingram via fax
Neal Guess, Vanguard via fax

300 South 5th Street
P. O. Box 2267
Paducah, KY 42002-2267
270-444-8511 Phone
270-444-8689 Fax

CITY OF PADUCAH
Engineering Department

Fax

To:	Mr. Pete Ciaramitaro	**From:**	Missy Yarbrough for Rick Murphy
Fax:	**615-695-3662**	**Pages:**	2
Phone:	615-298-7665	**Date:**	June 30, 2006
Re:	Abandonment of Pump Station No. 8	**CC:**	

- **Comments:** For your information.

SENDING CONFIRMATION

DATE : JUN-30-2006 FRI 09:12
NAME : CITY OF PAD PLANNING ENGINEERING
TEL : 2704448689

PHONE	:	916156953662
PAGES	:	3/3
START TIME	:	JUN-30 09:11
ELAPSED TIME	:	00'52"
MODE	:	ECM
RESULTS	:	OK

FIRST PAGE OF RECENT DOCUMENT TRANSMITTED...

300 South 5th Street
P.O. Box 2267
Paducah, KY 42002-2267
270-444-8511 Phone
270-444-8689 Fax

CITY OF PADUCAH
Engineering Department

Fax

To:	Mr. Pete Ciaramitaro	From:	Missy Yarbrough for Rick Murphy
Fax:	615-695-3662	Pages:	2
Phone:	615-798-7665	Date:	June 30, 2006
Re:	Abandonment of Pump Station No. 8	CC:	

• Comments: For your information

300 South 5th Street
P. O. Box 2267
Paducah, KY 42002-2267
270-444-8511 Phone
270-444-8689 Fax

CITY OF PADUCAH
Engineering Department

Fax

To:	Mr. Neal Guess	**From:**	Missy Yarbrough for Rick Murphy
Fax:	**270-538-1967**	**Pages:**	2
Phone:	270-442-8620	**Date:**	June 30, 2006
Re:	Abandonment of Pump Station No. 8	**CC:**	

- **Comments:** For your information.

SENDING CONFIRMATION

DATE : JUN-30-2006 FRI 09:18
NAME : CITY OF PAD PLANNING ENGINEERING
TEL : 2704448689

PHONE	:	95381967
PAGES	:	3/3
START TIME	:	JUN-30 09:17
ELAPSED TIME	:	00'46"
MODE	:	ECM
RESULTS	:	OK

FIRST PAGE OF RECENT DOCUMENT TRANSMITTED...

300 South 6th Street
P. O. Box 2287
Paducah, KY 42002-2287
270-444-8511 Phone
270-444-8689 Fax

CITY OF PADUCAH
Engineering Department

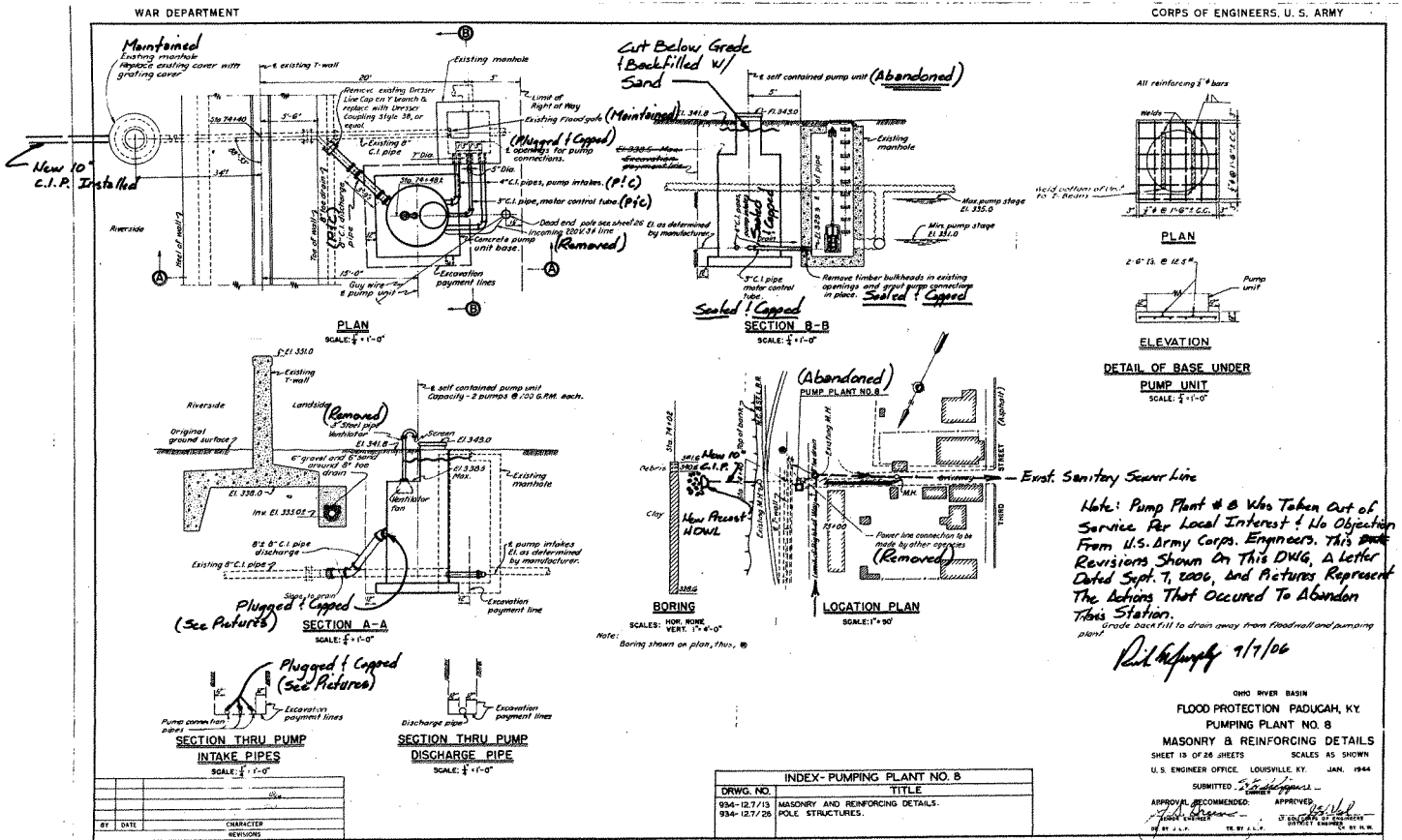
Fax

To: Mr. Neal Caress
From: Missy Yarbrough for Rick Murphy
Fax: 270-638-1967
Pages: 2
Phone: 270-442-8520
Date: June 30, 2006
Re: Abandonment of Pump Station No. 8
CC:

- **Comments:** For your information

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



Note: Pump Plant # 8 Was Taken Out of Service Per Local Interest & No Objection From U.S. Army Corps. Engineers. This Revisions Shown On This DWG, A Letter Dated Sept. 7, 2006, and Pictures Represent The Actions That Occured To Abandon This Station.

Grade back fill to drain away from floodwall and pumping plant

9/7/06

BY	DATE	CHARACTER REVISIONS

INDEX - PUMPING PLANT NO. 8	
DRWG. NO.	TITLE
934-12.7/13	MASONRY AND REINFORCING DETAILS.
934-12.7/26	POLE STRUCTURES.

OHIO RIVER BASIN

FLOOD PROTECTION PADUCAH, KY.

PUMPING PLANT NO. 8

MASONRY & REINFORCING DETAILS

SHEET 13 OF 26 SHEETS SCALES AS SHOWN

U. S. ENGINEER OFFICE, LOUISVILLE, KY. JAN. 1944

SUBMITTED: OWNER

APPROVAL RECOMMENDED: JOHN LEHNER

APPROVED: LT COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

DR. BY J.L.F. TR. BY J.L.F. CK. BY H.W.

824.1-51 934-12.7/13

1510

CITY OF PADUCAH

Rick Murphy, P.E.
City Engineer

300 South 5th Street
P. O. Box 2267
Paducah, KY 42002-2267

Phone: (270) 444-8511
Fax: (270) 444-8689
email: rmurphy@ci.paducah.ky.us

January 23, 2006

Mr. J. Douglas Moore, P.E.
Executive Director
Paducah-McCracken County Joint Sewer Agency
621 Northview
Paducah, KY 42001

Re: **Abandonment of Floodwall Pump Station No. 8, Toe Drain Pump Station**

Dear Doug:

As you are aware, the City of Paducah has been working with Ingram Barge regarding their new inland waterways operations headquarters located at 1000 South 3rd Street. As we have discussed, Ingram and the City desire to abandon the subject station if physically and feasibly possible. Should the removal of the station be possible, JSA is supportive of receiving the resulting minimal gravity flows to its system at no charge to the City. The City also understands should measurable flows become evident as a result of removing the station, JSA would have cause to begin billing the City for flows greater than those originally anticipated by JSA.

Therefore, pursuant to our conversations regarding the above referenced subject, please receive this correspondence as an official request by the City of Paducah to abandon the subject station as discussed herein and to permit the City to divert the minimal flow resulting from the removal of the station to the nearby JSA manhole currently serving the site's sanitary sewer needs. In the event it is determined the station cannot be abandoned, the City of Paducah and JSA will continue to operate their respective facilities as they currently exist.

On behalf of the City of Paducah I would like to extend my appreciation for your support as we continue to build partnerships with business, industry and our organizations. Should you or members of your staff have any questions regarding this subject please call. I look forward to hearing from you soon.

Sincerely,

Rick Murphy, P.E.
City Engineer

C: William F. Paxton, Mayor
Jim Zumwalt, City Manager
Kenny Brannon, Floodwall Superintendent

Paducah, Kentucky (Sponsor)
Paducah Local Flood Protection Project, (LFPP)
Flood Warning and Emergency Evacuation Plan, (FWEEP)

1.0 Introduction

1.1 Need For The Plan

The Paducah, Kentucky Local Flood Protection Project (LFPP) was federally designed and constructed to afford protection to the 1937 flood crest elevation plus 3 feet of freeboard. With this level of protection there is a possibility that flooding within the protected area could occur from either a rare overtopping event of the earthen levee, concrete floodwall, an unexpected failure of either of these structures, or any vital components integral to the functional operations that could allow an uncontrolled volume of water to enter the City. For this reason the local sponsor (City of Paducah) is required to develop a Flood Warning and Emergency Evacuation Plan (FWEEP). For the purposes of this plan, it is assumed the gravity outlets along the levee would be functioning properly and would be closed, in accordance with the City of Paducah's Operations Plan preventing the Ohio or Tennessee Rivers from infiltrating the City. The Operation and Maintenance Manual for this project contains detailed requirements for the pumping stations, closures, gravity outlet sluice gates, flap gates, and other necessary appurtenances. It should be noted the Paducah LFPP has been in operation since 1949. Whereas, over the past 61 years various operational and maintenance revisions to the project have been implemented due to the United States Army Corps of Engineers (USACE) requirements and/or by the desire of the local Sponsor having USACE approvals. Therefore, the LFPP is generally operated and maintained as originally constructed with minor modifications that have been mutually adopted by both the USACE and the City of Paducah.

2.0 General

2.1 Existing Flood Control Measures

The Paducah LFPP is located in McCracken County, Kentucky on the left bank of the Ohio River from about 934.4 miles below Pittsburgh, Pennsylvania. This combination levee/floodwall protection consists of 48,700 feet of earthen levee, 15,870 feet of concrete wall, currently 12 pumping plants for the disposal of interior drainage, 5 diversion channels, 47 movable closures including service openings, 8 earthen ramps, and other necessary appurtenant structures. The protection line lies along the left bank of Island Creek approximately 6 miles due south of the center of the city, then extends in a general northern direction to a point on the riverfront near the foot of Mill Street, thence along the riverfront to the vicinity of Burnett Street and, in westerly and southwesterly directions to high ground near the western limits of the city. The top of protection for this project varies from about elevation 350.00 at the LFPP's point of beginning to elevation 349.20 at the LFPP's point of ending. This information was taken from the National Levee Database (NLD) "Top of Levee

Profile based on NAVD 88. These elevations include 3 feet of freeboard above the 1937 flood crest elevation where the levee/floodwalls were raised this additional amount, to assure potential floodwaters would not overtop in the least hazardous areas.

2.2 Flood Events - (Flood History Since LFPP Completion - Based The Paducah Local Gage - 1949 to Present 2010)

Of the flood events occurring since 1949 to present 2010 that have reached the base of the levee or greater, the 13 February, 1950 flood was the most significant event with an approximate elevation of 339.0 feet NAVD 88. The 1950 event is considered to be the 1.00% chance (100-year) flood event by USACE Louisville District. Table I below shows the most significant flood events that have occurred since the LFPP's completion in 1949 with each flood event's associated crest elevations. As shown on the table, the 13 February 1950 flood is considered to be the 1.00% chance (100-year) event. The remaining events shown in the table were significant flooding events in their own rights, whereas, only two of these events have been considered by USACE Louisville District as being less than a 20 year frequency event. According to the City of Paducah's records the City has not ever experience any appreciable impacts or damages from interior flooding from any of these flood events occurring from 1949 to present. The fact that the City of Paducah has not experienced any appreciable damages or impacts due to any of these flood events can be solely attributed to the City of Paducah assuming its responsibility as a "Local Sponsor" and its Floodwall Operations Division's, continuous dedicated service to successfully operating and maintaining its LFPP systems as expected/intended by the USACE "second to none".

Table I
Paducah, Kentucky LFPP
*Peak Flood Events Based on Paducah Local Gage
(1949 to Present, 2010)

Date	Paducah Local Gage Elevation (PLG) (Feet)	U.S.E.D. - Ohio River Datum (ORD) Elevation *(feet)	NAVD 88 Datum Elevation *(Feet)	Frequency Estimated by USACE Louisville District
13 February 1950	53.3	339.6	338.8	100-Year
14 March 1997	51.7	338.0	337.2	60-Year
2 April 1975	51.6	337.9	337.1	60-Year
19 March 1963	50.3	336.6	335.8	40-Year
7 January 1991	49.9	336.2	335.4	35-Year
31 December 1990	49.4	335.7	334.9	30-Year
7 March 1979	49.3	335.6	334.8	30-Year
11 March 1962	48.5	334.8	334.0	20-Year
14 May 1984	48.1	334.4	333.6	<20-Year
21 March 1964	48.0	334.3	333.5	<20-Year

* ***Note: The elevations shown for the columns labeled ORD and NAVD 88 Datum elevations in Table I above were converted/calculated from the values denoted in the City of Paducah River Stage Logs. The values shown represent the Local Gage Elevation observed by City of Paducah Floodwall Operations Personnel for the dates shown.***

2.3 Future Floods

As previously stated, the Paducah LFPP was designed to an elevation equal to the 1937 flood crest elevation plus three feet of freeboard. By its design and as defined within the Paducah LFPP "General Plan Schedule of Operations," found in the Paducah Operations and Maintenance Manual, Plate 38, dated 1952 (GPSO), "The Top of Protection" is 63.8 feet Paducah Local Gage, 350.1 Ohio River Datum, and 349.3 NAVD 88 respectively. With this level of protection, it would be uncommon and very unlikely that the project would experience a flood event that could overtop the levee. More frequent flood events may cause flooding in Paducah, Kentucky should a failure by the Sponsor to properly install one or more of the closure structures or from an electrical/mechanical malfunction rendering one or more pump stations inoperable during an infrequent rainfall event. Should any of these circumstances occur the City of Paducah could experience internal flooding. Failure of the levee could occur if "under seepage" takes place causing a loss of levee foundation material to be piped to the landside of the levee. In the event "piping" or "sand boils" develop the sponsor will cause the construction of sand bag rings around any areas experiencing piping or sand boils to lessen the loss of foundation material and thus reduce the risk of any levee failure. Additionally, because there are either flap gates and/or sluice gates for each gravity pipe and for the discharge pipes associated with the various pump plants, backflow through any of these gravity pipes or pump plants should not occur. This assumption can only be realized if and only if the LFPP Sponsor properly operates and maintains all of these gates as outlined in the Paducah LFPP GPSO. In the event any of the flap gates and/or sluice

gates associated with the gravity through drains or those gates associated with the pump plants are not closed at the appropriate time, have not been properly maintained, or fail to function properly during high water events, then "back flooding" through any of these drainage structures could occur causing interior flooding. Should such an event occur evacuation of the potential inundated area would be put into action immediately.

3.0 Flood Threat Recognition

3.1 Purpose

This section delineates how a potential flood threat along the Ohio River can be recognized. The resources and methods used to determine the severity of the threat are also described.

3.2 National Weather Service

The National Weather Service Forecast Office in Paducah, Kentucky has the primary responsibility for providing rainfall forecasts and flood warnings for Paducah, Kentucky. The City of Paducah consistently monitors this forecast on a daily basis during low to moderate river stages less than 39.0 feet. The elevation of 39.0 feet is identified as Paducah's Local Flood Stage based on the Paducah River Gage. The Local Flood Stage Elevation of 39.0 feet equates to an elevation 325.3 feet ORD or an elevation of 324.5 feet NAVD 88. When river stages exceed an elevation greater than 39.0 feet on the Paducah Local Gage or 324.5 NAVD 88, the City of Paducah becomes even more vigilant with its monitoring of the local river stages as well as the monitoring precipitation events occurring in the upper Ohio and Tennessee River Valleys that can greatly impact flood stages for the entire Paducah-McCracken County community. The two websites most widely utilized by the City of Paducah for advanced warnings for the Lower Ohio and Tennessee River forecasts are listed below.

http://www.crh.noaa.gov/ahps2/hydrograph.php?wfo=pah&gage=pahk2&view=1,1,1,1,1,1,1,1]

http://www.srh.noaa.gov/lmrfc/?n=lmrfc-mississippiandohioriverforecast

3.3 Flood Warning System

There are two gages currently located in the vicinity of the Paducah, Kentucky LFPP that can be used to monitor the level of the Ohio River during flood events. The USACE, National Weather Service (NWS), and United States Geological Survey (USGS) share the primary gage station. The gage station, PAHK2, is located in a gauge house located outside the floodwall at the foot of Jefferson Street. This gage is maintained by the NWS and the zero reading corresponds to 286.26 feet ORD or 285.46 feet NAVD 88. Stages for this gage are read by satellite every hour. This information can be obtained from the NWS twenty-four hours a day. During flood periods, the NWS will also forecast river stages for the following five-day period.

The continuous monitoring of the existing gage coupled with the Paducah LFPP GPSO that procedures have been in place since 1949 with minimal modifications that determines the activities that must be accomplished for this FWEEP. This procedure is discussed in detail in the "Emergency Response Action" section of this report. The secondary gage is mounted on the outlet structure of Pump Plant 11 in order that the local LFPP Sponsor may monitor the Tennessee River exterior head elevation with respect to the Island Creek interior head elevation. This monitoring is necessary so as to prevent Island Creek from forming an interior head pressure on the Pump Plant No. 11 Sluices Gates that are not designed for this condition.

3.4 Rates of Rise

Rates of rise of the Ohio River can be determined from the gage station, PAHK2, through NWS or USACE. With this additional information, along with the NWS five-day forecasts for the Ohio River, slight modifications to the step-by-step plan discussed in "Emergency Response Action," may be made. This will be particularly true as experience is gained through observation with known flood events.

4.0 Warning Dissemination

4.1 Purpose

This section describes how local officials, responding agencies, and the public is notified of conditions, which may necessitate the installation of the movable and service closures or a worse case scenario of having to initiate an evacuation due to imminent flooding.

4.2 Agency Notification

The City of Paducah currently receives all of its severe weather and flood related advance warnings from the National Weather Service (NWS), a division of the National Oceanic Atmospheric Association (NOAA) located in Paducah Kentucky via tone activated radio. All advance notices for sever weather and flood related events are broadcast at a frequency of 162.475 MHz. The Paducah-McCracken County NWS Warning Coordinator Meteorologist's Office provides all advance warnings for all threatening weather conditions for this region. Contact information for this office is as follows:

NWS Warning Coordinator Meteorologist
National Weather Service (NWS)
8250 U.S. Hwy. 60 West
Paducah, Kentucky 42086
Telephone No. (270) 744-8029
Email address: ricky.shanklin@noaa.gov

4.3 Public Notification

The City of Paducah receives both radio and television broadcasts from area television media and broadcasting sources located in Paducah-McCracken County. WKYQ is the Official Broadcast Radio Station broadcasting on FM 93.3 Mhz. WPSD Local 6 television is the Official Broadcast Television Station that broadcast on DTV Channel 32 on TV Signal 578 – 584 Mhz. Both of these media broadcasting sources have their respective Emergency Alert System (EAS). The contact information for these two broadcast media sources are as follows:

Operator on Duty
WKYQ Radio
Bristol Broadcasting Company Inc.
6000 Bristol Drive
Paducah, Kentucky 42003
Telephone No. (270) 554-0959 (On Duty Operator's Line)
Telephone No. (270) 554-1433 (HOT LINE USED ONLY FOR MATTERS OF CIVIL DEFENSE)

Chief Meteorologist
WPSD Local 6
100 Television Lane
Paducah, Kentucky 42003
Telephone No. (270) 415-2001
Email address: wxcenter@wpsdlocal6.com

All area EASs are activated as threatening weather or flooding conditions require for advance (earliest possible) public notice regarding severe weather, rainfall, and/or potential flooding events that may threaten public safety. In the event it becomes necessary, the local broadcasting systems shall be activated to alert all homeowners and businesses of known threatening conditions for the potential of inundation due to flooding at the earliest possible moment. Such an occasion may be associated with a vital component of the Floodwall/Levee Systems indicating signs of failure due to extreme high water conditions or the potential for overtopping of the flood protection project. These warnings and when they may be given are more specifically described in "Section 5.3 Evacuation" within this FWEEP.

5.0 Emergency Response Action (Movable and Service Closure Sequence of Operations)

5.1 Movable And Service Closure Structures

Movable and Service closure structures are those elements of the LFPP that are installed to close off the surface openings in the levee or floodwall specifically constructed for the purpose of allowing normal traffic or pedestrian passage during low water periods. Each movable or service closure is sealed by erecting prefabricated structures specifically designed for that particular surface opening or by sandbagging various local or state road crossings that traverse the levee near its designed level of protection. The closures in the Paducah flood protection system (per the date of this FWEEP) include 37 movable closures and 10 service openings. The local or state highways that predated the construction of the Paducah LFPP were designed to pass over the levee have been identified/referred to as "Ramps" within the GPSO. Several of these ramps may be as much as 3 feet below the "Top of Protection 63.8 feet," (350.1 ORD or 349.3 NAVD 88). These ramps may require sandbagging under extreme high water conditions. The GPSO 1952, illustrates the Ohio River stage at which each closure should have been installed per that date. However, the City of Paducah in cooperation with USACE Louisville District have made several revisions to its LFPP that have permanently sealed many of the movable and service closures and raised sill elevations by 2 feet. Therefore, revisions have been made to the GPSO representative of the revisions for the sequencing of movable or service closure erections. Pump Plant No. 8 was also retired and removed in August of 2006. See the attached "Floodwall Gate Installation Order" representing the "GPSO 2010" currently maintained by the City of Paducah as of the date of this FWEEP. It should be noted the Local Sponsor has not included the entire LFPP's GPSO for the purposes of this FWEEP as the operations below elevation 333.5 NAVD 88 (Paducah Local Gage Elevation 48.0) are considered more routine operations and are not considered as emergency operations.

5.1.1 Maintenance

The requirements outlined in the Operations and Maintenance Manual (O&M) for the Paducah LFPP of closure structures provide that:

"Closure structures for traffic openings shall be inspected by the superintendent every 90 days to be certain that:

"(i) No parts are missing; (All parts are accounted for at each storage vault near each of the closures at all times. Parts may be removed for a short period of time only to perform necessary maintenance as outlined in the O&M manual)

"(ii) Metal parts are adequately covered with paint; (All part's coatings have been maintained in such a manor so as to prevent any section loss that may threaten the structural integrity for that particular support, member, or closure element)

"(iii) All movable parts are in satisfactory working order; (All parts have been maintained so as to prevent any damage or alterations that would prevent them from performing their intended structural purpose that is to withstand the hydrostatic forces equivalent to a flood event to the "Top of Protection.")

"(iv) Proper closure can be made promptly when necessary; (Based on the advanced forecast it receives from NOAA, the Paducah LFPP Sponsor has demonstrated on several occasions it is capable of properly installing any and all the movable or service closures in rapid succession. Upon receiving the advanced warning of the 1997 flood event, the City of Paducah work force installed 21 of 47 total openings within an initial 10 hour period. It should be noted that the City of Paducah's Engineering-Public Works, Floodwall Operations Division conducts movable and service closure gate erection and disassembly training for all of its Engineering-Public Works Public Works and Fire Department personnel every two years.)

"(v) Sufficient materials are on hand for the erection of sandbag closures; (The City of Paducah readily maintains a supply of ten thousand sandbags warehoused at its Public Works facility located at 1120 North 10th Street. The City of Paducah and McCracken County jointly own the Paducah-McCracken County Riverport Authority (PMRA) of which maintains an ample stockpile of river sand on its property at all times. When a flooding event presents itself, the City of Paducah and McCracken County require portions of these stockpiles to be delivered to sandbagging locations, it is at this time the sand is combined with the bags and properly placed for added protection.)

5.1.2 Operation (Movable and Service Closure Erection Procedure)

The requirements per the O&M Manual for the Movable and Service closure structures provide that:

Erection of each movable closure shall be started in sufficient time to permit completion before floodwaters reach the top of the structure sill. Information

regarding the proper method of erecting each individual closure structure, together with an estimate of the time required by an experienced crew to complete its erection is given in the O&M Manual. Closure structures will be inspected frequently during flood periods to ascertain that no undue leaking is occurring and that drains provided to care for ordinary leakage are functioning properly. Boats or floating plant shall not be allowed to tie up to closure structures or to discharge passengers or cargo over them.

5.1.3 Flood Period Operation

It is imperative that ample time be allowed to erect the gate closures before the water reaches the sills. Due consideration must be given to the rate of rise of the river. Records indicate that the rate of rise may be expected to average 0.40 foot per hour over the period required to affect closures. Consideration must also be given to possible delays in the operation because of inexperienced help and other contingencies. "Table 2 Gate Closures," page VII-4 and VII-5 of the Paducah O&M Manual shows the order of erection, erection time, manpower and sandbags needed for each closure. ***It should be NOTED the City of Paducah has revised the aforementioned "Table 2 Gate Closures" that is representative of the current "Floodwall Closure Installation Order" attached.*** The revised "Floodwall Closure Installation Order" resulted from the LFPP Sponsor's gaining approval from the USACE Louisville District to modify and or to permanently seal various closures over the past several years.

5.2 Sandbag Closures

Sandbags used for erecting the sandbag closure shall contain about 1/3 cubic foot of clay or silt and shall be filled and placed generally as outlined in the City of Paducah O&M Manual paragraph 10-07, 10-17 and shown on Plate 11. The description and location for the sandbag closures are included in the "Floodwall Closure Installation Order" attached. Each sandbag closure shall be erected to the level of the top of the adjacent protection.

5.3 Evacuation

In the event of an extreme high water event (Critical Stage or Greater) or potentially a rare overtopping event, evacuation of the protected areas could become necessary. Therefore, it should be noted it is beyond the scope of this FWEEP to show all of the possible scenarios for interior flooding have the potential to occur. However, it is the intent of this FWEEP to prepare a reasonable plan of action that could be executed within an appropriate time that would provide public safety for those citizens subject to floodwater inundation.

In the event any key component(s) of the LFPP systems fail under extreme flood conditions or an unlikely event of a rare overtopping occurring, several areas along the levee system would be subject to flooding inside the line of protection from precipitation (heavy rains) or from the swelling of the Ohio and Tennessee Rivers flooding. Local officials and emergency preparedness organizations will be on the alert to notify home owners and businesses for any potential interior flooding of the

flood protection project as it may become necessary. These warnings will be provided in a timely fashion allowing that contents of homes might be moved and again at a later time to allow for an orderly evacuation of the protected area before overtopping occurs. Reference paragraphs 4.2 and 4.3 for public notification information and "Floodwall Closure Installation Order" attached as Table II for when these notifications may become necessary.

Long before any evacuation should take place, local elected officials will have already declared a "State of Emergency" for our entire community, area emergency preparedness, first responders, local officials, and all service organizations will be operating at a heightened state of awareness. Should such an event occur, the Kentucky National Guard would be deployed to maintain order in a time of uncertainty.

In the event it becomes necessary for an evacuation to occur due to river stages projected to reach "Critical Stage" and/or a potential "Overtopping of the Floodwall/Levee," IS imminent, local government officials would direct its home and business owners to the best of its ability to area and surrounding organizations to use their facilities for a possible evacuation event. The services of the Red Cross and Salvation Army to provide food, clothing, and other assistance should be utilized.

Notwithstanding, as stated previously in this section, it is beyond the scope of this FWEEP to show all of the possible scenarios for interior flooding that have the potential to occur and more so the order of magnitude presented by such an event. For example, should an unexpected system failure occur that might create uncontrollable interior flooding to occur at "Critical Stage" (1937 Flood Crest Elevation) approximately 15.7 sq. miles of LFPP protection area would become inundated equal to the 1937 Flood. Should this occur, it is estimated that approximately 10,000 to 12,000 of area residence would have to be evacuated. It should also be noted that flooding exterior to the line of protection has already occurred causing those homeowners or business people to seek food and shelter away from their homes previous to any Paducah LFPP evacuations. Furthermore, should the proper authorities predict an "Overtopping" event, is immanent, the previous scenario would be further exacerbated. Therefore, should an evacuation due to a potential for inundation from a Critical Stage or greater occur, area officials would direct "Evacuees" as follows:

- For Safe Evacuation, Evacuees are to use local streets to make their way to major flood evacuation routes including the following routes (See Map Attached):
    - Cairo Road (KY Route 305) Westbound
    - DO NOT ATTEMPT TO USE Hinkleville Road (U.S. HWY 60) Westbound beyond Noble Park as it is subject to inundation and may not be passable due to flooding.
    - Blandville Road (U.S. HWY 62) Westbound
    - Lone Oak Road (U.S. HWY 45) Southbound
    - Old Mayfield Road (KY Route 994) Southbound
    - Interstate 24 Eastbound and Westbound

- Subject to the impacts of the flooding occurring prior to evacuation notifications and any flood related damages that may cause incapacitations of area utilities (availability to public power, water, gas, and sanitation facilities) evacuees would be directed to area government operated facilities that could be used for shelter for a brief period. Such buildings would include government owned and operated or similar facilities suitable for short-term temporary food and shelter stations including area schools, national guard armory, and churches
- If it was known the evacuation was going to be for an extended period of time, (in excess of 14 days) evacuees would be encouraged by local officials to seek food and shelter outside the Paducah-McCracken County area or any community impacted by the current flood event. Evacuees would be encouraged to seek shelter outside of the community due to the lessons learned from Hurricane Katrina and the City of New Orleans attempting to "Warehouse" mass numbers people in facilities that were not specifically designed for such a purpose and those facilities being rendered inoperable due to the impacts of the hurricane.
- Unfortunately at this time the Paducah-McCracken County community does not have a facility capable of sustaining the needs of an estimated 10,000 to 12,000 people food and shelter needs for an extended period of time nor would it prove feasible to build one.

5.6 Responsibilities

Table III lists the activities that must be accomplished during high river water events. These activities are based on the Paducah O&M manual assuming all closures are installed and holding.

The initiation of activities is based on the stage readings from the gage station, PAHK2, is located in the foot of Jefferson Street Stages for this gage are read by satellite every hour. This information can be obtained from USACE during normal working hours or from the NWS twenty-four hours a day. During flood periods, the NWS will also forecast river stages for the following five-day period, which can be used to predict the rate of rise.

Post Flood Recovery

Reoccupation

The following steps are a basic plan for safely reoccupying homes and businesses that have been flooded by the events previously discussed. Reoccupation and recovery should be done in accordance with the existing emergency response guides for Paducah, Kentucky. Once floodwaters have receded from the area in the event of a closure failure, or have drained from ponding areas from an overtopping event, and no further flooding is expected, reoccupation can begin. Highway crews can remove debris from the roadways and bridges and inspect for damage. If buildings have been severely flooded or if structural damage is suspected, the building should be inspected by the local building inspector to determine if they are safe. Flooded basements must be pumped out and flooded rooms cleaned. Residents may request assistance from the community when pumping is required. Various utility companies will inspect the areas that have been flooded to make sure that there are no dangerous conditions, such as leaking gas. Residents should be advised to photograph and/or video damages to their homes. They should also be advised to keep written records of damaged or discarded items and depth of the flooding.

Table II
Floodwall Closure Installation Order
Before Local Gage Elevation
49.5 Feet

Local Gage	U.S.E.D. (ORD) Datum	Supervisor Division-Men/Hrs.	Common Location	Station	Sect./Unit	Gate No.	Plan Type	Open.	Necessary Equipment			Contact Info. & Comments Prior to Installation (Info. Subject to Change)
									Backhoe & Pump Truck	Boom Truck	Manlift	
50.2 50.7	336.5 337.0	Street 3 6/4	Kentucky Ave. **Vault-Riverside** **Steel Plates**	119+62.7	B2	27 27-A	2-Trusses 1-Manway **Plan A**	2	Both		1	**Paducah Power – 575-4000** **Parks Dept. 444-8587**
50.6 50.1 50.6	336.9 336.4 336.9	Street 3 6/4	Broadway **Vault-Riverside** **Steel Plates**	123+80.4	B2	27-B 28 28-A	2 – Trusses 2-Manways **Plan A**	3	Both		1	**Paducah Power – 575-4000** **Parks Dept. – 444-8587**
50.6	336.9	Fire Dept Grounds 3 Backup 8/8	New Mural Opening **Vault-Riverside** **Boltdown Plates**	126+35	B2	28A	8 – Trusses New Opening	1	Both	1	2	**Paducah Power – 575-4000** **Parks Dept. – 444-8587** **Remove Bollards** **41.5 Riverfront Landing Elevation**
50.0	336.3	Grounds 2 6/4	Water & Jefferson St. **Vault-Landside** **Steel Plates**	128+19.8	B2	29	2 – Trusses **Plan A**	1	Both		1	**Parks Dept. – 444-8587**
50.0	336.3	Refuse 3 6/3	Monroe St. **Vault-Landside** **Brick Sill**	132+40.5	B2	30	1 – Truss **Plan A**	1	Pump Truck			**Parks Dept. – 444-8587**
49.9	336.2	Refuse 3 6/4	Madison St. Extended **Vault-Landside**	135+22.8	B2	31	3 – Trusses **Plan A**	1	Pump Truck		1	**Parks Dept. – 444-8587** **Sill Cleaning Req. No Hard Surface**
50.4 49.9 50.4	336.2 336.2 336.2	Refuse 2 6/6	2nd & Madison St. **Vault-Riverside** **Steel Plates**	138+23.3	B2	31-A 32 32-A	4 – Trusses 2-Manways **Plan A**	3	Both		1	**E911** **Executive Inn – 443-8000**
49.9	336.2	Refuse 2 6/5	3rd & Harrison St. **Vault at Pump Sta. #5 Steel Plates**	145+74.3	B2	33	4 – Trusses **Plan A**	1	Both		1	**E911** **Executive Inn – 443-8000**

Floodwall Closure Installation Order
Before Local Gage Elevation
49.5 Feet

Local Gage	U.A.E.S (ORD) Datum	Supervisor Division-Men/Hrs.	Common Location	Station	Sect./Unit	Gate No.	Plan Type	Open	Necessary Equipment			Contact Info. & Comments Prior to Installation (Info. Subject to Change)
									Backhoe & Pump Truck	Boom Truck	Manlift	
50.9	337.2	Street 2 8/8	5th & Park Ave **Vault-Landside** **Steel Plates**	161+53.2	B2	36	9 – Trusses **Plan A**	1	Both	1	2	State Highway Dept. – 898-2431 Residence of Robert King at 431 Park Avenue - 442-9505
49.9	336.2		725 North 5th St.	166+48.5	B2	37	N/A	2 Gate Valves				**Gate Permanently Sealed Sept. 2003** Notify Mid-West Terminal To Clear & Close Gate Valves – 442-0362
50.6	336.9	Grounds 3 6/3	Closure 100' North of Tennessee St. **Vault-Landside**	91+96	B2	19	Purling **Plan B**	1	Both			Ingram Barge Deckhand Training School – 441-1606 **To Be Permanently Sealed**
50.5	336.8	Grounds 2 6/4	Diagonal Closure 100' South of Ohio St. **Vault-Landside** **Brick Sill**	93+57.2	B2	20	2-Trusses **Plan A**	1	Both		1	Ronnie James – 898-7392 **To Be Permanently Sealed**
50.5	336.8	Refuse 3 6/4	Ohio St. **Vault-Landside** **Brick Sill**	94+63.8	B2	21	2-Trusses **Plan A**	1	Both			Ronnie James – 898-7392
50.5	336.8	Refuse 3 6/4	Jackson St. **Vault-Landside** **Brick Sill**	98+88.5	B2	22	1-Truss **Plan A**	1	Both			Ronnie James – 898-7392 AEP River Operations – 444-6151
50.3	336.6	Refuse 2 6/4	Clark St. at Pump Sta. #6 **Vault-Landside** **Steel Plates**	108+53	B2	25	1-Truss **Plan A**	1	Both			Crounse Corp. – 444-9611 Four Rivers Center – 443-9932 **1' Fill Riverside**
50.3	336.6	Fire Dept Street 3 Backup 8/6	Water St. **Vault-Riverside** **Steel Plates**	114+98.7	B2	26	6-Trusses **Plan A**	1	Both	1	2	Crounse Corp. – 444-9611 Four Rivers Center – 443-9932

Floodwall Closure Installation Order
Before Local Gage Elevation
51.0 Feet

Local Gage	U.S.E.D. (ORD) Datum	Supervisor Division-Men/Hrs.	Common Location	Station	Sect./Unit	Gate No.	Plan Type	Open.	Necessary Equipment			Contact Info. & Comments Prior to Installation (Info. Subject to Change)
									Backhoe & Pump Truck	Boom Truck	Manlift	
52.7	339.0	Street 2 6/4	2425 S. 4th St.- Vault – Riverside Upstream	4+49.5	B1	2	1-Truss Plan A	1	Pump Truck			Paducah Riverport Authority - 442-9326 To Be Permanently Sealed
52.7	339.0	Street 2 6/4	2425 S. 4th St.- Vault – Riverside Upstream	5+34.5	B1	3	1-Truss Plan A	1	Pump Truck			Paducah Riverport Authority - 442-9326
52.7	339.0	Refuse 2 6/4	2308 S. 4th St. Vault – Landside Upstream	9+44.0	B1	4	Purling Plan B	1	Pump Truck			Western Rivers Boat Management - 444-4772 To Be Permanently Sealed
52.7	339.0	Refuse 2 6/4	2308 S. 4th St. Vault-Riverside Upstream	10+40.0	B1	4-A	Purling Plan B	1	Pump Truck			Western Rivers Boat Management - 444-4772
52.7	339.0	Refuse 3 2/1	Old Shell Oil Opening 2030 S. 4th Panel @ Sta. 10+40	15+32.0	B1	4-B	Service Opening Plan C	1				Paducah Riverport Authority - 442-9326
50.4 49.9 50.4	336.7 336.2 336.7	Street 2 6/6	3rd & Clay St Vault-Riverside Steel Plates	149+87.3	B2	33-A 34 34-A	4-Trusses 2-Manways Plan A	3	Both		1	State Highway Dept. – 898-2431 Executive Inn – 443-8000 E911 + 3' Fill Protection Riverside
52.4 52.2 52.4	338.7 338.5 338.7	Street 3 8/5	4th & Park Ave Vault-Landside Steel Plates	157+26.1	B2	34-B 35 34-A	4-Trusses 2-Manways Plan A&C	3	Both		1	State Highway Dept. – 898-2431 Executive Inn – 443-8000 E911
51.9	338.2	Street 3 8/8	Campbell St. Vault-Landside Buried Sill Panel Downstream End of Opening	170+04.4	B2	38	4-Trusses Plan A	1	Both		1	Mid-West Terminal – 442-0362 Harper Industries – 442-2753 To Be Permanently Sealed

Floodwall Closure Installation Order
Before Local Gage Elevation
52.5 Feet

Local Gage	U.S.E.D. (ORD) Datum	Supervisor Division-Men/Hrs.	Common Location	Station	Sect./Unit	Gate No.	Plan Type	Open.	Necessary Equipment			Contact Info. & Comments Prior to Installation (Info. Subject to Change)
									Backhoe & Pump Truck	Boom Truck	Manlift	
53.7	340.0	Refuse 3 6/4	Wayne Sullivan Dr. Vault-Landside Upstream Buried Sill	31+01.3	B1	8	Purling Plan B	1	Both			Lone Star Cement – 442-5480 To Be Permanently Sealed
53.7	340.0	Refuse 3 6/4	Island Creek at Pump Sta. #11 Vault-Landside Buried Sill	36+84.5	B1	10	Purling Plan B	1	Both			Paducah River Fuel Services - & James Marine – 898-7392
53.6	339.9	Street 2 6/4	Tennessee St. at Pump Station #7 Vault-Landside	90+41.7	B2	18	1 – Truss Plan A	1	Both			Ingram Barge – 441-1606
53.4	339.7	Street 3 6/4	Adams St. Vault-Landside DGA Sill	103+63.5	B2	23	1 – Truss Plan A	1	Both			Crounse Corp. – 444-9611
53.0	339.3		2605 Cairo Rd.-Behind Sisteel in Levee	140+45.8	A	39	1 – Truss	1 Gate Valve				Permanently Sealed Gate July 2004 Close 10" Gate Valve; 4" Pump Maybe Req. At This Location

Floodwall Closure Installation Order
Before Local Gage Elevation
53.5 Feet

Local Gage	U.S.E.D. (ORD) Datum	Supervisor Division-Men/Hrs.	Common Location	Station	Sect./Unit	Gate No.	Plan Type	Open.	Necessary Equipment			Contact Info. & Comments Prior to Installation (Info. Subject to Change)
									Backhoe & Pump Truck	Boom Truck	Manlift	
~~52.7~~ 54.7	~~339.0~~ 341.0	Grounds 3 6/4	2000 S. 4th St. Diagonal Opening Vault-Landside Steel Plates	25+15.4	B1	5	1-Truss Plan A	1	Both			Paducah Riverport Authority - 442-9326 Raised Sill 2'-0"- December 2003
54.7	341.0	Refuse 3 6/4	2000 S. 4th St. Vault-Landside Steel Plates	26+90.3	B1	6	1 – Truss Plan A	1	Both			Paducah Riverport Authority - 442-9326
55.2	341.5	Refuse 3 6/4	1900 S. 4th St. Vault – Riverside Downstream Buried Sill	31+51.4	B1	9	1 – Truss Plan A	1	Both			Lone Star Cement – 442-5480
55.2	341.5	Street 3 6/5	1350 S. 3rd St. Vault-Riverside Buried Sill	62+84.3	B1	13	1 – Truss Plan A	1	Both			TransMontaigne – 442-5467 Raise Sill ?? Feet
55.2	341.5	Refuse 3 6/4	1130 S. 3rd St. Vault-Riverside Buried Sill	71+74.5	B1	15	1 – Truss Plan A	1	Pump Truck			Ingram Barge – 441-1606 Gate Temporarly Installed To Be Permanently Sealed
~~52.7~~ 54.7	~~339.0~~ 341.0	Grounds 2 6/6	900 S. 3rd St. –Lower Vault-Riverside	83+92.1	B1	17	3-Trusses Plan A	1	Pump Truck		1	Ingram Barge – 441-1606 Raised Sill 2'-0" – June 2006
54.4	340.7	Street 2 6/4	400 Marine Way Vault-Landside DGA Sill	106+10	B2	24	1 – Truss Plan A	1	Pump Truck	1		Crounse Corp. – 444-9611 To Be Permanently Sealed

Floodwall Closure Installation Order
Before Local Gage Elevation
55.0 Feet

Local Gage	U.S.E.D. (ORD) Datum	Supervisor Division-Men/Hrs.	Common Location	Station	Sect./Unit	Gate No.	Plan Type	Open.	Necessary Equipment			Contact Info. & Comments Prior to Installation (Info. Subject to Change)
									Backhoe & Pump Truck	Boom Truck	Manlift	
58.2	344.5	Street 2 6/4	1500 S. 3rd St. – Center Vault-Landside DGA Sill	51+87.3	B1	11	2 – Trusses Plan A????	1	Pump Truck			TransMontaigne – 442-1606
58.2	344.5	Street 2 6/4	Elizabeth St. – Center Vault-Landside DGA Sill	54+37.6	B1	12	2 – Trusses Plan A	1	Pump Truck			TransMontaigne – 442-1606
56.7	343.0	Refuse 3 6/5	1148 S. 3rd St. Vault-Landside Buried Sill	69+64.4	B1	14	Purling Plan B	1	Both			N/A
~~55.2~~ 57.2	~~341.5~~ 343.5	Refuse 3 6/4	1000 South 3rd St.- Upstream Vault-Riverside	75+85.1	B1	16	1 – Truss Plan A	1	Pump Truck			Ingram Barge – 441-1606 Raised Sill 2'-0"- October 2003

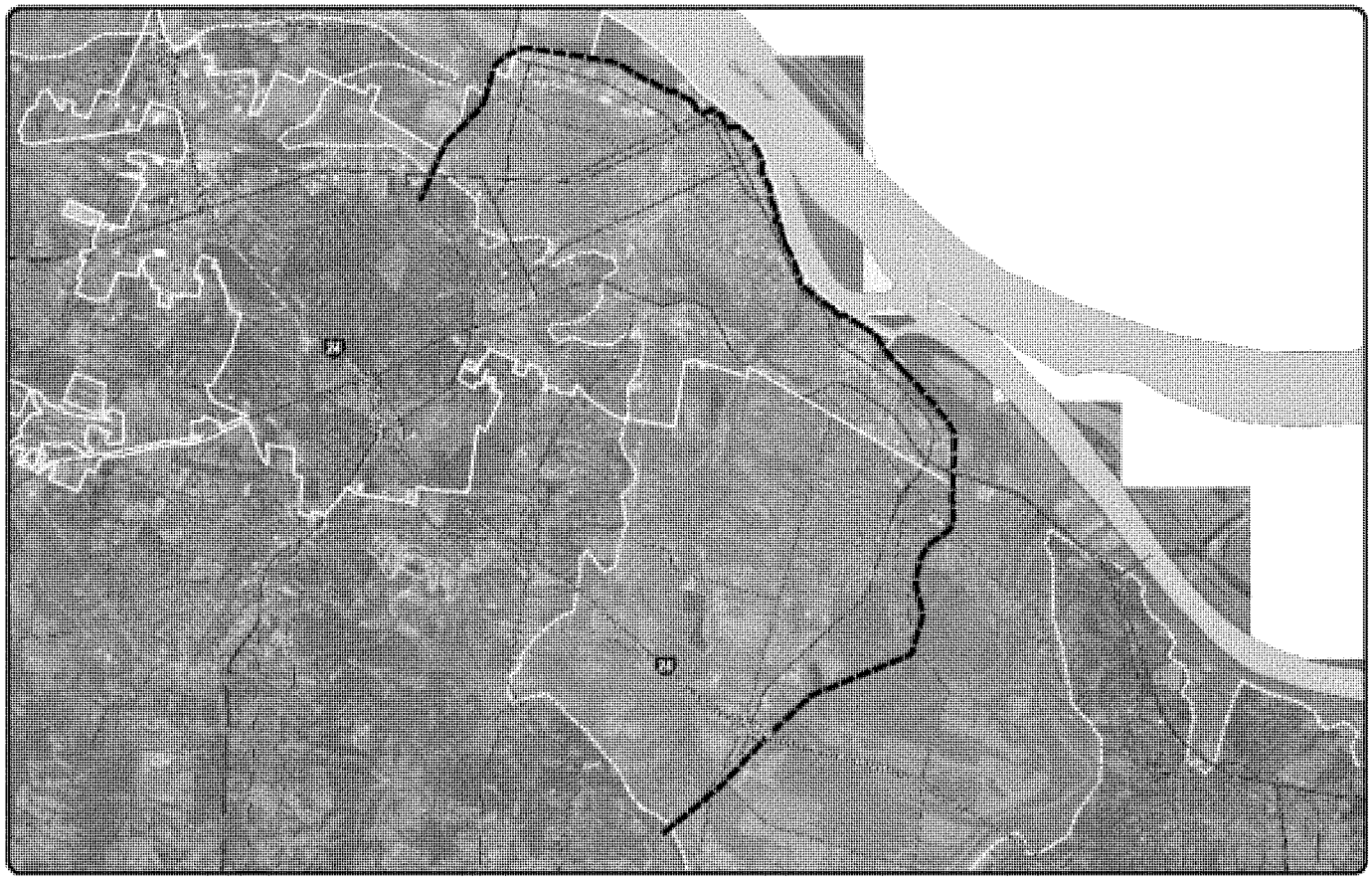
Table III
Critical Stage Operating Schedule
Sandbag Ramp Locations and Initiate Evacuation Plan
Upon Receiving Any River Forcast From NOAA > or = 60.0 Feet

NAVD 88 Datum (Feet)	U.S.E.D (O.R.D.) Datum (Feet)	Elev. Of Structure Local Gage (Feet)	O & M When Local Gage Is (Feet)	Required O & M Action	As-Built O & M Item	Floodwall Sta.	Floodwall Sect.	Comments
345.5	**346.3**	**60.0**	**60.0**	**-**	**CRITICAL STAGE**			***INITIATE PUBLIC NOTICE FOR THOSE AREAS THREATENED BY POTENTIAL INUNDATION***
~~347.3~~	~~348.1~~	~~61.8~~	~~61.8~~	~~Sandbag~~	~~-~~	~~-~~	~~-~~	~~Begin Sand Bagging Road Crossings By Previous O & M Schedules~~
346.0	346.8	60.5	59.5	Sandbag	Campbell Street	171+00	B	**Ramp Added By Sponsor By USACE Letter of No Objection**
346.7	347.5	61.2	60.2	Sandbag	Burnette Street	188+85	B	**Ramp Added By Sponsor By USACE Letter of No Objection**
347.6	348.4	62.1	61.5	Sandbag	Farm Access	124+15	A	Original Ramp Over Levee
347.7	348.5	62.2	61.5	Sandbag	Cairo Road (KY-305)	145+11	A	Original Ramp Over Levee
347.7	348.5	62.2	61.5	Sandbag	Park Avenue (US-60)	187+40	A	Original Ramp Over Levee
348.0	348.8	62.5	61.5	Sandbag	Benton Road (KY-284)	200+20	C	Original Ramp Over Levee
348.2	349.0	62.7	62.0	Sandbag	Clarks River Road (US- 60)	224+14	C	Original Ramp Over Levee
348.4	349.2	62.9	62.0	Sandbag	Oaks Road (KY-450)	149+40	C	Original Ramp Over Levee
348.5	349.3	63.0	62.0	Sandbag	Husbands Road (KY-1954)	28+60	C	Original Ramp Over Levee
348.7	349.5	63.2	62.0	Sandbag	P & L Railway	217+78	C	Original Ramp Over Levee
349.3	350.1	63.8	**63.8**	**TOP**	Carolina Street	220+05	C	Original Ramp Over Levee
349.3	**350.1**	**63.8**	**63.8**		**TOP OF PROTECTION (TOP)**			***UPON RECEIVING NOTICE FROM NOAA OF A CREST ELEVATION EXCEEDING THE TOP OF PROTECTION: ORDER OF MANDATORY EVACUATION FOR ALL AREAS HAVING THE POTENTIAL FOR INUNDATION. (SEE MAP)***

NAVD 88 Datum (Feet)	U.S.E.D (O.R.D.) Datum (Feet)	Elev. Of Structure Local Gage (Feet)	O & M When Local Gage Is (Feet)	Required O & M Action	As-Built O & M Item	Floodwall Sta.	Floodwall Sect.	Comments
350.1	350.9	64.6	64.6		York Lane	180+50	C	No Sandbagging Required
350.3	351.1	64.8	64.8		Cook Street	215+25	C	No Sandbagging Required
350.4	351.2	64.9	64.9		Mill Street	299+40	C	No Sandbagging Required
350.4	351.2	64.9	64.9		Northview Street	69+60	A	No Sandbagging Required
350.5	351.3	65.0	65.0		Lydon Road (KY-3075)	39+85	C	No Sandbagging Required
350.8	351.6	65.3	65.3		Georgia Street	206+30	C	No Sandbagging Required

Floodwall Closures Permanently Sealed To "Top of Protection" (TOP) At Each Station

Local Gage	U.S.E.D. (ORD) Datum	Supervisor Division-Men/Hrs.	Common Location	Station	Sect./Unit	Gate No.	Plan Type	Open.	Necessary Equipment			Contact Info. & Comments Prior to Installation (Info. Subject to Change)
									Backhoe & Pump Truck	Boom Truck	Manlift	
~~55.7~~ ~~54.7~~	~~342.0~~ ~~341.0~~		2425 S. 4th St.	2+86.5 3+20.7	B1 B1	1-A 1-B	Service Openings	2				Permanently Sealed October 2003
~~53.7~~	~~340.0~~		Wayne Sullivan Dr.	29+80.3	B1	7	Purling	1				Gate Permanently Sealed Sept. 2003
~~56.7~~	~~343.0~~		1350 South 3rd Street	67+73.4	B1		Purling	1				Gate Permanently Sealed ??
~~59.7~~	~~346.0~~		Pump Plant No.8	73+31.4	B1	15-A	Service Opening	1				Permanently Sealed November 2003
~~57.7~~	~~344.0~~		200 Norton	79+27	B1	16-A	Service Opening	1				Permanently Sealed December 2003
~~56.2~~	~~342.5~~		Oaks Rd. Levee	104+96.2	C	1	2 – Trusses	1				Permanently Sealed September 2004



Potential Flood Inundation Area (Shaded Area Approximates Flood Boundary Caused By the 1937 Flood)

OHIO RIVER SHORELINE, PADUCAH, KENTUCKY LFPP RECONSTRUCTION FEASIBILITY REPORT VOLUME 4 APPENDIX C

SECTION 2 GEOTECHNICAL CALCULATIONS

April 2011
Final Submittal

Paducah LFPP Station 7+60 B (Slope/W and Seep/W Parameters)

Embankment Clay

Used sample function "silty clay"

Symbol	Variable	Units	Value	Justification/Reference
w ɣ	Unit Weight Water	lb/cu. ft	62.4	Assumed
c	Cohesion - Drained/Undrained	lb/sq. ft	200/1000	NAVFAC 7.2-39 "CL", Paducah Phase II I-wall investigation report
Φ	Friction Angle - Drained/Undrained	degree °	26/0	Paducah Phase II I-wall investigation report
w_{sat}	Moisture Content Saturated	decimal %	0.22	Assumed
LL	Liquid Limit	decimal %	<0.3	Assumed from PI less than 50
w	Moisture Content Residual	decimal %	0.18	NAVFAC 7.2-39 "CL-ML"
ɣ	Unit Wieght Residual	lb/cu. ft	125	Paducah Phase II I-wall investigation report
K	Coefficient of Permeability	ft/sec	1.60E-08	Paducah Phase II I-wall investigation report

Foundation Clay

Symbol	Variable	Units	Value	Justification/Reference
w ɣ	Unit Weight Water	lb/cu. ft	62.4	Assumed
Gs	Specific Gravity		2.7	Paducah Certification Drilling by Florence and Hutchenson, AD-6 and AD-6A
e	Void Ratio		1	NAVFAC 7.1-22 "clay soils"
c	Cohesion - Drained/Undrained	lb/sq. ft	285/670	Paducah Certification Drilling by Florence and Hutchenson, AD-6 and AD-6A
Φ	Friction Angle - Drained/Undrained	degree °	27/14	Paducah Certification Drilling by Florence and Hutchenson, AD-6 and AD-6A
D_{60}	grain size @D60	mm	0.0167	Paducah Certification Drilling by Florence and Hutchenson, AD-6 and AD-6A, average
D_{10}	grain size @D10	mm	0.0006	Paducah Certification Drilling by Florence and Hutchenson, AD-6 and AD-6A
w_{sat}	Moisture Content Saturated	decimal %	0.37	equation "wsat=e/Gs" DAS Principles of Foundation Engineering 6th Edition
LL	Liquid Limit	decimal %	0.31	Paducah Certification Drilling by Florence and Hutchenson, AD-6 and AD-6A
w	Moisture Content Residual	decimal %	0.28	Paducah Certification Drilling by Florence and Hutchenson, AD-6 and AD-6A
ɣ	Unit Wieght Residual	lb/cu. ft	127	Paducah Certification Drilling by Florence and Hutchenson, AD-6 and AD-6A
K	Coefficient of Permeability	ft/sec	5.50E-09	Paducah Certification Drilling by Florence and Hutchenson, AD-6A

Debris

Used sample function "sand"

Symbol	Variable	Units	Value	Justification/Reference
w ɣ	Unit Weight Water	lb/cu. ft	62.4	Assumed
Gs	Specific Gravity		2.70	Paducah Certification Drilling by Florence and Hutchenson, AD-6 and AD-6A
e	Void Ratio		0.7	NAVFAC 7.1-22 "well-graded gravel, sand silt and clay mix"
c	Cohesion - Drained/Undrained	lb/sq. ft	0/0	NAVFAC 7.2-39 "SP"
Φ	Friction Angle - Drained/Undrained	degree °	27/27	EM 1110-2-2504 Figure 3-1 "SW" to "GP" minimal relative density
D_{60}	grain size @D60	mm		
D_{10}	grain size @D10	mm		
w_{sat}	Moisture Content Saturated	decimal %	0.26	equation "wsat=e/Gs" DAS Principles of Foundation Engineering 6th Edition
LL	Liquid Limit	decimal %		
w	Moisture Content Residual	decimal %	0.20	Paducah Certification Drilling by Florence and Hutchenson, AD-6 and AD-6A
ɣ	Unit Wieght Residual	lb/cu. ft	120	NAVFAC 7.2-39 "SC"
K	Coefficient of Permeability	ft/sec	9.00E-05	EM 1110-2-1913 Table C-1b K_{min} Silty Sand Converted

Paducah LFPP Station 67+17 A (Slope/W and Seep/W Parameters)

Embankment Clay

Used sample function "silty clay"

Symbol	Variable	Units	Value	Justification/Reference
w ɣ	Unit Weight Water	lb/cu. ft	62.4	Assumed
c	Cohesion - Drained/Undrained	lb/sq. ft	200/1000	NAVFAC 7.2-39 "CL", Paducah Phase II I-wall investigation report
Φ	Friction Angle - Drained/Undrained	degree °	26/0	Paducah Phase II I-wall investigation report
w_{sat}	Moisture Content Saturated	decimal %	0.22	Assumed
LL	Liquid Limit	decimal %	<0.3	Assumed from PI less than 50
w	Moisture Content Residual	decimal %	0.18	NAVFAC 7.2-39 "CL-ML"
ɣ	Unit Wieght Residual	lb/cu. ft	125	Paducah Phase II I-wall investigation report
K	Coefficient of Permeability	ft/sec	1.60E-08	Paducah Phase II I-wall investigation report

Clay and silt

Symbol	Variable	Units	Value	Justification/Reference
w ɣ	Unit Weight Water	lb/cu. ft	62.4	Assumed
Gs	Specific Gravity		2.7	Paducah Certification Drilling by Florence and Hutchenson, AD-2
c	Cohesion - Drained/Undrained	lb/sq. ft	225/250	Paducah Certification Drilling by Florence and Hutchenson, AD-3A
Φ	Friction Angle - Drained/Undrained	degree °	28/0	Paducah Phase II I-wall investigation report
D_{60}	grain size @D60	mm	0.01	Paducah Certification Drilling by Florence and Hutchenson, AD-2
D_{10}	grain size @D10	mm	0.001	Paducah Certification Drilling by Florence and Hutchenson, AD-2
w_{sat}	Moisture Content Saturated	decimal %	0.25	Paducah Certification Drilling by Florence and Hutchenson, AD-2
LL	Liquid Limit	decimal %	0.4	Paducah Certification Drilling by Florence and Hutchenson, AD-2
w	Moisture Content Residual	decimal %	0.23	Paducah Certification Drilling by Florence and Hutchenson, AD-2
ɣ	Unit Wieght Residual	lb/cu. ft	125	Paducah Certification Drilling by Florence and Hutchenson, AD-2
K	Coefficient of Permeability	ft/sec	1.20E-10	Paducah Certification Drilling by Florence and Hutchenson, AD-1

gravels

Used sample function "gravel"

Symbol	Variable	Units	Value	Justification/Reference
w ɣ	Unit Weight Water	lb/cu. ft	62.4	Assumed
Gs	Specific Gravity		2.70	Assumed
e	Void Ratio		0.34	EM 1110-2-2504 Figure 3-1 "GW"
c	Cohesion - Drained/Undrained	lb/sq. ft	0/0	NAVFAC 7.2-39 "GW"
Φ	Friction Angle - Drained/Undrained	degree °	35/35	EM 1110-2-2504 Figure 3-1 "GW"
w_{sat}	Moisture Content Saturated	decimal %	0.13	equation "wsat=e/Gs" DAS Principles of Foundation Engineering 6th Edition
LL	Liquid Limit	decimal %	NP	Assumed
w	Moisture Content Residual	decimal %	0.11	NAVFAC 7.2-39 "SC"
ɣ	Unit Wieght Residual	lb/cu. ft	125	NAVFAC 7.2-39 "GW"
K	Coefficient of Permeability	ft/sec	8.00E-04	NAVFAC 7.2-39 "GW"

Paducah LFPP Station 87+43B (Slope/W and Seep/W Parameters)

Embankment Clay

Used sample function "silty clay"

Symbol	Variable	Units	Value	Justification/Reference
w ɣ	Unit Weight Water	lb/cu. ft	62.4	Assumed
c	Cohesion - Drained/Undrained	lb/sq. ft	200/1000	NAVFAC 7.2-39 "CL", Paducah Phase II I-wall investigation report
Φ	Friction Angle - Drained/Undrained	degree °	26/0	Paducah Phase II I-wall investigation report
w_{sat}	Moisture Content Saturated	decimal %	0.22	Assumed
LL	Liquid Limit	decimal %	<0.3	Assumed from PI less than 50
w	Moisture Content Residual	decimal %	0.18	NAVFAC 7.2-39 "CL-ML"
ɣ	Unit Wieght Residual	lb/cu. ft	125	Paducah Phase II I-wall investigation report
K	Coefficient of Permeability	ft/sec	1.60E-08	Paducah Phase II I-wall investigation report

Foundation Clay

Symbol	Variable	Units	Value	Justification/Reference
w ɣ	Unit Weight Water	lb/cu. ft	62.4	Assumed
Gs	Specific Gravity		2.73	Paducah Certification Drilling by Florence and Hutchenson, AD-3 and AD-3A, average
e	Void Ratio		1	NAVFAC 7.1-22 "clay soils"
c	Cohesion - Drained/Undrained	lb/sq. ft	225/250	Paducah Certification Drilling by Florence and Hutchenson, AD-3A
Φ	Friction Angle - Drained/Undrained	degree °	28/21	Paducah Certification Drilling by Florence and Hutchenson, AD-3A
D_{60}	grain size @D60	mm	0.011	Paducah Certification Drilling by Florence and Hutchenson, AD-3 and AD-3A, average
D_{10}	grain size @D10	mm	0.0005	Paducah Certification Drilling by Florence and Hutchenson, AD-3 and AD-3A, average
w_{sat}	Moisture Content Saturated	decimal %	0.37	equation "wsat=e/Gs" DAS Principles of Foundation Engineering 6th Edition
LL	Liquid Limit	decimal %	0.35	Paducah Certification Drilling by Florence and Hutchenson, AD-3 and AD-3A, average
w	Moisture Content Residual	decimal %	0.26	Paducah Certification Drilling by Florence and Hutchenson, AD-3 and AD-3A.
ɣ	Unit Wieght Residual	lb/cu. ft	130	Paducah Certification Drilling by Florence and Hutchenson, AD-3 and AD-3A, average
K	Coefficient of Permeability	ft/sec	8.10E-10	Paducah Certification Drilling by Florence and Hutchenson, AD-3 and AD-3A, average

Exit Gradient of "5.0" this needs a transiant analysis

Paducah LFPP Station 156+25 A (Slope/W and Seep/W Parameters)

Embankment Clay — Used sample function "silty clay"

Symbol	Variable	Units	Value	Justification/Reference
w ɣ	Unit Weight Water	lb/cu. ft	62.4	Assumed
c	Cohesion - Drained/Undrained	lb/sq. ft	200/1000	NAVFAC 7.2-39 "CL", Paducah Phase II I-wall investigation report
Φ	Friction Angle - Drained/Undrained	degree °	26/0	Paducah Phase II I-wall investigation report
w_{sat}	Moisture Content Saturated	decimal %	0.22	Assumed
LL	Liquid Limit	decimal %	<0.3	Assumed from PI less than 50
w	Moisture Content Residual	decimal %	0.18	NAVFAC 7.2-39 "CL-ML"
ɣ	Unit Wieght Residual	lb/cu. ft	125	Paducah Phase II I-wall investigation report
K	Coefficient of Permeability	ft/sec	1.60E-08	Paducah Phase II I-wall investigation report

Clay and silt

Symbol	Variable	Units	Value	Justification/Reference
w ɣ	Unit Weight Water	lb/cu. ft	62.4	Assumed
Gs	Specific Gravity		2.7	Paducah Certification Drilling by Florence and Hutchenson, AD-2
c	Cohesion - Drained/Undrained	lb/sq. ft	225/250	Paducah Certification Drilling by Florence and Hutchenson, AD-3A
Φ	Friction Angle - Drained/Undrained	degree °	28/0	Paducah Phase II I-wall investigation report
D_{60}	grain size @D60	mm	0.01	Paducah Certification Drilling by Florence and Hutchenson, AD-2
D_{10}	grain size @D10	mm	0.001	Paducah Certification Drilling by Florence and Hutchenson, AD-2
w_{sat}	Moisture Content Saturated	decimal %	0.25	Paducah Certification Drilling by Florence and Hutchenson, AD-2
LL	Liquid Limit	decimal %	0.4	Paducah Certification Drilling by Florence and Hutchenson, AD-2
w	Moisture Content Residual	decimal %	0.23	Paducah Certification Drilling by Florence and Hutchenson, AD-2
ɣ	Unit Wieght Residual	lb/cu. ft	125	Paducah Certification Drilling by Florence and Hutchenson, AD-2
K	Coefficient of Permeability	ft/sec	1.20E-10	Paducah Certification Drilling by Florence and Hutchenson, AD-1

Paducah LFPP Station 175+12 B (Slope/W and Seep/W Parameters)

Embankment Clay — **Used sample function "silty clay"**

Symbol	Variable	Units	Value	Justification/Reference
w γ	Unit Weight Water	lb/cu. ft	62.4	Assumed
c	Cohesion - Drained/Undrained	lb/sq. ft	200/1000	NAVFAC 7.2-39 "CL", Paducah Phase III I-wall investigation report
φ	Friction Angle - Drained/Undrained	degree °	26/0	Paducah Phase III I-wall investigation report
θ_{sat}	Moisture Content Saturated	decimal %	0.22	Assumed
LL	Liquid Limit	decimal %	<0.3	Assumed from PI less than 50
w	Moisture Content Residual	decimal %	0.18	NAVFAC 7.2-39 "CL-ML"
γ	Unit Weight Residual	lb/cu. ft	125	Paducah Phase III I-wall investigation report
K	Coefficient of Permeability	ft/sec	1.60E-08	Paducah Phase III I-wall investigation report

Debris — **Used sample function "sand"**

Symbol	Variable	Units	Value	Justification/Reference
w γ	Unit Weight Water	lb/cu. ft	62.4	Assumed
Gs	Specific Gravity		2.70	Assumed
e	Void Ratio		0.55	EM 1110-2-2504 Figure 3-1 "SW" to "GP" minimal relative density
c	Cohesion - Drained/Undrained	lb/sq. ft	0/0	NAVFAC 7.2-39 "SP"
φ	Friction Angle - Drained/Undrained	degree °	27/27	EM 1110-2-2504 Figure 3-1 "SW" to "GP" minimal relative density
D_{60}	grain size @D60	mm		
D_{10}	grain size @D10	mm		
θ_{sat}	Moisture Content Saturated	decimal %	0.20	equation "wsat=e/Gs" DAS Principles of Foundation Engineering 6th Edition
LL	Liquid Limit	decimal %		
w	Moisture Content Residual	decimal %	0.15	NAVFAC 7.2-39 "SP"
γ	Unit Weight Residual	lb/cu. ft	120	NAVFAC 7.2-39 "SP"
K	Coefficient of Permeability	ft/sec	9.00E-06	NAVFAC 7.2-39 "SP-SM"

Foundation Clay

Symbol	Variable	Units	Value	Justification/Reference
w γ	Unit Weight Water	lb/cu. ft	62.4	Assumed
Gs	Specific Gravity		2.7	Paducah Certification Drilling by Florence and Hutcherson, AD-2
c	Cohesion - Drained/Undrained	lb/sq. ft	225/250	Paducah Certification Drilling by Florence and Hutcherson, AD-3A
φ	Friction Angle - Drained/Undrained	degree °	26/0	Paducah Phase III I-wall investigation report
D_{60}	grain size @D60	mm	0.01	Paducah Certification Drilling by Florence and Hutcherson, AD-2
D_{10}	grain size @D10	mm	0.001	Paducah Certification Drilling by Florence and Hutcherson, AD-2
θ_{sat}	Moisture Content Saturated	decimal %	0.25	Paducah Certification Drilling by Florence and Hutcherson, AD-2
LL	Liquid Limit	decimal %	0.4	Paducah Certification Drilling by Florence and Hutcherson, AD-2
w	Moisture Content Residual	decimal %	0.23	Paducah Certification Drilling by Florence and Hutcherson, AD-2
γ	Unit Weight Residual	lb/cu. ft	125	Paducah Certification Drilling by Florence and Hutcherson, AD-2
K	Coefficient of Permeability	ft/sec	1.20E-10	Paducah Certification Drilling by Florence and Hutcherson, AD-2

clayey gravel and sand

Symbol	Variable	Units	Value	Justification/Reference
w γ	Unit Weight Water	lb/cu. ft	62.4	Assumed
Gs	Specific Gravity		2.68	Paducah Certification Drilling by Florence and Hutcherson, AD-1
e	Void Ratio		0.5	NAVFAC 7.1-22 "well-graded gravel, sand silt and clay mix"
c	Cohesion - Drained/Undrained	lb/sq. ft	0/0	NAVFAC 7.2-39 "SC"
φ	Friction Angle - Drained/Undrained	degree °	31/31	NAVFAC 7.2-39 "SC"
D_{60}	grain size @D60	mm	3.35	Paducah Certification Drilling by Florence and Hutcherson, AD-1
D_{10}	grain size @D10	mm	0.001	Paducah Certification Drilling by Florence and Hutcherson, AD-1
θ_{sat}	Moisture Content Saturated	decimal %	0.19	equation "wsat=e/Gs" DAS Principles of Foundation Engineering 6th Edition
LL	Liquid Limit	decimal %	0.31	Paducah Certification Drilling by Florence and Hutcherson, AD-1 & AD-2
w	Moisture Content Residual	decimal %	0.15	Paducah Certification Drilling by Florence and Hutcherson, AD-2
γ	Unit Weight Residual	lb/cu. ft	125	Paducah Certification Drilling by Florence and Hutcherson, AD-1
K	Coefficient of Permeability	ft/sec	1.60E-09	NAVFAC 7.2-39 "SC"

Paducah LFPP Station 177+05 C* (Slope/W and Seep/W Parameters)

*after equation station

Embankment Clay

Used sample function "silty clay"

Symbol	Variable	Units	Value	Justification/Reference
w γ	Unit Weight Water	lb/cu. ft	62.4	Assumed
c	Cohesion - Drained/Undrained	lb/sq. ft	200/1000	NAVFAC 7.2-39 "CL", Paducah Phase II I-wall investigation report
Φ	Friction Angle - Drained/Undrained	degree °	26/0	Paducah Phase II I-wall investigation report
w_{Sat}	Moisture Content Saturated	decimal %	0.22	Assumed
LL	Liquid Limit	decimal %	<0.3	Assumed from PI less than 50
w	Moisture Content Residual	decimal %	0.18	NAVFAC 7.2-39 "CL-ML"
γ	Unit Wieght Residual	lb/cu. ft	125	Paducah Phase II I-wall investigation report
K	Coefficient of Permeability	ft/sec	1.60E-08	Paducah Phase II I-wall investigation report

Clay and silt

Symbol	Variable	Units	Value	Justification/Reference
w γ	Unit Weight Water	lb/cu. ft	62.4	Assumed
Gs	Specific Gravity		2.7	Paducah Certification Drilling by Florence and Hutchenson, AD-2
c	Cohesion - Drained/Undrained	lb/sq. ft	225/250	Paducah Certification Drilling by Florence and Hutchenson, AD-3A
Φ	Friction Angle - Drained/Undrained	degree °	28/10	Paducah Phase II I-wall investigation report
D_{60}	grain size @D60	mm	0.01	Paducah Certification Drilling by Florence and Hutchenson, AD-2
D_{10}	grain size @D10	mm	0.001	Paducah Certification Drilling by Florence and Hutchenson, AD-2
w_{Sat}	Moisture Content Saturated	decimal %	0.26	Paducah Certification Drilling by Florence and Hutchenson, AD-6A
LL	Liquid Limit	decimal %	0.3	Paducah Certification Drilling by Florence and Hutchenson, AD-6
w	Moisture Content Residual	decimal %	0.23	Paducah Certification Drilling by Florence and Hutchenson, AD-2
γ	Unit Wieght Residual	lb/cu. ft	125	Paducah Certification Drilling by Florence and Hutchenson, AD-2
K	Coefficient of Permeability	ft/sec	5.50E-09	Paducah Certification Drilling by Florence and Hutchenson, AD-6A

Silty Mud

Used sample function "silty clay"

Symbol	Variable	Units	Value	Justification/Reference
w γ	Unit Weight Water	lb/cu. ft	62.4	Assumed
Gs	Specific Gravity		2.65	Assumed
e	Void Ratio		1	EM 1110-2-2504 Figure 3-1 "ML" minimal relative density
c	Cohesion - Drained/Undrained	lb/sq. ft	100/200	NAVFAC 7.2-39 "ML"
Φ	Friction Angle - Drained/Undrained	degree °	27/10	EM 1110-2-2504 Figure 3-1 "ML" minimal relative density
D_{60}	grain size @D60	mm		
D_{10}	grain size @D10	mm		
w_{Sat}	Moisture Content Saturated	decimal %	0.38	equation "wsat=e/Gs" DAS Principles of Foundation Engineering 6th Edition
LL	Liquid Limit	decimal %		
w	Moisture Content Residual	decimal %	0.30	NAVFAC 7.2-39 "ML" and assumed based on w_{Sat}
γ	Unit Wieght Residual	lb/cu. ft	120	NAVFAC 7.2-39 "ML"
K	Coefficient of Permeability	ft/sec	1.00E-07	EM 1110-2-1913 Table C-1b K_{typ} Silt Converted and Kovacs and Holtz "Introduction to Geotechnical Engineering" 5th ed. fig 7

Toe Drain Sand

Used sample function "sand"

Symbol	Variable	Units	Value	Justification/Reference
w γ	Unit Weight Water	lb/cu. ft	62.4	Assumed
Gs	Specific Gravity		2.65	Assumed
e	Void Ratio		0.8	NAVFAC 7.1-22 "clean uniform sand"
c	Cohesion	lb/sq. ft	0	NAVFAC 7.2-39 "SP"
Φ	Friction Angle	degree °	37	NAVFAC 7.2-39 "SP"
D_{60}	grain size @D60	mm		
D_{10}	grain size @D10	mm		
w_{Sat}	Moisture Content Saturated	decimal %	0.30	equation "wsat=e/Gs" DAS Principles of Foundation Engineering 6th Edition
LL	Liquid Limit	decimal %		
w	Moisture Content Residual	decimal %	0.12	NAVFAC 7.2-39 "SP"
γ	Unit Wieght Residual	lb/cu. ft	110	NAVFAC 7.2-39 "SP"
K	Coefficient of Permeability	ft/sec	1.00E-03	NAVFAC 7.1-277 for "curve 6" gravel with a little sand

Slope Stability Rapid Draw Down

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File Information

Title: Paducah 156+25 A
Comments: Earthen Levee
Created By: Minges, George C LRL
Revision Number: 33
Last Edited By: Minges, George C LRL
Date: 11/8/2009
Time: 11:20:07 AM
File Name: Paducah 156+25 A F.gsz
Directory: S:\proj\112546\Others\FEASIBILITY FOLDER\Feasibility Writeup\BONNIE\ENGINEERING CALCULATIONS\FEASIBILITY GEOTECH CALC FILES\
Last Solved Date: 11/8/2009
Last Solved Time: 11:20:36 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Slope Stability Rapid Draw Down

Kind: SLOPE/W
Parent: Steady-State Seepage
Method: Spencer
Settings
- **Apply Phreatic Correction:** Yes
- **PWP Conditions Source:** Piezometric Line
- **Use Staged Rapid Drawdown:** Yes

SlipSurface
- **Direction of movement:** Left to Right
- **Use Passive Mode:** No
- **Slip Surface Option:** Auto-Search
- **Critical slip surfaces saved:** 1
- **Optimize Critical Slip Surface Location:** Yes
- **Tension Crack**

Tension Crack Option: (none)
FOS Distribution
FOS Calculation Option: Constant
Advanced
Number of Slices: 30
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 2000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

Materials

Embankment Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 200 psf
Phi: 26 °
Vol. WC. Function: Embankment Clay
Drawdown Total Cohesion: 1000 psf
Drawdown Total Phi: 0 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Clay and Silt

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 225 psf
Phi: 28 °
Vol. WC. Function: Clay and Silt
Drawdown Total Cohesion: 250 psf
Drawdown Total Phi: 0 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Clayey Gravel and Sand

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 31 °
Vol. WC. Function: Clayey Gravel and Sand

Slope Stability Rapid Draw Down

Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 31 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Slip Surface Limits

Left Coordinate: (0, 339.2011) ft
Right Coordinate: (428.1404, 328.001) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
	259	349.4
	428	349.4

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
	0	302
	428	302

Vol. Water Content Functions

Embankment Clay

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Mv: 4.79e-007 /psf
Porosity: 0.22
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.21999999)
Data Point: (0.018329807, 0.21999998)
Data Point: (0.033598183, 0.21999997)
Data Point: (0.061584821, 0.21999993)
Data Point: (0.11288379, 0.21999984)
Data Point: (0.20691381, 0.21999963)
Data Point: (0.37926902, 0.21999914)
Data Point: (0.6951928, 0.21999792)

Data Point: (1.274275, 0.21999489)
Data Point: (2.3357215, 0.21998722)
Data Point: (4.2813324, 0.21996761)
Data Point: (7.8475997, 0.21991719)
Data Point: (14.384499, 0.21978687)
Data Point: (26.366509, 0.21944947)
Data Point: (48.329302, 0.21857772)
Data Point: (88.586679, 0.21634893)
Data Point: (162.37767, 0.21082014)
Data Point: (297.63514, 0.19810028)
Data Point: (545.55948, 0.17327571)
Data Point: (1000, 0.13699113)

Estimation Properties
Vol. WC Estimation Method: Sample functions
Sample Material: Silty Clay
Saturated Water Content: 0.22 ft^3/ft^3
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum: 1000
Minimum: 0.01
Num. Points: 20

Clay and Silt

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Mv: 4.79e-007 /psf
Porosity: 0.30136034
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.25001108)
Data Point: (0.023357215, 0.25001108)
Data Point: (0.054555948, 0.25001108)
Data Point: (0.1274275, 0.25001108)
Data Point: (0.29763514, 0.25001108)
Data Point: (0.6951928, 0.25001108)
Data Point: (1.6237767, 0.25001108)
Data Point: (3.7926902, 0.25001108)
Data Point: (8.8586679, 0.25001108)
Data Point: (20.691381, 0.25001108)
Data Point: (48.329302, 0.25001108)
Data Point: (112.88379, 0.25001108)
Data Point: (263.66509, 0.25001108)
Data Point: (615.84821, 0.25001108)
Data Point: (1438.4499, 0.25001108)
Data Point: (3359.8183, 0.25001108)
Data Point: (7847.5997, 0.25001108)

Data Point: (22386.337, 0.24999713)
Data Point: (41676.621, 0.24961794)
Data Point: (100000, 0.24671383)
Estimation Properties
Vol. WC Estimation Method: Grain Size Function
Sample Material: Clay
Saturated Water Content: 0.25 ft^3/ft^3
Liquid Limit: 0.4 %
Diameter at 10% passing: 0.001
Diameter at 60% passing: 0.01
Maximum: 1e+005
Minimum: 0.01
Num. Points: 20

Clayey Gravel and Sand

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Mv: 4.79e-007 /psf
Porosity: 0.2015675
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.19079819)
Data Point: (0.023357215, 0.19079819)
Data Point: (0.054555948, 0.19079819)
Data Point: (0.1274275, 0.19079819)
Data Point: (0.29763514, 0.19079819)
Data Point: (0.6951928, 0.19079819)
Data Point: (1.6237767, 0.19079819)
Data Point: (3.7926902, 0.19079819)
Data Point: (8.8586679, 0.19079819)
Data Point: (20.691381, 0.19079819)
Data Point: (48.329302, 0.19079819)
Data Point: (112.88379, 0.19079819)
Data Point: (263.66509, 0.19079819)
Data Point: (615.84821, 0.19079819)
Data Point: (1438.4499, 0.19079819)
Data Point: (3359.8183, 0.19079819)
Data Point: (7053.0967, 0.19063688)
Data Point: (21364.961, 0.18949932)
Data Point: (42813.324, 0.18069069)
Data Point: (100000, 0.14428002)
Estimation Properties
Vol. WC Estimation Method: Grain Size Function
Sample Material: Clay
Saturated Water Content: 0.19 ft^3/ft^3
Liquid Limit: 0.31 %
Diameter at 10% passing: 0.001

Slope Stability Rapid Draw Down

Diameter at 60% passing: 3.35
Maximum: 1e+005
Minimum: 0.01
Num. Points: 20

Regions

	Material	Points	Area (ft²)
Region 1	Embankment Clay	6,7,8,9,23,10,18,11,20,22,21,19	1550.1716
Region 2	Clay and Silt	1,14,15,13,12,11,20,22,21,19,6,5,4,3,2	4858.5978
Region 3	Clayey Gravel and Sand	14,16,17,15	2996

Points

	X (ft)	Y (ft)
Point 1	0	339.2011
Point 2	29.1296	338.3419
Point 3	91.6863	326.041
Point 4	115.903	325.7188
Point 5	135.0478	329.2969
Point 6	177.4173	329.7749
Point 7	257.0184	348.8609
Point 8	260.4708	349.0436
Point 9	265.9396	348.834
Point 10	314.396	332.8219
Point 11	338.5169	328.774
Point 12	379.0807	328.269
Point 13	428.1404	328.001
Point 14	0	318.6
Point 15	428	318.6
Point 16	0	311.6
Point 17	428	311.6
Point 18	333	329.69983
Point 19	258	330
Point 20	266	330
Point 21	259	324
Point 22	265	324
Point 23	282	343.52695

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	1.231	(300.633, 375.198)	38.6031	(253.313, 347.973)	(330.259, 330.16)
2	626	1.282	(300.633, 375.198)	55.012	(252.888, 347.87)	(331.841, 329.894)

Slices of Slip Surface: Optimized

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)

Slope Stability Rapid Draw Down

1	Optimized	255.1657	345.0946	-2689.1326	25.862888	0	316.84
2	Optimized	257.1431	342.023	-2497.4802	94.970226	0	616.19
3	Optimized	258.1339	340.9552	-2430.8166	312.9335	0	854.99
4	Optimized	259.7354	339.33885	-2329.9317	524.7706	0	843.04
5	Optimized	261.93765	337.1162	-2191.2559	787.23892	0	843.86
6	Optimized	264.67205	334.1811	-2008.0924	1024.272	0	848.16
7	Optimized	266.10685	332.5345	-1905.3497	1203.9153	0	851.99
8	Optimized	267.312	331.15145	-1819.049	1318.4133	0	854.68
9	Optimized	268.74675	329.5048	-1716.2697	1939.566	0	285.59
10	Optimized	270.25885	328.53435	-1655.7411	2208.4147	0	304.21
11	Optimized	272.48935	327.5044	-1591.4702	2243.7454	0	305.76
12	Optimized	274.7198	326.47445	-1527.1992	2279.0761	0	307.31
13	Optimized	277.3236	325.121	-1442.7631	2303.8439	0	307.07
14	Optimized	280.3008	323.44405	-1338.1095	2386.7825	0	310.65
15	Optimized	281.8947	322.57925	-1284.1591	2539.6656	0	322.02
16	Optimized	283.24865	322.24015	-1262.9941	2526.3766	0	321.42
17	Optimized	285.74595	321.6147	-1223.9565	2501.8664	0	320.31
18	Optimized	288.24325	320.98925	-1184.9188	2477.3951	0	319.21
19	Optimized	290.88535	320.47115	-1152.6083	2471.7767	0	320.61
20	Optimized	293.67225	320.0605	-1126.9783	2408.66	0	317.73
21	Optimized	296.6654	319.7704	-1108.8669	2356.5373	0	316.87
22	Optimized	299.86475	319.6008	-1098.2858	2245.8878	0	311.74
23	Optimized	302.9235	319.48455	-1091.0357	2145.4134	0	307.57
24	Optimized	305.8417	319.42165	-1087.1301	2032.7331	0	302.32
25	Optimized	308.89685	319.90015	-1116.9667	1962.8235	0	304.31
26	Optimized	312.08895	320.92	-1180.6186	1695.5632	0	291.21
27	Optimized	314.0405	321.55445	-	1540.5598	0	284.01

Slope Stability Rapid Draw Down

				1220.1972			
28	Optimized	315.47585	322.05735	-1251.5901	1436.6564	0	278.01
29	Optimized	317.6355	322.814	-1298.7853	1292.0119	0	270.79
30	Optimized	319.79515	323.57065	-1346.0242	1147.4111	0	263.54
31	Optimized	322.04795	324.72535	-1418.0578	1034.4752	0	261.14
32	Optimized	324.39385	326.27805	-1514.9576	775.12767	0	247.38
33	Optimized	326.99465	327.99955	-1622.3668	487.25607	0	231.62
34	Optimized	329.3405	329.5523	-1719.2727	260.7341	0	273.05

Slices of Slip Surface: 626

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	626	253.9203	346.2065	-2758.415	-82.366926	0	262.75
2	626	255.9857	343.1058	-2564.9938	-103.40456	0	747.36
3	626	258.0092	340.4536	-2399.4993	249.0402	0	854.95
4	626	259.7354	338.4203	-2272.6177	593.42014	0	841.38
5	626	261.838	336.241	-2136.6422	931.45917	0	843.95
6	626	264.5724	333.6917	-1977.5603	1310.5699	0	850.92
7	626	267.6463	331.2236	-1823.5434	1614.665	0	858.34
8	626	270.6177	329.1195	-1692.2561	2090.6406	0	297.63
9	626	273.1471	327.5659	-1595.3145	2197.6152	0	303.3
10	626	275.6765	326.19205	-1509.5708	2281.8478	0	308.01
11	626	278.2059	324.98315	-1434.1574	2345.2475	0	311.81
12	626	280.7353	323.9275	-1368.2767	2389.2505	0	314.74
13	626	283.34985	322.98985	-1309.7508	2415.2641	0	316.89
14	626	286.0495	322.17175	-1258.7222	2423.0482	0	318.23
15	626	288.74915	321.5018	-1216.9303	2411.9436	0	318.69
16	626	291.44885	320.97445	-1183.9897	2382.6976	0	318.28
17	626	294.1485	320.58555	-1159.739	2335.7361	0	317.01
				-			

Slope Stability Rapid Draw Down

18	626	296.84815	320.3322	1143.9417	2271.365	0	314.9
19	626	299.54785	320.21245	-1136.4377	2189.8443	0	311.92
20	626	302.2475	320.22545	-1137.2796	2091.2082	0	308.08
21	626	304.94715	320.3713	-1146.3756	1975.3598	0	303.35
22	626	307.64685	320.6511	-1163.8215	1842.099	0	297.7
23	626	310.3465	321.06695	-1189.7739	1691.0883	0	291.1
24	626	313.04615	321.62195	-1224.422	1521.8038	0	283.49
25	626	315.72675	322.3145	-1267.6366	1362.4429	0	275.44
26	626	318.3882	323.14825	-1319.6394	1213.0271	0	268.52
27	626	321.04965	324.1343	-1381.1787	1043.6378	0	260.45
28	626	323.7111	325.28165	-1452.7871	852.92159	0	251.06
29	626	326.37255	326.60175	-1535.154	639.06367	0	240.09
30	626	329.03405	328.1092	-1629.1989	399.5699	0	226.91
31	626	331.10305	329.40305	-1709.9776	224.70979	0	267.04

Slope Stability Rapid Draw Down

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File Information

Title: 175+12A
Comments: Earthen Levee
Created By: Minges, George C LRL
Revision Number: 45
Last Edited By: Minges, George C LRL
Date: 11/8/2009
Time: 11:42:41 AM
File Name: Paducah 175+12B F.gsz
Directory: S:\proj\112546\Others\FEASIBILITY FOLDER\Feasibility Writeup\BONNIE\ENGINEERING CALCULATIONS\FEASIBILITY GEOTECH CALC FILES\
Last Solved Date: 11/8/2009
Last Solved Time: 11:49:58 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Slope Stability Rapid Draw Down

Kind: SLOPE/W
Parent: Steady-State Seepage
Method: Spencer
Settings
- **Apply Phreatic Correction:** Yes
- **PWP Conditions Source:** Piezometric Line
- **Use Staged Rapid Drawdown:** Yes

SlipSurface
- **Direction of movement:** Left to Right
- **Use Passive Mode:** No
- **Slip Surface Option:** Auto-Search
- **Critical slip surfaces saved:** 1
- **Optimize Critical Slip Surface Location:** Yes
- **Tension Crack**

Tension Crack Option: (none)
FOS Distribution
FOS Calculation Option: Constant
Advanced
Number of Slices: 30
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 2000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

Materials

Embankment Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 200 psf
Phi: 26 °
Vol. WC. Function: embankment clay
Drawdown Total Cohesion: 1000 psf
Drawdown Total Phi: 0 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Debris

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 0 psf
Phi: 27 °
Vol. WC. Function: Debris
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 27 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Clay and Silt

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 225 psf
Phi: 28 °
Vol. WC. Function: clay and silt

Drawdown Total Cohesion: 250 psf
Drawdown Total Phi: 0 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Clayey Gravel and Sand

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 31 °
Vol. WC. Function: clayey gravel and sand
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 31 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Slip Surface Limits

Left Coordinate: (0, 335.125) ft
Right Coordinate: (574.1246, 337.6329) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
	279	350.2
	575	350.2

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
	0	302
	575	302

Vol. Water Content Functions

Debris

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %

Segment Curvature: 100 %
Mv: 4.79e-007 /psf
Porosity: 0.19999934
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.1, 0.19999929)
Data Point: (0.14384499, 0.19999859)
Data Point: (0.20691381, 0.19999718)
Data Point: (0.29763514, 0.19999432)
Data Point: (0.42813324, 0.19998852)
Data Point: (0.61584821, 0.19997673)
Data Point: (0.88586679, 0.19995275)
Data Point: (1.274275, 0.19990397)
Data Point: (1.8329807, 0.19980471)
Data Point: (2.6366509, 0.19960286)
Data Point: (3.7926902, 0.19919303)
Data Point: (5.4555948, 0.19836402)
Data Point: (7.8475997, 0.19670002)
Data Point: (11.288379, 0.19341173)
Data Point: (16.237767, 0.18711026)
Data Point: (23.357215, 0.17571597)
Data Point: (33.598183, 0.15711748)
Data Point: (48.329302, 0.13126)
Data Point: (69.51928, 0.10214438)
Data Point: (100, 0.075804198)
Estimation Properties
Vol. WC Estimation Method: Sample functions
Sample Material: Sand
Saturated Water Content: 0.2 ft^3/ft^3
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum: 100
Minimum: 0.1
Num. Points: 20

embankment clay

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Mv: 4.79e-007 /psf
Porosity: 0.22
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.21999999)
Data Point: (0.018329807, 0.21999998)
Data Point: (0.033598183, 0.21999997)
Data Point: (0.061584821, 0.21999993)
Data Point: (0.11288379, 0.21999984)

Data Point: (0.20691381, 0.21999963)
Data Point: (0.37926902, 0.21999914)
Data Point: (0.6951928, 0.21999792)
Data Point: (1.274275, 0.21999489)
Data Point: (2.3357215, 0.21998722)
Data Point: (4.2813324, 0.21996761)
Data Point: (7.8475997, 0.21991719)
Data Point: (14.384499, 0.21978687)
Data Point: (26.366509, 0.21944947)
Data Point: (48.329302, 0.21857772)
Data Point: (88.586679, 0.21634893)
Data Point: (162.37767, 0.21082014)
Data Point: (297.63514, 0.19810028)
Data Point: (545.55948, 0.17327571)
Data Point: (1000, 0.13699113)

Estimation Properties
Vol. WC Estimation Method: Sample functions
Sample Material: Silty Clay
Saturated Water Content: 0.22 ft^3/ft^3
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum: 1000
Minimum: 0.01
Num. Points: 20

clayey gravel and sand

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Mv: 4.79e-007 /psf
Porosity: 0.19342789
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.18997613)
Data Point: (0.023357215, 0.18997613)
Data Point: (0.054555948, 0.18997613)
Data Point: (0.1274275, 0.18997613)
Data Point: (0.29763514, 0.18997613)
Data Point: (0.6951928, 0.18997613)
Data Point: (1.6237767, 0.18997613)
Data Point: (3.7926902, 0.18997613)
Data Point: (8.8586679, 0.18997613)
Data Point: (20.691381, 0.18997613)
Data Point: (48.329302, 0.18997613)
Data Point: (112.88379, 0.18997613)
Data Point: (263.66509, 0.18997613)
Data Point: (615.84821, 0.18997613)

Data Point: (1438.4499, 0.18997613)
Data Point: (4769.8134, 0.18949932)
Data Point: (11131.953, 0.18790673)
Data Point: (21364.961, 0.18267395)
Data Point: (42813.324, 0.16246761)
Data Point: (100000, 0.14006886)

Estimation Properties
Vol. WC Estimation Method: Grain Size Function
Sample Material: Silty Sand
Saturated Water Content: 0.19 ft^3/ft^3
Liquid Limit: 31 %
Diameter at 10% passing: 0.001
Diameter at 60% passing: 3.35
Maximum: 1e+005
Minimum: 0.01
Num. Points: 20

clay and silt

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Mv: 4.79e-007 /psf
Porosity: 0.2513675
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.24989967)
Data Point: (0.01610262, 0.24989967)
Data Point: (0.025929438, 0.24989967)
Data Point: (0.041753189, 0.24989967)
Data Point: (0.067233575, 0.24989967)
Data Point: (0.10826367, 0.24989967)
Data Point: (0.17433288, 0.24989967)
Data Point: (0.28072162, 0.24989967)
Data Point: (0.45203537, 0.24989967)
Data Point: (0.72789538, 0.24989967)
Data Point: (1.1721023, 0.24989967)
Data Point: (1.8873918, 0.24989967)
Data Point: (3.0391954, 0.24989967)
Data Point: (4.8939009, 0.24989967)
Data Point: (7.8804628, 0.24989967)
Data Point: (12.68961, 0.24989967)
Data Point: (20.433597, 0.24989967)
Data Point: (32.903446, 0.24989967)
Data Point: (52.983169, 0.24989967)
Data Point: (85.316785, 0.24989967)
Data Point: (137.38238, 0.24989967)
Data Point: (221.22163, 0.24989967)
Data Point: (356.22479, 0.24989967)

Slope Stability Rapid Draw Down

Data Point: (573.61525, 0.24989967)
Data Point: (923.67086, 0.24989967)
Data Point: (1812.7854, 0.2498454)
Data Point: (3414.0428, 0.24965581)
Data Point: (5730.6727, 0.24887847)
Data Point: (7641.3555, 0.24785682)
Data Point: (10000, 0.24514068)

Estimation Properties

Vol. WC Estimation Method: Grain Size Function
Sample Material: Clay
Saturated Water Content: 0.25 ft^3/ft^3
Liquid Limit: 40 %
Diameter at 10% passing: 0.01
Diameter at 60% passing: 0.001
Maximum: 10000
Minimum: 0.01
Num. Points: 30

Regions

	Material	Points	Area (ft^2)
Region 1	Clayey Gravel and Sand	34,32,33,35	6601
Region 2	Clay and Silt	33,28,29,11,12,13,14,15,30,26,27,31,32	10195.515
Region 3	Debris	25,27,31,21,22,20,19	1640.9231
Region 4	Debris	26,24,23,30	314.47259
Region 5	Debris	29,28,1,2,3,4,5,6,7,8,9,10,36	364.52734
Region 6	Embankment Clay	23,16,17,37,18,19,25,27,26,24	664.18275

Points

	X (ft)	Y (ft)
Point 1	0	335.125
Point 2	47.1877	334.6991
Point 3	52.7608	335.8419
Point 4	59.8609	335.6637
Point 5	62.8973	334.23
Point 6	65.4775	334.2425
Point 7	68.3984	335.378
Point 8	87.6283	335.665
Point 9	92.7868	334.9249
Point 10	105.1336	334.3675
Point 11	124.5526	327.4429
Point 12	136.5964	327.0624
Point 13	157.062	325.7087
Point 14	177.9576	326.025
Point 15	194.9604	325.3005
Point 16	280.1259	350.082
Point 17	288.2718	350.0541

Point 18	323.9674	339.1601
Point 19	334.8666	337.8629
Point 20	349.0074	337.4019
Point 21	574.1246	337.6329
Point 22	353.70395	337.06029
Point 23	236.89948	337.50396
Point 24	280.2	337.6
Point 25	288.2	337.7
Point 26	281.2	331.7
Point 27	287.2	331.7
Point 28	0	331.7
Point 29	113	331.7
Point 30	216.79302	331.70992
Point 31	574	331.7
Point 32	574	313.1
Point 33	0	313.1
Point 34	574	301.6
Point 35	0	301.6
Point 36	106.63124	333.83346
Point 37	304.85751	344.99228

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	1.350	(321.761, 379.253)	42.96937	(268.925, 346.823)	(359.831, 337.076)
2	716	1.600	(321.761, 379.253)	62.521	(268.401, 346.67)	(367.933, 337.097)

Slices of Slip Surface: Optimized

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	Optimized	270.23645	345.35485	-2705.2999	-6.1370934	0	287.61
2	Optimized	272.8591	342.41895	-2522.1523	33.903885	0	799.1
3	Optimized	275.48175	339.48305	-2338.954	426.90394	0	880.49
4	Optimized	276.95525	337.80415	-2234.2374	562.11992	0	889.5
5	Optimized	278.0587	336.36865	-2144.6127	994.04467	0	658.87
6	Optimized	279.3561	334.68085	-2039.2988	970.27563	0	944.03
7	Optimized	279.91905	333.98725	-1995.9751	1149.858	0	1011
8	Optimized	280.16295	333.71565	-1979.1008	1177.6863	0	1025.7
9	Optimized	280.6101	333.21775	-1948.0213	1228.5112	0	1050.8
10	Optimized	281.4966	332.23055	-1886.3823	1501.7154	0	877.95
11	Optimized	283.079	330.4684	-1776.427	2217.4074	0	268.73

Slope Stability Rapid Draw Down

12	Optimized	285.6925	327.42675	-1586.6382	2568.5497	0	277.13
13	Optimized	287.7	325.01635	-1436.2071	2846.6237	0	283.63
14	Optimized	288.2359	324.3729	-1396.0664	2910.4104	0	284.82
15	Optimized	289.6252	322.70475	-1291.9858	3062.928	0	288.57
16	Optimized	292.4569	320.0666	-1127.3657	3395.6563	0	300.29
17	Optimized	295.4135	318.0404	-1000.9249	3533.7592	0	303.87
18	Optimized	298.38595	316.45485	-901.97125	3689.8824	0	310.37
19	Optimized	301.37425	315.30995	-830.53603	3718.6315	0	311.14
20	Optimized	303.86295	314.5299	-781.84363	3764.188	0	313.89
21	Optimized	306.19915	314.0423	-751.45453	3736.1132	0	313.12
22	Optimized	308.8824	313.4823	-716.50486	3704.0091	0	312.25
23	Optimized	311.9333	313.18805	-698.13536	3674.2273	0	313.23
24	Optimized	315.3519	313.15955	-696.35105	3547.2776	0	309.71
25	Optimized	318.77045	313.1311	-694.59598	3420.328	0	306.18
26	Optimized	321.9142	313.3655	-709.2033	3315.1906	0	304.78
27	Optimized	323.65805	313.73795	-732.44953	3257.0484	0	305.06
28	Optimized	325.38415	314.4289	-775.57605	3136.4452	0	301.35
29	Optimized	328.2176	315.56315	-846.34807	2950.4393	0	295.92
30	Optimized	331.6505	317.2849	-953.77608	2721.4468	0	290.45
31	Optimized	334.26665	318.83535	-1050.5505	2504.9877	0	284.58
32	Optimized	336.46135	320.28335	-1140.8899	2305.1236	0	278.46
33	Optimized	339.65085	322.3877	-1272.1858	2024.5005	0	270.02
34	Optimized	343.07185	324.6379	-1412.5958	1723.6114	0	260.94
35	Optimized	346.72435	327.0339	-1562.1058	1404.057	0	251.29
36	Optimized	348.779	328.4032	-1647.5562	1239.7304	0	246.54
37	Optimized	351.07085	330.12215	-1754.8223	1001.0082	0	239.26
38	Optimized	353.15305	331.6849	-	793.2436	0	232.88

				1852.3281			
39	Optimized	353.4379	331.9148	-1866.7145	973.14209	0	580.88
40	Optimized	355.23585	333.36625	-1957.2556	736.23755	0	481.25
41	Optimized	358.29955	335.83955	-2111.594	338.36603	0	314.33

Slices of Slip Surface: 716

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	716	270.08755	344.1858	-2632.4514	-194.20761	0	616.18
2	716	273.45985	339.645	-2349.0713	393.00359	0	878.31
3	716	277.073	335.6154	-2097.5458	1170.3004	0	806.04
4	716	279.56295	333.12695	-1942.2979	1435.6058	0	1119.1
5	716	280.16295	332.5789	-1908.1439	1516.8435	0	1157.6
6	716	280.7	332.1104	-1878.9146	1585.1291	0	1188.2
7	716	282.7	330.47375	-1776.7679	2311.8251	0	269.69
8	716	285.7	328.2128	-1635.6726	2605.6911	0	277.37
9	716	287.7	326.82815	-1549.3098	2771.1649	0	281.38
10	716	288.2359	326.4805	-1527.5651	2801.7899	0	281.84
11	716	289.93035	325.47595	-1464.898	2871.0621	0	283.79
12	716	293.2475	323.6438	-1350.56	2986.7586	0	287.12
13	716	296.56465	322.06265	-1251.8994	3070.5041	0	289.64
14	716	299.8818	320.712	-1167.6382	3124.602	0	291.42
15	716	303.19895	319.5762	-1096.7482	3151.7836	0	292.5
16	716	306.45	318.65795	-1039.4553	3153.3421	0	292.91
17	716	309.635	317.9406	-994.67856	3131.8175	0	292.71
18	716	312.82	317.39545	-960.66509	3088.5468	0	291.93
19	716	316.00495	317.018	-937.13548	3024.0635	0	290.58
20	716	319.1899	316.8051	-923.83774	2938.7821	0	288.66
21	716	322.3749	316.75515	-920.71451	2832.9098	0	286.19
22	716	325.78395	316.88795	-929.01861	2738.4377	0	283.87

Slope Stability Rapid Draw Down

23	716	329.417	317.22935	-950.29909	2652.2433	0	281.9
24	716	333.05005	317.7872	-985.12899	2538.9629	0	279.19
25	716	336.6342	318.5539	-1032.9757	2419.6269	0	276.22
26	716	340.1694	319.53185	-1093.9831	2294.0665	0	273.13
27	716	343.7046	320.73955	-1169.3475	2139.9456	0	269.23
28	716	347.2398	322.19165	-1259.9694	1955.4179	0	264.45
29	716	351.3557	324.24425	-1388.0511	1684.2022	0	257.28
30	716	355.14535	326.41835	-1523.7191	1404.3917	0	249.61
31	716	358.02805	328.35615	-1644.6171	1172.6803	0	243.16
32	716	360.91075	330.5416	-1780.9877	910.30005	0	235.67
33	716	363.74725	332.9655	-1932.2498	779.63178	0	499.66
34	716	366.53755	335.66415	-2100.6415	382.25981	0	326.53

Slope Stability Rapid Draw Down

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File Information

Title: Paducah 177+05 C
Comments: earthen levee
Created By: Minges, George C LRL
Revision Number: 83
Last Edited By: Minges, George C LRL
Date: 11/8/2009
Time: 12:12:40 PM
File Name: Paducah 177+05c F.gsz
Directory: S:\proj\112546\Others\FEASIBILITY FOLDER\Feasibility Writeup\BONNIE\ENGINEERING CALCULATIONS\FEASIBILITY GEOTECH CALC FILES\
Last Solved Date: 11/8/2009
Last Solved Time: 12:13:02 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Slope Stability Rapid Draw Down

Kind: SLOPE/W
Parent: Steady-State Seepage
Method: Spencer
Settings
- **Apply Phreatic Correction:** Yes
- **PWP Conditions Source:** Piezometric Line
- **Use Staged Rapid Drawdown:** Yes

SlipSurface
- **Direction of movement:** Left to Right
- **Use Passive Mode:** No
- **Slip Surface Option:** Auto-Search
- **Critical slip surfaces saved:** 1
- **Optimize Critical Slip Surface Location:** Yes
- **Tension Crack**

Tension Crack Option: (none)
FOS Distribution
FOS Calculation Option: Constant
Advanced
Number of Slices: 30
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 2000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

Materials

Embankment Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 200 psf
Phi: 26 °
Vol. WC. Function: embankment clay
Drawdown Total Cohesion: 1000 psf
Drawdown Total Phi: 0 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Clay and Silt

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 225 psf
Phi: 28 °
Vol. WC. Function: clay and silt
Drawdown Total Cohesion: 250 psf
Drawdown Total Phi: 10 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Silty Mud

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 100 psf
Phi: 27 °
Vol. WC. Function: Silty Mud

Slope Stability Rapid Draw Down

Drawdown Total Cohesion: 200 psf
Drawdown Total Phi: 10 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Slip Surface Limits

Left Coordinate: (0, 329.44) ft
Right Coordinate: (261.8367, 327.54) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
	93	350.2
	265	350.2

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
	0	325
	260	325

Vol. Water Content Functions

embankment clay

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Mv: 4.79e-007 /psf
Porosity: 0.22
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.21999999)
Data Point: (0.020691381, 0.21999998)
Data Point: (0.042813324, 0.21999995)
Data Point: (0.088586679, 0.21999988)
Data Point: (0.18329807, 0.21999969)
Data Point: (0.37926902, 0.21999914)
Data Point: (0.78475997, 0.21999752)
Data Point: (1.6237767, 0.21999264)

Data Point: (3.3598183, 0.2199777)
Data Point: (6.951928, 0.2199314)
Data Point: (14.384499, 0.21978687)
Data Point: (29.763514, 0.2193343)
Data Point: (61.584821, 0.2179235)
Data Point: (127.4275, 0.21362613)
Data Point: (263.66509, 0.2014734)
Data Point: (545.55948, 0.17327571)
Data Point: (1128.8379, 0.12923352)
Data Point: (2335.7215, 0.087755139)
Data Point: (4832.9302, 0.060407646)
Data Point: (10000, 0.044010658)

Estimation Properties
Vol. WC Estimation Method: Sample functions
Sample Material: Silty Clay
Saturated Water Content: 0.22 ft^3/ft^3
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum: 10000
Minimum: 0.01
Num. Points: 20

clay and silt

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Mv: 4.79e-007 /psf
Porosity: 0.2601826
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.25998123)
Data Point: (0.020691381, 0.25998123)
Data Point: (0.042813324, 0.25998123)
Data Point: (0.088586679, 0.25998123)
Data Point: (0.18329807, 0.25998123)
Data Point: (0.37926902, 0.25998123)
Data Point: (0.78475997, 0.25998123)
Data Point: (1.6237767, 0.25998123)
Data Point: (3.3598183, 0.25998123)
Data Point: (6.951928, 0.25998123)
Data Point: (14.384499, 0.25998123)
Data Point: (29.763514, 0.25998123)
Data Point: (61.584821, 0.25998123)
Data Point: (127.4275, 0.25998123)
Data Point: (263.66509, 0.25998123)
Data Point: (545.55948, 0.25998123)
Data Point: (1151.9502, 0.2583442)

Data Point: (2335.7215, 0.24584199)
Data Point: (4832.9302, 0.21435066)
Data Point: (10000, 0.18619499)
Estimation Properties
Vol. WC Estimation Method: Grain Size Function
Sample Material: Clay
Saturated Water Content: 0.26 ft^3/ft^3
Liquid Limit: 30 %
Diameter at 10% passing: 0.01
Diameter at 60% passing: 0.001
Maximum: 10000
Minimum: 0.01
Num. Points: 20

Silty Mud

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Mv: 4.79e-007 /psf
Porosity: 0.37999999
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.37999999)
Data Point: (0.020691381, 0.37999997)
Data Point: (0.042813324, 0.37999992)
Data Point: (0.088586679, 0.3799998)
Data Point: (0.18329807, 0.37999947)
Data Point: (0.37926902, 0.37999851)
Data Point: (0.78475997, 0.37999571)
Data Point: (1.6237767, 0.37998729)
Data Point: (3.3598183, 0.37996148)
Data Point: (6.951928, 0.37988152)
Data Point: (14.384499, 0.37963187)
Data Point: (29.763514, 0.37885015)
Data Point: (61.584821, 0.37641332)
Data Point: (127.4275, 0.36899059)
Data Point: (263.66509, 0.34799952)
Data Point: (545.55948, 0.2992944)
Data Point: (1128.8379, 0.22322153)
Data Point: (2335.7215, 0.15157706)
Data Point: (4832.9302, 0.10434048)
Data Point: (10000, 0.07601841)
Estimation Properties
Vol. WC Estimation Method: Sample functions
Sample Material: Silty Clay
Saturated Water Content: 0.38 ft^3/ft^3
Liquid Limit: 0 %
Diameter at 10% passing: 0

Slope Stability Rapid Draw Down

Diameter at 60% passing: 0
Maximum: 10000
Minimum: 0.01
Num. Points: 20

Regions

	Material	Points	Area (ft²)
Region 1	Embankment Clay	5,27,6,7,8,25,26,9,13,16,15,14	1333.2343
Region 2	Silty Mud	21,19,17,18,20,22	2610
Region 3	Silty Mud	23,21,22,24	4489.2
Region 4	Clay and Silt	1,17,18,12,11,10,9,13,16,15,14,5,28,29,30,4,3,2	3534.0409
Region 5	Clay and Silt	30,29,28,5	16.401447

Points

	X (ft)	Y (ft)
Point 1	0	329.44
Point 2	2.6572	327.7818
Point 3	12.6443	327.7989
Point 4	14.7324	329.5039
Point 5	30.5158	330.8228
Point 6	93.2703	350.5922
Point 7	97.5013	350.874
Point 8	101.7313	350.6552
Point 9	162.9985	333.8041
Point 10	181.8955	332.5079
Point 11	214.0501	328.1119
Point 12	261.8367	327.54
Point 13	101.53514	332.42097
Point 14	93.47597	332.23961
Point 15	94.48622	326.23738
Point 16	100.52539	326.23738
Point 17	0	317.2
Point 18	261	317.2
Point 19	0	313.2
Point 20	261	313.2
Point 21	0	307.2
Point 22	261	307.2
Point 23	0	290
Point 24	261	290
Point 25	122.17126	345.03334
Point 26	129.49354	343.0194
Point 27	67	342.31633
Point 28	30.5	326
Point 29	27	326
Point 30	27	330.52901

Slope Stability Rapid Draw Down

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	1.476	(158.678, 379.599)	67.71483	(82.5272, 347.208)	(225.545, 327.974)
2	567	1.582	(158.678, 379.599)	82.226	(83.0328, 347.367)	(222.706, 328.008)

Slices of Slip Surface: Optimized

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	Optimized	83.987125	341.4684	-1027.663	552.3393	0	2.5944
2	Optimized	87.21226	333.9337	-557.47191	1161.135	0	910.08
3	Optimized	90.6985	330.3881	-336.21983	1783.0488	0	742.92
4	Optimized	92.70974	328.30425	-206.18261	1968.4254	0	803.82
5	Optimized	93.13515	327.81535	-175.67651	2215.2691	0	526.88
6	Optimized	93.373135	327.54185	-158.60943	2248.5548	0	531.52
7	Optimized	93.99209	326.83055	-114.22561	2326.7379	0	541.36
8	Optimized	95.04656	325.6187	-38.606498	2459.9419	0	558.14
9	Optimized	96.543105	323.8988	68.715563	2648.9796	0	581.95
10	Optimized	98.034895	322.1844	175.6909	2831.3034	0	604.08
11	Optimized	99.546945	320.75525	264.87376	3172.1195	0	638.99
12	Optimized	101.03025	319.51825	342.05801	3299.7231	0	652.96
13	Optimized	101.6332	319.0154	373.43726	3351.5467	0	658.64
14	Optimized	102.5588	318.24355	421.60274	3412.0708	0	662.48
15	Optimized	103.59825	317.37675	475.68527	3477.0535	0	666.92
16	Optimized	106.21145	315.19755	611.67997	3653.1287	0	630.7
17	Optimized	111.09955	311.6963	830.14268	4050.2325	0	670.65
18	Optimized	116.13955	308.65875	1019.6986	4224.7171	0	689.21
19	Optimized	120.432	306.407	1160.2069	4501.1281	0	716.01
20	Optimized	124.00185	304.9436	1251.5328	4550.8675	0	720.94
21	Optimized	127.66295	303.44275	1345.1684	4601.9185	0	725.99
22	Optimized	129.7353	302.5932	1398.1821	4630.9495	0	728.85
23	Optimized	132.7593	301.86495	1443.6295	4784.6949	0	742.16
24	Optimized	138.32365	300.60665	1522.1416	4745.6054	0	736.94
25	Optimized	144.5524	299.65485	1581.4831	4773.7709	0	736.68
26	Optimized	150.3331	299.4612	1593.6184	4741.9062	0	729.56
27	Optimized	155.0013	299.7192	1577.5126	4547.0538	0	707.44
28	Optimized	160.16695	300.3069	1540.8528	4392.0527	0	687.8
29	Optimized	163.7408	300.88585	1504.7177	4212.2256	0	666.39
30	Optimized	167.20735	301.66495	1456.1121	4155.2232	0	658.63
31	Optimized	172.6558	302.9826	1373.8889	3939.7196	0	634.79
32	Optimized	178.1042	304.30025	1291.6657	3724.2161	0	610.96
33	Optimized	181.36195	305.11135	1241.0338	3627.2213	0	599.54

Slope Stability Rapid Draw Down

34	Optimized	185.2888	306.2318	1171.1322	3418.3764	0	576.88
35	Optimized	191.41625	307.98015	1062.0336	3084.8268	0	539.96
36	Optimized	196.77625	309.86235	944.59496	2836.998	0	510.8
37	Optimized	202.02795	312.0664	807.0643	2451.9543	0	468.54
38	Optimized	208.0245	315.1842	612.50214	2027.1183	0	420.19
39	Optimized	212.72265	317.99385	437.19111	1583.6702	0	429.03
40	Optimized	214.3928	318.9926	374.85995	1416.2906	0	409.1
41	Optimized	218.30875	322.09875	181.03241	1056.5384	0	367.01
42	Optimized	223.71365	326.48715	-92.798176	403.98539	0	296.43

Slices of Slip Surface: 567

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	567	85.147675	343.10595	-1129.7819	183.15731	0	329.9
2	567	89.37733	335.5199	-656.44145	835.82277	0	835.6
3	567	92.24608	331.161	-384.44602	1624.2211	0	711.28
4	567	93.13515	329.9486	-308.79697	1975.3802	0	489.38
5	567	93.373135	329.63575	-289.27057	2017.9304	0	494.92
6	567	93.770065	329.12315	-257.28743	2082.6589	0	502.68
7	567	95.091625	327.4912	-155.45131	2058.0535	0	884.72
8	567	96.65758	325.6187	-38.60599	2532.3408	0	556.85
9	567	97.348685	324.8291	10.663937	2635.4874	0	569.33
10	567	99.01335	323.0625	120.89977	2851.2832	0	593.21
11	567	101.03025	320.97035	251.44993	3107.1098	0	621.19
12	567	101.6332	320.37945	288.32149	3179.801	0	629.14
13	567	102.5588	319.5121	342.44609	3268.0088	0	636.02
14	567	104.2579	317.9696	438.70381	3418.5098	0	650.12
15	567	107.5575	315.2705	607.12476	3688.0838	0	624.08
16	567	112.41355	311.6869	830.7283	4000.3009	0	657.57
17	567	117.2696	308.6164	1022.3334	4254.2231	0	684.78
18	567	120.93445	306.56085	1150.5927	4415.6873	0	702.06
19	567	124.00185	305.07	1243.6284	4523.996	0	713.6
20	567	127.66295	303.4725	1343.3219	4631.7867	0	725.03
21	567	131.88675	301.90145	1441.3437	4723.6965	0	734.68
22	567	136.6732	300.4112	1534.3442	4792.8757	0	741.8
23	567	141.4596	299.2334	1607.828	4824.056	0	744.75
24	567	146.246	298.3544	1662.6746	4818.7392	0	743.65
25	567	151.03245	297.7646	1699.4888	4777.1406	0	738.59
26	567	155.8189	297.4577	1718.6357	4700.2478	0	729.61
27	567	160.6053	297.4305	1720.3319	4587.5517	0	716.7
28	567	165.36065	297.6793	1704.8102	4501.9548	0	705.43
29	567	170.0849	298.203	1672.1407	4445.1087	0	699.18

Slope Stability Rapid Draw Down

30	567	174.8091	299.0068	1621.9762	4353.7189	0	689.05
31	567	179.53335	300.09925	1553.7983	4225.9612	0	674.84
32	567	184.52275	301.5893	1460.8209	4024.2939	0	652.92
33	567	189.7773	303.53385	1339.4878	3739.6582	0	621.05
34	567	195.03185	305.904	1191.5892	3396.9578	0	582.7
35	567	200.0871	308.6164	1022.3334	3006.256	0	539
36	567	204.94315	311.6869	830.7283	2563.7325	0	489.51
37	567	209.7992	315.2705	607.12476	2043.3106	0	431.37
38	567	213.13865	318.0059	436.41777	1677.4898	0	449.06
39	567	217.1054	321.9059	193.07239	1133.5285	0	384.34
40	567	221.4333	326.50415	-93.859184	486.12084	0	310.06

Slope Stability Rapid Draw Down

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File Information

Created By: Ghack, Mabior T LRL
Revision Number: 47
Last Edited By: Minges, George C LRL
Date: 11/8/2009
Time: 11:24:34 AM
File Name: Paducah 67+17A F.gsz
Directory: S:\proj\112546\Others\FEASIBILITY FOLDER\Feasibility Writeup\BONNIE\ENGINEERING CALCULATIONS\FEASIBILITY GEOTECH CALC FILES\
Last Solved Date: 11/8/2009
Last Solved Time: 11:25:06 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Slope Stability Rapid Draw Down

Kind: SLOPE/W
Parent: Steady-State Seepage
Method: Spencer
Settings
- **Apply Phreatic Correction:** Yes
- **PWP Conditions Source:** Piezometric Line
- **Use Staged Rapid Drawdown:** Yes

SlipSurface
- **Direction of movement:** Left to Right
- **Use Passive Mode:** No
- **Slip Surface Option:** Auto-Search
- **Critical slip surfaces saved:** 1
- **Optimize Critical Slip Surface Location:** Yes
- **Tension Crack**
  - **Tension Crack Option:** (none)

FOS Distribution

FOS Calculation Option: Constant

Advanced

Number of Slices: 30
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 2000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

Materials

embankment fill

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 200 psf
Phi: 26 °
Vol. WC. Function: embankment fill
Drawdown Total Cohesion: 1000 psf
Drawdown Total Phi: 0 °
Pore Water Pressure

Piezometric Line: 1
Piezometric Line After Drawdown: 2

gravels

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 35 °
Vol. WC. Function: gravels
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 35 °
Pore Water Pressure

Piezometric Line: 1
Piezometric Line After Drawdown: 2

clay and silt

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 225 psf
Phi: 28 °
Vol. WC. Function: clay and silt
Drawdown Total Cohesion: 250 psf
Drawdown Total Phi: 0 °

Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

clayey gravel

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 31 °
Vol. WC. Function: clayey gravel
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 31 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Slip Surface Limits

Left Coordinate: (0, 334.8625) ft
Right Coordinate: (374.9917, 321.3737) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
	211	349.4
	375	349.4

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
	0	302
	375	302

Vol. Water Content Functions

embankment fill

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Mv: 4.79e-007 /psf

Porosity: 0.22
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.21999999)
Data Point: (0.018329807, 0.21999998)
Data Point: (0.033598183, 0.21999997)
Data Point: (0.061584821, 0.21999993)
Data Point: (0.11288379, 0.21999984)
Data Point: (0.20691381, 0.21999963)
Data Point: (0.37926902, 0.21999914)
Data Point: (0.6951928, 0.21999792)
Data Point: (1.274275, 0.21999489)
Data Point: (2.3357215, 0.21998722)
Data Point: (4.2813324, 0.21996761)
Data Point: (7.8475997, 0.21991719)
Data Point: (14.384499, 0.21978687)
Data Point: (26.366509, 0.21944947)
Data Point: (48.329302, 0.21857772)
Data Point: (88.586679, 0.21634893)
Data Point: (162.37767, 0.21082014)
Data Point: (297.63514, 0.19810028)
Data Point: (545.55948, 0.17327571)
Data Point: (1000, 0.13699113)
Estimation Properties
Vol. WC Estimation Method: Sample functions
Sample Material: Silty Clay
Saturated Water Content: 0.22 ft^3/ft^3
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum: 1000
Minimum: 0.01
Num. Points: 20

gravels

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Mv: 4.79e-007 /psf
Porosity: 0.12977884
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.13)
Data Point: (0.018329807, 0.12999999)
Data Point: (0.033598183, 0.12999999)
Data Point: (0.061584821, 0.12999998)
Data Point: (0.11288379, 0.12999996)
Data Point: (0.20691381, 0.12999993)
Data Point: (0.37926902, 0.12999986)

Data Point: (0.6951928, 0.12999975)
Data Point: (1.274275, 0.12999945)
Data Point: (2.3357215, 0.12999692)
Data Point: (4.2813324, 0.12994609)
Data Point: (7.8475997, 0.12879092)
Data Point: (14.384499, 0.1086857)
Data Point: (26.366509, 0.048675218)
Data Point: (48.329302, 0.025073057)
Data Point: (88.586679, 0.016822363)
Data Point: (162.37767, 0.012726241)
Data Point: (297.63514, 0.010268092)
Data Point: (545.55948, 0.0086222321)
Data Point: (1000, 0.0074377998)

Estimation Properties
Vol. WC Estimation Method: Sample functions
Sample Material: Gravel
Saturated Water Content: 0.13 ft^3/ft^3
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum: 1000
Minimum: 0.01
Num. Points: 20

clayey gravel

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Mv: 4.79e-007 /psf
Porosity: 0.19532101
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.18997613)
Data Point: (0.023357215, 0.18997613)
Data Point: (0.054555948, 0.18997613)
Data Point: (0.1274275, 0.18997613)
Data Point: (0.29763514, 0.18997613)
Data Point: (0.6951928, 0.18997613)
Data Point: (1.6237767, 0.18997613)
Data Point: (3.7926902, 0.18997613)
Data Point: (8.8586679, 0.18997613)
Data Point: (20.691381, 0.18997613)
Data Point: (48.329302, 0.18997613)
Data Point: (112.88379, 0.18997613)
Data Point: (263.66509, 0.18997613)
Data Point: (615.84821, 0.18997613)
Data Point: (1438.4499, 0.18997613)
Data Point: (3359.8183, 0.18997613)

Data Point: (10429.375, 0.18959155)
Data Point: (22804.218, 0.18312897)
Data Point: (42813.324, 0.16246761)
Data Point: (100000, 0.14006886)
Estimation Properties
Vol. WC Estimation Method: Grain Size Function
Sample Material: Silty Sand
Saturated Water Content: 0.19 ft^3/ft^3
Liquid Limit: 31 %
Diameter at 10% passing: 0.001
Diameter at 60% passing: 3.35
Maximum: 1e+005
Minimum: 0.01
Num. Points: 20

clay and silt

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Mv: 4.79e-007 /psf
Porosity: 0.25114936
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.24989967)
Data Point: (0.020691381, 0.24989967)
Data Point: (0.042813324, 0.24989967)
Data Point: (0.088586679, 0.24989967)
Data Point: (0.18329807, 0.24989967)
Data Point: (0.37926902, 0.24989967)
Data Point: (0.78475997, 0.24989967)
Data Point: (1.6237767, 0.24989967)
Data Point: (3.3598183, 0.24989967)
Data Point: (6.951928, 0.24989967)
Data Point: (14.384499, 0.24989967)
Data Point: (29.763514, 0.24989967)
Data Point: (61.584821, 0.24989967)
Data Point: (127.4275, 0.24989967)
Data Point: (263.66509, 0.24989967)
Data Point: (545.55948, 0.24989967)
Data Point: (1128.8379, 0.24989967)
Data Point: (2282.0137, 0.2498454)
Data Point: (5107.633, 0.24853936)
Data Point: (10000, 0.24514068)
Estimation Properties
Vol. WC Estimation Method: Grain Size Function
Sample Material: Clay
Saturated Water Content: 0.25 ft^3/ft^3
Liquid Limit: 40 %

Slope Stability Rapid Draw Down

Diameter at 10% passing: 0.01
Diameter at 60% passing: 0.001
Maximum: 10000
Minimum: 0.01
Num. Points: 20

Regions

	Material	Points	Area (ft²)
Region 1	embankment fill	14,26,13,12,11,10,9,8,7,16,18,19,17	2264.308
Region 2	gravels	1,2,3,4,5,6,7,16,18,24	2011.0898
Region 3	clayey gravel	20,22,23,21	4124.9087
Region 4	gravels	19,17,14,15,25	869.8555
Region 5	clay and silt	25,21,20,24,18,19	1124.9751

Points

	X (ft)	Y (ft)
Point 1	0	334.8625
Point 2	12.9496	334.8222
Point 3	51.8256	333.6227
Point 4	75.5322	325.9003
Point 5	92.5865	326.3688
Point 6	109.279	326.1716
Point 7	124.9974	326.2999
Point 8	141.2426	332.3327
Point 9	148.057	334.1276
Point 10	164.1967	335.7904
Point 11	205.5546	349.3855
Point 12	211.0685	349.9124
Point 13	216.8613	349.5456
Point 14	302.4014	324.8389
Point 15	374.9917	321.3737
Point 16	207	325.8
Point 17	215	325.8
Point 18	208	318.9
Point 19	214	318.9
Point 20	0	315.9
Point 21	374.9917	315.9
Point 22	0	304.9
Point 23	374.9917	304.9
Point 24	0	318.9
Point 25	374.9917	318.9
Point 26	239.52363	343

Critical Slip Surfaces

Slope Stability Rapid Draw Down

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	1.681	(277.527, 401.935)	51.90009	(209.196, 349.733)	(314.949, 324.24)
2	545	1.870	(277.527, 401.935)	85.953	(209.238, 349.738)	(314.349, 324.269)

Slices of Slip Surface: Optimized

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	Optimized	210.09795	348.44185	-2897.956	-5.384217	0	235.8
2	Optimized	211.03425	347.10115	-2814.2726	135.1008	0	244.58
3	Optimized	212.5167	344.97845	-2681.7591	316.54878	0	286.76
4	Optimized	215.4131	340.8311	-2422.9928	380.81532	0	836.32
5	Optimized	216.86515	338.7519	-2293.3181	586.99305	0	830.65
6	Optimized	217.1172	338.562	-2281.4459	961.13732	0	830.69
7	Optimized	218.83525	337.2855	-2201.8173	1048.1138	0	831.76
8	Optimized	221.7749	335.10125	-2065.5092	1196.6001	0	834.7
9	Optimized	225.1024	332.9807	-1933.1879	1447.8953	0	840.75
10	Optimized	228.8178	330.92385	-1804.8534	1560.2174	0	844.36
11	Optimized	232.63695	329.09765	-1690.891	1747.6334	0	850.28
12	Optimized	236.55985	327.5022	-1591.3379	1801.6603	0	852.3
13	Optimized	239.02245	326.44945	-1525.6282	1766.4888	0	851.39
14	Optimized	240.19045	325.85505	-1488.5338	1796.0639	0	852.49
15	Optimized	242.30175	324.7806	-1421.5155	1759.0784	0	1319.6
16	Optimized	245.8263	322.7591	-1295.3751	1759.7745	0	1349.9
17	Optimized	249.98655	320.18635	-1134.8306	1890.7369	0	1450.5
18	Optimized	252.2979	318.757	-1045.6378	2259.8047	0	323.77
19	Optimized	254.55395	317.9964	-998.18252	2435.5824	0	338.24
20	Optimized	258.60365	316.76115	-921.09039	2443.3766	0	338.66
21	Optimized	262.6759	316.03015	-875.47606	2534.2086	0	348.12
22	Optimized	266.7676	315.9148	-868.2702	2433.3823	0	343.44
23	Optimized	270.8562	315.91075	-868.02562	2285.5073	0	335.08
24	Optimized	274.9448	315.9067	-867.78104	2137.6568	0	326.71

Slope Stability Rapid Draw Down

25	Optimized	278.4971	315.9085	-867.88401	2010.3078	0	319.56
26	Optimized	281.51305	315.9161	-868.34821	1899.8619	0	313.29
27	Optimized	284.52895	315.9237	-868.84557	1789.3829	0	307.02
28	Optimized	287.5556	315.92485	-868.89243	1677.4026	0	300.58
29	Optimized	290.59295	315.9195	-868.56319	1567.865	0	294.34
30	Optimized	293.63025	315.91415	-868.23395	1458.3275	0	288.1
31	Optimized	297.21605	316.20115	-886.15239	1346.7868	0	284.2
32	Optimized	300.8423	317.0935	-941.82272	1187.0448	0	279.4
33	Optimized	304.0297	318.3256	-1018.7069	946.84433	0	262.25
34	Optimized	307.2065	319.83585	-1112.9594	919.30364	0	556.84
35	Optimized	310.30355	321.5975	-1222.8942	554.89398	0	341.09
36	Optimized	313.4006	323.3591	-1332.8008	190.48432	0	125.34

Slices of Slip Surface: 545

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	545	210.11925	348.62385	-2909.3249	11.147183	0	230.35
2	545	211.03425	347.4684	-2837.2219	140.26071	0	241.84
3	545	212.5167	345.7509	-2730.0643	303.43831	0	279.35
4	545	215.4131	342.56015	-2530.9691	417.08863	0	838.49
5	545	217.11335	340.79605	-2420.8073	619.35472	0	829.14
6	545	219.0953	338.94235	-2305.1132	788.6081	0	826.45
7	545	222.5551	335.8977	-2115.223	1061.7655	0	828.03
8	545	226.0149	333.16195	-1944.5041	1300.0683	0	833.09
9	545	229.47465	330.6993	-1790.8395	1507.7576	0	839.2
10	545	232.9344	328.4822	-1652.4964	1687.7038	0	845.37
11	545	236.3942	326.48885	-1528.1026	1842.0418	0	851.17
12	545	238.82385	325.1928	-1447.2172	1850.8098	0	1368.6
				-			

Slope Stability Rapid Draw Down

13	545	241.10335	324.10065	1379.0664	1928.5028	0	1417.6
14	545	244.26285	322.6982	-1291.5771	2026.1858	0	1477.5
15	545	247.4223	321.44415	-1213.321	2109.26	0	1526.4
16	545	250.58175	320.33165	-1143.8869	2177.6529	0	1564.4
17	545	253.74125	319.355	-1082.9656	2231.231	0	1591.6
18	545	257.02915	318.48045	-1028.3891	2326.7951	0	338.46
19	545	260.4455	317.7144	-980.56625	2322.8422	0	339.05
20	545	263.8619	317.0928	-941.79428	2300.7349	0	338.58
21	545	267.2783	316.6125	-911.814	2260.485	0	337.04
22	545	270.6947	316.27105	-890.51404	2202.184	0	334.43
23	545	274.1111	316.06685	-877.77845	2125.7143	0	330.73
24	545	277.52745	315.9989	-873.52618	2030.8906	0	325.93
25	545	280.9438	316.06685	-877.77845	1917.4423	0	320
26	545	284.3602	316.27105	-890.51404	1784.9671	0	312.9
27	545	287.7766	316.6125	-911.814	1632.9826	0	304.58
28	545	291.193	317.0928	-941.79428	1460.8359	0	295
29	545	294.6094	317.7144	-980.56625	1267.6907	0	284.07
30	545	298.02575	318.48045	-1028.3891	1052.6364	0	271.69
31	545	301.06765	319.27985	-1078.2629	928.74256	0	604.95
32	545	304.39275	320.31515	-1142.8608	710.58234	0	458.83
33	545	308.37545	321.73655	-1231.5665	468.81221	0	302.66
34	545	312.35815	323.3855	-1334.4534	171.50405	0	115.32

Slope Stability Rapid Draw Down

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File Information

Title: Paducah 7+60 B
Comments: T-Wall
Created By: Minges, George C LRL
Revision Number: 43
Last Edited By: Minges, George C LRL
Date: 11/8/2009
Time: 11:29:22 AM
File Name: Paducah 7+60B F.gsz
Directory: S:\proj\112546\Others\GEOTECH SEEP AND SLOPE\FEASIBILITY\
Last Solved Date: 11/8/2009
Last Solved Time: 11:30:16 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Slope Stability Rapid Draw Down

Kind: SLOPE/W
Parent: Steady-State Seepage
Method: Spencer
Settings
- Apply Phreatic Correction: Yes
- PWP Conditions Source: Piezometric Line
- Use Staged Rapid Drawdown: Yes

SlipSurface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Auto-Search
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: Yes
- Tension Crack
  - Tension Crack Option: (none)

FOS Distribution
FOS Calculation Option: Constant
Advanced
Number of Slices: 30
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 2000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

Materials

T-wall

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 2
Piezometric Line After Drawdown: 1

Foundation Clay

Model: Mohr-Coulomb
Unit Weight: 127 pcf
Cohesion: 285 psf
Phi: 27 °
Vol. WC. Function: Foundation Clay
Drawdown Total Cohesion: 670 psf
Drawdown Total Phi: 0 °
Pore Water Pressure
Piezometric Line: 2
Piezometric Line After Drawdown: 1

Debris

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 0 psf
Phi: 27 °
Vol. WC. Function: Debris
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 27 °
Pore Water Pressure
Piezometric Line: 2
Piezometric Line After Drawdown: 1

Embankment Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 200 psf
Phi: 26 °
Vol. WC. Function: Embankment Clay
Drawdown Total Cohesion: 1000 psf
Drawdown Total Phi: 0 °
Pore Water Pressure
Piezometric Line: 2
Piezometric Line After Drawdown: 1

existing retaining wall

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 2
Piezometric Line After Drawdown: 1

Slip Surface Limits

Left Coordinate: (0, 334.9629) ft
Right Coordinate: (359.2597, 312.6319) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
	0	302
	359	302

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
	191.8	350.2
	359	350.2

Vol. Water Content Functions

Embankment Clay

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %

Mv: 4.79e-007 /psf
Porosity: 0.22
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.21999999)
Data Point: (0.018329807, 0.21999998)
Data Point: (0.033598183, 0.21999997)
Data Point: (0.061584821, 0.21999993)
Data Point: (0.11288379, 0.21999984)
Data Point: (0.20691381, 0.21999963)
Data Point: (0.37926902, 0.21999914)
Data Point: (0.6951928, 0.21999792)
Data Point: (1.274275, 0.21999489)
Data Point: (2.3357215, 0.21998722)
Data Point: (4.2813324, 0.21996761)
Data Point: (7.8475997, 0.21991719)
Data Point: (14.384499, 0.21978687)
Data Point: (26.366509, 0.21944947)
Data Point: (48.329302, 0.21857772)
Data Point: (88.586679, 0.21634893)
Data Point: (162.37767, 0.21082014)
Data Point: (297.63514, 0.19810028)
Data Point: (545.55948, 0.17327571)
Data Point: (1000, 0.13699113)
Estimation Properties
Vol. WC Estimation Method: Sample functions
Sample Material: Silty Clay
Saturated Water Content: 0.22 ft^3/ft^3
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum: 1000
Minimum: 0.01
Num. Points: 20

Foundation Clay

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Mv: 4.79e-007 /psf
Porosity: 0.3704873
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.36966087)
Data Point: (0.023357215, 0.36966087)
Data Point: (0.054555948, 0.36966087)
Data Point: (0.1274275, 0.36966087)
Data Point: (0.29763514, 0.36966087)
Data Point: (0.6951928, 0.36966087)

Data Point: (1.6237767, 0.36966087)
Data Point: (3.7926902, 0.36966087)
Data Point: (8.8586679, 0.36966087)
Data Point: (20.691381, 0.36966087)
Data Point: (48.329302, 0.36966087)
Data Point: (112.88379, 0.36966087)
Data Point: (263.66509, 0.36966087)
Data Point: (602.85683, 0.36114733)
Data Point: (1438.4499, 0.2901812)
Data Point: (3359.8183, 0.21242878)
Data Point: (7847.5997, 0.17220763)
Data Point: (18329.807, 0.14645868)
Data Point: (42813.324, 0.12590906)
Data Point: (100000, 0.10784644)

Estimation Properties
Vol. WC Estimation Method: Grain Size Function
Sample Material: Clay
Saturated Water Content: 0.37 ft^3/ft^3
Liquid Limit: 31 %
Diameter at 10% passing: 0.0005
Diameter at 60% passing: 0.0006
Maximum: 1e+005
Minimum: 0.01
Num. Points: 20

Debris

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Mv: 4.79e-007 /psf
Porosity: 0.25999999
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.25999998)
Data Point: (0.018329807, 0.25999996)
Data Point: (0.033598183, 0.25999988)
Data Point: (0.061584821, 0.25999963)
Data Point: (0.11288379, 0.25999885)
Data Point: (0.20691381, 0.25999634)
Data Point: (0.37926902, 0.2599882)
Data Point: (0.6951928, 0.2599617)
Data Point: (1.274275, 0.25987516)
Data Point: (2.3357215, 0.25959248)
Data Point: (4.2813324, 0.2586718)
Data Point: (7.8475997, 0.25571003)
Data Point: (14.384499, 0.24656017)
Data Point: (26.366509, 0.22150596)
Data Point: (48.329302, 0.17063801)

Slope Stability Rapid Draw Down

Data Point: (88.586679, 0.10916815)
Data Point: (162.37767, 0.065559185)
Data Point: (297.63514, 0.041878631)
Data Point: (545.55948, 0.029155966)
Data Point: (1000, 0.021736063)

Estimation Properties

Vol. WC Estimation Method: Sample functions
Sample Material: Sand
Saturated Water Content: 0.26 ft^3/ft^3
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum: 1000
Minimum: 0.01
Num. Points: 20

Regions

	Material	Points	Area (ft^2)
Region 1	Debris	12,27,7,30,29	43.292528
Region 2	Embankment Clay	6,14,12,27	32.306024
Region 3	T-wall	12,29,10,13,11,15,16,17,5,18,21,20,19,6,14	96.178322
Region 4	Debris	23,24,25,15	2.2524075
Region 5	Embankment Clay	23,28,26,5,17,16,15	31.157314
Region 6	Debris	26,28,22,1,2,3,4	636.27261
Region 7	Foundation Clay	29,10,13,11,15,25,24,23,28,22,31,32,9,8,36,35,30	14900.163

Points

	X (ft)	Y (ft)
Point 1	0	334.9629
Point 2	74.1988	335.4209
Point 3	133.6199	335.1982
Point 4	156.1492	333.8638
Point 5	189.94866	335.00041
Point 6	192.10634	335.14426
Point 7	217.58	333.7031
Point 8	305.4474	317.9361
Point 9	359.2597	312.6319
Point 10	203.30208	322.916
Point 11	200.21849	329.66493
Point 12	203.30208	331.92348
Point 13	201.84227	322.89996
Point 14	192.1851	331.93952
Point 15	182.20486	329.69835
Point 16	182.20486	331.21898
Point 17	189.89112	332.34859
Point 18	190.25176	349.20939

Point 19	191.76033	349.22332
Point 20	191.76033	350.21665
Point 21	190.29354	350.25378
Point 22	0	331.5
Point 23	180.7	329.7
Point 24	180.7	328.2
Point 25	182.2	328.2
Point 26	180.7	334.65
Point 27	203.30926	334.51046
Point 28	180.7	331.5
Point 29	203.3	331.5
Point 30	223.13081	331.50496
Point 31	0	285
Point 32	359	285
Point 33	189.75	334.8
Point 34	192.25	335.2
Point 35	243	323.9
Point 36	243	319.6

Critical Slip Surfaces

	Number	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	1.840	(234.664, 344.546)	24.29736	(205.289, 334.399)	(248.604, 319.451)
2	927	1.920	(234.664, 344.546)	28.663	(207.914, 334.25)	(248.518, 319.453)

Slices of Slip Surface: Optimized

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	Optimized	206.0673	333.6742	-1976.4812	56.264657	0	32.693
2	Optimized	207.65015	332.2014	-1884.5524	171.72339	0	95.639
3	Optimized	209.31095	330.53075	-1780.3171	233.20771	0	327.54
4	Optimized	211.0236	328.68645	-1665.2529	391.07934	0	375.14
5	Optimized	212.7328	326.6829	-1540.2315	514.39071	0	413.56
6	Optimized	214.12985	325.13435	-1443.5998	741.11206	0	587.83
7	Optimized	215.2181	324.2	-1385.2451	832.23468	0	588.55
8	Optimized	216.6711	323.02035	-1311.6513	981.38966	0	591.42
9	Optimized	218.17055	321.84505	-1238.3152	1076.454	0	594.75
10	Optimized	219.3989	320.9754	-1184.0745	1195.8392	0	598.28
11	Optimized	220.67455	320.1618	-1133.3143	1232.2571	0	599.72

12	Optimized	222.2216	319.2985	-1079.4293	1340.9319	0	603.28
13	Optimized	223.42615	318.6937	-1041.6922	1357.9396	0	604
14	Optimized	224.34545	318.28815	-1016.3713	1418.8007	0	605.9
15	Optimized	225.5934	317.7737	-984.29251	1423.0235	0	606.07
16	Optimized	226.9247	317.29815	-954.59703	1485.4916	0	607.94
17	Optimized	228.33935	316.86145	-927.37687	1473.1311	0	607.43
18	Optimized	229.81545	316.49335	-904.35631	1525.9018	0	608.81
19	Optimized	231.35295	316.1938	-885.71505	1490.9175	0	607.39
20	Optimized	232.9807	315.9617	-871.19814	1511.0965	0	607.52
21	Optimized	234.69875	315.79715	-860.94262	1449.7952	0	605.1
22	Optimized	236.16505	315.72725	-856.573	1468.5872	0	605.03
23	Optimized	237.3796	315.7519	-858.13699	1405.6984	0	602.65
24	Optimized	238.5942	315.77655	-859.61867	1342.8918	0	600.36
25	Optimized	240.06705	315.92115	-868.68629	1341.2329	0	599.49
26	Optimized	241.7981	316.1857	-885.18973	1217.7712	0	595.43
27	Optimized	242.8318	316.38235	-897.45316	1320.8571	0	660.3
28	Optimized	243.92405	316.80035	-923.53252	549.77348	0	414.33
29	Optimized	245.47415	317.53675	-969.48652	528.68632	0	408.93
30	Optimized	246.72625	318.3023	-1017.2522	391.78076	0	379.01
31	Optimized	247.9783	319.0679	-1065.0179	254.88201	0	349.08

Slices of Slip Surface: 927

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	927	208.52715	332.87575	-1926.6374	68.204553	0	52.097
2	927	209.84405	330.2781	-1764.5441	164.21929	0	303.77
3	927	211.2506	328.0562	-1625.9231	381.38532	0	374.6
4	927	212.65715	326.21345	-1510.9271	520.40364	0	591.82
				-			

Slope Stability Rapid Draw Down

5	927	214.06365	324.6414	1412.8106	730.76072	0	588.36
6	927	215.4702	323.2789	-1327.7886	916.68452	0	590.65
7	927	216.87675	322.0872	-1253.466	1083.8106	0	594.7
8	927	218.27385	321.04625	-1188.499	1210.1317	0	599.04
9	927	219.66155	320.1359	-1131.667	1296.7542	0	601.85
10	927	221.04925	319.3348	-1081.7206	1369.7145	0	604.3
11	927	222.43695	318.6327	-1037.8521	1430.183	0	606.36
12	927	223.7931	318.03375	-1000.533	1477.5393	0	607.87
13	927	225.1177	317.5282	-968.99059	1512.8155	0	608.89
14	927	226.4423	317.0958	-941.96484	1538.6028	0	609.55
15	927	227.76695	316.7332	-919.37465	1555.1771	0	609.86
16	927	229.0916	316.4377	-900.92425	1562.8066	0	609.81
17	927	230.4162	316.2071	-886.50973	1561.6577	0	609.43
18	927	231.7408	316.0399	-876.11589	1551.9402	0	608.71
19	927	233.0654	315.935	-869.54031	1533.6804	0	607.68
20	927	234.39	315.89165	-866.85544	1506.8624	0	606.34
21	927	235.7146	315.9096	-867.97173	1471.4403	0	604.7
22	927	237.0392	315.989	-872.93962	1427.1882	0	602.8
23	927	238.36385	316.13035	-881.72278	1374.0891	0	600.65
24	927	239.6885	316.33455	-894.49095	1311.6723	0	598.3
25	927	241.0131	316.603	-911.23518	1239.7157	0	595.82
26	927	242.3377	316.9376	-932.1166	1160.9452	0	604.16
27	927	243.6897	317.3506	-957.90107	435.8787	0	388.11
28	927	245.0691	317.8483	-988.94804	375.5044	0	374.23
29	927	246.4485	318.4283	-1025.0992	300.34685	0	357.37
30	927	247.8279	319.09625	-1066.8343	208.26706	0	337.23

Slope Stability RDD

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File Information

Title: Paducah 87+43 B
Comments: I-Wall
Created By: Minges, George C LRL
Revision Number: 44
Last Edited By: Minges, George C LRL
Date: 11/8/2009
Time: 11:37:26 AM
File Name: Paducah 87+43 B F.gsz
Directory: S:\proj\112546\Others\FEASIBILITY FOLDER\Feasibility Writeup\BONNIE\ENGINEERING CALCULATIONS\FEASIBILITY GEOTECH CALC FILES\
Last Solved Date: 11/8/2009
Last Solved Time: 11:38:16 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Slope Stability RDD

Kind: SLOPE/W
Parent: Steady-State Seepage
Method: Spencer
Settings
- **Apply Phreatic Correction:** Yes
- **PWP Conditions Source:** Piezometric Line
- **Use Staged Rapid Drawdown:** Yes

SlipSurface
- **Direction of movement:** Left to Right
- **Use Passive Mode:** No
- **Slip Surface Option:** Auto-Search
- **Critical slip surfaces saved:** 1
- **Optimize Critical Slip Surface Location:** Yes
- **Tension Crack**

Tension Crack Option: (none)
FOS Distribution
FOS Calculation Option: Constant
Advanced
Number of Slices: 30
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 2000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

Materials

I wall

Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Line: 2
Piezometric Line After Drawdown: 1

Embankment Fill

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 200 psf
Phi: 26 °
Vol. WC. Function: Embankment Clay
Drawdown Total Cohesion: 1000 psf
Drawdown Total Phi: 0 °
Pore Water Pressure
Piezometric Line: 2
Piezometric Line After Drawdown: 1

Foundation Clay

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion: 225 psf
Phi: 28 °
Vol. WC. Function: Foundation Clay
Drawdown Total Cohesion: 250 psf
Drawdown Total Phi: 21 °
Pore Water Pressure
Piezometric Line: 2
Piezometric Line After Drawdown: 1

Slip Surface Limits

Left Coordinate: (0, 339.3218) ft
Right Coordinate: (224.5, 330.75) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
	0	302
	225	302

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
	132.5	350.2
	225	350.2

Vol. Water Content Functions

Embankment Clay

Model: Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Mv: 4.79e-007 /psf
Porosity: 0.22
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.21999999)
Data Point: (0.018329807, 0.21999998)
Data Point: (0.033598183, 0.21999997)
Data Point: (0.061584821, 0.21999993)
Data Point: (0.11288379, 0.21999984)
Data Point: (0.20691381, 0.21999963)
Data Point: (0.37926902, 0.21999914)
Data Point: (0.6951928, 0.21999792)
Data Point: (1.274275, 0.21999489)
Data Point: (2.3357215, 0.21998722)
Data Point: (4.2813324, 0.21996761)
Data Point: (7.8475997, 0.21991719)
Data Point: (14.384499, 0.21978687)
Data Point: (26.366509, 0.21944947)